Draft Environmental and Safety Analysis of a Proposed Low-Level Radioactive Waste Disposal Facility in Andrews County, Texas

August 2008

Radioactive Materials Division

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

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Acronyms and Terms Used in this Document

AAPOR	American Association of Public Opinion Research
AASTHO	American Association of State Highway and Transportation Officials
ABSLIQD	Absorbed liquids
ACI	American Concrete Institute
AEC	Atomic Energy Commission
AISC	American Institute of Steel Construction
AL	Action level
ALARA	As low as reasonably achievable
AMC	Antecedent Moisture Condition
ANOD	Administrative Notice of Deficiency
API	American Petroleum Institute
ANSI	American National Standards Institute
ASTM	ASTM International: Formerly known as American Society for Testing and Materials, they changed the name in 2001.
BEG	Bureau of Economic Geology, part of the John A. and Katherine G. Jackson School of Geosciences at The University of Texas at Austin,
BP	Formerly known as British Petroleum, they changed their name officially in the year 2000 to "BP."
CBT	Computer-based training
CCEDS	Consolidated Compliance and Enforcement Data System
CCI	Construction cost index
CDE	Committed dose equivalent
CDU	Containerized disposal unit
CEDE	Committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CH	Contact-handled
CLSM	Controlled low-strength materials
CRSI	Concrete Reinforcing Steel Institute
CSA	Container Storage Area

CWF	Compact waste disposal facility
CPI	Consumer Price Index
CQA/QC	Construction Quality Assurance and Quality Control
DOE	Department of Energy
DOT	Department of Transportation
DQO	Data Quality Objective
DU	Depleted uranium
EA	Environmental Analysis
Eh	Oxidation/reduction potential
ENR	Engineering News Record
ES&H	Environmental Safety and Health
ET	Evapotranspiration
FAW	Facility Assigned Workers
FLAC	Fast Lagrangian Analysis of Continua
FRS	Fiber reinforced shotcrete
FWF	Federal facility waste disposal facility or Federal Waste Facility
FWF-CDU	Federal Waste Facility - Containerized Disposal Unit
FWF-NCDU	Federal Waste Facility - Non-Containerized Disposal Unit
GAM	Groundwater Availability Modeling
GET	General Employee Training
GHB	General head boundary
GM	WCS Vice-President and General Manager
HDPE	High density polyethylene
HEC-HMS	Hydrological Engineering Center Hydrologic Modeling System
HEC-RAS	Hydrological Engineering Center River Analysis System
HELP	Hydrologic Evaluation of Landfill Performance
HIC	High integrity container
IBC	International Building Code
IH	Interstate Highway
IL	Investigation level
ISD	Independent school district

ISO	International Organization for Standardization
ISW	Infrastructure Support Workers
JAST	Job activity specific training
JPM	Job Performance Measures
LES	Louisiana Energy Services
LES-NEF	Louisiana Energy Services' National Enrichment Facility
LDR	Land Disposal Restrictions
LLRW	Low-level radioactive waste
LSA	Low-Specific Activity
MCC	Modular concrete canisters
MDC	Minimum detectable concentrations
MLLW	Mixed low-level radioactive waste
MODFLOW	Modular Flow Code
MWTF	Mixed Waste Treatment Facility
NAPL	Non-aqueous phase liquids
NCDU	Non-containerized disposal facility (also known as a "bulk waste unit")
NEC	National Electrical Code
NEF	National Enrichment Facility
NIOSH	National Institute for Occupational Safety and Health
NOAA	National Oceanic and Atmospheric Administration
NOE	Notice of Enforcement
NORM	Naturally-occurring radioactive material
NRC	United States Nuclear Regulatory Commission
NTS	Nevada Test Site - DOE radioactive waste disposal location
NUREG	United States Nuclear Regulatory Commission Regulation
NWS	National Weather Service
OJT	On-the-job training
OSHA	Occupational Safety and Health Administration
PA	Performance assessment
pH	Measure of acidity and alkalinity
PHGA	Peak horizontal ground acceleration

P&I	Process and Instrumentation
PMP	Probable Maximum Precipitation
PPE	Personal protective equipment
QA	Quality Assurance
QAP	Quality Assurance Plan
QA/QC	Quality assurance and quality control
OAG	Ogallala, Antlers, and Gatuña formations
RASCALS	Response Spectrum and Acceleration Scaling
RCRA	Resource Conservation and Recovery Act
REMP	Radiological Environmental Monitoring Program
RESRAD	Residual Radiation Risk Assessment computer code
RH	Remote handled
RIMS II	Regional Input-Output Modeling System
ROI	Region of interest
RSO	Radiation Safety Officer
RSS	Radiation Safety Supervisor
RWP	Radiation work permit
SAP	Structural Analysis Program
SCS	Soil Conservation Services
SH	State Highway
SMEs	Subject matter experts
SOPs	Standard operation procedures
SWAT	Soil and Water Assessment Tool
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TDSHS	Texas Department of State Health Services
TEDE	Total effective dose equivalent
TLD	Thermoluminescent dosimeter
TLLRWDA	Texas Low-Level Radioactive Waste Disposal Authority
TMR	Telescopic mesh refinement
TNOD	Technical Notice of Deficiency

TOUGH2	Transport of Unsaturated Groundwater and Heat
TPDES	Texas Pollutant Discharge Elimination System
TRCA	Texas Radiation Control Act
TSCA	Toxic Substance Control Act
TWDB	Texas Water Development Board
UF_6	Uranium hexafluoride conversion waste
U.S.	United States
U.S.C.	United States Code
USDA	United States Department of Agriculture
USGS	United State Geological Survey
USLE	Universal Soil Loss Equation
VS2DI	Variable Saturated Two-Dimensional Infiltration
WAP	Waste Acceptance Plan
WCS	Waste Control Specialists, LLC.
WIPP	Waste Isolation Pilot Project
WPF	Waste Profile Form

Executive Summary

Waste Control Specialists, LLC (WCS or applicant) has applied to the Texas Commission on Environmental Quality (TCEQ or commission) for a license to develop two facilities under one license for the disposal of low-level radioactive waste at a site located approximately 30 miles west of the City of Andrews, Texas, and five miles east of the City of Eunice, New Mexico. The proposed facilities are located approximately one-half mile east of the Texas-New Mexico boundary and one mile north of Texas State Highway 176.

The TCEQ Executive Director and his staff has extensively reviewed the application, which includes technical data pertaining to the site and vicinity, information on proposed operations, an assessment of potential radiological and non-radiological impacts of the proposed facility, and a consideration of site closure and financial assurance. Supporting documentation for completion of the technical review include a draft Environmental Analysis (EA), a draft license, and a draft licensing order. The draft EA is a technical assessment of the Executive Director's staff review of the license application. The draft EA documents the review performed through the technical review period.

In completing the technical review of the application, the Executive Director of the TCEQ has determined that:

(1) As authorized in the draft license, the applicant is qualified by reason of training and experience to carry out the disposal operations in a manner that protects health and minimizes danger to life or the environment;

(2) As authorized in the draft license, the 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 in that they provide reasonable assurance that the general population will be protected from releases of radioactivity as specified in the performance objective in Title 30 Texas Administrative Code (TAC) §336.724 (relating to Protection of the General Population from Releases of Radioactivity);

(3) As authorized in the draft license, the 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 that they will provide reasonable assurance that individual inadvertent intruders are protected in accordance with the performance objective in 30 TAC §336.725 (relating to Protection of Individuals from Inadvertent Intrusion);

(4) As authorized in the draft license, the land disposal facility operations (including equipment, facilities, and procedures) are adequate to protect the public health and safety in that they will provide reasonable assurance that the standards for radiation

protection set out in Subchapter D of 30 TAC Chapter 336 of the commission's rules (relating to Standards for Protection Against Radiation) will be met;

(5) As authorized in the draft license, the disposal site, disposal site design, land disposal facility operations, disposal site closure, and post-closure institutional control are adequate to protect the public health and safety and the environment in that they will provide reasonable assurance that long-term stability of the disposed waste and the disposal site will be achieved and will eliminate to the extent practicable the need for ongoing active maintenance of the disposal site following closure;

(6) As authorized in the draft license, there is reasonable assurance that the applicable technical requirements of Subchapter H of 30 TAC Chapter 336 will be met;

(7) As authorized in the draft license, the institutional control provides reasonable assurance that institutional control will be provided for the length of time found necessary to ensure the findings in paragraphs (2)-(5) above and that the institutional control meets the requirements of 30 TAC §336.734 (relating to Institutional Requirements);

(8) As authorized in the draft license, the financial assurances met the requirements of Subchapter H of 30 TAC Chapter 336; and

(9) As authorized in the draft license, any additional requirements under the rules of the commission are met.

