DRC-2012-002140

ENERGYSOLUTIONS

October 25, 2012

CD12-0277

OCT 2012

Mr. Rusty Lundberg
Director
Utah Division of Radiation Control
195 North 1950 West
P O Box 144850
Salt Lake City, UT 84114-4850

Re Radioactive Material License No UT 2300249 Renewal Application

Dear Mr Lundberg

On 5 October 2000, Energy*Solutions*, LLC, a Utah Limited Liability Corporation (EnergySolutions), (known then as Envirocare of Utah, LLC) was first issued a license from the Utah Division of Radiation Control (the Division) to manage and dispose of Low-Level Radioactive Waste (LLRW) up to the Class A limits promulgated in UAC R313-15-1009 The Radioactive Material License UT 2300249 (the License) was later renewed by the Division on 25 January 2005 and is currently set to expire 25 January 2013 In compliance with Utah Administrative Code (UAC) R313-25-13(1), which stipulates that "*[a]n application for renewal shall be filed at least 90 days prior to license expiration,*" Energy*Solutions* submits this Application to the Division for renewal of the License for an additional period of 10 years, with proposed amendments

By submitting this Application prior to 26 October 2012, Energy*Solutions* has met the timely renewal regulatory deadline and understands it is authorized to continue its current waste management operations within the bounds of the expiring License, until the Division's renewal process has been completed Engineering and construction practices with respect to waste placement will continue as specified in the current approved LLRW and 11e (2) Construction Quality Assurance and Quality Control Manual

To the extent practicable, the information presented in this Application was prepared in accordance with UAC R313-25-13 and conforms to the format and outline directed by the Division

423 West 300 South, Suite 200 • Salt Lake City, Utah 84101
801 649 2000 • Fax 801 321 0453 • www energysolutions com

ENERGYSOLUTIONS

A complete Application has also been provided in electronic format If you have any questions regarding this issue, please contact me at 801-649-2000

Sincerely,

Sean McCandless
Director of Compliance and Permitting

enclosures

cc   John Hultquist, DRC (w/ encl)

STATE OF UTAH
RADIOACTIVE MATERIAL
LICENSE RENEWAL APPLICATION
(UT 2300249)

October 25, 2012

October 25, 2012 CD12-0277

Mr. Rusty Lundberg
Director
Utah Division of Radiation Control
195 North 1950 West
P.O. Box 144850
Salt Lake City, UT 84114-4850

Re: Radioactive Material License No. UT 2300249: Renewal Application

Dear Mr. Lundberg:

On 5 October 2000, Energy*Solutions*, LLC, a Utah Limited Liability Corporation (EnergySolutions), (known then as Envirocare of Utah, LLC) was first issued a license from the Utah Division of Radiation Control (the Division) to manage and dispose of Low-Level Radioactive Waste (LLRW) up to the Class A limits promulgated in UAC R313-15-1009. The Radioactive Material License UT 2300249 (the License) was later renewed by the Division on 25 January 2005 and is currently set to expire 25 January 2013. In compliance with Utah Administrative Code (UAC) R313-25-13(1), which stipulates that "*[a]n application for renewal… shall be filed at least 90 days prior to license expiration,*" Energy*Solutions* submits this Application to the Division for renewal of the License for an additional period of 10 years, with proposed amendments.

By submitting this Application prior to 26 October 2012, Energy*Solutions* has met the timely renewal regulatory deadline and understands it is authorized to continue its current waste management operations within the bounds of the expiring License, until the Division's renewal process has been completed. Engineering and construction practices with respect to waste placement will continue as specified in the current approved LLRW and 11e.(2) Construction Quality Assurance and Quality Control Manual.

To the extent practicable, the information presented in this Application was prepared in accordance with UAC R313-25-13 and conforms to the format and outline directed by the Division.

A complete Application has also been provided in electronic format. If you have any questions regarding this issue, please contact me at 801-649-2000.

Sincerely,

Sean McCandless
Director of Compliance and Permitting

enclosures

cc: John Hultquist, DRC (w/ encl.)

STATE OF UTAH RADIOACTIVE MATERIAL LICENSE RENEWAL APPLICATION (UT 2300249)

October 25, 2012

By
Energy*Solutions*, LLC
423 West 300 South, Suite 200
Salt Lake City, UT 84101

For
Utah Division of Radiation Control
Post Office Box 144850
195 North 1950 West
Salt Lake City, UT 84114-4850

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

SECTION 1. GENERAL INFORMATION

UAC R313-25-3(1-2)	*"(1) Persons proposing to construct or operate commercial radioactive waste disposal facilities, including waste incinerators, shall obtain a plan approval from the Executive Secretary before applying for a license.* *"(2) The siting criteria and plan approval requirements in R313-25-3 apply to prelicensing plan approval applications the applicant's"*
UAC R313-25-4(1-2)	*"(1) Persons shall not receive, possess, or dispose of waste at a land disposal facility unless authorized by a license issued by the Executive Secretary pursuant to R313-25 and R313-22.* *"(2) Persons shall file an application with the Executive Secretary pursuant to R313-22-32 and obtain a license as provided in R313-25 before commencement of construction of a land disposal facility. Failure to comply with this requirement may be grounds for denial of a license and other penalties established by law and rules. "*
UAC R313-25-5	*"In addition to the requirements set forth in R313-22-33, an application to receive from others, possess, and dispose of wastes shall consist of general information, specific technical information, institutional information, and financial information as set forth in R313-25-6 through R313-25-10."*
UAC R313-25-6	*"The general information shall include the following:* *(1) identity of the applicant including:* *(a) the full name, address, telephone number, and description of the business or occupation of the applicant;* *(b) if the applicant is a partnership, the names and addresses of the partners and the principal location where the partnership does business;* *(c) if the applicant is a corporation or an unincorporated association;* *(i) the state where it is incorporated or organized and the principal location where it does business; and* *(ii) the names and addresses of its directors and principal officers; and* *(d) if the applicant is acting as an agent or representative of another person in filing the application, the applicant shall provide, with respect to the other person, information required under R313-25-6(1).* *(2) Qualifications of the applicant shall include the following;* *(a) the organizational structure of the applicant, both offsite and onsite, including a description of lines of authority and assignments of responsibilities, whether in the form of administrative directives, contract provisions, or otherwise;* *(b) the technical qualifications, including training and experience of the applicant and members of the applicant's staff, to engage in the proposed activities. Minimum training and experience requirements for personnel filling key positions described in R313-25-6(2)(a) shall be provided;*

(c) a description of the applicant's personnel training program; and
(d) the plan to maintain an adequate complement of trained personnel to carry out waste receipt, handling, and disposal operations in a safe manner.
(3) A description of:
(a) the location of the proposed disposal site;
(b) the general character of the proposed activities;
(c) the types and quantities of waste to be received, possessed, and disposed of;
(d) plans for use of the land disposal facility for purposes other than disposal of wastes; and
(e) the proposed facilities and equipment; and
(4) proposed schedules for construction, receipt of waste, and first emplacement of waste at the proposed land disposal facility."

UAC R313-25-7(1,2,4-6) *"The application shall include certain technical information. The following information is needed to determine whether or not the applicant can meet the performance objectives and the applicable technical requirements of R313-25:*
(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.
(2) Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.
(4) Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria.
(5) Descriptions of codes and standards which the applicant has applied to the design, and will apply to construction of the land disposal facilities.
(6) Descriptions of the construction and operation of the land disposal facility. The description shall include as a minimum the methods of construction of disposal units; waste emplacement; the procedures for and areas of waste segregation; types of intruder barriers; onsite traffic and drainage systems; survey control program; methods and areas of waste storage; and methods to control surface water and ground water access to the wastes. The description shall also include a description of the methods to be employed in the handling and disposal of wastes containing chelating agents or other non-radiological substances which might affect meeting the performance objectives of R313-25"

UAC R313-25-8(4)(a-b) *"The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*
(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.
(b) Analyses of the protection of inadvertent intruders shall demonstrate a reasonable assurance that the waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion will be provided."

UAC R313-25-9 *"The institutional information submitted by the applicant shall include:*
(1) A certification by the federal or state agency which owns the disposal site that the agency is prepared to accept transfer of the license when the provisions of R313-25-16 are met and will assume responsibility for institutional control after site closure and for post-closure observation and maintenance.
(2) Evidence, if the proposed disposal site is on land not owned by the federal or a state government, that arrangements have been made for assumption of ownership in fee by the federal or a state agency."

UAC R313-25-10 *"This information shall demonstrate that the applicant is financially qualified to carry out the activities for which the license is sought. The information shall meet other financial assurance requirements of R313- 25."*

UAC R313-25-11(2, 4-5) *"A license for the receipt, possession, and disposal of waste containing radioactive material will be issued by the Executive Secretary upon finding that:*
(2) the applicant is qualified by reason of training and experience to carry out the described disposal operations in a manner that protects health and minimizes danger to life or property;
(4) the applicant's proposed disposal site, disposal site design, land disposal facility operations, including equipment, facilities, and procedures, disposal site closure, and post-closure institutional control are adequate to protect the public health and safety in accordance with the performance objectives of R313-25-20;
(5) the applicant's proposed land disposal facility operations, including equipment, facilities, and procedures, are adequate to protect the public health and safety in accordance with R313-15;"

UAC R313-25-13(1-4) *"(1) An application for renewal or an application for closure under R313-25-14 shall be filed at least 90 days prior to license expiration.*
(2) Applications for renewal of a license shall be filed in accordance with R313-25-5 through 25-10. Applications for closure shall be filed in accordance with R313-25-14. Information contained in previous applications, statements, or reports

filed with the Executive Secretary under the license may be incorporated by reference if the references are clear and specific.
(3) If a licensee has filed an application in proper form for renewal of a license, the license shall not expire unless and until the Executive Secretary has taken final action to deny application for renewal.
(4) In evaluating an application for license renewal, the Executive Secretary will apply the criteria set forth in R313-25-11."

UAC R313-25-20 *"Design, operation, and closure of the land disposal facility shall ensure protection of any individuals inadvertently intruding into the disposal site and occupying the site or contacting the waste after active institutional controls over the disposal site are removed."*

UAC R313-25-23(2) *"The disposal site shall be capable of being characterized, modeled, analyzed and monitored."*

UAC R313-25-23(3) *"Within the region where the facility is to be located, a disposal site should be selected so that projected population growth and future developments are not likely to affect the ability of the disposal facility to meet the performance objectives of R313-25."*

UAC R313-25-23(4) *"Areas shall be avoided having known natural resources which, if exploited, would result in failure to meet the performance objectives of R313-25."*

UAC R313-25-23(11) *"The disposal site shall not be located where nearby facilities or activities could adversely impact the ability of the site to meet the performance objectives of R313-25 or significantly mask the environmental monitoring program."*

UAC R313-25-24(4) *"Wastes shall be emplaced in a manner that maintains the package integrity during emplacement, minimizes the void spaces between packages, and permits the void spaces to be filled."*

UAC R313-25-25(1) *"Wastes designated as Class A pursuant to R313-15-1009 of these rules shall be segregated from other wastes by placing them in disposal units which are sufficiently separated from disposal units for the other waste classes so that any interaction between Class A wastes and other wastes will not result in the failure to meet the performance objectives of R313-25. This segregation is not necessary for Class A wastes if they meet the stability requirements of R313-15-1009(2)(b)."*

UAC R313-25-25(7) *"The boundaries and locations of disposal units shall be accurately located and mapped by means of a land survey. Near-surface disposal units shall be marked in such a way that the boundaries of the units can be easily defined. Three permanent survey marker control points, referenced to United States Geological Survey or National Geodetic Survey control stations, shall be established on the site to facilitate surveys. The United States Geological Survey or National Geodetic Survey control stations shall provide horizontal and vertical controls as checked* *against United States Geological Survey or National Geodetic Survey record files."*

UAC R313-25-25(12)	*"Proposals for disposal of waste that are not generally acceptable for near-surface disposal because the wastes form and disposal methods shall be different and, in general, more stringent than those specified for Class C waste, may be submitted to the Division Director for approval."*
UAC R313-25-30	*"The applicant shall show that it either possesses the necessary funds, or has reasonable assurance of obtaining the necessary funds, or by a combination of the two, to cover the estimated costs of conducting all licensed activities over the planned operating life of the project, including costs of construction and disposal."*
UAC R313-25-32	*"(1) Prior to the issuance of the license, the applicant shall provide for Executive Secretary approval, a binding arrangement, between the applicant and the disposal site owner that ensures that sufficient funds will be available to cover the costs of monitoring and required maintenance during the institutional control period. The binding arrangement shall be reviewed annually by the Executive Secretary to ensure that changes in inflation, technology, and disposal facility operations are reflected in the arrangements. (2) Subsequent changes to the binding arrangement specified in R313-25-32(1) relevant to institutional control shall be submitted to the Executive Secretary for prior approval."*
UAC R313-25-33	*"(1) Licensees shall maintain records and make reports in connection with the licensed activities as may be required by the conditions of the license or by the rules and orders of the Executive Secretary. (2) Records which are required by these rules or by license conditions shall be maintained for a period specified by the appropriate rules or by license condition. If a retention period is not otherwise specified, these records shall be maintained and transferred to the officials specified in R313-25-33(4) as a condition of license termination unless the Executive Secretary otherwise authorizes their disposition. (3) Records which shall be maintained pursuant to R313-25 may be the original or a reproduced copy or microfilm if this reproduced copy or microfilm is capable of producing copy that is clear and legible at the end of the required retention period. (4) Notwithstanding R313-25-33(1) through (3), copies of records of the location and the quantity of wastes contained in the disposal site shall be transferred upon license termination to the chief executive of the nearest municipality, the chief executive of the county in which the facility is located, the county zoning board or land development and planning agency, the State Governor, and other state, local, and federal governmental agencies as designated by the Executive Secretary at the time of license termination. (5) Following receipt and acceptance of a shipment of waste, the licensee shall record the date that the shipment is received at the disposal facility, the date of disposal of the waste, a traceable shipment manifest number, a description of any engineered barrier or structural overpack provided for disposal of the waste, the location of disposal at the disposal site, the condition of the waste packages as*

received, discrepancies between the materials listed on the manifest and those received, the volume of any pallets, bracing, or other shipping or onsite generated materials that are contaminated, and are disposed of as contaminated or suspect materials, and evidence of leakage or damaged packages or radiation or contamination levels in excess of limits specified in U.S. Department of Transportation and Executive Secretary regulations or rules. The licensee shall briefly describe repackaging operations of the waste packages included in the shipment, plus other information required by the Executive Secretary as a license condition.

(6) Licensees authorized to dispose of waste received from other persons shall file a copy of their financial report or a certified financial statement annually with the Executive Secretary in order to update the information base for determining financial qualifications.

(7) (a) Licensees authorized to dispose of waste received from other persons, pursuant to R313-25, shall submit annual reports to the Executive Secretary. Reports shall be submitted by the end of the first calendar quarter of each year for the preceding year.

(b) The reports shall include:

(i) specification of the quantity of each of the principal contaminants released to unrestricted areas in liquid and in airborne effluents during the preceding year;

(ii) the results of the environmental monitoring program;

(iii) a summary of licensee disposal unit survey and maintenance activities;

(iv) a summary, by waste class, of activities and quantities of radionuclides disposed of;

(v) instances in which observed site characteristics were significantly different from those described in the application for a license; and

(vi) other information the Executive Secretary may require.

(c) If the quantities of waste released during the reporting period, monitoring results, or maintenance performed are significantly different from those predicted, the report shall cover this specifically.

(8) In addition to the other requirements in R313-25-33, the licensee shall store, or have stored, manifest and other information pertaining to receipt and disposal of radioactive waste in an electronic recordkeeping system.

(a) The manifest information that must be electronically stored is:

(i) that required in Appendix G of 10 CFR 20.1001 to 20.2402, (2006), which is incorporated into these rules by reference, with the exception of shipper and carrier telephone numbers and shipper and consignee certifications; and

(ii) that information required in R313-25-33(5).

(b) As specified in facility license conditions, the licensee shall report the stored information, or subsets of this information, on a computer-readable medium."

1.1 INTRODUCTION

On 5 October 2000, Energy*Solutions,* LLC, a Utah Limited Liability Corporation (Energy*Solutions*), (known then as Envirocare of Utah, LLC) was first issued a license from the Utah Division of Radiation Control (the Division) to manage and dispose of Low-Level Radioactive Waste (LLRW) up to the Class A limits promulgated in UAC R313-15-1009. The Radioactive Material License UT 2300249 (the License) was later renewed by the Division on 25 January 2005 and is currently set to expire 25 January 2013. Since its last renewal, the License has been amended several times to reflect changes in Company governance, waste management, operating practices, administrative processes, and waste characteristics. In compliance with Utah Administrative Code (UAC) R313-25-13(1), which stipulates that ―*[a]n application for renewal… shall be filed at least 90 days prior to license expiration,*" Energy*Solutions* submits this Application to the Division for renewal of the License, with proposed amendments. Furthermore, in recognition of Energy*Solutions'* exceptional history of regulatory compliance and consistent with U.S. Nuclear Regulatory Commission (NRC) guidance in NUREG-1556, which recommends that ―*[any] license issued or renewed after July 10, 1998 . . . should have a 10-year term limit*" (NRC, 2000) Energy*Solutions* requests that the License be renewed for an additional period of ten years.

UAC R313-25-13(3) states that ―*[i]f a licensee has filed an application in proper form for renewal of a license, the license shall not expire unless and until the [Director] has taken final action to deny application for renewal.*" By submitting this Application prior to 26 October 2012, Energy*Solutions* has met the timely renewal regulatory deadline and understands it is authorized to continue its current waste management operations within the bounds of the expiring License, until the Division‘s renewal process has been completed. Engineering and construction practices with respect to waste placement will continue as specified in Energy*Solutions*‘ LLRW and 11e.(2) Construction Quality Assurance and Quality Control Manual, currently approved as revision 26d (CQA/QC Manual).

On 31 January 2005, Envirocare of Utah, Inc. was sold and became Envirocare of Utah, LLC. On 2 February 2006, Envirocare of Utah, LLC became Energy*Solutions*, LLC, which is a subsidiary of Energy*Solutions*, Inc., a publicly held corporation. Energy*Solutions*, LLC is a Utah limited liability corporation with corporate headquarters located at 423 West 300 South, Suite 200, Salt Lake City, UT 84102. All references, attachments, and appendices to this Application that were performed for, or in support of, Envirocare of Utah, Inc. or Envirocare of Utah, LLC, are pertinent to this Energy*Solutions* Application.

To the extent practicable, the information presented in this Application was prepared in accordance with UAC R313-25-13 and conforms to the format and outline directed by the Division (Johnson, 2012). Table 1-1 provides a compliance matrix relating requirements found in the Utah Radiation Control Rules (UAC R313-25) to the location of this information in the Application. Similarly, Table 1-2 provides a matrix relating this Application‘s information to guidelines set forth by NRC (1991), ―**Standard Format and Content of a License Application For a Low-Level Radioactive Waste Disposal Facility**." A complete list of NRC Regulatory Guides applicable to the Application is included in Section 1.6. Proposed revisions to the License are provided in redline/strikeout format in Appendix A. The proposed changes to the License and their justification include the following:

1. The format for citing procedures and requirements in the LLRW and 11e.(2) Construction Quality Assurance/Quality Control was unified.

Table 1-1

Utah Radiation Control Rules Compliance Matrix

Rule		Definition	RML References
R313-25-1		**Purpose and Scope**	
R313-25-2		**Definitions**	
R313-25-3		**Siting Criteria and Pre-Licensing Plan Approval for Commercial Radioactive Waste Disposal Facilities**	
	(1)	Persons proposing to construct or operate commercial radioactive waste disposal facilities shall obtain plan approval from the Executive Secretary before applying for a license.	1.1
	(2)	The siting criteria and plan approval requirements in R313-25-3 apply to pre-licensing plan approval applications.	1.1
	(3)	This license requirement delineates where treatment facilities, including commercial radioactive incinerators cannot be located. It specifies the hydrogeologic, seismic, archeological, and federal criteria that would prevent the licensing of a disposal facility.	2.1-2.10
	(5)	Facilities may not be located within a distance to existing drinking water wells and watersheds for public water supplies of one year ground water travel time plus 1000 feet for incinerators and of five years groundwater travel time plus 1000 feet for land disposal facilities.	6.4.1.1.3
	(6)	The plan approval application shall include hydraulic conductivity and other information necessary to estimate adequately the groundwater travel distance.	2.6.1.1, 2.6.1.2, 2.6.2.2
	(7)	The plan approval application shall include the results of studies adequate to identify the presence of ground water aquifers in the area of the proposed site and to assess the quality of the ground water of all aquifers identified in the area of the proposed site.	2.5, 2.6, 2.7, 2.9.2
	(9)	This license requirement specifies plan approval requirements pertinent to	4.5

Rule		Definition	RML References
		emergency response and safety during operations at the disposal facility.	
R313-25-4		**License Required**	1.1
	(1)	Persons shall not receive, possess, or dispose of waste at a land disposal facility unless authorized by a license issued by the Executive Secretary pursuant to R313-25 and R313-22.	1.1
	(2)	Persons shall file an application with the Executive Secretary pursuant to R313-22-32 and obtain a license as provided in R313-25 before commencement of construction of a land disposal facility. Failure to comply with this requirement may be grounds for denial of a license and other penalties established by law and rules.	1.1
R313-25-5		**Content of Application**	
	(1)	In addition to the requirements set forth in R313-22-33, an application to receive from others, possess, and dispose of waste shall consist of general information, specific technical information, institutional information, and financial information, as set forth by R313-25-6 through R313-25-10.	Section 1, Section 2, Section 3, Section 5, Section 10
R313-25-6		**General Information**	
	(1)	Identity of the applicant.	1.1.1, 1.1.3
	(2)	Applicant qualifications.	1.1.2.1, 1.1.2.2
	(3)	Description of site location, waste and technical abilities.	1.1, 1.2, 1.2.1.1, 1.2.3.4-1.2.3.13, 1.2.3.16-1.2.3.19, 2.1, 2.3-2.10, 6.1, 6.2
	(4)	Proposed schedules for construction, receipt, and waste emplacement.	1.3, 1.3.1-1.3.5, 6.2, 4.2, 4.3
R313-25-7		**Specific Technical Information**	
	(1)	A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archeological, meteorological, climatologic, and biotic features of the disposal site and vicinity.	1.2.2, 2.1-2.10

Rule	Definition	RML References
(2)	Design feature descriptions, including: water infiltration; cover integrity; structural stability; contact water management; disposal site drainage, closure, and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of buffer zone size.	1.2.3.1, 1.2.3.2, Section 2, 3.1, 3.1.3, 3.1.4, 3.2.4, 3.3.4, 3.4.4, Section 5, Section 7
(3)	Description of principal design criteria.	Section 3
(4)	Description of natural events or phenomena on which the design is based and their relationship to the principal design criteria.	1.2.3.5, 1.2.3.63.1, 2.1-2.11
(5)	Description of codes and standards which the applicant has applied to the design, and will apply to the construction of the land disposal facility.	1.1, 1.5, 1.6, Section 3, 6.2, 6.3.2, 4.8
(6)	Description of construction and operation of land disposal facility, including: disposal unit construction methods, waste emplacement and segregation methods, types of intruder barriers, onsite traffic and drainage systems, survey control program, methods and areas of waste storage, surface and groundwater waste access control, and methods to be employed in handling chelating agents or other non-radiological substances which might affect meeting the performance objectives.	1.2.3, Section 2, Section 3, Section 5, Section 7, 4.1-4.9
(7)	Description of site closure plan, including those design features which will facilitate disposal site closure and eliminate the need for active maintenance after closure.	Section 5
(8)	Identification of natural resources that could lead to inadvertent intrusion.	2.9
(9)	Description of radioactive waste (kind, amount, classification, and specifications).	6.2
(10)	Description of QA program.	Section 9
(11)	Description of radiation safety program.	4.4, Section 7
(12)	Description of environmental monitoring program.	2.11, 4.9

Rule		Definition	RML References
	(13)	Description of administrative procedures.	4.8, 9.5
	(14)	Description of the facility electronic recordkeeping system as required in R313-25-33.	4.2
R313-25-8		**Technical Analyses**	
	(1)	Air, soil, groundwater, surface water, animal burrowing will be considered in general population protection. Analysis will differentiate between roles performed by the natural site characteristics and roles performed by design features.	1.2.3.8, 1.2.3.9, 1.2.3.10, 2.1, 2.1.3, 6.4.1.2, 6.4.2.2, 4.7
	(2)	Inadvertent intruder protection.	1.2.3.8, 1.2.3.9, 1.2.3.10, 6.4.1.3, 6.4.2.3, 4.7
	(3)	Expected exposure to workers during operation.	4.4, 6.3, 7.2.2
	(4)	Long term stability. Analysis based on natural processes including erosion, mass wasting, slope failure, settlement, infiltration, and surface drainage.	Section 3, 6.4
R313-25-9		**Institutional Information**	1.4, 5.4, 10.3
	(1)	A certification from the agency which owns the disposal site that the agency is prepared to accept transfer of the license when the provisions of R313-25-16 are met and will assume responsibility for institutional control after site closure and for post-closure observation and maintenance.	1.4
	(2)	Evidence, if the proposed disposal site is on land not owned by the federal or state government, that arrangements were made for assumption of ownership in fee by the federal or state agency.	1.4
R313-25-10		**Financial Information**	1.4, 5.4.1, 10.1-10.3
R313-25-11		**Requirements for Issuance of a License by the Executive Secretary**	
	(1)	Won‘t cause unreasonable risk to public safety or health.	2.1, 2.4, 2.7
	(2)	Applicant is qualified.	1.1.2.1, 1.1.2.2
	(3)	Disposal site is adequate: to protect the public health and safety.	5.1, 6.3.1.1, 6.3.1.3-6.3.1.5, 4.4, 4.6-4.9
	(4)	Disposal site is adequate: to protect from inadvertent intrusion.	1.2.3, 4.7
	(5)	Disposal site is adequate: to protect public post-closure.	1.2.3.1, 2.1.1-2.1.3, 2.4-2.8, 4.7

Rule	Definition	RML References
(6)	Disposal site is adequate: long-term stability.	2.1-2.10, 3.1.1-3.1.2, 4.3.4, 5.1.2, 6.4.3
(7)	Applicant provides reasonable assurance that the requirements of R313-25 will be met.	
(8)	Demonstrate adequacy of institutional controls.	4.6, 5.4, 9, 10.3
R313-25-12	**Conditions of License**	
(5)	Requirement to confine waste and waste handling equipment to approved areas only.	4.1-4.3
R313-25-13	**Application for Renewal or Closure**	
(1)	An application for renewal or an application for closure shall be filled at least 90 days prior to license expiration.	1.1
(2)	Application requirements.	1.1
(3)	If a licensee has filed an application in proper form for renewal of a license, the license shall not expire unless and until the Executive Secretary has taken final action to deny application for renewal.	1.1
(4)	In evaluating an application for license renewal, the Executive Secretary will apply the criteria set forth in R313-25-11.	1.1
R313-25-14	**Contents of Application for Site Closure and Stabilization**	
R313-25-15	**Post-Closure Observation and Maintenance**	4.9.2, 6.4
R313-25-16	**Transfer of License: Following closure and the period of post-closure observation**	
R313-25-17	**Termination of License**	
R313-25-18	**General Requirement: Land Disposal Facilities shall be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposure to individuals do not exceed the limits stated in R313-25-19 and 25-22.**	Section 2, Section 3, Section 7
R313-25-19	**Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable**	6.3.2, 6.4.1.2, 6.4.2.2, 7.3.1
R313-25-20	**Protection of Individuals from Inadvertent Intrusion**	1.2.3.8-1.2.3.10, 4.7, 6.4.1.3, 6.4.2.3, 7.3.1

Rule		Definition	RML References
R313-25-21		**Protection of Individuals During Operations**	6.3, 4.4, 7.3, 7.4
R313-25-22		**Stability of the Disposal Site After Closure**	2.1, 2.3
R313-25-23		**Disposal Site Suitability Requirements for Land Disposal-Near-Surface Disposal**	
	(1)	Primary emphasis: Isolation of wastes and disposal site features that ensure that the long-term performance objectives are met.	2.1-2.10, 3.1-3.3
	(2)	The disposal site shall be capable of being characterized, modeled, analyzed, and monitored.	1.2, Section 2, 5.1, 5.3
	(3)	Future population growth considerations.	1.2.2, 2.1.3
	(4)	Natural resource considerations.	1.2.3.3, 2.9
	(5)	Flooding considerations.	2.5, 6.3.2
	(6)	Minimization of upstream drainage areas.	2.5
	(7)	The disposal site shall provide sufficient depth to the water table that groundwater intrusion, perennial or otherwise, into the waste will not occur.	2.6, 2.7
	(8)	The hydrogeologic unit used for disposal shall not discharge groundwater to the surface within the disposal site.	2.5-2.8
	(9)	Seismic considerations.	2.4.2, 5.1.2
	(10)	Geologic process considerations.	2.4, 5.1.2
	(11)	Environmental considerations.	1.2.3.16, 2.10, 2.11, 4.9
R313-25-24		**Disposal Site Design for Near-Surface Land Disposal**	
	(1)	Primary emphasis: Long-term isolation.	2.1, 2.3-2.8, 5.1.1
	(2)	Design compatible with closure plan.	5.1.1
	(3)	Disposal site design requirements.	6.4.3, 4.3
	(4)	Cover requirements.	1.2.3.6, 3.1.3, 3.2.3, 3.3.3, 5.1.1, 5.1.2
	(5)	Ditch requirements.	
	(6)	Water and waste contact issues.	2.5, 2.6, 5.1.1
R313-25-25		**Near Surface Land Disposal Facility Operation and Disposal Site Closure**	
	(1)	Segregation of Class A wastes.	1.2.1.1
	(3)	Waste acceptance requirements.	Section 6, Section 7
	(4)	Waste emplacement requirements.	4.3

Rule	Definition	RML References
(5)	Void space minimization requirements.	4.3.2
(6)	Radiation dose minimization requirements.	4.4
(7)	Boundary marking requirements.	1.2.3.9-1.2.3.11, 2.1.7, 6.3.5
(8)	Buffer zone requirements.	4.3.6
(9)	Closer and stabilization requirements.	Section 5
(10)	Disposal operation requirements.	4.3
(11)	Waste specifications.	
(12)	Executive secretary authority.	1.1
R313-25-26	**Environmental Monitoring**	
(1)	Requirement for pre-operational monitoring.	2.11, Section 2
(2)	Maintenance of an environmental monitoring program.	4.9
(3)	Post operational monitoring.	5.3
(4)	Emergency cleanup plans.	4.5
R313-25-28	**Institutional Requirements**	Section 4, Section 6, 5.4, 10.1-10.3
R313-25-30	**Applicant Qualifications and Assurances**	1.1, 9, 10.3
R313-25-31	**Funding for Disposal Site Closure and Stabilization**	10.1-10.3
R313-25-32	**Financial Assurances for Institutional Controls**	1.1, 5.4, 10.1-10.3
R313-25-33	**Maintenance of Records, Reports, and Transfers**	1.1.2.2, 1.2, 5.4.2, 9.4-9.6
R313-25-34	**Tests on Land Disposal Facilities**	5.1

Table 1-2

NUREG-1199 Compliance Matrix

Rule	Definition	RML References
1.0	**General Information**	
1.1	Introduction	1.1
1.2	General Facility Description	1.2
1.3	Schedules	1.3
1.4	Institutional Information	1.4, 5.4
1.5	Material Incorporated by Reference	1.5
1.6	Conformance to Regulatory Guides	1.6
1.7	Summary of Principle Review Matters	1.7
2.0	**Site Characteristics**	
2.1	Geography, Demography, and Future Developments	2.1
2.1.1	Site Location and Description	2.1.1
2.1.2	Population Distribution	2.1.3
2.2	Meteorology and Climatology	2.3
2.3	Geology and Seismology	2.4
2.3.1	Geologic Site Characterization	2.4.1
2.3.2	Seismic Investigation	2.4.2
2.4	Hydrology	2.5-2.6
2.4.1	Surface Water Hydrology	2.5
2.4.2	Groundwater Characterization	2.5-2.7
2.5	Geotechnical Characteristics	2.8
2.6	Geochemical Characteristics	2.7.3
2.7	Natural Resources	2.9
2.7.1	Geologic Resources	2.9.1
2.7.2	Water Resources	2.9.2
2.8	Biotic Features	2.1
2.9	Site Characterization Monitoring	2.11
3.0	**Design and Construction**	
3.1	Principle Design Features	3.1
3.2	Design Considerations for Normal and Abnormal/Accident Conditions	3.1-3.4
3.3	Construction Considerations	3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5
3.3.1	Construction Methods and Features	Section 2
3.3.2	Construction Equipment	4.3.4
3.4	Design of Auxiliary Systems and Features	3.4
3.4.1	Utility Systems	3.4.1
3.4.2	Auxiliary Facilities	3.3.2

Rule	Definition	RML References
3.4.3	Fire Protection System	3.3.3
3.4.4	Erosion and Flood Control System	3.4.4
4.0	**Facility Operations**	
4.1	Receipt and Inspection of Waste	4.1
4.2	Waste Handling and Interim Storage	4.2
4.3	Waste Disposal Operations	4.3
4.4	Operational Environmental Monitoring and Surveillance	4.9
5.0	**Site Closure Plan and Institutional Controls**	
5.1	Site Stabilization	5.1
5.1.1	Surface Drainage and Erosion Protection	5.1.1
5.1.2	Geotechnical Stability	5.1.2
5.2	Decontamination and Decommissioning	5.2
5.3	Post Operational Environmental Monitoring and Surveillance	5.3
6.0	**Safety Assessment**	
6.1	Release of Radioactivity	6.3-6.4
6.1.1	Determination of Types, Kinds, and Quantities of Waste	6.1
6.1.2	Infiltration	6.3.1.4
6.1.3	Radionuclide Release - Normal Conditions	6.3.1
6.1.4	Radionuclide Release - Accidents or Unusual Operating Conditions	6.3.2
6.1.5	Radionuclide Transfer to Human Access Location	6.4.2.1, 6.4.3.1
6.1.5.1	Transfer Mechanism - Groundwater	6.4.1, 6.4.2
6.1.5.2	Transfer Mechanism - Air	6.4.1, 6.4.2
6.1.5.3	Transfer Mechanism - Surface Water	6.4.1, 6.4.2
6.1.5.4	Other Transfer Mechanisms	6.4.1, 6.4.2
6.1.6	Assessment of Impacts and Regulatory Compliance	1.6, 6.3.1
6.2	Intruder Protection	4.1.7
6.3	Long-Term Stability	6.4.3.1
6.3.1	Surface Drainage and Erosion Protection	6.4.3.2
6.3.2	Stability of Slopes	6.4.3.3
6.3.3	Settlement and Subsidence	6.4.3.4
7.0	**Occupational Radiation Protection**	
7.1	Occupational Radiation Exposures	7.1
7.2	Radiation Sources	7.2

Rule		Definition	RML References
	7.3	Radiation Protection Design Features	7.3
	7.4	Radiation Protection Program	7.4
8.0		**Conduct of Operations**	
	8.1	Organizational Structure	1.1.3
	8.2	Qualifications of Applicant	1.1, 1.1.2
	8.3	Training Program	7.4.3
	8.4	Emergency Planning	4.5, 6.3.2
	8.5	Review and Audit	4.6
	8.6	Facility Administrative and Operating Procedures	Section 4
	8.7	Physical Security	4.7
9.0		**Quality Assurance**	
	9.1	Quality Assurance During the Design and Construction Phase	Section 9
	9.2	Quality Assurance During the Operations Phase	Section 9
10.0		**Financial Assurance**	Section 10
11.0		**References**	Section 11

2. Specific date references of the Waste Characterization Plan, Environmental Monitoring Plan, Organization Plan, CQA/QC Manual, and the Site Radiological Security Plan were replaced with “currently approved,” to be consistent with Division-approved License Conditions 7.A, 16.M(iv), 26, 39.B, and 39.F.

3. Position title was revised from **Director of Health Physics** to **Manager of Health Physics and Safety (RSO)**, to reflect Energy*Solutions'* October 2012 reorganization.

4. References to Division regulations to which Energy*Solutions* is already required to comply (even without their specific inclusion in the License) are deemed redundant and removed as specific License Conditions. Since inclusion of a random selection of regulatory requirements does not represent a comprehensive list of all requirements to which Energy*Solutions* must comply nor does their inclusion alter Energy*Solutions'* compliance obligation, their inclusion is arbitrary and unnecessary. Unnecessarily-duplicative License Conditions that were removed include 16.B, 16.C, 16.D, 16.E, 16.G, 16.H, 17.A, 18, 19, 23, 24, 43, 65, and 75.

5. Elevation references for Section 32 corners were shortened to tenths of a foot in 10.B. Since Section 32 corner markers have already been placed, Condition 10.D was revised to address marker protection.

6. Since waste acceptability and management are already controlled by other part of the License and Energy*Solutions'* State-issued Part B Permit, Condition 16.F.i was revised to permit receipt of nonaqueous liquids meeting the requirements of the Permit for thermal desorption treatment (McCandless, 2008).

7. License Condition 16.I was revised to remove ambiguity regarding whether the definition of “neutron source” includes sealed neutron source or simply a source of neutrons. This revision is justified, since the Containerized Waste Facility includes mass-based possession limits for Special Nuclear Materials (SNM) and the Radiation Protection Program (catalogued in Appendix J) provides the necessary protection protocols for handling neutron emitting waste.

8. The oversized DOT container size was corrected in License Condition 16.M.iv to be consistent with the definition presented in the CQA/QC Manual.

9. License Condition 17.A was amended with the requirements of Condition 49 for consistency.

10. License Condition 28 has been removed, since satisfaction of the Cover Test Cell requirements is demonstrated in Sections 3 and 4 of this Application.

11. The frequency required in License Condition 29.A was changed to semi-annually, to be consistent with proposed changes to the Environmental Monitoring Program (Appendix M).

12. License Condition 29.D was amended to include restrictions of Condition 55, for uniformity.

13. As is demonstrated by the Performance Assessment summarized in Section 6, the disposal-limited concentrations of License Condition 29.E were removed.

14. License Condition 34 was removed, since satisfaction of the Restoration of Grade requirement is demonstrated in Section 5 of this Application.

15. A definition of ―significant quantities" similar to that designated by the Division (DRC, 2012) has been included in License Condition 35.A.

16. Since it is used in subsequent License Conditions but not actually defined, a definition of the term DU has been included in License Condition 35.A.

17. The submittal deadline for a depleted uranium performance assessment was removed from License Condition 35.B (since it has already been submitted for Director‘s approval).

18. Since it was completed in 2010, the surety funding requirement of License Condition 35.E was removed.

19. Since the identification and management of CWF-waste containers with void spaces is governed by the CQA/QC Manual, other extraneous and unnecessary report citations were removed from License Condition 39.A.

20. The submittal deadline for a clayey soils study plan was removed from License Condition 41 (since it has already been submitted for Director‘s approval).

21. The required submittal of a revised cover design has been deleted, since it is satisfied within this Application. License Condition 45 was revised to include materials used in construction of the new cover design.

22. License Condition 52 was revised to acknowledge Energy*Solutions* is already subject to DOT requirements for removable contamination.

23. The disposal concentration limits in License Condition 55.A were removed, since the Performance Assessment of the alternate evapotranspirative cover system analyzed in Section 6 demonstrates that it is unnecessary.

24. License Conditions 55.B and 55.C were amended to Condition 29.D for uniformity.

25. Since Energy*Solutions* lacks the regulatory authority to require a third party to perform specific services, License Conditions 57.B and 57.C were revised to require Energy*Solutions* secure such services within the required time limit.

26. License Condition 63 was revised to be consistent with License Condition 57.D.

27. License Condition 62 was amended to incorporate Condition 61, for clarity.

28. Since Energy*Solutions* lacks the regulatory authority to require a third party to perform specific services, License Conditions 69 was revised to require Energy*Solutions* only accept waste from facilities compliant with UAC R313-15-1006.

29. License Condition 73.B was changed to reflect accepted and common U.S. Government practice for determining acceptable indirect cost multipliers by commercial companies, as documented by the U.S. Defense Contract Audit Agency (DCAA, 2012) and the U.S. Department of Labor‘s Division of Cost Determination (DOL, 2012). Justification for this proposed amendment is provided in Section 10.

30. The use of the R. S. Means reference for direct construction costs for which direct Clive-specific data is not readily available, was clarified in License Condition 73.C.

31. License Condition 73.G was expanded to clarify that gravel may be obtained by Energy*Solutions* from any of several publically-available sources.

32. License Condition 74 was revised to be consistent with NRC-1573 guidance (NRC, 1999; 64 FR 8644; see Footnote 1).

33. License Conditions 78.C and 78.D were removed as unnecessary, since Energy*Solutions'* Radiation Protection Program (catalogued in Appendix J) provides sufficient control to limit dose.

34. Because License Conditions 88.A and 88.C have been satisfied, they have been reserved.

35. License Condition 89 was re-set to begin with this Application, in acknowledgement that the historical record of the License incorporates the basis for prior amendments as formerly noted therein.

1.2 GENERAL FACILITY DESCRIPTION

Energy*Solutions'* licensed operations are conducted in Section 32, Township 1 South, Range 11 West, SLBM, Tooele County, Utah. This location is known as Clive, Utah.

Energy*Solutions'* original license was based on modeling which established upper limits to the concentrations of specific radionuclides in waste. After excluding unrealistic scenarios, the controlling factor selected for most nuclides was dose to the on-site worker. Dose calculations assumed no respiratory protection and full-time exposure to resuspended particulate radioactivity and external gamma radiation at the center of the disposal cell without consideration for shielding provided by equipment. The maximum concentrations for several nuclides were based on groundwater protection levels. The conclusion of the original modeling was that annual average concentrations in waste received should not exceed the calculated concentrations based on either worker exposure or groundwater protection standards. Subsequently, additional radionuclides were added to the license with concentration limits determined to provide the same level of worker protection as that established by the original model. Groundwater transport modeling was used to confirm that those concentrations were also protective of groundwater.

Energy*Solutions* has evaluated its employee exposures relative to the wastes received and actual waste management practices. By employing disposal techniques not envisioned at the time the original concentration limits were established, and through active controls to limit both internal and external exposures, Energy*Solutions* is able to control worker doses well below 5 rem per year, and has established

ALARA goals at 10 percent or less of the regulatory standards. Because Energy*Solutions* does provide respiratory protection to workers and controls gamma exposure by limiting the time spent in close proximity to waste material, worker doses can be controlled to ALARA goals without specifically controlling annual average concentrations, through such processes as ALARA training and use of radiation work permits.

1.2.1 Current Operations

Energy*Solutions* has licensed four disposal embankments. In addition, the U.S. Department of Energy constructed and owns the Vitro Embankment located adjacent to Energy*Solutions'* facilities.

<u>Vitro Embankment</u>: The Vitro Embankment was constructed and is owned by the U.S. Department of Energy between 1984 and 1988. It contains waste generated by the cleanup of the Vitro Chemical Company site in South Salt Lake City, Utah. This plant had processed uranium and vanadium ore from 1951 through 1968. Total capacity of the Vitro embankment is approximately 2.5 million cubic yards.

<u>LARW Embankment</u>: The LARW Embankment was Energy*Solutions*' first disposal embankment at the site. Disposal operations began in 1988 as a Naturally-Occurring Radioactive Materials (NORM) embankment, with Low-Activity Radioactive Waste (LARW) later included for disposal. The LARW Embankment is completed and covered, with final waste placed on May 26, 2004 and final cover completed June 12, 2006. Environmental monitoring activities continue, as described in this Application. Total capacity of the LARW Embankment is approximately 2.2 million cubic yards.

<u>Mixed Waste Embankment</u>: Disposal operations in the Mixed Waste Embankment began in early 1992, as authorized by a State-issued Part B Permit (EPA ID Number UTD982598898), issued to Energy*Solutions* by the Utah Division of Solid and Hazardous Waste on 30 November 1990. Mixed wastes contain both hazardous and radioactive constituents. Energy*Solutions* also disposes of select non-hazardous radioactive wastes in the Mixed Waste Embankment. Total capacity of the Mixed Waste Embankment is approximately 1.1 million cubic yards.

<u>11e.(2) Embankment</u>: Disposal operations in the 11e.(2) Embankment began in fall 1994 and are restricted to the disposal of 11e.(2) byproduct material (uranium and thorium wastes), as authorized by Byproduct Material License (UT 2300478) issued to Energy*Solutions* by the Division on November 30, 2003. Total capacity of the 11e.(2) Embankment is approximately 4.5 million cubic yards.

<u>Class A West Embankment</u>: Disposal operations in the Class A Embankment (a predecessor to the Class A West Embankment) began in summer 2000. A second LLRW Embankment was licensed in 2005 (the Class A North Embankment). The Class A and Class A North Embankments were combined into the Class A West Embankment in late 2012. Energy*Solutions* also licensed the Clive Containerized Waste (CWF) disposal concept to manage radioactive waste shipments with higher contact radioactivity (but with relatively low volumes) in contrast to the LLRW typically disposed at Clive (higher volumes of low activity waste). The CWF is wholly contained within the Class A West Embankment. Total capacity of the Class A West Embankment is approximately 3.8 million cubic yards.

Upon completion of the Embankment, it will be permanently fenced and posted, leaving a minimum 94 feet of buffer zone between the toe of waste and the fence. This allows room inside of the fence for an inspection roadway and groundwater monitoring wells. In preparation of drawings for a previous License action, it was discovered that the design waste limits do not allow for a 94 foot buffer zone along the east side of the

Embankment. However, due to prior Embankment construction specifications (LLRW & 11e.(2) CQA/QC Manual, Revision 23 and earlier) imposed at the time of construction, the actual toe of waste was held back a minimum of 5 ft from the design waste limits to accommodate 1 ft of temporary cover. Although the design drawings and specifications for temporary cover were revised in 2009 (LLRW & 11e.(2) CQA/QC Manual, Revision 24e) to allow waste to be placed to the design limits, Energy*Solutions* has not placed (nor will place) LLRW within the 5 ft offset from the design limits along the east boundary of the Embankment footprint, since this area is already built out —soil material within that offset is clean native material previously placed as temporary cover. Therefore, there is a minimum of 97.7 ft from the toe of actual LLRW to the property boundary, thus allowing for a minimum 94 ft buffer zone. The design drawings for the Embankment refer to Drawing 10014-C01 (of Appendix B) and identify a LLRW restricted area to prevent future placement of LLRW within the buffer zone. With this additional construction restriction and establishing the buffer zone limits along the Vitro property boundary, a minimum buffer zone of 97.7 ft is established along the east side of the Embankment.

This discrepancy in the buffer zone does not compromise the facility‘s ability to comply with the well network early warning requirement at Part I.F.1(f) of the GWQDP. Part I.F.1(f) requires that the monitoring well network be adequately spaced to provide early warning of a contaminant release from the Embankment before the contaminant leaves the buffer zone.

With the exception of the Vitro-Energy*Solutions* property line, a buffer zone of at least 300 feet is maintained between the closest edge of any Embankment (i.e., toe of waste) and the outside site boundary or property line. This 300 foot buffer zone is a requirement of the facility‘s Conditional Use Permit issued by Tooele County, reported here for informational purposes.

Permanent site boundary markers are affixed to provide documentation of the exact location of the disposal embankments. The markers are United States Geological Survey (USGS) quadrant ―brass cap" markers, whose design embankment locations have been verified by licensed surveyors. All locations have been tied into the USGS survey control stations. Upon closure, permanent markers will be placed at the head and toe of the Embankment.

1.2.2 Land Use

The Clive site is on the eastern edge of the Great Salt Lake Desert, three miles west of the Cedar Mountains, 2.5 miles south of Interstate 80, and 1 mile south of a switch point called Clive on the tracks of the Union Pacific system. Figure 1-1 shows the location of the site in relation to Salt Lake City and surrounding towns. The disposal site is a parcel of land, consisting of one square mile in Tooele County, Utah. The land was owned by the State of Utah, and, with the exception of approximately 100 acres used in the Vitro Remedial Action project, has been purchased by Energy*Solutions*. DOE owns the 100 acres used in the Vitro Remedial Action project. The licensed property owned by Energy*Solutions*, is Utah SLB&M, Section 32, Township 1 South, Range 11 West, Tooele County, Utah.

Most of the land within a 10-mile radius of the site is predominantly within the public domain, as administered by the U.S. Bureau of Land Management (BLM). As is illustrated in Figures 1-2 and 1-3, non-federally owned lands around the Clive facility have been designated as a Hazardous Industrial District MG-H by Tooele County. This designation limits, through zoning, the future uses of land in the area of the disposal facility to heavy industrial processes (General Industrial District M-G type uses) and to industries dealing with hazardous wastes, by the issuance of conditional use permits. Because the Hazardous

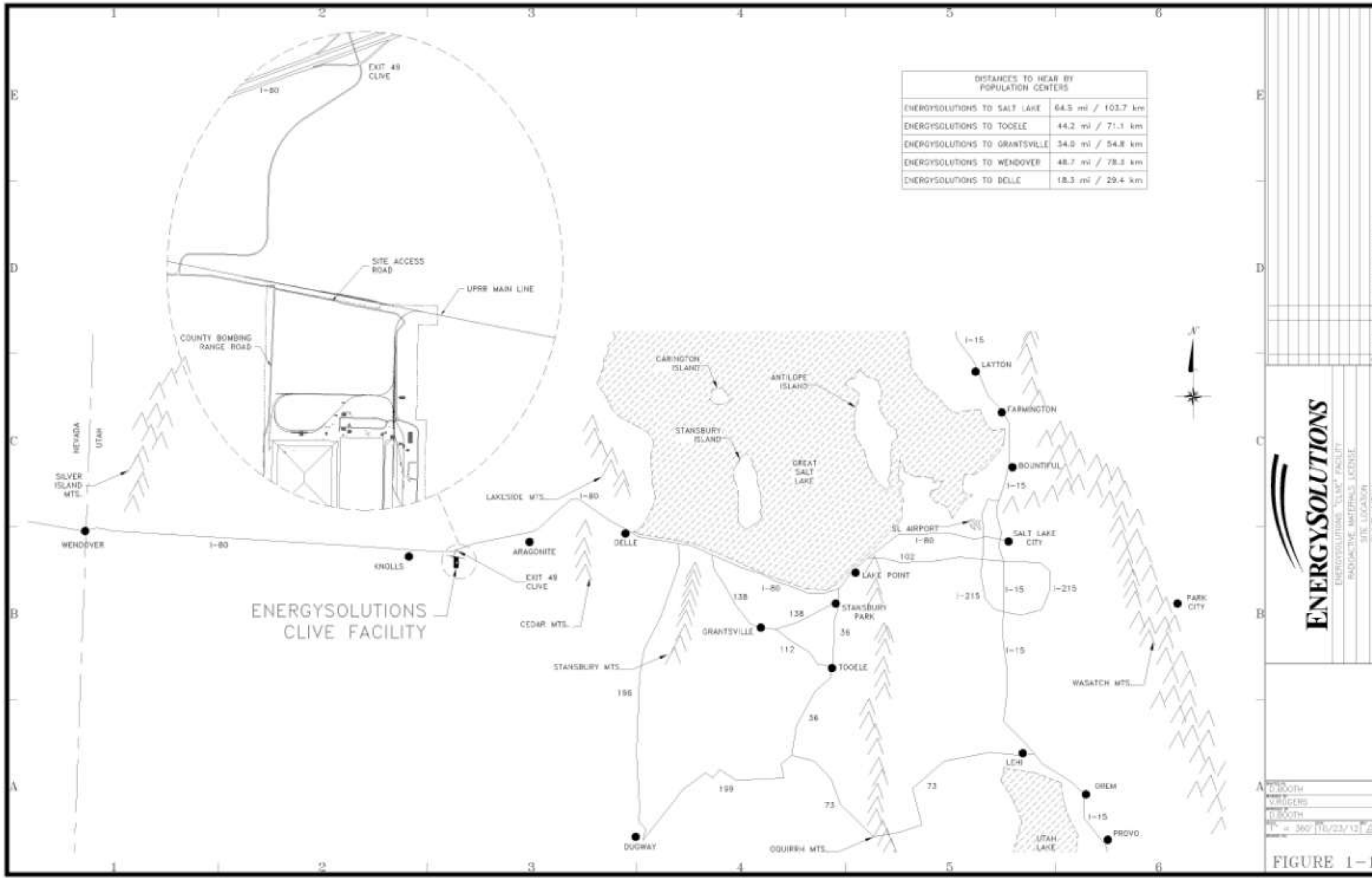


Figure 1-1. Energy*Solutions* Site Location

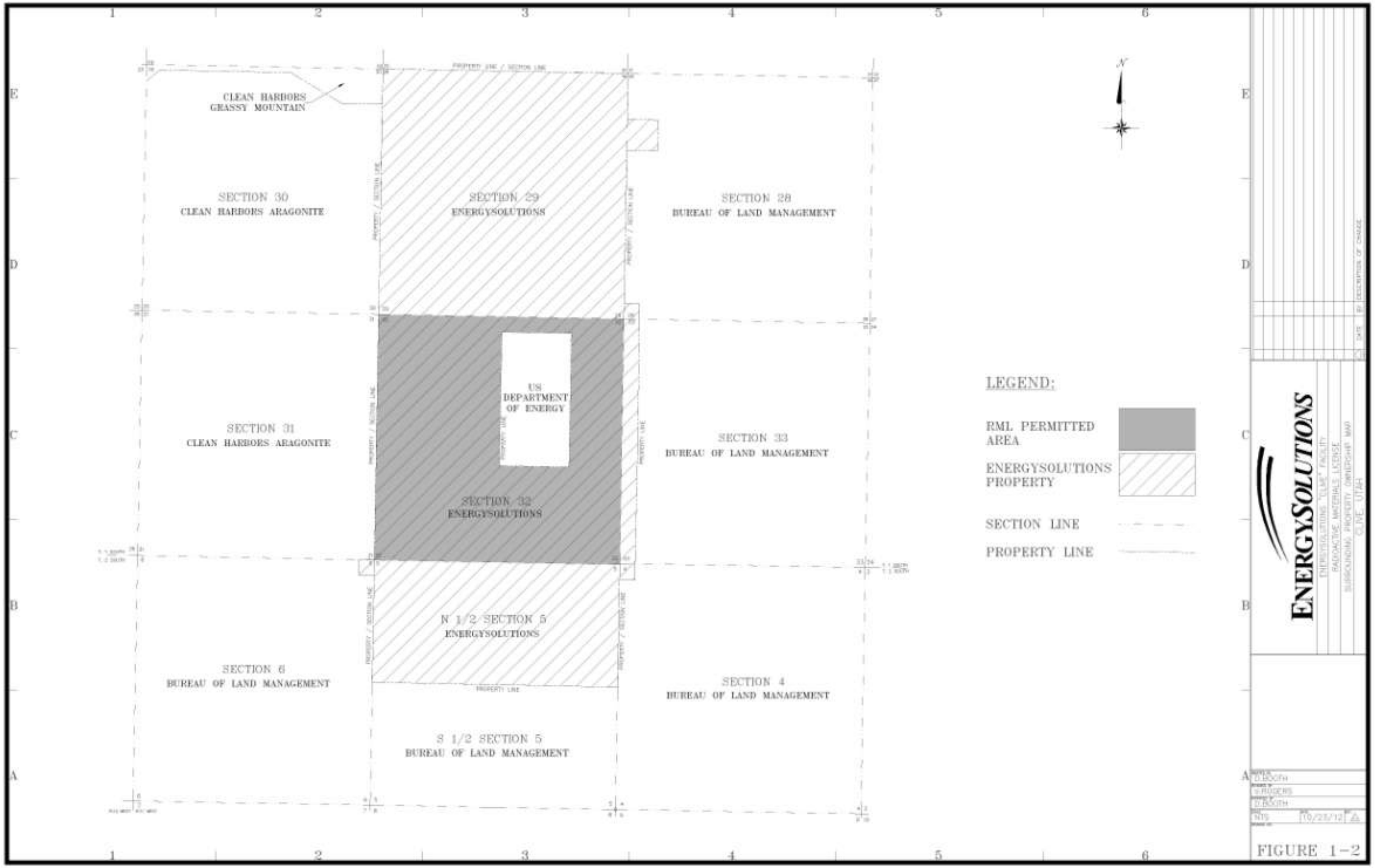


Figure 1-2. Energy*Solutions* Property Ownership

Figure 1-3. Tooele County Hazardous Industrial District Zoning.

Industrial District MG-H designation does not authorize any other types of land use, it also reduces the potential for population encroachment near Energy*Solutions*' Clive facility. In fact, previous to the Vitro project, there were no industrial, residential, or municipal activities near the site. Since that time, three hazardous waste facilities have located in the Clive area:

- Clean Harbors' Grassy Mountain facility, a commercial, hazardous waste, treatment, storage and disposal facility located greater than ten miles north-northwest of Energy*Solutions'* Clive facility;

- Clean Harbors' Aragonite facility a 140 million Btu slagging rotary kiln with a vertical afterburner chamber located approximately 8 miles east-northeast of Energy*Solutions'* Clive facility; and,
- Clean Harbors Clive facility, a defunct incinerator site currently permitted for transfer and storage of hazardous waste located one mile west of Energy*Solutions'* Clive facility.

No new industrial facilities have been established in this area of Tooele County's West Desert since June 30, 1988. Individuals who work at these facilities do not live on site, nor do they represent permanent residential population centers.

The remoteness of the site from the urbanized areas of Tooele County makes the surrounding area an improbable location for any other significant industrial use which might be impacted by the disposal project. BLM has seasonal sheep and cattle grazing allotments near Clive. Additionally, the low precipitation and high evaporation rates are not conducive to any sustainable crop yields.

The groundwater at Clive is classified as Class IV, *saline ground water* according to UAC R317-6-3 Ground Water Classes, with total dissolved solids (TDS) concentrations ranging from 30,000 mg/L to 100,000 mg/L. Because of the naturally poor quality and high salinity, the underlying groundwater in the vicinity of the Clive site is not suitable for most human uses or potable for humans. Analysis conducted by the World Health Organization in 2003 suggested associations between TDS concentrations in drinking water and the incidence of cancer, coronary heart disease, arteriosclerotic heart disease, cardiovascular disease, and total mortality rates in studies conducted in Australia and the former Soviet Union (WHO, 2003). Because of this, it is impossible to support a permanent, residential population center in this area as the groundwater dramatically exceeds U.S. Environmental Protection Agency (EPA) primary and secondary drinking water standards.

1.2.3 Principle Features

The Clive facility provides several principal features that provide long-term isolation of the disposed waste, minimize the need for continuing active maintenance after site closure, and improve the site's natural characteristics in order to protect public health and safety in accordance with the requirements of UAC R313-25-7(2) through (5), UAC R313-25-8(1,2, and 4), UAC R313-25-11(2) through (6), UAC R313-25-19 through UAC R313-25-22, UAC R313-25-23(7) and (8), UAC R313-25-24(1) through (6), and UAC R313-25-25(1) through (10). These features satisfy the following functional requirements:

1. Minimizes infiltration of water into the Embankment;

2. Ensures the integrity of the Embankment cover;

3. Provides the structural stability of backfill, wastes, and cover;

4. Minimizes contact of waste with standing water;
5. Provides adequate site drainage during operations and after Embankment closure;
6. Facilitates site closure and stabilization;
7. Minimizes the need for long-term maintenance;
8. Provides a barrier against inadvertent intrusion;
9. Maintains occupational exposures as low as reasonably achievable;
10. Provides adequate monitoring of the disposal site; and
11. Provides an adequate buffer zone for monitoring and potential mitigative action.

1.2.3.1 Restricted Areas

All areas utilized for LLRW material receiving, unloading, hauling, handling, and placement in the Embankment are considered a Restricted-Access (or Controlled) Area, (as defined in UAC R313-15-2). As such, any person entering the Controlled Area must check in and out through Access Control, or through a truck/vehicle entrance gate. Radiation exposure to persons working within the controlled area is monitored using Thermo Luminescent Dosimeters (TLD), or equivalent monitoring devices.

The fence is conspicuously posted with ―Caution -- Radioactive Materials" signs bearing the standard radiation symbol. Other signs are posted as appropriate. The Restricted Area boundary may change as waste placement proceeds in the Embankment. There are not, however, any changes to the requirements for control of the Restricted Areas as part of this Application.

1.2.3.2 Site Boundary and Buffer Zone

Energy*Solutions* controls all access to property at the Clive facility, through fences, gates, and security monitoring. Upon completion of the Embankment, it will be permanently fenced and posted, leaving a minimum 94 feet of buffer zone between the toe of waste and the fence (excluding the 90.9 foot distance from the southeast corner of the Embankment to the Vitro property line, as discussed in Section 1.2.1). This allows room inside of the fence for an inspection roadway and groundwater monitoring wells. Additionally, a buffer zone of at least 300 feet is maintained between the closest edge of any embankment (i.e., toe of waste) and the outside site boundary or property line. This 300 foot buffer zone is a requirement of the facility's Conditional Use Permit issued by Tooele County, addressed here for informational purposes. Drawing set 10014 (provided in Appendix B) shows the relationship between each embankment (i.e., Class A West, 11e.(2), LARW and Mixed Waste) and the property boundaries. Design basis submitted previously in support of a prior Licensing action demonstrates that there is adequate distance to respond to any potential contaminant release detected at wells within as little as 6 feet of the Vitro property line. (Energy*Solutions,* 2012a).

1.2.3.3 Groundwater Users

No domestic water use occurs within 10 km of the facility.

1.2.3.4 Utility Supplies and Systems

The facility is served by Rocky Mountain Power with electric power. Electric service includes three-phase 440-volt service. Additionally, Energy*Solutions* has installed a telephone cable. Energy*Solutions* does not have a public supply of water, and transports potable water to site storage tanks from the Grantsville area. Non-potable groundwater (provided by a well owned by Energy*Solutions*) and collected storm water are used for decontamination and dust suppression. Sanitary sewage is handled via septic tank drainage fields.

1.2.3.5 Class A West Embankment

The Embankment design is shown in detail in engineering drawing series 10014 of Appendix B. The construction materials are comprised of native clays (mined directly south on Section 5 and directly north on Section 29) and native rock (from local quarries).

1.2.3.6 Cover

The cover design for the Embankment is detailed on Drawing 10014-C03 of Appendix B. The cover for the Embankment is designed to maximize evapotranspiration (ET). Unlike the rock armor cover system employed in the completed Vitro and LARW Embankments, (which use materials with low permeability to limit movement of water into waste), the ET cover system minimizes water percolation by storing and releasing water through evaporation from the soil surface and through transpiration from vegetation. The primary objective of ET cover systems is to use the water balance components of soil and vegetation to hold precipitation and release it through soil surface evaporation or transpiration without allowing water percolation into waste layers. As is included in redline/strikeout format in Appendix C, proposed quality control/quality assurance requirements of the CQA/QC Manual have been included to accommodate the revised cover design.

As is further discussed in Appendix D, several ET cover systems and demonstration sites have been successfully installed and tested at hazardous and radioactive waste disposal facilities in the arid west, including Hill Air Force Base (Utah), Monticello Mill Tailings (Utah), Los Alamos National Laboratory (New Mexico), Sandia National Laboratories (New Mexico), Sierra Blanca (Texas), Rocky Mountain Arsenal (Colorado), and the Hanford Site (Washington) (Rock et.al, 2012). In addition to these facilities, ET cover systems have been proposed for the U.S. Ecology Nevada Site (Nevada), the Molycorp Tailings Facility (New Mexico), and Clean Harbors (Utah).

1.2.3.7 Surface Water Control Features

As is discussed in the CQA/QC Manual and the Run-on Berm Study contained in Appendix E, run-on berms are used to prevent storm-water run-on from ambient precipitation in the vicinity of the facility, into the emplaced waste before final cover is built. Similarly, precipitation that falls on emplaced waste during operations is contained by run-off berms; then collected, managed, evaporated, and residual solids disposed so that no contamination is carried off of the site. These surface water controls have been successfully utilized at the Clive facility for over 20 years.

1.2.3.8 Intruder Barriers

The entire Restricted Area of the project is fenced to ensure that intruders do not gain access to the site inadvertently. The fences are posted with appropriate warning signs, and all entrances into the work areas are locked or guarded by personnel when unlocked. All fences are of the chain link type.

Upon completion, permanent fencing will surround the Embankment and facility. Permanent fencing will be built with permanent posts cemented in concrete utilizing six feet of chain link fabric and topped with 3 strands of barbed wire.

1.2.3.9 Markers

Permanent granite markers will be placed at the Embankment to identify the location and type of disposed material. These markers are similar to those markers currently used to delineate the Vitro embankment located adjacent to the facility.

1.2.3.10 Boundaries and Markers

Embankment boundaries and markers are verified each year during preparation of annual As-Built Reports for each disposal Embankment. The As-Built Embankment Reports are submitted annually to the Division.

1.2.3.11 Survey Control Program

In accordance with the Ground Water Quality Discharge Permit (GWQDP), Condition I.H.6, CQA/QC Manual, and the State-issued Part B Permit, Condition V.F.13, Energy*Solutions* performs an annual As-Built survey of the Embankment. Survey control is the responsibility of the licensed land surveyor, in accordance with Utah licensing standards. The facility location is tied both to the USGS survey of Section 32, T1S, R11E and to the state plane coordinate system.

1.2.3.12 Site Utilization Plan

A current site layout is provided on Figure 1-4, including the location of the Embankment in relation to other site facilities. Waste placement has progressed from the southern boundary of the Embankment to the north, with large component and CWF disposal areas developed separately prior to being enveloped by bulk waste placement. This is consistent with current approved practices.

1.2.3.13 Support Facilities

Many of the Clive facilities, buildings, and infrastructure are common to the operating areas of the facility and support Energy*Solutions*' LLRW disposal operations. Key facilities and buildings utilized to support LLRW disposal operations include:

- **Rail Car Rollover (10)**: The Rail Car Rollover is the older of the two such facilities and is used to unload bulk rail shipments received in gondola type railcars.
- **Track #4 Rail Wash Facility (12)**: A railcar decontamination facility used on Track #4.
- **Intermodal Unloading Facility (16)**: This facility is used for unloading bulk intermodal containers.
- **1997 Evaporation Pond (19), 1995 Evaporation Pond (23), 2000 Evaporation Pond (42) and Northwest Corner Evaporation Pond (51)**: Storm water collected from LLRW and 11e.(2) waste management and disposal facilities is contained and evaporated in these ponds.
- **LARW Container Storage Pad (24)**: This facility is used for the short term storage of waste filled containers (boxes, drums, etc.).

- **Box Washing Facility (31)**: Facility is used to decontaminate containers used to ship waste to the facility and to wash waste handling and disposal equipment.

- **East LLRW Truck Unloading Facility (41)**: Trucks carrying containers of waste can be unloaded without bringing the truck into the restricted area.

- **Batch Plant (62)**: The batch plant produces concrete and CLSM for construction and waste disposal operations.

- **Waste Haul Roads (65)**: Waste haul roads are used to haul waste from receiving areas to final placement within the embankments. Also used for general operations within the facility.

- **Perimeter Road (66)**: The perimeter road provides general site access.

- **Rotary Dump Facility (Thaw, Rotary & Wash) (67)**: This facility is used to thaw and offload bulk rail shipments received in gondola type railcars. It is also used for the decontamination of railcars after waste is offloaded.

- **Meteorological Station (68)**: Weather station equipment is used to gather wind, temperature, evaporation, and precipitation data.

- **QC & GW Laboratories Building (70)**: Offices and laboratories for quality control (QC) and groundwater/environmental monitoring.

- **Shredder Facility (75)**: The shredder facility is utilized to size reduce waste debris.

- **Intermodal Container Wash Facility (78)**: Supports decontamination of waste shipping containers.

No new facilities are proposed in this Application.

1.2.3.14 Administration Buildings
Administrative activities common to the waste management support of Energy*Solutions*' LLRW disposal operations are conducted in several of Clive's buildings, including:

- **Administration Building (1)**: The Administration Building houses office space for Security, Shipping and Receiving, Health Physics, Engineering and Quality Assurance.

- **State Trailer (50)**: Offices for the Division of Radiation Control.

- **LLRW Operations Building (82)**: This building houses administrative offices, laboratories, and locker rooms; as well as the principal access control point to the Restricted Area for LLRW and 11e.(2) operations.

No new administration facilities are proposed in this Application to specifically support the Embankment.

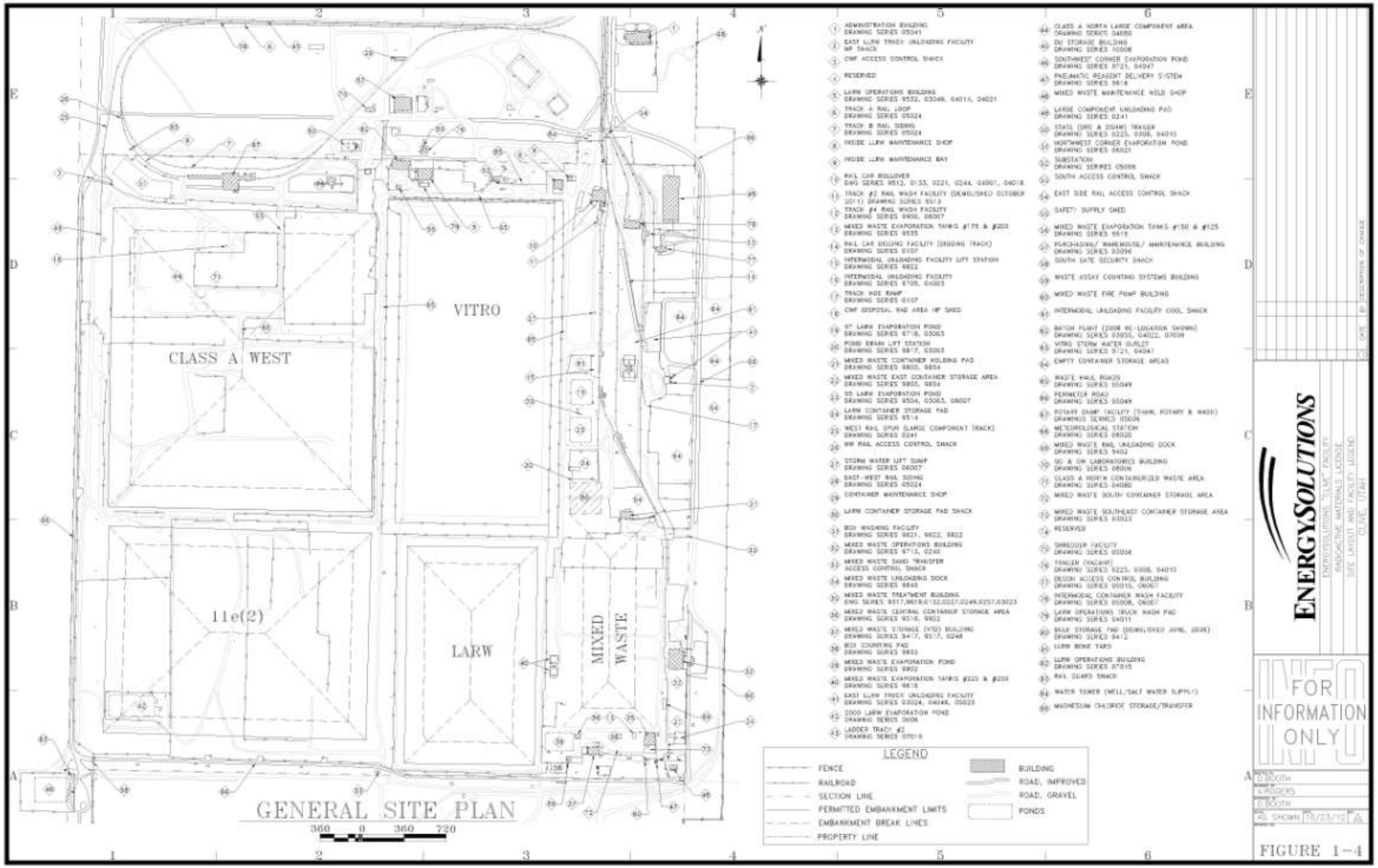


Figure 1-4. Energy*Solutions*' Clive Facility General Site Plan

1.2.3.15 Storage and Waste Handling Areas
The storage and LLRW handling areas include, but are not limited to, the rollover facility, the LARW storage pad, the truck unloading facility, and the Embankment. Additionally, the Shredder Facility, the Rotary Dump Facility, and other storage and waste handling areas have been permitted, constructed, and placed into operation. Design and continued operation of these facilities will be unaffected this Application.

1.2.3.16 Decontamination Areas
Decontamination of workers, if needed, takes place at the LLRW Operations Building, the Decon Access Control Building, or the Mixed Waste Operations Building. Equipment is decontaminated at the Mixed Waste Decontamination Pads or the Box Wash Facility. Railcars are decontaminated at the Railcar Decontamination Facilities. Containers, other than railcars, transported via rail are decontaminated at the Intermodal Container Wash Facility or the Box Wash Facility. Vehicle maintenance inside the Restricted Area is performed at the Inside Maintenance Shed, or in the north bay of the Mixed Waste Operations Building.

Since the License last renewal in 2005, additional decontamination and wastewater management facilities have been permitted, constructed, and placed into operation, including the Intermodal Container Wash Building, East Side Drainage and Gray Water System, and Northwest Corner Evaporation Pond. Design and operation of these facilities will be unaffected by this Application.

1.2.3.17 Physical Security
Site security procedures for the Clive facility are provided in the Site Radiological Security Plan, (see Appendix F). Proposed revisions, illustrated in redline/strikeout format include position and title corrections, as dictated by the Organization Plan (McCandless, 2012c). The Site Radiological Security Plan requires that personnel enter the Restricted Area through designated access control points in the LLRW Operations Building, Decon Access Control Building, and Mixed Waste Operation Building. Traffic is allowed to enter the site through one of the approved access gates.

The entire controlled area of the project is fenced to ensure that intruders do not gain access to the site inadvertently. The fences are posted with appropriate warning signs, and all entrances into the work areas are locked or guarded by personnel when unlocked. All fences are of the chain link type. Temporary fencing is constructed with –T” posts located at least every 12 feet. Permanent fencing is built with permanent posts cemented in concrete and topped with 3 strands of barbed wire. In order to assist security personnel in identifying material or equipment that has been removed from the Restricted Area without authorization, the Site Radiological Security Plan requires vegetation to be removed. Because records show no discovery of unauthorized equipment or material removed from the Restricted Area, a 7 calendar-day time limit is proposed for the removal of discovered growth of Restricted Area fence-line vegetation growth. Additionally, it is proposed that only those tools owned by subcontractors or rental equipment used inside the Restricted Area be controlled by markings, seals, and physical inventories.

The Site Radiological Security Plan requires that signs be present to guide visitors to the Administration Building. Because some visitors to the Clive facility remain within the Administration Building or are required to always be accompanied by an authorized escort, it is proposed that only those visitors desiring unescorted access beyond the Administration Building be briefed on security measures and general risks found at the facility.

1.2.3.18 Equipment and Equipment Storage
Standard heavy construction equipment is used for the operation of the facility. The actual equipment will vary, but it will normally consist of rock trucks, bulldozers, track mounted backhoes, front-end loaders, water trucks, and other equipment as required. Daily service and maintenance of the equipment is performed in the Restricted Area. If required, major service may be performed outside of the Restricted Area. Equipment serviced outside of the Restricted Area is decontaminated and surveyed to applicable release standards prior to release from the restricted area.

1.2.3.19 Excavated Materials Area
Excavated materials are used in the construction of the Embankment. Clays and other soil materials are mined from Sections 5 and 29, for use in the Embankment liner and cover construction, as required. Rock, rip-rap, and other borrow materials are mined from publically-available sources nearby. Excavated materials may be stockpiled on Energy*Solutions* property to the north and south of the facility.

1.3 SCHEDULES

Energy*Solutions* has conducted NORM waste disposal operations at the Clive facility since 1988. LLRW disposal operations began in 1991 and continue today. Mixed waste disposal operations have been conducted since 1992. Waste receipt, processing, management, and placement are expected to continue along currently-established schedules.

1.3.1 Construction

Much of the liner for the Embankment has already been constructed, including the portions associated with the legacy Class A Embankment and much of the legacy Class A North Embankments. Additional liner will be constructed in the area between the legacy Class A and Class A North Embankments. Construction of this liner is expected to continue during the 2013 construction season. The Division will continue to be notified of construction activities in order to facilitate inspection. Additionally, in accordance with the CQA/QC Manual requirements, Energy*Solutions* will continue to provide the Division with detailed weekly construction schedules during clay liner and embankment cover construction projects. Cover has not yet been constructed over any waste in the Embankment.

1.3.2 Receipt Of Waste

Energy*Solutions* estimates that waste receipt and disposal operations will continue for up to an additional 20 years.

1.3.3 First Waste Placement

First waste placement (in the LARW Embankment) occurred on July 6, 1988. Class A was first placed in the Embankment in 2000 (known then as the Class A Embankment). The Embankment‘s waste volume and nuclide-specific disposed activities are reported annually to the Division.

1.3.4 Operations

Energy*Solutions* estimates that disposal operations in the Embankment will continue for approximately 20 years.

1.3.5 Closure

Closure of the Embankment will take place during normal operations. As new areas are constructed, the filled areas will be covered to meet final design specifications before being closed. Closure activities will include a settlement monitoring program prior to cover construction as provided in the CQA/QC Manual. The settlement monitoring program includes a requirement that temporary cover be placed and monitored for at least one year prior to final cover construction, with evaluation of differential settlement. If differential settlement exceeds or is projected to exceed the established criteria, surcharging of affected areas is required.

This timing for final cover construction and closure is driven by the open cell time limit provided at Part I.E.6 of the GWQDP. The open cell time limit requires that final cover be complete on or before the end of 18 years after the date of initial placement of the first lift of LLRW waste in that portion of the open cell. Since the date of initial waste placement in some areas of the Embankment was as early as October, 2000, the final cover for these areas must be complete by October, 2018. In order to ensure compliance with this deadline, the CQA/QC Manual requires that temporary cover, the initial step of cover construction, be placed within 15 years of the date of initial waste placement on each lift area. Temporary cover is then monitored for total and differential settlement for at least one year. Settlement monitoring data is compiled, evaluated, and reported to the Division before cover construction begins. Upon final closure of all disposal embankments, the site will be decommissioned and the long-term surveillance period will begin.

1.4 INSTITUTIONAL INFORMATION

As a facility, the Energy*Solutions* Clive site has 25 years of experience with the design, construction, management, engineering, and operation of radioactive waste disposal embankments. Since receiving its first radioactive material license in 1988, Energy*Solutions* has constructed a low-activity radioactive waste (LARW) Embankment, a RCRA mixed radioactive and hazardous waste (Mixed Waste) Disposal Embankment, the Class A and Class A North Disposal Embankments (which have now been combined into the Class A West Embankment), and a uranium- and thorium-mill radioactive tailings 11e.(2) Disposal Embankment.

Division regulations UAC R313-25-3(8) and UAC R313-25-9(2) require that ~~"t~~*that if the proposed disposal site is on land not owned by state or federal government, that arrangements have been made for assumption of ownership in fee by a state or federal agency.*" However, on 16 March 1993, Energy*Solutions* and the Utah Department of Environmental Quality entered into an Agreement establishing covenants and restrictions related to LLRW disposal activities on privately owned land. This Agreement specifically applies to all of Section 32, less the defined property of the Vitro embankment, and allows Energy*Solutions* to retain ownership of the land and be responsible for site closure, as well as the long-term maintenance and monitoring of the disposal site. In return for this exemption, Energy*Solutions* has agreed to escrow sufficient funds to allow the Division to completely decontaminate, decommission, close the facility, and conduct any and all other reasonably expected activities during the institutional control period. Since

Energy*Solutions* continues to be bound by this Agreement, licensed activities are addressed by the existing land ownership exemption for LLRW management and disposal.

Funds for the closure, remediation and long-term surveillance of the facility have been made available through an Irrevocable Letter Of Credit, established by Energy*Solutions* at Zions First National Bank and Standby Trust Agreement established with Wells Fargo Bank. Energy*Solutions* annually submits a report to the Division that projects the amount of funds required to fully close the Embankment, decontaminate and demolish the associated buildings, remediate the affected sections of the site, and evaluate perpetual care requirements.

Furthermore, the State of Utah has established a Perpetual Care Fund with a target initial minimum balance of $100 million at the conclusion of the post-closure monitoring period (i.e., year 101 after site closure). The Perpetual Care Fund is funded by an annual payment and earnings accrued to the fund cash balance with an irrevocable letter of credit bringing the present value to $13 million.

1.5 MATERIAL INCORPORATED BY REFERENCE

Energy*Solutions* has compiled the references cited within this Report in Section 11 of this Application.

1.6 CONFORMANCE TO REGULATORY GUIDES

To the extent practicable, the information presented in this Application was prepared in accordance with R313-25-13 and conforms to the format and outline directed by the Division (Johnson, 2012). Additionally, Energy*Solutions* strives to meet and exceed all requirements applicable to its operations, including

- NUREG-1623, –Design of Long-Term Erosion Protection Covers for Reclamation of Uranium Mill Sites;”
- NUREG-0902, –Site Suitability, Selection and Characterization;”
- NUREG-1199, –Standard Format and Content of a License Application for a Low-Level Radioactive Waste Disposal Facility;”
- NUREG-1200, –Standard Review Plan for the Review of a License Application for a Low-Level Radioactive Waste Disposal Facility;”
- NUREG-1293, –Quality Assurance Guidance for a Low-Level Radioactive Waste Proposal Facility;”
- NUREG-1300, –Environmental Standard Review Plan for the Review of a License Application for a Low-Level Radioactive Waste Disposal Facility;”
- NUREG/CR-2700, –Parameters for Characterizing Sites for Disposal of Low-Level Radioactive Waste;”

- NUREG/CR-3038, “Tests for Evaluating Sites for Disposal of Low-Level Radioactive Waste;”
- Regulatory Guide 1.28, “Quality Assurance Program Requirements (Design and Construction);”
- Regulatory Guide 1.33, “Quality Assurance Program Requirements (Operational);”
- Regulatory Guide 1.74, “Quality Assurance Terms and Definitions;”
- Regulatory Guide 1.8, “Personnel Selecting and Training;”
- Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment;”
- Regulatory Guide 4.18, “Standard Format and Content of Environmental Reports for Near-Surface Disposal of Radioactive Waste;”
- Regulatory Guide 8.10, “Operating Philosophy for Maintaining Occupational Radiation Exposure As Low As Is Reasonably Achievable;”
- Regulatory Guide 8.15, “Acceptable Programs for Respiratory Protection;”
- NRC‘s “Final Standard Review Plan for Review and Remedial Action of Inactive Mill Tailings Sites under Title I of the Uranium Mill Tailings Radiation Control Act, Revision 1;” and
- NRC‘s 1982 “Technical Position on Near-Surface Disposal Facility Design and Operation.”

1.7 SUMMARY OF PRINCIPLE REVIEW MATTERS

Energy*Solutions* requests the Division renew the Radioactive Material License #UT 2300249 to allow continuing management and disposal of Class A LLRW. Proposed revisions to the License are provided in redline/strikeout format in Appendix A. Suggested revisions in redline/strikeout format of the CQA/QC Manual proposed to address the cover design change and to reflect other operational efficiencies are given and justified in Appendix C.

SECTION 2. SITE CHARACTERISTICS

UAC R313-25-3(3)	*"(3) Treatment and disposal facilities, including commercial radioactive waste incinerators, shall not be located:* *(a) within or underlain by:* *(i) national, state, and county parks, monuments, and recreation areas; designated wilderness and wilderness study areas; wild and scenic river areas;* *(ii) ecologically and scientifically significant natural areas, including wildlife management areas and habitats for listed or proposed endangered species as designated by federal law;* *(iii) 100 year floodplains;* *(iv) areas 200 feet distant from Holocene faults;* *(v) underground mines, salt domes and salt beds;* *(vi) dam failure flood areas;* *(vii) areas subject to landslide, mud flow, or other earth movement, unless adverse impacts can be mitigated;* *(viii) farmlands classified or evaluated as "prime", "unique", or of "statewide importance" by the U.S. Department of Agricultural Soil Conservation Service under the Prime Farmland Protection Act;* *(ix) areas five miles distant from existing permanent dwellings, residential areas, and other habitable structures, including schools, churches, and historic structures;* *(x) areas five miles distant from surface waters including intermittent streams, perennial streams, rivers, lakes, reservoirs, and wetlands;* *(xi) areas 1000 feet distant from archeological sites to which adverse impacts cannot reasonably be mitigated;* *(xii) recharge zones of aquifers containing ground water which has a total dissolved solids content of less than 10,000 mg/l; or* *(xiii) drinking water source protection areas designated by the Utah Drinking Water Board;* *(b) in areas:* *(i) above or underlain by aquifers containing ground water which has a total dissolved solids content of less than 500 mg/l and which aquifers do not exceed state ground water standards for pollutants;* *(ii) above or underlain by aquifers containing ground water which has a total dissolved solids content between 3000 and 10,000 mg/l when the distance from the surface to the ground water is less than 100 ft.;* *(iii) areas of extensive withdrawal of water, mineral or energy resources.*

	(iv) above or underlain by weak and unstable soils, including soils that lose their ability to support foundations as a result of hydrocompaction, expansion, or shrinkage; *(v) above or underlain by karst terrains."*
UAC R313-25-3(4)	*"Commercial radioactive waste disposal facilities may not be located within a distance to existing drinking water wells and watersheds for public water supplies of five years ground water travel time plus 1000 feet."*
UAC R313-25-3(6)	*"The plan approval siting application shall include the results of studies adequate to identify the presence of ground water aquifers in the area of the proposed site and to assess the quality of the ground water of all aquifers identified in the area of the proposed site."*
UAC R313-25-3(7)	*"Emergency response and safety.* *(a) The plan approval siting application shall demonstrate the availability and adequacy of services for on-site emergencies, including medical and fire response. The application shall provide written evidence that the applicant has coordinated on-site emergency response plans with the local emergency planning committee (LEPC).* *(b) The plan approval siting application shall include a comprehensive plan for responding to emergencies at the site.* *(c) The plan approval siting application shall show proposed routes for transportation of radioactive wastes within the state. The plan approval siting application shall address the transportation means and routes available to evacuate the population at risk in the event of on-site accidents, including spills and fires. "*
UAC R313-25-5	*"In addition to the requirements set forth in R313-22-33, an application to receive from others, possess, and dispose of wastes shall consist of general information, specific technical information, institutional information, and financial information as set forth in R313-25-6 through R313-25-10."*
UAC R313-25-6(3)	*"The general information shall include the following:* *(3) A description of:* *(a) the location of the proposed disposal site;* *(b) the general character of the proposed activities;* *(c) the types and quantities of waste to be received, possessed, and disposed of;* *(d) plans for use of the land disposal facility for purposes other than disposal of wastes; and* *(e) the proposed facilities and equipment;" –*
UAC R313-25-7	*"The application shall include certain technical information. The following information is needed to determine whether or not the applicant can meet the performance objectives and the applicable technical requirements of R313-25:*

(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.

(2) Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.

(4) Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria.

(6) Descriptions of the construction and operation of the land disposal facility. The description shall include as a minimum the methods of construction of disposal units; waste emplacement; the procedures for and areas of waste segregation; types of intruder barriers; onsite traffic and drainage systems; survey control program; methods and areas of waste storage; and methods to control surface water and ground water access to the wastes. The description shall also include a description of the methods to be employed in the handling and disposal of wastes containing chelating agents or other non-radiological substances which might affect meeting the performance objectives of R313-25

(8) Identification of the known natural resources at the disposal site whose exploitation could result in inadvertent intrusion into the wastes after removal of active institutional control.

(12) A description of the environmental monitoring program to provide data and to evaluate potential health and environmental impacts and the plan for taking corrective measures if migration is indicated.

UAC R313-25-8(4)(a) *"The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

(a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19."

UAC R313-25-11(1,5,6) *"A license for the receipt, possession, and disposal of waste containing radioactive material will be issued by the Executive Secretary upon finding that:*

(1) the issuance of the license will not constitute an unreasonable risk to the health and safety of the public;

	(5) the applicant's proposed land disposal facility operations, including equipment, facilities, and procedures, are adequate to protect the public health and safety in accordance with R313-15; *(6) the applicant's proposed disposal site, disposal site design, land disposal facility operations, disposal site closure, and post-closure institutional control plans are adequate to protect the public health and safety in that they will provide reasonable assurance of the long-term stability of the disposed waste and the disposal site and will eliminate to the extent practicable the need for continued maintenance of the disposal site following closure;"*
UAC R313-25-18	*"Land disposal facilities shall be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to individuals do not exceed the limits stated in R313-25-19 and 25-22."*
UAC R313-25-22	*"The disposal facility shall be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate, to the extent practicable, the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required."*
UAC R313-25-23(1)	*"The primary emphasis in disposal site suitability is given to isolation of wastes and to disposal site features that ensure that the long-term performance objectives are met."*
UAC R313-25-23(2)	*"The disposal site shall be capable of being characterized, modeled, analyzed and monitored."*
UAC R313-25-23(3)	*"Within the region where the facility is to be located, a disposal site should be selected so that projected population growth and future developments are not likely to affect the ability of the disposal facility to meet the performance objectives of R313-25."*
UAC R313-25-23(4)	*"Areas shall be avoided having known natural resources which, if exploited, would result in failure to meet the performance objectives of R313-25."*
UAC R313-25-23(5)	*"The disposal site shall be generally well drained and free of areas of flooding or frequent ponding. Waste disposal shall not take place in a 100-year flood plain, coastal high-hazard area or wetland, as defined in Executive Order 11988, "Floodplain Management Guidelines.""*
UAC R313-25-23(6)	*"Upstream drainage areas shall be minimized to decrease the amount of runoff which could erode or inundate waste disposal units."*
UAC R313-25-23(7)	*"The disposal site shall provide sufficient depth to the water table that ground water intrusion, perennial or otherwise, into the waste will not occur. The Executive Secretary will consider an exception to this requirement to allow disposal below the water table if it can be conclusively shown that disposal site*

characteristics will result in molecular diffusion being the predominant means of radionuclide movement and the rate of movement will result in the performance objectives being met. In no case will waste disposal be permitted in the zone of fluctuation of the water table."

UAC R313-25-23(8) *"The hydrogeologic unit used for disposal shall not discharge ground water to the surface within the disposal site."*

UAC R313-25-23(9) *"Areas shall be avoided where tectonic processes such as faulting, folding, seismic activity, vulcanism, or similar phenomena may occur with such frequency and extent to significantly affect the ability of the disposal site to meet the performance objectives of R313-25 or may preclude defensible modeling and prediction of long-term impacts."*

UAC R313-25-23(10) *"Areas shall be avoided where surface geologic processes such as mass wasting, erosion, slumping, landsliding, or weathering occur with sufficient such frequency and extent to significantly affect the ability of the disposal site to meet the performance objectives of R313-25, or may preclude defensible modeling and prediction of long-term impacts."*

UAC R313-25-23(11) *"The disposal site shall not be located where nearby facilities or activities could adversely impact the ability of the site to meet the performance objectives of R313-25 or significantly mask the environmental monitoring program."*

UAC R313-25-24(1) *"Site design features shall be directed toward long-term isolation and avoidance of the need for continuing active maintenance after site closure."*

UAC R313-25-24(6) *"The disposal site shall be designed to minimize to the extent practicable the contact of water with waste during storage, the contact of standing water with waste during disposal, and the contact of percolating or standing water with wastes after disposal."*

UAC R313-25-25(7) *"The boundaries and locations of disposal units shall be accurately located and mapped by means of a land survey. Near-surface disposal units shall be marked in such a way that the boundaries of the units can be easily defined. Three permanent survey marker control points, referenced to United States Geological Survey or National Geodetic Survey control stations, shall be established on the site to facilitate surveys. The United States Geological Survey or National Geodetic Survey control stations shall provide horizontal and vertical controls as checked against United States Geological Survey or National Geodetic Survey record files."*

UAC R313-25-26(1) *"At the time a license application is submitted, the applicant shall have conducted a preoperational monitoring program to provide basic environmental data on the disposal site characteristics. The applicant shall obtain information about the ecology, meteorology, climate, hydrology, geology, geochemistry, and seismology*

> *of the disposal site. For those characteristics that are subject to seasonal variation, data shall cover at least a 12-month period."*

Since first licensed, Energy*Solutions'* broad objective for its LLRW disposal siting and design decisions has focused on the permanent isolation of the LLRW and associated contaminants. These decisions have targeted minimizing disturbance and dispersion by natural forces, without the need of ongoing maintenance. For practical reasons, specific siting decisions and design standards have involved finite times. The following site features are considered in judging the adequacy of the Clive site:

a. Remoteness from populated areas;

b. Hydrologic and other natural conditions as they contribute to continued immobilization and isolation of contaminants from groundwater sources; and

c. Potential for minimizing erosion, disturbance, and dispersion by natural forces over the long term.

2.1 GEOGRAPHY, DEMOGRAPHY, AND FUTURE DEVELOPMENTS

The Clive site is situated in a remote area of Tooele County in the western portion of Utah. The nearest resident is a person acting as caretaker at a rest stop along I-80, roughly 7 miles to the Northeast, with the nearest community being approximately 35 miles from the site. Strict access control and security also provide additional assurance of protection to the public. The Embankment is designed to minimize dispersion of the waste by resisting water erosion, wind erosion, biointrusion, geotechnical instability and other natural events. All features are designed to promote embankment stability.

2.1.1 Site Location and Description

Operations are conducted in Sections 5, 29, and 32 (Township 1 South, Range 11 West, SLB&M), of Tooele County, Utah. These locations are known as Clive, Utah. Most of the land within a 10-mile radius of the Site is public domain administered by BLM. Land use in the immediate vicinity of the Site is not affected by the renewal of the License, since the Embankment and associated licensed actions are located entirely within the licensed area of Section 32.

The Clive site is on the eastern edge of the Great Salt Lake Desert, three miles west of the Cedar Mountains, 2.5 miles south of Interstate 80, and 1 mile south of a switch point called Clive on the tracks of the Union Pacific system. The disposal site is a parcel of land, consisting of one square mile in Tooele County, Utah. The land is owned by Energy*Solutions*, with the exception of approximately 100 acres owned by DOE for the Vitro Remedial Action project. The licensed property owned by Energy*Solutions*, is Utah SLB&M, Section 32, Township 1 South, Range 11 West, Tooele County, Utah, except for the following legal description of the Vitro site:

> *Beginning at a point located 1120.32 feet N 89 degrees 56' W., along the section line, and 329.49 feet South from the Northeast corner of Section 32, Township 1 South, Range 11 West, Salt Lake Base and Meridian and running thence: N 89 degrees 56' 32" W 1503.72 feet, thence S 0 degrees 03' 28" W 2880.50 feet, thence S 89 degrees 56' 32" E 1503.72 feet, N 0 degrees 03' 28" E 2880.50 feet to the point of the beginning.*

While Energy*Solutions* also owns property adjacent to the licensed area, properties outside of Section 32 are not licensed for LLRW management. The south portion of the site contains Energy*Solutions'* LARW embankment, Mixed Waste landfill cell, and the 11e.(2) Embankment. Energy*Solutions*' Class A West Embankment is located to the north of the 11e.(2) Embankment and west of the Vitro Embankment.

2.1.2 Use of Adjacent Lands and Waters

The uses, zoning classification, and ownership of the land near the site is discussed in Section 1.2.1. The low precipitation and high evaporation rates are not conducive to sustainable crop yields. Further, because the groundwater is saline with high TDS, it is impossible to support a permanent, residential population center in the site area.

2.1.3 Population Distribution

While an estimated 41,000 people resided within 50 miles of the Clive site at the time of the 2010 Census, most of the immediate area is uninhabited (Census, 2012). The closest resident lives roughly seven miles to the northeast of the site, and acts as a caretaker for the rest stop just off I-80. As is illustrated in Table 2-1, the largest group of people lives 48 - 80.5 miles to the east and southeast of the site in the Tooele-Grantsville area.

Table 2-2 summarizes a study projecting that Tooele County will increase its population at an annual rate of 5 percent until the year 2020, (Thomas Consultants, Inc, 2002). In this study, it is projected that Tooele and Grantsville Cities will continue to be the areas of greatest growth, with growth rates of roughly five percent to six percent per year, through the year 2020.

The remoteness of the site from the urbanized area of Tooele County makes the surrounding area an improbable location for any other significant industrial use. This was one of the chief reasons for its selection as a disposal site in the Vitro project.

The Tooele County Commission has designated the area around the Clive site as a hazardous industries zone by Tooele County. This designation prohibits all residential housing in the vicinity of the Clive site. Also, NRC identified the absence of any culinary water sources at the Clive Facility as a major deterrent to any potential population growth within a 12-kilometer radius (NRC, 1993).

2.2 TRANSPORTATION

The Clive site has very good access to both highway and rail transportation. Energy*Solutions* receives waste shipped by bulk truck, containerized truck, enclosed truck, bulk rail, rail boxcars, and rail intermodal. The transportation access allows Energy*Solutions* to operate year-round. The site is served off Interstate-80 at Exit 49, Clive. The all weather road to the site is maintained year round by Energy*Solutions*, the principal user of the road. The road is an asphalt-paved road from Exit 49 south to the rail crossing. The road east then south from the rail crossing is also an asphalt-paved road to Energy*Solutions*' site.

Table 2-1

12-Kilometer Population Wheel

Direction	Distance (km)					
	0 - 2	2 - 4	4 - 6	6 - 8	8 - 10	10 - 12
N - 0.0						
NNE - 22.5						
NE - 45.0						
ENE - 67.5						1
E - 90.0						
ESE - 112.5						
SE - 135.0						
SSE - 157.5						
S - 180.0						
SSW - 202.5						
SW - 225.0						
WSW - 247.5						
W - 270.0						
WNW - 292.5						
NW - 315.0						
NNW - 337.5						
Total	**0**	**0**	**0**	**0**	**0**	**1**

Table 2-2

Tooele County Growth Projection: 2010-2020

Area	Pop 2010*	Annual Growth Rate 2010-2015	Pop 2015	Annual Growth Rate 2015-2020	Pop 2020
Tooele City	32,021	4.49%	39,884	5.47%	52,053
Grantsville	8,597	4.98%	10,961	4.98%	13,977
Lake Point/ Stansbury Park	5,856	0.35%	5,959	0.33%	6,058
Stockton	633	4.99%	807	4.98%	1,029
Tooele County	47,106	4.98%	60,064	4.98%	76,585

* from the 2010 U.S. Census
Information prepared by Thomas Consultants Inc., 2002 & Source: Tooele County Engineering Department 2002

Energy*Solutions* is served by the Union Pacific Railroad at Energy*Solutions*' private siding. Energy*Solutions* maintains over 5 miles of track and operates two locomotives to switch rail cars at the facility.

2.3 METEOROLOGY AND CLIMATOLOGY

Energy*Solutions* has operated a weather station at Clive since April 1992. The station monitors wind speed and direction, 2-m and 9-m temperatures, precipitation, pan evaporation and solar radiation. Annual meteorological reports are submitted to the Division for Clive data collected from July 1992 to the most recent December, (MSI, 2012). The most recent annual revision of this report was provided to the Division on 23 February 2012 (McCandless, 2012b). Since the Embankment is located entirely within Section 32, this information adequately characterizes the site.

2.3.1 Weather Patterns

The site region is in the Intermountain Plateau climatic zone that extends between the Cascade-Sierra Nevada Ranges and the Rocky Mountains and is classified as a middle-latitude dry climate or steppe. The climate is characterized by hot dry summers, cool springs and falls, moderately cold winters, and a general year-round lack of precipitation.

While neighboring mountain ranges generally restrict the movement of weather systems into the area, there are occasional well-developed storms in the prevailing regional westerlies. The mountains act also as a barrier to frequent invasions of cold continental air. Precipitation is generally light during the summer and early fall and reaches a maximum in spring when storms from the Pacific Ocean are strong enough to move over the mountains. During the late fall and winter months, high pressure systems tend to settle in the area for as long as several weeks at a time.

2.3.2 Winds

In the 19-year period of time (July 1992 through December 2011) the most frequent (and predominant) winds were from the south-southwest direction, with the second most frequent direction being the east-northeast, followed by the south. Wind Rose data summarized in Figure 2-1 has been obtained from the on-site weather station and checked for accuracy by a certified meteorologist (MSI, 2012).

2.3.3 Temperature

Temperatures at Clive range from an hourly minimum of -25.5 ^{o}C to an hourly maximum of 41.3 ^{o}C. Monthly mean temperatures range from -2.5 ^{o}C (in December) to 26.4 ^{o}C (in July).

2.3.4 Precipitation and Evaporation

The Clive site receives an average of 8.62 inches of precipitation per year. Measurements taken at the Clive site showed that the lowest monthly precipitation recorded was 0 inches, during several distinct months. The highest recorded monthly precipitation was 4.28 inches, in May 2011.

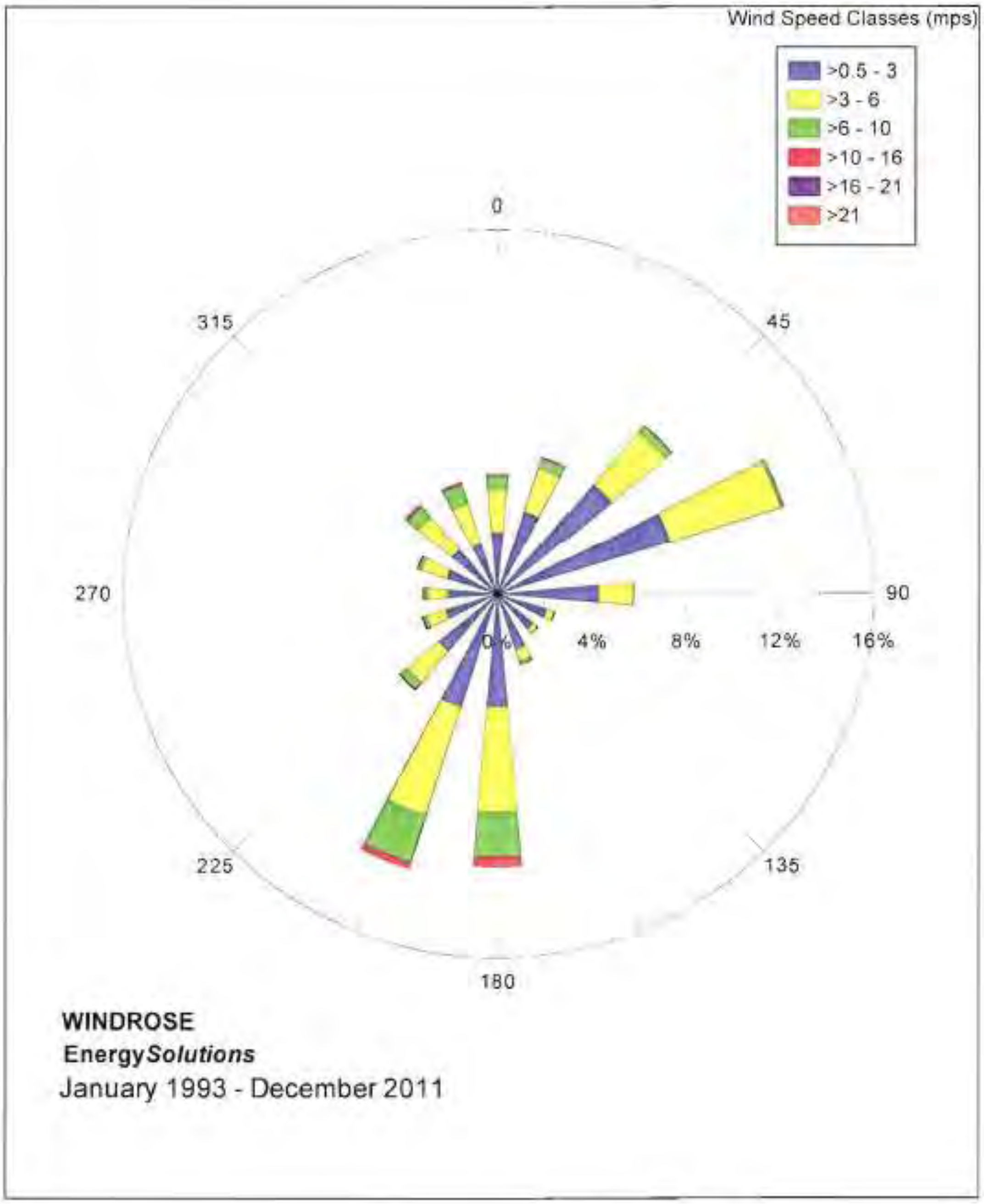


Figure 2-1. Energy*Solutions* Wind Rose January 1993 – December 2011 (MSI, 2012).

Pan evaporation measurements are taken from April through October when ambient temperatures remain above freezing. Maximum hourly evaporation values usually occur in July. The 17-year average annual evaporation at the Clive site is 52.73 inches (excluding 2 years of reported instrument malfunction).

2.3.5 Severe Weather Phenomena

Historically, a severe weather phenomenon in the west desert-region of Utah has taken one of four forms: tornadoes, severe thunderstorms, damaging hail, or dust devils. Tornadoes are rare in the State of Utah primarily due to the lack of atmospheric moisture and the presence of mountainous terrain. Utah tornadoes tend to be much weaker and smaller than their central U.S. counterparts. Utah tornadoes stay on the ground for an average of only a few minutes and their path widths are usually one-eighth of a mile or less. Five tornadoes were observed in Tooele County for the period 1847–2010 (Brough, et.al; 2010). Based on this historic record, the probability of a tornado strike at any one point in Tooele County is extremely low. Although tornadoes are very rare and not statistically likely to strike the Clive site, they are amongst weather phenomena that can occur in the State of Utah.

While thunderstorms are fairly common over Utah, especially in the late summer months, these storms are typically not severe. The Dugway, Utah station records an average of 20 thunderstorm-days per year. Historic records suggest than approximately 10% of these thunderstorms develop into the severe category, equating to two annual high-speed wind events (50 knots or greater) at the Clive site.

Large damaging hail is another rare phenomenon in the State of Utah, primarily due to the lack of atmospheric moisture needed to develop strong thunderstorms and related hail. During the last 60 years, there have been four severe thunderstorm events in Tooele County with reported hail damage (Brough, et.al; 2010). Two of these reports indicated hail with a diameter of one inch or greater. These reports also suggest a return interval of 10–15 years for such storms with potential damaging hail for the Energy*Solutions* site.

Dust devils are quite common throughout the west desert of Utah. They are caused by local thermally-induced updrafts and do little more than stir up dust and other light objects. Wind speeds associated with dust devils are normally less than 50 miles per hour and are short-lived. The highest recorded wind speed for a west desert dust devil is 60 miles per hour.

2.4 GEOLOGY AND SEISMOLOGY

The Energy*Solutions* Clive site is located on the eastern fringe of the Great Salt Lake Desert. Geophysical surveys performed in the surrounding region included (1) a regional gravity survey conducted over a study area that included the eastern half of the Great Salt Lake Desert - performed by the University of Utah Geophysics Department between 1957 and 1961 (Cook et. al, 1964); and (2) an earth resistivity survey (Bisdorf and Zohdy, 1980) conducted in the Fish Springs area, about 50 miles south of the site to delineate faults and their influence on springs in the area. Many basin and range faults, grabens and horsts are indicated in Cook‘s report on the Great Salt Lake Desert study area. The gravity data was used to determine regional geologic conditions (Cook et. al, 1964). In addition to these regional surveys, the Utah Department of Natural Resources has prepared two hydrologic reports for the Great Salt Lake West Desert area (Stephens, 1974; UDNR, 1981). These reports provide a description of physiographic conditions, regional characteristics, groundwater aquifers, flow characteristics and water quality. The U.S. Geological Survey has also prepared geologic and surface water resources maps for the same areas (Moore, 1979; Bucknam, 1977). These historic surveys and studies have been combined with characterization of the site geology and hydrogeology, in the Revised Hydrogeologic Report prepared by Energy*Solutions* in August, 2004 (Envirocare, 2004). The Revised Hydrogeologic Report is scheduled to be revisited December of 2012.

The Energy*Solutions* Clive facility is located in the extreme eastern margin of the Great Salt Lake Desert, which is part of the Basin and Range Province of North America. The Basin and Range topography is typified by block-faulted (normal fault) mountain ranges that generally trend north to south. This predominant geologic structural feature with alluvial filled basins is discontinuous and was created by extensional normal faulting. The basins consist primarily of sediments originating from Quaternary lacustrine Lake Bonneville deposits and Quaternary and Tertiary colluvial and alluvial materials eroded from adjacent mountains. The unconsolidated to semi-consolidated valley fill is generally about 800 to 1,000 feet thick throughout the central portions of the valleys in the Great Salt Lake Desert.

The block-faulted mountains mainly consist of Paleozoic limestones, dolomites, shales, quartzites, and sandstones. Tertiary extrusive igneous rocks of basaltic lava flows and pyroclastics are also found in isolated areas of the Great Salt Lake Desert. The valley sediments are composed of alluvial fans, evaporites and unconsolidated and semi-consolidated valley fill (Stephens, 1974). These sediments consist of intercalated colluvium, alluvium, lacustrine, and fluvial deposits with some basalt flows, pyroclastics and deposits of eolian material. Generally, the colluvial and coarse alluvial deposits are near the mountain ranges where they contain a wide range of grain sizes, varying from boulders to clay. Extending to the center of the valleys, the deposits grade into well sorted beds of sand and gravel interlayered with alluvial and lacustrine silt and clay. Thick beds of alluvial fans generally fringe the mountains ranges. The alluvial fans grade laterally into fine-grained alluvium and thin toward the center of the valleys where it is present as a veneer overlying and adjacent to fine-grained Lake Bonneville lakebed deposits.

The ranges are affected by mass-wasting and fluvial erosion where ephemeral streams that enter the desert basins deposit their load as they evaporate or infiltrate. The desert mountain perimeters of the basins are therefore impacted by the deposition and erosional processes of alluvial fans. The central portions of the basins, which typically demonstrate relatively flat topographic relief, are unaffected by surface fluvial activities, and therefore mechanical and chemical weathering processes advance at very slow rates. These geomorphic processes are typical of Clive‘s semiarid to arid desert setting.

Natural resources in Tooele County include limestone, metallic minerals, potassium salts, tungsten, salt, clays, and sand and gravel. Gravel quarries have been located in the alluvial fans that flank the Cedar Mountains (DOE, 1984). Mineral extraction by evaporation of brine occurs near Knolls, about 10 miles northwest of the site. Limestone is quarried in the Cedar Mountains about five miles east of the site. Presently no oil and gas production takes place in the area. The classification of the area as prospectively valuable for oil and gas is based solely on general criteria. Even so, there has been little interest in the western desert for oil and gas exploration. Previous exploration near the west side of the Great Salt Lake revealed a low-grade product with little or no yield. There is no coal production in the area or geologic formations with coal resources. No active or pending mining claims or mineral leases are located on the site.

2.4.1 Geologic Site Characteristics

The Energy*Solutions* site is located in, and is bounded by, the Great Salt Lake Desert to the west at approximate elevations of 4,250 to 4,300 feet above mean sea level (amsl). Also to the west, low-lying hills rise 50 to 100 feet from the desert floor. To the east and southeast, the site is bounded by the north-south trending Lone Mountains, which rise to a height of 5,362 feet amsl. At the base of the Lone Mountains alluvial fans slope gently toward the west at a gradient of approximately 40 feet per mile. The site has topographic relief of approximately 11 feet, sloping in a southwest direction at a gradient of approximately 0.0019.

To the north of the site are the Grayback Hills, composed of limestone and quartzite mapped as Permian-Pennsylvanian Oquirrh Formation, which is as much as 10,000 feet thick in western Utah. Igneous extrusives form a resistant cap on the Grayback Hills, and are mapped as Pliocene-age basalt/rhyolite, (Montgomery Watson, 2007).

The site rests on Quaternary lakebed deposits of Lake Bonneville. Site subsurface logs indicate that lacustrine deposits extend to at least 500 feet underneath the site. The underlying Tertiary and Quaternary age valley fill is composed of semi-consolidated clays, sands, and gravel where it comes in contact with bedrock. Although the exact depth to and relationships of various bedrock units are unknown, the presence of nearby outcrops and the regional block-faulted basins suggest that the valley-fill deposits are relatively thin within the area of the site. Estimated down-dip projections from bedrock outcrop on the southwest corner of Section 31 and bedrock found at depth in neighboring wells suggest that the contact may dip to the east about three degrees.

Geomorphic processes at the site are limited to micro processes that occur in the soil. For example the Great Salt Lake Desert is located in a semiarid to arid region where precipitation is less than evaporation. The soil moisture is available by infiltration and lateral flow as groundwater from adjacent mountain slopes and the water is drawn upward through the soil by capillarity and evaporates either in the soil profile or at the ground surface. When the soil water evaporates, dissolved mineral matter is precipitated and form calcium carbonate, gypsum and alkali (sodium and potassium carbonates) in the soil. Macro geomorphic processes are almost nonexistent where the general rate of weathering is very slow. This is due to the low amounts of precipitation, the lack of fluvial activities and the lack of relief at the site.

2.4.2 Seismology

The seismic hazard for the faults near the Clive site (as illustrated in Figure 2-2) was recently evaluated using methodology consistent with the requirements of UAC R313-25-8(5) (AMEC, 2012). The seismic hazard assessment includes analysis of the peak ground acceleration (PGA) associated with the Maximum Credible Earthquake (MCE) for known active or potentially active faults in the Clive site region. The PGA was obtained from a probabilistic seismic hazard analysis (PSHA) to assess the seismic hazard for earthquakes that may occur on unknown faults in the area surrounding the Clive site (i.e., background seismicity). For fault sources, the PGA was based on the maximum rupture length and rupture area for each fault. The return period for ground motions resulting from a background earthquake was estimated at 5,000 years (i.e., equal to a one percent probability of exceedance in 50 years).

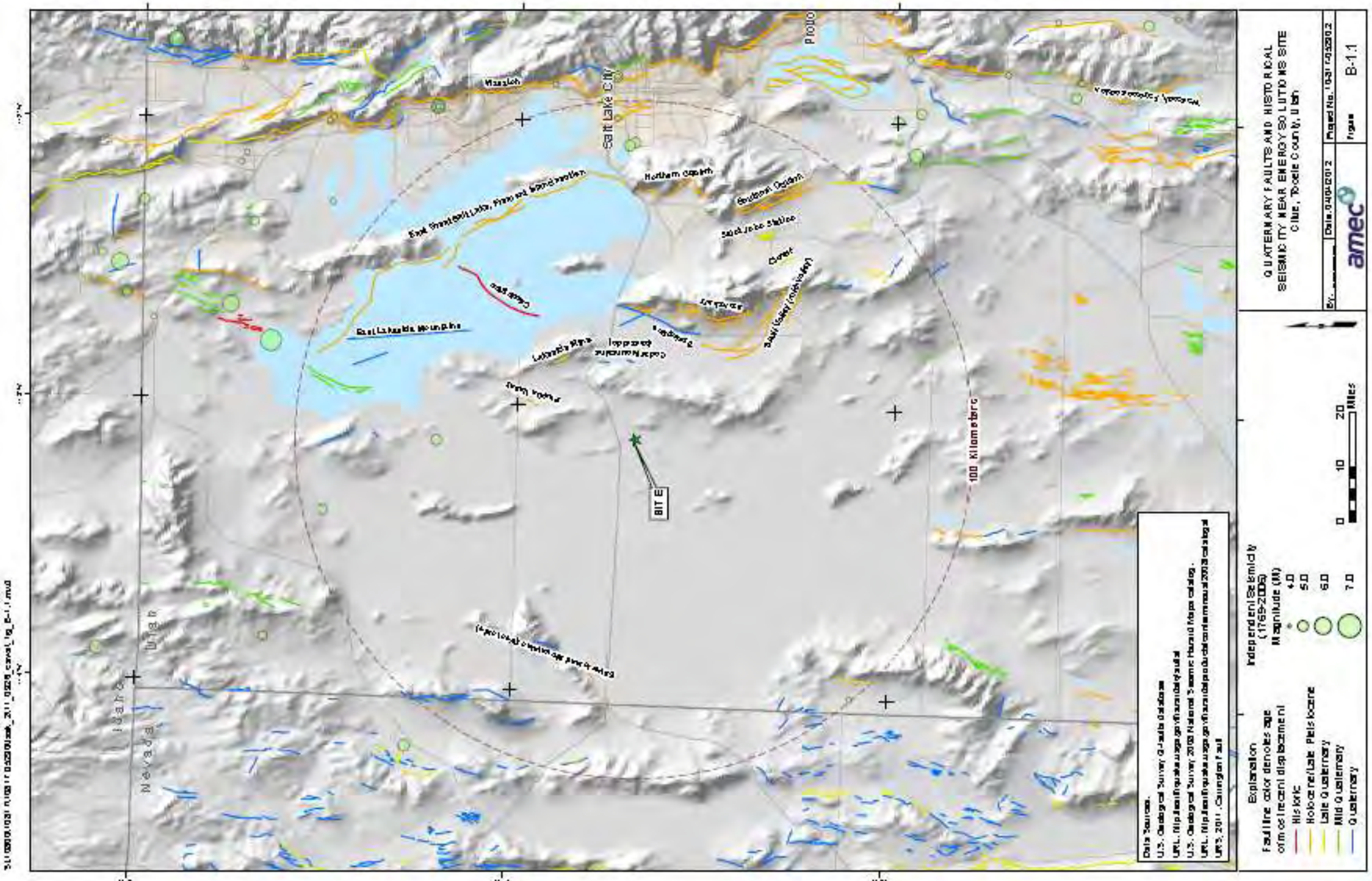


Figure 2-2. Energy*Solutions* Fault and Seismicity Map (AMEC, 2012).

The approach of selecting a MCE PGA from the larger of the values associated with the deterministic MCE for faults or the PSHA result for background earthquakes at a 5,000 year return period is consistent with recommendations of the Utah Seismic Safety Commission (2003) and requirements promulgated by the Utah Division of Water Rights (Dam Safety Section) for assessment of dams (AMEC, 2012).

The maximum PGA value that was calculated for the maximum events on neighboring fault sources was projected as 0.28 g, (which is the largest PGA from the deterministic assessment of fault-specific sources and the probabilistic assessment of the background earthquake). The maximum magnitude of the MCE varies from 7.0 to 7.3 for the sources that result in the maximum PGA. The largest value of 7.3 is considered conservatively appropriate for use in the seismic stability analyses for the Clive site.

The liquefaction/cyclic softening potential of the subsurface soil profiles below the Embankment have also been evaluated (AMEC, 2012). The potential for liquefaction of sand-like soil has been determined to be low and the potential for seismic settlement to be on the order of one to two inches. The potential for cyclic-softening was also found to be low.

2.4.3 Site Soils

A significant amount of field and laboratory information has been developed for the site and surrounding area, as a result of studies and investigations conducted in and adjacent to Section 32. Available geotechnical data adequately characterizes the subsurface soil conditions below the Embankment and Section 32. DOE collected initial geotechnical and hydrogeologic information to locate and dispose of the Vitro uranium waste in the north central part of Section 32. Dames & Moore, Jacobs Engineering Group and CSU collected information for DOE between 1982 and 1984 (DOE, 1985b). Additionally, Delta Geotechnical collected geotechnical and hydrogeologic information for Energy*Solutions* between 1988 and 1990 as part of the permitting process for the Mixed Waste landfill cell. Energy*Solutions* has further updated and revised the data collected. Results have been summarized in the Revised Hydrogeologic Report (Envirocare, 2004) and are scheduled to be updated in December of 2012.

Lacustrine deposits typically comprise the soils encountered at the site. These soils consist of silty clays and clayey silts, and oolitic silty sands and sands. Calcium carbonates in the form of aragonite and calcite contribute as much as 60 percent of the total mineralogy of the clayey materials. The remaining mineralogy consists of smectite, quartz, dolomite, K-feldspar, plagioclase, kaolin, illite and a trace of gypsum. Calcareous n nature the oolitic silty sands and sands, ranging in size from approximately 0.08 mm to 4.0 mm, will fizz when put in contact with dilute HCl.

Four hydrostratigraphic units have been delineated for the Clive site soils (extending from the surface, through the unsaturated zone, and into the shallow aquifer). This upper most layer consists of an upper silty clay/clayey silt (labeled Unit 4). Below the Unit 4 materials is an upper silty sand layer (Unit 3). Beneath the Unit 3 materials is a middle silty clay layer (Unit 2). Finally, below the Unit 2 material is a lower sand/silty sand layer (Unit 1).

The clayey soils, typically encountered from the surface down to a depth of 10 feet and between depths of 30 to 45 feet, typically are medium stiff, to stiff and moderately compressible. The majority of these clayey soils exhibit low to moderate plasticity and moisture contents ranging from 20 to 40 percent by weight.

The silty sand and sand layers, typically encountered between a depth of 10 and 30 feet and below a depth of 45 feet, are medium dense and low to moderately compressible. Moisture contents of the silty sands above the water table typically range from 5 to 15 percent by weight.

2.5 SURFACE WATER HYDROLOGY

The Energy*Solutions* site is located in the semi-arid desert of western Utah. The area containing the site lies within the Great Basin drainage, a closed basin having no outlet. The site drains into the normally-dry Ripple Valley depression on the eastern fringe of the Great Salt Lake Desert. The nearest usable body of water east of the Clive site is 28.1 miles away. At this location, a perennial stream flows from Big Spring (1,000 feet south of I-80) to the Timpie Springs Waterfowl Management Area, about 2,000 feet north of I-80. Stream flows from higher elevations evaporate and infiltrate into the ground before reaching lower, flatter land. The watershed up-gradient of the site covers approximately 46 square miles. There are no perennial surface-water systems associated with the Clive site. Activities at the Energy*Solutions* Clive Facility have no effect on surface-water quantities or quality at the Clive site. Water necessary for construction is provided by existing wells in the vicinity, or impounded water.

The lack of surface water bodies, the sparse precipitation and the high evaporation rate make it unlikely that any condition creating a permanent body of standing water will occur. Standing water at the Clive Site is managed during the operational life of the facility according to Condition I.E.7 of the GWQDP ―Run-on and Run-off Control Requirements" and ―Waste Water, Runoff, and Storm Water Management Requirements." Standing water in depressions outside waste management areas is not actively managed. UAC R313-25-23(5) states: ―*The disposal site shall be generally well drained and free of areas of flooding or frequent ponding*." Disposal site areas are managed to remove standing water, when necessary. Energy*Solutions* uses a mobile pumping truck to access and remove water from disposal site areas which are not designed to free-drain into an evaporation pond or equipped with permanent pumps. Other areas of the property are channeled to the southwest. The site has also been designed to drain any water that may accumulate during flooding.

Although there is no data indicating that historical floods have impacted the Clive site, analyses have been prepared to model the Probable Maximum Precipitation (PMP) and Probable Maximum Flood (PMF) for the Clive site (Appendix G). The largest ―instantaneous" value of runoff from the watershed was 29,800 cubic feet per second (cfs) and was associated with the six-hour PMP (Jones, 2012b). Modeling shows a PMP of 10.10 inches for the six-hour storm and 6.1 in. for a 1-hour storm. The Probable Maximum Flood expected at the site from a six-hour Probable Maximum Precipitation event is 13,100 cfs, as compared to an estimated 100-year flood of 1,300 cfs (Jones, 2012b). Additionally, Energy*Solutions* waste disposal operations do not take place in a 100-year flood plain (UGS, 1999).

The Probable Maximum Flood would most likely flow into the south and east borders of the site with the fringes of the flow encroaching on Energy*Solutions*' Clive Facility. The maximum depth of flow at the site was calculated to be between 2 and 4 feet and last for 6 hours. Thus, the Probable Maximum Flood would not infiltrate into groundwater beneath the facility. These events demonstrate that for post-closure, a short-term flood of any depth is likely to have no impact on the Embankment‘s performance. Additionally, short-term flooding of any depth on the order of days or even weeks can intuitively be seen to have minimal impact on long-term performance.

Runoff from such a hypothetical event as the Probable Maximum Flood will be diverted from encroaching into the embankment by using a berm surrounding the disposal area (Appendix E). Flow would be diverted around the site to the south and away from the embankments.

2.6 GROUNDWATER HYDROLOGY

Numerous geologic and hydrogeologic studies have been performed within and adjacent to Section 32. DOE performed the first detailed hydrogeologic investigations within Section 32 in the 1980s. Since Energy*Solutions*' operations began in 1988, additional studies were performed at the site in order to characterize the hydrogeology. In August 2004, Energy*Solutions* prepared a Revised Hydrogeologic Report that summarizes the hydrogeology of the site based upon historical data and prior hydrogeologic reports (Envirocare, 2004). An updated hydrogeologic report is under preparation in advance of renewal of the GWQDP and is scheduled for submittal to the Division by December of 2012.

2.6.1 Hydrogeology

Alluvial and lacustrine sediments that fill the valley floor are estimated to extend to depths of greater than 500 feet with unconsolidated sediments ranging from 300 to over 500 feet. North-south trending mountains and outcrops define the hydrogeologic boundaries for the aquifer system. Lone Mountain located two miles east of the site, rises approximately 950 feet above the valley floor. The Grayback Hills located to the north with outcropping features to the west rise 500 feet and 230 feet respectively above the valley floor.

The site aquifer system consists of a shallow unconfined aquifer that extends through the upper 40 feet of lacustrine deposits. A confined aquifer begins around 40 to 45 feet below the ground surface and continues through the valley fill. Due to the low precipitation and relatively high evapotranspiration, little or no precipitation reaches the upper unconfined aquifer as direct vertical infiltration. Groundwater recharge is primarily due to infiltration at bedrock and alluvial fan deposits which then travels laterally and vertically through the unconfined and confined aquifers. Groundwater flow in this area is generally directed northeasterly to northwesterly.

Fresh water from the recharge zones along the mountain slopes develops progressively poorer chemical quality in response to dissolution of evaporite-minerals during its travel through the regional-scale flow systems and through concentration by evaporation at the points of discharge. The groundwater quality in the unconfined aquifer at the Clive Facility is considered saline with concentrations of several chemical species (sulfate, chloride, total dissolved solids, iron, and manganese) significantly exceeding EPA's secondary drinking water standards.

2.6.2 Groundwater Flow Regime

The groundwater flow regime at the Energy*Solutions* Clive Facility has been evaluated and defined based on (1) information collected from water level measurements, (2) the aquifer hydraulic properties which were calculated from slug out tests and laboratory testing, (3) isotope dating of groundwater, and (4) hydraulic testing performed for wells in the shallow and deep aquifers. Water levels obtained from monitoring wells between 1991 and present day were used to develop contour maps and flow nets to define the direction of groundwater flow and hydraulic gradients within the aquifers. These data are combined with measured hydraulic conductivities to develop estimates of groundwater velocities.

Horizontal ground water gradients in the shallow aquifer range from 6.8 x 10^{-6} to 4.5 x 10^{-3}. The site-wide average gradient is 5.8 x 10^{-4}. Using these gradients, average horizontal velocities ranging from 0.002 ft/day to 0.007 ft/day are calculated (Envirocare, 2004).

In January and February of 1997, Adrian Brown Consultants performed slug tests of 44 wells at the site to characterize Clive's groundwater flow regime (Adrian Brown Consultants, 1997). These data were used in the development of revised groundwater modeling for the site. These slug tests were performed on wells screened within Unit 2 and/or Units 2 and 3. Adrian Brown Consultants reported a site-wide Unit 2 clay hydraulic conductivity of 2.98x10^{-4} cm/sec; with minimum and maximum values of 2.3 x 10^{-6} cm/sec and 4.3 x 10^{-3} cm/sec, respectively. The Unit 3 sandy material exhibits a saturated hydraulic conductivity of 3.2 x 10^{-4} cm/sec. The vertical hydraulic conductivity of Unit 1 was measured in the laboratory using soil core samples collected during the installation of deep well GW-139D located near the northeast corner of the Embankment (Energy*Solutions*, 2010). The samples were obtained from 43 to 60 feet below ground surface in Unit 1. Vertical conductivities ranged from 2.2 x 10^{-8} to 1.6 x 10^{-6} cm/sec, with an arithmetic mean of 2.9 x 10^{-7} cm/sec.

Data characterizing the shallow, unconfined groundwater surface are provided to the Division in the Semi-Annual Groundwater Quality Reports. The groundwater level data indicates that the water level fluctuations at any given well are generally less than 1 foot (with the exception of areas with localized mounding). The groundwater surface is relatively flat in Section 32, with elevations varying about two feet per mile.

Water level measurements from deeper monitor wells screened in Unit 1 between 70 and 100 feet below the ground surface have also been obtained and analyzed. When comparing water levels within deep and shallow monitor well clusters, the deep wells exhibit higher piezometric levels than the shallow wells, indicating an upward vertical gradient of approximately one foot based on fresh water equivalent heads. While this is offset somewhat by the downward density gradient of 0.2 feet, overall groundwater flow is from the confined to the unconfined aquifer. Based on the historic minimum depth to groundwater, groundwater levels would need to rise some 18 feet below the Embankment to begin to threaten contact with disposed waste. The historic minimum depth to shallow groundwater for this area is roughly 24 feet below original contour. The Embankments are constructed by excavating approximately eight feet below the ground surface, then constructing a two-foot thick liner of compacted low-permeability clay. Therefore, the groundwater would need to rise 18 feet and pass through the liner to threaten disposed waste.

Residual effects of three groundwater mounds that developed within or in the vicinity of the Embankments are apparent in piezometric surface maps derived from monthly water level measurements at the facility. All three mounds were created by focused infiltration of non-contact (i.e., uncontaminated) surface water resulting from precipitation events. A mound was first noticed in monitoring wells GW-36, GW-37, and GW-38 in the spring of 1993 when groundwater elevations increased over 5 feet in GW-37, 2.5 feet in GW-38, and 1 foot in GW-36. Groundwater elevation increases also occurred during the summer of 1995 with highest elevations occurring during this time. The cause of groundwater mounding in this area was the ponding of run-off water shed from the Vitro Embankment into the center of the 11e.(2) footprint. This area formed a catchment basin that accumulated run-off water as much as two feet deep over an area of at least one acre. This depression was formed in the 11e.(2) footprint where clay material was removed during the construction and completion of the Vitro Embankment by the State of Utah. Vitro run-off is now diverted into the eastern 11e.(2) embankment perimeter drainage ditch that transports run-off water away from the Embankments and into a collection pond located in the northeast portion of Section 6 (the Southwest

Evaporation Pond). In addition, Energy*Solutions* isolated the Vitro borrow area as well as current borrow areas to prevent surface water flow into these depressions.

A second mound formed in the area of monitoring well GW-19A during the summer of 1998. Groundwater elevations in GW-19A went from 4251.15 ft amsl on February 19, 1998, to 4,252.69 ft amsl on August 20, 1998. Groundwater elevation in GW-19A peaked on June 18, 1999, at 4,254.61 ft amsl. Increased groundwater elevations in GW-19A were due to mounding resulting from leakage from the Southwest Evaporation Pond. This pond is located up gradient of GW-19A. Subsequently, pond contents were removed and the pond was retrofitted for two liners and a leak detection system. Piezometer PZ-1 was installed down gradient of the pond and is monitored monthly to verify proper operation of the pond. Subsequently, the pond has overflowed from the outlet in response to periods of elevated precipitation, and the overflowing water has infiltrated and reached the groundwater table. Energy*Solutions* is currently extracting groundwater near the pond to reduce the mound.

A third area of groundwater mounding is located near monitoring wells GW-29 and GW-60. Although the extent is less than that associated with the mounds discussed above, this mounding may affect water levels in the southeast corner of the 11e.(2) Embankment. In April 2006, a groundwater mound formed near GW-29 in response to infiltration of surface water in an area where the LARW drainage joined the 11e.(2) drainage ditch. The culvert between LARW and the 11e.(2) Embankment was replaced in May 2006, and the groundwater elevation at GW-29 rapidly decreased for the next several months and has been on a slow decline since. Water elevations at GW-60 have fluctuated from 2003 to present due to localized recharge associated with the embankment runoff drainage system. Elevations have increased rapidly following large precipitation events and have decreased rapidly. Peak elevations of 3 to 9 feet above static have been observed. Since construction of a runoff lift station immediately south of the south access road in late summer 2009, Energy*Solutions* has actively removed water collecting in the station to reduce infiltration.

2.6.3 Groundwater Aquifer System

The aquifer system investigated in the area of the Energy*Solutions* Clive Facility consists of unconsolidated basin-fill and alluvial-fan aquifers which extend to depths on the order of 500 feet below Section 32. The lacustrine deposits, which comprise the majority of the aquifer system below the Clive Facility, are somewhat variable in depth and thickness, which makes the exact delineation of aquifers and aquitards difficult. Characterization of the aquifer system as a whole is based on subsurface stratigraphy and potentiometric data.

A shallow, unconfined aquifer has been identified in the upper 40 feet of lacustrine deposits, with groundwater surfaces ranging from 19 to 31 feet below the ground surface (with a historic minimum depth of approximately 24 feet). The unsaturated zone consists of an upper 8 to 15 foot thick silty clay and clayey silt (Unit 4) that overlies a 10 to 20 foot thick silty sand layer (Unit 3). Groundwater occurs within the lower part of Unit 3 below the approximate western half of Section 32 and the primary movement of groundwater is assumed to be in the silty sand lenses and layer of the shallow, unconfined aquifer here. Below this silty sand layer, a silty clay deposit (Unit 2) is present at variable depths and thickness. It appears that this silty clay layer is continuous based on exploratory boreholes and monitoring well installations. The top of Unit 2 generally slopes down from east to west across Section 32. In the eastern half of Section 32, groundwater in the shallow unconfined aquifer occurs in Unit 2, and Unit 3 is above the water table. Unit 1, which consists of a relatively thick silty sand layer, is present below the silty clay (Unit 2) at depths ranging from 40 to 45 feet below the ground surface. Wells and piezometers, which penetrate into Unit 1, typically exhibit higher freshwater equivalent heads than wells screened shallower in Units 2 and/or 3.

Because the shallow aquifer contains saline water with TDS concentrations ranging from approximately 30,000 mg/L in monitoring wells GW-26 and GW-63 to 100,000 mg/L in monitoring well GW-19A, it is classified as Class IV groundwater based on the criteria of TDS greater than 10,000 mg/l of the Utah Ground Water Quality Protection Regulations. Additionally, the saline water typically exhibits a specific gravity averaging 1.033.

The majority of the recharge to the shallow aquifer appears to occur as vertical leakage from the deeper confined aquifer. In addition, a small amount of vertical infiltration from the surface and some lateral movement of water from the recharge zone to the east occurs. Movement in the shallow aquifer is primarily laterally to the north, northeast and/or northwest.

The confined aquifer consists primarily of lacustrine deposits in Unit 1, which occurs below a depth of 40 to 45 feet. This deeper aquifer primarily consists of silty sand deposits with occasional silty clay layers and is overlain by one or more silty clay layers. Wells completed with screened intervals located at least 70 to 100 feet below the ground surface have static fresh water equivalent levels ranging from 3 to 18 inches above wells screened in the shallow, unconfined aquifer. In the vicinity of the GW-19A/B well nest, increased water levels in the shallow aquifer have caused a downward switch in gradients at the southwest corner of the site. It has been observed that as the mound decreases, and the site conditions return to normal, the vertical gradient in GW-19A/B has decreased. It is anticipated that the gradient in this area will eventually return to regional conditions.

This deeper, confined aquifer also contains saline water with TDS concentrations well above 20,000 mg/l, also classifying it as Class IV groundwater. However, it is generally better quality than the shallow groundwater. The deeper saline groundwater typically exhibits a specific gravity on the order of 1.019. Recharge to the deeper confined aquifer probably occurs south and east of the facility in the coarser alluvial deposits adjacent to Lone Mountain.

2.7 GROUNDWATER QUALITY AND GEOCHEMICAL CHARACTERISTICS

A significant amount of water quality data and geochemical information has been assembled for the subsurface soil and groundwater below Section 32 (Envirocare, 2004). Since groundwater quality is well characterized for all of Section 32, this information is applicable to the facility.

2.7.1 General

Embankment design minimizes the potential for transport of contaminants away from the waste. The cover reduces the potential for infiltration, which is already believed to be minimal in the area due to the low incident precipitation and high potential evapotranspiration. Additionally, seepage is not expected to reach the groundwater as a result of moisture redistribution within the disposal materials. The impact of this seepage on the groundwater is expected to be minimal for several reasons:

1. Waste must not exhibit free liquids at the time of disposal;

2. The volume of seepage is small, generally occurring over a long period of time;

3. There are no receptors for groundwater contamination, due to the existing poor quality of the groundwater;

4. The hydraulic head gradient in the groundwater is small, limiting the velocity of groundwater movement away from the site to a maximum of 1.1 feet per year; and

5. Analyses project that it would take approximately 400 to 600 years for leachate to move through the unsaturated zone and then another 800 years to travel to the nearest off-site groundwater well (Envirocare, 2004).

2.7.2 Summary of Groundwater Chemistry

Available groundwater quality data indicates that the shallow, unconfined aquifer exhibits variable quality within Section 32. Seasonal variations in water quality appear to be relatively small. However, spatial variations appear to be significant. One indicator parameter, TDS, had concentrations ranging from approximately 30,000 mg/L, in monitoring wells GW-26 and GW-63, to 100,000 mg/l in well GW-19A. Deeper screened wells below 70 feet exhibit lower TDS values than the shallow screened wells. There are significant water quality variations in the shallow, unconfined aquifer possibly due to the variations in subsurface soils that leach salts to the groundwater and the small gradients and corresponding velocities in the shallow groundwater system, which limit the mixing of the groundwater. Variations may also be related to groundwater mounding, which may dilute concentrations (e.g., GW-60) or may increase some concentrations (e.g., GW-19A).

The major effects of locally increased water elevations in the LLRW area have been changes in groundwater chemistries and local gradients. Mounding has caused increases in TDS, some metals, and total uranium. These increases are the result of re-dissolution of naturally occurring constituents of the lake sediments underlying the Clive facility.

2.7.3 Geochemistry

The water quality data collected for Section 32 includes results of laboratory analyses for organic, inorganic and radionuclide constituents and is reported in annual monitoring reports to the Division. The inorganic parameters analyzed indicate that many naturally-present concentrations are above the Criterion 5C limits for groundwater. Sulfate, chloride, and TDS concentrations in all wells also exceeded the EPA secondary drinking water standards. Analytical results for the radionuclide parameters also indicate that gross alpha, gross beta, sum of radiums, and total uranium have exceeded EPA‘s drinking water standards in two or more of the wells. Because of this, it is concluded there would be a minimal potential for degradation of water quality in the vicinity of the Clive site. The groundwater at the site is characterized as ~~–a~~ *brine*.” The water is suitable for limited industrial uses, without prior extensive treatment. The nearest current use of groundwater is located over three miles from the site and up-gradient.

Energy*Solutions* has performed geochemical compatibility testing of the brown and white Unit 4 clay materials being utilized for the clay bottom liner of the Embankment (Bingham, 1994). In addition to the geochemical compatibility testing, Energy*Solutions* has also performed numerous permeability tests of both the clay liner and radon barrier materials to evaluate the hydraulic conductivity and stability of the clay. Physical and chemical analyses, designed to approximate 80 years of leachate contact with the embankment liner material, show minimal loss of liner integrity for approximately 80 years, (demonstrating more than adequate performance for the time period during which the embankments are open for operations). This testing indicated that leachate will not reduce the hydraulic conductivity performance of the clay liner below design specifications. At the conclusion of the testing, the samples stabilized at hydraulic conductivity ranging from 5.0 x 10^{-8} to 1.0 x 10^{-7} cm/sec, comparable to their initial pre-test conductivities (Bingham, 1994). Once final cover is placed, infiltration will be minimized and leachate will not build up on top of the embankment liner.

Laboratory permeability tests of Clive‘s clay indicated that no significant volume of soil was leached out (even though approximately half is characterized as water soluble). Cation exchange capacity for the Unit 4 clay was determined to be 13.4 MEQ/100 g. In previous evaluations of distribution coefficient (k_d) values (calculated from available k_{oc} values), the organic percentage for Unit 3 was assumed to be 2 percent. This percentage is the recommended value for ―clean" soils without significant organic content.

2.8 GEOTECHNICAL

Analyses have been conducted to measure the geotechnical characteristics and features of the site and embankments in accordance with the requirements of UAC R313-25-7(1) and UAC R313-25-23. Information evaluated demonstrates that the geotechnical and geophysical field investigations and laboratory and field testing are adequate; interpretations of the data to develop typical soil and rock laying, typical cross-sections, and design parameters for use in design are reasonable and conservative; and geotechnical characterization of the Clive site meets the applicable guidance and acceptance criteria.

2.8.1 Field Investigations

Field investigations did not find any adverse conditions due to site characteristics that would affect the long-term performance of the facility (AMEC, 2005; AMEC, 2012).

2.8.2 Field and Laboratory Testing and Engineering Properties

Field and laboratory testing of soils at the site to determine engineering properties have been conducted over an extended period of time. This testing began with DOE‘s investigation of the suitability of the site for the Vitro remediation project (as published in their Final Environmental Impact Statement [DOE, 1984]) and has been continued by Energy*Solutions*, (AMEC, 2005; AMEC 2012).

2.8.3 Groundwater Conditions

A significant amount of water quality data has been developed for the subsurface soil and groundwater below Section 32. Since groundwater conditions were characterized for all of Section 32, this information is applicable to the embankments.

2.8.4 Borrow Materials

The Energy*Solutions* facility is an operational site that has access to adequate amounts of borrow material on site for proposed operations. The rock and bankrun borrow material is abundant in the Grayback Mountains and Energy*Solutions* has a contract with BLM for removal of sand and gravel from this site. Energy*Solutions* will continue to work with BLM and other commercial vendors to ensure sufficient amounts of material are available to complete operations. The rock must meet the construction quality assurance/quality control specifications listed in the CQA/QC Manual, prior to use.

Energy*Solutions* uses native clay materials from land owned by Energy*Solutions* for liner and radon barrier construction. In other liner and cover construction activities, Energy*Solutions* has demonstrated that the clays can be placed with a hydraulic conductivity as low as 1×10^{-6} cm/sec without any additives being used. Similarly, a hydraulic conductivity as low as 5×10^{-8} cm/sec can be achieved with the use of a deflocculant.

Table 2-3 summarizes the estimates of materials required for full cover construction of the Embankment, including estimates of materials required for full closure of the Embankment. As illustrated, the quantity of additional clay material required to construct the remaining liner and final cover of the Embankment is 1.1million yd^3. The sand, gravel, and rock materials needed to fully close the Embankment is 415,174 yd^3.

Drawing 10014-Figure D from Attachment 9 of Energy*Solutions* (2012a) shows four potential borrow areas located within Section 29 of Energy*Solutions* property. The calculations conservatively estimate a potential of nearly 3.2 million cubic yards of available clays from these four areas. The clay resource in these areas is 2.1 to 2.9 times (respectively) more than the 1.1 million yd^3 required for construction of clay liner, liner protective cover, temporary cover and radon barrier. A volume of at least 1.6 million cubic yards of mineral materials are available in S1/2SW1/4 per a letter dated October 11, 2011 from BLM to Energy*Solutions* (BLM, 2012).

2.8.5 Stratigraphy and Design Parameters

As is summarized in Table 2-4, the four stratigraphic units beneath the site are comprised of alternating clayey and sandy layers. All the units are Lake Bonneville lacustrine deposits and are part of the Lake Bonneville Formation. Unit 4 is the upper silty clay layer and is unsaturated across the site. The Unit 3 silty sand layer and Unit 2 silty clay layer comprise the upper aquifer. A confined aquifer extends from the top of the silty sand, Unit 1, down several hundred feet to bedrock.

Hydrogeologic cross-sections that illustrate the distribution of these units beneath Section 32 are shown in Envirocare, (2004). The cross-sections are based on stratigraphic information from well, borehole, piezometer, and lysimeter soil classification logs.

2.9 NATURAL RESOURCES

In preparation of this Application, Energy*Solutions* has evaluated known natural resources in the Clive site area and demonstrated that continued exploitation of such resources will not negatively impact the Embankment‘s ability to meet the performance objectives of UAC R313-25-19 through -22.

Table 2-3

Embankment Construction Material Estimates

COVER MATERIALS	EMBANKMENT AREA (ft^2)	THICKNESS (ft)	VOLUME (yd^3)
Waste Footprint Area	5,753,608		
Waste Area Top Slope	4,128,092		
Clay Liner Area	5,999,421		
Constructed Clay Liner & Liner Protective Cover	4,915,543		
Remaining Clay Liner	1,083,878	2.0	80,287
Remaining Liner Protective Cover	1,083,878	1.0	40,144
Full Cover (less Surface Layer) Area	5,950,435		
Top Slope			
Temporary Cover (clay)	4,131,394	1.0	153,015
Radon Barrier (clay)	4,131,394	2.0	306,029
Bankrun Borrow	4,131,394	1.5	229,522
Evaporative Zone (clay/loam)	4,131,394	1.0	153,015
Surface Zone (clay/loam)	4,131,394	0.5	64,736
Surface Zone (gravel)	4,131,394	0.5	11,424
Side Slope			
Temporary Cover (clay)	1,858,425	1.0	68,831
Radon Barrier (clay)	1,858,425	2.0	137,661
Bankrun Borrow	1,858,425	1.5	103,246
Evaporative Zone (clay/loam)	1,858,425	1.0	68,831
Surface Zone (clay/loam)	1,858,425	0.5	15,735
Surface Zone (gravel)	1,858,425	0.5	15,735
Ditch Slope			
Erosion Materials (rock)	379,197	1.0	14,044
TOTAL CLAY MATERIAL (BORROW)			**1,088,283**
SUBTOTAL SAND & GRAVEL PRODUCTS (w/o borrow factor)			373,971
GRAVEL BORROW FACTOR (excludes bankrun)			2.00
TOTAL SAND & GRAVEL BORROW			**415,174**

Table 2-4

Geotechnical Properties of Clive Site Soils

Unit Name	USCS	Approx. Thickness (feet)	Range of Particle Sizes (%) Sand	Silt	Clay	Atterberg Limits LL	PL	Bulk Density (g/cc)
Unit 4	CL	8 - 15'	2 - 11	42 -56	38 - 56	35	22	1.37-1.66
Unit 3	SM	10 - 16'	46 - 89	8 - 39	8 - 16	NA	NA	1.55-1.67
Unit 2	CL	12 - 20'	0 - 32	27 - 52	40 - 48	36	20	1.32
Unit 1	SM	100 +	40-60	20-30	10-20	NA	NA	NA

NA: Not Analyzed
Source: (DOE, 1984)

2.9.1 Geological Resources

Natural resources in Tooele County include limestone, metallic minerals, potassium, salts, tungsten, salt, clays, sand and gravel. Gravel quarries are located in the alluvial fans that flank the Cedar Mountains (DOE, 1984). Limestone is quarried in the Cedar Mountains about five miles east of the site. Presently, no oil or gas production takes place in the area. Although the area has been classified as possibly valuable for oil and gas, the classification is based on very general criteria. Additionally, little interest has been historically shown in the western desert for oil and gas exploration. Previous exploration near the west side of the Great Salt Lake revealed a low-grade product with little or no yield. There is neither coal production in the area nor geologic formations with coal resources. No active or pending mining claims or mineral leases are located on the site.

2.9.2 Water Resources

In general, the use of groundwater and surface water in the Great Salt Lake Desert is concentrated along mountain fronts where the majority of fresh groundwater and spring discharge occurs. This water is obtained from wells located up-gradient of the shallow aquifer below the site. Without extensive treatment, uses of the groundwater in the Clive area are confined to very limited industrial uses.

Other than the monitoring wells installed for the Vitro project, and wells used for construction and makeup water during the Vitro project, there are no existing groundwater wells near the Clive site. The closest known wells are approximately two to three miles west, northwest and east of the site. However, the well west of the site has been destroyed. While one of the two wells east of the site is in current use to water livestock, the second well has been destroyed.

2.10 BIOTIC FEATURES

In August 1993, NRC concluded an Environmental Impact Study (EIS) and generated a report detailing the potential impacts associated with the siting of Energy*Solutions*' 11e.(2) disposal facility in Utah's West Desert. In the process of creating this EIS, extensive research was performed into the vegetative and terrestrial populations in and around Section 32. Even though it was originally conducted in support of the 11e.(2) Embankment, the analysis is applicable to this Application. Data from the EIS was later revisited by SWCA (SWCA, 2011). This section summarizes SWCA's (provided in its entirety as Appendix I) and NRC's ecological findings.

2.10.1 Vegetation

The vegetation of the Clive site is a homogeneous, semi-desert low shrubland, primarily composed of shadscale (Atriplex confertifolia). The shrubland is part of the Northern Desert Shrub Biome of the Cold Desert Formation and is described as a Saltbush (Shadscale)-Greasewood Shrub complex. Plant communities identified on the site are Shadscale-Gray Molly (Kochia americana var. vestita), a transitional community type of Shadscale-Gray Molly-Black Greasewood (Sarcobatus vermiculatus), and Black Greasewood-Gardner Saltbush (Atriplex nuttallii). Dominant shrubs on the Clive site include shadscale, Nuttall's saltbush, and winterfat (SWCA, 2011). All three communities are low in species diversity. The Clive site occurs in the Desert Alkali range site, which is rated by BLM as being poor for grazing or forage production. However, the vegetation forms an important ground cover and deterrent to soil erosion and provides habitat for wildlife species. Annual production of the three community types ranged from 152 to 517 pounds per acre, air dry. Annual production for the range site is given as 50 to 200 and 500 to 1,500 pounds per acre during unfavorable and favorable years respectively. Livestock carrying capacity with such production would range from 3 to 80 acres per animal-unit month.

The vegetation of the Clive site is a homogeneous, semi-desert low shrub-land, primarily composed of shadscale (Atriplex confertifolia). The shrubland is part of the Northern Desert Shrub Biome of the Cold Desert Formation and is described as a Saltbush (Shadscale)-Greasewood Shrub complex. Plant communities identified on the site are Shadscale-Gray Molly (Kochia americana var. vestita), a transitional community type of Shadscale-Gray Molly-Black Greasewood (Sarcobatus vermiculatus), and Black Greasewood-Gardner Saltbush (Atriplex nuttallii). Representative of the desert shrub/saltbush community are low widely spaced shrubs, totaling approximately 10 percent ground cover (Cronquist et. al, 1972).

Dominant shrubs on the Clive site include shadscale, Nuttall‘s saltbush, and winterfat (SWCA, 2011). Vegetation patterns of the Clive site are correlated with soil salinity and corresponding shifts in presence or abundance of species. All three communities are low in species diversity. Seep-weed or inkweed (Suaeda torreyana) and scattered perfoliate pepperweek (Lepidium perfoliatum) are the only prominent understory species of the Shadscale-Gray Molly community. This community occurs over most of the Clive site, although black greasewood becomes prominent enough in the eastern quarter to form a Shadscale-Black Greasewood-Gray Molly community. Except for black greasewood and occasional stands of halogeton (Halogeton glomeratus), the composition is similar to the more prominent Shadscale-Gray Molly community. Maximum root depth of the late successional shadscale species is reported to be 39 inches, while fourwing saltbush roots generally extend to a maximum depth of 20 inches (SWCA, 2011).

Black greasewood may have tap roots that extend beyond 11 feet beneath the surface. The Black Greasewood-Gardner Saltbush community type is floristically the most diverse, but only occurs in the extreme northeast corner and eastern edge of the Clive site. In addition to Gardner saltbush, the flora is composed of all species found in the other communities except halogeton.

In the SWCA Study (2011), forty-one plant species were identified. However, because many desert forbs are spring ephemerals and field sampling was conducted at the end of a growing season, the plant species diversity and cover, particularly for herbaceous forbs, was underrepresented. Of the few forb species that were detected, all were dead or senesced, with the exception of Halogeton (Halogeton glomeratus), a late-season invasive annual weed. Biological soil crusts are a dominant feature of vegetation communities throughout the Great Salt Lake basin. Soil crusts were present in all vegetation associations sampled, but were more prevalent in the low desert vegetation associations (e.g., black greasewood, haltogeton-disturbed, and shadscale-gray molly) present on and adjacent to the Clive Site.

SWCA also examined the root density and maximum rooting depth of dominant plant species on the Clive Facility. Excavations were performed to obtain cross-sections of the rooting mass of dominant plant species. The roots were carefully exposed by gradual removal of vertical layers of soil with the backhoe and hand tools. Root density measurements were collected by measuring the width of the rooting mass and by counting visible roots across a set of sample widths or for the entire width of the root mass. Observed root densities were higher near the surface of the soil, where roots were mostly fibrous with few woody structures. A few large, woody roots were encountered in deeper soils. Rooting depths were shallower than expected, with the maximum rooting depth of dominant woody plant species ranging from 40 to 70 cm.

Woody plant species maximum rooting depths were proportional to aboveground plant mass with an above-ground height root depth ratio of 1:1 and an above-ground width root depth ratio of approximately 1.4:1. The halogeton had higher ratios of plant height and width to maximum rooting depth (1.4:1 and 1.7:1, respectively). The low proportion of roots to above-ground biomass is expected for annual plants, which invest the bulk of their energy in reproduction and little energy in root systems.

2.10.2 Terrestrial Life

The Clive site is located within the year-long range of the pronghorn antelope. The West Desert Herd Unit 2A occurs south of I-80 and includes the Clive site (BLM, 1988). Pronghorn are rare in the project area south of Interstate-80. The area is considered poor pronghorn habitat. Interstate-80 acts as a pseudo-barrier to most pronghorn movement south from the Puddle Valley Herd Unit.

Mourning doves are summer residents, arriving in February or March and migrating out of the area in August or September. Doves are most abundant in edge or ecotone areas, particularly interspersions of agricultural, sagebrush, and pinyon-juniper types. Mourning doves are the only game bird occurring on the Clive site.

A variety of other non-game mammals, birds, and reptiles are supported by habitats found in the area and associated utility, railroad, and access road right-of-ways. Species that may occur include the Townsend‘s ground squirrel, Ord‘s kangaroo rat, desert woodrat, western harvest mouse, side-blotched lizard, gopher snake, Brewer‘s sparrow, black-throated sparrow, and horned lark (BLM, 1987).

Supplemental terrestrial life analysis, conducted by SWCA (2011), also observed species of small mammal: deer mouse (Peromyscus maniculatus), northern grasshopper mouse (Onchomys leucogaster), and Great Basin kangaroo rat (Dipodomys microps). Deer mice accounted for 22 of the 24 captured mammals (92%). One northern grasshopper mouse and one Great Basin kangaroo rat were captured. At a second sampling location, SWCA observed deer mice comprised 84% of the captures, Great Basin kangaroo rats 14%, and Ord‘s kangaroo rat (D. ordii) 2%. Ord‘s kangaroo rats were captured only at this site.

SWCA also observed several ant mounds near the Clive Facility. A total of 1,624 ants in the genus Pogonomyrmex was collected in SWCA Sample Locations and determined to be the western harvester ant, (P. occidentalis [Cresson]). Four other ants collected were determined to be in the genus Lasius, with species not positively determined but most likely niger (Linnaeus). The western harvester ant is a widely distributed ant occurring throughout most of Utah and many other western states. It frequently occurs in areas that are relatively flat and have been recently disturbed by human activities.

2.10.3 Aquatic Biota

Aquatic ecosystems do not occur on or near the Clive site.

2.10.4 Endangered and Threatened Species

No important plant or animal species, as defined by NRC (1980a), are known to occur on the Clive site and no known important habitats have been identified in the area. Furthermore, no threatened or endangered plant species are known to occur in the vicinity of the Clive site. However, the Utah Division of Wildlife Resources reports that the area is used for foraging by bald eagles (Haliaeetus leucocephalus) and American peregrine falcon, which are federally listed endangered species, during the winter (SWCA, 2011). The bald eagle is a winter resident from late November to mid-March in the project vicinity. The majority of wintering eagles are found in Rush Valley with others occurring in Skull and Cedar Valleys. No bald eagle roosts are located within the proposed project area. However, the black-tailed jackrabbit is the primary food source utilized by bald eagles in Tooele County (BLM 1988), and eagles potentially hunt within this area.

One historical aerie of the American peregrine falcon was located near Timpie Springs Wildlife Management Area in the northern end of the Stansbury Mountains. The nest site became inactive following the construction of Interstate-80 in the late 1960s (BLM, 2012a). In an attempt to re-establish a breeding pair of peregrines, the Utah Division of Wildlife Resources, in cooperation with the U.S. Fish and Wildlife Service (USFWS), erected a hack tower at the Timpie Springs Wildlife Management Area, approximately 26 miles from the Clive site. The hack tower became active in 1983 and 1984, and a peregrine pair has since been occasionally observed using the site. Peregrines are known to arrive in the area in March and, if nesting, may remain until September (Public Lands, 2012). Due to the distance between the Clive site and the aerie, it is unlikely any peregrines utilize the project area.

Since 2001, Energy*Solutions* has been annually monitoring a nest (Nest 1379) located near the Northeast corner of Section 29, just north of and adjacent to the Union Pacific railroad tracks. Tooele County required this monitoring in accordance with a Conditional Use Permit (CUP) (CUP No. 2700-87) as the nest is large, and appears capable of housing larger birds, such as raptors. Since monitoring activities began in 2001, the nest has largely been unoccupied. However, Energy*Solutions* personnel did observe and report sightings of the Common Raven (Corvus Corax) in the Spring of 2001, 2002, and 2007. Energy*Solutions* will continue to monitor this nest for as long as required by the CUP.

The Great Basin fishhook cactus (Sclerocactus pubispinus) is currently under review for threatened status. This species is associated with gravelly beach terraces of Pleistocene Lake Bonneville in western Tooele County and is not expected to occur in the Clive area.

The Cedar Mountain is currently home to an estimated 362 horses or a range of 290 to 434 horses, protected under the Wild and Free Roaming Horse and Burro Act of 1971 (BLM, 2012b). This number fluctuates due to horse movement between the Cedar Mountains, the Onaqui Mountains, and Dugway Proving Grounds. Fences that might preclude horse movement between the three areas are generally insufficient to deter movement. The current established appropriate management level for the Cedar Mountains is set at 190 horses on the low end and 390 at the upper level (BLM, 2012b). Dependable summer water sources are a major problem. In drought years, natural water sources may dry up, generating the need for water to be trucked in. Hauling water is a financial impact to BLM and the transportation infrastructure. In times of reducing budgets, there is no certainty that BLM will be able to continue to haul water to wild horses in sufficient quantity to insure the quality of their existence and avoid mortality. During drought, increased stress is also placed on the water sources and adjacent vegetation as horses congregate around troughs whether or not water is in the spring. Wild horses are seldom encountered on the Clive site (BLM, 2012b), and are monitored so that the herd population does not exceed more than the environment could sustain (Grams, 2009).

The state sensitive kit fox may occur throughout the West Desert Hazardous Industry Area (UDWR, 2010).

Because nationwide populations have been declining for the past 25 years, the Greater sage-grouse have been designated a Federal Candidate species and heightened monitoring efforts are being conducted

(UDNR, 2009). On March 5, 2010, the US Fish and Wildlife Service announced that greater sage-grouse now have a ―*warranted, but precluded*" status, meaning the Service considers the Sage-grouse warrant listing on the Endangered Species Act, but that other species are a higher priority (BLM, 2012b). Because Sage-grouse require large tracts of sagebrush plant communities for their life-cycle, a range-wide Assessment of Greater Sage-grouse included potential distribution in the West Desert, but noted that, ―*barren habitats west of the Great Salt Lake and forested and alpine areas in mountainous areas were not historically occupied by sage-grouse*," (page 17 of UDNR, 2009).

The Assessment further noted that the most favorable Sage-grouse habitat is located near Vernon (eastern Tooele County) and in the Ibapah (western Tooele County), (UDNR, 2009). In 2006, a total of 190 males were counted on six mating sites in Vernon. In Ibapah, a total of 93 males were counted on five mating sites. The Assessment notes that a variable but stable pattern in sage-grouse numbers has been observed near Vernon since the late 1960s. However, because there has been difficulty in accessing private and Tribal lands, the Assessment has not been able confirm a similar trend for Sage-grouse mating sites near Ibapah. No Sage-grouse mating sites have been observed near the Clive facility. Additionally, the viable hazards identified Assessment‗s threat analysis (e.g., altered water distribution for irrigation, home and cabin development, tall structure construction, and aggressive road construction) have negligible to no likelihood of occurrence at the Clive facility.

2.11 PREOPERATIONAL ENVIRONMENTAL MONITORING

Energy*Solutions* collected radiological preoperational environmental samples before starting major construction of the Embankment, and continues operational sampling according to the requirements of the License. Preoperational and operational environmental results are reported annually to the Division. In addition to the currently licensed Embankment, Energy*Solutions* also operates an adjacent 11e.(2) byproduct disposal facility under an Agreement-State license issued by the Division. Because of the facilities‗ close proximity, some locations are used for monitoring both facilities. Subsequently, the results of environmental monitoring performed at those locations that are common to both facilities are reported to the Division as applicable (McCandless, 2012b; NRC, 1993c).

SECTION 3. DESIGN AND CONSTRUCTION

UAC R313-25-5	*"In addition to the requirements set forth in R313-22-33, an application to receive from others, possess, and dispose of wastes shall consist of general information, specific technical information, institutional information, and financial information as set forth in R313-25-6 through R313-25-10."*
UAC R313-25-7	*"The application shall include certain technical information. The following information is needed to determine whether or not the applicant can meet the performance objectives and the applicable technical requirements of R313-25:* *(2) Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.* *(3) Descriptions of the principal design criteria and their relationship to the performance objectives.* *(5) Descriptions of codes and standards which the applicant has applied to the design, and will apply to construction of the land disposal facilities.* *(6) Descriptions of the construction and operation of the land disposal facility. The description shall include as a minimum the methods of construction of disposal units; waste emplacement; the procedures for and areas of waste segregation; types of intruder barriers; onsite traffic and drainage systems; survey control program; methods and areas of waste storage; and methods to control surface water and ground water access to the wastes. The description shall also include a description of the methods to be employed in the handling and disposal of wastes containing chelating agents or other non-radiological substances which might affect meeting the performance objectives of R313-25*
UAC R313-25-8(4)(d)	*"The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:* (d) *Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent soils, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure."*
UAC R313-25-11(6)	*"A license for the receipt, possession, and disposal of waste containing radioactive material will be issued by the Executive Secretary upon finding that:*

	(6) the applicant's proposed disposal site, disposal site design, land disposal facility operations, disposal site closure, and post-closure institutional control plans are adequate to protect the public health and safety in that they will provide reasonable assurance of the long-term stability of the disposed waste and the disposal site and will eliminate to the extent practicable the need for continued maintenance of the disposal site following closure;"
UAC R313-25-18	*"Land disposal facilities shall be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to individuals do not exceed the limits stated in R313-25-19 and 25-22."*
UAC R313-25-23(1)	*"The primary emphasis in disposal site suitability is given to isolation of wastes and to disposal site features that ensure that the long-term performance objectives are met."*
UAC R313-25-24(4)	*"Wastes shall be emplaced in a manner that maintains the package integrity during emplacement, minimizes the void spaces between packages, and permits the void spaces to be filled."*

Energy*Solutions*' LLRW disposal design is a near-surface landfill embankment. The Embankment is constructed using materials native to the site or found in close proximity to the site. Engineered features of the Embankment are designed based upon State of Utah regulations, NRC guidance, EPA guidance, and Energy*Solutions*' past experience at this location. In order to simplify the information presented in this Application, the following presentation of design criteria, pertinent characteristics, and projected performance is limited to the Embankment.

Principal design features of the Embankment include: clay liner, waste placement, final cover, drainage systems, and a buffer zone. Auxiliary systems and facilities include utility systems, operational support facilities, fire protection systems, and water management systems.

The general design requirements for the licensing of a radioactive waste disposal facility are set forth in the UAC R313-25, administered by the Division. Rule R313-25-24 outlines six design requirements for near-surface land disposal of radioactive waste as follows:

1. Site design features shall be directed toward long-term isolation and avoidance of the need for continuing active maintenance after closure;

2. The disposal site design and operation shall be compatible with the disposal site closure and stabilization plan and lead to disposal site closure that provides reasonable assurance that the performance objectives will be met;

3. The disposal site shall be designed to complement and improve, where appropriate, the ability of the disposal site's natural characteristics to assure that the performance objectives will be met;

4. Covers shall be designed to minimize, to the extent practicable, water infiltration, to direct percolating or surface water away from the disposed waste, and to resist degradation by surface geologic processes and biotic activity;

5. Surface features shall direct surface water drainage away from disposal units at velocities and gradients which will not result in erosion that will require ongoing active maintenance in the future; and

6. The disposal site shall be designed to minimize to the extent practicable the contact of standing water with waste during disposal, and the contact of percolating or standing water with wastes after disposal.

R313-25-22 requires that the facility shall be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site without the need for ongoing active maintenance. Radiation protection standards are set forth in R313-25-19, R313-15-301 and R313-15-302.

The Utah Division of Water Quality (DWQ) has adopted performance based Best Available Technology (BAT) standards for Energy*Solutions*‘ disposal facility, requiring that groundwater protection standards will not be exceeded at compliance wells within 200 years for non-radioactive hazardous constituents and within 500 years for radioactive constituents.

Where UAC design criteria set forth specific criteria, the facility has been designed to meet that requirement, such as the DWQ water quality protection levels. However, the general criteria that the facility design must “*achieve long-term stability... to eliminate, to the extent practicable, the need for ongoing active maintenance of the disposal site after closure*,” requires a determination of the meaning of “long-term.” The EPA and the NRC, in setting design criteria for disposal facilities for LLRW have addressed the issue of long-term stability. Both agencies have adopted a standard that requires that the facility be designed for 1,000 years, whenever reasonably achievable, but in any case for a minimum of 200 years. Energy*Solutions* has adopted this standard to determine the design criteria for long-term stability.

For waste placement, Energy*Solutions* utilizes construction specifications that have already been approved and successfully implemented for the Embankment. No novel engineering designs or construction methods will be implemented for the Embankment without approval from the Division, nor will the waste disposed in the Embankment differ from waste currently being disposed in regards to radioactivity, physical form, or potential hazard.

Energy*Solutions* is constructing the Embankment in accordance with the waste placement, design and construction procedures and specifications found in the CQA/QC Manual. Information for the Embankment features is summarized in Tables 3-1 through 3-3.

In NUREG-1199 (section 6.3.2), NRC contemplates evaluation of design against a factor of safety only in the area of slope stability analysis. In the context of embankment retention systems at uranium recovery facilities, Regulatory Guide 3.11 (Revision 3, November 2008) further elaborates on the factors of safety considered in slope stability analysis. Importantly, Regulatory Guide 3.11 defines allowable minimum factors of safety for earthquake and liquefaction analyses as being 1.0. As with previous licensing actions that consider embankment performance against various design criteria, a minimum factor of safety of 1.0 is applied to the Embankment.

Table 3-1

Design Criteria of the Principle Design Features

Principal Design Feature	Required Function	Complementary Aspects	Design Criteria	Design Criteria Justification	Conditions	
Liner	Minimize contact of wastes with standing water	Minimize contact of wastes with standing water during operations	Permeability $\leq 1 \times 10^{-4}$ cm/sec	Prevent contact of water with waste. Operational experience shows that 10^{-4} cm/sec permeability promotes runoff and allows accumulation of water to occur. Water is then removed by pumping.	normal	25 yr. 24 hr. storm
					abnormal	100 yr. 24 hr. storm
					accident	Heavy equipment damage to liner
		Minimize contact of wastes with standing water after closure	Liner permeability $\geq$ cover permeability	Inflow into embankment < outflow out of embankment.	normal	Liner and cover retain design permeability over time
					abnormal	Degraded cover
					accident	Not required per NUREG-1199
	Ensure cover integrity	Mitigate differential settlement	Maximum allowable distortion in cover = 0.02	AMEC, August 1, 2012b “Clay Cracking Study Plan”	normal	Settlement completed during operations
					abnormal	One area to cover height with adjacent area less than 25 feet high
					accident	Not required per NUREG-1199
Waste Placement and Backfill	Ensure cover integrity	Mitigate differential settlement	Maximum allowable distortion in cover = 0.02	AMEC, August 1, 2012b “Clay Cracking Study Plan”	normal	All primary and portion of secondary settlement in soil layers complete during construction and 100-year institutional control period
					abnormal	Creep of compressible waste and additional secondary settlement of soils after 100-year institutional control period.
					accident	Not required per NUREG-1199
	Ensure structural stability	Maintain slope stability	Static safety factor $\geq$ 1.5 Seismic safety factor $\geq$ 1.2	State of Utah Statutes and Administrative Rules for Dam Safety, Rule R625-11-6	normal	Static conditions
					abnormal	Earthquake
					accident	Not required per NUREG-1199

` Cover	Minimize infiltration	Minimize Deep Infiltration	Average Infiltration ≤ 0.000079 inches/year (0.0002 cm/year)	HYDRUS model parameter that achieved performance based standards. Neptune, Inc., October, 2012.	normal	Average annual precipitation (8.42 ")
					abnormal	All abnormal conditions related to the Complementary Aspects of "Encourage Runoff", "Desiccation", "Frost Penetration", and "Biointrusion".
					accident	Not required per NUREG-1199
		Prevent desiccation	No desiccation cracking in Radon Barrier Clay	Ensure infiltration design criteria is attained	normal	Historic weather patterns
					abnormal	Drought
					accident	NA
		Limit frost penetration	Thickness of surface/evaporation/bankrun borrow zones ≥ maximum depth of frost (3 feet)	Ensure infiltration design criteria is attained	normal	Historic weather patterns
					abnormal	Monthly average minimum temperatures below those predicted by the 500 year return frequency
					accident	Not required per NUREG-1199
		Limit deep biointrusion	Deep biointrusion shall be discouraged and shall not cause increased infiltration	Ensure infiltration design criteria is attained	normal	Desert plant growth (shallow rooted)
					abnormal	Desert plant growth (deep rooted)
					accident	Not required per NUREG-1199
	Reduce Exposures	Surface dose rates	100 mrem TEDE	R313-15-301	normal	Low to moderate gamma emitters
					abnormal	High gamma emitter at top of waste
					accident	NA
	Ensure Cover Integrity	Mitigate Differential Settlement	Maximum Allowable Distortion = 0.02	AMEC, August 1, 2012b “Clay Cracking Study Plan”	normal	All primary and portion of secondary settlement in soil layers complete, no container deterioration up to 100 years
					abnormal	Container deterioration after 100 years, allowing creep of compressible waste and additional secondary settlement of soils. Earthquake.
					accident	Not Required per NUREG-1199
		Prevent Internal Erosion	Water velocity < 5.41 ft/sec on Radon Barrier Clay	NUREG/CR-4620	normal	100 yr. 24 hr. storm
					abnormal	PMP (1-hour = 6.1 inches)
					accident	Not Required per NUREG-1199

Cover			Prevent Piping: D_{15}(filter)/D_{85}(soil) ≤ 5 AND D_{50}(filter)/D_{50}(soil) ≤ 25 Prevent Upward Migration of Fines D_{15}(Lower Layer)/D_{85}(Upper Layer) ≤ 4	Reduce plugging of bankrun borrow zone. Cedergren, H.R., (1977), "Seepage, Drainage, and Flow Nets" second edition, John Wiley & Sons, New York, pp. 178-182. DOE, 1989. Technical Approach Document, Revision II, UMTRA-DOE/Al 050425.0002, pp. 82-83	normal	Performance calculations are developed for saturated conditions within dams. Conditions at Energy*Solutions* are much less severe. DOE ratios have been developed for abnormal saturated conditions within an UMTRA embankment.
					abnormal	
					accident	
		Material Stability / Endure Weathering, External Erosion	1,000 year life	NUREG-1623 NUREG/CR-4620	normal	Historic Weather Patterns
					abnormal	PMP (1-hour = 6.1 inches)
					accident	Not Required per NUREG-1199
	Ensure Structural Stability	Settlement	Maximum Total Settlement ≤ 15% of Embankment Height	Highway embankments and major waste storage embankments have settled up to 15% of their height and performed adequately	normal	Evenly Distributed Weight Loading
					abnormal	Creep of compressible waste and additional secondary settlement of soils after 100-year institutional control period.
					accident	Not Required per NUREG-1199
		Maintain Slope Stability	Static Safety Factor ≥ 1.5 Seismic Safety Factor ≥ 1.2	State of Utah Statutes and Administrative Rules for Dam Safety, Rule R625-11-6	normal	Static Conditions
					abnormal	Earthquake
					accident	Not Required per NUREG-1199
Drainage Systems	Provide Site Drainage	Facilitate flow away from the Embankment	Depth of water < depth of ditch. Promote free flowing conditions. Freeboard ≥ 0.5 foot under normal conditions.	Minimize potential deep infiltration into the waste.	normal	25 yr. 24 hr. storm
					abnormal	100 yr. 24 hr. storm
					accident	Downstream Blockage
		Minimize Infiltration under flood conditions	Flood water shall dissipate faster than water travels through the cover system.	So long as flood water drains or evaporates faster than the travel time through the cover, increased infiltration will be minimized.	normal	100 year flood (1,300 cfs)
					abnormal	PMF (29,800 cfs)
					accident	Downstream Blockage
	Ensure Ditch Integrity	Prevent Internal Erosion	Size of rock able to handle stresses related to flow	NUREG/CR-4620 NUREG-1623	normal	25 yr. 24 hr. storm
					abnormal	100 yr. 24 hr. storm
					accident	Not Required per NUREG-1199
Buffer Zone	Provide Site Monitoring	Not applicable	Sized adequate for monitoring and corrective measures	Compliance monitoring	normal	No releases
					abnormal	Contaminant releases
					accident	Not Required per NUREG-1199

Table 3-2

Pertinent Characteristics of the Principle Design Features

Principal Design Feature	Principal Design Element	Pertinent Characteristics	References
Liner	Clay Liner under Embankment	2 feet thick Permeability ≤ 1 x 10^{-6} cm/sec Compacted to 95% of a standard proctor 85% fines (<0.075 mm) 10 < plasticity index < 25 30 < liquid limit < 50	Thickness, permeability: GWQDP Condition I.D.4.(c) Compaction: Work Element - Clay Liner Placement; Compaction specification; Fines, plasticity index, and liquid limit in Work Element - Clay Liner Borrow Material, Material specification.
Waste Placement	Bulk Waste Placement	Compacted waste average lift thickness ≤ 24 inches Compacted with at least 4 machine passes of a CAT 826 compactor, and must meet CAES acceptance criteria. First one foot of material above liner debris-free native soil Last one foot before radon barrier debris-free Compressible debris ≤ 50% of uncompacted lift volume Incompressible debris ≤ 50% of uncompacted lift volume	CQA/QC Manual, Work Element – Waste Placement With Compactor
	Oversized Debris Placement	Stacked to minimize volume of void spaces. Placed to minimize entrapped air in lift. CLSM poured over waste, with maximum slope of 3:1	CQA/QC Manual, Work Element – Containerized Waste Facility Waste Placement
	Containerized Waste Placement	Stacked to minimize volume of void spaces. Placed to minimize entrapped air in lift. CLSM poured over waste, with maximum slope of 3:1	CQA/QC Manual, Work Element – Containerized Waste Facility Waste Placement

Cover	Temporary Cover	1 foot of native CL or ML soil. Placed within 15 years of date of waste placement. Compacted to 95% of a standard proctor. Placement and monitoring of pre-final cover settlement monuments. Surcharging required when distortions exceeding 0.007 foot/foot in adjacent areas.	Thickness, permeability, slope: CQA/QC Manual, Work Element – Interim Rad Cover Placement and Monitoring
	Clay Radon Barrier	1 foot of 1 x 10^{-6} cm/sec clay 1 foot of 5 x 10^{-8} cm/sec clay 85% fines (<0.075 mm) 10 < plasticity index < 25 30 < liquid limit < 50 Compacted to 95% of a standard proctor Top Slope: 2-4% Side Slope: 20%	Thickness, permeability, slope: GWQDP Condition I.D.4.a(5) Compaction: CQA/QC Manual, Work Element - Radon Barrier Placement, Compaction specification Fines, plasticity index, and liquid limit in CQA/QC Manual, Work Element - Clay Liner Borrow Material, Material specification.
	Bankrun Borrow Layer	18 inches thick with boulders >16 inches removed	Thickness, permeability, slope: (Drawing 10014-C04, Appendix B)
	Evaporation Layer	1 foot of 5 x 10^{-5} cm/sec clay 85% fines (<0.075 mm) 10 < plasticity index < 25 30 < liquid limit < 50 Top Slope: 2-4% Side Slope: 20%	Thickness, permeability, slope: (Drawing 10014-C04, Appendix B) Fines, plasticity index, and liquid limit in CQA/QC Manual, Work Element - Clay Liner Borrow Material, Material specification.