This draft EA is conducted in accordance with statutory requirements found in Chapter 401 of the Texas Health and Safety Code. The draft EA is organized according to statutory criteria in Chapter 401, focusing on the license application submitted by WCS and the related technical analysis of that application. The draft EA was developed based on contributions of individual review areas such as geology, engineering, hydrology, health physics, etc. The draft EA discusses the review and analysis of technical issues in several critical areas that were subsequently addressed in draft license conditions. These draft license conditions are intended to address areas identified in the draft EA that warrant specific attention.

This EA is accompanied by proposed license conditions requiring satisfactory completion and verification of additional studies prior to commencement of major construction. The Executive Director has reviewed and analyzed the license application in accordance with Texas Health and Safety Code §401.104, and has made a preliminary recommendation for issuance of the draft license, with several sequential phases outlined in conditions of the draft license.

Upon approval, the commission may incorporate in any license at the time of issuance additional requirements and conditions with respect to the licensee's receipt, possession, and disposal of waste as appropriate or necessary in order to protect the health and safety of the public and the environment, to require reporting or recordkeeping, or provide for inspection of activities that may be necessary or appropriate to effectuate the purpose of any applicable statute including Chapter 401 of the Texas Health and Safety Code or under the rules of the commission. In that light, the Executive Director and his staff have identified the following areas of the application that warrant specific attention:

(1) The application provides characterization and modeling of the proposed disposal site to meet the requirements of 30 TAC §336.728(a). The Executive Director recommends that additional site information be provided to verify the characterization provided in the application to address data gaps and areas of uncertainty. Supplemental site characterization work is currently being conducted by the applicant. Draft license conditions requiring additional site characterization work have been proposed as preconstruction requirements. Since additional field work and evaluation of that work is required in the draft license, the results of this work have not yet been reviewed by TCEQ staff. Analyses of the site characterization data that have been presented in the license application are presented in Sections 6.6, 6.7, and 6.8 of this EA.

(2) The application provides information to address sufficiency of depth to the water table so that groundwater, perennial or otherwise, shall not intrude into the waste to meet the requirements of 30 TAC §336.728(f). New final dimensions that differ from those presented in the application, of facility buffer zones have been proposed in draft license conditions to provide assurance that water will not contact waste. The Executive Director recommends license conditions to require predictive modeling to assess future locations of the water tables. An analysis of issues related to the hydrology, including the site hydrological conceptual model, of the proposed disposal site is presented in Sections 6.6 and 6.7 of this EA.

(3) The application provides information related to fee simple ownership of the mineral estate beneath the proposed disposal site to address the requirements of 30 TAC §336.808(c) and Texas Health and Safety Code §401.204(c). The application states that a condemnation proceeding will be necessary to meet statutory requirements for ownership of the mineral rights beneath the proposed facilities. Ownership of the proposed disposal facilities is discussed in Sections 8.1 and 8.2 of this EA. Under Texas Health and Safety Code §401.204(a), an application for a compact waste disposal facility license may not be considered unless the applicant has acquired the title to and any interest in land and buildings as required by commission rule. WCS does not own all of the mineral interests underlying the proposed land disposal facilities. In a petition dated November 29, 2005, WCS is requesting that the TCEQ request that the attorney general institute condemnation proceedings to acquire fee simple interest in the outstanding mineral rights (TCEQ Docket No. 2005-1994-RAW). A licensing order has been drafted stating the application will be conditionally granted upon a demonstration by WCS that the applicant has acquired free and clear title to and all interests in land and buildings, including the surface and mineral estates, of the proposed disposal site, by either having acquired an undivided ownership of the buildings, surface estate, and mineral estate in fee simple through purchase or completed condemnation. The licensing order provides that the

license may not be issued, signed, or granted and has no effect until the ownership demonstration required above has been approved by the Executive Director.

(4) The application provides information related to the United States Department of Energy assuming all right, title, and interest in the land and buildings for the disposal of federal facility waste to address the requirements of 30 TAC §336.909(2). A discussion of institutional ownership of the proposed facilities is provided in Section 8.2 of this EA.

(5) The application provides information on equipment, facilities, and procedures to protect and minimize danger to the public health and safety and the environment as required by 30 TAC §336.207. An analysis of the applicant's proposed operational radiation protection program is provided in Section 4.2 of this EA. The Executive Director recommends development of a clear plan to establish a site-wide safety and high-performance culture that is integrated into the daily operations of the proposed disposal facility.

(6) The application proposes financial assurance for operation and closure of the proposed disposal facilities to address the requirements of 30 TAC §336.736. Financial assurance and the financial qualifications of the applicant are discussed in Section 8.14 of this EA.

Section 1: Introduction and Background

1.0 General Introduction

Waste Control Specialists, LLC (WCS or applicant) has applied to the Texas Commission on Environmental Quality (TCEQ or commission) for a license to develop, operate, and close facilities for the disposal of low-level radioactive waste at a site located approximately 30 miles west of the City of Andrews, Texas, and approximately five miles east of the City of Eunice, New Mexico.

1.1 Jurisdiction for Radioactive Material

Regulation of radioactive material, including radioactive material disposal in the United States was restricted to the federal government, under provisions of the Atomic Energy Act of 1954, which created the Atomic Energy Commission (AEC). Section 274 of the Atomic Energy Act (codified as amended at 42 U.S.C. §2021(b)) was enacted by the United States Congress in 1959 to allow states to enter into formal agreements with the AEC to assume state regulatory authority over some radioactive materials. The federal government, however, retains authority over other radioactive materials and exclusive authority over nuclear reactors.

The State of Texas became an "Agreement State" in 1963. Texas has exclusive authority to regulate radioactive materials, other than nuclear reactors and certain types of high-level radioactive materials, which remain under federal jurisdiction. Texas' radiation control program is overseen by the United States Nuclear Regulatory Commission (NRC), a successor agency to the AEC. The NRC reviews the Texas regulatory program on a regular basis for its adequacy and compatibility with the federal program and retains the power to reassert federal authority if it finds that the state is unable to protect public health or is not in compliance with Section 274 of the Atomic Energy Act.

In 1980, the United States Congress passed the Low-Level Radioactive Waste Policy Act (codified as amended at 42 U.S.C. §§2021b-2021j), which required each state to be responsible for the low-level radioactive waste commercially generated within its borders, either by itself or in cooperation with other states by means of a compact. Texas entered into an agreement designated as the Texas Low-Level Radioactive Waste Disposal Compact (Texas Compact) with the states of Maine and Vermont wherein Texas will provide a low-level radioactive waste disposal facility (Chapter 403, Texas Health and Safety Code). The Texas Compact was ratified by the United States Congress and signed by President Clinton in September 1998. The State of Maine passed emergency legislation to withdraw from the Texas Compact in April 2002 and formally withdrew from the Texas Compact in April 2004.

Low-level radioactive waste is defined in Texas law and rule by what it is not. It does not include radioactive wastes that are high-level such as spent nuclear fuel, transuranic waste produced by the defense nuclear weapons program, tailings and other by-product material of source material recovery and uranium mining, oil and gas naturally-occurring radioactive material (NORM), and non-oil and gas NORM waste. Consequently, low-level radioactive waste is a subset of a broad category of nuclear waste. Generally, low-level radioactive waste is material which has been declared as waste that has been contaminated by or contains short-lived radionuclides or longer-lived radionuclides in relatively low concentrations.

All low-level radioactive waste must be managed and disposed to minimize risk to people and the environment. A system for classifying low-level radioactive waste based on relative risk has been developed in the United States of America. Because the risk of exposure increases for higher categories of low-level radioactive waste, waste in those categories must be disposed in more restrictive ways.

Low-level radioactive waste is defined as Class A, B, and C. Class A low-level radioactive waste is the least hazardous, containing mostly short-lived radionuclides that will be reduced in radioactivity in a relatively short time. The majority of the low-level radioactive waste produced in the Texas Compact is classified as Class A. Class B low-level radioactive waste is more hazardous than Class A waste. The majority of Class B and C low-level radioactive waste in the Texas Compact is generated by nuclear power reactors. It must be in a stable form for disposal and must be disposed in concrete overpacks or canisters. Stabilization can be accomplished by solidifying liquid waste, compacting solid waste, or placing the low-level radioactive waste in a container that will be stable for many years. Class B low-level radioactive waste makes up only a small percent of the waste volume generated; but along with Class C waste, it contains the largest portion of the total radioactivity. Class C low-level radioactive waste is the most hazardous and must be handled accordingly. It also must be disposed of in a stable form. The Texas Compact produces only a very small amount of Class C low-level radioactive waste, less than five percent of the total volume generated.

An additional category called Greater-than-Class-C low-level radioactive waste also exists, but the disposal of this waste is not the responsibility of the state and is generally not acceptable for near-surface land disposal. Greater-than-Class-C low-level radioactive waste is specifically prohibited for receipt and disposal by the proposed draft license.

Any of these classes of low-level radioactive waste, if they also contain materials classified as hazardous chemical waste, fall into a category called mixed waste. Mixed waste requires handling and disposal in accordance with low-level radioactive waste regulations as well as those applying to hazardous waste.

1.2 Proposed Action

Waste Control Specialists, LLC prepared and submitted to the Texas Commission on Environmental Quality (TCEQ or commission) a single license application for authorization to develop, operate, and close, two separate facilities for the disposal of low-level radioactive waste at a site located on the Texas-New Mexico state line. WCS is a Delaware limited liability company. The company corporate offices are located in Dallas, Texas. The TCEQ is the state agency with jurisdiction to regulate the disposal of low-level radioactive waste under Section 401.201 of the Texas Health and Safety Code. The TCEQ Executive Director and his staff have reviewed the license application and prepared this Environmental Analysis (EA or analysis) as supporting documentation of its review.

The proposed licensing action would authorize the development of two facilities under one license for near-surface land disposal of low-level radioactive waste. The compact waste disposal facility (CWF) will accept low-level radioactive waste as defined in Section 401.004 of the Texas Health and Safety Code for commercial disposal of compact waste (low-level radioactive waste generated in a host or party state of the Texas Compact or low-level radioactive waste approved for importation into Texas by the Texas Compact Commission). Waste receipts over the facility lifetime are estimated to be 2,800,000 cubic feet (102,000 cubic yards). Historical trending and waste generator forecasts reported in the license application suggest that approximately 90 percent of the CWF waste volume will be Class A low-level radioactive waste, nine percent will be Class B low-level radioactive waste, and approximately one percent will be Class C low-level radioactive waste. The application proposes that all waste will be stabilized prior to placement in the CWF disposal unit by emplacement in steel reinforced concrete canisters with grout.

The federal facility waste disposal facility or Federal Waste Facility (FWF) is proposed to accept low-level radioactive waste that is the responsibility of the federal government under the Low-Level Radioactive Waste Policy Act, as amended by the Low-Level Radioactive Waste Policy Amendments Act of 1985, such as low-level radioactive waste from federal facilities. WCS has also requested authorization to dispose of mixed waste, as defined in Section 401.221 of the Texas Health and Safety Code. Mixed waste is a combination of hazardous waste and low-level radioactive waste. Hazardous waste is regulated under the Solid Waste Disposal Act, Chapter 361 of the Texas Health and Safety Code, and the Resource Conservation and Recovery Act (RCRA) of 1976 (42 U.S.C. Section 6901 et seq.), as amended. In order to accept mixed waste at the facility, a hazardous waste disposal permit must be issued in accordance with 30 Texas Administrative Code (TAC) Chapter 335. Mixed waste accepted for disposal would be limited to federal facility waste, as defined in Section 401.2005(4) of the Texas Health and Safety Code. The overall waste volume for the lifetime of the federal facility waste disposal facility is limited to 6,000,000 cubic yards.

1.3 Site Location

Figure EA-1 of this document shows the location of the project site. The proposed facilities are described in Section 5.0 of the application as located approximately one-half mile east of the Texas-New Mexico boundary and one mile north of Texas State Highway

176. Section 2.0 of the application includes as Attachment C, a written legal description and figure for each of the proposed waste management areas:

- 29.66-acre compact waste facility or CWF
- 89.90-acre federal facility waste disposal facility or FWF
- 3.29-acre "Common Administrative Area".

Attachment C of the application also contains Figure C-1, which is a composite map depicting the surveyed outlines of the proposed waste management areas. A legal description of the proposed waste management areas is also provided in an Attachment B, Exhibit I, which includes a General Warranty Deed for the 1,338.121 acres representing the designed permitted area for the pre-existing RCRA, Subtitle C treatment, storage and disposal facility landfill, RCRA Hazardous Waste Permit Number HW-50358.

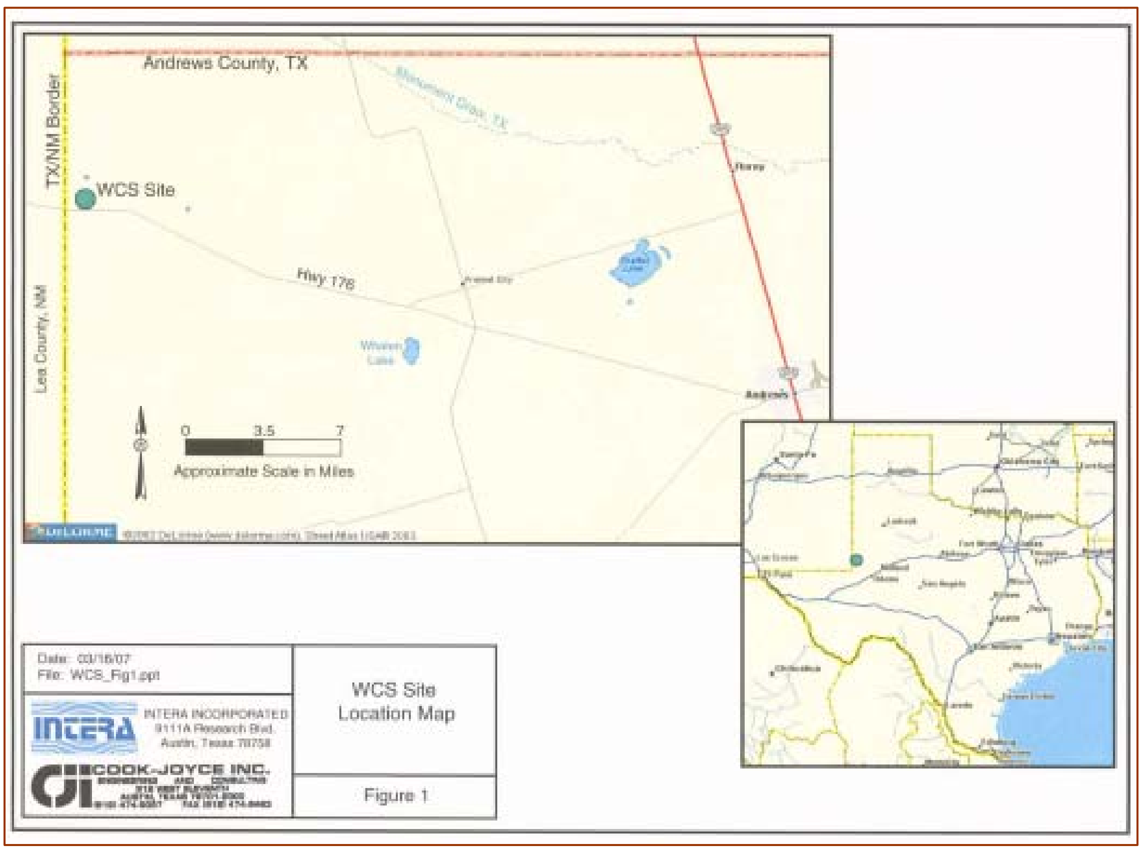

Figure EA-1: Site Location Map. Volume 1, Section 2, Attachment E.

1.4 Administrative and Technical Reviews of the Application

The TCEQ radioactive substance rules are found in Chapter 336 of Title 30 of the Texas Administrative Code (30 TAC). The license application was made under 30 TAC Chapter 336, Subchapter H, (Licensing Requirements for Near-Surface Land Disposal of Low-Level Radioactive Waste.). Many provisions of Chapter 336 are modeled directly on the NRC's rules for the federal regulations for the control of radiation, including low-level radioactive waste disposal. The federal regulations to which the state regulations for low-level radioactive waste disposal correspond are found in Title 10 of the Code of Federal Regulations, Part 61 (10 CFR 61), "Licensing Requirements for Land Disposal of Radioactive Waste."

In addition, the NRC publishes numerous guidance documents to assist TCEQ staff, as well as applicants and licensees, to carry out their responsibilities related to proposed activities. Although state law and regulations govern the review and licensing of a low-level radioactive waste disposal facility in Texas, WCS used some NRC documents for guidance to develop their application. TCEQ used NRC guidance in conducting their review and analysis of the application, primarily NRC Regulatory Guide 4.18 (NRC, 1983), NUREG-1199 (NRC, 1991), NUREG-1300 (NRC, 1987), and NUREG-1200 (NRC, 1994). The TCEQ staff also developed specific guidance for conducting performance assessments of low-level radioactive waste disposal facilities (TCEQ, 2004).