Cover	Surface Layer	6 inches clay + 15% gravel by volume for top-slope 6 inches clay + 50% gravel by volume for side-slope Clay 85% fines (<0.075 mm) 10 < plasticity index < 25 30 < liquid limit < 50 Top Slope: 2-4% Side Slope: 20%	Thickness, permeability, slope: (Drawing 10014-C04, Appendix B) Fines, plasticity index, and liquid limit in CQA/QC Manual, Work Element - Clay Liner Borrow Material, Material specification.
Drainage Systems	Drainage Ditches	4 feet deep "Irregular quadrilateral" with a 2% bottom slope and 5:1 (H:V) sides slopes Borrow Material = CL or ML soils Natural Ground or Imported Borrow Material Compacted to 95% of a Standard proctor 6 inches of Type A filter material 18 inches of Type A riprap material	Drawing 10014-C03 Borrow Material in CQA/QC Manual, Work Element - Drainage Ditch Imported Borrow, Material specification
Buffer Zone	Buffer Zone	94 feet from toe of waste to fence <90 feet from toe of waste to compliance well 300 feet from toe of waste to property line 90.9 feet from toe of waste to Vitro property line	

Table 3-3

Projected Performance of the Principle Design Features

Principal Design Feature	Required Function	Complementary Aspects	Design Criteria	Projected Performance	Performance Reference	Safety Factor
Liner	Minimize contact of waste with standing water	Minimize contact of wastes with standing water during operations	Permeability $\leq 1 \times 10^{-4}$ cm/sec	Design permeability = 1×10^{-6} cm/sec	CQA/QC Manual	100 (all conditions)
		Minimize contact of wastes with standing water after closure	Liner Permeability ≥ Cover Permeability	Liner design permeability = 1×10^{-6} cm/sec Cover design permeability = 5×10^{-8} cm/sec	CQA/QC Manual	20 (all conditions)
	Ensure Cover Integrity	Mitigate Differential Settlement	Maximum Allowable Distortion in Cover = 0.02	Normal maximum distortion = 0.001 Abnormal maximum distortion = 0.007	AMEC, 2012b	Normal = 20 Abnormal = 2.86
Waste Placement and Backfill	Ensure Cover Integrity	Mitigate Differential Settlement	Maximum Allowable Distortion in Cover = 0.02	Maximum differential settlement (distortion) calculated at 0.01 for bulk waste facility under abnormal conditions	AMEC, 2012b	Abnormal: 2.0
	Ensure Structural Stability	Maintain Slope Stability	Static Safety Factor ≥ 1.5 Seismic Safety Factor ≥ 1.2	Static Safety Factor ≥ 2.1 Seismic Safety Factor = 1.2	AMEC, 2012b	Static ≥ 2.5 (exceeds design criteria of 1.5) Seismic = 1.2 (meets design criteria of 1.2)
Cover	Minimize Infiltration	Minimize Infiltration	Average Infiltration ≤ 0.000079 inches/year (0.0002 cm/year)	Infiltration meets performance criteria of transport to monitoring wells for at least 500 years.	Neptune, 2012	Not applicable
		Encourage Evaporation	Maintain positive drainage; Minimize design velocity < drainage velocities;	Cover design slope = 4%		Top Slope: 4.01 Side Slope: 28.75

		Prevent Desiccation	No desiccation cracking in Radon Barrier Clay	HYDRUS modeling establishes that the steady-state moisture content of the clay radon barrier will remain constant through all conditions throughout the life of the embankment.	Neptune, 2012	1.91 (all conditions)
		Limit Frost Penetration	Thickness of surface/evaporation/bankrun borrow zones = maximum depth of frost	Frost depth = 3.0 feet	Montgomery Watson, 1998 Montgomery Watson, 2000	1.0
Cover	Minimize Infiltration	Limit Deep Biointrusion	Deep biointrusion shall be discouraged and shall not cause increased infiltration	Due to increased evapotranspiration, vegetation decreases infiltration through the cover under both the normal and the abnormal conditions.	SWCA, 2012 Neptune 2012	2.0
	Reduce Exposure	Surface Dose Rates	100 mrem TEDE	3.5 mrem/year through cover using abnormal event of high-gamma source at the top of waste.	Energy*Solutions*, 2012a	100/3.5 = 28.57 (abnormal condition)
	Ensure Cover Integrity	Mitigate Differential Settlement	Maximum Allowable Distortion = 0.02	Maximum differential settlement (distortion) calculated at 0.01 for bulk waste facility under abnormal conditions	AMEC, 2012b	Abnormal: 2.0
		Prevent Internal Erosion	Water velocity < 5.41 ft/sec on Radon Barrier Clay	Interstitial Velocities at Radon Barrier/Filter Zone Interface:	Energy*Solutions*, 2012a	Top ~ 15 Side ~ 6.1 (all conditions)
			Prevent Piping: D15(filter)/D85(soil) ≤ 5 AND D50(filter)/D50(soil) ≤ 25 Prevent Upward Migration of Fines D_{15}(Lower Layer) / D_{85}(Upper Layer) ≤ 4	Incorporated as construction specification on drawing 10014-C04 Top Slope: Gravel = 3 in minus (15% by volume) Side Slope: Gravel = 3 in minus (50% by volume)	Energy*Solutions*, 2011	Not applicable Top = 26.3 Side = 9.6 (all conditions)
		Material Stability / External Erosion	1,000 year life	Design riprap D50 3 inche - Top Slope volumetric mixture of 15% Side Slope volumetric mixture of 47%	Energy*Solutions*, 2012 Jones, 2012c	Top = 1.0 Side = 1.06 (abnormal condition)

	Ensure Structural Stability	Settlement	Long Term Cover Drainage (No Slope Reversal)	Even if the total potential settlement were focused at the crest of the embankment, the drop in elevation from the crest to the shoulder eliminates the potential for slope reversal.	AMEC, 2011 (sections 4.2.3 and 4.4)	21.6 / 3.5 = 6.1
			Maximum Total Settlement ≤ 15% of Embankment Height	Primary foundation settlement 1.25 feet Secondary foundation settlement 2.0 feet Waste settlement after cover construction 0.7 feet Total 3.95 feet	AMEC, 2011 (sections 4.2.3 and 4.4)	9.2 / 3.0 = 3.07
		Maintain Slope Stability	Static Safety Factor ≥ 1.5 Seismic Safety Factor ≥ 1.2	Static Safety Factor ≥ 2.3 Seismic Safety Factor = 1.3	AMEC, 2012a	Static ≥ 2.3 (exceeds design criteria of 1.5) Seismic = 1.3 (exceeds design criteria of 1.2)
Drainage System	Provide Site Drainage	Facilitate flow of precipitation away from the embankment	Depth of water < depth of ditch. Freeboard ≥ 0.5 foot under normal conditions.	Design ditch height = 4 feet. Max height of water during normal event = 3.07 feet at downstream limit of ditch system. Max height of water during abnormal event = 2.47 feet at downstream limit of ditch system. Downstream blockage improves post-closure performance	Energy*Solutions,* 2012a Drawing 10014-C04	Downstream: Normal SF = 2.64 Abnormal SF = 1.30
		Minimize Deep Infiltration under flood conditions	Flood water shall dissipate faster than water travels through the cover system.	Maximum depth of PMF is approximately one foot across the site. This depth would last about 11 hours.	Jones 2012a Jones 2012b	Abnormal SF > 13,100
	Ensure Ditch Integrity	Prevent Internal Erosion	Size of rock able to handle stresses related to flow	The type A riprap in the ditches is adequately sized with a D50 of 6 inches.	Energy*Solutions*, 2011	3 / 0.2 = 15
Buffer Zone	Provide Site Monitoring	NA	Sized adequate for monitoring and corrective measures	No contaminants will reach the monitoring wells located approximately 90 feet from the edge of waste, within the buffer zone boundary of 94 feet) within 500 years.	Neptune, 2012	Not applicable

Although factors of safety are not required by NRC to be developed for each aspect of the design, a factor of safety is calculated in Table 3-1 for each design criteria where supporting analyses provides a value for comparison. This approach is consistent with Energy*Solutions'* other major licensing actions. Thus, only the slope stability analysis has a regulatory basis for the minimum factor of safety evaluation; other factors of safety provide information about relative robustness of the design. In each case, cited references should be consulted in order to understand and evaluate the basis for the reported safety factor.

3.1 DESIGN CRITERIA OF THE PRINCIPLE DESIGN FEATURES

The principal objectives of the disposal facility design are to: (1) provide long-term isolation of disposed waste, (2) minimize the need for continued active maintenance after site closure, and (3) augment the site's natural characteristics in order to protect public health and safety. Energy*Solutions* has designed the Embankment to effectively control any radioactive release for at least 500 years. Accordingly, the principal design features include those elements of the completed Embankment that impact long-term performance of the facility.

3.1.1 Liner

The liner performs the required functions of minimizing contact of wastes with standing water and ensuring cover integrity.

3.1.1.1 Minimize Contact of Wastes with Standing Water During Operations
Embankment drainage is considered in terms of the complementary aspects of minimizing contact of waste with standing water during operations as well as following closure of the Embankment.

Design Criteria: A liner permeability of less than or equal to 1 x 10^{-4} cm/sec is sufficient to encourage runoff accumulation on the liner surface.

Design Criteria Justification: Permeability sufficient to encourage runoff accumulation causes precipitation to collect for active management via pumping or passive management via evaporation. Either active or passive management will limit the amount of infiltration into the ground beneath the embankment.

Conditions Evaluated: The normal condition evaluates impacts of the 25-year, 24-hour storm event for the site of 1.9 inches of rain (NOAA Atlas 2, Volume VI, Figure 28). The 25-year storm event has been selected to represent the probable worst-case precipitation event that may be encountered during active site operations. The abnormal condition evaluates impacts of the 100-year, 24-hour storm event for the site of 2.5 inches of rain (Jones, 2012b). The 100-year storm event was selected as a sensitivity case to represent the worst-case precipitation event that may be reasonably expected during active site operations. The accident condition of heavy equipment damage to the liner during operations was evaluated.

3.1.1.2 Minimize Contact of Wastes with Standing Water After Closure
Embankment drainage after closure is important to prevent the accumulation of water within the embankment, a condition referred to as ―bathtubbing." The cover of the embankment, although constructed of low-permeability clays that have been shown to maintain low permeability over time and a variety of

environmental conditions, may theoretically allow a certain low volume of infiltration. This section applies to embankment drainage only.

Design Criteria: Permeability of the liner shall be greater than or equal to that of the cover.

Design Criteria Justification: By designing the liner to be more permeable than the cover, the embankment system is free-draining, or assured of maintaining inflow through the cover less than or equal to outflow from the bottom of the liner. If the liner was less permeable than the cover (inflow greater than outflow), water could accumulate within the embankment, creating a condition where waste is in contact with standing water.

Conditions Evaluated: The normal condition evaluates liner performance with the cover performing as designed to limit infiltration. The abnormal condition evaluates the feasibility of phenomena that may degrade the permeability of the cover, causing greater infiltration than designed. An accident scenario is not required for embankment drainage after closure per Section 3.2 of NUREG-1199.

3.1.1.3 Ensure Cover Integrity

Cover integrity is evaluated as a function of the complementary aspect of mitigating differential settlement within the liner. Total settlement criteria and performance for the embankment, including the liner and native soils beneath the liner, are discussed below.

Design Criteria: The maximum allowable distortion in the cover is 0.02. ―Distortion" is a dimensionless ratio of differential settlement divided by the distance over which the differential settlement occurs.

Design Criteria Justification: The allowable distortion value for the cover was developed by reviewing published tensile ―beam tests," which measure the amount of deflection of a clay beam at which tensile cracking of the beam was first observed. The Energy*Solutions* cover soils were compared to the published tensile strain values based on similarities in clay content, moisture content at placement, density and plasticity index. It was assumed that permeability of the clay cover would be compromised should such tensile cracks initiate within the cover.

The ―tensile beam" tests underway present a conservative assessment of the maximum allowable distortion, since representing the clay cover by an unsupported simple beam is in itself a very conservative assumption, (AMEC, 2012b). The constructed embankment cover is subject to normal loading, which tends to reduce the potential for cracking. Energy*Solutions* is currently conducting additional analysis to characterize the maximum distortion to tensile strain relationship for Sections 5 and 29 clays. Upon completion, this report will also substantiate a maximum distortion design criteria in order to provide the desired factor of safety of three against the minimum distortion value where tensile cracking could actually occur.

Distortion is relevant only in terms of effects on the cover system, as the liner is designed to be free-draining following closure. Accordingly, should differential settlement lead to increased permeability of the liner following closure, performance of the disposal system will not be compromised.

Conditions Evaluated: The normal condition is that primary consolidation and settlement of the lower layers of the embankment will occur during construction, prior to completion of the final cover. The cut and cover nature of the operation will preclude dramatic differences in waste column height and, accordingly, in settlement within the active embankment. The abnormal condition considers possible effects of having one section of the embankment would have maximum weight loading on all layers of the embankment, liner, and foundation soils while the adjacent section would have minimum loading. This condition represents the maximum potential differential settlement for the liner. An accident condition is not required for differential settlement, per Section 3.2 of NUREG-1199.

3.1.2 Waste Placement and Backfill

Waste placement and backfill perform the required functions of ensuring cover integrity and ensuring structural stability.

3.1.2.1 Ensure Cover Integrity

Cover integrity was evaluated as a function of the complementary aspect of differential settlement due to differing physical properties of the waste material throughout the embankment.

Design Criteria: The maximum allowable distortion in the cover is 0.02. “Distortion” is a dimensionless ratio of differential settlement divided by the distance over which the differential settlement occurs.

Design Criteria Justification: The allowable distortion value for the cover was developed by reviewing published tensile “beam tests,” which measure the amount of deflection of a clay beam at which tensile cracking of the beam was first observed. The Energy*Solutions* cover soils were compared to the published tensile strain values based on similarities in clay content, moisture content at placement, density and plasticity index. It was assumed that permeability of the clay cover would be compromised should such tensile cracks initiate within the cover.

The “tensile beam” tests underway present a conservative assessment of the maximum allowable distortion, since representing the clay cover by an unsupported simple beam is in itself a very conservative assumption, (AMEC, 2012b). The constructed embankment cover is subject to normal loading, which tends to reduce the potential for cracking. Energy*Solutions* is currently conducting additional analysis to characterize the maximum distortion to tensile strain relationship for Sections 5 and 29 clays. Upon completion, this report will also substantiate a maximum distortion design criteria in order to provide the desired factor of safety of three against the minimum distortion value where tensile cracking could actually occur.

Distortion is relevant only in terms of effects on the cover system, as the liner is designed to be free-draining following closure. Accordingly, should differential settlement lead to increased permeability of the liner following closure, performance of the disposal system will not be compromised.

Conditions Evaluated: The normal condition is that all primary as well as part of the secondary settlement of the embankment foundation, liner, and contents will occur during construction and through the 100-year institutional monitoring period. The abnormal condition considers possible effects of delayed creep of compressible waste; as well as additional secondary settlement of soils after the 100-year institutional monitoring period within a soil/debris lift corridor between two incompressible Controlled Low Strength Material (CLSM) pyramids. This provides the worst-case condition for differential settlement within the embankment. The CLSM pyramids represent the most stable (incompressible) forms within the embankment while the soil/debris lift corridor represents the least stable (compressible) forms within the embankment. An accident condition is not required for differential settlement, per Section 3.2 of NUREG-1199.

3.1.2.2 Ensure Structural Stability

Structural stability has been evaluated in terms of slope stability within the layers that comprise the embankment contents.

Design Criteria: The embankment must meet global stability requirements for a Sliding Safety factor of 1.5 under static conditions and 1.2 under dynamic (i.e., earthquake) conditions.

Design Criteria Justification: These minimum factors of safety for static and seismic conditions are found in UAC R655-11-6. These minimum recommended factors of safety are based on reviewing case histories of embankment dams founded on non-liquefiable clay foundations or bedrock, which demonstrated adequate performance under seismic conditions (AMEC, 2012a).

Conditions Evaluated: The normal condition considers the performance of the Embankment under static conditions. The abnormal condition has been evaluated. The evaluation compares the calculated safety factor inherent to the Embankment design against the expected peak ground acceleration due to an earthquake that might affect the site. Analyses of reduced structural stability associated with accidents are not required per NUREG-1199, Section 3.2.

3.1.3 Cover

The cover is the most complex principal design feature of the embankment, consisting of five layers of clay, soil and bankrun borrow material. The cover performs the required functions of minimizing deep infiltration, reducing radiation exposure, ensuring cover integrity, and ensuring structural stability.

3.1.3.1 Minimize Deep Infiltration

Because the Embankment is designed to be free-draining, minimizing deep infiltration is critical to ensuring that groundwater contamination is minimized for the required time frame. The required function of minimizing infiltration is evaluated via five complementary aspects: minimize infiltration, encourage evaporation, prevent desiccation, limit frost penetration, and limit deep biointrusion.

Design Criteria: Average infiltration into the Embankment shall be less than or equal to 0.000079 inches per year (0.002 cm/year).

Design Criteria Justification: Infiltration was modeled using the HYDRUS computer model. At the maximum average infiltration rates provided above, RESRAD modeling of the fate and transport of hazardous constituents within the waste disposed demonstrates that Ground Water Protection Levels will not be exceeded for at least 500 years for radiologic constituents and at least 200 years for heavy metals (Neptune, 2012).

Conditions Evaluated: The normal precipitation condition was generated using the HELP model's synthetic precipitation generator to stochastically generate 100 years of daily precipitation data. This 100-year synthetic data set provided a mean precipitation of 8.4 inches/year, which is consistent with measured precipitation at the site weather station. The abnormal condition considers increased infiltration due to extreme weather events as well as damage to the radon barrier clay due to desiccation, frost penetration, or deep biointrusion. Evaluation of an accident condition is not required for water infiltration, per section 3.2 of NUREG-1199.

3.1.3.2 Prevent Desiccation
Design Criteria: There will be no desiccation cracking of the radon barrier clay.

Design Criteria Justification: The top foot of radon barrier clay is the primary infiltration barrier. If this barrier should be compromised, Embankment performance may be reduced.

Conditions Evaluated: The normal condition for desiccation considers performance under historic weather patterns of precipitation and evaporation. The abnormal condition evaluates effects of a prolonged drought on moisture content of the radon barrier clay. Evaluation of an accident condition for desiccation is not addressed in Section 3.2 of NUREG-1199. There is not a credible accident scenario that would cause desiccation of the radon barrier clay in excess of the evaluated abnormal condition.

3.1.3.3 Limit Frost Penetration
Design Criteria: The thickness of surface, evaporation, and frost barrier zones will be equal to or exceed the maximum projected depth of frost.

Design Criteria Justification: The top foot of radon barrier clay is the primary infiltration barrier. If this barrier should be compromised by the effects of freeze/thaw cycles, embankment performance may be reduced.

Conditions Evaluated: The normal condition for frost penetration considers performance under historic temperature patterns. The abnormal condition evaluates the effects of an extreme freeze (the 500-year freeze event). Evaluation of an accident condition for frost penetration is not addressed in section 3.2 of NUREG-1199. There is not a credible accident scenario that would cause frost penetration of the radon barrier clay in excess of the evaluated abnormal condition.

3.1.3.4 Limit Deep Biointrusion
Design Criteria: Deep biointrusion shall be discouraged and shall not cause infiltration to increase above the base case modeled.

Design Criteria Justification: The top foot of radon barrier clay is the primary infiltration barrier. If this barrier should be compromised, embankment performance may be reduced. While the establishment of vegetation on the cover will be facilitated and otherwise encouraged, the cover design must accommodate indigenous species growth with roots that may compromise the radon barrier layer‘s integrity, increasing infiltration above the base case modeled.

Conditions Evaluated: The normal condition for biointrusion evaluates the effects of indigenous plant species that may become established on the completed embankment (SWCA, 2012). The abnormal condition evaluates the effects of deep-rooted, indigenous plant species that may become established on the completed embankment following the 100-year period of institutional controls. Evaluation of an accident condition for biointrusion is not addressed in Section 3.2 of NUREG-1199. There is not a credible accident scenario that would cause biointrusion of the radon barrier clay in excess of the evaluated abnormal condition.

3.1.3.5 Reduce Exposure

Design Criteria: The dose rate at the surface of the completed embankment shall be less than 100 mrem total effective dose equivalent (TEDE) per year.

Design Criteria Justification: This is a regulatory requirement found in UAC R313-15-301. Evaluation of this limit at the surface of the embankment conservatively takes no credit for fences to be installed around the embankment at site closure. Fencing installed around the embankment and maintained for the 100-year institutional control period will discourage or prevent inadvertent intrusion onto the surface of the embankment.

Conditions Evaluated: The normal condition will be for wastes placed directly beneath the Embankment cover to have gamma source concentrations much less than the DOT limits on package activity for unshielded packaging. The abnormal condition considers effects of having a gamma source with a total activity of 11 curies of Co-60 at the top of the waste column. This activity was selected from DOT limits on package activity at 49CFR173.431 and the table of A1 and A2 values for radionuclides at 49CFR173.435. The A2 value of 10.8 curie for Co-60 was conservatively rounded up. The A2 value represents an activity limit for DOT Type A packages; materials with higher activity would require special transportation equipment, such as shielded casks, etc. Evaluation of an accident condition for reducing exposure to the general public is not addressed in Section 3.2 of NUREG-1199. There is not a credible accident scenario that would cause exposure to the general public in excess of the evaluated abnormal condition.

3.1.3.6 Mitigate Differential Settlement

Long-term cover integrity is evaluated in terms of differential settlement, internal erosion within and between the layers that make up the cover, and material stability/resistance to weathering.

Design Criteria: The maximum allowable distortion in the cover is 0.02. ―Distortion” is a dimensionless ratio of differential settlement divided by the distance over which the differential settlement occurs.

Design Criteria Justification: The allowable distortion value for the cover is being developed by laboratory studies of clays mined from Sections 5 and 29. The ―tensile beam” tests underway present a conservative assessment of the maximum allowable distortion, since representing the clay cover by an unsupported simple beam is in itself a very conservative assumption (AMEC, 2012b). The constructed Embankment cover is subject to normal loading, which tends to reduce the potential for cracking.

Conditions Evaluated: The normal condition is that all primary as well as part of the secondary settlement of the Embankment foundation, liner, and contents will occur during construction and through the 100-year institutional monitoring period. The abnormal condition considers possible effects of delayed unstable container deterioration occurring after 100 years, resulting in increased creep of compressible waste; as well as additional secondary settlement of soils after the 100-year institutional monitoring period. A second abnormal condition evaluates embankment performance under earthquake conditions. An accident condition is not required for differential settlement, per Section 3.2 of NUREG-1199.

3.1.3.7 Prevent Internal Erosion

The design criteria related to internal erosion of the cover materials addresses erosion of the radon barrier clay due to runoff water velocity on the surface of the clay.

Design Criteria: Runoff water velocity shall not exceed three feet per second on the surface of the radon barrier clay.

Design Criteria Justification: NUREG/CR-4620, ―Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments" provides tables of permissible velocities over different surfaces. The permissible velocity criterion is a velocity that will not erode the underlying material. The erosion potential of the material is determined based on the material properties as well as the degree of compaction that the material has undergone. Table 4.9 of NUREG/CR-4620 provides limiting velocities in cohesive materials. The permissible velocities presented in this table range from 1.05 ft/sec for an uncompacted lean clayey soil to 5.90 for a very compacted sandy clay. The radon barrier clay is best described in this table as a very compacted clay. The permissible velocity for this type of clay is 5.41 ft/sec. Therefore, the specified design criteria of a velocity < 3 ft/sec is conservative, providing an inherent factor of safety of 1.80.

Conditions Evaluated: The normal condition evaluated for internal erosion is the 100-year, 24-hour storm event of 2.4 inches of precipitation (Jones, 2012b). The abnormal condition evaluates impacts of the Probable Maximum Precipitation (one-hour storm of 6.1 inches) as the worst-case erosion event. The one-hour event was selected to maximize velocity of precipitation and, accordingly, flow through the cover drainage system.

3.1.3.8 Material Stability/External Erosion

Design Criteria: The bankrun borrow zone is designed to have internal stability and the surface zone to endure weathering/external erosion for a minimum of 1,000 years.

Design Criteria Justification: This design criterion has been applied from NUREG-1623, ―Design of Erosion Protection for Long-Term Stabilization." A 1,000-year minimum design life ensures that material degradation of the erosion barrier will not reduce embankment performance.

Conditions Evaluated: The normal condition evaluates historic weather data regarding maximum wind and water velocities that may impact the surface and bankrun borrow layers. The abnormal condition evaluates impacts of the Probable Maximum Precipitation (one-hour storm of 6.1 inches) as the worst-case erosion event (Jones, 2012b). The one-hour event was selected to maximize velocity of precipitation and accordingly flow through the cover drainage system. Analyses of increased cover erosion resulting from accidents are not required per Section 3.2 of NUREG-1199.

3.1.3.9 Settlement

The required function of ensuring structural stability is evaluated in terms of the complementary aspects of total settlement of the completed embankment and slope stability.

Design Criteria: Total settlement of the embankment shall not compromise the drainage capability of the cover; i.e., shall not cause slope reversal. Also, the maximum total settlement shall be less than or equal to 15 percent of the embankment height. The Embankment has a maximum height (measured from base of liner to top of cover) of 84 feet, which implies an allowable total settlement of 12.6 feet.

Design Criteria Justification: If Embankment settlement should cause the slope of the top of the embankment to be flattened or reversed (i.e., the elevation of the centerline of the embankment were lower than an area to either side), drainage off the top of the embankment would be compromised and infiltration may increase. The maximum total settlement to be used for design was based on reviewing the total settlement that other ―earthen" embankments with demonstrated satisfactory performance have undergone. Highway embankments (similar in height to the Energy*Solutions* embankment) located on the soft clay deposits in the Salt Lake valley typically settle from 12 to 18 percent of their height (average 15 percent) during construction. These embankments have performed adequately in supporting pavements and bridge abutments.

Conditions Evaluated: Under normal conditions, weight loading (from the cover, waste, and backfill) will be uniformly distributed with loads maximized at the center of the embankment and gradually decreasing to either side. The design criterion of Long Term Cover Drainage is directly related to the maximum distortion attained from the differential settlement analysis relating to waste placement. Therefore, the abnormal condition for Long Term Cover Drainage is the same as provided above to ensure cover integrity. The abnormal condition for total settlement evaluates a column of extreme loading within the center of the embankment. Such a condition might be caused by placement of a column of extremely dense waste forms such as large metal components or solid concrete. Analyses of increased settlement resulting from accidents are not required per Section 3.2 of NUREG-1199.

3.1.3.10 Maintain Slope Stability
Design Criteria: The embankment must meet global stability requirements for a Sliding Safety factor of 1.5 under static conditions and 1.2 under dynamic (i.e., earthquake) conditions.

Design Criteria Justification: These minimum factors of safety for static and seismic conditions are found in UAC R655-11-6. These minimum recommended factors of safety were based on reviewing case histories of embankment dams founded on non-liquefiable clay foundations or bedrock, which demonstrated adequate performance under seismic conditions (Seed, 1983).

Conditions Evaluated: The normal condition considers the performance of the embankment under static conditions. The abnormal condition evaluated compares the calculated safety factor inherent to the Embankment design against the expected peak ground acceleration due to an earthquake that might affect the site. Analyses of reduced structural stability associated with accidents are not required per NUREG-1199, Section 3.2.

3.1.4 Drainage Systems

The drainage systems perform the required functions of providing site drainage and ensuring structural stability. In contrast to the embankment, which is designed for a 1,000-year lifetime, the drainage ditch system is only operational during the active life of the facility. This yields a design life of approximately 25 years for the drainage ditch system. Due to this difference in design life of the two systems, different conditions have been evaluated for each system to more accurately reflect conditions at the site over the appropriate design life.

3.1.4.1 Facilitate Flow of Precipitation Away from the Embankment
Site drainage is considered in terms of two complementary aspects: (1) facilitating flow of precipitation away from the embankment, and (2) minimizing deep infiltration under flood conditions.

Design Criteria: During operations, storm water shall remain within the drainage ditch system with a minimum freeboard of 0.5 feet adjacent to any embankment under the normal precipitation event and no overflow under the abnormal precipitation event.

Design Criteria Justification: This criterion will promote the collection of precipitation as well as promote flow away from the embankment, thus minimizing standing water adjacent to the embankment; thereby minimizing potential infiltration into the waste.

Conditions Evaluated: The normal condition evaluates impacts of the 25-year, 24-hour storm event for the site of 1.9 inches of rain (Jones, 2012b). The 25-year storm event has been selected to represent the probable worst-case precipitation event that may be encountered during active site operations. The abnormal condition evaluates impacts of the 100-year, 24-hour storm event for the site of 2.4 inches of rain (Jones, 2012b). The 100-year storm event has been selected as a sensitivity case to represent the worst-case precipitation event that may reasonably be encountered during active site operations. The accident condition evaluates impacts of downstream blockage of the drainage ditch system.

3.1.4.2 Minimize Infiltration Under Flood Conditions

Design Criteria: Water, under a flood condition, shall be present vertically above waste for a time period less than the calculated travel time through the cover of the embankment.

Design Criteria Justification: This design criterion ensures that surface water due to flooding that could potentially accumulate above the toe of waste is not present for a long enough time period for infiltration to the waste to occur. Due to the meteorological conditions at the site (precipitation and evaporation), significant quantities of moisture could potentially infiltrate through the cover only if standing water is present for an extended period of time to generate a pressure head.

Conditions Evaluated: The normal design condition evaluates performance under the 100-year flood of 1,300 cubic feet per second (cfs) as a potential environmental event (Jones, 2012b). The abnormal design condition evaluates performance in response to the Probable Maximum Flood (PMF) of 29,800 cfs (Jones, 2012b). The accident condition evaluates impacts of downstream blockage of the drainage ditch system.

3.1.4.3 Ensure Ditch Integrity

Ditch Integrity is evaluated in terms of the drainage ditch's ability to prevent internal erosion of the soils beneath the rock erosion barrier.

Design Criteria: Runoff water velocity shall not exceed three feet per second on the surface of the radon barrier clay.

Design Criteria Justification: NUREG/CR-4620, ―Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments" provides tables of permissible velocities over different surfaces. The permissible velocity criterion is a velocity that will not erode the underlying material. The erosion potential of the material is determined based on the material properties as well as the degree of compaction that the material has undergone. Table 4.9 of NUREG/CR-4620 provides limiting velocities in cohesive materials. The permissible velocities presented in this table range from 1.05 ft/sec for an uncompacted lean clayey soil to 5.90 ft/sec for ―very compact" sandy clay. The drainage ditch sub-grade is comparable to ―compact clay" within this table. The permissible velocity for this type of clay is 3.94 ft/sec. Therefore, the specified design criterion of a velocity < 3 ft/sec is conservative.

Conditions Evaluated: The normal design condition evaluates performance under the 100-year, 24-hour storm event of 2.4 inches of precipitation (Jones, 2012b). The abnormal condition evaluates impacts of the Probable Maximum Precipitation (one-hour storm of 6.1 inches) as the worst-case extreme erosion event (Jones, 2012c). The one-hour event was selected to maximize velocity of precipitation and, accordingly, flow through the cover drainage system. Analyses of the effects of accidents on the drainage ditch integrity are not required per Section 3.2 of NUREG-1199.

3.1.5 Buffer Zone

The buffer zone performs the required function of providing an area for site monitoring.

3.1.5.1 Provide Site Monitoring
Design Criteria: The buffer zone shall be sized adequately to allow site monitoring as well as corrective measures.

Design Criteria Justification: Site monitoring is required during the 100-year period of institutional control to confirm performance of the disposal facility. Should unacceptable migration of radionuclides be identified, adequate area must be available for implementation of corrective measures.

Conditions Evaluated: The normal design condition for the buffer zone includes site monitoring activities with no unacceptable releases from the Embankment. The abnormal design condition assesses adequacy of the buffer zone for responding to hypothetical contaminant release. Analyses of the effects of accidents on the buffer zone are not required per Section 3.2 of NUREG-1199.

3.2 PERTINENT CHARACTERISTICS OF THE PRINCIPLE DESIGN FEATURES

This section describes the pertinent characteristics and construction of the principal design features. Embankment construction proceeds as a direct result of the receipt and disposal of waste materials. As such, the construction of the disposal facility is directly related to, and a part of, the operational phase of the project.

To ensure that embankment construction is performed to specification and in accordance with the design drawings, inspections are performed in accordance with the requirements of the CQA/QC Manual. Energy*Solutions* has included in this Application revision 27a to the CQA/QC Manual. The CQA/QC Manual and the design drawings for the Embankments, and any changes therein, must be reviewed and approved by the Division before implementation.

3.2.1 Liner

The liner system consists of a prepared foundation overlain by a two-foot thick layer of $1x10^{-6}$ cm/sec permeability clay. The following construction activities are required for construction of the embankment liner.

1. Existing terrain is excavated to a depth of approximately seven to ten feet below native grade. Excavation depth is determined based on the top of liner elevation shown on design drawings. The

minimum excavation depth is two feet deeper than the top of liner elevation. Overburden removed in reaching foundation elevation is stockpiled for future use in liner construction, capping the embankment, or as fill material.

2. The Embankment foundation is prepared from in-situ soils to meet design, grade, and compaction specifications. Specifications and inspection activities for foundation preparation are detailed in the CQA/QC Manual (Work Element – Foundation Preparation).

3. Clay liner construction methods are approved by the satisfactory construction of a clay liner test pad, as detailed in the CQA/QC Manual (Work Element – Clay Liner Test Pad). The equipment and procedures used for the test pad are reviewed and approved by a professional engineer qualified to certify such soil considerations. The test pad method is then reviewed and approved for construction by engineering staff of the Division.

4. Clay liner borrow materials are sampled and tested to verify their physical characteristics in accordance with the requirements outlined in the CQA/QC Manual (Work Element – Clay Liner Borrow Material). Once CQA/QC testing is complete and approved, the clay liner borrow materials become clay liner materials approved for clay liner construction. Borrow materials that fail testing may be reworked or may be discarded and replaced with materials meeting the criteria.

5. The clay liner materials are then placed in lifts and compacted to at least 95 percent of a Standard Proctor. Inspection and testing performed on the placed clay liner is described in the CQA/QC Manual (Work Element – Clay Liner Placement).

6. A number of CQA/QC specifications are applied to protect approved clay liner against damage. These include drying prevention, seasonal limitations on liner construction to protect against winter weather extremes, and minimization of heavy equipment travel on completed liner (Work Element – Clay Liner Placement; Specifications: Liner Drying Prevention, Snow Removal, Cold Weather Placement of Clay Liner, Contamination of Clay Liner, and Heavy Equipment on Clay Liner).

3.2.2 Waste Placement and Backfill

Waste disposed in the Embankment may take a variety of physical forms, including soil or soil-like material, compressible debris, incompressible debris, oversized debris, and containerized Class A LLRW. Liquid waste may not be disposed in the Embankment.

Waste placement is conducted in accordance with the CQA/QC Manual. Waste may be disposed in bulk soil lifts; oversized debris lifts; or the Containerized Waste Facility.

3.2.2.1 <u>Bulk Waste Placement</u>
Following acceptance and unloading, bulk waste packages are emptied and spread into bulk waste lifts that are 24 inches thick or less. Bulk waste may also be unloaded at the rollover facility or intermodal unloading facility and then delivered to the Embankment by rock truck. After spreading, bulk waste is compacted with at least 4 machine passes of a CAT 826 compactor. Computer-aided earthmoving systems (CAES) are then used to verify placement density (according to the Work Element – Waste Placement With compactor of the CQA/QC Manual). Bulk waste placement requires that the first foot of material above liner be debris-free native soil. Similarly, the final foot placed before Embankment cover‘s radon barrier must be debris-free.

These engineering controls prepare a stable engineered fill that will provide a suitable foundation for the final cover.

3.2.2.2 Oversized Debris Placement

Following acceptance and unloading, oversized debris waste packages and/or pieces are stacked in order to minimize the volume of void spaces between containers. Containers and large debris are placed to minimize entrapped air in each oversized debris lift. Associated container debris such as container lids or other incidental debris is placed so as to minimize potential entrapped air pockets. Quality control inspectors then visually inspect the placed debris for compliance with the CQA/QC specifications.

After an acceptable quality control inspection the lift is backfilled by pouring CLSM over the waste. CLSM is a low-strength, flowable concrete. Standard concrete mixing and delivery equipment is used to pour CLSM in each oversized debris pour. The flowability of the CLSM is controlled to ensure adequate filling of the voids within the oversized debris pour. Oversized debris and CLSM requirements are defined in the CQA/QC Manual, Work Element - Waste Placement.

Quality Control Inspectors test the CLSM against CQA/QC Manual specifications. Quality Control Inspectors document each oversized debris pour and observe the adequate filling of the void spaces within the pour.

CLSM lifts are grouped together in ―pyramids” with a maximum slope of 3:1. The footprint of any new CLSM pyramid may not overlap any previously established CLSM pyramid or CWF. After the CLSM pyramid is completed, bulk waste lifts are placed over and adjacent to the pyramid until the top-of-waste elevation is reached.

3.2.2.3 Containerized Waste Placement

In accordance with License Condition 16.M, Energy*Solutions* operates a Containerized Waste Facility within the Embankment. Following acceptance and unloading, waste packages are stacked in order to minimize the volume of void spaces created. Containerized Waste Facility operations are provided in the CQA/QC Manual, Work Element – Containerized Waste Facility Waste Placement Test Pad and Work Element – Containerized Waste Facility Waste Placement. Each waste placement configuration is evaluated and approved prior to construction through a test pad. Currently approved waste placement configurations include vertical drums, boxes up to four feet tall, and right circular cylinders (―liners” or high integrity containers) up to 331 cubic feet external volume (nine feet tall). Unusually shaped packages are placed and backfilled to ensure that voids are filled. In no case will packages be placed such that significant voids are created that cannot be filled.

Once waste containers are placed, quality control inspectors conduct a visual inspection for compliance with CQA/QC specifications. Backfilling is then conducted by placing free-flowing, cohesionless soil over the waste packages. Backfill soil must meet gradation and moisture content specifications approved through a test pad. Backfilling procedure and compactive effort, if required, is determined through an approved test pad. After the backfill layer of the CWF is completed, bulk waste lifts are placed over and adjacent to the CWF to complete the embankment. CWF may not be covered by a CLSM pyramid.

3.2.3 Cover

The Embankment cover is a multi-layer system consisting of a radon barrier, bankrun borrow layer, evaporation layer, and surface layer. Table 3-1 provides material specifications for each layer of the cover.

Once waste placement has reached the design elevation, radon barrier is constructed. Bankrun borrow zone, consisting of small and medium aggregate layers (below 16 inches) is placed directly over the radon barrier. The evaporation and surface layers are the final layers of the Embankment cover. As-built specifications, thickness, and slope of each layer are confirmed prior to construction of the next layer of the cover.

3.2.3.1 Temporary Cover

Temporary cover is 1 foot of native CL or ML soils that are free of debris material that is placed within 15 years of the date of initial waste placement on each lift area, and within 90 days of any survey that determines top of waste elevations and grades for each lot. Temporary cover shall be placed in accordance with the lift thickness and compaction requirements specified under Work Element – Waste Placement, above.

Pre-final cover settlement monuments are placed on the top of waste surface and then secured by the temporary cover as it is placed. Pre-final cover settlement is surveyed with GPS or approved equivalent equipment (with a tolerance no more than ± 0.1 foot). The pre-final cover settlement monuments are surveyed within 30 days of temporary cover installation and thereafter for at least one year. If the inspection indicates that waste material is exposed due to erosion, the temporary cover is repaired in that area within 7 calendar days.

If settlement monitoring surveys indicate that distortion is less than 0.007 foot/foot for all of the grid points in a given area, and each grid point has at least one year‘s monitoring data, then final cover construction proceeds. Once an area is approved, final cover construction shall be completed within 3 years of this determination. If monument surveys indicate distortions between any two adjacent points of more than 0.007 foot/foot, then surcharging over the area(s) in question is placed to stabilize settlement prior to final cover construction.

3.2.3.2 Radon Barrier

The Division is notified that waste placement has ceased for a section of the embankment and that cover construction will begin. The top of the completed waste zone is graded to meet the slopes specified in the engineering drawings. Slope of the top of waste surface is maintained by survey inspection and approved by quality control inspectors prior to the placement of radon barrier. Division inspectors are provided with notification and an opportunity to inspect the top of waste surface prior to temporary cover construction.

Radon barrier clay construction methods are approved by the satisfactory construction of a radon barrier test pad, as detailed in the CQA/QC Manual (Work Element – Radon Barrier Test Pad). The equipment and procedures used for the test pad are reviewed and approved by a professional engineer qualified to certify such soil considerations. Because the design specifications are identical for clay liner and the initial one foot of radon barrier clay (1×10^{-6} cm/sec permeability), the clay liner test pad results may be utilized for this portion of the radon barrier. A separate test pad is required for the top foot of radon barrier clay (5×10^{-8} cm/sec permeability).

3.2.3.3 Clay with $1x10^{-6}$ Permeability

1. Soil borrow materials are sampled and tested to verify their physical characteristics meet specification in accordance with the requirements outlined in the CQA/QC Manual (Work Element – Radon Barrier Borrow Material). These specifications are summarized in Table 3-1. Once CQA/QC testing is complete and approved, the radon barrier borrow materials become radon barrier materials approved for radon barrier construction. Borrow materials that fail testing may be re-worked or may be discarded and replaced with materials meeting the criteria.

2. The radon barrier materials are then placed in lifts and compacted to meet design criteria. Inspection, testing, and surveys performed on the placed radon barrier are described in the CQA/QC Manual (Work Element – Radon Barrier Placement).

3.2.3.4 Clay with $5x10^{-8}$ Permeability

1. Once the design thickness and grade for 1 x 10^{-6} cm/sec permeability clay have been reached and confirmed through CQA/QC testing and approval, placement of the 5 x 10^{-8} cm/sec permeability clay begins.

2. As with the 1 x 10^{-6} cm/sec permeability clay, radon barrier materials for the 5 x 10^{-8} cm/sec permeability clay are placed in lifts and compacted to meet design criteria. Testing frequency for the 5 x 10^{-8} cm/sec permeability clay is greatly increased compared to that for the 1 x 10^{-6} cm/sec permeability clay. This provides additional assurance that design performance is achieved, since the 5 x 10^{-8} cm/sec permeability clay is the primary infiltration barrier for the embankment. Inspection, testing, and surveys performed on the placed radon barrier are described in the CQA/QC Manual (Work Element – Radon Barrier Placement, Specification: Permeability).

3. A number of CQA/QC specifications (Work Element – Radon Barrier Placement) are applied to protect approved radon barrier against damage. These include drying prevention, seasonal limitations on radon barrier construction to protect against winter weather extremes, and minimization of heavy equipment travel on completed radon barrier (Work Element – Radon Barrier Placement; Specifications: Radon Barrier Drying Prevention, Snow Removal, Cold Weather Placement of Radon Barrier, Frozen Material, Contamination of Radon Barrier, and Heavy Equipment on Radon Barrier).

3.2.3.5 Bankrun Borrow Layer

The bankrun borrow layer is placed directly over the radon barrier. Specifications for thickness, gradation, and durability are found in Table 3-1. The bankrun borrow material is placed and spread ahead of construction equipment in order to minimize travel directly on the completed radon barrier surface. The material is handled in a manner to prevent concentration of finer materials in localized areas. The zone is the drainage layer of the multi-layer cover system. Inspections and testing performed on the placed bankrun borrow zone are described in the CQA/QC Manual (Work Element – Bankrun Borrow Layer).

3.2.3.6 Evaporation Layer

The evaporation zone is placed over the bankrun borrow zone. This layer consists of materials with the requirements outlined in the CQA/QC Manual (Work Element – evaporation material preparation). These specifications are summarized in Table 3-1. The evaporation materials are then placed in lifts and compacted to meet design criteria. Inspection, testing, and surveys performed on the placed evaporation zone are described in the CQA/QC Manual (Work Element – Evaporation Material Placement).

3.2.3.7 Surface Zone

The top layer of the cover is the erosion barrier. Erosion barrier is constructed of small pea gravel mixed with the evaporation zone material, meeting the specifications provided in Table 3-1. Higher volumetric gravel additions are designed for the Embankment side slope than for the top slope, as added erosion protection. Inspection, testing, and surveys performed on the placed surface material are described in the CQA/QC Manual.

3.2.4 Drainage Systems

Following completion of the cover for sections of the Embankment, permanent drainage ditches are constructed. Drainage ditches are constructed of filter zone and erosion barrier materials meeting the specifications provided in Table 3-1. Inspection, testing, and surveys performed on the drainage ditches are described in the CQA/QC Manual (Work Element – Drainage Ditches).

3.2.5 Buffer Zone

The minimum buffer zone width of 94 feet has been set as the design criteria. The distance from the edge of waste to the center of the perimeter ditch is 20.3 feet and the distance from the center of the ditch to the outer edge of the inspection road is approximately 39.6 feet. These two distances added together mean that the closest practical location for a monitoring well is 90 feet from the edge of waste. The location of the fence, therefore, was placed on the outside of the monitoring well (pads for the monitoring wells are approximately three feet wide). Since installation of monitoring wells at this location, radon barrier thickness has, with Division approval, been reduced for the Embankment. The 90-foot distance to a monitoring well is also found in the Statement of Basis for Energy*Solutions'* GWQDP, No. UGW450005.

Section 4.3.6 of NUREG 1200 states ―An acceptable buffer zone shall be a minimum of 30 meters wide [98.4 feet] around the entire facility." Energy*Solutions* has incorporated this criterion at its LARW, Class A West, and Mixed Waste embankments. Energy*Solutions'* property boundary is at a distance of at least 300 feet from the limits of waste disposal.

3.3 PROJECTED PERFORMANCE OF THE PRINCIPLE DESIGN FEATURES

Energy*Solutions* has designed the facility to meet or exceed the performance standards established by regulatory authority. Engineering evaluations performed on the design confirm that it meets or exceeds the design criteria. Engineering evaluations have been performed for the normal, abnormal, and accident (as appropriate) conditions.

Table 3-3, ―Projected Performance of the Principal Design Features," summarizes the projected performance of each design criteria with respect to the normal, abnormal, and accident (as appropriate) conditions. If applicable, a safety factor has also been calculated for the projected performance, relating the projected performance to the design criteria.

3.3.1 Liner

3.3.1.1 Minimize Contact of Wastes with Standing Water During Operations

Projected Performance – Normal Conditions: The design criteria is that the permeability must be low enough to allow flow and accumulation on the liner (less than or equal to 1 x 10^{-4} cm/sec). The design permeability of the clay liner is less than or equal to 1 x 10^{-6} cm/sec. CQA/QC tests during construction of the liner ensure that the maximum design permeability is achieved (CQA/QC Manual, Work Element – Clay Liner Placement). Therefore, the design criterion is met through the design and construction of the liner.

Projected Performance – Abnormal Conditions: The design permeability will promote precipitation accumulation for removal by pumping, regardless of the meteorological event. Thus, operational controls will minimize the contact of waste and water. Energy*Solutions'* GWQDP, Condition I.E.7 provides storm water management requirements for the embankments.

Projected Performance – Accident Conditions: CQA/QC Manual specifications minimize heavy equipment travel on the completed liner (Work Element – Clay Liner Placement; Specification: Heavy Equipment on Clay Liner). However, an accident condition may lead to liner damage prior to waste placement. Regular inspections will detect any damage and it will be repaired immediately by reworking the affected portions and completing QA/QC checks. Therefore, damage due to accident conditions will be repaired and will not affect projected performance.

Safety Factor: The design permeability is two orders of magnitude greater than the design criteria permeability. Therefore, the safety factor is 1 x 10^{-4} / 1 x 10^{-6} = 100.00.

3.3.1.2 Minimize Contact of Wastes with Standing Water After Closure

Projected Performance – Normal Conditions: As long as the permeability of the liner is greater than the permeability of the cover, a steady state situation will be reached where the influent in through the cover will be less than the effluent out through the liner. As constructed, the permeability of the liner is less than or equal to 1 x 10^{-6} cm/sec; cover permeability is less than or equal to 5 x 10^{-8} cm/sec. Any infiltrating moisture that reaches the liner will be able to move through it and out of the embankment at least as quickly as moisture enters the embankment through the cover. Therefore, the embankment will remain well drained and ―bathtubbing" will not occur.

Projected Performance – Abnormal Conditions: The abnormal condition associated with this design criterion is the possibility of a degraded cover condition. Analyses relating to degradation of the radon barrier clay are provided under the required function ―Minimize Infiltration," complementary aspects ―Prevent Desiccation," ―Limit Frost Penetration," and ―Limit Deep Biointrusion." The analyses for the complementary aspects ―Prevent Desiccation" and ―Limit Frost Penetration" both conclude that the clay radon barrier will not be affected by either of these phenomena. The analysis for ―Limit Deep Biointrusion" concludes that infiltration through the cover will not increase due to degradation of the clay radon barrier associated with root mass penetrating the clay. Therefore, under abnormal conditions the clay radon barrier permeability characteristic will not degrade to be greater than 5 x 10^{-8} cm/sec and the design criterion is met.

Projected Performance – Accident Conditions: No appropriate accident conditions exist for this design criterion.

Safety Factor: The factor of safety associated with the normal condition for this design criterion is calculated as the permeability ratio between the liner and the cover as built: $1 \times 10^{-6} / 5 \times 10^{-8} = 20.0$. The factor of safety for abnormal conditions is also 20.0, since degraded cover conditions will not lead to increased infiltration.

3.3.1.3 Ensure Cover Integrity

Projected Performance – Normal Conditions: Secondary foundation settlements were included as part of the analysis for compressible debris within the embankment completed by AMEC (2012a), with maximum secondary settlements of eight inches after 500 years, spread over a distance of approximately 550 feet from the toe of the embankment to the point of maximum settlement. This yields a distortion of approximately 0.001 after 500 years under normal conditions.

Projected Performance – Abnormal Conditions: The abnormal construction condition of an area of the embankment completely covered adjacent to an area 25 feet high was evaluated (AMEC, 2012a). This analysis used a 3:1 (H:V) construction slope and calculated a maximum differential settlement of approximately eight inches over the 100 foot internal slope area. This yields a distortion of approximately 0.007.

Projected Performance – Accident Conditions: No appropriate accident conditions exist for this design criterion.

Safety Factor: For normal conditions, the safety factor is calculated from the worst case distortion, between the toe of waste and the shoulder. This safety factor is calculated as follows: 0.02 / 0.001 = 20.00. The safety factor under abnormal conditions is 0.02 / 0.007 = 2.86.

3.3.2 Waste Placement and Backfill

Because the Containerized Waste Facility was separately reviewed in great detail and approved by the Division (License Amendment 12, October 19, 2001), this evaluation of projected performance is focused on bulk soil, soil/debris, and oversized debris placement. Performance evaluations for the Containerized Waste Facility are provided, in a similar format to this document, in the ―Containerized Waste Facility Engineering Justification Report," revision 1, April 12, 2001 and the ―Engineering Justification Report, Addendum ‗Fifteen Percent Void Space Criteria'," revision 1, October 10, 2001. CQA/QC Manual specifications applicable to the CWF have not materially changed since that time.

3.3.2.1 Ensure Cover Integrity

Projected Performance – Normal Conditions: Normal conditions for this required function and design criteria were not assessed because the performance is bounded by the abnormal conditions analysis.

Projected Performance – Abnormal Conditions: Analysis of settlements associated with compressible debris lifts within the embankment demonstrate that for compressible debris placed at 30 percent of the loose lift volume, the maximum differential settlement was approximately 0.009 (AMEC, 2012a). Therefore, the design criterion is met under abnormal conditions.

Projected Performance – Accident Conditions: No appropriate accident conditions exist for this design criterion.

Safety Factor: The safety factor for abnormal conditions is 0.02/0.009 = 2.0

3.3.2.2 Ensure Structural Stability

Projected Performance – Normal Conditions: Detailed seismic stability and deformation analyses of the Embankment projected a minimum static factor of safety of 2.1 under saturated conditions and 2.3 under unsaturated condition (AMEC, 2011; AMEC, 2012a), both exceeding the design static factor of safety of 1.5.

Projected Performance – Abnormal Conditions: Abnormal condition evaluations was performed for seismic loading of the Embankment due to a maximum credible earthquake. The calculated minimum seismic factor of safety is 1.3 (AMEC, 2011; AMEC, 2012a). This factor of safety exceeds the minimum design criteria (seismic factor of safety < 1.2).

Projected Performance – Accident Conditions: No appropriate accident conditions exist for this design criterion.

Safety Factor: The minimum static factor of safety is 2.1 under saturated conditions and 2.3 under unsaturated conditions; the minimum seismic factor of safety is 1.3. These values exceed the design criteria of static factor of safety < 1.5 and seismic factor of safety < 1.2.

3.3.3 Cover

3.3.3.1 Minimize Infiltration

Projected Performance – Normal Conditions: Infiltration modeling was performed based upon precipitation data from the Clive area for the last 19 years and for the last 50 years at Dugway. The Dugway data was correlated to site-specific data generated over nineteen years at Energy*Solutions,* yielding a long-term average annual precipitation value of 8.4 inches. Application of the HELP model's synthetic weather generator returned 100 years of data that set was applied for infiltration modeling.

Using this precipitation data, HYDRUS (2D/3D) infiltration modeling arrived at an average predicted infiltration rate of 0.0002 cm/year. These values were then used as inputs to the RESRAD transport modeling to demonstrate that performance criteria for ground water protection levels at the monitoring wells are met at 500 years (Neptune, 2012).

Assurance that this infiltration value will be met is related to many factors. The most important factor relating to minimizing infiltration is the permeability of the radon barrier clay (5×10^{-8} cm/sec). Engineering controls provided in the CQA/QC Manual provide quality assurance checks that the required permeability will be met during construction of the radon barrier clay. Therefore, at construction and under normal conditions the projected performance of the cover to minimize infiltration meets or exceeds the design criteria.

Projected Performance – Abnormal Conditions: Infiltration performance under abnormal conditions requires that positive drainage off the embankment be maintained and that the radon barrier permeability not increase due to the effects discussed under the complementary aspects of desiccation, frost penetration, and biointrusion. Based upon the analyses performed, the projected performance of the cover to minimize infiltration will meet the design criteria for all abnormal conditions.

Projected Performance – Accident Conditions: No appropriate accident conditions exist for this design criterion.

Safety Factor: A safety factor is not applicable to this complementary aspect.

3.3.2.2 Encourage Evaporation

Projected Performance – Normal Conditions: The design for the top slope of the cover provides a 3-4 percent slope away from the crest of the embankment and side slopes of 20 percent. Long-term stability and maintenance of the design slopes for maintaining positive drainage is evaluated below.

The projected performance for the evaporation design criteria is analyzed in terms of settlement (for both normal and abnormal conditions). Normal conditions for this required function and design criteria relating to allowable velocities within the drainage layer were not evaluated because performance is bounded by the abnormal condition analysis.

Projected Performance – Abnormal Conditions: An important consideration of this required function is the maximum allowable velocity within the drainage layer. Infiltration and transport modeling (Neptune, 2012) show that the majority of the evaporation within the cover occurs in the surface and evaporation layers.

SWCA performed an analysis to assess potential effects of native plants that may become established on the surface of the Embankment (SWCA, 2012). Roots associated with native plants may be considered a concern if they should cause a breach in radon barrier layer of the cover system, creating a preferential water transport route into the waste. The analysis concluded that potential radon barrier breach is more than compensated for by increased evapotranspiration due to plant communities.

Projected Performance – Accident Conditions: No appropriate accident conditions exist for this design criterion.

Safety Factor: No safety factor is associated with the water accumulation design criteria. For water velocity, the safety factor can be calculated as the ratio between the maximum theoretical velocity (associated with the hydraulic conductivity) and the maximum velocity associated with the one-hour PMP. This yields safety factors of $3.45 \times 10^{-3} / 8.6 \times 10^{-4} = 4.01$ for the top slope and $2.3 \times 10^{-2} / 8.0 \times 10^{-4} = 28.75$ for the side slope.

The critical concern for desiccation of radon barrier clay is during construction, when the cover is exposed to the elements. Following completion of the overlying cover layers, the radon barrier clay is isolated from the elements.

3.3.2.3 Prevent Desiccation

Projected Performance – Normal Conditions: Moisture content modeling has been performed for the cover and embankment system using the HYDRUS model (Neptune, 2012). This modeling establishes that steady-state moisture content for the clay layers of the cover remains relatively constant at approximately 0.42 by volume. This steady-state moisture content is comparable to the saturated moisture content of 0.43 for the upper foot of radon barrier.

The steady-state moisture content of the radon barrier can be compared against the projected moisture content at which desiccation may begin. Moisture content likely to lead to desiccation cracking can be derived from the plastic limit for a soil (ASTM D4318). The plastic limit is a laboratory-derived measurement of the moisture content at which a soil begins to crack, or desiccate. Energy*Solutions'* clay borrow sources for radon barrier construction have an average moisture content of 18.6 by weight at the plastic limit (90 data points from January through November 2000). This is equivalent to a moisture content at which cracking begins of approximately 22 percent by volume; or roughly half the steady-state moisture content of the radon barrier clay of 42 percent by volume.

Projected Performance – Abnormal Conditions: No matter the length or severity of drought, there is no credible evaporative mechanism to dry out the radon barrier, and moisture content of the radon barrier will remain constant for the life of the embankment. Potential evapotranspiration effects of plant life on moisture content within the layers of the cover system are discussed below. Two aspects of the cover design contribute to maintenance of moisture content in the radon barrier clays at a steady-state condition:

1. Moisture that enters the system is designed to evaporate from the embankment cover.

2. The field capacity of the bankrun borrow zone is over an order of magnitude less than that of the radon barrier (Neptune, 2012). Accordingly, moisture in the system will preferentially migrate to the radon barrier clay. The difference in field capacity confirms the effectiveness of the bankrun borrow material as a capillary break, as this layer will not be able to pull moisture from the radon barrier clay for transport to the surface of the cover.

Projected Performance – Accident Conditions: No appropriate accident conditions exist for this design criterion.

Safety Factor: The design criteria of ―no desiccation cracking in radon barrier clay" is met. A safety factor can be calculated as the steady-state moisture content divided by the moisture content at which desiccation could begin: 0.42 / 0.22 = 1.91. This safety factor applies to abnormal as well as normal conditions, as the abnormal condition evaluation establishes that there is no credible mechanism to dry out the radon barrier.

3.3.2.4 Limit Frost Penetration

Projected Performance – Normal Conditions: Normal conditions for this required function and design criteria were not assessed because the performance is bounded by the abnormal conditions analysis.

Projected Performance – Abnormal Conditions: Frost penetration analyses calculated frost depths of approximately 3feet for the highly porous traditional rock armored rip-rap surface layers (Montgomery

Watson, 2000). These frost penetration depths are equivalent to the surface/evaporation/bankrun borrow layer design depth of 3 feet. Additionally, the modeled average temperatures are lower than the projected 500-year return average minimum temperatures throughout the freezing season. Therefore, the frost penetration modeling provides conservative estimates of the abnormal condition frost depths.

Since the maximum frost penetration depth does not reach the surface of the clay radon barrier, degradation of this layer will not occur as a result of freeze/thaw processes. Therefore, the projected performance meets the design criteria for frost penetration under normal and abnormal conditions.

Projected Performance – Accident Conditions: No appropriate accident conditions exist for this design criterion.

Safety Factor: The safety factor associated with frost penetration is the ratio of the depth to the surface of the radon barrier (3.0 feet) to the projected frost depth. Since the temperature data utilized in this analysis is more conservative than the design criteria abnormal condition, the projected frost depth is conservative and the safety factor will be greater than calculated. Minimum safety factors are 3.0 / 3.0 = 1.0.

3.3.2.5 Limit Deep Biointrusion

Projected Performance – Normal Conditions: The completed Embankment cover is expected to deter establishment of deep-rooted plant communities. The required density of the radon barrier clay may provide some resistance to root intrusion compared to the native soil deposits (SWCA, 2011). The CQA/QC Manual requires that radon barrier clay be compacted to a minimum of 95 percent of a standard proctor; however, construction methods for the top foot (5×10^{-8} cm/sec permeability) of radon barrier effectively require meeting 100 percent of a standard proctor. It is not possible to quantify the degree of resistance to root intrusion provided by the density of the surface of the radon barrier. However, under normal conditions, it is estimated that the compacted surface of the radon barrier would provide and maintain a relatively high degree of resistance to root penetration; and therefore preclude significant root intrusion into the radon barrier.

A sensitivity analysis (Neptune, 2012) was performed to assess potential impacts on infiltration, should shallow-rooted (root depth 3.5 feet or less beneath the completed embankment surface) plants become established on the cover following closure. The sensitivity analysis concluded that siltation and root penetration of the cover system would result in a net decrease in infiltration. This situation would serve to improve the long-term performance of the embankment compared to the infiltration and transport modeling (Neptune, 2012) provided as a base case.

Projected Performance – Abnormal Conditions: SWCA, (2011) establishes that black greasewood (Sarcobatus vermiculatus) is the plant most likely to have deep tap roots in western Tooele County; accordingly, the following analysis is focused on this species. Black greasewood may have tap roots with a probable maximum effective depth of 11.8 feet (SWCA, 2011). A field evaluation of individual specimens on the Clive site found tap roots extending to 11 and 11.5 feet; with fine roots extending as deep as 13 feet beneath the surface. However, if black greasewood were established on the surface of the embankment, the analysis demonstrates that the tap root would not extend through the bankrun borrow layer.

Projected Performance – Accident Conditions: No appropriate accident conditions exist for this design criterion.

Safety Factor: The safety factor of 2.0 is calculated as the improved embankment performance relative to infiltration under normal and abnormal vegetated conditions as compared to the base case infiltration.

3.3.2.6 Reduce Exposure

Projected Performance – Normal Conditions: Normal conditions for this required function and design criteria were not assessed because the performance is bounded by the abnormal conditions analysis.

Projected Performance – Abnormal Conditions: An abnormal condition involving a 55-galon drum containing a total activity of 11 curies was assumed to be placed on its side at top of waste, just below the Embankment cover. MicroShield® projected a contact dose rate on top of the completed cover of approximately 3.5 mrem, well within the regulatory requirement of 100 mrem.

Projected Performance – Accident Conditions: No appropriate accident conditions exist for this design criterion.

Safety Factor: The safety factor associated with this required function of the cover is the ratio of the design criteria and the modeled dose rate. This yields an abnormal factor of safety greater than 100 / 3.5 = 28.57.

3.3.2.7 Mitigate Differential Settlement

Differential settlement within the cover is directly related to the waste placement strategies employed within the Embankment. Differential settlement within the layers of the cover itself was not considered to be a major design issue, as the layers of the cover system are constructed to narrow engineering specifications.

Projected Performance – Normal Conditions: Normal conditions for this required function and design criteria were not assessed because the performance is bounded by the abnormal conditions analysis.

Projected Performance – Abnormal Conditions: Analysis of settlements associated with compressible debris lifts within the embankment results in a maximum differential settlement of approximately 0.009. Therefore, the design criterion is met under abnormal conditions.

Projected Performance – Accident Conditions: No appropriate accident conditions exist for this design criterion.

Safety Factor: The safety factor for abnormal conditions is 0.02/0.009 = 2.0.

3.3.2.8 Prevent Internal Erosion

Projected Performance – Normal Conditions: Design calculations are provided in Energy*Solutions*, (2012a). This analysis uses the slopes and dimensions of the Embankment and the hydraulic conductivity of the bankrun borrow to calculate a maximum interstitial velocity at the interface. Maximum calculated interstitial flow velocities are 0.20 ft/sec on the top slope and 0.49 ft/sec on the side slopes. These velocities are maximum possible velocities at the interface and are not dependent on the amount of water flow. These velocities are both orders of magnitude below the design criteria velocity (3 ft/sec). Therefore, neither significant erosion of the radon barrier clay nor migration of fines between layers will occur.

Piping calculations have been assessed for the abnormal saturated condition. This condition bounds the normal conditions; therefore, a normal condition analysis is not necessary.

Projected Performance – Abnormal Conditions: Abnormal conditions are not applicable for the internal water velocity calculations because the calculated interstitial velocity at the clay/bankrun borrow interface is a maximum velocity. Any further water will flow in areas above the interface and will not cause erosion of the clay layer.

Projected Performance – Accident Conditions: No appropriate accident conditions exist for this design criterion.

Safety Factor: The safety factor of the internal water velocity over the radon barrier clay is the ratio of the calculated interstitial velocities to the design criteria (minimal erosion) velocity. Accordingly, for the top slope, the safety factor is 3 / 0.20 = 15 and for the side slope the safety factor is 3 / 0.49 = 6.1.

Safety factors for piping are calculated as the ratio of the two conditional calculations above (5 and 25) over the design ratio calculations (0.5 and 1.4).

3.3.2.9 Material Stability/External Erosion

Projected Performance – Normal Conditions: The basis of the design calculations is a 1,000-year life span considering both normal and abnormal conditions. Therefore, normal conditions are bounded by the abnormal condition analyses below.

Projected Performance – Abnormal Conditions: Cover design calculations provide an analysis of the minimum average riprap rock size (D50) that the Embankment should use for a 1,000-year minimum life span (Jones, 2012b; Jones, 2012c). These calculations account for effects of the one-hour PMP including erosion velocities that will be attained over the Embankment from this design event. This analysis concludes that the average gravel mixture rock size in the surface layer (D50) needs to be at least 3 inches. Embankment specifications call for a top slope D50 of 15% mixture, by volume. Similarly, specifications call for a side slope D50 of 50% mixture by volume. These calculations account for effects of the one-hour PMP including erosion velocities that will be attained over the embankment from this design event. Both of these design values exceed the design criteria for surface stability.

Projected Performance – Accident Conditions: No appropriate accident conditions exist for this design criterion.

Safety Factor: The safety factor associated with the volumetric gravel mixture of this design criterion is calculated as the ratio of the design rock D50 to the calculated minimum acceptable rock D50. This yields safety factors of 0.15 / 0.15 = 1.0 for the top slope and 0.50 / 0.47 = 1.06 for the side slopes.

3.3.2.10 Settlement

Projected Performance – Normal Conditions: The normal conditions associated with this design criteria are bounded by the abnormal conditions analysis.

Projected Performance – Abnormal Conditions: An analysis of the embankment cover slope drainage was performed during review of large liner placement specifications in the Containerized Waste Facility (AMEC, 2002, Section 3.4.4.3). This analysis concludes: ―…cover drainage would continue to be maintained [even] if actual settlements of the CWF are one and one-half times that calculated herein."

Cover slope drainage may also be evaluated by comparing the maximum potential settlement with the Embankment cover slope and distance. For the Embankment, the shortest distance from the crest to the shoulder is 540 feet at a slope of 4 percent (drawing 10014-C02). This implies a drop of 21.6 feet in elevation between the crest and shoulder. Total settlement potential is determined in the following paragraphs to be 3.5 feet. Clearly, even if total settlement were focused near the crest of the embankment, cover drainage would continue to be maintained.

Total long-term settlement of compressible debris lifts is evaluated for compressible debris lifts at a ratio of 30 percent debris/70 percent soil, predicted long-term settlement at year 500 is approximately 1.1 feet (Energy*Solutions*, 2012a). Projecting out to year 1200, predicted long-term settlement is approximately 1.5 feet. AGRA, 2000 (b) determines (Section 4.3) that ―*…incompressible debris settlements will always be less than the compressible debris settlements*." Total long-term settlement for the Containerized Waste facility has been evaluated as follows. For two drum lifts (the maximum approved in the CQA/QC Manual), total potential settlement has been calculated at 0.8 feet (AMEC, 2001, Table 1A). For two lifts of large liners (the maximum approved in the CQA/QC Manual), total potential settlement has been calculated at 1.7 feet (AMEC, 2002).

Foundation settlement is evaluated in Section 4.6 and Figure 15 of AGRA, 2000(a). This analysis concludes that a maximum of eight inches (0.7 feet) of secondary settlement would be expected over 500 years. The cumulative effects of secondary settlement (0.7 feet) plus CWF settlement (1.7 feet) plus the compressible debris settlement (1.1 feet) yields a maximum potential settlement of 3.5 feet; far below the design criteria. Note that the full profile of compressible debris settlement is included in this evaluation, since the Class A West Embankment is taller than the embankment design evaluated in AGRA, 2000(a). Considering CWF potential settlement plus compressible debris settlement conservatively accounts for the height increase. Therefore, the total settlement design criteria are met. Note that this approach overstates potential settlement for the LARW embankment since there is no CWF in that embankment.

Projected Performance – Accident Conditions: No appropriate accident conditions exist for this design criterion.

Safety Factor: The safety factor for the Long Term Cover Drainage design criteria may be calculated by the drop in design elevation from the crest to the shoulder of the embankment compared to the maximum calculated potential settlement. For the Embankment, this is 21.6 / 3.5 = 6.1.

For the maximum total settlement, a safety factor may be calculated by assessing the ratio of the design criteria settlement to the actual projected settlements. Therefore, the safety factor for the Embankment is 9.2 / 3.0 = 3.07.

3.3.2.11Maintain Slope Stability

Projected Performance – Normal Conditions: Detailed seismic stability and deformation analyses of the embankments developed site-specific seismic and shear strength parameters (AMEC, 2012a). A minimum static factor of safety of 2.3 was calculated, exceeding the design factor of safety of 1.5.

Projected Performance – Abnormal Conditions: Abnormal condition evaluations have been performed for seismic loading of the embankment due to a maximum credible earthquake, yielding a minimum seismic factor of safety is 1.3 (AMEC, 2012a). This factor of safety exceeds the design criteria (seismic factor of safety < 1.2).

Projected Performance – Accident Conditions: No appropriate accident conditions exist for this design criterion.

Safety Factor: The minimum static factor of safety is 2.3. The minimum seismic factor of safety is 1.3. These values exceed the design criteria of static factor of safety of 1.5 and seismic factor of safety of 1.2.

3.3.4 Drainage Systems

3.3.4.1Facilitate Flow of Precipitation Away From the Embankment

Projected Performance – Normal Conditions: Energy*Solutions* (2012a) presents calculations using methodologies described in NUREG-1623 and NUREG/CR-4620 to arrive at design flow velocities and storage capacity of the drainage ditch system surrounding the Embankment. s on site, including the previously proposed Class B & C embankment. Section 4 of these calculations provides drainage flow estimations for drainage ditches adjacent to the 11e.(2) embankment. The 11e.(2) embankment is the critical design case because it is downstream of all of the other embankment drainage ditches. During the normal storm event, water would rise in the 11e.(2) embankment ditch to a maximum depth of 2.68 feet, leaving 1.32 feet of freeboard in the ditch above the water level. This maximum storage amount would occur approximately one hour into the 24-hour event and would quickly subside to lower water levels. These calculations show that minimal storage will be needed 3 hours into the storm event; at 6 hours into the storm event no storage will be needed. Therefore, the ditch is adequately designed to contain the normal storm event.

Projected Performance – Abnormal Conditions: Energy*Solutions* (2012a) includes drainage flow calculations associated with the abnormal storm event. This evaluation also considers the Embankment ditches to be the critical design case. Under the abnormal storm event, the ditches will fill to a maximum depth of 3.07 feet, leaving approximately 0.93 feet of freeboard. This maximum storage amount would occur approximately one hour into the 24-hour event and would quickly subside to lower water levels within the ditch. These calculations show that minimal storage will be needed three hours into the storm event; at six hours into the storm event no storage will be needed. Therefore, the ditch is adequately designed to contain runoff associated with the abnormal storm event.

Projected Performance – Accident Conditions: A downstream blockage in the drainage ditch would lead to a localized flood situation in that section of the ditch. Once the water level reaches the outside berm height, water would disperse away from the Embankment as overland flow.

Safety Factor: Safety factors have been calculated for critical design case of the downstream ditch system. Consideration of the ditch system provides a maximum predicted drainage runoff.

For the normal condition, the safety factor is calculated as the ratio of projected freeboard to the design criteria for freeboard. The calculated freeboard adjacent to the Embankment during the normal event is 1.32 feet; therefore, the safety factor is 1.32 / 0.5 = 2.64.

For the abnormal event, the design criteria is that the ditch be able to contain the flow; no freeboard is necessary. The safety factor during the abnormal event in the drainage system is calculated as the ratio of design ditch depth to calculated flow depth: 4.00 / 3.07 = 1.30.

3.3.4.2Minimize Infiltration Under Flood Conditions

Projected Performance – Normal Conditions: Performance related to normal conditions for the complementary aspect of minimizing infiltration under flood conditions is not analyzed because performance is bounded by the abnormal conditions analysis.

Projected Performance – Abnormal Conditions: Jones (2012b) provides the length of time and depth of water expected from the PMF for the watershed upstream of the Clive site. This analysis calculates depth of the PMF across the site between 2 to 5 feet above grade. The depth and duration of the 100-year flood are considerably less.

PMF flow through the site is described as sheet flow from east to west and covers the southern half of Section 32 at an average depth of 2 feet. The total width of the flood flow is greater than two miles, extending south of the site. The 100-year flood is much smaller and would only flood the southwest corner of Section 32. USGS topographic maps [1973(a), 1973(b)] show that the lowest area in the basin is a shallow mud flat area beginning approximately four miles west of the site. The lowest point in this mud flat is approximately six miles west of the Clive site. The mud flat area has an elevation of approximately 4,239 feet above sea level. The lowest elevation on the Clive site is the southwest corner of Section 32 with an elevation of approximately 4,268 feet above sea level, 29 feet higher than the mud flat.

Jones (2012b) provides hydrographs of the PMF and the 100-year flood. Both flood events peak between six and seven hours after the beginning of the storm event. Both events are completed, with no additional flow, approximately 15 hours after the beginning of the storm. Therefore, the maximum time that flood waters could be present within the site boundaries is 15 hours.

An analysis of travel time through the Embankment cover reveals that deep infiltration does not migrate to a point of compliance 90 feet from the toe of the waste within 10,000 years, (Neptune, 2012). This travel time is far greater than the 15-hour time that the flood waters could be present on site.

Projected Performance – Accident Conditions: The accident condition considers the potential for downstream blockage that could promote ponding upon or adjacent to the embankment side slopes. Maximum depth of flood during the PMF is approximately two-foot above grade (ground elevation). The ditch is below grade. However, the inspection road is constructed to a height one-foot above grade. Under an accident condition, the entire ditch to the height of the inspection road could be infilled with silt. This would, in effect, elevate the ground surface at the edge of the embankment by one foot compared to local native grade. Accordingly, the PMF would be approximately one foot deep adjacent to the embankment under these conditions. As above, the travel time through the radon barrier layers is far greater than the 15-hour duration of the PMF. Thus, infilling of drainage ditches does not compromise protection of the embankment from PMF conditions.

Safety Factor: The safety factor is the ratio of the infiltration travel time through the cover to the amount of time the floodwaters could be present over the waste. For the abnormal condition, this safety factor is 89.2 years (~781,392 hours)/15-hours = 52,093.

3.3.4.3 Ensure Ditch Integrity

Projected Performance – Normal Conditions: Interstitial velocities for bankrun borrow material of the Embankment at 0.0 ft/sec (Energy*Solutions*, 2012a). Results are considered conservative for analysis of the performance of the ditch system. As detailed in Table 3-1, the drainage ditch is constructed of Type A filter rock. The drainage ditch slope is much less than that of the Embankment top slope. For example, across the north end of the LARW embankment, the drainage ditch centerline drops 2.0 feet in elevation over a distance of approximately 1,115 feet, for a slope of 0.0018. Across the east end of the Embankment, the drainage ditch centerline drops 1.4 feet in elevation over a distance of approximately 1,400 feet, for a slope of 0.001. These calculations represent the steepest slope in the drainage ditch for each embankment. Accordingly, the calculated interstitial velocity for the top slope is much higher than it would be in the drainage ditches. This velocity is the maximum possible velocity at the interface and is not dependent on the amount of water flow. This velocity is an order of magnitude below the design criteria velocity at which erosion may occur (3 ft/sec). Therefore, significant erosion of the ditch clay surface will not occur.

Projected Performance – Abnormal Conditions: Abnormal conditions are not applicable for the internal water velocity calculations because the calculated interstitial velocity at the clay/rock interface is a maximum velocity. Any further water will flow in areas above the interface and will not affect erosion of the clay layer.

Projected Performance – Accident Conditions: No appropriate accident conditions exist for this design criterion.

Safety Factor: The safety factor of the internal water velocity over the radon barrier clay is the ratio of the calculated interstitial velocity to the design criteria (minimal erosion) velocity. Use of the top slope interstitial velocity is conservative, since the material is the same but the slope is less for the drainage ditches. Accordingly, the safety factor is at least 3 / 0.2 = 15.

3.3.5 Buffer Zone

3.3.5.1 Provide Site Monitoring

Projected Performance – Normal Conditions: Under the normal condition of no releases, the monitoring network within the buffer zone will not be necessary and the design of the system will be adequate.

Projected Performance – Abnormal Conditions: Neptune (2012) shows, through performance objectives, that no contaminants will reach the monitoring wells within 500 years. The groundwater monitoring wells are located 90 feet from the edge of waste, within the boundary of the buffer zone (94 feet). If contaminants are detected at the monitoring wells within the 100-year monitoring period, remediation measures could be easily accommodated due to the extremely slow linear velocity of the groundwater (Neptune, 2012), and may include:

1. **Monitored Natural Attenuation**: Energy*Solutions* could demonstrate that, since there are no users of the groundwater (DOE does not perform groundwater monitoring for the Vitro disposal facility for this reason), there is no exposure pathway to the public. Additional wells may be needed to characterize and monitor the plume under this scenario, which would require only enough space for the drilling rig to access the desired well location(s).

2. **Pump and Treat**: Operational experience at the facility shows that groundwater extraction is feasible via the 2" diameter monitoring well. Larger-diameter extraction wells do not require larger surface completions than the 4' x 4' pad typically used at the Clive facility; and can be drilled from the embankment side of the buffer zone..

<u>Projected Performance – Accident Conditions</u>: No appropriate accident conditions exist for this design criterion.

<u>Safety Factor</u>: A safety factor is not applicable to this Principal Design Feature.

3.4 DESIGN OF AUXILIARY SYSTEMS AND FACILITIES

Auxiliary facilities include buildings and roadways that are designed to support the operational needs of the facility by directly contributing to worker safety in accordance with 10 CFR 61.43, support the construction requirements in accordance with 10 CFR 61.41, and not adversely affect completed closure measures.

3.4.1 Utility Systems

Due to remoteness, municipal utilities at Energy*Solutions*' Clive facility are limited. Fuel and potable water (culinary water) must be brought in from off-site locations and stored on-site for usage. Toilet facilities are available at office buildings, outside of the Restricted Area. No toilet facilities are available inside the Restricted Area. Decontamination showers are provided in the Decon Access Control Building, Mixed Waste Operations Building, and the LLRW Operations Building. Safety showers are available as detailed in the Contingency Plan, Attachment II-6 of the State-issued Part B Permit.

For personnel working with radioactive materials in the Restricted Area, communication with other workers is available through two-way radio or cellular phone communication. Radio and cellular range is adequate to reach all areas of the site at any time. During emergencies on site, personnel contact security via radio or cell phone; then security issues a general alert to affected personnel.

The site is served with electricity by Rocky Mountain Power. This service includes three phase 440 volt supply. This service is transformed down to 120 volt single phase service for supply to the administrative building and for general site conventional electric service.

3.4.2 Auxiliary Facilities

All auxiliary facilities on the site will be removed at decommissioning; accordingly, there will be no adverse impact on embankment performance due to failure of any of these facilities.

3.4.2.1 Decontamination Facilities

Energy*Solutions* has developed an extensive set of decontamination facilities in support of waste disposal operations (as outlined in the procedures catalogued in Appendix J, the drawings of Appendix B, and the Decontamination and Decommissioning Plan). These procedures address decontamination activities necessary for equipment and tools used in shipping, receiving, managing, and disposal of LLRW. Decontamination procedures have also been developed to address release of the various shipping containers from the Restricted Area.

The Embankment, being one of several active disposal facilities at the Energy*Solutions* Clive site, will be closed according to the Decontamination and Decommissioning Plan (Energy*Solutions,* 2012). At the time of closure, a detailed decommissioning plan will be prepared from the structure presented in the Decontamination and Decommission Plan for Division approval consistent with the Applicable Regulations and Requirements. It is assumed that additional support facilities will not be required beyond that specified in this Application. It is also assumed that these support facilities will be decontaminated and decommissioned upon closure. The decontamination and decommissioning activities include:

a. Decontaminating off-site soils and rail road spur, if necessary, by removing all surface materials contaminated with LLRW materials such that the contamination in the residual soil or rail road ballast is ALARA and below the respective cleanup limits. Soil will be disposed of at the Embankment using disposal methods approved in the CQA/QC Manual.

b. Decontaminating on-site soils within Energy*Solutions*' property but excluding the disposal embankments, by removing all surface soils contaminated with LLRW such that the contamination in the residual soils is ALARA and below the respective cleanup limits. Soils will be disposed of at the Embankment using disposal methods approved in the CQA/QC Manual.

c. Decontaminating on-site structures such as the rollover facility, geotechnical laboratory, and rail spur to meet the unconditional release criteria or, remove and place structures the Embankment.

d. Decontaminating the on-site support structures and contents including the change and laboratory facilities within the administration building to meet the unrestricted release criteria, or remove and dispose of contents and structures in the Embankment.

Clive waste handling facilities are used for both LLRW and 11e.(2) waste management activities. Since 11e.(2) radionuclides represent a subset of the potential contaminants in LLRW, it is appropriate to place decommissioning waste from these facilities into the Class A West Embankment. In fact, the GWQDP requires that sludge and other wastes from eventual decommissioning of the 2000 Evaporation Pond be disposed as LLRW, rather than 11e.(2) material.

3.4.2.2 Waste Handling Facilities

Energy*Solutions*' waste handling procedures and associated facilities, included in the Standard Operating Procedures catalogued in Appendix J and Embankment drawings of Appendix B, ensure that 11e.(2) or mixed wastes are not co-mingled with LLRW. These procedures discuss the necessary precautions required to ensure that vehicle, facility and equipment cleaning occurs prior to hauling or handling LLRW material at the intermodal unloading facility. They also address signage requirements for vehicles, facilities and equipment handling LLRW. The Standard Operating Procedures catalogued in Appendix J detail how waste streams are reviewed, assigned a Bates Number used for tracking purposes, and finally accepted for disposal.

Containers approved for storage in accordance with Condition I.E.10 of Energy*Solutions*' GWQDP are visually inspected to ensure that the containers have structural integrity. Drums and barrels of material are placed on pallets and stacked a maximum of two (2) high. Storage areas are inspected daily in accordance with the GWQDP, Appendix J. Containers which are found to be deteriorating are re-containerized or over-packed, i.e., placed inside another, larger container of assured structural integrity.

3.4.2.3 Waste Water Facilities

During operation, Energy*Solutions*' disposal facilities are managed to prevent precipitation from flowing into the Embankment. This is accomplished by construction of a run-on berm around the perimeter of the disposal embankment. Therefore, there are no design features to promote deposition during operations since there is no runoff which flows into the impoundment area. Energy*Solutions*' final embankment is designed to maintain sheet flow for all precipitation that falls on it. By maintaining sheet flow, the turbulence and velocity of the water are minimized; thus improving the deposition of sediment and minimizing the erosion of the cover.

The post-closure drainage system surrounding the Embankment has been designed to direct water from precipitation or sheet flow away from the disposal unit. Drainage systems designed for the Embankment are included in Appendix K. Potentially-contaminated standing water at the Clive Site is managed during the operational life of the facility according to Condition I.E.7 of the GWQDP. Embankment areas are managed to remove any intermediate standing water when necessary. Energy*Solutions* uses mobile pumping trucks and other equipment as needed to access and remove water from disposal site areas which are not designed to free-drain into an evaporation pond or equipped with permanent pumps. Other areas of the property are channeled to the southwest. Short-term bodies of standing water on the surface in other areas of the property will not affect the performance of the facility. This water dissipates primarily through evaporation due to the climatic features of the site rather than percolation; and thus will have no impact on groundwater horizontal gradients.

3.4.2.4 Mixed-Waste Treatment Facilities

Energy*Solutions* was initially permitted for treatment, storage, and disposal of Mixed Waste at the Clive Facility on November 30, 1990. This Permit was later renewed by the Utah Division of Solid and Hazardous Waste on April 4, 2003. An Application to again renew this Permit was submitted on October 5, 2012 and is currently under review.

The Clive Facility accepts mixed wastes as defined by the Low-Level Radioactive Waste Policy Act, Public Law 96-573. This law defines mixed wastes as radioactive waste not classified as high level radioactive waste, transuranic waste, spent nuclear fuel, or byproduct material, as defined in Section 11e.(2) of the ―Atomic Energy Act," that is also either listed as a hazardous waste in Subpart D of 40 CFR 261 and/or exhibits any of the hazardous waste characteristics identified in Subpart C of 40 CFR 261; or RCRA hazardous waste which contains naturally occurring radioactive materials.

Mixed Waste management occurs completely within the boundaries of Section 32. Mixed wastes managed at the Clive Facility include contaminated soils, process wastes, debris, ash, and sludges. The waste generally comes from industrial generators which use hazardous materials and are contaminated with low-level radioactivity. Other sources include decontamination waste and lead shielding from nuclear power plants, CERCLA operations, and RCRA corrective actions; particularly at DOD and DOE facilities.

The Mixed Waste Landfill Cell (MWLC) where waste disposal occurs has been designed and constructed using the criteria described in UAC R315-8. The MWLC also incorporates elements from radioactive waste disposal regulations found in UAC R313-25. The MWLC has a quadruple liner system (three synthetic liners and a re-compacted clay liner), a leachate collection system, a leak detection system, and a cover system. All of these systems have been approved by the Director of the Utah Division of Solid and Hazardous Waste.

3.4.3 Fire Protection System

Due to the remoteness of the Clive site, the availability of municipal fire protection is limited. The nearest services of this type are in the Tooele-Grantsville area, approximately 35-50 miles away.

Fires in offices or other building areas are controlled using portable fire extinguishers and/or water as available. If necessary for control, water may be obtained from nearby wells and/or the non-contact runoff containment pond located to the southwest of the site. Water trucks used for dust suppression on site roads would also be available in an emergency to provide water for fire control. There is at least one water truck on site during operations.

Fire in the disposal area could be initiated by construction equipment. Flammable waste forms (such as dry active wastes), as well as the presence of flammable fuels, represent potential fire hazards. In the event of a fire, measures taken to respond to and protect against the emergency situation will be conducted in accordance with the ―Emergency Response Plan," as catalogued in Appendix J. All employees at the site are trained upon initial employment and in annual refresher training to implement this program in the case of an emergency.

3.4.4 Operational Erosion and Flood Control Systems

During operations, the Embankment is protected against offsite flood waters by run-on berms. Construction QA/QC requirements for run-on berms are provided in the CQA/QC Manual (Work Element – General Requirements, Specifications ―Run-on Control During Project").

Run-on berms surround the perimeter of the embankment at all times. They are constructed of native soils to a minimum height of three feet above the original ground surface of the site (as determined by original engineering drawings showing site contours) and have a minimum width of 10 feet at the top (Jones, 2012a). The berms are compacted to 90 percent of a standard proctor to ensure their integrity and often serve as inspection/travel roads. Run-on berms are inspected regularly during operation of the facility for degradation or low spots caused by erosion or frequent traffic. In addition, run-on berms are surveyed and improved annually to verify compliance with height requirements.

The natural characteristics of the site as well as the facility design provide the necessary protection to minimize the potential of erosion and dispersion. The following administrative controls provide additional protection:

- Energy*Solutions*' Control of Fugitive Dust procedure (CL-LD-PR-103);
- Run-off berms constructed and maintained around open waste disposal cells (CQA/QC Manual);
- Energy*Solutions*' Stormwater Management Plan (CL-LD-PR-704).

3.5 DRAWINGS

Drawings cited in this Application have been included as Appendix B to this Application. Table 3-1, ―Pertinent Characteristics of the Principal Design Features" summarizes construction specifications for each principal design feature.

SECTION 4. FACILITY OPERATIONS

UAC R313-25-3(9)	*"Siting Authority. The Executive Secretary recognizes that Titles 10 and 17 of the Utah Code give cities and counties authority for local use planning and zoning. Nothing in R313-25-3 precludes cities and counties from establishing additional requirements as provided by applicable state and federal law."*
UAC R313-25-6(4)	*"The general information shall include the following:* *(4) proposed schedules for construction, receipt of waste, and first emplacement of waste at the proposed land disposal facility."*
UAC R313-25-7	**"***The application shall include certain technical information. The following information is needed to determine whether or not the applicant can meet the performance objectives and the applicable technical requirements of R313-25:* *(5) Descriptions of codes and standards which the applicant has applied to the design, and will apply to construction of the land disposal facilities.* *(6) Descriptions of the construction and operation of the land disposal facility. The description shall include as a minimum the methods of construction of disposal units; waste emplacement; the procedures for and areas of waste segregation; types of intruder barriers; onsite traffic and drainage systems; survey control program; methods and areas of waste storage; and methods to control surface water and ground water access to the wastes. The description shall also include a description of the methods to be employed in the handling and disposal of wastes containing chelating agents or other non-radiological substances which might affect meeting the performance objectives of R313-25* *(11) A description of the radiation safety program for control and monitoring of radioactive effluents to ensure compliance with the performance objective in R313-25-19 and monitoring of occupational radiation exposure to ensure compliance with the requirements of R313-15 and to control contamination of personnel, vehicles, equipment, buildings, and the disposal site. The applicant shall describe procedures, instrumentation, facilities, and equipment appropriate to both routine and emergency operations.* *(12) A description of the environmental monitoring program to provide data and to evaluate potential health and environmental impacts and the plan for taking corrective measures if migration is indicated.* *(13) Descriptions of the administrative procedures that the applicant will apply to control activities at the land disposal facility.* *(14) A description of the facility electronic recordkeeping system as required in R313-25-33."*
UAC R313-25-8(4)(a-c)	*"The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:* (a) *Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses*

shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.
(b) *Analyses of the protection of inadvertent intruders shall demonstrate a reasonable assurance that the waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion will be provided.*
(c) *Analysis of the protection of individuals during operations shall include assessments of expected exposures due to routine operations and likely accidents during handling, storage, and disposal of waste. The analysis shall provide reasonable assurance that exposures will be controlled to meet the requirements of R313-15."*

UAC R313-25-11 **"***A license for the receipt, possession, and disposal of waste containing radioactive material will be issued by the Executive Secretary upon finding that:*
(3) the applicant's proposed disposal site, disposal design, land disposal facility operations, including equipment, facilities, and procedures, disposal site closure, and post-closure institutional control, are adequate to protect the public health and safety as specified in the performance objectives of R313-25-19;
(4) the applicant's proposed disposal site, disposal site design, land disposal facility operations, including equipment, facilities, and procedures, disposal site closure, and post-closure institutional control are adequate to protect the public health and safety in accordance with the performance objectives of R313-25-20;
(5) the applicant's proposed land disposal facility operations, including equipment, facilities, and procedures, are adequate to protect the public health and safety in accordance with R313-15;
(6) the applicant's proposed disposal site, disposal site design, land disposal facility operations, disposal site closure, and post-closure institutional control plans are adequate to protect the public health and safety in that they will provide reasonable assurance of the long-term stability of the disposed waste and the disposal site and will eliminate to the extent practicable the need for continued maintenance of the disposal site following closure;
(8) the applicant's proposal for institutional control provides reasonable assurance that control will be provided for the length of time found necessary to ensure the findings in R313-25-11(3) through (6) and that the institutional control meets the requirements of R313-25-28."

UAC R313-25-12(5 *"Persons licensed by the Executive Secretary pursuant to R313-25 shall confine possession and use of the materials to the locations and purposes authorized in the license."*

UAC R313-25-15 *"The licensee shall observe, monitor, and carry out necessary maintenance and repairs at the disposal site until the site closure is complete and the license is transferred by the Executive Secretary in accordance with R313- 25-16. The licensee shall remain responsible for the disposal site for an additional five years. The Executive Secretary may approve closure plans that provide for shorter or* *longer time periods of post-closure observation and maintenance, if sufficient rationale is developed for the variance."*

UAC R313-25-20 *"Design, operation, and closure of the land disposal facility shall ensure protection of any individuals inadvertently intruding into the disposal site and occupying the site or contacting the waste after active institutional controls over the disposal site are removed."*

UAC R313-25-21 *"Operations at the land disposal facility shall be conducted in compliance with the standards for radiation protection set out in R313-15 of these rules, except for release of radioactivity in effluents from the land disposal facility, which shall be governed by R313-25-19. Every reasonable effort should be made to maintain radiation exposures as low as is reasonably achievable, ALARA."*

UAC R313-25-23(11) *"The disposal site shall not be located where nearby facilities or activities could adversely impact the ability of the site to meet the performance objectives of R313-25 or significantly mask the environmental monitoring program."*

UAC R313-25-24(3) *"Except as provided in R313-25-1(1), only waste classified as Class A, B, or C shall be acceptable for near-surface disposal. Wastes shall be disposed of in accordance with the requirements of R313-25-25(4) through 11."*

UAC R313-25-25(4) *"Wastes shall be emplaced in a manner that maintains the package integrity during emplacement, minimizes the void spaces between packages, and permits the void spaces to be filled. "*

UAC R313-25-25(5) *"Void spaces between waste packages shall be filled with earth or other material to reduce future subsidence within the fill."*

UAC R313-25-25(6) *"Waste shall be placed and covered in a manner that limits the radiation dose rate at the surface of the cover to levels that at a minimum will permit the licensee to comply with all provisions of R313-15-105 at the time the license is transferred pursuant to R313-25-16."*

UAC R313-25-25(8) *"A buffer zone of land shall be maintained between any buried waste and the disposal site boundary and beneath the disposed waste. The buffer zone shall be of adequate dimensions to carry out environmental monitoring activities specified in R313-25-26(4) and take mitigative measures if needed. "*

UAC R313-25-25(10) *"Active waste disposal operations shall not have an adverse effect on completed closure and stabilization measures."*

UAC R313-25-26(2) *"During the land disposal facility site construction and operation, the licensee shall maintain an environmental monitoring program. Measurements and observations shall be made and recorded to provide data to evaluate the potential health and environmental impacts during both the construction and the operation of the facility and to enable the evaluation of long-term effects and need for*

	mitigative measures. The monitoring system shall be capable of providing early warning of releases of waste from the disposal site before they leave the site boundary."
UAC R313-25-26(4)	*"The licensee shall have plans for taking corrective measures if the environmental monitoring program detects migration of waste which would indicate that the performance objectives may not be met."*
UAC R313-25-28	*"(1) Land Ownership. Disposal of waste received from other persons may be permitted only on land owned in fee by the Federal or a State government. (2) Institutional Control. The land owner or custodial agency shall conduct an institutional control program to physically control access to the disposal site following transfer of control of the disposal site from the disposal site operator. The institutional control program shall also include, but not be limited to, conducting an environmental monitoring program at the disposal site, periodic surveillance, minor custodial care, and other equivalents as determined by the Executive Secretary, and administration of funds to cover the costs for these activities. The period of institutional controls will be determined by the Executive Secretary, but institutional controls may not be relied upon for more than 100 years following transfer of control of the disposal site to the owner."*

Energy*Solutions'* waste receipt and inspection procedures and waste acceptance criteria are documented in the completely rewritten Waste Characterization Plan (Appendix L). Because this Plan has been completely revised, supplement L-1 (directly following the Waste Characterization Plan in Appendix L) has been prepared as an aid to the reviewer to identify changes from previously authorized Plans and that in Appendix L. Using this Plan, Energy*Solutions* ensures that arriving shipments are in compliance with applicable requirements and waste acceptance criteria. These procedures provide assurance that the waste receipt and inspection processes are conducted in accordance with UAC R313-25-34 and in a manner that assists in meeting the performance objectives of UAC R313-25-19 through UAC R313-25-22. Additionally, Energy*Solutions'* procedures verify that the classification and characteristics of waste entering the site are in accordance with UAC R313-15-1009. Of primary focus in these procedures is Energy*Solutions'* ability and objective to protect individuals during operations (in accordance with UAC R313-25-21). In addition to ensuring conformance with applicable Division regulations, Energy*Solutions* procedures demonstrate ability and commitment to identify and respond to waste packages requiring remediation. As such, waste not in compliance with Division regulations and License conditions are prohibited from entering the site disposal area.

4.1 RECEIPT AND INSPECTION OF WASTE

Prior to shipment, Energy*Solutions* obtains from the generator a description of the material in each waste stream to be managed at the Clive facility. The description made by the generator includes a statement declaring that the generator has determined that the material is within the parameters of the license, that it is LLRW, and that the material is not a hazardous waste as defined by 40 CFR 261. The generator's description also includes all of the nuclides, and their general range of activities, that are present in the waste, with supporting laboratory documentation. These descriptions and information includes documents and certifications provided by the generator or the generator's agents.

Each shipment must be properly characterized in order to manifest the shipment as required by 10 CFR 20, Appendix G.

During the acceptance procedures for a waste shipment, Energy*Solutions* obtains samples of the waste in accordance with approved sampling procedures. These samples are analyzed to confirm that the waste is within the parameters of the license. Energy*Solutions* generally receives laboratory results within 90 days of the applicable shipment‘s arrival (unless additional time is approved by the Director). If results from the laboratory show that the waste is beyond the limits of the License, and if the waste has been placed and disposed of in the Embankment, Energy*Solutions* must notify the Director and respond in accordance with the Waste Characterization Plan (see Appendix L), following the procedure below.

1. Within 24 hours of discovering nonconforming material had been disposed; Energy*Solutions* must notify the Director of the situation.

2. Within seven (7) calendar days of the notice, Energy*Solutions* must provide the Director with a written description of the situation. The following information must be included in the written description:
   a. Name of generator;
   b. Name of nonconforming waste stream;
   c. Amount of nonconforming disposed waste;
   d. Location of nonconforming waste in the disposal cell;
   e. Date nonconforming waste was accepted;
   f. Date nonconforming waste was placed in disposal cell; and,
   g. Description of waste placed on and around non-conforming waste.

3. Provide a written plan and compliance schedule to the Director for managing the non-conforming material.

4. Obtain approval from the Director for the plan to manage the non-compliant waste. This approval may require Energy*Solutions* to modify the initial plan.

5. Carry out the approved management plan.

The minimum frequencies for laboratory sampling are provided in the Waste Characterization Plan.

Representative samples of the waste material must be taken. Approved analytical laboratories must:

1. Hold a National Environmental Laboratory Accreditation Conference (NELAC) accreditation; or

2. Hold a current certification from the generator's state; or

3. Meet the requirements of the generator‘s state for chemical or radiological laboratories; or

4. Hold a current certification for the applicable chemical or radiological analytes from the Utah Bureau of Laboratory Improvement, insofar as such official certifications are given; or

5. Be a laboratory approved by the Division.

For each bulk waste stream, the minimum number of samples to be analyzed is:

1. One sample for each of the first ten (10) shipments (rail or highway); or,

2. One sample for each of the first 100 cubic yards (yd^3) up to 1,000 yd^3; thereafter,

3. One sample for each additional 500 yd^3 following the first ten (10) shipments or following the first 1,000 yd^3.

For ease in counting, one rail car (any type) may represent a nominal 100 cubic yards and one highway shipment (any type) may represent a nominal 20 cubic yards. The laboratory performs gamma spectrometry on all samples to identify and quantify the gamma emitting radionuclides present. Sample collection and analysis are performed in accordance with the Standard Operating Procedures catalogued in Appendix J. For containerized wastes to be disposed at the CWF, the certification procedures in Appendix L apply.

When an LLRW shipment arrives at the Clive site, it is not considered to be accepted to the Energy*Solutions* facility until the acceptance procedures have been completed and the material has been accepted for disposal. A transportation vehicle may be physically located on the Clive site property and may still not be considered ―accepted" for disposal at Energy*Solutions*. Energy*Solutions* does not direct that containers of non-accepted materials be unloaded or that railcars of non-accepted material be dumped or unloaded. Incoming waste shipments are accepted for disposal in accordance with the Standard Operating Procedures catalogued in Appendix J.

A completed Uniform Low-Level Radioactive Waste Manifest (Manifest), or equivalent documentation must be received by Energy*Solutions* before a shipment is accepted for disposal. The manifest may either accompany the shipment or may be received by Energy *Solutions* prior to the time that the shipment arrives. The manifest serves several functions. These functions include the following:

a. Complies with the requirements of a manifest as outlined in 10 CFR 20, Appendix G.

b. Describes container types, volumes, number.

c. Provides weights, activities, isotopes of material.

d. Documents generator's certification of packaging, classification, markings, labels, condition of containers, and compliance with the applicable regulations and conditions of the License.

e. Documents generator‘s certification as to RCRA or non-RCRA status of material.

f. Documents generator‘s certification that the waste is LLRW.

g. Documents generator‘s warranty that the information provided in the manifest is true and correct.

h. Provides a checklist for Energy*Solutions* for inspection of the incoming material and for possible violations.

i. Documents Energy*Solutions*' acceptance or rejection of the shipment for disposal.

j. Alert receiving staff to probable concentrations and gamma exposure rates to be expected.

The manifest is reviewed for completeness. The reviewer also ensures that the form is signed.

The freight container is externally surveyed for gamma radiation readings with a micro-R meter or equivalent, to assure compliance with DOT regulations. Other portable instruments appropriate to measure the radionuclides expected in the shipment are used as necessary to measure for external surface contamination. Container surveys are performed in accordance with the Standard Operating Procedures catalogued in Appendix J. Each incoming freight container is smear tested for removable contamination for comparison to the standards of 49 CFR 173.443, in accordance with the Standard Operating Procedures catalogued in Appendix J.

In accordance with 10 CFR 20.1906(d), Energy*Solutions* immediately notifies the final delivery carrier and the Director when:

1. Removable radioactive surface contamination exceeds the limits of 10 CFR 71.87(i); or

2. External radiation levels exceed the limits of 10 CFR 71.47.

Upon arrival at the site, each incoming shipment is visually inspected for the following items in compliance with the shipment inspection requirements of UAC R313-25-33(5) and the Standard Operating Procedures catalogued in Appendix J:

1. To ensure accuracy of information submitted on the radioactive waste manifest (the container/car ID numbers, number of cars or containers) and to ensure that the material is packaged, marked, labeled, and placarded according to DOT regulations in 49 CFR. Should Energy*Solutions* discover any discrepancies in the documentation, certification, or shipment, the discrepancies must be resolved with the generator or shipper prior to acceptance of the material. Energy*Solutions* does not unload/dispose of a shipment until such discrepancies have been settled, either through a generator visit to the disposal site or through written documentation that reflects the necessary changes in the manifest.

2. To verify whether there is any evidence of physical damage to the container that might jeopardize its integrity. This will be accomplished by visually examining the containers for any appearance of packaging breach or any such potential problem.

If there are any problems with the integrity of an incoming shipment, the problems are reported to the shipper within 24 hours of discovery. Energy*Solutions* also provides notification to the Director within 24 hours of discovery. If a shipment arrives on site that is unacceptable under the conditions of the license, Energy*Solutions* notifies the generator and the Director within seven days. When a shipment arrives, Energy*Solutions* takes samples for laboratory analysis.

As a result of these steps, Energy*Solutions* either accepts or rejects a shipment for disposal. If a shipment meets all acceptance criteria except for possible noncompliance with license conditions, it is placed into an approved storage area until additional testing can determine its status. In accordance with the Standard Operating Procedures catalogued in Appendix J, waste is not accepted from a Generator when one or more of the following conditions apply:

- The shipping and disposal documents do not agree with the waste profile record;
- The waste is exceeds License limits;
- The shipment contains PCBs and has liquid not approved by the Radiation Safety Officer;
- Generator sends a shipment to the Clive facility prior to receiving a notice to transport from Energy*Solutions*.

If the shipment is rejected for disposal, Energy*Solutions* documents the rejection in accordance with the Standard Operating Procedures catalogued in Appendix J, and notifies the Director. If the shipment is accepted, the material is placed in an approved management area or in the Embankment.

Shipments that are not found acceptable or approvable are sent back to the Generator or to another licensed radioactive waste management facility in accordance with the Standard Operating Procedures catalogued in Appendix J. A shipment which has been found to be in violation of DOT shipping regulations, but which is otherwise acceptable, is not accepted for disposal until:

1. The Director has been notified of the shipment discrepancy; and
2. The generator or generator's agent has made necessary corrections to bring the shipment into compliance with DOT regulations, if possible.

Pending such corrective action, the shipment remains on Energy*Solutions* property in order to eliminate the potential risk associated with transporting the waste, but is not disposed. If such a shipment is in violation of DOT regulations due to leakage of radioactive materials, it is placed over an approved surface in the Restricted Area until the situation is resolved in order to prevent contamination of the environment.

4.2 WASTE HANDLING AND INTERIM STORAGE

Waste handling and interim storage is managed in accordance with existing controls and at existing facilities, according to the waste type being managed.

Upon acceptance, each shipment is transferred to an appropriate unloading area. To prevent inadvertent cross-contamination of waste types, all waste containers received are labeled as to waste type, generator, receipt date, and disposal cell. Bulk wastes are taken to the Embankment for disposal or to the Intermodal Unloading Facility. Containers of LLRW wastes are taken to the embankment, placed in storage or emptied into the Intermodal Unloading Facility. Gondola railcars are unloaded at the Rotary Dump Facility or the

Rollover Facility. Waste is then placed into haul trucks and taken to the Embankment for disposal. CWF shipments are directly unloaded and placed at the CWF.

LLRW waste is unloaded and managed in accordance with procedures catalogued in Appendix J. All LLRW waste management facilities are visually inspected on a daily basis in accordance with the BAT Performance Monitoring Plan, Appendix J of the GWQDP, to ensure proper storage and management of the waste. Storm water is managed in accordance with Condition I.E.12 of the GWQDP.

All wastes received at the Clive facility are entered into and tracked with an electronic waste tracking system (the System). The System tracks waste type, volume, activity, and placement location within the disposal embankments. The System also contains waste profile information and provides automated compliance checks of the waste shipment against license limits, sampling frequency, etc.

Upon License termination, Energy*Solutions* will provide System records of the location and quantity of the radioactive waste disposed at the facility to each of the following:

a) Mayor of Grantsville;

b) Tooele County Commissioners;

c) Tooele County Planning Commissioners;

d) Governor of the State of Utah; and,

e) Utah Division of Radiation Control.

4.3 WASTE DISPOSAL OPERATIONS

LLRW is disposed at Energy*Solutions*' Embankment in accordance with the provisions of the Operating Procedures, catalogued in Appendix J, and the CQA/QA Manual. Waste placement is controlled in accordance with the CQA/QC Manual.

4.3.1 Waste Emplacement

Waste placement is controlled according to the type of waste as defined by the CQA/QC Manual. Debris is defined as any radioactive waste for disposal other than compactable soils. Compactable soil is defined as:

a. Having a graded material that passes through a four-inch grizzly; or

b. As having a density greater than seventy pounds per cubic foot dry weight in accordance with ASTM D-698 (ASTM, 2003); and

c. Having soil-like properties (i.e., standard tests in accordance with waste placement procedures can be performed).

Drums and metal containers that are to be disposed of in the Embankment are emptied before being crushed and placed in the lift to minimize the void space. After the drums and metal containers have been emptied and mixed with soil, the entire lift is compacted to the required density.

Large pieces of concrete and other debris may be broken into manageable pieces, or disposed in Controlled Low-Strength Material (CLSM) in accordance with the CQA/QC Manual.

The disposal material is placed in the Embankment in lifts and is compacted before the next lift is placed. Effective spreading equipment is used on each lift to obtain uniform distribution of the waste. Leveling and manipulating of the waste is required to assure uniform density is achieved.

Whenever the Embankment site is covered with snow of sufficient depth to impair the quality of placement of the waste material, snow must be removed beyond the limits of active construction. Where any material is frozen, it is removed before any compacted layers are placed. During winter months it may be necessary to stockpile contaminated material.

Computer-aided earthmoving systems (CAES) are used to approve the majority of bulk soil and debris lifts, in accordance with the CQA/QC Manual, Work Element – Waste Placement with CAES. CAES uses GPS technology to ensure compaction of each square meter of the lift surface.

For waste lifts placed without CAES, each lift is compacted to not less than 90 percent maximum density as determined by the Standard Proctor Method, or as otherwise approved in the CQA/QC Manual. No fill is placed upon the Embankment until that area of the Embankment has been approved by a Quality Control technician. All lift approvals are documented.

Workers are protected during waste emplacement procedures in accordance with the policies of Energy*Solutions'* Radiation Safety Plan and ALARA Plan.

4.3.2 Filling of Void Spaces

Minimizing void spaces is critical to long-term stability of the Embankment. The CQA/QC Manual provides controls for filling void spaces, including:

a. Debris placed with bulk soil is distributed throughout the lift. This prevents void containing material or materials that may degrade and leave void spaces from concentrating in one area of the Embankment. This also minimizes the voids that may occur between two pieces of debris by distributing the debris throughout the lift.

b. All debris placed with bulk soil is than ten inches (10") in at least one (1) dimension; and no more than 12 feet in all dimensions. This minimizes the possibility that a significant void space extends vertically through multiple lifts.

c. Drums and metal containers that are to be disposed of in the embankment are emptied before being crushed. This eliminates potential void spaces between containers when the waste is disposed of in the container.

d. CLSM used as fill around debris maintains minimum flowability requirements; and QC inspections are performed to verify it's infilling of voids.

4.3.3 Waste Covering

Waste covering operations will be controlled in accordance with the CQA/QC Manual. The designed cover has been modeled and found to be sufficiently impermeable to water, structurally sound, and erosion resistant.

The liner is protected from damage during operations by a minimum 1 ft thick layer of clean native material (referred to as liner protective cover). Similarly, the last one foot of the embankment below the radon barrier is constructed with clean native material to protect the radon barrier from waste debris and to facilitate cover construction (referred to as temporary cover). The construction of both the liner protective cover and temporary cover is specified in the CQA/QC Manual. Debris placement is subject to additional controls on size and percentage (by volume) of each lift in accordance with the CQA/QC Manual.

4.3.4 Disposal Unit Stabilization

The design of the facility enables isolation of the Embankment after it has been filled and covered. Once the Embankment is closed it will not be disturbed by continuing operations at the site. The final Embankment cover integrates long-term water and erosion control methods into the overall design, thus eliminating the need for active maintenance of a closed embankment.

4.3.5 Embankment Marking

Once closed, the Embankment is designed to have the same recognizable features as a closed uranium mill tailings embankment. In addition, permanent granite markers are placed on the closed Embankment. These markers are similar to those already existing on the Vitro Embankment located at the Clive site. Upon Embankment closure, the following information will be recorded upon disposal unit monuments:

- The total activity of radioactive materials in curies;
- The total amount of source material in kilograms;
- The total amount of special nuclear material in grams;
- The disposal unit excavation number;
- The date the excavation was opened and closed by completing the covering; and,
- The volume of waste in the disposal unit excavation.

4.3.6 Buffer Zone

Upon completion of the Embankment, it will be permanently fenced and posted, leaving a minimum 94 feet of buffer zone between the toe of waste and the fence. This allows room inside of the fence for an inspection roadway and groundwater monitoring wells. In preparation of drawings for a previous License action, it was discovered that the design waste limits do not allow for a 94 ft buffer zone along the east side of the Embankment. However, due to prior Embankment construction specifications (LLRW & 11e.(2) CQA/QC Manual, Revision 23 and earlier) imposed at the time of construction, the actual toe of waste was held back a minimum of 5 ft from the design waste limits to accommodate 1 ft of temporary cover. Although the design drawings and specifications for temporary cover were revised in 2009 (LLRW & 11e.(2) CQA/QC Manual, Revision 24e) to allow waste to be placed to the design limits, Energy*Solutions* has not placed (nor will place) LLRW within the 5 ft offset from the design limits along the east boundary of the Embankment footprint, since this area is already built out —soil material within that offset is clean native material previously placed as temporary cover. Therefore, there is a minimum of 97.7 ft from the toe of actual LLRW to the property boundary, thus allowing for a minimum 94 ft buffer zone. The design drawings for the Embankment refer to Drawing 10014-C01 (of Appendix B) and identify a LLRW restricted area to prevent future placement of LLRW within the buffer zone. With this additional construction restriction and establishing the buffer zone limits along the Vitro property boundary, a minimum buffer zone of 97.7 ft is established along the east side of the Embankment.

This discrepancy in the buffer zone does not compromise the facility‘s ability to comply with the well network early warning requirement at Part I.F.1(f) of the GWQDP. Part I.F.1(f) requires that the monitoring well network be adequately spaced to provide early warning of a contaminant release from the Embankment before the contaminant leaves the buffer zone.

In addition, a 300-foot buffer zone exists between the closest edge of the Embankment and the outer property boundary. Finally, the buffer zone beneath the emplaced waste consists of the two feet-thick clay liner, followed by a minimum depth of 10 feet to the unconfined aquifer water level.

4.4 HEALTH AND SAFETY PLAN

Energy*Solutions'* Health and Safety Plan, including radiation protection policies, are catalogued in Appendix J. The Health and Safety Plan includes the Emergency and Contingency Plan (also catalogued in Appendix J). Table 4-1 summarizes Energy*Solutions'* occupational doses through the year 2011. As illustrated in Table 4-1, employee doses are kept well below federal standards for radiation workers. This is due in large part to Energy*Solutions'* Radiation Safety Program, consisting of the Radiation Safety procedures catalogued in Appendix J of this Application, and the ALARA goals it sets for its employees.

4.5 ENVIRONMENTAL MONITORING AND SURVEILLANCES

The Environmental Monitoring Plan used during the operational monitoring phase is contained in Appendix M. Proposed revisions to the current approved revision are presented in redline/strikeout. Energy*Solutions* uses the Environmental Monitoring Plan to carry out the following functions:

1. Provide an early warning of a release before it reaches the site boundary;

2. Evaluate the need for mitigative measures;

3. Evaluate health and environmental effects;

Table 4-1

Energy*Solutions* Employee Annual Dose Summary

Dose (mrem)	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
<10	20	92	93	84	209	325	412	363	431	538
10 – 50	40	5	15	62	16	61	104	138	154	85
51 – 100	11	1	1	4		1	4	19	37	21
101 – 150	2				2			5	6	8
151 – 200	1						1	2	5	5
201 – 250	1							1	6	
251 – 500				1				1	5	1
500 +									1	

Dose (mrem)	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
<10	483	520	441	649	495	287	232	239	263	215
10 – 50	105	74	142	103	70	59	45	39	42	54
51 – 100	27	13	30	26	15	5	8	12	8	14
101 – 150	5	3	9	14	6	6	5	3	6	7
151 – 200	4	2	6	3	2	2	3	2	2	4
201 – 250	3	7	7	9	2	3	2		1	4
251 – 500	1				6	5	5	6	3	6
500 +					0					

4. Estimate dose as required by UAC R313-15-301(1)(a), UAC R313-15-101(4), and UAC R313-25-19; and

5. Assist in emergency response planning if accidental releases are to occur.

4.5.1 Pre-Operational Monitoring

Results of the 1981/1982 Environmental Monitoring Studies at the Clive site are reported in detail in the Final Environmental Impact Statement (FEIS) (DOE/EIS-0099-F) and the draft Disposal Site Characterization Report (UMTRA-DOE/AL-050102.0001). During this period, radioactive airborne particulate samples were collected with Eberline Model RAS-1 low volume air samplers at three locations on the Clive site and at Knolls and Delle on the transportation corridor along Interstate 80. Analysis of these samples showed that uranium and radium-226 airborne levels were below typical U.S. background levels at all five locations. Lead-210 levels could be considered to be typical of U.S. background for radon progeny in air. Thorium-230 levels in air, however, appeared to be approximately 2-10 times the expected U.S. background at all five locations, and were out of equilibrium with uranium and radium by approximately a factor of 30. Since uranium, radium, and thorium in soil results at all five stations indicate near equilibrium conditions at typical U.S. background levels, the air results are unusual since the air results normally reflect the soil levels. No explanation for the disequilibrium is given in the reports.

Radon concentrations in outdoor air were measured in late 1981 and during most of 1982 using Track-Etch detectors and Eberline Model RGM-2 Radon Gas Monitors. Measurements were made at three locations on the Clive site and at Knolls and Delle. Measurements made with both instruments showed radon levels typical of U.S. background, with values ranging from about 0.2 to 1.2 pCi/L. Track-Etch and RGM-2 values agreed within a factor of two to three.

Direct gamma exposure rates were measured at the Clive site in 1982 using scintillation survey meters (484 locations) and pressurized ion chambers (20 locations). Additional measurements were made in 1981 and 1982 using TLDs at five locations on the Clive site and five additional locations along the transportation corridor (Timpie, Lake Point Junction, Buena Vista, two miles north of the Vitro tailings, and in the railroad switch yard near the Vitro tailings). Gamma exposure rates measured at different locations at the Clive site ranged from 11.6 to 16.2 μR/h. At the Clive site, pressurized ionization chamber measurements gave an average exposure rate of 12.8 μR/h, comparing favorable with the TLD average of 13.3 μR/h. Both sets of data are within the expected range for Utah background.

Both surface soil samples and subsurface profile samples were collected at the Clive site. Samples were analyzed for radium-226, uranium-238, thorium-230, and lead-210. Not all samples were analyzed for all of these radionuclides but all of the samples were analyzed for radium-226. Samples were also collected at Knolls and Delle. All samples reported contained radionuclide levels at typical U.S. background: Ra-226, 0.9 - 1.2 pCi/g; U-238, 0.7 - 1.0 pCi/g; Th-230, 1.2 - 1.6 pCi/g. The Division issued a report (summarized in Table 4-2) establishing the radionuclide concentrations of native soil at the Clive site. The summary was based on data from Department of Energy, Energy*Solutions*, and the Division.

Table 4-2

Preoperational Radioactivity Concentrations in Soil

RADIONUCLIDE	**CONCENTRATION RANGE (pCi/g)**
Curium-244	0.0 +/- 0.1 - 0.1 +/- 0.1
Plutonium-238	0.0 +/- 0.1 - 0.0 +/- 0.1
Plutonium-239/240	0.0 +/- 0.1 - 0.1 +/- 0.2
Plutonium-241	0.0 +/- 0.1 - 0.0 +/- 1.6
Plutonium-242	0.0 +/- 0.1 - 0.3 +/- 0.4
Uranium-238	0.7 +/- 0.1 - 1.1 +/- 0.1
Thorium-232	0.9 +/- 0.1 - 1.1 +/- 0.2
Thorium-230	1.1 +/- 0.2 - 1.6 +/- 0.2
Radium-226	0.9 +/-0.1 - 1.2 +/- 0.1
Lead-210	1.1 +/- 0.1 - 1.8 +/- 0.2
Polonium-210	1.5 +/- 0.6 - 2.6 +/- 0.6
Cesium-137	0.4 +/- 0.1 - 1.1 +/- 0.2
Iodine-129	0.4 +/- 3.6 - 0.0 +/- 6.6
Technetium-99	0.0 +/- 0.7 - 0.7 +/- 1.0
Strontium-90	0.3 +/- 0.3 - 0.3 +/- 0.4
Nickel-63	0.0 +/- 3.1 - 5.0 +/- 1.4
Iron-55	0.0 +/- 2.1 - 0.0 +/- 2.9
Potassium-40	12.3 +/- 0.4 - 13.4 +/- 0.5
Carbon-14	0.0 +/- 6.6 - 3.1 +/- 8.9

Source: (DOE, 1984)

Vegetation samples were collected at the Clive site: to the north of the site, to the southeast, and to the south, during the spring, summer, and fall. Samples were analyzed for natural uranium, radium-226, thorium-230, polonium-210, and lead-210. Based on the DOE reported radionuclide levels in soil and the expected uptake coefficients for vegetation from soil, vegetation values for uranium, thorium-230, and radium-226 appear to be within the range of expected background values: natural uranium, 5.4 pCi/kg (wet); Ra-226, 3.1 pCi/kg (wet); Th-230, 6.0 pCi/kg (wet); Pb-210, 198 pCi/kg (wet); and Po-210, 48 pCi/kg (wet). DOE assumed that elevated lead and polonium results in vegetation samples were due to the deposition of airborne radon progeny on plant surfaces.

An intensive program of ground water monitoring was undertaken prior to issuance of Energy*Solutions'* initial Ground Water Quality Discharge Permit. On the basis of the results of this program, the Division of Water Quality established well-specific ground water protection levels (GWPL) for all parameters of interest. GWPL's are summarized in the GWQDP.

4.5.2 Operational Monitoring Program

Energy*Solutions* performs environmental monitoring in accordance with the Environmental Monitoring Plan (Appendix M) in and around its Embankment. These measurements provide data that is used to assess the potential net radiological impact of the licensed activities on the surrounding area, and form the basis for demonstrating compliance with the applicable regulations and license conditions. Data are compiled into a report and submitted to the Division on a regular basis. The Environmental Monitoring Plan is designed to detect and quantify the net radiological effects in Unrestricted Areas that occur as a result of the licensed activities. The data is also used to proactively adjust work practices and site operations as necessary to sustain continued compliance.

Because of the site's physical configuration, its remote location, and the nature of the licensed operations, a postulated individual member of the public near the site boundary must directly inhale airborne radionuclides to receive a measurable dose via any internal dose pathway. The results from the environmental soil samples therefore serve mainly as supplemental indicators of the degree to which otherwise undetected effluents may be accumulating on surfaces outside the restricted areas, while the airborne radioactivity and gamma monitoring provide the data used as the basis for dose estimates.

The Environmental Monitoring Plan (included in Appendix M) has been revised to include the following:

1. A definition of Soil Action Levels has been added. This definition has already been used by Energy*Solutions* for a number of years. Additionally, the practice of not including K-40 in the Soil Action Level requirements has been common since the construction of the Vitro Embankment. K-40 is typically found in soil around 17 pCi/g. Additionally, because industrial or scientific processes that generate such a K-40 enhance are highly uncommon, K-40 is a poor indicator of radioactivity release.

2. Energy*Solutions* proposes revision of its radon-222 (radon) exposure reporting to be more consistent with the practices in NRC interim draft guidance document for evaluating radon releases in compliance with 10 CFR 20.1301. Radon exposure is measured to demonstrate compliance with the dose to ―member of the public" limits listed in UAC R313-015-301 and R313-25-19. NRC's Draft Guidance uses the radon ―Effluent Concentrations" in 10 CFR 20, Appendix B, Table 2, 1E-8

μCi/ml (10 pCi/L) (daughters removed) and 1E-10 μCi/ml (0.1 pCi/L) (with daughters present) to calculate the potential dose from radon exposure. The dose contribution from radon daughters is readily identifiable from the difference in the ―daughters removed" and the ―with daughters present" effluent concentrations. Because of large variation in radon concentrations, radon exposure is typically determined using average radon concentrations over long periods. The passive monitors used to make these measurements do not have the ability to measure radon progeny. The radon progeny exposure contribution is defined using presented using Equilibrium Effective Concentration (EEC). An EEC considers the collective dose contribution from of the radon daughters as a fraction of the radon activity (Equation 1).

$$D = DCF \sum_i C_i F_i T_i \qquad (1)$$

Where:

D = dose (mrem/yr)
DCF = dose conversion factor (50 mrem CEDE /0.1 pCi/L radon*year)
C_i = Rn-222 concentration
F_i = progeny equilibrium factor (EEC) ($0.1 < Fi \leq 1$)
T_i = occupancy factor
i = for location or conditions

The NRC draft guidance presents three options to attribute the dose contribution from radon daughters. The simplest option is to use an EEC equal to one, which assumes that each the radon progeny (Po-218 (RaA), Pb-214(RaB), and Bi-214 (RaC)) concentrations are equal to the radon concentration. The second option is to use the upper value for the EEC ranges presented in the NCRP Report 160 (NCRP 2009). The NRC generally accepts; 0.5 EEC for indoor radon, where the time spent outdoor does not exceed the 90th percentile of the indoor/outdoor distribution presented in NUREG/CR-5512, and 0.7 EEC for outdoor radon. The third option is to present Site specific EEC concentrations.

Site specific EEC values can be determined for both outdoor and indoor exposures. For outdoors exposures, one site specific approach acceptable to NRC staff would be to determine radon progeny in-growth time or the time that it takes radon to be dispersed to the unrestricted area boundary or the nearest resident (or other receptor) location. Fractional in-growth of progeny can be calculated for this travel time based on standard equations for in-growth of progeny. Two references that provide information on radon-222 progeny in-growth are the EPA CAP-88 PC Users Guide (EPA, 2007) and a classic journal article (Evans, 1969). For indoors exposures, one site specific approach would be to measure radon concentrations and radon progeny concentrations indoors at actual receptor locations, and calculate the equilibrium fraction. Energy*Solutions* proposes using a site specific 0.4 EEC to calculate radon exposure to members of the public at the Clive, Utah Facility.

Clive will report radon exposure using: the dose conversion factor of 0.1 pCi/l = 50 mrem/yr @ 1 EEC as listed in 10 CFR 20, Appendix B, Table 2; a 0.7 EEC; and 0.25 occupancy for compliance with UAC R313-15-301 or 0.02 occupancy for compliance with UAC R313-25-19. To accommodate this change the radon detector minimum detectable concentration shall be less than

0.1 pCi/L. Radon will be monitored at locations; A-5, A-11, A-16, A-18, A-27, A-33, A-35, and B-2. Stations A-16, A-27, and B-2 will be used to determine radon background concentrations.

Energy*Solutions* submits that the proposed locations are adequate to demonstrate compliance as the significant radon effluent contributors are limited to large areas of dispersed waste placed in the embankments. Currently the radon measured at each Air Monitoring station is used to calculate the corresponding Total Effective Dose Equivalent (TEDE). Radon results will still be included in TEDE calculation for those stations where radon is monitored. The reported TEDE at stations where radon is not monitored will not include radon results but quarterly and annual radon concentrations measured at other locations will be considered when comparing the monitoring results at these stations with regulatory limits.

The use of the 10 CFR 20 radon dose conversion factor will make it more difficult to demonstrate compliance. There may be occasion when it will be necessary to provide a more detailed assessment of the measured radon exposure. Energy*Solutions* proposes to use the third option presented in the NRC Draft Guidance on a case-by-case basis. The process would determine the distance from the expected source to the air monitoring station. The radon EEC would be calculated using the wind speeds and durations from the quarterly meteorological data during the period of likely exposure. The calculated EEC value with be multiplied by 0.7 to adjust for NRC accepted outdoor EEC equilibrium maximums. The use of the calculated EEC value will consider the potential for indoor exposure, the location difference between the ―member of the public" receiving the highest dose and the air monitoring location, and occupancy.

3. The National Council on Radiation Protection and Measurements characterized radon-220 monitoring as:

> ―*The half-lives of 219Rn (actinon, t1/2 = 3.896 s) and 220Rn (thoron, t1/2 = 55.6 s) are short , and they have low abundance relative to 222Rn (radon, t1/2 = 3.82 d). Because of these properties and dosimetric considerations (the alpha dose delivered to the tracheobronchial tree from thoron is 1/3 that from radon per unit exposure) it is the measurement of radon that is generally of primary interest. Special situations, either occupational or environmental could pose unusual circumstances where measurement of actinon and thoron would be primary concern but so far these situations have been rare.*" (NCRP, 1988)

Energy*Solutions* submits that the dose contribution from thoron does not warrant environmental monitoring. Although EnergySolutions disposes of waste having unique nuclide characteristics and properties thoron‗s dose contribution can be qualified using radon. The primary source of radon and thoron exposure to the public from Clive disposal operations is the radon and thoron gas produced by the radioactive decay of Ra-226 and Th-232, respectively, in the embankment. Based on the manifest the Ra-226 and Th-232 inventory in the embankments are comparable. Radon and thoron present a unique dose concern because they form gases that diffuse out of the embankment. Radon has a 3.8 day radioactive half life and decays to Po-218, which has a 3.05 minute half-life. Thoron has a 55.6 second radioactive half life and decays to Po-216 which has a 0.15 second radioactive half life. Not considering physical removal processes Po-216 is present at the same radioactivity concentration as thoron. Po-216 decays to Pb-212, which has a 638 minute half life.

Radon exposure is determined by assigning a progeny equilibrium factor to a measured radon concentration. The factors effecting equilibrium are progeny in-growth and physical processes that remove the decay progeny from the air. The assumptions used for thoron exposure are quite different. Po-216 is essentially in equilibrium when the thoron is released from the embankment. Thoron released from the embankments must travel to the Restricted Area boundary to expose members of the public. Thoron decay during this travel is significant. With a wind speed of 10 miles per hour, from radioactive decay alone, both thoron and Po-216 will decay by more than six half-lives (one percent of its original concentration) before it travels one mile. In addition, Po-216 decays produces relatively long lived Pb-212 which inherently results in much lower Po-212 radioactivity concentrations. If thoron radioactivity reduction from decay is not considered the Pb-212 radioactivity is 0.0015 times lower than that of thoron. When considering the potential exposure to members of the public from Clive the need for thoron monitoring is not warranted.

4. The approach to dose assessment in UAC R313-25-19 is dated. In NUREG-1573 the NRC recommends the 25 mrem/year TEDE as the appropriate dose limit. As the dose limit is restricted to ~~"C~~oncentrations of radioactive material which may be released to the general environment," the calculated TEDE values used to demonstrate compliance, do not include the DDE exposure measured at the Environmental Monitoring stations.

5. Airborne particulate sampling filters are proposed to be changed at least once per week, rather than twice weekly. This change is justified by the lower volumes of material (compared to 5 or more years ago) for disposal in recent years, and projected for future years. A further consideration is the long track record, through both high and low volume years, of the facility easily meeting the various annual dose constraints.

4.5.2.1 Airborne Particulate and Gaseous Sampling and Analysis

Air is continuously sampled at multiple locations surrounding the Embankment, Restricted Area, and the Clive Facility. The stations located around the Restricted Area perimeter are used to determine the airborne concentration of radioactive particulates from disposal operations. Station A-16, located west of the Site, at the Clean Harbors Clive facility, is used to determine background.

Radioactive airborne particulate samples are collected using a constant-flow air sampler to draw air through a glass fiber filter, or a functionally similar particulate sampling media. The particulate air sampling apparatus maintains a flow rate of approximately 60 liters per minute through the filter media. The airborne particulate sampling filters are changed at least weekly.

All particulate filters are analyzed for alpha and beta activity at least 7 days but not more than 14 days after collection. The delay of 7 days is needed to allow for the decay of short-lived radon progeny that could potentially interfere with detecting the long-lived contaminants of concern. The time limit of 14 days is to ensure that samples are analyzed in a timely manner. The background alpha and beta concentrations measured at Station A-16 are subtracted from the concentrations measured at the other stations. If for some reason the data from A-16 are not available or are indeterminate, no background is subtracted for the samples collected during the sampling period (e.g., gross concentrations are reported, instead of the net concentrations).

Any individual sample filters with a net alpha or net beta concentration above the applicable Particulate Air Sample Action Level are analyzed by gamma spectroscopy within 3 working days of the alpha/beta analysis. Gamma spectroscopy analysis results are reviewed to determine if any additional actions need to be taken.

When an individual filter has a net alpha concentration above $3x10^{-12}$ µCi/ml or net beta concentration above $5x10^{-11}$ µCi/ml (approximately 25 times the Particulate Air Sample Action Level, based on 25 or 26 filters per reporting period per location), additional radiochemical analyses are performed on that filter according to the requirements for quarterly composite filters, unless gamma spectroscopy associates at least 50 percent of the net alpha or net beta activity present on the filter with gamma-emitting radionuclides.

All particulate air sample filters collected during the reporting period are gathered into a composite sample for each air monitoring station. Each composite sample is analyzed by gamma spectroscopy using either the on-site instruments or one of the qualified contractor laboratories. The composite samples are also analyzed specifically for U-238, U-234, U-235, Th-228, Th-230, Th-232, Ra-226, Pb-210, and Po-210. The specific analytical methods are determined by the accredited laboratories doing the analysis.

In order to maximize the detection sensitivity for the important radionuclides, any additional radiochemical analyses are limited to those radionuclides that could reasonably be expected to contribute more than five percent of the aggregate Committed Effective Dose Equivalent over the quarter. The potential relative dose fraction for each radionuclide is determined each quarter by weighting its effective inhalation dose coefficient according to its relative abundance in the waste disposed during the quarter. Air is also continuously sampled for radon using Landauer RadTrak® Dosimeters. Stations B-2, A-27, and A-16 sample results are used to determine background.

These facilities are operated in accordance with Energy*Solutions*' Air Approval Order. Prior to the issuance of this order the Division of Air Quality performed a review of air quality concerns. The Utah Division of Air Quality performs routine audits of Energy*Solutions'* facility to determine compliance with their Order. Further, Energy*Solutions* is required by License Condition 53.D of the License to cease all bulk waste handling operations when the 5-minute average wind speed reaches 35 mph. It should also be noted that the air order requires Energy*Solutions* to maintain minimum waste moisture conditions as well as optimum air opacity standards. When these conditions are not met, dust suppression is applied as needed regardless of the time of year.

4.5.2.2 Soil Sampling and Analysis

Soil sampling is conducted in accordance with the Environmental Monitoring Plan, as controlled by Condition 20 of the License. Environmental soil samples are analyzed by gamma spectroscopy. In order to facilitate the accurate measurement of radionuclides, the samples are collected from the top one inch of soil. Routine soil samples that exceed the Soil Action Levels are analyzed for isotopic thorium. The Soil Action Level is set at background values for the area, and therefore provides an extremely sensitive measure of potential offsite contamination. The location of any soil sample above action levels is further characterized by additional sampling to verify the initial finding, and to subsequently determine the nature, extent, and cause of any problem once the initial finding is verified. Areas with confirmed radioactivity above the Soil Action Level are remediated.

Soil samples are also collected annually to assess potential windblown contamination from the Embankment. Surface soil samples are taken at 300 meter intervals along the 8 compass directions centered near the center of Section 32. The first sample is taken just outside the site boundary and additional samples are taken at 300 meter intervals extending out to 1,500 meters. All 48 samples are analyzed by gamma spectroscopy.

Radioactivity concentrations in the soil near rail gates and gates that directly access Non-Contaminated Restricted Areas are also monitored. A soil sample is taken near rail gates used to exit the Restricted Area during the quarter. A soil sample is also taken at gates that directly access Non-Contaminated Restricted Areas; where vehicles, personnel, or materials were permitted to exit during the quarter without a radiological release. The sample is taken where the soil is most likely to be affected by contamination that may be present on vehicles exiting the Restricted Area. All soil samples are analyzed by gamma spectroscopy.

4.5.2.3 Groundwater Sampling and Analysis

Energy*Solutions* has initiated and performs a Groundwater Monitoring Program based on the requirements found in Ground Water Quality Discharge Permit No. UGW450005 issued and approved by the Utah Division of Water Quality. The detection monitoring strategy of the Program includes sampling all points of compliance wells (except those designated for groundwater elevation monitoring only) on an annual basis for the required set of constituents. Other indicator parameters may be selected and added to the constituents monitored, based on characterization of the actual waste that is disposed.

The points of compliance wells consist of a monitoring network of 68 wells identified in Part I.F.1. of the Ground Water Quality Discharge Permit. Should an out-of-compliance situation arise, sampling frequency and analyses will occur in accordance with Parts I.G.2 and I.G.3 of the Ground Water Quality Discharge Permit.

SECTION 5. SITE CLOSURE PLAN AND INSTITUTIONAL CONTROLS

UAC R313-25-3(8)	*"The plan approval siting application shall provide evidence that if the proposed disposal site is on land not owned by state or federal government, that arrangements have been made for assumption of ownership in fee by a state or federal agency."*
UAC R313-25-5	*"In addition to the requirements set forth in R313-22-33, an application to receive from others, possess, and dispose of wastes shall consist of general information, specific technical information, institutional information, and financial information as set forth in R313-25-6 through R313-25-10."*
UAC R313-25-7	*"The application shall include certain technical information. The following information is needed to determine whether or not the applicant can meet the performance objectives and the applicable technical requirements of R313-25:* *(2) Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures." –* *(6) Descriptions of the construction and operation of the land disposal facility. The description shall include as a minimum the methods of construction of disposal units; waste emplacement; the procedures for and areas of waste segregation; types of intruder barriers; onsite traffic and drainage systems; survey control program; methods and areas of waste storage; and methods to control surface water and ground water access to the wastes. The description shall also include a description of the methods to be employed in the handling and disposal of wastes containing chelating agents or other non-radiological substances which might affect meeting the performance objectives of R313-25* *(7) A description of the disposal site closure plan, including those design features which are intended to facilitate disposal site closures and to eliminate the need for active maintenance after closure."*
UAC R313-25-9	*"The institutional information submitted by the applicant shall include:* *(1) A certification by the federal or state agency which owns the disposal site that the agency is prepared to accept transfer of the license when the provisions of R313-25-16 are met and will assume responsibility for institutional control after site closure and for post-closure observation and maintenance.* *(2) Evidence, if the proposed disposal site is on land not owned by the federal or a state government, that arrangements have been made for assumption of ownership in fee by the federal or a state agency."*

UAC R313-25-10	*"This information shall demonstrate that the applicant is financially qualified to carry out the activities for which the license is sought. The information shall meet other financial assurance requirements of R313- 25."*
UAC R313-25-11	*"A license for the receipt, possession, and disposal of waste containing radioactive material will be issued by the Executive Secretary upon finding that: (3) the applicant's proposed disposal site, disposal design, land disposal facility operations, including equipment, facilities, and procedures, disposal site closure, and post-closure institutional control, are adequate to protect the public health and safety as specified in the performance objectives of R313-25-19; (6) the applicant's proposed disposal site, disposal site design, land disposal facility operations, disposal site closure, and post-closure institutional control plans are adequate to protect the public health and safety in that they will provide reasonable assurance of the long-term stability of the disposed waste and the disposal site and will eliminate to the extent practicable the need for continued maintenance of the disposal site following closure; (8) the applicant's proposal for institutional control provides reasonable assurance that control will be provided for the length of time found necessary to ensure the findings in R313-25-11(3) through (6) and that the institutional control meets the requirements of R313-25-28."*
UAC R313-25-23(2)	*"The disposal site shall be capable of being characterized, modeled, analyzed and monitored."*
UAC R313-25-23(9)	*"Areas shall be avoided where tectonic processes such as faulting, folding, seismic activity, vulcanism, or similar phenomena may occur with such frequency and extent to significantly affect the ability of the disposal site to meet the performance objectives of R313-25 or may preclude defensible modeling and prediction of long-term impacts."*
UAC R313-25-23(10)	*"Areas shall be avoided where surface geologic processes such as mass wasting, erosion, slumping, landsliding, or weathering occur with sufficient such frequency and extent to significantly affect the ability of the disposal site to meet the performance objectives of R313-25, or may preclude defensible modeling and prediction of long-term impacts."*
UAC R313-25-24(1)	*"Site design features shall be directed toward long-term isolation and avoidance of the need for continuing active maintenance after site closure."*
UAC R313-25-24(2)	*"Wastes designated as Class C pursuant to R313-15-1009 shall be disposed of so that the top of the waste is a minimum of five meters below the top surface of the cover or shall be disposed of with intruder barriers that are designed to protect against an inadvertent intrusion for at least 500 years."*
UAC R313-25-24(4)	*"Wastes shall be emplaced in a manner that maintains the package integrity during emplacement, minimizes the void spaces between packages, and permits the void spaces to be filled."*

UAC R313-25-24(6) *"The disposal site shall be designed to minimize to the extent practicable the contact of water with waste during storage, the contact of standing water with waste during disposal, and the contact of percolating or standing water with wastes after disposal."*

UAC R313-25-24(9) *"Closure and stabilization measures as set forth in the approved site closure plan shall be carried out as the disposal units are filled and covered."*

UAC R313-25-26(3) *"After the disposal site is closed, the licensee responsible for post-operational surveillance of the disposal site shall maintain a monitoring system based on the operating history and the closure and stabilization of the disposal site. The monitoring system shall be capable of providing early warning of releases of waste from the disposal site before they leave the site boundary."*

UAC R313-25-28 *"(1) Land Ownership. Disposal of waste received from other persons may be permitted only on land owned in fee by the Federal or a State government.*
(2) Institutional Control. The land owner or custodial agency shall conduct an institutional control program to physically control access to the disposal site following transfer of control of the disposal site from the disposal site operator. The institutional control program shall also include, but not be limited to, conducting an environmental monitoring program at the disposal site, periodic surveillance, minor custodial care, and other equivalents as determined by the Executive Secretary, and administration of funds to cover the costs for these activities. The period of institutional controls will be determined by the Executive Secretary, but institutional controls may not be relied upon for more than 100 years following transfer of control of the disposal site to the owner."

UAC R313-25-32 *"(1) Prior to the issuance of the license, the applicant shall provide for Executive Secretary approval, a binding arrangement, between the applicant and the disposal site owner that ensures that sufficient funds will be available to cover the costs of monitoring and required maintenance during the institutional control period. The binding arrangement shall be reviewed annually by the Executive Secretary to ensure that changes in inflation, technology, and disposal facility operations are reflected in the arrangements.*
(2) Subsequent changes to the binding arrangement specified in R313-25-32(1) relevant to institutional control shall be submitted to the Executive Secretary for prior approval."

UAC R313-25-33 *"(1) Licensees shall maintain records and make reports in connection with the licensed activities as may be required by the conditions of the license or by the rules and orders of the Executive Secretary.*
(2) Records which are required by these rules or by license conditions shall be maintained for a period specified by the appropriate rules or by license condition. If a retention period is not otherwise specified, these records shall be maintained and transferred to the officials specified in R313-25-33(4) as a condition of license termination unless the Executive Secretary otherwise authorizes their disposition.

(3) Records which shall be maintained pursuant to R313-25 may be the original or a reproduced copy or microfilm if this reproduced copy or microfilm is capable of producing copy that is clear and legible at the end of the required retention period.
(4) Notwithstanding R313-25-33(1) through (3), copies of records of the location and the quantity of wastes contained in the disposal site shall be transferred upon license termination to the chief executive of the nearest municipality, the chief executive of the county in which the facility is located, the county zoning board or land development and planning agency, the State Governor, and other state, local, and federal governmental agencies as designated by the Executive Secretary at the time of license termination.
(5) Following receipt and acceptance of a shipment of waste, the licensee shall record the date that the shipment is received at the disposal facility, the date of disposal of the waste, a traceable shipment manifest number, a description of any engineered barrier or structural overpack provided for disposal of the waste, the location of disposal at the disposal site, the condition of the waste packages as received, discrepancies between the materials listed on the manifest and those received, the volume of any pallets, bracing, or other shipping or onsite generated materials that are contaminated, and are disposed of as contaminated or suspect materials, and evidence of leakage or damaged packages or radiation or contamination levels in excess of limits specified in U.S. Department of Transportation and Executive Secretary regulations or rules. The licensee shall briefly describe repackaging operations of the waste packages included in the shipment, plus other information required by the Executive Secretary as a license condition.
(6) Licensees authorized to dispose of waste received from other persons shall file a copy of their financial report or a certified financial statement annually with the Executive Secretary in order to update the information base for determining financial qualifications.
(7) (a) Licensees authorized to dispose of waste received from other persons, pursuant to R313-25, shall submit annual reports to the Executive Secretary. Reports shall be submitted by the end of the first calendar quarter of each year for the preceding year.
(b) The reports shall include:
(i) specification of the quantity of each of the principal contaminants released to unrestricted areas in liquid and in airborne effluents during the preceding year;
(ii) the results of the environmental monitoring program;
(iii) a summary of licensee disposal unit survey and maintenance activities;
(iv) a summary, by waste class, of activities and quantities of radionuclides disposed of;
(v) instances in which observed site characteristics were significantly different from those described in the application for a license; and
(vi) other information the Executive Secretary may require.

	(c) If the quantities of waste released during the reporting period, monitoring results, or maintenance performed are significantly different from those predicted, the report shall cover this specifically. *(8) In addition to the other requirements in R313-25-33, the licensee shall store, or have stored, manifest and other information pertaining to receipt and disposal of radioactive waste in an electronic recordkeeping system.* *(a) The manifest information that must be electronically stored is:* *(i) that required in Appendix G of 10 CFR 20.1001 to 20.2402, (2006), which is incorporated into these rules by reference, with the exception of shipper and carrier telephone numbers and shipper and consignee certifications; and* *(ii) that information required in R313-25-33(5).* *(b) As specified in facility license conditions, the licensee shall report the stored information, or subsets of this information, on a computer-readable medium."*
UAC R313-25-34	*"Licensees shall perform, or permit the Executive Secretary to perform, any tests the Executive Secretary deems appropriate or necessary for the administration of the rules in R313-25, including, but not limited to, tests of; (1) wastes; (2) facilities used for the receipt, storage, treatment, handling or disposal of wastes;* *(3) radiation detection and monitoring instruments; or (4) other equipment and devices used in connection with the receipt, possession, handling, treatment, storage, or disposal of waste."*

The Embankment is designed to eliminate to the extent practicable the need for active maintenance after closure. Once the Embankment is closed, no further maintenance to the Embankment is anticipated. Closure of the Embankment is expected to begin well before overall facility decommissioning, since cover activities for the Embankment are expected to begin for some lift areas within the next 3years (while the facility is expected to continue operating for up to 20 years). Overall facility decommissioning is controlled by Condition 74 of the License. In satisfaction of this condition, Energy*Solutions* has submitted a detailed site Decontamination and Decommissioning Plan (Energy*Solutions*, 2012a). This Plan addresses site closure in the context of site conditions.

Prior to mining materials from Section 5 (located directly south of the Licensed Section 32), Energy*Solutions* applied for and was awarded a Conditional Use Permit (CUP) from the County of Tooele. As part of this CUP, Energy*Solutions* submitted a Reclamation Plan and Bond to address restoration and revegetation of the mined areas in Section 5. Even though Section 5 is not licensed by Energy*Solutions* for management of LLRW (thereby falling without the regulatory authority of the Division), the License was amended with Condition 34 in 2007 to require Energy*Solutions* to demonstrate that no adverse conditions are created by continued material mining in Section 5. In satisfaction of this Condition, Energy*Solutions* submitted the report ―Restoration of Grade Evaluation," (Whetstone, 2006) which evaluated the impacts of focused groundwater infiltration and surface erosion on the Licensed embankments topographically up-gradient from material mining activities in Section 5. In Whetstone (2006), Energy*Solutions* demonstrated that the focused infiltration of water into the mined portions of Section 5 will not adversely impact the hydraulic gradient beneath Section 32. The analysis also demonstrated that neither rill nor gully erosion of the mined portions of Section 5 would adversely impact the stability of the Embankments located in Section 32. Subsequent to this analysis, Energy*Solutions* has provided several detailed responses to additional requests for information from the Division. In addition to the Whetstone (2006) analysis and subsequent request responses, Energy*Solutions* has implemented an administrative control (Procedure CL-EN-PR-091, as catalogued in Appendix J) to maintain a minimum distance of one half mile from all Section 5 mining activities and the Section 32 boundary.

Energy*Solutions* has also conducted extensive field studies, as part of their development of the ET cover design (SWCA, 2012). Study plots were examined that are ecologically analogous to the conditions that exist in Section 5 and for the ET covered Embankment. As a result of the analysis, “*there was little to no evidence of water erosion even on those study plots with a discernible slope.*” (SWCA, 2012). Given the administrative control, the extremely arid environment (MSI, 2012), lack of area analogue sites with demonstrable erosion (SWCA, 2012), and extremely low projected erosion rate (Neptune, 2012; Neptune, 2011; Jones, 2012), it is exceptionally unlikely that the performance of the Embankments of Section 32 will be compromised. As a result, Condition 34 has been removed from the License (included in Appendix A). As an added, although unnecessary, precaution, Energy*Solutions* has also augmented its LLRW surety calculations to include sufficient costs for the construction of a trench to grade to drain any accumulated water from Section 5 mined sections to BLM lands southwestward.

5.1 SITE STABILIZATION

Energy*Solutions’* Embankment cover system is designed to minimize infiltration of water into the waste, to maximize evapotranspiration, direct precipitation away from disposed waste, and to resist degradation caused by surface geologic processes. The principal design systems are classified into two categories: 1) deep infiltration minimization, surface drainage and erosion protection, and 2) geotechnical stability.

In satisfaction of Condition 28 of the License, Energy*Solutions* constructed a Cover Test Cell to model the rock armored cover originally used for the LARW and Vitro Embankments (on land adjacent to the disposal facility in order to field test a model cover system). The Cover Test Cell was built September 2001 to confirm input parameters to the HELP model, originally used to predict infiltration through the traditional rock armored cover system design incorporated over the low-level radioactive waste disposal embankments at the facility. The base of the test pad is a lysimeter identical to collection lysimeters built beneath the disposal embankments. The purpose of the lysimeter is to collect and direct liquids through volumetric moisture monitoring instruments within a manhole outside the test pad. Permanent monitoring equipment has been placed during construction at specific intervals throughout the test pad. Monitoring equipment consists of water content reflectometers (WCRs), matric water potential sensors or heat dissipation units (HDUs), and temperature probes. The monitoring equipment provides cross-sectional data of the moisture content and temperatures throughout the constructed cover. Additionally, surface water runoff generated by precipitation is collected through a drainage trough and measured in order to perform a water balance over the entire test pad.

Data collected since its construction indicates that the rip rap, sacrificial soil, and filter zone materials protect the clay radon barrier layers from freezing temperatures. Water measured through the dosing basin suggests that the amount of water leaving the test cell through the lysimeter is far less than the values predicted by the HELP modeling. These sensors show good temperature and moisture correlations between the sacrificial soil and the environment.

Since its development and successful observation, Energy*Solutions* has decided to construct an evapotranspirative cover (see Appendix D), which significantly enhances the Embankment's ability to satisfy the required performance objectives. Additionally, Energy*Solutions* has modeled the fate and transport of water through this new cover system using the more comprehensive HYDRUS (2d/3d) model. The HYDRUS (2D/3D) model is preferred for the evapotranspirative Embankment cover, because of its ability to simulate processes known to have a significant role in water flow in landfill covers in arid regions and utilize easily measured environmental characteristics as input to its calculations. HYDRUS includes the capabilities to simulate:

- water flow in variably-saturated porous media;
- material hydraulic property functions;
- atmospheric surface boundary conditions including precipitation and evapotranspiration;
- root water uptake; and
- free-drainage boundary conditions.

5.1.1 Deep Infiltration Minimization, Surface Drainage and Erosion Protection

The Energy*Solutions* facility incorporates three separate design systems in the surface drainage plans for the site. These systems are designed to meet the requirements of UAC R313-25-7(7), UAC R313-25-8, UAC R313-25-24, and UAC R313-25-25, in that they are designed and constructed to prevent erosion and flooding of the disposal unit without active maintenance.

The first system consists of the two elements designed to control precipitation that falls on site. This system includes the perimeter or run-on berms and the drainage ditches. The berms and ditches are designed to promote Embankment stability and protection during normal, abnormal, and extreme storm and flood events (defined as Probable Maximum Precipitation and Flood events by UAC R313-25). The perimeter or run-on berms are constructed to sufficient height to contain water created from the worst storm event that could occur during the design life of the embankment. They will also prevent offsite floodwaters created during a worst-case flood event from running onto the Embankment.

Likewise, the drainage ditches are constructed to a sufficient depth to promote drainage of storm waters offsite, preventing the waters from backing up and infiltrating into the Embankment. These ditches intercept runoff from the Embankment and direct the flow into the natural drainage patterns to the southwest of the site. Infiltration and erosion barriers cover the drainage ditches in order to protect them from erosion forces. The run-on berms and drainage ditches are a key system for the following principal design features: a) they protect against water infiltration by directing surface water offsite, b) they promote disposal unit/cover integrity by preventing erosion due to contact with surface water, c) they minimize contact of the radon barrier or emplaced waste with standing water, and d) they allow the site to be free draining.

Upon completion of waste placement, a clay radon and infiltration barrier is constructed. The first layer of this cover is the radon barrier, consisting of no more than 1×10^{-6} permeability clay. The radon barrier is covered by the infiltration barrier, consisting of 5×10^{-8} cm/sec permeability clay. The infiltration barrier is a key system for the following principal design features: a) it encourages precipitation evapotranspiration rather than infiltrate into the Embankment, b) it maintains cover integrity by protecting it against severe storm events, and c) it protects against inadvertent intrusion into the radon barrier and emplaced waste.

Immediately over the filter layers is 18 inches of bankrun borrow zone, which protects the infiltration barriers from the influences of frost. The bankrun borrow zone also serves as a biointrusion barrier, protecting the Embankment from damage. It consists of bankrun borrow material, with boulders larger than 16 inches removed, to resist the erosive forces caused by severe storm events. It is a key system for the following principal design features: a) it provides leak resistance for the Embankment by protecting the radon barrier from cracking due to extreme cold/hot weather conditions, b) it maintains disposal unit and radon barrier integrity by protecting it against erosion, c) it promotes structural stability, and d) it protects against inadvertent intrusion.

Finally, above the bankrun borrow zone are the evaporation (12 inches) and surface layers (6 inches). These layers consist of loam clays that are designed to trap and absorb infiltrating precipitation. This entrained moisture can then be removed from the cover system by evapotranspiration. Gravel is added to the surface layer to provide additional erosion protection (15% by volume is added to the Embankment‘s top slope and 46% by volume is added to the Embankment‘s side slope).

5.1.2 Geotechnical Stability

The geotechnical stability of the Embankment is contingent upon proper execution of the design bases and construction procedures for the Embankment‘s design systems. These systems are also designed to meet the performance objectives and technical requirements of UAC R313-25. Analyses have been performed for each of these systems to justify their design and performance. Each of these systems is completed prior to closure of the Embankment and eliminates the need for active maintenance of the facility after closure.

The clay liner provides a firm construction base for the entire Embankment that minimizes contact of wastes with standing water. It is constructed over a compacted foundation of in situ soils. To ensure long-term stability of the Embankment, the clay liner is compacted to near maximum compaction. It is constructed with clay materials that will maintain their strength at relatively high moisture contents to ensure that: it can remain firm under the loads of the emplaced waste; long-term settlement is minimized; and liquefaction does not occur. In addition, the liner is constructed with a permeability greater than the top foot of radon barrier, to protect against ponding or ―bathtubbing” that could cause saturation of the bottom of the Embankment.

Drainage from the embankment is monitored by collection lysimeters that are placed beneath the clay liner at several locations in the Embankment. Lysimeter piping extends along the base of the Embankment and collects any leachate that may develop. A collection manhole is constructed with each lysimeter so that leachate can be monitored. Details of the construction and key elements of lysimeters are provided in Appendix C of the GWQDP.

The structural stability of the Embankment is also ensured by proper placement and compaction of waste materials. As outlined in the CQA/QC Manual, soil-like waste materials are placed in lifts and compacted near maximum compaction and optimum moisture to protect against long-term settlement. Waste placed as debris is also compacted with fill material or placed with CLSM to minimize voids in the Embankment. All placed materials are tested for density, moisture and thickness to ensure compliance with design bases and construction procedures. To protect against differential settlement, uniformity of the Embankment is developed by terracing or tying in intersecting sections of the Embankment. The Embankment is surveyed annually and As-Built drawings are produced and submitted to the Division. Settlement is monitored both before and after final cover construction in accordance with the CQA/QC Manual, Work Element – Temporary Cover Placement and Monitoring and Work Element – Settlement Monitoring.

Once waste material has been placed and graded to the design slopes and elevations indicated in the design drawings, a radon barrier is constructed. The radon barrier is constructed with low permeability clays and is sloped to promote precipitation runoff. This is also a key element to prevent against liquefaction as it minimizes water infiltration and saturation of the emplaced waste. The radon barrier, like the clay liner, is compacted to almost maximum compaction and near optimum moisture to protect against long-term settlement. The final cover protects the radon barrier against cracking due to freezing/thawing, and erosion. The Embankment‘s side slope of five horizontal to one vertical was studied in detail to assure that the slopes would not fail due to the expected maximum seismic event (AMEC, 2012a).

The DOE Technical Approach Document (DOE, 1989), provides data and calculations used in evaluating the slope stability and liquefaction potential for the Vitro embankment. It was concluded that ―due to the short- and long-term unsaturated embankment conditions, the dense nature of the granular site soils and a depth to groundwater in excess of 25 feet below existing grade, liquefaction in the embankment or foundation soils will not occur at the site due to MCE acceleration.”

In an updated study conducted by AMEC for Energy*Solutions* (AMEC, 2012a), it was found that all layers above 35 feet below grade would not liquefy. AMEC reports that some relatively thick layers deeper than 35 feet might liquefy during this event, but are sufficiently deep that they should not affect the stability of the site. However, the depth to those layers exceeds the depth to which the liquefaction analysis procedure is claimed to be valid; thus, it is questionable that those layers are really liquefiable. Based on their analysis, AMEC concluded that liquefaction in the embankment or foundation soils will not occur at the site due to an MCE-acceleration.

AMEC also prepared an updated assessment of the seismic hazard for the Clive site consistent with the requirements of the Utah Code of Regulations R313-25-8(5). The revisited seismic hazard assessment is based on an assessment of the peak ground acceleration associated with the Maximum Credible Earthquake for known active or potentially active faults in the site region, and the peak ground acceleration obtained from a probabilistic seismic hazard analysis to assess the seismic hazard for earthquakes that may occur on unknown faults in the area surrounding the project site (i.e., background seismicity). The approach utilized by AMEC to select a Maximum Credible Earthquake peak ground acceleration from the larger of the values associated with the deterministic Maximum Credible Earthquake for faults or the probabilistic seismic hazard analysis result for background earthquakes at a 5,000 year return period is consistent with the recommendations of the Utah Seismic Safety Commission (AMEC, 2012a) and as required by the Utah Division of Water Rights (Dam Safety Section) for assessment of dams.

Based on their reevaluation, AMEC determined that the maximum peak ground acceleration from fault-specific earthquake sources is computed to be 0.28 g for a maximum magnitude earthquake occurring on the Stansbury fault (M 7.3) or the Skull Valley fault (M 7.1). The probabilistic analysis of the background seismicity shows the mean peak ground acceleration for a return period of 5,000 years is 0.28 g for non-fault-specific earthquakes up to M 7.

Liquefaction and cyclic softening evaluations, as well as previous embankment stability calculations, were based on a peak ground acceleration of 0.28 g. It is also higher than the median peak ground acceleration value for background earthquakes with 5,000-year recurrence intervals calculated with probabilistic seismic hazard analysis procedures. Therefore, AMEC projects that the results of seismic stability calculations at the Clive site remain appropriate and applicable because the updated peak ground acceleration for the site does not exceed the peak ground acceleration previously used. Therefore, the analysis initially conducted continues to be conservative in demonstrating Embankment stability.

5.2 DECONTAMINATION AND DECOMMISSIONING

Decontamination and decommissioning of the facility will be in accordance with the Decontamination and Decommissioning Plan (Energy*Solutions*, 2012a), as amended at the time of closure. Energy*Solutions* has developed an extensive set of decontamination facilities in support of the Embankment and waste disposal operations. These procedures address decontamination activities necessary for equipment and tools used in shipping, receiving, managing, and disposal of LLRW. Decontamination procedures have also been developed to address release of the various shipping containers from the Restricted Area.

Being one of several active disposal facilities at the Energy*Solutions* Clive site, the Embankment will be closed according to the Decontamination and Decommissioning Plan submitted to the Division in support of a separate licensing action (Energy*Solutions*, 2012a). In the Plan, it is assumed that additional support facilities will not be required beyond that specified in this Application. It is also assumed that these support facilities will be decontaminated and decommissioned upon closure. The decontamination and decommissioning activities include:

a. Decontaminating off-site soils and rail road spur, if necessary, by removing all surface materials contaminated with LLRW such that the contamination in the residual soil or rail road ballast is ALARA and below the respective cleanup limits. Soil will be disposed of at the Embankment using disposal methods approved in the CQA/QC Manual.

b. Decontaminating on-site soils within the Energy*Solutions*' property but excluding the disposal Embankments, by removing all surface soils contaminated with LLRW such that the contamination in the residual soils is ALARA and below the respective cleanup limits. Soils will be disposed of at the Embankment using disposal methods approved in the CQA/QC Manual.

c. Decontaminating on-site structures such as the rollover facility, geotechnical laboratory, and rail spur to meet the unconditional release criteria or, remove and place structures in the Embankment.

d. Decontaminating the on-site support structures and contents including the change and laboratory facilities within the administration building to meet the unrestricted release criteria, or remove and dispose of contents and structures in the Embankment.

Clive waste handling facilities are used for both Class A and 11e.(2) waste management activities. Decommissioning waste from these facilities will be placed into the Embankment. Additionally, the GWQDP requires that sludge and other wastes from eventual decommissioning of the Evaporation Ponds will also be disposed as LLRW in the Embankment.

5.3 POST-OPERATIONAL ENVIRONMENTAL MONITORING AND SURVEILLANCE

After decontamination and decommissioning of the facility is complete, Energy*Solutions* has provided financial assurance for post-operational monitoring and maintenance during the period of institutional control. Post-operational monitoring includes annual inspections and minor maintenance of the Embankment and areas that may have been impacted by LLRW operations, to ensure that the Embankment and other required elements perform as intended and that there are no adverse impacts to the environment or the public due to degradation of the Embankment. Monitoring and surveillance includes inspection and minor maintenance of the Embankment, fencing, roads, and annual groundwater sampling.

5.3.1 Airborne Particulate Monitoring

The existing program for monitoring airborne particulate radioactivity (Environmental Monitoring Plan described in section 4.5.2 above) will continue with air samplers surrounding the operational area and at least one control station remote from the area for at least one sampling event after final cleanup and closure. Composite samples from each station will be analyzed by gamma spectrometry for gamma-emitting radionuclides, and by radiochemical techniques for Ra-226, Th-230, Pb-210 and total U as well as any other non-gamma-emitting radionuclides disposed of during the previous year. Air sample collection will continue during the period required for sample analysis. Measured concentrations will be compared with the dose standards in accordance with the Environment Monitoring Plan (Appendix M).

5.3.2 Radon in Outdoor Air and Gamma Radiation Exposure

Passive environmental radon monitors will be used for one year at all air sampling sites employed during post-closure airborne particulate monitoring. Samplers will be exchanged at the frequency prescribed by the Environmental Monitoring Plan. If these samples all demonstrate compliance with the concentration limit of R313-15-420, Table II for Rn-222 no further radon sampling will be required. For the purpose of this evaluation the concentration will be the measured concentration, minus the sum of the average baseline concentration, plus three standard deviations.

TLDs will be used for gamma exposure monitoring at the same locations for one year post-closure and will be exchanged at the frequency prescribed by the Environmental Monitoring Plan. If the net annual exposure rate does not exceed the baseline exposure rate, plus three standard deviations as adjusted for changes in worldwide fallout levels by 25 mR/year, no further monitoring of gamma exposure rates will be required.

5.3.3 Soil/Vegetation

Energy*Solutions* will make a final collection of soil samples at site closure. No further collections will be necessary post-closure. If any site boundary samples contain concentrations of radionuclides greater than the mean plus two standard deviations determined for the background samples an investigation will be made to determine the possible cause and sampling will continue in that area and at the background sites until the levels return to background.

5.3.4 Water Sampling

There is limited potential for degradation of water quality in the vicinity of the Embankment. The groundwater at the site is already characterized by a briny quality, with levels of many constituents (major ions, metals, total dissolved solids, uranium) establishing the water as Class IV in accordance with UAC R317-6-3.7. The water might be suitable only for limited industrial uses without extensive treatment. There are no identified uses of groundwater within 3 miles of the site.

Furthermore, the Embankment design minimizes the potential for transport of contaminants away from the tailings. The cover reduces the potential for deep infiltration, which is already likely to be minimal in the area due to the low incident precipitation and high potential evapotranspiration.

Seepage is not expected to reach the groundwater as a result of moisture redistribution within the waste. The impact of this seepage on the groundwater is expected to be minimal for several reasons:

1. Waste must have equal to or less than 1% free standing liquids upon arrival. Most shipments have no free standing liquids.

2. Waste must have no free liquids at disposal.

3. Evaporation at the site exceeds precipitation. Accordingly, even waste with some moisture content upon receipt is likely to dry out during placement.

4. The existing poor quality of the groundwater makes it difficult to significantly degrade it.

5. The hydraulic head gradient in the groundwater is minimal, limiting the velocity of groundwater movement away from the site to a maximum of about a foot per year.

6. Modeling analyses indicate that it would take approximately 400 to 600 years for leachate to move through the unsaturated zone.

Site closure and stabilization would include decontamination and decommissioning of the entire site. Even though highly unlikely, this will include any necessary groundwater quality restoration. Post-closure water sampling and analysis will be performed on the frequency and with the analysis type specified in Appendix F to the GWQDP.

Due to the high and variable concentrations of naturally occurring radionuclides, results for analysis of these radionuclides will be subjected to trend analysis to identify any increase in ground-water concentrations. Since manmade radionuclides are not expected to be found in groundwater, any positive findings will be considered as evidence of possible contamination from site operations. Any findings of radioactivity above predicted baseline values will be reason for increased frequency of sampling at the affected well to determine the reason for the finding and any possible course of action.

5.3.5 Settlement Monitoring

Settlement analyses were performed for the Embankment and cover materials to ensure that total and differential settlements would be in an acceptable range for the cover system. The foundation soils include both sand and clay that will settle under the weight of the LLRW and cover. The sand layers are relatively free draining and will settle rapidly and the LLRW are also assumed to consist of primarily sand size particles that will settle rapidly when the loads are applied. Please refer to sections 3.3.2.7 and 3.3.2.10 for summary of differential settlement and total settlement evaluations.

Energy*Solutions'* Long Term Settlement Monitoring Plan (included in the CQA/QC Manual) was developed in accordance with the recommendations contained in "Guidance for UMTRA Project Surveillance and Maintenance" (UMTRA-DOE/AL-350124.000). The Plan specifies that geotechnical monitoring inspections will be performed by Energy*Solutions* on the completed Embankment to evaluate settlement of the Embankment as well as slope stability. Surveys will be performed annually and will be made to second order standards. Settlement monitoring will be conducted for the first 20 years after site closure.

5.3.6 Visual Inspection

In accordance with the recommendations contained in ―Guidance for UMTRA Project Surveillance and Maintenance" (UMTRA-DOE/AL-350124.000), Energy*Solutions* will perform annual visual inspections of the completed Embankment. Among the items to be observed and/or inspected are:

1. Adjacent off-site features.

2. Access roads, fences, gates, and signs.
   a. Needed maintenance.
   b. Breach of integrity.

3. Monuments and wells.
   a. Disturbances.
   b. Replacement or protection.

4. Crest.
   a. Observation of erosion, soil color, vegetation, trails.
   b. Subsidence, settling, cracks, etc.
   c. Deterioration of cover.

5. Slopes.
   a. Settlement, sliding.
   b. Animal and/or plant intrusion.
   c. Vandalism.

6. Periphery.

7. Diversion Channels.
   a. Functional.
   b. Erosion, sediment.
   c. Vegetation, blockage.

8. Photography

In addition to the scheduled surveillance, Energy*Solutions* will provide unscheduled inspections following unusual events (e.g., tornadoes, extremely high winds, extended or high periods of precipitation, floods, earthquakes, or human events such as vandalism or inadvertent).

5.4 INSTITUTIONAL CONTROLS

The Embankment is designed to eliminate to the extent practicable the need for active maintenance after closure. Once the Embankment is closed, no further maintenance is anticipated. Embankment closure is executed on a continuing basis, with cover construction generally completed within a relatively short time after a section of the Embankment reaches its design limit of waste placement.

Close of the Embankment is expected to begin well before overall facility decommissioning, since cover activities for this Embankment are expected to begin for some lift areas within the next 3 years. Closure and stabilization of the Embankment will be conducted to ensure that the performance objectives and technical requirements of UAC R313-25 related to site closure and stabilization are met, including:

1. The Embankment cover, run-on control berms, and adjacent surface grading are adequate to direct the flow of surface water away from the closed Embankment;

2. The necessary environmental observational data have been collected to establish and verify satisfactory Embankment performance; and

3. Subsurface water migration is minimized and controlled.

5.4.1 Land Ownership

Division regulations UAC R313-25-3(8) and UAC R313-25-9(2) require that “*that if the proposed disposal site is on land not owned by state or federal government, that arrangements have been made for assumption of ownership in fee by a state or federal agency.*” However, on 16 March 1993, Energy*Solutions* and the Utah Department of Environmental Quality entered into an Agreement Establishing Covenants and Restrictions related to LLRW disposal activities on privately owned land. This Agreement specifically applies to all of Section 32, less the defined property of the Vitro embankment, allowing Energy*Solutions* to retain ownership of the land and be responsible for site closure, as well as the long-term maintenance and monitoring of the disposal site. In return for this exemption, Energy*Solutions* has agreed to escrow sufficient funds to allow the Division to completely decontaminate, decommission, close the facility, and conduct any and all other reasonably expected activities during the institutional control period. Since Energy*Solutions* continues to be bound by this Agreement, licensed activities are addressed by the existing land ownership exemption for LLRW management and disposal.

Even though Energy*Solutions* will retain ownership of the land, and will be responsible for site closure, as well as the long-term maintenance and monitoring of the disposal site, NRC determined that the State of Utah will have sufficient power to control the ownership, use, and maintenance of the Energy*Solutions* facility after closure to a degree equivalent to ownership of the site (as required by UAC R313-25-9). To facilitate this control, Wells Fargo Bank maintains an irrevocable Letter Of Credit for the benefit of the Division Director. Sufficient funds are maintained in trust for the benefit of the State of Utah with Wells Fargo Bank to complete all necessary closure, remediation, and long-term surveillance of the facility. As such, the State of Utah will retain a function in the post-closure activities at the site, in an oversight role.

5.4.2 Records Compilation and Transfer

Upon License termination, the following electronic records will be compiled and transferred to the Division:

- Results of surveys, measurements, and calculations used to determine individual occupational dose from external and internal sources;
- Results of air sampling, surveys, and bioassays;
- Records or the results of measurements and calculations used to release material and equipment from restricted areas or evaluate the release of effluents to the environment;
- NRC Form 4 or equivalent;
- Personal dose records;
- Dose records to members of the public required to demonstrate compliance;
- Provisions of the Radiation Safety Program;
- Records of the disposal of licensed or registered materials.
- Results of equipment calibrations and receipt of radioactive material;
- Results of audits and other reviews of program content and implementation;
- Records used in preparing NRC Form 4;
- Records of training and qualification to demonstrate that a person received appropriate information to perform the work assignment in a safe manner;
- Qualification standard records are retained for classroom, on-the-job, and practical factor training;
- Sufficient records to demonstrate compliance with the dose limit for individual members of the public;

- ALARA plans and goals are maintained to demonstrate the adequacy of the ALARA Program; and

- Records of quality assurance reviews and audits developed for Radiation Safety functions to ensure that sufficient records are specified, prepared, reviewed, approved and maintained to accurately reflect completed work.

Records required to be retained by UAC R313-15 will be compiled and transferred to the Division and will meet either of the following conditions:

- Records may be the original or a reproduced copy provided that the copy is authenticated by authorized personnel and capable of producing a clear copy throughout the required retention period;

- Records may be stored in electronic media with the capability for producing legible, accurate, and complete records during the required retention period; or

- Records such as letters, drawings, and specifications must include all pertinent information, such as, stamps, initials, and signatures.

SECTION 6. SAFETY ASSESSMENT

UAC R313-25-3(5)	*"The plan approval siting application shall include hydraulic conductivity and other information necessary to estimate adequately the ground water travel distance."*
UAC R313-25-6(3)	*"The general information shall include the following: (3) A description of: (a) the location of the proposed disposal site; (b) the general character of the proposed activities; (c) the types and quantities of waste to be received, possessed, and disposed of; (d) plans for use of the land disposal facility for purposes other than disposal of wastes; and (e) the proposed facilities and equipment;"*
UAC R313-25-6(4)	*"The general information shall include the following: (4) proposed schedules for construction, receipt of waste, and first emplacement of waste at the proposed land disposal facility."*
UAC R313-25-7(5)	*"The application shall include certain technical information. The following information is needed to determine whether or not the applicant can meet the performance objectives and the applicable technical requirements of R313-25: (5) Descriptions of codes and standards which the applicant has applied to the design, and will apply to construction of the land disposal facilities."*
UAC R313-25-7(9)	*"The application shall include certain technical information. The following information is needed to determine whether or not the applicant can meet the performance objectives and the applicable technical requirements of R313-25: (9) Descriptions of the kind, amount, classification and specifications of the radioactive material proposed to be received, possessed, and disposed of at the land disposal facility."*
UAC R313-25-8(4)	*"The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met: (a) Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19.*

	(b) Analyses of the protection of inadvertent intruders shall demonstrate a reasonable assurance that the waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion will be provided. (c) *Analysis of the protection of individuals during operations shall include assessments of expected exposures due to routine operations and likely accidents during handling, storage, and disposal of waste. The analysis shall provide reasonable assurance that exposures will be controlled to meet the requirements of R313-15.* (d) *Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent soils, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure."*
UAC R313-25-11	*"A license for the receipt, possession, and disposal of waste containing radioactive material will be issued by the Executive Secretary upon finding that:* *(3) the applicant's proposed disposal site, disposal design, land disposal facility operations, including equipment, facilities, and procedures, disposal site closure, and post-closure institutional control, are adequate to protect the public health and safety as specified in the performance objectives of R313-25-19;* *(6) the applicant's proposed disposal site, disposal site design, land disposal facility operations, disposal site closure, and post-closure institutional control plans are adequate to protect the public health and safety in that they will provide reasonable assurance of the long-term stability of the disposed waste and the disposal site and will eliminate to the extent practicable the need for continued maintenance of the disposal site following closure;"*
UAC R313-25-15	*"The licensee shall observe, monitor, and carry out necessary maintenance and repairs at the disposal site until the site closure is complete and the license is transferred by the Executive Secretary in accordance with R313- 25-16. The licensee shall remain responsible for the disposal site for an additional five years. The Executive Secretary may approve closure plans that provide for shorter or longer time periods of post-closure observation and maintenance, if sufficient rationale is developed for the variance."*
UAC R313-25-19	*"Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals shall not result in an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the whole body, 0.75 mSv (0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem)committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable."*

UAC R313-25-20	*"Design, operation, and closure of the land disposal facility shall ensure protection of any individuals inadvertently intruding into the disposal site and occupying the site or contacting the waste after active institutional controls over the disposal site are removed."*
UAC R313-25-21	*"Operations at the land disposal facility shall be conducted in compliance with the standards for radiation protection set out in R313-15 of these rules, except for release of radioactivity in effluents from the land disposal facility, which shall be governed by R313-25-19. Every reasonable effort should be made to maintain radiation exposures as low as is reasonably achievable, ALARA."*
UAC R313-25-23(5)	*"The disposal site shall be generally well drained and free of areas of flooding or frequent ponding. Waste disposal shall not take place in a 100-year flood plain, coastal high-hazard area or wetland, as defined in Executive Order 11988, "Floodplain Management Guidelines.""*
UAC R313-25-24(3)	*"Except as provided in R313-25-1(1), only waste classified as Class A, B, or C shall be acceptable for near-surface disposal. Wastes shall be disposed of in accordance with the requirements of R313-25-25(4) through 11."*
UAC R313-25-25(3)	*"Except as provided in R313-25-1(1), only waste classified as Class A, B, or C shall be acceptable for near-surface disposal. Wastes shall be disposed of in accordance with the requirements of R313-25-25(4) through 11."*
UAC R313-25-25(7)	*"The boundaries and locations of disposal units shall be accurately located and mapped by means of a land survey. Near-surface disposal units shall be marked in such a way that the boundaries of the units can be easily defined. Three permanent survey marker control points, referenced to United States Geological Survey or National Geodetic Survey control stations, shall be established on the site to facilitate surveys. The United States Geological Survey or National Geodetic Survey control stations shall provide horizontal and vertical controls as checked against United States Geological Survey or National Geodetic Survey record files."*
UAC R313-25-28	*"(1) Land Ownership. Disposal of waste received from other persons may be permitted only on land owned in fee by the Federal or a State government. (2) Institutional Control. The land owner or custodial agency shall conduct an institutional control program to physically control access to the disposal site following transfer of control of the disposal site from the disposal site operator. The institutional control program shall also include, but not be limited to, conducting an environmental monitoring program at the disposal site, periodic surveillance, minor custodial care, and other equivalents as determined by the Executive Secretary, and administration of funds to cover the costs for these activities. The period of institutional controls will be determined by the Executive Secretary, but institutional controls may not be relied upon for more than 100 years following transfer of control of the disposal site to the owner."*

The post-closure safety assessment was performed for Energy*Solutions* by Neptune and Company, Inc., in support of a request to authorize disposal of blended resins in annual volumes exceeding 40,000 ft^3 (Neptune, 2012). The operational safety assessment was performed by Streamline Consulting, LLC (Streamline, 2005). Modeling is based on meteorological measurements obtained at the Clive site from Energy*Solutions'* meteorological monitoring station. Energy*Solutions* has conducted intensive evaluations of groundwater transport and has collected site-specific meteorological data that further support the determinations that waste disposal operations will have a negligible dose impact on members of the general public or the local environment. In addition to these evaluations, Energy*Solutions* has in place an Environmental Monitoring Program that will demonstrate compliance with effluent concentration limits and doses to members of the general public and site radiation workers during the period of operation.

6.1 SOURCES AND QUANTITIES OF LOW-ACTIVITY RADIOACTIVE WASTE

Anticipated sources and radioactivity of wastes to be received are described in Appendix N. This estimate is based on information taken from three sources:

1. On-going research of potential waste sources conducted by Energy*Solutions'* Business Development Department;

2. Government Accountability Office (GAO), ―Low-Level Radioactive Waste – Status of Disposal Availability in the United States and Other Countries," GAO-08-813T, 20 May 2008.

3. DOE, ―Low-Level Waste Disposal Alternatives Analysis Report," (INL/EXT-06-1160-1, Rev. 1), September 2006;

4. GAO, ―Low-Level Radioactive Waste: Future Waste Volumes and Disposal Options are Uncertain", GAO-04-1097T, September 2004;

5. GAO, ―Low-Level Radioactive Waste: Disposal Availability Adequate in the Short Term, But Oversight Needed to Identify Any Future Shortfalls", GAO-04-604, June 2004;

6. DOE, ―Waste Volume Forecast – Revision 1,: LA-UR-04-6682, September 2004; and,

7. DOE, ―The Current and Planned Low-Level Waste Disposal Capacity Report – Revision 2," December 2000.

It is noted that projections of future waste receipts are highly speculative, since the LLRW market fluctuates with varying levels of government funding for environmental cleanup, competition between treatment and disposal options, and changing regulatory requirements.

6.2 COMPOSITE PROJECTION OF WASTE

Anticipated annual receipts and inventory at closure are discussed in Appendix P. Due to competition in the LLRW disposal industry as well as the changing nature of remediation and reclamation efforts nationwide, it is difficult to project waste receipts.

Waste will be accepted with radioactivity concentrations up to the limits of Class A (as defined by UAC R313-15-1009). Wastes up to the Class A limits may be disposed in the Embankment, subject to the waste placement controls provided, without degrading groundwater quality for at least 200 years (heavy metals) or 500 years (radionuclides).

Facility closure will generate material to be disposed in the Embankment. Energy*Solutions* conservatively estimates that approximately 82,000 cubic yards of material will be generated by site decontamination and decommissioning activities, and has allowed for this volume of waste in embankment design (Energy*Solutions*, 2012a). This waste is expected to have nuclide concentrations at or lower than averages disposed throughout the lifetime of facility operations.

6.3 RELEASES DURING OPERATIONS

Energy*Solutions'* Radiation Protection Program that is required by UAC R313-15-101(1) outlines the facility's radiation protection program. Additionally, Energy*Solutions'* Safety and Health Manual describes site safety, incident reporting, emergency response, equipment operation, personal protective equipment, respiratory protection, medical surveillance, exposure monitoring, hazard communication, confined space entry, and other safety related programs. Included therein are descriptions of Energy*Solutions'* ALARA program, including dose goals that are significantly below the regulatory dose criteria for workers. Since its creation in the early 1980s, Energy*Solutions'* radiological control program has successfully maintained worker exposures as a fraction of the regulatory limit, as demonstrated by worker dosimetry records and calculation of committed effective dose equivalents (CEDE). See also Table 4-1 above. Energy*Solutions* actively reviews work practices, performs operational radiological surveys and has a functional ALARA review committee.

6.3.1 Normal Releases

Generally, the most significant radioactivity transport mechanisms are air, groundwater, surface water, direct radiation and biotic pathways. For the Clive facilty, the most significant pathways are air, and direct radiation; due to the lack of surface water, poor groundwater quality, and limited use of biological materials at this site. During operations, waste is being handled and disposed. Environmental releases are monitored and occupational doses controlled by procedures catalogued in Appendix J. During the observational and surveillance period, the active institutional control period, and passive institutional control period, the site has already been decontaminated, wastes have been covered and there should again be no changes in exposures except possibly for any contamination in unconsumed groundwater.

The evaluations by Streamline Consulting address exposure pathways for the operational period. A variety of scenarios were considered in comparison to regulatory standards for public exposure. Results of modeling for that pathway show that disposal of wastes containing concentrations of radioactivity at the

Class A limits will not result in doses exceeding radiation protection standards. Although the Streamline Consulting projections were performed several years ago, they remain valid after being verified by reported occupational and public doses in the interim. See Table 4-1 above and environmental monitoring reports issued since those projections were performed.

Releases of radioactivity from waste handling performed by Energy*Solutions* can result from:

1. Resuspension of particulates while moving bulk waste, while working with the waste in the disposal cells, or from the surface of emplaced waste;

2. Release of radon to the atmosphere during unloading or after placement;

3. Surface runoff of waste during precipitation events;

4. Leaching from open or covered waste into the groundwater;

5. Surface contamination on vehicles, equipment and workers exiting the restricted area; and/or,

6. External gamma dose from CWF operations.

Streamline Consulting has evaluated the transfer mechanisms associated with normal releases of airborne particulates. Those evaluations were conservative and provided no credit for actions taken to minimize releases other than dust control measures. Energy*Solutions* is committed to controlling all forms of releases to levels not only below regulatory limits, but to keeping those releases as low as reasonably achievable.

6.3.1.1 Control of Windborne Dispersion

Energy*Solutions* employs a number of engineering and operational controls to prevent the resuspension and dispersion of particulate radioactivity. Waste generators are normally required to ship bulk soil-type waste at moisture contents that will allow for movement without creating visible dust. Water spray is used on an as-needed basis in the disposal cell to prevent resuspension of radioactivity. In addition, an enclosure has been constructed over the railcar rollover facility to reduce effluent concentrations at the site boundary. Haul roads, which can become contaminated by trucks leaving the disposal cell, are watered regularly to control dust and are cleaned and resurfaced when needed to prevent the release of airborne radioactivity from that source. Inactive areas of waste, such as that in storage or disposed, but not being actively worked, are sprayed with a polymer solution to bind the surface and prevent resuspension. Strategically placed air samplers alert Energy*Solutions* if an unacceptable release of airborne radioactivity might be developing so that corrective actions may be taken.

6.3.1.2 Radon

Radon in interstitial spaces within the waste are considered to be released during waste unloading operations. There is no practical method of controlling such releases, but monitoring, as provided in the Environmental Monitoring Reports, has shown that these are not released to the off-site area in significant concentrations.

6.3.1.3 Control of Surface Runoff

Since there are no permanent surface water features on or near the Clive site, the only potential source of surface runoff is during precipitation events strong enough to cause local runoff. Run-on control berms around the perimeter of the disposal cells are designed to prevent floodwaters from flowing into the cells and contacting waste. Any runoff from the cells is controlled by a runoff control berm constructed on the clay cell liner. Any water that is collected by the runoff control berms is removed and placed in an evaporation pond.

6.3.1.4 Infiltration
The effects of any potential infiltration are controlled primarily by the site selected for construction of the waste disposal facility. Low annual precipitation, high evaporation, low permeability soils and very slow movement of the underlying groundwater all contribute to making infiltration a minor source of release. In addition, design features such as the cell liner and cover construction further prevent infiltration. Results of groundwater modeling show that Ground Water Protection Levels will not be exceeded for at least 500 years for radionuclides and 200 years for metals.

6.3.1.5 Control of Surface Contamination
All equipment, vehicles, and personnel are screened for both alpha and beta contamination before being released from the site. Decontamination procedures are applied to reduce contamination of all items and personnel to levels as low as reasonably achievable.