The application, which is voluminous and technical in nature, was originally submitted to the TCEQ on August 4, 2004. The application was assigned the number R04100 for identification purposes and a review for administrative completeness was initiated in accordance with Section 401.230 of the Texas Health and Safety Code. The purpose of the review is to determine if the application contains sufficient information to allow TCEQ staff to review the technical merits of the application. The application was determined to be administratively incomplete and a series of three administrative notices of deficiency were issued to provide the applicant an opportunity to cure the noted deficiencies (Howell, 2004a-b, 2005). The application was determined to be administratively complete on February 18, 2005 (Nelon, 2005).

Technical review of the application began in May 2005 in accordance with Section 401.237 of the Texas Health and Safety Code. A courtesy letter was sent to the applicant in July 2005 to advise the applicant of numerous issues of fundamental importance to the ultimate consideration of the application (Wheatley, 2005a). Two technical notices of deficiency were issued to provide the applicant an opportunity to cure the noted deficiencies (Wheatley, 2005b, and Hardee, 2006a). On June 5, 2006, the applicant was informed that many deficiencies identified in previous notices have not been adequately addressed (Eden, 2006). An additional list of concerns was sent to the applicant on June 30, 2006 (Hardee, 2006b). The applicant requested an extension of time to address outstanding technical issues on August 8, 2006 (Baltzer, 2006). A conditional extension until May 1, 2007, was granted by the TCEQ Executive Director on August 30, 2006

(Shankle, 2006). Additional submissions to the license application were made by the applicant in March and May 2007. The history of submissions and applicant responses to the administrative and technical notices of deficiency are summarized in Table EA-1.

Each submission by the applicant included license application material which superseded earlier material. Not all parts of a previous submission were, however, always superseded, or replaced, by a subsequent submission. Therefore, any one section of the application may contain material representing several different revisions. This review document is based on the most recent revision for each topic, unless otherwise noted.

The application consists of 14 sections contained in 34 consecutively numbered volumes, including various appendices. Each volume contains a table of contents and tabs indicating section numbers and subject matter. The official TCEQ copy of the application (R04100), which is maintained in the Central Records File Room of the Information Resources Division, contains only the latest material submitted; i.e., all superseded material has been removed from it. The superseded material has been retained in separate binders. The applicant has maintained a current version of the application on a web site at: http://www.urs-slc.com/wcs/, and a current version of the application is available for review and photocopying at the Andrews County Library located at 109 Northwest First Street in Andrews, Texas.

During the review period, TCEQ staff made a number of visits to the site and vicinity and attended various technical briefings conducted by WCS and/or their consultants. Memos reporting on these activities were sent to Central Records and are cited as necessary in this document.

Table EA-1: Low-Level Radioactive Waste Disposal Application Timeline

Date	Event
July 8, 2004	Beginning of 30-day period in which HB 1567, 78th Legislature, Regular Session, allows parties to file applications for proposed low-level radioactive waste disposal facility.
Aug. 4, 2004	WCS files license application, Revision 0.
Aug. 6, 2004	Application submission 30-day period ends.
Aug. 20, 2004	WCS submits Revision 1 to application.
Sept. 17, 2004	TCEQ issues first Notice of Administrative Deficiency (ANOD) to WCS.
Oct. 18, 2004	WCS submits response to ANOD1 as Revision 2.
Nov. 17, 2004	TCEQ issues second ANOD to WCS.
Dec. 17, 2004	WCS submits response to ANOD2 as Revision 3.
Jan. 14, 2005	TCEQ submits third ANOD to WCS.

Date	Event
Jan. 31, 2005	WCS submits response to ANOD3 as Revision 4.
Feb. 18, 2005	TCEQ finds license administratively complete. Letter issued to WCS declaring administrative completeness of application.
Feb. 22, 2005	WCS submits Revision 5 to application.
March 31, 2005	TCEQ holds public hearing in Andrews County.
April 6, 2005	WCS submits Revision 6 to application.
May 2, 2005	TCEQ publishes Evaluation of Merit Report to Executive Director for consideration. Technical review of application begins.
May 16, 2005	WCS submits Revision 7 to application.
May 31, 2005	WCS submits Revision 8 to application.
July 20, 2005	TCEQ issues a courtesy letter to WCS advising of numerous significant issues in advance of issuance of formal First Technical Notice of Deficiency (TNOD).
Sept. 16, 2005	TCEQ issues First Technical Notice of Deficiency (TNOD1).
Nov. 30, 2005	WCS responds to TNOD1 as Revision 9.
Jan. 30, 2006	TCEQ issues Second Technical Notice of Deficiency (TNOD2).
March 9, 2006	WCS submits Revision 10 to application (Consists of submittal of a software manual to a single copy of the application).
March 31, 2006	WCS submits response to TNOD2 as Revision 11.
April 28, 2006	WCS submits Revision 12 to application.
June 5, 2006	TCEQ issues letter and advises WCS that many significant deficiencies remain unresolved with response to TNOD2.
June 30, 2006	TCEQ issues List of Concerns that provides details of the June 5, 2006 advisory letter.
Aug. 8, 2006	WCS requests extension until May 31, 2007 to more completely respond to unresolved issues.
Aug. 30, 2006	TCEQ Executive Director conditionally grants extension request for submission of a technically complete on or before May 1, 2007.
March 16, 2007	WCS submits response to List of Concerns as Revision 12a.
April 21, 2007	TCEQ sends informal electronic mail for WCS's consideration of apparent data omissions and other issues being evaluated to date in its Revision 12a submittal.
April 27, 2007	WCS submits Revision 12b and advises that an additional revision, to be called Revision 12c will be submitted May 1, 2007.
May 1, 2007	WCS submits Revision 12c.

Date	Event
October 2007	TCEQ begins preparation of draft license and Environmental Analysis.
December 2007	TCEQ submits initial draft license to WCS for review and comment.
August 2008	TCEQ mails notice to publish recommendation, draft environmental analysis, draft license, and notice of opportunity of contested case hearing and public meeting to the applicant.
	Contested case hearing, if held, projected to be completed, per one year statutory time limit. Administrative Law Judge Proposal for Decision issued.
	TCEQ Commissioners make final decision on application.
	If approved by TCEQ Commissioners, an 18-month period is projected for completion of construction of facilities followed by beginning waste acceptance.

1.5 Statutory Criteria for Environmental Analysis

This Environmental Analysis has been prepared in accordance with Texas Health and Safety Code §401.113 which requires preparation of a written analysis of the effect on the environment of a proposed licensed activity that the agency determines has a significant effect on the human environment. The statute further requires that the analysis shall be made available to the public not later than the 31st day before the date of a hearing under Texas Health and Safety Code §401.114.

This analysis addresses each of the four criteria specified by statute. These statutory criteria are listed as follows:

- An assessment of radiological and non-radiological effects of the activity on the public health;
- An assessment of any effect on a waterway or groundwater resulting from the activity;
- Consideration of alternatives to the activities to be conducted under the license; and
- Consideration of the long-term effects associated with activities, including decommissioning, decontamination, and reclamation impacts, including the management of low-level radioactive waste, to be conducted under the license.

The Environmental Analysis is organized according to statutory criteria in Chapter 401, focusing on the license application submitted and the related technical analysis of that application. The draft EA was developed based on contributions of individual review areas such as geology, engineering, hydrology, health physics, etc. Each of the following sections in this analysis will briefly summarize the information provided by the applicant and state where in the application that information is located. The sections discuss the review and analysis of technical issues in several critical areas that were subsequently addressed in draft license conditions. These draft license conditions are intended to address areas identified in the draft EA that warrant specific attention. These proposed license conditions are inserted into the following analysis sections, linking license conditions with the technical issues giving rise to them. For clarity, several of the proposed conditions are given multiple references.

References Section 1.0: Introduction and Background

Baltzer, 2006. Letter of August 8, 2006 from Rodney Baltzer, President, Waste Control Specialists, LLC to Glenn Shankle, Executive Director, Texas Commission on Environmental Quality. Request for extension.

Eden, 2006. Letter of June 5, 2006, from Dan Eden, Deputy Director, Office of Permitting, Remediation and Registration, Texas Commission on Environmental Quality to Rodney Baltzer, President, Waste Control Specialists, LLC. Remaining deficiencies.

Hardee, 2006a. Letter of January 30, 2006, from Jacqueline Hardee, Director, Waste Permits Division, Texas Commission on Environmental Quality to Dean Kunihiro, Senior Vice President, Waste Control Specialists, LLC. Second technical notice of deficiency.

Hardee, 2006b. Letter of June 30, 2006, from Jacqueline Hardee, Director, Waste Permits Division, Texas Commission on Environmental Quality to Rodney Baltzer, President, Waste Control Specialists, LLC. List of Concerns.

Howell, 2004a. Letter of September 17, 2004, from David Howell, Manager, Permits Administration Review Section, Registration, Review and Reporting Division, Texas Commission on Environmental Quality, to Dean Kunihiro, Senior Vice President, Waste Control Specialists, LLC. First administrative notice of deficiency.

Howell, 2004b. Letter of November 17, 2004, from David Howell, Manager, Permits Administration Review Section, Registration, Review and Reporting Division, Texas Commission on Environmental Quality, to Dean Kunihiro, Senior Vice President, Waste Control Specialists, LLC. Second administrative notice of deficiency.

Howell, 2005. Letter of January 14, 2005, from David Howell, Manager, Permits Administration Review Section, Registration, Review and Reporting Division, Texas Commission on Environmental Quality, to Dean Kunihiro, Senior Vice President, Waste Control Specialists, LLC. Third administrative notice of deficiency.

Nelon, 2005. Letter of February 18, 2005, from Donald Nelon, Team Leader, Permits Administration Review Section, Registration, Review and Reporting Division, Texas

Commission on Environmental Quality, to Dean Kunihiro, Senior Vice President, Waste Control Specialists, LLC. Declaration of Administrative Completeness.

NRC, 1983. United States Nuclear Regulatory Commission, Regulatory Guide 4.18: Standard Format and Content of Environmental Reports for Near-Surface Disposal of Radioactive Waste. Office of Nuclear Regulatory Research, Washington, D.C. June 1983. *

NRC, 1987. United States Nuclear Regulatory Commission, NUREG-1300, Environmental Standard Review Plan for the Review of a License Application for a Low-Level Radioactive Waste Disposal Facility: Environmental Report., Office of Nuclear Material Safety and Safeguards, Washington, D.C. April 1987
.

NRC, 1991. United States Nuclear Regulatory Commission, NUREG-1199. Revision 2, Standard Format and Content of a License Application for a Low-Level Radioactive Waste Disposal Facility, Office of Nuclear Material Safety and Safeguards, Washington, D.C. January 1991.

NRC, 1994. United States Nuclear Regulatory Commission, NUREG-1200. Revision 3, Standard Review Plan for the Review of a License Application for a Low-Level Radioactive Waste Disposal Facility, Office of Nuclear Material Safety and Safeguards, Washington, D.C. April 1994.

Shankle, 2006. Letter of August 30, 2006 from Glenn Shankle, Executive Director, Texas Commission on Environmental Quality, to Rodney Baltzer, President, Waste Control Specialists, LLC. Approval of Extension Request.

TCEQ, 2004. Performance Assessment: A Method to Quantitatively Demonstrate Compliance with Performance Objectives for LLRW Facilities. Draft Document Version 2. Radioactive Material Licensing Team, Waste Permits Division, Office of Permitting, Remediation & Registration. February 2004.

Wheatley, 2005a. Letter of July 20, 2005, from Wade Wheatley, Director, Waste Permits Division, Texas Commission on Environmental Quality to Dean Kunihiro, Senior Vice President, Waste Control Specialists, LLC. Courtesy letter.

Wheatley, 2005b. Letter of September 16, 2005, from Wade Wheatley, Director, Waste Permits Division, Texas Commission on Environmental Quality to Dean Kunihiro, Senior Vice President, Waste Control Specialists, LLC. First technical notice of deficiency.

Section 2: Proposed Facility Impacts

2.0 General Introduction

The principal design and technical features of the on-site facilities must comply with established TCEQ regulations. After giving the requirements from the regulation, this section reports on the TCEQ staff's analysis on engineering features of the proposed facility including construction methods, materials, and features in relationship to the performance objectives of the facility. Specific consideration is given to stability of the waste and management of water. Various models and computations are used to determine the performance of different aspects of the facility and its components. A number of license conditions are proposed as a result of this review and are described within this section.

2.1 Principal Design Features

Title 30 of Texas Administrative Code (30 TAC), Section 336.707 requires that specific technical information regarding the design features of the proposed facility be included in the application so that the agency can determine whether state regulations have been satisfied. Rule 30 TAC §336.707(1) requires that the application include a description of the principal design criteria and their relationship to the performance objectives. Title 30 TAC §336.707(2) requires that the application include a description of the design basis natural events or phenomena and their relationship to the principal design criteria. Title 30 TAC §336.707(4) requires that the application include a description of the design features of the land disposal facility and the disposal units. For near-surface disposal, the description shall include those design features related to the infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of waste with standing water, disposal site drainage, and other engineering features of the proposed facility.

The application includes a general description of the principal design features at the proposed facility. Section 3 of the application gives an overview of the facility design including a detailed description of the principal design criteria and their relationship to the performance objectives. Section 3 also includes a general discussion of the technical features of the on-site facilities, including the disposal unit covers, design consideration for natural events, and the design features associated with the management of water at the site. Appendix 3.0-1 gives a more detailed technical description of all salient designed components of the proposed facility including the construction of the disposal units, the reinforced concrete canisters, and compact waste facility (CWF) and federal facility waste disposal facility (FWF) cover systems, non-containerized waste placement procedures, water storage tanks, and water run-on control design features. A locational map for the FWF and CWF is provided in Figure EA-2.

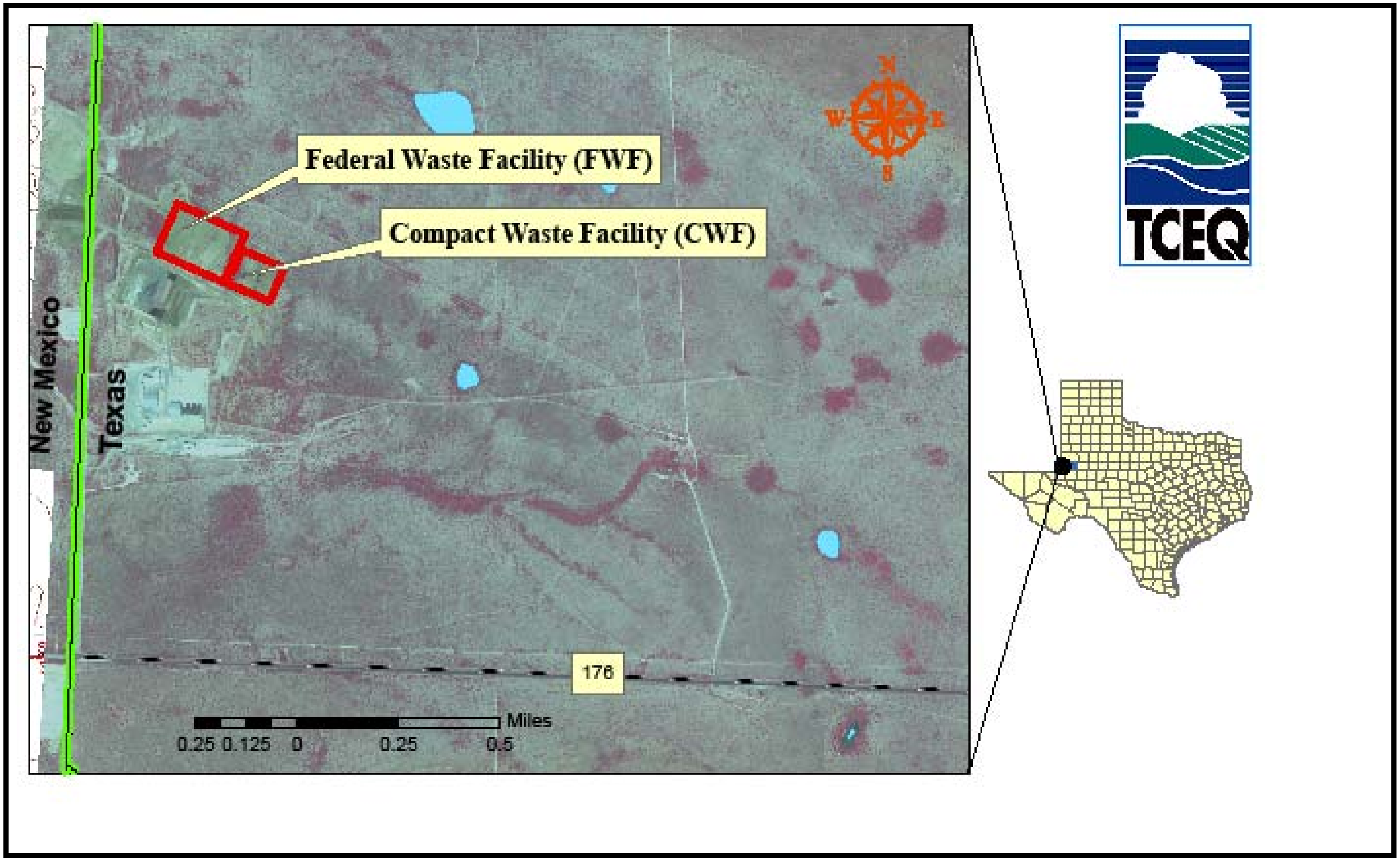

Figure EA-2: Map of Proposed Federal Waste Facility and Compact Waste Facility Location. (Note: base data used are Digital Ortho Quarter Quandrangles (DOQQ), a digtial version of an aerial photograph. U.S.G.S. Quandrangle, 2004, NAD 83.)