6.3.2 Potential Accident Releases

Energy*Solutions'* operations, by their nature, limit the magnitude of potential accidental releases. Flammable or explosive fuels are not stored in close proximity to the wastes and the principal flammable material is in the fuel tanks of the individual work vehicles. A fire in a loaded haul truck carrying closed containers of dry active waste (DAW) could result in some release of airborne particulate radioactivity and this scenario is discussed below. A fire in the disposal cell after waste is placed and blended or covered with soil is unlikely and would involve only isolated pieces of waste.

The possible release scenarios, all of low probability but ranged in order of decreasing magnitude (based on probability of happening times impact), are:

1. On-site truck turnover or collision;
2. Train derailment;
3. On-site truck fire;
4. Flooding;
5. Tornado; and
6. Severe wind.

The following discussion estimates consequences of the above scenarios.

On-site truck turnover or collision:

Any accident involving a truck turnover would be comparable to the same truck actually dumping its load in the disposal cell. For an on-site truck accident immediate assistance is available to wet down, cover, or clean up any spilled wastes; as well as to provide any necessary respiratory protection.

Assuming a moisture content of five percent, wind speed of 40 mph and spillage of the entire load, the total release of waste material is calculated at 265 g. Most of the material from the truck would be deposited on the ground in the immediate vicinity of the truck.

An on-site truck turnover or collision can be compared to normal rail car rollover emissions prior to construction of the rollover enclosure. The rail car rollover is equivalently close to the site boundary as the haul roads. Therefore, doses for a hypothetical train derailment are conservative in estimating dose from a truck turnover or collision. As input to the calculations, it was calculated that the total amount of resuspension annually from rail car rollover operations is about 65.6 kg with winds blowing toward the nearest site boundary monitoring station (Station A-14) 5.7 percent of the time. The model assumed an average uranium concentration in rollover waste of 17,000 pCi/g; 820 pCi/g of Ra-226 in equilibrium with its daughter products; 59 pCi/g of Th-230; and 27 pCi/g of Th-232 in equilibrium with its daughter products. The resultant committed effective dose equivalent (from annual rail car rollover operations) to a hypothetical receptor at Station A-14 was calculated to be 0.73 mrem. An enclosure has since been constructed over the rollover to further minimize fugitive dust emissions.

For the truck accident case, a uranium concentration of 270,000 pCi/g with the other nuclides proportionately the same as presented above was assumed, with winds blowing toward a receptor at the distance of the fence line for the duration of the accident. Under those conditions, the committed effective dose equivalent at that location, scaled from the modeled situation, would be 0.18 mrem. The individual organs receiving the maximum dose, for the mix of nuclides assumed at the rollover, would be either the lung or bone surface either of which would receive doses of no more than 10 times the committed effective dose, or less than two mrem. For on-site workers there would be a very short exposure time since there would be no reason to stand downwind and respiratory protection would be readily available.

From NUREG-0706 the probability of a truck accident is in the range of 1.0 to 1.6×10^{-6}/km (NRC, 1980a). There are two kinds of truck movements to be considered at the Clive site. These are arriving waste shipments and haul trucks moving material from the rollover or storage to the disposal cell. Assuming that there are 3 incoming trucks per day and 50 loaded trucks per day from the rollover or storage to the trench and assuming that the on-site distance traveled by any loaded truck is one kilometer, the probability of an accident in any one year is:

1.3 x 10-6/km x 53 loads/day x 260 days/year x 1 km/load
= 1.8 x 10-2 or about 1.8%.

Most of the material from the truck would be deposited on the ground in the immediate vicinity of the truck. Based on NUREG-0706, for a wind speed of 10 mph, about 0.1% of the material would become airborne immediately (for dry material) (NRC, 1980a). Obviously if the material is moist, the release fraction would be less. For a 20-ton (40,000 pound) truck, about 40 pounds or less might become airborne. This compares with about 24 pounds of dust that becomes airborne daily per hectare of a mill waste pile surface. If the spill is not cleaned up or dust controlled rapidly, the release fraction over a 24-hour period might increase to as much as 0.9 percent or 360 pounds. This is highly unlikely because of the presence on-site of crews and equipment that are there for the express purpose of managing bulk wastes. Because of moisture differences and differences in waste composition from the model mill assumptions, we would expect to have lower release fractions in an actual accident situation.

For on-site workers, there would be a very short exposure time since there would be no reason to stand downwind for 24 hours (or even one hour). For this scenario, it is assumed that an accident occurs involving the spill of a load of waste with a concentration of 15,000 pCi/g, a period of three hours for cleanup with no use of respiratory protection, an airborne concentration of 1 mg/m^3, and a respiratory rate of 1.2 m^3/hr a total of 54 pCi of each nuclide would be inhaled. Comparing these to the Allowable Limit of Intake (ALIs) from Appendix B of 10 CFR 20.1.001 - 4201, the sum of fractions is 0.022. The external gamma dose, using the relationship of 3.1 mrem/h/pCi/g for Ra-226 from Energy*Solutions*, (2012b) and doubling for the contribution from Ra-228, would be less than 140 mrem. Such a dose added to the projected maximum TEDE of 1,032 mrem/yr would still be well within the permissible annual exposures for radiation workers. In actual fact, no workers would be present under such conditions without respiratory protection and would not be standing on the spilled waste for more than a few minutes.

Radiation doses to non-radiation workers would be limited by promptly evacuating such persons from the vicinity of such an accident. Non-radiation workers who might respond as part of an emergency team would be monitored and would spend a limited amount of time in proximity to the waste. It is believed that no person who is not a radiation worker would remain in the vicinity for more than 30 minutes. Therefore, comparing inhalation exposures and external doses to those for radiation workers, it is obvious that no non-radiation worker would receive in excess of 100 mrem.

6.3.2.1 Train Derailment

A train derailment may occur on the Clive site. However, considering the short length of track involved, the small amount of train movement, the low train speeds, and the relatively small number of cars the impact of a derailment should be minor. The net effect of emptying one rail car on the rollover is the same as (or worse than) a one-car derailment. It is worse in the sense that, in the rollover the entire contents of the car are emptied from a height of several meters, which would not be the case in a derailment. The same reasoning as applied to a truck accident would apply here. If the same conditions prevail, with exception of a loss of five times as much material, the dose to a receptor would be approximately one mrem CEDE or an organ dose of less than 10 mrem. Energy*Solutions* would also expect no significant dose to workers for the same reasons discussed under truck accidents. The most serious problems associated with either type of accident are not radiological; they are the personnel safety impact and equipment damage that may occur.

The probability of a train derailment occurring on the Clive site is not readily calculable. However, because of the short length of track involved and the low train speeds compared to truck speeds, the impact of derailment should be much less than the impact of a truck accident.

The dose to the workers and to the population should be much less than that for an off-site derailment and spillage event since trained workers and equipment would be available to immediately use dust control measures to control releases and clean-up the spill. The DOE, as discussed above, concluded that the dose to cleanup workers and nearby residents from such an off-site spill was insignificant. As a worst case, the same assumptions could be applied as for the truck accident scenario above, with the same low total dose to emergency response teams.

6.3.2.2 Truck Fire

In the unlikely event of a truck fire involving a load of containers full of DAW a release of radioactivity in the smoke plume could occur. For this scenario, it is assumed that a fire occurs, involving a truck carrying 600 cubic feet of DAW with a density of 40 pounds per cubic foot and the following average concentrations: Co-60 and Cs-137, 4,000 pCi/g each; H-3, 100,000 pCi/g; and I-120, 100 pCi/g; and a fire which causes total burning of the material in one hour with complete release of the radioactivity under neutral atmospheric stability and a wind speed of 3.4 m/s. From the analysis, the following factors are calculated: plume rise 57 m, maximum ground level concentrations of Co-60 and Cs-137, 1.25 E-10 µCi/ml; H-3, 3.14 E-09 µCi/ml; and I-129, 3.14 E-12 µCi/ml. With a one-hour exposure these concentrations result in a total dose of 0.02 mrem. It can be seen that even with a range of other nuclides and wind conditions, the dose would be trivial.

6.3.2.3 Flooding

Flood control features for the Clive site have been designed and constructed to prevent erosion or off-site transport of wastes from the sites by overland flooding. No off-site transport of radioactive waste by flooding is anticipated. Flood control features for both the Vitro and Clive sites have been designed and constructed to prevent erosion or off-site transport of wastes from the sites by overland flooding. Details of the flood control features are provided in Appendices E and G. No off-site transport of radioactive waste by flooding is anticipated.

6.3.2.4 Tornado

From NUREG-0706, the probability of tornado occurrence in Utah is probably in the range of 1 to $5x10^{-4}$. NUREG-0706 also estimates the consequences of a tornado striking a model uranium mill. Wastes to be managed by Energy*Solutions* are different from the model mill in that additional radionuclides are expected. However, the model mill is a conservative source when the nuclides and their physical forms are considered. Yellowcake from a mill is essentially pure U3O8 in a dry powder form with a uranium concentration of approximately 570,000 pCi/g. Concentrations of Ra-226 and Th-230 in tailings typically exceed those found in wastes disposed of at Clive. It is possible that Energy*Solutions* might receive some uranium waste at concentrations up to approximately half that of yellowcake. The concentrations of radioactivity in tailings are greater than expected for the average in wastes to be received and the nuclides involved are among those with the greatest dose potential following exposure.

As a contributor to internal dose, Th-232 has the lowest annual limit on intake (ALI) of all nuclides at 0.001 µCi. The ALI for natural uranium (assuming a W lung clearance class) is 0.8 µCi, approximately two orders of magnitude greater than for Th-232. However, any Th-232 received under this license at concentrations greater than 1 nCi/g is most likely to be in the form of metallic alloys in sizes that are not subject to resuspension or intake by inhalation or ingestion. The same considerations apply to the other nuclides with ALIs lower than uranium. Therefore, modeling for the model uranium mill is a conservative estimator of doses that might result from any event resulting in resuspension of particulate radioactivity. In the case of the model mill about 12.6 tons of yellowcake is entrained in the vortex, the vortex dissipates at the site boundary, all of the yellowcake is respirable in size, and the cloud is dispersed as a volume source by the prevailing winds. Settling velocity is negligible. The model predicts a maximum exposure at 2.5 miles from the mill, where the 50-year dose commitment is estimated to be 0.83 microrem. At the fence line (1,600 feet) the dose is estimated to be 0.22 microrem. When the specific activities of natural uranium yellowcake is compared to the specific activity of depleted uranium, which will constitute the majority of uranium to be disposed of at Clive, these doses can be considered to be realistic upper limits to an individual receptor in the path of the tornado. As discussed above, the doses would be comparable for other radionuclides at the anticipated upper concentration levels.

6.3.2.5 Severe Winds
The preceding discussion of airborne exposures resulting from tornadoes concluded that the maximum 50-year dose commitment at 2.5 miles would be less than one mrem. The conclusion is derived from a NUREG-0706 analysis of tornado-dispersed yellowcake from a uranium mill, and is suitably conservative in comparison to Energy*Solutions'* operations due to the much higher specific activities of uranium in yellowcake than in the waste to be handled. Even though other radionuclides are proposed in this application, uranium has one of the most restrictive effluent concentration limits, and the much higher concentrations found in the hypothetical yellowcake source provide the basis for estimating that a severe wind occurrence would not result in higher doses.

While severe winds, on the order of 35 m/s, have been recorded in the vicinity, the occurrence is infrequent and the duration is short. Hourly average wind speeds exceed 6 m/s 9.8 percent of the time and exceed 10 m/s 1.4 percent of the time. If it is assumed that –severe” winds occur 1 percent of the time and that airborne concentrations are increased by a factor of ten during these periods, the time-weighted average concentration and resultant doses would increase by only 10 percent. Even in the case of the maximum annual dose at a fence line receptor, a 10 percent increase is negligible.

6.4 POTENTIAL RELEASES FOLLOWING OPERATIONS

At the completion of operations, Energy*Solutions* will no longer receive LLRW from offsite sources and will begin performing the final activities required to close and prepare the Embankment and disposal facility so that ongoing active maintenance is not required during the institutional control period.

The observation and surveillance period occurs after the closure period. During this time, Energy*Solutions* will remain at the Clive site and will carry out various site maintenance activities, as needed. It is expected that this period will last approximately 5 years and is intended to ensure that the site is stable and suitable for beginning institutional control. During this time, the Environmental Monitoring Program will continue to be executed. During the institutional control period, the Environmental Monitoring Program will continue to be executed to verify satisfactory performance of the Embankment, physical surveillance to restrict access to the facility, and miscellaneous minor custodial activities.

As with the period of active operation, Energy*Solutions* has conducted a series of performance assessments to bound potential impacts of Embankment post-operational performance for the purposes of informing regulatory and programmatic decisions. As such, it is important to realize that because the calculations are bounding, they are not intended to predict actual post-operational impacts.

6.4.1 Expected Conditions

The Embankment is designed to perform for a minimum of 500 years based on requirements of 10 CFR 61.7(a)(2), which provides a long-term disposal with minimal need for active maintenance after site closure. Even though the assumption that a member of the general public would build a residence near the edge of the Clive site and use local groundwater for potable needs is extremely unreasonable, the site-specific Performance Assessment evaluated exposure of the general population to releases of radioactivity via the air, soil, groundwater, surface water, plant uptake, and exhumation by burrowing animals pathways (following closure and institutional control of the Embankment) (Neptune, 2012). The analyses identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The Performance Assessment includes analyses demonstrating that the performance objectives of UAC R313-25-8(1) will continue to be met, even with the disposal of large volumes of blended ion-exchange resins. The analyses also demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in UAC R313-25-19.

6.4.1.1 Transfer Mechanism - Air

Following operations, the only potential source of airborne radioactivity will be the release of radon through the cell cover. The radon flux through the cover will be below the limit of 20 pCi/m^2-sec and will be an insignificant source of radiation dose to any member of the public. Analyses demonstrate that after final placement of the waste and closure of the Embankment with an evapotranspirative cover, the facility design prevents any further migration of radioactivity through the air pathway. Furthermore, analysis of the longevity of the alternate evapotranspirative cover designs, which provide equivalent isolation of waste from the atmosphere, also demonstrates that no such air-related doses are projected following closure and institutional control.

6.4.1.2 Transfer Mechanism – Surface Water

Due mainly to the natural site characteristics, there are no radioactive releases expected through the surface water pathway from non-intruder scenarios. The annual precipitation is low and the evaporation is high. No permanent surface water bodies exist in the site vicinity. In addition, the site is far from populated areas. The Embankment design features also minimize the potential for releases by the surface water pathway, including loss of cover integrity due to rill and gully erosion. Embankment design includes drainage ditches around the waste disposal areas. After precipitation events, these ditches divert runoff from the Embankment to areas away from the waste. Long-term surface water pathway doses are projected to be zero because of the absence of permanent surface water bodies at the site.

6.4.1.3 Transfer Mechanism - Biota

The biota uptake pathway is not a viable exposure pathway at the Embankment because of natural site characteristics and design features of the Embankment. Exposure by the plant uptake pathway could occur by (1) the production of food crops in contaminated soil at the site, and (2) root intrusion into the waste by native plants that are subsequently consumed by humans or animals. The natural site‘s characteristics prevent exposures via the plant uptake pathway because there is insufficient water at the site for the production of food crops. In addition, saline soils present at the site limit the number and type of plant species that can tolerate such conditions. Additionally, there are few deep-rooted native plants in the site vicinity.

Vegetation analysis evaluated the redistribution of soils, and contaminants within the soil, by native flora and fauna. The biotic models are consistent with flora and fauna characteristic of Great Basin alkali flat and Great Basin desert shrub communities. In these analyses, vegetation had two primary effects on the cover system: increasing the hydraulic conductivity of the cover material and root clogging of the lateral drainage layers of the rock armor design. After final placement of the cover, releases and doses from the plant pathway are negligible, limited by the site‘s natural characteristics, which include low rainfall, thin plant cover, and the presence of plants that are highly efficient at removing water from the soil and transpiring the moisture back to the atmosphere.

Design features of the Embankment also help limit exposures via the plant uptake pathway. The thick cover includes capillary break, biointrusion, and bioturbation barriers that make the waste less accessible to plant roots after closure of the facility. The overall scarcity of deep-rooted plant species in the site vicinity and the configuration of the earthen cover will offer an inhospitable environment for extension of these types of roots into the waste.

Because of the location of the Clive facility, the biotic characteristics of the area, and the lack of population within 25 miles of the facility, transfer of radioactivity through biotic pathways is limited. Cleanup of the surrounding area to background concentrations will limit the potential for biotic transfer of any materials from outside the closed cell. Cell cover design is expected to limit burrowing animals and vegetation so that there will be no removal of radioactivity from the cell by those vectors.

6.4.1.4 Transfer Mechanism – Direct Radiation

The design of the Embankment minimizes exposures to contaminated soil by members of the general public. After closure of the Embankment, all waste is covered by a cover system designed to protect against erosion and losses of integrity due to waste settlement. Furthermore, administrative controls and design requirements have been developed to ensure that external radiation levels at the top of the final cover will be at or below background radiation for the site, so no such soil-related doses are projected. The Embankment cover design and cleanup of all areas surrounding the closed cells to background levels will limit direct radiation doses to any member of the public to less than 15 mrem per year.

6.4.1.5 Transfer Mechanism – Groundwater

The primary site characteristics that prevent public exposures via the groundwater pathway are the very poor groundwater quality at the site, the low population density, arid meteorology, and the low yield of the aquifers. The groundwater is not potable because of its very high concentration of dissolved salts. This characteristic alone prevents any consumption of the water by humans or livestock. Additionally, the horizontal groundwater flow velocity is approximately 0.5 meters per year, resulting in groundwater travel times of approximately 60 years from the toe of the side slope region of the Embankment to the Point-of-Compliance well. Water quality impacts associated with the components of the Performance Assessment are addressed below, within the context of protection of a natural resource degradation performance objective. The low-yield aquifers found beneath the Clive site would also limit human consumption as numerous wells would need to be installed in order to provide sustainable water for a household.

The Embankment cover system allows very little water to flow into the disposed waste. This limits the contamination of the groundwater by minimizing the contact of water with the waste. Another design feature of the Embankment is the bottom clay liner below the disposed waste. The clay absorbs many of the radionuclides and retards their potential release from the Embankment and subsequent transport to the water table aquifer.

6.4.1.6 Transfer Mechanism – Borrowing Animals

In the arid environment of the Clive Facility, ants fill a broad ecological niche as predators, scavengers, trophobionts and granivores. Ants burrow for a variety of reasons but mostly for the procurement of shelter, the rearing of young and the storage of foodstuffs. How and where ant nests are constructed plays a role in quantifying the amount and rate of subsurface soil transport to the ground surface at the Clive site. Factors relating to the physical construction of the nests, including the size, shape, and depth of the nest, are key to quantifying excavation volumes. Factors limiting the abundance and distribution of ant nests such as the abundance and distribution of plant species, and intra-specific or inter-specific competitors, also can affect excavated soil volumes. Parameters related to ant burrowing activities include nest area, nest depth, rate of new nest additions, excavation volume, excavation rates, colony density, and colony lifespan. A site-specific Performance Assessment developed in support of the disposal of depleted uranium evaluated the impact of ant burrowing on the transport of contaminants and found no significant associated impact to the performance of the Embankment (Neptune, 2011).

Other burrowing animals at the site include jackrabbits, mice, and foxes. The first deterrent to burrowing animals is the rock armor rip-rap erosion barrier and evapotranspirative bioturbation barrier. The burrowing species at the site are not known to dig to such a depth that their burrows could penetrate through the entire cover and into the waste. After final placement of the cover, the design features of the Embankment, primarily the thick soil cover that isolates the waste from burrowing animals, will control releases and doses. Because of this, the likelihood of any animals burrowing through the entire cover and exhuming waste materials is sufficiently low that it was not included in the safety assessment calculations. As such, the burrowing animal pathway is not projected to result in any exposures to humans.

6.4.1.7 Projected Doses to Members of the General Public

It is possible that some members of the general public may enter onto the lands surrounding the site. Doses to these individuals were evaluated by Neptune and Streamline Consulting with the conclusion that such doses would be well below the exposure limit of 25 mrem per year.

6.4.1.8 Projected Doses to Inadvertent Intruders

For purposes of demonstrating performance, it is important to note that occupation of the site by inadvertent intruders after site closure is not likely due to a lack of natural resources in the area, particularly a lack of potable water. As such, contacting the waste after site closure by an onsite resident is highly unlikely due to the lack of natural resources (no reason to drill or dig) and the design of the Embankment cover system. Additionally, the design features and operations will minimize radiation dose to inadvertent intruders. Several design features provide the required protection. Overall features include:

- Site isolation and the resultant lack of nearby residential population;
- Embankment cover systems (rock armored rip-rap, evapotranspirative bioturbation/biointrusion); and
- Granite markers

While onsite occupation is unlikely, the impact on Embankment performance of viable inadvertent intrusion is modeled in Neptune‘s site-specific Performance Assessment (Neptune, 2012). The assessment projects annual radionuclide-specific doses related to the Intruder-Driller scenario within the assessment period of 1,000 years following embankment closure, (but not occurring within the first 100 years of institutional control – as outlined in NRC, 1981). Exposure pathways evaluated for the driller scenario include external radiation dose to a water well driller from drill cuttings in an open ―mud pit”, where the source term is diluted to account for the proportion of cuttings, cover material, unsaturated zone material, and saturated zone material comprising the cuttings. Annual doses for viable intrusion scenarios are compared to an annual dose limit of 500 mrem/yr.

The analysis demonstrates that, as currently performing, a maximum total effective dose equivalent to an intruder-driller is projected at 0.0072 mrem/yr (well below the 500 mrem/yr criteria). As a result of this analysis, compliance with a performance objective of protection of an inadvertent intruder at levels well below 500 mrem/yr is clearly established.

6.4.2 Design Basis Conditions

Transport of radioactivity through groundwater was modeled on the basis of site-specific hydrogeology, gained through years of drilling and testing of wells in the immediate vicinity of the disposal cells, plus long-term average regional meteorological data on precipitation and evaporation.

Protection levels for potential groundwater contaminants have been established for each well by the DWQ using US EPA drinking water standards or a standard based on the observed background concentration in cases where the background exceeded the US EPA drinking water standard.

Performance and design of the cell liner and cover were based on the potential for infiltration, leaching, transport to groundwater, and transport through groundwater to the compliance wells.

6.4.2.1 Transfer Mechanism - Air

Atmospheric transport of radioactive particles was calculated in the analysis conducted by Streamline Consulting (2005). The Embankment was considered. Sources modeled were: (1) resuspension during unloading of waste at the disposal cell; and (2) resuspension from the cell surface. Waste concentrations were based on the volumes and activities of waste received.

6.4.2.2 Transfer Mechanism – Surface Water

The only possible situation in which surface water could be a transfer mechanism for moving radioactivity from the site would be a flood, due to the use of berms during construction and the design of the closed cell. Therefore, the surface water transfer mechanism is not used in modeling, since the facility design has been shown to protect against floods up to the PMF (Jones, 2012b).

6.4.2.3 Transfer Mechanism - Biota

Because of the arid nature of the site and the lack of suitable irrigation water, consumption of locally grown foodstuffs was not considered. A sparse population of jackrabbits, mice and foxes are present in the area and could construct burrows into the waste. Construction activities prevent this from happening while the cell is open. The placement of rock filter zone and riprap erosion barrier will prevent such burrowing after closure. Therefore, biota is not considered to be a viable transfer mechanism.

6.4.2.4 Transfer Mechanism – Direct Radiation

Direct gamma radiation to members of the general public is not a viable scenario. There are no nearby residents, and access to the site perimeter is controlled by Energy*Solutions*. Site perimeter receptor doses were modeled and found to be well within the appropriate dose criteria.

6.4.2.5 Projected Doses to Members of the General Public

The only realistic doses to members of the general public occur during the operational period. The highest overall predicted dose was 10.2 mrem per year. The dose assessment took no credit for occupancy factors in deriving this dose (i.g., it was assumed that a member of the public was present at the fence line 24 hours a day, 7 days a week, for an entire year. This dose is below the limits of the Utah Radiation Control Rules.

6.4.2.6 Projected Doses to Inadvertent Intruders
As access to the site perimeter is controlled by Energy*Solutions*, the analysis considers doses to perimeter receptors only, and found these doses to be well within the appropriate limits. No other operational inadvertent intruder doses are modeled.

6.4.3 Degraded Conditions

The design of the Embankment will provide long-term stability and will be relatively maintenance-free after site closure. Investigations of slope stability, settlement and cover cracking, and frost penetration provide assurance that the completed cell will endure for at least 1,000 years. As required by UAC R313-25, the Embankment design is stable and will not require post-closure maintenance. On this basis, there are no credible transfer mechanisms due to degraded conditions.

6.4.3.1 Surface Drainage and Erosion Protection
Drainage ditches have been designed and constructed to the specifications of drawings found in Appendix B.

6.4.3.2 Stability of Slopes
Section 3 discusses design and construction features that Energy*Solutions* utilizes to ensure slope stability is maintained.

6.4.3.3 Settlement and Subsidence
Maximum settlement in the foundation soils and disposal material is estimated to be less than three feet, with the majority of the settlement occurring prior to placement of the radon and erosion cover material.

SECTION 7. OCCUPATIONAL RADIATION PROTECTION

UAC R313-25-7	*"The application shall include certain technical information. The following information is needed to determine whether or not the applicant can meet the performance objectives and the applicable technical requirements of R313-25:* *(2) Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures."* *(6) Descriptions of the construction and operation of the land disposal facility. The description shall include as a minimum the methods of construction of disposal units; waste emplacement; the procedures for and areas of waste segregation; types of intruder barriers; onsite traffic and drainage systems; survey control program; methods and areas of waste storage; and methods to control surface water and ground water access to the wastes. The description shall also include a description of the methods to be employed in the handling and disposal of wastes containing chelating agents or other non-radiological substances which might affect meeting the performance objectives of R313-25" –* *(11) A description of the radiation safety program for control and monitoring of radioactive effluents to ensure compliance with the performance objective in R313-25-19 and monitoring of occupational radiation exposure to ensure compliance with the requirements of R313-15 and to control contamination of personnel, vehicles, equipment, buildings, and the disposal site. The applicant shall describe procedures, instrumentation, facilities, and equipment appropriate to both routine and emergency operations."*
UAC R313-25-8(4)(c)	*"The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:* *(c) Analysis of the protection of individuals during operations shall include assessments of expected exposures due to routine operations and likely accidents during handling, storage, and disposal of waste. The analysis shall provide reasonable assurance that exposures will be controlled to meet the requirements of R313-15."*
UAC R313-25-18	*"Land disposal facilities shall be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to individuals do not exceed the limits stated in R313-25-19 and 25-22."*
UAC R313-25-19	*"Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals shall not result in an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the*

	whole body, 0.75 mSv (0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem)committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable."
UAC R313-25-20	*"Design, operation, and closure of the land disposal facility shall ensure protection of any individuals inadvertently intruding into the disposal site and occupying the site or contacting the waste after active institutional controls over the disposal site are removed."*
UAC R313-25-21	*"Operations at the land disposal facility shall be conducted in compliance with the standards for radiation protection set out in R313-15 of these rules, except for release of radioactivity in effluents from the land disposal facility, which shall be governed by R313-25-19. Every reasonable effort should be made to maintain radiation exposures as low as is reasonably achievable, ALARA."*
UAC R313-25-25(3)	*"Except as provided in R313-25-1(1), only waste classified as Class A, B, or C shall be acceptable for near-surface disposal. Wastes shall be disposed of in accordance with the requirements of R313-25-25(4) through 11."*

In compliance with UAC R313-15-101, Energy*Solutions* has developed a Radiation Protection Program, which contains procedures and policies to ensure that occupational radiation exposures are controlled within the limits of UAC R313-15-201, UAC R313-15-207, UAC R313-15-208, and UAC R313-15-301. The Program also ensures that exposures are maintained as low as is reasonably achievable, in accordance with UAC R313-15-101(2). Energy*Solutions* integrates the principles of ALARA into all activities related to exposures of personnel.

7.1 OCCUPATIONAL RADIATION EXPOSURES

Energy*Solutions* has created an organizational structure and established personnel responsibilities and activities to ensure that ALARA policy and procedures are not compromised because of pressures from operational activities. In support of this position, ALARA principles are incorporated into facility operations, training, development of radiation protection procedures, and design reviews.

7.1.1 Policy Considerations

The objective of the Clive Radiation Protection Program is to ensure that all reasonable actions are taken to reduce radiation exposures and effluent concentrations to levels that are considered ALARA. Energy*Solutions'* ALARA management policy is detailed in the ALARA Program (catalogued in Appendix J). The organizational structure of the ALARA Program and the responsibilities of those involved in managing and implementing the ALARA Program are also included.

7.1.2 Design Considerations

The ALARA Program is based upon past and continuing experience with radiation operations. As new waste-handling procedures are developed, the ALARA Program is modified to reflect the changes. Specific guidelines for operational reviews and modifications to the ALARA Program are detailed therein.

7.1.3 Operational Considerations

The methods used to define the plans and procedures of the ALARA Program are detailed in the ALARA Program catalogued in Appendix J.

7.2 RADIATION SOURCES

The types and quantities of materials received at the Energy*Solutions* site are discussed in Appendix P. These materials are sources of external gamma radiation at various times: while in the delivery conveyances awaiting unloading; during storage; while being sampled and prepared for laboratory analysis; while being actively worked in the disposal cell or mixed waste treatment; and while exposed following disposal. Dose rate on packages can be in excess of 200 R/hr.

Wastes are also potential sources of internal exposure: during unloading at the rail car rollover or bulk unloading area; while being sampled and prepared for laboratory analysis; while being worked in the disposal cell or mixed waste treatment; and while exposed following placement in the embankment. Internal doses are not expected to exceed 50 mrem per year.

The nuclear density gauges used to test waste compaction are consistent sources of external radiation and result in quarterly doses of 10 – 20 mrem to workers who are using them.

7.2.1 External Gamma Radiation Exposure

The most consistent source of radiation dose at the Clive facility is external gamma radiation. In recognition of that, Energy*Solutions* has set an investigation level of 50 mrem per quarter deep dose equivalent. Typically, a small fraction of workers at Clive exceed that level each quarter. Several others, primarily the engineering staff, who work daily with a Troxler nuclear density gauge, receive doses of 10 to 20 mrem per quarter.

Control of external gamma exposures during waste handling operations is the primary method of reducing dose. Energy*Solutions* will continue to rely primarily upon time, distance and shielding to control employee exposure. Energy*Solutions* manages shipments under a radiation work permit (RWP) to keep doses ALARA.

Energy*Solutions* has an aggressive policy of dose minimization. Waste streams require the preparation of an RWP that lists the specific radiation protection requirements. Common requirements include clothing to be worn, the use of self-reading personal dosimeters (SRPDs), respiratory protection, and special monitoring requirements. Special situations may include requiring a health physics specialist to be present, the use of remote handling equipment, dust suppression requirements, air monitoring or survey requirements, stay times, or other controls needed to keep exposure ALARA. In addition, all workers are trained in ALARA principles, especially in maintaining their distances from gamma sources and spending the least amount of time necessary in gamma fields to get the job done.

Energy*Solutions* will continue to use standard health physics practices of limiting time in areas with higher gamma dose rates, using respiratory protection at low airborne radioactivity concentrations, covering higher activity wastes with lower activity wastes or clean soil to reduce gamma exposures and resuspension of airborne particulates, and routinely monitoring work area radiation levels to protect workers from chronic exposure from low level radiation sources; as well as applying the ALARA Plan catalogued in Appendix J to maintain worker doses ALARA.

All personnel entering the Restricted Area are required to wear radiation dosimeters at all times. Permanent employees are issued a TLD badge or equivalent, as approved by the Manager of Health Physics and Safety. These badges are exchanged quarterly or read as soon as practical upon termination of employment. Badges are selected that measure the skin dose equivalent (shallow dose) as well as the deep dose equivalent for compliance with UAC R313-15-203 and UAC R313-15-502and are worn in the proper place as instructed by the Manager of Health Physics and Safety. All badges, along with control badges, are maintained in designated areas at the Clive site when the employee is not at work.

Processing is done by a dosimetry processor holding accreditation from the National Voluntary Laboratory Accreditation Program of the National Institute of Standards and Technology appropriate for the radiation fields at the Energy*Solutions* site. It is not anticipated that the measurement of the shallow dose equivalent will be significant since the very weak beta radiations will be absorbed by the protective clothing of the employees as well as the relatively large thickness of the air between the personnel and the waste.

Should the Manager of Health Physics and Safety determine that it is necessary to measure the shallow dose rather than use a TLD, or equivalent devices, Energy*Solutions* will implement a procedure to calculate the shallow dose by applying a correction factor to the TLD, or equivalent reading(s). All exposures will be recorded when received from the dosimetry vendor to demonstrate compliance with the standards. In the event that an individual loses their TLD or equivalent, the Manager of Health Physics and Safety or his designee will investigate the potential exposure conditions and provide a record of the exposure.

All employees will notify their supervisor immediately upon discovery that a TLD or equivalent has been lost. A new dosimeter will be issued prior to the employee‘s reentry into the Restricted Area. When the Radiation Safety Officer determines that extremity monitoring is warranted, appropriate dosimeters will be obtained from the dosimetry vendor.

Because of the low radionuclide activities in the waste, there is little potential for a significant penetrating or non-penetrating external radiation dose from airborne radioactive material. The deep dose equivalent component of this small dose will be included in the employee's personal dosimeter reading. Energy*Solutions* allows visiting members of the public to access the Controlled and Restricted Areas of the site for tours, visits, and inspections. All visitors requiring access to the Restricted Area are provided dosimetry and an informational briefing appropriate for the expected hazards, and are accompanied by a responsible Energy*Solutions* radiation worker. Procedurally, visitors are not allowed in posted radiation areas or areas where respiratory protection is required. Individuals who are visiting the site on a limited basis will be issued a pocket dosimeter or other self-reading dosimetry to monitor their external gamma radiation dose. The dosimeter is read upon exiting the Controlled Area and recorded on the Access Log. In the case of individuals visiting as a group, one dosimeter may be used providing they stay together.

7.2.2 Internal Dose

Energy*Solutions* pursues a policy of dust prevention to keep airborne particulate radioactivity ALARA. However, as part of its ALARA Program, Energy*Solutions* requires all workers, in situations where they may be unknowingly exposed to airborne particulate radioactivity, to wear respiratory protection providing a protection factor of at least 10. With the combination of dust control and respiratory protection it is anticipated that internal doses will never exceed 50 mrem per year.

Radon daughter concentrations were continuously monitored during activities at both Clive and Salt Lake City Vitro site during removal and disposal of uranium mill tailings containing an average concentration of Ra-226 in excess of 500 pCi/g. Data reported by the Division for 1986 and 1987 showed quarterly integrated working levels to be less than 0.004 working level (WL) for all sites and monitoring periods. The DAC for radon daughter working levels is 0.33, or about two orders of magnitude greater than that actually measured. Energy*Solutions* has made occasional WL measurements and has never observed levels greater than those measured for the Vitro embankment.

Ambient air radon concentrations are continuously monitored at the environmental stations on and around the site. Outdoor radon measurements have not shown any definite elevations above background levels. Laboratory measurements, where samples are stored and prepared for analysis, show occasional concentrations approximately 0.5 pCi/l above ambient concentrations. This is less than two percent of the DAC for radon with daughters present.

The regulatory requirements for determining the occupational internal dose are in UAC R313-15-204. Energy*Solutions* uses the dose calculations methods described in Regulatory Guide 8.34, but uses data based on the updated Dose Conversion Factors of ICRP 68 in lieu of the ICRP 30 Dose Conversion Factors to perform these dose calculations. The chemical form of significant dose contributors are determined as needed from the waste manifests, air sample data, or other available sources of information. The applicable lung clearance class is determined from the tables in ICRP 68. If the chemical form of significant dose contributors cannot be determined, the most restrictive class is used in the dose assessment.

The indication provided by workplace air sampling guides the subsequent assessments of possible internal doses from inhaled radioactive materials. Regulatory Guide 8.34 provides several acceptable methods for determining internal doses from inhaled radionuclides. When necessary to calculate an employee‘s internal dose from inhaled radioactive material, Regulatory Guide 8.34 guides the dose calculations, with updated data based on the Dose Conversion Factors of ICRP Publication 68. When initial estimates indicate a potential dose equivalent in excess of 100 mrem (CDE or CEDE), additional evaluations are performed to further assess the dose and guide follow-up actions.

The ingestion of radionuclides at the Energy*Solutions* site is suppressed primarily by prohibiting eating and drinking inside Restricted Areas (with the exception that drinking from closeable beverage containers is allowed). In addition, the use of respiratory protection in the most highly contaminated areas minimizes the potential for facial contamination and subsequent ingestion of radioactive material.

Employees at the Energy*Solutions* Clive site are normally protected from intake through wounds and skin absorption by wearing protective clothing. Should an accident result in an open wound, the Radiation Safety Officer informs the attending physician of the fact for his guidance in effecting removal or reduction of the amount of radioactive material remaining in the wound. The Radiation Safety Officer then performs an investigation and estimates the intake using data from wound monitoring or other available information.

The CDE to any organ will be estimated using methods similar to those used in NCRP Report 111, ―Developing Radiation Emergency Plans for Academic, Medical or Industrial Facilities." August, 1991. Table 4.2 of NCRP Report 111 provides values of maximum committed dose equivalent to any organ for adults per unit intake. These were derived by taking the ICRP Publication 30 values for ingestion and dividing by the gut transfer factor f1. Energy*Solutions* uses a similar approach by estimating the radionuclide mixture and intake for each radionuclide, and calculating the CDE to each organ using appropriate f1 values and CDE per unit intake for each radionuclide of significance via the ingestion pathway, using the dose conversion factors of ICRP 68. Calculated CDEs will be compared to UAC R313-15-201. Additional efforts at reducing dose are based on total CDE and the potential for reducing the CDE through available means.

7.3 RADIATION PROTECTION DESIGN FEATURES

Energy*Solutions* has incorporated the design and operational experience of its other embankments into the design of this License's Embankment to minimize the potential for radiation exposures. As such, the Embankment design is directed toward reducing the occupational exposures.

7.3.1 Facility Design Features

The entire Embankment and LLRW disposal area is enclosed by a fence, and considered a Restricted Area. All personnel working in the Restricted Area are required to pass through an Access Control point and are required to adhere to the Access Regulations.

Access to exposure areas at the facility is controlled in accordance with the policies and procedures catalogued in Appendix J. All vehicles and personnel working in the Restricted Area are monitored for removable contamination prior to release.

7.3.2 Shielding

Energy*Solutions* employs the radiation exposure controls of time, distance and shielding, as appropriate. Waste receipts with dose rates in excess of 5 mrem/hr are controlled and posted as described in the Radiation Safety Program catalogued in Appendix J. Radiation Work Permits are used to control worker exposure during waste handling and include time controls or take advantage of natural shielding afforded by equipment as necessary and appropriate. Higher activity wastes are covered, except when being actively worked, by lower activity wastes to reduce exposures to workers in the area. For management of bulk wastes, the primary radiation control factors are time and distance. Conversely, the CWF uses portable shielding during the waste disposal process, as needed, to minimize dose to the workers. Additionally, the nuclear density gauges are stored away from active work areas and are shielded by lead bricks when in storage.

7.3.3 Ventilation

Since LLRW handling and disposal activities are generally conducted outdoors, no special ventilation provisions are made for those activities. However, laboratory areas require normal ventilation and hoods. Work area air samples are collected in the building to confirm the effectiveness of ventilation.

7.3.4 Area Radiation and Monitoring

External gamma radiation monitors (Rad Elec E-PERM ion chamber detectors) are used to document gamma radiation exposure levels. Weekly surveys of gamma dose rates and surface contamination are made according to Appendix M. Any areas meeting the definition of a Radiation Area are posted.

Airborne radioactive particulates are monitored on a continuous basis as described in Appendix M. The continuous airborne particulate samplers, operated on-site as part of the Environmental Monitoring Program, provide an overall average airborne radioactivity concentration. In addition to the fixed-location environmental stations, work-place samples are also collected to better assess potential exposure to employees. The work area air samplers are used at locations such as the rail car rollover, haul roads, the mixed waste treatment building, or near excavation, disposal and other work activities to collect workday samples. Work area samples are collected several times a week.

In addition to the passive environmental radon monitors used at all environmental monitoring stations, indoor radon concentrations are measured in the LLRW and Mixed Waste Operations buildings.

7.3.5 Equipment, Instrumentation, and Facilities

Health Physics instrumentation used for the Radiation Protection Program include a variety of portable and laboratory equipment selected to perform specific functions in monitoring of gross gamma exposure rates, surface contamination, alpha and beta radioactivity of filters and smear samples and personnel contamination. Instruments are calibrated, at a minimum every 12 months and are checked each working day for consistency of response to a known source.

7.4 RADIATION PROTECTION PROGRAM

Energy*Solutions*' Radiation Protection Program (catalogued in Appendix J) has been developed to establish Clive Facility requirements to receive, possess, process, use, transfer or dispose of licensed LLRW. Energy*Solutions* is committed to managing its operations involving exposure to ionizing radiation and radioactive materials by incorporating the philosophy that such doses should be ALARA. The Radiation Protection Program establishes the measures that management uses to ensure that appropriate regulatory requirements and policies, programs and procedures are met. The Radiation Safety Officer reviews Radiation Protection Program annually.

7.4.1 Respiratory Protection Program

A respiratory protection program has been implemented, based on ANSI guidance (ANSI, 2006). The program elements include employee training, quantitative fit testing, cleaning and maintenance, written standard operating procedure covering the program, medical surveillance, and recordkeeping. The Radiation Safety Officer is responsible for administering the Respiratory Protection Program.

7.4.2 ALARA

It is the policy of Energy*Solutions*, to maintain personnel/occupational radiation exposures ALARA. Because of the nature of LLRW, experience has shown that radiation exposures are normally low and Energy*Solutions* is committed to continuing to minimize exposures to the workers and the environment. The average annual dose for 294 workers involved in the Vitro Remedial Action Project during 1986 was 50 mrem, with maximum exposures of 250 mrem. This maximum value is only 5% of the radiation dose standard of UAC R313-15-1101. Energy*Solutions*‘ annual employee dose summary since 1992 is presented in Table 4-1. Procedures and methods to keep internal exposures ALARA include:

a. Dust suppression on all operational roads by application of water or other dust suppressant materials or methods (e.g., Magnesium Chloride) as necessary;

b. Speed limit of 25 mph on all site roads;

c. Stopping operations in high wind conditions (all operations cease at winds of greater than or equal to 35 mph; radiation safety personnel have authority to stop operations at lower wind speeds if dusting or other safety considerations warrant);

d. Weekly area radiation surveys with investigation of increasing levels to determine the cause;

e. Requiring workers to wear respirators in areas of potential high dust concentrations, for example, the rollover and selected heavy equipment operations;

f. Pre-planning tasks that have the potential for higher than normal exposures to limit exposures through efficient use of time and handling procedures; and

g. Reviews of new proposed Waste Profile Records to assure that Energy*Solutions*‘ procedures, facilities, and equipment are appropriate and sufficient to limit exposures to workers and the environment.

The Radiation Safety Officer has the day-to-day responsibility for maintaining occupational and environmental radiation exposures ALARA, consulting such guidance documents as NRC Regulatory Guides 8.31 (NRC, 2002a) and 8.37 (NRC, 1993a). The Radiation Safety Officer documents ALARA activities including:

a. Monthly reviews of work area, perimeter, and environmental air monitoring results noting trends and adjusting work procedures when practical to further reduce potential exposures; and

b. Monthly reviews of work area gamma-ray exposure rates and advising the Vice President and General Manager of Clive Operations on operational changes that will reduce radiation exposure.

An audit of ALARA activities is conducted and documented by the Radiation Safety Officer at least annually.

7.4.3 Surveys

All personnel working in the Restricted Areas are monitored for potential skin contamination each time they exit the area. Workers are advised to consider any measurable skin contamination as excessive, and all personnel must meet release criteria before they leave the Restricted Area. Energy*Solutions* has set ALARA limits for personnel contamination monitoring at 100 dpm/100 cm^2 gross alpha for skin and clothing, 300 dpm/100 cm^2 gross alpha for the soles of shoes, and 1,000 dpm/100 cm^2 gross beta for skin, clothing, and the soles of shoes. A hand and foot monitor, or equivalent, sensitive to both alpha and beta contamination are used for routine monitoring for personnel contamination.

Personnel are expected to accomplish any necessary decontamination by washing exposed areas of the skin with soap and water. If this does not reduce the levels below the criteria, the Radiation Safety Officer is notified and other attempts made. Special radiation decontamination cleansers may be used to reduce skin contamination levels as needed. Personnel with skin contamination above the limits are not allowed to leave the site without approval of the Radiation Safety Officer. All personal contaminated clothing or personal articles that cannot be decontaminated below the limits are retained at the site and managed as radioactive waste. All personnel contamination events are documented.

Routine external gamma surveys using a gamma scintillation survey meter are conducted in waste management and disposal. In addition, random external gamma surveys are performed during daily operations as considered necessary by health physics personnel.

Routine smear surveys for surface contamination are conducted in office and laboratory areas. The smears are analyzed for gross alpha and gross beta contamination. Smear samples are compared to previous samples from the same area. The Radiation Safety Officer reviews any increase in surface contamination, deciding on the need for decontamination. In keeping with Energy*Solutions'* ALARA goals, any increase in contamination is normally cleaned when found and the area re-sampled.

Routine worker evaluations demonstrate that it is extremely unlikely that any employee could receive a lung burden of radioactivity that would require any action. If such an event happens, the individual involved receives a whole-body count to evaluate the potential dose. Subsequent actions, such as reassignment to a function not involving radiation exposure are then considered.

A worker might also be injured in an accident that would result in the impaction of radioactive material into a wound. In such a case, Energy*Solutions* attempts to monitor injured employees before they are transported to medical care. In any case, the treating physician is informed that the injury involves possible radioactive contamination. Because the radionuclides involved are relatively insoluble, normal cleansing of the wound generally removes most, if not all, of the radioactivity. A radiation survey is used to estimate any remaining radioactivity and potential doses calculated. The determination of need for additional treatment is based on monitoring results.

Bioassay samples are used, as necessary, to help determine the body burden of any radioactivity that has resulted from an unusual inhalation or wound. Any employees who are believed to have received a TEDE of greater than 100 mrem from any source in one quarter are notified and assist in determining the source of the exposure and in finding a way to reduce future exposures.

Summation of external and internal doses is required in UAC R313-15-202 when both internal and external monitoring of an individual are required by UAC R313-15-502(1) and (2). The cumulative operating experience at the Clive site indicates that the monitoring criteria of UAC R313-15-502(1) and (2) are not likely to be exceeded. However, should Energy*Solutions* find that summation of occupational internal and external doses is necessary, one of the five methods for calculating the Committed Effective Dose Equivalent (CEDE), as described by NRC (NRC, 1992b), or an equivalent method, is used. ALI, DAC, and ECL values based on the ICRP 68 conversion factors will be calculated, as needed for internal dose estimation, following the methodology described in the notes to 10 CFR 20 Appendix B.

If any employee is anticipated to receive an occupational dose in excess of 10 percent of the occupational limits, Energy*Solutions* will determine the previous radiation exposure for use in limiting the annual dose equivalent to the allowable limits and for planning special exposures. Determination of prior occupational exposures will be done by:

1. Obtaining a written, signed statement from the employee or his most immediate employer, that discloses the nature and the amount of any occupational dose that the individual may have received during the current year; or

2. Obtaining or attempting to obtain from the employee's most recent employer, a written, signed statement in the form of an NRC Form 4 or an equivalent form, showing the life-time occupational exposure history. In case this cannot be done, the guidance in 10 CFR 20.2104 will be followed.

Energy*Solutions* does not anticipate authorizing planned special exposures since the radiation levels and radioactive constituent concentrations in LLRW are low. In the event that circumstances warrant a planned special exposure, Energy*Solutions* does so in full compliance with the guidance in UAC R313-15-206.

The annual occupational dose limits for minors are 10 percent of the annual dose limits specified for adults. However, in accordance with the Radiation Protection Program, minors are not granted access to the Restricted Area. Similarly, the dose limit to an embryo/fetus is 0.5 rem during the entire pregnancy (in accordance with UAC R313-15-208). Energy*Solutions*‘ policy is to inform female workers of the regulations regarding protection of the embryo/fetus and to ask them to inform Energy*Solutions* in writing, upon discovery or suspicion of a pregnancy. The Radiation Safety Officer reviews the work assignments and offers the woman the opportunity to take available positions in non-radiation areas for the duration of the pregnancy. If no positions are available, the Radiation Safety Officer counsels the individual to assure an understanding by the individual of the additional risks of continued employment. If the woman continues to work in the Radiation Area, the Radiation Safety Officer monitors the work assignments and activities to assure that the Total Effective Dose Equivalent (TEDE) to the embryo/fetus is ALARA and limited to 0.5 rem.

Operations are conducted such that the resulting dose equivalent to any individual members of the public is less than the limits of UAC R313-15-301, UAC R313-25, and the ALARA constraint of UAC R313-15-

101. Compliance with UAC R313-15-301 is demonstrated using the data acquired under the Environmental Monitoring Plan (Appendix M). Airborne particulate monitoring is performed to confirm those predictions.

The analysis addresses the specific impacts of releases under normal operating conditions. Release mechanisms were evaluated, exposures to workers and the public assessed, and the results compared to applicable standards and regulations. It was concluded that with the proposed waste characteristics and operating procedures, exposures to the workers and the public will be within acceptable limits and the design limits the radon flux to less than 20 pCi/m^2/s as provided in 10 CFR Part 40, Appendix A.

7.4.3.1 Work place radiological air monitoring

Energy*Solutions'* Clive facilities are operated in accordance with Energy*Solutions*' Air Approval Order, which requires Energy*Solutions* to apply dust suppression when minimum waste moisture conditions as well as optimum air opacity standards do not exist. Air is continuously sampled at work place locations surrounding the Embankment, Restricted Area, and the Clive Facility. Individual results with a net alpha or net beta concentration above the applicable Particulate Air Sample Action Level are also analyzed by gamma spectroscopy. Gamma spectroscopy analysis results are reviewed to determine if any additional actions need to be taken. Air is also continuously sampled for radon using Landauer RadTrak® Dosimeters.

7.4.3.2 Weekly routine surveys

The following items are surveyed each week,

- Site warning signs must be visually checked weekly to determine that the signs are present, visible and legible.

- The supply of personal protection equipment is inspected weekly to ensure that each employee has a proper supply or access to gloves, boots, coveralls, hard-hat, goggles, and respiratory protection.

7.4.3.3 Daily work area surveys

The daily BAT inspection includes:

- **Check roads**. The inspector must drive the access and facility roads to visually inspect them for deterioration, erosion and evidence of spills;

- **Loading and Unloading Areas**. Visually inspect the loading and unloading areas. Note stains, residues, and any evidence of a spill or leak;

- **Container storage area**. The container storage area must be inspected for evidence of a spill; and

- **Inspect containers.** The inspector visually inspects the exterior surface area for evidence of leaks, corrosion, deterioration, holes, bulges, and poorly fitting lids.

Daily BAT inspections are to be performed each day that the facility is in operation. Problems are corrected accordingly:

- Problems that pose an imminent threat to human health or the environment are corrected as soon as possible but no later than 24 hours from the time of discovery;
- Problems that do not pose an imminent threat to human health or the environment are corrected within 72 hours of discovery; and
- If a longer time period is required to correct the problem, Energy*Solutions* notifies the Division prior to the end of the 72-hour period. At the time of notification, Energy*Solutions* proposes a time schedule for correcting the problem. The Division must approve the correction schedule.

The daily security inspection includes:

- **Check fences**. The inspector must inspect the site security devices (fences, gates, doors, and locks) to check for items such as proper functioning, breaks, gaps, erosion, vandalism or damage to the fence fabric, fence posts, gates, etc. The inspector must also check the gates and doors to ensure that the gates and doors are locked or attended by a person assigned to control entry; and
- **Check communication systems**. The inspector performs an audio test on the external communication system (telephone) by ensuring that dial tone exists and that the phone is operational. This test may be conducted by placing and completing a telephone call. The inspector tests the internal communication system (two-way radios, intercom, etc.) by operating the system and achieving communication through the system.

The facility is considered to be in operation in the following instances:

- When off-site shipments have been received to the facility;
- When waste is being added to or removed from the Embankment; or
- When LLRW containers are being added to or removed from the storage area.

7.4.3.4 Conveyance and equipment release surveys

All equipment, conveyances, railcars, and vehicles exiting the Restricted Area must be monitored, decontaminated if necessary, and released before leaving the Restricted Area. Designated Commercial transports for the exclusive use of waste transport may be released from a Restricted Area as long as the 49 CFR criteria are met. Entrances into parts of the Restricted Area that are not expected to be contaminated under routine conditions may not require equipment (vehicles, cement trucks, haul trucks, etc.), personnel or personal item decontamination. These areas include but are not limited to areas of new construction inside the Restricted Area, unloading docks, and areas in which embankment closure is being performed inside the Restricted Area.

Depending on individual circumstances, vehicles or equipment leaving the site are surveyed in accordance with the unrestricted use of release criteria or to the standards of the DOT release. Unrestricted use release entails decontamination and release to the standards of 49 CFR 173.443. All vehicles, packages, equipment, or other items leaving the Restricted Area, except conveyances used for commercial transport of radioactive waste material, are unrestricted use released.

Closed trucks and rail cars used exclusively for transport of radioactive materials are released as described in Table 7-1, measuring the removable contamination on the exterior surfaces only. Transport vehicles that are being released from exclusive use service will be released as described above, measuring removable contamination on both exterior and interior surfaces. Closed containers used solely for the transportation of radioactive materials may be released as described in Table 7-1, provided that the radiation level at any point on the external surface of the container does not exceed 0.5 millirem per hour:

a. The non-fixed (removable) radioactive surface contamination on the external surface of the container does not exceed the limits of Table 7-1;

b. The container does not contain more than 15 grams of U-235, the container is in unimpaired condition and is securely closed so that there will be no leakage of radioactive material under conditions normally incident to transportation;

c. Internal contamination does not exceed 100 times the limits of the table above; and

d. Any labels previously applied are removed, obliterated, or covered and the ―Empty" label prescribed in 49 CFR 172.450 and the notices are affixed to the container.

Regardless of the type of release, all items must be visibly clean, meaning that all potentially contaminated material that can be removed by a broom, shovel or other tool must be removed. Typical road dust and grime that is on a vehicle as it arrives and is not part of the radioactive waste material being carried does not have to be removed. Trucks, rail cars or reusable containers hauling waste to Energy*Solutions* are released to the DOT standards of 49 CFR 173.443, as set forth in Table 7-1, below.

Documentation of release surveys are kept in the operating record, including item identification number, item type, instruments used, survey results, surveyor's signature, and reviewer's signature. A Radiation Safety Technician performs the release survey and signs the completed form. As a quality control check, a second Radiation Safety Technician signs the completed forms daily after reviewing them for completeness and adherence to release policy. Release of waste conveyances may be performed remotely using field measurements.

Contaminated equipment or vehicles may be decontaminated using brooms, shovels, high pressure water, or other effective means. The waste water is allowed to drain into tanks and transferred to permitted evaporation ponds. In accordance with the GWQDP, wastewater may also be used for dust suppression on the Embankment.

Table 7-2 summarizes surface contamination levels of equipment, clothing, and personnel to be released without restriction from the Restricted Area

TABLE 7-1

REMOVABLE EXTERNAL

RADIOACTIVE CONTAMINATION - WIPE LIMITS

Contaminant	Maximum permissible limits	
	µCi/cm^2	**dpm/cm^2**
Beta-gamma emitting radionuclides; all radionuclides with half-lives less than ten days; natural uranium; natural thorium; uranium-235; uranium-238; thorium-232; thorium-228 and thorium-230 when contained in ores or physical concentrates.......................................	10^{-5}	22
All other alpha emitting radionuclides.........................	10^{-6}	2.2

Each transport vehicle used for transporting radioactive materials as an exclusive-use shipment... shall be surveyed with appropriate radiation detection instruments after each use. A vehicle shall not be returned to service until the radiation dose rate at each accessible surface is 0.5 millirem per hour or less, and there is no significant removable (non-fixed) radioactive surface contamination as specified in the above table, (49 CFR 173).

Table 7-2

Surface Contamination Levels of Equipment, Clothing, and Personnel

to be Released Without Restriction From the Restricted Area

Column I	Column II	Column III	
Nuclide [a]	**Average** [b,d,f]	**Maximum** [b,d,f]	**Removable** [b,e,f]
U-nat, U-235, U-238, and associated decay	5,000 dpm alpha/100 cm^2	15,000 dpm/100 cm^2	1,000 dpm/100 cm^2 products
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100 dpm/100 cm^2	300 dpm/100 cm^2	20 dpm/100 cm^2
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000 dpm/100 cm^2	3,000 dpm/100 cm^2	200 dpm/100 cm^2
Beta-gamma emitters (nuclides with decay modes other than alpha emissions or spontaneous fission) except Sr-90 and others noted above	5,000 dpm beta-gamma/100 cm^2	15,000 dpm beta-gamma/100 cm^2	1,000 dpm beta-gamma/100 cm^2

a. Where surface contamination by both alpha and beta-gamma emitting nuclides exist, the limits established for alpha and beta-gamma emitting nuclides should apply independently.

b. As used in this Table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

c. Measurements of average contaminant should not be averaged over more than one square meter. For objects of less surface area, the average should be derived for each object.

d. The maximum contamination level applies to an area of not more than 100 cm^2.

e. The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping the area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

f. The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters shall not exceed 0.2 mrad/hr at 1 cm and 1.0 mrad/hr at 1 cm, respectively.

7.4.4 Training Program

Energy*Solutions'* Training Program is designed to educate the employees in the fundamentals of handling radioactive materials, to provide information on ways of minimizing exposure, and to inform employees of practices and programs aimed at preventing possible spread of contamination. During this training, procedures and precautions are explained and the trainees are required to complete a written or computer based examination. In addition to the above training, all Energy*Solutions* site employees receive periodic refresher training. This training is tailored to the specific employee needs and duties and covers such topics as general occupational safety, radiological safety, and training on any specific items such as new procedures or safety deficiencies.

The Training Program is operated under the direction of the Radiation Safety Officer. Radiation safety training is provided to all persons before they are allowed to enter the Restricted Area. The amount of radiation safety training required for persons to enter the Restricted Area is related to the activities for which the person will enter the Restricted Area. There are three categories of Restricted-Area functions:

1. <u>Permanent Employee</u>. A “*Permanent Employee*” is an employee of Energy*Solutions* hired for a period longer than 20 days, or a long-term employee of a contractor to Energy*Solutions*;

2. <u>Temporary Worker</u>. A “*Temporary Worker*” is a service contractor (electrician, welder, consultant, surveyor, driller, sampler, engineer, fence installer, forklift operator, laborer, mechanic, liner installer, excavator, etc.) who works inside the Restricted Area under a contract or service order but who is not an employee on the payroll of Energy*Solutions* or a long-term contractor performing work inside the Restricted Area; and

3. <u>Visitor</u>. A “*Visitor*” is a person whose main interest inside the Restricted Area is to communicate with personnel in the Restricted Area, to observe and/or inspect the operations, facilities, programs, location and compliance at the site. Examples of visitors are compliance inspectors, visiting dignitaries, representatives of organizations and corporations, tour groups, and associates of the above. Most visitors will be required to be in the presence of a qualified escort while in the Restricted Area. Certain visitors, such as compliance inspectors or auditors will not require escorts.

Training requirements have been established for each category. Refresher training is provided to review and update training information. Radiation Safety training is directed by the Radiation Safety Officer. The training includes the following items and topics:

- radioactive nature of the material being handled;
- fundamentals of handling radioactive materials;
- ionizing radiation and biological effects;
- radiation safety standards, principles and procedures;
- emergency procedures;

- methods of radiation protection; and
- a written or computer based examination.

Records of training attendance and a copy of the examination provided are maintained by Energy*Solutions*.

7.4.5 Personnel Monitoring

All personnel entering the Restricted Area are required to wear radiation dosimeters at all times. Permanent employees are issued a TLD badge or equivalent, as approved by the Manager of Health Physics and Safety. Badges are exchanged quarterly or read as soon as practical upon termination of employment. They are selected to measure the skin dose equivalent (shallow dose) as well as the deep dose equivalent for compliance with UAC R313-15-203 and UAC R313-15-502 and are worn in the proper place as instructed by the Manager of Health Physics and Safety. All badges, along with control badges, are maintained in designated areas at the Clive site when the employee is not at work.

All employees will notify their supervisor immediately upon discovery that a TLD or equivalent has been lost. A new dosimeter will be issued prior to the employee‘s reentry into the Restricted Area. When the Radiation Safety Officer or designee determines that extremity monitoring is warranted, appropriate dosimeters will be obtained from the dosimetry vendor.

All visitors requiring access to the Restricted Area are provided dosimetry and an informational briefing appropriate for the expected hazards, and are accompanied by a responsible Energy*Solutions* radiation worker. Procedurally, visitors are not allowed in posted radiation areas or areas where respiratory protection is required. Individuals who are visiting the site on a limited basis will be issued a pocket dosimeter or other self-reading dosimetry to monitor their external gamma radiation dose. The dosimeter is read upon exiting the Controlled Area and recorded on the Access Log. In the case of individuals visiting as a group, one dosimeter may be used providing they stay together.

7.4.6 Change Facilities

Locker rooms are provided for employees to change shoes, put on coveralls and decontaminate. The locker room is equipped with showers, a washbasin, and lockers for personal items.

7.4.7 Personnel Contamination Monitoring

The use of protective clothing minimizes any potential skin contamination. However, monitoring is required for all persons before they leave the access control area. Personnel Contamination Monitors such as the IPM-9 and hand and foot monitors, alpha scintillation detectors, or GM pancake probes are used for routine monitoring of potential contamination of personnel.

Release limits for skin and clothing are based on the removable and fixed contamination limits specified in Regulatory Guide 1.86. The great majority of alpha-emitting nuclides in the LLRW are uranium and natural thorium with its decay products. For those nuclides, the appropriate alpha release limit for skin and clothing is 1,000 dpm/ 100 cm^2. Similarly, the removable limit for beta/gamma-emitting nuclides is 1,000 dpm/ 100 cm2. Energy*Solutions* also uses this level as the release limit for contamination of skin and clothing by beta/gamma-emitters. Regulatory Guide 8.30 recommends the use of fixed contamination limits for the soles of shoes. Following this example, the release limit for the soles of shoes has been set at 5,000 dpm/ 100 cm^2 for both alpha and beta/gamma activity.

Energy*Solutions* has set an ALARA goal for alpha-emitting radionuclides on the skin and clothing at 100 dpm/ 100 cm^2. Because of the high natural backgrounds associated with beta/gamma monitors, the ALARA goal is the same as the release limit for beta/gamma emitters - 1,000 dpm/ 100 cm^2. The ALARA goal for contamination of the soles of shoes is set at 500 dpm/ 100 cm^2 alpha and 1,000 dpm/ 100 cm^2 beta/gamma.

7.4.8 Control of Contamination of Personnel

Contamination of personnel in the Restricted Area is controlled through the use of protective clothing, access control, atmospheric monitoring, and bioassay analysis. Protective clothing is selected according to the requirements of the Safety and Health Manual. Each employee is responsible to keep contaminated clothing and other material inside the Controlled Area. Furthermore, access to the Restricted Area is controlled according to Standard Operating Procedures. While in the Restricted Area, engineering controls and dust suppression techniques are used to minimize levels of airborne particulates. Work area air samples are routinely collected and analyzed.

All monitored individuals are required to participate in a bioassay program to assist in evaluating internal deposition of radionuclides. A baseline sample is taken either through urinalysis or use of a whole body counter at the beginning of the monitoring period. A termination sample is taken whenever possible either through urinalysis or use of a whole body counter. All in-vivo baseline and termination samples are analyzed by gamma spectroscopy for naturally occurring radioactive material, including uranium and Ra-226. Urine samples are analyzed for total uranium and Ra-226. Energy*Solutions* evaluates laboratory bioassay analysis results in accordance with NRC Regulatory Guide 8.9 (NRC, 1993b).

For monitored individuals, a combination of air sampling, personnel contamination monitoring, and bioassay sampling are used to initiate action levels and assess dose intakes and/or uptakes. The radiation safety staff is responsible for taking appropriate actions when certain action levels are exceeded. In accordance with NRC Regulatory Guide 8.9, the action levels for monitored individuals working directly with the waste are:

> <u>Evaluation Level</u>: If internal bioassay measurements indicate that an intake is greater than an intake of 0.02 ALI, additional available data, such as airborne measurements or additional bioassay measurements, should be used to obtain the best estimate of actual intake.
>
> <u>Investigation Level:</u> If a potential intake exceeds an investigation level of 0.1 ALI, multiple bioassay measurements and an evaluation of available workplace monitoring data will be conducted.

Special bioassay sampling is done for individuals involved in an incident determined by the Radiation Safety Officer as having the potential for a significant intake of radionuclides in accordance with the established action levels. Appropriate samples are collected on a periodic basis until activities are below the minimum detectable levels or a determination is made that continued monitoring is not necessary. If the waste contained high Th-232 concentrations, lung or whole-body counting techniques may be employed to measure deposition in the body.

Specific bioassay sampling is also used on a periodic basis for individual personnel working in areas with an elevated potential of intake. The potential of an intake is evaluated by review of air sampling results, work practices, and pre-operational modeling.

Excretion models are used along with waste characterization data, bioassay data, and operational data to estimate the radionuclide intake and the resultant dose to the organs. Methods recommended by NCRP are used (NCRP, 1987). The guidance of UAC R313-15-201 is followed in cases where significant organ doses or Total Effective Dose Equivalents are found.

The worker exposure pathway for radionuclides under normal operations is via the inhalation pathway. Routine chronic exposure to radionuclides is limited by dust control measures and use of respiratory protection. However, to check the adequacy of these measures, in vivo or in vitro methods may be employed periodically, as determined by the Radiation Safety Officer or designee, to assure that intakes are a small fraction of the regulatory limits.

The radiation safety staff under the direction of the Radiation Safety Officer are responsible for selecting appropriate methods, properly assessing dose intakes and reporting the intakes.

7.4.9 Industrial Hygiene

The Radiation Safety Officer directs the Radiation Safety and Health Program. In addition, an Independent Industrial Hygienist conducts quarterly industrial hygiene audits.

7.4.10 Organization

The organization of the Radiation Protection Program and the responsibilities of each position within that organization are summarized in the Organization Plan (McCandless, 2012c). Additionally, specific ALARA responsibilities are defined in the procedure catalogued in Appendix J.

SECTION 8. CONDUCT OF OPERATIONS

Energy*Solutions'* corporate level management and technical organizations provide the technical resources to support site characterization, facility design, construction, testing, and operation. Energy*Solutions* corporate organization and technical staff also provide support for safe facility operation, closure, and post-closure activities.

8.1 ORGANIZATIONAL STRUCTURE

Detailed requirements and qualifications for significant organizational positions are described in the Organization Plan (McCandless, 2012c).

8.2 QUALIFICATIONS OF APPLICANT

Detailed requirements and qualifications for significant organizational positions are described in the Organization Plan (McCandless, 2012c).

8.2.1 Qualification of Radiation Safety Officer

Detailed requirements and qualifications for the Radiation Safety Officer are described in the Organization Plan (McCandless, 2012c).

8.2.2 Qualification of Assistant Radiation Safety Officers and Radiation Engineers

Detailed requirements and qualifications for the Assistant Radiation Safety Officer and Radiation Engineers are described in the Organization Plan (McCandless, 2012c).

8.2.3 Qualification of Radiation Safety Technicians

Detailed requirements and qualifications for the Health Physics (Radiation Safety) Technicians are described in the Organization Plan (McCandless, 2012c).

8.3 EMERGENCY AND CONTINGENCY PLAN

Energy*Solutions'* Emergency Response Plan is catalogued in Appendix J. This Plan establishes requirements to protect personnel and the environment in the event of an explosion, a fire, or an unplanned release to the environment. In addition to Energy*Solutions* Clive staff, the Emergency Response Plan also applies to contractors and visitors at the Clive facility.

Notification of the implementation of the Emergency Response Plan is transmitted on the Emergency Channel or EMT Channel of the Site Radio System and following the protocol established for emergency announcements on the mobile phone system. Emergency communication lists are established as follows:

- Emergency Coordinators and Site Managers: Notifications are made via Assigned Mobile Phone and/or e-mail to this distribution list.
- Facility EMTs First Responders and Ambulance Drivers: Notifications are made to Assigned Mobile Phones.
- Spill Response Team Members: Notifications are made to Assigned Mobile Phones.
- Facility Leads: Notifications are made to Assigned Mobile Phones (also include e-mail).
- All facility personnel: Notifications are made to group-assigned radios.

A radio group has been established for all facility EMTs. A radio compatible with transmission between facility EMTs is also maintained in the security office and on the facility ambulance. Prior to the beginning of each week the following responsibilities are assigned to qualified personnel:

- Emergency Coordinator
- EMT Leads
- Spill Response Team Leads

These designations are communicated in a weekly coordination meeting among the site management. An ambulance driver is also specified.

Leaking shipments of LLRW are managed and reported in accordance with the requirements found in the License. If the initial identifier observes liquids draining from a waste container or conveyance, the initial identifier contacts Security and implements the emergency response plan.

If the Spill Response Team Leader or Emergency Coordinator is unable to determine the source of the liquid, they must direct action to be taken to control the leaking liquid and move the container into the restricted area (if outside) so that further evaluation can be done to determine the source. The period of time for evaluation will not exceed twenty four hours.

If the Spill Response Team Leader or Emergency Coordinator determines that the liquid is potentially contaminated by means of analytical (pH, radiation detection, etc.) or visual (obvious container integrity breach, free liquids present inside the waste package, etc) observation, the Division will be notified of the incident within 24 hours.

At a minimum, measure the pH of the potentially contaminated liquid and record result(s) on 24 Hour/5 Day Spill Notification Report. Liquid grab sample(s) for radiological analysis may be taken if at least 500 ml of volume is collected.

Surface swipe for radiological or chemical analysis may be performed to identify contamination. All samples submitted to the lab require a Chain of Custody. All reviewed analytical data and Chain of Custodies are attached to the 24 Hour/5 Day Spill Notification Report.

8.4 REVIEW AND AUDIT OF FACILITY OPERATIONS

Energy*Solutions'* program for facility review and audit is managed by the Quality Assurance Department. The Quality Assurance procedures are catalogued in Appendix J. Audits and surveillances are performed in accordance with applicable procedures catalogued in Appendix J.

The Quality Assurance Manual also delineates the facility operations staff's review of operational activities, the independent review of facility operations, and the independent assessment of activities pertaining to safety enhancement. The Manual also addresses the following specific information:

1. The functioning of the onsite organization with respect to the review of proposed changes to systems or procedures and of unplanned events that have operational safety significance, including subject matter to be reviewed, organizational provisions for conducting the reviews, and the documentation and reporting of review activities;

2. The procedures and organization used to evaluate safety-related operational activities independent of the operating organization, including how and when such a program is to be implemented, subject matter to be reviewed, organizational provisions for conducting the review, and the documentation and reporting of review activities; and;

3. The provisions to perform independent reviews and assessments of facility activities, including the functions of the review group, organizational provisions for conducting the activities, and the documentation and reporting of these activities.

8.5 FACILITY ADMINISTRATIVE AND STANDARD OPERATING PROCEDURES

The provisions of Energy*Solutions'* facility administration and operating procedures are cataloged in the Organization Plan (McCandless, 2012c); and Appendix J (Standard Operating Procedure Catalogue), and C (CQA/QC Manual).

8.6 PHYSICAL SECURITY PLAN

The Site's physical security is managed by the site security procedures (as catalogued in Appendix J) and the Site Radiological Security Plan (Appendix F), which establish a barrier and a means to control entry to accomplish the requirements of site security. Additional measures are also identified for specific waste access areas within the Bulk Waste Facility. The Plan and procedures introduce a multi-layer security model containing specific security controls for site access, Restricted Area boundary, and overall waste access. This plan applies to all personnel who access Energy*Solutions'* facilities. The Plan and procedures further define those subjects and locations germane to physical security, responsible individuals for the implementation and requirements for site security. Security requirements are separated into three general areas:

1. Site Access Boundary Controls: This area addresses population flow control into and out of the Site. It includes security measures in place at the entrance gate to the facility and information electronically gathered from individuals who badge into and out of the Site.

2. Restricted Area Access Controls: All personnel and equipment enter and exit the Restricted Area through designated Access Control Points monitored by Health Physics personnel.

3. Waste Access Area Control: Security personnel perform daily random security searches on personnel and vehicles accessing these areas. The railcar rollover and intermodal unloading facility are monitored by security personnel, security cameras, or qualified access control personnel. Access to Mixed Waste treatment facilities is monitored by health physics personnel.

8.7 RECORDS KEEPING AND RECORD RETENTION

Retention of radiation safety records demonstrates the effectiveness of the Clive Facility Radiation Protection Program (catalogued in Appendix J). The work force and management are required to use records to document radiation safety afforded to personnel on-site. Records of the Radiation Safety Program are required to support worker health studies and future disputes or claims. Therefore, these electronic records are high quality, readily retrievable and managed until license termination. Hardcopy records are retained in accordance with the prescribed retention policy. Records are handled such that personal privacy is protected.

Documentation of completed operational inspections is maintained electronically in the site operating record for a minimum of three years from the date of the inspection. Hardcopy records are retained in accordance with CL-QA-PR-005, *Quality Assurance Records* (as catalogued in Appendix J).

The following information is maintained and electronic records retained until the Division terminates the License:

- Results of surveys, measurements, and calculations used to determine individual occupational dose from external and internal sources;
- Results of air sampling, surveys, and bioassays;
- Records or the results of measurements and calculations used to release material and equipment from restricted areas or evaluate the release of effluents to the environment;
- NRC Form 4 or equivalent;
- Personal dose records;
- Dose records to members of the public required to demonstrate compliance;
- Provisions of the Radiation Safety Program; and

- Records of the disposal of licensed or registered materials.

Hardcopy records are maintained and retained in accordance with CL-QA-PR-005, *Quality Assurance Records,* (as catalogued in Appendix J).

The following electronic records are maintained until License termination. Hardcopy records are retained in accordance with CL-QA-PR-005, *Quality Assurance Records,* (as catalogued in Appendix J):

- Results of equipment calibrations and receipt of radioactive material;
- Results of audits and other reviews of program content and implementation;
- Records used in preparing NRC Form 4;

Hardcopy records will be maintained and retained in accordance with CL-QA-PR-005, *Quality Assurance Records,* (as catalogued in Appendix J).

Radiation Safety records include the following:

- Company name, specific location, function and process;
- Signature or other identifying code of the preparer and date;
- Legible entries in black/blue ink; and
- Corrections identified by a single lineout, initialed and dated.

Additionally, the Radiation Safety Officer maintains a file of names, signatures and initials for future identification of the person who signed or initialed a record. Radiation Safety records do not include:

- Opaque substances for corrections; and
- Non-standardized terms or shorthand.

Units are clearly indicated for all quantities entered in records. Units used to denote radiological dose, exposure or contamination include curie, rad, becquerels, rem (including multiples of subdivisions of these units) and dpm. Working Level concentration units are presented in units of some multiple of curie per (multiple of) grams or liters.

A clear distinction is made among the quantities entered on the records required by Clive‘s Facility Radiation Protection Program (e.g. TEDE, SDE, DDE).

For each employee who enters the Clive Facility Restricted Area and is likely to have received in a year an occupational dose requiring monitoring, Clive management:

- Determines the occupational radiation dose received during the current year; and
- Attempts to obtain the records of lifetime cumulative occupational radiation dose.

Clive management may also:

- Accept as a record of the occupational dose that the individual received during the current year, a written signed statement from the individual, or from the individual's most recent employer for work involving radiation exposure that discloses the nature and the amount of any occupational dose that the individual may have received during the current year;
- Accept, as the record of lifetime cumulative radiation dose, an up-to-date NRC Form 4, or equivalent signed by the individual and countersigned by an appropriate official of the most recent employer for work involving radiation exposure, or the individual's current employer (if the individual is not employed by Energy*Solutions*); and
- Obtain reports of the individual's dose equivalent(s) from the most recent employer for work involving radiation exposure, or the individual's current employer (if the individual is not employed by Energy*Solutions*) by telephone, electronic media, or letter. Energy*Solutions* may request a written verification of the dose data if the authenticity of the transmitted report cannot be established.

Clive management records the dose history, as required on NRC Form 4 or other clear and legible record, of all the information required on the form. The form or record shows each period in which the individual received occupational dose to radiation or radioactive material. For each period for which Clive management obtains reports, Clive management uses the dose shown in the report in preparing NRC Form 4. For any period in which Clive management does not obtain a report, Clive management places a notation on NRC Form 4 indicating the periods of time for which data are not available. Records of all employees whom monitoring was required and records of doses received during planned special exposures, accidents, and emergency conditions include, when applicable:

- DDE, EDE, SDE to the skin, and SDE to the extremities;
- The estimated intake or body burden of radionuclides;
- The CEDE assigned to the intake or body burden of radionuclides;
- Specific information used to calculate the CEDE ;
- The TEDE when required; and
- The total of the DDE and the ODE to the organ receiving the highest total dose.

Personal dose records are updated at least annually. Personal dose records are maintained on NRC Form 5 or in clear and legible records containing all the information required by NRC Form 5. Electronic records are maintained until license termination. Hardcopy records are maintained in accordance with the CL-QA-PR-005, *Quality Assurance Records*, (as catalogued in Appendix J).

Required personal dose records are protected from public disclosure. Records of dose to an embryo/fetus are maintained with the dose to the declared pregnant woman. Declarations of pregnancy, including the estimated date of conception, are also kept on file. Radiation dose records contain information sufficient to identify each person, or employee number.

Additionally, Energy*Solutions* does not anticipate authorizing planned special exposures at the Clive facility. However, in exceptional situations, Energy*Solutions* employees may receive doses (planned special exposures) separate from and in addition to the annual occupational dose limits. All such planned special exposures must:

1. Receive prior written authorization from the Business Group President and the Corporate Radiation Safety Officer; and

2. Comply with all Federal or State regulations.

Pre-employment medical records, if available, and reports of periodic medical examinations are maintained. Physical examination reports and fit testing results for respirator are maintained for respirator users. Medical evaluations and treatment performed in support of the Radiation Safety program are documented. Maintenance of employee non-occupational radiation dose records for therapeutic or large amounts of diagnostic radiation doses for medical purposes is also included in Clive‘s Facility Radiation Protection Program.

Records of training and qualification are electronically maintained until license termination to demonstrate that a person received appropriate information to perform the work assignment in a safe manner. Hardcopy records are retained in accordance with the prescribed retention policy. Qualification standard records are retained for classroom, on-the-job, and practical factor training. Formal records of training and qualification are readily available to first-line supervision and management of involved personnel to aid in making work assignments. At a minimum, these records include the following:

- Course title;

- Attendance sheets with instructor‘s name;

- Employee‘s name and signature;

- Date of training;

- Documentation related to exceptions for training requirements and extensions of qualification;

- Quizzes, tests, responses and acknowledgments of training, with the date and signature of the person trained; and

- Special instructions to female workers concerning prenatal radiation dose acknowledged by the worker's signature.

Records are retained for the following types of training:

- Visitor Orientation;
- Radiation Worker Safety Training;
- Radiation Safety Technician Training;
- Periodic retraining;
- Respiratory Protection Training;
- Hazardous Waste and OSHA training;
- Instructor training;
- Qualifications for special tests or operations;
- Training of emergency response personnel;
- ALARA Training; and
- General Employee Training.

The following instructional materials are maintained:

- Course name, with revision and approval date;
- Instructor's manuals, course content, handouts, or lesson plans containing topical outlines;
- Video and audio instructional materials, include the dates and lessons for which they were used; and
- Job-specific training documents.

Terminating employees are provided a report that summarizes radiation dose for the total monitoring period at the reporting facility either:

1. upon receipt of a signed request at the time of termination, or
2. upon receipt of a signed request from the Radiation Safety Officer, or

3. on or before April 30 of the year following termination.

The most recent monitoring result estimate of dose is also provided at the time of termination, with a clear indication that it is an estimate with a formal record to follow within 30 days after final dose determination. If a written request has been received and all doses are final, a record is provided to the affected individual or requesting facility within 30 days of receipt.

For visitors and temporary radiation workers entering an area where radiation monitoring is required, the following records are maintained:

- Documented completion of Visitor or Temporary Radiation Worker Orientation;
- Any additional training given by Clive management to gain access into the Restricted Area; and
- Radiation dose records, including zero dose.

Electronic records are retained until license termination. Hardcopy records are maintained in accordance with the prescribed retention policy. Records are maintained sufficient to demonstrate compliance with the dose limit for individual members of the public.

Electronic records of ALARA plans and goals are maintained until license termination to demonstrate the adequacy of the ALARA Program. Hardcopy records are maintained in accordance with the prescribed retention policy.

Records of quality assurance reviews and audits developed for Radiation Safety functions are electronically retained until license termination if dosimetry related and a minimum of five years for all others to ensure that sufficient records are specified, prepared, reviewed, approved and maintained to accurately reflect completed work. Hardcopy records will be maintained in accordance with the prescribed retention policy.

The Radiation Safety program requires the performance of radiation, airborne radioactivity, and contamination surveys to determine existing conditions in a given location. Maps with sufficient detail to permit identification of original survey and sampling locations are maintained. Records should contain sufficient detail to be meaningful even after the originator is no longer available. Radiological surveys are recorded on standard forms and include the following common elements:

- Date and purpose of the survey;
- General and specific location of the survey;
- Name and signature of the surveyor and analyst;
- Pertinent information needed to interpret the survey results; and
- Reference to a specific Radiation Work Permit if the survey is performed to support the permit.

Radiation surveys also include, at a minimum:

- Instrument model, calibration date, and serial number; and
- Results of the measurements of area dose rates.

Records of airborne radioactivity measurements include, at a minimum:

- Sampler location identifier and laboratory counting instrument model, serial number, calibration date, and efficiency;
- Airborne radioactivity concentrations in general airborne areas and breathing zones; and
- Supporting parameters, flow rate, duration of sampling, correction factors and filter medium.

Records of contamination surveys include, at a minimum:

- Model and serial number of counting equipment;
- Contamination levels (using appropriate units) and supporting parameters including counting efficiency, counting time, correction factors, type of radiation, and whether the contamination was fixed plus removable or removable;
- Location of areas found to contain hot particles or high concentrations of localized contamination; and
- Follow up survey results for decontamination processes cross-referenced to the original survey.

Electronic records of calibration and periodic operational checks of fixed, portable, and laboratory radiation measuring equipment are maintained until license termination and include frequencies, method, dates, person performing calibration and calibration sources numbers. Only National Institute of Science and Technology or other acceptable standards are used for calibration. Hardcopy records are maintained in accordance with the prescribed retention policy. Calibration records are maintained for the following equipment:

- Portable survey instruments;
- Bioassay measurement equipment;
- Laboratory, counting room and fixed radiation measuring equipment;
- Process and effluent monitors and sampling equipment;
- Radiation area monitors;

- Portal monitors and other personnel contamination monitors;
- Electronic Dosimeters;
- Air sampling equipment;
- Tool and waste monitoring equipment; and
- Protective clothing and equipment monitors.

Maintenance histories, including the nature of any defects and corrective actions taken, and calibration results for each instrument are created and retained. Records of additional tests and checks of instrumentation used in conjunction with a suspected overexposure, questionable indication or unusual occurrence are retained. In addition, records of special instrument calibrations and modifications made are retained. Electronic records are maintained until license termination. Hardcopy records are maintained in accordance with CL-QA-PR-005, *Quality Assurance Records*, as catalogued in Appendix J.

Records required to be retained by UAC R313-15 are kept legible throughout the specified retention period and meet either of the following conditions. Records may be the original or a reproduced copy provided that the copy is authenticated by authorized personnel and capable of producing a clear copy throughout the required retention period. Records may be stored in electronic media with the capability for producing legible, accurate, and complete records during the required retention period. Records such as letters, drawings, and specifications must include all pertinent information, such as, stamps, initials, and signatures. Adequate safeguards are taken to prevent tampering with and loss of records.

Reports to the Division are required for the following events (refer to UAC R313-15-1202):
Immediate reporting is required for:

- Loss, stolen or missing licensed material in an aggregate quantity equal to or greater than 1000 times the quantity specified in UAC R313-15-1201.
- Any event involving LLRW possessed by the Clive Facility that may have caused or threatens to cause an individual to receive:
  1) A TEDE of 25 rems or more;
  2) An EDE of 75 rems or more;
  3) A SDE to the skin or extremities of 250 rads or more; or
  4) A release of radioactive material so that had an individual been present for 24 hours, the individual could have received an intake five times the occupational annual limit on intake.

A written notification is required within 24 hours after the following events:

- The loss of control of licensed material possessed by Clive Facility that may have caused or threatens to cause an individual to receive in a period of 24 hours any of the following conditions:
  1) A TEDE of 5 rems;
  2) An EDE of 15 rems; or

3) A SDE to the skin or extremities exceeding 50 rems; or the release of radioactive material inside or outside of the Restricted Area, so that had an individual been present for 24 hours, the individual could have received an intake in excess of one occupational annual limit on intake.

A written report is required within 30 days after the following events:

- Lost, stolen or missing licensed material in an aggregate quantity equal to or greater than 10 times the quantity specified in UAC R313-15-1201.

- Any incident for which notification is required

- Doses in excess of any of the following:
  1) The occupational dose limits for adults in Section UAC R313-15-201;
  2) The occupational dose limits for a minor in section 2.1.6;
  3) The limits for an embryo/fetus of a declared pregnant women;
  4) The limits for an individual member of the public;
  5) Any applicable limit of the license; or
  6) The ALARA constraints for air emissions established under Subsection UAC R313-1 5-101 (4).

- Levels of radiation or concentrations of radioactive material in:
  1) A restricted area in excess of any applicable limit in the license; and
  2) An unrestricted area in excess of 10 times any applicable limit set forth in this manual or in the license (whether or not it involved exposure to any individual in excess of the limits in section 2.1.3) or releases of radiation or radioactive material in excess of 40 CFR 190 levels or licensed material related to those standards.

Each report describes the extent of exposure of individuals to radiation and radioactive material, including, as appropriate:

1. Estimates of each individual‘s dose;

2. The levels of radiation and concentrations of radioactive material involved;

3. The cause of the elevated doses, dose rates or concentrations; and

4. Corrective steps taken or planned to ensure against a recurrence, including the schedule for achieving conformance with applicable limits, ALARA constraints, generally applicable environmental standards and associated license conditions.

Each report includes for each occupationally overexposed individual the name, Social Security number and date of birth. With respect to the limit for the embryo/fetus, the identifiers are those of the declared pregnant female. A copy of the report also is submitted to the overexposed individual. This report is transmitted at a time no later than the transmittal to the Director.

Any report pursuant to this section are prepared and filed with the Director so that names of individuals who have received exposure to sources of radiation are stated in a separate and detachable portion of the report.

SECTION 9. QUALITY ASSURANCE

UAC R313-25-7(10)	*"The application shall include certain technical information. The following information is needed to determine whether or not the applicant can meet the performance objectives and the applicable technical requirements of R313-25:* *(10) Descriptions of quality assurance programs, tailored to low-level waste disposal, including audit and managerial controls, for the determination of natural disposal site characteristics and for quality control during the design, construction, operation, and closure of the land disposal facility and the receipt, handling, and emplacement of waste." –* *(13) Descriptions of the administrative procedures that the applicant will apply to control activities at the land disposal facility."*
UAC R313-25-11(8)	*"A license for the receipt, possession, and disposal of waste containing radioactive material will be issued by the Executive Secretary upon finding that:* *(8) the applicant's proposal for institutional control provides reasonable assurance that control will be provided for the length of time found necessary to ensure the findings in R313-25-11(3) through (6) and that the institutional control meets the requirements of R313-25-28."*
UAC R313-25-30	*"The applicant shall show that it either possesses the necessary funds, or has reasonable assurance of obtaining the necessary funds, or by a combination of the two, to cover the estimated costs of conducting all licensed activities over the planned operating life of the project, including costs of construction and disposal."*
UAC R313-25-33	*"(1) Licensees shall maintain records and make reports in connection with the licensed activities as may be required by the conditions of the license or by the rules and orders of the Executive Secretary.* *(2) Records which are required by these rules or by license conditions shall be maintained for a period specified by the appropriate rules or by license condition. If a retention period is not otherwise specified, these records shall be maintained and transferred to the officials specified in R313-25-33(4) as a condition of license termination unless the Executive Secretary otherwise authorizes their disposition.* *(3) Records which shall be maintained pursuant to R313-25 may be the original or a reproduced copy or microfilm if this reproduced copy or microfilm is capable of producing copy that is clear and legible at the end of the required retention period.* *(4) Notwithstanding R313-25-33(1) through (3), copies of records of the location and the quantity of wastes contained in the disposal site shall be transferred upon license termination to the chief executive of the nearest municipality, the chief executive of the county in which the facility is located, the county zoning board or land development and planning agency, the State Governor, and other state, local, and federal governmental agencies as designated by the Executive Secretary at the time of license termination.* *(5) Following receipt and acceptance of a shipment of waste, the licensee shall record the date that the shipment is received at the disposal facility, the date of disposal of the waste, a traceable shipment manifest number, a description of any*

engineered barrier or structural overpack provided for disposal of the waste, the location of disposal at the disposal site, the condition of the waste packages as received, discrepancies between the materials listed on the manifest and those received, the volume of any pallets, bracing, or other shipping or onsite generated materials that are contaminated, and are disposed of as contaminated or suspect materials, and evidence of leakage or damaged packages or radiation or contamination levels in excess of limits specified in U.S. Department of Transportation and Executive Secretary regulations or rules. The licensee shall briefly describe repackaging operations of the waste packages included in the shipment, plus other information required by the Executive Secretary as a license condition.

(6) Licensees authorized to dispose of waste received from other persons shall file a copy of their financial report or a certified financial statement annually with the Executive Secretary in order to update the information base for determining financial qualifications.

(7) (a) Licensees authorized to dispose of waste received from other persons, pursuant to R313-25, shall submit annual reports to the Executive Secretary. Reports shall be submitted by the end of the first calendar quarter of each year for the preceding year.

(b) The reports shall include:

(i) specification of the quantity of each of the principal contaminants released to unrestricted areas in liquid and in airborne effluents during the preceding year;

(ii) the results of the environmental monitoring program;

(iii) a summary of licensee disposal unit survey and maintenance activities;

(iv) a summary, by waste class, of activities and quantities of radionuclides disposed of;

(v) instances in which observed site characteristics were significantly different from those described in the application for a license; and

(vi) other information the Executive Secretary may require.

(c) If the quantities of waste released during the reporting period, monitoring results, or maintenance performed are significantly different from those predicted, the report shall cover this specifically.

(8) In addition to the other requirements in R313-25-33, the licensee shall store, or have stored, manifest and other information pertaining to receipt and disposal of radioactive waste in an electronic recordkeeping system.

(a) The manifest information that must be electronically stored is:

(i) that required in Appendix G of 10 CFR 20.1001 to 20.2402, (2006), which is incorporated into these rules by reference, with the exception of shipper and carrier telephone numbers and shipper and consignee certifications; and

(ii) that information required in R313-25-33(5).

(b) As specified in facility license conditions, the licensee shall report the stored information, or subsets of this information, on a computer-readable medium."

Energy*Solutions'* Quality Assurance Program addresses design, construction, and operations of the facility. It includes a description of the management systems, assignments of responsibilities, and the organizational structure necessary to accomplish the performance objectives of UAC R313-25. Energy*Solutions* sees the Program as critical to prevent recurrence of problems. As such, root causes of problems are promptly identified and corrected.

9.1 INTRODUCTION

Energy*Solutions'* policy is to perform all of the work activities comprising facility operations in such a manner that required quality is attained or exceeded. In pursuit of this objective, Energy*Solutions* has developed a Quality Assurance Program, which is consistent with guidance provided by the Nuclear Quality Assurance Standard, ANSI/ASME NQA-1, Quality Assurance Program Requirements for Nuclear Facilities, and satisfies the special needs of a LLRW disposal facility. This Program is described in the Energy*Solutions'* Quality Assurance Program Document, containing a series of quality methods and procedures that define the requirements. The Energy*Solutions'* Quality Assurance Program is further documented by, and implemented using more specific and detailed functional procedures. This Program will ensure that risks, safety, reliability, and performance are maximized through the application of effective management systems commensurate with the risk posed by the facility and its operations. In addition, this program will provide an environmental management system to minimize environmental impacts with the prevention of pollution and continuous improvement of environmental performance.

9.1.1 Organization

Energy*Solutions'* organizational structure, functional responsibilities, levels of authority and lines of communication for activities affecting quality are established and documented. The Director, Corporate QA is responsible for assuring that the Quality Assurance Program is established and verifying activities affecting quality have been correctly performed. The Director, Corporate QA shall have sufficient authority, access to work areas and organizational freedom to:

- Identify quality problems;
- Initiate, recommend, or provide corrective actions to quality problems;
- Verify implementation of corrective actions; and
- Control further processing, installation or use of an item or activity until proper disposition of a nonconformance, deficiency, or unsatisfactory condition has occurred.

The Director, Corporate QA has direct access to responsible management at a level where appropriate actions can be effected. The Director, Corporate QA reports to the Senior Vice President, Regulatory Affairs.

Quality is achieved and maintained by those individuals who are assigned responsibility for performing the work. Quality achievement is verified by other individuals not directly responsible for directing the work. Where more than one organization is involved in the execution of verifying activities that affect quality, the responsibility and authority of each organization shall be clearly established and documented.

9.1.2 Quality Assurance Program

The Quality Assurance Program is implemented through the following documents:

- The Statement of Corporate Quality Assurance Policy;
- Quality Assurance Program Document;
- Quality Assurance Procedures; and
- Implementing Procedures – Controlled documents that prescribe processes (a sequence of actions) to be performed to achieve a desired outcome. Implementing procedures may apply to the entire company, an organization, a program or a project.

The Program identifies the activities and items to which it applies. The Program includes considerations of the technical aspects of the activities affecting quality. The Program provides control over activities affecting quality to the extent consistent with their importance. The Program provides assurance that activities affecting quality are documented and accomplished in accordance with written procedures, instructions and drawings.

The Program provides for the accomplishment of activities affecting quality under controlled conditions. Such conditions include the use of appropriate equipment, suitable environmental conditions, and prerequisites for a certain activity have been satisfied.

The Program takes into account the need for special controls, processes, test equipment, tools and skills to attain the required quality and verification of quality.

The Program provides for indoctrination and training of personnel performing quality related activities to assure that proficiency is achieved and maintained.

The Vice President, Regulatory Affairs reports to the President of Energy*Solutions* and is responsible and accountable for the effective implementation of the Quality Assurance Program. The CQAM has the authority, responsibility, and accountability for establishing and maintaining the Quality Assurance Program.

Vice Presidents, Corporate Directors and Managers, and Facility/Department Leads (Energy*Solutions* Management) have the authority, responsibility and accountability for establishing and maintaining programs and procedures consistent with the system description provided in this document. Energy*Solutions* Management may delegate tasks to contributing individuals or organizations, but they retain overall responsibility for:

- Providing resources to accomplish quality objectives in each work task;
- Continuously improving processes, products, and services;
- Ensuring that schedule and budget considerations are not used to compromise the attainment of the requisite level of quality;
- Identifying, monitoring, evaluating, and reporting results of selected performance indicators;
- Providing employees with adequate education and training;
- Participating in recommending specific changes to policy, programmatic, or procedural documents;
- Identifying, preparing and approving procedures necessary to implement requirements applicable to the scope of work;
- Working with support organizations to resolve concerns and issues; and
- Conducting management assessments.

All employees of Energy*Solutions* are responsible for achieving quality in their activities. Employees are empowered by Management to continuously improve their performance, identify and report problems, and participate in their resolution.

9.1.3 Design Control

Energy*Solutions* has established measures to define, control, and verify design. Applicable design inputs are specified and translated into design documents. Design interfaces are identified and controlled. Persons other than those who designed the item verify design adequacy. Design changes, including field changes, are governed by control measures commensurate with those applied to the original design. Design documents are adequate to support facility design, construction, and operation. Appropriate quality standards are identified and documented and their selection reviewed and approved. Changes from specified quality standards, including the reasons for the changes, are identified, approved, documented and controlled.

9.1.4 Procurement Document Control

Energy*Solutions'* Procurement System provides controls to ensure that items and services comply with established requirements and perform as specified. Applicable design bases and other requirements necessary to assure adequate quality shall be included or referenced in documents for the procurement of items or services.

Design and operational requirements are incorporated into corresponding purchase requirements so that prospective suppliers are evaluated before orders are placed; and that items received, and services provided are verified as complying with purchase requirements.

Procedures provide instructions for identifying, controlling, distributing and approving documents, including those provided by the supplier. They also specify criteria for purchasing commercial grade items and for preventing the purchase of suspect or counterfeit material.

Procurement documents shall require that all suppliers have an established management system that implements appropriate controls for the service of items being procured. The extent of the program required shall depend on the type and use of the item or service being procured.

9.1.5 Instructions, Procedures, and Drawings

Activities affecting quality shall be prescribed by documented instructions, procedures, or drawings of a type appropriate to the circumstances and shall be accomplished in accordance with these instructions, procedures, or drawings.

Instructions, procedures, or drawings shall include appropriate quantitative or qualitative acceptance criteria for determining that prescribed activities have been satisfactorily accomplished.

9.1.6 Document Control

Energy*Solutions* controls the preparation, approval, issue, and changes of documents that specify quality requirements or prescribe activities affecting quality. Such documents, including changes thereto, are reviewed for adequacy, and approved for release by authorized personnel.

Document Control is the act of assuring that documents are reviewed for adequacy, approved for release by authorized personnel, and distributed to and used at the location where the prescribed activities are performed. Energy*Solutions'* control system provides for:

- Identification of documents to be controlled and their specific distribution;
- Assignment of responsibility for preparing, reviewing, approving, and issuing documents; and
- Review of documents for adequacy, completeness, and correctness prior to approval and issuance.

Revisions to documents shall be reviewed and approved by the same individuals or organizations that performed the original review and approval.

9.1.7 Control of Purchased Items and Services

Energy*Solutions* controls the procurement of items and services affecting quality to assure conformance with specified requirements. Such control provides for the following as appropriate: source evaluation and selection, evaluation of objective evidence of the quality furnished by the supplier, source inspection, audit, and examination of items and services upon delivery or completion.

Procurement activities are planned and documented to assure a systematic approach to the procurement process.

The selection of suppliers is based on evaluation of their capability to provide items or services in accordance with the requirements of the procurement documents. The methods selected for evaluating a supplier are based on the importance, complexity, and value of the items or services being procured. Suppliers are monitored to ensure compliance with performance and schedule. Monitoring may include assessments, surveillance of work activities; inspection of items, facilities and processes; review of plans and progress reports; processing change information; and review and disposition of nonconformance reports.

The procurement process includes verification of acceptability of items or services. Verification includes (as appropriate) inspecting materials, equipment or activities at the supplier facility; reviewing objective evidence; testing items before or after shipment; inspecting products of services at receipt; or testing items after installation.

Nonconforming items or services are documented and controlled to preclude inadvertent use. Deviations from procurement requirements are documented and reviewed and approved in accordance with implementing procedures.

Commercial grade items are procured in accordance with Criterion 4 of the Quality Assurance Program Document. Commercial grade items shall be identified in the purchase requisition by the manufacturer‘s published product description. Receipt inspection shall be performed for damage, and that any specified documentation was received and is acceptable.

Commercial grade items are items not subject to design or specification requirements that are unique to nuclear facilities; used in applications other than nuclear facilities; and/or ordered from the manufacturer/supplier on the basis of specifications set forth in the manufacturer‘s published product description (for example, catalog).

9.1.8 Identification and Control of Items

Energy*Solutions* assures that only correct and accepted items are used, treated, installed or disposed. Identification shall be maintained on the items or in documents traceable to the item, or in a manner, which assures that identification is established and maintained.

Physical identification is the preferred method of identification. Where physical identification on the item is either impractical or insufficient, physical segregation, procedural control, or other appropriate means are employed.

When specified by permits, licenses, or specifications that include specific identification or traceability requirements, the program is designed to provide such identification and traceability control.

9.1.9 Control of Processes

The scope of the Clive facility‘s quality-affecting business activities requires no welding, heat treating or non-destructive examination. Therefore, this criterion is Not Applicable.

9.1.10 Inspection

Energy*Solutions* plans and executes inspections required to verify conformance of an item or activity to specified requirements. Inspection results are documented. Persons other than those who perform or directly supervise the activity perform inspections for acceptance.

Inspection requirements and acceptance criteria include specified requirements contained in the applicable design documents or other pertinent technical documents. Inspection activities are documented and controlled by instructions, procedures, drawings, checklist, travelers, or other appropriate means.

Each person who verifies conformance of work activities for the purpose of acceptance shall be qualified to perform the assigned inspection task. Inspections by persons during on-the-job training for qualification shall be performed under direct supervision of a qualified person and verification of conformance shall be by the qualified person until certification is achieved.

Inspection of items in process or under construction shall be performed for work activities where necessary to verify quality. If inspection of processed items is impossible or disadvantageous, indirect control by monitoring of processing methods, equipment, and personnel shall be provided. Both inspection and process monitoring shall be provided when control is inadequate without both.

Completed items shall be inspected for completeness, markings, calibration, adjustments, protection from damage or other characteristics as required to verify quality and conformance of an item to specified requirements. Final inspections shall include a record review of the results and resolution of nonconformance identified by prior inspections.

Inspection and test records as a minimum identify the following:

- Item inspected;
- Date of inspection;
- Inspector;
- Type of observation;
- Results or acceptability; and
- References to information or action taken in connection with nonconformance.

9.1.11 Test Control

Energy*Solutions* plans and executes tests required to verify conformance of an item or of a computer program to specific requirements and to demonstrate satisfactory performance for service. 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.

Test requirements and acceptance criteria shall be provided or approved by the organization responsible for design of the item to be tested. Required tests, including, as appropriate, prototype qualification tests, production tests, proof tests prior to installation; construction tests, pre-operational tests and operation tests, hardware integration, verification test, or in-use tests shall be controlled. Test requirements and acceptance criteria shall be based upon specified requirements contained in applicable design or other pertinent technical documents.

Test procedures shall include or reference test objectives and provisions for assuring that prerequisites for a given test have been met. In lieu of specially prepared written test procedures, appropriate sections of related documents, such as ASTM methods, supplier manuals, equipment maintenance instructions, or approved drawings with acceptance criteria can be used. Such documents shall include adequate instructions to assure the required quality of work.

Test results shall be documented and evaluated by a responsible authority to assure that test requirements are satisfied.

9.1.12 Control of Measuring and Test Equipment

Tools, gauges, instruments and other measuring and test equipment used for activities affecting quality shall be controlled and at specific periods calibrated and adjusted to maintain accuracy within necessary limits. The selection of measuring and test equipment shall be controlled to assure that such items are of proper type, range, accuracy and tolerance to accomplish the function for determining conformance to specified requirements.

Measuring and test equipment shall be calibrated, adjusted, and maintained at prescribed intervals or, prior to use, against certified equipment having known relationships to nationally recognized standards. If no nationally known standard exists, the basis for the calibration shall be documented.

Measuring and test equipment is calibrated at intervals depending on the required accuracy, intended use, stability characteristics and other conditions affecting the performance of the instrument.

When measuring and test equipment is found to be out of calibration, an evaluation shall be performed and documented of the validity of previous inspection or test results and the acceptability of the items previously inspected or tested. Out-of-calibration devices shall be tagged and segregated and not used until they have been recalibrated. If any measuring or test equipment is consistently found to be out of calibration, it shall be repaired or replaced. A calibration shall be performed when the accuracy of the equipment is suspect. Calibration and control measures are not required for rulers, tape measures, levels and other such devices; normal commercial equipment provides adequate accuracy. These items must be treated with care to prevent damage or excessive wear and be replaced before accuracy becomes questionable.

Measuring and test equipment shall be properly stored and handled to maintain accuracy. Calibration records shall be maintained and equipment shall be suitably marked to indicate calibration status.

9.1.13 Handling, Storage, and Shipping

Energy*Solutions* controls handling, storage, packaging, shipping and preservation of items to prevent damage or loss and to minimize deterioration.

Handling, storage and shipping of items shall be conducted in accordance with established work and inspection instructions, drawings, specifications, shipment instructions, or other pertinent documents or procedures specified for use in conducting the activity. Specific procedures shall be used when required for critical, sensitive, perishable or high-value articles.

Instructions for marking and labeling for packaging, shipment, handling, and storage of items shall be established as necessary to adequately identify, maintain and preserve the item, including indication of the presence of special environments or the need for special controls.

9.1.14 Inspection, Test, and Operating Status

The status of inspection and test activities shall be identified either on the items or in the documents traceable to the items where it is necessary to assure that required inspections and tests are performed and to assure that items which have not passed the required inspections and tests are not inadvertently installed, used or operated. Status shall be maintained through indicators, such as physical location and tags, markings, travelers, inspection records or other suitable means. The authority for the application and removal of tags, markings and labels shall be specified. Status indicators shall also provide for indicating the operating status of systems and components of the facility, such as tagging valves and switches, to prevent inadvertent operation.

9.2 QUALITY ASSURANCE PROCEDURES

Energy*Solutions'* Quality Assurance Program, developed in satisfaction of UAC R313-25-7(10), is implemented in the following procedures:

- CL-QA-PR-005 Quality Assurance Records
- CL-QA-PR-090 Receipt Inspection
- CL-QA-WI-018 Instructions for the Interim Storage and Destruction of Records
- CL-QA-WI-019 Quarterly Verification of Closed Condition Reports
- CL-QA-WI-021 Indoctrination and Training
- CL-QA-WI-120 Control of Measuring & Testing Equipment
- CL-QA-WI-163 Causal Analysis
- CL-QA-WI-171 Record Storage Environmental Control

- CL-QA-WI-172 Management of Clive Server Back Up Media
- CL-QC-PR-011 M and TE Calibration
- CL-QC-PR-015 Density Testing
- CL-QC-PR-016 Construction Surveying
- CL-QC-PR-018 In Cell Bulk Disposal
- CL-QC-PR-021 Standard Practice for Sampling Aggregates from Stockpiles
- CL-QC-PR-025 Standard Practice for Achieving Certified AMRL Results
- CL-QC-PR-032 Disposal of Waste with CLSM
- CL-QC-PR-034 Disposal of Waste Soils
- CL-QC-PR-035 Debris Placement in Soil Waste Lifts
- CL-QC-PR-036 CWF Waste Placement and Backfilling Specifications
- CL-QC-PR-037 Placement of Intermediate & Backfill Cover Layers
- CL-QC-PR-038 Lift Approval Using an 826 Compactor
- CL-QC-PR-040 Railcar Moisture Determination
- CL-QC-PR-092 Open Cell Tracking

SECTION 10. FINANCIAL ASSURANCE

UAC R313-25-5	*"In addition to the requirements set forth in R313-22-33, an application to receive from others, possess, and dispose of wastes shall consist of general information, specific technical information, institutional information, and financial information as set forth in R313-25-6 through R313-25-10."*
UAC R313-25-9	*"The institutional information submitted by the applicant shall include: (1) A certification by the federal or state agency which owns the disposal site that the agency is prepared to accept transfer of the license when the provisions of R313-25-16 are met and will assume responsibility for institutional control after site closure and for post-closure observation and maintenance. (2) Evidence, if the proposed disposal site is on land not owned by the federal or a state government, that arrangements have been made for assumption of ownership in fee by the federal or a state agency."*
UAC R313-25-10	*"This information shall demonstrate that the applicant is financially qualified to carry out the activities for which the license is sought. The information shall meet other financial assurance requirements of R313- 25."*
UAC R313-25-11(8)	*"A license for the receipt, possession, and disposal of waste containing radioactive material will be issued by the Executive Secretary upon finding that: (8) the applicant's proposal for institutional control provides reasonable assurance that control will be provided for the length of time found necessary to ensure the findings in R313-25-11(3) through (6) and that the institutional control meets the requirements of R313-25-28."*
UAC R313-25-28	*"(1) Land Ownership. Disposal of waste received from other persons may be permitted only on land owned in fee by the Federal or a State government. (2) Institutional Control. The land owner or custodial agency shall conduct an institutional control program to physically control access to the disposal site following transfer of control of the disposal site from the disposal site operator. The institutional control program shall also include, but not be limited to, conducting an environmental monitoring program at the disposal site, periodic surveillance, minor custodial care, and other equivalents as determined by the Executive Secretary, and administration of funds to cover the costs for these activities. The period of institutional controls will be determined by the Executive Secretary, but institutional controls may not be relied upon for more than 100 years following transfer of control of the disposal site to the owner."*
UAC R313-25-30	*"The applicant shall show that it either possesses the necessary funds, or has reasonable assurance of obtaining the necessary funds, or by a combination of the two, to cover the estimated costs of conducting all licensed activities over the planned operating life of the project, including costs of construction and disposal."*

UAC R313-25-31	*"(1) The applicant shall provide assurances prior to the commencement of operations that sufficient funds will be available to carry out disposal site closure and stabilization, including:* *(a) decontamination or dismantlement of land disposal facility structures, and* *(b) closure and stabilization of the disposal site so that following transfer of the disposal site to the site owner, the need for ongoing active maintenance is eliminated to the extent practicable and only minor custodial care, surveillance, and monitoring are required. These assurances shall be based on Executive Secretary approved cost estimates reflecting the Executive Secretary approved plan for disposal site closure and stabilization. The applicant's cost estimates shall take into account total costs that would be incurred if an independent contractor were hired to perform the closure and stabilization work.* *(2) In order to avoid unnecessary duplication and expense, the Executive Secretary will accept financial sureties that have been consolidated with earmarked financial or surety arrangements established to meet requirements of Federal or other State agencies or local governmental bodies for decontamination, closure, and stabilization. The Executive Secretary will accept these arrangements only if they are considered adequate to satisfy the requirements of R313-25-31 and if they clearly identify that the portion of the surety which covers the closure of the disposal site is clearly identified and committed for use in accomplishing these activities.* *(3) The licensee's financial or surety arrangement shall be submitted annually for review by the Executive Secretary to assure that sufficient funds will be available for completion of the closure plan.* *(4) The amount of the licensee's financial or surety arrangement shall change in accordance with changes in the predicted costs of closure and stabilization. Factors affecting closure and stabilization cost estimates include inflation, increases in the amount of disturbed land, changes in engineering plans, closure and stabilization that have already been accomplished, and other conditions affecting costs. The financial or surety arrangement shall be sufficient at all times to cover the costs of closure and stabilization of the disposal units that are expected to be used before the next license renewal.* *(5) The financial or surety arrangement shall be written for a specified period of time and shall be automatically renewed unless the person who issues the surety notifies the Executive Secretary; the beneficiary, the site owner; and the principal, the licensee, not less than 90 days prior to the renewal date of its intention not to renew. In such a situation, the licensee shall submit a replacement surety within 30 days after notification of cancellation. If the licensee fails to provide a replacement surety acceptable to the Executive Secretary, the beneficiary may collect on the original surety.* *(6) Proof of forfeiture shall not be necessary to collect the surety so that, in the event that the licensee could not provide an acceptable replacement surety within the required time, the surety shall be automatically collected prior to its expiration. The conditions described above shall be clearly stated on surety instruments.*

	(7) Financial or surety arrangements generally acceptable to the Executive Secretary include surety bonds, cash deposits, certificates of deposit, deposits of government securities, escrow accounts, irrevocable letters or lines of credit, trust funds, and combinations of the above or other types of arrangements as may be approved by the Executive Secretary. Self-insurance, or an arrangement which essentially constitutes self-insurance, will not satisfy the surety requirement for private sector applicants. *(8) The licensee's financial or surety arrangement shall remain in effect until the closure and stabilization program has been completed and approved by the Executive Secretary, and the license has been transferred to the site owner."*
UAC R313-25-32	*"(1) Prior to the issuance of the license, the applicant shall provide for Executive Secretary approval, a binding arrangement, between the applicant and the disposal site owner that ensures that sufficient funds will be available to cover the costs of monitoring and required maintenance during the institutional control period. The binding arrangement shall be reviewed annually by the Executive Secretary to ensure that changes in inflation, technology, and disposal facility operations are reflected in the arrangements.* *(2) Subsequent changes to the binding arrangement specified in R313-25-32(1) relevant to institutional control shall be submitted to the Executive Secretary for prior approval."*

Because License renewal typically is a multi-year process, revised surety calculations for the ET cover design presented in this Application are not included. Because the proposed ET cover design includes lower volumes of material, it is expected that the surety would be reduced by its approval. However, final approved ET cover design layer composition and thickness is not known at this time. Therefore, the surety calculations will be updated to address approved changes at the next update following License renewal.

Energy*Solutions* intends to close the Embankment and associated facilities and perform post-closure monitoring. However, in order to protect the State of Utah from financial damage arising from having to close and decommission the facility in the event that Energy*Solutions* is unwilling or unable to do so, a LLRW financial surety has been established for the closure of the Embankment in accordance with regulatory requirements. The amount of financial surety is calculated as the amount estimated for the placement of all contaminated material into the Embankment, for decommissioning and decontamination of the site, for completion of Embankment construction to the required standards, and to perform all required post closure monitoring and maintenance activities. The Decontamination and Decommissioning Plan for the facility (Energy*Solutions*, 2012) and the Post-Closure Monitoring Plan (Appendix F of the GWQDP) form the basis for surety calculations. The annual surety review is submitted to the Division annually on or before December 1st.

The calculations and cost estimates are reviewed on a yearly basis and the financial surety updated to assure that the amount remains sufficient to account for inflation, construction of new facilities, and other cost adjustments. The Division performs an annual review of the calculations and cost estimates to assure that the amount is sufficient to complete closure of the facility if Energy*Solutions* were to cease operation.

A detailed review of the quantities and costs associated with the closure of the facility is provided annually to the Division (the most recent is Energy*Solutions*, 2012a). In 2011, it was estimated that the cost to close the facility and provide long-term surveillance would be $ 66,029,592.55. This amount is maintained as an Irrevocable Letter of Credit with Wells Fargo Bank, National Association, accompanied by a Standby Trust Agreement, for the benefit of the Director.

It is important to note that NUREG-1199 requires compliance with UAC R313-25 when providing financial information for review. According to UAC R313-25-31, a record of an Irrevocable Letter of Credit and Standby Trust Agreement established for the purpose of covering the closure and monitoring costs is sufficient for licensing as long as the arrangement details are provided.

A financial surety has been arranged in an amount that allows for the closure of the disposal facility to the standards discussed within this document and in accordance with the license. The financial surety is for the amount that would be needed to place all LLRW properly into the Embankment and to complete all phases of the Embankment to the required standards, and to fund post-closure monitoring.

Any monies not used in the closure of the site or required for long term surveillance will be returned to Energy*Solutions*. Quantities are based on documents and figures provided to the Division annually by Energy*Solutions*. Where it is not possible to determine exact quantities from approved references, conservative assumptions are used. Cost estimates, detailed quantity calculations, and assumptions were most recently provided to the Division in 2012 (McCandless, 2012b).

Costs are largely based on the RS Means Heavy Construction Cost Data (Means) for the associated year. For elements that are not included in Means, such as sampling and analysis, costs were developed from Energy*Solutions*' historic cost for that item and are adjusted annually for inflation. The annual surety revision also anticipates costs associated with long-term site surveillance and monitoring. These costs include annual site inspections, groundwater sampling, soil sampling and other environmental activities specific to the Embankment. Site surveillance and monitoring costs for the adjacent 11e.(2) and Mixed Waste facilities are addressed in their respective sureties. The program is more intensive in the first years after closure compared to the last years of post-closure monitoring.

In addition to costs directly associated with closure and institutional control activities of the Embankment, surety calculations are projected for indirect cost items. The U.S. Defense Contract Audit Agency (DCAA) defines indirect cost rate as ―*simply a device for determining fairly and conveniently within the boundaries of sound administrative principles, what proportion of indirect cost each program should bear.*" (DCAA,2012). In addition to DCAA guidelines, the Department of Labor has published a guide to ―*assist . . . commercial organizations in understanding the requirements for the determination of indirect costs on cost reimbursable . . . contracts, and other agreements awarded by the U.S. Department of Labor.*" (DOL, 2012). These guidance and other similar documents are made available to independent DCAA auditors, who review and asses the validity of commercial contractor's indirect cost multipliers (as applied to federal contracts). As such, the guidance is applicable to those private-public contracts that would be executed by the Division, should the need arise to oversee the closure of Clive.

10.1 DECONTAMINATION AND DISMANTLEMENT OF LAND DISPOSAL FACILITY STRUCTURES

Decontamination and dismantlement of the land disposal facility structures will be performed in accordance with the Decontamination and Decommissioning Plan (Energy*Solutions*, 2012a). In accordance with Condition 74 of the License, Energy*Solutions* is required to submit a detailed decontamination and decommissioning plan one year prior to the anticipated closure of the site. The structures and operating facilities of the site will be decommissioned and either decontaminated or disposed of within the waste disposal embankment. Sufficient capacity must be maintained in the embankment to assure that decommissioning volumes can be disposed of in accordance with site closure. Estimated volumes and costs for the decommissioning of the facility are reported annually to the Division in conjunction with the annual surety revisions (Energy*Solutions*, 2012a).

Procedures for removing and disposing of structures and equipment contaminated with LLRW are addressed in Energy*Solutions* Annual Surety Revision (2012a). It is assumed that additional support facilities will not be required beyond that specified in this Application. It is also assumed that these support facilities will be decontaminated and decommissioned upon site closure. The decontamination and decommissioning activities addressed include:

a. Decontaminating off-site soils and rail road spur, if necessary, by removing all surface materials contaminated with LLRW such that the contamination in the residual soil or rail road ballast is ALARA and below the respective cleanup limits. Soil will be disposed of at the Embankment using disposal methods approved for LLRW.

b. Decontaminating on-site soils within the Energy*Solutions*' property but excluding the disposal embankments, by removing all surface soils contaminated with LLRW such that the contamination in the residual soils is ALARA and below the respective cleanup limits. Soils will be disposed of at the Embankment using disposal methods approved for LLRW.

c. Decontaminating on-site structures such as the rollover facility, geotechnical laboratory, and rail spur to meet the unconditional release criteria or, remove and place structures in the Embankment. Rail outside the Restricted Area will be salvaged.

d. Decontaminating the on-site support structures and contents including the change and laboratory facilities within the administration building to meet the unrestricted release criteria, or remove and dispose of contents and structures in the Embankment.

10.2 DISPOSAL SITE CLOSURE AND STABILIZATION FUNDING

The financial surety between Energy*Solutions* and Wells Fargo Bank includes the necessary amount of coverage to provide for the following:

a. The Letter of Credit is sufficient to cover all the costs of closure and post-closure care of the site.

b. The amount of the financial assurance is equal to the current cost estimates in the plan for site closure and stabilization, and reflects the total costs incurred if an independent contractor were hired.

c. The Letter of Credit provides coverage throughout the term of the License.

d. The Letter of Credit includes identification and specification of the types and number of activities required for each of Clive's facilities.

e. As part of the annual review/revision, the Letter of Credit is adjusted for inflation, using the inflation factor derived from the annual implicit price deflator for gross national product, as published in the U.S. Department of Commerce's Survey of Current Business.

10.3 FINANCIAL ASSURANCE FOR INSTITUTIONAL CONTROLS

In addition to the estimated costs for decommissioning the facility, the financial surety also covers estimated costs of long-term surveillance of the site. This includes sampling of groundwater monitoring wells, site inspections and repairs and other miscellaneous costs.

Custodial maintenance such as repair of a damaged perimeter fence is expected to be required at the site. Extreme natural events, intentional intrusion, or other events may occur at a site that may require contingency repair to ensure that the waste facility continues to function as intended.

The Embankment is being constructed in a manner that will minimize the need for long-term maintenance. The containment structure is made completely of natural materials. The only item at the facility that is man-made is the chain link fence that surrounds the site.

With the exception of the chain link fence all of the materials incorporated in the final Embankment have been designed to remain intact for 1,000 years. Since the embankment will be resistant to water erosion, wind erosion, and slope failure for the 1,000 year design life of the facility, there should be no active maintenance required on the Embankment after closure.

Prior to completion of remedial action at the Energy *Solutions* site, the final site conditions, including airborne particulate monitoring, will be defined and characterized as the first step in the surveillance and maintenance process. After completion of the remedial action, information will be assembled into a site file that will be reviewed by the Division prior to surveillance activities.

This section explains the procedures to be used by Energy*Solutions* to determine when maintenance or contingency repairs are required at the facility. The Energy*Solutions* site will not require scheduled maintenance.

When compared with contingency repair, maintenance is expected to be generally less costly, smaller in scale, and more frequent in occurrence. In contrast, contingency repairs are unlikely to be needed. However, repair costs may be substantial due to the size of the work force and technical skills required for repairs. The inspection report and monitoring results will be reviewed and site conditions compared from year to year so that trends of changing conditions can be identified. Extrapolation of identifiable trends will provide a means of predicting when maintenance or repair is required at the disposal site.

After a decision has been made to initiate maintenance or contingency repair, a statement of work will be prepared for the work to be performed. The maintenance or repair actions required to correct site problems will be dependent upon the nature of the problem or hazard. Although the details of maintenance or repair actions required cannot be reliably predicted in advance, a range of possible actions are outlined in Table 6-6. A remote possibility exists for failure of a site to adequately contain the waste material. For the Clive site, the only feasible scenario would be release of waste material from a site following a major earthquake, major flood, or other severe natural phenomena.

Energy*Solutions* will identify site failure in at least three ways:

1. Results of Phase I, Phase II, or contingency site inspections.

2. Reports from local government authorities or local residents.

3. Reports from National Oceanic & Atmospheric Administration (NOAA), the Earthquake Early Warning Service, or other agencies.

On the basis of the site contingency plan, appropriate action will be taken to notify individuals who may be affected and advise them of precautions that are necessary. Local law enforcement officials, news media, responsible agency representatives, and/or state representatives may be utilized in contacting affected parties.

After completion of maintenance or contingency repair actions, the responsible agency will certify that all work was completed in accordance with specifications. Copies of the certification statement will be attached to the License, the site inspection report, and will become part of the site file.

SECTION 11. REFERENCES

Adrian Brown Consultants, Inc. ―Final Slug Test Results.” Prepared for Envirocare of Utah, Inc, 14 October 1997.

AGRA ―Report: Evaluation of Settlement of Incompressible Debris Lifts LARW Embankments Near Clive, Tooele County, Utah,” AGRA Earth & Environmental, Inc., June 1, 2000b.

AGRA. ―Evaluation of Settlement of Compressible Debris Lifts, LARW Embankments.” AGRA Earth & Environmental, Inc., June 1, 2000a.

AMEC, ―EnergySolutions Clive Facility Clay Cracking Study Plan.” AMEC Environmental & Infrastructure, Inc., 1 August 2012b.

AMEC, Report: ―Geotechnical Update Report, Energy Solutions Clive Facility, Class A West Embankment”, AMEC Environmental & Infrastructure, Inc., February 15, 2011.

AMEC. ―Response to Interrogatory CAW R313-25-8(4)-16/3: Seismic Hazard Evaluation/Seismic Stability Analysis Update, Energy*Solutions* Clive Facility – Class A West Embankment, Clive, Tooele County, Utah.” (Job No. 10-817-05290) AMEC Environmental & Infrastructure, Inc., 6 April 2012a.

AMEC, ―Geotechnical Study: Increase in Height and Footprint.” AMEC Environmental & Infrastructure, Inc., 27 May 2005.

AMEC. ―Placement of Large Liners in Caissons.” AMEC Environmental & Infrastructure, Inc., 5 August 2002.

AMEC. ―Response to Interrogatory Number 2: Placement of HICs in Caissons.” AMEC Environmental & Infrastructure, Inc., 1 October 2001.

Bingham. ―Liner Compatibility Report.” Bingham Environmental, Inc., 8 March 1994.

Bisdorf, R.J., and Zohdy, A.A.R. ―U.S. Geological Survey Open-File Report.” 80-806, 26 p., 1980.

BLM. ―Cedar Mountain and Onaqui Mountain Wild Horse Herd Management Areas Capture, Treat, and Release Plan.” Environmental Assessment (DOI-BLM-UT-W010-2011-0031-EA), Bureau of Land Management, January 2012b.

BLM. Personal communication between Mike LeBaron or Energy*Solutions* and Kim Hershey of the U.S. Bureau of Land Management, 28 May 2012a.

BLM. ―Proposed Pony Express Resource Management Plan and Environmental Impact Statement,” Salt Lake District Office, Salt Lake City, UT, U.S. Department of Interior, May, 1988.

BLM, ―Timpie Solar Evaporation Pond System Environmental Assessment,” Salt Lake District Office, Salt Lake City, UT, Prepared by Bio/West, Inc. U.S. Department of the Interior, 1987.

Brough, C., et. al. "Utah's Tornadoes and Waterspouts – 1847 to the Present." National Weather Service Forecast Office, Salt Lake City, Utah 2010.

Bucknam, R.C. "Map of Suspected Fault Scarps in Unconsolidated Deposits, Tooele 20 Sheet." USGS Open-file Report 77-495, 1977.

Cedergren, H. R.. "Seepage, Drainage and Flow Nets," second edition, John Wiley and Sons, New York, NY, pp 178-182, , 1977

Census. "United States Census 2010." Electronic accessed at http://2010.census.gov/2010census/ on 3 April 2012.

Cook, K.L., M.O. Halverson, J.C. Steep, and J.W. Berg, Jr. "Regional Gravity Survey of the Northern Great Salt Lake Desert and Adjacent Areas in Utah, Nevada, and Idaho," Geological Society of America Bulletin, Vol., 75, p. 715-741, August 1964.

Cronquist, A., A. H. Holmgren, N. H. Holmren, and J. L. Reveal. "Intermountain Flora: Vascular Plants of the Intermountain West, U.S.A." Hafner Publishing Co., New York, 1972.

DCAA, "DCAA Contract Audit Manual 7640.1" U.S. Defense Contractor Audit Agency, (accessed 25 October 2012 - http://www.dcaa.mil/cam.htm), 22 October 2012.

DOE, "Low-Level Waste Disposal Alternatives Analysis Report," (INL/EXT-06-1160-1, Rev. 1), September 2006.

DOE, "Waste Volume Forecast – Revision 1,: LA-UR-04-6682, September 2004.

DOE, "The Current and Planned Low-Level Waste Disposal Capacity Report – Revision 2," December 2000.

DOE. "Vegetation Growth Patterns on Six Rock-Covered UMTRA Project Disposal Cells." (UMTRA – DOE/AL 400677.0000), 1992.

DOE. "Technical Approach Document, Revision II," UMTRA-DOE/AL 050425.0002., December, 1989.

DOE. "Guidance for UMTRA Project Surveillance and Maintenance" (UMTRA-DOE/AL - 350124.0000), 1985a.

DOE. "Disposal Site Characterization Report for the Uranium Mill Tailings Site at Salt Lake City, Utah", (UMTRA-DOE/AL-050102.0001), Uranium Mill Tailings Remedial Action Project Office, January 1985b.

DOE. "Final Environmental Impact Statement for Remedial Actions at the Former Vitro Chemical Company Site, South Salt Lake, Salt Lake County, Utah", (DOE-EIS-0099-F), U.S. Department of Energy Report, July 1984.

DOL. ―A Guide for Indirect Cost Rate Determination." U.S. Department of Labor, Division of Cost Determination. July 2012.

Envirocare of Utah, Inc., ―Comprehensive Groundwater Quality Evaluation Report", September 1, 2004.

Energy*Solutions*, ―Radioactive Material License #UT 2300249 and Ground Water Quality Discharge Permit NO. UGW450005. Amendment and Modification Request – Class A West Embankment: Response to Division Request and Round 3 Interrogatory", (submitted to the Utah Division of Radiation Control – CD12-0049), on 23 February 2012a.

Energy*Solutions*. ―Vertical Hydraulic Conductivity Test Data from Monitoring Well GW-139D," submitted to Utah Division of Radiation Control on March 16, 2010 (CD10-0077), 2010.

EPA. ―CAP-88 PC User's Guide." U.S. Environmental Protection Agency, 9 December 2007.

Evans, Robley D. ―Engineer's Guide to the Elementary Behavior of Radon Daughters." Health Physics. 17(2), August, 1969.

GAO ―Low-Level Radioactive Waste – Status of Disposal Availability in the United States and Other Countries," GAO-08-813T, Government Accountability Office (GAO), 20 May 2008.

GAO, ―Low-Level Radioactive Waste: Future Waste Volumes and Disposal Options are Uncertain", GAO-04-1097T, Government Accountability Office (GAO), September 2004;

GAO, ―Low-Level Radioactive Waste: Disposal Availability Adequate in the Short Term, But Oversight Needed to Identify Any Future Shortfalls", GAO-04-604, Government Accountability Office (GAO), June 2004;

Grams, Kayla. ―Hitch a Ride in Wild Horse Country." The Humane Society of the United States, (http://www.humanesociety.org/news/news/2009/11/hsus_land_rover_wild_horse_country_111909.html) accessed 30 May 2012, published 19 November 2009.

Johnson, Ryan ―RE: RML Renewal Application Format." Electronic communication from Ryan Johnson of the Utah Division of Radiation Control to Vern Rogers of Energy*Solutions* on 1 October 2012.

Jones, Gordon L. ―ET Cover Slope and Ditch Analysis." (Project Memorandum 106.06.100) Hansen Allen and Luce, Inc. 12 October 2012c.

Jones, Gordon L. ―PMF and 100-year Storm Analysis for Clive, Utah." (Project Report 106.04.100) Hansen Allen and Luce, Inc, 25 July 2012b.

Jones, Gordon L. ―Run-on Berm Analysis for Clive, Utah" (Project Memorandum 106.05.100) Hansen Allen and Luce, Inc. 25 July 2012a.

McCandless, Sean. ―2011 LLRW Annual Surety Submittal, Revision Date December 21, 2011, Engineering Module 13, Radioactive Materials License UT2300249: Response to Second Request for Information" Energy*Solutions* Letter (CD12-0048) to Rusty Lundberg, 18 April 2012a.

McCandless, Sean. “Annual/summary 2011 Meteorological Report.” Energy*Solutions* Letter (CD12-0103) to Rusty Lundberg, 23 February 2012b.

McCandless, Sean. “Request to Amend RML UT2300249 and UT2300478, Appendix I, Organization” Energy*Solutions* Letter (CD12-0275) to Rusty Lundberg, 24 October 2012c.

McCandless, Sean. “Radioactive Material License No. UT 2300249 – Request for Amendment to Condition 6.E, 9 and 10” Energy*Solutions* Letter (CD11-0183) to Rusty Lundberg, 2 August 2011.

McCandless, Sean. “Radioactive Material License No. UT 2300249 – Request for Amendment to Condition 16.F.i” Energy*Solutions* Letter (CD08-0133) to Dane Finerfrock, 28 April 2008.

Montgomery Watson. “Comparison of Two Gravel Borrow Areas on the Grayback Hills, Tooele County.” letter from John D. Garr of Montgomery Watson Harza to David F. Booth of Energy*Solutions*, 20 November, 2007.

Montgomery Watson. “LARW Cover Frost Penetration.” , March 1, 2000.

Montgomery Watson. “Review of Cover Design for LARW Cell.” , February 5, 1998

Moore, W.J., Sorensen, M.L. “Geologic Map of the Tooele 10 x 20 Quadrangle, Utah. U.S. Geological Survey, I-1132,” 1979.

MSI. “January 2011 Through December 2011 and January 1993 Through December 2011 Summary Report of Meteorological Data Collected at Energy*Solutions'* Clive, Utah Facility.” Meteorological Solutions, Inc Project No. 011110111 Report, February 2012.

NCRP. “Measurement of Radon and Radon Daughters in Air”, National Council on Radiation Protection and Measurements, Report No. 097, 1988.

NCRP. “Report No. 87, Use of Bioassay Procedures for Assessment of Internal Radionuclide Deposition,” 1987.

Neptune, Inc. “Modeling Report: Fate and Transport of Contaminants from the Class A West Embankment and Exposure to a Post-Closure Traditional Inadvertent Human Intruder at the EnergySolutions Clive, Utah Facility.” (NAC-0009_R1) Neptune and Company, Inc. 5 October 2012.

Neptune, Inc. “Final Report for the Clive DU PA Model – Version 1.0” Neptune and Company, Inc, 1 June 2011.

NRC, “Regulatory Guide 3.11: Design, Construction, and Inspection of Embankment Retention Systems at Uranium Recovery Facilities”, November 2008.

NRC, “NUREG-1623: Design of Erosion Protection for Long- Term Stabilization. Final Report,” September, 2002.

NRC. ―Consolidated Guidance About Materials Licenses: Guidance About Administrative Licensing Procedures." (NUREG-1556, Volume 20). U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, December 2000.

NRC, ―A Performance Assessment Methodology for Low-Level Radioactive Waste Disposal Facilities." (NUREG-1573), 1999.

NRC. ―Final Environmental Impact Statement to Construct and Operate a Facility to Receive, Store, and Dispose of 11e.(2) Byproduct Material Near Clive, Utah." (NUREG-1476). Office of Nuclear Materials Safety and Safeguards. August, 1993c.

NRC. ―Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program." (Regulatory Guide 8.9) Office of Nuclear Regulatory Research, July 1993b.

NRC. ―Standard Format and Content of a license application for a Low-Level Radioactive Waste Disposal Facility" (NUREG-1199), U.S. Nuclear Regulatory Commission, January 1991.

NRC, ―NUREG/CR-4620: Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments," June 1986.

NRC. ―Final Generic Environmental Impact Statement on Uranium Milling, Project M-25." (NUREG-0706, Volumes I – III). Office of Nuclear Material Safety and Safeguards, September, 1980a.

Public Lands. Public Lands Information Center website (http://publiclands.org/) accessed 30 May 2012.

Sherard, J.L., L.P. Dunnigan. ―Filters and Leakage Control in Embankment Dams and Impoundments" ASCE National Convention Proceedings, Denver Colorado., 1985.

Sinclair, William. ―Exemption to UAC R447-25-9(2) Granting Disposal on Privately Owned Land." Letter from William Sinclair of the Utah Division of Radiation Control to Ken Alkema of Envirocare of Utah, 18 November 1987.

Stephens, Jerry C. ―Hydrologic Reconnaissance Of The Wah Wah Valley Drainage Basin, Millard And Beaver Counties, Utah." Utah Department of Natural Resources, Technical Publication No. 47, 1974.

Streamline Consulting ―Potential Public Health Impacts From Open Disposal Cells at Energy*Solutions* of Utah's Waste Disposal Facility, Clive, Utah" , April 6, 2005.

SWCA, Inc. ―Vegetated Cover System for the EnergySolutions Clive Site: Literature Review, Evaluation of Existing Data, and Field Studies Summary Report." Report prepared by SWCA Environmental Consultants, August 2012.

SWCA, Inc. ―Field Sampling of Biotic Turbation of Soils at the Clive Site, Tooele County, Utah." Report prepared by SWCA Environmental Consultants (submitted to the Division - CD11-0153), January 2011.

Thomas Consultants, Inc. ―Tooele Valley Demographic and Market Assessment, 2002." Report for Energy*Solutions*, 2002.

UDWR. ―Kit Fox.” Wildlife Notebook Series No. 9, Utah Division of Wildlife Resources, 2010.

UDNR. ―Utah Greater Sage-Grouse Management Plan 2009.” (Publication 09-17). State of Utah. Department of Natural Resources, Division of Wildlife Resources, 4 June, 2009.

UDNR. ―Hydrologic reconnaissance of the southern Great Salt Lake Desert and summary of the hydrology of west-central Utah.” Utah Department of Natural Resources Technical Publication 71:55. 1981.

UGS. ―Utah Geological and mineral Survey, Map 111”, Utah Survey Special Study 96, 1999.

US Army Corps of Engineers, ―Manual EM1110-2-1091: Engineering and Design - Seepage Analysis and Control for Dams.” 30 September 1986 (original) 30 April, 1993 (change 1).

USGS. ―Aragonite, Utah.” 1:24,000 topographic map. , 1973(a)

USGS. ―Aragonite NW, Utah.” 1:24,000 topographic map. , 1973(b)

Whetstone Associates, ―Restoration of Grade Evaluation,” 2006.

WHO. ―Total Dissolved Solids in Drinking-Water: Background Document for Development of WHO Guidelines for Drinking-Water Quality” (WHO/SDE/WSH/03.04/16) World Health Organization, Geneva, 2003.

APPENDIX A

Radioactive Material License UT 2300249

(with proposed amendments in reline/strikeout format)

LICENSE AMENDMENT

UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY
DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIAL LICENSE

Pursuant to Utah Code Ann. Title 19, Chapter 3 and the Radiation Control Rules, Utah Administrative Code R313, and in reliance on statements and representations heretofore made by the licensee designated below, a license is hereby issued authorizing such licensee to transfer, receive, possess and use the radioactive material designated below; and to use such radioactive material for the purpose(s) and at the place(s) designated below. This licensee is subject to all applicable rules, and orders now or hereafter in effect and to any conditions specified below.
****

LICENSEE		
1. Name:	EnergySolutions, LLC (EnergySolutions)	3. License Number UT 2300249 Amendment # ~~14~~15
2. Address:	423 West 300 South Suite 200 Salt Lake City, UT 84101	4. Expiration Date ~~January 25, 2013~~ License Category – 4-a

****

6.	Radioactive material (element and mass number)	7.	Chemical and/or physical form	8.	Maximum quantity licensee may possess at any one time
A.	Any Radioactive Material including Special Nuclear Material specified in License Condition 13 A through J.	A.	Notwithstanding Conditions 9 (Authorized Use), 16 (Prohibitions and Waste Requirements), and 56 (containerized waste), typically large volume, bulky or containerized, soil or debris. Debris can include both decommissioning (cleanup) and routinely generated operational waste including but not limited to radiologically contaminated paper, piping, rocks, glass, metal, concrete, wood, bricks, resins, sludge, tailings, slag, residues, personal protective equipment (PPE) ~~that conforms to the size limitations in currently approved QA/QC Manual)~~.	A.	20,000 Curies***

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

6.	Radioactive material (element and mass number)	7.	Chemical and/or physical form	8.	Maximum quantity licensee may possess at any one time
B.	Special Nuclear Material	B.	See 7.A of this license	B.	As specified in License Condition 13.A through J. (1,000 Ci) total except as specified by Condition 15
C.	Cesium-137	C.	Sealed Source(s) registered pursuant to R313-22-210 or an equivalent U.S. Nuclear Regulatory Commission or Agreement State regulation	C.	Not to exceed 11 millicuries per source; Not to exceed 6 sources total
D.	Americium-241	D.	Sealed Neutron Source(s) registered pursuant to R313-22-210 or an equivalent U.S. Nuclear Regulatory Commission or Agreement State regulation	D.	Not to exceed 51 millicuries per source; Not to exceed 6 sources total.
E.	Americium-241 Americium-243 Neptunium-237 Plutonium-236 Plutonium-239 Plutonium-242 Thorium-229 Thorium-230 Uranium-232 Uranium-238 Curium-244 Hydrogen-3 Carbon-14 Iron-55 Nickel-59 Nickel-63 Technetium-99	E.	Liquid	E.	Not to exceed 5 microcuries total activity per isotope; Not to exceed 16 sources total.
F.	Strontium-90/Yttrium-90	F.	Liquid	F.	Not to exceed 5 microcuries total activity

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

6.	Radioactive material (element and mass number)	7.	Chemical and/or physical form	8.	Maximum quantity licensee may possess at any one time
G.	Americium-241	G.	Sealed Source(s) registered pursuant to R313-22-210 or an equivalent U.S. Nuclear Regulatory Commission or Agreement State regulation	G.	Not to exceed 5 microcuries total activity
H.	Thorium-230	H.	Sealed Source(s) registered pursuant to R313-22-210 or an equivalent U.S. Nuclear Regulatory Commission or Agreement State regulation	H.	Not to exceed 48.6 microcuries total activity
I.	Plutonium-239	I.	Sealed Source(s) registered pursuant to R313-22-210 or an equivalent U.S. Nuclear Regulatory Commission or Agreement State regulation	I.	Not to exceed 21.9 microcuries total activity
J.	Strontium-90/Yttrium-90 and Americium-241	J.	Sealed Source(s) registered pursuant to R313-22-210 or an equivalent U.S. Nuclear Regulatory Commission or Agreement State regulation	J.	Not to exceed 8.1 millicuries per source; Not to exceed 6 sources total.
K.	Am-241, Cd-109, Co-57, Te-123m, Cr-51, Sn-113, Sr-85, Cs-137, Co-60, Y-88, Th-230, Na-22, Mn-54, Eu-155 and Pb-210	K.	Calibration or Reference Source(s)	K.	Not to exceed 5 microcuries per isotope; Not to exceed 25 sources total.
L.	Uranium-234, Uranium-235, Uranium-238, Americium-241, and Plutonium-239	L.	Calibration or Reference Source(s)	L.	Not to exceed 20 nanocuries per isotope
M.	Cobalt-60 and Cesium-137	M.	Calibration or Reference Combined Source(s)	M.	Not to exceed 0.4 microcuries per source; Not to exceed 6 sources total.
N.	Reserved	N.	Reserved	N.	Reserved
O.	Americium-241 and Europium-152	O.	Calibration or Reference Combined Sources	O.	Not to exceed 2 microcuries per source; Not to exceed 4 sources total.
P.	Cesium-137	P.	Sealed Source(s) registered pursuant to R313-22-210 or an	P.	Not to exceed 12 millicuries per

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

6.	Radioactive material (element and mass number)	7.	Chemical and/or physical form	8.	Maximum quantity licensee may possess at any one time
			equivalent U.S. Nuclear Regulatory Commission or Agreement State regulation		source; Not to exceed 3 sources total.

***Applies to undisposed maximum quantity at the Class A West disposal cell and the Mixed Waste landfill cell.
****

9. AUTHORIZED USE

A. Licensee may receive, store, and dispose by land burial, radioactive material as naturally occurring and accelerator produced material (NARM) and low-level radioactive waste. Prior to receiving an initial, low-level radioactive waste shipment for disposal from a generator, the Licensee shall obtain documentation which demonstrates that the low-level radioactive wastes have been approved for export to the Licensee. Approval is required from the low-level radioactive waste compact of origin (including the Northwest Compact), or for states unaffiliated with a low-level radioactive waste compact, the state of origin, to the extent a state can exercise such approval.

B. In accordance with Utah Code Annotated 19-3-105, the Licensee may not receive Class B or Class C low-level radioactive waste without first receiving approval from the Director of the Utah Division of Radiation Control (Director) and also receiving approval from the Governor and the Legislature of the State of Utah.

C. The Licensee shall fulfill and maintain compliance with all conditions and shall meet all compliance schedules stipulated in the Ground Water Quality Discharge Permit, number UGW 450005 (hereafter GWQ Permit), issued by the Director of the Utah Division of Water Quality.

D. The Licensee may receive and store up to twenty (20) empty radioactive waste transportation casks under the following conditions:

- The casks are dedicated to the transportation of low level radioactive wastes.
- Storage of the casks is confined to the Restricted Area within the area specified in License Condition 10, except when staged for return to commerce within 7 days.
- Internal contamination is kept minimal as practical but will not exceed the contamination limits specified for Department of Transportation, Class 7 Hazardous Material, Radioactive Material, Excepted Package-Empty Packaging, UN2908.
- During storage, casks are to be secured in accordance with their Department of Transportation or Nuclear Regulatory Commission approved design specifications.

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

E. The Licensee may dispose of a volume of Class A Low-Level Radioactive Waste (LLRW) and Naturally Occurring and Accelerator Produced Radioactive Materials (NARM) in the Class A West disposal cell described in License Condition 40 not exceeding 8,724,097 cubic yards, and in the Mixed Waste Landfill Cell not exceeding 1,354,092 cubic yards. Together, the total aggregate volume of waste disposed of in the Class A West disposal cell and the Mixed Waste Landfill Cell shall not exceed 10.08 million cubic yards. Class A LLRW is defined in Utah Radiation Control Rule R313-15-1009 and NARM at R313-12-3.

F. ~~Effective January 1, 2002, t~~The Licensee shall not accept, possess, store or dispose of any radioactive waste delivered to the disposal site by any conveyance, unless the associated Shipping Documents have a valid Generator Site Access Permit number, issued by the Utah Division of Radiation Control, affixed.

G. The Licensee may receive and treat radioactively contaminated aqueous liquids and liquid mercury as characterized in the waste profile at the mixed waste facilities only, the waste must be Class A LLRW at receipt. Treated aqueous liquids may be disposed at the Mixed Waste Facility or the LLRW Facility, in accordance with Exhibit 3 of the Waste Characterization Plan. Treated (amalgamated) liquid mercury shall be disposed at the Mixed Waste Facility only.

H. Reserved

I. Licensed material in Items 6.C and 6.D, sealed source(s) contained in compatible portable gauging devices (registered pursuant to R313-22-210 or an equivalent U.S. Nuclear Regulatory Commission or Agreement State regulation) for measuring properties of materials.

J. Licensed material in Items 6.E through 6.O, for operational checks and efficiency determinations of radiation detection instrumentation.

K. Reserved

L. Licensed material in Item 6.P, sealed source(s) contained in MGP Instruments, Inc. Model IRD-2000 dosimeter calibrators/irradiators for tests and source checks of electronic dosimeters.

M. Licensed material listed in Item 6 in sealed sources possessed and used pursuant to Items 9.I through 9.L of this license may be used and stored within the Controlled Area of the Licensee's Facility located in Sections 29 and 32, Township 1 South, Range 11 West, Tooele County, Utah.

SITE LOCATION

10. A. Except as provided in Condition 9.M above, t~~T~~he Licensee may receive, store and dispose of licensed

material at the Licensee’s facility located in Section 32 of Township 1 South and Range 11 West, Tooele County, Utah.

B. Section 32, Township 1 South and Range 11 West, Tooele County, Utah, is defined by the following points of reference:

Southwest Section Corner:	Latitude 40° 40' 51.890" N
	Longitude 113° 7' 28.580" W
Elevation	4269.8~~76~~ feet above mean sea level (amsl)
Southeast Section Corner	Latitude 40° 40' 51.879" N
	Longitude 113° 6' 20.011" W
Elevation	4277.4~~27~~ feet-amsl
Northwest Section Corner	Latitude 40° 41' 44.098" N
	Longitude 113° 7' 28.654" W
Elevation	4273.1~~06~~ feet-amsl
Northeast Section Corner	Latitude 40° 41' 44.086" N
	Longitude 113° 6' 20.109" W
Elevation	4280.8~~3~~ feet-amsl

C. The Southwest Section Corner marker of Section 32 shall be the Point of Beginning (POB).

D. The existing section corner survey monuments will be maintained in a manner to protect them from being disturbed. ~~The Licensee shall cause a survey to be conducted by a Utah licensed land surveyor to identify the section corners of Section 32, Township 1 South, and Range 11 West, Tooele County, Utah (as defined in Condition 10.B). Licensee shall place monuments with brass caps at the identified section corner locations. Monuments shall be permanent and constructed in a manner that will protect them from being disturbed.~~

E. Authorized Use of Sealed Sources

i. Licensed material in Items 6.C and 6.D used as authorized in 9.I, and licensed materials in Items 6.E through 6.P used as authorized in 9.J and identified as sealed sources may be used and stored on all property owned by the Licensee at their Clive facility. The property is located in Sections 29, 32 and in parts of Sections 28 and 33 in Township 1 South, Range 11 West and parts of Sections 4, 5 and 6 in Township 2 South, Range 11 West SLBM, Tooele County, Utah.

ii. Licensed material not authorized for use specified in License Conditions 9.I and 9.J or not defined as sealed sources in License Condition 9.J shall be used and stored only at the Licensee's facilities referenced in Condition 10.B.

11. The open cell area within the Class A West disposal embankment where waste disposal/placement has

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

occurred or may occur, but the cover system has not been completed shall be limited to 3,650,000 square feet. Uncovered radioactive waste shall be limited to a surface area of 1,020,000 square feet.

12. Pursuant to UAC R313-12-55(1), the Licensee is granted an exemption to UAC R313-25-9, as it relates to land ownership and assumption of ownership.

SPECIAL NUCLEAR MATERIAL

13 In accordance with the Order issued by the U.S. Nuclear Regulatory Commission dated January 14, 2003, Docket No. 040-8989, License No. SMC-1559, EnergySolutions may possess Special Nuclear Material (SNM) within the restricted area of the ~~EnergySolutions~~ Clive facility as described in Condition 10 provided that:

A. Concentrations of SNM in individual waste containers must not exceed the values listed in Table 13-A at time of receipt:

Table 13-A

Column 1 Radionuclide	Column 2 Maximum Concentration (pCi/g)	Column 3 Measurement Uncertainty (pCi/g)
U-235[a]	1,900	285
U-235[b]	1,190	179
U-235[c]	26	10
U-235[d]	680	102
U-233	75,000	11,250
Pu-236	500	75
Pu-238	10,000	1,500
Pu-239	10,000	1,500
Pu-240	10,000	1,500
Pu-241	350,000	50,000
Pu-242	10,000	1,500
Pu-243	500	75
Pu-244	500	75

**UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET**

a - for uranium below 10 percent enrichment and a maximum of 20 percent of the weight of the waste of materials listed in License Condition 13.B
b - for uranium at or above 10 percent enrichment and a maximum of 20 percent of the weight of the waste of materials listed in License Condition 13.B
c - for uranium at any enrichment with unlimited quantities of materials listed in License Condition 13.B and License Condition 13.C
d - for uranium at any enrichment with sum of materials listed in License Condition 13.B and License Condition 13.C not exceeding 45 percent of the weight of the waste

* The measurement uncertainty values in Column 3 above represent the maximum one-sigma uncertainty associated with the measurement of the concentration of the particular radionuclide.

The SNM must be homogeneously distributed throughout the waste. If the SNM is not homogeneously distributed, then the limiting concentrations must not be exceeded on average in any contiguous mass of 600 kilograms.

B. Except as allowed by notes a, b, c, and d in Condition 13.A, waste must not contain "pure forms" of chemicals containing carbon, fluorine, magnesium, or bismuth in bulk quantities (e.g., a pallet of drums, a B-25 box). By "pure forms," it is meant that mixtures of the above elements such as magnesium oxide, magnesium carbonate, magnesium fluoride, bismuth oxide, etc. do not contain other elements. These chemicals would be added to the waste stream during processing, such as at fuel facilities or treatment such as at mixed waste treatment facilities. The presence of the above materials will be determined by the generator, based on process knowledge or testing.

C. Except as allowed by notes c and d in Condition 13.A, waste accepted must not contain total quantities of beryllium, hydrogenous material enriched in deuterium, or graphite above one percent of the total weight of the waste. The presence of the above materials will be determined by the generator, based on process knowledge, physical observations, or testing.

D. Waste packages must not contain highly water soluble forms of uranium greater than 350 grams of uranium-235 or 200 grams of uranium-233. The sum of the fractions rule will apply for mixtures of U-233 and U-235. Highly soluble forms of uranium include, but are not limited to: uranium sulfate, uranyl acetate, uranyl chloride, uranyl formate, uranyl fluoride, uranyl nitrate, uranyl potassium carbonate, and uranyl sulfate. The presence of the above materials will be determined by the generator, based on process knowledge or testing.

E. Mixed waste processing of waste containing SNM will be limited to stabilization (mixing waste with reagents), micro-encapsulation, macro-encapsulation using low-density and high density polyethylene, macroencapsulation using ~~cementatious~~ cementitious mix (Macro Mix), and thermal desorption.

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

When waste is processed using the thermal desorption process, EnergySolutions shall confirm the SNM concentration following processing and prior to returning the waste to temporary storage.

Liquid waste may be stabilized provided the SNM concentration does not exceed the SNM concentration limits in License Condition 13.A. For containers of liquid waste with more than 600 kilograms of waste, the total activity (pCi) of SNM shall not exceed the SNM concentration in License Condition 13.A times 600 kilograms of waste. Waste containing free liquids and ~~the~~ solids shall be mixed prior to treatment. Any solids shall be maintained in a suspended state during transfer and treatment.

F. EnergySolutions shall require generators to provide the following information for each waste stream:

Before Receipt

1. Waste Description. The description must detail how the waste was generated, list the physical forms in the waste, and identify uranium chemical composition.
2. Waste Characterization Summary. The data must include a general description of how the waste was characterized (including the volumetric extent of the waste, and the number, location, type, and results of any analytical testing), the range of SNM concentration ranges, and the analytical results with error values used to develop the concentration ranges.
3. Uniformity Description. A description of the process by which the waste was generated showing that the spatial distribution of SNM must be uniform, or other information supporting spatial distribution.
4. Manifest Concentration. The generator must describe the methods to be used to determine the concentrations on the manifests. These methods could include direct measurement and the use of scaling factors. The generator must describe the uncertainty associated with sampling and testing used to obtain the manifest concentrations.

EnergySolutions shall review the above information and, if adequate, approve in writing this pre-shipment waste characterization and assurance plan before permitting the shipment of a waste stream. This will include statements that EnergySolutions has a ~~written~~ copy of all the information required above, that the characterization information is adequate and consistent with the waste description, and that the information is sufficient to demonstrate compliance with Conditions 13.F.1 through 13.F.4. Where generator process knowledge is used to demonstrate compliance with Conditions 13.A, 13.B, 13.C, or 13.D, EnergySolutions shall review this information and determine when testing is required to provide additional information in assuring compliance with the conditions. EnergySolutions shall retain this information as required by the State of Utah to permit independent review.

At Receipt

EnergySolutions shall require generators of SNM waste to provide a written certification with each waste manifest that states the SNM concentrations reported on the manifest do not exceed the limits in Condition 13.A, that the measurement uncertainty does not exceed the uncertainty value in Condition

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

13.A, and that the waste meets Conditions 13.B through 13.D.

G. Sampling and radiological testing of waste containing SNM must be performed in accordance with the following: One sample for each of the first ten shipments of a waste stream; or one sample for each of the first 100 cubic yards of waste up to 1,000 cubic yards of a waste stream; and one sample for each additional 500 cubic yards of waste following the first ten shipments or following the first 1,000 cubic yards of a waste stream. Sampling and radiological testing of debris waste containing SNM can be waived if the SNM concentration is lower than one tenth of the applicable limit in License Condition 13.A.

H. EnergySolutions shall notify the NRC, Region IV office within 24 hours if any of the above conditions are violated, including if a batch during a treatment process exceeds the SNM concentration in License Condition 13.A. A written notification of the event must be provided within 7 days.

I. EnergySolutions shall obtain NRC approval prior to changing any activities associated with the above conditions.

J. Notwithstanding License Condition13.A through 13.I, for the Containerized Waste Facility described in License Condition 40, the following limits for possession of SNM apply to the total combined quantities of SNM at the Containerized Waste Facility:

Consistent with the definition of special nuclear material given in UAC R313-12-3, the maximum quantity of special nuclear material which the EnergySolutions may possess at any one time, shall not exceed: 350 grams of U-235, 200 grams of U-233, and 200 grams Pu, or any combination of them in accordance with the following formula:

$$\frac{\text{(Grams U-235)}}{350} + \frac{\text{(Grams U-233)}}{200} + \frac{\text{(Grams Pu)}}{200} \leq 1$$

"Possession" and "Disposal" are defined in License Conditions 63 and 64 respectively.

MIXED WASTE

14. A. The Licensee may receive for treatment, storage, and disposal any radioactive waste as authorized by this license that is also determined to be hazardous (commonly referred to as mixed waste) as permitted by the "Hazardous Waste Plan Approvals" issued and modified by the Director of the Utah Division of Solid and Hazardous Waste~~ and "HSWA Permit" issued by the U.S. Environmental Protection Agency~~.

B. The Licensee may dispose of treated mixed waste in the Class A West disposal cell if it meets the criteria described in Exhibit 3 of the Waste Characterization Plan.

C. All other mixed wastes shall be disposed in the Mixed Waste Landfill Cell only.

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

WASTE TREATMENT AND PROCESSING

15. A. Prior to receipt of any low level radioactive or mixed wastes requiring treatment before disposal, the Licensee shall, based on knowledge of the technology to be used for treatment/processing of each particular radioactive or mixed waste, calculate and document that the resultant processed waste ~~is~~ will be neither Class B nor Class C waste.

    B Reserved

    C. Following treatment at the Mixed Waste facility the Licensee shall classify the resultant processed waste in accordance with UAC R313-15-1009.

    D. The Licensee shall manifest treated waste from the Mixed Waste facility for disposal in accordance with UAC R313-15-1006.

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

PROHIBITIONS AND WASTE ACCEPTANCE REQUIREMENTS

16. A. Sealed sources as defined in Utah Administrative Code (UAC) R313-12 shall not be accepted for disposal.

B. ~~In accordance with UAC R313-15-1009(2)(a)(v), waste shall not be readily capable of detonation or of explosive decomposition or reaction at normal pressures and temperatures, or of explosive reaction with water.~~Reserved.

C. ~~In accordance with UAC R313-15-1009(2)(a)(vi), waste shall not contain, or be capable of generating, quantities of toxic gases, vapors, or fumes harmful to persons transporting, handling, or disposing of the waste.~~Reserved.

D. ~~In accordance with UAC R313-15-1009(2)(a)(vii), waste shall not be pyrophoric.~~Reserved.

E. ~~Waste containing untreated biological, pathogenic, or infectious material including radiologically contaminated laboratory research animals is prohibited~~Reserved.

F. Liquid Waste Restrictions

i. Except for liquid mercury, ~~-~~wastes to be treated by thermal desorption at the Mixed Waste facility in accordance with the State-issued Part B Permit, and minimal quantities as described in Condition 17 and in the currently approved Waste Characterization Plan, receipt of non-aqueous liquid waste is prohibited unless specifically approved by the Director.

ii. Treated liquid radioactive waste shall be disposed at the Mixed Waste Facility or the LLRW Facilities in accordance with Exhibit 3 of the currently approved Waste Characterization Plan.

iii. Only ~~Utah Division of Radiation Control~~ approved solidification or absorption agents as listed in the State-issued Part B Permit are authorized for liquid waste treatment.

iv. Liquid radioactive waste shall be solidified or absorbed in a manner such that no liquid component is disposed.

v. Only containers authorized by the U. S. Department of Transportation as specified in the regulations (49 CFR parts 100 thru 180) for transporting liquid radioactive materials shall be accepted for all liquid radioactive wastes, regardless of radioactivity concentrations.

G. ~~In accordance with UAC R313-15-1009(2)(a)(viii), gaseous waste received for disposal in the Containerized Waste Facility shall be packaged at an absolute pressure that does not exceed 1.5 atmospheres at a temperature of 20 degrees Celsius and the total activity of any container shall not exceed 100 curies (3.7 X 10^{12} Bequerels)~~Reserved.~~.~~

H. ~~In accordance with UAC R313-15-1009(2)(a)(ii), waste received for disposal in the Containerized~~

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

~~Waste Facility shall not be packaged in cardboard or fiberboard containers~~Reserved.

I. ~~The Licensee shall not accept for disposal any neutron source (e.g., polonium-210, americium-241, radium-226 in combination with beryllium or other target)~~All neutron-emitting waste with detectable neutron radiation (unpackaged, contact dose rate > 0.5 mrem/hr) shall be disposed at the Containerized Waste Facility unless otherwise approved by the Director.~~.~~

J. Incinerator ash shall be treated, in preparation for disposal, in a manner that renders it non-dispersible in air.

K. Radioactive waste containing chelating agents greater than 0.1 percent by weight shall be disposed of in the Mixed Waste Landfill Cell.

L. The Licensee shall not accept containerized radioactive waste unless each waste package has been:
  i. Classified in accordance with R313-15-1009, "Classification and Characteristics of Low-Level Radioactive Waste." In addition, the Licensee shall require that all radioactive waste received for disposal meet the requirements specified in the Nuclear Regulatory Commission, "Branch Technical Position on Concentration Averaging and Encapsulation", as amended.
  ii. Marked as either Class A Stable or Class A Unstable as defined in the most recent version of the "Low-Level Waste Licensing Branch Technical Position on Radioactive Waste Classification." originally issued May, 1983 by the U.S. Nuclear Regulatory Commission.
  iii. Marked with a unique package identification number, clearly visible on the package, that can be correlated with the manifest for the waste shipment in which the package arrives at the facility.

M. The Licensee may accept containerized Class A LLRW in the following waste packages for disposal in the Containerized Waste Facility of the Class A West disposal cell:
  i. DOT "strong, tight" containers in accordance with 49 CFR 173 and meeting the following void space criteria: void spaces within the waste and between the waste and its packaging shall be reduced to the extent practicable, but in no case shall less than 85 percent of the capacity of the container be filled.
  ii. High-Integrity Containers (HICs) exceeding the void space criteria provided in License Condition 16.M.i, shall be approved by the Director.
  iii. DOT "strong, tight" containers in accordance with 49 CFR 173 exceeding the void space criteria provided in License Condition 16.M.i and large components shall be placed as approved by the Director.
  iv. Oversized DOT containers (larger than ~~215~~ 331 cubic feet) meeting the void space criteria provided in License Condition 16.M.i shall be placed in accordance with the currently approved ~~LLRW Construction~~ CQA/QC Manual.

MANAGEMENT OF FREE LIQUIDS

17. A. ~~In accordance with UAC R313-15-1009(2)(a)(iv), solid waste received for disposal shall contain as little free standing and non-corrosive liquid as reasonably achievable, but shall contain no more free~~

**UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET**

License # UT 2300249
Amendment # ~~14~~15

~~liquids than one percent of the volume of the waste.~~Shipments containing free liquid in excess of 1% shall be absorbed, evaporated, or the liquids removed only at facilities with approved secondary containment or the rail rollover facility.

B. Solid waste received and containing unexpected aqueous free liquid in excess of 1% by volume shall have the liquid removed and placed in the evaporation ponds or the liquid solidified prior to management.

C. Unexpected non-aqueous free liquids less than 1% of the volume of the waste within the container shall be solidified prior to disposal.

D. Should shipment(s) arrive with greater than 1% unexpected free liquids (total of aqueous and non-aqueous), the Licensee shall notify the Division of Radiation Control within 24 hours that the shipment(s) failed the requirements for acceptance and manage in accordance with the currently approved Waste Characterization Plan.

RADIATION SAFETY

18. ~~The Licensee shall comply with the provisions of UAC R313-18, "Notices, Instructions and Reports to Workers by Licensees or Registrants - Inspections"; and UAC R313-15, "Standards for Protection Against Radiation.~~Reserved.~~"~~

19. ~~The Licensee may transport licensed material or deliver licensed material to a carrier for transport in accordance with the provisions of UAC R313-19-100, "Transportation."~~Reserved.

20. Written procedures incorporating operating instructions and appropriate safety precautions for licensed activities shall be maintained and available at the location specified in License Condition 10.A. The written procedures established shall include the activities of the radiation safety and environmental monitoring programs, the employee training program, operational procedures, analytical procedures, and instrument calibration. At least annually, the Licensee shall review all procedures to determine their continued applicability.

21. The Licensee's ~~Director of Health Physics~~ Radiation Safety Officer (RSO) shall review and approve written procedures as stated in License Condition 20 and subsequent changes to the procedures related to waste disposal operations.

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

ROUTINE MONITORING AND CONTAMINATION SURVEYS FOR NEW LICENSEES:

22. The Licensee shall conduct contamination surveys in accordance with Table 22-A:

TABLE 22-A

Type	Location	Frequency
A. Gamma Radiation Levels	1. Perimeter of Restricted Area(s)	1. Weekly
	2. Office Area (s)	2. Weekly
	3. Lunch/Change Area(s)	3. Weekly
	4. Transport Vehicles	4. Upon vehicle arrival at site and before departure.
	5. Mixed Waste Facility	5. Weekly
	6. Decontamination facilities	6. Weekly
B. Contamination Wipes	1. Eating Area(s) 2. Change Area(s)	1. Weekly 2. Weekly
	3. Office Areas(s)	3. Weekly
	4. Railcar rollover and control shack	4. Weekly
	5. Equipment/Vehicles	5. Once before release
	6. Decontamination facilities	6. Weekly
	7. Mixed Waste Facility	7. Weekly
	8. Shredder Facility and control room	8. Weekly
	9. Rotary Dump and control room	9. Weekly
C. Employee/Personnel	1. Skin & Personal clothing	1. Prior to exiting restricted area
D. Gamma Exposure	1. Administration Bldg.(s)	1. Quarterly
E. Radon Concentration	1. Administration Bldg.(s)	1. Quarterly

23. ~~The Licensee shall determine internal exposure of employees under its bioassay program, in accordance with UAC R313-15-204~~Reserved.

24. Reserved~~The Licensee shall implement a respiratory protection program that is in accordance with UAC R313-15-703~~.

25. The Licensee shall calibrate air sampling equipment at intervals not to exceed six months.

26. The operational environmental monitoring program shall be conducted in accordance with the currently approved Environmental Monitoring Plan~~ (dated January 5, 2012, or the most recent approved amendment to that plan)~~.

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

27. Vehicles, containers, facilities, materials, equipment or other items for unrestricted use shall not be released from the Licensee's control if contamination exceeds the limits found in Table 27-A. Except as provided in 49 CFR 173.443(d), conveyances used for commercial transport of radioactive waste or materials, may not be returned to service until the radiation dose rate at each accessible surface is 0.005 mSv per hour (0.5mrem per hour) or less, and there is no surface removable (non-fixed) radioactive surface contamination as specified in paragraph (a) of 49 CFR 173.443.

TABLE 27-A

Nuclide[a]	Column 1 Average [b,c,f]	Column 2 Maximum [b,d,f]	Column 3 Removable [b,e,f]
U-nat, U-235, U-238, and associated decay products	5,000 dpm alpha/ $100cm^2$	15,000 dpm alpha/ $100cm^2$	1,000 dpm alpha/ $100cm^2$
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100 dpm/$100cm^2$	300 dpm/$100cm^2$	20 dpm/$100cm^2$
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000 dpm/$100cm^2$	3,000 dpm/$100cm^2$	200 dpm/$100cm^2$
Beta-gamma emitters (nuclides with decay modes other than alpha emissions or spontaneous fission) except Sr-90 and other noted above.	5,000 dpm beta, gamma/$100cm^2$	15,000 dpm beta-gamma/$100cm^2$	1,000 dpm beta-gamma/$100cm^2$

a. Where surface contamination ~~on~~ of both alpha-and beta-gamma emitting nuclides exists, the limits established for alpha-and beta-gamma emitting nuclides should apply independently.

b. As used in this table, dpm (disintegration~~'~~s per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

c. Measurements of average contamination should not be averaged over more than one square meter. For objects of less surface area, the average should be derived for each such object.

d. The maximum contamination level applies to an area of not more than 100 cm^2.

e. The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping the area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

f. The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters shall not exceed 0.2 mrad/hr at 1 cm and 1.0 mrad/hr at 1 cm, respectively, measured

**UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET**

License # UT 2300249
Amendment # ~~14~~15

through not more than 7 milligrams per square centimeter of total absorber.

28. Reserved.~~The Licensee shall submit the following to the Director for review and approval pending resolution of all issues as judged by the Director:~~
    ~~A. The Licensee shall submit a corrective action plan for the Cover Test Cell for Director approval by no later than July 23, 2008. The corrective action plan shall identify all means necessary to collect valid data to verify actual performance of the cover system. Said plan shall include Cover Test Cell design, construction, instrumentation, monitoring, reporting, and comparison of actual performance to projected performance. The Cover Test Cell corrective action plan shall include:~~
        ~~i. Performance goals to meet the objective of verifying modeled cover system performance.~~
        ~~ii. Methodologies and plans that provide quantitative and qualitative results capable of satisfying the objective.~~
        ~~iii. Design, construction, and operational plans to implement the methodologies and plans.~~
        ~~iv. Quality control and quality assurance requirements of work to be performed. Quality control and quality assurance specifications and procedures shall state specific actions and processes the Licensee will use to ensure compliance with designs and specifications, monitoring, reporting, ensure data validity, timely detect data deficiencies, enhance accuracy of data interpretation, and ensure correctness of results prior to being submitted to the Division.~~
        ~~v. In the event that the plan results in new instrumentation or construction, the Licensee shall complete all such activities within 30-days of Director approval. Within 30-days of completion of said construction, the Licensee shall submit an As-Built report for Director approval.~~

    ~~B. The Licensee shall submit an annual report for Director approval by March 1 of each calendar year. This annual report shall detail the Licensee's progress in implementing the corrective action plan, provide the data collected in the past year, analyze the data, and interpret the meaning of the data relative to the overall objective of the corrective action plan.~~

REPORTING

29. The Licensee shall submit the following reports to the Director:

    A. ~~Quarterly~~ Semi-annual results from the Environmental Monitoring Program~~-~~, as amended. The report(s) shall be submitted within 90 days after the ~~expiration of each calendar quarter~~end of the reporting period. The reporting period shall be January through June; and July through December.
~~Calendar Quarter shall mean:~~

~~First Quarter~~	~~January, February, and March~~
~~Second Quarter~~	~~April, May, and June~~
~~Third Quarter~~	~~July, August, and September~~
~~Fourth Quarter~~	~~October, November, and December~~

    B. A quarterly summary report detailing the radioisotopes, activities, weighted average concentrations, volume, and tonnage for waste received during the calendar quarter. The report of volume (cubic feet

**UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET**

License # UT 2300249
Amendment # ~~14~~15

and cubic yards) and tonnage (tons) shall be partitioned according to waste type: Low Level Radioactive Waste (LLRW), LLRW with PCBs, Mixed Waste (MW), MW with PCBs, MW Treatment, NORM, Containerized Class A, uranium/thorium mill tailings (i.e. 11e.(2) wastes), and waste generated prior to congress passing the Uranium Mill Tailings Radiation Control Act in 1978. The report(s) shall be submitted within 30 days after the expiration of each calendar quarter. Calendar Quarter shall mean:

First Quarter	January, February, and March
Second Quarter	April, May, and June
Third Quarter	July, August, and September
Fourth Quarter	October, November, and December

C. Reserved

D. For the Mixed Waste Landfill Cell, the Licensee shall ensure that the maximum acceptable activities, used as source terms in the groundwater performance modeling are not exceeded after facility closure. ~~Therefore, the Licensee shall notify the Director, at the earliest knowledge, that the following nuclides are scheduled for disposal:~~ Accordingly, berkelium-247 is limited to a net concentration of 0.00314~~xxxxx~~ for the completed cell; and chlorine-36 is limited to a net concentration of 8.75~~xxxxx~~ for the completed cell.

E. Reserved.~~For the Class A West disposal cell, the Licensee shall ensure that the maximum acceptable activities used as source terms in the groundwater performance modeling are not exceeded after facility closure. Therefore, the Licensee shall notify the Director, at the earliest knowledge, that the following nuclides are scheduled for disposal: berkelium-247, calcium-41, chlorine-36, iodine-129, rhenium-187, and Technetium-99.~~

F. An annual report shall be submitted by March 31st and shall report the cumulative void space (expressed as a percent of waste volume) disposed of in the Containerized Waste Facility for the previous year.

30. ~~Except as provided by this condition, t~~The Licensee shall maintain the results of sampling, analyses, surveys, and instrument calibration, reports on inspections, and audits, employee training records as well as any related review, investigations and corrective actions, for no less than five ~~(5)~~ years.~~ The Licensee shall maintain personnel exposure records in accordance with UAC R313-15-201.~~

STAFFING/QUALIFICATIONS

31. Radiation Safety operations for bulk, containerized and mixed waste, portable gauging device(s), radioactive source(s), and dosimeter calibrator(s)/irradiator(s) shall be conducted by or under the supervision of Rick Chalk, ~~Director of Health Physics~~Radiation Safety Officer (RSO).

32. A. The Licensee's staff shall meet the qualifications as described in the currently approved Organization

**UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET**

License # UT 2300249
Amendment # ~~14~~15

Plan~~Appendix I (November 7, 2011, rev 23)~~.

B. Licensed material in License Conditions 6.C and 6.D. shall be used by, or under the supervision and in the physical presence of, the RSO~~Director of Health Physics~~ or individuals who have been trained in the Licensee's standard operating and emergency procedures and have satisfactorily completed at least one of the following:
   i. The device manufacturer's training course for safe use and handling of portable gauging devices containing licensed material; or
   ii. A portable gauge training program conducted in accordance with the provisions of a specific license issued by the Director, an Agreement State or the U.S. Nuclear Regulatory Commission.

C. Licensed material in License Conditions 6.E through 6.P shall be used by, or under the supervision of, the ~~Director of Health Physics~~RSO, or individuals designated in writing by the RSO~~Director of Health Physics~~.

D. The Licensee shall maintain the organizational independence of the programs that monitor and enforce employee safety, environmental protection, and public safety from programs responsible for production and profitability and other influences or priorities that might compromise quality and radiation safety.

E. The Licensee shall establish a method for any employee or contractor to anonymously submit questions, concerns, ideas, or other comments regarding employee safety, environmental protection, and public safety to the RSO~~Director of Health Physics~~. The method shall include documentation of all comments submitted, the Applicant's response to each comment, and a method for communicating the Licensee's response to employees and contractors.

CONSTRUCTION ACTIVITIES

33. The Licensee shall obtain prior written approval from the Director prior to construction of significant facilities. Significant facilities shall include, but are not limited to waste, stormwater, and wastewater related handling, storage, and transfer projects.

34. ~~The Licensee shall address and resolve all concerns the Division has identified regarding clay mining activities in areas adjacent to Section 32, as provided in a February 16, 2007 Division letter to the Licensee, including a February 9, 2007 Round 1 Interrogatory by the URS Corporation (URS 39400018.3090). The Licensee shall deliver detailed analyses, explanations, descriptions, and appropriate justification to the Division no later than July 1, 2008. If the Director determines that unacceptable adverse conditions exist or might develop or evolve, the Licensee shall submit for approval a remedial action plan within 30 days of written notice of the determination by the Director. The remedial action plan will address, among other topics, description of proposed activities, justification that the proposed activities will be adequate to protect the facilities in Section 32 from possible impacts of clay mining, and engineering design, specifications, and construction of proposed remedial actions~~Reserved.

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

35. A. In accordance with UAC R313-25-8, effective June 1, 2010 the Licensee shall not dispose of ~~significant~~ quantities of concentrated depleted uranium (DU) greater than 40,000 cy annually, prior to the approval by the Director of the performance assessment required in R313-25-8.

B. Performance assessment: ~~A performance assessment, in general conformance with the approach used by the Nuclear Regulatory Commission (NRC) in SECY-08-0147, shall be submitted for Director review and approval no later than June 1, 2011.~~ The DU performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC. For purposes of this performance assessment, the compliance period will be a minimum of 10,000 years. Additional simulations will be performed for a minimum 1,000,000-year time frame for qualitative analysis.

C. Revised disposal embankment design: If the performance assessment specified in paragraph 35.B indicates that changes to disposal operations and cover design are necessary to ensure compliance with the requirements of 10 CFR Part 61 or Utah Administrative Code R313, EnergySolutions will provide a revised design that does meet those requirements, for all wastes that have been and are reasonably anticipated to be disposed of at the facility within 180 days of Director approval of the performance assessment.

D. Remediation: If following the completion of ~~DRC's~~ the Director's review of the performance assessment described in paragraph 35.B, the disposal of DU as performed after the date of this license condition would not have met the requirements of the performance assessment, the facility will undertake remediation to ensure that the performance standards are met, or if that is not possible, shall remove the DU and transport it off-site to a licensed facility.

E. Surety: The Licensee shall fund the surety for the ~~remediation~~ revised embankment design, in License Condition 35.~~D~~C, at the next annual surety update following approval of a revised embankment design~~. Within 30 days of the effective date of this license condition, the licensee shall submit for Director review and approval, the surety cost estimates for remediation of existing Savannah River DU waste disposal and planned, similar large quantity DU waste disposal.~~

36. A. The West Rail Spur and Unloading facility shall be operated as a transfer station for Surface Contaminated Objects (SCO) and large components.~~, (~~ ~~w~~Waste storage is prohibited~~)~~. These objects may be set on the gravel pad for 24 hours to facilitate unloading and transferring to the Class A West disposal cell.

B. The West Rail Spur and Unloading facility shall be operated as a transfer station for conveyances to be unloaded at the Containerized Waste Facility. ~~(u~~Unloading of waste packages is prohibited~~)~~.

37. All ion exchange resins shall be disposed of as follows:

A. Solidified using solidification agents approved by the Director and disposed of in the Containerized Waste Facility; or

**UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET**

License # UT 2300249
Amendment # ~~14~~15

B. Packaged in High-Integrity Containers (HIC) approved by the Director, carbon-steel liners, unapproved HICs, or poly HICs meeting the void space criteria described in License Condition 16.M.i and disposed of in the Containerized Waste Facility; or

C. Packaged in High-Integrity Containers (HIC) approved by the Director, carbon-steel liners, unapproved HICs, or poly HICs not meeting the void space criteria described in License Condition 16.M.i and disposed of as approved by the Division under License Condition 16.M.ii or 16.M.iii in the Containerized Waste Facility; or

D. Disposed of in accordance with the requirements of the currently approved CQA/QC ~~Construction Quality Assurance/Quality Control~~ Manual.

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

38. The Licensee shall construct the Class A West disposal ~~C~~cell identified in the Ground Water Quality Discharge Permit No. UGW450005 ~~and~~ in accordance with approved engineering design drawings "Series 10014".

39 Waste placement and backfilling within the Containerized Waste Facility shall be conducted in accordance with the following:

A. ~~The Containerized Waste Facility shall conform to the characteristics defined, analyzed, and described in the Engineering Justification Report "Class A Disposal Cell Containerized Waste Facility" (dated April 12, 2001); Engineering Justification Report, Addendum "Fifteen Percent Void Space Criteria" (Revision 1 dated October 10, 2001); and the AMEC letter to Envirocare of Utah, Inc. "Placement of Drums and B-25 Containers with 15 Percent Voids; Envirocare Class A - Containerized Waste Facility Near Clive, Utah" (dated October 2, 2001).~~ Waste containers that have void space in excess of 15 percent shall be filled to the top of the container opening using an approved Controlled Low Strength Material (CLSM) mix design in accordance with the currently approved ~~Construction~~ CQA/QC manual. The Licensee is exempt from the CLSM cold weather requirements and the 48 hour notification for void remediation only at the CWF Facility.

B. Waste container configurations, backfill materials and associated placement activities, shall be those ~~approved by the Director following specifications contained in the Work Element: Containerized Waste Facility Waste Placement Test Pad and the Work Element Containerized Waste Facility- Waste Placement Sections~~ of the currently approved CQA/QC ~~LLRW Construction Quality Assurance/Quality Control~~ Manual.

C. Waste delivered in a shielded transportation cask shall remain in the cask until the waste is approved for disposal and the disposal location is prepared for the shipment. Waste received for disposal in the Containerized Waste Facility shall not be handled, stored or transferred within the contaminated portion of the Restricted Area without the approval of the ~~Director of Health Physics~~RSO.

D. The Containerized Waste Facility shall be operated as a contamination-free portion of the Restricted Area until containerized waste disposal operations are completed. Bulk waste may then be used to complete the filling of the cell.

E Interim storage is applicable only to the Containerized Waste Facility. Packages containing radioactive material shall not be stored for a period of longer than 30 days from the date of receipt. Retention of waste materials above ground pending disposal up to 3 working days does not constitute storage. All packages in storage shall be shielded so that the package or shielding shall not exceed 40 mR/hour at one meter from the surface.

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

F. Disposal of non-containerized decomposable or compressible waste, such as blocking and bracing used for transportation, at the Containerized Waste Facility is prohibited. Such waste shall be disposed of as debris in bulk waste portions of the Class A West disposal embankment, in accordance with debris placement requirements of the currently approved ~~LLRW and 11e.(2)~~ CQA/QC Manual.

40. The LARW and Class A West Disposal Cells~~,~~ shall be defined by the areas enclosed by the points of reference in ~~the~~ Ground Water Quality Discharge Permit No. UGW450005. The Containerized Waste Facility within the Class A West disposal cell shall be separated from the non-containerized area by a 6-foot chain link fence on the berm around the Containerized Waste Facility perimeter area.

41. ~~On or before August 1, 2012, the Licensee shall submit, for Director's review and approval, a detailed plan for a study of the clayey soils to be used in the radon barrier of the CAW embankment cover. The objective of this study is to determine the amount of strain that the soils can withstand without cracking when subjected to both axial lengthening and bending as would be experienced when the clay settles differentially as part of the cover system.~~ Within nine months of Director's approval of the Clayey Soils S~~s~~tudy P~~p~~lan, developed to determine the amount of strain that the cover soils can withstand without cracking when subjected to both axial lengthening and bending strains, the Licensee shall execute the study and submit a report with results of the study. Based on results of the study and the Director's review, the Director may require the Licensee to modify the embankment and cover design.