Volumes 21, 22, and 23 of the application consist of a series of appendices that present detailed engineering design calculations for specific components of the proposed disposal system (e.g., concrete canister numerical calculations, leachate collection pipe design, and structural stability of waste). These appendices are not detailed here but each was thoroughly reviewed by TCEQ technical staff. The review of these appendices are discussed in separate sections of this EA. These appendices were supported by more than 340 engineering drawings of specific facility components included in Volume 24 (WCS LLRW Disposal Facility Drawing Set) of the application. These drawings depict detailed features and dimensions of each of the designed facility components.

Several proposed license conditions may alter the principal design features at the proposed site. For instance, one proposed license condition requires a relocation and reconfiguration of the proposed disposal units in order to provide an additional margin of safety so that the constructed units have a "sufficient depth to groundwater" as required by 30 TAC §336.728(f). If implemented, this condition will result in disposal units differing in location, dimension, and configuration from those depicted in the drawings of Volume 24 of the application. These differences will require some reconciliation between the engineering design calculations submitted in Volumes 21, 22, and 23 of the application and the newly configured units. Such reconciliation would be required by a proposed license condition stating that the design and construction of the proposed disposal units shall be in accordance with the application and specifications "as modified by this license, and any applicable conditions of this license." The Executive Director has included license conditions that require submission of revised final engineering, design, drawings, specifications and calculations prior to commencement of major construction.

Other proposed license conditions require the maintenance of individual buffer zones, for both the CWF and the FWF. Each zone would be defined by a lateral perimeter of at least one hundred feet around all disposed waste in each respective unit, and beneath each unit to a depth below the waste to allow monitoring for early detection of releases and to allow for remediation, if necessary. These zones will also establish a sufficient envelope of unsaturated porous media around the units so that a "sufficient depth to groundwater" is maintained. The creation of such buffer zones for the dedicated purpose of monitoring and remediation will require that certain on-site structures and associated infrastructure proposed in the application be relocated outside of the buffer zones. In order to maintain a dedicated buffer zone, a proposed license condition stating that the applicant should not handle, store or dispose of waste, or engage in any waste-related activities in the buffer zone. The Executive Director has included license conditions that require submission of revised final engineering, design, drawings, specifications and calculations prior to commencement of major construction.

2.2 Construction Methods and Features

State regulation 30 TAC §336.707(5) requires that the application contain accurate drawings and descriptions of all on-site buildings and their components and additional sufficient information so that the TCEQ will know the principal features of all planned construction at the proposed disposal site. Furthermore, 30 TAC §336.707(3) requires that the application contain codes and standards relating to the design and construction of the land disposal facility so that the TCEQ will know the principal methods used for all planned constructions. TCEQ staff's technical review of the codes and standards cited in the application is presented in Section 2.7 of this EA; in this section the engineering drawings submitted in the application are reviewed.

Volume 2, Section 4 of the application contains a detailed description of the construction methods and procedures to be used by the applicant in developing the proposed disposal units. This section includes discussions of construction management and quality assurance and details of how the FWF, the CWF, and all common facilities will be constructed. Section 4 includes an illustrated explanation of how the disposal unit cells will be expanded during operation. Section 4 also includes discussions of construction safety and equipment, equipment types, equipment specifications and capabilities, and equipment storage, maintenance, replacement and inspection. Finally, Section 4 discusses construction of environmental monitoring systems.

Title 30 TAC §336.707(5) requires that the application contain accurate drawings and descriptions of all on-site areas utilized for waste storage, all on-site buildings (including foundation details, instrumentation, ventilation, plumbing, and fire suppression systems), and all intruder barriers, physical survey systems, and onsite traffic systems. Volume 24 of the application contains approximately 340 sealed engineering drawings that address the requirements of 30 TAC §336.707(5), which were reviewed by TCEQ technical staff for completeness and accuracy.

A proposed license condition requires a relocation of the boundaries of the proposed disposal units and a reconfiguration of these units in order to provide an additional margin of safety so that the constructed units have a "sufficient depth to groundwater" as required by 30 TAC §336.728(f). Therefore, any of the engineering design features and dimensions conditioning the engineering analyses presented in the application would ultimately need to be reconciled with the relocated and reconfigured disposal units. The Executive Director has included license conditions that require submission of revised final engineering, design, drawings, specifications and calculations prior to commencement of major construction.

Other proposed license conditions consider some of the possible effects of a relocated and reconfigured facility. A license condition is recommended requiring that the CWF and FWF "design and construction shall be in accordance with the application and specifications as modified by this license, and any applicable conditions of this license."

Finally, two proposed license conditions will require maintenance of a buffer zone for both the CWF and FWF (See Sections 6.6.1 and 6.6.5 of this EA for further discussion). The creation of such zones would necessitate the relocation and possible reconfiguration of several of the on-site buildings and associated infrastructures proposed in the application. Thus, while construction methods reviewed here will likely still be applicable, the actual engineering drawings of these structures and the associated infrastructures, as currently characterized in the application, will need to be reconciled with their relocated and reconfigured counterparts. The Executive Director has included license conditions that require submission of revised final engineering, design, drawings, specifications and calculations prior to commencement of major construction.

2.3 Structural Stability of Waste Disposal Units

In accordance with state regulations at 30 TAC §336.707(4) and 30 TAC §305.54(f), TCEQ staff reviewed the design features of the land disposal facility and the disposal units. This part of the review describes design features related to structural stability of backfill and wastes. During the technical review, TCEQ staff also considered the performance objective of 30 TAC §336.726 requiring protection of individuals during operations.

2.3.1 Structural Stability of Backfill and Wastes

The application must describe the design features of the land disposal facility and the proposed disposal units. The submitted near-surface disposal design in the application includes three different disposal units: the Federal Waste Facility – Non-Containerized Disposal Unit (FWF-NCDU); the Federal Waste Facility – Containerized Disposal Unit (FWF-CDU); and the Compact Waste Facility (CWF). The cornerstone of a near surface disposal system is stability of the waste and the disposal site so that once emplaced and covered, the access of water to the waste can be minimized. Thus the application must provide sufficient technical information to demonstrate that the facility and each of three proposed disposal units have been designed to ensure that the backfill and wastes to be placed in each unit will be structurally stable. The regulatory requirements relevant to this discussion are 30 TAC §336.362(b)(2), (b)(2)(A), and (b)(2)(C).

A proposed license condition requires a relocation of the boundaries of the proposed disposal units and a reconfiguration of these units, to provide additional assurance that the proposed units have a "sufficient depth to groundwater" as required by 30 TAC §336.728(f). Accordingly, the design features and dimensions conditioning the analyses presented in the application and characterizing the engineering performance and stability of the initially configured waste disposal units, including the structural stability analyses reviewed in this section of the EA, would need to be reconciled with the relocated and reconfigured disposal units. This is expressed in another proposed license condition, which requires that the CWF and FWF design and construction "shall be in accordance with the application and specifications as modified by this license and any applicable conditions of this license." The structural stability of the proposed reconfigured units would have to be demonstrated. The Executive Director has included license conditions that require submission of revised final engineering, design, drawings, specifications and calculations prior to commencement of major construction.

Title 30 TAC §336.362(b)(2) states that: "The following requirements are intended to provide stability of the waste. Stability is intended to ensure that the waste does not degrade and affect overall stability of the site through slumping, collapse, or other failure of the disposal unit and thereby lead to water infiltration. Stability is also a factor in limiting exposure to an inadvertent intruder, since it provides a recognizable and non-dispersible waste."

Title 30 TAC §336.362(b)(2)(A) states that waste intended for disposal shall have structural stability. A structurally stable waste form will generally maintain its physical dimensions and its form, under the expected disposal conditions such as weight of overburden and compaction equipment, the presence of moisture, and microbial activity and internal factors such as radiation effects and chemical changes. Structural stability can be provided by the waste form itself, processing the waste to a stable form, or placing the waste in a disposal container or structure that provides stability after disposal.