42. ~~On or before December 25, 2012, the Licensee shall submit a revised cover design (including at least descriptions, design calculations, drawings, and specifications) and an assessment addressing performance of the revised Class A West cover design and transport of releases from the proposed Class A West disposal unit~~Reserved.

43. ~~The Licensee shall construct the Class A West disposal cell identified in the Ground Water Quality Discharge Permit No. UGW450005 and in accordance with approved engineering design drawings "Series 10014". The Licensee shall, in the 2012 Surety submittal, provide cost estimates based on the Class A West design submitted on Drawings 10014 C01 through C06 listed in Table 2C of the GWQDP.~~ The Licensee shall provide surety funding corresponding to the 2012 LLRW Annual Surety Revision, as approved by the Executive Director prior to commencing construction of the clay liner in the area between the previously approved Class and Class A North embankments.

44. The Licensee shall fulfill all requirements and maintain compliance with all conditions in the ~~LLRW~~ currently approved CQA/QC Manual and engineering drawings ~~currently approved by the Director~~.

45. All engineering related soil tests conducted by the Licensee to demonstrate compliance with Condition 44 shall be performed by a laboratory certified and accredited by the AASHTO Materials Reference Laboratory (AMRL). Said certification/accreditation shall apply to clay liner, clay radon barrier, ~~soil filter layers, sacrificial soils, and riprap materials~~bankrun borrow, evaporative zone, and surface zone materials, or other soil or man-made materials as directed by the Director. Said certification shall include all engineering test

**UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET**

License # UT 2300249
Amendment # ~~14~~15

methods required by License Condition 44, or as directed by the Director. Certification is not required for the DRC approved sealed single ring infiltrometer permeability test contained in Appendix B of ~~to~~ the ~~LLRW and 11e(2)~~ currently approved CQA/QC Manual.

46. Reserved

47. The Licensee shall not initiate disposal operations in newly excavated areas until the Division has inspected and the Director has approved the cell/embankment liner.

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

CONSTRUCTION DRAWINGS.

48. A. The Licensee shall provide a comprehensive set of drawings for the entire Clive site. The drawings shall correctly: (1) locate all structures, utilities, fences, ponds, drainage features railroad tracks, roads, storage facilities, loading and off-loading facilities, disposal embankments, all environmental monitoring locations including instruments/devices, and any other appurtenances related to the operation, maintenance and closure of the disposal facility; and (2) provide survey control including elevations in sufficient detail to fully describe the site. The drawings shall be developed in accordance with the standards of professional care. A drawing index shall be included that identifies drawings by discrete number. Each drawing shall include a revision block that documents the latest changes or modifications by date and includes the initials of the responsible reviewer for QA/QC tracking purposes.

B. Drawings showing approved future designs shall be marked as "Final Drawings." Final drawings or drawings developed for construction shall be sealed by a Utah registered professional engineer. The drawings shall be developed in accordance with the standards of professional care.

C. Within 30 days of completion of any project that requires approval by the Director, a set of "As-Built" drawings shall be submitted for review. The drawings shall indicate as-built conditions as they existed no earlier than 30 days prior to the submittal. Drawings of finished construction shall be marked as "As-Built" in the final entry in the revision block.

SITE OPERATING PROCEDURES

49. ~~Shipments containing free liquid in excess of 1% shall be absorbed, evaporated, or the liquids removed only at facilities with approved secondary containment or the rail rollover facility.~~Reserved.

50. A. On-site generated waste shall be managed according to its radiological, physical and chemical characteristics. Solid phase material shall be disposed in either the Class A West Cell, Mixed Waste Cell, or the 11e.(2) Cell. Waste water from decontamination facilities will be put in the evaporation ponds or sprayed on the Class A West disposal cell~~s~~ for purposes of dust and engineering controls.

B. Site equipment that has reached the end of its useful life, is not operational and does not meet the removable contamination limits of License Condition 27, Table 27-A, shall be disposed in the LLRW Class A West Cell within 90 days as debris in accordance with requirements of the currently approved ~~LLRW Construction Quality Assurance/Quality Control~~ CQA/QC Manual or stored on approved facilities for storage, transfer, and sampling of bulk waste.

C. Facility vehicles transferring or unloading bulk waste shall not be left unattended outside of the disposal cell.

51. The following shall be implemented for LLRW and 11e.(2) Waste segregation purposes:

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

A. LLRW and 11e.(2) waste shall not be managed simultaneously at the Rail rollover facility, Shredder Facility, Rotary Dump Facility, or Rail Digging facility;

B. Any vehicle or facility used to manage waste for disposal within the 11e.(2) disposal embankment, must be clearly labeled to designate 11e.(2) management. The labels shall be visible from both sides of a vehicle/facility designated for 11e.(2) waste management.

C. Equipment, vehicles and facilities, which are used for management of LLRW will be cleaned of any material before being used for 11e.(2) waste management activities. Equipment, vehicles and facilities shall be cleaned of all waste material to a limit of 500 grams per square foot prior to being used for other waste types.

52. Licensee shall only accept w~~W~~aste shipments or transportation packages ~~received shall~~ that meet ~~the following contamination control~~ DOT requirements for removable contamination.
~~* Less then 220 dpm/100cm² alpha~~
~~* Less then 2200 dpm/100cm² Beta-gamma~~

~~If a shipment or transportation package does not meet the above contamination requirements, the Licensee shall take actions to reduce the risk for spread of contamination.~~

53. A. Quarterly, the Licensee shall clean the facility roads, or more frequently when needed. The material collected from cleaning the roads shall be disposed within an approved disposal embankment for Class A waste.

B. On a biweekly basis (once every two weeks) between the first day of May and the last day of September, the Licensee shall spray a polymer solution on all exposed contaminated cell areas and areas of waste within the Class A West Cell which ~~has~~ have been disturbed in the previous two weeks. The Licensee will apply a polymer-based stabilizer in accordance with the manufacturer's instructions.

C. The Licensee shall minimize the dust created during the process of placing and moving waste, through the use of water. Water or other engineering controls shall be placed on roads and in areas which work is being performed.

D. The Licensee shall cease loading, hauling, and dumping of un-containerized waste whenever the 5-minute average wind velocities exceed 35 miles per hour. When both the 5-minute average and 5-minute maximum wind velocities are less than 35 mph as observed on the meteorological station, management of un-containerized waste may resume.

54. The Licensee shall fulfill and maintain compliance with all conditions and requirements in the currently approved Site Radiological Security Plan ~~(Revision 4, October 6, 2011)~~.

**UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET**

License # UT 2300249
Amendment # ~~14~~15

55.
Reserved. ~~For the Class A West disposal cell, the Licensee shall ensure that the average concentrations of selected radionuclides do not exceed the limits stated in Table 55A.~~

~~A.~~ Reserved.

~~B. Table 55A. Limiting Radionuclide Concentrations in Waste Disposed of in Class A West Disposal Cell.~~		
~~C. Radionuclide~~	~~D. Maximum Average Radionuclide Concentration[1] in Waste Disposed of Under Top Slope (pCi/g)~~	~~E. Maximum Average Radionuclide Concentration[1] in Waste Disposed of Under Side Slope (pCi/g)~~
~~F. berkelium-247~~	~~G. 0.0065~~	~~H. 0.00388~~
~~I. calcium-41~~	~~J. 35,300~~	~~K. 34.1~~
~~L. chlorine-36~~	~~M. 15.9~~	~~N. 9.72~~
~~O. iodine-129~~	~~P. --~~	~~Q. 21.9~~
~~R. rhenium-187~~	~~S. --~~	~~T. 19,100~~
~~U. technetium-99~~	~~V. --~~	~~W. 1,720~~

~~X. 1. Maximum average radionuclide concentration for a radionuclide is determined as the quotient of the Total Activity (in picocuries) of that radionuclide disposed of under the respective slope and the Total Mass disposed of under the respective slope for the Active Cell (in grams) + Completed Cell (in grams).~~

~~Y.~~ A.

B~~C~~. ~~For the Mixed Waste disposal cell, the Licensee shall ensure that the actual cumulative activity of chlorine-36 does not exceed 8.75 picocuries per gram in accordance with the following formula:~~

~~*Total Activity of chlorine-36 Received (picocuries)* ≤ 8.75 picocuries per gram~~
~~*Total Mass of Active Cell (grams) + Completed Cell (grams)*~~

B~~C~~. ~~For the Mixed Waste disposal cell, the Licensee shall ensure that the actual cumulative activity of berkelium-247 does not exceed 0.00314 picocuries per gram in accordance with the following formula:~~

~~*Total Activity of berkelium-247 Received (picocuries)* ≤ 0.00314 picocuries per gram~~
~~*Total Mass of Active Cell (grams) + Completed Cell (grams)*~~

Reserved.

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

56. Containerized Class A waste shall be certified by the generator to meet the Waste Acceptance Criteria in accordance with the currently approved Waste Characterization Plan ~~described in License Condition 58~~.

57. A. The Licensee shall move rail shipments into the Restricted Area within seven (7) days of arrival. The shipments may be returned to the carrier when management of the waste is not possible within the seven (7) day period, unless additional time is approved by the Director ~~of the Utah Division of Radiation Control~~.

    B. Services for e~~E~~mpty outbound railcar pickup ~~s shall be picked up~~ by ~~the~~ a local rail service shall be secured within seven (7) days of release from the Restricted Area, unless additional time is approved by the Director ~~of the Utah Division of Radiation Control~~.

    C. Pickup services for r~~R~~ailcars that have been decontaminated and surveyed both internally and externally and found to meet criteria of non-fixed radioactive surface contamination less than 220 dpm/100 cm^2 Alpha, 2,200 dpm/100 cm^2 Beta and a dose rate less than 0.5 mrem/hr or that meet the limits found in Table 27-A are not required ~~do not have~~ to be secured ~~picked up by local rail service~~ within seven (7) days.

    D. The Licensee may perform the following activities on incoming shipments on rail lines outside of Section 32, not including the main line adjacent to Section 32:
    1. Visual Inspection
    2. Radiation level surveys
    3. Affix labels

58. The Licensee shall fulfill and maintain compliance with all conditions and requirements in the currently approved ~~LLRW~~ Waste Characterization Plan ~~(dated October 8, 2009)~~.

59. Reserved.

60. Wind dispersed Dry Active Waste (DAW) located outside of the Contaminated Restricted Area is prohibited.

61. ~~Truck, railcar, and other equipment washdown (decontamination) facilities, including evaporation ponds, shall be controlled with fences or other approved barriers to prevent intrusion.~~Reserved

62. All burial embankments, ~~and~~ waste storage areas, decontamination facilities, and evaporation ponds, ~~including immediately adjacent drainage structures,~~ shall be controlled areas, surrounded by a six-foot chain link fence. Upon site closure, all permanent fences shall be six feet high chain link topped with three strand barbed wire, tip tension wire, and twisted selvedge.

63. Radioactive and mixed wastes within Section 32 and all rail spurs controlled by the Licensee around the Licensee's Disposal Facility are possessed by the Licensee. Waste conveyed to the facility by truck is in

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

transport as long as the commercial carrier driver and vehicle remain at the Clive disposal facility. The Licensee does not possess such waste for purposes of determining compliance with surety requirements and SNM quantity limits, except that the Licensee does, however, possess any waste containing SNM that is not disposed of on the day it is delivered to the facility.

64. "Disposal" is the locating of radioactive waste into a lift of the disposal embankment. Disposal does not include the storage of waste in containers on a lift when the container will ultimately be emptied, the staging of containerized waste in the disposal embankment; or waste as "In Cell Bulk Disposal."

MANIFEST/SHIPPING REQUIREMENTS

65. ~~The Licensee shall comply with UAC R313-15-1006 and UAC R313-25-33(8), Requirements for Low-Level Waste Transfer for Disposal at Land Disposal Facilities and Manifests~~Reserved.

66. The Licensee shall not accept radioactive waste for storage and disposal unless the Licensee has received from the shipper a completed manifest that complies with UAC R313-15-1006 and UAC R313-25-33(8).

67. The Licensee shall maintain copies of complete manifests or equivalent documentation ~~required under Conditions 65 and 66~~ until the Director authorizes their disposition.

68. The Licensee shall immediately notify the Director or the Division's on-site representative of any waste shipment ~~where there may be a possible~~ in violation of applicable rules or license conditions.

69. The Licensee shall only accept radioactive waste transfer ~~require anyone who transfers radioactive waste~~ to the facility from those ~~entites~~ entities in compliance with ~~to comply with the requirements in~~ UAC R313-15-1006.

70. The Licensee shall acknowledge receipt of the waste within one (1) week of waste receipt by returning a signed copy of the manifest or equivalent document to the ~~shipper. The shipper to be notified is the~~ Licensee who last possessed the waste and transferred the waste to the Licensee. The returned copy of the manifest or equivalent documentation shall indicate any discrepancies between materials listed on the manifest and materials received.

71. The Licensee shall notify the entity who last possessed the waste and is transferring the waste to the Licensee ~~shipper (e.g., the generator, the collector, or processor)~~ and the Division when any shipment or part of a shipment has not arrived within 60 days after receiving the advance manifest.

72. The Licensee shall maintain a record for each shipment of waste disposed of at the site. At a minimum, the record shall include:
    A. The date of disposal of the waste;

    B. The location of the waste in the disposal site;

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

C. The condition of the waste packages received;

D. Any discrepancy between the waste listed on the shipment manifest or shipping papers and the waste received in the shipment; and

E. A description of any evidence of leaking or damaged packages or radiation or contamination in excess of applicable regulatory limits.~~; and~~

~~F. A description of any repackaging of wastes in any shipment.~~

FINANCIAL ASSURANCE/CLOSURE

73. The Licensee shall at all times maintain a Surety that satisfies the requirements of UAC R313-25-31 in an amount adequate to fund the decommissioning and reclamation of Licensees' grounds, equipment and facilities by an independent contractor. The Licensee shall annually review the amount and basis of the surety and submit a written report of its findings by December 1 each year for Director approval. At a minimum, this annual report shall meet the following requirements:
    A. Summary of Changes – the annual report shall include a written summary of any change in the cost estimate previously approved by the Director, including, but not limited to:
        i. A description of any modification, addition, or deletion of any direct cost or post-closure monitoring and maintenance (PCMM) cost line item, including supporting justification, calculations and basis;
        ii. Any change to the unique reference number (cost line item) assigned approved by the Director for any direct or PCMM cost line item.

    B. Indirect Costs shall be determined for the following categories, using methodology published by the U.S. Defense Contract Audit Agency (in the most recent version of the DCAA Contract Audit Manual) and the U.S. Department of Labor (DOL, 2012)~~based on the sum of all direct costs in accordance with the following values:~~.

Surety Reference No.	Description
300	Working Conditions
301	Mobilization / Demobilization
302	Contingency
303	Engineering and Redesign
304	Overhead and Profit

**UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET**

License # UT 2300249
Amendment # ~~14~~15

Surety Reference No.	Description
305	Management Fee and Legal Expenses
306	DEQ Oversight

C. RS Means Guide estimates of direct construction costs provided in the annual report shall be derived from or based on the most recent hardcopy edition of the RS Means Guide for Heavy Construction Cost Data.

D. Report Certification – the annual report shall be prepared under the direct supervision of and certified by a Professional Engineer or Professional Geologist currently licensed by the State of Utah with at least five (5) years of construction cost estimation experience. The annual report shall be developed in accordance with the standards of professional care.

E. Electronic Format – the Licensee shall provide the report in ~~both paper and~~ electronic format~~s~~, as directed by the Director.

F. Within 60-days of Director approval of said annual report, the Licensee shall submit written evidence that the surety has been adequately funded.

G. The Licensee shall prepare and maintain current a gravel resource evaluation report on-site that quantifies the gravel reserves available to the Licensee and the Division of Radiation Control from public sources. ~~remaining in the Grayback Hills Gravel Pit located in Section 24 of T. 1 N., R. 12 W (SLBM).~~ Such report shall be ~~prepared and certified~~ updated as needed on or before December 1 of each year by a professional engineer or professional geologist currently registered in the State of Utah.

74. One ~~(1)~~ year prior to the anticipated closure of the site, the Licensee shall submit for review and approval by the Director a S~~s~~ite D~~d~~econtamination and D~~d~~ecommissioning P~~p~~lan. As part of this P~~p~~lan, the Licensee shall demonstrate by measurements and/or modeling that concentrations of radioactive materials which may be released to the general environment, after site closure, will not result in a total effective dose equivalent ~~an annual dose~~ exceeding 25 millirems per year ~~to the whole body, 75 millirems to the thyroid, and 25 millirems~~ to ~~any other organ of~~ any member of the public.

75. ~~In accordance with UAC R313-25-33(6), the Licensee shall submit a financial statement annually by March 31st of each year for the previous year~~Reserved.

76. Reserved.

SPECIAL HANDLING

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

77. Except while waste packages are being handled in the active areas of the Containerized Waste Facility, external gamma radiation levels shall not exceed 40 mR/hr at one meter from the surface of any emplaced waste package or from shielding placed around disposed waste containers.

78. The Licensee shall observe the following controls on waste handling at the Containerized Waste Facility:
   A. Before unloading any waste container whose external gamma radiation at the surface exceeds 10 R/hr, an ALARA review shall be performed and documented and a pre-job briefing shall be conducted.

   B. As part of the ALARA review, the Licensee shall determine and record (1) estimates of the radiation dose rates for the waste container, disposal unit working face, and any other potentially significant radiation sources; (2) expected durations of exposures to and distances from each radiation source; and (3) expected doses to each person involved in the actual disposal operation.

   ~~C. Before unloading any waste container whose external gamma radiation at the surface exceeds 200 R/hr, a practice run shall be conducted. The practice run shall involve shielding, container(s) filled with non-radioactive material, and handling equipment that are similar to those involved with the actual shipment. Similarity includes similar rigging and physical characteristics (e.g., weight, dimensions, and attachments). Those personnel who will participate in receiving, processing, handling, and disposing of the actual waste will participate in the practice run, using actual procedures. The Licensee shall notify the Division 24 hours in advance of conducting the practice runs.~~

   ~~D. On a case-by-case basis, the Director may exempt the Licensee from conducting the required practice run, considering the results of earlier practice runs and actual experience handling waste containers with high radiation levels.~~

79. Reserved.

80. The Licensee shall notify in writing the Director at the earliest possible date, but no later than 10 days before scheduled receipt of each shipment with contact radiation levels in excess of 200 R/hr. The notification shall include the anticipated dates of receipt and plan for disposal in the Containerized Waste Facility.

81. The RSO ~~Director of Health Physics~~ or other qualified person designated by the RSO ~~Director of Health Physics~~ shall be present for and shall observe the receipt, processing, handling, and disposal of each waste package with contact radiation levels in excess of 200 R/hr.

82. The Licensee shall dispose of only closed containers in the Containerized Waste Facility. The Licensee shall not dispose of any breached waste container in the Containerized Waste Facility without first repairing the breached container or overpacking it in an undamaged container. The Licensee is authorized to open packages at its facility only to:

   A. Repair or repackage breached containers.

**UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET**

License # UT 2300249
Amendment # ~~14~~15

B. Inspect for compliance with conditions of this license.

C. Confirm package contents and fill voids in packages/containers that have greater than 15% void space.

D. Accomplish other purposes as approved by the Director.

83. The Licensee shall handle and emplace LLRW packages in the Containerized Waste Facility such that packaging integrity is maintained during handling, emplacement, and subsequent backfilling. Waste packages deposited in the Containerized Waste Facility shall be protected from any adverse effects of operations which may damage them.

SEALED SOURCES AND/OR DEVICES

84. A. i. Sealed sources shall be tested for leakage and/or contamination at intervals not to exceed the intervals specified in the certificate of registration issued by the U.S. Nuclear Regulatory Commission under 10 CFR 32.210 or by equivalent regulations of an Agreement State.

ii. In the absence of a certificate from a transferor indicating that a leak test has been made within the intervals specified in the certificate of registration issued by the U.S. Nuclear Regulatory Commission under 10 CFR 32.210 or by equivalent regulations of an Agreement State prior to the transfer, a sealed source received from another person shall not be put into use until tested.

iii. Sealed sources need not be tested if they are in storage and are not being used. However, when they are removed from storage for use or transferred to another person, and have not been tested within the required leak test interval, they shall be tested before use or transfer. No sealed source shall be stored for a period of more than 3 years without being tested for leakage and/or contamination.

iv. The leak test shall be capable of detecting the presence of 185 becquerels (0.005 μCi) of radioactive material on the test sample. If the test reveals the presence of 185 becquerels (0.005 μCi) or more of removable contamination, a report shall be filed with the Director in accordance with R313-15-1208, and the source shall be removed immediately from service and decontaminated, repaired, or disposed of in accordance with Utah Radiation Control Rules. The report shall be filed within 5 days of the date the leak test result is known with the Division of Radiation Control~~, P.O. Box 144850, Salt Lake City, Utah 84114-4850~~. The report shall specify the source involved, the test results, and corrective action taken.

v. (a) The Licensee is authorized to collect leak test samples in accordance with Condition 85.D of this license, the Licensee's renewal application (dated March 1, 2001), and the Licensee's Memo (dated March 11, 2002).

(b) The analysis of leak test samples shall only be performed by individuals who meet the qualifications of a Radiation Safety ~~Health Physics~~ Technician I or II, as defined by this license. The analysis of leak test samples shall be performed in accordance with the Licensee's renewal application (dated March 1, 2001), and the Licensee's Memo (dated March 11, 2002). Alternatively, tests for leakage and/or contamination, including sample

**UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET**

collection and analysis, may be performed by other persons specifically licensed by the Director, the U.S. Nuclear Regulatory Commission, or an Agreement State to perform such services.

vi. Records of leak test results shall be kept in units of Becquerels or microcuries and shall be maintained for inspection by representatives of the Director.

B. Sealed sources or source rods, containing licensed material shall not be opened or sources removed from source holders, devices, or detached from source rods by the Licensee, except as specifically licensed by the Director, an Agreement State, or the U.S. Nuclear Regulatory Commission to perform such services.

C. The Licensee shall conduct a physical inventory every six months to account for all sealed sources and/or devices received and possessed under this license. The records of inventories shall be maintained for three years from the date of the inventory for inspection by the Division, and shall include the quantities and kinds of radioactive material, manufacturer's name and model numbers, location of the sources and/or devices, and the date of the inventory.

PORTABLE GAUGING DEVICES:

85. A. Each portable gauging device shall have a lock or outer locked container designed to prevent unauthorized or accidental removal of the sealed source from its shielded position. The gauge or its container must be locked when in transport, storage or when not under the direct surveillance of an authorized user.

B. Each portable gauging device shall be kept under the constant surveillance (direct surveillance) of individuals trained in accordance with Condition 32.B of this license, when the device is not in secured storage~~, as required by Condition C of this license condition~~.

C. Reserved.

D. Any cleaning and/or maintenance of portable gauging device(s) or the collection of leak test samples, performed by the Licensee, shall only be performed with the radioactive source/source rod in the safe shielded position; and in accordance with the manufacturer's instructions and recommendations.

E. ~~All cleaning and/or maintenance of portable gauging device(s), performed by the Licensee shall only be performed in accordance with Condition D of this license condition, and the manufacturer's instructions and recommendations.~~Reserved.

F. Any cleaning, maintenance, or repair of portable gauging device(s) that requires removal of the sources/source rod shall be performed only by the manufacturer or by other persons specifically licensed by the Director, an Agreement State, or the U.S. Nuclear Regulatory Commission to perform such services.

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

DOSIMETER CALIBRATOR(S)/IRRADIATOR(S):

86. A. The LDM-2000 reader shall only be connected to a maximum of two IRD-2000 irradiator modules.

B. Devices(s) shall only be:

i. installed in areas where device(s) can be secured and limited to individuals authorized to use device(s) pursuant to ~~Condition A of this license condition and~~ Condition 32.C of this license.

ii. used by individuals who meet the qualifications of a ~~Health Physics~~ Radiation Safety Technician I or II, as defined by this license.

iii. used in accordance with the manufacturer's operating manual and certificate of registration issued by the U.S. Nuclear Regulatory Commission under 10 CFR 32.210 or by equivalent regulations of an Agreement State. The Licensee shall follow the manufacturer's recommendations for preventative maintenance and operational testing.

C. Maintenance and servicing of device(s) shall only be performed by the manufacturer or persons specifically licensed by the Director, an Agreement State, or the U.S. Nuclear Regulatory Commission ~~, or an Agreement State~~ to perform such services.

D. The Licensee shall not perform calibration(s) for non-MGP Instrument dosimeters.

INCREASED CONTROL CONDITIONS

87. ~~The Licensee shall comply with the requirements described in the Division's letter dated November 14, 2005 and attached document to the Division's letter entitled "Increased Controls for Licensees that Possess Sources Containing Radioactive Material Quantities of Concern." The Licensee shall complete implementation of said requirements before May 15, 2006 or the first day that radionuclides in quantities of concern are possessed at or above the limits specified in Table 1, provided as an attachment to the Division's letter dated November 14, 2005, whichever is later. Within 25 days after the implementation of the requirements of this License Condition, the Licensee shall notify the Director in writing that it has completed the requirements of this License Condition.~~Reserved.

88. The licensee shall comply with requirements described in the Director's letter dated May 16, 2008, Attachment 1, "Fingerprinting and Criminal History Records Check Requirements for Unescorted Access to Certain Radioactive Material" and Attachment 2, "Specific Requirements Pertaining to Fingerprinting and Criminal History Records Checks." The requirements of this license condition shall be implemented as part of the trustworthiness and reliability program of the Increased Controls requirements.

A. ~~On or before August 14, 2008, the licensee shall provide under oath or affirmation, a certification that the Trustworthiness and Reliability Official is deemed trustworthy and reliable by the licensee as required in paragraph 2.B of Attachment 1, "Fingerprinting and Criminal History Records Check Requirements for Unescorted Access to Certain Radioactive Material."~~Reserved.

B. All fingerprints obtained by the licensee pursuant to this requirement must be submitted to the U.S.

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

Nuclear Regulatory Commission for transmission to the U.S. Federal Bureau of Investigation (FBI). Additionally, the licensee's submission of fingerprints shall also be accompanied by a certification, under oath and affirmation, of the trustworthiness and reliability of the Trustworthiness and Reliability Official as required by paragraph 2.B of Attachment 1, "Fingerprinting and Criminal History Records Check Requirements for Unescorted Access to Certain Radioactive Material."

C. ~~The licensee shall complete implementation of the fingerprinting requirements on or before November 12, 2008. The licensee shall notify the Director when full compliance with the requirements described in the Director's letter dated May 16, 2008, Attachment 1, "Fingerprinting and Criminal History Records Check Requirements for Unescorted Access to Certain Radioactive Material" and Attachment 2, "Specific Requirements Pertaining to Fingerprinting and Criminal History Records Checks" have been achieved. Notification to the Director shall be made within twenty-five (25) days after full compliance has been achieved.~~Reserved.

D. The licensee shall notify both the Director and the U.S. Nuclear Regulatory Commission within 24 hours if the results from a criminal history records check indicate that an individual is identified on the FBI's Terrorist Screening Data Base.

CLOSEOUT CONDITIONS

89. Except as specifically provided otherwise in this license, the Licensee shall conduct its program in accordance with the statements, representations, and procedures contained in the documents, including any enclosures, listed below. The Utah Radiation Control Rules, Utah Administrative Code R313 shall govern unless the statements, representations, and procedures in the Licensee's application and correspondence are more restrictive than the rules.

A. License renewal application, Revision ~~2~~0, dated ~~June~~ October 2~~0~~5, 20~~05~~12.

~~B. The following documents refer to revisions made in Amendment 22:~~
~~(1) Letter CD04-0481, dated October 27, 2004, Amendment and Modification Request – Class A North Embankment.~~
~~(2) Letter CD04-0548, dated December 23, 2004, Revised Class A North Disposal Embankment License Amendment Request.~~
~~(3) URS Review of Revised Class A North Embankment Amendment Request, dated December 29, 2004.~~
~~(4) Letter CD05-0024, dated January 17, 2005, Class A North Disposal Embankment License Amendment Request Revision 2.~~
~~(5) Letter CD05-0265, dated May 20, 2005, Revision of Appendix R, Environmental Monitoring and Surveillance Plan.~~
~~(6) Letter CD05-0266, dated May 25, 2005, Surety Calculations for the Class A North Disposal Cell.~~
~~(7) Memo: Treesa Parker to John Hultquist, dated May 25, 2005, proposed revisions to RML for Amendment 22~~
~~(8) Email: Treesa Parker to Christine Hiaring, dated June 1, 2005, License Amendment 22 Minor~~

**UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET**

License # UT 2300249
Amendment # ~~14~~15

~~Changes for Consistency.~~

~~C. The following documents refer to revisions made in Amendment 22A:~~
~~(1) Division letter dated November 14, 2005.~~

~~D. The following documents refer to revisions made in Amendment 22B:~~
~~(1) Letter CD05-0333, dated June 30, 2005, RML no. UT 2300249 Request for approval of revisions to Appendix I, Organization, and amendment of License Condition 32.A.~~
~~(2) Memorandum dated August 2, 2005, Subject; Review of Appendix I~~
~~(3) Letter CD05-0398, dated August 16, 2005, Request for approval of revisions to Appendix I, Organization and amendment of license condition 31.A,B,C, and 32.A.~~
~~(4) Letter CD05-0507, October 26, 2005, Additional information regarding proposed revisions to Appendix I, Organization and amendment of license condition 31.A,B,C, and 32.A.~~
~~(5) Letter CD05-0453, dated September 19, 2005 Request for amendment of License Condition 9.10 RML UT2300478; Organization.~~
~~(6) Letter dated November 22, 2005, Request for information regarding request to revise Appendix I of the 11e(2) License Application and Amendment of L.C. 9.10.~~
~~(7) Letter dated October 11, 2005, Re: Request for Information: Revision to Appendix I and amendment 31A. B. C. and 32.A. dated August 16, 2005 (CD05-0398).~~
~~(8) Memorandum, dated October 3, 2005, Subject; Appendix I, revisions to RML UT2300249 conditions 31 A, B, C, and 32 A.~~
~~(9) Letter CD05-0411, dated August 23, 2005, Payment of administrative cost for Appendix I amendment request dated August 16, 2005.~~
~~(10) Letter CD05-0472, dated September 30, 2005, License condition 39.E amendment~~
~~(11) Email dated August 10, 2005, Subject: Draft amendment for LC 39.E and attached August 10, 2005, License Condition 39 E. amendment "draft".~~
~~(12) Email dated September 16, 2005, Subject: RE: FW: Draft amendment for LC 39.E.~~
~~(13) Letter CD05-0285, dated June 1, 2005, Envirocare containerized waste facility concrete overpacks corrective action plan.~~
~~(14) Letter dated June 2, 2005, filling waste package voids at the containerized waste facility using controlled low strength material (CLSM)~~
~~(15) Letter CD05-0326, dated June 27, 2005, Re: Letter to Mr. Dane Finerfrock, dated April 13, 2005, CD05-0181.~~
~~(16) Letter CD05-0366, dated July 26, 2005, Re: Letter to Dane Finerfrock, dated June 27, 2005, CD05-0326.~~
~~(17) Letter CD06-0011, dated January 12, 2006, Request to amend License Condition No. 2, Address.~~
~~(18) Letter CD06-0043, dated February 3, 2006, Request to amend License Condition No. 1, Company Name.~~
~~(19) Letter dated February 6, 2006, evidence of name change with the Utah Department of Commerce.~~
~~(20) Email dated October 6, 2005, Subject: License condition 39.E.~~
~~(21) Memorandum from Woodrow W. Campbell through Loren Morton and Dane Finerfrock to~~

**UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET**

License # UT 2300249
Amendment # ~~14~~15

~~Envirocare File, dated January 13, 2006 regarding AMRL Soils Lab Certification for the Envirocare Soils Lab.~~

~~(22) Email dated February 15, 2006, from Loren Morton to Dan Shrum, Subject: License Amendment for Condition 73.~~

~~(23) Email dated December 23, 2005, from Loren Morton to Dane Finerfrock, Subject: Proposed Changes to License Condition 73 – Annual Surety Evaluation Report.~~

~~(24) Letter dated February 22, 2006, Subject: Revise void remediation procedure OPC-6.0.~~

~~E. The following documents refer to revisions made in Amendment 22C:~~

~~(1) Letter CD05-0435, dated September 8, 2005, Request to amend RML UT 2300249: Condition 58, Waste Characterization Plan.~~

~~(2) Letter CD05-0557, dated December 5, 2005, RML UT 2300249; Condition 58 Waste Characterization Plan - Revised License Amendment Request.~~

~~(3) Letter CD06-0072, dated February 27, 2006, Radioactive Material License UT 2300249: Condition 58 Waste Characterization Plan – Revised License Amendment Request.~~

~~(4) Email dated February 24, 2006, from Boyd Imai to Sean McCandless Re: Waste Characterization Plan.~~

~~(5) Letter CD06-0059, dated February 15, 2006, Radioactive Material License UT 2300249 - Self Identified Noncompliance.~~

~~(6) Letter dated March 17, 2006, from the DRC regarding the February 15, 2006, letter of noncompliance.~~

~~(7) Letter CD06-0055) dated February 9, 2006, Request to Amend RML UT 2300249 to show addition of Liquid Radioactive Sources to License Condition 6.E.~~

~~(8) Letter (CD06-0092) dated March 8, 2006, RML UT 2300249; Request for administrative amendment. Conditions 21.A and B and Condition 81.~~

~~F. The following documents refer to revisions made in Amendment 22E:~~

~~(1) CD06-0389, "Request to amend Radioactive Materials License No. UT 23000249 and 11e.(2) Radioactive Materials License No. UT 23000478 – Request for approval revised Appendix I, *Organization*," October 6, 2006.~~

~~(2) Shredder Facility~~

~~a. CD05-0448, "Radioactive Materials License No. UT 2300249 (RML) and Groundwater Quality Discharge Permit UGW450005 (GWQDP). Request to Construct Shredding Facility," September 15, 2005.~~

~~b. CD05-0532, "Request to Construct Shredding Facility – Revised Design and Interrogatory Response," November 14, 2005.~~

~~c. CD05-0556, "Request to Construct Shredding Facility – Additional Information," December 2, 2005.~~

~~d. CD06-0036, "Request to Construct Shredding Facility – Response to Round 2 Interrogatories", February 1, 2006.~~

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

~~e. CD06-0098, "Request to Construct Shredding Facility – Response to Round 3 Interrogatory," March 10, 2006.~~
~~f. ASTM F-1417, "ASTM Method F 1417-92," March 29, 2006.~~
~~g. CD06-0188, "Request to Construct Shredder Facility – Response to Round 4 Interrogatory," May 9, 2006.~~
~~h. CD06-0211, "Request to Construct Shredder Facility – Response to Round 4B Interrogatory," May 25, 2006.~~
~~i. CD06-0234, "Requests to Construct Shredder and Rotary Dump Facilities – Revised Wastewater Management Process," June 19, 2006.~~
~~j. "EnergySolutions LLC Low-Level Radioactive Waste Closure & Post-Closure Trust License UT 2300249 Trust #16673400," June 29, 2006.~~
~~k. CD-0346, "Interim Wastewater Management Plan for the Shredder Facility – Response to August 18, 2006, Request for Additional Information," August 31, 2006.~~
~~l. CD06-0388, "Radioactive Material License UT 2300429 and Groundwater Quality Discharge Permit (GWDP) No UGW450005 Shredder Facility – Request to Operate," October 5, 2006.~~
~~m. CD06-0407, "Comment on Proposed Amendment of Radioactive Material License UT 2300249 and Groundwater Quality Discharge Permit (GWDP) No UGW450005, October 18, 2006.~~
~~n. CD06-0414, "Radioactive Material License UT 2300249 and Groundwater Quality Discharge Permit No UGW450005 Shredder Facility – Submittal of Revised Drawings" October 25, 2006.~~
~~o. CD06-0425, "Groundwater Quality Discharge Permit No UGW450005 (GWQDP) Submittal of Revised Appendix J and K," November 7, 2006.~~

~~(3) Rotary Dump Facility~~
~~a. CD05-0564, "Request to Construct – Rotary Dump," December 12, 2005.~~
~~b. CD05-0570, "Request to Construct Rotary Dump 00 Submittal of Dose Assessment," December 16, 2005.~~
~~c. CD06-0086, "Request to Construct Rotary Dump Facility – Response to Round 1 Interrogatory", March 2, 2006.~~
~~d. ASTM F-1417, "ASTM Method F 1417-92," March 29, 2006.~~
~~e. CD06-0147, "Request to Construct Rotary Dump Facility – Revised Drawings," April 10, 2006.~~
~~f. CD06-0210, "Request to Construct Rotary Dump Facility – Response to Round 2 Interrogatory," May 25, 2006.~~
~~g. CD06-0211, "Request to Construct Rotary Dump Facility – Response to Round 4B Interrogatory", May 25, 2006.~~
~~h. CD06-0226, "Request to Construct Rotary Dump Facility – Response to Round 2B Interrogatories," June 8, 2006.~~
~~i. CD06-0234, "Requests to Construct Shredder and Rotary Dump Facilities – Revised Wastewater Management Process," June 19, 2006.~~

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

~~(4) Intermodal Container Wash Building~~

~~a. CD05-0291a, "Radioactive Materials License No. UT 2300249 (RML) and Groundwater Quality Discharge Permit UGW450005 (GWQDP). Request to Construct Intermodal Container Wash Building and Access Control Building," June 9, 2005.~~

~~b. CD05-0388, "Request to Construct Intermodal Container Wash Building – Revised Design and Supplemental Information," August 8, 2005.~~

~~c. CD05-0432, "Request to Construct Intermodal Container Wash Building – Revised Design and Interrogatory Response," September 1, 2005.~~

~~d. CD06-0110, "MARSSIM Release for New Intermodal Container Wash Facility," March 22, 2006.~~

~~e. CD06-0206, "Radioactive Material License UT 2300249 and Groundwater Quality Discharge Permit No UGW450005 Intermodal Container Wash Building – Request to Operate," May 22, 2006.~~

~~f. "EnergySolutions LLC Low-Level Radioactive Waste Closure & Post-Closure Trust License UT 2300249 Trust #16673400," June 29, 2006.~~

~~g. CD06-0259, "Groundwater Quality Discharge Permit (GWDP) No UGW450005 Intermodal Container Wash Building – Revised Appendix J and K," July 10, 2006~~

~~(5) Decontamination Access Control Building~~

~~a. CD05-0291b, "Radioactive Materials License No. UT 2300249 (RML) and Groundwater Quality Discharge Permit UGW450005 (GWQDP). Request to Construct Intermodal Container Wash Building and Access Control Building," June 9, 2005.~~

~~b. CD05-0367, "MARSSIM Release of New Boxwash Access Control", July 26, 2005.~~

~~c. CD06-0139, "Radioactive Material License UT 2300249 and Groundwater Discharge Quality Permit (GWDP) No UGW450005 Decontamination Access Control Building – Request to Operate", April 6, 2006.~~

~~d. "EnergySolutions LLC Low-Level Radioactive Waste Closure & Post-Closure Trust License UT 2300249 Trust #16673400," June 29, 2006.~~

~~e. CD06-0245, "Groundwater Discharge Quality Permit (GWDP) No UGW450005 Decontamination Access Control Building – Revised Appendix J and K and Drawing No 05015-S100," June 30, 2006.~~

~~(6) East Side Drainage Project~~

~~a. CD06-0175, "Request to Construct East Side Drainage and Gray Water System Modifications," May 1, 2005.~~

~~b. CD06-0244, "East Side Drainage and Gray Water System Modifications – Response to DRC Review," June 30, 2006.~~

~~c. CD06-0293, "Groundwater Discharge Quality Permit No UGW450005 East Side Drainage and Gray Water System – Revised Design and BAT Plans," August 4, 2006.~~

~~d. CD06-0327, "Groundwater Discharge Quality Permit No UGW450005 East Side Drainage and Gray Water System – Revised Appendix J BAT Performance Monitoring Plan and Appendix K BAT Contingency Plan," August 23, 2006.~~

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

~~e. CD06-0328, "Groundwater Discharge Quality Permit No UGW450005 East Side Drainage and Gray Water System – Revised Drawings," August 24, 2006.~~

~~G. The following documents refer to revisions made in Revision 0 of the License Renewal Application:~~

~~(1) AGRA Earth & Environmental, Inc. 1999. Summary Seismic Stability and Deformation Analysis: Envirocare LARW Disposal Facility, Clive, Tooele County, Utah. September 1, 1999. (1998 LRA Appendix J)~~

~~(2) AGRA Earth & Environmental, Inc. 2000a. Evaluation of Settlement of Compressible Debris Lifts: LARW Embankments, Clive, Tooele County, Utah. June 1, 2000.~~

~~(3) AGRA Earth & Environmental, Inc. 2000b. Evaluation of Settlement of Incompressible Debris Lifts: LARW Embankments, Clive, Tooele County, Utah. June 1, 2000.~~

~~(4) AMEC Earth & Environmental, Inc. 2000a. Letter Report: Allowable Differential Settlement and Distortion of Liner and Cover Materials. October 4, 2000.~~

~~(5) AMEC Earth & Environmental, Inc. 2000b. Letter Report Stability Considerations: Proposed LLRW Embankment. October 25, 2000.~~

~~(6) AMEC Earth & Environmental, Inc. 2000c. Letter Report Stability Considerations - Addendum: Proposed LLRW Embankment. November 8, 2000.~~

~~(7) AMEC Earth & Environmental, Inc. 2001. Response to Interrogatory Number 2: Placement if HICs in Caissons. October 1, 2001.~~

~~(8) AMEC Earth & Environmental, Inc. 2002. Placement of Large Liners in Caissons. June 19, 2002.~~

~~(9) Bingham Environmental. 1996. Project Memorandum HEC-1 and HEC-2 Analysis, LARW Application for License Renewal, Envirocare Disposal Facility, Clive Utah. November 26, 1996. (1998 LRA Appendix KK)~~

~~(10) EnergySolutions (Rebeccah McCloud) to Utah Division of Radiation Control (Dane Finerfrock). 2006. Correspondence concerning corporate ownership and name changes. February 6, 2006.~~

~~(11) EnergySolutions (Tye Rogers) to Utah Division of Radiation Control (Dane Finerfrock). 2006. Correspondence concerning corporate ownership and name changes. February 3, 2006.~~

~~(12) EnergySolutions LLC. 2007. "2006 Annual 083106 Rev 052107.xls" [annual surety review], Revision 22, May 21, 2007~~

~~(13) EnergySolutions to Utah Division of Radiation Control. 2006. Letter number CD06-0348, Radioactive Materials License No. UT2300249 – Revision to License Condition 26, Appendix R request submitted to DRC on March 17, 2006. September 1, 2006.~~

~~(14) Envirocare of Utah, Inc. to URS Corporation. 2005. Personal communication via electronic mail (Sean McCandless and Robert D. Baird, PE). January 27, 2005.~~

~~(15) Envirocare of Utah, Inc. to Utah Division of Radiation Control. 2004. Letter number CD04-0287, Updated Specific Gravity Report and Request for Eliminating Specific Gravity Monitoring. June 9, 2004.~~

~~(16) Envirocare of Utah, Inc. to Utah Division of Radiation Control. 2005. Letter number CD05-0487, Cover Test Cell Evaporative Zone Depth (EZD) Report. October 13, 2005 June 9, 2004.~~

~~(17) Envirocare of Utah, Inc. 2000a. Pre-Licensing Plan Approval Application for a License~~

**UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET**

License # UT 2300249
Amendment # ~~14~~15

~~Amendment Allowing Disposal of Class B & C Low-Level Radioactive Waste. (revision of January 5, 2000 plan) March 15, 2000.~~

~~(18) Envirocare of Utah, Inc. 2000b. Rock Cover Design. July 26, 2000.~~

~~(19) Envirocare of Utah, Inc. 2001. "Clive Facility Total Ditch Flow Calculations." October 30, 2001.~~

~~(20) Envirocare of Utah, Inc. 2003c. Application for Renewal: Radioactive License Materials License Number UT-2300249. July 2, 2003.~~

~~(21) Envirocare of Utah, Inc. 2005d. Application for Renewal: Radioactive License Materials License Number UT-2300249, Revision 2 (including all Appendices). June 20, 2005.~~

~~(22) Montgomery Watson (John Pellicer and Patrick Corser) to Envirocare of Utah, Inc. (Tim Orton). 2000. Letter Report LLRW Cover Frost Penetration. March 1, 2000.~~

~~(23) Rogers and Associates Engineering for the Utah Division of Radiation Control. 2000. Siting Evaluation Report for Proposed Disposal Under URCR R-313-25-3 of Class B & C Low Level Radioactive Waste. May 2, 2000.~~

~~(24) Shrum, Dan to Robert D. Baird, PE, CCE (URS Corporation). 2005. Via electronic mail. February 28, 2005.~~

~~(25) SWCA Environmental Consultants, Inc. 2000. Assessment of Vegetative Impacts on LLRW.~~

~~(26) Tooele County Recorder. 1993. Entry No. 5489, Book 348, Page 104. March 16, 1993.~~

~~(27) Utah Bureau of Radiation Control (Larry F. Anderson) letter to Envirocare of Utah, Inc. (Khosrow B. Semnani, President). 1987. "Radioactive Material License No. UT 2300249." November 18, 1991.~~

~~(28) Utah Department of Environmental Quality (Diane R. Nielson, Executive Director) and Envirocare of Utah, Inc. (Khosrow B. Semnani, President). 1993. "Agreement Establishing Covenants and Restrictions." March 16, 1993.~~

~~(29) Utah Division of Radiation Control (Dane Finerfrock) to Envirocare of Utah, Inc. (Daniel Shrum). 2007. "EnergySolutions 2006 Annual Surety Submittal, May 21, 2007 Update." June 1, 2007.~~

~~(30) Utah Division of Radiation Control (Dane Finerfrock) to Envirocare of Utah, Inc. (Tye Rogers). 2004. "Restoration of Site Drainage." November 12, 2004.~~

~~(31) Utah Division of Radiation Control (Dane Finerfrock) to Envirocare of Utah, Inc. (Tye Rogers). 2005a. "Response to December 4, 2004 Report - Restoration of Site Drainage: Request for Additional Information." February 23, 2005.~~

~~(32) Utah Division of Radiation Control (Dane Finerfrock) to Envirocare of Utah, Inc. (Tye Rogers). 2005b. "Response to March 25, 2005 Envirocare Response to the February 27, 2005 DRC Request for Information - Restoration of Site Drainage." April 22, 2005.~~

~~(33) Utah Division of Radiation Control (Dane Finerfrock) to Envirocare of Utah, Inc. (Tye Rogers). 2007. "Restoration of Grade - Round 1 Interrogatories: Notice of Upcoming Requirements and Request for Schedule." February 16, 2007.~~

~~(34) Utah Division of Radiation Control (Loren Morton) to EnergySolutions (Tye Rogers) . 2006. Correspondence regarding "DRC Response to Eight Submittals by EnergySolutions Regarding Proposed Class A Combined (CAC) Disposal Cell: Request for Additional Information, Round 3 Interrogatory." March 3, 2006.~~

~~(35) Utah Division of Radiation Control to EnergySolutions, LLC. 2006. Letter of approval of~~

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

~~Revision 20 of the CQA/QC Manual. September 21, 2006.~~

~~(36) Utah Division of Radiation Control (William Sinclair) to Envirocare of Utah, Inc. 2000. Correspondence concerning expectations in addressing the land ownership issue. March 6, 2000.~~

~~(37) Utah Division of Radiation Control. 2006a. Memorandum: Analysis of the December 20, 2005 Envirocare Submittal of Settlement Monitoring Plan Update. February 2, 2006. (Johnathan P. Cook to Loren Morton)~~

~~(38) Whetstone Associates, Inc. memorandum to Envirocare of Utah, Inc. 2000. Technical Memorandum 41010 Infiltration Through Lower Radon Barrier, Class A, B, & C Cell Cover. November 7, 2000.~~

~~(39) Whetstone Associates, Inc. 2000a. Revised Envirocare of Utah Western LARW [Class A] Cell Infiltration and Transport Modeling. July 19, 2000.~~

~~(39a) Whetstone Associates, Inc. memorandum to Envirocare of Utah, Inc. 2001. Technical Memorandum 4101M Results of Cf-251 Modeling for the Class A Cell, Using the 898-year Half Life, August 21, 2001.~~

~~(40) Whetstone Associates, Inc. 2001a. "Travel Time Through Class A Cell Cover." June 22, 2001.~~

~~(41) Whetstone Associates, Inc. 2003b. Memorandum to Dan Shrum, Envirocare of Utah, "Open Cell Modeling Results for Years 7 – 12," Technical Memorandum 4101T, August 28, 2003.~~

~~(42) Whetstone Associates, Inc. 2004. Revised Western LARW Cell Infiltration and Transport Modeling. July 19, 2004.~~

~~(43) Zion's Bank and Energy Solutions, LLC, 2007. Surety Details. March 27, 2007.~~

~~(44) "Envirocare's Cover Test Cell Evaporative Zone Depth (EZD) Report", Daniel B. Shrum of Envirocare of Utah, LLC to Dane L. Finerfrock of Utah Division of Radiation Control, CD05-0487, October 13, 2005.~~

~~(45) "Cover Test Cell Data Report Addendum: Justification to Change EZD from 18-inches to 24-inches", Envirocare of Utah, LLC, October 5, 2005.~~

~~(46) "October 13, 2005 Envirocare Submittal Regarding Cover Test Cell Evaporative Zone Depth (EZD) Report: CAC Cell Round 2 Interrogatory", Loren B. Morton of Utah Division of Radiation Control to Daniel B. Shrum of Envirocare of Utah, LLC, November 1, 2005.~~

~~(47) "Class A Combined Embankment Interrogatories: Clarification of Envirocare October 13, 2005 Evaporative Zone Depth Report", Daniel B. Shrum of Envirocare of Utah, LLC to Dane L. Finerfrock of Utah Division of Radiation Control, CD05-0518, November 2, 2005.~~

~~(48) "Response to DRC Letter dated November 1, 2005 in Regards to Envirocare's October 13, 2005 Evaporative Zone Depth Report", Daniel B. Shrum of Envirocare of Utah, LLC to Dane L. Finerfrock of Utah Division of Radiation Control, CD05-0520, November 3, 2005.~~

~~(49) "Cover Test Cell As-Built Report", Envirocare of Utah, LLC, January 24, 2002.~~

~~(50) Appendix N, "Cover Test Cell Monitoring Report" dated June 20, 2003, Envirocare of Utah, LLC, License Renewal Application, Revision 2, dated June 20, 2005~~

~~(51) Appendix G, "Drawings" variously dated, Envirocare of Utah, LLC, License Renewal Application, Revision 2, dated June 20, 2005.~~

~~(52) "Attachment 4: EZD Cover Test Cell Data" CD-ROM attached to "Radioactive Material License #UT2300249 and Groundwater Quality discharge Permit No. UGW450005. Class A Combined~~

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

~~Disposal Embankment – Response to September 19, 2005 Interrogatories", Tye Rogers of Envirocare of Utah, LLC to Dane L. Finerfrock of Utah Division of Radiation Control, CD05-0574, December 16, 2005.~~

~~(53) "HDU Data", Mike LeBaron of Envirocare of Utah, LLC to Loren Morton of Utah Division of Radiation Control and Robert Baird of URS Corporation, e-mail dated December 19, 2005.~~

~~(54) "Cover Test Cell WCR Data", Mike LeBaron of Envirocare of Utah, LLC to Loren Morton of Utah Division of Radiation Control and Robert Baird of URS Corporation, e-mail dated December 20, 2005.~~

~~(55) "Matric Potential Conversion Factor", Mike LeBaron of Envirocare of Utah, LLC to Loren Morton of Utah Division of Radiation Control and Robert Baird of URS Corporation, e-mail dated December 21, 2005.~~

~~(56) "RE: Evaporative Pan Data (39400085.10300 OUT)", Mike LeBaron of Envirocare of Utah, LLC to Loren Morton of Utah Division of Radiation Control and Robert Baird of URS Corporation, e-mail dated December 22, 2005.~~

~~(57) "Report Combined Embankment Study: Envirocare", AMEC Earth and Environmental, Inc., December 13, 2005.~~

~~(58) "Geotechnical Study Increase in Height and Footprint: Envirocare LARW Facility Near Clive, Utah", AMEC Earth and Environmental, Inc., May 27, 2005.~~

~~(59) "Class A Disposal Cell: Containerized Waste Facility: Engineering Justification Report", Envirocare of Utah, April 12, 2001.~~

~~(60) "Class A Disposal Cell: Containerized Waste Facility: Engineering Justification Report: Addendum 15 Percent Void Space Criteria", Envirocare of Utah, October 2, 2001.~~

~~(61) "Mixed Waste Embankment Engineering Justification Report" Revision 2, Envirocare of Utah, October 20, 2001~~

~~(62) "Minimum Temperature Return Rates", personal communication from Jim Ashby, November 1, 2000.~~

~~(63) "Review of Cover Design for LARW Cell", TerraMatrix/Montgomery Watson to Envirocare of Utah, February 5, 1998.~~

~~(64) "Cover Test Cell As-Built Report", Envirocare of Utah, January 24, 2002.~~

~~(65) Letter CD02-0097, "Revised CQA/QC Manual – Containerized Waste Facility: Placement of Large Liners/HICs", Envirocare of Utah to Utah Division of Radiation Control, March 18, 2002.~~

~~(66) Letter CD02-0269, "Revised CQA/QC Manual – Containerized Waste Facility: Placement of Large Liners/HICs – Response to Interrogatories", Envirocare of Utah to Utah Division of Radiation Control, July 3, 2002.~~

~~(67) Letter CD02-0315, "Revised CQA/QC Manual – Containerized Waste Facility: Placement of Large Liners/HICs - Revised Settlement Analysis and CQA/QC Language", Envirocare of Utah to Utah Division of Radiation Control, August 7, 2002.~~

~~(68) Letter CD02-0339, "Revised CQA/QC Manual – Containerized Waste Facility: Placement of Large Liners/HICs - Proposed Revision 15 of the LLRW CQA/QC Manual", Envirocare of Utah to Utah Division of Radiation Control, August 26, 2002.~~

~~(69) Letter CD01-0212, "Engineering Justification Report - Waste Placement with CLSM", Envirocare~~

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

~~of Utah to Utah Division of Radiation Control, May 16, 2001.~~

~~(70) Letter CD01-0296, "Containerized Waste Facility - Placement of Class A Ion Exchange Resins in Polyethylene HICs and Steel Liners", Envirocare of Utah to Utah Division of Radiation Control, July 5, 2001.~~

~~H. The following documents refer to revisions made in Amendment 1:~~

~~(1) Letter CD07-0420, "RML UT2300249, Condition 58 - Request for Amendment to the Waste Characterization Plan, dated July 23, 2007.~~

~~(2) Letter CD08-0078, "RML UT2300249, Condition 58 - Request for Amendment to the Waste Characterization Plan."~~

~~(3) Letter CD08-0004, "RML UT2300249 Amendment for Calibration Sources" dated January 2, 2008.~~

~~(4) Letter CD08-0066, "RML UT2300249; Request to amend License Condition 32" dated February 28, 2008.~~

~~(5) Email dated February 29, 2008, from Boyd Imai to Mark Ledoux Re: Amendment Request (CD08-004).~~

~~(6) Email dated November 23, 2007, from John Hultquist to Sean McCandless, Request for Information regarding WCP:~~

~~(7) Letter dated March 7, 2008, Utah Division of Radiation Control (Dane Finerfrock) to EnergySolutions, LLC. (Sean McCandless). "Appendix I Organization dated February 28, 2008."~~

~~(8) Memorandum from John Hultquist to File; dated March 11, 2008, Review of WCP revised November 9, 2007, and March 10, 2008.~~

~~I. The following documents refer to revisions made in Amendment 2:~~

~~(1) Director's letter dated May 16, 2008 [LA# 116-2008]~~

~~J. The following documents refer to revisions made in Amendment 3:~~

~~(1) Letter CD08-0218, "Clive Transportation Hub" dated July 9, 2008.~~

~~(2) Email dated July 28, 2008, from Mark Ledoux to Boyd Imai, "Clive cask hub."~~

~~(3) Letter CD08-0339, Request to Amend License Conditions 10, 38, 43, and Table 40.A, dated October 21, 2008.~~

~~(4) Letter CD08-0137, Request for Amendment to Condition 54, Site Radiological Security Plan, dated May 5, 2008.~~

~~(5) Email dated May 6, 2008, from Mark Ledoux to John Hultquist, License condition 57 proposed changes.~~

~~(6) Letter CD08-0111, RML UT2300249 License Condition 26, and RML UT2300478 License Condition 13.1.D Environmental Monitoring Plan, dated April 4, 2008~~

~~(7) Letter CD08-0115, RML UT2300249 License Condition 26, and RML UT2300478 License Condition 13.1.D Environmental Monitoring Plan, dated April 9, 2008~~

~~(8) Email dated November 13, 2008, from John Hultquist to Sean McCandless, Summary of meeting regarding the Env. Monitoring Plan.~~

~~(9) Email dated December 11, 2008, from Sean McCandless to John Hultquist, Procedure CL-RS-PR-~~

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

~~120 Rev 2. Access Control Points, DRC Comment Rev.~~

~~(10) Letter CD08-0376, RML UT2300249 License Condition 26, and RML UT2300478 License Condition 13.1.D Environmental Monitoring Plan, dated November 24, 2008~~

~~(11) Email dated December 15, 2008, from Sean McCandless to John Hultquist, Procedure CL-RS-PR-120 Rev 2. Access Control Points, Form update.~~

~~K. The following documents refer to revisions made in Amendment 4:~~

~~(1) Letter dated January 26, 2009, (CD09-0020) from Daniel Shrum to Dane Finerfrock; Radioactive Material License No: UT230029 and UT2300478; Revision of Appendix I, *Organization*.~~

~~(2) Letter dated January 28, 2009, John Hultquist to Dan Shrum, Request for Information, Revision to Appendix I *Organization* submitted January 26, 2009.~~

~~(3) Letter dated February 9, 2009, (CD09-0038) from Dan Shrum to Dane Finerfrock, Revision to Appendix I *Organization*. Response to Request for Information.~~

~~L. The following documents refer to revisions made in Amendment 5:~~

~~(1) Letter dated July 27, 2009, (CD09-0188) from Daniel Shrum to Dane Finerfrock; Radioactive Material License Number UT 2300249 - Request for Amendment.~~

~~(2) Letter dated May 6, 2009, (CD09-0116) from Sean McCandless to Dane Finerfrock, Radioactive Material License #UT 2300249 – Request for Amendment and Response to April 15, 2009, Request for Information.~~

~~(3) Letter dated May 28, 2009, Dane Finerfrock to Sean McCandless, 2009 Module 14 Engineering Inspection – Soil Lab and Testing Methods with accreditation for License Condition 45, Radioactive Materials License UT 2300249 Closeout Letter.~~

~~(4) Letter dated April 7, 2009, (CD09-0091) from Sean McCandless to Dane Finerfrock Radioactive Material License #UT 2300249 and Ground Water Quality Discharge Permit No. UGW450005 - Response to DRC Request for Information~~

~~(5) Memorandum from Dave Esser to File, dated May 21, 2009, Proposed correction to the Ground Water Quality Discharge Permit UGW45005 and Radioactive Material License UT2300249 – Amendment Review regarding section, disposal cell, and buffer zone Latitude and Longitude coordinates.~~

~~M. The following documents refer to revisions made in Amendment 6:~~

~~(1) Letter dated October 22, 2007, (CD07-0340) from Sean McCandless to Dane Finerfrock; Radioactive Material License Number UT 2300249 - Request for Amendment to Conditions 14.B and 16.F.ii.~~

~~(2) Letter dated November 20, 2007, from John Hultquist to Sean McCandless, Formerly Characteristic Hazardous Waste meeting, request to Amendment, Radioactive Material License #UT 2300249.~~

~~(3) URS Memorandum dated December 10, 2007, Gary Merrell to Dane Finerfrock Review of Whetstone Technical Memorandum, "Formerly Characteristic Waste Modeling of Class A and Class A North Cells," from Susan Wyman to Dan Shrum, September 25, 2007.~~

**UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET**

~~(4) Letter dated January 21, 2009, (CD09-0015) from Sean McCandless to Dane Finerfrock Formerly Characteristic Waste – Response to Letter dated November 20, 2007.~~

~~(5) Letter dated January 21, 2009, (CD09-0014) Timothy Orton to Dennis Downs, Div. of Solid and Hazardous Waste, Class 2 Modification – Management of Wastes at the Mixed Waste Facility that will be disposed at the LLRW Facility.~~

~~(6) Memorandum dated February 18, 2009, from Boyd Imai to John Hultquist, EnergySolutions Amendment Request (CD07-0340).~~

~~(7) Memorandum dated September 21, 2009, from Boyd Imai to John Hultquist, Review; Formerly Characteristic Waste – License Amendment Request.~~

~~(8) Letter dated August 31, 2009, Sean McCandless to Dane Finerfrock, Radioactive Material License No. UT2300249 – Revised request for Amendment – Formerly Characteristic (LLRW Destined) Waste.~~

~~(9) Email dated October 15, 2009, Sean McCandless to John Hultquist, Formerly Characteristic, Attachments Revised RML 10/8/09 and WCP Revised 10/8/09.~~

~~(10) Memorandum dated October 19, 2009, from Boyd Imai to John Hultquist, Formerly Characteristic Wastes – Transfer to LLRW.~~

~~N. The following documents refer to revisions made in Amendment 7:~~

~~(1) Letter dated September 21, 2009, (CD09-0241) from Val J. Christensen to Amanda Smith; RML No. UT2300249 – Commitments Relating to Depleted Uranium Disposal.~~

~~(2) Letter dated October 1, 2009, (CD09-0258) from Val J. Christensen to Dane Finerfrock; RML No. UT2300249 – Commitments Relating to Depleted Uranium Disposal~~

~~(3) Notice of Agency Action to Consider Proposed License Condition No. 35 dated October 21, 2009.~~

~~(4) Email dated February 22, 2010, from Laura Lockhart to Dane Finerfrock and John Hultquist, License Condition documents - comment response document.~~

~~O. The following document refer to revision made in Amendment 8:~~

~~(1) Letter dated June 1, 2010, (CD10-0162) from Sean McCandless to Dane Finerfrock; RML No. UT2300249 – Request for Amendment.~~

~~(2) Letter dated July 15, 2010, (CD10-0200) from Sean McCandless to Rusty Lundberg; RML No. UT2300249 – Revision of Appendix I, *Organization.*~~

~~(3) Letter dated August 2, 2010, (CD10-0219) from Sean McCandless to Rusty Lundberg; RML No. UT2300249 – Revision of Appendix I, *Organization.*~~

~~(4) Letter dated November 1, 2010, (CD10-0298) from Rick Chalk to Rusty Lundberg; 1. Radioactive Material License UT 2300249, License Condition 16.1 (sic) Letter dated November 23, 2009 to Dane Finerfrock from Mark Ledoux, CD09-0323, 2. Administrative request from DRC to EnergySolutions to amend License UT 2300249, License Conditions 6, 7, and 8.~~

~~(5) Email date November 18, 2010, from Thomas Brown to Boyd Imai, LC 8 E, K, M and O.~~

~~P. The following documents refer to revision made in Amendment 9:~~

~~(1) Letter dated December 6, 2010, (CD10-0347) from Dan B. Shrum to Rusty Lunberg; RML No.~~

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

~~UT2300249 – Amendment Request – Condition 35.B, Depleted Uranium.~~

~~(2) Memorandum dated December 13, 2010, from John Hultquist to File regarding Amendment request.~~

~~Q. The following documents refer to revision made in Amendment 10:~~

~~(1) Letter dated February 24, 2011, (CD11-0045) from Dan Shrum to Rusty Lundberg; Radioactive Material License No. UT2300249, License Condition 35.B.~~

~~(2) Letter dated February 24, 2011, from Rusty Lundberg to Dan Shrum Radioactive Material License No. UT2300249, License Condition 35.B Depleted Uranium Performance Assessment.~~

~~(3) Letter dated March 14, 2011 (CD11-0075) from Dan Shrum to Rusty Lundberg Radioactive Material License No. UT2300249, License Condition 35.B Depleted Uranium Performance Assessment.~~

~~R The following documents refer to revision made in Amendment 11:~~

~~(1) Letter dated September 30, 2010, (CD10-0264) from L. Wayne Johns to Rusty Lundberg; Radioactive Material License No. UT2300249, License Condition 26, and Radioactive Material License No. UT2300478, License Condition 13.1.D Environmental Monitoring Plan.~~

~~(2) Letter dated October 21, 2010, (CD10-0290) from L. Wayne Johns to Rusty Lundberg; Radioactive Material License No. UT2300249, License Condition 26, and Radioactive Material License No. UT2300478, License Condition 13.1.D Environmental Monitoring Plan.~~

~~(3) Memorandum dated October 21, 2010, from Bill Craig to File; EnergySolutions request to change Appendix R.~~

~~(4) Email dated January 25, 2011, from John Hultquist (DRC) to Sean McCandless (ES) regarding draft license and statement of basis.~~

~~(5) Email dated January 27, 2011, from John Hultquist (DRC) to Sean McCandless (ES) responding to proposed language change to LC 60.~~

~~S The following documents refer to revisions made in Amendment 12:~~

~~(1) Letter dated August 2, 2011, (CD11-0183) from Sean McCandless to Rusty Lundberg; Radioactive Material License No. UT2300249, Request to Amend License Conditions 6.E, 9 and 10.~~

~~(2) Letter dated August 17, 2011, (CD11-0224) from Sean McCandless to Rusty Lundberg; Radioactive Material License No. UT2300249, Request to Amend License Conditions 6.E, 9 and 10; Revised Request.~~

~~(3) Letter dated August 25, 2011, (CD11-0234) Sean McCandless to Rusty Lundberg; Radioactive Material License No. UT2300249, Request to Amend License Conditions 52 and 54.~~

~~(4) Email dated October 5, 2011, from Ryan Johnson (DRC) to Sean McCandless (ES); Request to Amend License Condition 52.~~

~~(5) Email dated October 5, 2011, from Ryan Johnson (DRC) to Sean McCandless (ES); Request to Amend License Condition 54.~~

~~(6) Letter dated October 13, 2011 (CD11-0282) Sean McCandless to Rusty Lundberg; Radioactive~~

~~Material License No. UT2300249, Request to Amend License Conditions 52 and 54.~~

~~(7) Letter dated October 27, 2011, from Rusty Lundberg to Dan Shrum; Radioactive Material License No. UT2300249: Division of Radiation Control's (DRC) Response to Amend License Conditions 52 and 54, dated August 25, 2011.~~

~~(8) Letter dated October 27, 2011, (CD11-0293) from Sean McCandless to Rusty Lundberg; Radioactive Material License No. UT2300249, Response to Inspection Report dated October 18, 2011. Radiation Safety Inspection, Containerized Waste Facility (CWF) Operations.~~

~~(9) Letter dated November 2, 2011, (CD11-0298) from Rick Chalk to Rusty Lundberg; Radioactive Material License No. UT2300249, Request to Amend License Conditions 6.E, 9 and 10; Revised Request.~~

~~(10) Letter dated November 7, 2011, from Rusty Lundberg to Sean McCandless; Radioactive Material License No. UT2300249: Division of Radiation Control's (DRC) Response to Amend License Conditions 39.B, dated October 27, 2011.~~

~~(11) Email dated November 8, 2011, from Ryan Johnson (DRC) to Sean McCandless (ES); Draft Statement of Basis and Amendment #12 of Radioactive Material License UT2300249.~~

~~(12) Letter dated November 8, 2011, (CD11-0307) from Sean McCandless to Rusty Lundberg, Radioactive Material License No. UT2300249; Revision of Appendix I, *Organization*.~~

~~(13) Email dated November 15, 2011, from Ryan Johnson (DRC) to Sean McCandless (ES); Amendment request for LC 32.A.~~

~~T The following documents refer to revisions made in Amendment 13:~~

~~(1) Letter dated August 2, 2011, (CD11-0183) from Sean McCandless to Rusty Lundberg; Radioactive Material License No. UT2300249, Request to Amend License Conditions 6.E, 9 and 10.~~

~~(2) Letter dated August 17, 2011, (CD11-0224) from Sean McCandless to Rusty Lundberg; Radioactive Material License No. UT2300249, Request to Amend License Conditions 6.E, 9 and 10; Revised Request.~~

~~(3) Letter dated November 2, 2011, (CD11-0298) from Rick Chalk to Rusty Lundberg; Radioactive Material License No. UT2300249, Request to Amend License Conditions 6.E, 9 and 10; Revised Request.~~

~~(4) Email dated November 17, 2011, from Ryan Johnson (DRC) to Sean McCandless (ES); Amendment request to store gauges on Section 29.~~

~~U. The following documents were submitted in support of proposed Amendment #14:~~

~~1) AMEC Earth & Environmental, Inc. 2011. Report: Geotechnical Update Report – EnergySolutions Clive Facility Class A West Embankment, February 15, 2011~~

~~2) AMEC Earth & Environmental, Inc. 2011. Cover Letter – Response to Interrogatory CAW R313-25-8(4)-16/1: Seismic Hazard Evaluation, EnergySolutions Clive Facility, Class A West Embankment, Clive, Tooele County, Utah. eport: Geotechnical Update Report – EnergySolutions Clive Facility Class A West Embankment, Clive, Tooele County, Utah. October 25, 2011.~~

~~3) AMEC Earth & Environmental, Inc. 2011. Response to Interrogatory CAW R313-25-8(4)-16/1:~~

UTAH DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIALS LICENSE
SUPPLEMENTARY SHEET

License # UT 2300249
Amendment # ~~14~~15

~~Seismic Hazard Evaluation, EnergySolutions Clive Facility, Class A West Embankment, Clive, Tooele County, Utah. October 25, 2011~~

~~4) AMEC Earth & Environmental, Inc. 2011. Response to Interrogatory CAW R313-25-8(4)-16/2: Seismic Hazard Evaluation, EnergySolutions Clive Facility, Class A West Embankment, Clive, Tooele County, Utah. December 23. 2011.~~

~~5) AMEC Earth & Environmental, Inc. 2012. Report: Response to Interrogatory CAW R313-25-8(4)-16/3: Seismic Hazard Evaluation/Seismic Stability Analysis Update, EnergySolutions Clive Facility, Class A West Embankment, Clive, Tooele County, Utah. April 6, 2012.~~

~~6) AMEC Earth & Environmental, Inc. 2012. Addendum: Additional Cyclic Softening Analysis, EnergySolutions Clive Facility, Class A West Embankment, Clive, Tooele County, Utah. May 3, 2012.~~

~~7) EnergySolutions, LLC. 2011. License Amendment Request: Class A West Embankment, with Attachments 1 Through 7 and cover letter to Mr. Rusty Lundberg at Utah Division of Radiation Control dated May 2, 2011.~~

~~8) EnergySolutions, LLC. 2011. Responses to Round 1 Interrogatories: License Amendment Request (UT2300249) for the Class A West Embankment and cover letter to Mr. Rusty Lundberg at Utah Division of Radiation Control, October 28, 2011.~~

~~9) EnergySolutions, LLC. 2011. Supplemental Responses to Round 1 Interrogatories: License Amendment Request (UT2300249) for the Class A West Embankment, November 28, 2011 and cover letter to Mr. Rusty Lundberg at Utah Division of Radiation Control, November 29, 2011.~~

~~10) EnergySolutions 2012. Radioactive Material License #UT2300249 and Ground Water Quality Discharge Permit No. UGW450005, Amendment and Modification Request – Class A West Embankment: Response to Round 3 Interrogatory URCR R313-25-7(3)-04, with attachments. Letter from Tim Orton, EnergySolutions, to Mr. Rusty Lundberg, Utah Division of Radiation Control, dated March 20, 2012.~~

~~11) Whetstone Associates, Inc. 2011. EnergySolutions Class A West Disposal Cell Infiltration and Transport Modeling Report, April 19, 2011.~~

~~12) Whetstone Associates, Inc. 2011. EnergySolutions Class A West Disposal Cell Infiltration and Transport Modeling Report, November 28, 2011.~~

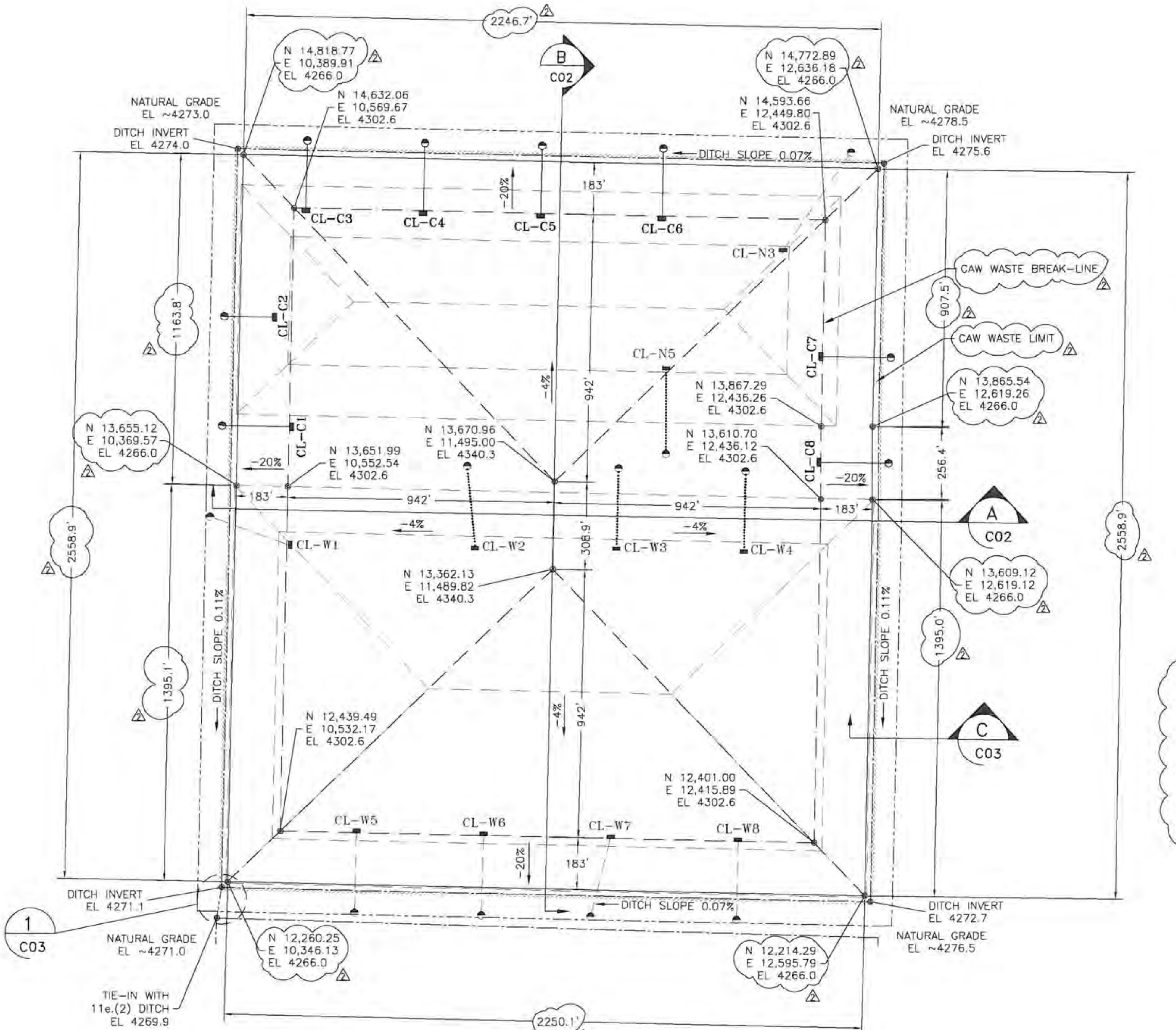
~~13) Whetstone Associates, Inc. 2012. EnergySolutions Class A West Disposal Cell Infiltration and Transport Modeling Report, February 23, 2012.~~

UTAH DIVISION OF RADIATION CONTROL

________________________________ _______
Rusty Lundberg, Director Date

APPENDIX B

Engineering and Construction Drawings



LEGEND:

	CAW WASTE LIMIT (TOE OF WASTE)
	CAW WASTE BREAK-LINES
	EDGE OF CLAY LINER (MIN)
	DITCH CENTERLINE
	BUFFER ZONE LIMITS
	CLASS A AND CLASS A NORTH EMBANKMENTS
CL-XY	EXISTING LYSIMITER
CL-XY	PROPOSED LYSIMTER
CL-XY	EXISTING OR CURRENT PLANNED LYSIMETER TO BE ABANDONED

200 0 200 400

NOTES:

1. ALL ELEVATIONS ARE FOR TOP OF WASTE, UNLESS OTHERWISE NOTED.
2. LYSIMETER CL-W2 HAS NOT BEEN CONSTRUCTED.
3. EMBANKMENT CAPACITY FROM THE TOP OF THE LINER PROTECTIVE COVER (EL 4266') TO THE TOP OF WASTE IS CALCULATED TO BE 8,724,097 CY.
4. DESIGN AND AS-BUILT TOP OF CLAY LINER ELEVATIONS FOR THE CLASS A, CLASS A NORTH AND CLASS A WEST EMBANKMENTS ARE ALL 4265 (LEVEL SURFACES).

LICENSED PROFESSIONAL ENGINEER
No. 189500
DAVID F BOOTH
1/5/12
STATE OF UTAH

	DATE	BY	DESCRIPTION OF CHANGE
2	1/5/12	DFB	FOR LICENSING/CONSTRUCTION: REVISED WASTE LIMIT (TOE); REMOVED WASTE RESTRICTION AREA
1	10/4/11	DFB	FOR LICENSING/CONSTRUCTION: ADDED DETAIL 1 & WASTE RESTRICTION AREA
0	4/28/11	DFB	FOR LICENSING/CONSTRUCTION

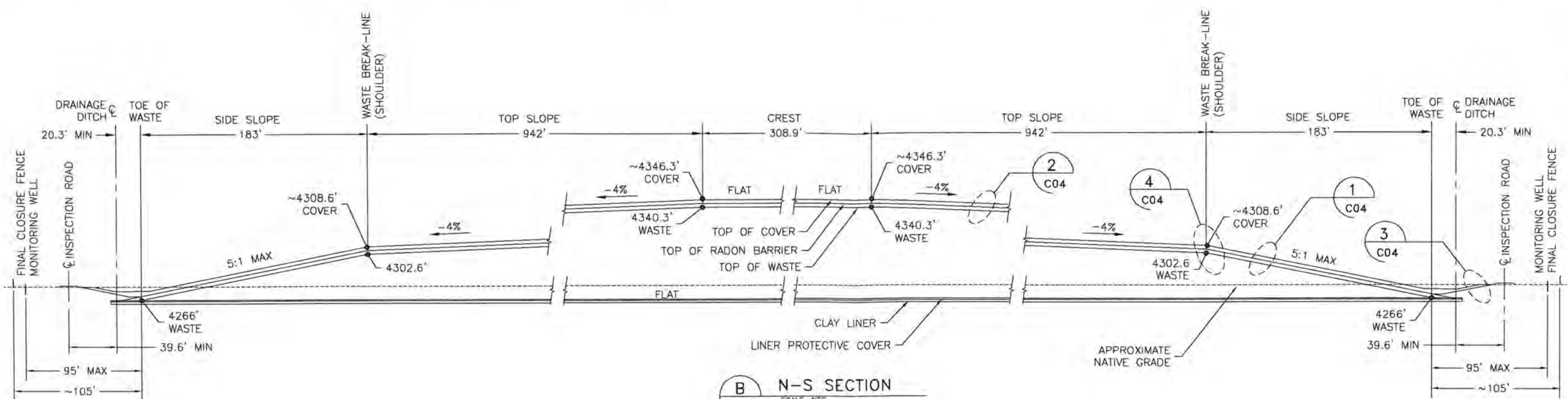
ENERGYSOLUTIONS

ENERGYSOLUTIONS "CLIVE" FACILITY
CLASS A WEST EMBANKMENT
EMBANKMENT FEATURES AND CONTROLS
CLIVE, UTAH

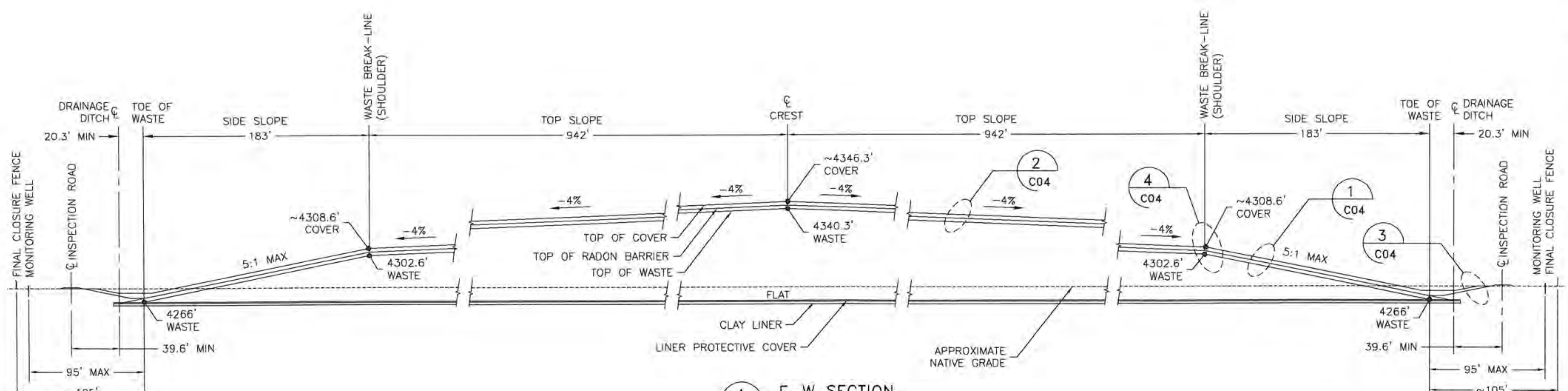
FINAL DRAWING

DRAWN BY: D. BOOTH
REVIEWED BY: G. DUTSON
APPROVED BY: D. BOOTH
SCALE: AS NOTED | DATE: 04/28/11 | REV: 2

10014
C01



B N-S SECTION
C01 SCALE: NTS



A E-W SECTION
C01 SCALE: NTS

NOTES:
1. ELEVATIONS SHOWN ARE FOR THE TOP OF LINER, WASTE AND COVER AS INDICATED.
2. TOP OF COVER ELEVATIONS ARE APPROXIMATE. AS-BUILT ELEVATIONS MAY VARY DUE TO CONSTRUCTION TOLERANCES OF THE VARIOUS COVER LAYERS.

LICENSED PROFESSIONAL ENGINEER
No. 189500
DAVID F BOOTH
10/23/12
STATE OF UTAH

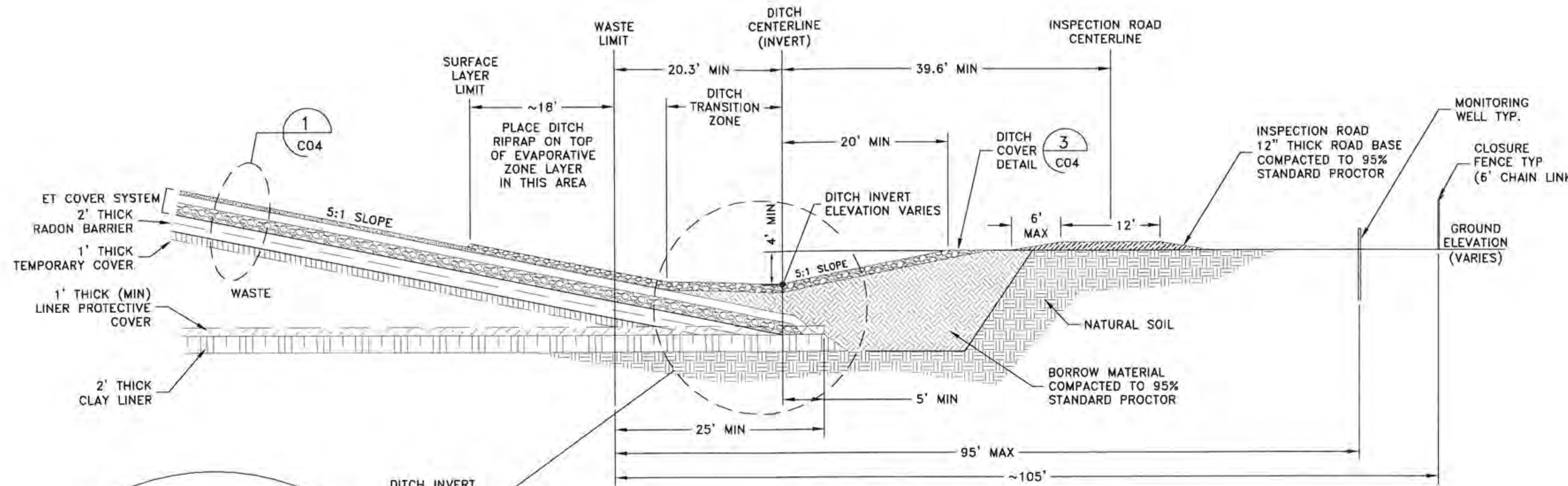
	DATE	BY	DESCRIPTION OF CHANGE
4	10/23/12	DFB	REVISED FOR PROPOSED ET COVER SYSTEM
3	1/5/12	DFB	FOR LICENSING/CONSTRUCTION: REVISED WASTE LIMIT; ADDED & CHANGED LABELS
2	11/4/11	DFB	FOR LICENSING/CONSTRUCTION: REVISED COVER THICKNESS AND ELEVATIONS
1	4/28/11	DFB	FOR LICENSING/CONSTRUCTION

ENERGYSOLUTIONS

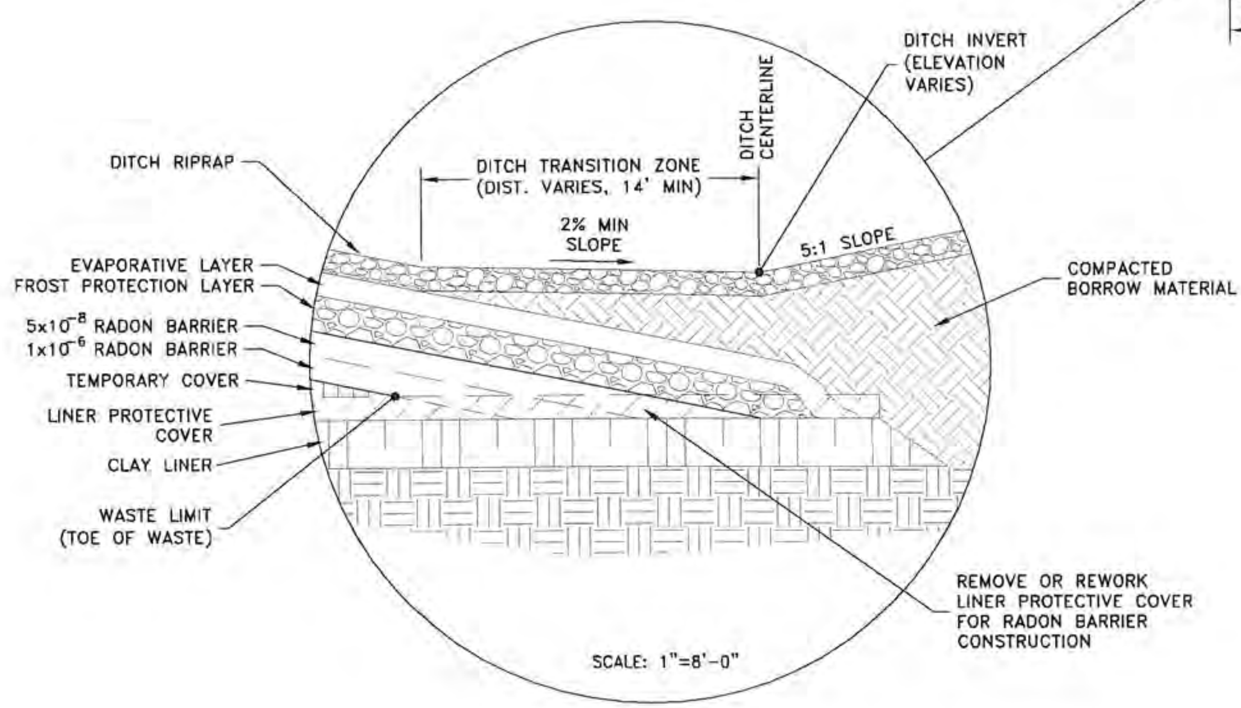
ENERGYSOLUTIONS "CLIVE" FACILITY
CLASS A WEST EMBANKMENT
EMBANKMENT CROSS SECTIONS
CLIVE, UTAH

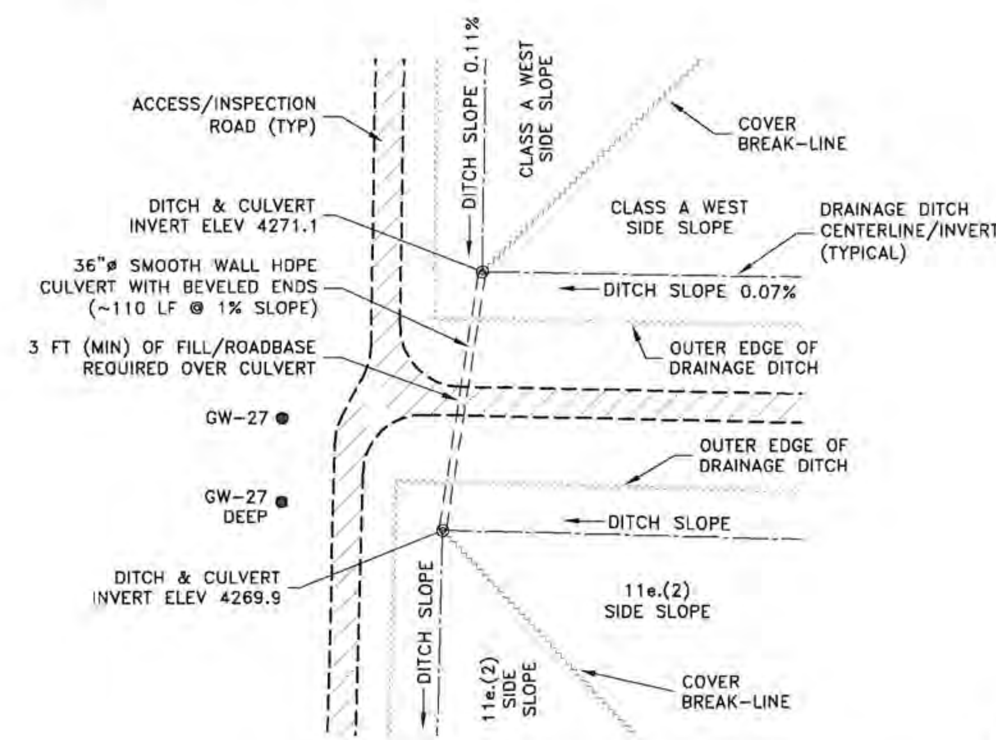
FINAL DRAWING

DRAFTED BY D. BOOTH
REVIEWED BY G. DUTSON
APPROVED BY D. BOOTH
SCALE AS NOTED | DATE 04/28/11 | REV. 4
DRAWING NO. 10014 C02



C
C01
DITCH & ROAD DETAIL TYP.
SCALE: 1"=16'-0"





1
C01
DITCH CONFLUENCE DETAIL
SCALE: 1"= 80'

LICENSED PROFESSIONAL ENGINEER
No. 189500
DAVID F BOOTH
10/23/12
STATE OF UTAH

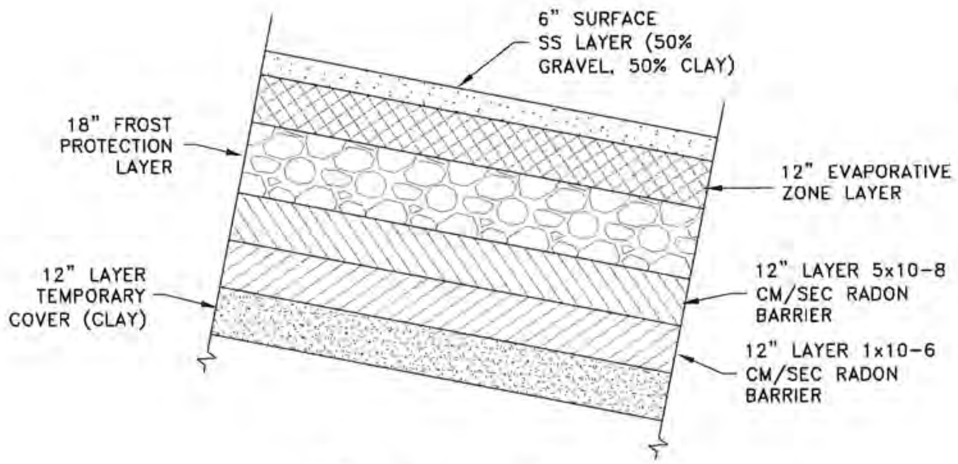
⚠	10/23/12	DFB	REVISED FOR PROPOSED ET COVER SYSTEM
⚠	1/5/12	DFB	FOR LICENSING/CONSTRUCTION: REVISED WASTE LIMIT (TOE OF WASTE)
⚠	11/4/11	DFB	FOR LICENSING/CONSTRUCTION: REVISED TYPE B AND RIPRAP THICKNESSES
⚠	10/4/11	DFB	FOR LICENSING/CONSTRUCTION: ADDED DITCH CONFLUENCE DETAIL & DIMENSION
⚠	4/28/11	DFB	FOR LICENSING
⚠	DATE	BY	DESCRIPTION OF CHANGE

ENERGYSOLUTIONS

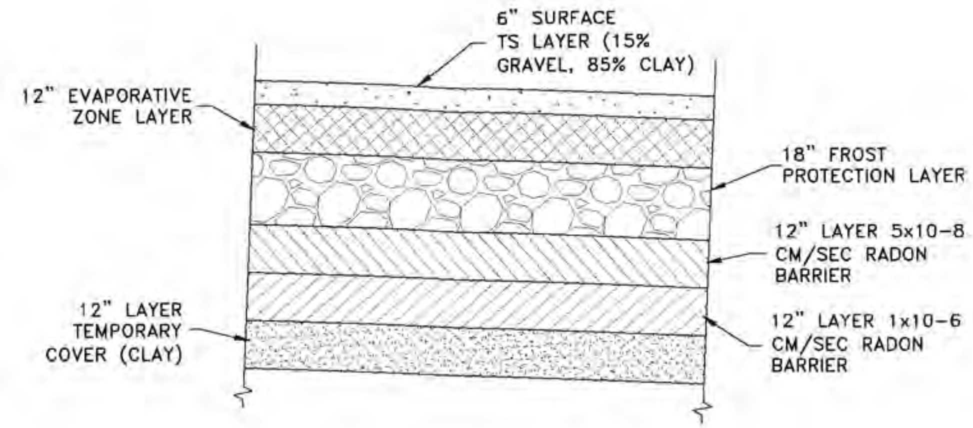
ENERGYSOLUTIONS "CLIVE" FACILITY
CLASS A WEST EMBANKMENT
SECTIONS AND DETAILS, 1 OF 2
CLIVE, UTAH

FINAL DRAWING

DRAFTED BY: D. BOOTH
CHECKED BY: G. DUTSON
APPROVED BY: D. BOOTH
SCALE: AS NOTED
DATE: 04/28/11
REV: ⚠
DRAWING NO.: 10014 C03



1 C02 DETAIL–SIDE SLOPE
NTS TYPICAL SIDE SLOPE COVER DETAIL



2 C02 DETAIL–TOP SLOPE
NTS TYPICAL TOP SLOPE COVER DETAIL

ET COVER MATERIAL SPECIFICATIONS

SURFACE LAYER, SIDE SLOPE (SS):
50% UNIT 4 MATERIAL AMENDED WITH 50% (±3%), BY VOLUME, GRAVEL. REFER TO NOTE 2.

SURFACE LAYER, TOP SLOPE (TS):
85% UNIT 4 MATERIAL AMENDED WITH 15% (±3%), BY VOLUME, GRAVEL. REFER TO NOTE 2.

EVAPORATIVE ZONE LAYER:
UNIT 4 MATERIAL (CLAY). REFER TO NOTE 2.

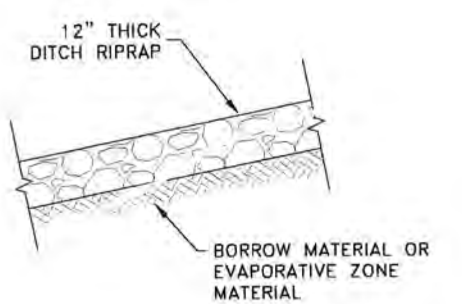
FROST PROTECTION LAYER:
16" MINUS BANK RUN COBBLE/GRAVEL/SOIL MATERIAL. REFER TO NOTE 2.

DITCH RIPRAP:
FINE GRADED ROCK WITH A D_{50} OF 6". SEE NOTE 2.

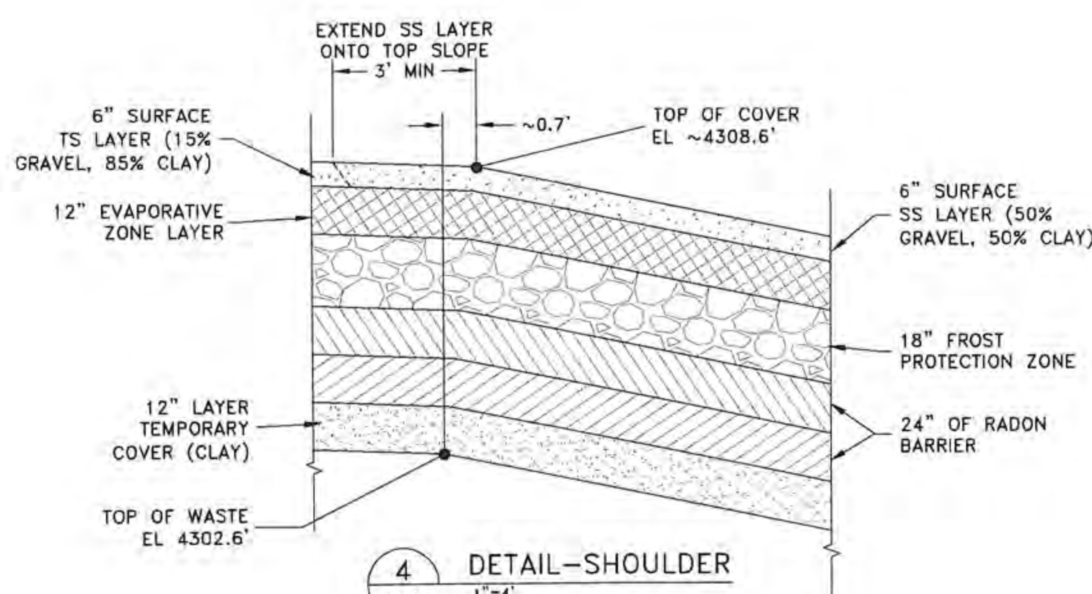
NOTES:

1. EXTEND THE SIDE SLOPE SURFACE LAYER ONTO THE TOP SLOPE A MINIMUM OF 3 FT PAST THE BREAK OVER BETWEEN THE TOP AND SIDE SLOPES.

2. REFER TO THE CURRENT APPROVED LLRW/11e.(2) CQA/QC MANUAL FOR ADDITIONAL MATERIAL SPECIFICATIONS, GRADATIONS, CONSTRUCTION AND TESTING REQUIREMENTS.



3 C02 DETAIL–DITCH OUTER SLOPE
NTS TYPICAL PERIMETER DITCH COVER DETAIL



4 C02 DETAIL–SHOULDER
1"=4'

REV	DATE	BY	DESCRIPTION OF CHANGE
4	10/23/12	DFB	REVISED FOR PROPOSED ET COVER SYSTEM
3	5/3/12	DFB	FOR LICENSING: CORRECTED LABELS FOR TOP SLOPE & SIDE SLOPE RIPRAP
2	11/3/11	DFB	FOR LICENSING: INCREASED RIP RAP TO 24" AND SIDE SLOPE TYPE B FILTER TO 18"
1	10/4/11	DFB	FOR LICENSING: INCREASED DITCH RIPRAP THICKNESS & ADDED MATIL SPEC
0	4/28/11	DFB	FOR LICENSING

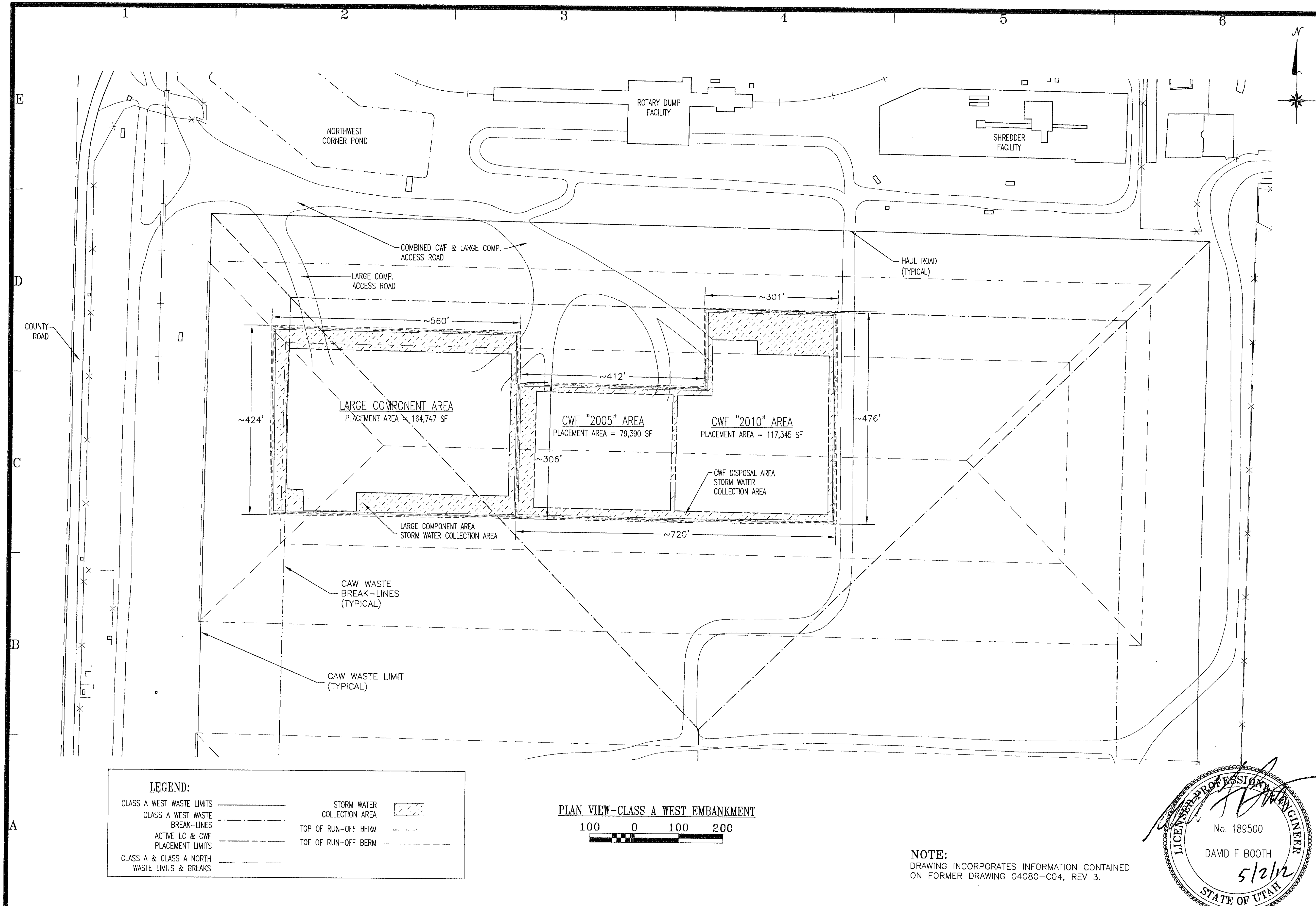
ENERGYSOLUTIONS

ENERGYSOLUTIONS "CLIVE" FACILITY
CLASS A WEST EMBANKMENT
SECTIONS AND DETAILS, 2 OF 2
CLIVE, UTAH

LICENSED PROFESSIONAL ENGINEER
No. 189500
DAVID F BOOTH
10/23/12
STATE OF UTAH

FINAL DRAWING

DRAFTED BY: D. BOOTH
REVIEWED BY: G. DUTSON
APPROVED BY: D. BOOTH
SCALE: AS NOTED
DATE: 04/28/11
REV: 4
DRAWING NO.: 10014 C04



NOTE:
DRAWING INCORPORATES INFORMATION CONTAINED ON FORMER DRAWING 04080-C04, REV 3.

LICENSED PROFESSIONAL ENGINEER
No. 189500
DAVID F BOOTH
5/2/12
STATE OF UTAH

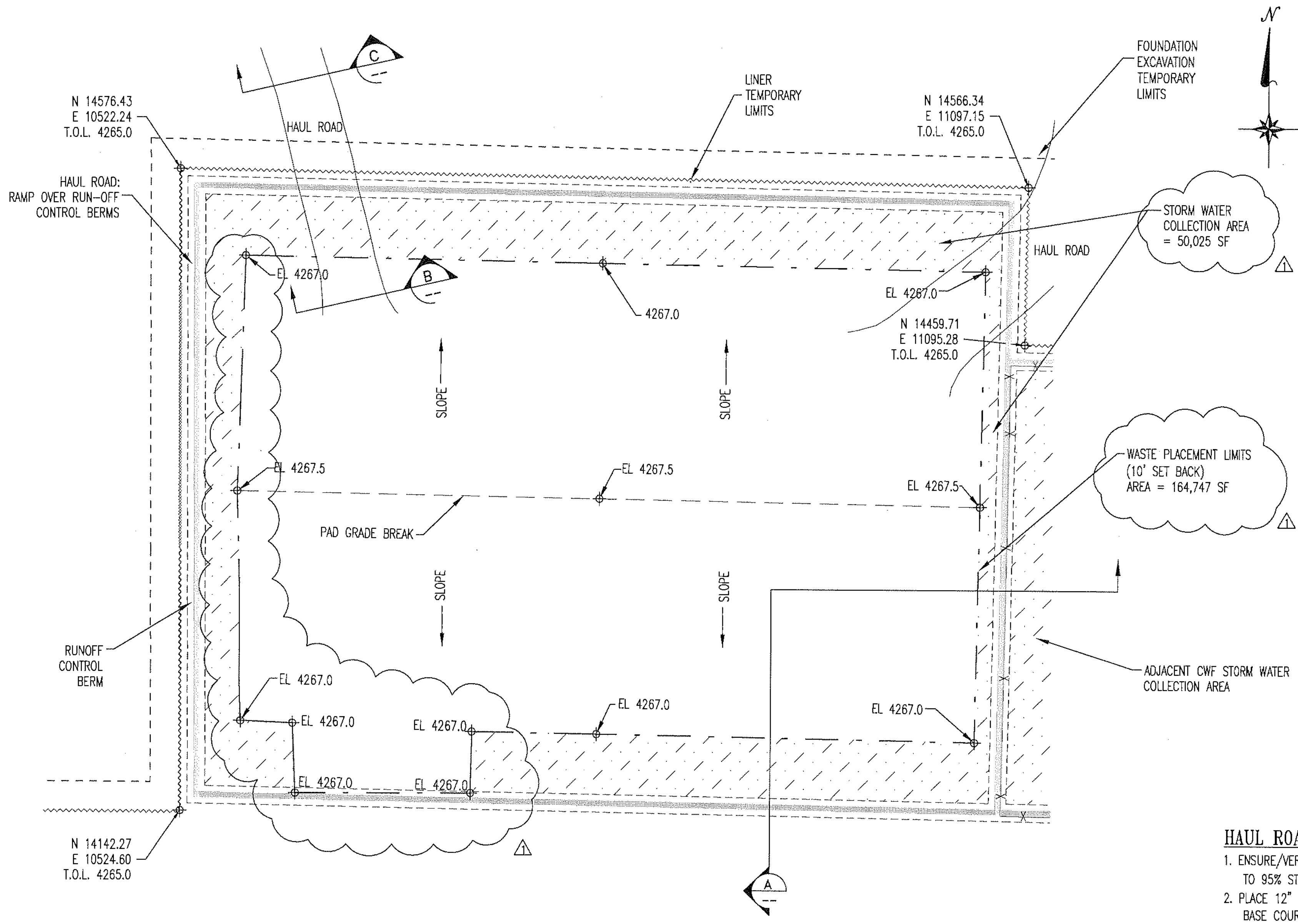
	DATE	BY	DESCRIPTION OF CHANGE
	4/28/11	DFB	FOR LICENSING/CONSTRUCTION
	8/29/11	DFB	FOR LICENSING/CONSTRUCTION-ADDED LABELS TO CAW BOUNDARY AND BREAKOVERS
	1/5/12	DFB	FOR LICENSING/CONSTRUCTION: REVISED WASTE LIMIT & LINE TYPES
	5/2/12	DFB	FOR LICENSING/CONSTRUCTION: REVISED "2009" CWF TO "2010"
	5/2/12	DFB	FOR LICENSING/CONSTRUCTION: REVISED LARGE COMPONENT PLACEMENT AREA

ENERGYSOLUTIONS

CLASS A WEST EMBANKMENT
ACTIVE CWF & LC AREAS
AREA & HAUL ROAD LAYOUT
CLIVE, UTAH

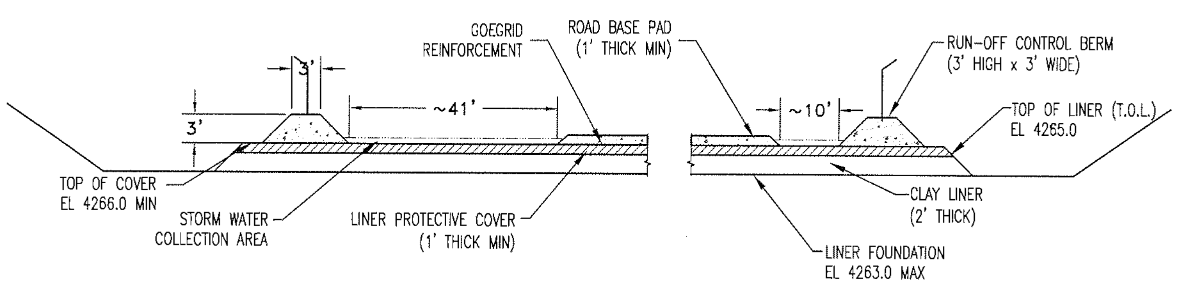
FINAL DRAWING

DRAFTED BY: D. BOOTH
REVIEWED BY: G. DUTSON
APPROVED BY: D. BOOTH
SCALE: AS NOTED
DATE: 04/28/11
DRAWING NO. 10014 C05



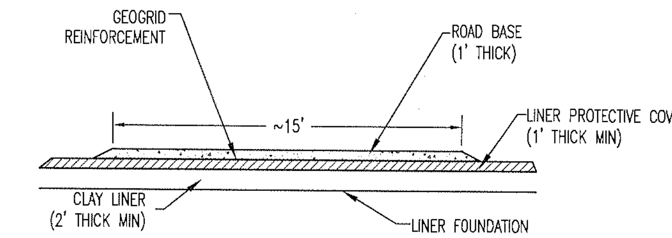
LARGE COMPONENT AREA PLAN VIEW

SCALE 1" = 50'



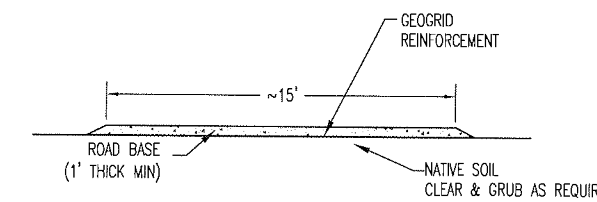
A -- TYPICAL PAD X-SECTION

NOT TO SCALE



B -- TYPICAL ROAD X-SECTION ON LINER

NOT TO SCALE



C -- TYPICAL ROAD X-SECTION ON NATIVE SOIL

NOT TO SCALE

HAUL ROAD NOTES:

1. ENSURE/VERIFY SOIL PROTECTIVE OVER COMPACTED TO 95% STANDARD PROCTOR (ASTM D-698)
2. PLACE 12" (MAX 8" LIFTS) UDOT SPEC 02721 BASE COURSE CONFORMING TO THE FOLLOWING GRADATION, OR ALTERNATIVE APPROVED BY EC DIRECTOR OF ENGINEERING.

SIEVE SIZE	PERCENT FINER
25 mm (1")	100
12.5 mm (1/2")	79-91
4.75 mm (#4)	49-61
1.18 mm (#16)	27-35
.075 mm (#200)	7-11

3. COMPACT BASE COURSE TO 95% STANDARD PROCTOR (ASTM D-698)

STORM WATER CALCULATIONS:

METHOD USED: RATIONAL, V=CiA WHERE,
V = VOLUME OF RUNOFF
C = RUNOFF COEFFICIENT, 0.95 (IMPERVIOUS SURFACE)
i = DESIGN STORM EVENT, 25 YR-24 HOUR, 2.5 IN. (0.208')
A = AREA OF RUNOFF COLLECTION, 222,935 SF

V = 0.95 x 0.208 x 222,935 = 44,052 CF

AREA OF EVAPORATION BASIN = 50,025 SF
DEPTH OF COLLECTED RUNOFF = 44,052 CF/50,025 SF = 0.88 FT

CONCLUSION: 1 FT DEPTH OF EVAPORATION BASIN IS ADEQUATE TO STORE RUNOFF FROM A 25 YR-24 HR STORM EVENT.

NOTES:

1. COORINATES ARE IN THE CLIVE SITE SYSTEM WITH N10,000, E10,000 AT THE SW CORNER OF SECTION 32.
2. DRAWING INCORPORATES INFORMATION CONTAINED ON FORMER DRAWING 04080-C05, REV 5.

LICENSED PROFESSIONAL ENGINEER
No. 189500
DAVID F BOOTH
5/2/12
STATE OF UTAH

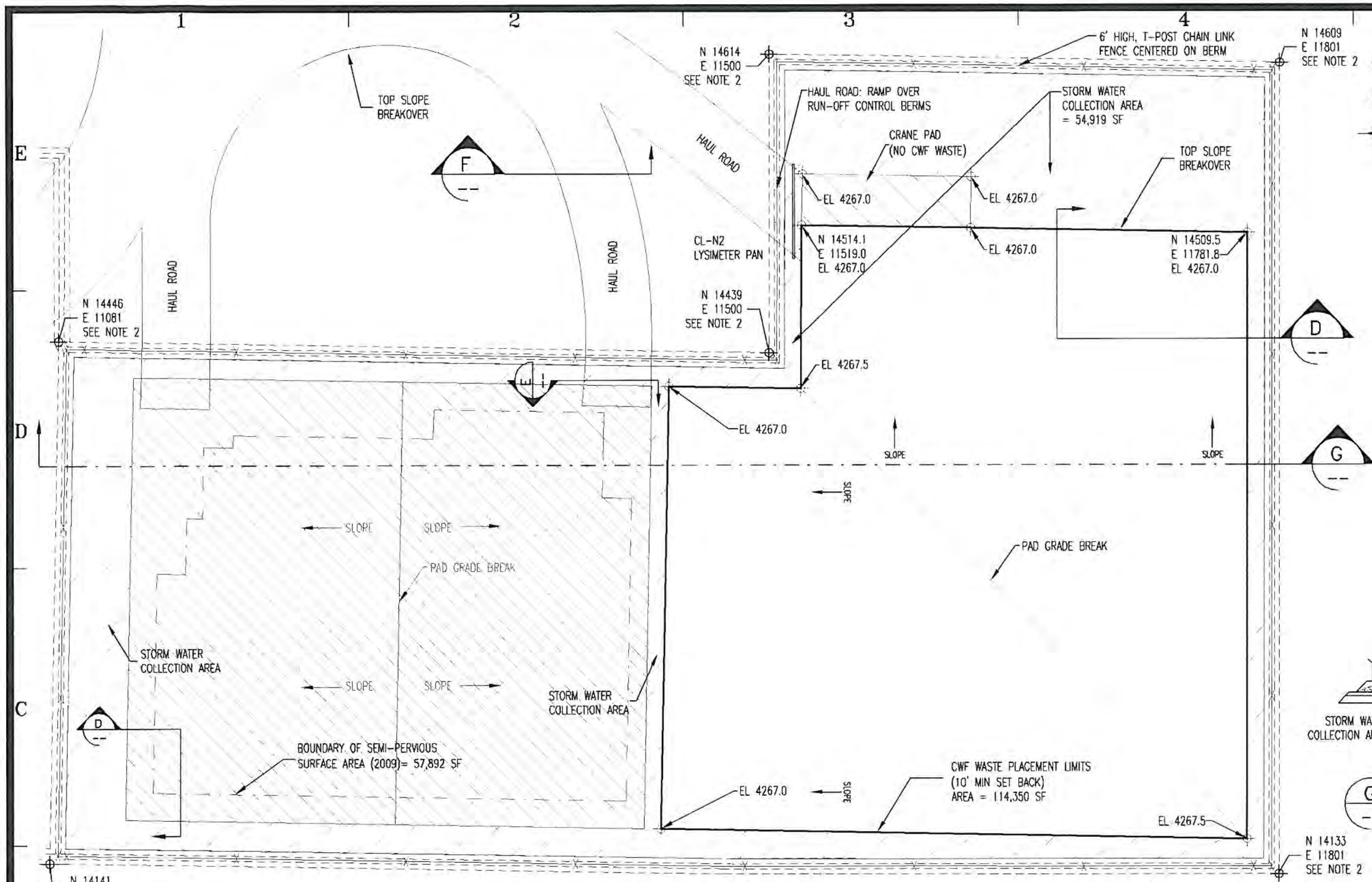
DATE	BY	DESCRIPTION OF CHANGE
4/28/11	DFB	FOR LICENSING/CONSTRUCTION
5/2/12	DFB	FOR LICENSING/CONSTRUCTION: UPDATED DISPOSAL AREA FOR 2011 CHANGES

ENERGYSOLUTIONS

CLASS A WEST EMBANKMENT
ACTIVE LARGE COMPONENT AREA
LARGE COMPONENT AREA PLAN & DETAILS
CLIVE, UTAH

FINAL DRAWING

DRAFTED BY: D. BOOTH
REVIEWED BY: G. DUTSON
APPROVED BY: D. BOOTH
SCALE: AS NOTED
DATE: 04/28/11
DRAWING NO.: 10014 C06



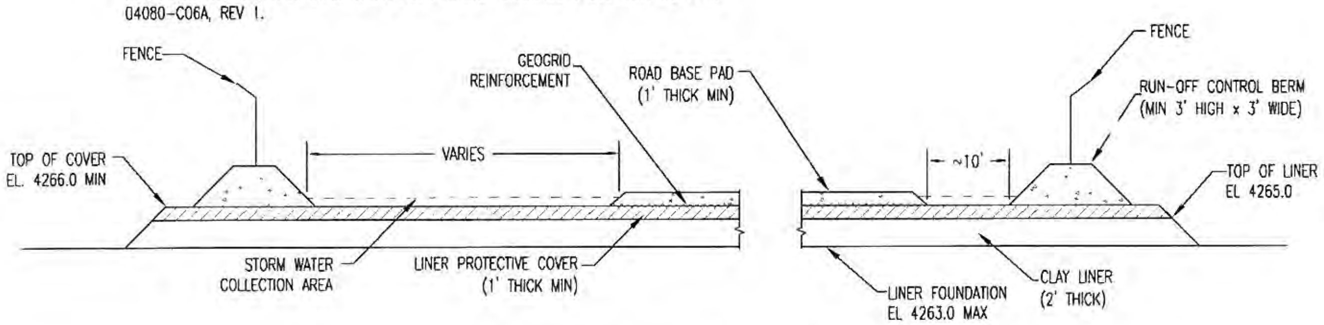
CWF AREA PLAN VIEW

SCALE 1" = 40'

40 0 40 80

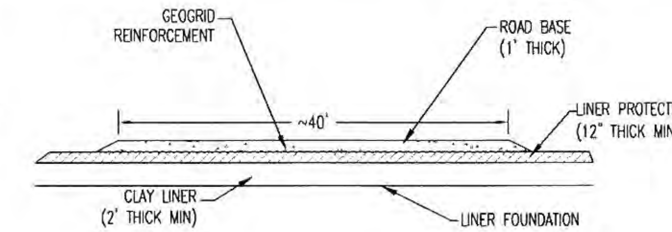
NOTES:

1. COORDINATES ARE IN THE LOCAL GRID SYSTEM (CLIVE) WITH N10,000, E10,000 LOCATED AT THE SW CORNER MONUMENT OF SECTION 32.
2. COORDINATES SHOWN ARE THE APPROXIMATE LIMITS OF THE COMPLETED CWF "PYRAMIDS". ACTUAL LOCATIONS MAY VARY, BUT ALL CWF WASTE MUST BE PLACED UNDERNEATH THE TOP SLOPE IN THE PLACEMENT AREAS.
3. DRAWING INCORPORATES INFORMATION FROM FORMER DRAWINGS 04080-C06, REV 4 & 04080-C06A, REV 1.



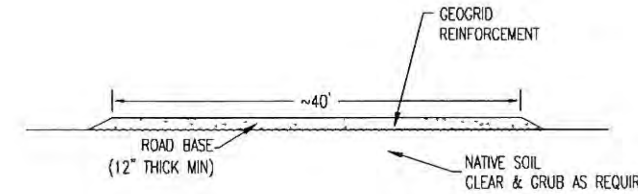
D TYPICAL PAD X-SECTION

NOT TO SCALE



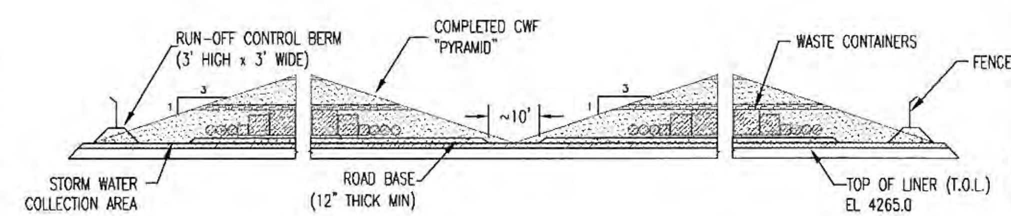
E TYPICAL ROAD X-SECTION ON LINER

NOT TO SCALE



F TYPICAL ROAD X-SECTION ON NATIVE SOIL

NOT TO SCALE



G TYPICAL TRANSITION BETWEEN PADS X-SECTION

NOT TO SCALE

HAUL ROAD NOTES:

1. ENSURE/VERIFY SOIL PROTECTIVE COVER COMPACTION TO BE 95% STANDARD PROCTOR (ASTM D-698)
2. PLACE 12" (MAX 8" LIFTS) UDOT SPEC 02721 BASE COURSE CONFORMING TO THE FOLLOWING GRADATION, OR ALTERNATIVE APPROVED BY ES DIRECTOR OF ENGINEERING.

SIEVE SIZE	PERCENT FINER
25.0 mm (1")	100
12.5 mm (1/2")	79-91
4.75 mm (#4)	49-61
1.18 mm (#16)	27-35
.075 mm (#200)	7-11

3. COMPACT BASE COURSE TO 95% STANDARD PROCTOR (ASTM D-698)

STORM WATER CALCULATIONS:

METHOD USED: RATIONAL, $V_{IMP}=C_{IMP}iA_{IMP}$, $V_{SP}=C_{SP}iA_{SP}$, WHERE,
V_{IMP} = VOLUME OF RUNOFF FROM IMPERVIOUS SURFACE
V_{SP} = VOLUME OF RUNOFF FROM SEMI-PERVIOUS SURFACE
C_{IMP} = RUNOFF COEFFICIENT, 0.95 (IMPERVIOUS SURFACE)
C_{SP} = RUNOFF COEFFICIENT, 0.80 (SEMI-PERVIOUS SURFACE)
i = DESIGN STORM EVENT, 25 YR-24 HOUR, 2.5 IN. (0.208')
A_{IMP} = AREA OF RUNOFF COLLECTION (IMPERVIOUS SURFACE), 199,673 SF
A_{SP} = AREA OF RUNOFF COLLECTION (SEMI-PERVIOUS SURFACE), 57,892 SF

IMPERVIOUS SURFACE VOLUME CALCULATION:
V_{OL} = 0.95 x 0.208 x 199,673 = 39,455 CF

SEMI-PERVIOUS SURFACE VOLUME CALCULATION:
V_{OL} = 0.80 x 0.208 x 57,892 = 9,633 CF

AREA OF EVAPORATION BASIN = 54,919 SF
DEPTH OF COLLECTED RUNOFF = (39,455+9,633) CF/54,919 SF = 0.89 FT

CONCLUSION: 1 FT DEPTH OF EVAPORATION BASIN IS ADEQUATE TO STORE RUNOFF FROM A 25 YR-24 HR STORM EVENT

LICENSED PROFESSIONAL ENGINEER
No. 189500
DAVID F BOOTH
4/28/11
STATE OF UTAH

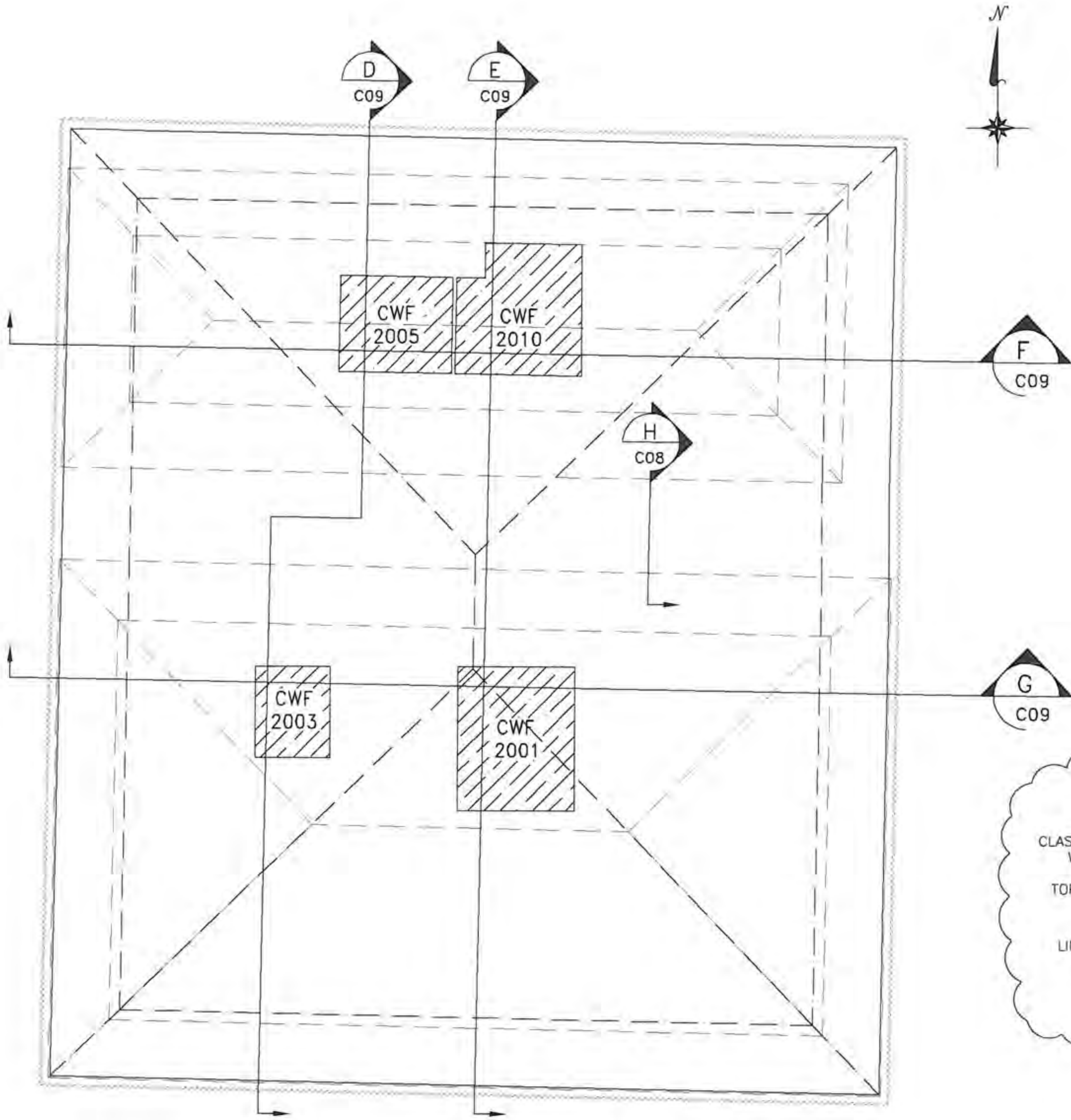
REV	DATE	BY	DESCRIPTION OF CHANGE
1	4/28/11	DFB	FOR LICENSING/CONSTRUCTION

ENERGYSOLUTIONS

CLASS A WEST EMBANKMENT
ACTIVE CWF AREA
CWF AREA PLAN & DETAILS
CLIVE, UTAH

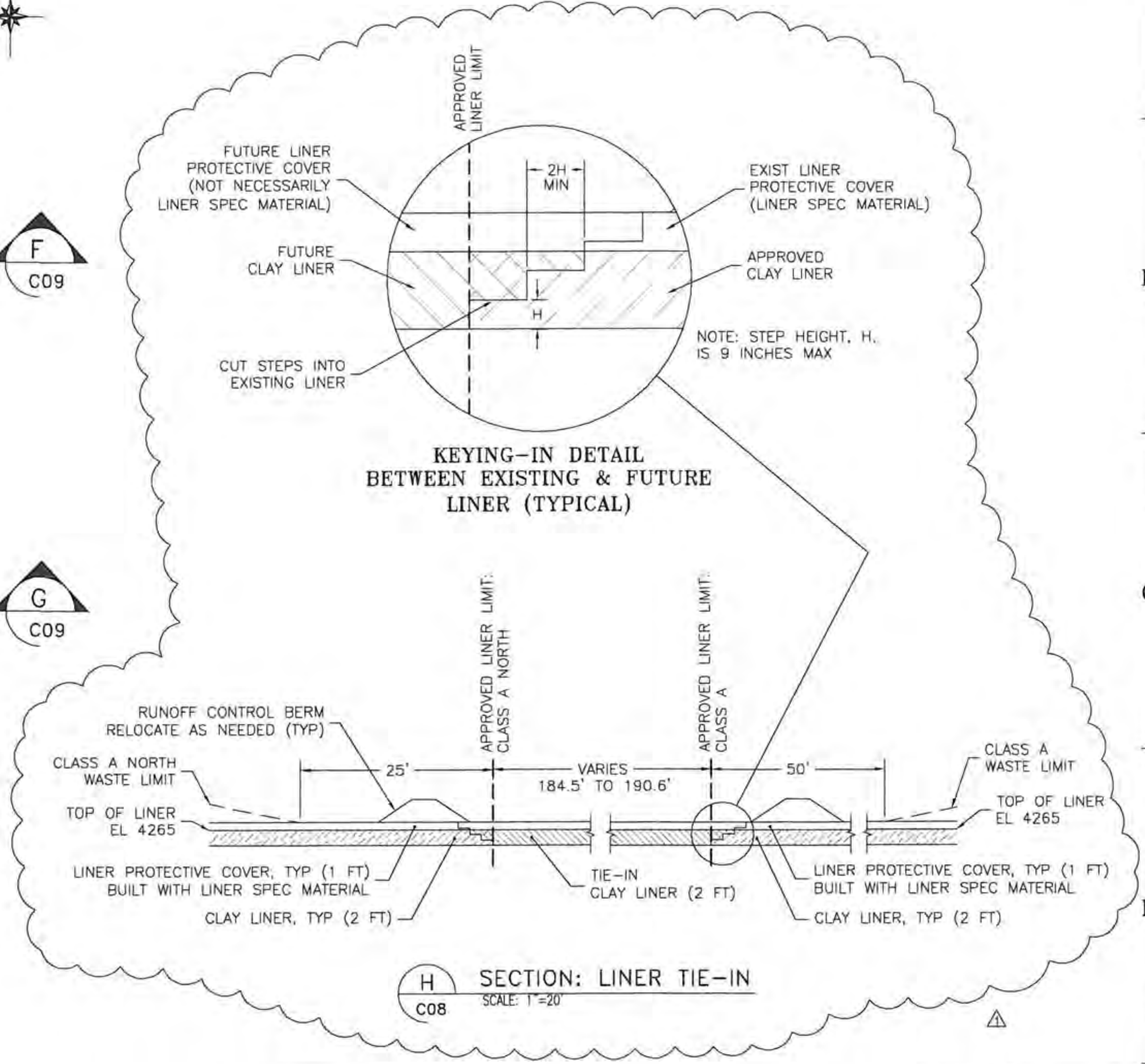
FINAL DRAWING

DRAWN BY: D. BOOTH
CHECKED BY: G. DUTSON
APPROVED BY: D. BOOTH
SCALE: AS NOTED
DATE: 04/28/11
REV: 1
DRAWING NO. 10014 C07



PLAN VIEW - CLASS A WEST EMBANKMENT

200 0 200 400



LEGEND:

- CLASS A & CLASS A NORTH EMBANKMENTS
- WASTE LIMITS: CLASS A WEST
- BREAKLINES: CLASS A WEST
- LINER LIMITS: CLASS A WEST
- CWF DISPOSAL AREAS

LICENSED PROFESSIONAL ENGINEER
No. 189500
DAVID F BOOTH
1/5/12
STATE OF UTAH

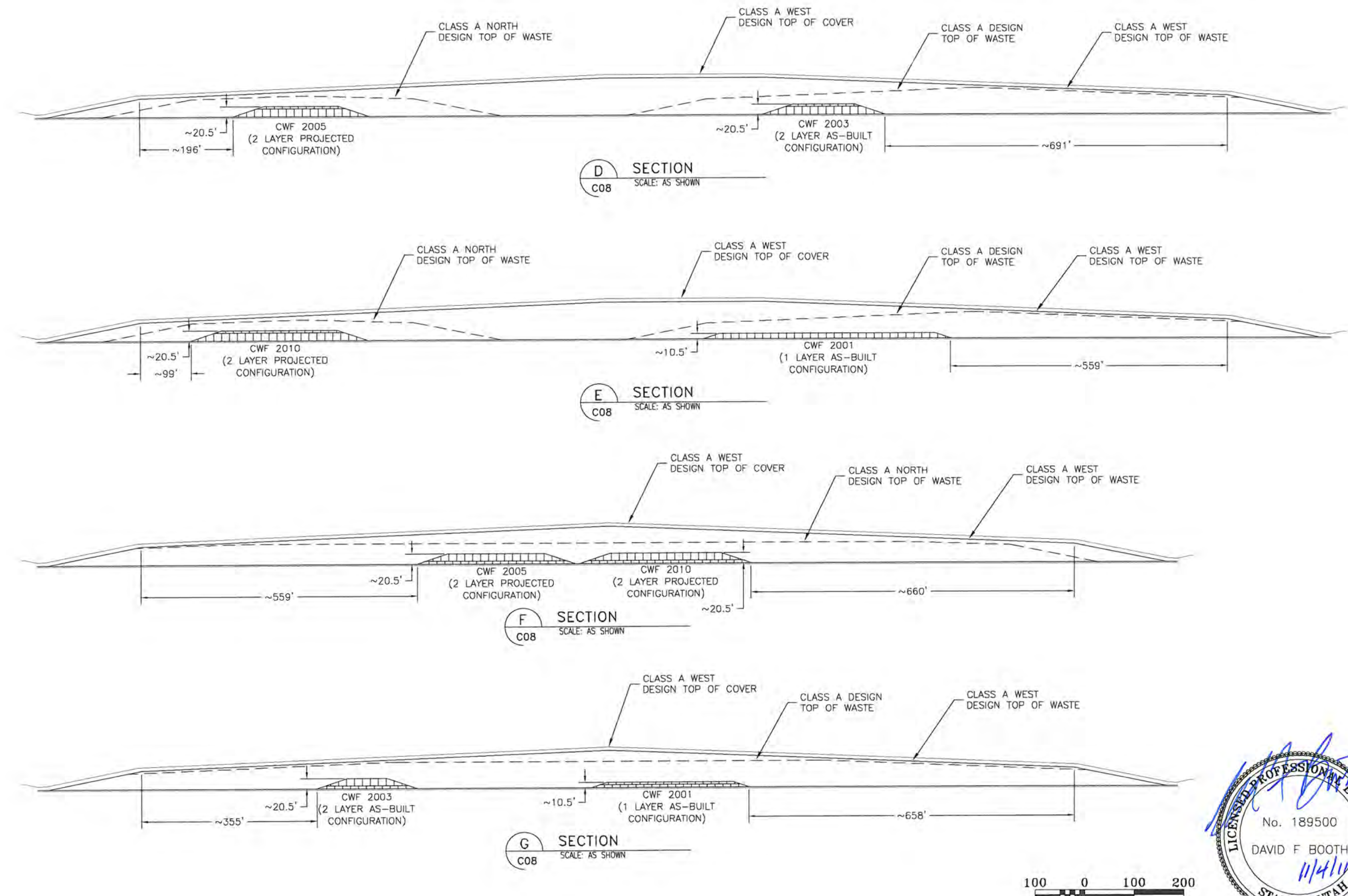
REV	DATE	BY	DESCRIPTION OF CHANGE
1	1/5/12	DFB	FOR LICENSING/CONSTRUCTION: REVISED WASTE LIMIT (TOE OF WASTE), ADDED LINER TIE-IN DETAIL
0	4/28/11	DFB	FOR LICENSING/CONSTRUCTION

ENERGYSOLUTIONS

ENERGYSOLUTIONS "CLIVE" FACILITY
CLASS A WEST EMBANKMENT
CLASS A, CLASS A NORTH & CLASS A WEST MAP
CLIVE, UTAH

FINAL DRAWING

DRAWN BY: D. BOOTH
REVIEWED BY: G. DUTSON
APPROVED BY: D. BOOTH
SCALE: AS NOTED
DATE: 04/28/11
REV: 1
DRAWING NO.: 10014 C08



LICENSED PROFESSIONAL ENGINEER
No. 189500
DAVID F BOOTH
11/4/11
STATE OF UTAH

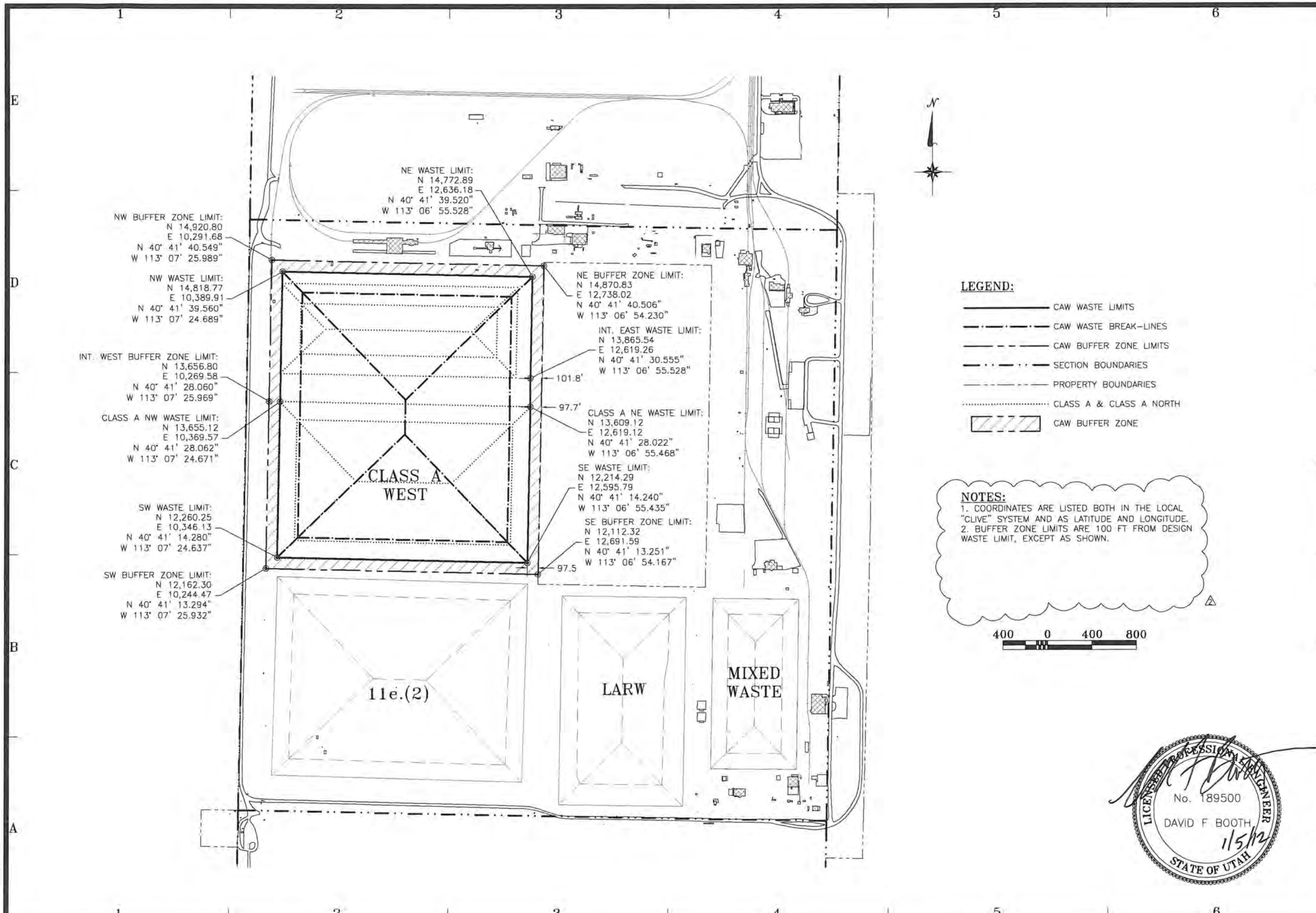
DATE	BY	DESCRIPTION OF CHANGE
11/4/11	DFB	FOR LICENSING/CONSTRUCTION: INCREASED COVER THICKNESS
4/28/11	DFB	FOR LICENSING/CONSTRUCTION

ENERGYSOLUTIONS

ENERGYSOLUTIONS "CLIVE" FACILITY
CLASS A WEST EMBANKMENT
CWF CROSS SECTIONS
CLIVE, UTAH

FINAL DRAWING

DRAWN BY: D. BOOTH
REVIEWED BY: G. DUTSON
APPROVED BY: D. BOOTH
SCALE: AS NOTED
DATE: 04/28/11
DRAWING NO.: 10014 C09



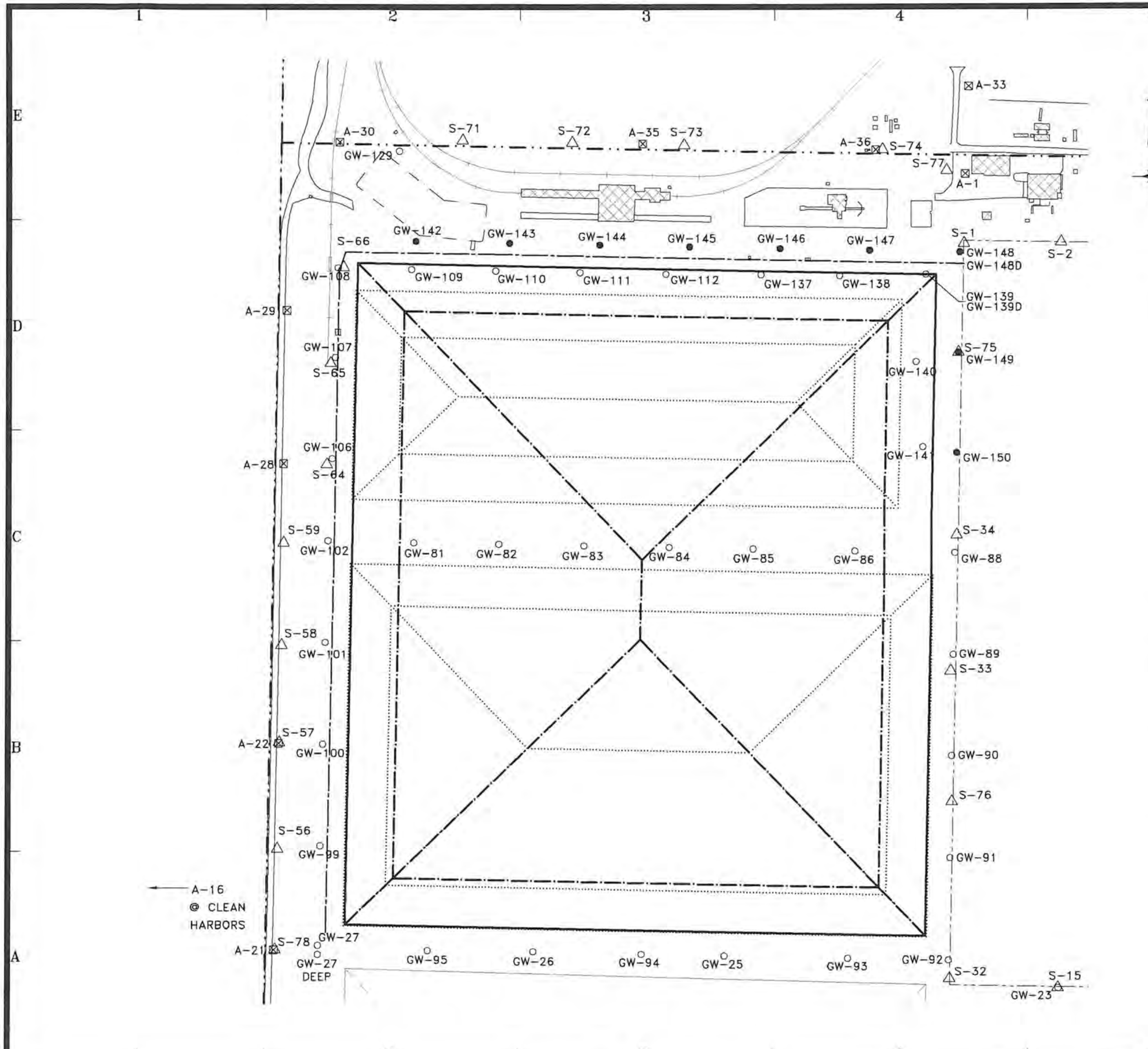
DATE	BY	DESCRIPTION OF CHANGE
1/5/12	DFB	FOR LICENSING/CONSTRUCTION: REVISED WASTE & BUFFER ZONE LIMITS & COORDINATES
10/4/11	DFB	FOR LICENSING/CONSTRUCTION: ADDED BUFFER ZONE DIMENSIONS AND NOTES 2 & 3
4/28/11	DFB	FOR LICENSING/CONSTRUCTION

ENERGYSOLUTIONS

ENERGYSOLUTIONS "CLIVE" FACILITY
CLASS A WEST EMBANKMENT
EMBANKMENT LOCATION MAP & BUFFER ZONE
CLIVE, UTAH

FINAL DRAWING

DRAWN BY: D. BOOTH
REVIEWED BY: G. DUTSON
APPROVED BY: D. BOOTH
SCALE: AS NOTED DATE: 04/28/11 REV: 2
DRAWING NO. 10014 U01



LEGEND:

- CAW WASTE LIMITS
- CAW WASTE BREAK-LINES
- RUN-ON BERM CENTERLINE
- SECTION BOUNDARIES
- PROPERTY BOUNDARIES
- CLASS A & CLASS A NORTH
- A-XX ⊠ EXIST. AIRSAMPLING STATION
- S-YY △ EXIST. SOIL SAMPLING STATION
- GW-ZZ ○ EXIST. GROUNDWATER MONITORING WELL
- GW-ZZ ● NEW GROUNDWATER MONITORING WELL

200 0 200 400

GROUNDWATER MONITORING WELLS TO BE ABANDONED OR RELOCATED	
GW-81	GW-111
GW-82	GW-112
GW-83	GW-137
GW-84	GW-138
GW-85	GW-139
GW-86	GW-139D
GW-109	GW-140
GW-110	GW-141

LICENSED PROFESSIONAL ENGINEER
No. 189500
DAVID F BOOTH
1/5/12
STATE OF UTAH

DATE	BY	DESCRIPTION OF CHANGE
1/5/12	DFB	FOR LICENSING/CONSTRUCTION: REVISED WASTE LIMIT
10/4/11	DFB	FOR LICENSING/CONSTRUCTION: REMOVED SOIL S-66 STATION FROM TABLE
4/28/11	DFB	FOR LICENSING/CONSTRUCTION

ENERGYSOLUTIONS

ENERGYSOLUTIONS "CLIVE" FACILITY
CLASS A WEST EMBANKMENT
EMBANKMENT ENVIRONMENTAL MONITORING
CLIVE, UTAH

FINAL DRAWING

D. BOOTH
G. DUTSON
D. BOOTH
AS NOTED 04/28/11

10014
U02

APPENDIX C

LLRW and 11e.(2) Construction Quality Assurance and Quality Control Manual

(with proposed amendments for revision 27a in reline/strikeout format)

LLRW and 11e.(2) Construction Quality Assurance/Quality Control (CQA/QC) Manual

TABLE 1 – CQA/QC ACTIVITIES

Work Elements:

TABLE 2 – MATERIAL PROPERTIES FOR PORTLAND CEMENT CLSM

TABLE 3 – MATERIAL PROPERTIES FOR FLY ASH CLSM

FIGURE 1 – LARW Settlement Monuments, May 1, 2006
FIGURE 2 – Class A West Settlement Monuments, rev. 3, September 20, 2011

Formatted: Normal

Formatted: Font: Times New Roman

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to all construction activities in the Class A West and 11e.(2) embankments.		
QC DOCUMENTATION APPROVAL: QC documentation shall be approved/rejected by the Lead, QC Embankment Construction ~~QC Officer~~ and submitted to the Construction QA Officer. The Construction QA Officer shall approve/reject the documentation.	Sign the reports indicating documentation is adequate, correct, and has been accepted by QC. Provide QA with copies of the documentation and obtain their signature on the documentation indicating QA acceptance. Ensure that corrective actions required by QA personnel are accomplished.	Review the documentation generated by QC. Report deficiencies to the ~~QC officer~~Lead, QC Embankment Construction and the Construction QA Officer. Verify that corrective action has been taken (where required) and recorded on the QC documentation. Countersign reports indicating documentation is adequate, correct, and has been accepted by QA. Record findings on the "Daily Quality Assurance Report".
QC DOCUMENTATION FILES: Original QC documents shall be maintained in accordance with CL-QA-PR-005, Quality Assurance Records~~at the site~~. A copy shall be saved into the electronic database.	After the QC documentation has been accepted by QA, a copy of the original shall be saved into the electronic database. ~~Originals of all QC documentation shall be maintained in the site engineering file.~~	~~Periodically review the site engineering files to ensure the correct documentation is being retained by QC personnel.~~
QA DOCUMENTATION FILES: Original QA documents shall be maintained in accordance with CL-QA-PR-005, Quality Assurance Records~~at the site~~. A copy shall be saved into the electronic database.	None	~~A copy of the original shall be saved into the electronic database and originals maintained in the site QA file.~~

Formatted: Font: CG Times, 10 pt

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the Class A West and 11e.(2) embankments.		
RUNON CONTROL DURING PROJECT: The perimeter berms shall be constructed to a minimum of 3 feet above the ground elevations (GL) shown in the engineering drawings. The first lift of material shall have an uncompacted thickness of no greater than 12 inches. There is no lift thickness specification for subsequent lifts. Elevations for the berms between the specified ground elevations shall be linearly interpreted between the shown elevations. The berms shall be a minimum of 3~~10~~ feet wide at the top and shall be compacted to 90 percent of a standard Proctor.	Verify that the required berms have been constructed to the specified dimension. Record any findings on the "Daily Construction Report". Spot check the density of the first lift and subsequent lifts of the berm to ensure that it meets specifications. Record density tests on the "Field Density Test" form.	Verify that berms have been inspected by QC personnel.
RUNOFF CONTROL DURING PROJECT: Berms shall be constructed around the outside edge of the clay liner to a height of 3 feet. This height is measured as the elevation above the design elevation of the clay liner; or as the elevation above the design elevation of the liner protective cover, whichever is higher. Berms shall be a minimum of 3 feet wide at the top. The first lift of material shall have an uncompacted thickness of no greater than 12 inches. There is no lift thickness specification for subsequent lifts. The berm will be constructed on top of the clay liner such that the berm is not in contact with native ground. A minimum distance of 10 feet shall be maintained between the toe of the berm and the toe of the waste. The berms shall be compacted to 90 percent of a standard Proctor.	Verify that the required berms have been constructed to the specified dimension. Record any findings on the "Daily Construction Report". Spot check the density of the first lift and subsequent lifts of the berm to ensure that it meets specifications. Record density tests on the "Field Density Test" form.	Verify that the berms have been inspected by QC personnel.
Contact water shall be controlled inside the runoff control berm system. Contact water is defined as any storm water that falls within the runoff berm system in the active, unfinished portions of the embankment. Access ramps that cross runoff berms shall be constructed to prevent such runoff from leaving the	Inspect the access ramps that cross runoff berms on a weekly basis for the presence of runoff control channels and document the inspection on the "Daily Construction Report".	Verify that the weekly access ramp inspections have been performed and documented.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
lined portion of the embankment.		
~~Fences or other barriers will be installed at the active cell boundary, (the run-off berm and near the radon barrier/waste interface) The barriers will be "chicken-wire", snow fence, chain-link fence, or herculite (or other materials similar to herculite) secured to "T" posts.~~	~~Verify fences are installed around the active cell boundary and near the radon barrier/waste interface and document the inspection on the "Daily Construction Report".~~	~~Verify that fences are in place and have been inspected by QC personnel.~~
Storm runoff for up to a 10-year, 24-hour event that runs off from those portions of the embankment that have been completed to final cover design shall be managed and controlled to prevent such runoff from contacting contaminated waste material in the active unfinished portions of the embankment.		
After the first lift of radon barrier material for an entire side slope area (i.e., from the toe of waste to the side slope breakover) has been constructed, verified, and approved, the adjacent runoff berm for that side slope area may be removed. During placement of this first lift of radon barrier, there is no minimum offset to the runoff berm.		
MONTHLY BERM INSPECTION: The berms and fences are to be inspected monthly. Inspect for obvious damage to berms and fences. Ensure berm height where roads cross berms.	Inspect the berm on a monthly basis and document the inspection and any corrective actions taken (if required) on the "Daily Construction Report". Marker posts indicating the required berm height should be placed at both side of a road at the point where the road crosses the berm. This is to aid in identifying damage to the berm due to road traffic. Repair any noted damage of berm or wind dispersal fences and fill low spots to meet the design height.	Verify that the monthly berm inspections have been performed and properly documented. Verify proper installation of marker posts and wind dispersal fences or other barriers.
BERM MAINTENANCE: The runon and runoff berms shall be surveyed and improved, as required, by July 1 of each year.	Survey the berms at 100 foot intervals and key points. Repair any noted damage and fill low spots to meet the design height.	Verify that the berms are surveyed and improved, as required.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
MOVING OR BREACHING A RUNOFF CONTROL BERM: When moving or breaching a berm, the work must be authorized by the Lead, QC Embankment Construction~~QC officer~~ prior to commencing work. A temporary breach of a berm may be accomplished without a temporary berm, provided the work is expected to be ~~may be~~ completed and the berm replaced the same day. A temporary berm will ~~have the same specifications as a permanent berm~~be designed to ensure runoff is contained withint the cell and approved by the Site Engineer.	Review the work to be performed. Document the approval to move or breach a berm on the "Breach of Berm" Form.	Verify that the approval to move or breach a berm has been properly documented.
NUCLEAR DENSITY/MOISTURE GAUGE CALIBRATION: ~~To ensure proper calibration, a sand-cone density test shall be performed jointly with five percent of the nuclear density test. The frequency of sand-cone tests shall be reduced to two percent of the nuclear density tests for the clay liner or radon barrier to minimize the damage to these low permeability layers from the sand-cone test. Holes in the clay liner and radon barrier created by the nuclear density gauge shall be filled with dry bentonite.~~ ~~To ensure proper calibration, an oven drying test shall be performed jointly with five percent of the nuclear moisture tests.~~Each nuclear density gauge shall have current calibration, performed in accordance with the manufacturer‟s specifications, prior to use on the project.	~~Perform sand-cone density tests and oven-drying tests to calibrate the nuclear moisture/density gauge. Review the results with the Construction QA Officer.~~ ~~When performing the sand-cone density test or the oven-drying test to calibrate the nuclear moisture/density gauge, the data obtained from the sand-cone density test or the oven-drying test takes precedence over the data obtained from the nuclear moisture/density gauge.~~	~~Review the results with the QC officer~~Lead, QC Embankment Construction~~. Verify that the data obtained from the sand-cone density tests and oven-drying tests (when performed) are used in the calculations for ultimate acceptance of the tested media.~~
SAMPLING LOCATIONS FOR LOTS: For sample locations chosen by random numbers, two random numbers shall be employed. The first number (X) shall be between 0 and the largest east-west distance of the lot. The second number (Y) shall be between 0 and the largest north-south distance of the lot. The test location will be located at X feet east and Y feet south of the	Generate random numbers for each lot by using a calculator or computer with a random number generator. Locate the test location within five feet of the location specified by the random numbers. If the sample location is outside the lot, generate two new random numbers.	Verify that the test methods are being chosen by random number.

Formatted: Font: CG Times, 10 pt

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
north-west corner of the lot. For a linear lot (e.g. the intersection of lifts), a single random number shall be generated.		
~~For borrow sources which consist of multiple lots which will be sampled by a single test pit, the test pit shall be located by two random numbers as outlined above and will be the same for all lots.~~		
TEST METHODS: All tests shall be performed in accordance with the test methods specified in Appendix B.	~~Use the test methods in Appendix B to perform the require testing.~~	~~Verify that the test methods being use to conduct the tests are the methods specified in Appendix B.~~
QA AUDITING: Energy*Solutions* shall contract with an independent firm to perform an annual audit of the CQA/QC. The auditor shall: a) audit at least 15% of the CQA\QC documentation; and b) observe QC procedures for field density/moisture tests, classification tests, Proctors, permeability tests, and surveying. A copy of the auditor's report shall be submitted to the DRC.	Schedule times with the QA auditor to observe the specified testing. Cooperate with QA auditor in the review of QC documentation.	Cooperate with QA auditor in the review of QC documentation.
~~**WEEKLY CONSTRUCTION SCHEDULE:** During clay liner and embankment cover construction projects, including test pads, a weekly construction schedule will be provided to DRC. This specification also applies to permitted facilities under construction within Section 32. The schedule does not constitute a binding commitment; but is a reasonable estimate of when listed construction activities will occur. No submittal is required if there are no clay liner, cover, or other permitted facilities under construction.~~	~~Support the Director of Engineering in preparing the schedule for submittal.~~	
TEST FAILURE ~~PROTOCAL~~ PROTOCOL: Unless otherwise specified in this Manual, any failing test shall be addressed as follows: 1. Document the failing test result in applicable		

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
QC records. 2. Notify construction personnel of the failing test result and re-work as needed. 3. After re-work is complete, re-test and document results. 4. If the re-test results pass, approve the work. 5. If the re-test results fail, direct further re-work until passing results are achieved. 6. Any circumstance where re-work is not desired or possible shall be documented on a ~~Condition~~ Nonconformance Report (NCR). ~~The Director of Engineering or designee shall be responsible for determining and originating a Condition Report.~~ Any circumstance addressed via ~~Condition Report~~ NCR in accordance with this specification requires DRC notification and written approval prior to proceeding.		
QUALITY OF ROCK: Applies to the following cover materials. 11e.(2): Filter Zone, Top Rock and Side Rock. Class A West: Surface Layer Gravel and Ditch Riprap. The rock shall have a "Rock Quality" score of at least 50 based on the following tests: Specific Gravity (ASTM C-128), Absorption (ASTM C-127), Sodium Soundness (ASTM C-88), and L.A. Abrasion (ASTM C-131 or ASTM C-535). The procedures for scoring "Rock Quality" are found in Appendix C.	As described in NUREG-1623, appendix F, perform at least one petrographic examination for each rock source in accordance with ASTM C-295. If a combination of limestone, sandstone, and igneous rock is found for a source, percentages of each type of material shall be determined for scoring. Perform Na soundness, LA abrasion, absorption, and specific gravity testing at a rate of one set of tests per 10,000 cubic yards of rock. Record the location of all collected samples in the "Sampling Log".	Verify the frequency of laboratory quality control tests and compliance of test results. Perform quality assurance testing for Rock Quality parameters at a minimum of one set of tests per 100,000 cubic yards of rock. A minimum of one set of tests is required each year that filter zone is placed. Record the samples on the "Sampling Log". Promptly report results to the Construction QA Officer so that a comparison of QA and QC testing results can be made. The Construction QA Officer, in consultation with the Lead, QC Embankment Construction, shall be responsible for determining the adequacy of correlation and documentation of the rationale used to determine adequacy. If the correlation is not adequate, new QC and QA samples shall be taken immediately. The Construction QA Officer, in consultation with the Lead, QC Embankment Construction, shall then evaluate the accuracy of the QC sampling and testing

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
		and, if necessary, provide for improved sampling and testing procedures and closer inspection and control. Record findings of the quality assurance sampling in the "Daily QA Report".

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the Class A West and 11e.(2) embankments.		
CLEARING AND GRUBBING: Remove vegetation, debris, organic, or deleterious material from areas to be excavated for construction of cells. Grubbing depth will depend on the type of vegetation, debris, organic, or deleterious material on the site. If the area is free of these materials then no clearing and grubbing will be necessary.	Inspect the area once clearing and grubbing has been completed. Record observations and corrective actions (where required) on the "Daily Construction Report".	Verify that the clearing and grubbing has been inspected by QC.
EXCAVATION: Excavation shall be made to the lines, grades, and dimensions prescribed in the approved plans. Any over excavation shall be backfilled with select materials and compacted to 95 percent of Standard Proctor. The uncompacted lift thickness shall not exceed ~~9~~12 inches.	Observe the cell excavation. Record observations and corrective actions taken (where required) on the "Daily Construction Report". In areas of over excavation, conduct in-place density tests at a rate of one test per lot and record the results on the "Field Density Test" form. A lot is defined as a maximum of 10,000 square feet of a lift of a specified type of material. Test locations shall be chosen on the basis of random numbers. a. Approve lots which meet the specified compaction. b. Rework and retest lots not meeting the specified compaction. Proctors shall be performed at a rate of one test per 100,000 square feet for each material type. At least one proctor shall be performed for each material type. Record the location of the sample on the "Sampling Log".	Observe~~, at a minimum, five percent of the tests performed by~~ QC personnel to ensure that the tests and observations are being performed correctly. Verify that the tests are being performed at the correct frequency and that the documentation is being completed.
SCARIFICATION AND COMPACTION: The foundation shall consist of either: a. scarifying the in-situ clays to at least six inches and compacting it to at least 95 percent of a standard proctor or; b.~~ inspecting the in-situ sands and if cracking of the surface is observed, then scarify the in-situ sands to at least six~~	Observe the foundation. Record observations and corrective actions on the "Daily QC Report". Conduct in-place density tests at a rate of one test per lot and record the results on the "Field Density Test" form. A lot is defined as a maximum of 10,000 square	Observe~~, at a minimum, five percent of the tests performed by the~~ QC personnel to ensure that the tests and observations are being performed correctly. Verify that the tests are being performed at the correct frequency and that the documentation is being completed.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
~~inches and compact it to at least 95 percent of a standard proctor, or, if no cracking is observed, then~~ compact the in-situ sands to at least 95 percent of a standard proctor without prior scarification.	feet of a ~~6 inch~~ lift of a specified type of material. Test locations shall be chosen on the basis of random numbers. ~~a. Approve lots which meet the specified compaction.~~ ~~b. Rework and retest lots not meeting the specified compaction.~~ Proctors shall be performed at a rate of one test per 100,000 square feet for each material type. At least one proctor shall be performed for each material type. Record the location of the sample on the "Sampling Log".	
FINAL GRADING: The foundation surface shall be smooth-drum rolled and moist prior to clay liner placement. The foundation shall be free from surface debris, soft (wet) spots greater than 3 inches deep, and loose soil areas with a loose surface greater than 3 inches deep. Foundation shall be at or below grade. ~~The foundation for the clay liner shall be fairly smooth and free from clods, rocks, soft spots, wet areas, etc. Foundation elevations shall be at grade or below grade.~~	Survey the foundation on a 50 ft grid and at key points. Final survey measurements will be documented and provided to the Lead, QC Embankment Construction~~QC officer~~ and Construction QA Officer. ~~a. Indicate where the foundation meets design line and grade.~~ ~~b. Rework and resurvey areas not meeting the specified grade.~~	Review the final survey data. Verify the frequency of the survey points.
UNSUITABLE MATERIAL: Remove unsuitable material as required. Unsuitable material is non-soil material or soil which cannot be reworked to meet the compaction criteria.	Define areas of unsuitable material and advise the project manager that such areas must be removed. Observe the areas once the unsuitable material has been removed. Report corrective actions (where required) on the "Daily Construction Report".	Verify that the removal of unsuitable material has been properly documented.
FOUNDATION APPROVAL: Foundation ~~to~~ shall be approved by ~~Construction QA Officer~~the Manager, Engineering and Maintenance (or designee). Prepare a "Notice of Acceptance" indicating that the foundation meet the required specifications.	Obtain the "Notice of Acceptance" from the Manager, Engineering and Maintenance (or designee) ~~Construction QA Officer~~ before construction of the clay liner begins.	~~Provide a "Notice of Acceptance" to the QC officer~~Lead, QC Embankment Construction ~~indicating that the foundation meet the required specifications.~~

Formatted: Font: CG Times, 10 pt

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the Class A West and 11e.(2) embankments.		
CLEARING AND GRUBBING: Remove vegetation, debris, organic, or deleterious material from areas to be used for borrow. Grubbing depth will depend on the type of vegetation, debris, organic, or deleterious material on the site. If the area is free of these materials then no clearing and grubbing will be necessary.	Inspect the area once clearing and grubbing has been completed. Record observations and corrective actions (where required) on the "Daily Construction Report".	Verify that the clearing and grubbing has been inspected by QC.
MATERIAL: Satisfactory material shall be defined as CL and ML soils based on the Unified Soil Classification~~ with at least 85 percent passing the No. 200 sieve (silt and clay), a plasticity index (PI) between 10 and 25, and a liquid limit (LL) between 30 and 50~~. The clay shall also have a dry clod size less than or equal to 1 inch.	Perform laboratory classification tests (ASTM D 2487) at a rate of 1 test per lot prior to use of material in the clay liner. A lot is defined as a maximum of~~ 3,000~~ 5,000 cubic yards (compacted) of specified material type. Record the location of the classification sample on the "Sampling Log". ~~a. Approve lots (which meet the specified classification) for use in the clay liner.~~ ~~b. Lots not meeting the specified classification can not be used.~~	Verify the frequency of laboratory tests and compliance of test results.
PROTECTION: The clay borrow material shall be handled in such a manner as to prevent contamination with radioactive waste material or other deleterious material. The in-place clay may contain up to 5 percent additional rocks and sand above the content found in the classification test.	Visually check clay liner materials for contamination by foreign materials. Remove clays which have been contaminated above the specified requirements. Document corrective actions (where required) on the "Daily Construction Report".	Verify that the clay liner is being inspected for ~~contaminates~~ contaminants and that corrective actions (if required) are properly documented.
PROCESSING: These procedures may be used to provide suitable material for construction of the clay liner.		
1. Apply deflocculant at a rate determined by the ~~production engineer~~Manager, Engineering and Maintenance	Measure the mixing areas and verify that the application rate of the deflocculant is equal to or greater than the rate determined by the ~~production engineer~~Manager, Engineering and Maintenance. Record the size of the mixing areas and the amount of deflocculant applied on the "Embankment Construction Lift Approval Form".	Verify that the size of the mixing areas and the amount of deflocculant applied have been properly documented.
2. Mix the deflocculant thoroughly into the soils by tilling or similar action.	Observe the mixed clay and advise the project manager of areas which are adequately mixed.	Verify that the clay is being inspected by QC.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the Class A West and 11e.(2) embankments.		
NOTICE OF TEST PAD CONSTRUCTION: The test pad plan shall be ~~approved by~~ provided to the DRC prior to the test pad construction. The DRC shall be notified 48 hours in advance of the start-up of test pad construction.	Obtain documentation confirming that the test pad plan has been ~~approved by~~ provided to the DRC. Verify that the DRC has been notified, as required.	~~Verify that the test pad plan has been approved by the DRC. Verify that the DRC has been notified as required.~~
TEST PAD: An approximately 60 feet by 75 feet large test pad will be constructed using the procedure proposed for construction of the clay liner.	Observe the construction of test pads. Measure test pads to ensure that they are constructed to the size indicated. Record the test pad size on the "Embankment Construction Lift Approval Form".	Observe the construction of the test pads. Verify that the test pad has been measured and is properly documented.
Prior to use of manually operated compaction equipment, a~~A~~ small test pad with ~~minimum~~ approximate dimensions of 5 feet by 5 feet (or other size appropriate to the equipment used) will be constructed. The purpose of this small test pad is to establish equipment and procedures for construction of clay liner in locations where large equipment is not practical (e.g. repairs). If manually operated compaction equipment is not used on the project, a small test pad is not required.	The large test pad shall be divided into three lots per lift (approximately 1,500 square feet per lot). Each lift of the small test pad shall equal a lot.	
A new test pad shall be constructed each time there is a change in specifications, construction procedures, types of equipment, or unified soil classification~~, or QC testing equipment or procedure~~.		
Test pads are to be constructed and tested in accordance with the following specifications:		
1. Place the clay in at least three lifts with the first lift uncompacted thickness not exceeding twelve inches. Remaining lifts shall have a loose material thickness not exceeding nine inches for each lift. The clay material will be	Measure the lift thickness at a rate of 1 test per lot. Record thicknesses on the "Embankment Construction Lift Approval Form". Inspect the loose clay material during the unloading	Verify that the number of lifts and lift thicknesses have been documented. Verify that the clod size inspection has been performed and documented for each uncompacted lift thickness.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
inspected for dry clod size during placement of each lift of clay liner.	and spreading process for each uncompacted lift to ensure any dry clods that are present are less than or equal to one (1) inch. Record inspection of the clod size on the "Embankment Construction Lift Approval Form".	
2. The clay is to be placed and compacted by equipment proposed for use during construction of the clay liner.	~~Verify with the project manager that the same or similar type equipment and compaction efforts will be used in the cell for construction of the clay liner.~~ Record type of equipment used, and number of passes on the "Embankment Construction Lift Approval Form".	~~Verify equipment used and the number of passes made in preparing the test pad are those to be used during the construction of the clay liner.~~Perform a minimum of 1 visual inspection per test pad.
3. The lifts of clay shall be bonded by: a) providing a rough upper surface on the underlying layer of clay liner. The surface should have changes in grade of approximately one inch or more at a rate of two per linear foot; ~~- OR -~~ ~~b) by compacting with a sheepsfoot with feet approximately two inches longer than the lift thickness.~~	Verify that there are adequate changes in grade by placing a straight edge at least two feet long on the surface. Count the number of points approximately one inch or more below the straight edge. ~~- OR -~~ ~~Verify that the feet on the sheepsfoot compactor are approximately two inches longer than the lift thickness.~~	Verify the frequency of measurements and compliance of test results.
4. The clay is to be compacted to at least 95 percent of a standard Proctor with a moisture content ~~of~~ between 3 percentage points below optimum ~~to~~ and 5 percentage points over optimum. Compaction of the large test pad is to be accomplished by at least four passes of suitable compaction equipment.	Conduct in-place moisture-density tests at a rate of one test per lot. The test location shall be chosen on the basis of random numbers. Record the test result on the "Field Density Test" form. a. Approve lots which meet the specified moisture and compaction. b. Rework and retest lots not meeting the specified moisture or compaction. c. Any additional work under b. shall be included in the test pad construction method.	Verify the frequency of tests and compliance of test results.
5. The clay is to be constructed to provide a permeability less than or equal to 1 x 10^{-6} cm/sec. Permeability testing on the bottom lift will be performed at the surface. Permeability on the second	Conduct in-place permeability tests at a rate of one test per lot per lift. The permeability test shall be run in close proximity to the moisture-density test. Record the test result on the "Field Permeability Test" form.	Verify the frequency of tests and compliance of test results.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
lift will be performed ≥ 2" below the surface. Permeability on the third lift will be performed ≥ 4" below the surface.	a. Approve lots which meet the specified permeability. b. Rework and retest lots not meeting the specified permeability c. Any additional work under b. shall be included in the test pad construction method.	
6. At least one ~~PI, LL,~~ classification and gradation test shall be conducted for each test pad.	Conduct ~~PI, LL,~~ classification and gradation tests at a rate of one of each type of test per test pad.	Verify the frequency of tests and compliance of test results.~~Verify that the PI, LL, and gradation tests have been conducted and documented.~~
7. The procedures used to construct the test pad shall be reviewed and approved by the certifying engineer. The test must be approved by a Professional Engineer.	Provide the certifying engineer with copies of the documentation for the test pad for review and approval.	Verify that proper approval has been obtained for the test pad and that the necessary construction procedure documents are in place for use during clay liner construction.
8. The ~~procedures used to construct the test pad shall be reviewed and approved~~ test pad certification report shall be provided to~~by~~ the DRC prior to using the new test pad construction method.	~~Obtain documentation confirming the DRC approval of the test pad.~~	~~Verify that proper approval has been obtained for the test pad and that the necessary construction procedure documents are in place for use during clay liner construction.~~

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the Class A West and 11e.(2) embankments.		
LIFT IDENTIFICATION: Each lift shall be given a discrete designation for testing and surveying purposes.	Assign a lift identification number to each lift. Use the lift identification number to identify all paper work for that lift.	Verify that a lift identification number has been assigned to each lift. Verify that the lift identification number is used on all paper work for that lift.
PLACEMENT: The clay liner will be prepared, placed, and compacted using the same type of equipment and mixing and compacting procedures that were approved in the test pad.	Observe the clay liner placement. Record the equipment used to place the clay liner and any corrective actions (where required) on the “Embankment Construction Lift Approval Form”.	Verify the equipment used to construct the clay liner has been documented and that it is the same type of equipment used to construct the test pad.
LIFT BONDING: The lifts of clay shall be bonded by: 1) providing a rough upper surface on the underlying layer of clay liner. The surface should have changes in grade of approximately one inch or more at a rate of two per linear foot; ~~**- OR -**~~ ~~2) by compacting with a sheepsfoot with feet approximately two inches longer than the lift thickness.~~	Verify that there are adequate changes in grade by placing a straight edge at least two feet long on the surface. Count the number of points approximately one inch or more below the straight edge. ~~**- OR -**~~ ~~Verify that the feet on the sheepsfoot compactor are approximately two inches longer than the lift thickness.~~	Verify the frequency of measurements and compliance of test results.
LIFT THICKNESS: The first lift of material shall have an uncompacted thickness of no greater than 12 inches. For the remaining lifts, the loose lift thickness shall not exceed the lesser of the lift thickness used to construct the test pad or nine inches. Thickness for the lift will be established by installing grade poles on at least a 70-foot grid and at all control points. The grade poles must not be installed deeper than 1 inch into the underlying clay liner. The grade poles must be marked at the appropriate depth to establish the grade. After the grade for the lift has been checked and approved by QC personnel, the grade poles shall be removed. The clay material will be inspected for dry clod size during placement of each lift of clay liner.	Verify that the required grading tolerance is achieved as follows: a. Ensure that the required frequency for placement of grade poles has been met. b. Compare soil level with the marked level on the grade poles. c. Use a string line where necessary between poles to check for high or low spots. d. Define high out of specification areas and advise the project manager to rework those areas. e. Review areas reworked and approve areas meeting criteria. f. Continue "b" through "d" above until all areas meet criteria. g. Indicate areas meeting criteria on the “Embankment	Observe~~, at a minimum, five percent of the measurements performed by the~~ QC personnel to ensure that the measurements are being performed correctly. Verify that the measurements are being performed at the correct frequency and that the documentation is being completed. Verify that the clod size inspection has been performed and documented for each uncompacted lift thickness.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
- OR - Survey to determine lift thickness	Construction Lift Approval Form". **- OR -** a. Verify equipment calibration, b. Verify correct set-up and operation of equipment. ~~Dig a hole and measure the loose lift thickness at a rate of one per lot. A lot is defined as 10,000 square feet of a single lift and record on the "Lift Approval Form". The location of the measurement shall be chosen on the basis of random numbers.~~ ~~a. Approve lots which meet the specified lift thickness.~~ ~~b. If the thickness is greater than the specified thickness, measure the thickness at four points (north, east, south, and west) within ten feet of the first measurement. Average the five measurements together.~~ ~~c. Approve lifts with an average less than or equal to the specified lift thickness.~~ ~~d. Rework and retest lots with an average lift thickness greater than the specified lift thickness.~~ Inspect the loose clay material during the unloading and spreading process for each uncompacted lift to ensure any dry clods that are present are less than or equal to one (1) inch. Record inspection of the clod size on the "Embankment Construction Lift Approval Form".	
KEYING-IN: Segments of cell clay liner constructed at times more than 30 days apart from each other shall be keyed-in to each other ~~at vertical steps no greater than nine inches and at least twice as wide as they are high.~~ by sloping the full thickness of old liner at a maximum slope of 5:1.	Verify that the new liner has been properly keyed-in to the existing liner. Record deficiencies on the "Embankment Construction Lift Approval Form".	Verify that the keying-in of the liner has been documented.
COMPACTION: Clay liner material will be compacted to at least 95 percent of standard Proctor with a moisture content between ~~optimum~~ 3 percentage points below and 5 percentage points over optimum.	Conduct in-place moisture-density tests at a rate of one test per lot and record the results on the "Field Density Test" form. A lot is defined as ~~200~~ 2500 cubic yards (compacted) of a single lift. The test location shall be	Verify the frequency of measurements and compliance of test results.~~Observe, at a minimum, five percent of the tests performed by the QC personnel to ensure that the tests and observations are being performed~~

Formatted: Left

Formatted: Font: CG Times, 10 pt

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
	chosen on the basis of random numbers. ~~a. Approve lots which meet the specified moisture and compaction.~~ ~~b. Rework and retest lots not meeting the specified moisture or compaction.~~	~~correctly. Verify that the tests are being performed at the correct frequency and that the documentation is being completed.~~
	Proctors shall be performed at a rate of one test per borrow lot. A borrow lot is defined as ~~3,000~~ 5000 cubic yards (compacted) or less of a specific material type. Record the location of the Proctor sample on the "Sampling Log".	
PERMEABILITY: Clay liner will have an in-place permeability less than or equal to 1 x 10^{-6} cm/sec.	Permeability is verified by strict adherence to the test pad construction method and equipment. Observe compaction activities to ensure that the minimum number of passes are completed by the appropriate equipment. ~~Conduct in-place permeability tests at a rate of one test per lot and record the results on the "Field Permeability Test" form. A lot is defined as 2,000 cubic yards (compacted) of clay liner. The permeability test shall be run in close proximity to a moisture density test location.~~ ~~a. Approve lots which meet the specified permeability.~~ ~~b. Rework and retest lots not meeting the specified permeability.~~ ~~c. Restore all test areas to assure no leaks.~~	Visually observe 1 lift being compacted per construction season.~~Observe, at a minimum, five percent of the tests performed by the QC personnel to ensure that the tests and observations are being performed correctly. Verify that the tests are being performed at the correct frequency and that the documentation is being completed.~~
LINER DRYING PREVENTION: To prevent the clay liner from drying, water will be applied to the clay surface on an as needed basis or the liner will be covered with 9 ~~six~~ inches of loose clay or 6 inches of compacted clay ~~or 12 inches of loose waste~~. Newly constructed liner will be covered ~~with six inches of loose clay or 12 inches of loose waste~~ within 15 days of liner completion. Desiccation cracks larger than one-fourth inch wide and one-inch deep in the clay liner will be reported to the DRC and will be documented as	Observe the liner surface for drying. Advise the project manager of any deficiencies. Record corrective actions taken (where required) on the "Daily Construction Report".	Verify that the liner is being inspected.

Formatted: Font: CG Times, 10 pt

Formatted: Font: CG Times, 10 pt

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
a non-conformance item when discovered.		
SNOW REMOVAL: When clay liner material is to be placed and the work area is covered with snow, the snow must be removed.	Observe that snow is removed. Advise the project manager of any deficiencies. ~~Construction may not continue without taking corrective action to remove the snow.~~ Record these corrective actions (where required) in the "Daily Construction Report".	Verify that snow removal is being documented.
COLD WEATHER PLACEMENT OF CLAY LINER: For purposes of this CQA/QC Manual, "frozen" is defined as a soil temperature of less than or equal to 27ºF. Clay liner shall not be placed above frozen material. In addition, no frozen material shall be processed or placed. If the air temperature has dropped below 32ºF since the last lift of clay liner was approved, one of the following three scenarios apply: (1) If less than 30 days have passed since the date of lift approval and the last lift of clay liner has been covered since the approval date with at least 9 inches of loose clay or 6 inches of compacted clay, then the cover clay may be worked with no additional testing of the lower approved lift. (2) If less than 30 days have passed since the date of lift approval and the last lift of clay liner has not been covered with at least 9 inches of loose clay or 6 inches of compacted clay, then: (a) Perform spring start-up testing as discussed below; or (b) Monitor the liner/foundation temperature approximately 1 inch beneath the surface. If the temperature 1 inch beneath the surface is greater than 27ºF, re-roll the surface with one pass of the same type of construction equipment (i.e., a compactor for intermediate lifts or a smooth drum roller for the final surface) and continue with liner construction. If the	As needed, observe the area where clay liner is to be placed. If frozen material is observed, cease placement of clay liner. If frozen material is suspected, measure soil temperature. Record the stopping of placement in the "Daily Construction Report." Review ambient air temperature records as measured at the site meteorological station. Document status of clay liner cover placement on the "Daily Construction Report." Monitor liner/foundation temperature when triggered under 2.(b). Clay temperature shall be measured between 6:00 am and 8:00 am on the day that clay liner will be placed. Temperature measurements shall include a location that is most likely to be coldest; i.e., if there is a portion of the liner that is shaded or at a low point. Temperature monitoring frequency shall be at least one point per 100,000 square feet or one point per contiguous project area, whichever is smaller. If the initial clay temperature measurement is less than or equal to 27ºF, the affected area may be resampled before 8:30 am the same day as follows: a. Measure the liner/foundation temperature at a frequency of one measurement per lot (defined as no more than 10,000 square feet). b. Lots where the temperature is greater than 27ºF do not require rework; except that the lot where the initial temperature less than or equal to 27ºF was measured shall be reworked regardless of resampling results.	Verify that clay liner is tested during cold weather conditions.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
temperature 1 inch beneath the surface is less than or equal to 27ºF, re-work and re-test density and permeability of the affected area after the clay temperature has risen above 27ºF. (3) If more than 30 days have passed since the date of lift approval, perform spring start-up testing.		
SPRING START-UP: See "Cold Weather Placement of Clay Liner" above for situations that trigger this specification. For spring start-up testing, the surface lift is treated as protective cover, regardless of whether it was an approved lift of clay liner at one time or not. Excavate 9 inches below the clay surface and re-test for density ~~and permeability~~. Excavation for testing purposes may consist of removing the protective cover lift; or may be performed by „potholing" only at the testing locations. Areas that have been „potholed" for ~~permeability~~ testing shall be repaired by applying the same level of effort as prescribed by the approved test pad for liner construction. Spring start-up testing shall be conducted on 11e.(2) embankment lift areas S-11, R-12, L-12, H-12, and D-12 prior to and in the same construction season as initial waste placement for each area.	Perform density~~ and permeability~~ testing at the frequencies outlined for liner construction above. This testing may be performed outside of the approved lift area so long as the area tested is representative of the clay in the approved lift area (i.e., was constructed at the same time and with the same method). Moisture testing is not required for spring start-up. a. Approve lots that meet specification. The protective cover lift may then be worked in place and tested to become the next lift of clay liner. b. For lots that do not meet specification, test the surface at successively deeper 9 inch increments until a passing lift is found; remove all failing lifts; re-work all failing areas; and re-test. Document that repairs are completed to the same level of effort as required by the approved test pad for clay liner construction.	
CONTAMINATION OF CLAY LINER: The clay liner material shall not become contaminated with radioactive soils or debris during construction. The in-place clay may contain up to 5 percent additional rocks and sand above the content found in the classification test.	Visually check clay liner for contamination by foreign materials. Remove clays which have been contaminated above the specified requirements.	Verify that removal of contaminated material has been properly documented.
FINAL GRADING: Final grading shall be from grade	Survey ~~the foundation~~ on a 50 ft grid and at key points.	Review the final survey data. Verify the frequency of

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
to above grade. Survey on a 50 ft grid and key points to verify the minimum design liner thickness requirement is met.	Final survey measurements will be documented and provided to the Lead, QC Embankment Construction~~QC officer~~Lead, QC Embankment Construction and Construction QA Officer. ~~a. Indicate where the clay liner meets design line and grade.~~ ~~b. Rework and resurvey areas not meeting the specified grade.~~	the survey points.
HEAVY EQUIPMENT ON CLAY LINER: Heavy equipment travel will be minimized on top of the finished clay liner. Heavy equipment will not be operated on saturated clay liner.	Observe work on clay liner. Advise the project manager of problems with equipment on the clay liner. Record corrective actions taken (where required) on the "Daily Construction Report".	Verify that the work is being inspected.
DRC APPROVAL: The DRC shall approve documentation associated with completed clay liner. Documentation shall include all QC and QA records associated with clay liner construction, as well as photographs of the completed liner surface. In addition, 48 hour notification shall be provided to the DRC prior to placement of soil material over the clay liner (waste or soil protective cover). However, DRC approval of clay liner documentation is not required prior to placement of waste material over the clay liner.	Notify the Construction QA Officer that the clay liner is prepared and ready for inspection by the DRC. Obtain written authorization on the "Liner Inspection Form" from the Construction QA Officer that the clay liner has been inspected. Obtain documentation confirming the DRC approval of the clay liner documentation.	Provide written approval of the clay liner prior to the placement of material over clay liner (waste or soil protective cover). Notify the DRC that the clay liner is prepared and ready for inspection at least 48 hours prior to covering with soil material.
LINER PROTECTIVE COVER: At least 1 ft of compacted native soils, free of debris, shall be constructed on top of the clay liner. This layer is termed Liner Protective Cover. Liner Protective Cover shall be placed in accordance with the lift thickness and compaction requirements specified under Work Element – Waste Placement or in accordance with the lift thickness and compaction requirements specified under Work Element – Clay Liner Placement. Contaminated equipment may be used to place Liner Protective Cover.	Verify and test Liner Protective Cover in accordance with the specifications for the relevant Work Element (Clay Liner Placement or Waste Placement).	

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
QUALITY ASSURANCE SAMPLING: Assurance samples for clay liner materials tests are to be obtained at the following minimum frequency: 1. In-place moisture-density tests (ASTM D6938): 1 per 50,000 cubic yards (compacted). 2. ~~Moisture/density relationship testing~~ Standard Proctor (ASTM D698): 1 per 50,000 cubic yards (compacted). 3. Classification tests (ASTM D2487~~, D1140, and D4318~~): 1 per 50,000 cubic yards (compacted). A minimum of one of each of the above tests is required for each year that clay liner is placed.	Coordinate with QA personnel in obtaining the quality assurance samples. Record the samples on the "Sample Log" and moisture-density test on the "Density Testing Log". Promptly report result of QC testing to Construction QA Officer so that a comparison of QA and QC testing results can be made.	Conduct or coordinate quality assurance sampling and testing in accordance with the designated frequencies. Obtain test results of QC samples so that a comparison of QA and QC test results can be made. The Construction QA Officer, in consultation with the ~~QC officer~~Lead, QC Embankment Construction, shall be responsible for determining the adequacy of correlation and documentation of the rationale used to determine adequacy. If the correlation is not adequate, new QC and QA samples shall be taken immediately. The Construction QA Officer, in consultation with the ~~QC officer~~Lead, QC Embankment Construction, shall then evaluate the accuracy of the QC sampling and testing and, if necessary, provide for improved sampling and testing procedures and closer inspection and control. Record findings of the quality assurance sampling in the "Daily QA Report".

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the Class A West and 11e.(2) embankments.		
APPLICABILITY: This work element is applicable to waste placed with the CAT 826 compactor. With prior DRC approval, this work element may be implemented by equipment demonstrated to perform equivalent to the CAT 826 compactor.	Document equipment used for compaction on the Lift Approval Form.	
DEFINITIONS: Machine Pass is defined as movement of the compactor across an area of the lift in any direction, which also meets compaction criteria calculated by an algorithm in the compactor's system. For example, movement of the compactor from south to north across the lift, which also meets compaction criteria calculated by an algorithm in the compactor's system, constitutes one machine pass; the return trip from north to south, which also meets compaction criteria calculated by an algorithm in the compactor's system, constitutes a second pass. Wheel Pass is defined as movement of any of the compactor's drums across an area of the lift, which also meets compaction criteria calculated by an algorithm in the compactor's system. Since there are forward and rear drums on the CAT 826 compactor, each machine pass constitutes two wheel passes. The CAES compaction tracking system reports wheel passes.		
LINER PROTECTION: The compactor shall not be operated on the surface of finished clay liner or on the surface of the Liner Protective Cover directly over the clay liner. The compactor may not be used to compact the first lift of waste above the Liner Protective Cover. When operating on a slope that terminates on the	When disposal and compaction is being performed on or adjacent to the first lift above the Liner Protective Cover, observe compactor operation for protection of the liner and Liner Protective Cover. Document observations on the Daily Construction Report.	

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
surface of the first lift of waste above the Liner Protective Cover, the compactor shall be operated in a manner to prevent impact to the Liner Protective Cover.		
LIFT IDENTIFICATION: Each lift shall be given a discrete designation.	Assign a lift identification number to each lift. Use the lift identification number to identify all paper work for that lift. Summarize all lifts on the lift summary form or master sheet.	Verify that a lift identification number has been assigned to each lift. Verify that the lift identification number is used on all paper work for that lift.
LIFT ACCEPTANCE: At the time of acceptance, the date and time of lift approval shall be recorded.	Record the date and time of lift approval on the lift approval form.	Verify that the date and time of lift approval is recorded on the lift approval form.
No waste material will be disposed on a lift until the prior lift is approved, except for management of in-cell bulk disposal	Verify that the previous waste lift has been approved prior to waste disposal.	
LIFT THICKNESS: The waste material will be placed in lifts with a compacted average thickness not exceeding 24 inches.	Survey the mean elevation of the top of each lift by surveying at least five points and taking the average. Where practical, survey the corners and at least one spot in the middle. Survey measurements will be documented and forwarded to the Construction QA Officer. Lift thickness may also be verified via GPS. a. Approve lifts with an average less than or equal to the specified lift thickness. b. Remove excess material from the thicker areas of the lift if the average lift thickness is greater than 24 inches, and re-compact lift in the areas where wastes are removed. OR Download the CAES system report of beginning and ending lift elevations. For lifts that are not sloped, survey data may be used for beginning lift elevation. Lift thickness shall be reported using CAES in accordance with operating procedure CL-QC-PR-038. When calculating the average lift thickness on a side	Perform a monthly assessment of the survey documentation performed by the QC personnel to ensure that the measurements and observations are being performed correctly. Verify that the surveys are being performed at the correct frequency and that the documentation is being completed. Verify that the survey data has been received from the QC personnel.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
	slope, no point shall be more than 2.1". If CAES is used to document lift thickness on the side slope, there shall be no white pixels shown in the lift. CAES data may be supplemented by GPS for areas where compactor coverage is inconclusive.	
LIFT AREA: Identify the dimensions and the location of the northwest corner of the lift. There is no minimum lift area for this work element.	Locate the northwest corner of each lift, and document the location and lift dimensions.	
CLASSIFICATIONS: Soil classification testing is not required for waste placed using this work element.		
TERRACING OF LIFTS: As new lifts are placed next to old lifts, at least one foot, measured horizontally, shall be removed from the outer edge of the old lift (except for CLSM lifts).	Inspect the intersections of old and new lifts. Verify that the outer one foot of the old lifts are being removed (except for CLSM lifts). Record any problems on the "Daily Construction Report".	Verify that the required inspections are being performed.
COMPACTION WITH CAES: When using the CAES system, each lift and lift interface shall be compacted by at least 4 machine passes with the CAT 826 compactor. The lift surface shall be firm and unyielding to the compactor"s weight. A minimum of 90% of the grid points reported for the lift by CAES shall exhibit adequate compaction and machine passes. Adequate compaction as well as meeting the minimum number of wheel passes is reported by CAES when the pixel turns green. Furthermore, a maximum of 5 non-green pixels shall be adjacent to each other within the lift area limits. "Adjacent" means that two pixels share a common side; pixels that share only a common corner are not adjacent to each other. **a.** Additional compaction may be required if, after the minimum number of passes is complete, the minimum percentage of grid points do not exhibit adequate compaction, as reported by the CAES	Document the CAES system report of compaction for each lift area. Compactive effort is reported by CAES on a roughly 3.3" x 3.3" grid; with each on-screen pixel representing one square meter. Ensure that the CAES reports a minimum of 4 machine passes (i.e., 8 wheel passes) for at least 90% of the grid points in the lift, as detailed in operating procedure CL-QC-PR-038. Record this information on the Lift Approval Form. Perform a QC inspection of the compacted lift by observing the CAES control screen for evidence of uniform and adequate compaction. This condition is indicated by having a majority of the screen light green, with only isolated pixels in other colors. Evaluate all pixels that are not green to ensure the maximum number of adjacent pixels is not exceeded. Print the screen as a color image and include with the lift approval form. Record QC inspection results on the Lift Approval Form.	Perform a monthly assessment of the compaction documents generated by the QC technician.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
system. **b.** Evaluate the lift interface when compacting adjacent to previously poured CSLM. Visually inspect for obstructions (e.g., CLSM surface, irregularities in CLSM side slope, etc.) that may affect compaction data. More than 5 non-green adjacent pixels are permitted in this situation if QC visually observes and documents a minimum of 6 machine passes to within 12 inches of the obstruction.	Perform a visual inspection of the CLSM/Soil interface. Identify areas of the CLSM pour that present an obstacle for the 826 compactor. Visually observe the compactor operator make a minimum of 6 machine passes to within 12 inches of the obstruction. Document the observations on the Lift Approval form.	
COMPACTION WITHOUT CAES: If the CAES system is not available to be used for compaction under this work element, the following requirements apply. 1. Verbal notice shall be provided to DRC within 24 hours of beginning to approve lifts without CAES. This notice may be provided via email. 2. Written notice shall be provided to DRC no later than 3 calendar days (72 hours) after beginning to approve lifts without CAES. The written notice shall explain why CAES is down; an estimate of when CAES will be back online; a map of the areas being compacted without CAES; and a map of pre-final cover settlement monitoring points over the area being compacted without CAES. 3. Compaction without CAES is limited to 10 calendar days per occurrence. Each lift and lift interface shall be compacted by at least 6 machine passes with the CAT 826 compactor. The lift surface shall be firm and unyielding to the compactor˝s weight. Additional compaction may be required if, after the minimum number of passes is complete, any of the following are observed: a. The lift surface exhibits ruts or compression	Document that the minimum number of passes is completed for each lift area. Passes shall be counted by the QC technician or by using a GPS unit communicating with the GPS unit on the compactor. Perform a visual inspection of the compacted lift surface. If rutting or other indications of inadequate compaction are present, direct the equipment operator to complete additional passes until the situation is corrected. If additional passes are unable to correct the situation, moisture adjustment or other corrective actions may be needed and the lift shall not be approved until these actions are completed. Survey lift elevation and thickness in accordance with the specification "Lift Thickness" above, with the further requirement that the greater of the following number of points shall be surveyed per lift: a. At least 5 points; or b. One point per 2,000 square feet of lift area. Record number of passes and visual inspection results on the Lift Approval Form.	Perform a monthly assessment of the compaction documents generated by the QC technician.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
(excluding depressions caused by the tines of the compactor wheel) in excess of four inches; b. The waste material exhibits pumping behavior, or has other indications of excess moisture content; or c. The lift does not appear to be uniformly compacted.		
DEBRIS PLACEMENT WITH THE COMPACTOR: For purposes of this work element, debris shall be defined as provided in the work element "Waste Placement", below.	Determine the volume of debris. Volume determination shall be established by either: a) inspecting the debris on the lift and calculating the quantity of debris, or b) using the manifested waste volume for shipments placed on the lift.	
Debris placed in accordance with this work element shall be limited to no more than 50% by volume of the compacted volume of the lift. The debris shall be uniformly distributed across the lift.	Inspect debris once it is spread out on the lift and prior to placement of fill material. Ensure that debris is spread out uniformly across the lift and in a manner to minimize void spaces and does not exceed volume requirements. Document the debris inspection on the Lift Approval Form. Record the debris fill calculations and estimates on the Lift Approval Form.	Observe in the field that the debris calculations and estimates are being performed and properly documented. Review documentation to verify that the visual observations of debris shipments are being properly performed by QC personnel or that the manifested volume of waste is used to calculate the volume of fill material required.
Lifts containing materials susceptible to wind dispersal shall be covered with soil-like waste, fill material, or a commercial fixative so that these materials are secured by the end of the shift the materials were placed into the lift. "Secure" means a visual inspection to confirm that cover material has been applied to all materials susceptible to wind dispersal so that no material is obviously blowing around. Plastic, etc., may be visible at the surface.	Document cover material used, location, and result of visual inspection to ensure materials are secure on the "Daily Construction Report".	
DEBRIS SIZE: All debris placed in accordance with this work element shall be less than ~~10~~ 18 inches in at least one dimension and no longer than 12 feet in any dimension. Note: bags of asbestos-containing debris may be larger than 10 inches in all dimensions before	Inspect debris placed in soil lifts to ensure that it meets the debris size requirements.	

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
compaction.		
SNOW REMOVAL: When waste material is to be placed and the work area is covered with snow and/or ice, the snow and/or ice must be removed so that no more than ¼ inch remains on the surface. Isolated individual clumps of snow and/or ice may be present, but shall be no larger than 2 inches in diameter.	Observe that snow is removed. Advise the project manager of deficiencies. Construction may not continue without corrective action. Record corrective action (where required) in the "Daily Construction Report".	Verify that snow removal is being performed and documented.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the Class A West and 11e.(2) embankments.		
LIFT IDENTIFICATION: Each lift shall be given a discrete designation for testing and surveying purposes.	Assign a lift identification number to each lift. Use the lift identification number to identify all paper work for that lift.	Verify that a lift identification number has been assigned to each lift. Verify that the lift identification number is used on all paper work for that lift.
LIFT ACCEPTANCE: At the time of acceptance, the date and time of lift approval shall be recorded.	The QC technician shall record the date and time of lift approval on the lift approval form.	Verify that the date and time of lift approval is recorded on the lift approval form.
No waste material will be disposed on a lift until the prior lift is approved, except for management of in-cell bulk disposal	Verify that the previous waste lift has been approved prior to waste disposal.	
LIFT THICKNESS: The radioactive disposal material will be placed in lifts with a compacted average thickness not exceeding 12 inches (except CLSM lifts).	Survey the mean elevation of the top of each lift by surveying at least five points and taking the average. Where practical, survey the corners and at least one spot in the middle. Survey measurements will be documented and forwarded to the Construction QA Officer. ~~a. Approve lifts with an average less than or equal to the specified lift thickness.~~ ~~b. Remove excess material and retest lots with an average lift thickness greater than the specified lift thickness.~~	Verify the frequency of measurements and compliance of test results.~~Observe, at a minimum, five percent of the surveys performed by the QC personnel to ensure that the measurements and observations are being performed correctly. Verify that the surveys are being performed at the correct frequency and that the documentation is being completed.~~ ~~Verify that the survey data has been received from the QC personnel.~~
~~**LIFT AREA:** The lift area shall be at least 10,000 square feet except CLSM, Containerized Waste Facility, and Mixed Waste lifts. Identify the dimensions and the location of the northwest corner of the lift.~~	~~Locate the northwest corner of each active lift, and determine the dimension.~~ ~~a. Allow placement to continue on any lift that meets the lift area requirement.~~ ~~b. Stop placement on any lift which does not meet the lift area requirements.~~ ~~c. The Construction QA Officer may grant a waiver, for up to five percent of the lifts, if it is deemed impracticable to place at the specified lift area (e.g. a narrow lift on the outside edge of the cell). Insufficient material from a specific generator does not constitute grounds for a waiver.~~	~~Verify that the lift area meets the lift area requirements.~~

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
COMPACTION: Each lift shall be compacted to 90 percent of a standard Proctor, except lifts with greater than ten (10%) compressible debris, which shall be compacted to a minimum of 95 percent of a standard Proctor. The moisture content of all lifts shall be equal to at least 2 percent and no greater than up to 3 percentage points above the optimum moisture (except for CLSM lifts).	Except for CLSM lifts, conduct in-place moisture-density tests at a rate of one test per lot and record the results on the "Field Density Test" form. A lot is defined as 1,000 cubic yards (compacted) of a single lift. At least one test will be performed per lift. At least one test will be performed per soil type in the lift. The test location shall be chosen on the basis of random numbers. Approve lots when: a. Material is observed to be properly compacted throughout the lot; b. Moisture/density tests performed meet moisture and compaction specifications.	Verify the frequency of measurements and compliance of test results.~~Observe, at a minimum, five percent of the tests performed by the QC personnel to ensure that the tests and observations are being performed correctly. Verify that field moisture/density tests are being performed at the correct frequency and that the documentation is being completed.~~
	Outliers shall be resolved according to the following: a. For lot sections where the material is observed to not be properly compacted throughout the entire lot: 1) Identify the section requiring further compaction and rework the material until it is observed to be adequately compacted; 2) Perform moisture/density testing as outlined above. b. For lots where the dry density reading from a nuclear gauge moisture/density test is less than or equal to the required percentage of the standard Proctor: 1) Identify the section(s) of the lot (including dimensions) requiring further compaction, and re-work the material. Re-test at the location previously tested. Test one more location in the re-worked lot section. Identify the test location using the lot section dimensions and random numbers. - If the test results from both tests meet moisture/density requirements, approve the lot; - If either test fails, repeat the above process until all tests at both locations meet	Ensure that resolution of any outliers is properly accomplished and documented.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
	moisture and compaction requirements. **- OR -** 2) If the lot is observed by the QC Technician to be adequately compacted, investigate the reason for the low density reading. If it is determined that the test results were <u>improperly influenced</u> (e.g. debris directly beneath the gauge), take two more density tests within 5 feet of the original test. **NOTE: <u>All tests are to be recorded.</u>** - If the results from both tests are above the required compaction requirements, record both tests and approve the lot. If either test fails to meet moisture/density specifications – and the test results were not improperly influenced as described above - follow instructions for a.1 above.	
	Proctors shall be performed at a rate of one test per 15,000 cubic yards (compacted) or less of a specific material type.	~~Observe, at a minimum, five percent of the tests performed by the QC personnel to ensure that the tests and observations are being performed correctly. Verify that proctor tests are being performed at the correct frequency for each specific material type and that the documentation is being completed properly.~~
CLASSIFICATIONS: One soil classification test shall be performed at six month intervals for each large soil waste generator.	Perform a soil classification test (ASTM D2487) every six months for each large soil waste generator. A large soil waste generator is defined as a generator disposing of at least 30,000 cubic yards (compacted) of compactable soil in a given calendar year. Record the location of the classification sample on the "Sampling Log".	Verify the frequency of laboratory tests.
TERRACING OF LIFTS: As new lifts are placed next to old lifts, at least three feet, measured horizontally, shall be removed from the outer edge of the old lift (except for CLSM lifts).	Inspect the intersections of old and new lifts. Verify that the outer three feet of the old lifts are being removed (except for CLSM lifts). Record any problems on the "Daily Construction Report".	Verify that the required inspections are being performed.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
~~**INTERSECTION OF LIFTS:** In addition to the density testing of the lift, an average of one density test per three lifts shall be performed at the old/new lift interfaces. For lifts intersecting with CLSM lifts, the interface density testing is performed on the non-CLSM lift within 2 feet of the CLSM interface.~~	~~Conduct in-place moisture-density tests at an average rate of one test per three lifts and record the results on the "Field Density Test" form. For each lift random numbers between 0 and 1 shall be generated. If the random number is 0.65 or greater, then a moisture-density test is required on the lift interface between the new lift and old lift. On lifts requiring an interface test, the test location shall be chosen on the basis of a random number. For intersections with CLSM, perform a density test on the non-CLSM portions of the intersection within 2 feet of the CLSM interface.~~ ~~a. Approve lots which meet the specified compaction.~~ ~~b. Rework and retest lots not meeting the specified compaction.~~	~~Observe, at a minimum, five percent of the tests performed by the QC personnel to ensure that the tests are being performed correctly. Verify that tests are performed at the correct frequency and the documentation has been completed.~~

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
DEBRIS PLACEMENT		
DEBRIS DEFINITION: For the purposes of this CQA/QC project plan, debris is defined as any radioactive waste for disposal other than compactable soils. Compactable soil is defined as: (a) having a graded material that will pass through a four inch grizzly; (b) as having a bulk density greater than seventy pounds per cubic foot dry weight in accordance with ASTM D-698; and (c) having soil-like properties (i.e., standard tests in accordance with waste placement procedures can be performed. Additionally, debris shall be classified as either incompressible debris (i.e. concrete, stone, or solid metal) or compressible debris (all other debris types). A large object is defined as any debris that does not have at least one dimension less than 10-inches or that has any dimension in excess of 12-feet. A large component is defined as a large object that weighs more than 100,000 pounds.	No action required.	No action required.
DEBRIS PLACEMENT METHODS: Debris may be placed in the embankment using two different methods: 1) placement of the debris in a lift with compactable soil at a limited ratio of debris to soil, or 2) placement of the debris in a lift and in-filling the debris with Controlled Low Strength Material (CLSM).		
For placement of large components, the maximum allowable load on the clay liner surface must be less than 3000 psf.	Perform a Large Component Engineering Review. Ensure that the bearing pressure at the clay liner surface meets specification for the load associated with placement of any large component.	
When CLSM is required as structural fill in the Large Component Engineering Review in order to meet the load specification, the first 4 feet of CLSM shall be placed around the large component within 30 calendar days of large component disposal.	Document the following on the Lift Approval Form: 1. Date of large component disposal and date of CLSM pour.	

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
DEBRIS QUANTITY IN SOIL WASTE LIFTS: Debris that is placed in the embankment with compactable soil shall be limited to a portion of the total volume of the waste lot. Furthermore, the debris shall be uniformly distributed across the lot. Lifts containing materials susceptible to wind dispersal shall be covered with soil-like waste, fill material, or a commercial fixative so that materials susceptible to wind dispersal are secured by the end of each working day. A lot is defined as an area for the placement of waste from a single generator. The volume of a lot is limited to one thousand (1000) cubic yards for testing purposes. A lift is defined as one or more lots which are compacted and tested together to meet lift placement requirements. The minimum fill required will be controlled by the volume of uncompacted debris placed in the lift. For compressible debris, the volume of the debris in a lot shall be limited to less than or equal to thirty percent (30%) by volume of the calculated compacted volume of the lot. Incompressible debris (concrete, stone, or solid metal) may be placed in a lot up to twenty-five percent by volume of the calculated compacted volume of the lot. When combining the two types of debris in one lot, the above volume limit applies and the maximum volume of all debris shall be less than or equal to 25 percent. At least one moisture/density test shall be performed per soil type in the lift.	For shipments containing debris material, determine the volume of debris for the shipments. Volume determination shall be established by either a) inspecting the debris in the shipment and calculating the quantity of debris, or b) using the manifested waste volume. Visually inspect lifts containing materials susceptible to wind dispersal are covered with soil-like waste or fill material by the end of each working day. Inspect debris once it is spread out on the lot and prior to placement of fill material. Ensure that debris is spread out uniformly across the lot and in a manner to minimize void spaces and does not exceed volume requirements. Document the debris inspection on the “Lift Approval Form.” Record the debris fill calculations and estimates on the "Lift Approval Form".	Observe in the field that the debris calculations and estimates are being performed and properly documented. Review documentation to verify that the visual observations of debris shipments are being properly performed by QC personnel or that the manifested volume of waste is used to calculate the volume of fill material required.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
DEBRIS SIZE: All debris placed in soil waste lifts shall be less than ten (10) inches in at least one dimension, and no longer than twelve (12) feet in any dimension. Note: bags of asbestos-containing debris may be larger than 10 inches in all dimensions before compaction.	Inspect debris placed in soil lifts to ensure that it meets the debris size requirements.	Review documentation associated with debris lifts to verify that debris inspections are being performed.
RESIN LIFTS: ~~Unless disposed in the Containerized Waste Facility, r~~Resins shall be disposed in one of three ways:~~as follows or~~ 1. in accordance with Work Element – Containerized Waste Facility Waste Placement; or 2. in accordance with the specification "CLSM Pours with Resin-Filled Containers" below; or 3. with RSO approval, as compressible debris in bulk waste lifts. ~~For resin lifts, resins will be less than one inch thick, at any location on the surface of the lift, prior to tilling.~~	~~For resin lifts, inspect the spread resin prior to tilling to ensure:~~ ~~a) resin is less than one inch thick at any location on the surface of the lift;~~ ~~b) resin is spread throughout the resin lift area;~~ ~~c) there are no areas larger than 25 ft^2 without resin;~~ ~~d) there are no depressions or wheel ruts deeper than one inch.~~ ~~e) verify native clay meets CL classification and is blended at a 9 to 1 ratio.~~ ~~f) Verify a minimum of 2-inches of native soil cover must be placed by the end of each workday.~~	~~Review documentation associated with resin lifts to verify blending and disposal requirements are being performed.~~
~~Ion Exchange Resin (IER) must be blended with native clay that meets the CL classification in a minimum ratio of 1:9 (one part IER to nine parts CL clay) on a volumetric basis. This native clay shall be tested by ASTM method D-2487 at a rate of one test every 250 cubic yards.~~	~~Require additional spreading for any resin lift not meeting these specifications. Record the debris inspection on the Lift Approval Form.~~	
~~Blending of IER must take place where native soil has been placed and approved by the Construction Quality Control Officer (CQCO) as a marker layer over the previous lift. The CQCO may approve the 6-inch fill cover for the 10% debris lifts as the bottom marker layer provided verification of the following:~~ ~~10% debris is placed in previous lifts; and cover fill is native soil that is distinguishable from the previous lift and resin clay.~~	~~Notify DRC during normal working hours of placement of blended materials at least 24 hours prior to covering beyond this 2" clay layer in order to allow inspection and sampling of placed blended materials.~~	
~~Exposed blended resins shall be compacted, tested and~~		

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
~~approved after placement of at least 2-inches of native soil cover. A minimum of 2-inches of native soil cover must be placed by the end of each workday. The minimum 2-inch native soil cover may be used to blend the resin in the next lift.~~		
CLSM POURS:		
CLSM PYRAMID: 1) CLSM lifts shall form a pyramid with a maximum 3H:1V outside edge slope. Thus, with a six foot CLSM lift and six inch (6") cap, the next CLSM lift must be constructed to minimum of 19.5 feet inside the edge of the lift immediately below it. 2) The pyramid base dimensions and maximum 3H:1V side slope requirements will control the location of all subsequent CLSM lifts throughout the full height of the embankment. 3) Adjacent pyramids shall not be placed above any portion of previous CLSM pyramids.	Determine the location of the northwest corner and the dimensions of each lift and document on the ES-1904 form. Use the lift location and dimensions to ensure compliance with the CLSM pyramid specification. Document the dimensions of the previous CLSM lift on the ES-1904 form diagram. In locating a new pyramid, document on the ES-1904 form: a) The pyramid base is placed on the Liner Protective Cover; or, b) The pyramid base has not been placed above a previously placed pyramid	Verify compliance with the CLSM pyramid specification and proper documentation of the QC requirements.
CLSM Lift Preparation: The average height of each pour shall be limited to six feet. Large objects taller than six feet shall be poured with the subsequent CLSM pours (in layers) until completion. Debris disposed with CLSM will be placed to minimize the entrapment of air in the CLSM pour.	Perform an inspection of the preparation of debris for placement with CLSM. Ensure that the average formed height of the CLSM lift is less than six feet and that any large objects are localized into specific areas. Also, ensure that debris is placed in a manner to minimize the possible entrapment of air during the CLSM pour and to allow maximum in-filling of the debris. Document the inspection on the CLSM Inspection Form.	Review inspection documentation to ensure that inspections are performed and properly documented.
DRC NOTIFICATION FOR CLSM POURS: The DRC shall be notified at least 48 hours in advance of any CLSM pour. A CLSM pour will be defined as a formed area approved and documented by Engineering for CLSM designated on a waste lift.	Verify that the DRC has been notified at least 48 hours in advance of any CLSM pour. Document DRC notification on the "Daily Construction Report".	Verify that the DRC has been notified at least 48 hours in advance of any CLSM pour.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
PORTLAND CEMENT OR FLY ASH CLSM DESIGN SPECIFICATIONS: Notwithstanding the following specifications, Macro Vaults as approved by the Division of Solid and Hazardous Waste in the Mixed Waste Landfill Cell are considered large objects that do not require CLSM. Macro Vaults shall not be proof rolled. CLSM shall have the following characteristics: a) The design mix is approved by the ~~production engineer~~Manager, Engineering and Maintenance prior to use in the cell area and meets the material specifications provided in Table 2 or Table 3 of this Attachment II-A. b) The CLSM passes a Slump Test (procedure provided in Appendix B of this manual), Flow Consistency Test (ASTM D6103) or Efflux test (procedure provided in Appendix B of this manual), as applicable. Passing criteria for each test is specified in Table 2 "Material Specifications for Portland Cement CLSM" or Table 3 "Material Specifications for Fly Ash CLSM" of this Attachment II-A. c) The CLSM shall have a wet unit weight in all cases of at least 100 lbs/ft^3 as determined by ASTM D6023 (Unit Weight, Yield, Cement Content, and Air Content (Gravimetric) of CLSM).	Two types of tests will be performed to ensure that the CLSM meets the design specifications: initial screening tests and lot acceptance tests. The results of these tests and corrective actions, if any, shall be documented on the CLSM Testing Form. a. Initial screening tests shall be performed on the first load of CLSM for each day that CLSM is poured. This screening test shall be performed from the "front end" of the load. The initial screening test includes either a Flow Consistency Test (ASTM D6103) or Efflux test (procedure given in Appendix A), as well as a unit weight test (ASTM D6023). The results from this initial screening test shall indicate whether or not any adjustments need to be made at the batch plant to ensure loads meet design specifications. b. If adjustments are made to the load to produce a product that passes the testing requirements, perform initial screening testing on the subsequent two loads to verify that the batch plant adjustments are sufficient c. CLSM pouring shall only be authorized to proceed upon verification that the initial load (and subsequent two loads if the initial load failed) meets mix specifications. d. Acceptance tests shall be performed at a rate of	Verify the frequency of measurements and compliance of test results.~~Observe, at a minimum, five percent of the tests performed by QC personnel on the CLSM to ensure that the tests and observations are being performed correctly. Verify that the required testing has been performed and properly documented.~~

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
	one test per lot, with a minimum of one acceptance test performed for each CLSM pour. A lot is defined as 100 cubic yards of CLSM. Sampling for acceptance tests shall be performed in accordance with ASTM D5971 (Sampling Freshly Mixed CLSM). These acceptance tests shall be performed from a composite of two samples from near the middle of the load. a. Accept loads that meet specification. b. For loads with unsatisfactory results, accept the first part of the load and reject the remainder, or modify the load and/or pour techniques and retest.	
d) The CLSM shall have a minimum 28-day strength of 150 pounds per square inch (psi) as determined by ASTM D4832. A minimum of 3 cylinders shall be cast for compressive strength testing.	Cast a minimum of 3 cylinders per 2000 cubic yards of CLSM placed, with at least one set per lift for lifts smaller than 2000 cubic yards. Perform compressive strength testing in accordance with ASTM D4832 at 28 days to ensure the minimum strength requirements are met. If the CLSM cap does not meet specification, evaluate why it failed and implement corrective actions to prevent recurrence.	Ensure compressive strength testing is being performed at the correct frequency.
e) A load ticket shall be furnished for each truck of CLSM to be poured.	Obtain the load ticket for each truck load of CLSM and ensure the load meets the mix specifications provided in Table 2 "Material Specifications for Portland Cement CLSM" or Table 3 "Material Specifications for Fly Ash CLSM" of this Attachment II-A. Reject any loads not meeting the mix specifications. Include the load ticket with the Lift Approval Form for the CLSM lift. During each CLSM pour, a QC Technician shall be present at or near the pour at all times and shall visually observe pour activities.	Verify that the load tickets have been obtained by QC personnel for each truck load of CLSM and that the load ticket has been checked against Table 2 "Material Specifications for Portland Cement CLSM" or Table 3 "Material Specifications for Fly Ash CLSM".
CLSM PLACEMENT OF UNCONTAINERIZED DEBRIS: Debris shall be placed to minimize the entrapment of air in the CLSM pour. To accomplish	Visually inspect the debris pour to ensure that the CLSM can flow throughout all uncontainerized debris in the waste matrix. Inspect pipes, valves, and other	Verify the large debris inspections have been performed and documented on the CLSM Inspection and Testing Form.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
this, any plastic caps, wrappings, or other obstructions placed on pipes, valves, and other debris objects shall be cut or removed prior to pouring CLSM. The uncontainerized debris shall be spread horizontally across the lift. Any compressible debris in the lift shall be secured to ensure proper disposal and cover with CLSM. Any wood materials shall be spread throughout the lift to prevent localized stacking or concentration of wood materials.	debris objects and ensure that sufficient access exists for CLSM to enter the debris interior and fill voids. Verify that all compressible debris is properly secured. Ensure that wood materials are spread throughout the lift and not stacked or nested together.	
CLSM POURS WITH DEBRIS-FILLED CONTAINERS: In-filling of debris inside containers with CLSM shall be maximized. A minimum of two holes shall be punched into the bottom of one of the walls of each box container to allow for flow throughout the container. Containers filled with primarily wood materials shall not be disposed with CLSM, and must be emptied and spread out prior to placement.		
Lids shall be removed from all box containers prior to pouring CLSM (unless a specific waste stream or shipments are exempted by UDRC for safety or ALARA considerations). Drum containers do not require removal of the lid. However, a drum container lid shall be pierced with a hole size of at least 2" X 4" to allow flow of CLSM into the container. If any container includes compressible debris, the material shall be secured to remain inside the container. Drum containers that contain compressible debris shall have the lid removed or a six-inch CLSM cap shall be placed over the filled container.	Visually inspect compressible debris inside containers to ensure the debris is secured. Ensure lids are removed from all box containers. If the lid shall remain on the drum container (or other waste container specifically exempted by UDRC), ensure that the lid has been pierced with the proper size and number of holes. Record results on the CLSM Inspection Form. If the lid remains on the drum container, ensure that the required number and size of holes exist in the lid. A flowability test is not required on containers filled with soil or fine-grained materials.	Review inspection results to ensure that compressible debris is being properly secured and that adequate holes exist for containers where lids remain on the container.
Hot particles are very small, often microscopic discrete radioactive fragments with high specific activity. Their presence or potential presence in a waste stream is documented on the waste profile record. To protect	Ensure that containers with asbestos, beryllium or hot particle waste are marked. Document the location of each such container within the pour. Ensure that the lift is not approved without placement of a six-inch CLSM	

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
worker health and safety, waste containers up to ~~115~~ 215 cubic feet containing asbestos, beryllium, DU metal, or hot particles do not require in-filling of debris inside the containers to be maximized. Box lids and at least one wall shall be punctured with a minimum of two holes at least 2" x 4". Containers placed in this manner shall be marked as "asbestos", "beryllium" or "hot particle" waste and shall have a six-inch CLSM cap placed over them.	cap.	
CLSM POURS WITH SOIL-FILLED CONTAINERS: Containers that are filled with soil-like materials may be placed with CLSM. The lid may remain on the container. However, holes must be placed in the lid as required for compressible debris-filled containers above.		
CLSM POURS WITH RESIN-FILLED CONTAINERS: Containers that include or are filled with ion-exchange resin materials may be placed with CLSM. Only watertight steel or poly containers are permitted for resin disposal in CLSM. Cardboard, wood, and soft plastic "supersack" containers are expressly prohibited from use as the sole container for resin disposal in CLSM.	Verify that ion-exchange resin containers are constructed of steel or poly. Document this inspection on the CLSM Inspection Form.	
Each container shall be inspected for headspace void and have any headspace void filled with an inert material. Provide a minimum of 24 hours notice to DRC prior to filling headspace void and sealing containers. CLSM and other concrete products are expressly prohibited for use filling this headspace void. After filling the headspace void, the lid shall be replaced on the container and latched, banded, or otherwise secured. The container shall be watertight to minimized potential CLSM contact with ion-exchange resins. Paint or mark the word "RESIN" on all 4 sides	Verify that DRC has been notified at least 24 hours prior to the following activities. Inspect each container of ion-exchange resins for headspace void. Document the material used to fill any headspace voids. Document that the lid has been replaced and secured on the container. Document that the container is inherently watertight (i.e., a drum with the ring secured around the lid) or has been rendered watertight (i.e., a steel box with a flexible gasket in place before the lid is secured or that has been otherwise sealed). Document that the container has been painted or marked as required.	
	Prior to the CLSM pour, calculate the ratio of resins to	

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
and the lid of each container when void filling and sealing operations are complete. The total waste resin volume shall be limited to no more than 25 percent of the total volume of the CLSM pour. Other wastes meeting the criteria for CLSM disposal as outlined in this CQA/QC Plan may be used to make up the remainder of the volume of the pour.	other material in the pour as follows: (1) Document the container type and volume for each container of resins in the pour; (2) Document the total pour volume based on the formed area x height; (3) Resin volume divided by total volume x 100 = resin percentage. Container volume may be calculated from the nominal capacity or from manifested volume of resins in the container.	
Containers of ion-exchange resins shall not be placed directly adjacent to each other within the CLSM pour. Containers of ion-exchange resins shall not be placed directly above containers of ion-exchange resins in previous lifts within the CLSM pyramid.	Survey and document the location of each resin-filled container on the CLSM Inspection Form. Verify that each resin-filled container is not placed directly above resin-filled containers in previous lifts within the CLSM pyramid.	Review the documentation to ensure proof-roll testing is being performed and properly documented.
CLSM pours with resin-filled containers are subject to all CLSM pyramid controls under the specification “CLSM Pyramid” above.	Visually inspect the final CLSM pour surface to ensure the area is acceptable for proof rolling.	Review the documentation to ensure rework, if required, has been performed and documented
FINAL CLSM POUR SURFACE: The final CLSM surface will be a horizontal plane with no exposed debris that impedes contact with the surface area during proof rolling. (with the exception of large objects that require multiple pours to completely dispose with CLSM). **PROOF-ROLL TESTING:** A proof roll test shall be performed on all CLSM lifts a minimum of 3 calendar days following completion of the CLSM pour and prior to placement of any additional waste lifts on top of the completed pour. The test shall consist of a loaded truck (rock truck, cement truck, or other vehicle of equal or greater surface load) driving across the entire footprint of the completed	Inspect the entire cured CLSM pour surface. Following inspection, direct the truck (rock truck, cement truck, or other vehicle of equal or greater surface load) across the entire CLSM pour surface. Inspect the surface during rolling for any cracking or depressions resulting from the proof-rolling. Identify any surface cracks or depressions with a vertical displacement of ½-inch or greater, or cracks greater than ½-inch in depth. Mark these areas for repair or re-work. Document observations on the Lift Approval Form. Approve all lift areas not marked for repair or rework. For any areas with surface cracking or	

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
CLSM pour.	depressions with a vertical displacement of ½-inch or greater, or cracks greater than ½-inch in depth, one of the following methods shall be followed to remedy the failed area(s): a. The area may be compacted and then re-poured. Following three days from the re-pour, perform another proof-roll test to evaluate if the repair was adequate; or b. Remove the CLSM and debris from the marked area and replace it with debris and CLSM. Following three days from the re-pour, perform another proof-roll test of the area to evaluate if the repair was adequate. Repeat this process until satisfactory results are achieved; or c. Place a six-inch CLSM cap over the pour lift area after the area in question has been compacted. The six-inch cap shall extend a minimum of three feet (3′) past the damaged areas created during proof rolling in each direction. Following a minimum of three calendar days, perform a proof roll test of the six-inch cap area to evaluate if the cap was adequate. This process may also be repeated (i.e., placement of additional cap to a 12-inch cap) until satisfactory results are achieved.	Review the documentation associated with the CLSM cap.
SIX-INCH CAP: All containers filled with	Visually inspect the CLSM pour area and identify the highest elevations of debris that requires a six-inch cap. Survey and document these designated elevations on the CLSM Inspection Form. Following completion of the six-inch cap, perform a final survey of the entire lift	

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
compressible debris that do not have the lids removed shall have a six inch CLSM cap poured over the top of the containers prior to proof rolling. In addition, any CLSM pours that have areas which did not pass the proof-rolling test may have a CLSM cap placed over those areas. Areas poured with a CLSM cap shall still require a proof-rolling test (as described above) to verify adequacy of the cap. The six inch cap shall extend a minimum of three feet in each direction past the edge of the container area that requires a cap.	as required for determining lift thicknesses above. Ensure that the thickness of the cap is six inches above all debris requiring a CLSM cap and that the cap extends three feet in each direction past the edge of the area that requires the cap. Document the inspection and completion of the CLSM cap on the Lift Approval Form.	Verify that compressive strength testing is performed at a rate of 1 per CLSM lift. Ensure that the compressive strength of the cap is greater than or equal to 500 psi.
The minimum compressive strength of the CLSM cap shall be 500 psi. Table 2 and Table 3 specifications do not apply to the CLSM cap.	Perform compressive strength testing of the CLSM used for caps at the rate of 1 test per CLSM lift. Test specimens/samples shall be collected in accordance with ASTM D5971 (Sampling Freshly Mixed CLSM). The samples shall then be tested in accordance with ASTM D4832 (Preparation and Testing of CLSM Test Cylinders). If the CLSM cap does not meet specification, evaluate why it failed and implement corrective actions to prevent recurrence.	Review documentation of in-cell bulk disposal and ensure that volumes do not exceed the trust agreement.
IN-CELL BULK DISPOSAL: For both LLRW and 11e.(2) waste: Any waste material taken to the disposal cell but not spread out (for lifts placed with compactable soil) or set into a CLSM lift area for forming (for debris to be placed using CLSM) shall be considered in-cell bulk disposal. In-cell bulk disposal may be temporarily managed in piles up to twenty-five feet high on the embankment. For 11e.(2) waste: In-cell bulk disposal cannot be placed on slopes steeper than approximately 5H:1V. The volume of in-cell bulk disposal shall not exceed the limits found in RML #UT 2300478, condition 10.8.e. All 11e.(2) in-cell bulk placement material shall be placed to final specifications by August 1 of each year.	On a monthly basis, calculate and document the volume of in-cell bulk disposal and waste stored on the LLRW storage pads. Stop waste unloading before the volume of waste stored exceeds the volume specified in the trust agreement.	
Open-air storage of PCB/Radioactive waste and Dry Active Waste (DAW) is prohibited. DAW is defined in	Obtain reports from waste disposal personnel as to the location and status of PCB and DAW in-cell bulk disposal at the beginning of each shift. When material requiring cover has been placed into in-cell bulk	

SPECIFICATION	**QUALITY CONTROL**	**QUALITY ASSURANCE**
condition I.E.10.(d) of the Ground Water Quality Discharge Permit. In-cell bulk disposal of PCB and DAW shall be managed to prevent open-air storage as follows: 1. Maintained in a water-tight container; or 2. Covered within 24 hours of the end of the shift that the waste was unloaded with a nominal 6" of soil or soil-like waste material that is free of PCB and DAW; or 3. Covered within 24 hours of the end of the shift that the waste was unloaded with a commercial fixative to prevent wind dispersal and leachate generation, applied in accordance with the manufacturer"s instructions; or 4. The following PCB wastes do not require cover to prevent wind dispersal: a. Drained equipment; b. Large objects with inaccessible PCB contamination; or c. PCB bulk product waste (as defined in 40 CFR 761.62(b)(1)(i)) with a bulk density greater than 70 pounds per cubic foot. When cover is required, maintain documentation of the date and shift that PCB and DAW were placed in in-cell bulk disposal and of the date and shift that cover was applied. The volume of in-cell bulk disposal plus the volume of waste stored at the LLRW container storage pads (e.g. LLRW bulk storage pad, LLRW container storage pad, etc.) shall not exceed the volume allowed in the trust agreement.	disposal during the preceding shift, track placement of the specified cover material. Document completion of cover within the required timeframe on the Daily Construction Report.	Verify that inspections for frozen material are being conducted during cold weather and that any corrective actions (if required) are properly documented.
COLD WEATHER PLACEMENT **FROZEN MATERIAL:** No frozen material shall be disposed directly on or within 24 inches of the clay	During cold weather, inspect material to be disposed directly on the clay liner. Do not allow frozen material to be disposed on the clay liner. Record corrections on the "Daily Construction Report".	

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
liner. Frozen material is defined as material which cannot meet the compaction requirements because of frozen water mixed within the material.		
PLACEMENT OF WASTE DURING COLD WEATHER: Waste material shall only be placed when the required moisture and compaction can be met.	1. For soil lifts: a) On November 1, decrease density and moisture lot size to 750 cubic yards (compacted). b) On December 1, and continuing to March 1, decrease density and moisture lot size to 500 cubic yards (compacted). c) Stop placement of waste on a lift when two consecutive tests fail compaction requirements due to frozen material. The first "unapproved" lift is classified as in-cell bulk disposal. d) When temperatures are high enough to place the in-cell bulk disposal material, place the material in accordance with lift thickness and compaction requirements specified for waste lifts above. a) If more than 2 feet of waste was stored as in-cell bulk disposal, excavate to a maximum of 12 inches above the last approved waste lift. Test and approve this in accordance with lift thickness and compaction requirements given above. b) If less than 2 feet of in-cell bulk waste was disposed over the last approved lift, excavate to the top of the last approved lift and re-test this lift in accordance with lift thickness and compaction requirements specified above.	1. For soil lifts: Verify that the testing frequency is increased at the beginning of November, and December. Verify that work stops on a lift after the failure of two consecutive compaction test and that the lift is surveyed before the placement of in-cell bulk disposal.
For CLSM pours:	2. For CLSM pours:	2. For CLSM pours:

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
a) Do not pour CLSM on a frozen soil base.	a) If the CLSM is to be poured on a soil base, perform a soil density test on adjacent material prior to the pour to determine if the underlying soil is frozen. If the soil is found to be frozen do not allow placement of material.	a) Review documentation of soil base testing verify that CLSM is not to be poured on a frozen soil base. During freezing conditions, verify that QC personnel have performed initial sampling and testing of the CLSM to ensure flowability ensured that the CLSM has been covered with concrete blankets or tented and heated, where required. Verify that QC personnel have periodically checked the temperature of the CLSM and recorded the results on the "CLSM Inspection and Testing Form".
b) If the ambient air temperature is forecast to drop below 5°F anytime during the CLSM pour, CLSM shall not be poured. When the ambient or expected air temperature will fall below 35°F anytime during the CLSM pour, the CLSM shall be sampled and an initial screening test performed as outlined under CLSM Design Specifications above. This initial sample may be used to prompt an adjustment of the load water content or temperature, modify the pour techniques, motivate rescheduling of the pour event, etc., but should not be considered acceptance sampling and testing. Acceptance sampling and testing should be obtained in accordance with ASTM D5971 (Sampling Freshly Mixed CLSM).	b) When the ambient or expected air temperature will fall below 35°F anytime during the CLSM pour, perform an initial screening test of the CLSM immediately before pouring to ensure that it meets the flowability criteria. This screening test includes either a Flow Consistency Test (ASTM D6103) or Efflux test (procedure given in Appendix A), as well as a unit weight test (ASTM D6023). The result from this initial screening test shall indicate whether or not any adjustments need to be made at the batch plant to ensure loads meet design specifications. 1) If adjustments are made to the load to produce a product that passes the testing requirements, perform initial screening testing on the subsequent two loads to verify that batch plant adjustments are sufficient. 2) CLSM pouring shall only be authorized to proceed upon verification that the initial load (and subsequent two loads if the initial load failed) meets mix specifications. Perform acceptance sampling and testing from near the center of the load. a. Accept loads which meet specification. b. For loads with unsatisfactory results, accept the first	b) Review documentation of screening tests to ensure that CLSM met flowability specifications during cold weather.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
	part of the load and reject the remainder, or modify the load and/or pour techniques and retest. Record the results on the "CLSM Inspection and Testing" forms.	
c. Unless the ambient air temperature is at least 35°F and rising, measures must be taken to ensure the CLSM temperature does not fall below 40°F. To ensure this occurs and therefore the CLSM can adequately cure prior to exposure to freezing temperatures, the following should occur: Limit the pour to a surface area of no more than 4,800 ft^2. Heat the CLSM prior to pouring (as possible). Cover, or tent and heat, the CLSM directly following pouring (i.e. - pour one truck load, cover or tent the in-place material, then pour the next truck load). Following completion of the pour, cover the CLSM with concrete blankets, or tent and heat the CLSM. Likewise, if following placement, the ambient air temperature decreases below 35°F, or is anticipated to decrease below 35°F anytime in the 24 hours following placement, the CLSM must be covered with concrete blankets, or tented and heated.	c) When the ambient air temperature decreases to below 35°F, ensure the CLSM temperature does not fall below 40°F. Measure and record the temperature of each CLSM load prior to introduction to the cell. Ensure the freshly poured CLSM is covered or tented and heated in a timely manner. Measure and record the temperature of the in-place CLSM every two hours during pouring, at the end of the work shift and at the beginning of the next work shift. Temperature results of pour temperatures shall be recorded on the "CLSM Inspection and Testing" forms. If, following placement, the ambient air temperature decreases below 35°F, or is anticipated to decrease below 35°F anytime in the 24 hours following placement of the CLSM, verify that concrete blankets or tenting and heating has been employed to ensure the CLSM is maintained greater than 40°F. Record the results of the inspection on the "CLSM Inspection and Testing" forms.	c) Review documentation of CLSM temperature measurements and actions taken for cold weather pouring to verify that CLSM temperatures meet specifications.
SNOW REMOVAL: When waste material is to be placed and the work area is covered with snow and/or ice, the snow and/or ice must be removed so that no more than ¼ inch remains on the surface. Isolated individual clumps of snow and/or ice may be present, but shall be no larger than 2 inches in diameter.	Observe that snow is removed. Advise the project manager of deficiencies. Construction may not continue without corrective action. Record corrective action (where required) in the "Daily Construction Report".	Verify that snow removal is being performed and documented.
FINAL GRADING BEFORE TEMPORARY COVER PLACEMENT: Top of waste elevations shall be at grade or below grade. Also, special attention shall be taken to emphasize complete and thorough void filling around and within any debris in the final waste lift.	Survey the top lift of waste on a 50 ft grid and at key points. Final survey measurements will be documented and provided to the QC and Construction QA Officers. ~~a. Indicate where the waste meets design line and grade.~~ ~~b. Rework and resurvey areas not meeting the specified grade.~~	Review the final survey data. Verify the frequency of the survey points.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
~~If the last lift of waste was built to work element – Waste Placement (as opposed to work element – Waste Placement with Compactor), then a proof roll of the top of waste surface shall be performed.~~	~~Observe the proof roll and document on the "Daily Construction Report". Advise the project manager of any "soft spots" or other areas of concern.~~	
A visual inspection shall be performed of the top of waste surface. Any incompressible debris protruding greater than ~~0.1~~ 0.5 foot above the surface shall be compacted into the lift or removed.	Perform the visual inspection. Advise the project manager of any deficiencies. Document inspection results on the "Daily Construction Report".	
~~DRC~~ REGULATORY APPROVAL: The DRC or DSHW (for the LLRW/11e.(2) or Mixed Waste embankments, as applicable) shall approve the final grade before temporary cover placement. 48 hour notification shall be provided to the DRC or DHSW prior to placement of temporary cover material over the finished final grade surface. Energy*Solutions* may proceed with temporary cover placement 48 hours after ~~DRC~~ notification if the DRC or DSHW has not inspected and has not notified the ~~Director of Engineering~~Manager, Engineering and Maintenance of its intent to inspect the final grade surface.	Notify the Construction QA Officer that the final grade surface is ready for DRC or DSHW inspection. Obtain written authorization from the Construction QA Officer that the final grade surface has been inspected. Obtain documentation confirming the DRC or DSHW inspection and approval.	Provide written approval of the final grade surface. Notify DRC or DSHW that the final grade surface is ready for inspection.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the Class A West embankment.		
NOTICE OF TEST PAD CONSTRUCTION: The test pad plan shall be approved by the DRC prior to the test pad construction. The DRC shall be notified 48 hours in advance of the start-up of test pad construction.	Obtain documentation confirming that the test pad plan has been approved by the DRC. Notify the DRC 48-hours in advance of test pad construction.	Verify that the test pad plan has been approved by the DRC. Verify that the DRC has been notified as required.
CONTAINERIZED WASTE PLACEMENT TEST PAD: A test pad with a minimum area of 400 ft^2 will be constructed using the procedure (container or large component type, container configuration, backfill material properties, placement and compaction methods) proposed for construction of the waste lifts. The test pad shall be representative of anticipated field placement conditions and of dimensions suitable to the equipment to be used for production. The minimum area of the test pad may be reduced with DRC concurrence with the test pad plan. Prior to implementation, within the Containerized Waste Facility, of a containerized waste configuration that has not been previously approved, a waste placement test pad shall be constructed utilizing the proposed containerized waste configuration. Test pads are to be constructed and tested in accordance with the following specifications:	Observe the construction of test pads. Measure test pads to ensure that they are constructed to the size indicated. Record the test pad size on the "Daily Construction Report".	Daily, observe the construction of the test pads. The Quality Assurance review for test pad specifications shall cover each specification in this work element. Review 100% of the QC documentation to verify that the tests were performed and documented correctly.
1. Construct the proposed configuration of containerized waste in the test pad area.	Document the constructed configuration of containers in the test pad on the "Daily Construction Report."	Perform a minimum of one (1) QA visual inspection of the resulting waste form per test pad.
2. At least one Proctor (or relative density) and classification test shall be conducted on the backfill material for each test pad.	Conduct the required proctor (or relative density) and classification (PL, LL, and gradation) tests.	

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
3. Backfill shall be placed over and between the waste packages in a manner that encourages flow into void spaces. The backfill is to be placed and compacted by equipment and methods proposed for use during construction of the waste lifts. Other equivalent equipment may be used for placement or compaction of backfill with approval from the ~~Director of Engineering~~Manager, Engineering and Maintenance and DRC.	Record type of equipment used, and number of passes on the "Daily Construction Report". Verify DRC approval has been received for equivalent equipment when used.	
4. The backfill surrounding the containers shall achieve an average density of at least 85% standard proctor or 55-percent relative density for drum configurations, or an average density of at least 80-percent standard proctor or 50-percent relative density around B-12 or B-25 boxes, HICs, cask liners, large components, or container overpack configurations. The completed test pad shall have no greater than 1% external void space by volume of the entire test pad.	Conduct direct or indirect in-place moisture-density tests at a rate of at least four tests per test pad. The test location shall be chosen to verify backfill compaction throughout the test pad. Record the test result on the "Field Density Test" form. Inspect the constructed test pad for void spaces surrounding the containers. Observe destructive testing of the test pad and measure external void spaces found in the backfill in accordance with the "Containerized Waste Facility Waste Placement Test Pad Destructive Testing" method in Appendix B. a. Approve test pads which meet the specified compaction, and minimize void space conditions. b. Rework and retest test pads not meeting the specified moisture or compaction or minimize void space conditions. Document all rework that was performed. c. Where rework and retesting is impractical, reject the test pad procedure.	
5. The procedures used to construct the test pad (container type, container configuration/orientation, backfill material properties, placement and compaction methods) shall be reviewed and approved by the ~~Director of Engineering~~Manager, Engineering and Maintenance. The test must be approved by a Professional Engineer.	Provide the ~~Director of Engineering~~Manager, Engineering and Maintenance with copies of the documentation for the test pad for review and approval.	

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
6. The ~~procedures used to construct the test pad shall be reviewed and approved by~~ test pad report shall be provided to the DRC prior to using the new test pad construction method.	~~Obtain documentation confirming DRC approval of the test pad.~~	~~Verify that proper approval has been obtained for the test pad and that the necessary construction procedure documents are in place for use during backfill construction.~~

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the Class A West embankment.		
LIFT IDENTIFICATION: Each lift shall be given a discrete designation for testing and surveying purposes.	Assign a lift identification number to each lift. Use the lift identification number to identify all paperwork for that lift. Summarize all lifts on the lift summary form.	The Quality Assurance review for waste placement specifications shall cover each specification in this work element. Review a minimum of 50.0% of the QC documentation to verify that the tests were performed and documented correctly.
LIFT ACCEPTANCE: At the time of acceptance, the date and time of lift approval shall be recorded.	The QC technician shall record the date and time of lift approval on the CWF Lift Approval Form	
DEFINITIONS: For the purpose of this CQA/QC project plan, the following terms are defined:	No action required.	No action required.
Backfill is defined as ~~poorly graded type SP or well graded type SW~~ sand with a minimum of 95% passing the #4 sieve, a minimum of 35% passing the #30 sieve, and less than ~~5~~10% passing the #200 sieve. The maximum moisture content for backfill shall be less than or equal to 4.1% at the time of backfill placement. This specification may be modified following successful completion ~~and DRC approval~~ of a test pad.		
Backfill cover is defined as a minimum of one foot of soil placed over containerized waste packages after backfilling is complete. In the case of standard liners and large liners, the placement sequence is: (1) backfill between the waste forms; (2) intermediate sand; (3) backfill cover.		
Containerized waste is defined as any containers of Certified Containerized Waste in accordance with applicable requirements of the Waste Characterization Plan. Certified Containerized Waste is defined as monolithic units in the form of the following filled containers.		

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
1. Any DOT "Strong, Tight" Containers up to 5 feet tall 2. Standard Liners are High Integrity Containers (HICs) or other cylindrical packages up to 6.65 feet tall (up to 215 cubic feet external volume) 3. Large Liners are HICs or other cylindrical packages ~~between 6.65 and~~ up to 9 feet tall (~~between 215 and~~ up to 331 cubic feet external volume) 4. Other Large Components and oversized DOT containers (larger than 331 cubic feet) Containerized Waste Facility (CWF) pyramid is limited to a maximum of two lifts of containerized waste. Containers up to 5 feet tall are limited to a single lift at the pyramid base. Containers greater than 5 feet tall are limited to two lifts. The volume of the embankment above and surrounding the pyramid shall be filled with bulk waste lifts placed in accordance with the Bulk Waste Placement Work Element of this plan. Intermediate sand is defined as a minimum of 2 feet of sand meeting gradation specifications for backfill, placed above the top of caissons used for placement of cylindrical containers greater than 5 feet tall. In the case of containers placed using removable steel forms, intermediate sand shall be placed to an elevation at least 9 feet above the base of the container for standard liners and 11.5 feet above the base of the container for large liners. Lift is defined as containerized waste packages, backfill between packages, intermediate sand (when applicable), and the backfill cover layer. A containerized waste placement lift may contain one layer of containers or more than one stacked layer of containers, depending on the container type and height. Removable Steel Form is a circular steel form used to		

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
ensure the spacing of standard or large liners. Removable steel forms are placed in an approved disposal configuration (hexagonal for example) prior to placement of liners. Removable steel forms can be used in either the first lift or second lift in place of caissons. All removable steel forms shall be pulled after liner placement and before backfill.		
CONTAINERIZED WASTE PLACEMENT: 1) All containers shall be placed in accordance with an approved container placement method. Containers shall be placed in a configuration that has been approved through the successful completion of a waste placement test pad. Figures 7 and 8 illustrate approved waste placement configurations. A minimum 6-inch layer of loose sand shall be placed prior to placement of containers. Containers shall be worked into this loose sand to minimize any voids underneath the containers. Containers shall be placed with a minimum distance as specified by individual container type below. Backfill shall be placed over and between the containers in accordance with the approved container placement method for the type of container being placed. The containerized waste placement backfill soil properties shall be tested once per 2,500 square feet of placement area or once per lift.	1) Verify through observation and document that the appropriate container placement method and spacing is followed for the type of container stacking in each lift. Perform at least one moisture content and ~~classification (PL, LL, and~~ gradation~~)~~ test per 2,500 square feet of placement area, or change in backfill material type, or change in borrow source. Conduct an inspection of the container placement configuration prior to commencement of backfill placement. This inspection shall document that an approved configuration has been utilized for the container types present. Observe placement and compaction of the backfill to ensure that type of equipment, equipment load (if applicable), and number of passes meet the specifications approved by the containerized waste placement test pad. Record type of equipment used, equipment load (if applicable), and number of passes on the CWF Lift Approval Form.	1) Review the QC documentation to confirm that the appropriate container placement and backfilling method has been used and properly documented.
2) Standard Liners shall be placed as follows. Spacing and backfill of standard liners may be facilitated by the use of concrete caissons or removable steel forms; use of caissons or removable steel forms is not required. Caissons or other forms shall not exceed 7 feet tall. When used, removable steel forms shall be removed prior to backfill. Caissons shall not be removed without prior	2) Verify through observation and document on the CWF Lift Approval Form that standard liners are placed with the appropriate container placement method and spacing. Conduct in-place density tests at the surface of the intermediate sand layer at a rate of one test per lot and	

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
DRC notification. Backfill shall be placed to a minimum height of 7 feet above the container base elevation by dropping from the bucket of a front-end loader or equivalent around and above the container (whether in a caisson or not). Backfill shall achieve a minimum density of at least 80% of a standard Proctor, as demonstrated by the approved test pad(s). The backfill layer shall be covered by an intermediate sand layer to a minimum depth of 2 feet above the top of the caisson (9 feet above the container base elevation). Intermediate sand shall achieve a minimum density of 85% of a standard Proctor. The backfill cover layer is then placed above the intermediate sand layer. Caissons shall be placed in a hexagonal or other approved (through a test pad) configuration, such as rectangular, that meets the following criteria. Caissons with an outer diameter of 100 inches shall be placed a minimum of 4 inches apart. If no caisson is used, or if a caisson or other form of smaller outer diameter is used, the container shall be placed as if the 100-inch diameter caisson were there for spacing purposes; i.e., within a minimum area of 108-inch diameter centered around the container, no other caisson or container shall intrude.	record the results on the "Field Density Test" form. A lot is defined as 10,000 square feet of a single lift. At least two tests will be performed per lift. The test location shall be chosen on the basis of random numbers. Approve lots when: a. Material is observed to be properly compacted throughout the lot; b. Density tests performed meet compaction specifications. Verify the mean elevation of the top of each intermediate sand lift by installing grade poles, or other methods approved by the Site Engineer. For each lift larger than 50' x 50', survey the corners and at least one spot in the middle. For lifts less than 50' x 50', a minimum of four grade poles, one in each direction, shall be used. Lifts larger than 50' x 50' may be segmented to areas 50' x 50' or less and elevation verified with the use of grade poles. The use of grade poles to verify the compacted thickness of the intermediate sand material shall be verified as part of the test pad for intermediate sand. Thickness measurements of the compacted intermediate sand will be documented and forwarded to the Construction ~~QC Officer~~Lead, QC Embankment Construction. ~~a. Approve lifts with an average compacted intermediate sand thickness greater than or equal to the specified compacted intermediate sand thickness.~~ ~~b. Add intermediate sand and retest lots with an average compacted intermediate sand lift thickness less than the specified compacted intermediate sand lift thickness.~~	
3) Unusually shaped containers shall be placed and backfilled in a manner that allows void spaces to be filled. In no case shall unusually shaped containers be placed such that a significant amount of external void space cannot be filled. A significant amount of external void space for unusually shaped containers is 5 percent of	3) Verify through observation and document that the unusual containers are placed such that all significant voids can be filled.	

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
the volume of the unusually shaped containers in the lift, unless otherwise approved by the Division.		
4) Large components and oversized DOT containers shall be placed and backfilled such that void spaces are filled and the bearing capacity of the embankment is not exceeded.	4) Verify through observation and document that the large components and oversized DOT containers are placed in accordance with an approved large component placement method.	
5) Large Liners shall be placed as follows. Spacing and backfill of large liners may be facilitated by the use of concrete caissons or removable steel forms; use of caissons or removable steel forms is not required. Caissons or other forms shall not exceed 9.5 feet tall. When used, removable steel forms shall be removed prior to backfill. Caissons shall not be removed without prior DRC notification. Backfill shall be placed to a minimum height of 9.5 feet above the container base elevation by dropping from the bucket of a front-end loader or equivalent around and above the container (whether in a caisson or not). Backfill shall achieve a minimum density of at least 80% of a standard Proctor, as demonstrated by the approved test pad(s). The backfill layer shall be covered by an intermediate sand layer to a minimum depth of 2 feet above the top of the caisson (11.5 feet above the container base elevation). Intermediate sand shall achieve a minimum density of at least 85% of a standard Proctor. The backfill cover layer is then placed above the intermediate sand layer. Caissons shall be placed in a hexagonal or other approved (through a test pad) configuration, such as rectangular, that meets the following criteria. Caissons with an outer diameter of 114 inches shall be placed a minimum of 5 inches apart and no more than 11 inches apart (at the nearest point between two adjacent caissons). If no caisson is used, or if a caisson or other form of smaller outer diameter is used, the container shall be placed as if the 114-inch diameter caisson were there for spacing purposes; i.e.,	5) Verify through observation and document that large liners are placed with an approved container placement method and spacing. Conduct in-place density tests at the surface of the intermediate sand layer at a rate of one test per lot and record the results on the "Field Density Test" form. A lot is defined as 10,000 square feet of a single lift. At least two tests will be performed per lift. The test location shall be chosen on the basis of random numbers. Approve lots when: a. Material is observed to be properly compacted throughout the lot; b. Density tests performed meet compaction specifications. Verify the mean elevation of the top of each intermediate sand lift by installing grade poles, or other methods approved by the Site Engineer. For each lift larger than 50'' x 50'', survey the corners and at least one spot located near the center. For lifts less than 50'' x 50'', a minimum of four grade poles, one in each direction, shall be used. Lifts larger than 50'' x 50'' may be segmented to areas 50'' x 50'' or less and elevation verified with the use of grade poles. The use of grade poles to verify the compacted thickness of the intermediate sand material shall be verified as part of the test pad for intermediate sand. Thickness measurements of the compacted intermediate sand will be documented and forwarded to the	

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
within a minimum area of 124-inch diameter centered around the container, no other caisson or container shall intrude and adjacent caissons shall be within a maximum area of 136-inch diameter.	Construction ~~QC Officer~~Lead, QC Embankment Construction. a. Approve lifts with an average compacted intermediate sand thickness greater than or equal to the specified compacted intermediate sand thickness. b. Add intermediate sand and retest lots with an average compacted intermediate sand lift thickness less than the specified compacted intermediate sand lift thickness.	
6) Large Liners shall meet the following void space criteria: void spaces within the waste and between the waste and its packaging shall be reduced to the extent practicable, but in no case shall less than 90 percent of the capacity of the container be filled.	6) For large liners, document that the void space criteria is met.	
7) Drums shall be placed horizontally at least 1 inch apart in a single layer. There shall be no continuous contact between drums. Forklifts may be used for drum placement provided that protective measures are taken to prevent damage to the drums. The forklift tines shall not come into direct contact with the drums. Sand shall be compacted to an average standard proctor density of 85% with a minimum of a single pass of a hoe mounted vibratory compactor or its equivalent, prior to placement of the next layer of drums. For purposes of this specification, the “Standard I-13 Liner” and “NUHIC-55 liners” may be placed as a drum.	7) Document that drums have been placed as required. Document equipment used and number of passes.	
8) When backfilling between standard or large caissons placed in a hexagonal pattern, the following controls apply as demonstrated in the “Test Pad Report for the Containerized Waste Facility Tri-Arc Test Pad Plan, Revised Plan” dated September 18, 2007. The loader or other equipment shall have a bucket of at least 25 cubic foot capacity and the bucket shall be totally filled. Dump the backfill sand from a height of approximately 2 feet above the top of the caisson (measured from the lower lip of the bucket to the top of the caisson).		

SPECIFICATION	**QUALITY CONTROL**	**QUALITY ASSURANCE**
9) If placing ion-exchange resins in containers other than standard liners or large liners, ensure that each 50" x 50" lift area contains no more than 25% resins by volume. Increase spacing of resin containers as needed to maintain this criteria.	8) Document that the bucket used to place backfill sand meets or exceeds the minimum capacity. Observe sand dumping operations for compliance with the specification. Document on the Daily Construction Report.	
	9) Calculate the ratio of resins to other material (soil, non-resin wastes) in the lift based on manifested resin volume and actual lift dimensions. Nominal container capacity may be used instead of manifested volume. Resin volume divided by total volume x 100 = resin percentage. Document on the CWF Lift Approval Form.	
PYRAMID CONTROLS: Refer also to Figure 7. Containerized Waste Facility (CWF) Pyramid: 1) Containerized waste lifts shall form a pyramid with a maximum 3H:1V outside edge slope. The slope shall be measured to the top of the backfill cover above containers in the lift. 2) Drums and boxes less than 5 feet tall are limited to a single lift on the lower layer of the CWF pyramid. Standard and large liners are limited to two lifts. 3) The pyramid base dimensions and maximum 3H:1V side slope requirements will control the location of the second lift of containers. 4) Adjacent pyramids shall not be placed above a previous CWF pyramid. 5) CLSM pyramids for bulk waste shall not be placed above a previous CWF pyramid. 6) CLSM may be used for fill within the initial lift of the container pyramid. 7) The first	Determine the location of the northwest corner and the dimensions of each lift and document on the CWF Lift Approval Form. Use the lift location and dimensions to ensure compliance with the containerized waste facility pyramid specification. As each lift of backfill cover is placed, survey and document that the corners of the lift meet the 3H:1V slope. If applicable, document the dimensions of the previous containerized waste facility lift on the CWF Lift Approval Form. In locating a new pyramid, document on the CWF Lift Approval Form: a) The pyramid base is placed on the liner protective cover; or b) The pyramid base does not encroach the vertical limits of a previous pyramid.	Verify compliance with the containerized waste facility pyramid specification and proper documentation of the QC requirements.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
liner placed in a second lift using this method shall be offset from liners in the lower lift. 8) Large Liners placed in the upper lift of the Containerized Waste Facility shall be placed at least 75 feet from the outer perimeter of the lower lift.	Prior to positioning the first liner in a second lift, document the location of containers in the first lift. Ensure that the first liner placed in the second lift is offset so that it is not directly above any single liner in the lower lift. Document that large liners placed in the upper lift meet the setback criteria.	
CLSM USE AS FILL: CLSM use as fill within the initial lift of the container pyramid shall comply with specifications "DRC Notification for CLSM Pours" and "Portland Cement or Fly Ash CLSM Design Specifications" under Work Element – Waste Placement above. However, CLSM used as fill at the Containerized Waste Facility is not required to meet the compressive strength requirements referenced above.	Document DRC notification and CLSM mix inspections and approval in accordance with the referenced specifications.	
CLSM may be used for fill with up to two, 5-drum pallets stacked inside a standard or large caisson. CLSM may also be used for fill with other waste containers that fit inside a standard or large caisson. The entire caisson height may be filled in a single CLSM pour.		
CLSM may also be used for fill around ~~drums and boxes~~ containers less than 5 feet tall around the perimeter of the CWF pyramid, so long as the 3H:1V pyramid slope is maintained. Drums placed in this manner may be oriented vertically.		
BACKFILL COVER: After backfilling of voids between containers is complete and intermediate sand is placed (as needed), each lift of containerized waste shall be covered by at least one foot of compacted backfill cover material.	1. For containerized waste lifts: Verify the mean elevation of the top of each backfill cover lift by installing grade poles, or other methods approved by the Site Engineer. For each lift larger than 50' x 50', survey the corners and at least one spot in the middle. For lifts less than 50' x 50', a minimum of four grade poles, one in each direction, shall be used. Lifts larger than 50' x 50' may be segmented to areas 50' x 50' or less and elevation verified with the use of grade poles.	Review the QC documentation.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
	The use of grade poles to verify the compacted thickness of the backfill cover material shall be verified as part of the test pad for backfill cover. Thickness measurements of the compacted backfill cover will be documented and forwarded to the Construction ~~QC Officer~~Lead, QC Embankment Construction. a. Approve lifts with an average compacted backfill cover thickness greater than or equal to the specified compacted backfill cover thickness. b. Add backfill and retest lots with an average compacted backfill cover lift thickness less than the specified compacted backfill cover lift thickness.	
Backfill cover for each lift shall achieve a density of at least 95 percent of a standard Proctor.	Conduct in-place density tests at the surface of the backfill cover at a rate of one test per lot and record the results on the "Field Density Test" form. A lot is defined as 10,000 square feet of a single lift. At least two tests will be performed per lift. The test location shall be chosen on the basis of random numbers. Approve lots when: a. Material is observed to be properly compacted throughout the lot; b. Density tests performed meet compaction specifications. Perform a laboratory classification test on the backfill cover material at a rate of one test per 3,000 cubic yards (compacted), or change in backfill cover material type, or change in borrow source. The sample for this test will be taken from the backfill cover stockpile.	
SET BACK OF WASTE: Maintain a distance of at least 10 feet between the inside toe of the runoff berm and the outside toe of the waste containers.	Initial waste set back approval shall measure the set back distance around the edge of the runoff berm at 100 foot intervals. Record the inspection of the setback on the "Daily Construction Report". Inspect the waste setback on a monthly basis. Record findings on the "Daily Construction Report".	Review the QC documentation to confirm that the monthly inspections have been performed and properly documented.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
	Require removal of any waste necessary to maintain the required set back.	
SNOW REMOVAL: When waste material is to be placed and the work area is covered with snow, the snow must be removed.	Observe that snow is removed. Advise the project manager of deficiencies. Construction may not continue without corrective action. Record corrective action (where required) in the "Daily Construction Report".	Review the QC documentation to verify that snow removal is being performed and documented.
Cold Weather Placement of Backfill: The following requirements apply to placement of flowable sand backfill when the ambient air temperature is below 32 degrees Fahrenheit: a. Backfill with frozen clods shall not be accepted for placement. b. The backfill stockpile shall be worked using heavy equipment prior to use. c. The minimum average spread diameter for the flowability tests shall be 8.75”. d. If backfill is observed to have frozen clods or does not meet the flowability specification, the backfill stockpile may be re-worked. Each inspection and test shall be repeated for re-worked material.	When the ambient air temperature falls below 32 degrees Fahrenheit: a. Inspect the backfill stockpile to be used that day for any visible frozen clods. b. Observe working of the backfill stockpile. c. Perform a flowability test (ASTM D6103) on material from the backfill stockpile: 1) Collect a minimum of three representative samples from the backfill stockpile. 2) Test each sample using ASTM D6103. d. Record these actions and test results on the “Daily Construction Report.”	Verify that the backfill stockpile is inspected, worked, and tested during cold weather conditions.
~~**FINAL GRADING:** Top of waste elevations shall be at grade or below grade.~~	~~Survey the top lift of waste on a 50 ft grid and at key points. Final survey measurements will be documented and provided to the Director of Engineering and Construction QA Officer.~~ ~~a. Indicate where the waste meets design line and grade.~~ ~~b. Rework and resurvey areas not meeting the specified grade.~~	~~Review the final survey data. Verify the frequency of the survey points.~~

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the Class A West embankment.		
DEFINITION: Interim rad cover is non-waste soil used to comply with the "uncovered radioactive waste" limit at Radioactive Material License UT 2300249, Condition 11. This material was formerly referred to as "temporary cover" or "interim temporary cover". Waste in closed containers may be stored on interim rad cover. If bulk waste is placed or stockpiled on interim rad cover, the affected area shall no longer be considered to have interim rad cover on it.		
The following areas do not count against the "uncovered radioactive waste" limit at RML Condition 11 and do not require interim rad cover to be placed over them: 1. Containerized Waste Facility 2. Large Component disposal areas 3. CLSM pour areas that have been poured and covered. *Note: Areas where debris has been staged or formed for CLSM, but have not yet been poured and covered, shall be counted against the "uncovered radioactive waste" limit.*		
INTERIM RAD COVER MATERIAL: Interim rad cover shall be native soil that is free of debris material.	Visually inspect interim rad cover soil and document on the Daily Construction Report.	
INTERIM RAD COVER PLACEMENT: Interim rad cover shall be a minimum of 6 inches thick in order for an area to be removed from the "uncovered radioactive waste" inventory. Thickness shall be evaluated through use of grade poles or survey. Contaminated equipment may be used to place interim rad cover.	Survey at least the perimeter of the area covered and document. Document thickness of cover on the Daily Construction Report.	Periodically observe lift approval documentation.
A commercial fixative product (i.e., polymer), magnesium chloride, or non-contact water may be applied, in accordance with the manufacturer"s		

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
instructions, to the surface of the interim rad cover to aid in dust control and erosion prevention. Erosion control blankets, mats, or fiber mulch may also be used, in accordance with the manufacturer"s instructions, for erosion prevention. DRC shall be notified at least 48 hours prior to deployment of erosion control blankets, mats, or fiber mulch.		
OPERATIONAL CONTROLS: Interim rad cover shall be fenced, roped, or otherwise marked to identify as distinct from active waste placement areas. Traffic across interim rad cover shall be minimized. Haul roads are prohibited on interim rad cover.		
INSPECTIONS: Monthly, inspect interim rad cover for the presence of erosion gullies. If the inspection indicates that waste material is exposed due to erosion, the interim rad cover shall be repaired in that area within 7 calendar days.	Perform monthly inspections and document on the Daily Construction Report.	
SURVEYS: Quarterly, perform an elevation survey on interim rad cover that is within 2 feet of the design top of debris waste elevation. Surveys shall be performed at the temporary and final settlement monument locations provided in Figure 2, within an 18-inch radius of the design monument location.	Perform quarterly surveys and document.	
REMOVAL: Interim rad cover may be removed. Soils used as interim rad cover may be used as fill for debris wastes. If used, erosion control blankets, mats, or fiber mulch may be left in place or removed, but either way must be placed and compacted as waste.		

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the Class A West and 11e.(2) embankments. Because there is no open cell time limit for the 11e.(2) embankment, time limits within this specification do not apply there.		
TEMPORARY COVER MATERIAL: Temporary cover shall be native CL, ~~or~~ ML, or CL-ML soils that are free of debris ~~material~~that could penetrate the radon barrier. ~~This material provides an adequate thickness of material free of debris to protect the overlying radon barrier.~~	Perform laboratory classification tests at a rate of 1 test per lot prior to use of material. A lot is defined as a maximum of ~~6000~~ 5000 cubic yards (compacted) of specified material type. Record the location of the classification sample on the "Sampling Log". ~~a. Approve lots which meet the specified classification for use.~~ ~~b. Lots not meeting the specified classification can not be used.~~ Visually inspect temporary cover soil and verify that it is free of debris. Record results on the Lift Approval Form.	
TEMPORARY COVER PLACEMENT: Temporary cover shall be placed within 15 years of the date of initial waste placement on each lift area~~, and within 90 days of any survey that determines top of waste elevations and grades for each lot~~. Top of waste elevations and grades are defined as those found on the approved engineering design drawings authorized under the license. DRC shall be notified in writing at least 48 hours in advance of the start-up of temporary cover placement. ~~A side slope exemption is limited to the 90 calendar day requirement for temporary cover placement, which does not apply to side slope areas immediately adjacent to top slope lifts that have not reached the top of waste elevations. Once the adjacent top slope area has reached the top of waste elevation all top slope and adjacent side slope areas shall have temporary cover placed within 90 calendar days.~~ Temporary cover shall be a minimum of 1 foot thick.	Provide DRC notification. Document lift area, location, thickness, and compaction on the Lift Approval Form.	Periodically observe lift approval documentation.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
Temporary cover may be over-built in order to achieve this thickness. Temporary cover shall be placed in accordance with the lift thickness and compaction requirements specified under Work Element – Waste Placement, above. Contaminated equipment may be used to place temporary cover.		
The edge of the temporary cover shall be marked with fencing, rope, snow fence, or equivalent marking to prevent heavy equipment travel on the temporary cover surface. Haul routes may traverse temporary cover, provided that the haul route does not travel over any pre-final cover settlement monuments and that the haul route is marked with fencing, rope, snow fence, or equivalent markings. Temporary cover may encroach ~~up to 5 feet~~ into the offset for the run-off berm.		
A commercial fixative product, magnesium chloride, or clean water may be applied to the surface of the temporary cover to aid in dust control and erosion prevention. Contaminated water shall not be used for dust suppression on temporary cover. Erosion control blankets, mats, or fiber mulch may also be used, in accordance with the manufacturer"s instructions, for erosion prevention. DRC shall be notified at least 48 hours prior to deployment of erosion control blankets, mats, or fiber mulch. If used, such erosion control materials shall be removed prior to radon barrier construction.	Provide DRC notification. Document application and removal of erosion control materials on the Daily Construction Report.	

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
PRE-FINAL COVER SETTLEMENT MONUMENTS: Pre-final cover settlement monuments shall consist of approximately 18-inch long #5 or greater rebar that is welded to a metal plate. The metal plate shall be approximately 18 inches square with a thickness of 3/16 inch to 1/4 inch. The metal plate shall be placed on the top of waste surface and then secured by the temporary cover as it is placed. Each monument shall be labeled, flagged, and documented on a reference drawing.	Inspect pre-final cover settlement monuments for compliance with the specification prior to installation.	Perform a surveillance of monument installation activities.
PRE-FINAL COVER SETTLEMENT MONUMENT PLACEMENT: Pre-final cover settlement monuments shall be placed as close as practical to the locations of final cover settlement monuments identified in Figures 2 and 4. In addition, pre-final cover settlement monuments shall be placed at the locations identified as "additional final temporary cover monuments" on Figures 2 and 4.	Perform and document a post-construction survey of the pre-final cover settlement monuments.	Verify that surveys have been performed.
SURVEY REQUIREMENTS: Surveys shall be performed with GPS or approved equivalent equipment. Tolerance shall be no more than ± 0.1 foot.	Calibrate and operate survey equipment in accordance with the manufacturer"s recommendations.	
SURVEY INTERVAL: The pre-final cover settlement monuments shall be surveyed within 30 days of temporary cover installation. New monuments shall be surveyed again during the months of January, March, May, July, September, and November. After at least one year of data has been obtained for a monument, it shall be surveyed semi-annually during the months of May and November until final cover construction begins. Weather conditions at the time of the survey and a discussion of the potential for frost to be present shall be documented in the survey report.	Perform and document the required surveys. Provide survey data to the ~~Director of Engineering~~Manager, Engineering and Maintenance.	Verify that monument surveys are completed as required.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
INSPECTIONS: Monthly, inspect temporary cover for the presence of erosion gullies. If the inspection indicates that waste material is exposed due to erosion, the temporary cover shall be repaired in that area within 7 calendar days.	Perform and document monthly inspections.	
~~Semi-a~~Annually by July 1 of each year, maintain the temporary cover surface. Maintenance shall consist of filling in any erosion gullies and, if necessary, re-grading to prevent ponding on the temporary cover.	Document ~~semi-annual~~ maintenance activities. Document any areas requiring filling or re-grading.	
REPORTING: Survey data for pre-final cover settlement monuments shall be compiled and analyzed to evaluate total and differential settlement. This data and analysis shall be submitted to DRC with the annual as-built report. Review and analysis of settlement monitoring data will include the following: • A drawing identifying the location of each point. • Graphical or tabular presentation of the incremental settlement for each point (how much each point has moved since the last set of readings), • Graphical or tabular presentation of the total settlement for each point, • Graphical or tabular presentation of the time rate of settlement for each point (to include both the overall rate from the first data for the point, and the incremental rates for each period), • Graphical or tabular presentation of the differential settlement for each point with respect to the nearest adjacent points, and • A discussion about the general nature of the observed settlement, and any areas of the landfill that are behaving in an anomalous manner.		
TRANSITION TO FINAL COVER: If distortion is less	The ~~Director of Engineering~~Manager, Engineering and	

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
than 0.007 foot/foot for all of the grid points in a given area, and each grid point has at least one year's monitoring data; then final cover construction may proceed. Once an area is approved, final cover construction shall be completed within 3 years of this determination.	Maintenance shall evaluate pre-final cover settlement data for each area of cover construction to determine distortion between all adjacent points in that area. If the criteria are met, a written report shall be prepared and forwarded to DRC at least 7 calendar days prior to removing the pre-final cover settlement monuments.	
The ~~Director of Engineering~~Manager, Engineering and Maintenance shall perform the analysis of projected future distortions. The analysis shall be submitted no later than the end of the 16th year since waste placement began in the oldest lift area subject to analysis.	Inspect and document that all pre-final cover settlement monuments have been removed prior to final cover construction.	
If an area is not approved for final cover construction by the end of the 16th year of the 18-year open cell period, an analysis of projected future distortions shall be performed and submitted to DRC. The analysis shall evaluate settlement through the end of year 17 of the open-cell period, at a minimum. If the analysis indicates that the future distortions between any two adjacent points will be more than 0.007 foot/foot, then surcharging over the area(s) in question will be required to stabilize settlement prior to final cover construction. If surcharging is required, a plan and schedule shall be provided to DRC by the end of the 16th year of the open-cell period. The surcharging schedule shall show that surcharging will be complete by the end of the 17th year of the open-cell period. Settlement monitoring frequency during surcharging shall be at least equivalent to that required in Year 16.	Survey and document the temporary cover surface to confirm that the top of waste design grades and elevations are achieved. Document lift thickness and compaction for any debris-free soil material placed to bring the temporary cover surface to the design top of waste grades and elevations.	Verify that pre-final cover settlement monuments have been removed and that the temporary cover surface meets design top of waste grades and elevations.
Immediately prior to placement of the first lift of radon barrier, the pre-final cover settlement monuments shall be removed and the temporary cover surface restored.	Provide DRC notification of pending temporary cover removal. Document lift area and location on a Daily Construction Report.	
Additional clean debris-free soil material shall be placed; or excess temporary cover material shall be cut, as needed		Periodically observe paperwork for temporary cover removal.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
to return the area for final cover construction to the original top of waste design grades and elevations. When placing clean debris-free soil material for this purpose, the soil shall be placed in lifts with a compacted average thickness not exceeding 12” and compacted to 90% of a standard Proctor. If an area has settled more than 12”, bulk waste may be placed in accordance with the applicable work elements and specifications of this manual, so long as at least 1 ft of temporary cover is in place prior to radon barrier construction. DRC shall be notified at least 48 hours in advance of the start-up of temporary cover removal in previously placed areas.		

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the Class A West and 11e.(2) embankments.		
CLEARING AND GRUBBING: Remove vegetation, debris, organic, or deleterious material from areas to be used for borrow. Grubbing depth will depend on the type of vegetation, debris, organic, or deleterious material on the site. If the area is free of these materials then no clearing and grubbing will be necessary.	Inspect the area once clearing and grubbing has been completed. Record observations and corrective action (where required) on the "Daily Construction Report".	Verify that the clearing and grubbing has been inspected by QC.
MATERIAL--NATURAL CLAY MIXTURE: Satisfactory material shall be defined as CL and ML soils based on the Unified Soil Classification~~ with at least 85 percent passing the No. 200 sieve (silt and clay), a plasticity index (PI) between 10 and 25, and a liquid limit (LL) between 30 and 50~~. The clay shall also have a dry clod size less than or equal to 1 inch.	Perform laboratory classification tests at a rate of 1 test per lot prior to use of material in the radon barrier. A lot is defined as a maximum of 3,000 cubic yards (compacted) of specified material type. Record the location of the classification sample on the "Sampling Log". ~~a. Approve lots (which meet the specified classification) for use in the radon barrier.~~ ~~b. Lots not meeting the specified classification can not be used.~~	Verify the frequency of laboratory tests and compliance of test results.
PROTECTION: The borrow material will be handled in such manner as to prevent contamination with radioactive waste material or other deleterious material. The in-place material may contain up to 5 percent additional rocks and sand above the content found in the classification test.	Visually check radon barrier materials for contamination by foreign materials. Remove clays that have been contaminated above the specified requirements. Document corrective actions (where required) on the "Daily Construction Report".	Verify that the radon barrier is being inspected for contaminates and that corrective actions (if required) are properly documented.
PROCESSING: These procedures may be used to provide suitable material for construction of the radon barrier.		
1. Apply deflocculant at a rate determined by the ~~production engineer~~Manager, Engineering and Maintenance.	Measure the mixing areas and verify that the application rate of the deflocculant is equal to or greater than the rate determined by the ~~production engineer~~Manager, Engineering and Maintenance. Record the size of the mixing areas and the amount of deflocculant applied on the "Embankment Construction	Verify that the size of the mixing areas and the amount of deflocculant applied have been properly documented.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
	Lift Approval Form".	
2. Mix the deflocculant thoroughly into the soils by tilling, or similar action.	Observe the mixed clay and advise the project manager of areas which are adequately mixed.	Verify that the clay is being inspected by QC.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the Class A West and 11e.(2) embankments.		
NOTICE OF TEST PAD CONSTRUCTION: The test pad plan shall be approved by the DRC prior to test pad construction. The DRC shall be notified 48 hours in advance of the start-up of test pad construction.	Obtain documentation confirming that the test pad plan has been approved by the DRC. Verify that the DRC has been notified as required.	Verify that the test pad plan has been approved by the DRC. Verify that the DRC has been notified as required.
TEST PAD: An approximately 60 feet by 75 feet large test pad will be constructed using the procedure proposed for construction of the radon barrier when using heavy equipment for compaction. An approximately 5 feet by 5 feet small test pad will be constructed using the procedure proposed for construction of the radon barrier when using hand compaction equipment.	Observe the construction of test pads. Measure test pads to ensure that they are constructed to the size indicated. Record the test pad size on the "Embankment Construction Lift Approval Form". The large test pad shall be divided into three lots per lift (approximately 1,500 square feet per lift). Each lift of the small test pad shall equal a lot.	Observe the construction of the test pads. Verify that the test pad has been measured and is properly documented.
A new test pad shall be constructed each time there is a significant change in specifications, construction procedures, types of equipment, or unified soil classification~~, QC testing equipment or procedure. A new test pad must be constructed each time there is a change in the grade or source of bentonite~~.		
Test pads are to be constructed and tested in accordance with the following specifications:		
1. Place the clay in at least three lifts with the first lift uncompacted thickness not exceeding twelve inches. Remaining lifts shall have a loose material thickness not exceeding nine inches for each lift. The clay material will be inspected for dry clod size during placement of each lift of radon barrier.	Measure the lift thickness at a rate of 1 test per lot. Record thickness on the "Embankment Construction Lift Approval Form". Inspect the loose clay material during the unloading and spreading process for each uncompacted lift to ensure any dry clods that are present are less than or equal to one (1) inch. Record inspection of the dry clod size on the "Embankment Construction Lift Approval Form".	Verify that the number of lifts and lift thicknesses have been documented. Verify that the clod size inspection has been performed and documented for each uncompacted lift thickness.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
2. The clay is to be placed and compacted by equipment proposed for use during construction of the radon barrier.	Verify with the project manager that the same or similar type equipment and compaction efforts will be used in the cell for construction of the radon barrier. Record type of equipment used, and number of passes on the "Embankment Construction Lift Approval Form".	Verify equipment used and the number of passes made in preparing the test pad are those to be used during the construction of the radon barrier.
3. The lifts of clay shall be bonded by~~:~~ ~~a)~~ ~~P~~providing a rough upper surface on the underlying layer of radon barrier. The surface should have changes in grade of approximately one inch or more at a rate of two per linear foot~~;~~ ~~- OR -~~ ~~b) By compacting with a sheepsfoot with feet approximately two inches longer than the lift thickness~~.	Verify that there are adequate changes in grade by placing a straight edge at least two feet long on the surface. Count the number of points approximately one inch or more below the straight edge. ~~- OR -~~ ~~Verify that the feet on the sheepsfoot compactor are approximately two inches longer than the lift thickness.~~	Verify the frequency of measurements and compliance of test results.
4. The clay is to be compacted to at least 95 percent of a standard Proctor with a moisture content between 3 percentage points below optimum and 5 percentage points ~~of optimum to 5 percent~~ over optimum. Compaction of the large test pad is to be accomplished by at least four passes of suitable compaction equipment.	Conduct in-place moisture-density tests at a rate of one test per lot per lift. The test location shall be chosen on the basis of random numbers. Record the test result on the "Field Density Test" form. a. Approve lots which meet the specified moisture and compaction. b. Rework and retest lots not meeting the specified moisture or compaction. c. Any additional work under b. shall be included in the test pad construction method	Verify the frequency of tests and compliance of test results.
5. The clay is to be constructed to provide a permeability of less than or equal to the specified permeability as shown on the approved engineering drawings. Permeability testing on the bottom lift will be performed at the surface. Permeability on the second lift will be performed ≥ 2" below the surface. Permeability on the third lift will be performed ≥ 4" below the surface.	Conduct in-place permeability tests at a rate of one test per lot per lift. The permeability test shall be run in close proximity to the moisture-density test. Record the test result on the "Field Permeability Test" form. a. Approve lots that meet the specified permeability. b. Rework and retest lots not meeting the specified permeability c. Any additional work under b. shall be included in the test pad construction method	Verify the frequency of tests and compliance of test results.

Formatted: Body Text, Left, No bullets or numbering, Hyphenate, Tab stops: Not at -0.5"

Formatted: Body Text, Left, Tab stops: 1.63", Left

Formatted: No bullets or numbering

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
6. At least one ~~PI, LL, and~~ gradation test~~s~~ shall be conducted for each test pad.	Conduct ~~PI, LL, and~~ gradation test~~s at a rate of one of each type of test per test pad~~.	Verify the frequency of tests and compliance of test results.~~Verify that the PI, LL, and gradation tests have been conducted and documented.~~
7. The procedures used to construct the test pad shall be reviewed and approved by the certifying engineer. The test must be approved by a Professional Engineer.	Provide the certifying engineer with copies of the documentation for the test pad for review and approval.	Verify that proper approval has been obtained for the test pad and that the necessary construction procedure documents are in place for use during radon barrier construction.
8. The ~~procedures used to construct the test pad shall be reviewed and approved by~~ test pad certification report shall be provided to the DRC prior to using the new test pad construction method.	~~Obtain documentation confirming the DRC approval of the test pad.~~	~~Verify that proper approval has been obtained for the test pad and that the necessary construction procedure documents are in place for use during radon barrier construction.~~

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the Class A West and 11e.(2) embankments.		
NOTICE OF COVER CONSTRUCTION: The DRC shall be notified of ~~the cessation of waste placement and the~~ start-up ~~of cover construction~~ for each phase of ~~the "cut and cover" operation~~cover construction.	~~Verify that the DRC has been notified of the anticipated cessation of waste placement and the start-up of cover construction, prior to the placement of radon barrier.~~	Verify that the DRC has been notified ~~of the anticipated cessation of waste placement and the start-up of cover construction,~~ prior to the placement of radon barrier.
PROJECT AREA: Radon barrier projects shall have a minimum total area of 300,000 square feet, unless otherwise approved in advance, in writing by DRC. Radon barrier projects may continue over more than one construction season, so long as the specifications for cold weather placement and spring start-up are met. A radon barrier project may consist of any number of lift areas.	Document the radon barrier project area dimensions.	
LIFT IDENTIFICATION: Each lift shall be given a discrete designation for testing and surveying purposes.	Assign a lift identification number to each lift. Use the lift identification number to identify all paper work for that lift.	Verify that a lift identification number has been assigned to each lift. Verify that the lift identification number is used on all paper work for that lift.
PLACEMENT: The radon barrier will be prepared, placed and compacted using the same type of equipment and mixing and compacting procedures that were approved in the test pad.	Observe the radon barrier placement. Record the equipment used to place the radon barrier, along with any corrective actions (where required) on the "Daily Construction Report".	Verify the equipment used to construct the radon barrier has been documented and that it is the same type of equipment used to construct the test pad.
LIFT BONDING: The lifts of clay shall be bonded by: 1) Providing a rough upper surface on the underlying layer of radon barrier. The surface should have changes in grade of approximately one inch or more at a rate of two per linear foot; ~~- OR -~~ ~~2) By compacting with a sheepsfoot with feet approximately two inches longer than the lift thickness.~~	Verify that there are adequate changes in grade by placing a straight edge at least two feet long on the surface. Count the number of points approximately one inch or more below the straight edge. ~~- OR -~~ ~~Verify that the feet on the sheepsfoot compactor are approximately two inches longer than the lift thickness.~~	Verify the frequency of measurements and compliance of test results.
LIFT THICKNESS: The first lift of material shall	Verify that the required grading tolerance is achieved	Verify the frequency of measurements and compliance

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
have an uncompacted thickness of no greater than 12 inches. For the remaining lifts, the loose lift thickness shall not exceed the lesser of the lift thickness used to construct the test pad or nine inches. Thickness for the lift will be established by installing grade poles on at least a 70-foot grid and at all control points. The grade poles must not be installed deeper than 1 inch into the underlying clay liner. The grade poles must be marked at the appropriate depth to establish the grade. After the grade for the lift has been checked and approved by QC personnel, the grade poles shall be removed. The clay material will be inspected for dry clod size during placement of each lift of radon barrier. **- OR -** Survey to determine lift thickness	as follows: a. Ensure that the required frequency for placement of grade poles has been met. b. Compare soil level with the marked level on the grade poles. c. Use a string line where necessary between poles to check for high or low spots. d. Define out of specification areas and advise the project manager to rework those areas. e. Review areas reworked and approve areas meeting criteria. f. Continue "b" through "d" above until all areas meet criteria. g. Indicate areas meeting criteria in the "Embankment Construction Lift Approval Form". **- OR -** a. Verify equipment calibration. b. Verify correct set-up and operation of equipment. ~~Dig a hole and measure the loose lift thickness at a rate of one per lot. A lot is defined as 10,000 square feet of a single lift and record on the "Lift Approval Form". The location of the measurement shall be chosen on the basis of random numbers.~~ ~~a. Approve lots which meet the specified lift thickness.~~ ~~b. If the thickness is greater than the specified thickness, measure the thickness at four points (north, east, south, and west) within ten feet of the first measurement. Average the five measurements together.~~ ~~c. Approve lifts with an average less than or equal to the specified lift thickness.~~ ~~d. Rework and retest lots with an average lift thickness greater than the specified lift thickness.~~ ~~Inspect the loose clay material during the unloading and spreading process for each uncompacted lift to ensure any dry clods that are present are less than or equal to one (1) inch. Record inspection of the clod~~	of test results.~~Observe, at a minimum, five percent of the measurements performed by the QC personnel to ensure that the measurements are being performed correctly. Verify that the measurements are being performed at the correct frequency and that the documentation is being completed. Verify that the clod size inspection has been performed and documented for each uncompacted lift.~~

Formatted: Indent: Left: 0.03"

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
	~~size on the "Embankment Construction Lift Approval Form".~~	
KEYING-IN: Segments of cell radon barrier constructed at times more than 30 days apart than each other shall be keyed-in to each other by sloping the full thickness of old radon barrier at a maximum slope of 5:1. ~~at vertical steps no greater than nine inches and at least twice as wide as they are high.~~	Verify that the new liner has been properly keyed-in to the existing liner. Record deficiencies on the "Embankment Construction Lift Approval Form".	Verify that the keying-in of the liner has been documented.
COMPACTION: Radon barrier material will be compacted to at least 95 percent of standard Proctor with a moisture content between 3 percentage points below optimum and 5 percentage points ~~between optimum and 5 percent~~ over optimum.	Conduct in-place moisture-density tests at a rate of one test per lot and record the results on the "Field Density Test" form. A lot is defined as 200 cubic yards (compacted) of a single lift. The test location shall be chosen on the basis of random numbers. a. Approve lots which meet the specified moisture and compaction. b. Rework and retest lots not meeting the specified moisture or compaction. Proctors shall be performed at a rate of one test per borrow lot. A borrow lot is defined as 3,000 cubic yards (compacted) or less of a specific material type. Record the location of the Proctor sample on the "Sampling Log".	Observe, at a minimum, five percent of the tests performed by the QC personnel to ensure that the tests and observations are being performed correctly. Verify that the tests are being performed at the correct frequency and that the documentation is being completed.
PERMEABILITY: The radon barrier shall have an in-place permeability of less than or equal to 1 x 10^{-6} cm/sec for the bottom layer. The radon barrier shall have an in-place permeability of less than or equal to 5 x 10^{-8} cm/sec for the final top foot.	Permeability is verified by strict adherence to the test pad construction method and equipment. Observe compaction activities to ensure that the minimum number of passes are completed by the appropriate equipment. ~~Conduct in-place permeability tests at a rate of one test per lot and record the results on the "Field Permeability Test" form. A lot is defined as 2,000 cubic yards (compacted) of 1 x 10 $^{-6}$ cm/sec or 200 cubic yards (compacted) of 5 x 10 $^{-8}$ cm/sec radon barrier. The permeability test shall be run in close proximity to a moisture-density test location.~~	Visually observe 1 lift being compacted per construction season.~~Observe, at a minimum, five percent of the tests performed by the QC personnel to ensure that the tests and observations are being performed correctly. Verify that the tests are being performed at the correct frequency and that the documentation is being completed.~~

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
	~~a. Approve lots that meet the specified permeability.~~ ~~b. Rework and retest lots not meeting the specified permeability.~~ ~~c. Restore all test areas with the approved construction method.~~	
LAYER THICKNESS: For the ~~LLRW~~ CAW ~~e~~Eembankment, the bottom (1 x 10^{-6} cm/sec permeability) layer shall be at least 1.0 ~~feet~~ foot thick. For the 11e.(2) embankment top slopes, the bottom (1 x 10^{-6} cm/sec permeability) layer shall be at least 3.0 feet thick. For the 11e.(2) embankment side slopes, the bottom (1 x 10^{-6} cm/sec permeability) layer shall be at least 2.5 feet thick. For the ~~LLRW~~ CAW and 11e.(2) embankments, the top (5 x 10^{-8} cm/sec permeability) layer shall be at least 1.0 ~~feet~~ foot thick.		
LINER TRANSITIONS BETWEEN RADON BARRIER WITH DIFFERENT SPECIFIED PERMEABILITIES: The radon barrier with the higher permeability (i.e. the bottom radon barrier) shall be final graded from grade to 0.4 feet below grade design grade. Survey on a 50 ft grid and key points.	Survey the radon barrier surface on a 50 ft grid and at key points. Final survey measurements will be documented and provided to the ~~QC Officer~~Lead, QC Embankment Construction and Construction QA Officer. ~~a. Indicate where the radon barrier meets design line and grade.~~ ~~b. Rework and resurvey areas not meeting the specified grade.~~ a.	Review the final survey data. Verify the frequency of the survey points.
RADON BARRIER DRYING PREVENTION: To prevent the radon barrier from drying, water will be applied to the clay surface on an as needed basis or the radon barrier will be covered with 6 inches of loose clay. Finished radon barrier shall be covered with 12 inches of filter zone, sacrificial soil layer, or 6 inches of loose clay within 30 days of completion. Unfinished radon barrier shall be covered with 6 inches of loose clay within 30 days of the last activity for the lift.	Observe the liner surface for drying. Advise project manager of any deficiencies. Record corrective actions taken (where required) on the "Daily Construction Report".	Verify that the liner is being inspected.

Formatted: Indent: First line: 0"

Formatted: Normal, Justified, Indent: Left: 0", First line: 0", Don't hyphenate, Tab stops: -0.5", Left + 1.63", Left

Formatted: No bullets or numbering, Tab stops: Not at 0.35"

Formatted: Indent: Left: 0.23"

Formatted: Numbered + Level: 1 + Numbering Style: a, b, c, ... + Start at: 1 + Alignment: Left + Aligned at: 0" + Tab after: 0.25" + Indent at: 0.25"

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
Desiccation cracks larger than one-fourth inch wide and one-inch deep in the radon barrier will be reported to the DRC and will be documented as a non-conformance item when discovered.		
SNOW REMOVAL: When radon barrier material is to be placed and the work area is covered with snow, the snow must be removed.	Observe that snow is removed. Advise the project manager of deficiencies. ~~Construction may not continue without taking corrective actions to remove the snow.~~ Record corrective actions (where required) in the "Daily Construction Report".	Verify that snow removal is being documented.
COLD WEATHER PLACEMENT OF RADON BARRIER: For purposes of this CQA/QC Manual, "frozen" is defined as a soil temperature of less than or equal to 27ºF. Radon barrier shall not be placed above frozen material. In addition, no frozen material shall be processed or placed.	As needed, observe the area where radon barrier is to be placed. If frozen material is observed, cease placement of radon barrier. If frozen material is suspected, measure soil temperature. Record the stopping of placement in the "Daily Construction Report."	Verify that radon barrier is tested during cold weather conditions.
If the air temperature has dropped below 32ºF since the last lift of radon barrier was approved, one of the following three scenarios apply: (1) If less than 30 days have passed since the date of lift approval and the last lift of radon barrier has been covered since the approval date with at least 9 inches of loose clay or 6 inches of compacted clay, then the cover clay may be worked with no additional testing of the lower approved lift. (2) If less than 30 days have passed since the date of lift approval and the last lift of radon barrier has not been covered with at least 9 inches of loose clay or 6 inches of compacted clay, then: (a) Perform spring start-up testing as discussed below; or (b) Monitor the radon barrier temperature approximately 1 inch beneath the surface. If the temperature 1 inch beneath the surface is greater than 27ºF, re-roll the surface with one pass of the same type	Review ambient air temperature records as measured at the site meteorological station. Document status of radon barrier cover placement on the "Daily Construction Report." Monitor radon barrier temperature when triggered under 2.(b). Clay temperature shall be measured between 6:00 am and 8:00 am on the day that radon barrier will be placed. Temperature measurements shall include a location that is most likely to be coldest; i.e., if there is a portion of the radon barrier that is shaded or at a low point. Temperature monitoring frequency shall be at least one point per 100,000 square feet or one point per contiguous project area, whichever is smaller. If the initial radon barrier temperature measurement is less than or equal to 27ºF, the affected area may be resampled before 8:30 am the same day as follows: a. Measure the radon barrier temperature at a frequency of one measurement per lot (defined as no more than	

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
of construction equipment (i.e., a compactor for intermediate lifts or a smooth drum roller for the final surface) and continue with radon barrier construction. If the temperature 1 inch beneath the surface is less than or equal to 27ºF, re-work and re-test density and permeability of the affected area after the clay temperature has risen above 27ºF. (3) If more than 30 days have passed since the date of lift approval, perform spring start-up testing.	10,000 square feet). b. Lots where the temperature is greater than 27ºF do not require rework; except that the lot where the initial temperature less than or equal to 27ºF was measured shall be reworked regardless of resampling results.	
In addition, the final lift of 5 X 10^{-8} cm/sec radon barrier requires that the Type B filter zone and sacrificial soil be placed over the radon barrier prior to the end of the work day when ambient temperatures will drop below 32 degrees Fahrenheit. If this protective cover is not applied prior to freezing conditions, an additional density test and permeability test shall be performed directly prior to covering the radon barrier final surface with filter zone and sacrificial soil. This process must be repeated whenever any final surface material is not covered with the filter zone and sacrificial soil prior to overnight freezing conditions.	Perform an additional density test and permeability test on 5 x 10^{-8} cm/sec final surface that has been exposed to overnight freezing conditions prior to placement of the Type B filter zone and sacrificial soil material. If passing test results are achieved, but it is not possible to cover all of the exposed radon barrier material with filter zone and sacrificial soil prior to the end of the workday, testing must be repeated for the exposed materials. This testing may be performed outside of the approved lift area so long as the area tested is representative of the clay in the approved lift area (i.e., was constructed at the same time and with the same method).	
SPRING START-UP: See "Cold Weather Placement of Radon Barrier" above for situations that trigger this specification.	Perform density ~~and permeability~~ testing at the frequencies outlined for radon barrier construction above. This testing may be performed outside of the approved lift area so long as the area tested is representative of the clay in the approved lift area (i.e., was constructed at the same time and with the same method). Moisture testing is not required for spring start-up.	
For spring start-up testing, the surface lift is treated as protective cover, regardless of whether it was an approved lift of radon barrier at one time or not. Excavate 9 inches below the clay surface and re-test for density~~ and permeability~~. Excavation for testing purposes may consist of removing the protective cover lift; or may be performed by „potholing" only at the testing locations. Areas that have been „potholed" ~~for permeability testing~~ shall be repaired by applying the	a. Approve lots that meet specification. The protective cover lift may be worked in place and tested to become the next lift of radon barrier. b. For lots that do not meet specification, test the surface at successively deeper 9 inch increments until a	

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
same level of effort as prescribed by the approved test pad for radon barrier construction.	passing lift is found; remove all failing lifts; re-work all failing areas; and re-test. Document that repairs are completed to the same level of effort as required by the approved test pad for radon barrier construction.	
CONTAMINATION OF RADON BARRIER: The radon barrier material shall not become contaminated with radioactive soils or debris during construction. The in-place clay may contain up to 5 percent additional rocks and sand above the content found in the classification test.	Visually check radon barrier for contamination by foreign materials. Remove clays which have been contaminated above the specified requirements.	Verify that removal of contaminated material has been properly documented.
FINAL GRADING: Final grading shall be from grade to 0.2 feet above grade. Survey on a 50 ft grid and key points. ~~Upon completion, the surface shall be rolled with a smooth drum roller.~~	Survey the foundation on a 50 ft grid and at key points. Final survey measurements will be documented and provided to the ~~QC officer~~Lead, QC Embankment Construction and Construction QA Officer. ~~a. Indicate where the radon barrier meets design line and grade.~~ ~~b. Rework and resurvey areas not meeting the specified grade.~~	Review the final survey data. Verify the frequency of the survey points.
EROSION CONTROL FOR EXPOSED SOIL: If DRC-approved final grade 5 x 10-8 cm/sec radon barrier soil surfaces are not covered by filter zone within 30 days of lift approval, the following erosion control repair measures shall apply. Semi-annually, inspect exposed radon barrier soil surfaces for evidence of erosion. Rivulet or gullied areas wider than 6 inches or deeper than 6 inches require maintenance to fill the rivulet or gully and restore the area to design grade. Soils imported as fill shall meet the requirements of "Radon Barrier Borrow Material", above. Maintenance shall be performed	Perform monthly inspections. Document the inspection as well as associated maintenance activities on the Daily Construction Report.	

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
within 30 calendar days when needed. Erosion control blankets, mats, or fiber mulch may be used, in accordance with the manufacturer"s instructions, for erosion prevention. DRC shall be notified at least 48 hours prior to deployment of erosion control blankets, mats, or fiber mulch. If used, such erosion control materials shall be removed prior to filter zone construction.		
RADIOLOGICAL SAMPLING FOR EXPOSED SOIL: If DRC-approved final grade 5 x 10-8 cm/sec radon barrier soil surfaces are not covered by filter zone within 30 days of final approval, the area shall be either: (a) sampled and radiologically released in accordance with the Environmental Monitoring Plan; or (b) have a minimum of 6 inches of clay removed and replaced prior to filter zone placement. Under option (b), no environmental sampling is required.	Coordinate sampling and analysis with environmental personnel. Attach a copy of the release report to the lift approval documentation.	
HEAVY EQUIPMENT ON RADON BARRIER: Heavy equipment travel will be minimized on top of the finished radon barrier. Heavy equipment will not be operated on saturated radon barrier.	Observe work on radon barrier. Advise the project manager of problems with equipment on the radon barrier. Record corrective actions taken (where required) on the "Daily Construction Report".	Verify that the work is being inspected.
QUALITY ASSURANCE SAMPLING: Assurance samples for radon barrier materials tests are to be obtained at the following minimum frequency: 1. In-place moisture-density tests (ASTM D6938): 1 per 50,000 cubic yards. 2. ~~Moisture/density~~ Standard Proctor relationship testing (ASTM D698): 1 per 50,000 cubic yards. 3. Classification tests (ASTM D2487~~, D1140, and D4318~~): 1 per 50,000 cubic yards.	Coordinate with QA personnel in obtaining the quality assurance samples. Record the samples on the "Sample Log" and moisture-density test on the "Density Testing Log". Promptly report result of QC testing to Construction QA Officer so that a comparison of QA and QC testing results can be made.	Conduct or coordinate quality assurance sampling and testing in accordance with the designated frequencies. Obtain test results of QC samples so that a comparison of QA and QC test results can be made. The Construction QA Officer, in consultation with the ~~QC officer~~Lead, QC Embankment Construction, shall be responsible for determining the adequacy of correlation and documentation of the rationale used to determine adequacy. If the correlation is not adequate, new QC and QA samples shall be taken immediately. The construction QA Officer, in consultation with the ~~QC officer~~Lead, QC Embankment Construction, shall then

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
A minimum of one of each of the above tests is required for each year that radon barrier is placed.		evaluate the accuracy of the QC sampling and testing and, if necessary, provide for improved sampling and testing procedures and closer inspection and control. Record findings of quality assurance sampling in the "Daily QA Report".
DRC APPROVAL: The DRC shall approve documentation associated with completed radon barrier. Documentation shall include all QC and QA records associated with construction, as well as photographs of the completed surface. In addition, 48 hour notification shall be provided to the DRC prior to placement of filter zone material over the finished radon barrier. Energy*Solutions* may proceed with filter zone placement 48 hours after DRC notification if the DRC has not inspected and has not notified the ~~Director of Engineering~~Manager, Engineering and Maintenance of its intent to inspect the radon barrier surface.	Notify the Construction QA Officer that the radon barrier is ready for inspection by the DRC. Obtain written authorization on the "Liner Inspection Form" from the Construction QA Officer that the radon barrier has been inspected. Obtain documentation confirming the DRC approval of the radon barrier documentation.	Provide written approval of the radon barrier. Notify DRC that the radon barrier is ready for inspection.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the ~~Class A West and~~ 11e.(2) embankment~~s~~.		
~~**QUALITY OF ROCK:** The rock shall have a "Rock Quality" score of at least 50 based on the following tests: Specific Gravity (ASTM C-128), Absorption (ASTM C-127), Sodium Soundness (ASTM C-88), and L.A. Abrasion (ASTM C-131 or ASTM C-535). The procedures for scoring "Rock Quality" are found in Appendix C.~~	~~As described in NUREG-1623, appendix F, perform at least one petrographic examination for each rock source in accordance with ASTM C-295. If a combination of limestone, sandstone, and igneous rock is found for a source, percentages of each type of material shall be determined for scoring.~~ ~~Perform Na soundness, LA abrasion, absorption, and specific gravity testing at a rate of one set of tests per 10,000 cubic yards of rock. Record the location of all collected samples in the "Sampling Log".~~ ~~a. Approve rock for use in the filter zone which meet the specifications for rock quality.~~ ~~b. Rock not meeting the specifications for rock quality can not be used.~~	~~Verify the frequency of laboratory quality control tests and compliance of test results.~~ ~~Perform quality assurance testing at a minimum of one set of tests per 100,000 cubic yards of rock. A minimum of one set of tests is required each year that filter zone is placed. Record the samples on the "Sampling Log". Promptly report results to the Construction QA Officer so that a comparison of QA and QC testing results can be made. The Construction QA Officer, in consultation with the QC officer, shall be responsible for determining the adequacy of correlation and documentation of the rationale used to determine adequacy. If the correlation is not adequate, new QC and QA samples shall be taken immediately. The Construction QA Officer, in consultation with the QC officer, shall then evaluate the accuracy of the QC sampling and testing and, if necessary, provide for improved sampling and testing procedures and closer inspection and control. Record findings of the quality assurance sampling in the "Daily QA Report".~~
~~TYPE B~~ FILTER ZONE PERMEABILITY: ~~The type B filter zone rock on the Class A and Class A North embankments will have a minimum permeability of 3.5 cm per second.~~ The filter zone rock on the 11e.(2) embankment will have a minimum hydraulic conductivity of 42 cm/sec.	Perform permeability testing at a rate of one test per 10,000 cubic yards placed. Record the location of all samples in the "Sampling Log". ~~a. Approve rock for use in the filter zone which meet the specified gradation.~~ ~~b. Rock not meeting the specified gradation can not be used.~~	Verify the frequency of laboratory tests and compliance of test results.
GRADATION: ~~LLRW embankment rock gradation shall be as specified on the currently approved engineering drawings 10014.~~ 11e.(2) embankment rock gradation shall be as specified on the currently	For ~~Type B~~ filter zone rock, if material is to be stockpiled, perform gradation testing at a rate of one test per 2,500 cubic yard stockpile. If ~~Type B~~ filter zone rock material is transferred directly to the cell	Verify the frequency of laboratory quality control tests and compliance of test results. Perform quality assurance testing at a minimum of one

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
approved engineering drawing 9420-4.	from the production plant, perform at least one gradation test (ASTM C-136) per source per day material is placed, or at least one test per ~~2,500~~10,000 cubic yards. ~~For Type A filter zone rock, perform gradation testing at a rate of one test per 10,000 cubic yards. In addition, perform a minimum of one test per change in soil type by ASTM D 2488.~~ Record the location of all samples in the "Sampling Log". ~~a. Approve rock for use in the filter zone which meet the specified gradation.~~ ~~b. Rock not meeting the specified gradation can not be used.~~	set of tests per 100,000 cubic yards of rock. A minimum of one set of tests is required each year that filter zone is placed. Record the samples on the “Sampling Log”. Promptly report results to the Construction QA Officer so that a comparison of QA and QC testing results can be made. The Construction QA Officer, in consultation with the ~~QC officer~~Lead, QC Embankment Construction, shall be responsible for determining the adequacy of correlation and documentation of the rationale used to determine adequacy. If the correlation is not adequate, new QC and QA samples shall be taken immediately. The Construction QA Officer, in consultation with the ~~QC officer~~Lead, QC Embankment Construction, shall then evaluate the accuracy of the QC sampling and testing and, if necessary, provide for improved sampling and testing procedures and closer inspection and control. Record findings of the quality assurance sampling in the "Daily QA Report".
PLACEMENT: Filter zone material will be placed over the radon barrier. ~~The thickness of the filter zone layer for the LLRW embankments shall be as specified on the currently approved engineering drawings 10014.~~ The thickness of the filter zone layer for the 11e.(2) embankment shall be as specified on the currently approved engineering drawings 9420-4, 9420-5, and 9420-6. Filter zone material shall be handled in such a manner as to prevent contamination from waste material and segregation of finer materials.	Observe the placement of the filter zone material. Ensure that soil fines are not concentrated in localized areas. If soil fines are concentrated in localized areas, the project manager shall be directed to evenly distribute the fines or to remove them. Record corrective actions (where required) in the "Daily Construction Report".	Verify that QC personnel observe the placement of the filter zone material such that soil fines are not concentrated in localized areas.
SNOW REMOVAL: When filter zone material is to be placed and the work area is covered with snow, the snow must be removed.	Observe that snow is removed. Advise the project manager of any deficiencies. ~~Construction may not continue without taking corrective actions to remove the snow.~~ Record corrective actions (where required) in the "Daily Construction Report".	Verify that snow removal is being documented.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
FINAL GRADING: Thickness for the lift will be established by installing grade poles on at least a 50" grid and at all control points. The grade poles shall consist of PVC pipe (approximately ½-inch diameter) with surveyors ribbon (or other distinguishable markings) attached to the appropriate lift thickness. The poles shall be held in place by placing the filter rock adjacent to the base of the grade pole to secure it in a vertical position (long axis of the grade pole perpendicular to the radon barrier surface). With the grade pole marked at the appropriate thickness and secured at the appropriate locations, the filter rock may be placed throughout the project area. The base of the grade poles shall rest on the surface of the radon barrier and therefore will not damage the radon barrier surface. After the grade has been checked and approved by QC personnel, the grade poles shall be removed from the filter zone placed directly above the radon barrier.	Verify that the grade poles are marked at the appropriate depth to establish grade for the layer that will be placed. Observe the installation of some of the grade poles to ensure that the installation method has been followed and verify that the grade poles have not penetrated or damaged the surface of the radon barrier. Verify the required grade is achieved at all control points throughout the placed filter rock in the project area. Rework and re-verify areas not meeting the specified grade. Ensure all grade poles have been removed following verification of grade. Document all inspections and corrective actions, where required, on the "Daily Construction Report".	Review documentation for final grading.

WORK ELEMENT - ~~SACRIFICIAL SOIL~~FROST PROTECTION PLACEMENT

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the Class A West embankment.		
PLACEMENT: ~~Sacrificial~~ Bankrun borrow material ~~soil~~ will be placed over the radon barrier ~~filter~~ zone as specified on currently approved engineering drawings 10014. Bankrun borrow material ~~Sacrificial soil~~ shall be handled in such a manner as to prevent contamination from waste material and segregation of finer materials.	Observe the placement of the ~~sacrificial soil~~bankrun borrow material. ~~Ensure that fines are not concentrated in localized areas. If fines are concentrated in localized areas, the project manager shall be directed to evenly distribute the fines or to remove them.~~ Record observations and corrective actions (where required) in the "Daily Construction Report".	Verify that QC personnel observe the placement of the sacrificial soil such that fines are not concentrated in localized areas.
GRADATION: Gradation of the bankrun borrow ~~sacrificial soil~~ material shall be ~~as specified on the currently approved engineering drawings 10014.~~ 16" minus material.	Periodically observe the production of bankrun material to verify the removal of rock greater than 16". In addition, perform a minimum of one test per change in soil type by ASTM D 2488. Record observations and corrective actions (where required) in the "Daily Construction Report".~~If material is to be stockpiled, perform gradation testing at a rate of one test per 2,500 cubic yard stockpile. If material is transferred directly to the cell from the production plant, perform at least one test per source per day material is placed, or at least one test per 2,500 cubic yards. In addition, perform a minimum of one test per change in soil type by ASTM D 2488. Record the location of all samples in the "Sampling Log".~~ ~~a. Approve material for use as sacrificial soil which meet the specified gradation.~~ ~~b. Material not meeting the specified gradation can not be used.~~	Verify the frequency of laboratory tests and compliance of test results.
SNOW REMOVAL: When ~~sacrificial soil~~ bankrun borrow material is to be placed and the work area is covered with snow, the snow must be removed.	Observe that snow is removed. Advise the project manager of any deficiencies. ~~Construction may not continue without taking corrective action to remove the snow.~~ Record corrective actions (where required) in the "Daily Construction Report".	Verify that snow removal is being documented as per DRC requirement.
FINAL GRADING: Thicknesses for the lift will be	Verify the required grade is achieved at all control	Review the documentation for final grading.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
established by installing grade poles on at least a ~~50~~70" grid and at all control points or by GPS survey. The grade poles must be marked at the appropriate depth to establish grade. After the grade has been checked and approved by QC personnel, the grade poles shall be removed.	points. Rework and re-verify areas not meeting the specified grade. Visually inspect for rock greater than 16" during lift placement. Mark oversized rock for removal and verify removal. Record observations and corrective actions (where required) in the "Daily Construction Report".	

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the ~~C Class A West and~~ 11e.(2) embankment~~s~~.		
~~**QUALITY OF ROCK:** The rock shall have a "Rock Quality" score of at least 50 based on the following tests: Specific Gravity (ASTM C-128), Absorption (ASTM C-127), Sodium Soundness (ASTM C-88), and L.A. Abrasion (ASTM C-131 or ASTM C-535). The procedures for scoring "Rock Quality" are found in Appendix C.~~	~~As described in NUREG-1623, appendix F, perform at least one petrographic examination for each rock source in accordance with ASTM C-295. If a combination of limestone, sandstone, and igneous rock is found for a source, percentages of each type of material shall be determined for scoring.~~ ~~Record the location of all collected samples in the "Sampling Log". Test rock at a rate of one set of test for every 10,000 cubic yards of rock.~~ ~~a. Approve rock for use in the rock erosion barrier which meet the specifications for rock quality.~~ ~~b. Rock not meeting the specifications for rock quality can not be used.~~	~~Verify the frequency of laboratory quality control tests and compliance of test results.~~ ~~Perform quality assurance testing at a minimum of one set of tests per 100,000 cubic yards of rock. A minimum of one set of tests is required each year that filter zone is placed. Record the samples on the "Sampling Log". Promptly report results to the Construction QA Officer so that a comparison of QA and QC testing results can be made. The Construction QA Officer, in consultation with the QC officer, shall be responsible for determining the adequacy of correlation and documentation of the rationale used to determine adequacy. If the correlation is not adequate, new QC and QA samples shall be taken immediately. The Construction QA Officer, in consultation with the QC officer, shall then evaluate the accuracy of the QC sampling and testing and, if necessary, provide for improved sampling and testing procedures and closer inspection and control. Record findings of the quality assurance sampling in the "Daily QA Report".~~
GRADATION: ~~Gradation of the rock for the LLRW embankments shall be as specified on the currently approved engineering drawings 10014.~~ Gradation of the rock (top slope and side slope) for the 11e.(2) embankment shall be as specified on the currently approved engineering drawing 9420-4. Gradation for the Ditch Rock (Class A West) shall be well graded rock with 100% passing a 9" screen, 50% passing a 6" screen and no more than 10% passing a 0.75" screen.	Perform gradation testing, in accordance with ASTM D-5519 or C-136, at a rate of one test per 10,000 cubic yards. Record the location of all samples in the "Sampling Log". ~~a. Approve rock for use in the rock erosion barrier which meet the specified gradation.~~ ~~b. Rock not meeting the specified gradation can not be used.~~	Verify the frequency of laboratory quality control tests and compliance of test results. Perform quality assurance testing at a minimum of one set of tests per 100,000 cubic yards of rock. A minimum of one set of tests is required each year that filter zone is placed. Record the samples on the "Sampling Log". Promptly report results to the Construction QA Officer so that a comparison of QA and QC testing results can be made. The Construction QA Officer, in consultation with the ~~QC officer~~Lead, QC Embankment Construction, shall be responsible for

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
		determining the adequacy of correlation and documentation of the rationale used to determine adequacy. If the correlation is not adequate, new QC and QA samples shall be taken immediately. The Construction QA Officer, in consultation with the ~~QC officer~~Lead, QC Embankment Construction, shall then evaluate the accuracy of the QC sampling and testing and, if necessary, provide for improved sampling and testing procedures and closer inspection and control. Record findings of the quality assurance sampling in the "Daily QA Report".
PLACEMENT: 11e.(2): Rock erosion material will be placed over the filter zone. Thickness of rock erosion barrier shall be 18 inches inside the centerline of the perimeter ditch and 12 inches outside the centerline of the perimeter ditch. Rock erosion material shall be handled in such a manner as to prevent contamination from waste material and segregation of finer materials. Class A West: Ditch riprap material will be placed as specified on currently approved engineering drawings 10014.	Observe the placement of the ~~filter zone material~~rock. Ensure that soil fines are not concentrated in localized areas. If soil fines are concentrated in localized areas, the project manager shall be directed to evenly distribute the fines or to remove them. Record corrective actions (where required) in the "Daily Construction Report".	Verify that QC personnel observe the placement of the filter zone material such that soil fines are not concentrated in localized areas.
SNOW REMOVAL: When rock erosion barrier material is to be placed and the work area is covered with snow, the snow must be removed.	Observe that snow is removed. Advise the project manager of any deficiencies. ~~Construction may not continue without taking corrective action to remove the snow.~~ Record corrective actions (where required) in the "Daily Construction Report".	Verify that snow removal is being documented as per DRC requirement.
FINAL GRADING: Thickness for the lift will be established by installing grade poles on at least a ~~50~~70' grid and at all control points or by GPS survey. The grade poles shall consist of PVC pipe (approximately ½-inch diameter) with surveyor ribbon (or other distinguishable markings). The grade poles must be marked at the appropriate depth to establish grade.	Verify the required grade is achieved at all control points. Rework and re-verify areas not meeting the specified grade. Document all inspections and corrective actions, where required, on the "Daily Construction Report".	Review the documentation for final grading.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
After the grade has been checked and approved by QC personnel, the grade poles shall be removed.		
NOTICE OF COVER CONSTRUCTION: Provide written notice of the completion of cover construction to the DRC within 30 days of completion of each phase of cover construction in the "cut and cover" operation.	Verify the DRC has been notified of completion of cover construction within 30 days of completion of each phase of cover construction.	Verify the DRC has been notified of completion of cover construction within 30 days of completion of each phase of cover construction.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the Class A West embankment.		
NATURAL CLAY MIXTURE: Satisfactory material shall be defined as CL, ML and CL-ML soils based on the Unified Soil Classification.	Perform laboratory classification tests at a rate of 1 test per lot prior to use of material. A lot is defined as a maximum of 5,000 cubic yards (placed) of specified material type. Record the location of the classification sample on the "Sampling Log".	Verify the frequency of laboratory tests and compliance of test results.
PLACEMENT: Evaporative zone material will be placed over the frost protection zone as specified on currently approved engineering drawings 10014. Evaporative zone material shall be handled in such a manner as to prevent contamination from waste material.		
LIFT THICKNESS: The evaporative zone material may be placed in a single lift or multiple lifts, without a maximum loose lift thickness. Thickness for the lift will be established by installing grade poles on at least a 70-foot grid and at all control points. The grade poles must be marked at the appropriate depth to establish the grade. After the grade for the lift has been checked and approved by QC personnel, the grade poles shall be removed. **- OR –** Perform a survey using GPS to determine lift thickness. There is not a compaction (density) requirement.	Verify that the required grading tolerance is achieved as follows: a. Ensure that the required frequency for placement of grade poles has been met. b. Compare soil level with the marked level on the grade poles. c. Use a string line where necessary between poles to check for high or low spots. d. Define out of specification areas and advise the project manager to rework those areas. e. Review areas reworked and approve areas meeting criteria. f. Continue "b" through "d" above until all areas meet criteria. g. Indicate areas meeting criteria in the "Embankment Construction Lift Approval Form". **- OR –** a. Verify GPS equipment calibration. b. Verify correct set-up and operation of GPS equipment.	Verify the frequency of laboratory tests and compliance of test results.

Formatted: Font: Not Bold

Formatted: Font: Not Bold

Formatted: Font: Not Bold

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
LIFT BONDING: The lifts of evaporative material shall be bonded by providing a rough upper surface on the underlying layer of evaporative material. The surface should have changes in grade of approximately one inch or more at a rate of two per linear foot.	Verify that there are adequate changes in grade by placing a straight edge at least two feet long on the surface. Count the number of points approximately one inch or more below the straight edge.	Verify the frequency of measurements and compliance of test results.
SNOW REMOVAL: When evaporative zone material is to be placed and the work area is covered with snow, the snow must be removed.	Observe that snow is removed. Advise the project manager of any deficiencies. Record corrective actions (where required) in the "Daily Construction Report".	Verify that snow removal is being documented as per DRC requirement.
FINAL GRADING: Thicknesses for the lift will be established by installing grade poles on at least a 70" grid and at all control points or by GPS survey verification. The grade poles must be marked at the appropriate depth to establish grade. After the grade has been checked and approved by QC personnel, the grade poles shall be removed. Final grade shall be from grade to 0.2 ft above grade.	Verify the required grade is achieved at all control points. Rework and re-verify areas not meeting the specified grade.	Review the documentation for final grading.

Formatted: Font: Not Bold

Formatted: Font: Not Bold

Formatted: Font: Not Bold

Formatted: Font: Not Bold

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the Class A West embankment.		
MATERIAL: Satisfactory surface material shall be defined as CL, ML, and CL-ML soils based on the Unified Soil Classification.	Perform laboratory classification tests at a rate of 1 test per lot prior to use of material. A lot is defined as a maximum of 5,000 cubic yards (placed) of specified material type. Record the location of the classification sample on the "Sampling Log".	Verify the frequency of laboratory tests and compliance of test results.
Gravel admixture shall meet the requirements of the Quality of Rock specification as described in Work Element-General Requirements. The gravel admixture shall be well graded gravel with 100% passing a 3" screen and less than 10% passing a 0.75" screen.	Perform gradation testing (ASTM C136) at a frequency of 1 test per 5,000 cubic yards of gravel. In addition, perform a minimum of one gradation test (ASTM C136) per change in soil type by. Record observations and corrective actions (where required) in the "Daily Construction Report".	
PROTECTION: The surface material shall be handled in such a manner as to prevent contamination with radioactive waste material or other deleterious material.	Visually check surface materials for contamination by foreign materials. Remove surface materials which have been contaminated above the specified requirements. Document corrective actions (where required) on the "Daily Construction Report".	Verify that the surface layer material is being inspected for contaminates and that corrective actions (if required) are properly documented.
PROCESSING: These procedures may be used to provide suitable material for construction of the surface layer. 1. Apply gravel to surface material at a rate determined by the ~~production engineer~~Manager, Engineering and Maintenance to arrive at a volumetric mixture of 15% gravel for application to the Embankment"s top slope. 2. Apply gravel to surface material at a rate determined by the ~~production engineer~~Manager, Engineering and Maintenance to arrive at a volumetric mixture of 50% gravel for application to the Embankment"s side slope. 3. Mix the gravel thoroughly into the soils by tilling	Measure the mixing areas and verify that the application rate of the gravel is equal to the rate determined by the ~~production engineer~~Manager, Engineering and Maintenance. Record the size of the mixing areas and the amount of gravel applied on the "Embankment Construction Lift Approval Form".	Verify that the size of the mixing areas and the amount of gravel applied have been properly documented.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
or similar action. xxxxx		

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the Class A West embankment.		
QUALITY OF MATERIAL: Surface material shall be prepared according to Work Element – Surface Material Preparation.		
PLACEMENT: Top- and side-slope surface zone material will be placed over the evaporative zone as specified on currently approved engineering drawings 10014. Surface zone material shall be handled in such a manner as to prevent contamination from waste material and segregation of finer materials.		
LIFT THICKNESS: The surface material may be placed in a single lift or multiple lifts, without a maximum loose lift thickness. Thickness for the lift will be established by installing grade poles on at least a 70-foot grid and at all control points. **- OR –** Perform a survey using GPS to determine lift thickness. After the grade for the lift has been checked and approved by QC personnel, the grade poles shall be removed.	Verify that the required grading tolerance is achieved as follows: a. Ensure that the required frequency for placement of grade poles has been met. b. Compare soil level with the marked level on the grade poles. c. Use a string line where necessary between poles to check for high or low spots. d. Define out of specification areas and advise the project manager to rework those areas. e. Review areas reworked and approve areas meeting criteria. f. Continue "b" through "d" above until all areas meet criteria. g. Indicate areas meeting criteria in the "Embankment Construction Lift Approval Form". **- OR –** a. Verify GPS equipment calibration, b. Verify correct set-up and operation of GPS equipment.	Verify the frequency of tests and compliance of test results.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SNOW REMOVAL: When evaporative zone material is to be placed and the work area is covered with snow, the snow must be removed.	Observe that snow is removed. Advise the project manager of any deficiencies. Record corrective actions (where required) in the "Daily Construction Report".	Verify that snow removal is being documented as per DRC requirement.
FINAL GRADING: Thicknesses for the lift will be established by installing grade poles on at least a 70" grid and at all control points or by GPS survey verification. The grade poles must be marked at the appropriate depth to establish grade. After the grade has been checked and approved by QC personnel, the grade poles shall be removed. Final grade shall be from grade to 0.2 ft above grade.	Verify the required grade is achieved at all control points. Rework and re-verify areas not meeting the specified grade.	Review the documentation for final grading.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the Class A West and 11e.(2) embankments.		
EXCAVATION: Excavation shall be made to the lines, grades, and dimensions prescribed in the approved plans. Prior DRC approval in writing must be obtained before diverting ditches from the current approved design. The purpose and duration of diversion shall be specified in any request to do so. Any over excavation shall be backfilled with select materials and compacted to 95 percent of standard Proctor. The uncompacted lift thickness shall not exceed 9 inches.	Provide daily observation of the cell excavation. Record observations and corrective actions (where required) on the "Daily Construction Report". In areas of over excavation, conduct in-place density test at a rate of one test per lot and record the results on the "Field Density Test" form. A lot is defined as a maximum of 10,000 square feet of a lift of a specified type of material. Test locations shall be chosen on the basis of random numbers. a. Approve lots which meet the specified compaction. b. Rework and retest lots not meeting the specified compaction. Proctors shall be performed at a rate of one test per 100,000 square feet for each material type. At least one proctor shall be performed for each material type. Record the location of the sample on the "Sampling Log".	Verify the frequency of laboratory tests and compliance of test results.~~Observe, at a minimum, five percent of the tests performed by the QC personnel to ensure that the tests and observations are being performed correctly. Verify that the tests are being performed at the correct frequency and that the documentation is being completed.~~
FINAL GRADING: Smooth roll the excavated surface to prepare for filter zone. Final grading of this surface shall be ±0.1 of a foot.	Inspect the surface for smoothness. Survey the surface on a 50 ft grid and at key points. Final survey measurements will be documented and provided to the ~~QC officer~~Lead, QC Embankment Construction and Construction QA Officer. ~~a. Indicate where the surface meets design line and grade.~~ ~~b. Rework and resurvey areas not meeting the specified grade.~~	Review the final survey data. Verify the frequency of the survey points.
FILTER ZONE AND ROCK EROSION BARRIER: The filter zone and rock erosion barrier shall be constructed in accordance with the specifications outlined under work elements "Filter	See work elements "Filter Zone" and "Rock Erosion Barrier".	See work elements "Filter Zone" and "Rock Erosion Barrier".

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
Zone" and "Rock Erosion Barrier".		
EROSION CONTROL FOR EXPOSED SOIL: If reviewed and approved drainage ditch soil surfaces are not covered by filter zone within 30 days of lift approval, the following erosion control repair measures shall apply.	Perform monthly inspections. Document the inspection as well as associated maintenance activities on the Daily Construction Report.	
Semi-annually, inspect exposed drainage ditch soil surfaces for evidence of erosion. Rivulet or gullied areas wider than 6 inches or deeper than 6 inches require maintenance to fill the rivulet or gully and restore the area to design grade. Soils imported as fill shall meet the requirements of "Drainage Ditch Imported Borrow", above. Maintenance shall be performed within 30 calendar days when needed, unless additional time is approved by DRC.		
Erosion control blankets, mats, or fiber mulch may be used, in accordance with the manufacturer"s instructions, for erosion prevention. DRC shall be notified at least 48 hours prior to deployment of erosion control blankets, mats, or fiber mulch. If used, such erosion control materials shall be removed prior to filter zone construction.		
RADIOLOGICAL SAMPLING FOR EXPOSED SOIL: If reviewed and approved drainage ditch soil surfaces are not covered by filter zone within 30 days of lift approval, the area shall either (a) be sampled and radiologically released in accordance with the Environmental Monitoring Plan; or (b) have a minimum of 6 inches of clay removed and replaced prior to filter zone placement. Under option (b), no environmental sampling is required.	Coordinate sampling and analysis with environmental personnel. Attach a copy of the release report to the lift approval documentation.	

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the Class A West and 11e.(2) embankments.		
MATERIAL: The material used to construct the road shall conform to the following specification: Sieve Size — % Passing 1-1/2" — 100 3/4" — 75-95 1/2" — 62-82 # 4 — 38-58 # 16 — 16-36 # 200 — 0-18	Perform laboratory classification tests at a rate of 1 test per lot prior to use of material in the road. A lot is defined as a maximum of 3,000 cubic yards (compacted) of specified material type. Record the location of the classification sample on the "Sampling Log". ~~a. Approve lots (which meet the specified classification) for use in the road.~~ ~~b. Lots not meeting the specified classification can not be used.~~	Verify the frequency of laboratory tests and compliance of test results.
SUBSURFACE PREPARATION: The subsurface will be scarified and re-compacted to at least 95 percent of a standard proctor (ASTM D-698).	Conduct in-place density tests at a rate of one test per lot and record the results on the "Field Density Test" form. A lot is defined as 200 cubic yards (compacted) of material. The test location shall be chosen on the basis of random numbers. ~~a. Approve lots which meet the specified compaction.~~ ~~b. Rework and retest lots not meeting the specified compaction.~~ Proctors shall be performed at a rate of one test per borrow lot. A borrow lot is defined as 3,000 cubic yards (compacted) or less of a specific material type. Record the location of the Proctor sample on the "Sampling Log".	Verify the frequency of tests and compliance of test results.~~Observe, at a minimum, five percent of the tests performed by the QC personnel to ensure that the tests and observations are being performed correctly. Verify that the tests are being performed at the correct frequency and that the documentation is being completed.~~
ROAD THICKNESS: The compacted road shall be 12 inches thick plus or minus 0.2 feet.	Measure the thickness of the road at both edges of the road at no greater than 50 foot intervals. Record the results on the "Lift Approval Form". ~~a. Approve section of the road which meet the specified thickness.~~ ~~b. Rework and retest sections not meeting the required thickness.~~	Verify the frequency of tests and compliance of test results.~~Observe, at a minimum, five percent of the measurements performed by the QC personnel to ensure that the measurements are being performed correctly. Verify that the measurements are being performed at the correct frequency and that the documentation is being completed.~~

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
COMPACTION: The road will be compacted to at least 95 percent of standard Proctor (ASTM D-698).	Conduct in-place density tests at a rate of one test per lot and record the results on the "Field Density Test" form. A lot is defined as 200 cubic yards (compacted) of material. The test location shall be chosen on the basis of random numbers. ~~a. Approve lots which meet the specified compaction.~~ ~~b. Rework and retest lots not meeting the specified compaction.~~ Proctors shall be performed at a rate of one test per borrow lot. A borrow lot is defined as 3,000 cubic yards (compacted) or less of a specific material type. Record the location of the Proctor sample on the "Sampling Log".	Verify the frequency of tests and compliance of test results.~~Observe, at a minimum, five percent of the tests performed by the QC personnel to ensure that the tests and observations are being performed correctly. Verify that the tests are being performed at the correct frequency and that the documentation is being completed.~~

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the Class A West and 11e.(2) embankments.		
MATERIALS: All burial embankments and waste storage areas, including immediately adjacent drainage structures, shall be controlled areas, surrounded by six foot high, chain link fence. All permanent fence shall be chain link, six feet high, topped with three strand barbed wire, top tension wire and twisted selvedge. Zinc coated chain link fence shall meet the requirements of ASTM A-392 with Class I coating. Aluminum Coated fence fabric shall meet the requirements of ASTM A-491. Fence Fabric: Fence fabric shall be made of 0.148 inch or larger diameter wire. The fabric shall have twisted selvedge. Wire and Ties: Tension wires shall be 0.177 inch or larger diameter spiral type. Ring ties for tying fabric to supporting members shall be made of 0.148 inch or larger diameter wire. Wire ties for tying fabric to support members shall be made of 0.12 inch or larger diameter wire. Ties to line posts shall be made of 0.192 inch or larger diameter wire. All wire shall have Class II coating as specified by ASTM A-116. Barbed Wire: Barbed wire on zinc coated fence shall meet the requirements of ASTM A-121, including a Class I zinc coating. Barbed wire shall be made of 0.099 inch or larger diameter wire with 0.080 inch or larger diameter wire four point barbs on 5 inch centers. When aluminum or aluminum coated fence is used, aluminum coated barbed ware shall be used meeting the requirements of ASTM A-0491. The support arm on the fence for the barbed wire shall be capable of	Obtain a copy of the manufacture's specification for the materials to be used in the construction of the fence. Verify that the materials meet the required specifications. Document materials acceptance on the "Daily Construction Report".	Verify that the materials to be used in the construction of the fence have been approved.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
supporting a 200 pound vertical load at the end of the arm without permanent deflection. <u>Posts</u>: Line posts may be "H" section or pipe. The minimum strength requirements are as follows: 1. Load at top: 600 lbs. 2. Maximum Moment: 1200 ft-lbs. 3. Maximum permanent set: 0.010 in. "H" posts shall be coated in accordance with the requirements of ASTM A-123. Pipe posts shall conform to the requirements of ASTM A-120 (Schedule 40) for zinc coated pipe. All pipe posts shall be fitted with a weather resistant tip, designed to fit securely over the post, and carry an apron around the outside of the post. <u>Fittings</u>: Fittings shall be malleable cast iron or pressed steel and be coated in accordance to ASTM A-123. <u>Gates</u>: Gate posts and frames shall be constructed of the sizes shown on the approved plans for the various gate dimension. The corners of the gate frame shall be fastened together with pressed steel or malleable iron corner ells riveted or welded in accordance with the plans. Welded steel gate frames shall be galvanized after fabrication in accordance with the provision of ASTM A-123. Chain link fence fabric for covering the gate frames shall be the same as required for the fence. Each gate shall be furnished complete with necessary galvanized hinged, latch, and drop bar locking device for the type of gate used on the project.		
INSTALLATION: The steel posts shall be set true to line and grade in concrete bases. The distances between posts shall be uniform and not exceeding 10 feet. Fence corners and ends shall be constructed in accordance with Detail A on sheet L9 of the approved engineering	Verify that the fence is constructed in the location shown on the plans and in accordance with sheet L9. Document any problems in the "Daily Construction Report".	Verify that the fence has been inspected and problems have been properly documented.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
drawings. Gates shall be constructed in accordance with Detail B on sheet L9 of the approved engineering drawings.		
A minimum of 6 inches of concrete shall be provided below the bottom of each post. End posts, pull posts, corner posts, and gate posts shall have a concrete base at least 12 inches in diameter. Bases for line posts shall be at least 10 inches in diameter.	Spot check the depth and diameter of the post holes to verify that the holes meet the required specification. Document any problems in the "Daily Construction Report".	~~Verify that the fence has been inspected and problems have been properly documented.~~
Pull posts shall be provided at 500 feet maximum intervals. Changes in line of 30 degrees or more shall be considered as corners.	Inspect the fence for proper placement of pull and corner posts. Document any problems in the "Daily Construction Report".	~~Verify that the fence has been inspected and problems have been properly documented.~~
The fabric shall be stretched taut, and securely fastened to the posts. Fastening to end, gate, corner, and pull posts shall be with stretcher bars and metal bands, spaced at one foot intervals. The fabric shall be cut and each span fastened independently at all pull and corner posts. Fastening to line posts shall be with tie wire, metal bands, or other approved method at 14 inch intervals. The top edge of fabric shall be attached to the top rail or tension cable at approximately 24 inch intervals. The bottom tension wire is required and shall be attached to the fabric with tie wires at 24 inch intervals and shall be secured to the end or pull posts with brace bands.	Inspect the fencing fabric to verify that it has been installed in accordance with the specifications. Document any problems in the "Daily Construction Report".	~~Verify that the fence has been inspected and problems have been properly documented.~~

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the LARW, Class A West, 11e.(2), and Mixed Waste embankments.		
SETTLEMENT MONUMENTS: Settlement monuments constructed before January 1, 2005 consist of #4 or greater rebar that is approximately 3 feet long, secured in place using a sand-cement grout. Grout shall consist of approximately 0.5 cubic foot of low slump fiber reinforced grout per monument. The top of the rebar shall be placed roughly even with the top of the riprap rock. Each monument shall be permanently labeled, flagged, and documented on a reference drawing.		
Settlement monuments constructed after January 1, 2005 shall consist of approximately 4-foot long #5 or greater rebar that is welded to a metal plate. The metal plate shall be approximately 18 inches square with a thickness of 3/16 inch to 1/4 inch. The rebar shall be sized to extend no more than 6 inches above the rock erosion barrier surface. The settlement plate shall be placed on top of the final approved radon barrier (Class A and LARW cells) or on top of the final approved geosynthetics layer (Mixed Waste) and then secured by the rock cover layers as they are built. Each monument shall be permanently labeled, flagged, and documented on a reference drawing.	Inspect settlement monuments for compliance with the specification prior to installation. Observe installation to ensure that the radon barrier or geosynthetic layer is not damaged.	Perform a surveillance of monument installation activities.
SETTLEMENT MONUMENT PLACEMENT: Settlement monuments constructed prior to January 1, 2005 are set at 100- and 200-foot grids, as indicated on Figure 1.		
Settlement monuments constructed after January 1, 2005 on the LARW, Class A, Mixed Waste, 11e.(2), and Class A North embankments shall be placed at the	Perform and document a post-construction survey of the placed settlement monument.	Verify that surveys have been performed.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
locations identified on Figures 1, 2, 3, and 4, respectively.		
SURVEY REQUIREMENTS: Surveys shall be performed with GPS or approved equivalent equipment. Tolerance shall be no more than ± 0.1 feet.	Calibrate and operate survey equipment in accordance with the manufacturer"s recommendations	
SURVEY INTERVAL: Settlement monuments constructed before January 1, 2005 shall be surveyed prior to grouting and again afterwards within 30 days of grouting for coordinate verification. Annual surveys of the existing monuments shall continue for a minimum of 5 years from the date of grouting. In cases where monuments are reset, measurements shall continue at the specified frequency continuing from the last reliable measurement. Weather conditions at the time of the survey and a discussion of the potential for frost to be present shall be documented in the survey report.	Perform and document the required surveys. Provide survey data to the ~~Director of Engineering~~Manager, Engineering and Maintenance.	Verify that monument surveys are completed as required.
Settlement monuments constructed after January 1, 2005 shall be set and surveyed for initial location within 30 days of the completion of final cover construction. New monuments shall be surveyed again at 2, 4, and 12 months (± 10 calendar days) after the initial survey. Thereafter, monuments shall be surveyed once annually between October 1 and December 31 until a minimum of 5 years after initial placement. Weather conditions at the time of the survey and a discussion of the potential for frost to be present shall be documented in the survey report.	Perform and document the required surveys. Provide survey data to the ~~Director of Engineering~~Manager, Engineering and Maintenance.	Verify that new monument surveys are completed as required.
During the annual survey, perform a visual inspection of the completed cover to evaluate potential areas of settlement that may not be captured by the settlement monument network.	Document observations made during the inspection, and denote areas where differential settlement may be occurring. Provide documentation to the ~~Director of~~	Perform a surveillance of visual inspection activities.

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
REPORTING: Settlement monitoring data shall be summarized and evaluated in the annual as-built report for each embankment. Calculate total and differential settlement for each settlement monument against the most recent measurement and against the baseline monument location. Total settlement of more than 1.5 feet at any settlement monument or differential settlement of more than 1.0 percent slope between adjacent monuments shall be reported to and evaluated by the ~~Director of Engineering~~Manager, Engineering and Maintenance within 30 days of measurement and discussed in the annual as-built report. Any failure in the settlement monuments shall be documented. A replacement monument shall be reset as close as possible to the previous location, surveyed, and documented.	~~Engineering~~Manager, Engineering and Maintenance. Provide settlement monitoring data to the ~~Director of Engineering~~Manager, Engineering and Maintenance.	

WORK ELEMENT – ANNUAL AS-BUILT REPORT

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
SCOPE: This work element applies to the LARW, Class A West, and 11e.(2) embankments.		
AERIAL SURVEY REQUIREMENTS: An aerial survey of the disposal cells and areas within 100 feet of the respective embankment waste limits ~~permitted area~~ shall be performed between August 15 and September 15 each year.	Review the aerial survey report for compliance with this specification.	
The aerial survey shall be performed by a registered land surveyor.		
Survey control points shall be identified in the survey report.		
Survey tolerance shall not exceed ± 0.75 ft. Actual tolerance of the survey shall be stated in the report.		
ANNUAL AS-BUILT VOLUMES: Calculate embankment volumes from the aerial survey data using AutoCAD or approved equivalent equipment.		
Provide plan view and cross-sections of the as-built embankment based on the aerial survey data. Include in each cross-section the profile of the maximum authorized waste elevation. Also include in each cross-section the elevation profile of the top of the uppermost approved waste lift (as of the time the lift was approved). Provide a clear key to each cross-section to define the meaning of each symbol and line used.		
For each embankment, report the design capacity, capacity used to date, and remaining capacity, including overburden. Compare remaining capacity with the surety reserve capacity for each embankment. Report any volume of waste that is placed over the		

SPECIFICATION	QUALITY CONTROL	QUALITY ASSURANCE
design top of waste.		

TABLE 2

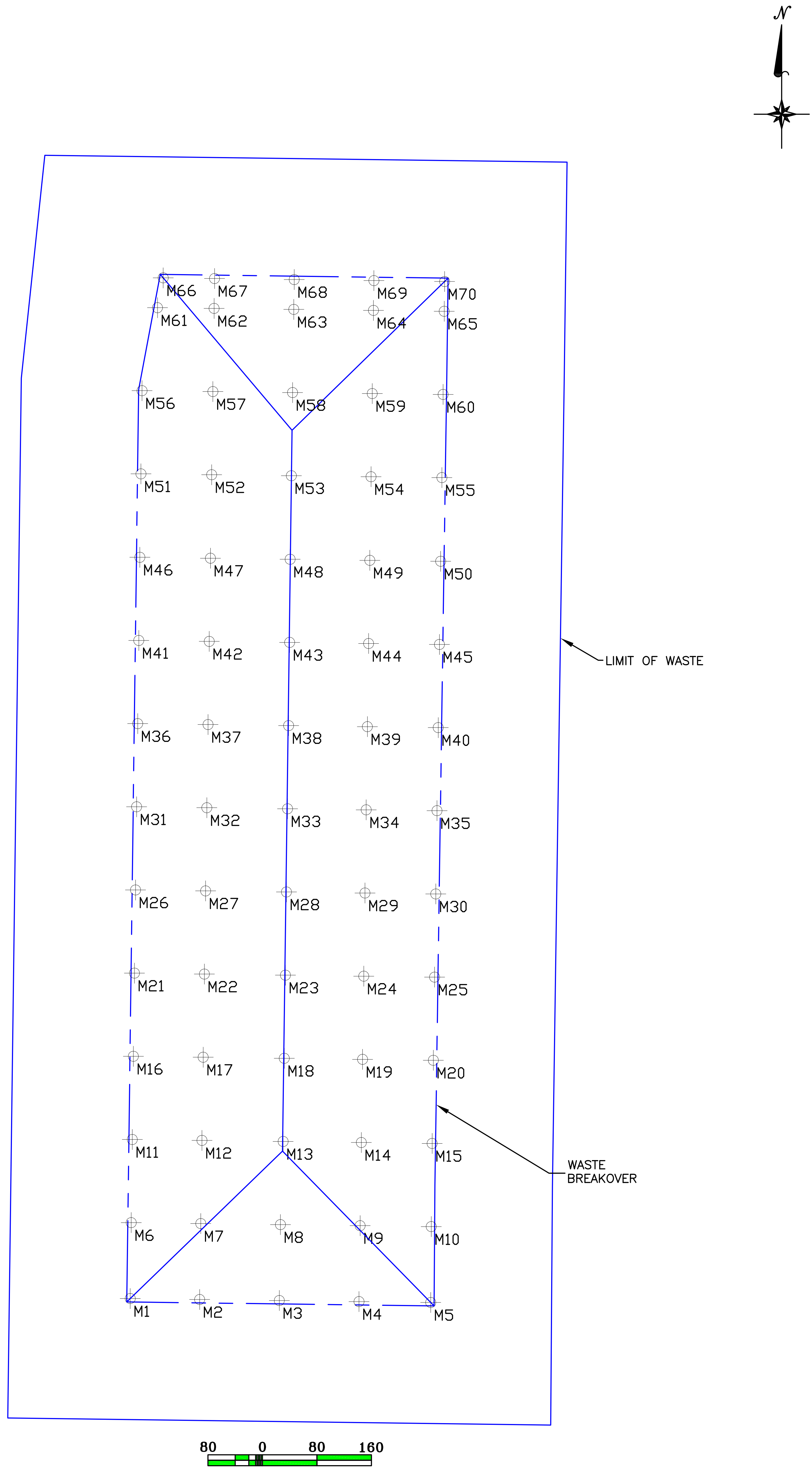
MATERIAL SPECIFICATIONS FOR PORTLAND CEMENT CLSM

PROPERTY	TEST METHOD	MINIMUM	MAXIMUM	FREQUENCY
WET UNIT WEIGHT	ASTM D6023	100 lbs/ft^3	None	1 Test/100 Cubic Yards/Lift
SLUMP	Energy*Solutions* Slump Test (Appendix B)	8 inches	None	1 Test/100 Cubic Yards/Lift
-OR-				
FLOW	Energy*Solutions* Efflux Test (Appendix B)	NA	26 seconds	1 Test/100 Cubic Yards/Lift
-OR-				
FLOW CONSISTENCY	Flow Consistency (ASTM D6103)	8 inches	None	1 Test/100 Cubic Yards/Lift
28 DAY COMPRESSIVE STRENGTH	ASTM D4832	150 psi	None	1 Test/2000 Cubic Yards Placed at 28 days
CEMENT	None	50 lbs for each cubic yard of CLSM	None	Inspect each load ticket prior to pour
POZZOLAN	None	None	375 lbs for each cubic yard of CLSM	Inspect each load ticket prior to pour
AGGREGATE SIZE	Gradation Test Certificate from Batch Plant	<u>Percent Passing</u> <u>Sieve</u> 100 3/8" 60 #8	<u>Percent Passing</u> <u>Sieve</u> 30 100	1 Test/Pour day if material is received form exterior batch plant or 1 certification/stockpile if material is received from site batch plant. **Gradation certificate shall be received by QC Technician prior to pouring any CLSM**

TABLE 3

MATERIAL SPECIFICATIONS FOR FLY ASH CLSM

PROPERTY	TEST METHOD	MINIMUM	MAXIMUM	FREQUENCY
WET UNIT WEIGHT	ASTM D6023	100 lbs/ft^3	None	1 Test/100 Cubic Yards/Lift
FLOWABILITY	ASTM D6103	NA	11-inch spread	1 Test/100 Cubic Yards/Lift
28 DAY COMPRESSIVE STRENGTH	ASTM D4832	150 psi	None	1 Test/2000 Cubic Yards Placed at 7 days 1 Test/2000 Cubic Yards Placed at 28 days
TYPE F FLY ASH	None	40.5% of design mix	50.5% of design mix	Inspect each load ticket prior to pour
TYPE C FLY ASH	None	25.1% of design mix	35.1% of design mix	Inspect each load ticket prior to pour
WATER	None	23.0% of design mix	25.4% of design mix	Inspect each load ticket prior to pour
ACTIVATORS	None	0.19% of design mix	0.21% of design mix	Inspect each load ticket prior to pour



MIXED WASTE SETTLEMENT MONUMENTS

Monuments shall be placed within a 18" radius of design location

FIGURE 3

REVISION 4

September 26, 2012

ENERGYSOLUTIONS

APPENDIX D

SWCA Alternative Cover Design Study

Vegetated Cover System for the Energy*Solutions* Clive Site:

Literature Review, Evaluation of Existing Data, and Field Studies Summary Report

Prepared for

Energy*Solutions*

Prepared by

SWCA Environmental Consultants

August 2012

VEGETATED COVER SYSTEM FOR THE ENERGY*SOLUTIONS* CLIVE SITE: LITERATURE REVIEW, EVALUATION OF EXISTING DATA, AND FIELD STUDIES SUMMARY REPORT

Prepared for

Energy*Solutions*
423 West 300 South, Suite 200
Salt Lake City, Utah 84101
Attn: Robert Sobocinski
(801) 303-0187

Prepared by

J. Hope Hornbeck
Project Manager

SWCA Environmental Consultants
257 East 200 South, Suite 200
Salt Lake City, Utah 84111
(801) 322-4307
www.swca.com

August 21, 2012

EXECUTIVE SUMMARY

Evapotranspiration (ET) covers are increasingly being employed as an alternative cover design for municipal solid waste and hazardous waste sites in arid and semiarid climates. Unlike conventional cover systems, which use materials with low permeability to limit movement of water into waste, ET cover systems minimize water percolation by storing and releasing water through evaporation from the soil surface and through transpiration from vegetation. The primary objective of ET cover systems is to use the water balance components of soil and vegetation to hold precipitation and release it through soil surface evaporation or transpiration without allowing water percolation into storage layers.

ET cover systems are desirable because they cost less to construct and maintain, and provide aesthetic benefits because they use native vegetation and materials. However, the ultimate goal of such systems is to prevent the movement or release of waste, and to prevent contamination of surface or groundwater. The use of ET cover systems for waste containment is relatively new. Since the amendment of the Resource Conservation and Recovery Act Subtitle D (40 Code of Federal Regulations § 258.60) in March 2004, ET cover systems and demonstration sites have been installed at hazardous and radioactive waste disposal facilities in the arid west: Hill Air Force Base (Utah), Monticello Mill Tailings (Utah), Los Alamos National Laboratory (New Mexico), Sandia National Laboratories (New Mexico), Sierra Blanca (Texas), Rocky Mountain Arsenal (Colorado), and the Hanford Site (Washington) (Rock et al. 2012). These facilities consist of research and demonstration ET cover systems and fully operational ET covers. In addition to these existing sites, ET cover systems have been proposed for the U.S. Ecology Nevada Site (Nevada), the Molycorp Tailings Facility (New Mexico), and Clean Harbors (Utah).

Energy*Solutions* is evaluating an ET cover system for its proposed Class A West embankment at the Clive Site, Utah. The ET cover system would use locally available soils and native vegetation and would be expected to naturally develop into a stable community that would endure for the 1,000-year life of the landfill cap. This type of cover design is expected to attract grazing and burrowing animals and to follow natural successional development to a climax natural biotic community, and could therefore increase the amount of bioturbation occurring on and around the cover relative to the existing conventional cover design. A literature review of published studies of operational and demonstration ET covers was conducted to identify regionally relevant design parameters and to identify site-specific data needs.

This report summarizes supporting literature on ET cover systems, and evaluates regionally relevant ET cover systems and demonstration sites that have published studies on the physical and biological processes that occur in different ET cover systems.

This report also includes a summary of the geology, climate, biogeography, and biological communities near the Clive Site; and the results of field studies conducted on and around the Clive Site to support the design of a site-specific ET cover design. The objective of field studies was to assess local ecological analogs to the Clive Site to identify the composition and density of biotic communities, assess bioturbation, and to assess soil characteristics and water and soil transport mechanisms.

Field studies were initiated on June 13, 2012, and completed on June 23, 2012. The results of field studies are as follows:

- Vegetation: Average plant species cover consisted of 14.3% black greasewood (*Sarcobatus vermiculatus*), 5.9% Sandberg bluegrass (*Poa secunda*), and approximately 3% cover each of shadscale saltbush (*Atriplex confertifolia*) and Mojave seablite (*Suaeda torreyana*). Fourwing saltbush (*Atriplex canescens*) and gray molly (*Bassia americana*) occurred in low densities with 1.6% and 1.3% cover, respectively. Ground cover was dominated by 79.2% average biological soil crust cover.

- Small Mammal Trapping: In all, 84 small mammals were captured during small mammal trapping, comprising 83 deer mice (*Peromyscus maniculatus*) and one kangaroo rat (*Dipodomys* sp.). Small mammals were concentrated in the northern portion of the study area, with exactly half (42/84 or 50%) of the total small mammal captures in Plots 12 and 13.
- Burrow Surveys: Burrows of deer mice, kangaroo rats, ground squirrels (*Spermophilus* spp.), and badgers (*Taxidea taxus*) were located in the study plots during the field studies.
- Ant Mound Surveys: Nineteen ant mounds were recorded and measured, with an average of 24 ant mounds per hectare. The average individual ant mound area estimate was approximately 1,900 square centimeters (cm^2), and the average ant mound volume estimate was 19,345 cm^3.
- Ant Mound Excavations: The average aboveground area and volume of the excavated ant mounds was 2,683 cm^2 and 28,348 cm^3, respectively. The belowground area of the excavated ant mounds was found to be sparsely distributed, with most of the ant nests within 0.6 meter (2 feet) of the surface.

Analyses of plant species cover, small mammal densities, animal burrow volumes, ant mound volumes, and soil chemistry and nutrition parameters identified several strong relationships between the variables. There were strong, positive relationships between total vegetation cover and mammal densities and burrow volumes. In contrast, there was no correlation between total vegetation cover and ant mound area or volume. There were also strong positive correlations between ant mound area and volume and cover of weedy species. This relationship was anecdotally observed in the 2010 study as well. There was a strong, negative correlation between ant mounds and soil silt, and somewhat strong negative correlations between animal densities and burrow volumes and soil clay content. High soil pH does not appear to be limiting for any of the native or weedy plant species that occurred in the plots. However, plant cover, particularly of shadscale saltbush, showed strong, negative correlations with high soil salinity.

The field study results point to several key design features for an ET cover system at the Clive Site:

- The plant species selected for the ET cover system should consist of native and desirable non-native, salt-tolerant shrubs and grasses.
- Although a vegetation community of sufficient diversity and density is desired to maximize transpiration from the soil, vegetation density was positively correlated with small mammal and burrowing activity. As such, bioturbation should be expected to increase with increasing vegetation cover.
- Small mammal activity should be expected to increase with a developing vegetation community that is established as part of an ET cover system. The field studies demonstrated that the density of small mammals and animal burrows increases with increasing vegetation cover.
- The presence of badgers and a large family of burrowing owls (*Athene cunicularia*) in the study plots indicates that the biota can potentially move large volumes of soil. A bioturbation barrier will be needed. Cover designs that maximize the depth of upper soil layers or that incorporate bioturbation barriers would also minimize penetration by ants into waste layers.
- Soil conditions on and near the Clive Site are typical of soils formed in arid environments. Soils were mostly silty clay loams with elevated pH and salinity and low organic matter. The soils collected in the study plot soils are not analogous to soils in the borrow units. For example, the following may be necessary: blending borrow soils to obtain the proper texture that allows for enough infiltration to support plants while avoiding deep infiltration and excessive runoff.

CONTENTS

APPENDICES

FIGURES

TABLES

INTRODUCTION

Energy*Solutions*' facilities at the Clive Site must meet regulatory requirements for containing waste and waste byproducts, prevent the infiltration of precipitation into final storage layers, and prevent the movement of waste into the surrounding environment. Waste products at the Clive Site are currently buried beneath an impermeable clay layer and capped with concrete riprap. Energy*Solutions* is evaluating an alternative ET cover system for its proposed Class A West embankment at the Clive Site, Utah. Permitting of an ET cover system will require that Energy*Solutions* provides scientifically rigorous data supporting the long-term functionality of such a system under expected and worst-case scenarios for the required 500–1,000-year functional life of the cap.

Evapotranspiration (ET) covers are increasingly being employed as an alternative cover design for municipal solid waste and hazardous waste sites in arid and semiarid climates. Unlike conventional cover systems, which use materials with low permeability to limit movement of water into waste, ET cover systems minimize water percolation by storing and releasing water through evaporation from the soil surface and through transpiration from vegetation. The primary objective of ET cover systems is to use the water balance components of soil and vegetation to hold precipitation and release it through soil surface evaporation or transpiration without allowing water percolation into storage layers.

ET cover systems are desirable because they cost less to construct and maintain, and provide aesthetic benefits because they use native vegetation and materials. However, the ultimate goal of such systems is to prevent the movement or release of waste, and to prevent contamination of surface or groundwater. The use of ET cover systems for waste containment is relatively new. Since the amendment of the Resource Conservation and Recovery Act Subtitle D (40 Code of Federal Regulations § 258.60) in March 2004, ET cover systems and demonstration sites have been installed at hazardous and radioactive waste disposal facilities in the arid west: Hill Air Force Base (Utah), Monticello Mill Tailings (Utah), Los Alamos National Laboratory (New Mexico), Sandia National Laboratories (New Mexico), Sierra Blanca (Texas), Rocky Mountain Arsenal (Colorado), and the Hanford Site (Washington) (Rock et al. 2012). These facilities consist of research and demonstration ET cover systems and fully operational ET covers. In addition to these existing sites, ET cover systems have been proposed for the U.S. Ecology Nevada Site (Nevada), the Molycorp Tailings Facility (New Mexico), and Clean Harbors (Utah).

Energy*Solutions* is evaluating an ET cover system for its proposed Class A West embankment at the Clive Site, Utah. The ET cover system would use locally available soils and native vegetation and would be expected to naturally develop into a stable community that would endure for the 1,000-year life of the landfill cap. This type of cover design is expected to attract grazing and burrowing animals and to follow natural successional development to a climax natural biotic community, and could therefore increase the amount of bioturbation occurring on and around the cover relative to the existing conventional cover design. A literature review of published studies of operational and demonstration ET covers was conducted to identify regionally relevant design parameters and to identify site-specific data needs.

ET cover systems are designed to store infiltrated water within a monolithic soil layer until it is removed by evaporation from the soil surface or through transpiration by vegetation. The proposed ET cover system would incorporate fine materials such as sand, silt, or clay to provide stability and protection from erosion, and to enhance ET relative to the existing design. The cover would incorporate some amount of coarse material to provide stability in the uppermost layers and to prevent burrowing animal access to waste or contaminated soils.

Small amounts of radiation may be absorbed by soils surrounding low-level radioactive waste. As such, soil turbation by plants and animals is a key consideration in the design of alternative cover systems, because bioturbation can transport buried waste to upper layers of the subsurface soil profile or to the soil surface. Studies of existing, traditional waste covers, and alternative cover systems indicate that ants, burrowing mammals, and deeply rooted plants are the primary biota of interest for movement and mixing of soils in arid ecosystems (Arthur et al. 1983; Arthur and Markham 1983; Cadwell et al. 1989; Smallwood et al. 1998; Mackay and Gaglio 1999; Hampton 2006). Ants and burrowing mammals provide constant mixing of the soil column, whereas plants can move buried wastes through root uptake and translocation of contaminants to various parts of the plant. Contaminants can also be transported by animal consumption of contaminated plants or by other means.

An ET cover system at the Clive Site would use locally available soils and native plant species that would be expected to naturally develop into a stable community that would endure for the life of the cap. Because alternative cover designs allow and potentially encourage plant growth to enhance ET and enhance stability, careful evaluation of the plant materials used for cap vegetation and the associated biotic community is required. This type of cover design is expected to attract grazing and burrowing animals, to follow natural successional development over the life of the cap, and could therefore increase the amount of bioturbation occurring on and around the cover relative to the current cover design.

In 2010, SWCA Environmental Consultants (SWCA) was contracted by Energy*Solutions* to assess soil bioturbation in biotic communities at and near the Clive Site. Five study plots were established: three on the Clive Site, and two off the Clive Site on lands administered by the Bureau of Land Management (BLM). These plots were selected to represent the range of existing biotic conditions at the Clive Site, and to represent potential biotic communities that could exist on the site a minimum of 1,000 years into the future. At each site, the following data were collected: ant diversity, nest size, and densities; plant species diversity, cover, and stem densities of grasses, forbs, shrubs, and trees in each vegetation association; and burrowing mammal diversity, burrow density, and estimates of soil excavation in each vegetation association. In addition to these data, site excavations were conducted at six locations on the Clive Site (Plots 3 and 4) to measure the maximum rooting depth and width of root masses of the dominant plant species at each site (SWCA 2010).

In March 2012, Energy*Solutions* retained SWCA to gather and summarize regional and site-specific data regarding the physical and biological processes that would occur in an alternative (ET) cover system. This report summarizes SWCA's review of supporting literature and existing vegetated cover systems and regional demonstration sites. Because the alternative cover performance timeframe is 500–1,000 years, climatic conditions significantly different than current climate in the region are not considered in this review.

Site-specific data from ecological analogs relevant to the Bonneville Basin and the Clive Site are also needed to support the design of an alternative cover system. This review includes a summary of additional data needed in support of a site-specific ET cover design. These data include site-specific scientific studies of local ecological analogs for climate, biotic communities, soils, bioturbation, and other water and soil transport mechanisms. Field studies to assess vegetation and animal diversity and densities, animal burrows and ant mounds, soils, and erosion mechanisms were conducted in June 2012.

Evapotranspiration Cover Systems

Final cover systems for waste landfills have relied on conventional designs that rely on a barrier layer to impede the downward percolation of precipitation and to minimize leaching of contaminants into groundwater (McGuire et al. 2009; Rock et al. 2012). Alternatively, ET cover systems are designed to take advantage of the ability of locally available soils and plants to store and release water through soil storage capacity and evaporation from the soil surface, and transpiration by vegetation (Hakonson 1997; Hauser et al. 2001; Dwyer 2003). ET cover systems are constructed of a uniform (monolithic) layer of soil, or monofill covers (Hauser 2009), or modified to provide a capillary break to impede the downward movement of water, or to provide layers that provide structural support or prevent burrowing by animals. There are numerous current publications that outline design requirements and considerations for ET cover systems (Hakonson et al. 1994; Gee et al. 1997, 1998; Benson et al. 2002; Albright et al. 2002, 2010; Hauser 2009; Environmental Protection Agency [EPA] 2011).

ET covers are increasingly being employed as an alternative cover design in arid and semiarid climates (Benson et al. 2005; EPA 2003). Because ET covers limit water percolation by storing water in upper soil layers and releasing it through soil surface evaporation and transpiration from vegetation (Albright et al. 2006; Albright et al. 2010; McGuire et al. 2009; EPA 2011), these systems do not function properly in humid environments (Albright and Benson 2005). Although the ET cover also functions to limit erosion and runoff, the primary objective of ET cover systems is to use the water balance components of soil and vegetation to hold precipitation and release it through soil surface evaporation or transpiration without allowing water percolation into storage layers (EPA 2011).

Predictive models have been widely used to assess the performance of alternative landfill cover systems (Benson et al. 2005; Fayer et al. 1992; Gee et al. 2005; Khire et al. 2000; Scanlon et al. 2005; Zornberg et al. 2003) and demonstration cover designs (Albright et al. 2004; Andraski 1997; Chadwick et al. 1999; Dwyer 2001; Gee et al. 2002; Melchior 1997; Ward and Gee 1997). The objective of numerical predictive models is to aid ET cover design by quantifying the performance and limitations of different cover designs under differing soil depths, impermeable layer components, vegetation composition, and climatic conditions. In general, predictive models are used to quantify percolation into an ET from the vadose zone for different cover designs under varying climatic conditions. Models do not replace data collection and experimental assessment of cover designs (Schwartz et al. 1990).

Need for an Evapotranspiration Cover System at the Clive Facility

Energy*Solutions*' facilities at the Clive Site must meet regulatory requirements for containing waste and waste byproducts, prevent the infiltration of precipitation into final storage layers, and prevent the movement of waste into the surrounding environment. The permitting and design of the Clive Site is regulated under 10 Code of Federal Regulations § 61.51(a) (Disposal site design for near-surface disposal), and Utah Administrative Code R649-9 (Waste Management and Disposal). To meet these requirements, an ET cover system must be designed such that there is long-term isolation of the waste and avoidance of continuing active maintenance after site closure. Waste products at the Clive Site are currently buried beneath an impermeable clay layer and capped with concrete riprap. Energy*Solutions* is evaluating an alternative ET cover system for its proposed Class A West embankment at the Clive Site, Utah.

Energy*Solutions* requires support on the following:

- The timing of establishment and the characteristics of the biological system(s) that will develop on a Clive Facility embankment with an ET cover
- Pertinent data to inform performance modeling (primarily hydrologic) of the embankment
- Potential design and construction recommendations to improve/enhance cover performance and stability

Evapotranspiration Cover Design Considerations

There have been two federal research programs to evaluate the performance of ET cover systems: 1) the Alternative Landfill Cover Demonstration (Dwyer 2003) and 2) the Alternative Cover Assessment Program (Benson et al. 2002; Albright and Benson 2005). These research programs have contributed to a set of design considerations and site specific data that should be compiled to inform site-specific design of an ET cover system.

General Design Considerations

The purpose of this literature review is to provide Energy*Solutions* with scientifically supported information on the current and historic biological systems that occur on and adjacent to the Clive Site, and to identify data needs to inform the design of an ET cover system. There are several studies of existing and demonstration cover systems in the arid Southwest (Albright et al. 2010; Dwyer 1998, 2003; Dwyer et al. 2000; McGuire et al. 2009; Rock et al. 2012; Warren et al. 1997; Waugh et al. 2008) that demonstrate a general set of site-specific data that would be required for the design an ET cover system and for subsequent modeling of preliminary cover designs or demonstration sites. The general parameters that should be assessed are climate, soils, vegetation, and animal activity. Site-specific data needs should consist of evaluating historic climate, geology, and plant and animal communities; assessment of on-site climate, soils, and biotic communities; and laboratory analyses of soil chemistry and nutrition (*sensu* Albright et al. 2010). The following sections outline the specific parameters that should be evaluated:

CLIMATE

The total water storage required for the uppermost soils layers is determined by the total annual precipitation relative to the growing season, temperature, and resulting total annual ET (EPA 2000; Hauser et al. 2001). The timing of precipitation should also be considered because high-volume precipitation events or spring snowmelt can demand large soil water storage capacity even though total annual precipitation is low.