Title 30 TAC §336.362(2)(b)(C) states that void spaces within the waste and between the waste and its package shall be reduced to the extent practicable. The structural stability of the waste and backfill is strongly conditioned by the interaction of that waste with the structural response of all the engineered components (cover, liners, concrete canisters, lifts of backfill and/or bulk waste) of the proposed disposal units, under both static and dynamic loadings. Therefore, the structural stability of all engineered components of the proposed units and their interaction with the disposed waste must be an integral part of the waste structural stability demonstration. The centerpiece of the analysis of the structural stability of the disposed waste and backfill materials presented in the application is a series of soil-structure interaction computations performed using the continuum mechanics computer code, Fast Lagrangian Analysis of Continua (FLAC). Review of Appendix 3.4-1 of the application, detailing these computations, is discussed below. The FLAC computations depend upon a preliminary engineering design of each engineered component of the proposed units, as individual components. For instance, the applicant also presents a detailed presentation of the design of the concrete canisters to be used as waste containment structures in both the proposed FWF and CWF disposal units. Concrete canisters as disposal unit components should be designed to be stable, i.e., maintain gross physical properties and identity over 300 years as suggested in 10 CFR §61.7(b)(2).

Title 30 TAC §336.730(b) states: "Wastes designated as containerized Class A, Class B, or Class C under §336.362(a) of this title or §336.702 of this title (relating to Definitions) shall be disposed in the following manner: within a reinforced concrete container and within a reinforced concrete barrier, or within containment structures made of materials technologically equivalent or superior to reinforced concrete." This regulatory requirement intends, in part, to give additional assurance that containerized disposed waste will maintain structural stability over the 300-year design period specified in 10 CFR §61.7(b)(2). Any demonstration that the requirements of 30 TAC §336.362(b)(2)(A), (B), and (C) have been met must include an analysis of the structural stability of the reinforced concrete barrier and the effect of its structural response on the structural stability of the engineered cover systems and containerized wastes and backfill.

Finally, 30 TAC §336.726 states that operations at the land disposal facility must be conducted in compliance with the standards for radiation protection set out in Subchapter D of Chapter 336 and effort must be made to maintain radiation exposures as low as reasonably achievable. The application describes a series of analyses of the proposed disposal units following closure, including their response to a seismic event. It is important to study the loss of canister stability due to slope failure or tipping caused by a seismic event during operations. Such instability might result in an unexpected exposure of radiation to an individual worker. The Executive Director recommends a license condition requiring additional analysis of a seismic event that could occur during the operational phase of the land disposal facility to address potential exposure of radiation to an individual worker.

Other regulatory requirements relevant to the structural stability of the disposed wastes are reviewed in Sections 2.3.1, 3.6.8 – 3.6.13, and 8.12 of this EA.

In order to ascertain if the application has demonstrated compliance with the above regulatory requirements, TCEQ technical staff reviewed 17 different appendices and attachments in the license application. TCEQ staff review and analysis of these application items are given below.

2.3.2 General Engineering

TCEQ staff reviewed the LLRW Disposal Engineering Report in Volume 23, Attachment 3.0-1, of the application. This attachment contains a lengthy narrative description of all of the engineering components (cover system, concrete canisters, backfill materials, and bottom liner system including the reinforced shotcrete liner) contributing to the structural stability of the waste and backfill. Schematics of these components and the configurations of each of the three proposed disposal units are also presented. More precise depictions of these components are given in the LLRW Disposal Facility Drawing Set, in Volume 24, Appendix 3.0-2, relevant portions of which were also reviewed by TCEQ staff. While the application describes an epoxy coating that is to be applied to the reinforcing steel used in the concrete canisters (protection from corrosion induced by possible intrusion of water), no reference is made to an elastomer cold-applied waterproofing intended to serve as the principal moisture barrier for the concrete canisters.

A description of this waterproofing is included in Section 07 14 16 of the technical specifications in Appendix 4.2.3 of the application, but it is not discussed anywhere in any of the engineering related attachments or in any of the attachments related to cost estimates (i.e., Volume 1, Annex 4). Because the applicant has committed to use waterproofing materials for the disposal canisters, the Executive Director recommends a draft license condition requiring that the waterproofing be applied to all canisters. And, the Executive Director also recommends that complete technical specifications of the waterproofing materials be provided prior to commencement of major construction to assure that the waterproofing materials are compatible with the design life of the concrete canister overpacks.

2.3.3 Use of Concrete

Two different types of concrete will be utilized in the construction of engineered components at the proposed disposal units. The canisters will be constructed of conventional reinforced concrete. Waste in the CWF and the FWF-CDU will be placed inside these concrete canisters. The concrete canisters will then be emplaced within a containment structure made of fiber reinforced shotcrete (FRS). A brief discussion of both types of concrete is given below.

The low-level radioactive waste disposal engineering report in Appendix 3.0-1 of the application describes the properties of reinforced concrete to be used in the disposal canisters. For example, the report states that the concrete will be normal weight with a specific compressive strength of 5,000 pounds per square inch at 28 days when tested according to the American Society for Testing and Materials (ASTM) Method C39 (Standard Test Methods for Cylindrical Concrete Specimens). Also, the report states that the concrete cover will be provided over epoxy-coated, reinforcing steel or welded wire fabric and specifies the diameter of the steel to be used in the different canister elements (i.e., roof, walls, and floor). The report states that the welded wire fabric will conform to ASTM A185 (Standard Specification for Welded Wire Fabric for Concrete Reinforcement) and the reinforcing steel will conform to ASTM A775 (Standard Specification for Epoxy-Coated Reinforcing Bars). Also, the reinforcement will be fabricated in accordance with the fabricating tolerances given in the American Concrete Institute (ACI) SP-66 (Detailing Manual). Appendix 3.2 of the application gives a description of codes and standards to be followed in the fabrication, construction and inspection of the concrete canisters and intruder barrier. The application states that the primary standards to be followed will be ACI 318-02, Building Code Requirements for Structural Concrete and Commentary, and two applicable standards and ACI 349, Code Requirements for Nuclear Safety Concrete Structures. The application states that the canisters and barrier will satisfy the strength requirements of these two standards. Appendix 3.2 of the application lists numerous other codes and standards that deal with the design and construction of reinforced concrete structures.

TCEQ staff reviewed four attachments related to the strength and long-term performance of the concrete the applicant intends to use in the construction of the concrete canisters. TCEQ staff reviewed the analysis presented in Appendix 3.0-3, Attachment 3.0-3.26 of the application, of the thermal heating of the concrete canisters due to the radioactive decay of the disposed waste. Such heating is a potential issue since excessively elevated temperatures can influence the strength and creep behavior of concrete and reinforcing steel. Initially, it appeared that the thermal analysis presented in the application may have failed to account for several important factors (e.g., effect on each canister of radioactive decay in surrounding canisters). However, supplemental analyses performed by TCEQ staff using the thermal option in the FLAC indicated that temperature increases due to radioactive decay may be appropriately ignored as a parameter in the design of the concrete canisters and surrounding engineering components.

TCEQ staff reviewed the analysis of the degradation of concrete due to chloride attack in Appendix 3.0-3, Attachment 3.0-3.10, of the application. TCEQ staff also reviewed the analysis of the degradation of the concrete canisters in Appendix 3.0-3, Attachment 3.0-3.11 of the application. Finally, TCEQ staff reviewed Appendix 3.0-3, Attachment 3.0-3.25 presenting an analysis of the long-term strength of the Type V (Sulfate Resistant) concrete intended for use in the proposed units. Based on the analysis, the Type V concrete should achieve a long-term compressive strength in excess of the design strength of 5,000 pounds per square inch.

This section of the EA describes the simulated performance of the engineered components of the disposal units that are to be fabricated from conventional reinforced concrete. While these simulations indicate that all engineered components maintain their structural stability over the 300-year design period these simulations are only valid if the components, as fabricated, constructed, and configured have the strengths, dimensions, and integrity assumed in the simulations. A correspondence between the actual and modeled properties of the reinforced concrete components can only be assured by a rigorous adherence to the relevant codes, standards, technical specifications, and testing and inspection procedures cited in the application.

2.3.4 Use of Shotcrete

The low-level radioactive waste engineering report in Appendix 3.0-1 of the application describes the concrete containment as follows:

> The FWF-CDU includes a continuous envelope of reinforced concrete, surrounding the placed and waste filled concrete canisters. The reinforced concrete barrier, as a continuous envelope barrier, is placed on the cell floor (including the berms), side slopes, and as part of the cover system. The concrete barrier is constructed of epoxy coated welded wire fabric and high strength shotcrete. The geostructural behavior of this barrier is demonstrated in the structural stability modeling using FLAC. Drawings showing sections and details of the reinforced concrete barrier are provided in Appendix 3.0-2, a technical specification is provided in Appendix 4.2.3.