- <u>Precipitation</u>: Annual average and extreme precipitation, seasonal time series of average precipitation, snowfall (average and extreme), snow depth (average and extreme)
- <u>Temperature</u>: Annual average and extreme temperature, seasonal time series of average temperature, heating degree days, cooling degree days, growing degree days
- <u>Severe weather</u>: Extended periods of drought, extended wet periods
- <u>Shifts and trends</u>: Long-term trends or shifts in seasonality of precipitation and temperature
- <u>Past climate</u>: Proxy records of past changes in climate, extended meteorological records or detect long-term shifts and trends in drought, wet periods, seasonality of precipitation, and temperature Tree ring records, pollen records, and packrat middens are examples of proxy records

- Global change projections: Models, future scenarios
- Other parameters: Solar radiation, humidity, wind speed and direction, micro-meteorology

SOIL COMPOSITION AND CHEMISTRY

Single-layer ET cover systems and capillary barrier systems have typically been constructed of silt or clay because of the high porosity and water-holding capacity of these find-grained soils (Rock et al. 2012). Soil bulk density and particle size are both determinants of water storage capacity, with high bulk density soils having low water storage capacity as well as limited plant growth (Chadwick et al. 1999; Hauser et al. 2001). The depth of monolithic or topsoil layers will depend on water storage capacity and structural concerns based on slope of embankments and likelihood of large volume precipitation events. ET cover systems have been constructed with soil layers 0.6–3.0 meters (m) (2–10 feet) thick.

- Soil types and distributions
- Geomorphic history geomorphology
- Drainage Patterns: Rilling, channel density, aeolian deposits, and channels
- Krotovinas: Animal burrows that have been filled with organic or mineral material from another horizon; evidence of animal burrows and root channels
- Soil Morphology: Samples collected at borrow location study sites only
- Soil Classification: Soil series descriptions and distributions of soil types
- Soil Profile: Soil horizonation, including presence/absence of calcium carbonate horizons (location and degree of calcite development; *sensu* Rettalack 1988)
- Soil physical properties
- Standard Soil Physical Properties: Texture or particle size (% sand, silt, and clay), gravel and cobble content, dry-weight bulk density (compaction), porosity, pH, electrical conductivity (salinity), cation exchange capacity (CEC), sodicity (sodium adsorption ratio (SAR) or exchangeable sodium percentage)
- Soil samples would be collected at the surface of ecological analogue study sites, and at the surface and at depth at borrow source study sites.

SOIL FERTILITY

Topsoil layers need sufficient fertility to support the survival and growth of a functioning vegetation community. Soils used for upper layers of the cover should be evaluated to determine if the pH, CEC, organic matter, nitrogen, phosphorus, potassium, and micronutrient content is sufficient to support the target vegetation. Although there are numerous soil amendments that can be used to improve soil fertility, organic matter content, and water holding capacity, the use of such amendments is expensive, and may require levels of maintenance that are not sustainable over the long term (Rock et al. 2012). Ideally, soil borrow materials will be of sufficient quality to support the establishment and succession of a native vegetation community. The soil fertility parameters that should be evaluated are macronutrients (nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur), micronutrients (manganese, iron, zinc, copper, molybdenum, chloride, and boron), and soil texture and organic matter content.

VEGETATION

Vegetation is established on the ET cover to promote transpiration of water from soil and to stabilize surface materials. ET cover systems should use native plant species that are well-adapted to local conditions, as well as a mixture of cool- and warm-season species (e.g., grasses and forbs) so that components of the vegetation community are physiologically active for the entire growing season (Dwyer et al. 1999).

To this end, the historic and current vegetation diversity of the region should be evaluated to identify appropriate species for revegetation, and expected patterns of succession from the installation of the target vegetation community to potential climax vegetation communities (Albright et al. 2010). The following vegetation community characteristics should be evaluated:

- Plant species richness
- Relative vegetation cover and density (number of plants per unit area) and spatial distributions (e.g., clumped, uniform, random)
- Vegetation structure and growth forms (e.g., grass, forb, shrub, tree)
- Species tolerances to disturbance, fire, grazing, disease, invasive species, drought
- Life histories of dominant plant species to identify season of growth (e.g., annual, perennial, evergreen, deciduous), and time to maturity and senescence
- Average and maximum rooting depths of dominant plant species

Transpiration indices have also been recommended as a method to assess potential ET by species and vegetation community. These measures are costly, and there are limited published leaf area indices (Albright et al. 2010).

BIOTURBATION

An ET cover system must also be designed to use the natural biotic community and physical characteristics of the site to enhance the performance of the cover system. That is, to minimize water infiltration and erosion, to direct percolating or surface water away from the disposed waste, and to resist degradation by surface geologic processes and biotic activity. Bioturbation is the mixing of underlying soils and geologic materials, and movement of these materials to the soil surface where they are exposed to the surrounding atmosphere (Smallwood et al. 1998). Animal burrowing contributes to soil formation, mixing, and erosion (Hole 1981; Smallwood et al. 1998), which, in combination with plant and fungal growth, transports materials from underlying rock to open air. The long-term stability of ET cover systems can be adversely affected by the loss or movement of soil caused by physical and biological processes. Physical processes consist of deflation (erosion) by wind or water, soil compaction, soil eluviation, and cryoturbation (sorting and heaving from freeze-thaw processes). Biological processes consist of bioturbation or biointrusion impacts from plant root growth and animal burrowing or other activities by animals. These processes can alter soil structure and soil evaporative potential, and can facilitate the movement of contaminants from storage layers to the soil surface, where further movement of contaminants occur by wind, water, or biotic activity.

Western harvester ants (*Pogonomyrmex occidentalis*) play a significant role in pedogenesis (soil development) (Carlson 1991; Green 1998; Mandel 1982; Salem 1968). This species moves large amounts of soil to the land surface during mound construction (Mandel 1982). Ants also increase soil fertility, porosity, water-holding capacity, and hydraulic conductivity during nest construction and subsequent movement of organic matter below ground (Green 1998; Wheeler 1986). The population size of a western harvester ant colony is estimated to be 400–9,000 individuals, with the average lifespan of a colony around 44 years (Keeler 1993). Mature mounds are cone-shaped, and average about 1 m (3.2 feet) in diameter and 35 cm (13.7 inches) in height (Scott 1951). Western harvester ant nest can be up 6 m (10.6 feet) deep. And, although western harvester ants clear the vegetation on and several meters around their nests, they secrete materials onto the mound to waterproof and stabilize its surface (Taber 1998; Wheeler 1963). Because of their large numbers and ubiquitous distributions, ants are a significant source of bioturbation and associated movements of hazardous wastes.

Examinations of ecological analog sites allow evaluation of soil turbation processes relevant to site-specific ET cover design. Key processes and soil components that could limit or enhance ET cover functioning need to be identified on a site-specific basis. The following should be evaluated for soil borrow sources and ecological analog locations: soil structure, soil composition, maximum potential rooting density and rooting depth of dominant plant species, animal burrowing densities and depths, and the potential vegetation that would be supported by a given soil type.

The following bioturbation parameters may be collected depending on the system being assessed:

- Habitat value of vegetation communities for grazing livestock and game animals
- Burrowing animal species composition and density
- Animal species burrow densities, depths, and soil volumes removed and replaced
- Soil sampling to determine how bioturbation affects soil properties
- Plant species areal cover: density relationships
- Plant species rooting densities and maximum rooting depths

Control layers that are designed to prevent penetration of waste layers are used in both conventional and ET cover systems (Rock et al. 2012). Control layers of rock or other coarse material can be used to prevent animal intrusion and exclude plant roots to some extent. These layers can also serve as capillary barriers that prevent the downward movement of water while excluding burrowing animals.

Regionally Relevant Evapotranspiration Cover Systems and Demonstration Sites for Hazardous Waste

The objective of ET cover systems is to store precipitation and release the water from the soil surface (evaporation) or from vegetation (transpiration). This “store and release” cover type requires that the potential ET of the area is greater than annual average precipitation. The Clive Site is well suited for this type of final cover design. The location of the Clive Site relative to other hazardous or radioactive waste sites in the arid southwest is shown in Figure 1.

This page intentionally blank

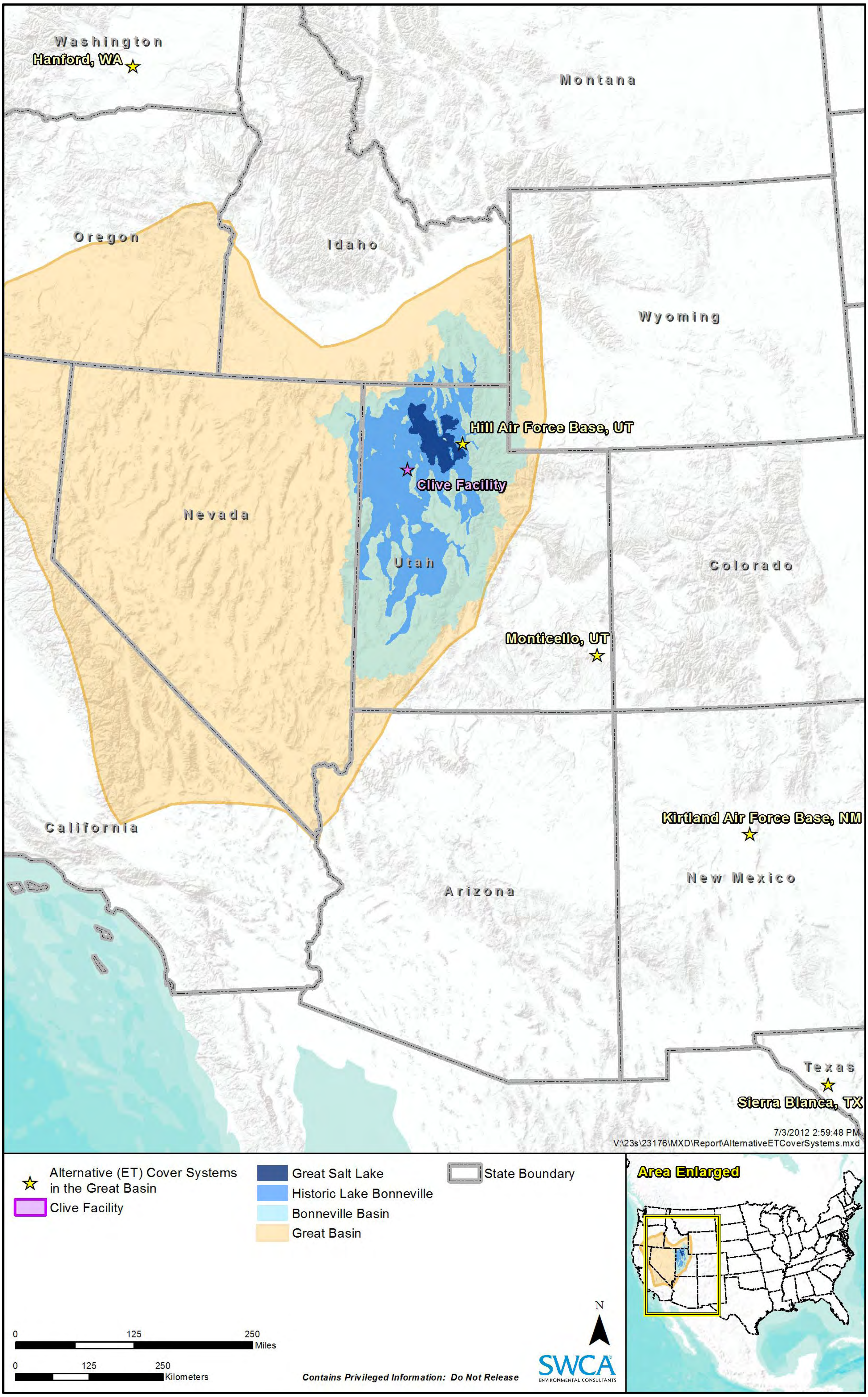


Figure 1. Location of the Clive Facility relative to other alternative (ET) cover systems for radioactive or hazardous waste in the Bonneville Basin, Great Basin, and arid west.

This page intentionally blank

SWCA conducted a literature review of recent and current ET cover systems and demonstration sites. The focus of the review was on the arid southwestern United States, with particular focus on systems in the Great Basin and other desert regions that are ecologically similar to the Clive Site. The location of the Clive Site in Utah's West Desert makes it comparable to other cold desert ecosystems, which are characterized by annual average precipitation of less than 400–500 millimeters (mm) (16–20 inches) and winter temperatures below freezing. On average, the Clive Site receives approximately 200 mm (8 inches) annual precipitation, and total annual ET would exceed total precipitation, even where precipitation occurs predominantly as snow in the winter when ET rates are very low. The low precipitation and high ET:precipitation ratio in the West Desert region of the Bonneville Basin and at other existing hazardous waste containment sites in the arid west, makes them well-suited for ET cover systems.

Numerous experimental and demonstration ET cover systems exist in the western United States (EPA 2011). Alternative cover systems for waste containment in arid and semiarid regions include monolithic ET covers, capillary barrier ET covers, and anisotropic barrier ET covers (Scanlon et al. 2005). These designs all use enhanced water storage in soil layers to reduce water percolation into waste (Albright et al. 2002; Scanlon et al. 2005). Review of the literature and other sources of data identify only a few research and demonstration sites for ET cover systems for hazardous or radioactive waste that possess meteorological, geological, and biological conditions similar to those at the Clive Site. These are Hill Air Force Base in Ogden, Utah; the Monticello uranium mill tailings disposal cell in Monticello, Utah; the Hanford Site in Richland, Washington; Sierra Blanco in northwestern Texas; and the Alternative Covers Assessment Program at Kirtland Air Force Base in Albuquerque, New Mexico. These sites also represent some of the most up-to-date research on alternative cover systems. There are numerous additional alternative cover systems in the arid southwest that could serve as important reference sites for the Clive Site, but many research and demonstration sites are outdated or obsolete (e.g., Andraski 1997), or there are limited or no published data available for the site. In addition, supporting information for the Clean Harbors proposed ET cover in Knolls, Utah, was evaluated, but the site is not described here because the project is not yet constructed, and the cover will not be vegetated. Several additional ET cover systems have been proposed or approved in the arid southwest, but have not been completed. These include the U.S. Ecology Nevada Site in Beatty, Nevada (approved), and the Idaho National Engineering Laboratory Superfund Site in Idaho Falls, Idaho (proposed) (Rock et al. 2012).

In general, operational, experimental, and demonstration ET cover systems have been successful in enhancing soil water storage, evaporation, and transpiration by cover vegetation once established. Successful establishment of cover vegetation has been shown to be a vital feature for enhancing water movement out of the cover and preventing drainage into underlying storage layers (Dwyer 2003; Scanlon et al. 2005). Initial vegetation establishment often requires supplemental irrigation that may contribute to initial drainage; however, nearly all of the sites examined showed that drainage ceased two or more years after construction (Scanlon et al. 2005). Capillary breaks have also been shown to prevent or minimize percolation into lower layers under most conditions (Hakonson 1997; Hauser et al. 2001; Dwyer 2003). Key considerations for design are the depth and density of soil layers. Other considerations, particularly biological composition and bioturbation, were not studied at most of the sites examined for this summary. Additional information on the potential biota of the proposed ET cover system is needed. The following pages summarize existing alternative cover systems that would be relevant to the physical and ecological conditions at the Clive Site.

HANFORD SITE/US DEPARTMENT OF ENERGY

Location: Richland, Washington	**Average Annual Precipitation:** 172 mm/year 1994–2002	
Type of Cover System: ET	**Position:** Above grade	
Design Target: < 0.5 mm/year water recharge for 1,000-year design life		
Date Constructed: 1994	**Status:** Experimental/full-scale operational project	
ET Layer Materials (upper-lower)	**Depth**	**Purpose**
Silt-loam soil with admix	1 m	ET/stability/H_2O storage
Silt-loam	1 m	ET/H_2O storage
Sand	0.15 m	Filter
Gravel	0.30 m	Filter
Basalt rock riprap	1.50 m	Barrier
Gravel	0.30 m	Drainage
Composite asphalt	0.15 m	Barrier
Top course	0.10 m	Barrier
Sandy soil	n/a	Fill
Materials source: Gee et al. 2002		
Monitoring/Research	**Results**	**Source**
ET	Met design target	Gee et al. 2002
Drainage/hydrology	Met design target	Gee et al. 2002
Erosion	No measurable erosion	Gee et al. 2002
Hydrologic modeling	Silt-loam layer H_2O storage exceeds 480-mm/year	Campbell et al. 1990; Gee et al. 1993b
Irrigated gravel side slope 10:1	Less drainage than expected	Sackschewsky et al. 1995; Ward and Gee 1997; U.S. Department of Energy 1999; Gee et al. 1993a, 2002
Irrigated basalt side slope 2:1	Less drainage than gravel	
Non-irrigated gravel side slope 10:1	Less drainage than expected	
Non-irrigated basalt side slope 2:1	Less drainage than gravel	
Vegetation composition	Sagebrush-rabbitbrush at 2 shrubs/m^2	Gee et al. 1996, 2002
Revegetation success	75% cover; 57%–97% revegetation species survival	Gee et al. 1996
1,000-year event (71 mm/8 hours)	Within design target	Gee et al. 1997, 2002
Max precipitation (480 mm/year)	Within design target	Gee et al. 1997, 2002

MONTICELLO URANIUM MILL TAILINGS DISPOSAL CELL/USDOE

Location: Monticello, Utah	**Average Annual Precipitation:** 390 mm/year	
Type of Cover System: ET	**Position:** Above grade	
Design Target: UMTRCA 200–1000-year design life; annual average percolation < 3.0 mm		
Date Constructed: 2000	**Status:** Operational (2012 CERLA review)	
ET Layer Materials (upper-lower)	**Depth**	**Purpose**
Gravel admix	20.0 cm	Stability, storage
Topsoil	41.0 cm	ET, storage
Fine-grained soil	41.0 cm	Storage, growth medium, frost protection
Cobbles filled with fine soil	30.5 cm	Animal intrusion barrier
Fine-grained soil	30.5 cm	Capillary barrier
Geotextile fabric	n/a	Enhance ET performance
Coarse sand	30.0–38.0 cm	Capillary barrier
HDPE geomembrane	n/a	Infiltration barrier
Compacted soil	60.0 cm	Radon/infiltration barrier
Materials source: Waugh 2002; Waugh et al. 2008		
Monitoring/Research	**Results**	**Source**
ET	Percolation < 3mm/year; 150 cm loam and clay designs had best performance	Waugh 2002; Waugh et al. 2008
Climate/edaphic factors	All percolation occurred during one exceptionally wet year	Waugh et al. 2008
Drainage/hydrology	Cumulative percolation 0.6 mm/year	Waugh et al. 2008
Water storage capacity	80%–90% of computed storage capacity based on soil water characteristic curves	Waugh 2002; Waugh et al. 2008
Soil hydraulic properties	Percolation was 100–1,000 times less than conventional cover systems	Waugh 2002; Waugh et al. 2008
Vegetation establishment	Success criteria of 40% not met until 2006	Sheader and Kastens 2008; Waugh et al. 2008
Vegetation density	Total of 28–142 shrubs/acre < target of 1,000 shrubs/acre	Waugh et al. 2008

HILL AIR FORCE BASE

Location: Ogden, Utah	**Average Annual Precipitation:** 436 mm/year	
Type of Cover System: ET	**Position:** Above grade	
Design Target: Lysimeter-based testing of five cover designs		
Date Constructed: ca. 1991	**Status:** Experimental	
ET Layer Materials (upper-lower)	**Depth***	**Purpose**
Vegetation	Native grasses/native grasses/native grasses and shrubs/none/native grasses	ET, stability
Gravel mulch	0.0cm/1cm/1cm/0.0cm/0.0cm	Erosion control
Sandy-loam at 1.86 g/cm compaction	0.9m/1.5m/1.5m/0.0m/1.2m	ET, stability, storage
Silt-loam with 15% pea gravel	0.0m/0.0m/0.0m/1.0m/0.0m	ET, erosion control, storage
Silt-loam	0.0m/0.0m/0.0m/1.0m/0.0m	ET, storage
Geotextile (GT)	None/GT/GT/GT/GT	Barrier
Sand	0.0m/0.0m/0.0m/0.15m/0.3m	Drainage
Gravel	0.0m/0.3m/0.3m/0.15m/0.0m	Barrier
Clay at 4% slope	0.0m/0.0m/0.0m/0.0m/0.6m	Lateral water diversion
* Depths listed for five cover types: Control (ET) cover/capillary barrier cover with grasses only/capillary barrier cover with grasses and shrubs/Hanford-type cover/modified RCRA cover; materials source.		
Monitoring/Research	**Results**	**Source**
ET	n/a	
Drainage/hydrology	41 cm/24.0cm/30.0cm/0.0cm/0.01cm	Warren et al. 1997
Erosion	n/a	
Biointrusion/bioturbation	n/a	
Drainage	All cover types had drainage possibly due to high soil density/low water holding capacity, limited plant root growth, and/or above-average snowfall and subsequent snowmelt	Warren et al. 1997

KIRTLAND AIR FORCE BASE/SANDIA NATIONAL LABORATORIES

Location: Albuquerque, New Mexico	**Average Annual Precipitation:** 220 mm/year	
Type of Cover Systems: Capillary barrier/anisotropic/ET	**Position:** Above grade	
Design Target: Testing of rates of annual percolation from traditional and alternative cover systems		
Date Constructed: 1995–1996	**Status:** Demonstration project	
Capillary Barrier Materials (upper-lower)	**Depth**	**Purpose**
Topsoil	0.30 m	Growth medium, storage
Sand	0.15 m	Filter
Gravel	0.22 m	Drainage
Compacted native soil (fine)	0.45 m	Capillary barrier
Sand (coarse-grained)	0.30 m	Capillary barrier
Anisotropic Capillary Barrier Materials (upper-lower)	**Depth**	**Purpose**
Topsoil and pea gravel mixture	0.15 m	Stability, erosion control
Native soil (fine-grained)	0.60 m	Anisotropic capillary barrier
Fine sand	0.15 m	Wicking layer
Pea gravel (coarse-grained)	0.15 m	Anisotropic capillary barrier
ET Cover Materials (upper-lower)	**Depth**	**Purpose**
Topsoil with gravel veneer	0.15 m	Stability, erosion control
Native soil	0.90 m	ET barrier
Materials source: Dwyer 1997, Scanlon et al. 2005		

Monitoring/Research	**Results**	**Source**
Capillary barrier system	Average annual percolation of 0.87 mm; percolation higher than expected first year, slowed as vegetation developed.	Dwyer 1998, Dwyer et al. 2000; Scanlon et al. 2005
Anisotropic capillary barrier	Average annual percolation of 0.16 mm; percolation rate decreased as vegetation developed.	Dwyer 1998, Dwyer et al. 2000
ET cover system	Average annual percolation of 0.19 mm; percolation rate was lowest of the test systems by third year of testing; most effective at controlling infiltration. Drainage of 0.1-0.4 mm/year occurred only in the first 2 years of 5-year study.	Dwyer 1998, Dwyer et al. 2000; Scanlon et al. 2005
Vegetation cover	Drill-seeding with cool-season and warm-season native grasses was successful. Opportunistic shrubs (Atriplex spp.) also developed on the cover.	Scanlon et al. 2005
Hydrologic modeling	HELP/UNSAT-H (neither program was sufficiently accurate for regulatory settings).	Dwyer 2003; Scanlon et al. 2005

SIERRA BLANCA

Location: Chihuahuan Desert, Texas	**Average Annual Precipitation:** 311 mm/year	
Type of Cover System: GABET/CBET	**Position:** Above grade	
Design Target: Monitoring of prototype engineered covers for proposed low-level radioactive waste disposal site		
Date Constructed: 1997	**Status:** Experimental prototypes for proposed facility	
ET Layer Materials (upper-lower)	**Depth***	**Purpose**
Vegetation + mulch pad of 20-mm aspen shavings with biodegradable net	Five perennial warm-season bunchgrass species. Seedlings transplanted second year.	ET, stability
Sandy clay loam at 1.5 milligrams/m^3 bulk density with gravel (24% by weight)	0.3 m/0.3 m	ET, stability, erosion control, storage
Sandy clay loam at 1.8 mg/m^3 bulk density		ET, storage
Geosynthetic clay layer	1.3 m/none	resistive barrier
Sand	none/2.0 m	capillary barrier
Muddy gravel	none/ca. 2.3 m	not specified
Gravel	none/ca. 2.5 m	not specified
Sand	none/ca. 2.8 m	capillary barrier
* Depths listed for 2 cover types: geosynthetic clay layer overlying an asphalt barrier (GABET)/capillary barrier design (CBET)		
Monitoring/Research	**Results**	**Source**
ET	Vegetation was key in promoting rapid water storage and controlling water balance of both systems, particularly due to monsoonal precipitation during growing season.	Scanlon et al. 2005
Drainage/hydrology	0.4–0.5 mm/year estimated drainage due to irrigation (226–2,340 mm/year)	Scanlon et al. 2005
Erosion		Scanlon et al. 2005
Biointrusion/bioturbation	n/a	
Drainage	Capillary barriers increased water storage by a factor of 2.5 and prevented drainage.	Scanlon et al. 2005
Hydrologic modeling	Measured water balance was successfully reproduced by the models. Twenty-five-year models predicted drainage due to drainage events. Models were most sensitive to the presence/absence of vegetation and soil hydraulic parameters.	Scanlon et al. 2005

Geologic and Biogeographic History of the Clive Site

Energy*Solutions*' Clive Site is located in Tooele County, Utah, on the eastern edge of the Great Salt Lake Desert at ca. 40.690891˚ latitude -113.112073˚ longitude at approximately 1,307 meters (m) (4,288 feet) (in elevation (Figure 2). The Clive Site is nearly centrally located within the Bonneville Basin region of the Great Basin. The Clive Facility is located approximately 40 miles west of Great Salt Lake to the west of the Cedar Mountains and southwest of the Grassy Mountains. The facility is in a low elevation basin, with surrounding mountains rising to approximately 2,012 m (6,600 feet) and the highest elevations in the Deep Creek Mountains to the south rising to 3,658 m (12,000 feet).

This page intentionally blank

Figure 2. Location of the Clive Facility.

This page intentionally blank

The Bonneville Basin is the remains of ancient Lake Bonneville, a large closed-basin lake that inundated the Great Basin from approximately 32,000 to 14,000 years ago (Oviatt 1997). The Bonneville Basin occurs within the Basin and Range physiographic province (McNab and Avers 1994). The area is characterized by small, north-south-trending mountain ranges separated by valleys formed by alluvial erosion and sedimentation. The valleys are dominated by saltbush-desert scrub vegetation, playas, and salt flats. Elevation in the area ranges from approximately 1,200 to 2,400 m (4,000 to 8,000 feet).

The climate of the Bonneville Basin is semiarid with hot, dry summers and cold, dry winters. Average annual temperatures are from 7 degrees Celsius (°C) to 13°C (45 degrees Fahrenheit [°F] to 55°F) and the growing season ranges from 60 to 150 days (McNab and Avers 1994). The climate of Utah's West Desert is among the driest in the United States (Jewell and Nicoll 2011). Annual average precipitation is from 10.0 to 25.0 centimeters (cm) (4 to 10 inches), with most precipitation occurring in late winter and early spring (Knapp 1994, McNab and Avers 1994).

The topography of the West Desert of Utah, or Great Salt Lake Desert, is characterized by the aeolian formation of dunes. This pattern is present just south of Knolls, Utah, in the immediate vicinity of the Clive Site. The formation of dune features as a result of aeolian transport of fine materials or sand occurs in a pattern produced by predominant southwesterly winds, but wind direction can be highly variable (Jewell and Nicoll 2011).

Biotic Communities

Historic Flora

The historic vegetation communities of the lowlands of the Bonneville Basin were dominated by sagebrush and coniferous forest, and contained a species composition similar to the flora of montane areas of the basin today due to the colder and moister climate of the late Pleistocene/early Holocene (Rhode et al. 2005). The climate has been following a significant drying trend since the end of the Pleistocene, with the vegetation trending toward shrub-dominated stands of sagebrush (*Artemisia* spp.) and shadscale (*Atriplex* spp.). The vegetation communities that dominated throughout the Holocene were similar to the current vegetation: xerophilic shrub communities dominated by sagebrush, shadscale, black greasewood (*Sarcobatus vermiculatus*), and horsebrush (*Tetradymia* spp.) (Rhode et al. 2005).

Historic Fauna

A detailed record of historic small animal and plant occurrences in the Bonneville Basin has been identified from Homestead Cave on the southwestern edge of Great Salt Lake, which contains fossil-rich stratified layers of woodrat (*Neotoma* spp.) middens, owl pellets, and other remnants of animal occupation (Grayson 2000, 2006; Madsen 2000).

The fauna of the Bonneville Basin historically included bison (*Bison bison*), pronghorn (*Antilocapra americana*), desert bighorn sheep (*Ovis canadensis nelsoni*), mule deer (*Odocoileus hemionus*), and extensive populations of lagomorphs (rabbits and hares), and sage-grouse. Historic large predators included grizzly bear (*Ursus arctos*), gray wolf (*Canis lupus*), cougar (*Felis concolor*), and coyote (*Canis latrans*). Bison, grizzly bear, wolf, and bighorn sheep were extirpated following European colonization. There have been several reintroductions of large animals to the basin, such as desert bighorn sheep in the Deep Creek Mountain Range, elk (*Cervus canadensis*) in the Canyon Mountain Range, and bison to Antelope Island in Great Salt Lake.

The fauna associated with the open xerophilic shrublands that have dominated the landscape of the Bonneville Basin for the past 10,000 years are predominantly small mammals: cottontail rabbits (*Sylvilagus* spp.), pygmy rabbits (*Brachylagus idahoensis*), kangaroo rats (*Dipodomys* spp.), voles (*Microtus* spp.), pocket mice (*Perognathus* spp.), harvest mice (*Reithrodontomys* spp.), pocket gophers (*Geomys* and *Thomomys* spp.), woodrats (*Neotoma* spp.), and marmots (*Marmota* spp.; Grayson 1993, 1998; Madsen et al. 2001; Rhode et al. 2005).

The historic fauna of the Bonneville Basin included harvester ants (*Pogonomyrmex* spp.) and other ground-nesting insects, as well as dozens of species of burrowing reptiles. Based on the current distributions of reptiles in the region, the historic herpetofauna of the area likely comprised dozens of species of lizards, skinks, and snakes (Bosworth 2001). However, the historic distribution and abundance of reptiles in the Great Basin are not well understood (Mead et al. 1989).

Current Flora

Valley floors of the Bonneville Basin are typically dominated by big sagebrush (*Artemisia tridentata* spp.), saltbush (*Atriplex* spp.), and other xeric-adapted shrubs and grasses, with an ephemeral flora of perennial and annual forbs (Barbour and Billings 2000; Grayson 2006). Successional patterns in these xerophilic communities generally tend toward denser vegetation, from disturbed bare ground to grass-forb–dominated systems to saltbush and saltbush-greasewood–dominated shrublands.

The basins of the western desert of Utah are dominated by xerophilic shrub communities grading to sagebrush-grasslands and pinyon-juniper woodlands at increasing elevations. The 2010 bioturbation study (SWCA 2010) conducted at and near the Clive Site identified three primary vegetation communities on the Clive Site: 1) saltbush–gray molly (*Bassia americana*); 2) black greasewood; and 3) halogeton (*Halogeton glomeratus*)-disturbed (SWCA 2010).The vegetation at the Clive Site is dominated by sparsely distributed halophytic shrubs, with very limited distribution of grasses or forbs, except in disturbed sites where annual weeds dominate seasonally. Vegetation diversity at the elevational range of the Clive Facility is generally low, and ground cover is predominantly biological soil crust with one or two sparsely distributed xerophilic shrub species and limited grass and forb cover. A more detailed description of the existing vegetation at the Clive Site is given in the Field Studies Results sections below.

Current Fauna

The distribution of small mammals in the Bonneville Basin is complex due to the basin and range topography of the Great Basin region, which has created islands of low-lying habitats surrounded by mountain ranges and vice-versa (Brown 1971; Grayson 2006; Rickart 2001). The dry climate of the Great Basin has contributed to a wealth of fossil evidence of mammalian fauna of the region (Grayson 2006; Rhode and Madsen 1995).

There is limited historic evidence for the large mammal and ungulate distributions in the Great Basin (Grayson 2006). Long-distance seed dispersal was likely historically facilitated by now extinct large mammals (e.g., mastodons, mammoths, and other large herbivores). Present and near-future dispersal of seed would likely be limited to movements by small mammals and extant large herbivores (e.g., deer, elk, mountain sheep, horses, and pronghorn) (Grayson 2006).

The current fauna of the West Desert region of the Bonneville Basin include pronghorn, several species of lagomorphs, and mule deer in the mountain ranges. Extant large predators are cougar, coyote, and bobcat. Game bird populations consist of greater sage-grouse (*Centrocercus urophasianus*), non-native chukar (*Alectoris chukar*), and Hungarian partridge (*Perdix perdix*). Resident and migratory bird species and small reptile species also occur throughout the basin.

Small mammal trapping conducted at and near the Clive Site in 2010 identified four small mammal species across five study plots (see maps 1 and 2 in SWCA 2010): deer mouse (*Peromyscus maniculatus)*, northern grasshopper mouse (*Onchomys leucogaster)*, Great Basin kangaroo rat (*Dipodomys microps*), and Ord's kangaroo rat (*Dipodomys ordii*). Trapping conducted in 2010 on the three study plots on the Clive Site resulted in only seven total captures of deer mice (SWCA 2010). Mammal burrow surveys also indicated that badgers, ground squirrels, and voles are present at or near the Clive Site (SWCA 2010).

Ant diversity and mound distribution studies were also conducted at and near the Clive Site in 2010. In all, 1,628 ant specimens were collected across the five 2010 study plots. All but four ant specimens were western harvester ants; the remaining four specimens were *Lasius* species (possibly *L. niger*). Western harvester ants are widely distributed throughout most of Utah and other western states (Cole 1942). This species produces large, conical mounds whose basal area is presumably roughly proportional to the depth and subterranean area of the nest and quantity of soil excavated.

Climate

Historic Climate

The historic climate of the Bonneville Basin has been shaped by the decline of Lake Bonneville, with the climate of the region warming and drying with dropping lake levels starting approximately 15,000 years ago (Atwood 1994). Rapid warming and drying of the climate approximately 12,000 years ago caused the lake level to fall rapidly, and resulted in the desert climate of the region that persists today.

Current Climate

Meteorological Solutions (2012) summarized 19 years of meteorological data collected at the Energy*Solutions* monitoring station at Clive, Utah. The current climate of the region is classified as desert, which is characterized by precipitation levels that are less than half of the potential ET in a given year (Donn 1975). The area has cold winters and hot summers, with most of total annual precipitation falling from April through July during summer storms, and the remainder falling as isolated rain and limited winter snow (Meteorological Solutions 2012). Average daily temperatures range from lows of -2.5°C (27.5°F) in December to highs of 26.4°C (79.5°F) in July. Average annual precipitation is 218.4 millimeters (mm) (8.6 inches). Total average annual ET for the 19-year dataset was 1,338.6 mm (52.7 inches).

The greatest total precipitation for the period of study was 108.6 mm (4.3 inches) in May 2011, with a maximum daily precipitation event of 29.5 mm (1.2 inches; Meteorological Solutions 2012).

Potential Future Climate

Climate change is expected to significantly affect the Great Basin region within this century (Chambers 2008). Climate scenarios over the next ca. 1,000 years will likely be a continuation of the regional warming trend, but conditions will vary locally within the Great Basin. Recent trends have shown an increase in minimum temperatures and a 6%–16% increase in precipitation across most of the Great Basin (Chambers 2008). Temperatures in the Western United States are expected to increase approximately 2°C –5°C (3.6°F–9°F) in the next century (Cubashi et al. 2001). Associated increases in fire frequencies in the warmest regions of the Great Basin should also be expected, particularly in association with increasing cover of invasive annual grasses (cheatgrass [*Bromus tectorum*]; Smith et al. 2005; Ziska et al. 2005), and increasing variability in springtime precipitation that may contribute to fuel loading in some years and drought in others (Westerling et al. 2006).

Near-future climate warming is expected to increase the mean temperature of the coldest months, which may facilitate the northward migration of more southern desert species, particularly creosote bush (*Larrea tridentata*), and associated reductions in the ranges of more cold-adapted dominants such as sagebrush (Grayson 2006). Another potential scenario would predict the expansion of woodlands into desert shrub and sagebrush habitats (Wagner et al. 2003).

Under near-future climate scenarios (within the next several hundred to thousand years), the natural vegetation of the West Desert region of the Bonneville Basin would be expected to succeed to invasive grasslands, salt desert scrub, and greasewood shrubland communities. This assumes that current trends toward a hotter, drier climate will continue (Chambers 2008). A wetter future climate would result in the expansion of conifer woodland communities such as pinyon-juniper woodlands, although the very basic and saline conditions of the valley floor soils would exclude many higher elevation species.

2012 FIELD STUDIES OF ECOLOGICAL ANALOGS TO THE CLIVE SITE

The diversity and bioturbation data collected at the Clive Site in 2010 provides baseline data on the existing biological community at the Clive Site as well as estimates of species diversity, densities, and bioturbation potential. Because the objectives of the 2010 studies (SWCA 2010) were to assess potential future conditions over geologic time periods, data were collected across a wide range of ecological conditions and elevations, and most of the study plots possess different biotic communities than those that currently exist on the Clive Facility. These data are not applicable as ecological analogs to the Clive Facility within a 1,000-year time frame. However, Plot 3 (2010) was located on the Clive Site, and much of the data collected at that plot can be used as part of the ecological analog data to demonstrate current conditions and to evaluate how an ET cover system would perform under different successional scenarios.

Examination of ecologically analogous sites to the Clive Facility was needed. In June 2012, a set of ecological analog study sites (study plots) was selected at and near the Clive Site. These sites were selected based on having similar soils and elevational ranges that exist on the Clive Facility, and to provide a detailed assessment of the native vegetation and animal communities that could exist at the Clive Facility. Field study plots were also chosen to capture conditions at on-site soil borrow sources. These ecological analog study sites were also selected to provide data on the distribution and density of burrowing animals (ants and mammals) in different vegetation communities, and estimates of the density, depth, and volume of potential bioturbation that could occur on the cap. In June 2012, SWCA collected site-specific climate, soils, and geologic data to support the design of an ET cover system at the Clive Site, Utah. Field studies included examination of soils, vegetation diversity, areal cover and density, animal diversity, and burrow and ant mound densities and dimensions at eight ecological analog locations (2012 study plots) on and near the Clive Facility.

Objectives

The objective of the 2012 field studies was to provide a scientific basis for the design of an alternative cover system to meet Energy*Solutions*' permitting requirements under the EPA and the State of Utah. To achieve this objective, SWCA examined study plots that are ecologically analogous to the conditions that would exist on an alternative cover system at the Clive Facility. In addition to limited 2010 data (SWCA 2010), additional study plots were needed to examine the potential biotic communities that could exist within the elevational range of the cap, the biotic communities currently associated with borrowed soils and other borrow source materials, and the biotic communities associated with reclaimed sites with similar ecological conditions.

Methods

Study Plot Selection

Field study plots were selected to be ecologically analogous to the Clive Site, with similar soils, elevations, and with locally adapted, native biotic communities. Field study plots were also chosen to capture conditions at potential soil borrow sources and at any existing reclaimed sites near the Clive Facility.

This page intentionally blank

Figure 3. Range of potential ecological analog study sites at and near the Clive Site within an elevational range of 1,303–1,309 m (4,275–4,295 feet) in elevation.

This page intentionally blank

The Clive Facility occurs in Tooele County, Utah, on the eastern edge of the Great Salt Lake Desert at ca. 40.690891˚ latitude -113.112073˚ longitude at approximately 1,307 m (4,288 feet) (in elevation (see Figure 1). A target elevational range for ecological analog study sites was chosen as 1,303–1,309 m (4,275–4,295 feet) to capture the vegetation, soils, and biota that would be associated with the cap. Figure 3 shows the relatively limited distribution of this elevational range in the Bonneville Basin. The area for study plot selection was also limited to the Clive Site and BLM-administered lands.

Eight study plots and one soil borrow site were selected based on the following criteria: ecological relevance, soil or fill borrow source, and disturbance or reclamation history. All study plots are within the elevational range of the Clive Facility (1,303–1,309 m [1,275–4,295 feet] in elevation). The study plots were distributed so that all potential vegetation types within the target elevation range were captured, and to include variations in aspect and slope. Three study plots were positioned on isolated hills, comprising one on an east-facing aspect, one on a west-facing aspect, and one on a south-facing aspect. One study plot, in the immediate vicinity of Plot 3 (2010), was placed on the Clive Site in a soil borrow site to assess ant mound size and depth. No rock or gravel borrow sites were selected, because none fell within the study area elevational range or possessed relevant ecological conditions. Figure 4 shows the distribution of the five 2010 study plots (Plots 1–5) relative to the distribution of the eight 2012 study plots (Plots 6–13). Only Plot 3 from the 2010 field studies falls within the target elevation range for the Clive Facility.

Because the soils that will be used in the alternative cover system must be able to support the desired native vegetation and meet ET and erosion-resistance requirements for the cover, the vegetation and soil conditions at on-site soil borrow sites were examined as part of field studies. Soil samples were collected at study and borrow sites for analysis of soil physical and chemical properties in order to quantify soil fertility, stability, evaporation potential, and bioturbation potential. SWCA acquired a research permit to conduct these studies on BLM lands, and consulted with Energy*Solutions* on selection of on-site borrow sources and associated excavations

One study plot was on the Clive Facility and seven plots were on BLM-administered lands. At each study plot, a 31.6 × 31.6–m (0.10 hectare or 1,000 m^2) plot was established using three 50-m tapes. Each plot is oriented with each side aligned with the cardinal directions (north-south-east west). The 2012 study plot sizes were 1/10th the size of the 2010 study plots, but the sample size was larger (eight plots) within one community type, and sampling for all parameters (vegetation, mammals, burrows, ant mounds) was more intensive within each sample plot compared to the 2010 sampling effort.

A 0.10-hectare field study plot was established at each study plot. The center of each study plot was recorded using a Trimble GPS. Each 31.6 × 31.6–m plot was oriented in a north-south direction. Vegetation and small mammal sampling, and burrow and ant mound quantification were conducted following the sampling methods employed for 2010 bioturbation studies for the Clive Site (SWCA 2010). Soil samples were collected from each study plot and from the soil borrow site. The following ecological parameters were measured at each study plot:

- Vegetation diversity, cover, and density
- Small mammal diversity and abundance (live trapping)
- Animal burrow density and soil volumes
- Ant mound area, volume, and density
- Soil erosion, channeling, and aeolian transport

Photographs were taken at each study plot to show representative vegetation conditions, burrows and ant mounds, and evidence of surface erosion or soil transport. The following sections describe the specific methods used, results, discussion of key findings, and a set of recommendations based on the results of the field studies.

This page intentionally blank

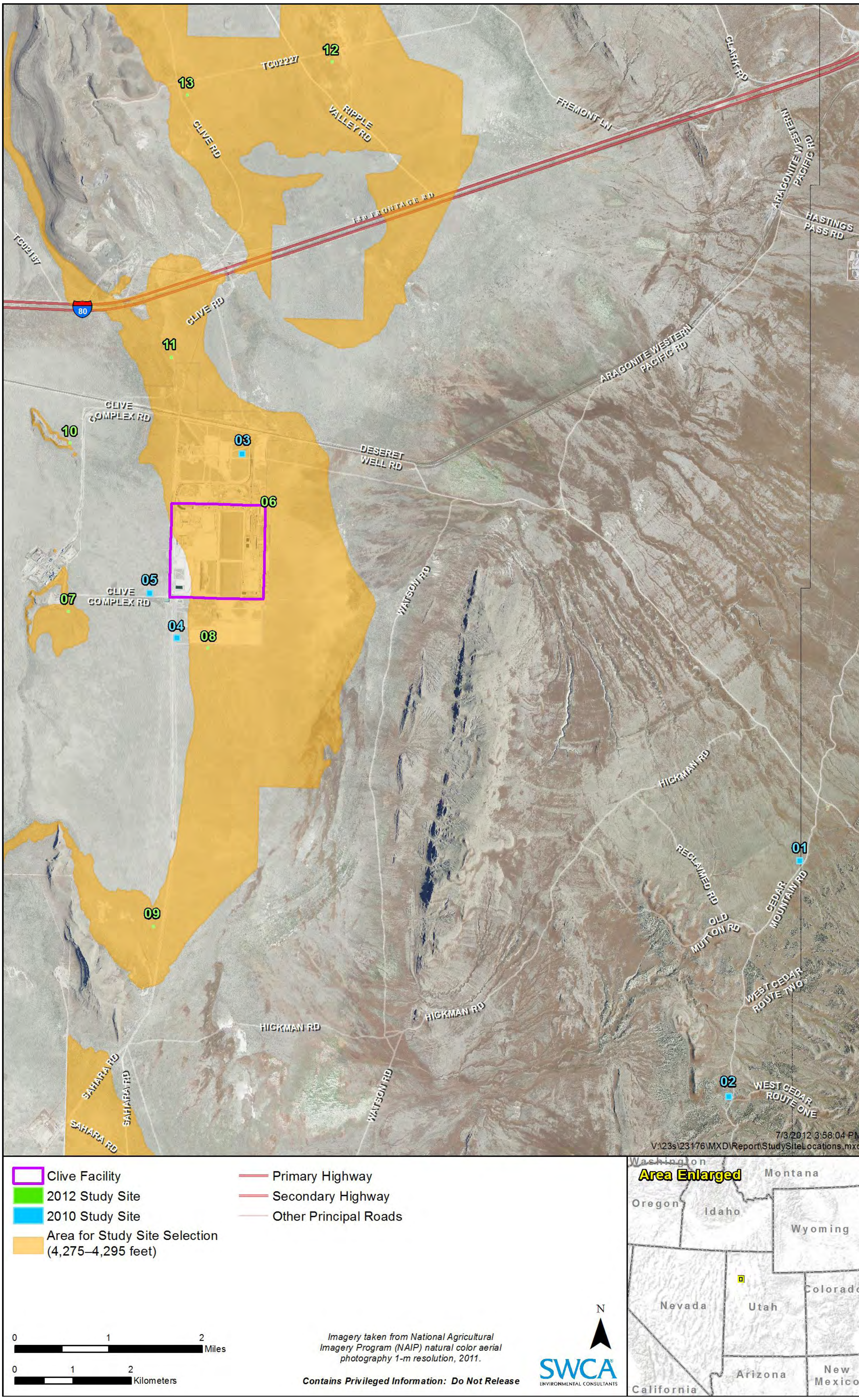


Figure 4. The distribution of 2010 Plots 1–5 and 2012 Plots 6–13 within the study area for the Clive Facility.

This page intentionally blank

Vegetation Study Methods

VEGETATION COMMUNITY DISTRIBUTION

The distribution of land cover and vegetation community types was mapped using the Southwest Regional Gap Analysis Project (SWReGAP) database.

SPECIES COMPOSITION METHODS

In each study plot, five 30-m transects were established at 6, 12, 18, 24, and 30 m along the south edge of the plot (Figure 5). Six 1-m^2 quadrats were sampled on the west side of each transect at 5, 10, 15, 20, 25, and 30 m, for a total of 30 quadrats per plot (30 m^2 or 3% of each 1,000-m^2 plot area). At each quadrat location, each plant was identified to species and listed on the datasheet.

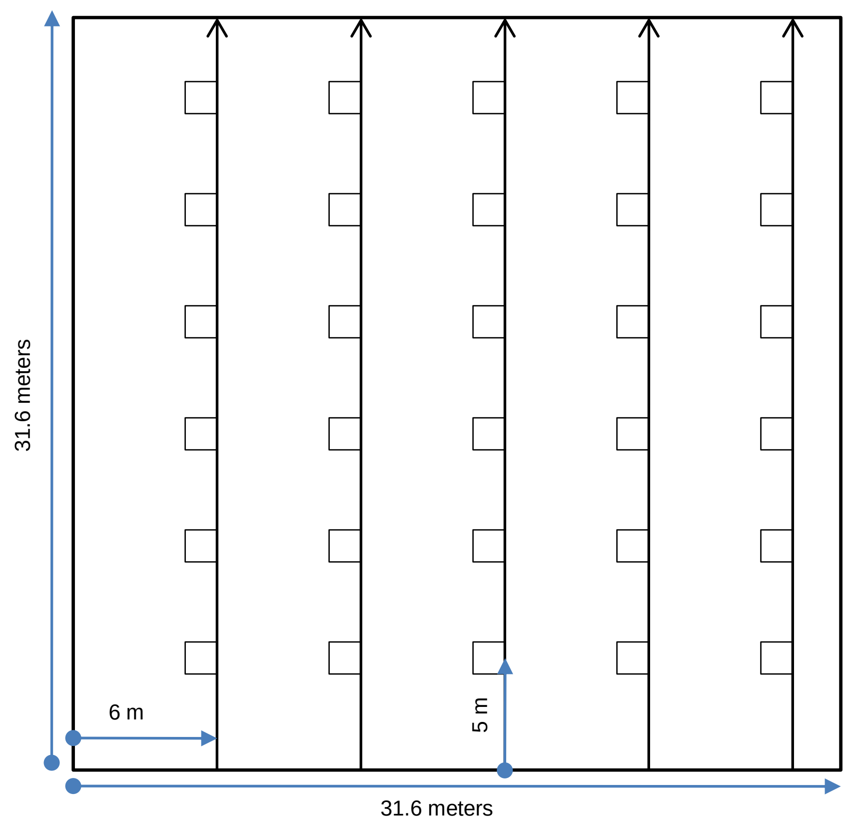


Figure 5. Study plot design showing vegetation sampling transects and quadrat locations.

COVER ESTIMATION METHODS

The areal percentage cover of each plant species, biological soil crust, litter, rock, and bare ground within each quadrat was visually estimated and recorded.

DENSITY ESTIMATION METHODS

The number of individual stems of each plant species within each quadrat was recorded.

A copy of the vegetation datasheet is provided in Appendix A.

Animal Bioturbation Study Methods

The objective of small mammal trapping was to identify the distribution and density of small mammals associated with each study plot. Animal burrow surveys were conducted to estimate the density, depth, and soil volumes that can be displaced by the native biota. Ant mound surveys were also conducted to provide estimates of the density of ant mounds and the volume of soil displaced by ant colonies in each study plot.

SMALL MAMMAL TRAPPING METHODS

Each 0.1-hectare plot was subdivided into nine 10.5 × 10.5–m subplots. One large trap (approximately 8 × 8 × 23 cm) was placed at each trapping station and one extra-large trap (approximately 10 × 10 × 40 cm) was placed at every other station, for a total of 14 traps per plot. Figure 6 shows the trapping station design and layout of the nine large and five extra-large traps installed at each plot.

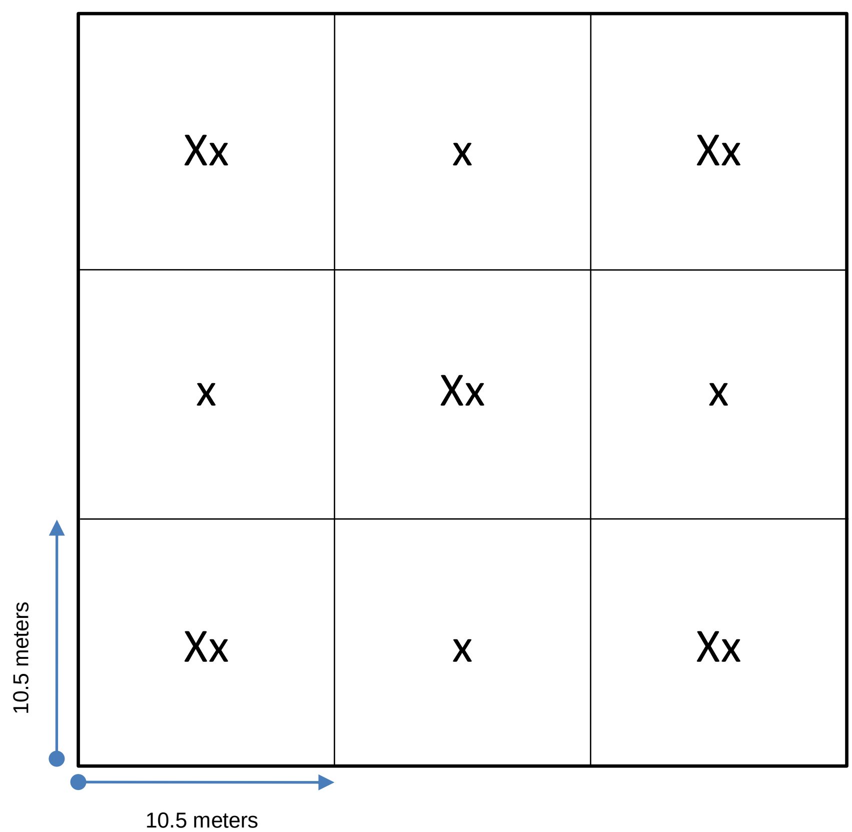


Figure 6. Small mammal trapping station layout, where X represents extra-large traps and x represents large traps.

Mammal traps were placed on-site prior to baiting and setting the traps in order to accustom animals to the presence of the traps. Traps were baited with four-grain horse feed rolled in molasses and set in the evening. Cotton balls were also placed in the traps to be used as bedding and insulation by trapped animals in order to prevent hypothermia. The traps were checked around sunrise the following morning, and any captured animals were identified to species, marked, and released. The purpose of marking captured animals was to prevent overestimation of small mammal densities. Representative photographs of captured small mammal species and other observations of animal activities were also recorded at each plot location.

A copy of the small mammal trapping datasheet is provided in Appendix B.

MAMMAL BURROW SURVEY METHODS

Mammal burrow surveys at the eight study plots were conducted on June 13, 16, 22, and 23, 2012. To ensure 100% survey coverage, each 0.10-hectare plot was surveyed by walking transects approximately 3 m (10 feet) apart. The universal transverse mercator (UTM) location of each individual burrow or groupings of burrows was recorded using a handheld global positioning system (GPS) unit for individual burrows or a group of similar burrows. Burrows were identified to species level when possible; however, in many cases, burrows were assigned a likely "group" of burrowers (i.e., mouse/vole/rat). Considering the large number of deer mice captured during trapping efforts, it is possible that burrows in this particular category are deer mice burrows. Soil excavations (digging locations with no burrow entrance) were not recorded.

A copy of the burrow survey datasheet is provided in Appendix C.

ANT MOUND SURVEY METHODS

Ant mound surveys of the eight study plots were conducted on June 13, 16, 22, and 23, 2012. To ensure 100% survey coverage, each 0.10-hectare plot was surveyed by walking transects approximately 3 m (10 feet) apart. The UTM location of each ant mound was recorded using a handheld GPS unit. The following information was collected for each ant mound in the study plots:

- Date, observer, plot number, and UTM coordinates
- Height, width, and length of the mound
- A photograph of the mound
- The orientation of the mound entrance (e.g., north, south, north-northeast)

No ant specimens were collected for identification to species, because it is assumed that all ants in the study area are western harvester ants (*Pogonomyrmex occidentalis*). This assumption was made based on the results of the 2010 ant mound surveys, which identified over 99.7% of 1,624 ant specimens as western harvester ants (SWCA 2010). In addition, the four ants that were identified to *Lasius* species in 2010 were collected from Plot 1, a grassland vegetation community at a considerably higher elevation than the Clive Facility. The western harvester ant is widely distributed in Utah and other western states, and frequently occurs in flat areas that have been recently disturbed by human activities (Allred 1982). These habitat conditions are descriptive of the entire study area and are representative of the habitat conditions that would exist on the cap.

Western harvester ant mounds are generally conical in shape. However, because ant mounds are usually irregular cone shapes, the formula for the volume of a cone does not provide an accurate estimate. Formulas for an ellipsoid and elliptic paraboloid have also been used to estimate the three-dimensional characteristics and volume of ant mounds (Porter et al. 1992; Vogt et al. 2004). Although these formulas provided more accurate volume estimations, they did not account for the irregular shape of ant mounds and overestimated volume, especially with increasing ant mound size. A recently published study of fire ant (*Solenopsis invicta*) mound volume identified the formula for an oblique cone or hyperboloid as a more accurate estimator (Vogt 2007). Vogt's (2007) volume formula provides a better estimator because it accounts for the eccentric base and oblique cone shape of ant mounds. Both published studies of ant mound architecture (Porter et al. 1992; Vogt et al. 2004; Vogt 2007) and field observations in the Bonneville Basin demonstrate that the surface area and volume of western harvester ant mounds are generally oblique cones with eccentric bases, as described in Vogt (2007).

The surface area occupied by ant mounds was estimated using the area of an ellipse (or eccentric base), given as $A = \pi \times a \times b$, where *a* is the radius of the long (major) axis and *b* is the radius of the short (minor) axis ($\pi = 3.14159265359$). The approximate soil volume occupied by ant mounds was estimated using Vogt's formula: $1/3 \times \pi \times (a/2) \times (b/2) \times c$ (Vogt 2007), where *a* is the radius of long axis (x), *b* is the radius of short axis, and *c* is the radius of height (vertical) axis.

A copy of the ant mound survey datasheet is provided in Appendix D.

ANT MOUND EXCAVATION METHODS

The objective of ant mound excavations was to estimate the relationship between above and belowground nest volumes in native vegetation and soils on and near the Clive Facility. Ant mound excavations were conducted on the Clive Site using an excavator and hand tools, as needed.

OTHER BURROWING ANIMAL OBSERVATIONS

Incidental occurrences of burrowing animals are also an important consideration in assessing the bioturbation potential in study plots near the Clive Facility. The presence of mammals, birds, or insects in or anywhere near the study plots was noted during all field activities. Animal occurrences were captured in photographs where feasible.

Soils

The objectives of the soil field studies and analyses were to characterize existing soil properties. From both an engineering and reclamation perspective, understanding soil properties such as physical characteristics, chemical parameters, and capacity as a growth medium are integral to reclamation success.

SOIL MAPPING AND CLASSIFICATION

The objective of evaluating soil type distributions and classifications was to understand the relationship between soil properties in the study plots, and the vegetation, biophysical components, and chemical processes the vegetated cover system seeks to replicate. General information regarding parent material, soil formation, and characteristics complied by Natural Resources Conservation Service (formerly Soil Conservation Service) are available at the soil map unit and series level for the Clive site. However, very limited site-specific data are available that describe organic matter content, macronutrients, micronutrients, and other parameters that must be considered by Energy*Solutions* for the establishment and long-term development of an ecologically functioning vegetation community on the cap.

SOIL EROSION

In addition to collecting soil samples, SWCA mapped the location of wind and water erosion features at each study plot. Identifying the presence and relative abundance of these features is important because local climatic and weather conditions, soil characteristics, and wind speed and direction patterns are conducive to moving sediment by wind and water. Excessive erosion at the study plots could be of concern to Energy*Solutions* during the vegetation establishment period because loose topsoil on the ET cover would have no physical or biological structures to keep it in place.

SOIL SAMPLING

Soil sampling methods followed the recommended soil sampling protocol from Utah State University (USU) Analytical Laboratories in Logan, Utah. At each study plot, SWCA gathered soil subsamples at five locations. Soil subsample locations were randomly selected along five transects within the study plots using a random number generator. The number generated (range of 0–32) represents the distance in meters from the southern boundary to the northern boundary of the plot (Figure 7). Subsample locations were characteristic of conditions within the study plot. All subsamples were taken at a depth of 0–30 cm (0–12 inches) using a 5-cm (2-inch) soil auger, as per the recommended sampling protocol. The five soil subsamples were combined to create one composite sample. The soil samples were stored in resealable plastic bags and labeled with the study plot number, date, and time of collection.

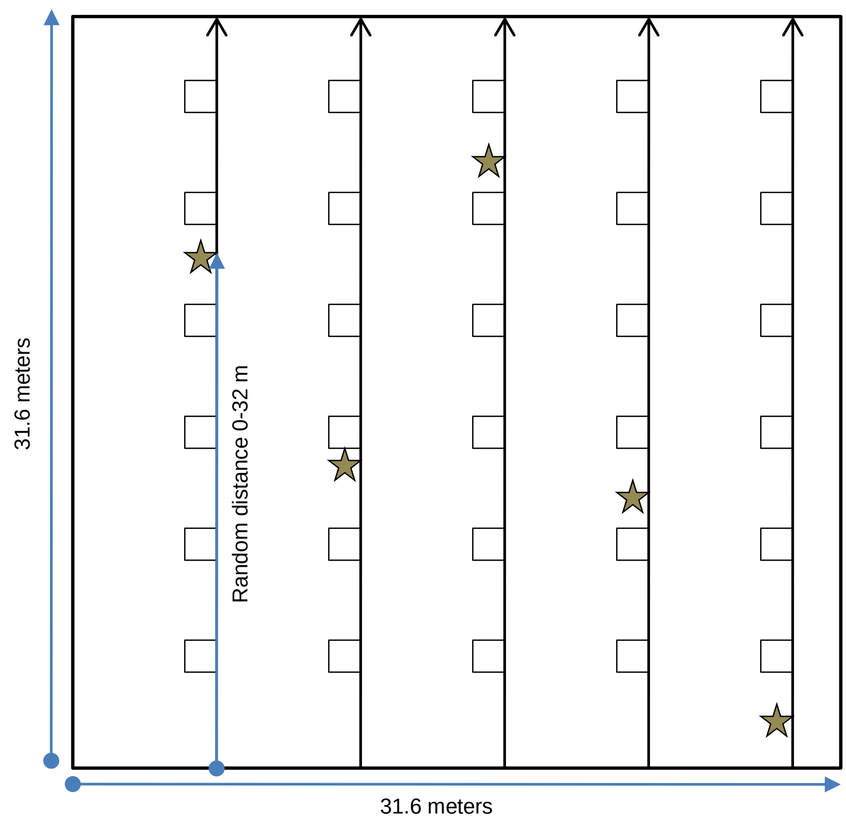


Figure 7. Example random soil sample distribution relative to vegetation transects in study plots.

In addition to those samples obtained from the study plots, SWCA gathered soil samples from three ant mound excavation sites at depths of 0.3 m and 1.1 m (1.0 and 3.5 feet), one ant mound excavation site at a depth of 0.2 m (0.5 feet), and a soil borrow site at depths consistent with the bottom of Borrow Unit 4 and top of Borrow Unit 3 on the Clive Site.

Field study data were compiled into an Excel workbook for databasing and summary analyses. Soil samples were submitted to USU Analytical Laboratories for analyses of soil physical and chemical parameters. The soil parameters that were analyzed are listed in Table 1, including a description of each parameter and its effect on vegetation growth and survival.

Table 1. Clive Site Soil Parameters

Parameter	Description	Effect on Vegetation
Soil texture	Proportion of particles of various sizes in the soil	Determines nutrient, water, and air supply ability of soils.
pH	Ratio of hydrogen to hydroxyl ions resulting in acidic, neutral, or alkaline conditions	Although the hydrogen ion in high concentrations may be toxic and may directly affect plants, the availability of some essential nutrients is affected by pH.
Salinity ECe	Measure of soil salinity and indicative of an aqueous solution to carry an electric current	Plants may be affected physically and chemically by excess salts. Reclamation in soils with high salinity should avoid salt-sensitive plants. Salinity can be defined in terms of suitable plant species for a reclamation site.
SAR	Comparative concentrations of Na^{+} (sodium ion), Ca^{2+} (calcium ion), and Mg^{2+} (magnesium ion) in soil solutions	Soils that are high in Na+ relative to other salts may cause plants to have difficulty absorbing water. This typically occurs when the SAR rises above 12–15. (Ecosystem Restoration 2004)
Phosphorous, potassium, nitrate-nitrogen, sulfate-sulfur	Macronutrients	Essential elements used by plants in relatively large amounts that are important constituents for growth. Concentrations of these elements determine the need for the type and amount of soil amendments.
Zinc, iron, copper, and manganese	Micronutrients	Essential elements used by plants in relatively small amounts that are important constituents for growth.
Organic matter	The percentage of recognizable organic material and humus in the soil	Organic matter influences physical (open and loose) and chemical (source of nutrient elements) properties of soil, which affect plant growth.
Metals (cadmium, chromium, nickel, and lead)	Heavy metals	Essential elements that are essential for healthy plant growth but that may be toxic to plants at high levels.

CORRELATION ANALYSES

To assess the relationships between biotic and abiotic features of the ecological analog study sites, Pearson's correlation analyses were performed to identify relationships among the variables that were assessed during field studies: vegetation cover and density; small mammal distributions and densities; burrow volumes; ant mound area, volume, and densities; and soil structure and chemistry. The Pearson product-moment correlation coefficient (Rodgers and Nicewander 1988) is a widely used measure of the degree of correlation, or linear dependence, between two variables. The relationship between two variables, X and Y, is given geometrically, with Y plotted as a function of X with a resulting slope value between +1.0 and -1.0 (Rodgers and Nicewander 1988). The Pearson product-moment correlation coefficient, often given as r, represents a slope ranging from -1.0, which is a perfect negative relationship where Y decreases linearly with increasing values of X, to 1.0, which is a perfect positive relationship between X and Y. A coefficient of 0 indicates that there is no linear relationship between the variables.

Correlation coefficients, or *r* values, between -0.5 to -1.0 and +0.5 to 1.0 are generally considered indicative of a strong linear association between two variables (Cohen 1988). All correlation analyses were performed in MS Excel (Microsoft Office 2010).

ORDINATION ANALYSES

Ordination analyses were also performed to assess trends in the distribution of vegetation community features (species cover, ground cover, and total cover) with small mammals, other burrowing animals, ants, and abiotic site features. All ordination analyses were performed in PC-Ord Version 5.0 (MjM Software Corporation 2007).

Results

Field studies were initiated on June 13, 2012, and completed on June 23, 2012. The locations of the eight analog study sites were determined in the field to confirm the spatial distributions of vegetation cover types and to ensure that the entire plot is contained within a distinct vegetation community. Small mammal trapping was initiated immediately due to the two-week window for field studies. Burrow and ant mound surveys were conducted concurrently with mammal trapping or after trapping was completed. Vegetation and soil sampling were conducted concurrently during the second week of field studies.

Vegetation Sampling Results

Vegetation sampling was performed from June 19 to 21, 2012. In each field plot, five 31.6-m-long transects were oriented south to north every 6 m (6 m, 12 m, 18 m, 24 m, and 30 m) from the southwestern corner of the plot. On each transect, six 1-m^2 sampling quadrats were sampled at 5, 10, 15, 20, 25, and 30 m for a total of 30 sample quadrats per plot (30 m^2 or 3% of each 1,000-m^2 plot area). Figure 8 shows the typical mix of black greasewood and saltbush vegetation on and near the Clive Site.

Figure 8. Typical vegetation community near the Clive Site: a mosaic of black greasewood and shadscale saltbush dominated by biological soil crust.

Ten plant species were identified in the eight 2012 field plots. Vegetation cover was sparse in all of the plots. Biological soil crusts are a dominant feature of vegetation communities throughout the Great Salt Lake Basin, and were the dominant ground cover in all eight sample plots.

VEGETATION COMMUNITY DISTRIBUTION RESULTS

Vegetation communities in the study area consist of three cover types: 1) Inter-Mountain Basins Greasewood Flat; 2) Inter-Mountain Basins Mixed Salt Desert Scrub; and 2) Developed/Disturbed land cover. Figure 9 shows the distribution of the study sites relative to these land cover types. The dominant vegetation and other features of these cover types are described following the map.

The vegetation in the study area is generally sparse, and comprises a matrix of greasewood-dominated to desert scrub-dominated habitats. Although the SWReGAP database includes Invasive Annual Grassland in the study area, this vegetation type was not found in the study area during the field studies. The locations of Invasive Annual Grassland and Inter-Mountain Basins Playa (shown in Figure 9) were actually dunes of windblown soil and sand that are similar in color to grassland and playa communities in the area, but that occur at higher and lower elevations than the Clive Facility, respectively.

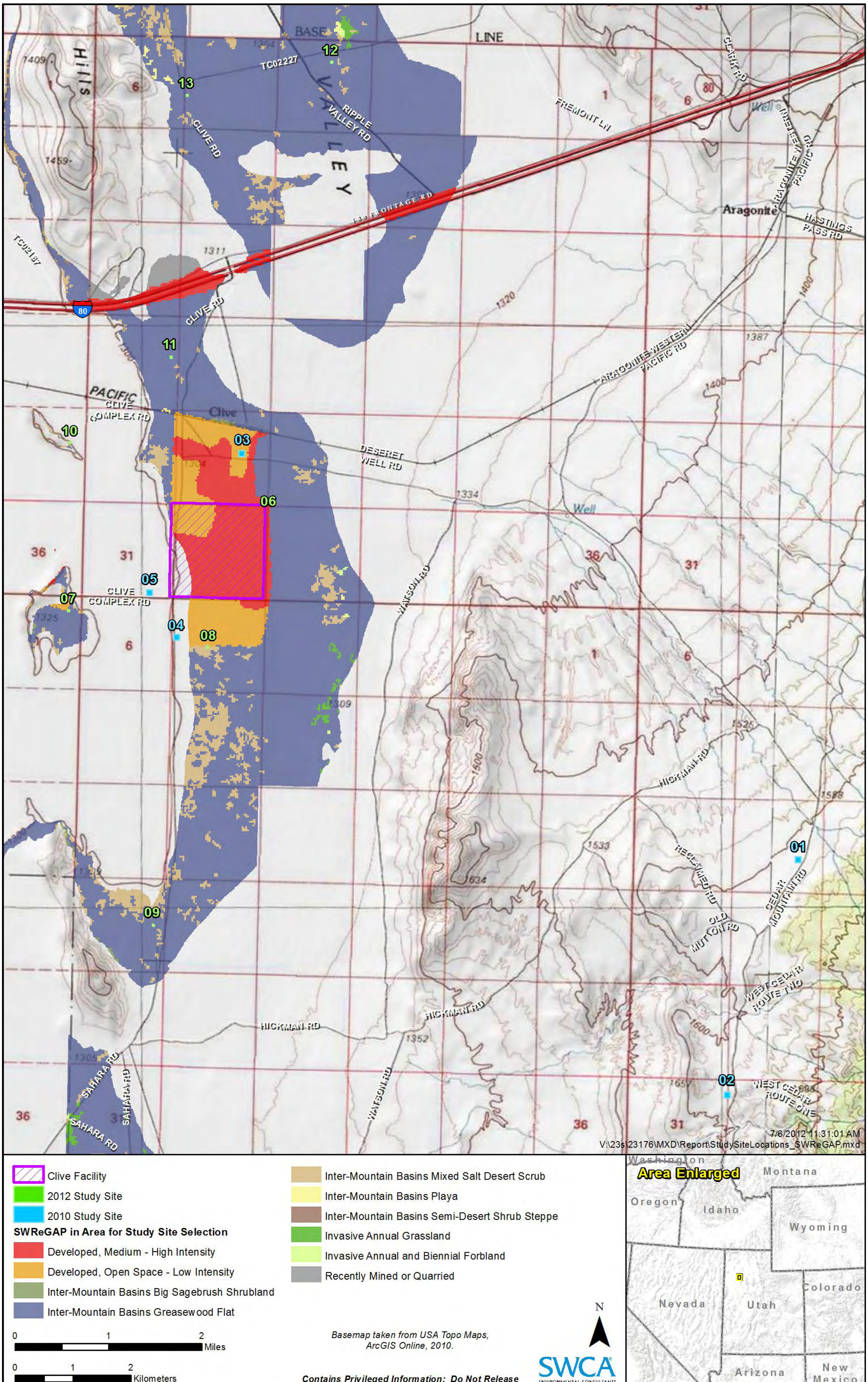


Figure 9. SWReGAP vegetation community distributions near the Clive Facility.

This page intentionally blank

LAND COVER DESCRIPTIONS

Inter-Mountain Basins Greasewood Flat

This vegetation community usually occurs near drainages on flats and stream terraces, but in the western Bonneville Basin, it occurs in association with sparsely vegetated playas. This association typically has saline soils, a shallow water table, and remains dry for most growing seasons. The vegetation consists of open to moderately dense shrublands dominated or co-dominated by black greasewood. Other shrub and forb species that are present in the study area are shadscale saltbush (*Atriplex confertifolia*), fourwing saltbush (*Atriplex canescens*), Mojave seablite (*Suaeda torreyana*), gray molly, and bug sage (*Picrothamnus desertorum*). Non-native invasive species associated with this community include fivehorn smotherweed (*Bassia hyssopifolia*), herb sophia (*Descurania sophia*), halogeton, and clasping pepperweed (*Lepidium perfoliatum*). Groundcover is dominated by biological soil crust, with limited cover of rock/cobble, litter, and bare ground.

Inter-Mountain Basins Mixed Salt Desert Scrub

The vegetation of this ecological system is characterized by open to moderately dense shrubland composed of one or more *Atriplex* species. Shrub, forb, and graminoid species present in the study area consist of shadscale saltbush, fourwing saltbush, Mojave seablite, gray molly, and sandberg bluegrass (*Poa secunda*). Halogeton can also occur as a dominant forb in this community type. Groundcover was dominated by biological soil crust with limited cover of litter and bare ground.

Developed/Disturbed

Developed and disturbed conditions predominate on the Clive Site, with small areas of greasewood and salt desert scrub vegetation intermixed with roads and facilities to the north and east. Impervious surfaces are limited to access roads and parking areas associated with the Clive Facility.

SPECIES COMPOSITION, COVER, AND DENSITY RESULTS

The species and cover composition of each plot, and the percentage cover and density of each is summarized in Table 2. Biological soil crust was the dominant cover in all study plots.

Table 2. Vegetation Species Distributions, Percentage Cover, and Densities for the 2012 Study Plots and 2010 Study Plot 3

Species or Cover Type	**Plot 3 (2010)**		**Plot 6**		**Plot 7**		**Plot 8**		**Plot 9**		**Plot 10**		**Plot 11**		**Plot 12**		**Plot 13**	
	% Cover	**Density**	**% Cover**	**Density**	**% Cover**	**Density**	**% Cover**	**Density**	**% Cover**	**Density**	**% Cover**	**Density**	**% Cover**	**Density**	**% Cover**	**Density**	**% Cover**	**Density**
Fourwing saltbush *Atriplex canescens*	–	–	0.7	1.0	–	–	–	–	–	–	–	–	3.5	7.5	–	–	–	–
Shadscale saltbush *Atriplex confertifolia*	1.3	1.4	1.3	16.2	1.5	3.2	5.1	6.8	1.6	3.9	2.3	1.0	2.3	14.7	17.3	1.7	2.1	2.9
Gray molly *Bassia americana*	0.9	1.2	0.8	1.0	0.9	2.1	1.3	2.6	2.3	2.0	1.3	1.0	3.8	6.4	1.2	1.3	1.7	4.3
Fivehorn smotherweed *Bassia hyssopifolia*	0.6	0.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Burningbush *Bassia scoparia*	0.1	1.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Herb Sophia *Descurainia sophia*	–	–	–	–	0.5	3.0	–	–	–	–	–	–	–	–	–	–	–	–
Halogeton *Halogeton glomeratus*	1.1	12.3	–	–	0.5	3.0	0.5	3.0	0.6	19.6	0.7	6.7	–	–	0.5	1.0	–	–
Clasping pepperweed *Lepidium perfoliatum*	–	–	–	–	1.6	28.3	–	–	–	–	–	–	–	–	–	–	–	–
Bug sage *Picrothamnus desertorum*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.3	1.0	–	–
Sandberg bluegrass *Poa secunda*	–	–	–	–	–	–	–	–	–	–	5.9	40.4	–	–	–		–	–
Black greasewood *Sarcobatus vermiculatus*	11.5	0.7	16.6	1.0	19.0	1.3	–	–	–	–	–	–	–	–	18.4	0.6	17.7	2.4
Mojave seablite *Suaeda torreyana*	3.0	0.7	1.3	4.4	3.4	1.8	7.4	2.7	4.8	1.7	2.0	1.0	0.8	1.4	0.8	1.0	1.2	1.0
Bare ground	3.1	–	3.8	–	2.8	–	2.3	–	1.2	–	59.5	–	5.5	–	1.3	–	0.0	–
Biological soil crust	85.3	–	85.0	–	80.0	–	87.1	–	84.8	–	25.4	–	83.0	–	80.8	–	84.0	–
Litter	6.0	–	3.4	–	9.0	–	6.9	–	13.1	–	11.9	–	9.5	–	7.4	–	8.9	–
Cobble	–	–	–	–	7.5	–	–	–	–	–	–	–		–	5.0	–		–

A summary of average plant species cover, plant density per square meter, and ground cover types is given in Table 3. The average total vegetation cover was 2.9%, consisting of 8.6 total plant stems per square meter. Average total shrub cover was 4.2% for 3.0 shrubs per square meter. Average plant species cover consisted of 14.3% black greasewood, 5.9% Sandberg bluegrass, and approximately 3% cover each of shadscale saltbush and Mojave seablite. Fourwing saltbush and gray molly occurred in low densities with 1.6% and 1.3% cover, respectively. Ground cover was dominated by 79.2% average biological soil crust cover. Summary tables of average plant species cover for each plot are given in Appendix E.

Table 3. Average Plant Species Cover and Density, and Average Ground Cover for All Plots

Species or Cover Type	Average Cover (%)	Average Plant Density (plants per square meter)
Black greasewood *Sarcobatus vermiculatus*	14.3	0.9
Sandberg bluegrass *Poa secunda*	5.9	40.4
Shadscale saltbush *Atriplex confertifolia*	3.2	7.3
Mojave seablite *Suaeda torreyana*	2.8	2.2
Fourwing saltbush *Atriplex canescens*	1.8	3.6
Gray molly *Bassia americana*	1.6	2.9
Clasping pepperweed *Lepidium perfoliatum*	1.6	28.3
Bug sage *Picrothamnus desertorum*	1.3	1.0
Halogeton *Halogeton glomeratus*	1.0	12.3
Fivehorn smotherweed *Bassia hyssopifolia*	0.6	0.7
Herb Sophia *Descurainia sophia*	0.5	3.0
Burningbush *Bassia scoparia*	0.1	1.0
Average	**2.9**	**8.6**
Biological soil crust	79.2	–
Litter	7.9	–
Bare ground	7.8	–
Cobble	6.7	–

Bioturbation

SMALL MAMMAL TRAPPING RESULTS

Small mammal trapping was conducted from June 13 through June 23, 2012. Mammal traps are usually placed on-site for 48–72 hours before baiting and setting them; this helps accustom animals to the presence of the traps. However, because of a short trapping window of 14 days for eight plot locations, some of the traps were left on-site for only 1–48 hours prior to baiting. The traps on Plots 7, 8, and 9 were baited within 1 hour of placement. Traps on Plot 6 were left in place without bait for 48 hours prior to baiting. The traps at Plots 10, 11, 12, and 13 were left in place for 48 hours prior to baiting. The traps on Plots 6 through 9 were baited from June 15 to June 17 before dusk and checked the following mornings. The traps on Plots 10 through 13 were baited from June 17 to June 22 and checked the following mornings. The new moon occurred on June 19, 2012, so moonlight during trapping was minimal.

Captured mammals were identified to species and released. Mouse species were marked with nail polish before release; however, kangaroo rats did not tolerate the marking process. Additionally, during the course of trapping, it became apparent that some mice were chewing off nail polish markings or pulling out marked fur, making recapture information difficult to obtain. For these reasons, the recapture estimates may be underestimated, and the total small mammals captured may be overestimated for some plots.

Table 4. Summary of Small Mammal Species and Number Captured (number of recaptures) for 2012 Study Plots and 2010 Study Plot 3

Study Plot	Deer Mice (*Peromyscus maniculatus*)	Kangaroo Rats (*Dipodomys* species)
Plot 3 (2010)	2 (1)	0
Plot 6	11 (3)	0
Plot 7	6 (0)	0
Plot 8	0	0
Plot 9	13 (3)	–
Plot 10	4 (2)	0
Plot 11	22 (6)	0
Plot 12	47 (13)	1
Plot 13	12 (4)	0

In all, 115 captures (including 31 recaptures) or a total of 84 individuals were trapped during small mammal trapping. Small mammals were concentrated in the northern portion of the study area (Plots 11, 12, and 13; see Figure 4). In all, 83 deer mice and one kangaroo rat were captured. Exactly half (42/84 or 50%) of these captures occurred on Plots 12 and 13.

The kangaroo rat captured on Plot 12 (Figure 10) was most likely Ord's kangaroo rat (*D. ordii*) based on measurements taken in the field, but that species can be very difficult to distinguish from the chisel-toothed kangaroo rat (*D. microps*; personal communication between George Oliver, UDWR and Amanda Christensen, SWCA, June 25, 2012).

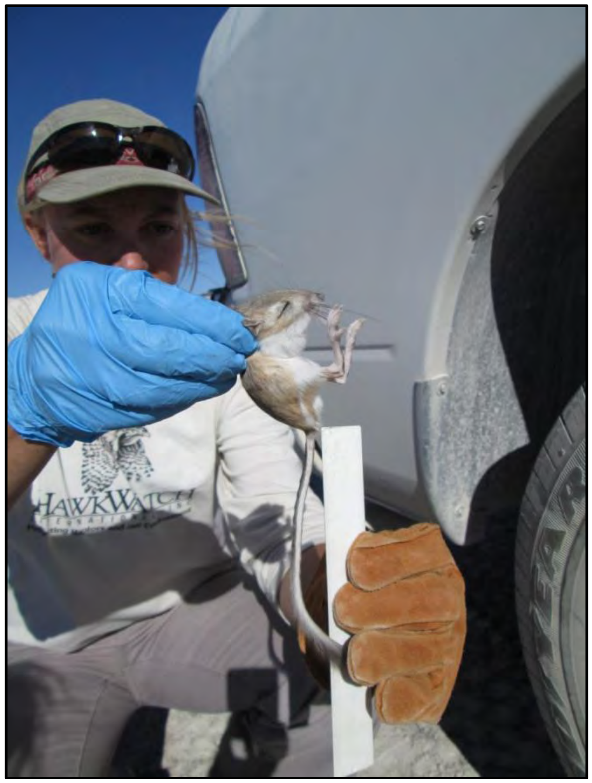


Figure 10. Kangaroo rat captured at Plot 12.

Several mice died either in the traps or shortly after being released, presumably due to shock or hypothermia. Two mice died during trapping on Plot 12, and one mouse was unintentionally left in a trap on Plot 11. This occurred because only one mouse exited the trap when it was checked on the morning of June 22, and the second mouse in the trap was not detected. The trap was shut and replaced on-site.

MAMMAL BURROW SURVEY RESULTS

Mammal burrow surveys were conducted on June 13, 16, 22, and 23, 2012. The geographic location of each burrow was recorded using a handheld GPS unit. Burrows were mapped as either individual burrows or as groups of similar burrows. No burrows were found on Plots 6, 8, 9, 10, or 13.

Burrows were identified to species level when possible; however, in many cases, burrows were assigned a likely “group” of burrowers (i.e., mouse/vole/rat). Considering the large number of deer mice captured during trapping efforts, it is highly probable that most of the mouse/vole/rat burrows were made by deer mice. Soil excavations (digging locations with no burrow entrance) were not recorded. Table 5 displays the number of burrows for all plots by burrow type. Burrows only occurred on Plots 7, 11, and 12. Coyote burrows/dens were observed near survey plots, but none fell within plot boundaries.

Table 5. Summary of Mammal Burrow Survey Results by Species for 2012 Study Plots and 2010 Study Plot 3 (average soil displacement per burrow in parentheses (liters)

Study Plot	Mouse (*Peromyscus* spp.)	Kangaroo rat (*Dipodomys* species)	Ground squirrel (*Spermophilus sp.*)	Badger (*Taxidea taxus*)
Plot 3 (2010)	–	–	–	–
Plot 6	0	0	0	0
Plot 7	1 (0.0L)*	1 (0.25L)	0	1 (13.5L)
Plot 8	0	0	0	0
Plot 9	0	0	0	0
Plot 10	0	0	0	0
Plot 11	0	0	1 (45.5L)	0
Plot 12	9 (6.2L)†	6 (18.2L)‡	0	3 (26.0L)
Plot 13	0	0	0	0

* 5 burrow entrances in complex; no soil displacement.

†9 total burrow entrances in plot.

‡30 total burrow entrances in plot.

After each burrow location was documented, the volume of soil that had been brought to the surface was measured. To do this, the obviously mounded or disturbed soil around a burrow entrance was collected and measured in liters.

The locations of two soil excavations (without burrow entrances; Figure 11) were also recorded on Plot 11, but soil volumes were not measured.

Figure 11. Soil excavation.

ANT MOUND SURVEY RESULTS

Nineteen ant mounds were recorded and measured in Plots 6–13, with an average of 2.4 ant mounds per 1/10th hectare plot (Table 6). This is a very similar estimate to the results of the 2010 ant mound surveys, which found an average density of 2–33 mounds per hectare (SWCA 2010). Table 6 summarizes the total mounds per plot, total mound area (cm^2) per plot, and total aboveground volume (cm^3) per plot. A very large active ant mound occurred in Plot 7 (Figure 12). Well-developed biological soil crust is also visible surrounding the ant mound.

Table 6. Ant Mound Surface Area and Density for 2012 Study Plots and 2010 Study Plot 3

Study Plot	Total Number of Mounds per 1,000-m^2 Plot	Total Mound Area (cm^2) per 1,000-m^2 Plot	Total Aboveground Volume (cm^3) per Plot
Plot 3 (2010*)	3.3	9,500.0	25,268.3
Plot 6	3	11,815.9	47,881.1
Plot 7	4	25,612.6	144,686.3
Plot 8	2	13,160.1	52,264.5
Plot 9	2	7,747.2	16,320.4
Plot 10	4	15,473.9	77,217.7
Plot 11	1	5,103.9	10,888.4
Plot 12	1	1,540.6	3,286.6
Plot 13	2	6,209.0	18,881.4
Average per plot	2.4	4,561.2	46,428.3

* The values given for Plot 3 (SWCA 2010) are averages due to the larger plot size and sample size.

Based on the measurements recorded for ant mounds in the study plots, the average ant mound density and area in the study area is 24 mounds covering 456.1 m^2, respectively, *per hectare* (10,000 m^2). The average area of each harvester ant mound was 1,900.5 cm^2. Based on the ant mound dimensions measures and volume estimates, the average aboveground volume of harvester ant mounds per hectare is approximately 0.5 m^3. Belowground ant mound volume estimates are discussed in the next section.

Figure 12. Large ant mound in Plot 7.

ANT MOUND EXCAVATION RESULTS

Presumably, the aboveground area and volume of each ant mound is proportional to the depth and belowground volume of the nest, but that relationship has not been clearly established for *P. occidentalis* mounds in the particular soil types present on the study plots. Four ant mound locations were selected north of the Clive Facility near soil borrow Units 3 and 4. The aboveground height, long axis, and short axis (cm) of each ant mound was measured. An excavator removed soil along a straight line starting at the outside edge of the ant mound and then excavated three to four additional sections toward the center of the ant mound. The average aboveground area and volume of the excavated ant mounds was 2,683 cm^2 and 28,348 cm^3, respectively. The average ant mound area estimate from Plots 3–13 was approximately 1,900 cm^2, and the average ant mound volume estimate was 19,345 cm^3. The belowground area of the excavated ant mounds was found to be sparsely distributed, with most of the ant nest within 0.6 m (2.0 feet) of the surface. Some scattered chambers occurred in deeper soil layers, but were very difficult to locate using a large excavator and hand tools. Figure 13 shows one of the excavated ant mound locations, with evidence of large chambers near the surface of the soil and rapidly decreasing root densities and ant structures as soil depths approach the condensed clay layer that is typical of the soils on the Clive Site (SWCA 2010).

Figure 13. Ant mound excavation showing some large ant chambers near the soil surface with very little root biomass or evidence of ant activity at or below the condensed clay layer at approximately 0.6 m (2 feet) below the soil surface.

OTHER BURROWING ANIMAL OBSERVATIONS

Animals observed during field surveys included pronghorn, black-tailed jackrabbits (*Lepus californicus*), badgers (*Taxidea taxus*; Figure 14), and burrowing owls (*Athene cunicularia*; Figure 15). The presence of the badgers and jackrabbits in the study area indicates the potential for large volume soil bioturbation within the existing vegetation communities and soil types.

Figure 14. Badger (*Taxidea taxus*) photographed near Plot 12 (Photograph: Thomas Sharp, SWCA, June 2012).

Figure 15. Seven burrowing owl (*Athene cunicularia*) fledglings in burrow immediately south of the Clive Facility (Photograph: Thomas Sharp, SWCA, June 2012).

Soils

Soil sampling was conducted concurrently with vegetation sampling. Using the recommended soil sampling protocol from USU Analytical Laboratories in Logan, Utah, SWCA gathered soil subsamples at five locations within each of the eight study plots on the Clive Site. Soil sampling occurred from June 19 to 21, 2012. Subsample locations were characteristic of conditions within the study plot. All subsamples were taken at a depth of 0–30 cm (0–12 inches) using a 5-cm (2-inch) soil auger, as per the recommended sampling protocol. The five soil subsamples were combined to create one composite sample. SWCA stored the soil in a resealable plastic bag and labeled it with the appropriate study plot information, date, and time. Seventeen soil samples were sent to the USU Analytical Laboratories on June, 22, 2012.

SOIL MAPPING AND CLASSIFICATION

Soil Map Units

The study plots fall within three soil maps units (Figure 16), which delineate broad areas with distinctive soils, relief, and drainage (U.S. Department of Agriculture 2000). These map units are useful in describing conditions over large areas and suitability for land uses, and characterize the general conditions found at the eastern extent of the Great Basin. Table 7 describes similar elevation, climate, and vegetation characteristics in the soil map units present near the Clive Site.

This page intentionally blank

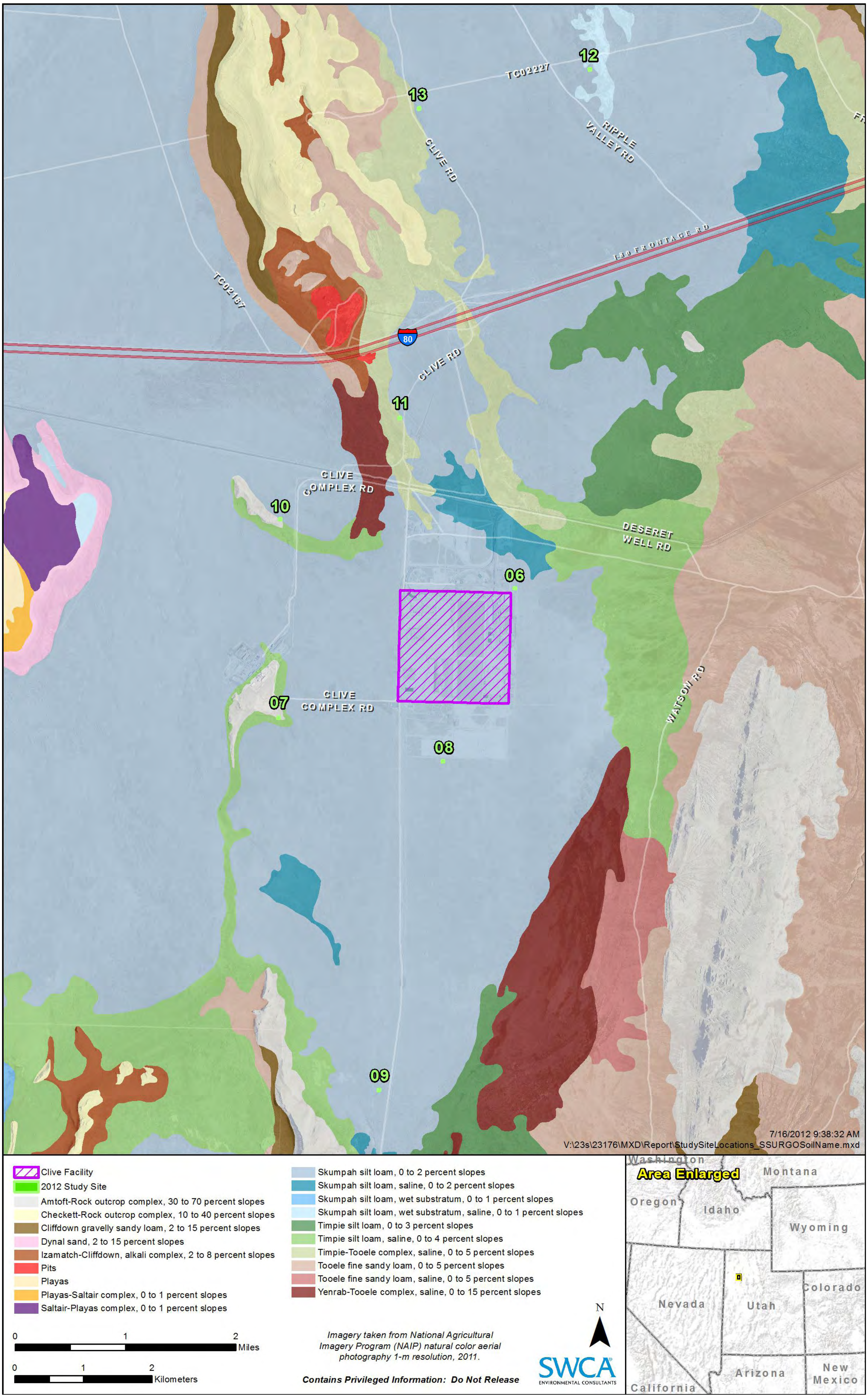


Figure 16. Soil map units.

This page intentionally blank

Table 7. Clive Site Soil Map Unit Characteristics

Soil Map Units	Elevation (feet)	Precipitation (inches)	Slope (%)	Mean Annual Air Temperature (°F)	Average Frost-Free Period (days)	Native Vegetation	Land Use
Skumpah-Yenrab-Dynal	4,200–5,050	6–8	0–15	45–52	120–160	Shadscale, greasewood, bottlebrush squirreltail (*Elymus elymoides*), Indian ricegrass (*Acnatherum hymenoides*), and fourwing saltbush	Rangeland and wildlife habitat; controlling grazing is necessary to maintain forage production.
Tooele-Cliffdown-Timpie	4,200–6,000	6–8	0–15	45–52	120–160	Shadscale, greasewood, Indian ricegrass, horsebrush (*Tetradymia* spp.), and bottlebrush squirretail	Rangeland, wildlife habitat, and irrigated alfalfa hay; controlling grazing is necessary to maintain forage production.
Amtoft-Rock Oucrop-Checkett	4,250–7,000	8–12	30–70	45–49	100–140	Black sagebrush, Utah juniper (*Juniperus osteosperma*), bluebunch wheatgrass (*Pseudoroegneria spicata*), Indian ricegrass, and Salina wildrye (*Leymus salinus*)	Rangeland and wildlife habitat; controlling grazing is necessary to maintain forage production.

Source: U.S. Department of Agriculture (2000)

Soil Series

Soil series descriptions provide more detailed and localized information concerning soil formation and drainage. The study plots are located across three soils series: Amtoft, Skumpah, and Timpie-Tooele Complex. As described in Table 8, these soils series were formed under different conditions but have similar drainage characteristics. The distribution of the 40 soil samples (5 per plot) within each soil series is also identified in Table 8. Most of the study plots occurred on the Skumpah soil series.

Table 8. Soil Series Characteristics near the Clive Site

Soil Series		Soil formation	Drainage	Number of Soil Samples
Amtoft-rock outcrop		Residuum and colluviums derived from calcareous sedimentary rocks	Well drained and somewhat excessively drained	5
Skumpah silt loam		Alluvium and lacustrine sediments derived from mixed rock sources	Very deep, well drained, moderately slowly permeable soils on lake terraces	30
Timpie-Tooele Complex	Timpie series	Alluvium and lacustrine sediments derived dominantly from limestone and quartzite	Very deep, well drained, moderately slowly permeable soils on lake terraces and fan remnants	5
	Tooele Series	Aeolian material, lacustrine sediments, and alluvium derived from mixed rock sources	Very deep, well drained, moderately rapidly permeable soils on lake terraces and fan remnants	

Source: U.S. Department of Agriculture (2000)

Soil Parameters

Site characteristic data that quantify landscape-level processes are available from NRCS for the three soils series. Those relevant to the design of an alternative cover system for the Clive Site are wind erodibility index (tons/acre/year), depth to restrictive layer (cm), depth to water table (cm), drainage class (well drained to poorly drained), pH, and range production value (pounds/acre/year). Table 9 lists the soil parameters and range of ratings or values for the three soil series present near the Clive Site.

Table 9. Soil Parameters Available for Soil Series near the Clive Site

Parameter	Rating or Value Range
Wind Erodibility Index (tons/acre/year)	48–86
Depth to restrictive layer (cm)	>200
Depth to water table (cm)	>200
Drainage class	Well drained
pH	Strongly alkaline (8.5–8.8)
Range production (pounds/acre/year)	500–850

Source: NRCS SSURGO data

SOIL SAMPLING RESULTS

Seventeen composite samples were hand delivered to the USU Analytical Laboratories for analysis. After coordination with the USU Analytical Laboratories, SWCA requested that a suite of parameters be analyzed.

Soil Analyses

Table 10 lists the results of analytical tests performed by the USU Analytical Laboratories on the soil samples taken from study plots and potential soil borrow sources on the Clive Site.

Table 10. Soil Analysis Results

Parameter	Unit	Study Plot/Borrow Unit / Ant Mound Excavation Number																
		Plot 6	**Plot 7**	**Plot 8**	**Plot 9**	**Plot 10**	**Plot 11**	**Plot 12**	**Plot 13**	**Unit 4**	**Unit 3**	**Ex 1-0.5**	**Ex 2-1.0**	**Ex 2-3.5**	**Ex 3 1.0**	**Ex 3-3.5**	**Ex 4-1.0**	**Ex 4-3.5**
		Texture																
		Silty Clay Loam	**Clay Loam**	**Silty Clay Loam**	**Silty Clay Loam**	**Loam**	**Silty Clay Loam**	**Silt Loam**	**Silty Clay**	**Silty Clay**	**Sand**	**Silt Loam**	**Silt Loam**	**Silty Clay**	**Clay Loam**	**Silty Clay**	**Silty Clay Loam**	**Silty Clay**
>2mm	%	2.22	13.3	0.66	0.48	2.88	1.94	0.63	1.67	10.1	13.5	4.3	17.9	10.9	2.94	8.14	7.2	7.65
Sand	%	13	26	15	20	27	19	23	9	0	91	28	20	0	21	4	16	12
Silt	%	49	39	51	51	47	48	51	53	61	0	51	54	47	50	50	56	47
Clay	%	38	35	34	29	26	33	26	38	39	9	21	26	53	29	46	28	41
pH	n/a	8.3	8.2	8.3	8.3	8.2	8.2	8.4	8.1	8.3	8.0	7.6	8.4	8.0	8.4	7.9	8.0	7.9
Salinity ECe	dS/m	16.0	16.4	10.8	10.90	6.02	6.78	3.34	12.70	55.60	11.10	17.7	15.90	29.40	25.90	12.60	24.00	29.00
Phosphorous	mg/kg	11.6	8.5	7.4	5.40	6.80	5.60	8.60	6.90	3.90	4.40	37	4.90	6.70	2.90	6.90	3.50	5.60
Potassium	mg/kg	899	811	899	899	804	899	680	899	548	167	899	899	667	776	805	128	899
Nitrate-Nitrogen	mg/kg	9.47	8.78	10.90	9.95	9.18	8.58	11.00	12.60	5.89	3.12	19.20	1.58	4.51	3.88	7.48	4.87	5.08
Zinc	mg/kg	0.20	0.14	0.09	0.09	0.05	0.09	0.08	0.14	0.12	0.01	0.13	0.05	0.13	0.03	0.23	0.04	0.10
Iron	mg/kg	2.34	3.28	2.34	2.55	2.33	2.70	1.88	2.67	7.19	5.68	1.69	2.28	2.92	2.60	2.92	2.25	1.82
Copper	mg/kg	0.50	0.50	0.40	0.39	0.04	0.44	0.33	0.53	0.75	0.06	0.35	0.40	1.15	0.43	1.30	0.39	0.81
Manganese	mg/kg	2.75	2.59	2.25	2.28	2.11	1.91	2.04	2.52	1.11	1.56	5.76	0.94	0.96	0.80	0.91	0.82	0.95
Sulfate-Sulfur	mg/kg	154	136	107	80	18	126	11	105	623	13	78	146	388	157	463	188	277
Organic Matter	%	2.7	1.8	2.6	2.9	1.2	1.70	1.9	1.9	1.7	1.2	2.1	1.2	0.8	2.0	1.0	1.2	1.2
SAR	n/a	72.2	92.7	68.8	81.9	37.8	40.2	28.9	67.3	176.0	24.6	131.0	62.3	88.5	110.0	94.7	98.4	73.9

Soil Texture

Soil texture in the study plots ranges from silty clay loam to loam. Soils from all plots contain relatively similar proportions of sand, silt, and clay with the exception of Plot 13, which contains only 9% sand.

Soil pH, Salinity, and Sodium Adsorption Ratio

The results for pH show high alkalinity with a range of 8.0–8.4 across the study plots and soil borrow site. Salinity ranges from 3.3 to 55.6 decisiemens per meter (dS/m), which is weakly saline to very strongly saline, respectively. Qualitative descriptions for salinity such as strong or weak are relative measures. When considering the pH of the soil and the potential for reclamation, it is generally understood that certain plants have salinity and pH thresholds that make them more or less successful in establishing under saline conditions. The Sodium Absorption Ratio is a comparison of the concentrations of sodium (Na+), calcium (Ca2+) and magnesium (Mg2+) ions in soil solution. Results range from 24.6 to 176 milliequivalents (meq)/L and are as such considered sodic soils. These soils do not contain equal amounts of neutral soluble salts and can have a detrimental effect on plants due to sodium toxicity (Brady 1974).

Macronutrients

The amount of phosphorous, potassium, and nitrate-nitrogen in the study plot soils is generally consistent across the eight plots. Phosphorous ranges from 5.4 to 11.6 milligrams/kilogram (mg/kg). Potassium ranges from 680 to 899 mg/kg. Nitrate-nitrogen ranges from 8.58 to 12.60 mg/kg. Whether or not these values reflect high, medium, or low levels of macronutrients requires additional research, but it is assumed that these essential elements are not readily available to plants given high pH and other physical and chemical conditions.

Micronutrients

The amount of zinc, iron, copper, manganese, and sulfate-sulfur in the study plot soils is generally consistent across the eight plots. Zinc ranges from 0.05 to 0.2 mg/kg. Iron ranges from 1.88 to 3.28 mg/kg. Copper ranges from 0.04 to 0.53 mg/kg. Manganese ranges from 1.91 to 2.75 mg/kg. Sulfate-Sulfur ranges from 11 to 154 mg/kg. Study plots 10 and 12 comprise loam and silt loam, respectively, and consistently have micronutrients at the low end of these ranges.

Organic Mater

Organic matter in the study plots ranges from 1.2% to 2.9%. Soils in arid lands typically have low amounts of organic matter (Perry and Perry 1989). Identifying "healthy" soil based on organic matter percentage requires additional research.

Metals

Cadmium and chromium are generally undetectable in the study plots with the exception of Plots 6, 11, and 13, which have 0.005 mg/kg, 0.002 mg/kg, and 0.001 mg/kg, respectively. Nickel and lead are found in all soil samples in relatively consistent amounts.

Missing Soil Analyses

As of the finalization of this report, SWCA had still not received the analysis results for three soil parameters; CEC; sand sieve analysis; and water soluble elements.

Cation Exchange Capacity

CEC is an estimate of the rate at which nutrient cations are stored and released. It is a function of positive and negative charges of cations. CEC is related to soil texture because clays and organics typically have a negative charge that bonds with positive cations such as calcium, magnesium, potassium, sodium, and hydrogen. Low CEC values can mean that soils lack the ability to hold applied nutrients. High CEC values can mean the soil lacks airspaces, resulting in anaerobic conditions.

Sand Sieve Analysis

This test classifies soils based on course grain size. It is more commonly used for engineering purposes to determine Atterberg limits (e.g., liquid limit, plastic limit, and shrinkage limit) than to assess plant growth medium suitability.

Water Soluble Elements

Water soluble elements (saturation paste) is a measure of bioavailable nutrients. For plants to use certain nutrients (e.g., potassium), these elements must be in a readily available (i.e., water soluble) form. This analysis measures the amount of water-soluble elements in the soil, including nitrate-N, potassium, and sulfur.

The results of these analyses will be incorporated into the soils data analyses here and provided to Energy*Solutions* as soon as they are made available to SWCA.

SOIL EROSION RESULTS

In general, there was limited evidence of wind and water erosion on the study plots. Wind erosion, where evident, appears to be associated with breaks in the biological soil crusts (e.g., animal trials). In addition to soil stabilization, biological soil crusts provide nitrogen fixation, increase nutrient availability, and improve vascular plant establishment (Pendleton et al. 2007). There was little to no evidence of water erosion (e.g. rilling) even on those study plots (e.g., Plot 13) with a discernible slope. In general, all soil types are susceptible to erosion regardless of proportion of particle size. The elevated position of an ET cap relative to the surrounding landscape is likely to increase the susceptibility of surface soils to wind erosion. The use of gravel, application of spray-on soil adhesives, and inoculation of soil with crust-forming soil algae and mycorrhizal fungi are potential strategies for reducing soil erosion.

SOIL EXCAVATION RESULTS

In addition to those samples obtained from the study plots, SWCA gathered soil samples from three ant mound excavation sites at depths of 0.3 m and 1.1 m (1.0 and 3.5 feet), one ant mound excavation site at a depth of 0.2 m (0.5 feet), and a borrow area at depths consistent with the bottom of Borrow Unit 4 and top of Borrow Unit 3 on the Clive Site. Table 11 compares the soil analysis results for the soil excavations from Borrow Unit 4 and ant mound excavation sites with the soil samples from the eight study plots. There are some dissimilarities between the soil features of these locations.

Table 11. Summary of Soil Analysis Results from the Ecological Analogue Study Sites (Plots 6–13) and Soil Borrow Locations at the Clive Site (Unit 4 and Adjacent Topsoil Excavations)

Soil Parameter	Units	Ecological Analogue Soils (Plots 6–13)			Borrow Soils (Unit 4 and on-site excavations)		
		Range	Mean	Standard Deviation	Range	Mean	Standard Deviation
Particle size >2mm	%	0.48–13.3	2.97	4.26	2.94–17.9	8.64	4.59
Sand	%	9.0–27.0	19.00	6.35	0.0–28.0	12.63	10.46
Silt	%	39–53	48.63	4.34	47–61	52.00	4.78
Clay	%	26–38	32.38	4.87	21–53	35.38	11.07
pH	n/a	8.1–8.4	8.25	0.09	7.6–8.4	8.06	0.28
Salinity (ECE)	dS/m	3.34–16.4	10.37	4.71	12.6–55.6	26.26	13.37
Phosphorus (PO_4)	mg/kg	5.4–11.6	7.60	1.99	2.9–37.0	8.93	11.44
Potassium	mg/kg	680–899	848.75	79.76	126–899	702.63	263.74
Nitrogen (NO_3)	mg/kg	8.58–12.6	10.06	1.36	1.58–19.2	6.56	5.38
Zinc	mg/kg	0.05–0.20	0.11	0.05	0.03–0.23	0.10	0.07
Iron	mg/kg	1.88–3.28	2.51	0.40	1.69–7.19	2.96	1.77
Copper	mg/kg	0.04–0.53	0.39	0.16	0.35–1.30	0.70	0.37
Manganese	mg/kg	1.91–2.75	2.31	0.29	0.80–5.76	1.53	1.71
Sulfur (SO_4)	mg/kg	11.2–154.0	92.14	52.72	77.7–623	289.96	186.89
Organic matter	%	1.2–2.9	2.09	0.58	0.8–2.1	1.40	0.48
SAR	n/a	28.9–92.7	61.23	22.89	62.3–176	104.35	35.76

Soil Texture

Borrow Units 4 and 3 at the borrow source location have very different soil textures when compared to the study plots. Borrow Unit 4 is silty clay with no sand particles, and Borrow Unit 3 is 91% sand.

Soil pH, Salinity, and Sodium Adsorption Ratio

Soil pH in Borrow Units 4 and 3 are 8.3 and 8.0, respectively, and within the range of the study plots. Salinity and SAR in Borrow Unit 4 significantly exceed the range of values found in the study plots. Salinity and SAR in Borrow Unit 3 are within the range of values found in the study plots.

Macronutrients

All three macronutrients are consistently lower than the levels of these essential elements found in the study plots.

Micronutrients

Borrow Unit 4 has comparable zinc, high iron, high copper, low manganese, and high sulfate-sulfur when compared to the study plots. Borrow Unit 3 has low zinc, high iron, low copper, low manganese, and comparable sulfate-sulfur when compared to the study plots.

Organic Mater

Organic matter content falls within the range found in the study plots.

Metals

Cadmium, chromium, and nickel are undetectable in Borrow Units 4 and 3. Lead in Borrow Unit 4 is within the range found in the study plots. Lead is considerable lower in Borrow Unit 3 relative to the study plots.

CORRELATION ANALYSES

The Pearson product-moment correlation coefficient (*r*) was used to assess relationships between biotic and abiotic variables that were assessed in each plot: plant species cover, small mammal densities, animal burrow volumes, ant mound volumes, and soil chemistry and nutrition parameters. Strong relationships that were identified between variables are described here:

- There were strong, positive relationships between total vegetation cover and mammal densities and burrow volumes, with *r* ranging from 0.62 (deer mouse density) to 0.84 (badger burrow volume). Total badger and deer mouse burrow volumes were particularly strongly correlated with shadscale saltbush cover (r = 0.95 and 0.97, respectively).
- In contrast, there was no correlation between total vegetation cover and ant mound area or volume.
- There were strong, positive correlations between ant mound area and volume and cover of weedy species (r = 0.77). This relationship was anecdotally observed in the 2010 study as well.
- There was a strong, negative correlation between ant mounds and soil silt content (r = -0.83), and somewhat strong, negative correlations between animal densities and burrow volumes and soil clay content (r = 0.53).
- There are strong, positive correlations between ant mound surface area and soil salinity (ECE; r = 0.60), iron (r = 0.65), and SAR (r = 0.59).
- High soil pH does not appear to be limiting for any of the native or weedy plant species that occurred in the plots. However, plant cover, particularly of shadscale saltbush, showed strong, negative correlations with high soil salinity (ECE), potassium, iron, sulfur, and SAR (r = -0.64, -0.81, -0.68, -0.63, and -0.59, respectively).

ORDINATION ANALYSES

Because of the small data set and large numbers of variables, ordination analyses did not clearly identify trends in the distribution of plant species with mammals, ants, or soils. The ordination axes that resulted did not sufficiently separate the plots so that trends in habitat-bioturbation distributions could be identified.

Recommendations

Vegetation

The plant species selected for the ET cover system should consist of native and desirable non-native, salt-tolerant shrubs and grasses. Localized native species will be best adapted to the high pH and highly saline and toxic contents of the local soils. Although a vegetation community of sufficient diversity and density is desired to maximize transpiration from the soil, vegetation density was positively correlated with small mammal and burrowing activity. As such, bioturbation should be expected to increase with increasing vegetation cover.

Bioturbation

Because kangaroo rats did not tolerate the marking process and markings were wearing off or being chewed off the deer mice, total recaptures are likely underestimated, and the resulting total small mammal captures may be overestimated for some plots. However, the species distributions and densities identified during field studies are an approximate estimate of total small mammal densities and associated bioturbation potential in the study plots. Overall, small mammal activity is to be expected in any native vegetation community that is established as part of an ET cover system at the Clive Facility. As stated above, the density of small mammals and animal burrows should be expected to increase with increasing vegetation cover.

The levels of animal activity that were observed in and near the plots, including the documented presence of badgers and a large family of burrowing owls, indicate that bioturbation that could move large volumes of soil is to be expected in any native vegetation community in the area. A bioturbation barrier will likely be needed that is designed to exclude large and small burrowing mammals (i.e., mice, rats, hares, badgers). Designs that maximize the depth of upper soil layers or that incorporate bioturbation barriers would help to prevent penetration by ants into waste layers.

Soils

The soil analyses performed on the soil samples taken from the eight study plots confirm that conditions are typical of soils formed in arid environments. There is a range in soil texture, with most being silty clay loams, elevated pH and salinity, and low organic matter. Even when considering these constraining conditions, recreating them within the root zone of the ET Cap in order to support a native vegetation community may be challenging given the difference between the study plot soils and those taken from the Borrow Units. For example, blending borrow soils to obtain the proper texture that allows for enough infiltration to support plants while avoiding deep infiltration and excessive runoff is likely necessary. Buffering the amount of sodium found in the borrow soils with and amendments, e.g. gypsum, or leaching it below the root zone may also be necessary given the high SAR values of Borrow Unit 4. Soil amendments or fertilizer may also be necessary since borrow soils have less macronutrients than the study plots. However, additional analysis is needed to determine the appropriate application rates since overfertilization could result in establishment of non-native or invasive species. Finally while the soil analyses are sufficient to characterize study plot soils and provide baseline conditions, additional investigation is need to prescribe suitable types and amendments and qualities to create suitable conditions for native plant establishment on the ET Cap. Also, soils may need to be treated to minimize disturbance at the biogeochemical level. Inoculation with crust forming soil algae and mycorrhizal fungi can serve a variety of functions from soil stabilization, to moisture regulation to nitrogen fixation to nutrient mobilization.

BIBLIOGRAPHY

Albright, W., and C. Benson. 2005. *Alternative cover assessment program: report to Office of Research and Development National Risk Management Research Lab Land Remediation and Pollution Control Division (Phase II Report – Monitoring)*. Reno, Nevada: Desert Research Institute and the University of Wisconsin.

Albright, W.H, C.H. Benson, G.W. Gee, A.C. Roesler, T. Abichous, P. Apiwantragoon, B.F. Lyles, and S.A. Rock. 2004. Field water balance of landfill final covers. *Journal of Environmental Quality* 33:2317–2332.

Albright, W.H., C.H. Benson, G.W. Gee, T. Abichou, S. Tyler, and S.A. Rock. 2006. Field performance of three compacted clay landfill covers. *Vadose Zone Journal* 5:1157–1171.

Albright, W.H., C.H. Benson, and W.J. Waugh. 2010. Water balance covers for waste containment principles and practice. Reston, Virginia: ASCE Press.

Albright, W.H., G.W. Gee, G.V. Wilson, and M.J. Fayer. 2002. Alternative cover assessment project Phase I report. Prepared by Division of Hydrologic Sciences, Desert Research Institute, University and Community College System of Nevada for the U.S. Environmental Protection Agency, Contract No. 44-0000-2038. Publication No. 41183. October 2002.

Allred, D.M. 1982. Ants of Utah. *Great Basin Naturalist* 42(4):415–511.

Andraski, B.J. 1997. Soil-water movement under natural-site and waste-site conditions: A multiple-year field study in the Mojave Desert, Nevada. *Water Resources Research* 33:1901–1916.

Arthur, W.J. III., and O.D. Markham. 1983. Small mammal soil burrowing as a radionuclide transport vector at a radioactive waste disposal area in southeastern Idaho. *Journal of Environmental Quality* 12(1):117–122.

Arthur, W.J. III, J.C. Grant, and O.D. Markham. 1983. Importance of biota in radionuclide transport at the SL-1 radioactive waste disposal area. In *Idaho National Engineering Laboratory Radioecology and Ecology Programs, 1983 progress report,* edited by Markham, O.D. DOE/ID-12098. Idaho Falls, Idaho: U.S. Department of Energy Idaho Operations Office.

Atwood, G. 1994. Bonneville Basin. In *Utah History Encyclopedia*, edited by A.K. Powell (ed). Salt Lake City, Utah: University Press, University of Utah. Website maintained by Media Solutions, University of Utah.

Barbour, M.G, and W.D. Billings. 2000. *North American Terrestrial Vegetation*. Second Edition. Cambridge University Press.

Barnswell, K.D. 2010. Determining the preliminary components for a landfill evapotranspiration cover. Ph.D. Dissertation, Toledo, Ohio: University of Toledo.

Barnswell, K.D. and D.F. Dwyer. 2011. Assessing the performance of evapotranspiration covers for municipal solid waste landfills in northwestern Ohio. *Journal of Environmental Engineering* 137(4):301–305.

Benson, C., G. Bohnhoff, A. Ogorzalek, C. Schackelford, P. Apiwantragoon, and W. Albright. 2005. Field data and model predictions for an alternative cover. In *Waste Containment and Remediation*, edited by Alshawabkeh et al., pp. 1–12. GSP No. 142. Reston, Virginia: ASCE.

Benson, C.H., W.H. Albright, A.C. Roesler, and T. Abichou. 2002. Evaluation of final cover performance: field data from the Alternative Landfill Cover Assessment Program (ACAP). In *Proceedings of the Waste Management 2002 Conference*. February 24028, Tucson, Arizona.

Bjornstad, B.N., and S.S. Teel. 1993. *Natural analog study of engineered protective barriers at the Hanford Site*. Prepared for the U.S. Department of Energy, Contract DE-AC06-76RLO 1830. Pacific Northwest Laboratory, PNL-8840 UC-510. Richland, Washington: U.S. Department of Energy.

Bosworth, W. 2001. Inventory of amphibians and reptiles in the Utah Test and Training Range and the associated Military Operations Area Final Report. Contract Number 700309 Prepared For Environmental Management, Natural Resources Ogden Air Logistics Center Prepared by William Bosworth. Salt Lake City, Utah: Utah Division of Wildlife Resources.

Brady, N.C. 1974. *The nature and properties of soils*. New York: Macmillian Publishing Co., Inc.

Brown, J.H. 1971. Mammals on mountaintops: nonequilibrium insular biogeography. *American Naturalist* 105:467–478.

Cadwell, L. L., L. E. Eberhardt, and M. A. Simmons. 1989. *Animal intrusion studies for protective barriers: status report for FY 1988. PNL-6869*. Richland, Washington: Pacific Northwest Laboratory.

Campbell, M.D., G.W. Gee, M.J. Kanyid, and M.L. Rockhold. 1990. *Field lysimeter test facility: Second year (FY 1989) test* results. PNL-7209. Richland, Washington: Pacific Northwest Laboratory.

Carlson, S.R., and W.G. Whitford. 1991. Ant Mound Influence on Vegetation and Soils in a Semiarid Mountain Ecosystem. *The American Midland Naturalist* 126:125–139.

Chadwick, D.G., M.D. Ankeny, L.M. Greer, C.V. Mackey, and M.E. McClain. 1999. Field test of potential RCRA-equivalent covers at the Rocky Mountain arsenal. In *Proceedings of the Solid Waste Association of North America (SWANA) 4th Annual Landfill Symposium*. SWANA Publication No. GR-LM-0004. Pp. 12–33. Silver Spring, Maryland: Solid Waste Association of North America.

Chambers, J.C. 2008. Climate change and the Great Basin. In *Collaborative management and research in the Great Basin - examining the issues and developing a framework for action*, edited by Chambers, J.C., N. Devoe, and A. Evenden. Pp. 29–32. Gen. Tech. Rep. RMRS-GTR-204. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Clean Harbors Grassy Mountain, LLC. 2001. State-issued part B permit for hazardous waste treatment, storage, disposal, and transfer. Safety-Kleen (Lone and Grassy Mountain), Inc. Grassy Mountain Facility.

Cohen, J. 1988. *Statistical power analysis for the behavioral sciences,* 2nd edition. Lawrence Erlbaum Associates, Inc., New Jersey. 567 pp.

Cole, A.C., Jr. 1942. The ants of Utah. *The American Midland Naturalist* 28(2):358–388.

Cubashi, U., G.A. Meehl, and G.J. Boer. 2001. Projections of future climate change. In *Climate Change 2001. The Scientific Basis. Contribution of the working group I to the third assessment report of the intergovernmental panel on climate change*, edited by Houghton, J. T., et al. Pp. 525–582. Cambridge University Press.

Daniel B. Stephens & Associates, Inc. 1998. *Alternative final cover assessment, Trenches 10 and 11 at ESII Site B.* Prepared for Environsafe Services of Idaho, Inc. December 23, 1998.

Dwyer, S.F. 1997. Cost comparisons of alternative landfill covers. In *Proceedings, International Containment Technology Conference, St. Petersburg, Florida,* pp. 400–406.

———. 1998. Alternative landfill covers pass the test. Civil Engineering, *ASCE* 68(9):50–52.

———. 2001. Finding a better cover. Civil Engineering, *ASCE* 71(1):58–63.

———. 2003. Water balance measurements and computer simulations of landfill covers. Abstract of dissertation. Albuquerque, New Mexico: The University of New Mexico.

Dwyer, S.F., B. Reavis, and G. Newman. 2000. *Alternative landfill cover demonstration FY2000 annual data report*. SAND2000-2427. Albuquerque, New Mexico: Sandia National Laboratories.

Dwyer, S.F., R.E. Rager, and J. Hopkins. 2007. *Cover system design guidance requirements document. Los Alamos National Laboratory*. LA-UR-06-4715 April 2007 EP2006-0667.

Ecosystem Restoration. 2004. Montana State University. Available at: http://ecorestoration.montana.edu/default.htm. Accessed on August 9, 2012.

EPA. 2003. *Evapotranspiration landfill cover systems fact sheet*. EPA 542-F-03-015. Cincinnati, Ohio: EPA National Service Center for Environmental Publications.

———. 2011. *Fact sheet on evapotranspiration cover systems for waste containment*. EPA 542-F-11-001Washington, DC: EPA Office of Solid Waste and Emergency Response.

Fayer, M. J. 2000. UNSAT-H version 3: Unsaturated soil water and heat flow model, prepared for U.S. Department of Energy under Contract No. DE-AC06-76RLO 1830. Richland, Washington: Pacific Northwest Laboratory.

Fayer, M.J. and T.L. Jones. 1990. UNSAT-H version 2.0: Unsaturated soil water and heat flow model. Prepared for U.S. Department of Energy. PNL-6779. Richland, Washington: Pacific Northwest Laboratory.

Fayer, M.J., M.L. Rockhold, and M.D. Campbell. 1992. Hydrologic modeling of protective barriers: Comparison of field data and simulation results. *Soil Science Society of America Journal* 56:690–700.

Gaglio, M.D., W.P. Mackay, D. Padilla, R. Webb, and D.V. LeMone. 2001. The effectiveness of biobarrier layers within protective caps at preventing penetration of waste sites by the harvester ant *Pogonomyrmex salinus* Olsen (Hymenoptera: Formicidae). In *Proceedings of the Waste Management 2001 Symposium*. Tucson, Arizona. February 25–March 1, 2001.

Gee, G.W., L.L. Cadwell, H.D. Freeman, M.W. Ligotke, S.O. Link, R.A. Romine, and W.H. Walters Jr. 1993b. *Testing and monitoring plan for the permanent isolation surface barrier prototype. PNL-8391.* Richland, Washington: Pacific Northwest National Laboratory.

Gee, G.W., D.G. Felmy, J.C. Ritter, M.D. Campbell, J.L. Downs, M.J. Fayer, R.R. Kirkham, and S.O. Link. 1993a. *Field lysimeter test facility status report IV: FY 1993*. PNL-8911. Richland, Washington: Pacific Northwest National Laboratory.

Gee, G.W., J. M. Keller, and A.L. Ward. 2005. Measurement and prediction of deep drainage from bare sediments at a semiarid site. *Vadose Zone Journal* 4:32–40.

Gee, G.W., A.L. Ward, and R.R. Kirkham. 1998. Long-term performance of surface covers estimated with short-term testing. In *Proceedings of long-term stewardship workshop LTSM, June 1998, Denver, Colorado.* Grand Junction, Colorado: U.S. Department of Energy, Grand Junction Office.

Gee, G.W., A.L. Ward, and M.J. Fayer. 1997. Surface barrier research at the Hanford Site. *Land Contamination and Reclamation* 5(3):233–238.

Gee, G.W., A.L. Ward, B.G. Gilmore, S.O. Linki, G.W. Dennis, and T.K. O'Neil. 1996. *Hanford protective barrier status report: FY 1996*. PNNL-11367. Richland, Washington: Pacific Northwest National Laboratory.

Gee, G.W., A.L. Ward, and C.D. Wittreich. 2002. *The Hanford Site 1000-year cap design test*. PNNL-14143. Richland, Washington: Pacific Northwest National Laboratory and CH2MHill Hanford Group.

Gibbons, S. 1996. *Statistical Methods for Ground-Water Monitoring at the USPCI/Laidlaw Grassy Mountain Facility*. Prepared for Safety-Kleen (Lone and Grassy Mountain), Inc.

Grayson, D.K. 1993. *The desert's past: A natural prehistory of the Great Basin*. Washington: Smithsonian Institution Press.

———. 1998. Moisture history and small mammal community richness during the latest Pleistocene and Holocene, northern Bonneville basin, Utah. *Quaternary Research* 49:330–334.

———. 2000. The Homestead Cave mammals. In: Madsen, D. B. (Ed.), Late Quaternary paleoecology in the Bonneville Basin. *Utah Geological Survey Bulletin* 130:67–89.

———. 2006. The late Quaternary biogeographic histories of some Great Basin mammals (western USA). *Quaternary Science Reviews* 25:2964–2991.

Green, W.P., D.E. Pettry, and R.E. Switzer. 1998. Formicarious Pedons, the Initial Effect of Mound-Building Ants on Soils. *Soil Survey Horizons* 39:33–44.

Hakonson, T., K. Bostick, G. Truililo, K. Manies, R. Warren, L. Lane, I. Kent, and W. Wilson. 1994. *Hydrologic evaluation of four landfill cover designs at Hill Air Force Base, Utah*. LAUR-93-4469. Los Alamos, New Mexico: Los Alamos National Laboratory.

Hampton, N.L. 2006. *Biological data to support operable unit 7-13/14 modeling of plant and animal intrusion at buried waste sites*. Idaho Cleanup Project. Prepared for the U.S. Department of Energy, Assistant Secretary for Environmental Management. DOE Idaho Operations Office. DE-AC07-05ID14516. 54 p.

Hauser, V.L. 2009. *Evapotranspiration covers for landfills and waste sites*. Boca Raton, Florida: CRC Press.

Hauser V.L. and D.M. Gimon. 2004. *Evaluating evapotranspiration (ET) landfill cover performance using hydrologic models*. Prepared for Air Force Center for Environmental Excellence, Brooks City-Base, Texas. January 2004.

Hole, F.D. 1981. Effects of animals on soils. *Geoderma* 25: 75–212.

Jewell, P.W., and K. Nicoll. 2011. Wind regimes and Aeolian transport in the Great Basin, U.S.A. *Geomorphology* 129:1–13.

Keeler, K.H. 1993. Fifteen Years of Colony Dynamics in Pogonomyrmex occidentalis, the Western Harvester Ant, in Western Nebraska. *The Southwestern Naturalist* 38:286–289.

Khire, M.V., C.H. Benson, and P.J. Bosscher. 2000. Capillary barriers: Design variables and water balance. *Journal of Geotechnical and Geoenvironmental Engineering* 126:695–708.

Knapp, P.A. 1994. Seasonal associations between mid-tropospheric pressure patterns and precipitation in the western Great Basin. *Climate Research* 4:75–78.

Louderback, L.A. and D.E. Rhode. 2009. 15,000 years of vegetation change in the Bonneville basin: the Blue Lake pollen record. *Quaternary Science Reviews* 28:308–326.

Mackay, W.P., and M.D. Gaglio. 1999. Effectiveness of biobarriers in preventing harvester ants from entering waste sites: Methods for detection of penetration of biobarriers by harvester ants. In *Annual Technical Report to DOE-ID: Calendar Year 1998*, edited by D.L. Weigmann and R.D. Blew. Idaho Falls, Idaho: Environmental Science and Research Foundation.

Madsen, D.B. 2000. *Late Quaternary paleoecology in the Bonneville Basin*. Utah Geological Survey Bulletin 130. Salt Lake City: Utah Geological Survey.

Madsen, D.B., D. Rhode, D.K. Grayson, J.M. Broughton, S.D. Livingston, J. Hunt, J. Quade, D.N. Schmitt, and M.W. Shaver III. 2001. Late Quaternary environmental change in the Bonneville basin, western USA. *Palaeogeography, Palaeoclimatology, Palaeoecology* 167:243–271.

Mandel, R.D., and C.J. Sorenson. 1982. The Role of the Western Harvester Ant (Pogonomyrmex occidentalis) in Soil Formation. *Soil Science of America Journal* 46:785–788.

McGuire, P.E., B.J. Andraski, and R.E. Archibald. 2009. Case study of a full-scale evapotranspiration cover. *Journal of Geotechnical and Geoenvironmental Engineering* 135(3):316–332.

McNab, W.H. and P.E. Avers (compilers). 1994. *Ecological subregions of the United States*. Prepared in cooperation with Regional Compilers and the ECOMAP Team of the Forest Service July 1994. WO-WSA-5.

Mead, J. I., T. H. Heaton, and E. M. Mead. 1989. Late Quaternary reptiles from two caves in the East-central Great Basin. *Journal of Herpetology* 23(2):186–189.

Melchior, S. 1997. In-situ studies on the performance of landfill caps. In *Proceedings of the International Containment Technology Conference.* Pp. 365–373. St. Petersburg, Florida.

Meteorological Solutions, LLC. 2012. *January 2011 through December 2011 and January 1993 through December 2011 summary report of meteorological data collected at EnergySolutions' Clive, Utah Facility*. Prepared for Energy*Solutions*, Salt Lake City, Utah. Project No. 011110111. February 2012.

Nyhan, J.W., T.G. Schofield, and R.H. Starmer. 1997. A water balance study of four landfill cover designs varying in slope for semiarid regions. *Journal of Environmental Quality* 16:1385–1392.

Oviatt, C.G., 1997. Lake Bonneville fluctuations and global climate change. *Geology* 25:155–158 (February).

Pendleton, R.L., Pendleton, B.K., Warren, S.D., Johansen, J.R., and L.L St Clair. 2007. *Shrub establishment in the presence of cheatgrass: The effect of soil microorganisms*. In *proceedings: Shrubland dynamics- fire and water.* RMRS-P-47. 173 pp. Fort Collins, Colorado: U.S. Department of Agriculture Forest Services Rocky Mountain Research Station.

Perry, A.S. and R.Y. Perry. 1989. Effects in Arid Regions. In *Ecotoxicology and Climate*, edited by P Bourdeau, J.A. Haines, W. Klein and C.R. Krisna Murti. San Francisco, California: John Wiley and Sons Ltd.

Porro, E. and K.N. Keck. 1998. Engineered barrier testing at the INEEL Engineered Barriers Test Facility: FY-1997 and FY-1998. INEEL/EXT-98-00964. Idaho Falls, Idaho: Idaho National Engineering and Environmental Laboratory, Lockheed Martin Idaho Technologies Co.

Porter, S. D., H.G, Fowler, and W.P. MacKay. 1992. Fire ant mound densities in the United States and Brazil (Hymenoptera: Formicidae). *Journal of Economic Entomology* 85:1154–1161.

Rhode, D. and D.B. Madsen. 1995. Late Wisconsin vegetation in the Bonneville Basin. *Quaternary Research* 44:246–256.

Rhode, D., T. Goebel, K.E. Graf, B.S. Hockett, K.T. Jones, D.B. Madsen, D.B. Madsen, C.G. Oviatt, and D.N Schmitt. 2005. Latest Pleistocene-early Holocene human occupation and paleoenvironmental change in the Bonneville Basin, Utah-Nevada. In *Interior Western United States: Geological Society of America Field Guide 6,* edited by Pederson, J. and C. M. Dehler.

Rickart, E.A. 2001. Elevational diversity gradients, biogeography and the structure of montane mammal communities in the intermountain region of North America. *Global Ecology & Biogeography* 10:77–100.

Rock, S., B. Myers, and L. Fiedler. 2012. Evapotranspiration (ET) covers. *International Journal of Phytoremediation* 14(supl1):1–25.

Rodgers, J.L., and W.A. Nicewander. 1988. Thirteen ways to look at the correlation coefficient. *The American Statistician* 42(1):59–66.

Sackschewsky, M. R., C. J. Kemp, and L. L. Cadwell. 1992. *Status report for the small-tube lysimeter facility, fiscal year 1992.* WHC-EP-0597. Richland, Washington: Westinghouse Hanford Co.

Sackschewsky, M.R., C.J. Kemp, S.O. Link, and W.J. Waugh. 1995. Soil water balance changes in engineered soil surfaces. *Journal of Environmental Quality* 24:352–359.

Salem, M.Z., and F.D. Hole. 1968. Ant (Formica exsectoides) Pedoturbation in a Forest Soil. *Soil Science Society of America Proceedings* 32:563–567.

Scanlon, B.R., R.C. Reedy, K.E. Keese, and S.F. Dwyer. 2005. Evaluation of evapotranspirative covers for waste containment in arid and semiarid regions in the Southwestern USA. *Vadose Zone Journal* 4:55–71.

Schroeder, P.R., T.S. Dozier, P.A. Zappi, B.M. McEnroe, J.W. Sjostrom, and R.L. Peyton. 1994. The hydrologic evaluation of landfill performance (HELP) model: Engineering documentation for version 3. U.S. Environmental Protection Agency Risk Reduction Engineering Laboratory, Cincinnati, Ohio. EPA/600/R-94/168a.

Scott, H.W. 1951. The Geological Work of the Mound-building Ants in Western United States. *Journal of Geology* 59:173–175.

Sheader, L.R.L. and M.K. Kastens. 2008. Changes in vegetation at the Monticello, Utah disposal site. Available at: http://www.lm.doe.gov/Monticello/Documents.aspx. Accessed on August 17, 2012.

Smallwood, S.K., M.L. Morrison, and J. Beyea. 1998. Animal burrowing attributes affecting hazardous waste management. *Environmental Management* 22(6):831–847.

Smith, S.D., T.E. Huzman, S.F. Zitzer, T.N. Charlet, D.C. Housman, J.S. Coleman, L.K. Fenstermaker, J.R. Seeman, and R.S. Nowak. 2000. Elevated CO_2 increases productivity and invasive species success in an arid system. *Nature* 408:79–81.

SWCA. 2010. *Field sampling of biotic turbation of soils at the Clive Site, Tooele County, Utah*. Prepared for Energy*Solutions*, Salt Lake City, Utah.

Taber, S.W. 1998. *The World of the Harvester Ants*. College Station: Texas A&M Press.

Traynham, B. 2010. Monitoring the long-term performance of engineered containment systems: The role of ecological processes. Ph.D. dissertation. Nashville, Tennessee: Vanderbilt University.

U.S. Department of Agriculture. 2000. *Soil Survey of Tooele Area, Utah*. Salt Lake City, Utah: Natural Resources Conservation Service.

U.S. Department of Energy. 1999. *200-BP-1 prototype barrier treatability test report*. DOE/RL-99-11. Richland, Washington: U.S. Department of Energy.

Vogt, J.T. 2004. Quantifying imported fire ant (Hymenopter: Formicidae) mounds with airborne digital imagery. *Environmental Entomology* 33:1045–1051.

———. 2007. Three-dimensional sampling method for characterizing ant mounds. *Florida Entomologist* 90(3):553–558.

Wagner, F.H. (ed.). 2003. *Preparing for a changing climate – the potential consequences of climate variability and change. Rocky Mountain/Great Basin regional climate-change assessment*. A report of the Rocky Mountain/Great Basin Regional Assessment Team for the U.S. Logan, Utah: Global Change Research Program. USU.

Ward, A.L. and G.W. Gee. 1997. Performance evaluation of a field-scale surface barrier. *Journal of Environmental Quality* 26:694–705.

Ward, A.L., G.W. Gee, and S.O. Link. 1997. *Hanford prototype-barrier status report: FY 1997*. PNNL-11789, Richland, Washington: Pacific Northwest National Laboratory.

Warren, R.W., T.E. Hakonson, and K.V. Bostick. 1995. The hydrologic evaluation of four cover designs for hazardous waste landfills at Hill Air Force Base. *Federal Facilities Environmental Journal* 6(1):91–110.

Warren, R.W., T.E. Hakonson, and K.V. Bostick. 1996. Choosing the most effective hazardous waste landfill cover. John Wiley & Sons, Inc. *Remediation* (spring):23–41.

Warren, R.W., T.E. Hakonson, and K.V. Bostik. 1997. The Hydrologic Evaluation of Four Cover Designs for Hazardous Waste Landfills. In *Landfill Capping in the Semi-Arid West: Problems, Perspectives, and Solutions*, edited by Reynolds, T. D., and R. C. Morris. Idaho Falls, Idaho: Environmental Science and Research Foundation.

Waugh, W.J. 2002. Monticello field lysimetry: Design and monitoring of an alternative cover. In *Proceedings of the Waste Management 2002 Symposium*, Tucson, Arizona.

———. 2009. *Design, performance, and sustainability of engineered covers for uranium mill tailings*. U.S. Department of Energy, Office of Legacy Management.

Waugh, W.J., Kastens, M.K., L.R.L. Sheader, C.H. Benson, W.H. Albright, and P.S. Mushovic. 2008. Monitoring the performance of an alternative landfill cover at the Monticello, Utah, uranium mill tailings disposal site. In *Proceedings of the Waste Management 2008 Symposium, Phoenix, Arizona.*

Westerling, A.L., H.G. Hildago, D.R. Cayan, and T.W. Swetnam. 2006. Warming and earlier spring increase in U.S. forest wildfire activity. *Science* 313(5789):940–943.

Wheeler, G.C., and Jeanette Wheeler. 1963. *The Ants of North Dakota*. Grand Forks: University of North Dakota Press.

Wing, N.R. 1993. Permanent isolation surface barrier: Functional performance. Richland, Washington: Westinghouse Hanford Company.

Wing, N.R. and G.W. Gee. 1994. Quest for the perfect cap. *Civil Engineering* 64(10):38–41.

Ziska, L.H., J.B. Reeves III, and B. Blank. 2005. The impact of recent increases in atmospheric CO_2 on biomass production and vegetative retention of cheatgrass (*Bromus tectorum*): implications for fire disturbance. *Global Change Biology* 11:1325–1332.

Zornberg, J.G., L. LaFountain, and J.A. Caldwell. 2003. Analysis and design of evapotranspirative cover for hazardous waste landfill. *Journal of Geotechnical and Geoenvironmental Engineering* 129:427–438.

APPENDIX E

HAL Run-On Berm Study

HANSEN ALLEN & LUCE INC
ENGINEERS

Memorandum

DATE: July 25, 2012

TO: Vern C. Rogers, PhD
EnergySolutions, Chief Scientist
423 West 300 South, Suite 200
Salt Lake City, Utah 84101

FROM: Gordon L. Jones, P.E.
Hansen, Allen & Luce, Inc.
6771 South 900 East
Midvale, Utah 84047

PROFESSIONAL ENGINEER
GORDON L. JONES
No. 6048470-2202
7/25/12
STATE OF UTAH

PROJECT: Run-on Berm Analysis for Clive, Utah

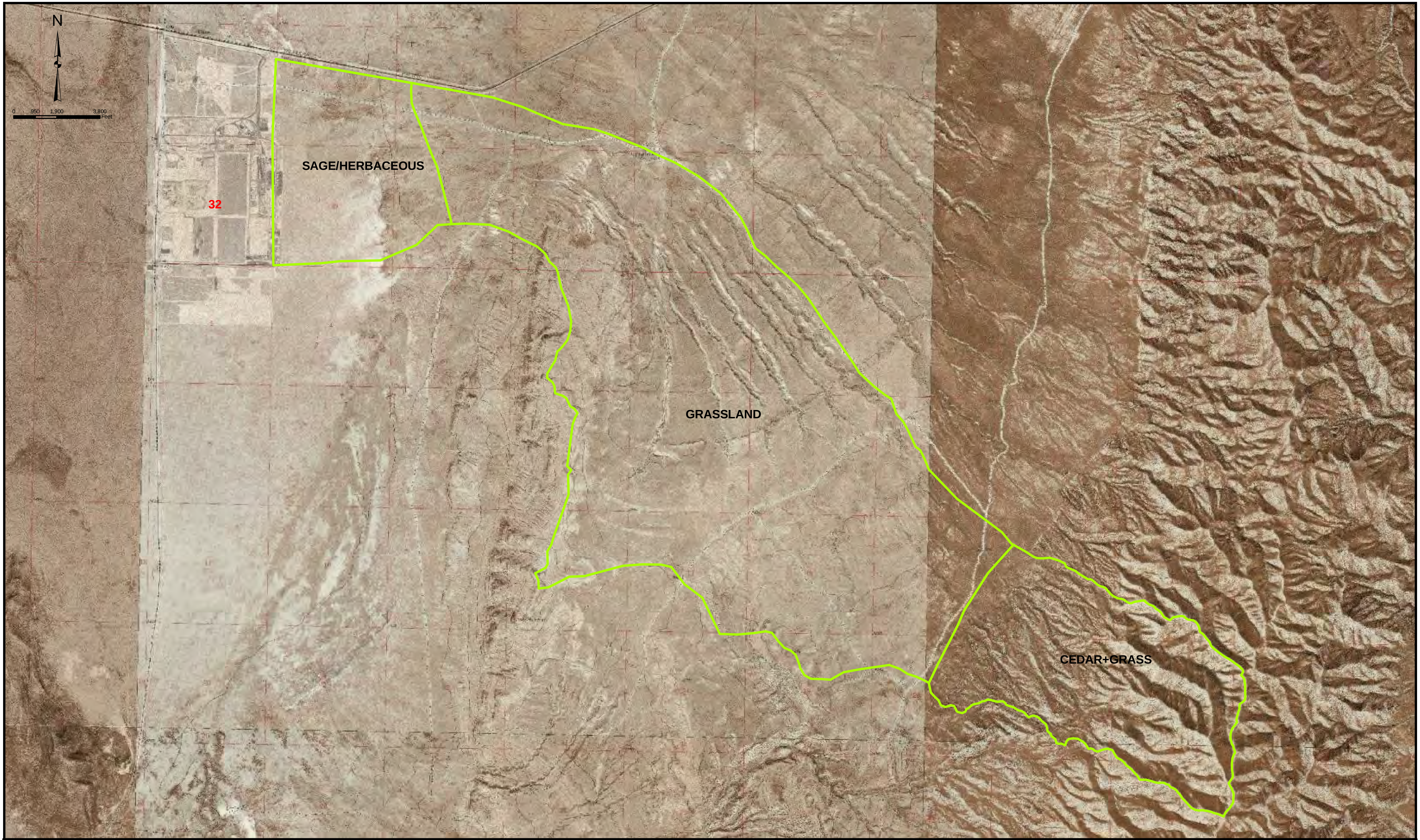
PROJECT NO.: 106.05.100

BACKGROUND

Hansen, Allen & Luce (HAL) was requested by EnergySolutions to complete an analysis of the run-on control berms for the Clive, Utah facility given the updated PMF analysis completed by HAL in April 2012. The EnergySolutions Clive, Utah facility is protected from storm water run-on by a berm system. EnergySolutions desired to define the required berm heights and a cost-efficient berm cross section for a berm system to be placed along the eastern edge of Section 32, from the rail spur southward, and then along the southern edge of Section 32. This study is in preparation of completion of a new berm construction plan for submittal to the State, along with the new run-on berm analysis.

PMF STORM RUNOFF ANALSYIS REVIEW

Prior to starting the run-on berm analysis, HAL completed a Probable Maximum Flood (PMF) study that identified the PMF peak flow rate and a HEC-RAS hydraulic model to identify the PMF water level. The analysis resulted in the revision of the tributary area for the PMF based on the findings of an initial floodplain analysis. The final subbasin boundaries for the PMF analysis are shown on Figure 1 and include three subbasins. Subbasin hydrologic characteristics for the PMF analysis were calculated using the methodologies addressed in the PMF Analysis technical memorandum and are summarized in Table 1.



HANSEN ALLEN & LUCE inc
ENGINEERS

ENERGYSOLUTIONS RUN-ON CONTROL BERM ANALYSIS

SUBBASIN DELINEATIONS FOR PMF ANALYSIS

FIGURE 1

TABLE 1
HYDROLOGIC CHARACTERISTICS OF TRIBUTARY SUBBASINS FOR PMF

Subbasin	Area (square miles)	CN	Lag Times (hrs)
Cedar+Grass	3.2	73	1.84
Grassland	11.4	70	2.98
Sage/Herbaceous	2.0	78	3.05
Total Tributary Area	16.6		

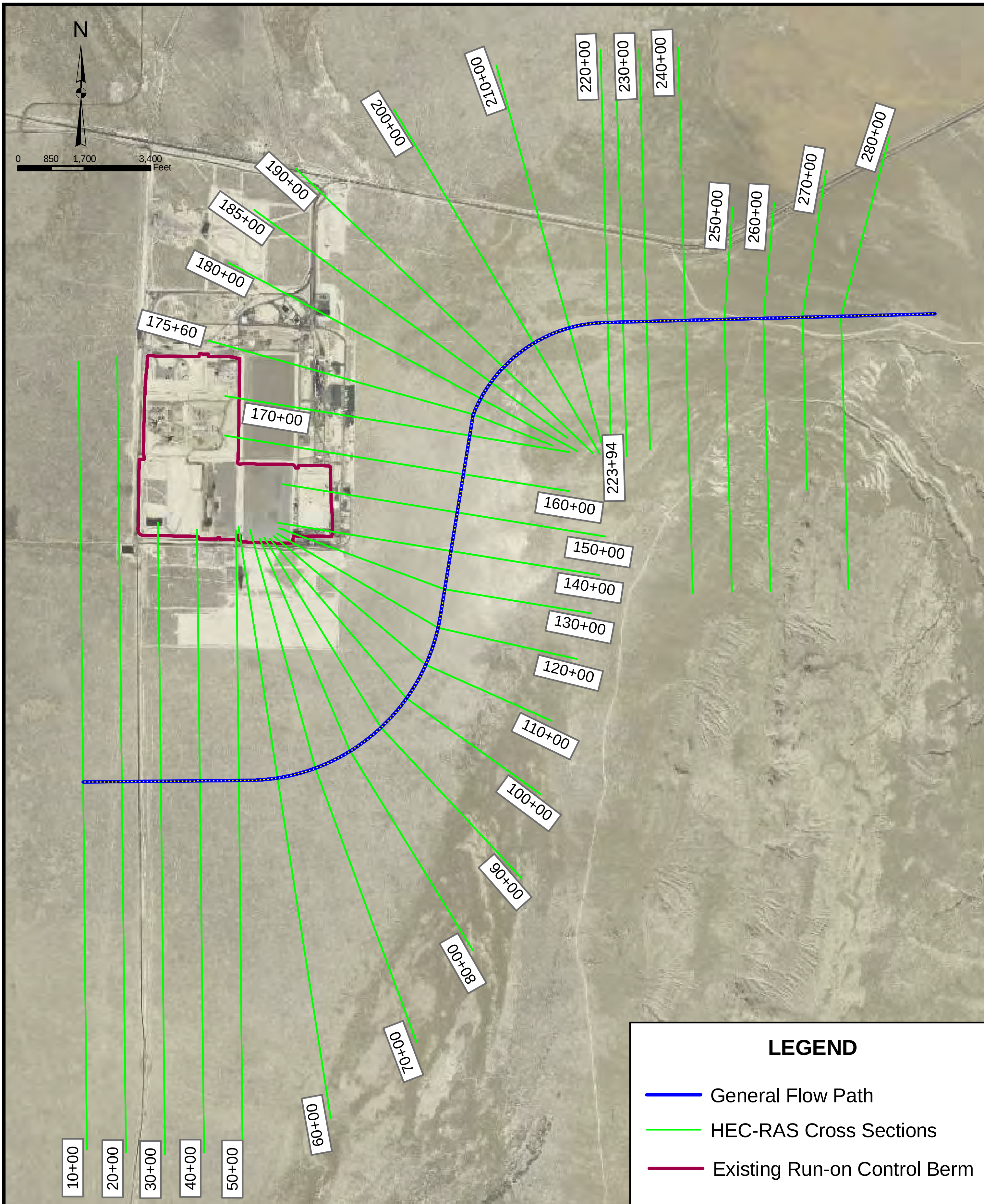
The predicted final peak PMF using the 6 hour local storm has a flow rate of 13,100 cfs at the eastern edge of Section 32.

FLOODPLAIN ANALYSIS – EXISTING CONDITIONS

The cross sections for the HEC-RAS analysis are shown on Figure 2. The floodplain was modeled for the PMF analysis using the peak flow rate of 13,100 cfs. The predicted PMF flood elevations under the existing run-on control berm conditions are summarized in Table 2. Flood depths within the flood plain between cross section 20+00 and 190+00 vary between 2 to 5 feet. Flood flow velocities of less than 2 feet per second occur between cross-sections 30+00 to 190+00 with the exception of a small portion between 90+00 and 110+00 being slightly above 4 feet per second (HEC-RAS output table in the Appendix).

TABLE 2
PREDICTED PMF FLOOD ELEVATIONS – EXISTING BERM SCENARIO

Cross Section	PMF Flood Water Surface Elevation (feet)
30+00	4266.4
40+00	4266.6
50+00	4266.8
60+00	4267.0
70+00	4267.4
80+00	4267.7
90+00	4268.8
100+00	4272.9
110+00	4277.7
120+00	4279.2



HANSEN ALLEN & LUCE INC ENGINEERS

ENERGYSOLUTIONS RUN-ON CONTROL BERM ANALYSIS
HEC-RAS GENERAL FLOW PATH AND CROSS SECTIONS

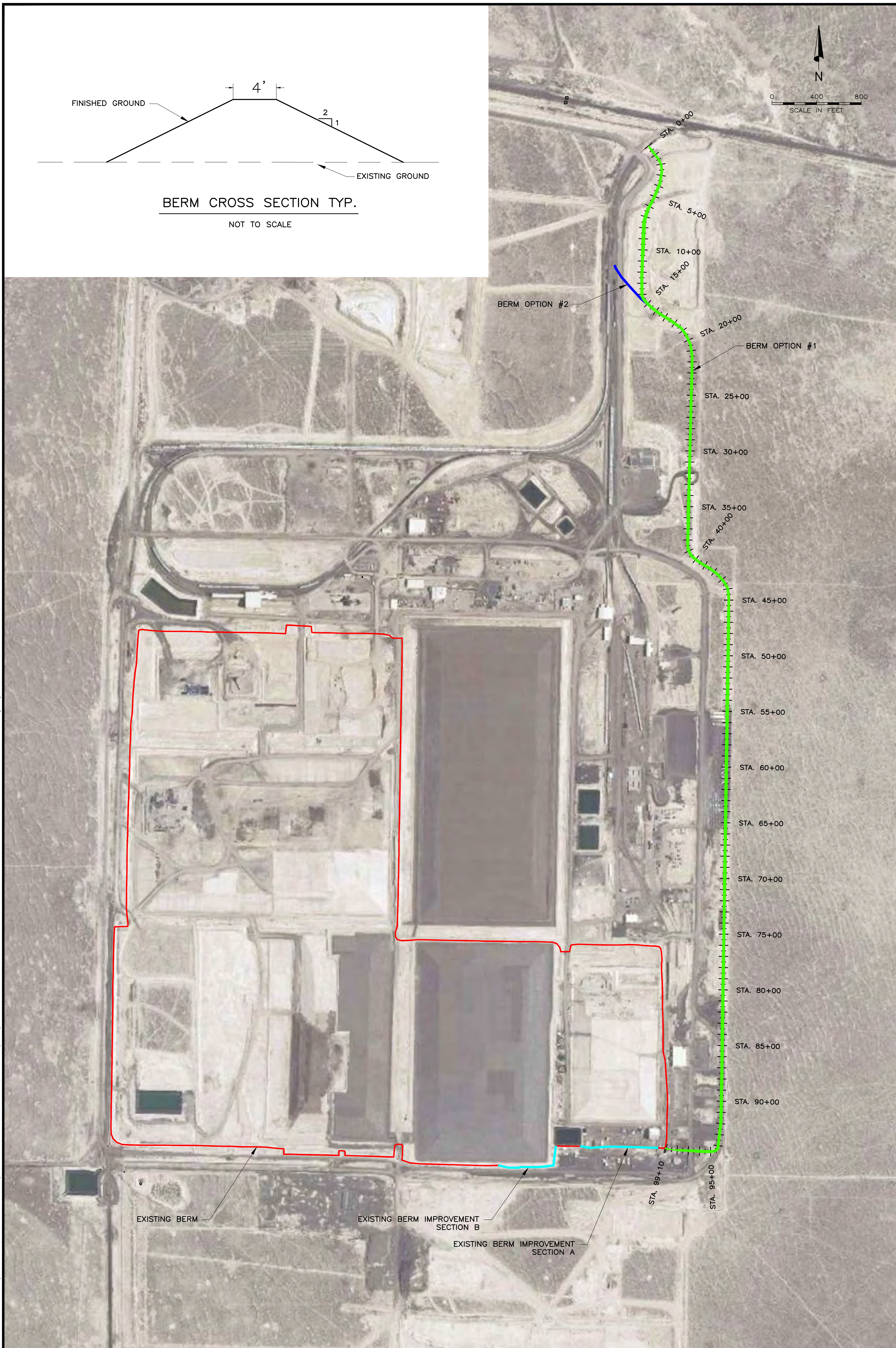
FIGURE 2

TABLE 3 (CONTINUED)

Cross Section	PMF Flood Water Surface Elevation (feet)
130+00	4280.0
140+00	4281.5
150+00	4282.7
160+00	4283.1
170+00	4283.4
175+60	4283.6
180+00	4284.0
185+00	4284.6
190+00	4285.4

PROPOSED RUN-ON CONTROL BERM IMPROVEMENTS

The methodology for determining a conceptual run-on berm alignment consisted of the initial selection of an alignment. AutoCAD Civil 3D was used as a tool to lay out a proposed berm and to extract HEC-RAS cross sections using the surfaces created by the new berm and the existing ground. An initial alignment was laid out based on the findings of the PMF analysis. The PMF analysis showed that a large portion of the EnergySolutions' railroad spur would have sufficient elevation to provide part of the run-on control. However, after this initial alignment was input into HEC-RAS it became clear that the loss of flow area caused by moving the berm to the east created water levels that would limit the use of the railroad spur as part of the run-on berm. The resulting iteration of the berm alignment settled on bringing the berm off of the railroad spur at the north end of the facility and to the east of the main entry road. This option (Option #1) removes the need to cross the entry road from the railroad spur. This option is considered the preferred alignment and is shown on Figure 3. The resulting HEC-RAS water surface elevations for the PMF using this new berm alignment are shown in Table 3. The rise of the water surface elevations compared to the existing berm scenario can be noted.



FILE NAME: PROJECTS\106 – ENERGY SOLUTIONS\05.100 – RUN-ON BERM ANALYSIS\CAD\BERM FIGURE.DWG

FILE DATE: 7.9.2012 11:14:15 (TGA)

HANSEN ALLEN & LUCE INC ENGINEERS

10/07

ENERGYSOLUTIONS RUN–ON CONTROL BERM ANALYSIS

PROPOSED RUN–ON BERM ALIGNMENT AND IMPROVEMENTS

FIGURE 3

TABLE 3
PREDICTED PMF FLOOD ELEVATIONS – PROPOSED BERM SCENARIO (OPTION #1)

Cross Section	PMF Flood Water Surface Elevation (feet)
30+00	4266.5
40+00	4266.6
50+00	4266.8
60+00	4267.0
70+00	4267.4
80+00	4267.7
90+00	4270.1
100+00	4277.7
110+00	4279.2
120+00	4279.8
130+00	4280.5
140+00	4281.8
150+00	4283.1
160+00	4284.2
170+00	4284.8
175+60	4285.1
180+00	4285.6
185+00	4286.0
190+00	4286.3

Another option (Option #2) utilizes the railroad spur as far south as possible and is also presented on Figure 3. This option would require maintaining the berm elevation across the main entry road, which may not be desired. Both options require crossing the asphalt access road at the south east corner of the facility. The design of the transition on the road that would require a certain amount of fill to raise it from the current elevation to around 4 feet higher was not part of this analysis. It is assumed that this transition would use an acceptable slope of 2 – 4% up to the desired elevation and back down at the same slope. This would require an approximate fill transition area along the roadway of about 200- 400 feet (or 100 – 200 feet on either side of the high point of the road), depending on the transition slope used.

PROPOSED RUN-ON BERM IMPROVEMENTS – DESIGN REQUIREMENTS

The preferred alignment for the proposed run-on berm improvements shown on Figure 3 has the elevation requirements identified in Table 4. These elevations are based on a berm design criteria of providing 6-inches of free board during the PMF.

TABLE 4
REGQUIRED ELEVATIONS FOR PROPOSED BERM ALIGNMENT

Berm Station	Elevation (feet)
0+00	4287.71
1+00	4287.49
2+00	4287.26
3+00	4287.04
4+00	4286.81
5+00	4286.79
6+00	4286.77
7+00	4286.76
8+00	4286.74
9+00	4286.73
10+00	4286.71
11+00	4286.70
12+00	4286.69
13+00	4286.67
14+00	4286.66
15+00	4286.64
16+00	4286.63
17+00	4286.61
18+00	4286.60
19+00	4286.58
20+00	4286.57
21+00	4286.56
22+00	4286.54
23+00	4286.53
24+00	4286.51

TABLE 5 (CONTINUED)

Berm Station	Elevation (feet)
25+00	4286.49
26+00	4286.46
27+00	4286.43
28+00	4286.40
29+00	4286.37
30+00	4286.34
31+00	4286.31
32+00	4286.28
33+00	4286.24
34+00	4286.21
35+00	4286.18
36+00	4286.15
37+00	4286.12
38+00	4286.09
39+00	4286.06
40+00	4286.03
41+00	4286.00
42+00	4285.97
43+00	4285.94
44+00	4285.91
45+00	4285.88
46+00	4285.85
47+00	4285.82
48+00	4285.79
49+00	4285.76
50+00	4285.73
51+00	4285.70
52+00	4285.67
53+00	4285.64
54+00	4285.61
55+00	4285.57

TABLE 5 (CONTINUED)

Berm Station	Elevation (feet)
56+00	4285.54
57+00	4285.51
58+00	4285.48
59+00	4285.44
60+00	4285.41
61+00	4285.38
62+00	4285.35
63+00	4285.31
64+00	4285.26
65+00	4285.21
66+00	4285.15
67+00	4285.09
68+00	4285.03
69+00	4284.97
70+00	4284.91
71+00	4284.85
72+00	4284.79
73+00	4284.73
74+00	4284.65
75+00	4284.54
76+00	4284.43
77+00	4284.32
78+00	4284.21
79+00	4284.10
80+00	4283.99
81+00	4283.88
82+00	4283.78
83+00	4283.67
84+00	4283.55
85+00	4283.42
86+00	4283.29

TABLE 5 (CONTINUED)

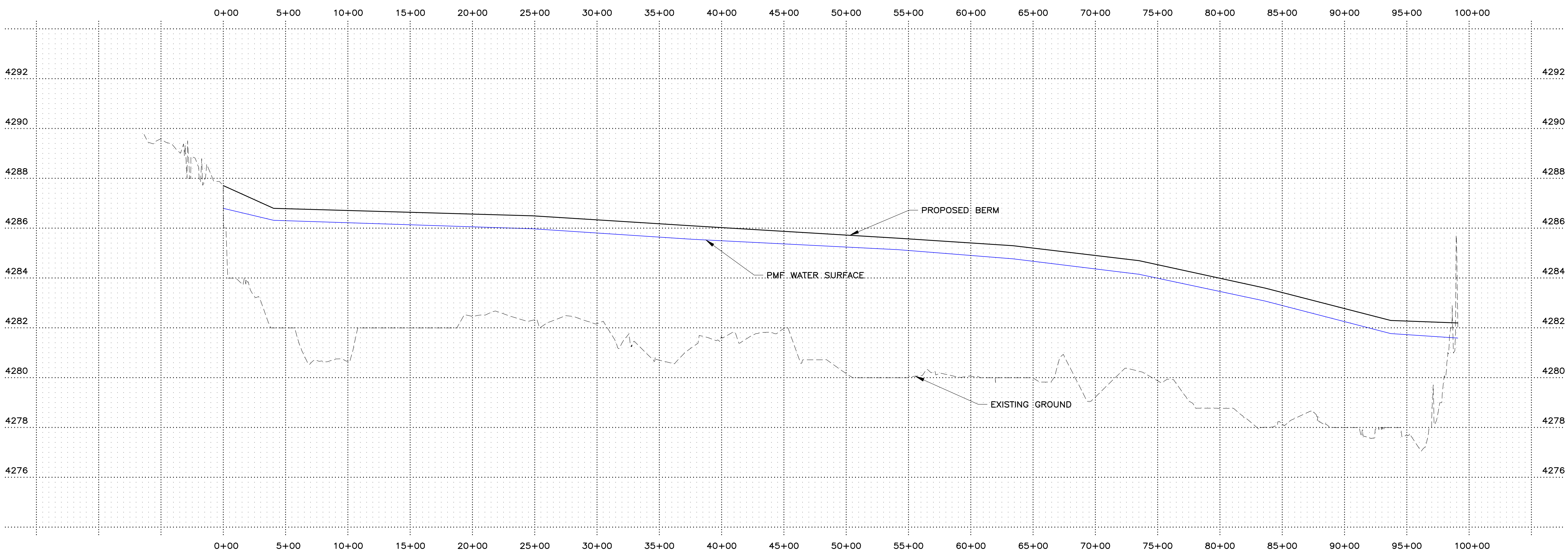
Berm Station	Elevation (feet)
87+00	4283.16
88+00	4283.04
89+00	4282.91
90+00	4282.78
91+00	4282.65
92+00	4282.52
93+00	4282.39
94+00	4282.29
95+00	4282.28
96+00	4282.26
97+00	4282.24
98+00	4282.22
99+00	4282.20
99+09.85	4282.20

A typical berm section has been included on Figure 3. This berm section is based on rule-of-thumb maximum slopes and minimum top width, as well as a consultation with a geotechnical engineer. The side slopes are shown at 2 ft Horizontal:1ft Vertical with a 4 foot top width. The top of the berm is shown with a 2% gradient towards the east for drainage purposes.

A profile of the proposed berm is shown on Figure 4. The profile shows the proposed top of the centerline of the berm, the existing ground surface along the centerline and the PMF water level.

EXISTING BERM IMPROVEMENTS

There is a need to improve two sections of the existing berm along the south side of the facility as shown on Figure 3. The elevations along the Existing Berm Improvement Section A would need to be increased to around 4281.6 feet with an approximate maximum additional fill height of 2.1 feet. The elevations along the Existing Berm Improvement Section B would need to be increased to around 4279.7 to 4280.3 feet with an approximate maximum additional fill height of 1.7 feet. These improvements will give the berm the 6-inch freeboard that has been provided with the proposed new berm along the eastern side of the facility. The remaining existing berms



FILE NAME: PROJECTS\106 – ENERGY SOLUTIONS\05.100 – RUN-ON BERM ANALYSIS\CAD\BERM FIGURE.DWG FILE DATE: 7.9.2012 11:14:15 (TGA)

HANSEN ALLEN & LUCE inc ENGINEERS

10/07

ENERGYSOLUTIONS RUN-ON CONTROL BERM ANALYSIS

PROPOSED RUN-ON BERM PROFILE

FIGURE

4

along the south side appear to be sufficient to contain the run-on from the PMF based on the HEC-RAS model.

The remaining berms along the west side of the facility and the interior of the facility along the cells are no longer needed. This is because the new run-on berms and improved berm along the south side of the facility will convey PMF storm water around the facility where it will continue to the west.

REFERENCES

Hansen, Allen & Luce, 1991. USPCI - Prediction of 100-Year Flood Plain Section 36 Township 1 South, Range 12 West. Hansen, Allen and Luce, Midvale, Utah.

Hansen, Allen & Luce, 2012. PMF and 100-year Storm Analysis for Clive, Utah (Draft). Midvale, Utah.

U.S. Army Corps of Engineers, 2008. HEC-RAS River Analysis System Version 4.0. Hydrologic Engineering Center, Davis, California.

U.S. Army Corps of Engineers, 2010. Hydrologic Modeling System (HEC-HMS). Hydrologic Engineering Center, Davis, California.

U.S. Geological Survey, 1973. Aragonite NW, Utah; Aragonite, Utah; Hastings Pass, Utah; and Low, Utah Quadrangle Maps.

U.S. Geological Survey, 1987. Bonneville Salt Flats, Utah, 30 x 60 Minute Quadrangle Map.

APPENDIX

Contents:

HEC-RAS Output Summary Report

HEC-RAS Plan: Plan 01   River: HEC RAS   Reach: HEC RAS   Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
HEC RAS	28000	PF 1	13100.00	4389.83	4396.59	4395.58	4397.38	0.010336	7.15	1833.37	497.29	0.66
HEC RAS	27000	PF 1	13100.00	4377.20	4383.03	4382.55	4384.02	0.017875	7.98	1640.67	571.25	0.83
HEC RAS	26000	PF 1	13100.00	4363.43	4372.66		4373.27	0.007040	6.27	2089.59	517.11	0.55
HEC RAS	25000	PF 1	13100.00	4350.51	4358.88	4358.88	4359.51	0.037855	6.35	2061.77	1780.65	1.04
HEC RAS	24000	PF 1	13100.00	4317.82	4335.31		4335.40	0.002699	2.47	5305.49	6781.04	0.31
HEC RAS	23000	PF 1	13100.00	4312.91	4328.39	4328.25	4329.09	0.027455	6.72	1949.65	6062.64	0.94
HEC RAS	22393.68	PF 1	13100.00	4310.21	4320.86	4320.21	4320.98	0.007630	2.84	4619.42	8850.59	0.47
HEC RAS	22000	PF 1	13100.00	4306.97	4314.84	4314.84	4315.27	0.037199	5.22	2510.03	6822.55	0.99
HEC RAS	21000	PF 1	13100.00	4299.62	4303.74	4302.57	4303.89	0.004824	3.08	4246.93	4544.15	0.40
HEC RAS	20000	PF 1	13100.00	4290.12	4293.07	4293.07	4293.58	0.035160	5.77	2271.94	2158.06	0.99
HEC RAS	19000	PF 1	13100.00	4280.78	4286.32		4286.35	0.000589	1.34	9774.84	4934.65	0.15
HEC RAS	18500	PF 1	13100.00	4257.20	4285.98		4286.02	0.000738	1.71	7651.36	5216.24	0.17
HEC RAS	18000	PF 1	13100.00	4278.27	4285.56		4285.61	0.000903	1.91	6871.58	5453.84	0.19
HEC RAS	17560	PF 1	13100.00	4276.00	4285.14		4285.19	0.001009	1.80	7272.81	6147.93	0.20
HEC RAS	17000	PF 1	13100.00	4269.44	4284.77		4284.80	0.000498	1.37	9553.07	5378.52	0.14
HEC RAS	16000	PF 1	13100.00	4267.32	4284.15		4284.19	0.000759	1.59	8218.24	5105.55	0.17
HEC RAS	15000	PF 1	13100.00	4275.83	4283.08		4283.14	0.001554	1.98	6619.17	3840.76	0.23
HEC RAS	14000	PF 1	13100.00	4275.95	4281.77		4281.82	0.001124	1.85	7068.20	4414.52	0.20
HEC RAS	13000	PF 1	13100.00	4275.00	4280.51		4280.55	0.001443	1.72	7617.11	4333.70	0.22
HEC RAS	12000	PF 1	13100.00	4273.00	4279.79		4279.81	0.000441	1.23	10692.73	4061.68	0.13
HEC RAS	11000	PF 1	13100.00	4273.23	4279.17		4279.20	0.000898	1.46	8994.89	4457.11	0.18
HEC RAS	10000	PF 1	13100.00	4275.00	4277.74	4276.79	4277.80	0.002500	1.96	6695.12	4530.87	0.28
HEC RAS	9000	PF 1	13100.00	4264.40	4270.08	4270.08	4271.90	0.024257	10.81	1211.48	334.27	1.00
HEC RAS	8000	PF 1	13100.00	4259.22	4267.73		4267.78	0.000576	1.72	7619.81	2033.08	0.16
HEC RAS	7000	PF 1	13100.00	4256.66	4267.36		4267.38	0.000284	1.00	13060.32	4600.82	0.10
HEC RAS	6000	PF 1	13100.00	4259.31	4267.04		4267.06	0.000358	1.02	12890.42	5303.75	0.11
HEC RAS	5000	PF 1	13100.00	4257.53	4266.78		4266.79	0.000200	0.83	15810.89	5714.25	0.09
HEC RAS	4000	PF 1	13100.00	4257.66	4266.61		4266.62	0.000151	0.74	17631.43	6073.31	0.08
HEC RAS	3000	PF 1	13100.00	4255.98	4266.46		4266.47	0.000147	0.73	17977.08	6239.59	0.08
HEC RAS	2000	PF 1	13100.00	4260.05	4266.11		4266.14	0.001322	1.40	9368.54	6358.40	0.20
HEC RAS	1000	PF 1	13100.00	4255.55	4264.17	4262.73	4264.23	0.003003	1.94	6764.13	5206.32	0.30

APPENDIX F

Site Radiological Security Plan

(with proposed amendments in reline/strikeout format)

Energy*Solutions* Clive Site Radiological Security Plan

Revision ~~4~~5

October 25~~6~~, 2012~~1~~

Table of Contents

1.0 PURPOSE

This plan outlines the required security measures to be implemented and which are enforced at the Energy*Solutions* Clive facility to prevent radioactive waste material(s) and contaminated equipment without authorization from being used within or exiting the facility.

2.0 SCOPE

This plan outlines the security measures in place for the Energy*Solutions* Clive facilities; with additional measures identified for specific waste access areas within the Bulk Waste Facility (BWF). It introduces a multi-layer security model containing specific security controls for site access, restricted area boundary, and overall waste access. This plan applies to all personnel who access the Energy*Solutions* Clive facility located within Section 32.

3.0 DEFINITIONS

Waste Access Areas
Areas where personnel can come in direct contact with un-containerized waste. These areas include the following:

- 11e.(2), Class A~~, Class A North~~ West, and Mixed Waste disposal cells
- Railcar Rollover Facility
- Intermodal Unloading Facility
- Mixed Waste Treatment Facilities when they contain waste
- Rail Digging Facility
- Rotary Dump Facility
- Shredder

Access Control Stations
The only points (designated areas) established for normal personnel and personal item entrance and egress to and from the Restricted Area.

Restricted Area Boundary
The area within the controlled area that requires control of access and occupancy for radiation protection purposes. The restricted area boundary is posted "Caution, Radioactive Material" and is bordered by a 6-foot high fence.

Controlled Area
The area within Energy*Solutions'* property boundaries that is controlled for purposes other than radiation protection, i.e., security.

Un-Containerized Waste
Bulk waste that has been unloaded from a transportation container.

Debris
Debris is material for disposal other than soil.

Unloading
For the purposes of this plan, unloading is the removal of unpackaged waste from the container.

Authorized Personnel – Personnel with Unescorted/Unrestricted access demonstrated by a green, blue, or orange badge. Every individual issued a green, blue, or orange badge shall have completed training as required by operating procedure CL-TN-PR-010, *General Training Procedure*.

4.0 RESPONSIBILITIES

4.1 The **Vice President and General Manager, ~~of~~ Clive Opertations** has the ultimate responsibility and accountability for establishing and implementing this plan**.** The Vice President and General Manager, Clive Operations~~Vice President of Clive~~ delegates authority to implement this program to the Security Department.

4.2 The **~~Director~~ Manager, ~~of~~ Waste Disposal Operations ~~(LLRW or MW)~~** is responsible for the management of all waste handling operations and coordinating resources to implement and ensure compliance with this plan.

4.3 The **~~Quality Assurance Manager~~ Director, Corporate QA** or designee is responsible for performing surveillance and/or audit activities to verify implementation and compliance with the requirements of this plan. The Director, Corporate QA ~~Quality Assurance Manager~~ is also responsible for administering the Condition Report program used to document deficiencies and corrective actions relating to this Plan.

4.4 The **~~Director~~ Radiation Safety Officer~~of Health Physics~~** is responsible for providing radiation safety support to the Director of Operations in implementing this plan. The Radiation Safety Officer~~Director of Health Physics~~ is also responsible for the performance and documentation of radiological inspections and surveys, and controlling and monitoring Access Control Points.

4.6 The **Security Department** is responsible for monitoring waste access areas, restricted area boundaries and site access areas, and performing random security checks on personnel and vehicles accessing these facilities.

4.7 **Energy*Solutions* Employees and Contractor Personnel** are responsible for understanding and enforcing portions of this procedure as applied to their job assignment/ work area, and reporting ANY suspicious activity to their supervisor. **All personnel** are responsible for the safe operation of the facility and compliance with this plan.

5.0 GENERAL

Facility vehicles transferring or unloading waste shall not be left unattended.

Prior to removal from the Restricted Area, a~~A~~ll hand and small power tools ~~procured and~~ used to perform operations activities by Energy*Solutions* employees or by any of Energy*Solutions'* contractor's employees within the Bulk Waste Facility restricted areas shall be surveyed by Health Physics and found clean of all loose and fixed contamination.~~uniquely identified and distinguishable from waste material tools delivered to the site for disposal.~~

> *NOTE: Tools that are owned by subcontractors or rental equipment used inside the restricted areas for special projects, shall be controlled by markings, security seals, security escorts or physical inventories. Individuals assigned as security escorts shall have no other responsibility while performing the assigned task.*

Facility (Site) security patrols shall be performed seven days a week and twenty-four hours a day. A minimum of three patrols is required within a 24-hour period.

Facility (Site) Security patrols will include the following:

- Random searches
- Detection of breaches in fencing
- Detection of any other discrepancy in fencing such as height
- Detection of unattended vehicles
- Detection of suspicious items, persons, or activities
- Detection of unauthorized access by individuals

Restricted Area interior security patrols shall be performed when personnel are present within the Restricted Area and will include the following:

- Random searches
- Detection of breaches in fencing
- Detection of any other discrepancy in fencing such as height
- Detection of unattended vehicles
- Detection of suspicious items, persons, or activities
- Detection of unauthorized access by individuals

6.0 SECURITY PLAN REQUIREMENTS

6.1 Site Access Boundary Controls

Visitors to the Energy*Solutions* Clive site will be directed to the administration building via road signs. Prior to being allowed unescorted access beyond the administration building, v~~V~~isitors will be briefed on security measures and general risks found at the facility.

All individuals who access the site will be subject to camera surveillance and random inspections by security personnel.

6.2 Restricted Area Access Controls

Activities within the Restricted Area shall be monitored by Security, either by presence or by the use of security cameras.

Within 7 calendar days of discovery, Restricted Area fence lines shall be free of vegetation, equipment, and debris to help security personnel identify unauthorized material or equipment.

The nominal 6’ chain-link fence shall be considered compromised and require repair if the height from the ground surface to the top of the fence or gate is less than 5’9”. Fencing greater than 6’ tall is acceptable. Any fencing breach or area of inadequate height shall be identified and repairs tracked on a Condition Report in accordance with operating procedure ES-AD-PR-008, *Condition Reports*. In addition, any unplanned breach of the restricted area fencing shall require 24-hour verbal notification to DRC, followed within 7 calendar days by a written report.

All material and equipment shall exit the Restricted Area through designated access control points unless an exception is granted by the ~~Director of Health Physics~~Radiation Safety Officer.

Unless otherwise approved by the Radiation Safety Officer ~~Director of Health Physics~~ for periods of limited operations in accordance with the following paragraph, Health Physics personnel shall be present at personnel access control point areas during periods of operation. They shall monitor personnel and other items entering and exiting the restricted area.

During periods of limited operations such as nights, weekends, or holidays, Health Physics personnel assigned to the access control points may perform monitoring duties within the operational area in addition to duties at the access control point. The access control point shall be locked to prevent outside access if Health Physics personnel are not present.

Personnel Exiting Restricted Area

All personnel must exit the restricted area through designated access control points except during a designated emergency or unless an exception is granted by the ~~Director of Health Physics~~ Radiation Safety Officer.

Upon request, items inside clothing shall be removed and presented to the Health Physics personnel located at the control point.

Random security checks shall be performed on personnel exiting the area by Security personnel.

Designated and approved Transfer Areas established for relocation of cell construction material, fill material, and CLSM into the restricted area shall be monitored by security officers and/or security cameras.

Transport Containers Exiting the Restricted Area shall be subject to the following:

1. A satisfactory radiological survey shall be completed; and
2. Security seals shall be installed on empty containers exiting the facility.

Note: The point of compliance for security seals being present on containers is at the time of transfer out of the Restricted Area. Security seals may fall off or be removed for follow-up inspection from containers that are held in storage outside of Restricted Areas at the Clive facility.

The ~~applicable Director of Operations~~Manager, Waste Disposal Operations shall be immediately notified if security seals are found to be breached or of any other suspicious items found during inspections.

6.3 Waste Access Areas Control

Security personnel shall perform documented daily random security searches on personnel and vehicles accessing these areas.

Access to the railcar rollover, rotary dump, and the intermodal unloading facility shall be monitored either by security personnel or security cameras.

Only authorized personnel shall be permitted to enter designated waste access areas.

Security officers shall conduct physical inspections of designated waste access areas when work is being performed. Any unauthorized individuals or equipment found in these areas without the proper clearance shall be immediately reported to the ~~applicable Director of Operations~~ Manager, Waste Disposal Operations.

7.0 REFERENCES

CL-TN-PR-010, *General Training Procedure*
ES-AD-PR-008, *Condition Reports*

8.0 ATTACHMENTS

None

Formatted: Body Text

APPENDIX G

HAL PMF Study

HANSEN ALLEN & LUCE INC
ENGINEERS

Memorandum

DATE: July 25, 2012

TO: Vern C. Rogers, PhD
EnergySolutions, Chief Scientist
423 West 300 South, Suite 200
Salt Lake City, Utah 84101

FROM: Gordon L. Jones, P.E.
Hansen, Allen & Luce, Inc.
6771 South 900 East
Midvale, Utah 84047

PROFESSIONAL ENGINEER
GORDON L. JONES
No. 6048470-2202
7/25/12
STATE OF UTAH

PROJECT: PMF and 100-year Storm Analysis for Clive, Utah

PROJECT NO.: 106.04.100

BACKGROUND

Hansen, Allen & Luce (HAL) was selected by EnergySolutions to complete an analysis of the Probable Maximum Flood (PMF) for the Clive, Utah facility. Several studies completed for this area were referred to during this analysis:

<u>HEC-1 and HEC-2 Analysis</u>, Bingham Environmental, 1996

<u>Prediction of 100-Year Flood Plain Section 36 Township 1 South, Range 12 West</u>, Hansen, Allen & Luce, 1991.

HYDROLOGIC DESCRIPTION AND SETTING

The drainage basin tributary to Section 32 is shown on Figure 1. The drainage basin is bounded by the Cedar Mountains on the east with elevation ranging up to 6600 feet. There are five culverts which cross the railroad on the north side of the drainage area. Field inspections performed during HAL's initial analysis of the area in 1991 revealed that in a runoff event that exceeds the capacity of the culvert to the north of the Aragonite road crossing (labeled C1 in Figure 1) a spill would occur across the railroad. Therefore, the road crossing near Aragonite is the practical northern limit of the tributary area to the proposed incinerator site. The four culverts to the southwest of Aragonite have inadequate capacity for a 100-year event and excess flood waters spill to the south and west along the south side of the railroad joining with other runoff flows which are tributary to Section 32. The calculations for the determination of flow capacity for the four culverts are included in the Appendix.

Runoff Factors

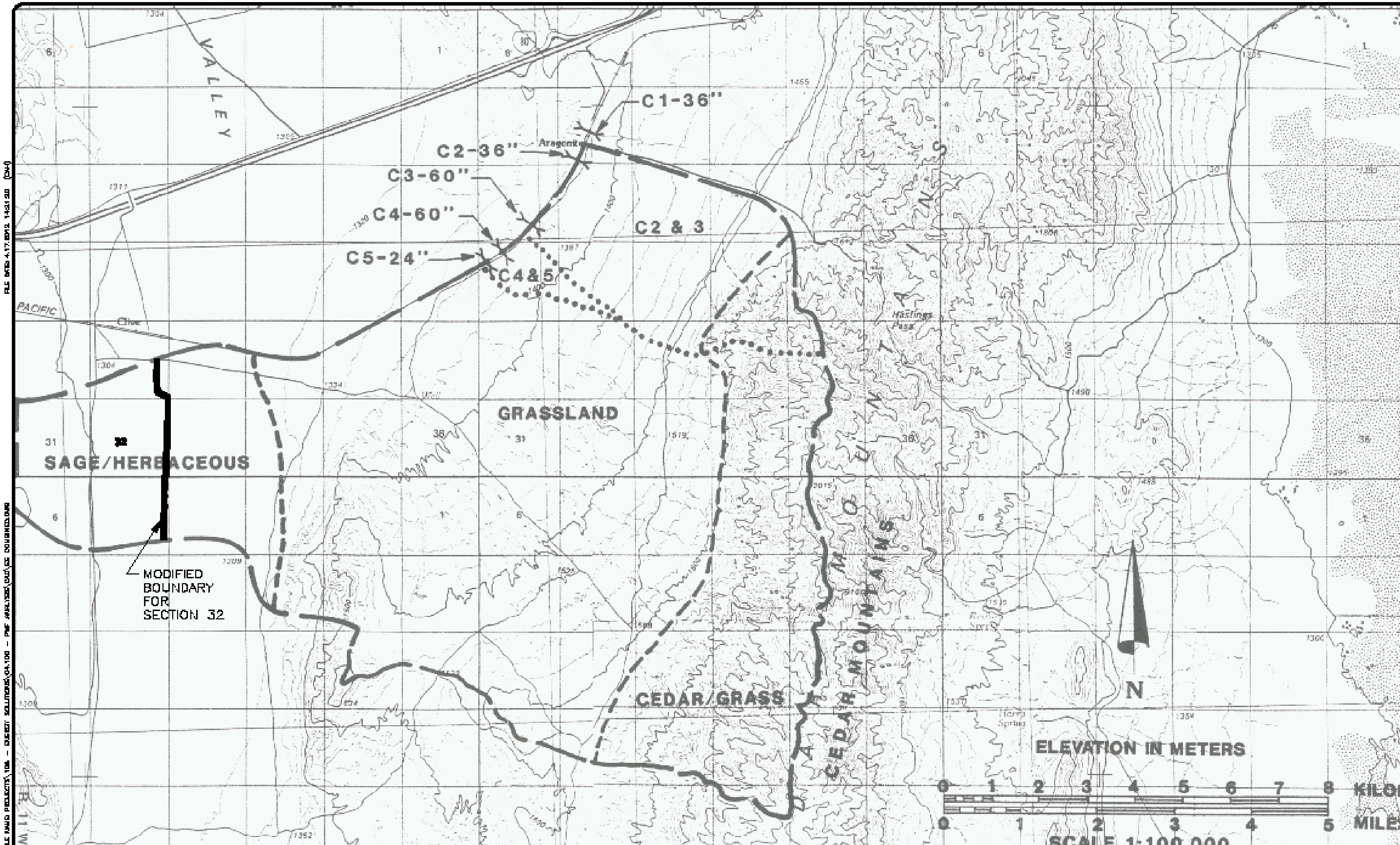
The tributary area to Section 32 consists of three major vegetation complexes: sage/herbaceous complex, grassland complex, and cedar/grass complex (see Figure 1). The lower areas of the watershed grade from a poor cover of sage and herbs in the lowest areas to a good cover of sage and grass about two miles east of the facility (Section 32). The sage/grass complex grades to a good to excellent cover of grass rangeland. The slopes of the Cedar Mountains consist of a cedar/grass complex with some rock outcrop. The runoff potential for each vegetation type was evaluated using the Soil Conservation Service Curve Number (CN) technique. Curve numbers were selected based on information supplied by the SCS (1972, 1986) based on soils information from the Wilson et. al., 1975, and based on vegetation type and cover density. Antecedent Moisture Condition II (AMC II) was used based on the criteria for the PMF analysis outlined in Utah Rule R655-11-4. Table 1 gives a summary of the area and curve number for each vegetation complex. Following Table 1, a description of the basis for each of the selected curve numbers is given.

TABLE 1
EASTERN EDGE OF SECTION 32
TRIBUTARY VEGETATION COMPLEXES

Vegetation Complex	Area (square miles)	CN
Sage / Herbaceous	3.8	78
Grassland	34.3	70
Cedar / Grass	10.8	73
Total Tributary Area	48.9	

Sage/Herbaceous Complex: Ground cover consists mainly of sagebrush, shadscale and salt tolerant grasses. Ground cover ranges from fair to poor. Wilson et. al. indicates that the soils of this portion of the drainage area consists of Typic Natrargids-Xerollic Natrargids-Typic Calciorthids Association with mostly Hydrologic Soil Type C and D. The field inspection completed for the 1991 study indicated that the soil type in the vicinity of Section 36 is Type D. SCS Technical Release No. 55 Table 2-2d (see copy of table in Appendix A) with a soil type D indicates a curve number of 85 for poor soil cover and 70 for fair cover, therefore the representative curve number for the site based on the average of the curve numbers for the fair and poor soil cover conditions is about 78.

Grassland Complex: Principal ground cover consists of bluebunch wheatgrass with some big sagebrush, shadscale, other grasses, forbes and shrubs. Ground cover ranges from fair to good. Wilson et. al. indicates that the soils of this portion of the drainage area consists mostly of Xeric Torrifluvents-Xerollic Calciorthids Association with mostly Hydrologic Soil Type B. SCS



ENERGYSOLUTIONS PMF ANALYSIS

1991 SUBBASIN BOUNDARIES MODIFIED FOR SECTION 32

FIGURE 1

Technical Release No. 55 Table 2-2d with a soil type B indicates a curve number of 71 for fair soil cover and 62 for good cover. Use a curve number of 70.

Cedar/Grassland Complex: Principal ground cover consists of cedars and grasses. Ground cover is fair. Wilson et. al. indicates that the soils of this portion of the drainage area consists of Xeric Calciorthids-Xeric Torrifluvents Association and Typic Argixerolls-Typic Haploxerolls Association consisting of Hydrologic Soil Types B and C. The field inspection completed for the 1991 study revealed some small areas of rock outcrop. Therefore a soil type C is conservatively assumed (soil type C produces larger volumes of runoff than soil type B). SCS Technical Release No. 55 Table 2-2d with a soil type C indicates a curve number of 73 for fair soil cover.

Both cedar/grass and grassland vegetation complexes have very similar curve numbers (73 and 70). Therefore volume weighting to find a representative curve number is appropriate. The flow rates at the mouths of the various canyons of the Cedar Mountains are not needed for purposes of this study, therefore the storm runoff model can be simplified without a loss in accuracy by combining the two cover types into one subbasin. Hereinafter the two cover types will be referred to as Cedar+Grass.

PMP DETERMINATION

Utah Rule R655-11-4 specifies that the acceptable method for determining the Probable Maximum Precipitation (PMP) is found in Hydrometeorological Report No. 49 (HMR49) entitled "Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainages". This methodology was used to determine both the General and Local Storm PMP values. The method calls for calculating both types of storms and then choosing the larger of the two as the PMP. The general storm PMP was calculated for the 1996 PMF Project Memorandum and was verified for this study. The PMP for the local storm was recalculated for this analysis. The worksheets showing the calculation for each are located in the Appendix. A summary of the General and 1-hour and 6-hour Local Storm PMPs are located in Tables 2, 3 and 4, respectively.

TABLE 2
GENERAL STORM PROBABLE MAXIMUM PRECIPITATION (INCHES)
(Cumulative)

DURATION (HOURS)					
6 hr	**12 hr**	**18 hr**	**24 hr**	**48 hr**	**72 hr**
4.53	6.52	7.89	8.98	12.11	13.57

TABLE 3
LOCAL STORM PROBABLE MAXIMUM PRECIPITATION (INCHES)
(1-Hour Incremental)

DURATION (MINUTES)			
15 min	**30 min**	**45 min**	**60 min**
2.9	1.5	0.9	0.8

TABLE 4
GENERAL STORM PROBABLE MAXIMUM PRECIPITATION (INCHES)
(6-Hour Incremental)

DURATION (HOURS)					
1 hr	**2 hr**	**3 hr**	**4 hr**	**5 hr**	**6 hr**
0.5	0.8	6.1	1.6	0.7	0.4

100-YEAR STORM DISTRIBUTION

The 100-year analysis relied on the storm duration sensitivity analysis that was completed for the 1991 HAL study that found that the 24-hour storm was the most critical. This 24-hour storm used the SCS Type II distribution. The 100-year precipitation depths were unchanged from the 1991 study which were based on the NOAA Atlas 2 and are shown in Table 5.

TABLE 5
100-YEAR 24-HOUR PRECIPITAION

Subarea	Depth (inches)
Sage/Herbaceous	2.3
Cedar+Grass	2.5

INITIAL STORM RUNOFF ANALYSIS

The Army Corps of Engineers Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) was used to develop a storm runoff hydrograph for the different PMPs for the tributary watershed to Section 32.

The tributary watershed to Section 32 was subdivided in our analysis into four subareas designated C2&3, C4&5, Cedar+Grass, and Sage/Herbaceous (see Figure 1). Subarea C2&3 consists of the tributary area to culverts 2 and 3. Subarea C4&5 consists of the tributary area to culverts 4 and 5. The Cedar+Grass subarea includes all of the tributary grassland and cedar/grass complexes except for the areas tributary to the above referenced culverts. The Sage/Herbaceous subarea includes the entire tributary sage/herbaceous vegetation complex tributary to the east edge of Section 32. Table 5 presents hydrologic characteristics for each of the subareas included in the runoff analysis. The time of concentration for each subarea was computed using the Simas and Hawkins method outlined in their publication "Lag Time Characteristics for Small Watersheds in the U.S" (Simas & Hawkins, 1988).

The Simas and Hawkins method is based on the evaluation of over 50,000 rainfall-runoff events in 168 watersheds in the United States which resulted in the development of a regression equation. The regression equation is:

$$\mathbf{t_{lag} = 0.0051 \times width^{0.594} \times slope^{-0.150} \times S_{nat}^{0.313}}$$

Where t_{lag} is lag time in hours, *width* is in feet, *slope* is a decimal fraction and S_{nat} is in inches.

TABLE 6
HYDROLOGIC CHARACTERISTICS OF TRIBUTARY SUBBASINS

Subbasin	Area (square miles)	CN	Lag Times (hrs)
C2&3	8.9	71	3.11
C4&5	0.6	70	1.05
Cedar/Grass+Grassland	35.6	71	4.33
Sage/Herbaceous	3.8	78	3.56
Total Tributary Area	48.9		

The Army Corps of Engineers model HEC-HMS was used with the subbasin characteristics presented in Table 6 to generate hydrographs for each subbasin. The tributary area to Section 32 is affected by the Union Pacific Railroad which acts as a barrier for the natural flow path to the northwest. There are several culverts that pass some amount of flow to the northwest and the excess flow was presumed to be carried to the southwest along the railroad all the way to Section 32. Culverts C2, C3, C4 and C5 were included in the model based on the 1991 analysis for USPCI. As part of that analysis a field visit and survey were completed. At that time the culverts were found to be in good condition, except for culvert C4 which appeared to be failing and was propped up in the middle with timbers. The current condition of the culverts was not established as part of this analysis. The culvert capacities computed for the 1991 analysis were used to establish flow diversions in the HEC-HMS model. The hydrographs resulting from the culvert spills to the southwest along the railroad tracks were routed to the confluence with the Cedar+Grass subbasin using the Muskingum Routing method. The resulting hydrographs were then combined with the runoff hydrograph from the Sage/Herbaceous subbasin to produce the total runoff hydrograph for the eastern edge of Section 32.

The predicted peak PMF and 100-year flow rates at the eastern edge of Section 32 are presented in Table 7.

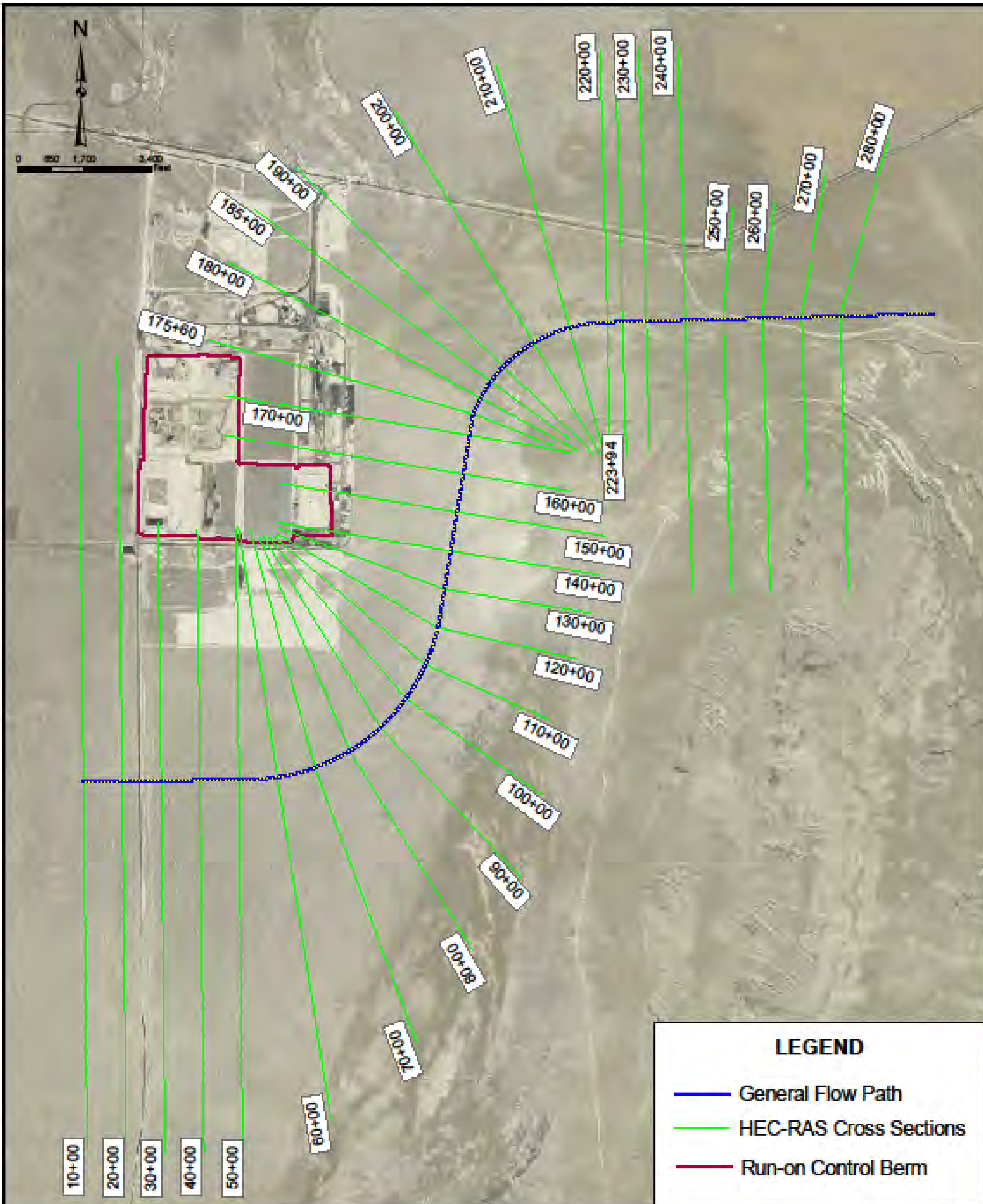
TABLE 7
PREDICTED PEAK FLOW RATES

Storm Event	Peak Flow (cfs)
PMF – General Storm (72hr)	3,700
Initial PMF – Local Storm (6hr)	29,800
Initial PMF – Local Storm (1hr)	14,800
100-Year 24hr Storm	1,300

INITIAL FLOODPLAIN ANALYSIS

The Army Corps of Engineers model HEC-RAS was used to simulate the passage of the predicted PMF runoff through Section 32. The flood plain analysis was performed using the peak PMF flow rate of 29,800 cfs. The topography of the flood plain to the east and south of Section 32 was typified with 31 cross sections. The HEC-RAS cross sections were created from the 5-Meter Auto-Correlated Elevation Model (DEM) from the State of Utah's GIS Portal (AGRC) in AutoCad Civil 3D and exported into HEC-RAS. The AGRC has a statewide coverage of 5-Meter DEMs that were created from the imagery collected during the 2006 NAIP aerial photography flight. This data set consists of point elevations on a 5 meter grid. The HEC-RAS cross sections were augmented by more precise topographical information from EnergySolution's 2011 aerial survey performed by Aero-Graphics and their most recent run-on control berm survey. The general flow path and cross sections are shown on Figure 2. A Manning's n value of 0.05 was applied to all of the cross sections based on the sage/herbaceous cover (Chow, 1959).

During the analysis of the PMF with the HEC-RAS model (notably cross sections 250+00 to 280+00) it was discovered that a large portion of the PMF will spill over the railroad to the north. The topographic data in this area indicates that the railroad is almost at grade and that the land in this area slopes from southeast to northwest. The large flows that were diverted southwest



HANSEN ALLEN & LUCE INC ENGINEERS

ENERGYSOLUTIONS PMF ANALYSIS
HEC-RAS GENERAL FLOW PATH AND CROSS SECTIONS

FIGURE 2

along the railroad from the tributary areas to the east were therefore determined to be diverted out of the critical flow path and would no longer be tributary to Section 32. Based on input from EnergySolutions personnel the assumption was made that the diverted flows would not return south across the railroad until downstream of Section 32. Because of this, the tributary area and hydrology were revised as presented in the following sections.

FINAL STORM RUNOFF ANALSYIS

The tributary area for the PMF was revised based on the findings of the initial floodplain analysis. The tributary area for the 100-year storm runoff event did not change. The revised subbasin boundaries for the PMF analysis are shown on Figure 3 and include three subbasins. Subbasin hydrologic characteristics for the final PMF analysis were calculated using the same methodologies addressed in the Initial Storm Runoff Analysis section and are located in Table 8.

TABLE 8
HYDROLOGIC CHARACTERISTICS OF TRIBUTARY SUBBASINS FOR FINAL PMF

Subbasin	Area (square miles)	CN	Lag Times (hrs)
Cedar+Grass	3.2	73	1.84
Grassland	11.4	70	2.98
Sage/Herbaceous	2.0	78	3.05
Total Tributary Area	16.6		

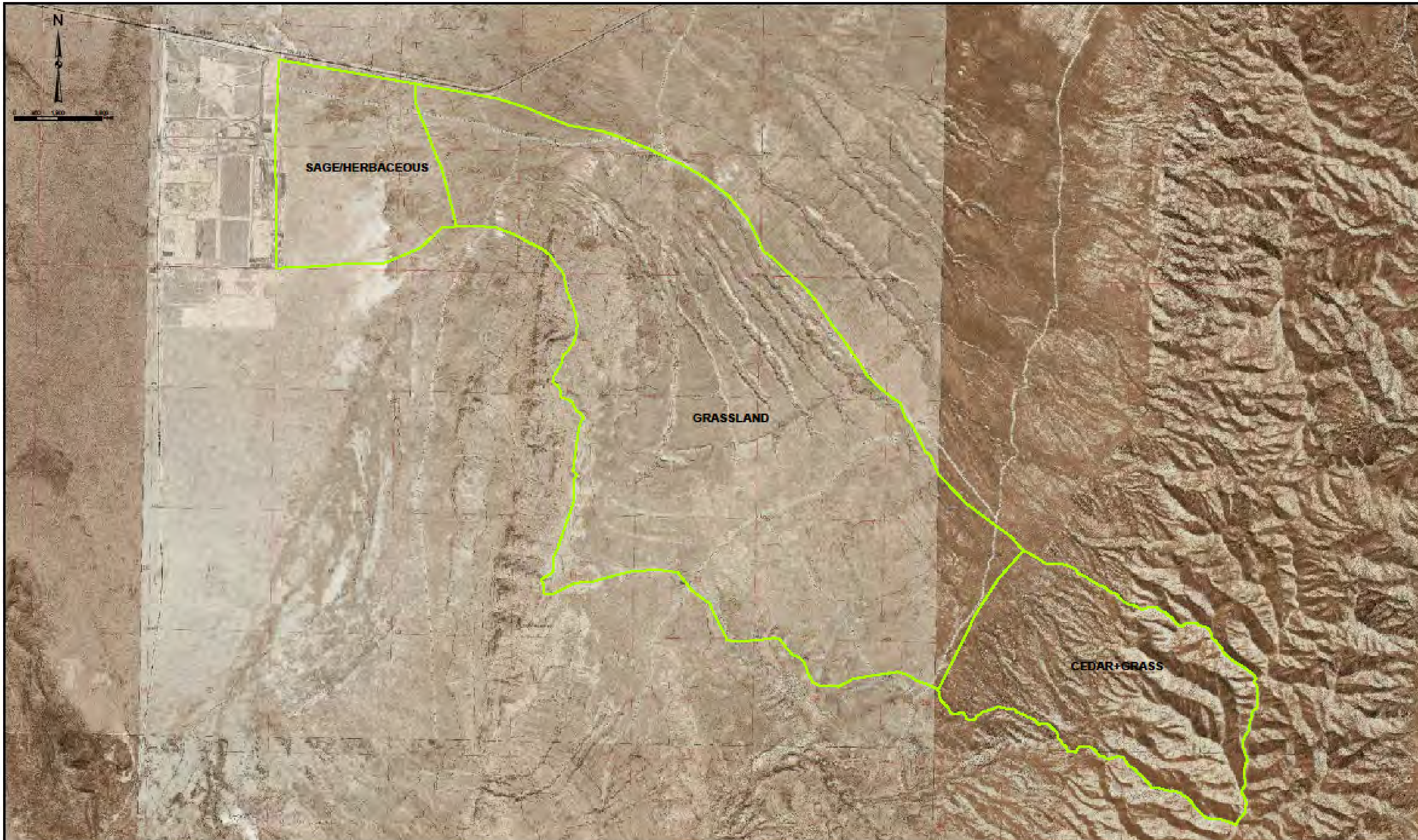
The predicted final peak PMF flow rate at the eastern edge of Section 32 is presented in Table 9. The 6-hour Local Storm PMF was previously determined to produce the highest flow rate and was therefore the only duration calculated for the final analysis.

TABLE 9
PREDICTED FINAL PMF PEAK FLOW RATE

Storm Event	Peak Flow (cfs)
Final PMF – Local Storm (6hr)	13,100

FINAL FLOODPLAIN ANALYSIS

The floodplain was modeled for the final analysis using the PMF peak flow rate of 13,100 cfs. The predicted PMF flood elevations in the area of Section 32 are summarized in Table 10. Flood depths within the flood plain between cross section 20+00 and 190+00 vary between 2 to 5 feet with flood flow velocities of less than 2 feet per second with a small portion between



HANSEN ALLEN & LUCE INC ENGINEERS

ENERGYSOLUTIONS PMF ANALYSIS

REVISED SUBBASIN DELINEATIONS FOR FINAL PMF ANALYSIS

FIGURE 3

90+00 and 110+00 being slightly above 4 feet per second (HEC-RAS output table in the Appendix).

TABLE 10
PREDICTED PMF FLOOD ELEVATIONS

Cross Section	PMF Flood Water Surface Elevation (feet)	Run-On Control Berm or Other Barrier Elevation (feet)
30+00	4266.4	4272.2
40+00	4266.6	4274.0
50+00	4266.8	4277.0
60+00	4267.0	4278.6
70+00	4267.4	4278.0
80+00	4267.7	4278.0
90+00	4268.8	4278.0
100+00	4272.9	4278.3
110+00	4277.7	4278.0
120+00	4279.2	**4278.8**
130+00	4280.0	4281.7
140+00	4281.5	**4281.0**
150+00	4282.7	4283.0
160+00	4283.1	**4277.9**
170+00	4283.4	4285.0
175+60	4283.6	4286.8
180+00	4284.0	4284.4 (RR Spur)
185+00	4284.6	4284.9 (RR Spur)
190+00	4285.4	4290.0 (RR Spur)

Bold indicates Run-on control berm elevation is below predicted PMF flood water elevation

REFERENCES

Bingham Environmental, Inc., 1996. PMF Project Memorandum.

Chow, Ven Te, 1959. Open-Channel Hydraulics. McGraw-Hill Book Company, New York.

Hanson, C. L., E. L. Neff, J. T. Doyle, and T. L. Gilbert, 1981. Runoff Curve Numbers for Northern Plains Rangelands. Journal of Soil and Water Conservation, September-October 1981.

Hansen, Allen & Luce, 1991. USPCI - Prediction of 100-Year Flood Plain Section 36 Township 1 South, Range 12 West. Hansen, Allen and Luce, Midvale, Utah.

Hood, J. W., and K. M. Waddell, 1968. Hydrologic Reconnaissance of Skull Valley, Tooele County, Utah. U.S. Geological Survey and Utah Department of Natural Resources. Salt Lake City, Utah.

Miller, J. F., R. H. Frederick, and R. J. Tracey, 1973. NOAA Atlas 2 - Precipitation-Frequency Atlas of the Western United States, Volume VI-Utah. U.S. Department of Commerce National Oceanic and Atmospheric Administration, National Weather Service. Washington D.C.

Robertson, Lee. 1990. Personal communication of survey data of Western Pacific Culverts and the Vitro Railroad Spur Dike. Schuchert and Associates, Salt Lake City Utah.

Simas, M.J. and R.H. Hawkins. 1998. Lag Time Characteristics for Small Watersheds in the U.S. International Water Resources Engineering Conference Procedures, Vol. 2, pp. 1290-1296. ASCE. Reston, VA.

Soil Conservation Service, 1972. SCS National Engineering Handbook Section 4 Hydrology, Washington, D.C.

Soil Conservation Service (SCS), 1986. Technical Release No. 55, Urban Hydrology for Small Watersheds. Washington, D.C.

U.S. Army Corps of Engineers, 2008. HEC-RAS River Analysis System Version 4.0. Hydrologic Engineering Center, Davis, California.

U.S. Army Corps of Engineers, 2010. Hydrologic Modeling System (HEC-HMS). Hydrologic Engineering Center, Davis, California.

U.S. Army Corps of Engineers, 1977. Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainages, Hydrometeorological Report No. 49. US Departement of Army Corps of Engineers, Silver Spring, Maryland.

U.S. Geological Survey, 1973. Aragonite NW, Utah; Aragonite, Utah; Hastings Pass, Utah; and Low, Utah Quadrangle Maps.

U.S. Geological Survey, 1987. Bonneville Salt Flats, Utah, 30 x 60 Minute Quadrangle Map.

Wilson, L., M. E. Olsen, T. B. Hutchings, A. R. Southard, and A. J. Erickson, 1975. Soils of Utah. Soil Conservation Service, Agricultural Experiment Station Bulletin 492, Logan, Utah.

APPENDIX

Contents:

Three different vegetation cover types have been defined for the Section 36 tributary area based on USGS Quad Maps and field reconnaissance.

Sage/Herbaceous Complex: Ground cover consists mainly of sagebrush, shadscale and salt tolerant grasses. Ground cover ranges from fair to poor. Wilson et. al. indicates that the soils of this portion of the drainage area consists of Typic Natrargids-Xerollic Natrargids-Typic Calciorthids Association with mostly Hydrologic Soil Type C and D. Field inspection indicates that the soil type in the vicinity of Section 36 is Type D. SCS Technical Release No. 55 Table 2-2d (see copy of table in Appendix A) with a soil type D indicates a curve number of 85 for poor soil cover and 70 for fair cover, therefore the representative curve number for the site based on the average of the curve numbers for the fair and poor soil cover conditions is about 78.

Grassland Complex: Principal ground cover consists of bluebunch wheatgrass with some big sagebrush, shadscale, other grasses, forbes and shrubs. Ground cover ranges from fair to good. Wilson et. al. indicates that the soils of this portion of the drainage area consists mostly of Xeric Torrifluvents-Xerollic Calciorthids Association with mostly Hydrologic Soil Type B. SCS Technical Release No. 55 Table 2-2d with a soil type B indicates a curve number of 71 for fair soil cover and 62 for good cover. Use a curve number of 70.

Cedar/Grassland Complex. Principal ground cover consists of cedars and grasses. Ground cover is fair. Wilson et. al. indicates that the soils of this portion of the drainage area consists of Xeric Calciorthids-Xeric Torrifluvents Association and Typic Argixerolls-Typic Haploxerolls Association consisting of Hydrologic Soil Types B and C. Field inspection reveals some small areas of rock outcrop. Therefore a soil type C is conservatively assumed (soil type C produces larger volumes of runoff than soil type D). SCS Technical Release No. 55 Table 2-2d with a soil type C indicates a curve number of 73 for fair soil cover.

Table 2-2d.—Runoff curve numbers for arid and semiarid rangelands[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type	Hydrologic condition[2]	A[3]	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

[1]Average runoff condition, and $I_a = 0.2S$. For range in humid regions, use table 2-2c.

[2]*Poor:* <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: >70% ground cover.

[3]Curve numbers for group A have been developed only for desert shrub.

Culvert Hydraulics;

based on available mapping and field inspection areas north of Aragonite RR road crossing will not contribute flow in a 100 year event to the flood plain at New Land. South of Aragonite there are 4 culverts (numbered 2, 3, 4, and 5 consecutively from Aragonite crossing south) which convey runoff flows under the Rail Road grade on to the north west and away from the New Land area. Survey work of these 4 culverts has been completed by Schuchert and Associates (Nove 1990).

Culvert No 2

36" RCP culvert w/ concrete head wall and bell inlet.

from survey Hw before spill to south =
4522.12 - 4517.91 = 4.2'

Based on field inspection, inlet conditions will control the culvert discharge.

Hydraulic Engineering Circular No. 5
U.S. D.O.T., 1965 (hereafter entitled HEC 5)
Chart 2 (see attached copy) indicates that
with $\frac{Hw}{D} = \frac{4.2}{3} = 1.4 \Rightarrow \underline{\underline{Q_{inlet} = 52\,cfs}}$

Detention at the inlet to culvert No 2 is negligible. For modeling purposes the 52cfs culvert No 2 capacity will be removed prior to modeling detention at culvert No 3

HA&L ENGINEERING		
CLIENT USPCI		SHEET 2 OF 8
PROJECT New Land		COMPUTED GWP
FEATURE Watershed Hydraulics		CHECKED
PROJECT NO.		DATE Nov 1990

Culvert No. 3

60" CMP culvert w/ concrete head wall
Hw max before spill = 5.8 feet.

CULVERT NO. 3
STAGE-DISCHARGE-DETENTION TABLE

STAGE (ft)	W.S. ELEV (ft)	AREA (acres)	DELTA CAPACITY (ac-ft)	SUMMATION CAPACITY (ac-ft)	HW/D	Q CULVERT (cfs)	Q SPILL (cfs)	TOTAL Q (cfs)
0	4483	0	0.00	0.00	0	0		0
2	4485	0.026	0.03	0.03	0.4	30		30
4	4487	0.183	0.21	0.24	0.8	90	0	90
6	4489	1.28	1.46	1.70	1.2	160	2.8	162.8
7	4490	1.93	1.61	3.30	1.4	190	77	267
8	4491	2.5	2.22	5.52	1.6	205	400	605

Q spill was computed assuming weir flow to the south along the railroad using the survey data of the high section south of the culvert

$Q = C L H^{3/2}$ $C = 3.0$ L = width of spill
H = average spill depth

Culvert No. 4

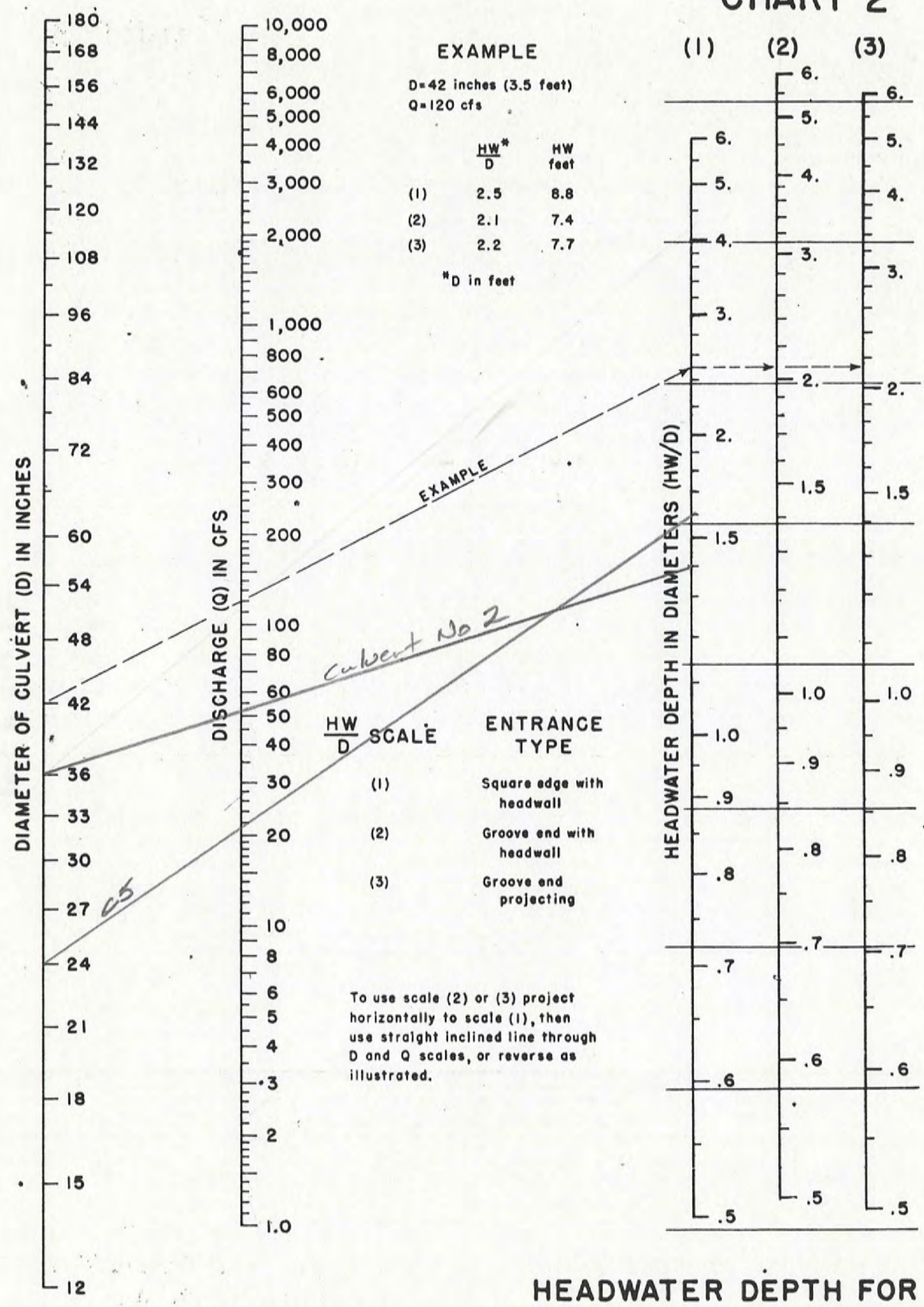
60" CMP culvert w/ concrete head wall
Hw max before spill = 5.3 feet.

CULVERT NO. 4
STAGE-DISCHARGE-DETENTION TABLE

STAGE (ft)	W.S. ELEV (ft)	AREA (acres)	DELTA CAPACITY (ac-ft)	SUMMATION CAPACITY (ac-ft)	HW/D	Q CULVERT (cfs)	Q SPILL (cfs)	TOTAL Q (cfs)
0	4461.1	0	0.00	0.00	0	0		0
0.9	4462	0.057	0.03	0.03	0.18	10		10
2.9	4464	0.297	0.35	0.38	0.58	52	0	52
5.3	4466.4	1.38	2.01	2.39	1.06	130	0	130
5.9	4467	2.19	1.07	3.46	1.18	152	15	167
6.9	4468	2.9	2.55	6.01	1.38	180	360	540

3/8

CHART 2



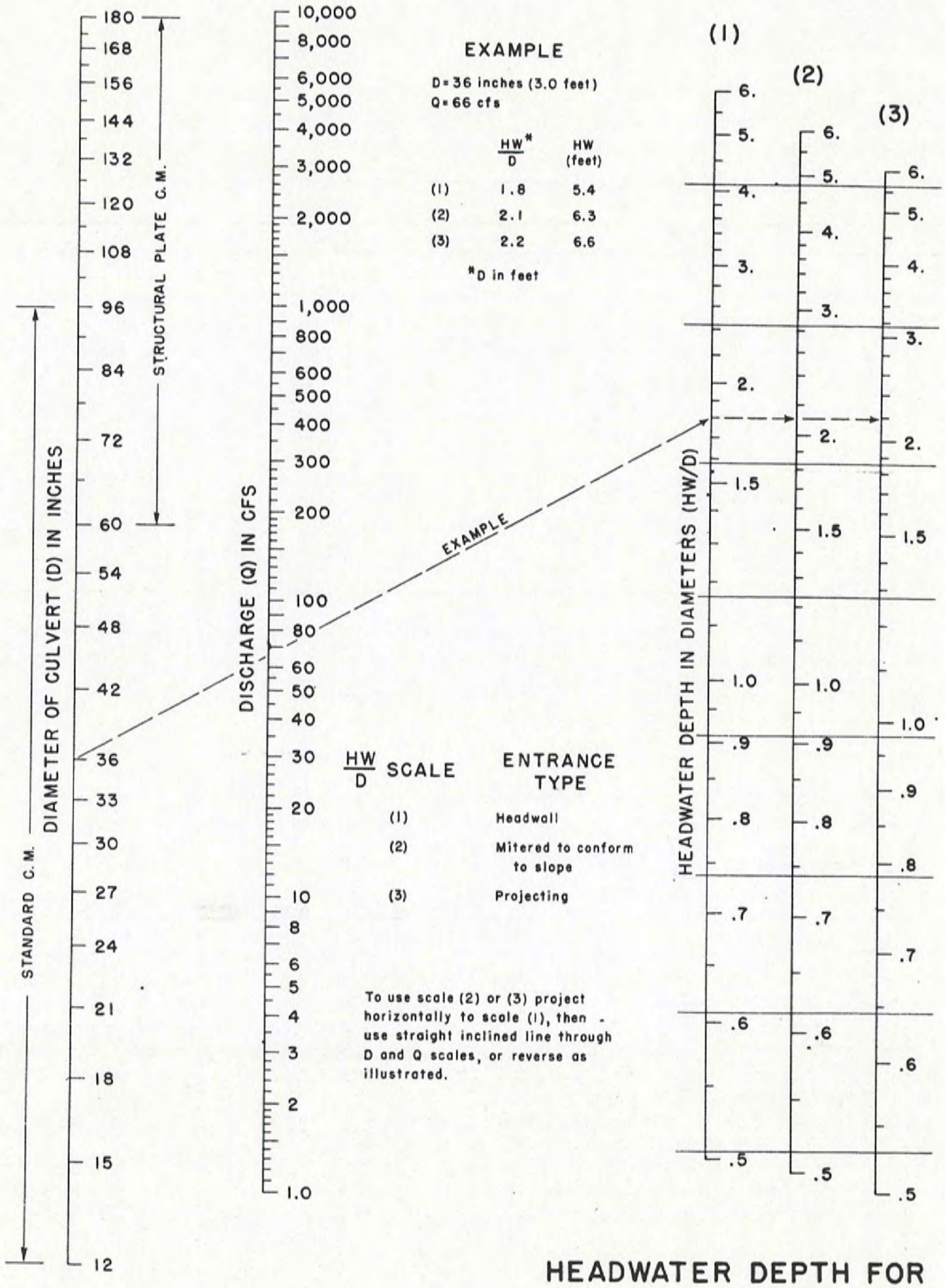
HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

HEADWATER SCALES 2&3
REVISED MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963

4/8

CHART 5



HEADWATER DEPTH FOR
C. M. PIPE CULVERTS
WITH INLET CONTROL

+ 10
BUREAU OF PUBLIC ROADS JAN. 1963

HA&L ENGINEERING	CLIENT USPCI	SHEET 5 OF 8
	PROJECT New Land	COMPUTED GIP
	FEATURE Watershed Hydraulics	CHECKED
	PROJECT NO. 64-	DATE Nov 90

Culvert No. 5.

24" RCP culvert w/ concrete head wall and bell inlet

H_w max = 4455.8 − 4452.65 = 3.15'

inlet control

$$\frac{H_w}{D} = \frac{3.15}{2} = 1.6$$

chart 2 ⇒ $\underline{Q_{inlet} = 21 \text{ cfs}}$

VITRO Railroad spur

Run off flows from subbasin sage/grass travel west along the Western Pacific Railroad until the RR spur dike constructed to serve the Vitro Uranium mine tailings containment site is encountered. The Vitro RR spur will divert low flows south along the spur. During high flood flows, the RR dike will be overtopped and flows will spill on to the west. Both flows that are diverted to the south and flows that spill to the west reach the New Land site (Section 36), however flows diverted to the south have a longer travel time.

Sheet 4 details a cross section surveyed normal to the Vitro RR dike at the lowest dike height where spill onto the west will occur in large flood events.

Capacity of the cross section before a spill takes place can be computed with Mannings equation:

$$Q = \frac{1.49}{n} A \left(\frac{A}{P}\right)^{2/3} \sqrt{S_f}$$

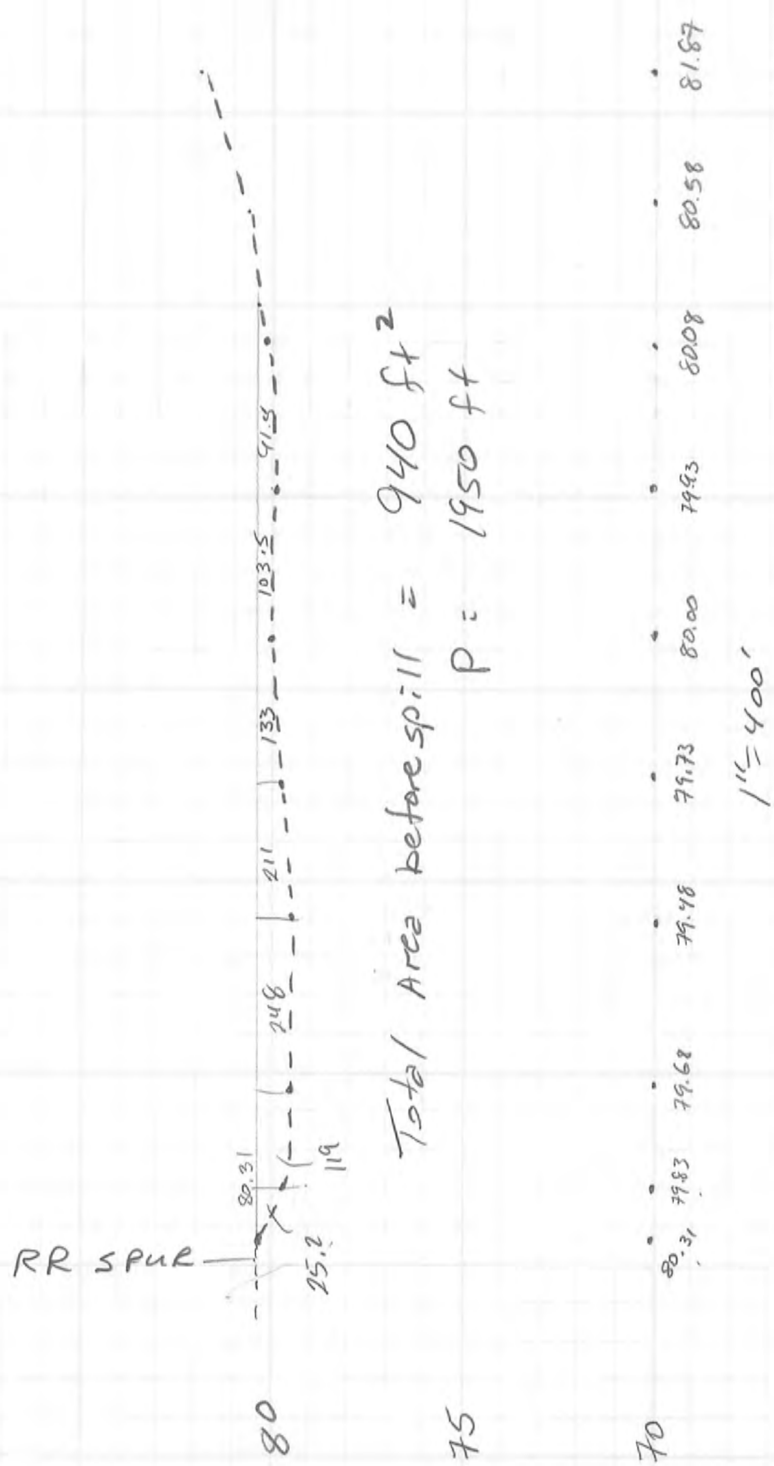
assume S_f = ground slope = 0.0006 ft/ft

$n = .04$ $A = 940 \text{ ft}^2$ $P = 1950$ ft

∴ Q = 530 cfs at spill elevation, therefore all flows 530 cfs and less will divert to south around Vitro facilities, thence on west to New Land site.

HA&L ENGINEERING	CLIENT USPCI PROJECT New Land FEATURE Watershed Hydraulics PROJECT NO. 64-
	SHEET 6 OF 8 COMPUTED GSP CHECKED DATE 11/13/90

Cross section of Vitro RR spur at lowest point.
Data from Survey by Schuchert and Associates.



HA&L ENGINEERING

CLIENT USPCI

PROJECT New Land

FEATURE Watershed Hydraulics

PROJECT NO. 64 -

SHEET 7 OF 8

COMPUTED GJP

CHECKED

DATE Nov 90

Vitro Railroad Spur (cont.)

The spill on to the west can be modeled as a broadcrested weir.

$Q = CLH^{3/2}$

$C = 3.0$

L = crest length ≈ 1000 feet.

H = head on weir = w.s. elev − 4280.3

As head increases flow both to the south and west increases.

∴ $Q_{west} = 3(1000')(\text{w.s. elev} - 4280.3)^{3/2}$

$Q_{south} = \frac{1.49}{n} A \left(\frac{A}{P}\right)^{2/3} \sqrt{S_f}$

assume $A = 940\,ft^2 + 1950\,(\text{w.s. elev} - 4280.3)$

$P = 1950'$

$S_f = .0006$ ft/ft

$n = .04$

VITRO RAILROAD DIKE FLOW DIVERSION

W.S. ELEV. (ft)	SPILL OVER DIKE TO WEST H (FT)	WEIR FLOW (cfs)	DIVERT TO SOUTH AREA (FT2)	MANNINGS (cfs)	TOTAL Q (cfs)
4280.3	0	0	940	527	527
4280.4	0.1	95	1135	722	817
4280.5	0.2	268	1330	940	1209
4280.6	0.3	493	1525	1181	1674
4280.7	0.4	759	1720	1443	2202
4280.8	0.5	1061	1915	1726	2787
4280.9	0.6	1394	2110	2029	3423
4281	0.7	1757	2305	2351	4108
4281.1	0.8	2147	2500	2692	4839
4281.2	0.9	2561	2695	3051	5612
4281.3	1	3000	2890	3428	6428
4281.4	1.1	3461	3085	3822	7283
4281.5	1.2	3944	3280	4233	8176
4281.6	1.3	4447	3475	4661	9107

HA&L ENGINEERING

CLIENT USPCI
PROJECT New Land
FEATURE Watershed Hydraulics
PROJECT NO. 64-

SHEET 8 OF 8
COMPUTED GJP
CHECKED
DATE Nov 90

Channel Routing:

Muskingum Routing Method

Routing from Subbasin Cedar/Grass to Vitro RR dikes spill point

Muskingum $X = 0.25$ for channel routing
reference "Applied Hydrology and Sedimentology for Disturbed Areas" by Barfield, Warner and Haan

Muskingum $K \cong$ channel flow time

2000 feet along RR @ .001 ft/ft

$V = \frac{1.49}{n} (1)^{2/3} \sqrt{.001} = 1.2 \text{ fps} = 0.46 \text{ hrs}$

4000 feet along Vitro Spur Dike

@ .0006 ≈ 1 fps — 1.11 hrs

Total reach K = 1.6 hrs

Routing of spill to west to New Land

$X = 0.25$
K: 8000 ft @ 1.2 fps — 1.9 hrs

Routing of diversion to south thence to New Land (sect. 36)

$X = 0.25$
K: 5000 ft @ 1 fps — 1.4 hrs
9000 ft @ 1.2 fps — 2.1 hrs

Total reach K = 3.5 hrs

From: SCS National Engineering Handbook Section 4 1/2

CHAPTER 7. HYDROLOGIC SOIL GROUPS

This chapter gives definitions of four soil groups that are used in determining hydrologic soil-cover complexes (chap. 9), which are used in a method for estimating runoff from rainfall (chap. 10). A table gives the group-classifications of more than 4,000 soils in the United States and Puerto Rico. Methods of making and using the classifications are briefly discussed.

Watershed-Soils Classification

Soil properties influence the process of generation of runoff from rainfall and they must be considered, even if only indirectly, in methods of runoff estimation. When runoff from individual storms is the major concern, as in flood prevention work, the properties can be represented by a hydrologic parameter: the minimum rate of infiltration obtained for a bare soil after prolonged wetting. The influences of both the surface and the horizons of a soil are thereby included. The influence of ground cover is treated independently, as discussed in chapters 8, 9, and 10.

The parameter, which indicates the runoff potential of a soil, is the qualitative basis of the classification in this chapter of all soils into four groups. The classification is broad but the groups can be divided into subgroups, as shown in example 7.1, whenever such a refinement is justified. Chapter 9 describes how the groups are given quantitative significance in the runoff-estimation method of chapter 10.

DEFINITIONS

In the definitions to follow, the infiltration rate is the rate at which water enters the soil at the surface and which is controlled by surface conditions, and the transmission rate is the rate at which the water moves in the soil and which is controlled by the horizons. The hydrologic soil groups, as defined by SCS soil scientists, are:

A. (Low runoff potential). Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission.

B. Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

C. Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

D. (High runoff potential). Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

The Soil List

The list at the end of this chapter contains the names of more than 4,000 soils in the United States and Puerto Rico. The capital letter following a name designates the hydrologic soil group classification.

The original classifications were based on the use of rainfall-runoff data from small watersheds or infiltrometer plots, but the majority are based on the judgments of soil scientists and correlators who used physical properties of the soil in making their decisions. They classified a soil in a particular group by comparing its profile with profiles of soils already classified. They assumed that the soil surfaces were bare, maximum swelling had taken place, and rainfall rates exceeded surface intake rates. Thus, most of the classifications are based on the premise that similar soils (similar in depth, organic-matter content, structure, and degree of swelling when saturated) will respond in an essentially similar manner during a rainstorm having excessive intensities.

The classification of a soil in the list can be checked by using the procedure of example 5.4. The soil in question must be the only one

-area relations for fixed areas. ıetworks for the determination the National Weather Service

ed entirely of recording gages. greatly increase the number work, but it involves the con- duces additional subjectivity. ous hours, usually early morn- ause of conflicting activities, a be able to read his precipita- In these cases, the exact time ble, so it is hard to relate the nding stations with the preci- th-area relations.

ord should be established to -yr areal precipitation.

res should remain consistent

that there is at least one gage area.

in this Atlas (fig. 14) are for n dense networks meeting the prepared for an earlier study nd have since been rechecked es were needed. Application of th the manner in which they are used:

a grid of many points over the l return period required.

point values obtained in step 1. areal reduction factor required ze of area under consideration. obtained in step 2 by the ratio ined in this step provides the st for the duration and return

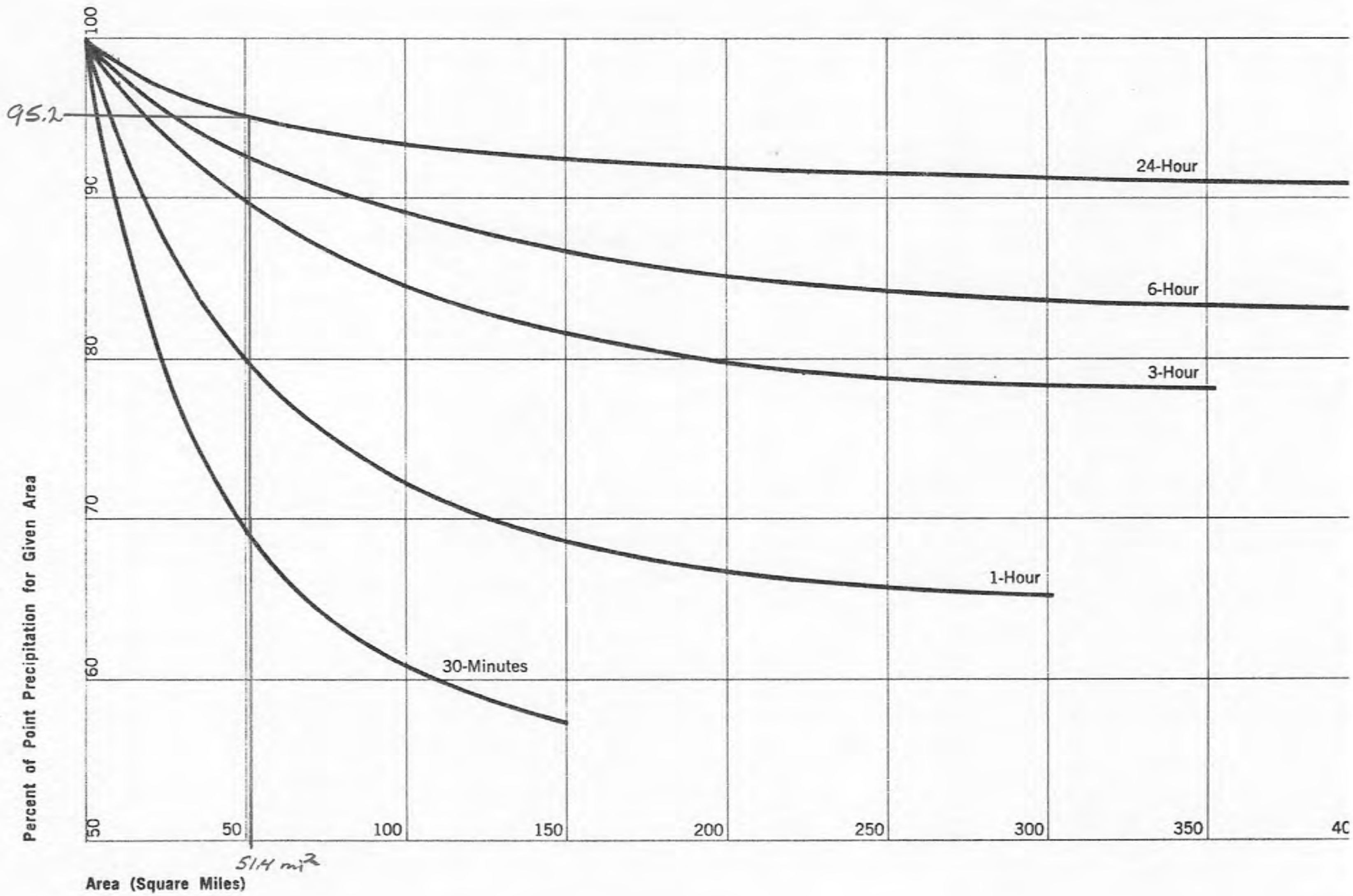


Figure 14. *Depth-Area curves.*

Reference: NOAA ATLAS 2 VOLUME VI UTAH

TABLE 5-6. VALUES OF THE ROUGHNESS COEFFICIENT n (*continued*)

Type of channel and description	Minimum	Normal	Maximum
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
1. Bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
2. Bottom: cobbles with large boulders	0.040	0.050	0.070
D-2. Flood plains			
a. Pasture, no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Dense willows, summer, straight	0.110	0.150	0.200
2. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
3. Same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. Same as above, but with flood stage reaching branches	0.100	0.120	0.160
D-3. Major streams (top width at flood stage >100 ft). The n value is less than that for minor streams of similar description, because banks offer less effective resistance.			
a. Regular section with no boulders or brush	0.025	.....	0.060
b. Irregular and rough section	0.035	.....	0.100

From "OPEN-CHANNEL HYDRAULICS" CHOW 1959

EnergySolutions-Clive Facility
Initial PMF Analysis Lag Time Calculations
Computed: GLJ
4/3/2012

Regression Equation **$Lag = 0.0051 \times width^{.594} \times slope^{-.15} \times S_{nat}^{.313}$**

from Simas and Hawkins "Lag Time Characteristics for Small Watersheds in the U.S."

Where: **Width = Watershed Area / Watershed Length**

Slope = Maximum Elevation Difference / Longest Flow Path

S_{nat} = 1000/CN - 10

Subbasin Name	Area (ft^2)	Watershed Length (ft)	CN	S_{nat}	Width	Max Elev Difference (ft)	Slope	Lag Time (hours)
C2&3	248,117,760	19,200	71.0	4.08	12922.80	1877	0.0978	3.11
C4&5	16,727,040	12,100	70.0	4.29	1382.40	268	0.0221	1.05
Cedar/Grass+Grassland	992,471,040	55,200	71.0	4.08	17979.55	2190	0.0397	4.33
Sage/Herbaceous	106,024,729	10,560	78.0	2.82	10040.22	71	0.0067	3.56

Lag Time (minutes)
186
63
260
214

EnergySolutions-Clive Facility
Final PMF Analysis Lag Time Calculations
Computed: GLJ
4/16/2012

Regression Equation **$Lag = 0.0051 \times width^{.594} \times slope^{-.15} \times S_{nat}^{.313}$**

from Simas and Hawkins "Lag Time Characteristics for Small Watersheds in the U.S."

Where: Width = Watershed Area / Watershed Length
Slope = Maximum Elevation Difference / Longest Flow Path
S_{nat} = 1000/CN - 10

Subbasin Name	Area (ft^2)	Watershed Length (ft)	CN	S_{nat}	Width	Max Elev Difference (ft)	Slope	Lag Time (hours)	Lag Time (minutes)
Cedar/Grass	89,059,290	15,750	73.0	3.70	5654.56	1581	0.1004	1.84	110
Grassland	317,087,892	36,120	70.0	4.29	8778.73	1128	0.0312	2.98	179
Sage/Herbaceous	56,721,071	8,000	78.0	2.82	7090.13	38	0.0048	3.05	183

Table 6.3A.--Local-storm PMP computation, Colorado River, Great Basin and California drainages. For drainage average depth PMP. Go to table 6.3B if areal variation is required.

Drainage Energy Solutions Area 48.9 mi^2 ($\cancel{km^2}$)
Latitude 40.69° Longitude -113.11° Minimum Elevation 4290 ft ($\cancel{m}$)

Steps correspond to those in sec. 6.3A.

1. Average 1-hr 1-mi^2 (2.6-km^2) PMP for drainage [fig. 4.5]. 9.9 in. ($\cancel{mm}$)

2. a. Reduction for elevation. [No adjustment for elevations up to 5,000 feet (1,524 m): 5% decrease per 1,000 feet (305 m) above 5,000 feet (1,524 m)]. 100 %

   b. Multiply step 1 by step 2a. 9.9 in. ($\cancel{mm}$)

3. Average 6/1-hr ratio for drainage [fig. 4.7]. 1.38

	Duration (hr) 1/4	1/2	3/4	1	2	3	4	5	6	
4. Durational variation for 6/1-hr ratio of step 3 [table 4.4].	63	83	93	100	118	126	132	137	140	%
5. 1-mi^2 (2.6-km^2) PMP for indicated durations [step 2b X step 4].	6.2	8.2	9.2	9.9	11.7	12.5	13.1	13.6	13.9	in. ($\cancel{mm}$)
6. Areal reduction [fig. 4.9].	47	54	58	62	66	68	70	71	73	%
7. Areal reduced PMP [steps 5 X 6].	2.9	4.4	5.3	6.1	7.7	8.5	9.2	9.7	10.1	in. ($\cancel{mm}$)

8. Incremental PMP [successive subtraction in step 7].

1	2	3	4	5	6	
6.1	1.6	0.8	0.7	0.5	0.4	in. ($\cancel{mm}$)

2.9	1.5	0.9	0.8	} 15-min. increments
1	2	3	4	

9. Time sequence of incremental PMP according to:

   Hourly increments [table 4.7]. 0.5 0.8 6.1 1.6 0.7 0.4 in. ($\cancel{mm}$)

   Four largest 15-min. increments [table 4.8]. 2.9 1.5 0.9 0.8 in. ($\cancel{mm}$)

```
Basin: Basin 1
     Description: Initial PMF Analysis - (SECT. 32)
     Last Modified Date: 17 April 2012
     Last Modified Time: 00:10:01
     Version: 3.5
     Filepath Separator: \
     Unit System: English
     Missing Flow To Zero: No
     Enable Flow Ratio: No
     Allow Blending: No
     Compute Local Flow At Junctions: No

     Enable Sediment Routing: No

     Enable Quality Routing: No
End:

Subbasin: CEDAR+GR
     Canvas X: 672.134715827343
     Canvas Y: 727.641307317456
     Area: 35.6
     Downstream: Junction-1

     Canopy: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 71

     Transform: SCS
     Lag: 260
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Subbasin: C-2&3
     Canvas X: 668.0572772680399
     Canvas Y: 1170.9865099556926
     Area: 8.9
     Downstream: C2

     Canopy: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 71

     Transform: SCS
     Lag: 186
```

```
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Diversion: C2
     Canvas X: 378.0811702435228
     Canvas Y: 1177.643427554765
     Downstream: DET3

     Diverter: Inflow-Diversion Table
     Inflow Diversion Table Name: C2(Basin 1)
     End Diverter:
End:

Reservoir: DET3
     Canvas X: 355.3229894362282
     Canvas Y: 1116.1963393750696
     Downstream: C3

     Route: Modified Puls
     Routing Curve: Storage-Elevation-Outflow
     Initial Elevation: 4483
     Storage-Outflow Table: DET3(Basin 1)
     Elevation-Storage Table: DET3(Basin 1)
     Primary Table: Storage-Outflow
End:

Diversion: C3
     Canvas X: 339.39226287112206
     Canvas Y: 1059.3008873568333
     Downstream: COMBINE

     Diverter: Inflow-Diversion Table
     Inflow Diversion Table Name: C3(Basin 1)
     End Diverter:
End:

Subbasin: C-4&5
     Canvas X: 676.2133388190816
     Canvas Y: 979.6472545313022
     Area: 0.6
     Downstream: COMBINE

     Canopy: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 70

     Transform: SCS
     Lag: 63
```

```
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: COMBINE
     Canvas X: 332.56480862893363
     Canvas Y: 1016.0603438229734
     Downstream: DET4
End:

Reservoir: DET4
     Canvas X: 312.0824459023686
     Canvas Y: 954.6132556432782
     Downstream: C4

     Route: Modified Puls
     Routing Curve: Storage-Elevation-Outflow
     Initial Elevation: 4461.1
     Storage-Outflow Table: DET4(Basin 1)
     Elevation-Storage Table: DET4(Basin 1)
     Primary Table: Storage-Outflow
End:

Diversion: C4
     Canvas X: 255.1869938841321
     Canvas Y: 890.8903493828534
     Downstream: C5

     Diverter: Inflow-Diversion Table
     Inflow Diversion Table Name: C4(Basin 1)
     End Diverter:
End:

Diversion: C5
     Canvas X: 196.0157237851663
     Canvas Y: 831.7190792838875
     Downstream: ROUTE

     Diverter: Inflow-Diversion Table
     Inflow Diversion Table Name: C5(Basin 1)
     End Diverter:
End:

Reach: ROUTE
     Canvas X: 148.22354408984768
     Canvas Y: 715.6523571666852
     From Canvas X: 196.0157237851663
     From Canvas Y: 831.7190792838875
     Downstream: Junction-1

     Route: Muskingum
     Muskingum K: 2.1
     Muskingum X: 0.25
```

```
     Muskingum Steps: 20
     Channel Loss: None
End:

Junction: Junction-1
     Canvas X: 148.22354408984768
     Canvas Y: 715.6523571666852
     Downstream: Reach-1
End:

Reach: Reach-1
     Canvas X: 116.36209095963534
     Canvas Y: 610.9647254531302
     From Canvas X: 148.22354408984768
     From Canvas Y: 715.6523571666852
     Downstream: Reach-2

     Route: Muskingum
     Muskingum K: 1.6
     Muskingum X: 0.25
     Muskingum Steps: 20
     Channel Loss: None
End:

Reach: Reach-2
     Canvas X: 89.05227399088187
     Canvas Y: 440.278369398421
     From Canvas X: 116.36209095963534
     From Canvas Y: 610.9647254531302
     Downstream: Junction-3

     Route: Muskingum
     Muskingum K: 1.9
     Muskingum X: 0.25
     Muskingum Steps: 20
     Channel Loss: None
End:

Junction: Junction-3
     Canvas X: 89.05227399088187
     Canvas Y: 440.278369398421
     Downstream: East
End:

Subbasin: SAGE/GRA
     Canvas X: 364.4262617591462
     Canvas Y: 362.90055465361945
     Area: 3.8
     Downstream: East

     Canopy: None

     Surface: None
```

```
     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 78

     Transform: SCS
     Lag: 214
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: East
     Canvas X: 104.1031739783864
     Canvas Y: 381.2478715518713
End:

Basin Schematic Properties:
     Last View N: 1191.2983360391418
     Last View S: 219.52401556766358
     Last View W: -181.77007761592347
     Last View E: 676.2133388190816
     Maximum View N: 1191.2983360391418
     Maximum View S: 219.52401556766358
     Maximum View W: -181.77007761592347
     Maximum View E: 676.2133388190816
     Extent Method: Elements
     Buffer: 0
     Draw Icons: Yes
     Draw Icon Labels: Yes
     Draw Map Objects: No
     Draw Gridlines: No
     Draw Flow Direction: No
     Fix Element Locations: No
     Fix Hydrologic Order: No
End:
```

```
Basin: Basin 1
     Description: Final PMF Analysis - (SECT. 32)
     Last Modified Date: 17 April 2012
     Last Modified Time: 00:03:43
     Version: 3.5
     Filepath Separator: \
     Unit System: English
     Missing Flow To Zero: No
     Enable Flow Ratio: No
     Allow Blending: No
     Compute Local Flow At Junctions: No

     Enable Sediment Routing: No

     Enable Quality Routing: No
End:

Subbasin: GRASSLAND
     Canvas X: 672.134715827343
     Canvas Y: 727.641307317456
     Area: 11.4
     Downstream: Junction-1

     Canopy: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 70

     Transform: SCS
     Lag: 179
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Subbasin: CEDAR+GRASS
     Canvas X: 676.2133388190816
     Canvas Y: 979.6472545313022
     Area: 3.2
     Downstream: Junction-1

     Canopy: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 73

     Transform: SCS
     Lag: 110
```

```
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: Junction-1
     Canvas X: 148.22354408984768
     Canvas Y: 715.6523571666852
     Downstream: Reach-1
End:

Reach: Reach-1
     Canvas X: 116.36209095963534
     Canvas Y: 610.9647254531302
     From Canvas X: 148.22354408984768
     From Canvas Y: 715.6523571666852
     Downstream: Reach-2

     Route: Muskingum
     Muskingum K: 1.6
     Muskingum X: 0.25
     Muskingum Steps: 20
     Channel Loss: None
End:

Reach: Reach-2
     Canvas X: 89.05227399088187
     Canvas Y: 440.278369398421
     From Canvas X: 116.36209095963534
     From Canvas Y: 610.9647254531302
     Downstream: Junction-3

     Route: Muskingum
     Muskingum K: 1.9
     Muskingum X: 0.25
     Muskingum Steps: 20
     Channel Loss: None
End:

Junction: Junction-3
     Canvas X: 89.05227399088187
     Canvas Y: 440.278369398421
     Downstream: East
End:

Subbasin: SAGE/GRA
     Canvas X: 373.8814647131047
     Canvas Y: 359.78010305839246
     Area: 2.0
     Downstream: East

     Canopy: None

     Surface: None
```

```
     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 78

     Transform: SCS
     Lag: 183
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: East
     Canvas X: 109.1123199601983
     Canvas Y: 386.97260981679904
End:

Basin Schematic Properties:
     Last View N: 1191.2983360391418
     Last View S: 219.52401556766358
     Last View W: -181.77007761592347
     Last View E: 676.2133388190816
     Maximum View N: 1191.2983360391418
     Maximum View S: 219.52401556766358
     Maximum View W: -181.77007761592347
     Maximum View E: 676.2133388190816
     Extent Method: Elements
     Buffer: 0
     Draw Icons: Yes
     Draw Icon Labels: Yes
     Draw Map Objects: No
     Draw Gridlines: No
     Draw Flow Direction: No
     Fix Element Locations: No
     Fix Hydrologic Order: No
End:
```

HEC-RAS Plan: Plan 01 River: HEC RAS Reach: HEC RAS Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
HEC RAS	28000	PF 1	13118.00	4389.88	4396.60	4395.54	4397.37	0.010183	7.03	1866.34	513.33	0.65
HEC RAS	27000	PF 1	13118.00	4377.37	4382.98	4382.55	4384.00	0.018208	8.10	1619.21	559.32	0.84
HEC RAS	26000	PF 1	13118.00	4363.43	4372.65		4373.25	0.006953	6.25	2098.33	516.66	0.55
HEC RAS	25000	PF 1	13118.00	4350.51	4358.89	4358.89	4359.51	0.038875	6.32	2075.30	1843.01	1.05
HEC RAS	24000	PF 1	13118.00	4317.82	4335.28		4335.38	0.002696	2.49	5266.81	6717.60	0.31
HEC RAS	23000	PF 1	13118.00	4312.91	4328.44	4328.27	4329.11	0.026662	6.59	1991.88	6099.46	0.92
HEC RAS	22393.68	PF 1	13118.00	4308.41	4321.00	4320.39	4321.13	0.007590	2.87	4576.54	8752.62	0.47
HEC RAS	22000	PF 1	13118.00	4307.23	4314.94	4314.94	4315.35	0.038838	5.17	2539.73	7173.23	1.00
HEC RAS	21000	PF 1	13118.00	4299.62	4303.79	4302.61	4303.93	0.004764	3.05	4300.81	4614.89	0.40
HEC RAS	20000	PF 1	13118.00	4290.12	4293.07	4293.07	4293.60	0.036634	5.81	2258.10	2187.37	1.01
HEC RAS	19000	PF 1	13118.00	4280.78	4285.39		4285.49	0.003394	2.61	5020.14	4179.92	0.34
HEC RAS	18500	PF 1	13118.00	4281.29	4284.55		4284.60	0.001062	1.77	7428.87	4408.67	0.20
HEC RAS	18000	PF 1	13118.00	4278.27	4284.02		4284.07	0.001066	1.65	7973.21	4895.75	0.20
HEC RAS	17560	PF 1	13118.00	4276.00	4283.62		4283.66	0.000808	1.63	8049.63	5080.66	0.18
HEC RAS	17000	PF 1	13118.00	4269.44	4283.37		4283.39	0.000302	1.12	11724.47	4281.71	0.11
HEC RAS	16000	PF 1	13118.00	4268.00	4283.13		4283.15	0.000202	0.97	13488.45	4282.30	0.09
HEC RAS	15000	PF 1	13118.00	4275.83	4282.69		4282.74	0.001152	1.77	7416.14	3417.38	0.20
HEC RAS	14000	PF 1	13118.00	4275.95	4281.54		4281.58	0.001165	1.57	8358.46	4338.71	0.20
HEC RAS	13000	PF 1	13118.00	4275.00	4279.96		4280.03	0.002161	2.05	6411.48	3662.79	0.27
HEC RAS	12000	PF 1	13118.00	4270.00	4279.20		4279.22	0.000411	1.22	10764.36	3733.89	0.13
HEC RAS	11000	PF 1	13118.00	4273.27	4277.72	4277.36	4277.98	0.015092	4.14	3172.07	2629.55	0.66
HEC RAS	10000	PF 1	13118.00	4266.00	4272.89		4273.15	0.002346	4.06	3228.96	678.51	0.33
HEC RAS	9000	PF 1	13118.00	4264.40	4268.82		4269.15	0.008205	4.66	2814.95	1230.98	0.54
HEC RAS	8000	PF 1	13118.00	4259.27	4267.70		4267.74	0.000515	1.61	8167.49	2218.11	0.15
HEC RAS	7000	PF 1	13118.00	4256.66	4267.35		4267.37	0.000279	0.94	13899.85	5287.66	0.10
HEC RAS	6000	PF 1	13118.00	4259.31	4267.03		4267.05	0.000370	0.99	13315.46	5880.38	0.12
HEC RAS	5000	PF 1	13118.00	4257.53	4266.75		4266.77	0.000218	0.84	15706.60	5981.33	0.09
HEC RAS	4000	PF 1	13118.00	4257.66	4266.57		4266.58	0.000166	0.73	17880.89	6721.08	0.08
HEC RAS	3000	PF 1	13118.00	4255.98	4266.43		4266.44	0.000114	0.64	20556.83	7223.00	0.07
HEC RAS	2000	PF 1	13118.00	4260.05	4266.14		4266.17	0.001234	1.35	9737.92	6640.73	0.20
HEC RAS	1000	PF 1	13118.00	4255.55	4264.28	4262.85	4264.34	0.003002	1.94	6758.83	5184.05	0.30

APPENDIX H

Cover/Liner Construction Estimates

TOP SLOPE AREA (SURFACE LAYER):

LWPOLYLINE Layer: "DRAW"
Space: Model space
Color: 3 (green) Linetype: "DASHED"
Linetype scaling = 0.2000
Handle = 9a099
Closed
Constant width 0.0000
area 4109366.9621
perimeter 8132.0798

at point X=10554.8421 Y=13651.9487 Z=4265.0000
at point X=10534.5085 Y=12441.7378 Z=4265.0000
at point X=12413.6303 Y=12403.3513 Z=4265.0000
at point X=12433.8208 Y=13610.7212 Z=4265.0000
at point X=12433.9562 Y=13867.3151 Z=4265.0000
at point X=12447.4593 Y=14591.4044 Z=4265.0000
at point X=10571.9323 Y=14629.7174 Z=4265.0000

SIDE SLOPE AREA (SURFACE LAYER):

LWPOLYLINE Layer: "DRAW"
Space: Model space
Color: 3 (green) Linetype: "DASHED"
Linetype scaling = 0.2000
Handle = 9a161
Closed
Constant width 0.0000
area 5581839.0840
perimeter 9470.6951

at point X=12601.2554 Y=13865.7112 Z=4265.0000
at point X=12617.8440 Y=14755.2587 Z=4265.0000
at point X=10407.5902 Y=14800.4095 Z=4265.0000
at point X=10387.5665 Y=13654.8097 Z=4265.0000
at point X=10364.4317 Y=12277.8772 Z=4265.0000
at point X=12578.0992 Y=12232.6567 Z=4265.0000
at point X=12601.1201 Y=13609.2784 Z=4265.0000

FULL COVER SECTION AREA:

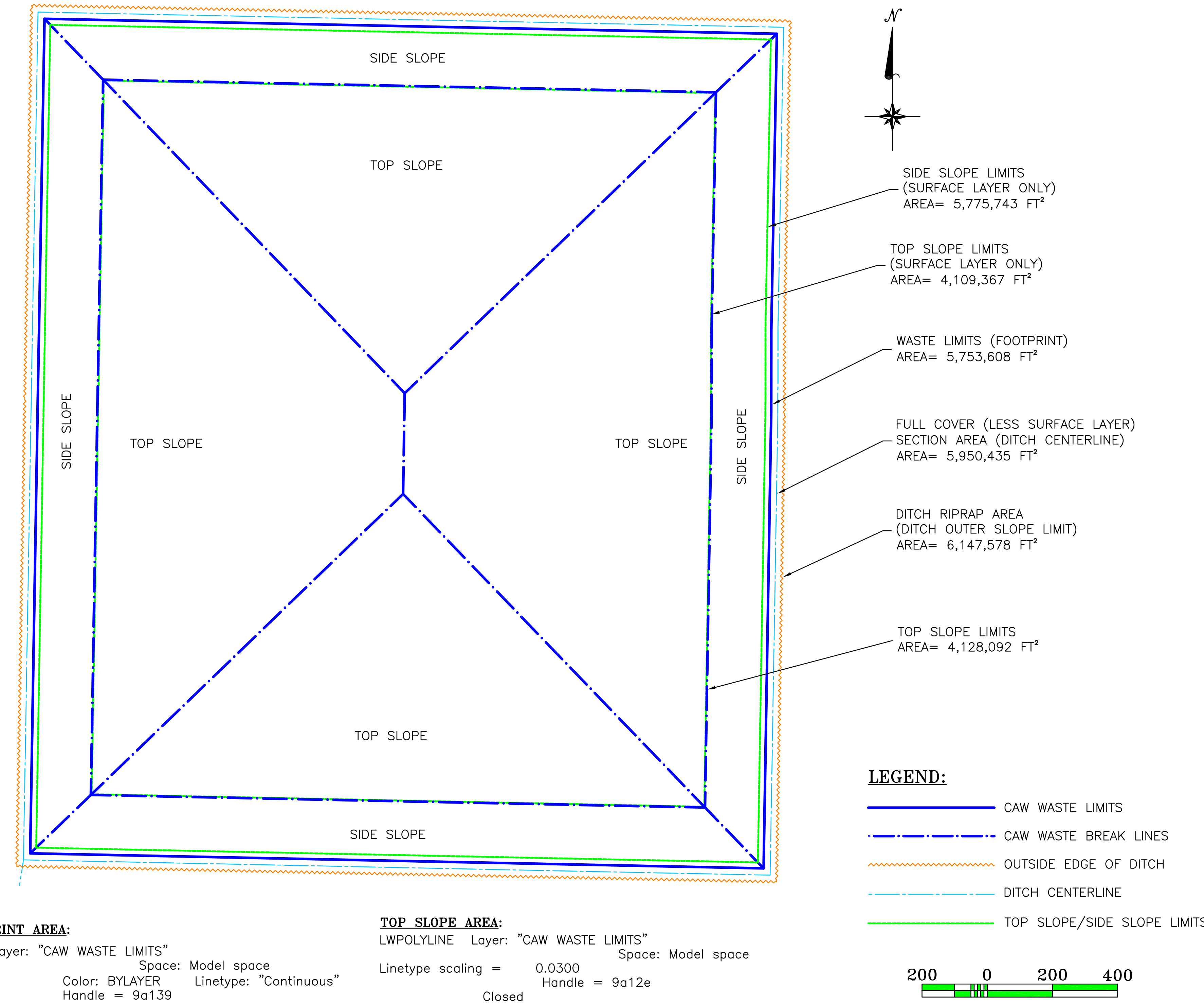
LWPOLYLINE Layer: "CAW DITCH CL"
Space: Model space
Linetype scaling = 0.3750
Handle = 99d79
Closed
Constant width 0.0000
area 5950435.2064
perimeter 9777.1444

at point X=10349.2722 Y=13655.4670 Z=4265.0000
at point X=10325.4961 Y=12240.3645 Z=4265.0000
at point X=12615.7511 Y=12193.5796 Z=4265.0000
at point X=12639.4199 Y=13608.9480 Z=4265.0000
at point X=12639.5552 Y=13865.3440 Z=4265.0000
at point X=12656.8502 Y=14792.7699 Z=4265.0000
at point X=10369.9674 Y=14839.4860 Z=4265.0000
at point X=10349.2723 Y=13655.4774 Z=4265.0000
bulge 0.0002
center X=10364.5700 Y=13655.2100 Z=4265.0000
radius 15.3000
start angle 179d

DITCH OUTER SLOPE AREA:

LWPOLYLINE Layer: "DITCH OUTER LIMITS"
Space: Model space
Linetype scaling = 0.1000
Handle = 9a098
Closed
Constant width 0.0000
area 6147578.3510
perimeter 9937.1701

at point X=10329.2750 Y=13655.8030 Z=4265.0000
at point X=10305.1641 Y=12220.7757 Z=4265.0000
at point X=12635.4126 Y=12173.1737 Z=4265.0000
at point X=12659.4198 Y=13608.7756 Z=4265.0000
at point X=12659.5551 Y=13865.1522 Z=4265.0000
at point X=12677.2190 Y=14812.3580 Z=4265.0000
at point X=10350.3210 Y=14859.8915 Z=4265.0000
at point X=10329.2754 Y=13655.8269 Z=4265.0000
bulge 0.0002
center X=10364.5700 Y=13655.2100 Z=4265.0000
radius 35.3000
start angle 179d



WASTE FOOTPRINT AREA:

LWPOLYLINE Layer: "CAW WASTE LIMITS"
Space: Model space
Color: BYLAYER Linetype: "Continuous"
Handle = 9a139
Closed
Constant width 0.0000
area 5753607.8010
perimeter 9614.7182

at point X=12619.2553 Y=13865.5386 Z=4265.0000
at point X=12636.1759 Y=14772.8880 Z=4265.0000
at point X=10389.9085 Y=14818.7744 Z=4265.0000
at point X=10369.5693 Y=13655.1243 Z=4265.0000
at point X=10346.1330 Y=12260.2472 Z=4265.0000
at point X=12595.7946 Y=12214.2915 Z=4265.0000
at point X=12619.1200 Y=13609.1231 Z=4265.0000

TOP SLOPE AREA:

LWPOLYLINE Layer: "CAW WASTE LIMITS"
Space: Model space
Linetype scaling = 0.0300
Handle = 9a12e
Closed
Constant width 0.0000
area 4128091.9090
perimeter 8150.4828

at point X=10552.5424 Y=13651.9881 Z=4265.0000
at point X=10532.1703 Y=12439.4850 Z=4265.0000
at point X=12415.8914 Y=12401.0047 Z=4265.0000
at point X=12436.1208 Y=13610.7014 Z=4265.0000
at point X=12436.2562 Y=13867.2930 Z=4265.0000
at point X=12449.8017 Y=14593.6571 Z=4265.0000
at point X=10569.6730 Y=14632.0641 Z=4265.0000

DATE | BY | DESCRIPTION OF CHANGE

ENERGYSOLUTIONS

ENERGYSOLUTIONS "CLIVE" FACILITY
CLASS A WEST EMBANKMENT-ET COVER REVISION
COVER MATERIAL AREAS
CLIVE, UTAH

DRAFTED BY: D. BOOTH
REVIEWED BY:
APPROVED BY: D. BOOTH
SCALE: AS NOTED DATE: 10/22/12 REV.:
DRAWING NO.

APPENDIX I

SWCA Biota Study

SWCA®
ENVIRONMENTAL CONSULTANTS
Sound Science. Creative Solutions.®

Field Sampling of Biotic Turbation of Soils at the Clive Site, Tooele County, Utah

Prepared for

EnergySolutions

Prepared by

SWCA Environmental Consultants

January 2011

FIELD SAMPLING OF BIOTIC TURBATION OF SOILS AT THE CLIVE SITE, TOOELE COUNTY, UTAH

Prepared for

EnergySolutions
423 West 300 South
Suite 200
Salt Lake City, Utah 84101

Prepared by

Hope Hornbeck, Bridget Crokus, Eleanor Gladding, Amanda Childs

SWCA Environmental Consultants
257 East 200 South
Suite 200
Salt Lake City, Utah 84111

January 12, 2010

CONTENTS

APPENDICES

FIGURES

TABLES

MAPS

1 INTRODUCTION

EnergySolutions operates a mixed-waste nuclear disposal facility at their Clive Site in Clive, Utah on privately-owned lands. Nuclear waste emits radiation for thousands of years. Over the course of time entire landscapes may change due to biologic, climatic, and geologic shifts. Because site conditions may radically change before nuclear waste is entirely depleted, careful consideration must be given to projections of future site conditions.

Waste products at the Clive Site are buried in an impermeable clay layer and covered with concrete. Small amounts of radiation may be absorbed by surrounding soils. Soil turbation (mixing) by plants and animals is a potentially important pathway through which buried waste can be transported to the soil surface or to different layers of the subsurface soil profile. Studies indicate that ants, burrowing mammals, and deeply rooted plants are the primary biota of interest for movement and mixing of soils in arid ecosystems. Ants and burrowing mammals provide constant mixing of the soil column, whereas plants can move buried wastes through root uptake and translocation of contaminants to various parts of the plant.

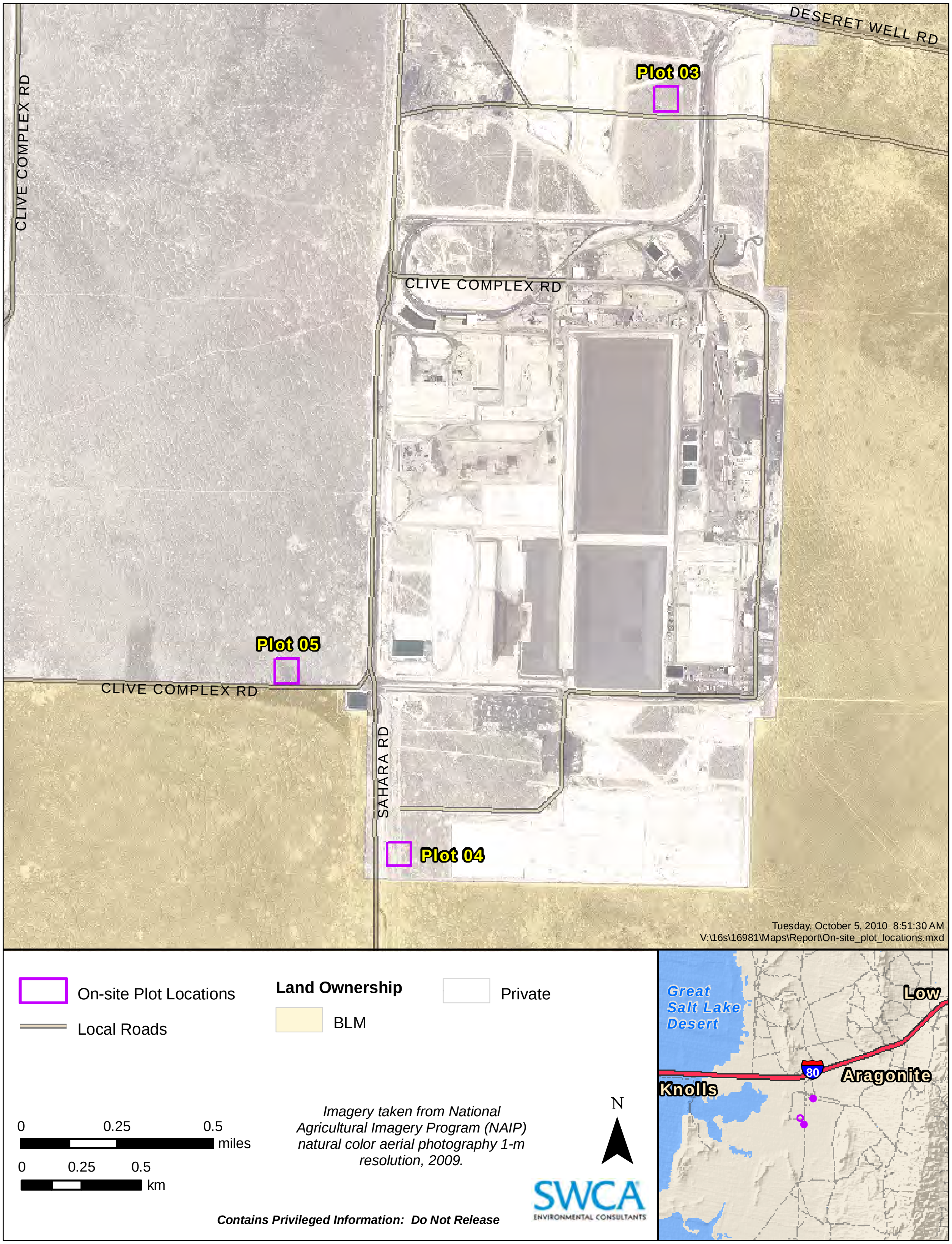
SWCA Environmental Consultants (SWCA) was contracted by Energy*Solutions* to gather soil turbation data at five sites in and around the Clive Site. Sites were established in three locations at the Clive Site, and two locations off the Clive site on lands administered by the Bureau of Land Management (BLM).

SWCA's field sampling objectives were to 1) identify ant species present and nest density of each species, and quantify surface features of each nest; 2) identify plant species present and estimate the percent cover and stem densities of grasses, forbs, shrubs, and trees in each vegetative association; and 3) identify burrowing mammal species present and density of mammal burrows in each vegetative association, and quantify volume of soil excavated at each mammal burrow. In addition to the field sampling objectives, site excavations were conducted at six locations in two field plots (Plot 3 and Plot 4) located on the Clive Site. The objective of the site excavations was to measure the aboveground and belowground biomass of dominant plant species, and to determine the maximum rooting depth and width of root masses for dominant plant species.

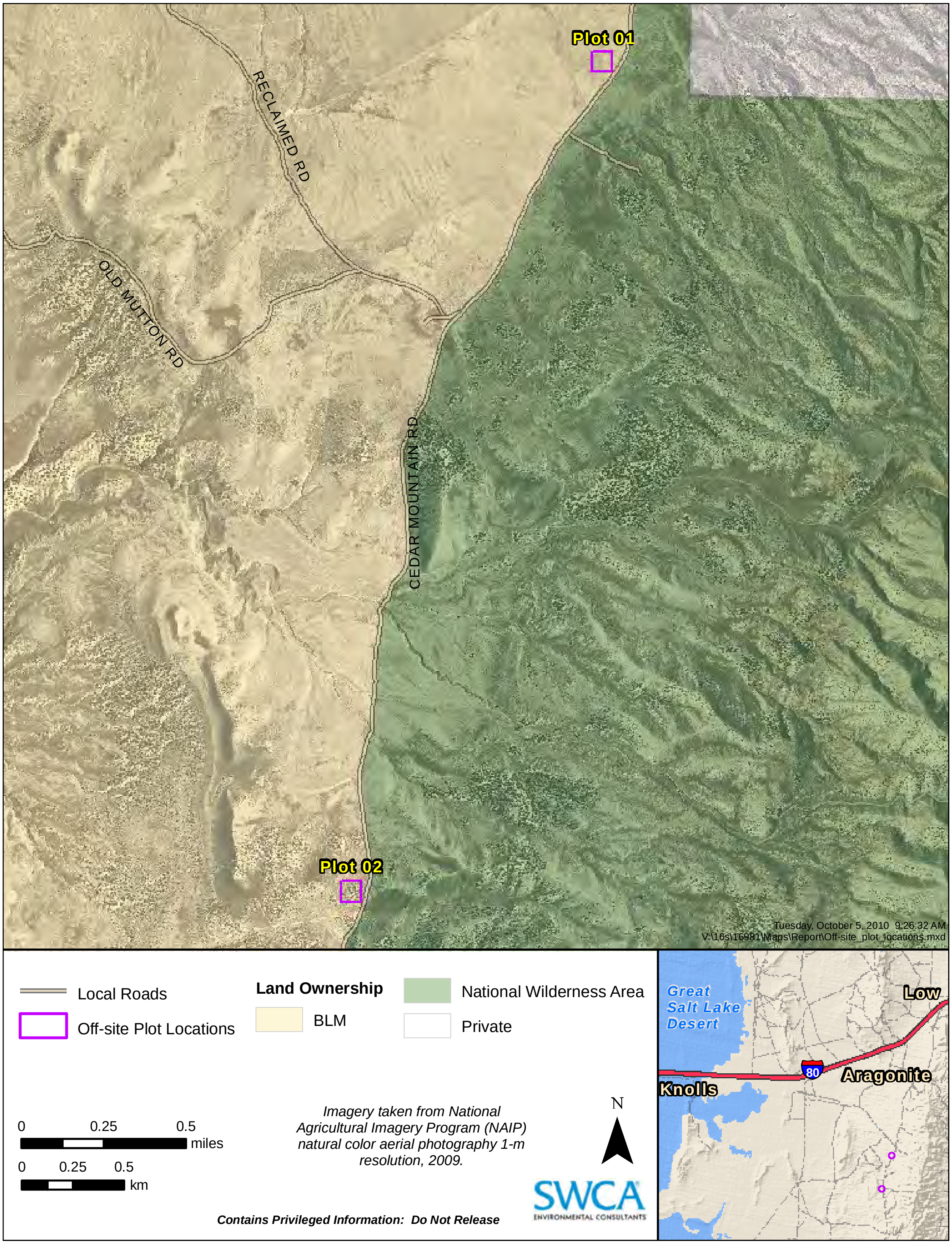
The following report presents the field sampling data. These results, along with other variables, will be placed into a predictive landscape model currently being developed by Neptune and Company, Inc. Once complete, the model will contribute understanding of future conditions at the Clive Site.

1.1 Field Sampling Locations

Field sampling was conducted in September and October 2010 in five 1-ha plots (100 × 100 m; 10,000 m^2) that were each subdivided into four 50 × 50–m subplots. Field plots were oriented from north to south. Three plots were established in each of the three primary vegetation associations present at the Clive Site: 1) shadscale–gray molly, 2) black greasewood, and 3) halogeton-disturbed (Map 1). Two plots were established off of the Clive Site in vegetation associations that represent 1) potential vegetation on elevated soil mounds with lower soil salinities, and/or 2) potential future climatic conditions that would be cooler than present-day conditions at the Clive Site (Map 2). The two off-site field plots were on lands administered by the BLM: one in a mixed grassland association and one in a juniper-sagebrush association. Additional field sampling of plant stem densities was conducted on December 13, 2010.



Map 1. On-site field plots.



Map 2. Off-site field plots.

2 RESULTS

Five field plots were established: three in the primary vegetation associations present at the Clive Site (shadscale–gray molly, black greasewood, and halogeton-disturbed), and two in nearby upland areas (mixed grassland and juniper-sagebrush).

2.1 Vegetation

Vegetation sampling was performed from September 30 through October 12, 2010. In each field plot, two of the four subplots were randomly selected for sampling. Five 50-m-long transects were oriented south to north every 10 m from the southeastern corner of the subplot. Ten 1-m^2 sampling quadrats were sampled at 0, 5, 10, 15, 20, 25, 30 35, 40 and 45 m along each 50-m transect for a total of 50 sample quadrats per subplot, or 100 quadrats per plot (100 m^2 or 1% of each 10,000 m^2 plot area).

Plot 1 (mixed grassland) and Plot 2 (juniper-sagebrush) were located to the southeast of the Clive Site on BLM-administered lands. Plots 3 and 4 (black greasewood and halogeton-disturbed) were located in the Clive Site. Plot 5 (shadscale–gray molly) was located immediately west of the Clive Site on adjacent private property.

Additional field sampling of plant stem densities was performed on December 13, 2010. In each plot, one transect comprised of 10 quadrats was randomly selected in each of the previously sampled plot quadrants. A total of 100 quadrats, or 20 quadrats per plot, were sampled and vegetation cover and stem densities were recorded for each species in each quadrat. Stem counts were made as follows: individual shrubs were counted as 1 stem; perennial bunchgrasses were counted as 1 stem; annual grass culms (grass stems) were each counted as 1 stem; and annual forb species were counted where plant condition allowed counting. Plants were counted only if rooted in the plot. Bunch grasses were counted if 50% or more of the plant base was rooted in the plot. From these data we modeled species-specific relationships between percent cover and plant density and used the model parameters to calculate stem densities from percent cover for the entire data set.

Forty-one plant species were identified in the five field plots. Because many desert forbs are spring ephemerals and field sampling was conducted at the end of the growing season, the plant species diversity and cover, particularly for herbaceous forbs, is underrepresented. Of the few forb species that were detected during vegetation cover sampling, all were dead or senesced, with the exception of *Halogeton* (*Halogeton glomeratus*), a late-season invasive annual weed.

Biological soil crusts are a dominant feature of vegetation communities throughout the Great Salt Lake basin. Soil crusts were present in all five vegetation associations sampled, but were more prevalent in the low desert vegetation associations (e.g., black greasewood, haltogeton-disturbed, and shadscale-gray molly) present on and adjacent to the Clive Site.

2.1.1 Plot 1: Mixed Grassland

Plot 1 comprised a mix of native and non-native grass species with a few scattered shrubs and forbs (Figure 1, Table 1). The ground cover was dominated by biological soil crust (52%). Twenty plant species were recorded. Eleven species of grass, dominated by needle-and-thread grass (*Hesperostipa comata*), comprised approximately 25% of total cover. The mixture of primarily desirable non-native grass species present in Plot 1 and surrounding grasslands is the result of recent fire disturbance and subsequent seeding with a mixture of needle-and-thread, intermediate wheatgrass (*Thinopyrum intermedium*), bluegrass (*Poa* spp.), crested wheatgrass (*Agropyron cristatum*), tall wheatgrass (*Thinopyrum ponticum*), slender wheatgrass (*Elymus trachycaulus*), western wheatgrass (*Pascopyrum smithii*), and other species. The reseeded area covers a large portion of uplands surrounding the Clive Site, and these desirable non-native grass species have become established in the area and are likely to persist.

Table 1. Plot 1 Average Vegetation Percent Cover, Ground Cover, and Stem Densities (plants per $100m^2$; nd = no data)

Cover Type	Name	Percent Cover	Plants / $100m^2$
Shrubs	Broom snakeweed	2.0%	48.6
Forbs	Bur buttercup	2.2%	nd
Grasses	Needle-and-thread grass	12.3%	495.6
	Cheatgrass	3.7%	20,783.5
	Intermediate wheatgrass	2.6%	47.9
	Sandberg bluegrass	2.3%	360.4
	Crested wheatgrass	1.6%	37.3
	Slender wheatgrass	1.1%	111.5
	Tall wheatgrass	1.1%	13.5
	Western wheatgrass	1.0%	nd
	Indian ricegrass	0.7%	39.2
Ground Cover	Biological soil crust	51.6%	
	Plant litter	16.1%	
	Bare ground	1.7%	
Total		**100.0%**	

Figure 1. Mixed grassland vegetation association (Plot 1).

2.1.2 Plot 2: Juniper-sagebrush

Plot 2 comprised an overstory of Utah juniper (*Juniperus osteosperma*; 6.2%) with a multilayered mid-level canopy of big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*; 17.1%), and a subcanopy of broom snakeweed (*Gutierrezia sarothrae*; 1.0%), grasses (9.8%), and forbs (1.4%) (Figure 2, Table 2). This plot was the most diverse of the five field plots with 25 plant species recorded. The ground cover was dominated by biological soil crust (44.9%) and plant litter (23.5%), with some bare ground (9.9%) where game and livestock trails pass through the plot.

Table 2. Plot 2 Average Vegetation Percent Cover, Ground Cover, and Stem Densities (plants / 100 m^2; nd = no data)

Cover Type	Name	Percent Cover	Plants / 100 m^2
Trees	Utah juniper	6.2%	7.0
Shrubs	Big sagebrush	17.1%	36.9
	Broom snakeweed	1.0%	24.7
	Varying buckwheat	0.3%	11
	Prickly phlox	0.3%	9
	Spiny hopsage	0.2%	1
Forbs	Curveseed buttercup	1.2%	nd
	Globemallow	0.1%	nd
	Milkvetch	0.1%	nd
Grasses	Cheatgrass	3.7%	20,417.6
	Needle-and-thread grass	2.9%	128.3
	Muttongrass	1.4%	207.7
	Bluebunch wheatgrass	0.6%	23.1
	Sangberg bluegrass	0.6%	170.7
	Fringed fescue	0.4%	16,045.9
	Indian ricegrass	0.2%	17.0
Ground Cover	Biological soil crust	44.9%	
	Plant litter	23.5%	
	Bare ground	9.9%	
Total		**100.0%**	

Figure 2. Juniper-sagebrush vegetation association (Plot 2).

2.1.3 Plot 3: Black Greasewood

Plot 3 comprised primarily black greasewood (*Sarcobatus vermiculatus*; 4.5%) and halogeton (0.7%) (Figure 3, Table 3). The ground cover was dominated by biological soil crust (84.8%). Six plant species were recorded within the sample quadrats. Total cover was greater than 100% in some areas due to the presence of a shrub overstory. Total cover is slightly less than 100% due to rounding error.

Table 3. Plot 3 Average Vegetation Percent Cover, Ground Cover, and Stem Densities (plants / 100 m^2; nd = no data)

Cover Type	Name	Percent Cover	Plants / 100m^2
Shrubs	Black greasewood	4.5%	11.5
	Mojave seablite	0.3%	6.6
	Gray molly	0.2%	34.4
	Shadscale saltbush	0.1%	16.4
Forbs	Halogeton	0.7%	720.5
	Fivehook smotherweed	<0.1%	1.5
Ground Cover	Biological soil crust	84.8%	
	Plant litter	6.1%	
	Bare ground	2.3%	
Total		**99.1%**	

Figure 3. Black greasewood vegetation association (Plot 3).

2.1.4 Plot 4: Halogeton-disturbed

Plot 4 comprised scattered native shrubs (5.2%) and halogeton (3.3%) (Figure 4, Table 4). The ground cover is dominated by biological soil crust (85.6%). Nine plant species were recorded. Crested wheatgrass and squirreltail (*Elymus elymoides*) are not included in Table 4 because they were detected at trace levels (less than 0.005%). Total cover was slightly less than 100% due to rounding error.

Table 4. Plot 4 Average Vegetation Percent Cover, Ground Cover, and Stem Densities (plants / 100 m^2; nd = no data)*

Cover Type	Name	Percent Cover	Plants / 100m^2
Shrubs	Shadscale saltbush	2.3%	107.2
	Mojave seablite	1.5%	19.3
	Gray molly	1.2%	68.9
	Black greasewood	0.2%	0.4
Forbs	Halogeton	3.3%	3534.0
	Fivehook smotherweed	0.5%	28.9
	Bur buttercup	<0.1%	nd
Ground Cover	Biological soil crust	85.6%	
	Plant litter	4.3%	
	Bare ground	0.2%	
Total		**99.2%**	

*Two plant species were detected at trace levels (<0.01%): squirreltail and crested wheatgrass.

Figure 4. Halogeton-disturbed vegetation association (Plot 4).

2.1.5 Plot 5: Shadscale–Gray Molly

Plot 5 comprised native shrubs (13.3%) and scattered weeds (1.1%) (Figure 5, Table 5). The ground cover is dominated by biological soil crust (70.7%) and plant litter (11.7%). Fifteen plant species were recorded. Nine of these plant species are listed in the footnote in Table 5 because they were detected at trace levels (less than 0.01%). Total cover was slightly greater than 100% due to the presence of a shrub overstory.

Table 5. Plot 5 Average Vegetation Percent Cover, Ground Cover, and Stem Densities (plants / 100 m^2; nd = no data)*

Cover Type	Name	Percent Cover	Plants / 100m^2
Shrubs	Shadscale saltbush	12.5%	430.1
	Gray molly	0.6%	34.7
	Black greasewood	0.2%	0.6
Forbs	Halogeton	0.9%	959.1
	Bur buttercup	0.1%	nd
Grasses	Cheatgrass	0.1%	126.1
Ground Cover	Biological soil crust	70.7%	
	Plant litter	11.7%	
	Bare ground	3.8%	
Total		**100.6%**	

Nine plant species were detected at trace levels (<0.01%): squirreltail, fivehook smotherweed, rockcress sp., burningbush, alkali birdsbeak (*Cordylanthus maritimus*), broom snakeweed, Sandberg bluegrass, Mojave seablite, and an unknown forb species.

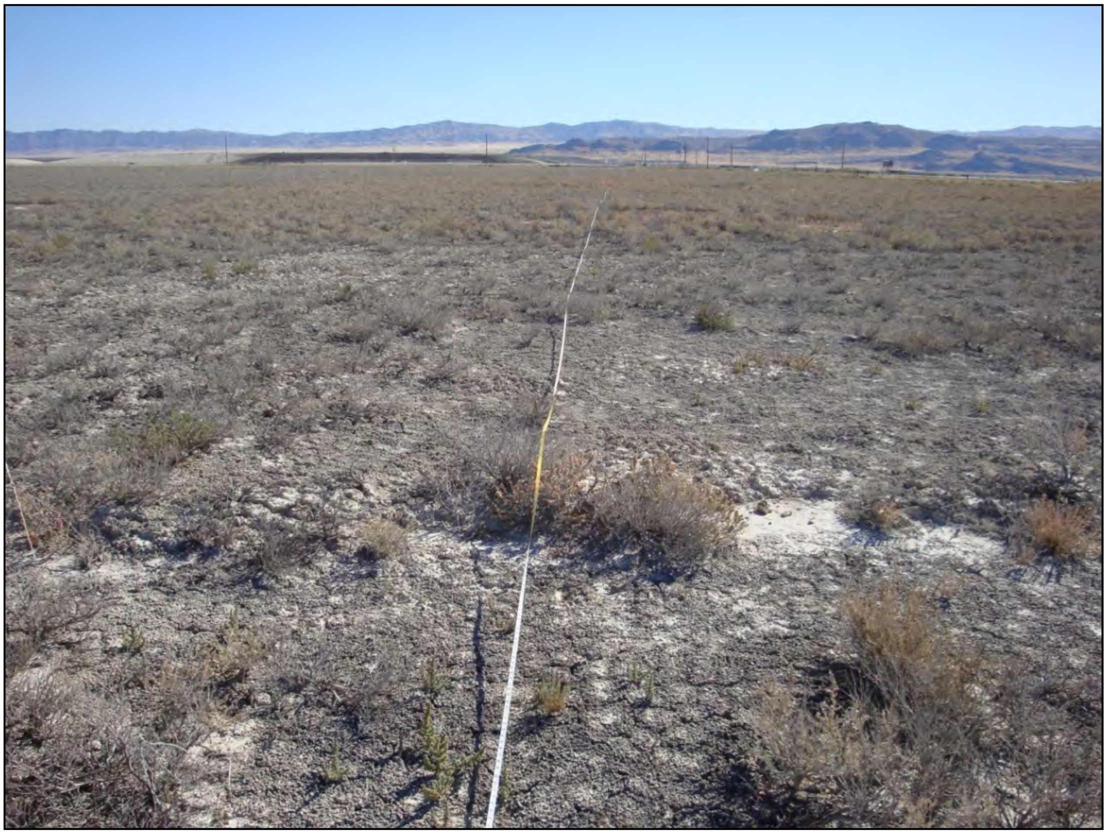


Figure 5. Shadscale–gray molly vegetation association (Plot 5).

2.1.6 Plant Root Densities and Rooting Depths

Excavations were conducted to examine the root density and maximum rooting depth of dominant plant species on the Clive Site. Excavations were performed in the two plots on the Clive Site: Plot 3 (black greasewood) and 4 (halogeton-disturbed). Three excavation locations were selected in each plot and excavated using a backhoe. Six locations were excavated.

Figure 6. Mojave seablite biomass measurements in Plot 4.

The focus of the excavations was to obtain cross-sections of the rooting mass of dominant plant species in each field plot. The roots were carefully exposed by gradual removal of vertical layers of soil with the backhoe and hand tools. Root density measurements were collected by measuring the width of the rooting mass and by counting visible roots across a set of sample widths or for the entire width of the root mass. Root density measurements were taken at the soil surface and at 10 cm increments until no roots could be detected. Roots were continuous at just below the soil surface in all excavated soil profiles. A summary of the average root densities and maximum rooting depth of dominant plant species in Plots 3 and 4 is given in Table 6.

Root densities were higher near the surface of the soil, where roots were mostly fibrous with few woody structures. A few large, woody roots were encountered in deeper soils. Rooting depths were shallower than expected, with the maximum rooting depth of dominant woody plant species ranging from 40 to 70 cm. Woody plant species maximum rooting depths were proportional to aboveground plant mass with an aboveground height:root depth ratio of 1:1 and an aboveground width:root depth ratio of approximately 1.4:1. The herbaceous dominant in Plot 4, halogeton, had higher ratios of plant height and width to maximum rooting depth (1.4:1 and 1.7:1, respectively). The low proportion of roots to aboveground biomass is expected for annual plants, which invest the bulk of their energy in reproduction and little energy in root systems.

Table 6. Average root density (roots per cm) and maximum rooting depth (cm) of dominant plant species in Plots 3 and 4

	Plot 3			Plot 4		
	Excavation Number			Excavation Number		
	1	2	3	1	2	3
Rooting Depth (cm)	**Black greasewood roots/cm**					
0	2.7	0.9	1.8	–	–	–
10	2.7	2.0	0.9	–	–	–
20	0.7	0.4	0.4	–	–	–
30	0.3	0.2	0.2	–	–	–
40	0.1	0.2	0.2	–	–	–
50	0.2	0.1	0.0	–	–	–
60	0.1	0.2	0.0	–	–	–
70	2.0	0.0	–	–	–	–
80	0.0	–	–	–	–	–
Rooting Depth (cm)				**Halogeton roots/cm**		
0	–	–	–	–	–	2.0
10	–	–	–	–	–	2.0
20	–	–	–	–	–	0.2
30	–	–	–	–	–	0.0
Rooting Depth (cm)				**Mojave seablite roots/cm**		
0	–	–	–	–	2.4	–
10	–	–	–	–	0.5	–
20	–	–	–	–	0.5	–
30	–	–	–	–	0.2	–
40	–	–	–	–	0.1	–
50	–	–	–	–	0.0	–
Rooting Depth (cm)				**Shadscale saltbush roots/cm**		
0	–	–	–	2.0	2.0	1.6
10	–	–	–	2.0	0.5	0.9
20	–	–	–	0.7	0.3	0.5
30	–	–	–	0.5	0.2	0.2
40	–	–	–	0.1	0.1	0.3
50	–	–	–	0.3	0.0	0.0
60	–	–	–	2.0	–	–
70	–	–	–	0.3	–	–
80	–	–	–	0.0	–	–

In Plot 3, a compacted layer of clay was encountered at approximately 60 cm depth in all three excavation sites. Plant roots spread out laterally across the top of this dense clay layer that appears as a smooth line of soil across the bottom of the soil cross section in Figure 7.

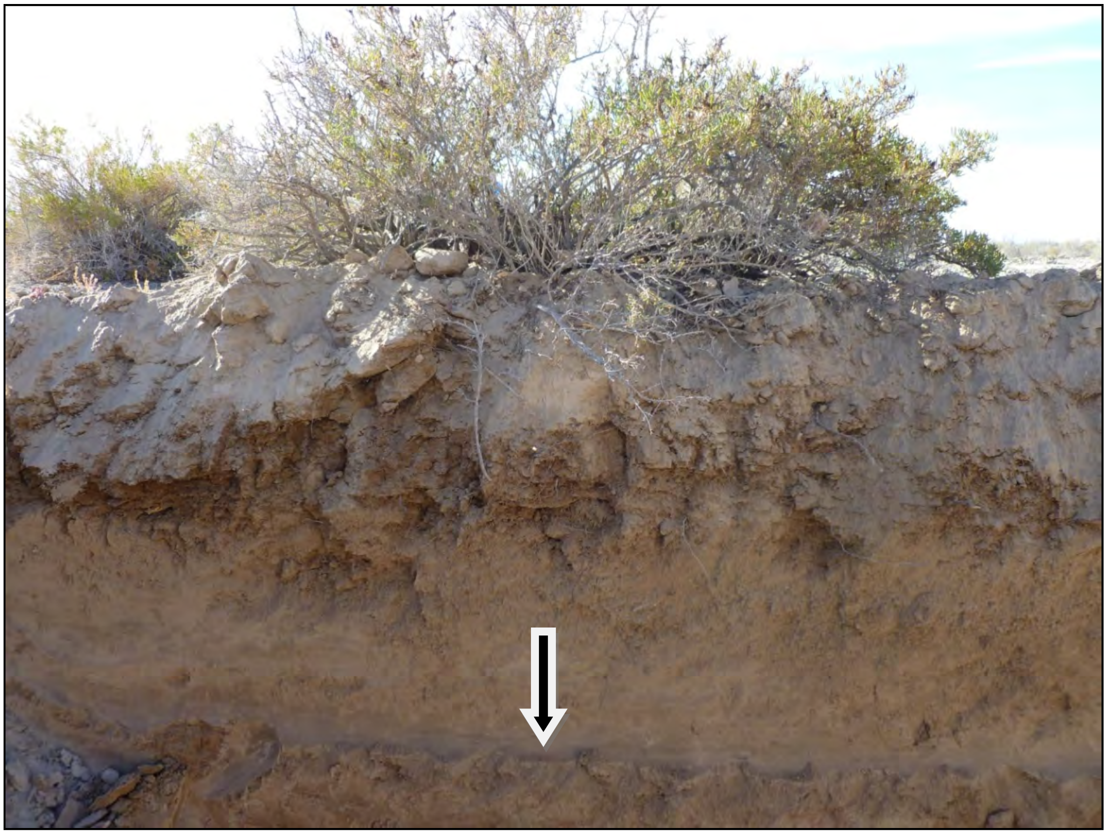


Figure 7. Plot 3 soil cross section with compacted clay layer at approximately 60 cm depth.

2.2 Mammals

2.2.1 Mammal Trapping

Each 1.0-ha plot was subdivided into 25 20 × 20–m subplots. At the center of the each subplot, two Sherman® live traps were placed, for a total of 50 traps per plot. Of the 50 traps, 37 were large traps (approximately 8 × 8 × 23 cm) and 13 were extra-large traps (approximately 10 × 10 × 40 cm). One large trap was placed at each trapping station and one extra-large trap was placed at every other station. The remaining stations had one additional large trap placed in them. Figure 8 illustrates the trapping station design.

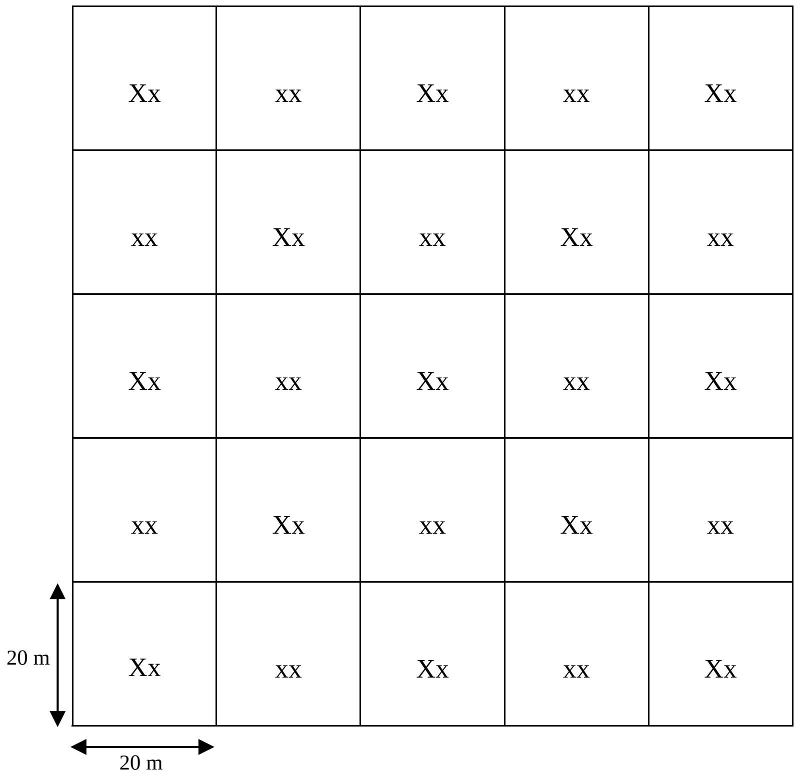


Figure 8. Trapping station layout, where X represents extra-large traps and x represents large traps.

The traps were placed at trapping stations for a minimum of three days prior to the beginning of trapping efforts in order to acclimate the animals to the presence of the traps. The traps were set during the week of the new moon (October 4–7, 2010) before dusk, and checked the following mornings. The traps were baited with a four-grain horse feed rolled in molasses. Cotton balls were also placed in the traps to be used as bedding by any captured small mammal.

Captured mammals were identified to species and released. Mouse species were marked with nail polish before release; however, kangaroo rats did not tolerate the marking process. Additionally, during the course of trapping, it became apparent that at least some mice were chewing off the mark or pulling out marked fur, making recapture information difficult to obtain. For these reasons, no attempts to analyze recapture data were made.

2.2.1.1 PLOT 1

The mixed grassland plot yielded three species of small mammal: deer mouse (*Peromyscus maniculatus*), northern grasshopper mouse (*Onchomys leucogaster*), and Great Basin kangaroo rat (*Dipodomys microps*). Deer mice accounted for 22 of the 24 captured mammals (92%). One northern grasshopper mouse and one Great Basin kangaroo rat were captured. Northern grasshopper mice were only trapped at Plot 1. Plot 1 experienced the only mortalities during trapping (13% of captures). No cause of death was apparent in any of the three mortalities. Table 7 summarizes the mammal captures at Plot 1.

Table 7. Summary of Species Captured, Number of Individuals Recaptured, and Number Found Deceased in Trap in Plot 1

Species	Captured	Recaptured	Deceased
10/5/2010			
P. maniculatus	4	0	0
Subtotal	*4*	*0*	*0*
10/6/2010			
P. maniculatus	4	0	1
Subtotal	*4*	*0*	*1*
10/7/2010			
D. microps	1	0	0
O. leucogaster	1	n/a	0
P. maniculatus	6	3	1
Subtotal	*8*	*3*	*1*
10/8/2010			
P. maniculatus	8	4	1
Subtotal	*8*	*4*	*1*
Total	**24**	**7**	**3**

2.2.1.2 PLOT 2

The most individuals (43) were captured at the juniper-sagebrush plot. Deer mice comprised 84% of the captures, Great Basin kangaroo rats 14%, and Ord's kangaroo rat (*D. ordii*) 2%. Ord's kangaroo rats were captured only at this site. One deer mouse gave birth to four live young in a trap. Table 8 summarizes the mammal captures at Plot 2.

Table 8. Summary of Species Captured, Number of Individuals Recaptured, and Number Found Deceased in Trap in Plot 2

Species	Captured	Recaptured	Deceased
10/5/2010			
P. maniculatus	7	0	0
Subtotal	*7*	*0*	*0*
10/6/2010			
P. maniculatus	8	2	0
Subtotal	*8*	*2*	*0*
10/7/2010			
D. microps	3	n/a	0

Table 8. Summary of Species Captured, Number of Individuals Recaptured, and Number Found Deceased in Trap in Plot 2

Species	Captured	Recaptured	Deceased
D. ordii	1	n/a	0
P. maniculatus	10	0	0
Subtotal	*14*	*0*	*0*
10/8/2010			
D. microps	3	n/a	0
P. maniculatus	11	3	0
Subtotal	*14*	*3*	*0*
Total	**43**	**5**	**0**

2.2.1.3 PLOT 3

Two deer mice were captured in the black greasewood plot. Table 8 summarizes the mammal captures at Plot 3. Table 9 summarizes the mammal captures at Plot 3.

Table 9. Summary of Species Captured, Number of Individuals Recaptured, and Number Found Deceased in Trap in Plot 3

Species	Captured	Recaptured	Deceased
10/5/2010			
Subtotal	*0*	*0*	*0*
10/6/2010			
P. maniculatus	1	0	0
Subtotal	*1*	*0*	*0*
10/7/2010			
P. maniculatus	1	1	0
Subtotal	*1*	*1*	*0*
10/8/2010			
Subtotal	*0*	*0*	*0*
Total	**2**	**1**	**0**

2.2.1.4 PLOT 4

One deer mouse was captured during the last night of trapping in the halogeton-disturbed plot. Table 10 summarizes the mammal captures at Plot 4.

Table 10. Summary of Species Captured, Number of Individuals Recaptured, and Number Found Deceased in Trap in Plot 4

Species	Captured	Recaptured	Deceased
10/5/2010			
Subtotal	*0*	*0*	*0*
10/6/2010			
Subtotal	*0*	*0*	*0*
10/7/2010			
Subtotal	*0*	*0*	*0*
10/8/2010			
P. maniculatus	1	0	0
Subtotal	*1*	*0*	*0*
Total	**1**	**0**	**0**

2.2.1.5 PLOT 5

Four deer mice were captured in the shadscale–gray molly plot. Table 11 summarizes the mammal captures at Plot 5.

Table 11. Summary of Species Captured, Number of Individuals Recaptured, and Number Found Deceased in Trap in Plot 5

Species	Captured	Recaptured	Deceased
10/5/2010			
Subtotal	*0*	*0*	*0*
10/6/2010			
P. maniculatus	1	0	0
Subtotal	*1*	*0*	*0*
10/7/2010			
P. maniculatus	1	0	0
Subtotal	*1*	*0*	*0*
10/8/2010			
P. maniculatus	2	1	0

Table 11. Summary of Species Captured, Number of Individuals Recaptured, and Number Found Deceased in Trap in Plot 5

Species	Captured	Recaptured	Deceased
Subtotal	*2*	*1*	*0*
Total	**4**	**1**	**0**

2.2.2 Mammal Burrow Surveys

Each 1.0-ha plot was surveyed for mammal burrows by walking transects approximately 3 m (10 feet) apart, depending on topography and vegetation. These surveys were conducted September 28 and 30, October 21, and November 4, 2010. The universal transverse mercator (UTM) location was recorded using a handheld global positioning system (GPS) unit for individual burrows or a group of similar burrows. If a group of burrows was recorded, an approximate area was recorded. Burrows were identified to species level when possible; however, in many cases burrows were assigned a likely “group” of burrowers (i.e., mouse/vole/rat). Considering the large number of deer mice captured during trapping efforts, it is possible burrows in this particular category are deer mice burrows.

The plots on the Clive Site (Plots 3–5) were found to have far fewer burrows than the reference plots (Plots 1 and 2) on BLM land. Though the Clive Site field plots had fewer burrows, those burrows had larger amounts of displaced soil at their entrances than the BLM field plots.

After burrow surveys were completed, soil volumes were collected in a randomly selected ¼-plot (0.25 ha) in each plot. The obviously mounded or disturbed soil around a burrow entrance was collected and measured (in L).

2.2.2.1 PLOT 1

A total of 235 burrow locations were located during the burrow survey (see Table 12). The majority (56%) of burrows were identified as mouse/vole/rat burrows.

Table 12. Number of Burrows, by Type, in Plot 1

Burrow Type	Number of Burrows
Ground squirrel	2
Kangaroo rat	102
Mouse/vole/rat	131
Total	**235**

The southwest quadrant of Plot 1 was randomly selected for burrow soil volumes. Because of heavy disturbance in the area from cattle grazing, human foot traffic, and winds, it was somewhat difficult to determine exact amounts of disturbed soils at burrow entrances. Only small amounts of soil were found around burrow entrances. This may indicate burrowing activity is only taking place in a shallow sub-surface layer. Table 13 summarizes soil mound volumes in Plot 1.

Table 13. Summary of Soil Mound Volume (in L) by Burrow Type in the Southwestern Quadrant of Plot 1

Burrow ID	Kangaroo Rat (L)	Mouse/Vole/Rat (L)	Total (L)
1SW104	3.500	–	3.500
1SW105	–	0.010	0.010
1SW106	–	0.200	0.200
1SW107	–	0.010	0.010
1SW108	0.050	–	0.050
1SW110	1.250	–	1.250
1SW111	0.300	–	0.300
1SW112	0.560	–	0.560
1SW113	–	0.030	0.030
1SW114	–	0.010	0.010
1SW115	0.250	–	0.250
1SW116	0.050	–	0.050
1SW117	2.500	–	2.500
1SW118	–	0.080	0.080
1SW119	0.030	–	0.030
1SW120	0.030	–	0.030
1SW121	0.090	–	0.090
1SW122	0.030	–	0.030
1SW123	0.030	–	0.030
1SW124	0.200	–	0.200
1SW125	0.150	–	0.150
1SW126	0.100	–	0.100
1SW127	–	0.010	0.010
1SW128	2.860	–	2.860
1SW129	0.050	–	0.050
1SW130	–	0.040	0.040
1SW131	–	0.050	0.050
1SW132	–	0.030	0.030
1SW133	–	0.100	0.100
1SW134	–	0.020	0.020
Total	**12.030**	**0.590**	**12.620**

2.2.2.2 PLOT 2

A total of 239 burrows were located during the burrow survey (see Table 14). The majority (93%) of burrows were identified as kangaroo rat burrows.

Table 14. Number of Burrows, by Type, in Plot 2

Burrow Type	Number of Burrows
Badger	1
Kangaroo rat	222
Mouse/vole/rat	16
Total	**239**

The northeast quadrant of Plot 2 was randomly selected for burrow soil volumes. Because of the extreme sandiness of the soil in the northeastern quadrant and windiness at the site, it was difficult to determine the amount of disturbed soil outside of burrows. Burrows with no recent digging (prior few days) had very small amounts of soil disturbed at their entrances. The eastern portion of Plot 2 is very sandy and dune-like. This sandy area is most likely experiencing constant soil mixing at the surface and shallow subsurface. Most burrows in Plot 2 appeared to be shallow, sub-surface burrows and only one deep badger burrow was identified. Table 15 summarizes soil mound volumes in Plot 2.

Table 15. Summary of Soil Mound Volume (in L) by Burrow Type in the Northeastern Quadrant of Plot 2

Burrow ID	Badger (L)	Kangaroo Rat (L)	Mouse/Vole/Rat (L)	Total (L)
2NE002	–	0.050	–	0.050
2NE006	–	–	0.010	0.010
2NE007	–	0.010	–	0.010
2NE009	–	0.150	–	0.150
2NE010	–	–	0.060	0.060
2NE012	–	0.225	–	0.225
2NE015	6.000	–	–	6.000
2NE019	–	1.350	–	1.350
2NE020	–	6.830	–	6.830
2NE021	–	2.975	–	2.975
2NE025	–	0.060	–	0.060
2NE026	–	0.185	–	0.185
2NE027	–	–	0.100	0.100
2NE028	–	0.050	–	0.050
2NE029	–	0.200	–	0.200
2NE037	–	–	0.010	0.010
2NE040	–	0.010	–	0.010

Table 15. Summary of Soil Mound Volume (in L) by Burrow Type in the Northeastern Quadrant of Plot 2

Burrow ID	Badger (L)	Kangaroo Rat (L)	Mouse/Vole/Rat (L)	Total (L)
2NE041	–	0.040	–	0.040
2NE044	–	–	0.010	0.010
2NE046	–	0.300	–	0.300
2NE048	–	0.100	–	0.100
2NE051	–	15.010	–	15.010
2NE052	–	9.500	–	9.500
2NE104	–	0.800	–	0.800
Total	**6.000**	**37.845**	**0.190**	**44.035**

2.2.2.3 PLOT 3

Three burrows were located during the burrow survey (see Table 14).

Table 16. Number of Burrows, by Type, in Plot 3

Burrow Type	Number of Burrows
Ground squirrel	1
Kangaroo rat	1
Mouse/vole/rat	1
Total	**3**

The northeastern quadrant of Plot 3 was randomly selected for burrow soil volumes. One burrow was found in this quadrant (see Table 17).

Table 17. Summary of Soil Mound Volume (in L) by Burrow Type in the Northeastern Quadrant of Plot 3

Burrow ID	Mouse/Vole/Rat (L)	Total (L)
3NE003	1.000	1.000
Total	**1.000**	**1.000**

2.2.2.4 PLOT 4

No burrows were found in Plot 4.

2.2.2.5 PLOT 5

One burrow was located during the burrow survey (see Table 18).

Table 18. Number of Burrows, by Type, in Plot 5

Burrow Type	Number of Burrows
Mouse/vole/rat	1
Total	**1**

The southwestern quadrant of Plot 5 was randomly selected for burrow soil volume. One burrow was present in the quadrant (see Table 19).

Table 19. Summary of Soil Mound Volume (in L) by Burrow Type in Plot 5

Burrow ID	Mouse/Vole/Rat (L)	Total (L)
5SW001	13.750	13.750
Total	**13.750**	**13.750**

2.3 Ants

2.3.1 Methods

2.3.1.1 FIELD METHODS

Each field plot was surveyed via pedestrian transects to ensure 100% coverage of the whole plot. Ant mounds were located, the UTM location of each mound was recorded using a handheld GPS unit, details regarding the mound were recorded, and sample specimens were taken from the mound. Each plot was surveyed three times. The first time was the most intensive and required mapping and data recording of each mound, whereas the other two visits were only to collect additional specimens. Multiple specimen collection was done to determine if more than one species was utilizing the same mound, because data on desert ant species suggest that this is possible. At minimum, 10 individuals from each mound were collected on the first survey, and then 5–10 each survey thereafter. At each mound, sample specimens were collected with either forceps or aspirator and placed into a vial filled with a 95% ethyl alcohol solution and labeled with the sample number and date.

The following information was collected at each mound:

- Height and width/diameter (in order to calculate the surface area of the mound)
- A photograph of the mound
- A brief description of the mound and its location, i.e., soil and vegetation features
- The orientation of the mound entrance, i.e., N, S, NNE, etc.
- Date, observer, plot number, subplot number, and UTM coordinates

2.3.1.2 ANT IDENTIFICATION METHODS

Identification of ant species was performed by Kenneth J. Kingsley, a Ph.D. entomologist with extensive experience in insect identification. He examined all of the 188 vials containing the collected species under a binocular dissecting microscope, and identified each of the 1,628 collected ants to genus and all *Pogonomyrmex* individuals to species, using the keys in Allred (1982)[1].

2.3.2 Ant Identification Results

A total of 1,624 ants in the genus *Pogonomyrmex* was collected in all plots and determined to be the western harvester ant, (*P. occidentalis* [Cresson]). Four other ants collected in Plot 1 were determined to be in the genus *Lasius*, with species not positively determined but most likely *niger* (Linnaeus). The western harvester ant is a widely distributed ant occurring throughout most of Utah and many other western states. It frequently occurs in areas that are relatively flat and have been recently disturbed by human activities[2]. A table for each field plot listing the number of ants collected by mound, date, and species can be found in Appendix A.

2.3.3 Mound Dimension Results

Because the mounds were roughly conical in shape, the formula for surface area of a cone was used to estimate area of the mounds. The maximum (basal) diameter of each mound, as measured by the field crew, was then entered into a Microsoft Excel© spreadsheet, which was used to calculate the surface area of the mound. It is possible that the basal area of the mound may have some mathematical relationship to the depth and subterranean area of the nest and the quantity of soil excavated, but that relationship has not been clearly established for *P. occidentalis* mounds in the particular soil types present on the sampling sites. Table 20 summarizes the results of the mound dimension survey.

Table 20. Mound Surface Area and Density By Plot

Plot	Average surface area (dm^2)	Average mound density (mounds/hectare)
Plot 1	95	33
Plot 2	39	2
Plot 3	120	7
Plot 4	84	16
Plot 5	138	6
Average across plots	**97**	**13**

Density of the mounds was determined by tallying the number of mounds observed per plot and calculating the density per hectare.

[1] Allred, D.M. 1982. Ants of Utah. *Great Basin Naturalist* 42(4):415–511.
[2] Allred, D.M. 1982. Ants of Utah. *Great Basin Naturalist* 42(4):415–511.

This page intentionally left blank.

Appendix A

Ant Collection Results

PLOT 1

Four *Lasius* individuals and 804 *Pogonomyrmex occidentalis* individuals were collected in Plot 1.

Table A-1. Ant Species by Mound in Plot 1

Mound No.	Collection Date	Number of Ants Collected	Species
P1-NE-20	10/5/2010	13	*P. occidentalis*
P1-NE-20	10/6/2010	6	*P. occidentalis*
P1-NE-20	10/7/2010	6	*P. occidentalis*
P1-NE-21	10/5/2010	12	*P. occidentalis*
P1-NE-21	10/6/2010	6	*P. occidentalis*
P1-NE-21	10/7/2010	8	*P. occidentalis*
P1-NE-22	10/5/2010	11	*P. occidentalis*
P1-NE-22	10/6/2010	8	*P. occidentalis*
P1-NE-22	10/7/2010	7	*P. occidentalis*
P1-NE-23	10/5/2010	11	*P. occidentalis*
P1-NE-23	10/6/2010	8	*P. occidentalis*
P1-NE-23	10/6/2010	2	*Lasius* sp.
P1-NE-23	10/7/2010	7	*P. occidentalis*
P1-NE-24	10/5/2010	16	*P. occidentalis*
P1-NE-24	10/6/2010	8	*P. occidentalis*
P1-NE-24	10/7/2010	8	*P. occidentalis*
P1-NE-25	10/5/2010	20	*P. occidentalis*
P1-NE-25	10/6/2010	7	*P. occidentalis*
P1-NE-25	10/7/2010	7	*P. occidentalis*
P1-NE-31	10/5/2010	14	*P. occidentalis*
P1-NE-31	10/6/2010	11	*P. occidentalis*
P1-NE-31	10/7/2010	8	*P. occidentalis*
P1-NW-17	10/5/2010	17	*P. occidentalis*
P1-NW-17	10/6/2010	5	*P. occidentalis*
P1-NW-17	10/7/2010	5	*P. occidentalis*
P1-NW-18	10/5/2010	14	*P. occidentalis*
P1-NW-18	10/6/2010	6	*P. occidentalis*
P1-NW-18	10/7/2010	5	*P. occidentalis*
P1-NW-19	10/5/2010	15	*P. occidentalis*
P1-NW-19	10/6/2010	9	*P. occidentalis*
P1-NW-19	10/7/2010	5	*P. occidentalis*
P1-NW-26	10/5/2010	14	*P. occidentalis*
P1-NW-26	10/6/2010	6	*P. occidentalis*
P1-NW-26	10/7/2010	5	*P. occidentalis*

Table A-1. Ant Species by Mound in Plot 1

Mound No.	Collection Date	Number of Ants Collected	Species
P1-NW-27	10/5/2010	12	*P. occidentalis*
P1-NW-27	10/6/2010	7	*P. occidentalis*
P1-NW-27	10/7/2010	5	*P. occidentalis*
P1-NW-28	10/5/2010	12	*P. occidentalis*
P1-NW-28	10/6/2010	5	*P. occidentalis*
P1-NW-28	10/7/2010	5	*P. occidentalis*
P1-NW-29	10/5/2010	15	*P. occidentalis*
P1-NW-29	10/6/2010	5	*P. occidentalis*
P1-NW-29	10/7/2010	6	*P. occidentalis*
P1-NW-30	10/5/2010	12	*P. occidentalis*
P1-NW-30	10/6/2010	5	*P. occidentalis*
P1-NW-30	10/7/2010	6	*P. occidentalis*
P1-SE-1	10/5/2010	11	*P. occidentalis*
P1-SE-1	10/6/2010	12	*P. occidentalis*
P1-SE-1	10/7/2010	6	*P. occidentalis*
P1-SE-10	10/5/2010	14	*P. occidentalis*
P1-SE-10	10/6/2010	8	*P. occidentalis*
P1-SE-10	10/7/2010	5	*P. occidentalis*
P1-SE-11	10/5/2010	14	*P. occidentalis*
P1-SE-11	10/6/2010	6	*P. occidentalis*
P1-SE-11	10/7/2010	7	*P. occidentalis*
P1-SE-12	10/5/2010	14	*P. occidentalis*
P1-SE-12	10/5/2010	2	*Lasius* sp.
P1-SE-12	10/6/2010	6	*P. occidentalis*
P1-SE-12	10/7/2010	6	*P. occidentalis*
P1-SE-13	10/5/2010	11	*P. occidentalis*
P1-SE-13	10/6/2010	8	*P. occidentalis*
P1-SE-13	10/7/2010	6	*P. occidentalis*
P1-SE-14	10/5/2010	14	*P. occidentalis*
P1-SE-14	10/6/2010	9	*P. occidentalis*
P1-SE-14	10/7/2010	4	*P. occidentalis*
P1-SE-15	10/5/2010	13	*P. occidentalis*
P1-SE-15	10/6/2010	5	*P. occidentalis*
P1-SE-15	10/7/2010	5	*P. occidentalis*
P1-SE-2	10/5/2010	11	*P. occidentalis*
P1-SE-2	10/6/2010	6	*P. occidentalis*
P1-SE-2	10/7/2010	7	*P. occidentalis*

Table A-1. Ant Species by Mound in Plot 1

Mound No.	Collection Date	Number of Ants Collected	Species
P1-SW-16	10/5/2010	17	*P. occidentalis*
P1-SW-16	10/6/2010	5	*P. occidentalis*
P1-SW-16	10/7/2010	8	*P. occidentalis*
P1-SW-3	10/5/2010	13	*P. occidentalis*
P1-SW-3	10/6/2010	5	*P. occidentalis*
P1-SW-3	10/7/2010	5	*P. occidentalis*
P1-SW-4	10/5/2010	11	*P. occidentalis*
P1-SW-4	10/6/2010	5	*P. occidentalis*
P1-SW-4	10/7/2010	5	*P. occidentalis*
P1-SW-5	10/5/2010	11	*P. occidentalis*
P1-SW-5	10/6/2010	5	*P. occidentalis*
P1-SW-5	10/7/2010	5	*P. occidentalis*
P1-SW-6	10/5/2010	11	*P. occidentalis*
P1-SW-6	10/6/2010	5	*P. occidentalis*
P1-SW-6	10/7/2010	5	*P. occidentalis*
P1-SW-7	10/5/2010	10	*P. occidentalis*
P1-SW-7	10/6/2010	5	*P. occidentalis*
P1-SW-7	10/7/2010	5	*P. occidentalis*
P1-SW-7	10/7/2010	6	*P. occidentalis*
P1-SW-8	10/5/2010	12	*P. occidentalis*
P1-SW-8	10/6/2010	5	*P. occidentalis*
P1-SW-8	10/7/2010	5	*P. occidentalis*
P1-SW-9	10/4/2010	9	*P. occidentalis*
P1-SW-9	10/5/2010	13	*P. occidentalis*
P1-SW-9	10/7/2010	5	*P. occidentalis*
Total		**806**	

Plot 2

A total of 20 *Pogonomyrmex occidentalis* individuals were collected in Plot 2.

Table A-2. Ant Species by Mound in Plot 2

Mound No.	Collection Date	Number of Ants Collected	Species
P2-SE-2	10/4/2010	8	*P. occidentalis*
P2-SE-2	10/5/2010	5	*P. occidentalis*
P2-SE-2	10/6/2010	7	*P. occidentalis*
Total		**20**	

Plot 3

A total of 148 *Pogonomyrmex occidentalis* individuals were collected in Plot 3.

Table A-3. Ant Species by Mound in Plot 3

Mound No.	Collection Date	Number of Ants Collected	Species
P3-NW-4	10/4/2010	14	*P. occidentalis*
P3-NW-4	10/6/2010	5	*P. occidentalis*
P3-NW-4	10/9/2010	6	*P. occidentalis*
P3-SE-3	10/4/2010	8	*P. occidentalis*
P3-SE-3	10/6/2010	5	*P. occidentalis*
P3-SE-3	10/7/2010	5	*P. occidentalis*
P3-SE-5	10/5/2010	9	*P. occidentalis*
P3-SE-5	10/6/2010	5	*P. occidentalis*
P3-SE-5	10/7/2010	5	*P. occidentalis*
P3-SW-1	10/4/2010	10	*P. occidentalis*
P3-SW-1	10/6/2010	6	*P. occidentalis*
P3-SW-1	10/7/2010	8	*P. occidentalis*
P3-SW-2	10/4/2010	6	*P. occidentalis*
P3-SW-2	10/6/2010	7	*P. occidentalis*
P3-SW-2	10/7/2010	9	*P. occidentalis*
P3-SW-6	10/5/2010	11	*P. occidentalis*
P3-SW-6	10/6/2010	2	*P. occidentalis*
P3-SW-6	10/7/2010	10	*P. occidentalis*
P3-SW-7	10/5/2010	10	*P. occidentalis*
P3-SW-7	10/7/2010	7	*P. occidentalis*
Total		**148**	

Plot 4

A total of 477 *Pogonomyrmex occidentalis* individuals were collected in Plot 4.

Table A-4. Ant Species by Mound in Plot 4

Mound No.	Collection Date	Number of Ants Collected	Species
P4-NE-13	10/4/2010	16	*P. occidentalis*
P4-NE-13	10/6/2010	6	*P. occidentalis*
P4-NE-13	10/7/2010	10	*P. occidentalis*
P4-NE-14	10/4/2010	16	*P. occidentalis*
P4-NE-14	10/6/2010	5	*P. occidentalis*
P4-NE-14	10/7/2010	11	*P. occidentalis*
P4-NE-15	10/4/2010	18	*P. occidentalis*
P4-NE-15	10/6/2010	5	*P. occidentalis*
P4-NE-15	10/7/2010	6	*P. occidentalis*
P4-NE-16	10/4/2010	12	*P. occidentalis*
P4-NE-16	10/6/2010	5	*P. occidentalis*
P4-NE-16	10/7/2010	5	*P. occidentalis*
P4-NW-1	10/4/2010	19	*P. occidentalis*
P4-NW-1	10/6/2010	5	*P. occidentalis*
P4-NW-1	10/7/2010	6	*P. occidentalis*
P4-NW-2	10/4/2010	17	*P. occidentalis*
P4-NW-2	10/6/2010	5	*P. occidentalis*
P4-NW-2	10/7/2010	5	*P. occidentalis*
P4-NW-3	10/4/2010	16	*P. occidentalis*
P4-NW-3	10/6/2010	5	*P. occidentalis*
P4-NW-3	10/7/2010	6	*P. occidentalis*
P4-NW-4	10/4/2010	14	*P. occidentalis*
P4-NW-4	10/6/2010	5	*P. occidentalis*
P4-NW-4	10/7/2010	5	*P. occidentalis*
P4-SE-10	10/4/2010	12	*P. occidentalis*
P4-SE-10	10/6/2010	8	*P. occidentalis*
P4-SE-10	10/7/2010	10	*P. occidentalis*
P4-SE-11	10/4/2010	15	*P. occidentalis*
P4-SE-11	10/6/2010	6	*P. occidentalis*
P4-SE-11	10/7/2010	8	*P. occidentalis*
P4-SE-12	10/4/2010	7	*P. occidentalis*
P4-SE-12	10/4/2010	16	*P. occidentalis*
P4-SE-12	10/7/2010	16	*P. occidentalis*
P4-SE-9	10/4/2010	16	*P. occidentalis*
P4-SE-9	10/6/2010	6	*P. occidentalis*

Table A-4. Ant Species by Mound in Plot 4

Mound No.	Collection Date	Number of Ants Collected	Species
P4-SE-9	10/7/2010	15	*P. occidentalis*
P4-SW-5	10/4/2010	22	*P. occidentalis*
P4-SW-5	10/6/2010	5	*P. occidentalis*
P4-SW-5	10/7/2010	6	*P. occidentalis*
P4-SW-6	10/4/2010	20	*P. occidentalis*
P4-SW-6	10/6/2010	5	*P. occidentalis*
P4-SW-6	10/7/2010	7	*P. occidentalis*
P4-SW-7	10/4/2010	17	*P. occidentalis*
P4-SW-7	10/6/2010	5	*P. occidentalis*
P4-SW-7	10/7/2010	5	*P. occidentalis*
P4-SW-8	10/4/2010	16	*P. occidentalis*
P4-SW-8	10/6/2010	6	*P. occidentalis*
P4-SW-8	10/7/2010	5	*P. occidentalis*
Total		**477**	

Plot 5

A total of 177 *Pogonomyrmex occidentalis* individuals were collected in Plot 5.

Table A-5. Ant Species by Mound in Plot 5

Mound No.	Collection Date	Number of Ants Collected	Species
P5-NW-5	10/4/2010	11	*P. occidentalis*
P5-NW-5	10/5/2010	6	*P. occidentalis*
P5-NW-5	10/6/2010	5	*P. occidentalis*
P5-NW-6	10/4/2010	16	*P. occidentalis*
P5-NW-6	10/5/2010	5	*P. occidentalis*
P5-NW-6	10/6/2010	5	*P. occidentalis*
P5-SE-1	10/4/2010	20	*P. occidentalis*
P5-SE-1	10/5/2010	5	*P. occidentalis*
P5-SE-1	10/6/2010	5	*P. occidentalis*
P5-SE-3	10/4/2010	12	*P. occidentalis*
P5-SE-3	10/5/2010	5	*P. occidentalis*
P5-SE-3	10/6/2010	5	*P. occidentalis*
P5-SE-4	10/4/2010	15	*P. occidentalis*
P5-SE-4	10/5/2010	7	*P. occidentalis*
P5-SE-4	10/6/2010	5	*P. occidentalis*
P5-SW-1	10/4/2010	12	*P. occidentalis*
P5-SW-1	10/5/2010	5	*P. occidentalis*
P5-SW-1	10/6/2010	6	*P. occidentalis*
P5-SW-2	10/4/2010	16	*P. occidentalis*
P5-SW-2	10/5/2010	6	*P. occidentalis*
P5-SW-2	10/6/2010	5	*P. occidentalis*
Total		**177**	

APPENDIX J

Standard Operating Procedure Catalogue

Policy and Procedure Catalogue

SUBCATEGORY		REFERENCE	REV[1]	TITLE	DATE[1]
	(14)	CL-AD-PO-001	0	Clive Equipment and Facility Operation Maintenance Policy	22-Jan-10
	(14)	CL-AD-PR-010	0	Clive Facility Regulatory Notification Control	11-Jan-11
	(14)	CL-AD-PR-020	1	Operating Work Permit	6-Dec-10
	(14)	CL-AD-PR-021	0	Procedure Prep Guidelines	1-Nov-06
	(14)	CL-AD-PR-030	3	LLRW Export Approval	20-Dec-11
Administr	(14)	CL-AD-PR-040	0	Classification of Discrepant Incoming Shipments	8-Jun-11
	(14)	CL-AD-PR-060	1	EWIS WITS Administrative Procedure	12-Jan-10
	(14)	CL-AD-PR-080	1	Stored Volume Surety Control	18-Jun-08
Administrativ	(14)	CL-AD-WI-001	6	Document Preparation	20-Jan-10
	(14)	CL-AD-WI-002	8	Document Control	8-Nov-11
	(14)	CL-AD-WI-003	1	Review Cycle Initiation	9-Jul-10
	(14)	CL-AD-WI-004	3	Distribution Process	22-Dec-10
	(14)	CL-AD-WI-005	0	Instructions for Correspondence	29-May-09
	(14)	CL-AD-WI-007	0	Scanning Process	29-Oct-10
	(1)	CL-BD-WI-001	0	Business Development QADEP for EWIS	5-Aug-09
	(9)	CL-CL-WI-001	2	Regulatory Submittal Control	3-Jun-11
	(9)	CL-CL-WI-002	2	Groundwater Compliance Tracking	8-Feb-12
	(9)	CL-CL-WI-003	0	Annual Compliance Facility Assessment	24-Oct-11
	(9)	CL-CL-WI-004	0	Surety Review Instruction	16-Apr-09
	(9)	CL-CL-WI-013	1	Shipment Report	11-Apr-11
	(9)	CL-CL-WI-015	1	Reports Due Compliance Tracking	3-Jun-11
	(9)	CL-CL-WI-016	0	Biennial Review of Licenses and Permits	13-Jul-09
	(9)	CL-CL-WI-017	0	WITS Container Movement	16-Nov-09
	(9)	CL-LM-PR-001	0	Equipment and Facility Labeling Requirements	5-Dec-07
(14)		CL-CW-PR-001	0	Containerized Waste Facility Incoming Shipment Acceptance	26-Nov-07
(14)		CL-CW-PR-003	0	Containerized Waste Unloading and Handling	2-May-08
(14)		CL-CW-PR-004	0	Storage and Shipment of Empty Type A Cask Containers	2-Jul-08
(14)		CL-CW-PR-005	2	Transloading of Containers	2-Nov-10
Containe (14)		CL-CW-PR-100	0	Overpacking and Repairing Containers	2-May-08
(14)		CL-CW-PR-101	2	CWF Waste Placement and Backfill Operations	16-Jan-12
(14)		CL-CW-PR-102	1	Containerized Waste Void Remediation	19-Jul-10
(14)		CL-CW-PR-200	2	Package Liquid Void Verification	19-Jul-10
		CL-CW-PR-	0	Operations & Maintenance of the CWF	2-May-08

[1] Most current revision, as of 25 October 2012.

SUBCATEGORY		REFERENCE	REV[1]	TITLE	DATE[1]
(14)		201		Electronic Waste Information System	
(14)		CL-CW-PR-202	0	Generator Certification	19-Oct-09
(14)		CL-CW-PR-203	0	CWF Waste Acceptance Criteria	23-Feb-10
(14)		CL-CW-PR-204	0	Tracking of Special Nuclear Material	30-May-08
(14)		CL-CW-PR-301	2	Cask Operations at the CWF	16-Jan-12
(14)		CL-CW-PR-400	2	CWF Waste Tracking	16-Jan-12
	(12)	CL-CH-PR-002	2	Incoming Waste Unloading and Handling at the Intermodal Unloading Facility	24-May-11
	(12)	CL-CH-PR-003	2	NORM LLRW 11E(2) Incoming Waste Unloading and Handling Rail Operation	16-Jun-11
	(12)	CL-CH-PR-004	0	Transferring Mixed Waste at East Truck Unloading Area	24-May-11
	(12)	CL-CH-PR-005	2	Incoming Waste Transferring and Handling at the East Truck Unloading Area	21-Feb-12
	(12)	CL-CH-PR-100	3	Container Management and Storage	4-Feb-11
	(12)	CL-CH-PR-101	3	Rail Movement Contamination Control	3-Feb-12
	(12)	CL-CH-PR-104	0	Decontamination Procedure	4-Jan-10
	(12)	CL-CH-PR-106	3	One Percent Free Liquid Volume Determination	26-May-11
	(12)	CL-CH-PR-109	2	Rotary Dump Facility Operation	4-Jan-12
	(12)	CL-CH-PR-110	0	Intermodal Container Wash Building Operation	31-Jan-08
Contain	(12)	CL-CH-PR-200	3	Container Return Inspection	27-Feb-12
	(12)	CL-CH-PR-201	1	FiberGlass Lid Repair	27-Aug-08
	(1)	CL-DM-WI-001	0	Document Control Indoctrination and Training	12-Feb-10
	(5)	CL-EN-PR-001	4	Engineering Design Control	13-Oct-11
	(5)	CL-EN-PR-002	0	Test Control	23-Oct-07
	(5)	CL-EN-PR-003	0	Readiness Reviews	28-Apr-11
	(5)	CL-EN-PR-023	0	Annual Evaporation Pond Pump Inspection	28-May-09
	(5)	CL-EN-PR-091	1	Clay Mining and Excavation	4-Feb-11
	(17)	CL-EV-PR-001	1	Weather Station Monitoring	5-Dec-07
	(17)	CL-EV-PR-002	1	Radtrak Devices	24-Aug-10
	(17)	CL-EV-PR-003	3	Area Radiation Monitoring	20-Sep-10
	(17)	CL-EV-PR-004	3	Groundwater Monitoring	2-Feb-12
	(17)	CL-EV-PR-005	0	Cover Test Cell Monitoring	2-Mar-09
	(17)	CL-EV-PR-006	1	Environmental Tritium Monitoring	13-May-10
	(17)	CL-EV-PR-007	0	PCB Soil Sampling	18-May-09
	(17)	CL-EV-PR-008	0	PCB Air Sampler Single Point Flow Check	8-Mar-10
	(17)	CL-EV-PR-009	0	PCB Air Sampler Calibration	8-Mar-10
	(17)	CL-EV-PR-010	0	PCB Shredding Air Sample Collection	8-Mar-10
	(17)	CL-EV-PR-022	1	Annual Bladder Pump Inspection and Total Depth Measurement	20-May-11

SUBCATEGORY	REFERENCE	REV[1]	TITLE	DATE[1]
(17)	CL-EV-PR-024	1	Monthly Monitoring Well Apron Inspection	5-Jun-09
(17)	CL-EV-PR-320	1	Airborne Particulate Monitoring Lo Vol	21-May-10
(17)	CL-EV-PR-330	3	Environmental Soil Monitoring	13-May-10
(17)	CL-EV-WI-001	1	Environmental Compliance Tracking	10-Jun-09
(17)	CL-EV-WI-002	0	SW Corner Pond and Well Nest Custodial Responsibilities	7-Jan-09
(17)	CL-EV-WI-003	0	Well Installation and Abandonment	17-Nov-11
(26)	CL-IN-PR-001	0	PCB Air Sampler-Single Point Flow Check	8-Jan-08
(26)	CL-IN-PR-002	0	PCB Air Sampler-Calibration	8-Jan-08
(26)	CL-IN-PR-003	1	PCB Shredding-Air Sample Collection	27-Feb-08
(26)	CL-IN-PR-310	0	E PERM Monitors	14-May-10
(26)	CL-IN-PR-401	1	MDA and CHI Square Test	12-May-11
(26)	CL-IN-PR-402	0	Calibration and Operation of the Canberra Tennelec Series 5XLB	21-Dec-11
(26)	CL-IN-PR-410	2	Calibration of the Ludlum Model 2360 w Model 43 93 Probe	11-May-10
(26)	CL-IN-PR-411	0	Calibration of the Ludlum Model 3030P	15-Nov-11
(26)	CL-IN-PR-412	2	Calibration of the Ludlum Model 3030	18-Feb-11
(26)	CL-IN-PR-413	1	Operation of the Ludlum Model 3030P	23-Mar-12
(26)	CL-IN-PR-414	0	Operation & Calibration of the Bladewerx SabreBPM	2-Dec-11
(26)	CL-IN-PR-418	1	Operation of the Ludlum Model 3030	8-Sep-10
(26)	CL-IN-PR-419	1	Operation of Ludlum Model 193 and 193-6 Gamma Survey Meters	24-Mar-11
(26)	CL-IN-PR-420	1	Protean Counter Model WPC-9550 Calibration and Operating Instruction	11-May-10
(26)	CL-IN-PR-422	2	Air Sample Pump Maintenance and Calibration	25-Jan-11
(26)	CL-IN-PR-425	2	Operation of the Ludlum Model 375-30 Rotary Monitor	26-Jul-11
(26)	CL-IN-PR-426	0	Operation of Victoreen 451B-RYR-SS Ion Chamber Survey Meters	7-Mar-11
(26)	CL-IN-PR-430	1	Lung Count Operation	7-Apr-10
(26)	CL-IN-PR-436	1	Use and Maintenance of Electronic Dosimeters	17-Nov-10
(26)	CL-IN-PR-437	1	Dose Rate Instrumentation	7-Mar-11
(26)	CL-IN-PR-439	1	Calibration of MGP DMC2000S Elec. Dosimeters	1-Feb-10
(26)	CL-IN-PR-441	2	Operation of the Ludlum Model 2360 with 43-93 Probe	15-Mar-12
(26)	CL-IN-PR-460	1	Canberra Argos 4AB Calibration	28-Dec-10
(26)	CL-IN-PR-461	1	Canberra 4AB Operation	8-Apr-11
(26)	CL-IN-PR-462	2	Operation of the Eberline Model PCM 2	17-Aug-11
(26)	CL-IN-PR-463	2	Calibration of the Eberline Model PCM 2	15-Feb-12
(88)	CL-001	4	Shredder Maintenance	10-Dec-09
(88)	CL-002	3	Shredder Operation 12.10.09	10-Dec-09
(88)	CL-003	6	Rotary Dump Facility Operations	10-Dec-09
(88)	CL-004	3	Waste Preparation for Shredder 12.10.09	10-Dec-09

SUBCATEGORY	REFERENCE	REV[1]	TITLE	DATE[1]
(88)	CL-005	1	hipping concrete out of cement truck drums	10-Dec-09
(88)	CL-006	1	Waste Drum Repackaging-Compacting	10-Dec-09
(88)	CL-007	2	Flowable Filling Containers for Macro-Encapsulation	10-Dec-09
(88)	CL-008	2	Incoming Shipment Sampling and Inspecting Boxes	10-Dec-09
(88)	CL-009	4	Hyster Yardmaster Operation	10-Dec-09
(88)	CL-010	3	Intermodal Decon	10-Dec-09
(88)	CL-011	1	Operation of the Trackmobile 4500	10-Dec-09
(88)	CL-012	3	Digestions, Separations and Analysis Using Acids in the Chem Lab	10-Dec-09
(88)	CL-013	3	Excavation and Trenching	10-Dec-09
(88)	CL-014	3	Maintenance Field Work on the Cells	10-Dec-09
(88)	CL-015	0	g Lids on Box Type Containers	10-Dec-09
(88)	CL-016	2	Inflating Tires on Equipment	10-Dec-09
(88)	CL-017	3	Pre Inspection of the Trackmobile 4500	10-Dec-09
(88)	CL-018	4	Track 4 Decon	10-Dec-09
(88)	CL-019	1	Sorting and Repackaging Elemental Mercury	10-Dec-09
(88)	CL-020	2	Incoming Shipment Sampling and Inspecting Drums	10-Dec-09
(88)	CL-021	2	Loading and Unloading Track Hoe on to Railcars	10-Dec-09
(88)	CL-022	2	Macro Vault Construction	10-Dec-09
(88)	CL-023	2	Setting Hand Brakes on Rail Cars	10-Dec-09
(88)	CL-024	3	Docking and Removing Containers at Intermodal Decon Bays	10-Dec-09
(88)	CL-025	3	Loading and Unloading Railcars and Flatbed Trucks with the Hyster Yardmaster or Forklifts	10-Dec-09
(88)	CL-026	1	Health Physics Functions and Unloading Trucks From an Elevated Dock	10-Dec-09
JH (88)	CL-027	1	Amalgamation of Mercury Hg	10-Dec-09
(88)	CL-028	1	Off-loading and Placement of Large Components 2.28.08	28-Feb-08
(88)	CL-029	3	Vehicle Railroad Crossings 5.31.11	31-May-11
(88)	CL-030	2	CWF Cask Shipments and Waste Placement 6.2.10	2-Jun-10
(88)	CL-031	2	Unloading End Dumps	10-Dec-09
(88)	CL-032	1	Extricating Vehicles and Equipment	10-Dec-09
(88)	CL-033	2	Operation of Hand Held Grinder	10-Dec-09
(88)	CL-034	2	Dumping Intermodals with Sterling Trucks	10-Dec-09
(88)	CL-035	1	Vehicle Searches by Security	10-Dec-09
(88)	CL-036	2	Debris Inspection	10-Dec-09
(88)	CL-037	0	ial Duties Bathrooms	10-Dec-09
(88)	CL-038	3	Hauling Waste Container to MW Embankment in Rock Trucks	10-Dec-09
(88)	CL-039	1	Operation of Loader with Forks	10-Dec-09
(88)	CL-040	2	Jump Starting Batteries	10-Dec-09

SUBCATEGORY	REFERENCE	REV[1]	TITLE	DATE[1]
(88)	CL-041	2	of dry material from rail cars (Rev 2).doc	10-Dec-09
(88)	CL-042	3	Rail Switching	10-Dec-09
(88)	CL-043	1	Container Movement	10-Dec-09
(88)	CL-044	1	Beryllium Waste Disposal in a Soil Lift.doc	10-Dec-09
(88)	CL-045	0	Roll-off Hoist Operation 5.27.08	27-May-08
(88)	CL-046	0	Use of Scissor Lift and Ladder for Entering or Exiting Railcars 10.22.08	22-Oct-08
(88)	CL-047	2	HP Functions at (ICWF) Intermodal Container Wash Facility	10-Dec-09
(88)	CL-048	1	peration of Servomat 75 MS Tire Changing Machine	10-Dec-09
(88)	CL-049	0	Offloading from railcars with lifting equipment	10-Dec-09
(88)	CL-050	2	Covering CLSM Pours with Tarps	10-Dec-09
(88)	CL-051	0	LP Rotor Size Reduction with Track-hoe and Shear Attachment 1.13.09	13-Jan-09
(88)	CL-052	1	Plasma Cutting	10-Dec-09
(88)	CL-053	1	Carbon Arc Cutting	10-Dec-09
J (88)	CL-054	1	Hauling Waste Containers with Flatbed Trailer	10-Dec-09
(88)	CL-055	0	Unloading End Dumps with Forklift	10-Dec-09
(88)	CL-056	0	Shredding and Repackaging PCB Waste	10-Dec-09
(88)	CL-057	0	Scanning Vehicles and Personnel at Gates	10-Dec-09
(88)	CL-058	0	Gas Powered Weed Sprayer	10-Dec-09
(88)	CL-059	1	Unloading-Hauling Waste from the Rotary Pit	10-Dec-09
(88)	CL-060	0	Use of Low Speed Floor Finishing Machine	10-Dec-09
(88)	CL-061	0	Mixed Waste Stabilization, Rev. 0	10-Dec-09
(88)	CL-062	1	Operation of Hand Drill or Impact Gun	10-Dec-09
(88)	CL-063	0	General Operation of Equipment	10-Dec-09
(88)	CL-064	2	Large Intermodal Rollover (Bertha)	10-Dec-09
(88)	CL-065	1	peration of 36K Pressure Washer	10-Dec-09
(88)	CL-066	0	Liquid Waste Transfer Using Vacuum Truck or Trailor Rev. 0	10-Dec-09
(88)	CL-068	0	Mixed Waste Shredder Operations, Rev. 0	10-Dec-09
(88)	CL-069	0	Treatment Buidling Decon and Maintenance Activities, Rev. 0	10-Dec-09
(88)	CL-070	1	Work in Monument Area 7.20.11	20-Jul-11
(88)	CL-071	0	umping Containers inside Treatment Building	10-Dec-09
(88)	CL-072	0	Operation of PTO Driven, Trailer Mounted Weed Sprayer	10-Dec-09
(88)	CL-073	0	Operation and Maintenance of Shop Band Saw	10-Dec-09
(88)	CL-074	0	Dumping of SeaLands with Sterling truck	10-Dec-09
(88)	CL-075	0	Vehicle Lifts in Maintenance Shop	10-Dec-09
(88)	CL-076	0	Welding Outside of the RA	10-Dec-09
(88)	CL-077	0	De-Vegetating Soil Stations by Hand	10-Dec-09
(88)	CL-078	0	Decon of End Dumps	10-Dec-09

SUBCATEGORY	REFERENCE	REV[1]	TITLE	DATE[1]
(88)	CL-079	1	Rotary Wash Facility	10-Dec-09
(88)	CL-080	0	Removal of Dunnage from Conveyance	10-Dec-09
(88)	CL-081	0	Alternative Cover Machine	10-Dec-09
(88)	CL-082	0	CLSM Debris Inspection	10-Dec-09
(88)	CL-083	0	QC Use of Troxler	10-Dec-09
(88)	CL-084	0	Using Lime Kilin Dust Silo to fill rock truck's	10-Dec-09
(88)	CL-085	0	Unloading Diaphragms from Intermodals or Sealands with the use of a Crane	10-Dec-09
(88)	CL-086	0	Chiming of Drums	10-Dec-09
(88)	CL-087	0	Rotary Facility Inspection	10-Dec-09
(88)	CL-088	0	Container Movement with Hyster Yardmaster	10-Dec-09
(88)	CL-089	0	Sieve Shaker	10-Dec-09
(30)	CL-LB-PR-001	1	Sample Control C of C Procedure	22-Mar-12
(30)	CL-LB-PR-002	1	Sample Management	2-Nov-10
(30)	CL-LB-PR-010	0	Pre-Shipment Waste Sample Acceptance & Tracking	30-Apr-10
(30)	CL-LB-PR-011	3	Sampling Incoming Waste Shipments	28-Dec-10
(30)	CL-LB-PR-012	0	Establishing Incoming Waste Sampling Requirements	28-Dec-10
(30)	CL-LB-PR-015	0	Remote Sampling Procedure	19-Nov-10
(30)	CL-LB-PR-020	0	Immediate Chemical Screening (Fingerprint) Analysis	10-Oct-07
(30)	CL-LB-PR-030	2	Laboratory Instrument Calibration and Maintenance	15-Feb-12
(30)	CL-LB-PR-040	1	Analytical Data Review	7-Sep-11
(30)	CL-LB-PR-100	2	Gamma Spectroscopy	16-Jun-11
(30)	CL-LB-PR-100	2	Gamma Spectroscopy	16-Jun-11
(30)	CL-LB-PR-101	2	Radiological Review of Incoming Waste Shipments	27-Apr-11
(30)	CL-LB-PR-102	0	Calibration of Gamma Spectroscopy Systems	3-Aug-11
(30)	CL-LB-PR-130	0	PT 2900 TR Liquid Scintillator Analyzer Calibration & Operation	5-Dec-07
(30)	CL-LB-PR-131	1	PT 2900tr Liqid Scintillation Analyzer Maintenance	31-Dec-09
(30)	CL-LB-PR-132	0	Detection of Tritium by Scintillation Analysis	5-Dec-07
(30)	CL-LB-WI-002	1	PCB Wipe Sampling	19-Jun-08
(30)	CL-LB-WI-003	0	Sampling Equipment Decontamination	11-Feb-08
(30)	CL-LB-WI-014	0	Preparation of Standards and Solutions for Trace Metals Analysis	16-Sep-11
(30)	CL-LB-WI-016	0	Acid Digestion of Water for Total Recoverable or Dissolved Metals Analysis	16-Sep-11
(30)	CL-LB-WI-017	0	Acid Digestion of Aqueous Samples and Extracts for Total Metals Analysis	16-Sep-11
(30)	CL-LB-WI-018	0	Determination of Metals and Trace Elements in Waters and Wastes by ICP Emission Spectroscopy	16-Sep-11
(30)	CL-LB-WI-022	0	Mercury in Liquid Waste Digestion and Analysis	16-Sep-11
(30)	CL-LC-PR-001	1	Guidelines For Ensuring Data Integrity	31-Dec-09

SUBCATEGORY		REFERENCE	REV[1]	TITLE	DATE[1]
	(30)	CL-LC-PR-100	0	Glassware Washing for Metal Prep and Analysis	31-Dec-09
	(30)	CL-LC-PR-110	0	Toxicity Characteristic Leaching Procedure	19-Jan-10
	(30)	CL-LC-PR-120	0	Operation of the TEII II ICP Spectrometer	26-Aug-09
	(30)	CL-LC-PR-121	0	Maintenance of the TEII II ICP Spectrometer	26-Aug-09
	(30)	CL-LC-WI-001	0	Test Methods for Oxidizing Solids	7-Dec-09
	(30)	CL-LC-WI-017	0	Acid Digestion of Aqueous Samples and Extracts for Total Metals Analysis	16-Sep-11
	(8)	CL-LD-PR-006	0	Disposal of Metals with HPTC	4-Jan-10
	(8)	CL-LD-PR-007	0	ES Generated Waste at LLRW Disposal Facility	4-Jan-10
LLRW Disp	(8)	CL-LD-PR-100	1	Large Component Handling and Disposal	4-Oct-10
	(8)	CL-LD-PR-101	0	Management of High Security Waste Types	4-Jan-10
	(8)	CL-LD-PR-102	0	Ion Exchange Resin Blending and Disposal	4-Jan-10
	(8)	CL-LD-PR-103	0	Control of Fugitive Dust	4-Jan-10
	(8)	CL-LD-PR-209	0	Asbestos Disposal	4-Jan-10
	(8)	CL-LD-PR-704	1	Stormwater Management	1-Jun-10
	(5)	CL-MN-PR-001	2	Used Oil Management	26-May-11
Maintenanc	(5)	CL-MN-WI-001	0	WI for Maintenance Filing & Record Keeping	29-Jun-09
	(5)	CL-MN-WI-002	0	Contaminated Equipment Maintenance and Decommissioning	25-Nov-09
	(5)	CL-MN-WI-003	0	Pressure Washing Stationary Equipment	21-Jul-11
M	(5)	CL-MN-WI-004	0	Air Brake System External Inspection	21-Sep-11
	(37)	CL-MD-PR-001	5	Unloading and Handling Highway Shipments	1-Jun-11
	(37)	CL-MD-PR-002	2	EnergySolutions Generated Waste	27-Jul-11
	(37)	CL-MD-PR-003	3	Container Movement	28-Mar-11
	(37)	CL-MD-PR-004	2	Waste Disposal Direct and Treated	27-Feb-12
	(37)	CL-MD-PR-006	1	Removal of Placed Waste	18-May-09
Mixed Waste Disposa	(37)	CL-MD-PR-007	3	Update Facility Tracking Record	16-Mar-12
	(37)	CL-MD-PR-008	1	Incoming Shipment Inspection and Sampling	27-Aug-10
	(37)	CL-MD-PR-009	2	Unloading and Handling Rail Shipments	1-Jun-11
Mixed	(37)	CL-MD-PR-010	1	Management of UNNPI Waste from US DOE and DOD	21-Oct-10
	(37)	CL-MD-PR-011	2	Empty PCB Container Management	2-Jun-10
	(37)	CL-MD-PR-012	1	Management of Waste for Disposal at LLRW	1-Jul-10
	(37)	CL-MD-PR-100	1	Decontamination of Transport Vehicles	7-Aug-09
	(37)	CL-MD-PR-101	2	Decontamination of Containers	28-Nov-11
	(37)	CL-MD-PR-102	1	Decontamination of Equipment	18-May-09

SUBCATEGORY	REFERENCE	REV[1]	TITLE	DATE[1]
(37)	CL-MD-PR-103	4	90 Day and Satellite Accumulation Container Management	17-Mar-11
(37)	CL-MD-PR-104	2	Leachate Collection	7-Nov-11
(37)	CL-MD-PR-105	2	Waste Water Transfer	27-Jun-11
(37)	CL-MD-PR-106	2	90 Day Evaporation and Settling Tank Clean Out	17-Oct-11
(37)	CL-MD-PR-107	1	PCB Contaminated Empty Container Management	29-Sep-10
(37)	CL-MD-PR-108	2	Polymer Application and Dust Suppression	25-Jul-11
(37)	CL-MD-PR-109	0	Universal Waste Identification and Management	3-Apr-08
(37)	CL-MD-PR-110	0	Decontamination of Gondolas in the MW Area	26-Aug-08
Mixed Waste Disp (37)	CL-MD-PR-200	4	Daily Weekly and Monthly Inspections	24-Jun-11
(37)	CL-MD-PR-201	1	Annual Inspections	7-Dec-10
(37)	CL-MD-PR-202	1	Storage Summary Verification	27-Aug-10
(37)	CL-MD-WI-001	1	MW to LLRW Equipment Transfer	30-Mar-11
(37)	CL-MD-WI-002	1	MW Container Tracking	30-Mar-11
(37)	CL-MD-WI-007	1	MW Operations QADEP	30-Mar-11
(37)	CL-MD-WI-300	1	Stationary Truck Scale Operation	7-Feb-11
(37)	CL-MD-WI-301	1	Vactor Truck Operations	14-Oct-10
(37)	CL-MD-WI-302	2	Decontamination Pressure Pump Operations	19-Jan-12
(37)	CL-MD-WI-303	1	Vacuum Trailer Operations	14-Oct-10
(37)	CL-MD-WI-304	1	Portable Truck Scale Operation	7-Feb-11
(37)	CL-MD-WI-305	2	Offloading of Liquid Waste Tankers	16-Dec-09
(37)	CL-MD-WI-307	0	PCB Container Decontamination	23-Jan-08
(37)	CL-MD-WI-308	0	Sampling Plan - 9407-03 Railcars	12-Mar-08
(37)	CL-MD-WI-999	0	SPRU Drum Characterization	22-Nov-10
(31)	CL-MT-PR-001	1	Pre Operational Briefing	28-Sep-10
(31)	CL-MT-PR-002	3	Waste Stabilization	18-Aug-10
(31)	CL-MT-PR-003	0	Decontamination Between Stabilization Waste Streams	6-Mar-08
(31)	CL-MT-PR-004	1	Stablization Formula Development	10-May-10
(31)	CL-MT-PR-005	0	Solidification Formula Development	8-Mar-11
(31)	CL-MT-PR-101	2	Pre Processing Waste	28-Sep-10
(31)	CL-MT-PR-103	0	Draining Battery Acid	18-Apr-08
(31)	CL-MT-PR-104	0	Foam Filling Internal Voids	17-Apr-08

SUBCATEGORY	REFERENCE	REV[1]	TITLE	DATE[1]
(31)	CL-MT-PR-105	0	Macro Vault Operations	30-Oct-08
(31)	CL-MT-PR-107	1	Draining Large Capacitors	22-Jul-10
Mixed Waste (31)	CL-MT-PR-108	0	Draining and Flushing of PCB Items	22-Jul-10
(31)	CL-MT-PR-200	3	Waste Constituent Verification	27-Jul-11
(31)	CL-MT-PR-203	1	Fire System Inspection	7-Jan-11
Mixed Waste Treatm (31)	CL-MT-PR-300	1	Drum Compactor Operation	27-Aug-10
(31)	CL-MT-PR-301	1	Mixer Number One Operation	27-Aug-10
(31)	CL-MT-PR-302	1	Small Scale Operation	31-Mar-11
(31)	CL-MT-PR-304	2	Primary Shredder Operation	29-Nov-11
(31)	CL-MT-PR-305	1	Tertiary Shredder Operation	16-Feb-11
(31)	CL-MT-PR-307	2	Baghouse Operation	31-Mar-11
(31)	CL-MT-PR-400	1	Waste Solidification	14-Jan-10
(31)	CL-MT-PR-401	1	Spray Wash Operation	14-Dec-10
(31)	CL-MT-PR-500	1	Thermal Desorption Pre Operational Briefing	27-Aug-10
(31)	CL-MT-PR-501	2	Thermal Desorption Operations	27-May-11
(31)	CL-MT-PR-502	1	Thermal Desorption Waste Sampling	27-Aug-10
(31)	CL-MT-WI-004	0	Treatment Reagent Management	2-Mar-09
(31)	CL-MT-WI-006	0	Liquid Waste Repackaging	3-Mar-09
(31)	CL-MT-WI-016	1	VTD Condensate Management	13-May-09
(31)	CL-MT-WI-025	0	Antifreeze Recycling	2-Aug-09
(31)	CL-MT-WI-306	1	Air Compressor Operation	15-Feb-11
Mixed Waste T (31)	CL-MT-WI-313	1	VTD Waste Sort and Segregation Plan	13-May-09
(31)	CL-MT-WI-320	0	Portable Mixer WI	22-Jul-09
(1)	CL-OS-PR-300	2	Batch Plant Operations	6-Sep-11
(1)	CL-PU-PR-001	0	Completing Purchasing Requisitions in Oracle	3-Aug-10
(23)	CL-QA-PR-005	2	Quality Assurance Records	25-May-11
(23)	CL-QA-PR-090	3	Receipt Inspection	11-Apr-11
Quality Assurance/Quality Cont (23)	CL-QA-WI-018	2	Instructions for the Interim Storage and Destruction of Records	5-Aug-11
(23)	CL-QA-WI-019	0	Quarterly Verification of Closed Condition Reports	1-Aug-11

SUBCATEGORY	REFERENCE	REV[1]	TITLE	DATE[1]
(23)	CL-QA-WI-021	2	Indoctrination and Training	2-Dec-10
(23)	CL-QA-WI-120	2	Control of Measuring & Testing Equipment	16-Feb-12
(23)	CL-QA-WI-163	2	Causal Analysis	18-May-11
Quality Assuran (23)	CL-QA-WI-171	2	Record Storage Environmental Control	6-Nov-09
(23)	CL-QA-WI-172	0	Management of Clive Server Back Up Media	20-May-09
(23)	CL-QC-PR-011	5	M and TE Calibration	6-Mar-12
(23)	CL-QC-PR-015	3	Density Testing	20-Jun-11
(23)	CL-QC-PR-016	1	Construction Surveying	28-Aug-09
(23)	CL-QC-PR-018	1	In Cell Bulk Disposal	20-Jun-11
(23)	CL-QC-PR-021	1	Standard Practice for Sampling Aggregates from Stockpiles	16-Mar-10
(23)	CL-QC-PR-025	2	Standard Practice for Achieving Certified AMRL Results	1-Nov-11
(23)	CL-QC-PR-032	3	Disposal of Waste with CLSM	6-Mar-12
(23)	CL-QC-PR-034	2	Disposal of Waste Soils	6-Mar-12
(23)	CL-QC-PR-035	3	Debris Placement in Soil Waste Lifts	6-Mar-12
(23)	CL-QC-PR-036	1	CWF Waste Placement and Backfilling Specifications	2-Sep-11
(23)	CL-QC-PR-037	0	Placement of Intermediate & Backfill Cover Layers	13-May-08
(23)	CL-QC-PR-038	4	Lift Approval Using an 826 Compactor	26-May-11
(23)	CL-QC-PR-040	1	Railcar Moisture Determination	16-Mar-10
	CL-QC-PR-092	1	Open Cell Tracking	29-Sep-10

SUBCATEGORY		REFERENCE	REV[1]	TITLE	DATE[1]
(23)					
	(23)	CL-RS-PR-051	0	Health Physics Training and Qualification	27-Aug-10
	(23)	CL-RS-PR-061	2	Director of Health Physics Inspections	20-Oct-10
	(23)	CL-RS-PR-112	3	Radiological Surveys	12-May-11
	(23)	CL-RS-PR-113	1	VTD Radiological Monitoring	28-Apr-10
	(23)	CL-RS-PR-114	2	Receipt and Evaluation of Radiologically Contaminated Material and Equipment for Use Reuse at EnergySolutions	23-Mar-12
	(23)	CL-RS-PR-120	9	Access Control Points	29-Nov-11
	(23)	CL-RS-PR-130	12	ALARA	16-Nov-11
	(23)	CL-RS-PR-130	2	Radiological Control	15-Nov-11
	(23)	CL-RS-PR-140	3	Radiation Work Permit	9-Mar-11
	(23)	CL-RS-PR-150	2	Posting Requirements for Radiological Hazards	15-Nov-11
	(23)	CL-RS-PR-155	6	Radiation Protection Program	12-Mar-12
	(23)	CL-RS-PR-170	6	Restricted Area Material Release	29-Sep-11
	(23)	CL-RS-PR-180	1	Restricted Area Release Surveys	9-Jun-11
	(23)	CL-RS-PR-210	1	Personnel External Radiation Monitoring	9-Mar-10
	(23)	CL-RS-PR-220	1	Bioassay Monitoring	17-Mar-10
	(23)	CL-RS-PR-230	2	Work Area Air Sampling	29-Sep-11
	(23)	CL-RS-PR-240	2	Lapel Pump Air Sampling	23-Mar-12
	(23)	CL-RS-PR-250	1	Working Level Measurements Radon Thoron	20-Jan-10
Radiation	(23)	CL-RS-PR-280	1	Internal Dose Determination	3-Jun-11
	(23)	CL-RS-PR-290	1	Rn 222 Working Level Measurement Using Kusnetz Procedure	14-Jan-11
	(23)	CL-RS-PR-434	1	Source Leak Check Procedure	28-Apr-10
Radiati	(23)	CL-RS-PR-438	0	Radioactive Source Inventory	3-Jun-10
	(23)	CL-RS-PR-701	1	HIS 20 Health Physics Information System	9-Jun-11
(26)		CL-SH-PR-020	2	Safety Incidents	8-Dec-11
(26)		CL-SH-PR-050	3	Equipment Operations	5-Oct-11
(26)		CL-SH-PR-052	7	Safe Rail Operations	10-Feb-12
(26)		CL-SH-PR-053	1	Motor Carrier Safety Compliance	4-Jan-11
(26)		CL-SH-PR-070	3	Clive Respiratory Protection Program	21-Feb-12
(26)		CL-SH-PR-071	1	Respirator Maintenance and Issue	12-Jul-10
(26)		CL-SH-PR-072	0	Supplied Air Respirator Use	22-Sep-10
(26)		CL-SH-PR-120	1	Machine Guarding Flying Debris Protection	30-Dec-10
		CL-SH-PR-	1	Clive Heat Stress Program	23-Dec-10

SUBCATEGORY	REFERENCE	REV[1]	TITLE	DATE[1]
(26)	130			
(26)	CL-SH-PR-140	1	Material Handling	1-Feb-11
(26)	CL-SH-PR-141	2	Propane Storage Filling and Handling	26-Sep-11
Safety (26)	CL-SH-PR-142	2	Extension Cord Safety	23-Aug-11
(26)	CL-SH-PR-150	1	Laboratory Chemical Hygiene Plan	3-Jun-09
(26)	CL-SH-PR-170	1	Hand and Power Tools	23-Dec-10
(26)	CL-SH-PR-201	3	Control of Hot Work	26-Mar-12
(26)	CL-SH-PR-301	0	Bloodborne Pathogens	7-Jul-11
(26)	CL-SH-PR-302	1	Beryllium Waste Handling	29-Mar-11
(26)	CL-SH-PR-303	1	Hazard Communication Labeling	3-Nov-08
(26)	CL-SH-PR-500	3	Emergency Response Plan	6-Aug-10
(26)	CL-SH-PR-501	3	Safe Site Shutdown Plan	9-Jun-11
(26)	CL-SH-PR-502	1	Medical Emergencies	30-Jun-08
(26)	CL-SH-PR-503	2	Clive Facility Fire Protection and Prevention Plan	5-Jan-12
(26)	CL-SH-WI-110	4	Confined Space Evaluation and Labeling	21-Jun-11
(26)	CL-SH-WI-111	0	Industrial Hygiene Surveys	13-Aug-09
(26)	CL-SH-WI-112	1	Confined Space Permit Issue	22-Jun-11
(26)	CL-SH-WI-113	0	Safety and Health Waste Stream Review	12-Sep-11
(2)	CL-SE-PR-010	5	Security Operations Protocol	5-Jan-12
(2)	CL-SE-PR-020	6	Issuing Badges to Visitors	28-Jan-11
(8)	CL-SR-PR-041	8	Incoming Radioactive Waste Shipment Acceptance	30-Jun-11
(8)	CL-SR-PR-051	1	Shipment of Radioactive Material	10-Feb-09
(8)	CL-SR-PR-052	0	Package Preparation of Radioactive Material for Transportation	2-Jul-09
(8)	CL-SR-PR-053	0	Shipping of Hazardous Material Lab Samples	28-Mar-08
(8)	CL-SR-WI-001	0	Waste Acceptance Notification	28-Sep-09
Shipping and (8)	CL-SR-WI-002	1	Electronic Manifest 7 Day Return	6-Jul-10
(8)	CL-SR-WI-009	0	EWIS QA Instruction	16-Sep-09

SUBCATEGORY	REFERENCE	REV[1]	TITLE	DATE[1]
(8)	CL-SR-WI-021	0	Empty Container Storage	18-May-09
(1)	CL-TS-WI-001	0	QADEP for Technical Services	12-Jun-09
(7)	CL-TN-PR-010	2	General Training Procedure	2-Sep-11
(7)	CL-TN-PR-020	2	Initial Training Procedure	2-Sep-11
(7)	CL-TN-PR-030	6	Qualification Procedure	3-Nov-11
(7)	CL-TN-PR-040	2	Continuing Training Procedure	2-Sep-11
(7)	CL-TN-PR-050	2	Testing and Evaluation Procedure	2-Sep-11
(7)	CL-TN-PR-060	2	Training Documentation and Storage Procedure	2-Sep-11
(7)	CL-TN-PR-080	2	Trained Personnel Badging Procedure	2-Sep-11
(1)	CL-WM-PR-001	4	Waste Profile Acceptance Process	11-Nov-11
(1)	CL-WP-PR-001	2	Shredder Operations	3-Nov-10

APPENDIX K

HAL Side Slope/Drainage Ditch Design Analysis

HANSEN ALLEN & LUCE INC
ENGINEERS

Memorandum

DATE: October 12, 2012

TO: Vern C. Rogers, PhD
EnergySolutions, Chief Scientist
423 West 300 South, Suite 200
Salt Lake City, Utah 84101

FROM: Gordon L. Jones, P.E.
Hansen, Allen & Luce, Inc.
6771 South 900 East
Midvale, Utah 84047

PROJECT: ET Cover Slope and Ditch Analysis

PROJECT NO.: 106.06.100

BACKGROUND

Hansen, Allen & Luce (HAL) was requested by EnergySolutions to complete an analysis of slope configurations for a potential Evapotranspiration (ET) Cover System for the Class A West (CAW) embankment at the Clive, Utah facility. EnergySolutions has proposed to construct a Class A embankment that effectively combines the current Class A and Class A North embankments. Included in the request to the Utah Division of Radiation Control was a proposed rock-armor cover similar to what was used to close the LARW and VITRO embankments. In order to better manage runoff water, EnergySolutions is in the process of analyzing an ET cover system. As part of the revised cover design analysis, EnergySolutions asked HAL to analyze the optimal angle of the cover side-slope and water management ditches to better maximize evapotranspiration and minimize the precipitation runoff management currently required by LARW and VITRO.

POTENTIAL SLOPE CONFIGURATIONS

The potential slope configurations are somewhat limited due to the proximity of the CAW embankment to the Section 32 property line to the west and other embankments to the south and east. The north side of the CAW embankment is the only side without limitations from property or facility constraints. HAL was provided with drawings showing the proposed CAW configuration, including the location of existing and proposed groundwater monitoring wells. The monitoring wells are typically 85 to 90 feet from the toe of the waste and would need to be able to be maintained at that distance. The south side of the CAW embankment is limited by the 11(e)2 embankments to the south where the existing monitoring wells are between the two facilities. Due to the site limitations of the south side, only the 5:1 side slope scenario will be looked at for the south side slope. The east side is limited by the VITRO embankment. The slope configurations for each side are presented in Table 1.

TABLE 1
CLASS A WEST EMBANKMENT SIDE SLOPE CONFIGURATIONS

Side Slope	Slope Scenario	Slope Length (ft)	Slope (%)
North Side	#1	188	20.0
	#2	268	13.7
	#3	366	10.0
West Side	#1	188	20.0
	#2	268	13.7
	#3	366	10.0
East Side	#1	188	20.0
	#2	268	13.7
	#3	268	13.7
South Side	#1	188	20.0
	#2	188	20.0
	#3	188	20.0

CAW EMBANKMENT HYDROLOGY

A hydrologic analysis was performed in order to determine the optimal side slope angle from a runoff perspective. The analysis was completed using the SCS Curve Number method with the Army Corps of Engineers Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS).

Drainage Basin Characteristics

The curve number for the facility was selected based on the area's Skumpah silt loam that has been proposed to use as the cover soil. This soil has a defined hydrologic soil type of Type D. Although the characteristics of the soil may be altered following its removal and placement as cover, the native characteristics were selected in order to be conservative for the runoff analysis. The curve number was selected based on the vegetation cover information provided by EnergySolutions. Information from nine vegetation survey plots in the Clive area were provided and showed that the average vegetation cover is 18%. The sagebrush with grass understory cover type was chosen (TR-55, Table 2-2d) with a poor condition (<30% ground cover) resulting in an initial curve number of 85.

The curve numbers were adjusted based on the methodology presented in the Hydrologic Evaluation of Landfill Performance (HELP) model user manual. The methodology utilizes a regression equation which was developed to adjust the AMC-II curve number for surface slope conditions. The regression was developed based on kinematic wave theory where hundreds of runoff estimates were generated using different combinations of soil texture class, level of vegetation, slope, slope length, and rainfall depth, duration and temporal distribution using the KINEROS kinematic runoff and erosion model. The resulting regression equation for adjusting the curve number for slope is:

$$\mathbf{CN_{II} = 100 - (100 - CN_{IIo}) * (L^{*2} / S^*) \wedge CN_{IIo}^{-0.81}}$$

Where

CN_{II} = *Slope Adjusted Curve Number*

CN_{IIo} = *Initial Curve Number*

L = standardized dimensionless length, (L/500 ft) where L is slope length in feet*

S = standardized dimensionless slope, (S/0.04) where S is slope in ft/ft*

Lag times were calculated using the time of concentration methodology outlined in the TR-55 manual, including sheet flow and shallow concentrated flow.

The proposed CAW Embankment was divided into eight subbasins. The top slope subbasins are shown in Table 2. The top slopes will not be varied as part of the analysis and will maintain the dimensions shown in the table.

TABLE 2
CLASS A WEST EMBANKMENT TOP SLOPE SUBBASIN CHARACTERISTICS

Subbasin	Area (acres)	Initial CN_{IIo}	L (ft)	S (ft/ft)	Adjusted CN_{II}	Lag Time (min)
North Top	20.33	85	942	0.04	84.47	55.1
West Top	27.04	85	942	0.04	84.47	55.1
East Top	20.37	85	942	0.04	84.47	55.1
South Top	27.01	85	942	0.04	84.47	55.1

Table 3 contains the side slope subbasin characteristics for each slope scenario presented in Table 1. The South Side slope scenario contains the same geometry for each because of its facility limitations to the south.

TABLE 3
CLASS A WEST EMBANKMENT SIDE SLOPE SUBBASIN CHARACTERISTICS

Subbasin	Slope Scenario	Area (acres)	Initial CN_{IIo}	L (ft)	S (ft/ft)	Adjusted CN_{II}	Lag Time (min)
North Side	#1	8.93	85	188	0.20	86.39	17.9
	#2	13.22	85	268	0.14	85.99	27.7
	#3	18.88	85	366	0.10	85.62	40.6
West Side	#1	10.27	85	188	0.20	86.39	17.9
	#2	15.14	85	268	0.14	85.99	27.7
	#3	21.50	85	366	0.10	85.62	40.6
East Side	#1	10.29	85	188	0.20	86.39	17.9
	#2	15.15	85	268	0.14	85.99	27.7
	#3	15.15	85	268	0.14	85.99	27.7
South Side	#1	8.94	85	188	0.20	86.39	17.9
	#2	8.94	85	188	0.20	86.39	17.9
	#3	8.94	85	188	0.20	86.39	17.9

Design Frequency

The 100-year storm frequency, or a storm with a 1% chance of occurring in any given year, was chosen as the basis for the hydrology analysis for the ET cover slope and ditch analysis.

Design Rainstorm

A sensitivity analysis was performed using 1-hour, 3-hour, 6-hour, 12-hour and 24-hour storm events. The 1-hour, 3-hour and 6-hour storm events were distributed using the Farmer-Fletcher storm distribution. Farmer and Fletcher (1971) examined rainfall gage records and classified storms based on whether the heaviest rainfall of the storm fell in the first, second, third or fourth quarter of the storm period. Farmer and Fletcher found that "first and second quartile storms together comprise 76 percent of those storms containing a burst of 5-minute duration with a 2-year recurrence interval and 92 percent of storms containing a burst of 10-minute duration, with a 10-year recurrence interval." Farmer and Fletcher developed model storms for the first and second quartile storms.

The 12-hour and 24-hour storm events were analyzed using the GBEA storm distribution. Thirteen separate gaging stations in the Great Basin Experimental Area (GBEA) (ranging in elevation from 5,500 feet to over 10,000 feet) were maintained for varying periods of time from 1919 to 1965. Fifteen gaging stations were maintained in the Davis County Experimental Watershed (ranging in elevation from 4,350 feet to 9,000 feet) for varying periods of time between 1939 and 1968. After completing their analyses of the data, Farmer and Fletcher found that “more than 50 percent of the storm rainfall depth occurs in 25 percent of the storm periods;” and that “usually more than half of the total depth of rain is delivered as burst rainfall.” Farmer and Fletcher developed design storm distributions which have become accepted by governmental entities including Salt Lake County and Davis County as the characteristic distributions for storms in Utah of short duration (generally less than six hours).

The work of Farmer and Fletcher was expanded in 1985 to develop a longer duration rainfall distribution from the GBEA data (VHA, 1985). For the derivation of the design 24-hour rainfall event, a storm was defined “as a period of continuous or intermittent precipitation delivering at least 0.1 inches of rainfall during which time dry periods without rainfall did not exceed four hours.” Storm having durations ranging from 20 hours to 28 hours were accepted to be representative of a 24-hour storm duration. The 24-hour duration storms were then screened to include only storms which contained rainfall meeting the burst criteria of having over 50 percent of the precipitation occurring in less than 25 percent of the time. Storms meeting the burst criteria were further categorized in accordance with which quartile of the storm the burst had occurred (i.e. the first, second, third or fourth quarter of the storm period). Identified storms were used to develop a 24-hour design storm distribution for use in Utah. A sensitivity analysis for all storm distributions developed shows the 3rd quartile storm distribution to produce the higher runoff peaks. The GBEA 3rd Quartile storm distribution developed in 1985 includes a burst of rainfall with an approximate 10 percent of the 24-hour total rainfall falling within a half hour period. In a similar comparison, the SCS Type II distribution allows approximately 62 percent of the total precipitation to occur within the same period. Because the distribution was developed based on local data, the GBEA distribution is believed to be the best available storm distribution for Utah for storms lasting between 6 and 24 hours.

Additionally, the SCS Type II rainfall distribution was also analyzed because of its acceptability to regulators. While the SCS Type II distribution produced a higher peak runoff flow rate than the GBEA distribution for a 24 hour storm, this duration using either distribution was not found to govern based on the results of the sensitivity analysis.

Precipitation depths were determined based on the NOAA Atlas 14 Point Precipitation Frequency Estimates data server. The design rainfall amounts used for the hydrologic analysis and the sensitivity analysis are shown in Table 4.

TABLE 4
DESIGN RAINFALL DEPTHS FOR CLIVE, UTAH

Storm Duration	100-Year Rainfall Depth (inches)
1-hour	1.37
3-hour	1.45
6-hour	1.47
12-hour	1.57
24-hour	1.77

.

Computation of Runoff Hydrographs

Hydrographs were computed for each subbasin, conveyance and junction within the storm drain model. The maximum value from each hydrograph is the peak runoff flow rate. Hydrographs were computed for Slope Scenario #1 using the 1-hour, 3-hour, 6-hour, 12-hour and 24-hour storm durations. The 3-hour storm was found to result in the highest peak runoff flow rates and was therefore selected for use in the hydrologic analysis. The peak flow rate for each subbasin and for the overall CAW embankment at the southwest corner ditch confluence are reported in Table 5.

TABLE 5
PREDICTED PEAK FLOW RATES FOR CAW SIDE SLOPE SCENARIOS
(3-hr 100-year Storm)

Slope Scenario	Subbasin/Location	Slope (ft/ft)	Peak Flow (cfs)
#1	North Top	0.04	5.1
	West Top	0.04	6.8
	East Top	0.04	6.8
	South Top	0.04	5.1
	North Side	0.20	4.7
	West Side	0.20	5.4
	East Side	0.20	5.4
	South Side	0.20	4.7
	Southwest Confluence	-	**28.0**
#2	North Top	0.04	5.1
	West Top	0.04	6.8
	East Top	0.04	6.8
	South Top	0.04	5.1
	North Side	0.14	6.9
	West Side	0.14	7.9

TABLE 5 (Continued)

Slope Scenario	Subbasin/Location	Slope (ft/ft)	Peak Flow (cfs)
	East Side	0.14	7.9
	South Side	0.20	4.7
	Southwest Confluence	-	**33.0**
#3	North Top	0.04	5.1
	West Top	0.04	6.8
	East Top	0.04	6.8
	South Top	0.04	5.1
	North Side	0.10	6.5
	West Side	0.10	7.4
	East Side	0.14	7.9
	South Side	0.20	4.7
	Southwest Confluence	-	**32.3**

ET COVER EROSION ANALYSIS

Gully Erosion Analysis

As opposed to the long-term effects of precipitation over time with rill erosion, the effects of gully erosion are determined from large single rainfall events. Procedures for gully erosion protection determination were taken from NUREG-1623 "Design of Erosion Protection for Long-Term Stabilization" for vegetated soil cover. First, the peak flow (Q) is computed using the rational formula based on the intensity from the PMP. From the previous PMF analysis, the 1-hour PMP was computed to be 10.1 inches. Therefore, an intensity of 10.1 inches/hour was used for the analysis. The equation for the computation of flow is:

$$Q = Fci\,A$$

Where:

Q = Runoff Rate, cfs/ft

F = Flow concentration factor, recommended to use a factor of 3.

c = dimensionless runoff coefficient

i = rainfall intensity, in/hr

A = catchment area, in this case a 1 foot wide strip along the length of the slope, acres

Using this flow rate, a flow depth is calculated by solving the Manning Equation for normal depth on a one foot wide strip along the slope length. The derivation is as follows:

$$\mathbf{y^{5/3} = Qn / (1.486\ S^{1/2})}$$

and $\mathbf{V = Q/y}$

The findings of both the top slope and the side slope using the vegetated slope condition are summarized in Table 6.

Slope Description	Cover Type	Length (ft)	Slope (ft/ft)	i (in/hr)	c	Q (cfs/ft)	V ft/sec
Top Slope (4%	ET Cover System	942	0.04	10.1	0.5	0.33	0.81
Side Slope (20%)	ET Cover System	188	0.20	10.1	0.5	0.39	1.41

The acceptable Maximum Permissible Velocity (MPV) for this area is in the 2.5 to 3.5 ft/sec range. Therefore, all slope scenarios using the ET Cover system provide acceptable protection against gully erosion.

Rill and Interrill Erosion Analysis

Soil erosion by water can be quantified as the amount of soil lost from a given slope which can be predicted on a per unit area basis. The Universal Soil Loss Equation (USLE) and the subsequently revised (RUSLE) were used to determine the adequacy of the ET cover to protect against excessive rill and interrill erosion, and is defined as:

A = R*K*LS*C*P

Where:

A = the average soil loss per unit of area, expressed in tons/acre/year

R = the rainfall/runoff factor, which is the number of rainfall units for rainfall energy and runoff and snowmelt.

K = Soil erodibility factor in tons per acre per year per unit of R

LS = Topographic factor (length and steepness of the slope

C = the cover and management factor (equivalent to the VM factor), which is the ratio of soil loss from an area with a given cover and management relative to that from an identical area in continuous fallow.

P = the supporting conservation practice factor, in this case assumed to be equal to 1

This procedure is taken from the publication "Erosion and Sedimentation in Utah – A Guide for Control" (Utah Water Research Laboratory, February 1984) and from "Design Hydrology and Sedimentation for Small Catchments" (C.T. Haan et al., Academic Press, Inc., 1994). The erosion characteristics and factors as well as the computed average soil loss are presented in Table 5.

TABLE 5
EFFECTS OF RILL EROSION WITH ET COVER SYSTEM – SOIL LOSS ANALYSIS
(PROCESSED SECTION 5 CLAYS)

Slope Segment(s)	R (ft tons/ac/hr)	K (tons/ac/EI)	L (ft)	S (%)	C	A (tons/ac/yr)	
Top Slope (4%) plus Side Slope (20%)	6	0.26	942 (4%)	4%	0.2	0.4	1.5 overall
			188 (20%)	20%		7.2	
Top Slope only (4%)	6	0.26	942	4%	0.2	0.4	

= exceeds design limit

According to a 1991 Seminar Publication from the EPA entitled "Design and Construction of RCRA/CERCLA Final Covers", the minimum criteria is a cover soil loss of less than 2 tons/acre/year. The criteria have been applied to this application because specific requirements for low-level radioactive and hazardous waste facilities are not defined in the State of Utah. Therefore, as shown in Table 5 above, the combination of a top slope and side slope with the vegetative cover will not be sufficient to protect against excessive erosion using the processed clays alone. The effects of rill erosion if a 15% gravel mixture were added to the processed clays are presented in Table 6.

TABLE 6
EFFECTS OF RILL EROSION WITH ET COVER SYSTEM – SOIL LOSS ANALYSIS
(PROCESSED SECTION 5 CLAYS WITH 15% GRAVEL)

Slope Segment(s)	R (ft tons/ac/hr)	K (tons/ac/EI)	L (ft)	S (%)	C	A (tons/ac/yr)	
Top Slope (4%) plus Side Slope (20%)	6	0.18	942 (4%)	4%	0.2	0.3	1.0 overall
			188 (20%)	20%		5.0	
Top Slope only (4%)	6	0.18	942	4%	0.2	0.3	

= exceeds design limit

A 15% gravel mixture improves the performance against soil loss but still does not reduce the side slope to less than 2 tons/acre/year as shown in Table 6. The top slope, however, is additive due to length but independent with regard to the K value to the side slope. Therefore, it would be acceptable to use the section 5 clays (processed or unprocessed) without any gravel mixture which would achieve less than 2 tons/acre/year for the top slope. If the side slope geometry were kept at the current 20% design, than the only option for reaching the 2 tons/acre/year criteria would be to reduce the K value to 0.07. This would require adding approximately 47% gravel to the processed clay. The ability of this type of soil mixture to support the 20% native vegetative cover is unknown. This scenario is shown in Table 7.

TABLE 7
EFFECTS OF RILL EROSION WITH ET COVER SYSTEM – SOIL LOSS ANALYSIS
(TOP SLOPE WITH PROCESSED SECTION 5 CLAY AND SIDE SLOPE WITH PROCESSED SECTION 5 CLAY AND 47% GRAVEL)

Slope Segment(s)	R (ft tons/ac/hr)	K (tons/ac/EI)	L (ft)	S (%)	C	A (tons/ac/yr)	
Top Slope (4%) plus Side Slope (20%)	6	0.26	942 (4%)	4%	0.2	0.4	0.6 overall
		0.07	188 (20%)	20%		1.9	
Top Slope only (4%)	6	0.26	942	4%	0.2	0.4	

The other option available is to adjust the side slope lengths and grade in order to achieve the design criteria for soil loss. The ability to vary the slope is limited on the west because of the property line (toe of waste must be greater than 300 feet from the property line and the current design places it at 300 feet) and on the south because of another cell and the need to maintain proper distance to the monitoring well (85-90 feet from the toe of waste which is where it is located for the current design). One option to get around these constraints is to use clean fill instead of waste to flatten the slope thereby keeping the actual toe of waste in the same location. The east side is limited by the Vitro cell. The north slope does not have any constraints beyond EnergySolutions' own facility buildings and operations. The acceptable slopes with respect to soil loss for a given gravel mix for the side slopes are shown in Tables 8 and 9.

TABLE 8
EFFECTS OF RILL EROSION WITH ET COVER SYSTEM – SOIL LOSS ANALYSIS
(4% TOP SLOPE WITH PROCESSED SECTION 5 CLAY AND 10% SIDE SLOPE WITH PROCESSED SECTION 5 CLAY AND 15% GRAVEL)

Slope Segment(s)	R (ft tons/ac/hr)	K (tons/ac/EI)	L (ft)	S (%)	C	A (tons/ac/yr)	
Top Slope (4%) plus Side Slope (10%)	6	0.26	942 (4%)	4%	0.2	0.4	0.7 overall
		0.18	366 (10%)	10%		1.6	

TABLE 9
EFFECTS OF RILL EROSION WITH ET COVER SYSTEM – SOIL LOSS ANALYSIS
(4% TOP SLOPE WITH PROCESSED SECTION 5 CLAY AND 13.7% SIDE SLOPE WITH PROCESSED SECTION 5 CLAY AND 30% GRAVEL)

<table>
<tr><th>Slope Segment(s)</th><th>R
(ft tons/ac/hr)</th><th>K
(tons/ac/EI)</th><th>L
(ft)</th><th>S
(%)</th><th>C</th><th colspan="2">A
(tons/ac/yr)</th></tr>
<tr><td rowspan="2">Top Slope (4%) plus Side Slope (13.7%)</td><td rowspan="2">6</td><td>0.26</td><td>942 (4%)</td><td>4%</td><td rowspan="2">0.2</td><td>0.4</td><td rowspan="2">0.7 overall</td></tr>
<tr><td>0.13</td><td>268 (13.7%)</td><td>10%</td><td>1.99</td></tr>
</table>

REFERENCES

Haan, C.T., Barfield, B.J., Hayes, J.C., 1994. Design Hydrology and Sedimentology for Small Catchments. Academic Press, Inc, San Diego, California.

Hansen, Allen & Luce, 1991. USPCI - Prediction of 100-Year Flood Plain Section 36 Township 1 South, Range 12 West. Hansen, Allen and Luce, Midvale, Utah.

Hansen, Allen & Luce, 2012. PMF and 100-year Storm Analysis for Clive, Utah (Draft). Midvale, Utah.

Israelsen, C. Earl, Fletcher, Joel E., Haws, Frank W., Kisraelsen, Eugene K., 1984. Erosion and Sedimentation in Utah: A Guide for Control. Utah Water Research Laboratory, Logan, Utah.

U.S. Army Corps of Engineers, 2008. HEC-RAS River Analysis System Version 4.0. Hydrologic Engineering Center, Davis, California.

U.S. Army Corps of Engineers, 2010. Hydrologic Modeling System (HEC-HMS). Hydrologic Engineering Center, Davis, California.

U.S. Geological Survey, 1973. Aragonite NW, Utah; Aragonite, Utah; Hastings Pass, Utah; and Low, Utah Quadrangle Maps.

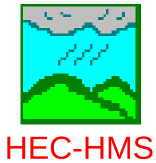
U.S. Geological Survey, 1987. Bonneville Salt Flats, Utah, 30 x 60 Minute Quadrangle Map.

U.S. Nuclear Regulatory Commission, 2002. Design of Erosion Protection for Long-Term Stabilization. Office of Nuclear Material Safety and Safeguards, Washington, DC.

APPENDIX

Contents:

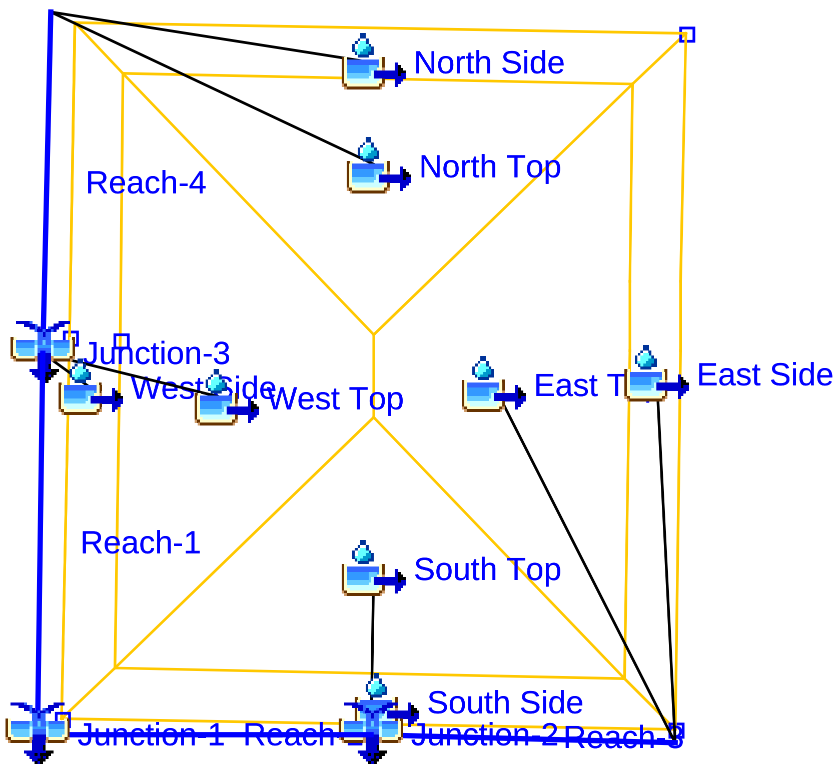
HEC-HMS Output Summary Report
Erosion Calculation Background Information



Project : Slope Scenarios

Basin Model : Basin 2

Oct 12 17:50:29 MDT 2012



Project: Slope Scenarios Simulation Run: 1 - 100yr_3hr

Start of Run: 01Jan2000, 00:00 Basin Model: Basin 1
End of Run: 01Jan2000, 06:00 Meteorologic Model: 3-hr
Compute Time: 12Oct2012, 17:47:31 Control Specifications: 3-hr

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
East Top	0.04221	6.8	01Jan2000, 02:39	0.9
East Side	0.01607	5.4	01Jan2000, 01:54	0.4
Reach-3	0.05828	8.8	01Jan2000, 03:11	1.3
South Top	0.03183	5.1	01Jan2000, 02:39	0.7
South Side	0.01397	4.7	01Jan2000, 01:54	0.4
Junction-2	0.10408	14.2	01Jan2000, 02:47	2.3
Reach-2	0.10408	14.2	01Jan2000, 03:13	2.3
North Top	0.03177	5.1	01Jan2000, 02:39	0.7
North Side	0.01395	4.7	01Jan2000, 01:54	0.4
Reach-4	0.04572	6.9	01Jan2000, 03:19	1.0
West Top	0.04225	6.8	01Jan2000, 02:39	0.9
West Side	0.01605	5.4	01Jan2000, 01:54	0.4
Junction-3	0.10402	13.8	01Jan2000, 02:52	2.3
Reach-1	0.10402	13.8	01Jan2000, 03:16	2.3
Junction-1	0.20810	28.0	01Jan2000, 03:15	4.7

Project: Slope Scenarios Simulation Run: 2 - 100yr_3hr

Start of Run:	01Jan2000, 00:00	Basin Model:	Basin 2
End of Run:	01Jan2000, 06:00	Meteorologic Model:	3-hr
Compute Time:	12Oct2012, 17:49:42	Control Specifications:	3-hr

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
North Top	0.03177	5.1	01Jan2000, 02:39	0.7
North Side	0.02065	6.9	01Jan2000, 01:54	0.5
Reach-4	0.05242	8.6	01Jan2000, 02:58	1.2
West Top	0.04225	6.8	01Jan2000, 02:39	0.9
West Side	0.02365	7.9	01Jan2000, 01:54	0.6
Junction-3	0.11832	16.5	01Jan2000, 02:51	2.7
Reach-1	0.11832	16.5	01Jan2000, 03:15	2.7
East Top	0.04221	6.8	01Jan2000, 02:39	0.9
East Side	0.02367	7.9	01Jan2000, 01:54	0.6
Reach-3	0.06588	10.4	01Jan2000, 02:49	1.5
South Top	0.03183	5.1	01Jan2000, 02:39	0.7
South Side	0.01397	4.7	01Jan2000, 01:54	0.4
Junction-2	0.11168	16.6	01Jan2000, 02:43	2.5
Reach-2	0.11168	16.6	01Jan2000, 03:09	2.5
Junction-1	0.23000	33.0	01Jan2000, 03:13	5.2

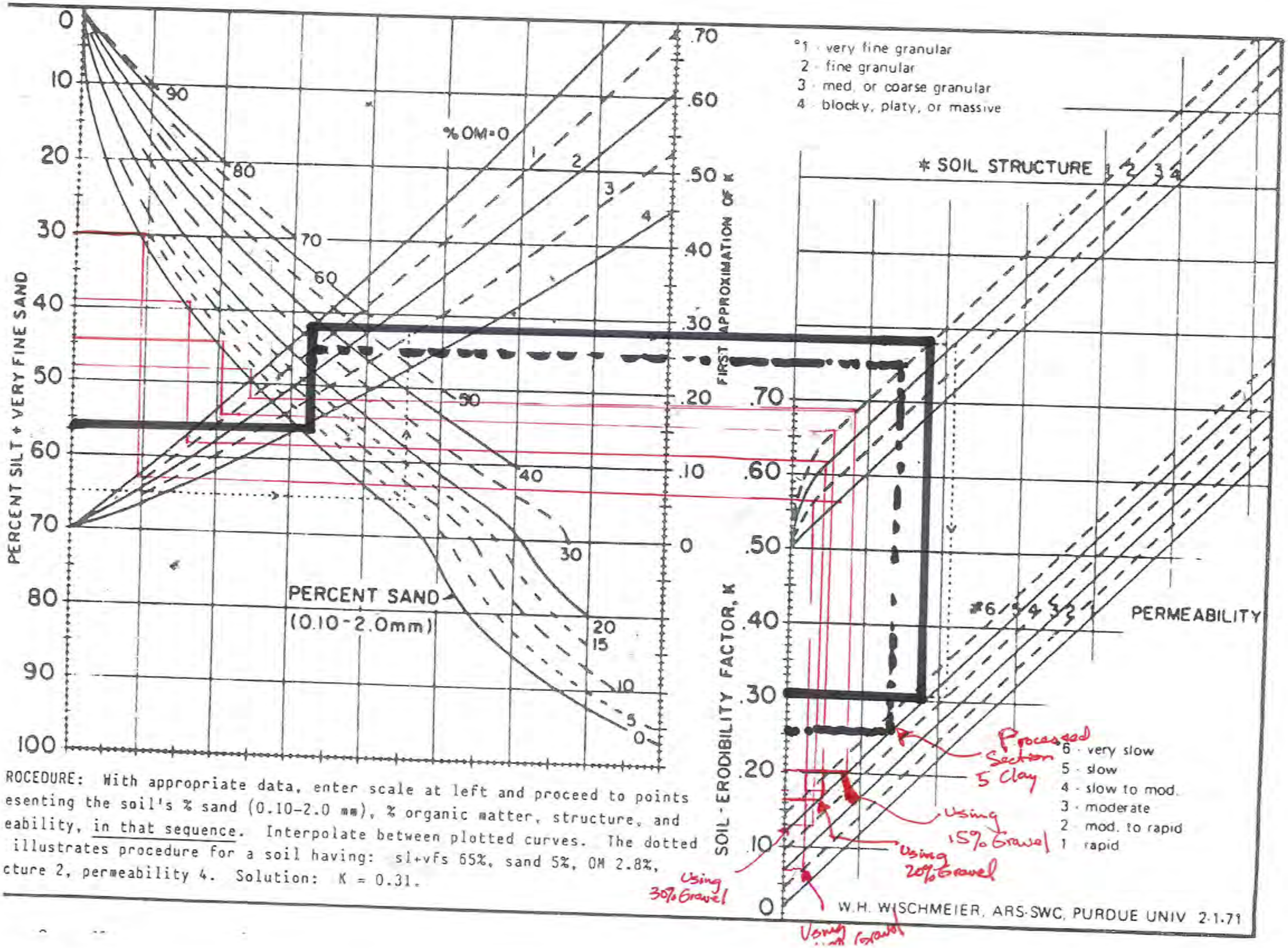
Project: Slope Scenarios Simulation Run: 3 - 100yr_3hr

Start of Run: 01Jan2000, 00:00 Basin Model: Basin 3
End of Run: 01Jan2000, 06:00 Meteorologic Model: 3-hr
Compute Time: 12Oct2012, 17:49:16 Control Specifications: 3-hr

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
North Top	0.03177	5.1	01Jan2000, 02:39	0.7
North Side	0.02065	6.5	01Jan2000, 01:54	0.5
Reach-4	0.05242	8.3	01Jan2000, 02:59	1.2
West Top	0.04225	6.8	01Jan2000, 02:39	0.9
West Side	0.02365	7.4	01Jan2000, 01:54	0.6
Junction-3	0.11832	16.1	01Jan2000, 02:51	2.6
Reach-1	0.11832	16.1	01Jan2000, 03:15	2.6
East Top	0.04221	6.8	01Jan2000, 02:39	0.9
East Side	0.02367	7.7	01Jan2000, 01:54	0.6
Reach-3	0.06588	10.2	01Jan2000, 02:50	1.5
South Top	0.03183	5.1	01Jan2000, 02:39	0.7
South Side	0.01397	4.7	01Jan2000, 01:54	0.4
Junction-2	0.11168	16.4	01Jan2000, 02:43	2.5
Reach-2	0.11168	16.4	01Jan2000, 03:09	2.5
Junction-1	0.23000	32.3	01Jan2000, 03:13	5.1

...om distribution curve Zone II, Figure 1.

loss rates. On any given site these interactions tend to average out over a year's time so that their effect at any particular time is minimal.



ROCEDURE: With appropriate data, enter scale at left and proceed to points esenting the soil's % sand (0.10-2.0 mm), % organic matter, structure, and eability, in that sequence. Interpolate between plotted curves. The dotted illustrates procedure for a soil having: si+vfs 65%, sand 5%, OM 2.8%, cture 2, permeability 4. Solution: K = 0.31.

ES-1908
Rev. 0

ENERGYSOLUTIONS

SOIL CLASSIFICATION FORM

PROJECT: ____ CAN X MW ____ 11e.(2) ____ CLASS A Other ________

SAMPLE NAME: S5120927 DATE: 10/5/2012

GRADATION AS RECEIVED			
SCREEN SIZE	WEIGHT DRY (g)	PERCENT RETAINED	PERCENT PASSING
3"			
1-1 / 2"			
1"			
3 / 4"			
3 / 8"			
#4	0.0	0	100
-#4	1,984.3	100	
TOTAL DRY MASS	1,984.3	100	
#8			
#10	0.0	0	100
#30			
#40			
#100			
#200	1.7	3	97
-#200	49.7	97	
TOTAL MASS	51.4	100	

AS TESTED MOISTURE DETERMINATION		
	+#4	-#4
CONTAINER & WT. AGGREGATE (g)	N/A	N/A
CONTAINER & DRY AGGREGATE	N/A	N/A
CONTAINER MASS (g)	N/A	N/A
PERCENT MOISTURE	N/A	N/A

GRADATION TEST	
PERCENT GRAVEL	N/A
PERCENT SAND	3
PERCENT FINE SAND	N/A
PERCENT SILT & CLAY	97

ATTERBERG LIMITS	
LIQUID LIMIT	N/A
PLASTIC LIMIT	N/A
PLASTIC INDEX	N/A
CLASSIFICATION	NA

Notes: Sieve set QC-1 was used. Sieves inspected for damage with no damage found. Material finer than the 75-µm (No. 200) sieve was performed in accordance with ASTM D 422

TEST RESULTS: PASS FAIL By: [signature] Date 10-5-12

QC OFFICER APPROVAL ________ DATE ________ QA APPROVAL ________ DATE ________

ENERGYSOLUTIONS

HYDROMETER ANALYSIS

PROJECT: ______ CAN __X__ MW ______ 11e.(2) ______ CLASS A **Other:** ______

Sample Name: S5120927 **Date:** 10/3/2012

Hydrometer Type/Number: 151H / 152H 140665 Beaker/Graduate #'s B4 / G2

Dispersing Agent Used: Sodium Hexametaphosphate Quantity: 5 g/L

Specific Gravity of soil solids (G_s) : 2.70
(round to nearest 0.05)

Sieve size used: # 10 Mass of sample (M_s) : 52.1 g. Percent Fines (P_f) : 100%

Description of sand and gravel particles: Hard, rounded, and durable

Dispersion Device: High-speed mechanical stirrer (apparatus A) Dispersion period: 1 min.

Time	Elapsed Time (T) minutes	Actual Hydrometer Reading (R^1)	Correction (R_c)	Corrected Reading (R)	Temp. °C	Temperature and Specific Gravity Constant (K)	Effective Depth (L) cm	Particle Diameter (D) mm	Percent Finer Partial (P_p)	Percent Finer Total (P_t)
8:16	0								100.0%	100.0%
8:18	2	48	5	43	22	0.01312	9.2	0.0281	83.4%	83.4%
8:21	5	45.5	5	40.5	21	0.01328	9.7	0.0185	78.5%	78.5%
8:31	15	42	5	37	21	0.01328	10.2	0.0110	71.8%	71.8%
8:46	30	39	5	34	21	0.01328	10.7	0.0079	65.9%	65.9%
9:16	60	36	5.5	30.5	20	0.01344	11.4	0.0059	59.2%	59.2%
10:16	120	34	5.5	28.5	20	0.01344	11.7	0.0042	55.3%	55.3%
12:16	240	30.5	5.5	25	20	0.01344	12.2	0.0030	48.5%	48.5%
8:16	1440	21	5.5	15.5	20	0.01344	13.8	0.0013	30.1%	30.1%

Hygroscopic Moisture Correction

Container ID: C9

Mass of container & wet specimem (M_{cms}) 31.18

Mass of container & dry specimen (M_{cds}) 30.86

Mass of Water (M_w) $M_w = M_{cms} - M_{cds}$ 0.32

Mass of Container (M_c) 15.35

Moisture Content as a percentage (P_w) $P_w = (M_w / M_s) \times 100$ 2.1%

Mass of Oven-dry sample used (M_{ods}) $M_{ods} = M_s / [1 + (P_w / 100)]$ 51.0 g.

Formulas

Corrected Reading (R) = $R_1 - R_c$

Particle Diameter (D) = $K \times [(L/T)^{\wedge} ½]$

Percent Finer Partial (P_p)

151H $P_p = [(G_s / (G_s - 1)) \times (100000 / M_{ods})] (R - 1)$

152H = $[(R \times A) / M_{ods}] \times 100$

152H correction factor (A) = 0.99

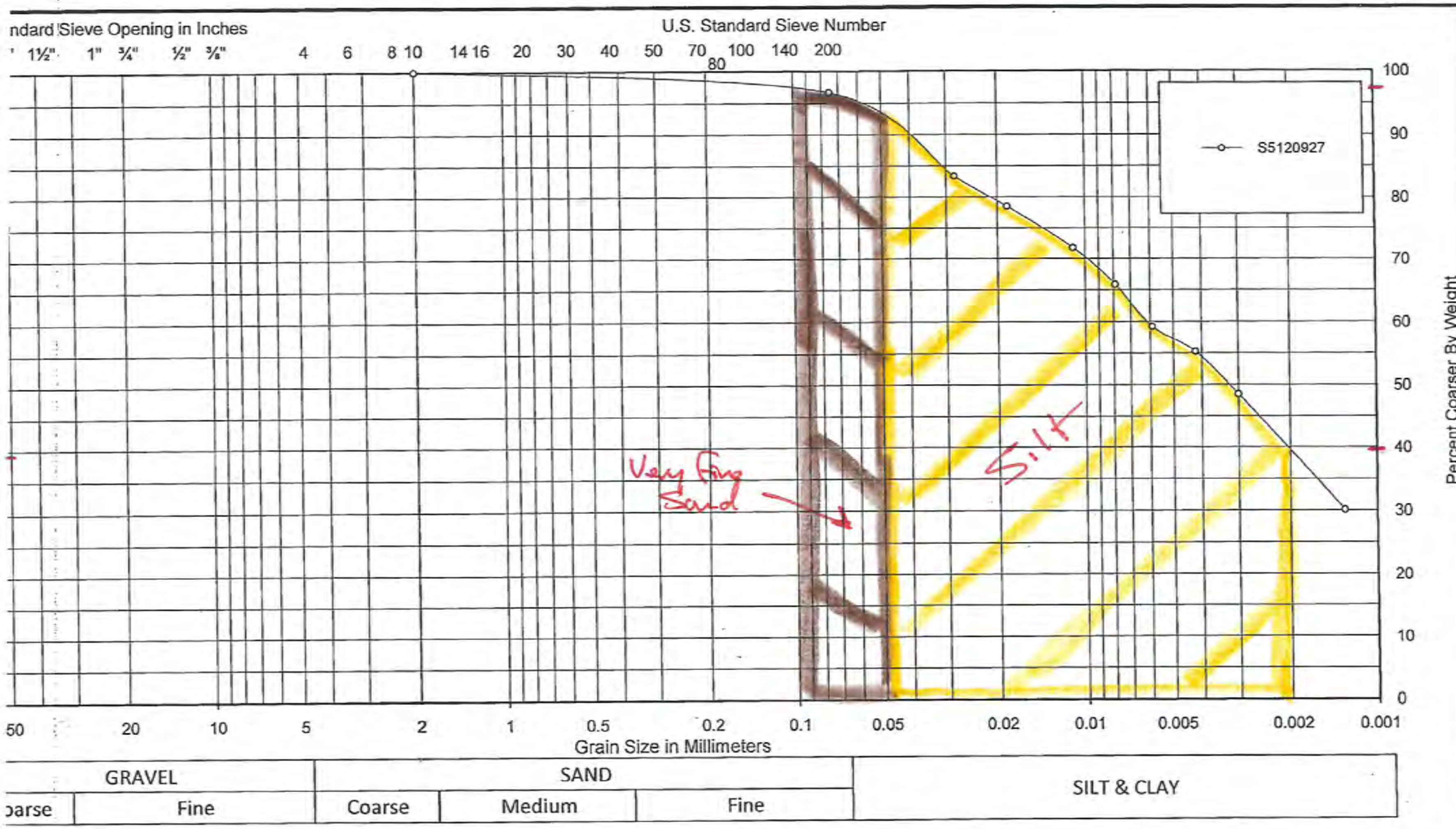
Percent Finer Total (P_t) = $P_p \times P_f$

Temperature and Specific Gravity Constant (K), Effective Depth (D), and 152H correction factor (A) are obtained from charts in ASTM D422

COMMENTS: Specific gravity for this sample was estimated to be 2.70.
This sample represents the same material used for proctor ID S5120725

TEST PERFORMED BY: [signature] DATE: 10/4/2012 TIME: 8:20

58% Silt + Very Fine Sand



Sample	P200	D 60	D 30	D 10	Cu	Cc		CLASSIFICATION / DESCRIPTION
S5120927	96.7							

ENERGYSOLUTIONS

GRADATION ANALYSIS
0
0
EnergySolutions

DW/	JOB NO:	5-Oct-12

ENERGYSOLUTIONS

HYDROMETER ANALYSIS

PROJECT: X CAN X MW X 11e.(2) X CLASS A **Other:**

Sample Name: S5120911 **Date:** 9/27/2012

Hydrometer Type/Number: 151H / 152H 140665 Beaker/Graduate #'s B3 / G2

Dispersing Agent Used: Sodium Hexametaphosphate Quantity: 5 g/L

Specific Gravity of soil solids (G_s): 2.70 (round to nearest 0.05)

Sieve size used: #10 Mass of sample (M_s): 50.0 g. Percent Fines (P_f): 100%

Description of sand and gravel particles: Hard, rounded, and durable

Dispersion Device: High-speed mechanical stirrer (apparatus A) Dispersion period: 1 min.

Time	Elapsed Time (T) minutes	Actual Hydrometer Reading (R')	Correction (R_c)	Corrected Reading (R)	Temp. °C	Temperature and Specific Gravity Constant (K)	Effective Depth (L) cm	Particle Diameter (D) mm	Percent Finer Partial (P_p)	Percent Finer Total (P_t)
8:35	0								100.0%	100.0%
8:37	2	47	5	42	21	0.01328	9.4	0.0288	84.3%	84.3%
8:40	5	44	5	39	21	0.01328	9.9	0.0187	78.3%	78.3%
8:50	15	40	5	35	21	0.01328	10.6	0.0112	70.3%	70.3%
9:05	30	38	5.5	32.5	20	0.01344	11.1	0.0082	65.3%	65.3%
9:35	60	36	5.5	30.5	20	0.01344	11.4	0.0059	61.3%	61.3%
10:35	120	32.5	5.5	27	20	0.01344	11.9	0.0042	54.2%	54.2%
12:35	240	28.5	5.5	23	20	0.01344	12.5	0.0031	46.2%	46.2%
8:35	1440	20.5	5.5	15	20	0.01344	13.8	0.0013	30.1%	30.1%

Hygroscopic Moisture Correction

Container ID: C12

Mass of container & wet specimen (M_{cms}): 30.20

Mass of container & dry specimen (M_{cds}): 29.99

Mass of Water (M_w) $M_w = M_{cms} - M_{cds}$: 0.21

Mass of Container (M_c): 15.29

Moisture Content as a percentage (P_w) $P_w = (M_w / M_s) \times 100$: 1.4%

Mass of Oven-dry sample used (M_{ods}) $M_{ods} = M_s / [1 + (P_w / 100)]$: 49.3 g.

Formulas

Corrected Reading (R) = $R_1 - R_c$

Particle Diameter (D) = $K \times [(L/T)^{\wedge} \tfrac{1}{2}]$

Percent Finer Partial (P_p)

151H $P_p = [(G_s/(G_s-1)) \times (100000/M_{ods})](R-1)$

152H $= [(R \times A)/M_{ods}] \times 100$

152H correction factor (A) = 0.99

Percent Finer Total (P_t) = $P_p \times P_f$

Temperature and Specific Gravity Constant (K), Effective Depth (D), and 152H correction factor (A) are obtained from charts in ASTM D422

COMMENTS: Specific gravity for this sample was estimated to be 2.70.

TEST PERFORMED BY: [signature] DATE: 10/1/2012 TIME: 7:46

QC OFFICER APPROVAL DATE QA APPROVAL DATE

EnergySolutions
Clive, Utah

ENERGYSOLUTIONS

SOIL CLASSIFICATION FORM

PROJECT: X CAN X MW X 11e.(2) X CLASS A Other ______

SAMPLE NAME: S5120911 DATE: 10/1/2012

GRADATION AS RECEIVED			
SCREEN SIZE	WEIGHT DRY (g)	PERCENT RETAINED	PERCENT PASSING
3"			
1-1 / 2"			
1"			
3 / 4"			
3 / 8"			
#4	0.0	0	100
-#4	49.3	100	
TOTAL DRY MASS	49.3	100	
#8			
#10	0.0	0	100
#30			
#40			
#100			
#200	1.5	3	97
-#200	47.8	97	
TOTAL MASS	49.3	100	

AS TESTED MOISTURE DETERMINATION		
	+#4	-#4
CONTAINER & WT. AGGREGATE (g)	N/A	N/A
CONTAINER & DRY AGGREGATE	N/A	N/A
CONTAINER MASS (g)	N/A	N/A
PERCENT MOISTURE	N/A	N/A

GRADATION TEST	
PERCENT GRAVEL	0
PERCENT SAND	3
PERCENT FINE SAND	3
PERCENT SILT & CLAY	97

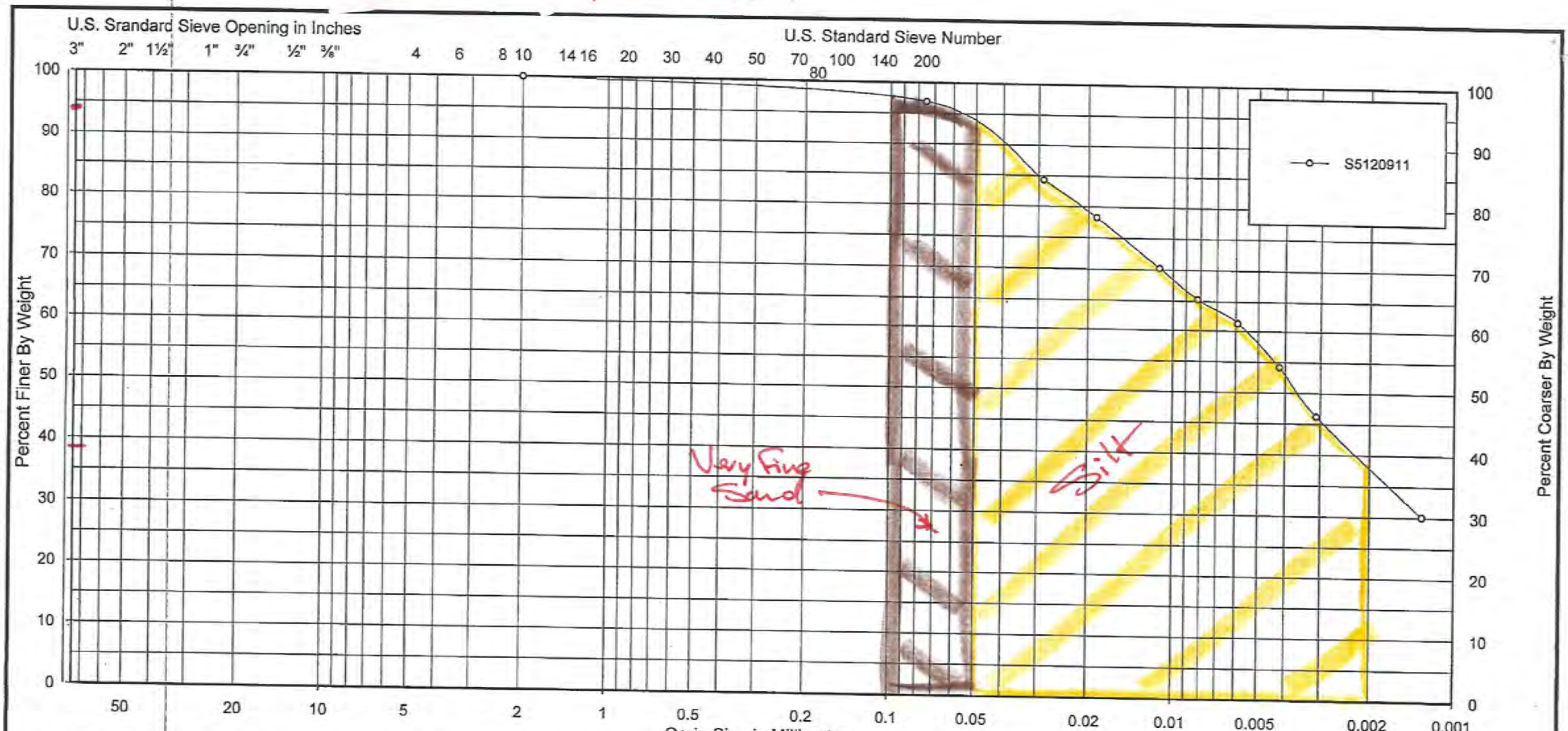
ATTERBERG LIMITS	
LIQUID LIMIT	N/A
PLASTIC LIMIT	N/A
PLASTIC INDEX	N/A
CLASSIFICATION	NA

Notes: Sieves inspected for damage with no damage found. Material finer than the 75-µm (No. 200) sieve was performed in accordance with ASTM D 422

TEST RESULTS: PASS FAIL By: [signature] Date 10-1-12

QC OFFICER APPROVAL DATE QA APPROVAL DATE

56% Silt + Very Fine Sand



GRAVEL		SAND			SILT & CLAY
Coarse	Fine	Coarse	Medium	Fine	

#	Source	Sample	P200	D_{60}	D_{30}	D_{10}	Cu	Cc		CLASSIFICATION / DESCRIPTION
1		S5120911	97.0	0.0055	0.0014					
2										
3										
4										
5										
6										
7										
8										

ENERGYSOLUTIONS

GRADATION ANALYSIS
0
0
EnergySolutions

DW/	JOB NO:	1-Oct-12

S5120911 gradation analysis Fine

10/1/2012 8:04 AM

APPENDIX L

Waste Characterization Plan

WASTE CHARACTERIZATION PLAN

Table of Contents

I. GENERAL PROVISIONS AND REQUIREMENTS

1. This Waste Characterization Plan (WCP) describes procedures for identifying, characterizing, controlling, sampling, and accepting incoming waste for disposal at the Licensee‟s Facility.

2. The Licensee‟s Facility consists of the Mixed Waste (MW) Facility and the Low-Level Radioactive Waste (LLRW) Facility.

3. This WCP is applicable to the radioactive component of all waste destined for disposal at the Licensee‟s Facility.

4. This WCP is also applicable to the chemical component of all low-level radioactive wastes (excluding mixed wastes) received at the Licensee‟s Facility.

    a. Characterization and acceptance for the chemical component of mixed wastes shall be completed in accordance with Attachment II-1, *Waste Analysis Plan*, of the Licensee‟s State-issued Part B Permit.

5. Wastes destined for disposal at the Containerized Waste Facility (CWF) shall be characterized and accepted in accordance with Section VIII of this WCP.

6. For each waste stream received at the Licensee‟s Facility from an off-site generator (off-site waste), the generator shall characterize the waste and the Licensee shall evaluate the associated Waste Profile Record (WPR) to ensure the waste is acceptable for management prior to allowing that waste stream to be shipped to the Licensee‟s Facility. WPR requirements are outlined in Section II of this WCP.

7. Each shipment shall be inspected, and accepted or rejected, in accordance with Section III of this WCP.

8. Each waste stream shall be sampled and analyzed, and the data evaluated, in accordance with Section IV of this WCP.

    a. Waste destined for the CWF does not require sampling and analysis as long as the requirements of Section VIII of this WCP are met.

    b. Waste that is remote sampled in accordance with Section VII of this WCP does not require sampling and analysis upon receipt at the Licensee‟s Facility.

    c. Debris and pure product waste may be exempted from sampling and analysis in accordance with Section IV.6 of this WCP; however, shipments containing debris and pure product wastes shall be visually inspected to confirm that material amenable to analysis is not present.

i. Waste containing SNM cannot be waived for radiological sampling and analysis unless the SNM concentration is lower than one tenth of the applicable limit in License Condition 13.A.

d. Other wastes may be exempted from sampling and analysis through a petition to the Director of the Utah Division of Radiation Control.

i. Petitions to exempt waste streams from sampling may be based on ALARA (e.g., dose rate, DAC, removable contamination) or other personnel health and safety concerns.

ii. Approval by the Director of the Utah Division of Radiation Control is required prior to managing petitioned wastes without sampling and analyzing the waste.

9. If a waste sample is analyzed and it is determined that the sample results do not match the WPR, two or more additional samples may be collected and analyzed for those parameters that were not met. If the additional sample results confirm the first analysis, the procedures for resolving discrepancies outlined in Section III.5 of this WCP shall be followed. If the additional sample results do not confirm the results of the first analysis, the original result shall be viewed as an anomaly and the waste shall be managed in accordance with this WCP.

10. Analytical data for this WCP shall be obtained from laboratories meeting one of the following criteria:

a. Laboratories that hold a current National Environmental Laboratory Accreditation Conference (NELAC) accreditation, or

b. Laboratories certified by the Utah Department of Health (UDOH), insofar as official certifications are given, or

c. Laboratories with reciprocity with the State of Utah for the parameter being analyzed, or

d. Laboratories that are certified in a state that has been determined by the UDOH to have a laboratory certification program equal to or more stringent that Utah‟s, or

e. Laboratories approved by the Utah Division of Radiation Control.

11. Wastes that do not contain Resource Conservation and Recovery Act (RCRA) hazardous material may be transferred from the MW Facility for disposal at the LLRW Facility in accordance with Section IX of this WCP.

12. Wastes that contain greater than 1% free liquids are referred to as “liquid wastes” and shall be managed in accordance with Section V of this WCP.

13. Wastes that contain less than 1% free liquids may be managed within areas of the Licensee‟s Facility (MW or LLRW) with approved secondary containment.

14. Samples sent to the Licensee‟s Facility for treatability study testing, solidification study testing, or other pre-shipment waste characterization purposes shall be managed in accordance with Section VI of this WCP.

15. Following waste receipt and acceptance, waste containers shall be marked or labeled with the following information, at a minimum:

    a. Generator identification number;

    b. Licensee identification number;

    c. The date the waste was received; and

    d. Specific hazards (e.g., "Resin", "Asbestos", "PCB", "Liquid Radioactive Waste", etc.), when applicable.

II. WASTE PROFILE RECORD REQUIREMENTS

1. The WPR shall provide the necessary information for management of a waste stream. The following information shall be provided in the WPR:

    a. A description of the generator, including the generator‟s:

        i. Company or Facility Name;

        ii. Generator number and waste stream number assigned by the Permittee;

        iii. Mailing address;

        iv. Business telephone number, a 24-hour emergency telephone number, or both; and

        v. WPR contact person.

    b. A description of the waste, including:

        i. A determination that the waste is not a hazardous waste as defined in 40 CFR 261;

        ii. Whether the waste includes liquids;

        iii. A general indication of the waste‟s density;

        iv. Any distinguishing color or odor;

v. A statement that the sample(s) used for characterization was representative of the waste;

vi. If sorbents are used, a statement on the type used; and

vii. Other additional information necessary for determining appropriate management of the waste stream such as:

A. Chemical, physical, and general characteristics and properties;

B. Information relating to the waste‟s generation and history;

C. An indication of the possible presence of non-RCRA hazardous constituents such as asbestos, PCBs, etc.; and

D. A statement that the waste is not air reactive, water reactive, shock sensitive or pyrophoric.

c. A description of the radioactive characteristics of the waste, including worst-case isotopic concentrations.

d. TCLP analytical results for the characteristically hazardous list of elements and compounds described in Table 1 of 40 CFR 261 (8 metals and 32 organics).

i. For the purposes of this requirement, total results on a dry weight basis may be used to show that a waste is not toxic. The total results will be divided by a conversion factor of 15 (mg/kg)/(mg/L) in order to determine whether a TCLP limit has the possibility of being exceeded. For example, an analytical result of 75 mg/kg for silver on a soil sample would demonstrate that the characteristic limit of 5 mg/L TCLP silver would not be exceeded.

ii. Analytical data shall meet the laboratory requirements of Section I.9 of this WCP.

iii. The generator may provide certified process knowledge in place of some or all of the analytical data (e.g., the waste may have been generated in a closed system in which organic contaminants could not enter, or the waste may be pure product material with associated Material Safety Data Sheets, etc.).

iv. The wastes described in Section IV.6 of this WCP do not require chemical analytical data.

2. The Licensee shall conduct and document Radiological and Chemical Evaluations of the WPR prior to approving the waste for shipment.

a. The Radiological Evaluation shall ensure that the profiled waste meets License limits.

b. The Chemical Evaluation shall ensure that the profiled waste is not RCRA hazardous.

3. Acceptance of the profile will be documented through the issuing of a waste stream specific “Notice to Transport” (NTT) to the generator.

a. An NTT will not be issued until the evaluations of Section II.2 of this WCP have been completed.

b. An electronic copy of each NTT shall be maintained at the Licensee‟s Facility.

c. If a shipment arrives prior to receiving an NTT, the shipment shall be rejected and the Director of the Utah Division of Radiation Control notified within 24-hours of the shipment‟s arrival.

4. The Licensee may provide information for a generator‟s WPR in coordination with the generator.

5. Copies (electronic or paper) of WPRs, Radiological and Chemical Evaluations, and NTTs shall be maintained at the Licensee‟s Facility for a period of five (5) years.

III. INCOMING SHIPMENT INSPECTION REQUIREMENTS

1. In conjunction with each waste shipment or shipment campaign, a file review shall be conducted to ensure that there is a current WPR and NTT on file.

2. On the date a shipment arrives at the Licensee‟s Facility, the following shall be completed before the Licensee signs the shipping manifest:

a. The Uniform Low-Level Radioactive Waste Manifest or shipping papers shall be reviewed for discrepancies; and

b. The shipment shall be inspected for compliance with DOT and DRC radioactive material shipment regulations. This inspection shall include:

i. an external survey of the transportation packages for gamma radiation; and

ii. a physical inspection of the shipment for Inspection or Appearance Discrepancies as described in Section III.5 of this WCP.

A. If free liquids are present, a liquid volume determination shall be made prior to waste management. If the free liquid volume is less than 1% of the waste by volume, the waste shall be solidified prior to disposal or managed in accordance with Section V of this WCP.

3. Shipments that have been inspected remotely in accordance with Section VII of this WCP do not require further inspection upon arrival at the Licensee"s Facility.

4. Incoming Shipment Discrepancies

   a. Manifest Discrepancies:

      i. Manifest incompleteness

      ii. Typographical errors (e.g., wrong telephone number, address, names, etc.)

   b. Inspection Discrepancies:

      i. Unexpected free liquids exceeding 1% of the waste, by volume.

      ii. Damaged, leaking or open container(s).

      iii. Waste outside of the container.

   c. Appearance Discrepancies:

      i. Different appearance than is described in the WPR.

5. Incoming Shipment Discrepancy Resolution

   a. Where discrepancies are identified, the discrepancies shall be noted and resolved with the generator. Discrepancies shall be resolved prior to management of the waste.

      i. The waste shall be labeled "hold" and segregated to clearly identify the shipment(s) or package(s) with discrepancies.

      ii. If discrepancies cannot be resolved, the waste shall be returned to the generator.

      iii. If waste is beyond the limits of the License, the waste shall be returned to the generator.

      iv. "Resolved" means that the generator has acknowledged the discrepancy and has approved a path forward for the waste.

   b. Notification requirement for Inspection Discrepancies:

i. Within 24 hours of discovery, the Licensee shall provide electronic mail or verbal notice of the discrepancy to the Director of the Utah Division of Radiation Control.

ii. Within 7 calendar days of discovery, the Licensee shall provide written notice of the discrepancy to the Director of the Utah Division of Radiation Control. At a minimum, the written notice shall include:

A. a description of the discrepancy;

B. the disposition of the waste;

C. corrective actions taken; and

D. a compliance schedule for resolving any associated non-conformance with the License.

c. Discrepancies involving wastes containing regulated concentrations of Polychlorinated Biphenyls (PCBs) shall be managed in accordance with the State-issued Part B Permit, Attachment II-1-10.1, *Management of Waste Containing Polychlorinated Biphenyls (PCBs) at the LLRW Facility*.

d. Shipments with unexpected free liquid exceeding 1% of the waste by volume shall be managed in accordance with Section V of this WCP.

e. Leaking shipments or packages shall have the leak immediately contained and the shipment or package moved into the Restricted Area.

i. The 1% free liquid determination will be made after the shipment is contained and within the Restricted Area.

A. If the volume of free liquid exceeds 1% of the waste by volume, the waste shall be managed in accordance with Section V of this WCP.

B. If the volume of free liquid is less than 1% of the waste by volume, the liquid may be solidified in place or managed in accordance with Section V of this WCP.

ii. Shipments with greater than 1% free liquid shall remain on hold until the discrepancy is resolved with the generator.

f. Any generator with a repeat occurrence within 12 months of shipments with free-liquids in excess of 1% by volume shall have their NTT revoked until a corrective action plan is completed and approved.

g. Discrepancies, such as typographical errors that are overlooked or discovered at a later date, shall be resolved by making corrections as information becomes available. Corrections of this type shall be initialed and dated.

h. Appearance discrepancies may be resolved with the generator by either:

i. Adding information to the WPR; or

ii. Arranging for the return of the shipment.

IV. SAMPLING AND ANALYSIS REQUIREMENTS

1. Representative samples shall be collected from incoming shipments. These samples shall be documented and analyzed for the following parameters:

a. Deferred Chemical Screening Parameters – hazardous waste characteristics D001-D043 as designated in 40 CFR 261, Subpart C.

i. Non-liquid waste does not require analyses for the ignitable (D001) or corrosive (D002) characteristics.

ii. The reactivity characteristic (D003) will be assessed using a reactive cyanide analysis.

b. Radiological Analytical Parameters – gamma spectroscopy analysis.

i. All significant photopeaks shall be accounted for using the "unidentified peak summary". A peak is not significant if it has less than 0.10 counts per second or has uncertainty of more than 50%.

ii. When non-gamma radionuclide concentrations are contributing to the waste being within 75% of Class A limits, the contributing non-gamma radionuclide(s) shall also be analyzed.

2. Sampling Frequencies

a. For ease in counting, one rail car (any type) may represent a nominal 100 cubic yards and one highway shipment (any type) may represent a nominal 20 cubic yards. Actual manifested volumes may also be used for counting purposes.

b. For purposes of sampling and analysis, a highway shipment with a truck and a pup shall be considered two separate shipments. Each railcar shall be considered a separate shipment.

c. Deferred Chemical Screening Parameters – for each waste stream, the minimum number of samples to be analyzed for deferred chemical screening parameters is:

i. The first shipment to arrive at the site.

ii. Thereafter,

A. Annually for Non-Treated Wastes. For off-site wastes that have never retained RCRA hazardous waste codes prior to arrival at the Licensee"s Facility, the first shipment following or any one shipment prior to the one-year anniversary date of the most recent shipment that was sampled and analyzed for deferred chemical screening parameters; or

B. Semi-Annually for Treatment Residue Wastes. For wastes that have been treated to remove RCRA hazardous characteristics prior to arrival at the Licensee"s Facility, the first shipment following or any one shipment prior to the date six months after the most recent shipment that was sampled and analyzed for deferred chemical screening parameters.

d. Radiological Analytical Parameters – for each waste stream, the minimum number of samples to be analyzed for radiological analytical parameters is:

i. Initially,

A. One sample for each of the first ten (10) shipments (rail or highway); or

B. one sample for each of the first 100 cubic yards (yd^3) up to 1,000 yd^3.

ii. Thereafter,

A. One sample for each additional 500 yd^3 following the first ten (10) shipments or following the first 1,000 yd^3.

e. For purposes of the sample requirement in Sections IV.2.c and IV.2.d of this WCP, a sample from a specified shipment may be replaced by a sample from a shipment among a set of available shipments, provided that the shipment that is selected for sample substitution arrives within three days of the date of arrival of the specified shipment.

3. Required Sample Collection

a. Samples for Deferred Chemical Screening Parameters or Radiological Analytical Parameters shall be collected as follows:

i. Bulk Rail Shipments. The sample shall be a composite sample consisting of six aliquots from random locations.

ii. Bulk Highway Shipments. The sample shall be a composite sample consisting of four aliquots from random locations.

iii. Liquid Tanker Shipments. One sample shall be collected per tanker car.

iv. Container Shipments (rail or highway).

A. One composite sample consisting of aliquots from ten (10) percent of the containers on a shipment.

B. For shipments consisting of six or more containers, at least six aliquots shall be collected from six different containers.

C. For shipments consisting of fewer than six containers, one aliquot shall be collected from each container.

D. Containers from which aliquots are collected shall be randomly selected, if necessary, from all of the containers on a shipment.

b. The sample collection requirements of IV.3.a of this WCP are minimum aliquots. The Licensee may collect additional aliquots as necessary to ensure representative samples are collected.

c. Proper chain of custody in accordance with federal standards shall be maintained on all samples collected.

d. Once all required samples have been collected, the waste may be placed in the disposal embankment prior to receipt and review of analytical results.

4. Receipt of Analytical Results

a. Laboratory results for deferred chemical screening and radiological analytical parameters shall be received within 90 days of the arrival date of the shipment, with the following exceptions:

i. When ^{90}Sr analysis is necessary, the required time period for the radiological analytical parameters shall be 120 days.

ii. Upon request of the Licensee, the Director of the Utah Division of Radiation Control may allow additional time for receipt of analytical data.

5. Review of Analytical Results

a. The Licensee shall perform a review of analytical results received from off-site laboratories.

i. Analytical data from Deferred Chemical Screening Parameters shall be reviewed against applicable characteristic concentrations as described in 40 CFR 261.

ii. Analytical data from Radiological Analytical Parameters shall be reviewed against License limits.

iii. The Licensee shall document the analytical data reviews.

iv. Analytical laboratory results and data reviews shall be maintained at the Licensee‟s Facility until closure of the facility.

b. Non-Conforming Waste

i. Waste is non-conforming when the following occurs:

A. the Deferred Chemical Screening Parameters analytical review indicates that the waste is a characteristic hazardous waste as described in 40 CFR 261; or

B. The Radiological Analytical Parameters review indicates that the waste is beyond the License limits.

(1) For waste exceeding radiological limits, the notification requirements in Section III.5.b of this WCP shall be followed.

ii. On a case-by-case basis, waste that does not meet the criteria in Section IV.5.b.i of this WCP may be granted a variance by the Director of the Utah Division of Radiation Control or the Director of the Utah Division of Solid and Hazardous Waste.

A. Waste that has been granted an exemption is not considered non-conforming.

iii. Non-conforming waste shall be labeled “hold” and segregated from other waste streams.

iv. The generator shall be contacted for disposition of non-conforming waste.

A. The waste may be rejected and returned to the generator; or

B. the waste may be sent to a facility that has permits in place to manage the non-conforming waste (e.g., hazardous waste may be moved to the Licensee"s MW Facility).

v. Container shipments with non-conforming waste in some of the containers but not in others may be split such that only those containers which are non-conforming shall be managed in accordance with Section IV.5.b.iv of this WCP.

vi. If the non-conforming waste has been disposed:

A. Within 24 hours of discovery that non-conforming waste has been disposed, the Licensee shall provide electronic mail or verbal notice to the Director of the Utah Division of Radiation Control.

B. Within 7 calendar days of discovery that non-conforming waste has been disposed, the Licensee shall provide written notice to the Director of the Utah Division of Radiation Control. At a minimum, the written notice shall include:

(1) the name of the generator;

(2) the designation of the non-conforming waste stream;

(3) the amount of non-conforming waste disposed;

(4) the location of the non-conforming waste in the Disposal Cell;

(5) the date the non-conforming waste was accepted;

(6) the date the non-conforming waste was placed in the Disposal Cell;

(7) a description of waste placed on and around the non-conforming waste;

(8) the plan of action for resolving the non-conformance; and

(9) a compliance schedule.

6. Waiver of Sampling or Analysis

a. Individual Shipment Sampling Waivers

i. Some wastes do not lend themselves to sampling or to the analyses required by this WCP. The debris components listed below do not require sampling or analysis:

A. Solid-phase metals

B. Wood (excluding sawdust or shavings)

C. Concrete (excluding pulverized)

D. Brick

E. Stone (not to include drywall)

F. Glass

G. Plastic (not to include ion-exchange resins)

H. Rubber

ii. Clearly labeled pure product waste, with associated Material Safety Data Sheets may be waived for sampling and analysis.

iii. If a portion of a waste is amenable to analysis, that portion must be analyzed according to this WCP.

iv. A waste may be analyzed for some parameters and waived for others (e.g., the physical form may be too large for chemical analysis, but still applicable to radiological analysis).

v. Explanations of all waivers shall be documented and maintained at the Licensee"s Facility.

b. Overall WPR Sampling Waivers

i. All waste associated with a specific WPR may be designated waived during the WPR review process (Section II.2 of this WCP) as long as the following requirements are met and approved:

A. The physical description of the waste is contained within the list in Section IV.6.a.i of this WCP;

B. The generator documents that the waste does not lend itself to sampling;

C. Quality data is used during the WPR process. This requirement is met through the Licensee"s review of the following:

(1) Analytical methods;

(2) Characterization instrument calibration curves and efficiency determinations;

(3) Certificate files for sources used in characterization;

(4) Quality Assurance (QA) checks, including analytical spike data;

(5) Results of the laboratory cross-check program, if the laboratory participates in that program.

ii. The Licensee"s waiver review shall be documented in the Radiological or Chemical Evaluation for the particular WPR.

iii. Upon receipt, the Licensee shall perform a visual inspection of the waste to confirm it meets the approved WPR description.

A. Visual inspections shall be performed at the sampling frequencies described in Section IV.2 of this WCP.

B. Waste that does not meet the approved WPR description shall be managed in accordance with Section III.5 of this WCP.

(1) Waste that has been resolved but does not meet the approved WPR description shall have sampling and analysis completed in accordance with Section IV of this WCP.

7. Logistics

a. Intermodal containers holding waste may be placed on unimproved surfaces adjacent to the rail track to facilitate sampling or loading operations, provided that the movement to an approved waste storage area or disposal embankment is completed within 48 hours.

b. Waste which remains in off-site transportation equipment or vehicles (e.g., rail cars, flatbeds, vans, trucks, etc.) and are awaiting analytical results may remain at the Licensee"s Facility for up to 30 days.

c. For these logistics items, additional conveyance storage time may be approved by the Director of the Utah Division of Radiation Control.

V. LIQUID WASTE MANAGEMENT

1. Except as noted below, liquid waste shall be managed at the MW Facility regardless of whether the waste is low-level radioactive waste or mixed waste.

    a. Liquid wastes may be managed at the LLRW Facility upon approval from the Director of the Utah Division of Radiation Control.

    b. Unexpected aqueous liquid waste may be separated from the solid waste and placed in the evaporation ponds.

2. Unexpected non-aqueous liquid waste in excess of 1% of the volume of the waste shall either be:

    a. approved for management (at the MW Facility) in accordance with License Condition 16.F.i.; or

    b. returned to the generator.

3. Liquid wastes managed at the MW Facility shall be solidified such that no free-liquids are present in the waste prior to disposal.

    a. Liquid waste shall be managed in accordance with Attachment II-1-4, *Liquid Waste Management Plan*, of the State-issued Part B Permit.

    b. If applicable, non-RCRA hazardous liquid waste may be managed in accordance with Attachment II-1-15, *Management of Waste for Disposal at the LLRW Facility*, of the State-issued Part B Permit.

4. Liquid Waste Sampling Requirements

    a. Liquid waste shall be analyzed for liquid pH and photoionizer ("sniffer") in accordance with Attachment II-1, *Waste Analysis Plan*, of the State-issued Part B Permit.

    b. Liquid waste that exhibits a pH less than or equal to 2 or greater than or equal to 12.5 exhibits the RCRA characteristic of corrosivity and is a mixed waste.

        i. The Directors of the Utah Division of Radiation Control and the Utah Division of Solid and Hazardous Waste shall be notified of low-level waste containing the RCRA characteristic of corrosivity within 24-hours of determination.

        ii. Liquid waste exhibiting the characteristic of corrosivity shall be:

A. transferred to the MW Facility and managed as a mixed waste, including all applicable incoming shipment sampling and analysis;

B. sent to another facility that has proper Permits to manage mixed waste; or

C. returned to the generator.

iii. Liquid waste exhibiting the characteristic of corrosivity shall be stored at the MW Facility while awaiting a decision on final disposition.

c. Low-level radioactive liquid waste is subject to Deferred Chemical Screening Parameters and Radiological Analytical Parameters as described in Section IV of this WCP.

VI. SAMPLE MANAGEMENT

1. All samples sent to the Licensee"s Facility shall meet the radiological and chemical acceptance criteria of the Radioactive Material License and the State-issued Part B Permit.

2. A draft waste profile record shall be completed as much as possible prior to shipment of a sample.

   a. Radiological characterization shall be complete and reviewed and approved by the Licensee to ensure the sample meets License limits.

   b. The Licensee shall perform a chemical review of the available information and approve the sample for shipment.

3. The Licensee shall submit a Preshipment Sample Authorization Record to the generator, giving them authorization to ship the sample. An NTT is not required for a sample.

4. Samples shall be accompanied by a Uniform Low-Level Radioactive Waste Manifest.

5. The Director of the Utah Division of Radiation Control shall be notified within seven (7) calendar days of any sample received at the Licensee"s Facility that does not meet the criteria in Section VI.1. through VI.4. of this WCP.

6. Sample Requirements.

   a. The requirements of R315-2-4(f) shall be met for all treatability study samples accepted at the Licensee"s Facility.

b. Samples not regulated under R315-2 shall not exceed 15 cubic feet per waste stream unless prior authorization is received from the Director of the Utah Division of Radiation Control.

7. Samples shall be stored in the on-site laboratory or permitted waste storage areas.

8. Samples shall be disposed or returned to the generator within one-year of receipt.

   a. The sample (or sample residue) may be combined with other waste in the waste stream from which it originated.

   b. The sample (or sample residue) may be managed as a Licensee-generated waste for storage and disposal.

VII. REMOTE SAMPLING AND INSPECTION

1. Remote inspection of off-site waste shall meet the incoming shipment inspection requirements of Section III of this WCP.

2. Remote sampling of off-site waste (Deferred Chemical Screening Parameters, Radiological Analytical Parameters, or both) shall meet the appropriate sampling and analysis requirements of Section IV of this WCP.

3. Applicable Waste. The following wastes or situations may be remote sampled and/or inspected in accordance with the requirements of this section:

   a. Wastes that are subject to the RCRA treatment technology of MACRO (macroencapsulation) and that are treated at an off-site location.

      i. Off-site MACRO waste shall meet the requirements of Attachment II-1-5, *Macroencapsulation Plan*, of the State-issued Part B Permit.

   b. Supercompaction performed on waste at an off-site location.

   c. Situations where on-site sampling would interfere with the applied treatment.

   d. Specific cases approved by the Director of the Utah Division of Radiation Control (e.g., cases where remote sampling promotes the ALARA principle).

4. The Licensee shall provide the Director of the Utah Division of Radiation Control with at least 14 calendar days notice of its intent to perform remote sampling or inspection of off-site wastes.

5. The Licensee"s notice of intent to perform remote sampling or inspection shall be accompanied by a detailed remote sampling/inspection plan. This plan shall include at a minimum, the following information:

   a. A physical description of the waste being remote sampled or inspected;

      i. The total amount of waste (tonnage and volume) represented by the remote sampling/inspection event;

   b. The purpose for the remote sampling/inspection;

   c. A description of remote sampling/inspection activities;

   d. The identity of Licensee representatives (personnel) who will perform the remote sampling/inspection;

      i. These personnel shall be employees or consultants of the Licensee;

      ii. Unless the generator is associated with the Licensee, these personnel shall be independent of the waste generator or treater;

      iii. These personnel shall have documentation demonstrating they have completed all applicable qualifications and training for performing incoming waste sampling and/or inspections at the Clive Facility.

      iv. The Licensee shall keep documentation of training and qualifications for these personnel.

   e. If applicable, a description of off-site waste treatment (e.g., MACRO, supercompaction, stabilization, etc.), including the following additional information:

      i. The treatment technology employed;

      ii. The projected amount of waste (tonnage and volume) after treatment;

      iii. A certification from the generator or treater that the treatment has met appropriate QA/QC objectives (e.g., for MACRO, the QA/QC objectives are the requirements of Attachment II-1-5 of the State-issued Part B Permit);

      iv. A description of off-site treatment operating procedures, including procedures to fill voids, if applicable;

      v. A certification from the Licensee that they have reviewed the generator or treater"s documentation and concur that the appropriate QA/QC objectives will be, or have been, met by this process; and

vi. The generator or treater"s regulatory conditions governing treatment operations.

6. Off-site waste that has been remote sampled/inspected shall have a tamper-evident seal applied and signed by the Licensee representative performing the remote sampling/inspection.

7. If unable to physically perform remote sampling, the Licensee representative shall be present to observe and direct all activities associated with the remote sampling event.

8. Upon receipt of remote sampled/inspected waste, the following conditions apply:

a. The Licensee shall confirm that the tamper-evident seal is present and uncompromised;

i. If there is evidence that the tamper-evident seal has been broken, the Licensee shall reject the waste for disposal. Rejected waste may be managed as follows:

A. Returned to the generator/treater; or

B. Managed as a normal shipment, including the inspection and sampling requirements in Sections III and IV of this WCP; or

C. Upon approval from the Director of the Utah Division of Radiation Control, accepted for management without performing inspection or sampling of the waste (i.e., accepting the remote sampling results even though the seals have been broken).

(1) A request to accept remote sampled/inspected waste which may have been tampered with shall include justification for waiving the inspection and/or sampling requirements in Sections III and IV of this WCP.

VIII. CONTAINERIZED WASTE CHARACTERIZATION

1. Waste that is not certified in accordance with this section shall not be disposed at the CWF.

a. Waste that has been remote sampled in accordance with Section VII of this WCP may be disposed at the CWF.

b. Waste that has been certified in accordance with this section is designated Certified Containerized Waste.

2. Wastes destined for disposal at the CWF shall have a unique Certified Containerized Waste Profile Record (CCWPR) specifically for that waste. Other wastes from the same generator that require disposal at other areas of the Licensee‟s Facility will have separate WPRs.

3. Prior to shipment, the Licensee shall document review and acceptance of CCWPRs for disposal at the CWF. The following aspects of the generator‟s waste management program shall be reviewed:

   a. Procedures for radioactive and hazardous waste characterization, packaging, and transportation. These procedures shall adequately address that the waste sent under the CCWPR will meet the following criteria:

      i. License radiological requirements;

      ii. License prohibitions (License Condition 16);

      iii. waste acceptance criteria (including the absence of RCRA regulated waste); and

      iv. receipt and disposal requirements.

   b. Programs and procedures for the following:

      i. radiological characterization;

      ii. free liquid management;

      iii. inspections; and

      iv. void space minimization.

   c. Quality Assurance/Quality Control (QA/QC) program applicable to those items reviewed in VIII.3.a and VIII.3.b.

   d. Inspection reports or summaries for the previous three years from agencies with oversight over the generator‟s program (e.g., NRC audits, DOE audits, EPA audits, agreement state compliance records, etc.).

      i. Responses and corrective actions to identified deficiencies applicable to waste characterization, packaging, and/or transportation.

      ii. Concurrence from the oversight agency that deficiencies have been adequately addressed.

e. Generator"s primary point of contact and responsible corporate authority for compliance of shipments to the Licensee"s facility.

4. After the CCWPR has been reviewed and approved in accordance with Section VIII.3 of this WCP, an NTT shall be issued to the generator. The requirements of Sections II.3.b and II.3.c of this WCP shall be enforced.

5. The incoming shipment inspection requirements (including discrepancy management and resolution) of Section III of this WCP shall be followed with the following additions/changes:

   a. Container integrity.

      i. Containers that do not meet the DOT definition of "strong, tight" shall be managed in accordance with the Special Handling section of the License (License Conditions 77-83).

      ii. Leaking containers shall be managed in accordance with Section III.5.e of this WCP.

   b. 1% free liquids determination.

      i. Free liquids determination shall only be completed on Class A-unstable waste.

      ii. Free liquids determination shall not be completed for waste with a contact dose rate greater than 80 mR/hr.

      iii. Free liquids inspections shall be performed within the footprint of the disposal cell.

      iv. The package shall be sealed upon completion of the free liquids determination.

6. The sampling and analysis requirements of Section IV of this WCP are not required for Certified Containerized Waste.

7. Certified Containerized Waste shipments that are determined to exceed License limits shall be rejected and returned to the generator or another licensed facility.

   a. The notification requirements of Section III.5.b of this WCP shall be followed.

IX. TRANSFER OF WASTE FROM THE MIXED WASTE FACILITY

1. Transfer of waste from the MW Facility to the LLRW Facility shall be performed in accordance with the requirements of this section and Attachment II-1-15,

Management of Waste for Disposal at the LLRW Facility, of the State-issued Part B Permit.

2. Only waste that is no longer hazardous and/or that has been completely solidified will be transferred between the facilities. All waste transfer approvals will be based upon regulatory statutes codified within R315-2 and R315-13 of the Utah Administrative Code, and by reference 40 CFR 261 and 40 CFR 268 of the Federal Regulations.

3. Prohibited Waste Transfers. The following wastes are prohibited to be transferred from the MW Facility to the LLRW Facility:

   a. Wastes which maintain a listed hazardous waste code as described in R315-2-10 and R315-2-11 (40 CFR 261.30 – 261.33 incorporated by reference). This includes any waste that maintains an F-, K-, P-, or U-hazardous waste code.

   b. Wastes which maintain a characteristic (D-) hazardous waste code and have not been treated to meet the treatment standards described in R315-13 (40 CFR 268 incorporated by reference).

   c. Thermal desorption residues.

   d. Evaporation tank liquids.

   e. Amalgamated mercury.

   f. Debris that has been treated using an immobilization technology (e.g., macroencapsulation).

   g. Any waste that does not meet the descriptions provided in Section IX.4 of this WCP.

4. Applicable Waste Transfers.

   a. The following wastes are not hazardous waste as defined by the Utah Hazardous Waste Management Rules (R315-2-3) and therefore may be transferred from the MW Facility to the LLRW Facility:

      i. Formerly Characteristic Wastes that have been treated to meet the treatment standards described in R315-13 (40 CFR 268 incorporated by reference) and do not retain listed hazardous waste codes.

         A. Wastes which were formerly ignitable (D001), corrosive (D002), or reactive (D003) will meet the treatment requirement of deactivation (DEACT) to remove the hazardous waste characteristic.

B. Wastes which were formerly toxicity characteristic (D004-D043) will meet the nonwastewater concentration-based treatment standards described in R315-13 (40 CFR 268.40 incorporated by reference).

C. All formerly characteristic wastes which also meet the Universal Treatment Standard (UTS) concentrations described in R315-13 (40 CFR 268.48 incorporated by reference) for all Underlying Hazardous Constituents (UHCs) identified within the waste.

(1) UHCs are defined as any constituent listed in the UTS table of R315-13 (40 CFR 268.48 incorporated by reference) except fluoride, selenium, sulfides, vanadium, and zinc, which can reasonably be expected to be present at the point of generation of the hazardous waste at a concentration above the constituent-specific UTS treatment standards.

ii. Wastes that are solidified at the MW Facility and that never had; or do not retain listed or characteristic hazardous waste codes.

iii. Formerly Characteristic or Listed debris waste which has been treated to the treatment standards for hazardous debris using an extraction or destruction technology described in R315-13 (40 CFR 268.45 incorporated by reference; e.g., spray washing).

A. Debris waste is defined as solid material exceeding 60 mm particle size that is intended for disposal and that is:

(1) A manufactured object;

(2) plant or animal matter; or

(3) natural geologic material.

iv. Contaminated soil that has been treated to the alternative LDR treatment standards described in R315-13 (40 CFR 268.49 incorporated by reference), provided that:

A. the soil was not originally contaminated with a listed waste; and

B. the treated waste does not exhibit any hazardous characteristics as described in R315-2-9 (40 CFR 261, Subpart C incorporated by reference).

v. Empty containers that are certified „visibly clean."

A. "Visibly clean" is the criterion in which all observable contamination has been removed from surfaces. This criterion includes the removal of all material that can be removed with a broom, shovel or other tool.

b. When required, analytical verification of waste contaminant concentrations will be conducted in accordance with treatment and solidification provisions in the State-issued Part B Permit. All required analyses will use Environmental Protection Agency (EPA) approved methods (e.g., SW-846) and will be performed by a laboratory certified as described in Section I.10 of this WCP.

c. Documentation and certification of treatment will be performed in accordance with the requirements of Attachment II-1-15 of the State-issued Part B Permit.

5. <u>Facility Preparation to Avoid Cross Contamination</u>. Precautions employed at the MW Facility prior to managing a waste that is expected to be transferred to the LLRW Facility are described in Section 6 of Attachment II-1-15 within the State-issued Part B Permit. If these precautions are not completed and documented, the waste may not be transferred to the LLRW Facility. Highlights of these precautions include the following:

a. All containers, tanks, and equipment that may come into contact with the waste will be triple rinsed with water or another suitable solvent prior to managing the waste.

b. Floors and surfaces will be swept and kept free of contaminants prior to and during the processing of waste that is expected to be transferred. Alternatively, a tarp or other non-contaminated covering may be placed onto the floor prior to waste management.

c. Waste operations for waste that will be transferred to the LLRW Facility will be segregated from other hazardous wastes.

END OF WASTE CHARACTERIZATION PLAN

WASTE CHARACTERIZATION PLAN

REVISION CROSSWALK SUPPLEMENT

WASTE CHARACTERIZATION PLAN

REVISION CROSSWALK SUPPLEMENT

Table of Contents

WASTE CHARACTERIZATION PLAN

Purpose and Scope

This plan describes the procedures for characterizing, sampling, and accepting incoming waste at the Energy*Solutions* Clive facility. I.1.

~~This plan is a requirement of Ground Water Quality Discharge Permit UGW450005, as amended, and Radioactive Material License No. UT2300249.~~ The plan is designed to identify and characterize wastes destined for disposal at the Clive Facility and to ensure that wastes accepted for management are characterized and controlled. I.1.

This plan applies to the radioactive component of all waste destined for disposal at the Clive facility and to the chemical component of wastes destined for Energy*Solutions'* Class A Low-Level Radioactive Waste (LLRW) disposal cells. I.3. & I.4.

The chemical components of wastes destined for mixed waste (MW) management are accepted to the Mixed Waste Facility according to waste analysis plans administered by the Utah Division of Solid and Hazardous Waste (Attachment II-1, *Waste Analysis Plan*, of the State-issued Part B Permit). ~~Therefore, the requirements of this plan for chemical-screening analyses do not apply to pre-shipment characterization or to the analysis of incoming shipments for the chemical and physical characteristics of wastes destined for management as MW~~. I.4.a.

Wastes destined for disposal at the Containerized Waste Facility shall be Certified Containerized Waste in accordance with the requirements in Exhibit 2. I.5. Containers received following remote sampling performed in accordance with the applicable requirements of this plan and Exhibit 1 (Remote Sampling Requirements) may also be disposed at the Containerized Waste Facility, if packaged, transported, and accepted in accordance with Radioactive Material License UT2300249 requirements for the Containerized Waste Facility. VIII.1.a. Alternate waste characterization procedures applicable to Certified Containerized Waste are outlined in Exhibit 2. I.5. (Exhibit 2 is now Section VIII)

Wastes that do not contain Resource Conservation and Recovery Act (RCRA) hazardous material may be transferred from the Mixed Waste Facility for disposal at the LLRW cells in accordance with the requirements outlined in Exhibit 3. I.11.

Wastes may be exempted from sampling in accordance with the criteria provided in "Requirements for Debris Waste Streams" below. In addition, Energy*Solutions* may petition the Executive Secretary of the Utah Radiation Control Board to exempt specific waste streams from sampling. Petitions to exempt waste streams from sampling may be based on ALARA concerns (dose rate, DAC, or removable contamination) or other personnel health and safety concerns as outlined in the petition to exempt each waste stream. I.8.c. & I.8.d.

Wastes that are characterized to contain greater than 1% free liquids are referred to as "liquid wastes" for the purposes of this plan. Liquid wastes are addressed under the heading "Requirements for Liquid Wastes" below. I.12.

Outline of Waste Characterization Plan Procedures

~~There are four steps that are taken for a waste to be accepted for management and final disposal~~.

The first step is a characterization of the waste by the generator. The characterization procedures are described below in the Pre-shipment Waste Characterization Procedures of this plan. I.6.

For the second step, Energy*Solutions* will sample and analyze the incoming waste shipments for radiological and chemical screening analyses. The requirements for the radiological and chemical screening analysis are outlined in the Acceptance Sampling and Analysis Procedures of this plan. I.8.

The third step is to accept or reject the material following its arrival at the Clive site. This determination is made according to the Procedures for Accepting or Rejecting a Shipment for Management outlined below. I.7.

The fourth step is to determine final disposal of a waste by obtaining results from approved laboratories to verify the chemical and radiological properties of the waste as outlined in the Procedures for Receipt of Results from Approved Laboratories. I.8.

STEP 1 -- Pre-shipment Waste Characterization Procedures

Prior to shipment, Energy*Solutions* must obtain a description of the material to be managed at the Clive facility. I.6. This characterization is documented using information from the Radiological Evaluation and the Waste Profile records. I.6. & II.2. When wastes or shipments solely contain materials from the list of debris provided in "Requirement for Debris Waste Streams" below, Energy*Solutions* shall follow the waste characterization and sampling requirements provided in that section of this plan. II.1.d.iv.

Once the waste is characterized, analyzed and found to be acceptable for disposal, Energy*Solutions* may provide the generator with a Notice to Transport. The generator must be issued a Notice to Transport prior to shipping wastes to the Clive facility. II.3.

The Waste Profile

> Includes information about the waste"s physical and chemical characterization and a determination by the generator that the material is not a hazardous waste as defined in 40 CFR 261. II.1.b.
>
> As part of the characterization, the generator shall provide information that the waste is not a RCRA hazardous waste and may be disposed at the LLRW cells. II.1.b.i. This information may

include certified process knowledge of the waste stream or the generator may provide TCLP analytical results (8 metals and 32 organics). II.1.d & II.1.d.iii.

> *NOTE: Total Analytical Results divided by a factor of 15 may be used to determine compliance with TCLP Limits for low-level waste.* II.1.d.i.

The Radiological Evaluation shall include a determination by the generator of the radioactive characteristics of the waste. II.1.c. Energy*Solutions* shall have procedures in place to ensure that license limits are met upon receipt. II.2.a. ~~Waste with concentrations greater than Class A limits will not be accepted at the site.~~

Energy*Solutions* will document that the waste characterization requirements of this plan have been met by issuing a "Notice to Transport", to the generator or owner of the waste. Energy*Solutions* will maintain copies of the Notice to Transport at the disposal site for State inspection. II.3.a. & II.3.b.

Should a generator or waste owner send a shipment of waste to the Clive facility prior to receiving a Notice to Transport from Energy*Solutions*, Energy*Solutions* must reject the shipment and provide immediate (24-hour) notice of the shipment to the Executive Secretary of the Utah Radiation Control Board. II.3.c.

Energy*Solutions* must keep a copy of the completed documentation: Waste Profile, Radiological Evaluation, and the Notice to Transport for a period of five (5) years. II.5.

~~Any waste which is determined to be a hazardous waste or to exceed License limits shall not be disposed of in the LLRW cells. Such waste must be handled and disposed of elsewhere in compliance with all other applicable regulations or returned to its place of origin.~~

STEP 2 -- Acceptance Sampling and Analysis Procedures

Upon arrival, the freight container is externally surveyed for gamma radiation readings to assure compliance with DOT regulations. III.2.b.i.

Waste containers shall be marked or labeled with the following information, at a minimum:

Generator identification number;
Waste stream number;
Bates number
The date the waste was received;
The word "Resin" (when applicable);
The word "Asbestos" (when applicable);
The acronym "PCB" (when applicable);
The words "Liquid Radioactive Waste" (when applicable); I.15.

Energy*Solutions* must obtain representative samples for analyses from incoming shipments of waste to confirm that the waste is within the parameters of the license and permit. The following analyses are to be performed on samples of incoming shipments: IV.1.

- Deferred Chemical Screening Parameters
- Radiological Analytical Parameters
- Visual Inspection for Free Liquids (for non-liquid shipments) - When a visual inspection indicates free liquids are present, the 1% Free Liquid Volume Determination procedure will be implemented. III.2.b.ii.A.

Approved analytical laboratories used for purposes of this plan must hold a current certification from the generator's state -- OR -- must meet the requirements of the generator's state for chemical or radiological laboratories -- OR -- must hold a current certification for the applicable chemical or radiological analytes from the Utah Bureau of Laboratory Improvement insofar as such official certifications are given -- OR -- must be a laboratory approved by the Utah Division of Radiation Control. I.10.

Energy*Solutions* must take chemical-screening samples of incoming shipments according to the frequencies outlined in the Frequency of Analyses and Sample Collection Requirements section. Chemical-screening sample parameters are listed below. IV.1.

Deferred Chemical Screening Parameters:

Hazardous waste characteristics D001-D043 (40 CFR 261, subpart C) IV.1.a.

- ~~The deferred chemical screening parameters may be analyzed within the time frames established for obtaining results outlined in Step 4.~~ The results of these analyses will be documented and retained in the operating record until closure of the facility. IV.5.a.iv.
- Analysis for the ignitable (D001) and corrosive (D002) characteristics are not required for a non-liquid waste. II.1.a.i.
- The reactivity (D003) characteristic will be assessed using a reactive cyanide analysis. II.1.a.ii.

Radiological Analytical Parameters: IV.1.b.

- Grab samples shall be analyzed using gamma spectroscopy, where the laboratory must identify and quantify each observed peak. When manifested non-gamma radionuclide concentrations are within seventy-five percent of the license limit, the grab sample shall be analyzed for each non-gamma radionuclide identified in the waste manifest. (clarified in IV.1.b.i. & IV.1.b.ii.)

During the transfer process, intermodal containers may be placed on the unimproved surface adjacent to the rail track to facilitate sampling or loading operations, provided that the movement to an approved waste storage area or a disposal embankment is completed within 48 hours. IV.7.a.

STEP 3 -- Procedures for Accepting or Rejecting a Shipment for Management

The shipping manifest will not be signed until Energy*Solutions* has performed an initial inspection of the shipment and shipping papers for compliance with DOT and DRC radioactive material shipment regulations. III.2.

Energy*Solutions* shall document that the required samples for radiological and deferred chemical-screening parameters have been taken. IV.1. Shipment(s) or package(s) which do not meet the acceptance criteria shall be managed as follows:

a. Labeled "hold" and segregated to clearly identify the shipment(s) or package(s) to prevent further management of the waste until the problem has been resolved; or III.5.a.i.
b. Returned to the generator. III.5.a.ii.

Energy*Solutions* shall provide electronic mail or verbal notice of the shipment discrepancy to the Executive Secretary of the Utah Radiation Control Board within 24 hours. III.5.b.i. Within 7 calendar days of discovery, Energy*Solutions* will also provide written notice to the Executive Secretary of the Utah Radiation Control Board regarding the disposition of the non-conforming waste and a plan of action and compliance schedule for resolving any associated non-conformance with the license. III.5.b.ii.

~~As a result of the radiological and chemical-screening procedures taken as outlined above, Energy*Solutions* will either accept or reject a shipment for management at the Clive site.~~

When a leaking shipment or package is identified, the licensee shall immediately contain the leak, and move the shipment or package into the Restricted Area. III.5.e. Once inside the restricted area, Energy*Solutions* shall determine the liquid volume. III.5.e.i. If the volume exceeds 1%, a sample of the liquid shall be tested for pH. III.5.e.i.A. If the pH is 2 or less or 12.5 or greater, the liquids exhibit the RCRA characteristic of corrosivity. V.4.b. The Executive Secretaries of the Utah Radiation Control Board and Utah Solid and Hazardous Waste Control Board shall be notified within 24 hours. V.4.b.i.

If a shipment or package has unexpected free liquids in excess of 1% by volume, the following requirements apply, ~~in accordance with License Condition 17~~: III.5.d.

a. Aqueous liquid shall be solidified using approved solidification agents III.5.e.i.B. & V.3.a. or removed and placed in the evaporation ponds prior to further management of the waste. V.1.b.
b. Nonaqueous liquid shall be returned to the generator V.2.b. or approved for management by the Executive Secretary in accordance with License Condition 16.F.i. V.2.a.

Within 24 hours, Energy*Solutions* shall inform the generator and the Executive Secretary of the Utah Radiation Control Board that the shipment(s) failed the requirements for acceptance. III.5.b.i. Within 7 calendar days of notification, Energy*Solutions* must provide the Executive Secretary of the Utah Radiation Control Board with a written description of the event and corrective actions taken. III.5.b.ii. If the free liquid is less than 1% by volume, the licensee may manage the shipment at facilities with approved secondary containment. I.13.

When a generator has a repeat occurrence of shipments with free-liquids in excess of 1% by volume, Energy*Solutions* shall require a corrective actions plan from the generator. III.5.f.

Shipments of LLRW waste which remain in off-site transportation equipment or vehicles (rail cars, flatbeds, vans, trucks, etc.) and which are awaiting analyses or results may remain at the Clive facility for up to 30 days unless additional time is approved by the Executive Secretary of the Utah Radiation Control Board. IV.7.b. & IV.7.c.

STEP 4 -- Procedures for Receipt of Results from Approved Laboratories

Energy*Solutions* must receive laboratory results for the radiological and deferred chemical-screening parameters within 90 days of the applicable shipment's arrival, unless additional time is approved by the Executive Secretary of the Utah Radiation Control Board. When ^{90}Sr analysis is included, the required time period is 120 days. IV.4.

Should the results from the approved analytical laboratory for radiological parameters or from the deferred chemical screening analysis show that the waste is beyond the limits of the license, Energy*Solutions* must follow the Contingency Plan for Non-Conforming Results outlined in this plan. IV.5.b.i.B.

Requirements for Liquid Wastes

Liquid wastes are defined as wastes that are characterized to contain greater than 1% and up to 100% free liquids. I.11. ~~Examples include but are not limited to liquid mercury for MW treatment, and sludges (which could be LLRW or MW)~~.

Liquid waste shall be managed at the Mixed Waste Facility regardless of whether the waste is LLRW or MW, unless specifically approved by the Executive Secretary. V.1. & V.1.a. Liquid Waste shall be managed in accordance with Attachment II-1-4, *Liquid Waste Management Plan*, of the State-issued Part B Permit. V.3.a.

Liquid radioactive waste shall be processed to render a solid phase product prior to disposal. V.3. & II.v.2.b.ii.A. ~~Treated or processed liquid radioactive waste shall have no free liquids prior to disposal~~. Treated liquid radioactive waste shall be stored at the Mixed Waste Facility prior to disposal, regardless of whether the waste is LLRW or MW. V.1. & V.1.a.

All Radiological Screening Parameters apply to liquid waste shipments. Specific testing parameters and frequency for Deferred Chemical Screening depend on the waste‟s characterization as LLRW or MW. Liquid waste that is MW is subject to the chemical screening requirements of Attachment II-1, *Waste Analysis Plan*, of the State-issued Part B Permit. LLRW liquid waste is subject to the radiological sampling and analysis requirements of this Waste Characterization Plan; and shall be analyzed for liquid pH and photoionizer (“sniffer”) in accordance with Attachment II-1, *Waste Analysis Plan*, of the State-issued Part B Permit. V.4.

~~Liquid waste profiles shall document the generator‟s packaging and transportation plan for compliance with applicable DOT regulations.~~ [This is a DOT issue and is not applicable to a profile]

Requirements for Debris Waste Streams

When waste shipments contain solely materials from the list of debris below, Energy*Solutions* may waive deferred chemical and radiological sampling and analytical requirements. However, if a portion of a waste is amenable to analysis, i.e. contains material not listed below, that portion must be analyzed according to this plan. IV.6.a.iii. Energy*Solutions* shall perform a visual inspection of the waste shipment to confirm that it does not contain material amenable to analysis. When an analysis is waived, an explanation or justification must be provided, and written documentation maintained at the disposal site for State inspection. IV.6.a.v.

Debris: IV.6.a.i.

Solid-phase metals	~~(excluding TCLP-related metals, e.g. lead, unless the waste is to be managed as MW)~~
Wood	(excluding sawdust or shavings)
Concrete	
Brick	
Stone	(not to include dry wall)
Glass	
Plastic	(not to include ion-exchange resins)
Rubber	

Energy*Solutions* may exempt debris from sampling on a waste stream basis, as well. IV.6.b. For waste exempt from sampling, ~~the Director of Health Physics shall~~ verify the generator‟s waste characterization process prior to approving the Waste Profile Record as follows: IV.6.b.i. & IV.6.b.ii.

- Compare the physical description of the waste against the list of debris provided above. IV.6.b.i.A. The generator shall document that the waste does not lend itself to sampling. IV.6.b.i.B.
- Evaluate analytical methods used. IV.6.b.i.C.(1)
- Review characterization instrument calibration curves and efficiency determinations. IV.6.b.i.C.(2)
- Review certificate files for sources used in characterization. IV.6.b.i.C.(3)
- Review Quality Assurance Checks including analytical spike data. IV.6.b.i.C.(4)
- If a generator‟s laboratory participates in a cross-check program, results from these comparisons will be reviewed. IV.6.b.i.C.(5)

The Waste Profile Record for the exempt waste stream will include documentation of this review of the generator‟s waste characterization process. IV.6.b.ii. Energy*Solutions* shall perform a visual inspection of the exempt waste stream against the waste profile record. IV.6.B.iii. If the waste does not match the description provided on the waste profile record, the contingency plan for non-conforming results (below) shall be followed. IV.6.B.iii.B. Visual inspections shall be performed at the sampling frequency for radiological analysis provided below. IV.6.b.iii.A.

Frequency of Analyses and Sample Collection Requirements

For ease in counting, one rail car (any type) may represent a nominal 100 cubic yards and one highway shipment (any type) may represent a nominal 20 cubic yards. Energy*Solutions* may also use the actual manifested volumes for counting purposes. IV.2.a.

Radiological Analysis

For each waste stream, the minimum number of samples to be analyzed for the approved laboratory radiological analyses is:

- One sample for each of the first ten (10) shipments (rail or highway) -- OR -- One sample for each of the first 100 cubic yards (yd^3) up to 1,000 yd^3.

  -- THEREAFTER --

- One sample for each additional 500 yd^3 following the first ten (10) shipments or following the first 1,000 yd^3. IV.2.d.

Deferred Chemical Screening Parameters Analysis

For each waste stream, the minimum number of samples to be analyzed for the deferred chemical screening parameters is:

- The first shipment to arrive at the site.

  -- THEREAFTER --

- Annually for Non-Treated Wastes. For off-site wastes that have not been treated to remove RCRA hazards prior to arrival at the site:

  - The first shipment following or any one shipment prior to the one-year anniversary date of the most recent shipment that was sampled and analyzed for deferred chemical screening.

    -- OR --

- Semi-Annually for Treatment Residue Wastes. For wastes that have been treated to remove RCRA hazards prior to arrival at the site:

  - The first shipment following or any one shipment prior to the date six months after the most recent shipment that was sampled and analyzed for deferred chemical screening. IV.2.c.

Grab Sample Collection Requirements

In order to collect a representative sample for verification of radionuclide content and deferred chemical-screening parameters, the following procedure for sample collection is provided according to the applicable frequencies. Although minimum numbers of aliquots are provided, the samplers should collect enough aliquots as appropriate to ensure that all portions of the corresponding waste volume are represented. IV.3.b.

- Bulk Rail Shipments. The sample shall be a composite sample consisting of six aliquots from random locations. IV.3.a.i.
- Bulk Highway Shipments. The sample shall be a composite sample consisting of four aliquots from random locations. IV.3.a.ii.
- Liquid Tanker Shipments. One sample shall be collected per tanker car. IV.3.a.iii.
- Container shipments (rail or highway). The sample shall be a composite consisting of one aliquot for each ten percent of the containers on a shipment. Containers shall be randomly selected from all of the containers on the shipment. IV.3.a.iv.

Contingency Plan for Non-Conforming Results

Upon discovery of leaking packages, Energy*Solutions* shall inform the generator III.5.a. that the shipment(s) failed the requirements for acceptance and will notify the Executive Secretary of the Utah Radiation Control Board within 24 hours. Within 7 calendar days of the notification of a leaking shipment, Energy*Solutions* must provide the Executive Secretary of the Utah Radiation Control Board with a written description of the event and corrective actions taken. III.5.b.

If the results from the approved laboratory or from the deferred chemical screening parameters analysis show that the waste is beyond the limits of the license, Energy*Solutions* must follow the procedure below: IV.5.a.i. & IV.5.b.i.A. &

(1) Within 24 hours of discovering that non-conforming[1] material had been disposed, Energy*Solutions* must notify the Executive Secretary of the Utah Radiation Control Board of the situation. IV.5.b.vi.A.

(2) Within 7 calendar days of the notice, Energy*Solutions* must provide the Executive Secretary of the Utah Radiation Control Board with a written description of the situation. The following information must be included in the written description: IV.5.b.vi.B.

- Name of Generator

[1] Non-Conforming Waste is a waste that (1) exceeds the limits of the radioactive material disposal license or (2) exhibits hazardous waste characteristics and which has not been granted a case-by-case variance as an exempt material from the Executive Secretary of the Utah Solid and Hazardous Waste Control Board.

- Name of Non-Conforming Waste Stream
- Amount of Non-Conforming Disposed Waste
- Location of Non-Conforming Waste in the Disposal Cell
- Date Non-Conforming Waste was Accepted
- Date Non-Conforming Waste was Placed in Disposal Cell
- Description of Waste Placed on and Around Non-Conforming Waste
- Plan of Action for Resolving Non-Conformance
- Compliance Schedule IV.5.b.vi.B.

Requirements for Remote Sampling of Waste

Energy*Solutions* shall follow the Remote Sampling Requirements in Exhibit 1 when the following conditions apply:

- Mixed wastes (i.e. radioactive lead solids) and radioactive hazardous debris that are subject to the RCRA land-disposal restriction treatment standard of macroencapsulation ("MACRO") are treated at an off-site location. VII.3.a.
- Supercompaction is performed on waste at an off-site location. VII.3.b.
- On-site sampling would interfere with the applied treatment. VII.3.c.
- Specific cases approved by the Executive Secretary of the Utah Radiation Control Board. VII.3.d.

Material which is macroencapsulated at an off-site location shall meet the criteria set forth in Attachment II-1-5, *Macroencapsulation Plan*, of the State-issued Part B Permit, prior to disposal. VII.3.a.i.

Sample Management Requirements

The following requirements apply to samples sent to the Clive facility for treatability study testing, solidification study testing, or other pre-shipment waste characterization purposes: I.14.

1. All samples shall meet the radiological and chemical acceptance criteria of the Radioactive Material License and the State-issued Part B Permit. VI.1.
2. A waste profile record identifying preliminary chemical characterization shall be received prior to approving samples for shipment. The waste profile record does not need to complete the formal review process for chemical and physical properties; however, radiological characterization shall be complete and reviewed by the ~~Director of Health Physics or designee~~. Furthermore, the ~~Environmental Engineer, or designee~~, shall approve samples for shipment. VI.2.
3. The Notice to Transport is not required for shipment of samples; instead, Energy*Solutions* shall document permission to ship samples using the Preshipment Sample Authorization Record. VI.3.
4. Samples shall be accompanied by the Uniform Low-Level Radioactive Waste Manifest. VI.4.

Energy*Solutions* shall notify the Executive Secretary within 5 days of any sample shipment that does not comply with these requirements. VI.5.

Treatability study samples shall meet the requirements of and be managed in accordance with 40 CFR 261.4(f). All other samples not regulated under 40 CFR 261 shall not exceed 15 cubic feet per waste stream, unless prior authorization for a larger sample size is received from the Executive Secretary of the Utah Radiation Control Board. VI.6.

Samples shall be stored either in the on-site laboratory or at permitted containerized waste storage facilities. VI.7. All samples shall be disposed or returned to the generator within one year of receipt. VI.8.

Samples analyzed at the Clive facility on-site laboratory shall be disposed by either:

a) Placing the sample residue in storage or disposal with the waste stream from which it originated; or, VI.8.a.
b) Accumulating sample residues by waste type (i.e., LLRW, MW solids, MW liquids, 11e.(2)) in closed containers as an Energy*Solutions* waste stream for storage and disposal. VI.8.b.

WASTE CHARACTERIZATION PLAN
EXHIBITS AND ATTACHMENTS

EXHIBIT 1: REMOTE SAMPLING REQUIREMENTS

New Section VII - made much more generic and provided much more detail

Frequency of Remote Sampling: The same frequency for remote sampling as for the regular incoming-shipment sampling required in the LLRW Waste Characterization Plan. VII.2. ~~For example, if a generator has waste that would require six (6) samples to be taken from incoming shipments, then Energy*Solutions* would require six (6) samples to be remotely obtained and then analyzed~~.

Analytical Parameters: The same analytes for remote sampling as for the regular incoming-shipment sampling required in the LLRW Waste Characterization Plan. VII.2. ~~Currently, this list of radiological analytical parameters includes a gamma scan, where the laboratory must identify and quantify each observed peak, and a quantification of each non-gamma emitting radionuclide identified by the generator on the shipping manifest~~.

Training and Expertise Required of the Individuals Authorized by Energy*Solutions* to Perform the Remote Sampling: The individual(s) must be contacted, interviewed, and provided guidance as necessary ~~by one of the following Energy*Solutions* officials: Corporate Director, Radiation Safety, Director of Health Physics, or Laboratory Manager. The purpose of the interview is to ensure that samples are obtained which will properly represent the waste.~~ Energy*Solutions* will document these determinations of authorization for remote sampling personnel in the operating record. During the remote sampling efforts, these individuals must work for Energy*Solutions* as an employee or consultant and must be independent of the waste generator or treater. VII.5.d. (proper training rather than interviewed and provided guidance)

Sample Chain-of-Custody Requirements: Standard chain-of-custody procedures and documentation are required for remotely-obtained samples.

UDRC Prior Written Notification Requirements: For each generator for which remote sampling is to be implemented, Energy*Solutions* will submit the following information seven days prior to the scheduled sampling event: VII.4. (changed to 14 days)

- A description of the physical form(s) of the wastes to be encapsulated or supercompacted. VII.5.a.
- The tonnage and volume requiring encapsulation or supercompaction VII.5.a.i.
- The projected tonnage and volume after encapsulation or supercompaction VII.6.e.ii
- The encapsulation or supercompaction technology employed VII.6.e.i.
- Certification from the generator that encapsulation or supercompaction has met appropriate quality control/quality assurance objectives VII.6.e.iii.

- Certification from Energy*Solutions* that encapsulation or supercompaction has met appropriate quality control/quality assurance objectives VII.6.e.v.

All - Section VII (made much more generic and provided much more detail)

EXHIBIT 2: CERTIFIED CONTAINERIZED WASTE CHARACTERIZATION

Section VIII

This exhibit outlines waste characterization requirements associated with containerized wastes destined for disposal at the Containerized Waste Facility. These certification requirements outline the process for qualifying waste as Certified Containerized Waste. VIII.1. These certification requirements are the specified alternative to the requirements for sampling and analysis following receipt that are outlined in the main body of this plan. I.8.

Note: Some generators seeking waste certification may also have wastes they do not designate for this certification program. Certified Containerized Waste will be profiled separately from any non-certified wastes from the same generator using a separate Waste Profile Record. Non-certified waste streams that are characterized in accordance with the requirements outlined in the main body of this plan will not be disposed at the Containerized Waste Facility. VIII.2. However, remote-sampled waste may be accepted for disposal in the Containerized Waste Facility if characterized in accordance with Exhibit 1. VIII.1.a.

Certified Containerized Waste. Energy*Solutions'* review and acceptance of the Certified Containerized Waste Profile Record will include an assessment of the following issues ~~to the satisfaction of Energy*Solutions'* Corporate Director, Radiation Safety (or designee), Quality Assurance Manager (or designee), and Environmental Engineer (or designee), as applicable~~.

1. Review the generator‟s procedures for radioactive and hazardous waste characterization, packaging, and transportation for adequacy in meeting Energy*Solutions'* license limits, waste acceptance criteria, receipt and disposal requirements. Particular attention will be given to radiologic characterization, free liquid management and inspections, and void space minimization procedures. VIII.3.a. & VIII.3.b.
2. Review the generator‟s QA/QC program applicable to the procedures provided in item 1 above for adequacy. VIII.3.c.
3. Review inspection reports or summaries (for the previous three years) completed by the generator‟s primary radioactive waste management regulatory agency. Examples of such reports include: NRC audits, DOE inspections, or Agreement State compliance records. Ensure that any identified deficiencies applicable to waste characterization, packaging, and/or transportation have been adequately addressed. VIII.3.d.
4. The generator will name its primary point of contact and responsible corporate authority for the compliance of shipments to the Clive facility. VIII.3.e.

Alternative Waste Characterization Requirements for Certified Containerized Waste.

Waste characterization for Certified Containerized Waste follows many of the same requirements as other wastes disposed at the Clive facility, in accordance with the body of the Waste Characterization Plan. The following discussion outlines the receipt and acceptance process by highlighting in bold type the steps excluded from or added to the process for Certified Containerized Waste as compared to non-certified wastes. VIII.5.

- ~~Certified Containerized Waste will be profiled by the generator. **Record review will assess items 1-4 above.**~~
- A Notice to Transport will be issued by Energy*Solutions* for Certified Containerized Wastes following acceptance of the Certified Containerized Waste Profile Record. A current Notice to Transport is required prior to scheduling and receiving a shipment. VIII.4.
- Container integrity will be inspected. Containers that are leaking or fail to meet a minimum of a "strong, tight" criteria will be managed in accordance with Radioactive Material License UT2300249. VIII.5.a.
- Certified Containerized Waste may contain up to 1% free liquids (by volume). **Verification of compliance with this limit shall be accomplished in accordance with standard operating procedure "Package Liquid Verification," when applicable, as follows:**

    1. **Only Class A-unstable waste.**
    2. **Maximum contact dose rate will be less than or equal to 80 mR/hr.**
    3. **Inspection is performed within the foot print of the disposal cell.**
    4. **The package will be sealed upon completion. VIII.5.b.**

- Deferred Chemical and Radiologic Analyses are **not required** for Certified Containerized Wastes. All sections of the Waste Characterization Plan related to sample collection, frequency, receipt of results, remote sampling, and sample disposal are **not applicable** to Certified Containerized Wastes. VIII.6.

Contingency Plan for Nonconforming Shipments of Certified Containerized Waste

If a shipment of Certified Containerized Waste is determined to be greater than Class A LLRW in accordance with UAC R313-15-1008 (i.e., the waste is Class B or Class C LLRW), the shipment will be rejected and returned to the generator. Any alternative to return of the shipment (such as disposal at the Clive facility or shipment to another disposal facility) shall have prior written approval of DRC. The DRC and the generator will be notified within 24 hours of discovery that a waste shipment is greater than Class A LLRW. VIII.7.

All other incoming-shipment discrepancies, such as manifesting errors, free-liquids exceedances, or containers not meeting the strong, tight criteria, shall be managed in accordance with Radioactive Material License UT2300249. VIII.5.

EXHIBIT 3: TRANSFER OF WASTE FROM THE MIXED WASTE FACILITY

Section IX – Very Similar

1. INTRODUCTION

This plan shall govern proper practices employed to transfer waste from the Energy*Solutions* Mixed Waste Facility to the Low-Level Facilities at Clive. This plan outlines conditions of waste management and waste analysis to be completed prior to waste transfer. This plan also describes controls to prevent the inadvertent transfer of hazardous waste. This plan works together with Attachment II-1-15, *Management of Waste for Disposal at the LLRW Facility*, within the State-issued Part B Permit issued to the Mixed Waste Facility.

2. SCOPE

This plan shall apply to all waste that is managed at the Mixed Waste Facility and subsequently is transferred to the Low-Level Facility for final disposal. Only waste that is no longer hazardous or that has been completely solidified will be transferred. All waste transfer approvals will be based upon regulatory statutes codified within R315-2 and R315-13 of the Utah Administrative Code, and by reference 40 CFR 261 and 40 CFR 268 of the Federal Regulations.

3. <u>PROHIBITED WASTE TRANSFERS</u>

The following wastes are prohibited to be transferred from the Mixed Waste Facility to the Low-Level Facility:

a. Wastes which maintain a listed hazardous waste code as described in R315-2-10 and R315-2-11 (40 CFR 261.30 – 261.33). This includes any waste that maintains an F-, K-, P-, or U- hazardous waste code.

b. Wastes which maintain a characteristic (D-) hazardous waste code and have not been treated to meet the treatment standards described in R315-13 (40 CFR 268 incorporated by reference).

c. Thermal desorption residues.

d. Evaporation tank liquids.

e. Amalgamated mercury.

f. Debris that has been treated using an immobilization technology (e.g., macroencapsulation).

g. Any waste that does not meet the descriptions provided in Section 4 of this plan.

4. <u>APPLICABLE WASTE TRANSFERS</u>

a. The following wastes are not hazardous waste as defined by the Utah Hazardous Waste Management Rules (R315-2-3) and therefore may be transferred from the Mixed Waste Facility to the Low-Level Facility:

i. Formerly Characteristic Wastes that have been treated to meet the treatment standards described in R315-13 (40 CFR 268 incorporated by reference) and do not retain listed hazardous waste codes.

A. Wastes which were formerly ignitable (D001), corrosive (D002), or reactive (D003) will meet the treatment requirement of deactivation (DEACT) to remove the hazardous waste characteristic.

B. Wastes which were formerly toxicity characteristic (D004-D043) will meet the nonwastewater concentration-based treatment standards described in R315-13 (40 CFR 268.40).

C. All formerly characteristic wastes will also meet the Universal Treatment Standard (UTS) concentrations described in R315-13 (40 CFR 268.48) for all Underlying Hazardous Constituents (UHCs) identified within the waste.

(1) UHCs are defined as any constituent listed in the UTS table of R315-13 (40 CFR 268.48) except fluoride, selenium, sulfides, vanadium, and zinc, which can reasonably be expected to be present at the point of generation of the hazardous waste at a concentration above the constituent-specific UTS treatment standards.

ii. Wastes that are solidified at the Mixed Waste Facility and that never had; or do not retain listed or characteristic hazardous waste codes.

iii. Formerly Characteristic or Listed debris waste which has been treated to the treatment standards for hazardous debris using an extraction or destruction technology described in R315-13 (40 CFR 268.45; e.g., spray washing).

A. Debris waste is defined as solid material exceeding 60 mm particle size that is intended for disposal and that is: A manufactured object; or plant or animal matter; or natural geologic material.

iv. Contaminated soil that has been treated to the alternative LDR treatment standards described in R315-13 (40 CFR 268.49), provided that:

A. the soil was not originally contaminated with a listed waste; and

B. the treated waste does not exhibit any hazardous characteristics as described in R315-2-9 (40 CFR 261, Subpart C).

v. Empty containers that are certified „visibly clean."

A. "Visibly clean" is the criterion in which all observable contamination has been removed from surfaces. This criterion includes the removal of all material that can be removed with a broom, shovel or other tool.

b. When required, analytical verification of waste contaminant concentrations will be conducted in accordance with treatment and solidification provisions in the State-issued Part B Permit. All required analyses will use Environmental Protection Agency (EPA) approved methods (e.g., SW-846) and will be performed by a laboratory certified by the National Environmental Laboratories Accreditation Conference (NELAC) or through the State of Utah.

c. Documentation and certification of treatment will be performed in accordance with the requirements of Attachment II-1-15 of the State-issued Part B Permit.

5. <u>FACILITY PREPARATION TO AVOID CROSS-CONTAMINATION</u>

Precautions employed at the Mixed Waste Facility prior to managing a waste that is expected to be transferred to the Low-Level Facility are described in Section 6 of Attachment II-1-15 within the State-issued Part B Permit. If these precautions are not completed and documented, the waste may not be transferred to the Low-Level Facility. Highlights of these precautions include the following:

a. All containers, tanks, and equipment that may come into contact with the waste will be triple rinsed with water or another suitable solvent prior to managing the waste.

b. Floors and surfaces will be swept and kept free of contaminants prior to and during the processing of waste that is expected to be transferred. Alternatively, a tarp or other non-contaminated covering may be placed onto the floor prior to waste management.

c. Waste operations for waste that will be transferred to the Low-Level Facility will be segregated from other hazardous wastes.

APPENDIX M

Environmental Monitoring Plan

(with proposed amendments in reline/strikeout format)

ENVIRONMENTAL MONITORING PLAN

1.0 PURPOSE AND SCOPE

Purpose: The purpose of the Environmental Monitoring Plan is to provide a comprehensive plan for monitoring radiation and radioactive emissions to the environment. This information will be used to verify regulatory compliance and evaluate the effectiveness of measures to control the environmental impact of disposal operations.

Scope: The scope of this plan includes the activities EnergySolutions performs to monitor the site and surrounding area during operations at the Clive radioactive waste disposal facilities, and to report the net radiological effects that result from managing the licensed material. The details of this Plan include the applicable assumptions, tested parameters, and testing methods that collectively express regulatory compliance with regard to radioactive emissions and non-occupational radiation doses.

With the exception of the PCB soil sampling this plan does not include occupational, chemical, or groundwater monitoring requirements.

2.0 REFERENCES

Clive, *Radiation Protection Program*, Salt Lake City, Energy*Solutions,* Inc, Utah, As Revised.

ICRP Publication 30, *Limits for the Intake of Radionuclides by Workers*, Annals of the International Commission on Radiation Protection Vol. 19, November 1978.

ICRP Publication 60, *Recommendations of the International Commission on Radiation Protection*, Annals of the International Commission on Radiation Protection Vol. 21 No. 1-3, 1990.

ICRP Publication 65, *Protection against Radon-222 at Home and at Work*, Annals of the International Commission on Radiation Protection Vol. 23 No. 2, 1993.

ICRP Publication 66, *Human Respiratory Tract Model for Radiation Protection*, Annals of the International Commission on Radiation Protection Vol. 24, 1994.

ICRP Publication 68, *Dose Coefficients for Intakes of Radionuclides by Workers*, Annals of the International Commission on Radiation Protection Vol. 24 No. 4, 1995.

ICRP Publication 72, *Age-dependent Doses to Members of the Public from Intake of Radionuclides*, Annals of the International Commission on Radiation Protection Vol. 26 No. 1, 1996.

Regulating the Disposal of Low-Level Radioactive Waste – A Guide to The Nuclear Regulatory Commission's 10 CFR Part 61, United States Nuclear Regulatory Commission, 1989

Regulatory Guide 1.86, *Termination of Operating Licenses for Nuclear Reactors*, United States Nuclear Regulatory Commission, 1974

NUREG-1573, A Performance Assessment Methodology for Low-Level Radioactive Waste Disposal Facilities, United States Nuclear Regulatory Commission, 2000

NRC Regulatory Guide 3.64, *Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers*, United States Nuclear Regulatory Commission, 1989

NRC Regulatory Guide 4.14, *Radiological Effluent and Environmental Monitoring at Uranium Mills*, United States Nuclear Regulatory Commission, 1980

NRC Regulatory Guide 4.15, *Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment, United States Nuclear Regulatory Commission*, 2007.

NRC Regulatory Guide 4.20, *Constraint on Releases of Airborne Radioactive Materials to the Environment for Licensees Other Than Power Reactors*, United States Nuclear Regulatory Commission, 1996.

NRC Regulatory Guide 8.34, *Monitoring Criteria and Methods to Calculate Occupational Radiation Doses*, United States Nuclear Regulatory Commission, 1992.

NRC Regulatory Guide 8.37, *ALARA Levels for Effluents from Materials Facilities*, United States Nuclear Regulatory Commission,1993.

NRC, *NRC Staff Interim Guidance, Evaluation of Uranium Recovery Facility Surveys of Radon and Radon Progeny in Air and Demonstrations of compliance with 10 CFR 20.1301*, September 2011.

10 CFR Part 20, *Standards for Protection Against Radiation*, United States Nuclear Regulatory Commission, As Revised.

10 CFR Part 40, *Domestic Licensing of Source Material*, United States Nuclear Regulatory Commission, As Revised.

49 CFR.173.428, *Empty Class 7 (radioactive) materials packaging*, United States Department of Transportation, As Revised

49CFR 173.443, *Contamination control*, United States Department of Transportation, As Revised

Utah Administrative Code, R313-15, *Standards for Protection against Radiation*, As Revised.

Utah Administrative Code, R313-25, *Requirements for the Land Disposal of Radioactive Waste*, As Revised.

3.0 DEFINITIONS

Activity Mean Aerodynamic Diameter (AMAD): Fifty percent of the activity in the aerosol is associated with particles of aerodynamic diameter greater than the Activity Mean Aerodynamic Diameter.

As Low As Reasonably Achievable (ALARA): Reasonable effort to maintain exposures to radiation as far below the dose limits as is practical consistent with the purpose for which the licensed activity is undertaken. The determination of what is "reasonable" considers; the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations.

Non-contaminated Restricted Area Exits: A gate in the Restricted Area Security fence used to exit directly from a Non-contaminated Restricted Area.

Committed Dose Equivalent (CDE): The dose equivalent to organs or tissues from an intake of radioactive material by an individual during the 50-year period after intake.

Committed Effective Dose Equivalent (CEDE): is the sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues.

Controlled Area: an area, outside of a restricted area but inside the site boundary, access to which can be limited by the licensee for any reason.

Deep Dose Equivalent (DDE): applies to external whole-body exposure, is the dose equivalent at a tissue depth of 1 cm (1000 mg/cm^2).

Dose Coefficient: Factors determining the radiation exposure of individual organs and the whole body by incorporated radioactive substances. Dose factors depend on the radionuclide, the incorporation type (inhalation/ingestion), the chemical compound of the radionuclide and on the age of the person.

Effluent Concentration Limit (ECL): Radionuclide which, if inhaled or ingested continuously over the course of a year, would produce a stochastic total effective dose equivalent of 50 mrem. With the exception of radon-220 (radon) and radon-222 (thoron), the dose coefficients from International Commission on Radiation Protection Publication 68 and International Commission on Radiation Protection Publication 72 were used to calculate effluent concentration limit values. The Dose Coefficients used assume a 50 year CEDE and a 1 um AMAD particle size. ~~International Commission on Radiation Protection Publication 65 "Protection against Radon-222 at Home and at Work"~~ The ECL values from 10CFR20, Appendix B, Table 2 are used for radon and thoron. ~~was used to calculate the Radon ECL and the thoron ECL was taken from 10CFR20.~~ Table 3 lists the "ECL" values for several licensed radionuclides, and provides additional details regarding the ECL derivation process.

Member of the Public: A member of the public as defined by UAC, R313-15-301 is "any individual except when that individual is receiving an occupational dose". A member of the public as applied to Utah Administrative Code R313-15-101(4), and Utah Administrative Code R313-25-19 is unassociated with Site operations and located outside controlled area boundaries.

Minimum Detectable Concentration (MDC): the smallest amount~~radioactivity~~ of radioactivity~~e material~~ in a sample that will yield a net count (above system background) that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal.

Occupancy Factor: The fraction of time a person may have occupied a space or area having a known quantity of exposure. The exposure rate is assumed to be fairly constant for the entire exposure period.

Particulate Air Sample (PAS) Action Levels: Airborne particulate alpha or net beta concentration used to insure that the PAS results remain below the ECL. The alpha action level is 1.4E-13 uCi/ml, based on the thorium-230 Class S effluent concentration limit, and the beta action level is 2.1E-12 uCi/ml, based on the lead-210 Type F effluent concentration limit.

In the past the alpha PAS action level was based on the Th-232 ECL. While Table 3 of the Environmental Monitoring Plan indicates that Th-232 is more restrictive, Th-232 is always accompanied by several alpha emitting decay progeny at or near secular equilibrium with the Th-232 parent. The Th-232 ECL must be adjusted to account for the alpha emitting daughters when it used as the PAS Action Level. For this reason the Th-230 ECL is more restrictive.

Regulatory Guide 3.51 states that thorium in ore, yellowcake, and tailings dusts is 100% class Y, which is consistent with most of the waste containing Th-230. Class "Y" under the ICRP 30 system is analogous to type "S" under the newer ICRP recommendations.

~~**Radiological Release:** Survey, documentation and actions as required to meet the following:~~

- ~~DOT Empty Release, in accordance with 49CFR173.428.~~
- ~~Return to Service Release, in accordance with 49CFR173.443~~
- ~~Unrestricted Use Release, in accordance with NRC Regulatory Guide 1.86~~

Replicate Error Ratio (RER): The difference between two different analytical results divided by the statistical sum of their analytical uncertainty. The value is used to assess amount of agreement between two different analytical results with respect to their analytical uncertainty.

$$RER = \frac{|A-B|}{\sqrt{\sigma_A{}^2 + \sigma_B{}^2}}$$

Where:

A = First analytical result.

B= Second analytical result

σ_A= Reported analytical uncertainty for the first sample.

σ_B= Reported analytical uncertainty for the second sample.

Restricted Area: An area where access is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. The fenced area that includes the disposal embankments and associated radioactive waste handling areas is generally referred to as the Restricted Area.

Soil Action Levels: 5 pCi/g by gamma spectroscopy for a naturally occurring radionuclide (other than potassium-40), 3 pCi/g cesium-137, or 2 pCi/g for any other radionuclide. Potassium-40 (K-40) is typically found in soil around 17 pCi/g. There are few if any industrial or scientific processes that generate a K-40 enhanced waste. Therefore, K-40 is a poor indicator of radioactivity release so it is excluded from the Soil Action Level definition.

Total Effective Dose Equivalent (TEDE): The sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

Vacuum Assisted Thermal Desorption (VTD): Treatment used to extract volatile contaminants from Mixed Waste. The VTD unit is located in the Mixed Waste Storage Building.

4.0 DESCRIPTION

The Site is located in the semi-arid west desert of Utah. The surrounding region is restricted by zoning statute for exclusive use by the hazardous waste industry. The closest residents are the live-in care takers at the I-80 rest stop, seven miles northeast of the Site.

The disposal site is a parcel of land, consisting of one square mile in Tooele County, Utah. Energy*Solutions* also owns the adjacent one square mile section of land to the n~~N~~orth and an adjacent 0.5 square mile section of land to the south. The area used for waste disposal, unloading, hauling, and handling waste (Restricted Area) is completely surround by fence. ~~There is a buffer area of 100 feet between the Restricted Area fence and the foot print of any embankment.~~ There is ~~also~~ a ~~secondary~~ buffer area of 300 feet between the closest edge of any embankment and the property line. Most of the other land within a 10 mile radius of the site is public domain administered by the Bureau of Land Management. ~~The dry arid desert limits use of the land to sheep grazing, jack rabbit hunting, and recreational driving.~~

The site boundaries are under continuous electronic surveillance by a full-time security staff. ~~This security staff physically patrols the site boundary several times during each 24 hour period.~~ Any unauthorized individuals found near the controlled area are advised by the security staff not to loiter near the Site.

4.1 EXPOSURE PATHWAY: INGESTION

Regulatory Guide 4.14 states that vegetation and surface water samples should be collected "Where a significant pathway to man is identified in individual licensing cases." Because there is no significant ingestion pathway, vegetation and surface water samples are not taken.

The site has no nearby residents or crops. The groundwater is not suitable for irrigation, or consumption by either humans or animals. Surrounding vegetation is accessible to grazing animals but the sparse foliage and water sources are not adequate to keep livestock near the site for extended periods of time.

There are no natural bodies of surface water near the site, and storm water quickly evaporates from the puddles which appear temporarily in shallow depressions following precipitation events. There is no natural drainage of this storm water away from the site area, and the facility design precludes runoff outside the approved waste management areas.

Administrative procedures require an immediate response to promptly characterize and remediate any suspected radioactive liquid found anywhere outside of the approved ~~liquid~~ waste management areas. Any incidental deposition of effluent radionuclides outside of the restricted areas is easily detected by soil sampling.

4.2 EXPOSURE PATHWAY: EXTERNAL RADIATION

External radiation to members of the public is limited to gamma radiation. The potential sources of radiation include the waste disposal cells, waste unloading areas, treatment areas, storage pads, the railcar rollover, the rotary dump, the shredder, the laboratory, and haul roads. Historically, external radiation contributes a small fraction of the off-site dose.

External radiation is monitored at designated air stations located along the Restricted Area boundaries. In addition, monitors are set up, as needed, inside buildings and on the Restricted Area fence to ensure compliance with the regulations.

4.3 EXPOSURE PATHWAY: INHALATION

Direct inhalation of radioactive airborne particulates~~,~~ and radon~~, and thoron~~ has the highest potential for off-site dose. Sources of inhalation exposure particulates include the rollover, the rotary dump, the shredder, rail car unloading area, bulk waste storage areas, haul roads, the VTD, and waste disposal cells.

Airborne radioactive particulates and gasses are continuously monitored at designated monitoring stations. With the exception of locations used to establish background and the VTD effluent monitoring station, the monitored locations are situated near the fenced boundaries that surround waste management areas. The overall sampling pattern is designed to intercept airborne radioactive effluents leaving the site in any direction. The airborne exposure measured at these monitoring stations is used to calculate the dose received from Site airborne effluents.

4.4 DOSE LIMITS

EnergySolutions' RML requires compliance with Utah Administrative Code (UAC) R313 unless "the statements, representations, and procedures in the Licensee's application and correspondence are more restrictive than the rules." Environmental (member of the public) dose limits are listed in Utah Administrative Code (UAC)~~The dose calculated from the environmental monitoring results is compared with the limits in Utah Administrative Codes (UAC),~~ R313-15-301, R313-15-101(4), and R313-25-19.~~ to demonstrate compliance.~~ ~~Energy*Solutions*~~ These UAC dose limits were generated from 10 CFR 20.1301(a), 10 CFR 20.1101(d), and 10 CFR 61.41 respectively. The methodology used to compare monitoring results with dose limits is consistent with applicable NRC issued regulatory standards.

The application of each of these regulations requires; identifying the "member of the public", determining occupancy, identifying the applicable exposure types, converting measured results to potential exposure, and identifying the applicable limit. A general process is used to convert measured results to potential exposure for all three limits. The process assumes the monitoring results measured at the environmental monitoring station represent the potential exposure for the "member of the public" for a continuous occupancy. Compliance with "member of public" limits is determined by adjusting the measured monitoring station results by an occupancy factor related to the specific limit being evaluated. EnergySolutions may opt to do a more detailed assessment of; occupancy, "member of the public" location, and nuclide absorption type parameters to demonstrate compliance with regulatory limits.~~monitors the boundaries of the restricted areas and calculates an estimated radiation dose at each monitored location. The estimated radiation dose is calculated by multiplying the measured dose, CEDE, TEDE or CDE, by an occupancy factor. The occupancy factor should be a conservative estimate of the time a person may have been present at the location where the exposure occurs. The estimated radiation dose is used to demonstrate compliance with regulatory standards and is not intended represent the dose to an actual individual. The assumption and methods used to apply the environmental monitoring results are described in Energy*Solutions*' ALARA Program document.~~

4.4.1 UAC R313-15-101(4) ALARA Constraint

This regulation requires meeting a constraint of 10 mrem per year CEDE (excluding radon-222 and its decay products) to the individual member of the public~~, located outside the Site boundary,~~ who is likely to receive the highest dose from effluent air emissions. NRC Regulatory Guide 4.20, "Constraint on Releases of Airborne Radioactive Materials to the Environment for Licensees other than Power Reactors", outlines the acceptable methods for demonstrating compliance with this regulatory requirement. Additional instructions in NRC Regulatory Guide 4.20 state, " licensees need not consider nonresidents within the facility boundary.' An occupancy of 0.02 is generally used to demonstrate compliance.~~Energy*Solutions* will employ one or more of the general techniques in Reg. Guide 4.20 to demonstrate compliance.~~

4.4.2 UAC R313-15-301 Public Dose limits

This regulation requires that the TEDE to individual members of the public from licensed or registered operations does not exceed 100 mrem in a year. Compliance is determined using one of the approved options presented in UAC R313-15-302. An occupancy of 0.25 is generally used to demonstrate compliance.

4.4.3 UAC R313-25-19 Public Dose limits

The radioactive material which may be released to the general environment shall not result in an annual dose exceeding 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ of a member of the public. The approach to dose assessment in UAC R313-25-19 is dated. In NUREG-1573 the NRC recommends the 25 mrem/year TEDE as the appropriate dose limit. As the dose limit is restricted to "Concentrations of radioactive material which may be released to the general environment," the calculated TEDE values used to demonstrate compliance, do not include the DDE exposure measured at the Environmental Monitoring stations.

The limit applies to members of the public, not associated with the facility. An occupancy of 0.02 is generally used to demonstrate compliance. ~~Compliance is~~

Formatted: Indent: Left: 0.5"

~~demonstrated by calculating the CDE multiplying the airborne monitoring results measured at each of the air monitoring stations by an occupancy factor, which is representative of a member of the public located outside the Site Boundary.~~

5.0 OPERATIONAL REQUIREMENTS

5.1 AIR SAMPLING

5.1.1 AIRBORNE PARTICULATES - Alpha/Beta Screening

Air is continuously sampled at the sample locations, listed in Table 1 and Drawing 07007-J01, Revision 4, with the exception of the VTD effluent which is only sampled during VTD operation. The stations located around the Restricted Area perimeter are used to determine the airborne concentration of radioactive particulates from disposal operations. Station A-16, located west of the Site, at the Clean Harbors Clive facility, is used to determine background.

Radioactive airborne particulate samples are collected using a constant-flow air sampler to draw air through a glass fiber filter, or a functionally similar particulate sampling media. The particulate air sampling apparatus maintains a flow rate of approximately 60 liters per minute through the filter media. The airborne particulate sampling filters are changed at least once a week~~twice weekly under most circumstances. When holidays or other production stoppages limit radioactive waste handling or disposal operations to three days or less during any calendar week, the particulate filters collection may be reduced to once a week.~~

All particulate filters are analyzed for alpha and beta activity at least 7 days but not more than 14 days after collection. The delay of 7 days is needed to allow for the decay of short-lived radon progeny that could potentially interfere with detecting the long-lived contaminants of concern. The time limit of 14 days is to ensure that samples are analyzed in a timely manner. With the exception of the VTD sample, the alpha and beta concentration measured at Station A-16 is subtracted from the concentrations measured at the other stations. If for some reason the data from A-16 is not available or is indeterminate, no background will be subtracted for the samples collected during the sampling period, so the gross concentrations will be used instead of the net concentrations.

Any individual sample filters with a net alpha or net beta concentration above the applicable PAS Action Level will be analyzed by gamma spectroscopy within 3 working days of the alpha/beta analysis. Gamma spectroscopy analysis results will be reviewed to determine if any additional actions need to be taken.

When an individual filter has a net alpha concentration above 3E-12 uCi/ml or net beta concentration above 5E-11 uCi/ml (approximately 25 times the PAS Action Level~~, based on 25 or 26 filters per quarter per location)~~, additional radiochemical analyses will be performed on that filter according to the requirements for quarterly composite filters, unless gamma spectroscopy associates at least 50 percent of the net alpha or net beta activity present on the filter with gamma-emitting radionuclides.

5.1.2 AIRBORNE PARTICULATE – ~~Quarterly~~ Composite

All particulate air sample filters collected during the quarter are gathered into a composite sample for each air monitoring station. Each composite sample is analyzed by gamma spectroscopy using either the on-site instruments or a ~~one of the qualified~~ contractor laboratory~~ies~~. The composite samples (with the exception of VTD) will also be analyzed specifically for uranium-238 (U-238), uranium-234 (U-234), and uranium-235 (U-235), thorium-228 (Th-228), thorium-230 (Th-230), and thorium-232 (Th-232), radium-226 (Ra-226), lead-210 (Pb-210), and polonium-210 (Po-210). The specific analytical methods are determined by the accredited laboratories doing the analysis.

In order to maximize the detection sensitivity for the important radionuclides, any additional radiochemical analyses shall be limited to those radionuclides that could reasonably be expected to contribute more than five percent of the aggregate CEDE over the monitoring period~~quarter~~. The potential relative dose fraction for each radionuclide will be determined each ~~quarter~~monitoring period by weighting its effective inhalation dose coefficient according to its relative abundance in the waste ~~disposed~~received during the monitoring period~~quarter~~. Containerized Waste, large components, and encapsulated Mixed Waste are inherently not wind dispersible, so the nuclide activities of these waste types are therefore excluded from consideration for the semi-annual~~quarterly~~ nuclide dose fraction determination.

5.1.3 RADON ~~AND THORON~~

Air is continuously sampled at the locations listed in Table 1 and Drawing 07007-J01, Revision 4 for radon ~~and thoron~~. Stations B-2, A-27, and A-16 sample results will be used to determine radon background concentrations~~are used to determine background~~.

The radon dose conversion factor of 0.1 pCi/l = 50 mrem/yr @ 1 EEC as listed in 10CFR20, Appendix B, Table 2; a 0.7 EEC; and 0.25 occupancy for compliance with Utah Administrative Code (UAC) R313-15-301, "Dose Limits for Individual Members of the Public" or 0.02 occupancy for compliance with UAC R313-25-19, "Protection of the General Population from Release of Radioactivity". The radon detector minimum detectable concentration shall be less than 0.1 pCi/L. The monitoring locations are adequate to demonstrate compliance as the significant radon effluent contributors are limited to large areas of dispersed waste placed in the embankments. Radon results will still be included in TEDE calculation for those stations where radon is monitored. The reported TEDE at stations where radon is not monitored will not include radon results but semi-annual and annual radon concentrations measured at other locations will be considered when comparing the monitoring results at these stations with regulatory limits.

The use of the more conservative 10CFR20 radon dose conversion factor may make it necessary to provide a more detailed assessment of the measured radon exposure. The third option presented in the NRC Draft Guidance (NRC, 2011) will be applied on a case-by-case basis as needed to demonstrate compliance. The assessment would consider the most likely radon source, the potential "member of the public", occupancy and meteorological data. The radon EEC would be calculated using the wind speeds and durations from the meteorological data during the period of likely exposure. The calculated EEC value ~~with~~ will be multiplied by 0.7 to adjust for NRC accepted outdoor EEC equilibrium maximums. The application of calculated EEC values will consider the potential for indoor exposure.

~~The ICRP 65 radon dose conversion factor is 388 mrem CDE per working-level month (WLM) for members of the public, and 227 Bq/m^3 per Working Level (WL). The radon concentration that will result in 50 mrem TEDE per year of continuous exposure is approximately 1 WL, or 6 pCi/L, when the ICRP 66 lung weighting factor of 0.12 is applied. ICRP 65 does not provide a dose conversion factor for thoron so the thoron ECL in 10 CFR 20 is assumed. Radon and Thoron working levels have been too low to empirically determine an equilibrium factor for radon released from waste so the radon dose estimate assumes that particulate decay products are not present.~~

Radon ~~and thoron~~ concentration~~s~~ is~~are~~ monitored using Landauer RadTrak® Dosimeters. ~~A single dosimeter is used to measure both radon and thoron concentrations. The algorithm used to calculate exposure assumes that total exposure is due to radon. Because the radon ECL is lower than the thoron ECL, the calculated dose from the single radon plus thoron measurement is more conservative. The radon plus thoron concentration will be reported as "radon equivalent" to indicate that the radon efficiency was used to determine the reported concentration.~~

~~5.1.4 AIRBORNE TRITIUM (H-3)~~

~~Tritium is monitored at the air stations identified in Table 1 and Drawing 07007-J01, Revision 4. The airborne tritium concentration is determined by collecting water vapor in a desiccant material, at a flow rate of approximately 200-300 ml/min. The samples shall be analyzed at the end of each quarter. The H-3 ECL used to calculate dose is 1.0E-07 uCi/ml.~~

Formatted: Normal, Indent: First line: 0", Tab stops: Not at 0.5"

Formatted: Tab stops: 1", Left

5.2 VTD EFFLUENT

General

The VTD discharge is sampled for airborne particulates~~, and shall be sampled for H-3, iodine-129 (I-129), krypton-85 (Kr-85), and krypton (Kr-81) if these contaminants are present within the waste fed into the VTD unit~~. The VTD discharge stack is located down stream of the stack filters but up stream of the discharge blower. VTD effluent concentration for each of these sample types is determined by dividing the measured VTD air sample concentrations by 200. This is done to account for the effluent dilution resulting from the blower. Because the VTD particulate air sampler draws suction from a closed system the results do not include a background, consequently the A-16 concentration is not subtracted from the measured concentrations.

Alpha/Beta Screening

Air is continuously sampled at the VTD discharge while the VTD is used to treat radioactive wastes. Radioactive airborne particulate samples are collected using a constant-flow air sampler to draw air through a glass fiber filter, or a functionally similar particulate sampling media. The particulate air sampling apparatus maintains a flow rate of approximately 60 liters per minute through the filter media. Filters are changed at least once for each VTD startup. All particulate filters are analyzed for alpha and beta radioactivity at least 7 days but not more than 14 days after collection.

Any individual sample filters with a net alpha or net beta concentration above the applicable PAS Action Level will be analyzed by gamma spectroscopy within 3 working days of the alpha/beta analysis. Gamma spectroscopy analysis results will be reviewed to determine if any additional actions need to be taken.

When an individual filter has a net alpha concentration above 3E-12 uCi/ml or net beta concentration above 5E-11 uCi/ml (approximately 25 times the PAS Action Level~~, based on 25 or 26 filters per quarter per location~~), additional radiochemical analyses will be performed on that filter according to the requirements for semi-annual~~quarterly~~ composite filters, unless gamma spectroscopy associates at least 50 percent of the net alpha or net beta activity present on the filter with gamma-emitting radionuclides.

Airborne Particulate – Composite samples

Semi-annual~~Quarterly~~ composite VTD samples will be analyzed by gamma spectroscopy using either the on-site instruments or a qualified laboratory ~~qualified in accordance with section 6.1 below~~~~one of the qualified contractor laboratories~~ and those isotopes expected to contribute more than five percent to the aggregate CEDE. The potential relative dose fraction for each radionuclide will be determined semi-annually~~each quarter~~ by weighting its effective inhalation dose coefficient according to its relative abundance in the waste treated using VTD during the ~~quarter~~reporting period.

~~**Tritium, Iodine -129, Krypton – 85, and Krypton – 81**~~

~~Tritium is monitored at the VTD discharge when tritium is manifested in the waste. The airborne tritium concentration is determined by collecting water vapor in a desiccant material, at a flow rate of approximately 200-300 ml/min. VTD effluent tritium samples shall be analyzed at the end of each quarter. The H-3 ECL used to calculate dose is 4.6E-08 uCi/ml.~~

~~Iodine-129 (I-129) is also continuously monitored at the VTD discharge, when I-129 is manifested in the waste being treated. The sample is collected using a charcoal cartridge installed in the sampling line after the particulate sampling filter. Iodine-129 cartridges shall be analyzed by gamma spectroscopy within seven days of sample collection. The I-129 ECL used to calculate dose is 5E-11 uCi/ml.~~

~~Radioactive gasses, Kr-81 and Kr-85, are monitored by taking a “grab sample” at the VTD discharge, when these gasses are manifested in the waste being treated. The sample is collected using a Marinelli beaker installed in the stack sampling manifold. Kr-81 and Kr-85 samples from the VTD discharge shall be analyzed by gamma spectroscopy within seven days of sample collection. The Kr-81 ECL and the Kr-85 ECL used to calculate dose is 3E-06 uCi/ml and 7E-07 uCi/ml, respectively.~~

5.3 GAMMA RADIATION

Gamma radiation is continuously monitored at each designated airborne radioactivity monitoring location listed in Table 1 and Drawing 07007-J01, Revision 4 using an optically stimulated luminescent dosimeter (OSL) or a functionally equivalent device.

Locations B-2, A-27, and A-16 are used to determine the background gamma radiation exposure. Additional monitoring is performed ~~near the fenced boundary that surrounds the waste management areas, and at additional locations~~ as directed by the Director of Health Physics (DHP).

5.4 SOIL

5.4.1 General

Environmental Soil samples ~~required by the Environmental Monitoring Plan~~ are analyzed by Gamma spectroscopy. In order to facilitate the accurate measurement of radionuclides, the samples shall be collected from the top one inch of soil. To prepare the soil samples for gamma spectroscopy analysis the soil sample shall be dried, sifted, homogenized for matrix uniformity, and placed in sealed containers. Alternative soil collection and analytical preparation methods may be used ~~provided it is~~if authorized ~~and documented~~ by the Environmental Manager and documented in the environmental monitoring report.

Soil samples shall be sealed, or canned, for at least 14 days prior to analysis in order to ensure ~~that~~ the accurate measurement of Ra-226. Soil samples used to facilitate remediation activities are not required to be held for 14 days after canning for gamma spectroscopy analysis however, a 14 day hold time is required for the soil samples used to verify that an area is below the soil action levels.

Routine soil samples that exceed the Soil Action Levels shall also be analyzed for isotopic thorium. The locations of any ~~quarterly or annual~~ soil sample above these action levels will be further characterized by additional sampling to verify the initial finding, and to subsequently determine the nature, extent, and cause of any problem once the initial finding is verified. Areas with confirmed radioactivity above the Soil Action Level shall be remediated.

Except for sampling activities, the Director~~Executive Secretary~~ of the Division of Radiation Control shall be notified prior to disturbing the soil inside semi-annual~~quarterly~~ soil monitoring stations.

5.4.2 Semi-annual~~Quarterly~~ Soil Samples

The semi-annual~~quarterly~~ soil sample locations and analytical requirements are listed in Table 1 and Drawing 07007-J01, Revision 4. Semi-annual~~Quarterly~~ soil samples are also required at active Non-contaminated Restricted Area exits, in accordance with Section 5.4.5.

5.4.3 Annual Soil Samples

Soil samples will also be collected annually to assess potential wind blown contamination from the site. Surface soil samples will be taken at 300 meter intervals along the 8 compass directions centered near the center of Section 32. The first sample will be taken just outside the site boundary and additional samples will be taken at 300 meter intervals extending out to 1500 meters. All 48 samples will be analyzed by gamma spectroscopy.

5.4.4 PCB Soil Samples

Samples are also collected to determine PCB concentrations in soil. Soil samples are collected twice each year from the Soil Monitoring stations identified in Table 1 and Drawing 07007-J01, Revision 4. The samples are collected from the soil surface and each sample will weigh approximately 30 g. Samples are refrigerated and stored in the dark when collected. Sample analytical preparation shall be started within 14 days after collection and the analysis shall be completed within 40 days after collection.

5.4.5 Semi-annual~~Quarterly~~ Restricted Area Exit Gate Soil Samples

Radioactivity concentrations in the soil near rail gates and gates that directly access Non-contaminated Restricted Areas shall be monitored. A soil sample shall be taken near rail gates used to exit the Restricted Area during the reporting period~~quarter~~. A soil sample shall also be taken at gates that directly access Non-contaminated Restricted Areas; where vehicles, personnel, or material were permitted to exit during the reporting period~~quarter~~ without a radiological release. The sample should be taken where the soil is most likely to be affected by contamination that may be present on vehicles exiting the Restricted Area. All soil samples will be analyzed by gamma spectroscopy.

Additional soil samples shall be collected when soil sample radioactivity exceeds the soil action level to determine the cause and scope of the elevated radioactivity. Areas found to exceed the soil action levels shall be remediated as necessary until the radioactive contamination in the area is below the Soil Action Level.

6.0 QUALITY ASSURANCE/QUALITY CONTROL

6.1 ANALYTICAL LABORATORY QUALIFICATIONS

Analyses to be used for dose determination or for comparison to standards are performed by ~~a~~ laboratoriesy~~y~~ in conformance with industry accepted quality assurance programs~~accredited or certified by the National Environmental Laboratory Accreditation Conference (NELAC) or the State of Utah to perform radiochemical and gamma spectroscopy analysis on environmental samples.~~

~~The Energy*Solutions* gamma spectroscopy system has been qualified by a company that performs such evaluations as a commercial service. The State of Utah has accepted that as evidence of Energy*Solutions*' qualifications for performing gamma spectroscopy analysis.~~

Formatted: Space Before: 6 pt, Keep lines together, Tab stops: Not at 1" + 1.5" + 2" + 2.5" + 3" + 3.5"

6.2 MDC REQUIRMENTS

6.2.1 General

The detection sensitivity can be influenced by several factors. These include branching ratios, the presence of interfering contaminants, and the probability of a given type of emission per disintegration. Most gamma emitting radionuclides of concern are easily detected by gamma spectroscopy at the specified sensitivity levels. In practice the typical detection levels achieved in radiological analysis of environmental samples are very close to natural background radiation levels.

All analyses will achieve the specified MDC at the commonly accepted error of two standard deviations, or an approximate confidence interval of 95%.

Samples that indicate a positive result for the target analyte(s) need not be counted to achieve the specified MDC(s) if the counting uncertainty is less than 50% of the reported concentration.

6.2.2 Particulate Air Sample Alpha/Beta screening

The required MDC for the initial alpha and beta screening is based on 50% of the Th-230 concentration action level, or 7E-14 uCi/ml for gross alpha before the background contribution from A-16 is subtracted. The gamma spectroscopy performed on samples above the alpha or beta action levels will be sensitive enough to detect 50% of the concentration listed in Table 3 of the Environmental Monitoring Plan for the gamma emitting nuclides of concern, or as needed to positively characterize the major contributors to the activity present.

6.2.3 Particulate Air Sample Semi-annual~~Quarterly~~ Composite

The MDC for the semi-anunal~~quarterly~~ composite air samples will be sufficiently sensitive to detect or reject the presence of the target analyte(s) at a concentration equal to 10% of the applicable ECL. The use of certified or accredited laboratories is considered sufficient evidence of analysis quality, since an approved Quality Assurance plan is one prerequisite for attaining certification. Each contractor laboratory performs a method blank, split, duplicate, and/or spike tests as controls for each analysis according to the requirements of the approved Quality Assurance plan.

6.3 RADON DETECTOR QUALITY CONTROL REQUIREMENTS

As a test of repeatability, each quarter one additional radon monitor will be placed at three air monitoring station as a field replicate. The stations to be used as field replicates will be selected at random each quarter.

Each quarter, Energy*Solutions* will submit four detectors used to measure radon for exposure to a calibrated radon chamber standard. The results will be compared to the exposure to demonstrate the accuracy and precision of the routine measurement technique and the associated calculations.

6.4 GAMMA DETECTOR QUALITY CONTROL REQUIREMENTS

As a test of repeatability, each reporting period~~quarter~~ one additional gamma monitor will be placed at three air monitoring station as a field replicate. The stations to be used as field replicates will be selected at random~~ each quarter~~.

Each reporting period~~quarter~~ four detectors used to monitor gamma radiation will be concurrently exposed to a known dose from a calibrated gamma source. The results will be compared to the known exposure value.

6.5 SOIL SAMPLING QUALITY CONTROL REQUIREMENTS

Soil sample gamma spectroscopy:

- Shall be counted for at least 1000 seconds
- The uranium-238 MDC value shall be less than or equal to 1.5 pCi/g except when the uncertainty is less than 50% of the measured activity.

Four of the routine soil samples from each semi-annual~~quarterly~~ sampling event will be split. The routine samples and the split samples will be analyzed at different laboratories. The results from the routine samples will be compared with the corresponding split samples to verify the precision of the results obtained between different laboratories.

Four of the routine soil samples are collected twice as simultaneous blind field replicates. All four routine samples and their blind duplicate will be analyzed by gamma spectroscopy at the same laboratory. One of the four routine samples and its blind duplicate will also be analyzed for Th-230 and Th-232. The analytical results will be used to indicate the laboratory's analytical repeatability and the error associated with the sampling technique.

6.6 AIR SAMPLER FLOW INDICATOR CALIBRATION FREQUENCY

Air sampler flow indicators will be calibrated at intervals not to exceed 6 months.

7.0 ENVIRONMENTAL MONITORING REPORT

A semi-annual report will be created for monitoring periods; January 1 to June 30 and July 1 through December 31. The reports will be submitted to the UDRC within three months after the last day of each monitoring period, unless otherwise approved by the Director of the Division of Radiation Control.~~A quarterly report will be submitted to the UDRC within 90 days after the expiration of each calendar quarter, unless otherwise approved by the Executive Secretary of the Division of Radiation Control.~~

Each ~~quarterly~~ report shall include a brief introduction and narrative that summarizes and explains the data, the results obtained, and conclusions. The narrative shall also explain any unusual or anomalous results and list any exceedances of a limit listed in this plan that occurred during the reporting period.

Each ~~quarterly~~ report shall also include the following data from the reporting period~~current report quarter~~:

- Contract laboratory data that pertains to any sample analysis that was performed under this program. The data package shall include the results of QC checks the contractor laboratory performs in the course of analyzing the samples (splits and duplicates, for example). The outside laboratory data may be submitted either electronically or by hard copy.
- The analytical results from gamma spectroscopy performed on semi-annual~~quarterly~~ soil samples and associated analytical results from soil samples used to verify soil radioactivity in areas where the environmental soil samples exceed the action level.
- ~~Historical Ra-226 and U-238 in soil data used for trending to determine if a positive change in soil concentrations is occurring;~~

- The results of any quality control tests performed to meet a requirement of the Environmental Monitoring Plan, including but not limited to duplicates, split samples, and known exposures.~~;~~
- A summary and tabulation of any data acquired as a result of sampling performed during the reporting period ~~quarter~~, to the extent that such data applies to a requirement of the Environmental Monitoring Plan.~~;~~
- A table listing the activities and estimated relative dose weighting of each disposed radionuclide considered for additional radiochemical analysis according to the selection criteria of section 5.1.2 of the Environmental Monitoring Plan.~~;~~
- ~~VTD operating history and t~~The results for any VTD monitoring performed during the reporting period.
- Results of weekly alpha-beta counting of air filters at each monitored location.
- Semi-annual~~Quarterly~~ average alpha and beta air particulate concentrations at each monitored location.
- The cumulative TEDE, DDE, and CEDE at each POC for the current reporting period ~~quarter and the prior three quarters~~.
- The calculated annual dose from the monitoring results to demonstrate compliance with UAC R313-15-301, R313-15-101(4), and R313-25-19. The information shall include DDE, CDE, CEDE, and TEDE calculations.
- Soil Sample Results.
- A brief narrative summarizing the dosimetry data and explaining the CEDE estimates.

TABLE 1: RADIOLOGICAL PROGRAM SUMMARY TABLE

	Air		Soil			Rad
Location Number	PAS - (5.1.1, 5.1.2, or 5.2)	Radon - (5.1.4)	Gamma Spec - (5.4.2)	Th-232 & 230 (5.4.2)	PCB - (5.4.4)	Gamma - (5.3)
S-1			x			
S-2			x			
S-3			x			
S-4			x			
S-5			x			
S-8			x			
S-12			x		x	
S-13			x			
S-15			x			
S-17			x			
S-18			x			
S-19			x	x		
S-21			x			
S-22			x			
S-23			x			
S-24			x		x	
S-25			x	x	x	
S-26			x		x	
S-27			x		x	
S-28			x		x	
S-29			x	x	x	
S-32			x		x	
S-33			x		x	
S-34			x		x	
S-36			x	x		
S-37			x	x		
S-38			x			
S-39			x			
S-40			x			
S-50			x			
S-51			x			
S-52			x			
S-53			x			
S-54			x			
S-56			x	x	x	
S-57			x	x	x	
S-58			x			
S-59			x		x	

	Air		Soil			Rad
Location Number	PAS - (5.1.1, 5.1.2, or 5.2)	Radon - (5.1.4)	Gamma Spec - (5.4.2)	Th-232 & 230 (5.4.2)	PCB - (5.4.4)	Gamma - (5.3)
S-64			x			
S-65			x	x		
S-66			x			
S-71			x			
S-72			x		x	
S-73			x	x		
S-74			x		x	
S-75			x			
S-76			x			
S-77			x			
S-78			x			
S-79			x			
A-1	x					x
A-4	x		x			x
A-5	x	x	x			x
A-10	x		x		x	x
A-11	x	x	x	x		x
A-13	x		x	x		x
A-16	x	x				x
A-17	x					x
A-18	x	x	x			x
A-19	x					x
A-20	x					x
A-21	x					x
A-22	x					x
A-26	x					x
A-27		x				x
A-28	x					x
A-29	x					x
A-30	x					x
A-33	x	x				x
A-35	x	x				x
A-36	x					x
A-37	x					x
VTD	x					
B-2		x	x			x
SC						x

~~Air~~ ~~Soil~~ ~~Rad~~ ~~Air~~ ~~Soil~~ ~~Rad~~

Formatted: Centered

Field Code Changed

~~Location Number~~	~~PAS (5.1.1, 5.1.2, or 5.2)~~	~~Radon/Thoron (5.1.4)~~	~~Tritium (5.1.3 or 5.2)~~	~~VTD I-129, Kr-85, Kr-81 (5.2)~~	~~Gamma Spec (5.4.2)~~	~~Th-232 & 230 (5.4.2)~~	~~PCB (5.4.4)~~	~~Gamma (5.3)~~
~~S-1~~	-	-	-	-	x	-	-	-
~~S-2~~	-	-	-	-	x	-	-	-
~~S-3~~	-	-	-	-	x	-	-	-
~~S-4~~	-	-	-	-	x	-	-	-
~~S-5~~	-	-	-	-	x	-	-	-
~~S-8~~	-	-	-	-	x	-	-	-
~~S-12~~	-	-	-	-	x	-	x	-
~~S-13~~	-	-	-	-	x	-	-	-
~~S-15~~	-	-	-	-	x	-	-	-
~~S-17~~	-	-	-	-	x	-	-	-
~~S-18~~	-	-	-	-	x	-	-	-
~~S-19~~	-	-	-	-	x	x	-	-
~~S-21~~	-	-	-	-	x	-	-	-
~~S-22~~	-	-	-	-	x	-	-	-
~~S-23~~	-	-	-	-	x	-	-	-
~~S-24~~	-	-	-	-	x	-	x	-
~~S-25~~	-	-	-	-	x	x	x	-
~~S-26~~	-	-	-	-	x	-	x	-
~~S-27~~	-	-	-	-	x	-	x	-
~~S-28~~	-	-	-	-	x	-	x	-
~~S-29~~	-	-	-	-	x	x	x	-
~~S-32~~	-	-	-	-	x	-	x	-
~~S-33~~	-	-	-	-	x	-	x	-
~~S-34~~	-	-	-	-	x	-	x	-
~~S-36~~	-	-	-	-	x	x	-	-
~~S-37~~	-	-	-	-	x	x	-	-
~~S-38~~	-	-	-	-	x	-	-	-
~~S-39~~	-	-	-	-	x	-	-	-
~~S-40~~	-	-	-	-	x	-	-	-
~~S-50~~	-	-	-	-	x	-	-	-
~~S-51~~	-	-	-	-	x	-	-	-
~~S-52~~	-	-	-	-	x	-	-	-
~~S-53~~	-	-	-	-	x	-	-	-
~~S-54~~	-	-	-	-	x	-	-	-
~~S-56~~	-	-	-	-	x	x	x	-
~~S-57~~	-	-	-	-	x	x	x	-
~~S-58~~	-	-	-	-	x	-	-	-
~~S-59~~	-	-	-	-	x	-	x	-

~~Location Number~~	~~PAS (5.1.1, 5.1.2, or 5.2)~~	~~Radon/Thoron (5.1.4)~~	~~Tritium (5.1.3 or 5.2)~~	~~VTD I-129, Kr-85, Kr-81 (5.2)~~	~~Gamma Spec (5.4.2)~~	~~Th-232 & 230 (5.4.2)~~	~~PCB (5.4.4)~~	~~Gamma (5.3)~~
~~S-64~~	-	-	-	-	x	-	-	-
~~S-65~~	-	-	-	-	x	x	-	-
~~S-66~~	-	-	-	-	x	-	-	-
~~S-71~~	-	-	-	-	x	-	-	-
~~S-72~~	-	-	-	-	x	-	x	-
~~S-73~~	-	-	-	-	x	x	-	-
~~S-74~~	-	-	-	-	x	-	x	-
~~S-75~~	-	-	-	-	x	-	-	-
~~S-76~~	-	-	-	-	x	-	-	-
~~S-77~~	-	-	-	-	x	-	-	-
~~S-78~~	-	-	-	-	x	-	-	-
~~S-79~~	-	-	-	-	x	-	-	-
~~A-1~~	x	x	x	-		-	-	x
~~A-4~~	x	x	x	-	x	-	-	x
~~A-5~~	x	x	x	-	x	-	-	x
~~A-10~~	x	x	-	-	x	-	x	x
~~A-11~~	x	x	-	-	x	x	-	x
~~A-13~~	x	x	x	-	x	x	-	x
~~A-16~~	x	x	-	-	-	-	-	x
~~A-17~~	x	x	x	-	-	-	-	x
~~A-18~~	x	x	x	-	x	-	-	x
~~A-19~~	x	x	-	-	-	-	-	x
~~A-20~~	x	x	-	-	-	-	-	x
~~A-21~~	x	x	-	-	-	-	-	x
~~A-22~~	x	x	x	-	-	-	-	x
~~A-26~~	x	x	-	-	-	-	-	x
~~A-27~~	-	x	-	-		-	-	x
~~A-28~~	x	x	x	-	-	-	-	x
~~A-29~~	x	x	-	-	-	-	-	x
~~A-30~~	x	x	x	-	-	-	-	x
~~A-33~~	x	x	-	-	-	-	-	x
~~A-35~~	x	x	x	-	-	-	-	x
~~A-36~~	x	x	x	-	-	-	-	x
~~A-37~~	x	x	-	-	-	-	-	x
~~VTD~~	x	-	x	x	-	-	-	-
~~B-2~~	-	x	-	-	x	-	-	x
~~SC~~	-		-	-	-	-	-	x

* SC is used to identify the Sample Control. Area inside the Operations Building

• TABLE 2: MONITORING LOCATIONS

NOTE: Point of Beginning is the Clive monument at the Southwest corner of Section 32

Station	North	East	Station	North	East	Station	North	East
A-1	5163	2749	S-3	4891	3463	S-38	40	600
A-4	-88	5252	S-4	4883	3812	S-39	1050	200
A-5	-14	2647	S-5	4877	4204	S-40	1600	200
A-10	-10	4124	S-8	3599	4209	S-50	4440	4175
A-11	28	1196	S-12	1992	4155	S-51	4023	4168
A-13	499	198	S-13	2002	3679	S-52	3118	4149
A-16	2412	-6633	S-15	2011	3111	S-53	2659	4140
A-17	2167	5323	S-17	5195	3399	S-54	2367	4137
A-18	5417	4853	S-18	5035	4015	S-56	2551	85
A-19	3965	5383	S-19	5213	5162	S-57	2963	91
A-20	5084	5409	S-21	4537	5359	S-58	3339	99
A-21	2162	71	S-22	3967	5356	S-59	3735	106
A-22	2962	88	S-23	3347	5344	S-64	4038	272
A-26	-129	3282	S-24	2764	5335	S-65	4430	286
A-27	-2701	3406	S-25	2169	5322	S-66	4801	335
A-28	4043	104	S-26	1596	5375	S-71	5291	796
A-29	4636	115	S-27	379	5355	S-72	5282	1222
A-30	5287	319	S-28	-70	4754	S-73	5273	1658
A-33	5501	2762	S-29	-229	3389	S-74	5256	2429
A-35	5280	1495	S-32	2047	2690	S-75	4471	2724
A-36	5256	2402	S-33	3238	2694	S-76	2784	2703
A-37	658	5377	S-34	3764	2717	S-77	5174	2678
B-2	2650	13200	S-36	-5	2200	S-78	2162	76
S-1	4892	2745	S-37	10	1600	S-79	-2709	3438
S-2	4896	3126						

TABLE 3: ECL FOR SELECTED RADIONUCLIDES

The listed concentration values are listed in units of uCi/ml and are based on continuous exposure for one year equals 50 mrem.

Element	Isotope	Type	ECL**
Thorium	Th-228	M	6.3E-14
		S	5.1E-14
	Th-230	M	4.7E-14
		S	1.4E-13
	Th-232	M	4.5E-14
		S	8.2E-14
	Th-234	M	3.0E-10
		S	2.6E-10
Uranium	U-234	F	3.4E-12
		M	6.1E-13
		S	2.2E-13
	U-238	F	3.8E-12
		M	7.2E-13
		S	2.6E-13
Radium	Ra-224	M	6.5E-13
	Ra-226	M	5.9E-13

Element	Isotope	Type	ECL**
Actinium	Ac-228	F	7.5E-11
		M	1.2E-10
		S	1.3E-10
Bismuth	Bi-210	F	1.7E-09
		M	2.2E-11
	Bi-212	F	2.0E-10
		M	6.3E-11
	Bi-214	F	2.6E-10
		M	1.3E-10
Lead	Pb-210	F	2.1E-12
	Pb-212	F	9.9E-11
	Pb-214	F	6.5E-10
Polonium	Po-210	F	3.1E-12
		M	6.3E-13
Protactinium	Pa-234	M	4.9E-09
		S	4.7E-09
Radon*	Rn-222		1.1E-03

Notes:

*Radon ECL is a working level.

** ECL is provided in Units of uCi/ml, unless otherwise noted.

These updated "ECL" values were calculated following the general technique described in Appendix B to Part 20 which relates the Annual Limit on Intake to the Effluent Concentration Limit.

The 50-year committed effective equivalent inhalation dose conversion factors for an adult worker, for an AMAD of 1 um, from ICRP 68 were multiplied by the 3.7 E 9 conversion factor which relates the given units of Sv/Bq to mrem/uCi.

The resulting DCF in uCi/ml was then divided into the effective dose limit off 5000 mrem/year to obtain the value for the ALI in uCi/year.

The ALI is divided by breathing rate for an adult worker of 2.4e9 ml/yr, and also divided by the additional factor of 300 used in Appendix B to Part 20 to relate the stochastic DAC to the ECL.

The ICRP 68 biological elimination type designations "F" (Fast), "M" (Medium), and "S" (Slow) are roughly analogous to the Part 20 "D" (Day), "W" (Week), and "Y" (Year) solubility classes.

APPENDIX N

Projected Waste Streams

PROJECTED WASTE STREAMS

1 Determination of Types, Kinds, and Quantities of Waste

Waste to be received will consist of naturally occurring and accelerator produced radioactive material (NARM), source material, special nuclear material and byproduct [11e.(1)] material. The nature of remediation activities has changed with time and it is expected that this pattern will continue. Energy*Solutions* has researched currently known sources of radioactive and mixed waste to develop the following general waste categories and volume projections. The projections are estimates, and will change over the period of the license. Volumes provide a general basis for comparing the expected fraction of annual waste receipts of different types; the projections are not constraints on annual operations. Competition within the LLRW disposal industry, government and private funding for cleanup and decommissioning projects, and regulatory changes all affect the volume and characteristics of waste to be disposed at the Clive Facility. So long as the License waste acceptance criteria are met, changes to the nature of individual waste streams received for disposal will not have a significant impact on the overall nature of the waste disposed or on the environment.

Materials being considered for disposal include:

1. Naturally occurring radioactive material (NORM) waste - contaminated soils and building debris, less than 100 pCi/g weighted average concentration, with Uranium, Thorium-230, and Radium-226 considered to be in equilibrium.

   200,000 cubic feet per year (cf/y)

2. Radium waste (NORM) - contaminated soils with scrap metal, glass, wood and masonry rubble. Weighted average concentration approximately 40 pCi/g; with small amounts up to 10,000 pCi/g.

   3,000,000 cf/y

3. Sludges, tailings, or residues from industrial waste streams containing various NORM materials. Uranium and thorium decay chain nuclides 50 - 5,000 pCi/g with weighted average concentration approximately 500 pCi/g.

   160,000 cf/y

4. Soils from decommissioning of reactor facilities contaminated with any of the activation and byproduct materials associated with such operations. Major radionuclides are Fe-55, Co-58, Co-60 and Cs-137 with weighted average concentrations of approximately 100 pCi/g; with small quantities up to 60,000 pCi/g of Cs-137 and 30,000 pCi/g of other nuclides.

   400,000 cf/y

5. Non-compactible debris from decommissioning of reactor facilities contaminated with any of the activation and byproduct materials associated with such operations. Major radionuclides are Fe-55, Co-58, Co-60 and Cs-137 with weighted average concentrations of approximately 100 pCi/g; with some small quantities up to 60,000 pCi/g of Cs-137 and 30,000 pCi/g of other nuclides.

   200,000 cf/y

6. Dry active waste from cleanup and maintenance of nuclear reactors, fuel processing and D&D operations. May contain any source, special nuclear material, or byproduct material nuclides. Most nuclides are in the range of a few tens of pCi/g, but C-14 and tritium may be as high as 100,000 pCi/g in some wastes and Co-58, Co-60, Cs-137 or Fe-55 may reach 30,000 pCi/g.

   350,000 cf/y

7. Resins and solidified cleaning agents containing byproduct materials from nuclear power plants. Most nuclides are at a few tens of pCi/g, but Co-60 will be as high as 30,000 pCi/g and Cs-137 will be as high as 60,000 pCi/g in some waste streams.

   80,000 cf/y

8. Sludges, tailings, slag or residues from industrial waste streams containing various source, byproduct or special nuclear materials. Weighted average concentrations less than 50 pCi/g.

   2,500,000 cf/y

9. Smelter flue dust contaminated by introduction of sealed sources or uranium metal. Depleted uranium weighted average 1,000 pCi/g; maximum 200,000 pCi/g. Cs-137 averaging 500 pCi/g; maximum 20,000 pCi/g. Some may contain Ra-226 at approximately 100 - 1,000 pCi/g.

   10,000 cf/y

10. Depleted uranium from Department of Defense target area cleanups or from Department of Energy gaseous diffusion plants. Target area concentrations weighted average about 400 pCi/g; gaseous diffusion plant wastes as high as 280,000 pCi/g. Waste can include solid depleted uranium metal in the form of spent rounds and penetrators with specific activities as high as 370,000 pCi/g. NOTE: disposal of significant volumes of depleted uranium is constrained by License condition 35.

    400,000 cf/y

11. Cleanup of industrial areas with trace quantities of fission products or fallout from past above ground testing.

    20,000 cf/y

12. Accelerator-produced radioactive materials from D&D projects. May contain any activation products, primarily Co-60 and H-3 at approximately 100 pCi/g.

    60,000 cf/y

13. Treated mixed waste containing any source, special nuclear or by-product materials in concentrations approximately 100 pCi/g.

    60,000 cf/y

14. Site-generated waste including material removed from haul roads and from building sites. Includes a small amount annually of laboratory wastes. Weighted average concentrations 10 pCi/g for the uranium and thorium decay chain nuclides, less than one pCi/g for all others.

    25,000 cf/y

15. Other unforeseen waste streams as remediation, waste treatment and waste-generating processes develop. Radioactivity could include any of the naturally occurring or manmade radionuclides. Concentrations will not exceed Class A limits.

    3,000,000 cf/y

16. Any of the above waste streams may contain some hazardous materials and, therefore, be classified as mixed waste.

    500,000 cf/y

2 Composite Projection of Waste Inventories

2.1 "Initial" Inventory

A comprehensive nuclide disposal inventory as of August 2011 has been previously submitted to the Division (EnergySolutions, 2012). The uranium and thorium decay chain nuclides comprise the majority of radioactivity in inventory. This reflects the remediation of large projects involving various source material waste streams. This inventory also demonstrates the low overall concentration of radioactivity in waste received by Energy*Solutions*.

2.2 Delivery Rate by Year of Facility Life

Information for this section was taken from two reports generated by the Government Accountability Office (GAO) entitled "Low-Level Radioactive Waste: Future Waste Volumes and Disposal Options are Uncertain", GAO-04-1097T, September 2004, and, "Low-Level Radioactive Waste: Disposal Availability Adequate in the Short Term, But Oversight Needed to Identify Any Future Shortfalls", GAO-04-604, June 2004.

The GAO discovered that it is difficult to project the timing and volume of low-level radioactive waste disposal (LLRW). Uncertainty arises due to the difficulty of forecasting disposal shipments from DOE and nuclear utilities (GAO, September 2004). This report also notes the difficulty in forecasting the number of new facilities that might come online for LLRW disposal in the United States. These two factors make it extremely difficult to accurately predict what future disposal rates Energy*Solutions* will experience over the next five years.

A recent report by the U.S. Department of Energy (DOE) assessed DOE generation and disposal for LLRW. The vast majority of DOE waste is projected for disposal at DOE facilities; with a small fraction to be disposed at commercial facilities. From a total projected inventory for the period 1998 to 2070 of 6.9 million cubic meters (244 million cubic feet), only 0.5 million cubic meters (17.6 million cubic feet) is projected for offsite disposal. Section 2.3.3 of DOE, 2009 states:

> *"The Department estimates that approximately 510,000 m^3 of low-level waste will be disposed in commercial (not DOE-owned) facilities from 1998 to 2070. This includes 500,000 m^3 of waste from the Environmental Restoration Program and 11,000 m^3 of waste from the Waste Management Program. A portion of the 330,000 m^3 of low-level waste that does not have a specified disposal option (to be determined) may also be disposed at commercial sites. Evaluation of commercial disposal site capacity is outside the scope of this Report. This analysis assumes that adequate commercial disposal capacity will be available. However, Section 2.6, Alternative Scenarios, considers alternative dispositions for currently projected to be determined low-level waste."* (DOE, 2009).

Despite the difficulty of waste projection, it is possible to make reasonable forecasts of future disposal volumes at the Clive facility. It is expected that disposal volumes may remain roughly constant over the next five to ten years.

3 Radioactivity Concentrations for Receipt

The Clive facility is licensed to receive waste with radionuclide concentrations up to Class A limits. Modeling of the potential discharge to ground water and transport in ground water, as well as potential radiation doses to workers have been based on these maximum concentrations. The license renewal application demonstrates that these concentrations in wastes can be safely managed to protect worker health and safety, human health and safety, and all other requirements.

4 References

DOE, "Current and Planned Low-Level Waste Disposal Capacity Report – Revision 2." U.S. Department of Energy, Waste Management Program. (accessed 25 October 25 at http://www.em.doe.gov/pdfs/llwrev2.pdf), December 2000.

Energy*Solutions*, "GWDQP: Manifest Radionuclide Inventory Report." Energy*Solutions'* submittal to the Utah Division of Radiation Control - CD12-0203, 23 August 2012.

Government Accountability Office (GAO), "Low-Level Radioactive Waste: Future Waste Volumes and Disposal Options are Uncertain", GAO-04-1097T, September 2004.

Government Accountability Office (GAO), "Low-Level Radioactive Waste: Disposal Availability Adequate in the Short Term, But Oversight Needed to Identify Any Future Shortfalls", GAO-04-604, June 2004.

EnergySolutions

423 West 300 South, Suite 200
Salt Lake City, Utah 84101
801.649.2000

www.energysolutions.com