TCEQ staff reviewed the referenced technical specification in Section 03 37 13 of Appendix 4.2.3 of the application. It consists of 16 pages of detailed instructions of how the shotcrete will be mixed, applied, tested, and inspected. The specifications also describe the necessary qualifications of the workers involved in the construction, testing, and inspection of the shotcrete liner. The technical specification states that the design, construction, testing, and inspection of the shotcrete containment structure will comply with each of 24 listed codes and standards. For example, the first standard listed is ACI 506.1: State of the Art Report on Fiber Reinforced Concrete. The specification also makes reference to attachments detailing quality control and quality control procedures applicable to the shotcrete and to the construction of the shotcrete liner. The specification further indicates that the shotcrete will be fiber reinforced shotcrete (FRS). That is, discrete, hard drawn, wire steel fibers with hooked ends will be uniformly distributed in the shotcrete to improve the bending capacity and durability of the completed structure. The specification requires compliance with the standard ASTM A820: Standard Specification for Steel Fibers for Reinforced Concrete.

Appendix 3.0-2 of the application contains drawings showing typical cross-sections of the reinforced concrete barrier. Appendix 3.0-1 describes the application of the shotcrete by jetting from a nozzle at high velocity onto the surface to be shotcreted. The appendix describes the details of how the joints between reinforced concrete floor and the shotcrete side slope will be constructed and monitored during the curing process.

Paragraph 3.4.4.10 of the engineering report states that the physical properties of sound shotcrete are comparable to those of conventional concrete having the same composition. TCEQ technical staff reviewed technical journal articles regarding the use of FRS in various engineering application (e.g. "Design Guidelines for the Use of Fiber-Reinforced Shotcrete in Ground Support", F. Papworth, *Shotcrete,* Spring, 2002; "Quality and Shotcrete", E. Brennan, *Shotcrete,* Winter, 2005). All of the articles noted that the physical properties of sound shotcrete are comparable to those of conventional concrete having the same composition. On the other hand, most of the articles cautioned that improperly applied shotcrete may create conditions worse than the untreated condition.

The engineering report in the application gives further details: "Shotcrete placement methods will be used to construct the side slope walls, trench floor and floor berms, and concrete header in the cover system. Concrete design parameters include 5,000 pounds per square inch compression strength and 60,000 pounds per square inch steel yield strength." These parameters are comparable to the design parameters stated in the report for the concrete to be used for the concrete canisters. The application details the characteristics of the concrete with respect to resistance to chloride attack, degradation, and development of long-term strength. The application also provides simulations on the effects of possible collapse of the concrete canisters and the effects of creep on the concrete canisters. The Executive Director recommends a license condition to require a similar demonstration of the resistance of the shotcrete to chemical attack, the use of an elastomer coating on the shotcrete to prolong its stability, and the development of long-term strength in the shotcrete to assure that the containment structures are made of materials technologically equivalent or superior to reinforced concrete.

Finally, the caveat given above for the conventional concrete must be restated for the shotcrete to be used in the construction of the containment barrier. This section of the EA describes the simulated performance of the FRS containment barrier in the disposal units. While these simulations indicate that all engineered components maintain their structural stability over the 300-year design period these simulations are only valid if the FRS containment barrier, as fabricated, constructed, and configured has the strengths, dimensions, and integrity assumed in the simulations. A correspondence between the actual and modeled properties of the fiber reinforced concrete liner can only be assured by a rigorous adherence to the relevant codes, standards, technical specifications, and testing and inspection procedures cited in the application.

2.3.5 Disposal Canister Design

TCEQ staff reviewed the Concrete Canister Structural Design Analysis presented in Appendix 3.0-3, Attachment 3.0-3.9 of the application. This detailed analysis was accomplished using the finite element computer code SAP (Structural Analysis Program). Use of this computer code allowed the study of detailed variations in the stress, strain, and deformations fields in the canisters initially sized and configured using only the elementary procedures of basic reinforced concrete design practice. TCEQ staff concluded that the SAP computations showed that a single reinforced concrete canister, constructed and emplaced as planned, has a high probability of maintaining its structural integrity for the required 300-year period. The SAP code was not used to complete an individual study of the shotcrete liner.

The SAP computations could not be utilized to study the stress, strain, displacements, and stability of a concrete canister interacting with surrounding canisters, backfill materials, and other components in an entire disposal unit. Such study required the use of the FLAC code.

2.3.6 FLAC Soil-Structure Interaction Computations

TCEQ staff reviewed Appendix 3.4-1 of the application which presented an evaluation of the structural stability of the disposal units by numerical modeling with FLAC. This evaluation consisted of a series of numerical simulations of the interaction of the engineered components of the disposal units with each other, with the fractured geologic materials in which the units are founded, and with the water table in those geologic materials. In all scenarios studied, the soil-structure interactions were studied over several sets of values for the relevant controlling parameters. These sets included a set of the most likely parameter values (based on available data), and a set of conservative values designed to induce larger than expected stresses, strains, and deformations in the engineered components and in-situ materials.

Simulations were completed of the proposed units during different stages of construction and operation, and after closure of the units. The effects of the excavation of a unit near to an operating unit were also simulated. In all these simulations the stability of all open faces and slopes were evaluated, as were settlements and rebound in the bottom and sides of the excavations. Perturbations to the geostatic stress field due to excavation, construction, and operation of the units were also computed. Appendix 3.4-1 also presented estimates of the rotations, absolute displacements, and relative displacements of each canister in each canister stack during operation and following closure. Stresses induced in each canister by these rotations and displacements were estimated as were the stresses, strains, and displacement~~s~~ strains in the shotcrete liner and cover system. In all simulations computed stresses, strains, and displacements were quite small, in some locations almost indistinguishable from numerical noise, and in all cases but one (discussed below), of no concern relative to the stability of the waste and disposal units. The response of the interacting components to a design earthquake occurring after closure was also evaluated. The seismically induced stresses, strains, and displacements were everywhere below the level of concern. The FLAC analysis of the reinforced shotcrete liner included multiple analyses at increasingly refined spatial scales.

All of the simulations presented in the application were completed assuming that the capillary fringe above the underlying water table in the Dockum red bed materials was within 14 feet of the bottom of the FWF disposal unit. The effect on the location of the water table due to the excavation and filling of the proposed disposal units was also estimated. Another series of simulations was completed to study various scenarios in which the void spaces within the FWF and CWF disposal units were significantly reduced due to different spatial configurations of collapsing canisters or due to complete loss of void space in backfill materials. These simulations were intended to account for the low probability of canister failure inherent in the standard reinforced concrete design procedures. Finally, simulations were performed to study the geomechanical effects of long-term creep in the canisters.

These FLAC computations were supported by the seven different attachments to Appendix 3.4-1. TCEQ staff evaluated the computation of composite canister moduli contained in Attachment A. These moduli were a necessary input to the FLAC computations. TCEQ staff evaluated Attachment B presenting the boring log of a 300-foot boring drilled by the applicant for the purposes of characterizing the mechanical properties of the in-situ geologic materials in order to develop realistic elasto-plastic constitutive equations for these materials. TCEQ staff also evaluated Attachment C presenting the results of unconfined compression and triaxial compression test data developed from samples obtained from this boring. TCEQ staff reviewed the technical data in Attachment D related to the design earthquake utilized in the FLAC calculations to simulate the seismic response of the FWF and CWF disposal units. TCEQ staff evaluated mechanical tests performed on clay liner materials described in Attachment E and also evaluated Attachment F assessing the effect of the in-situ fractures on the estimated mechanical properties determined from laboratory compression tests.

Finally, TCEQ staff evaluated historical reports contained in Attachment G of Appendix 3.4-1, documenting void percentages in disposed wastes on projects in which the applicant's consultants have had previous experience. These reports were submitted to provide support for an alternative procedure for disposing of uncontainerized waste in the FWF-NCDU. Their relevance to the FLAC computations will be discussed below.

Using realistic mathematical models of the stress-strain behavior of all the materials comprising the disposal unit components, the application presents FWF and CWF designs so that after excavation, operation, and closure, the geostatic stresses in the Dockum red bed materials will be nearly equal to the geostatic stresses present prior to excavation. One effect of this is that rebound on the bottom surfaces of the excavated disposal units is almost exactly equal to the subsequent settlement of these surfaces as the disposal units are filled and then covered. The application states that settlement at the ground surface is minimized. The application further states that this design feature helps maintain the current distance from the water table and prevents relative motions along fracture planes in the subsurface fracture system or generation of additional fracturing.

Also, while the FLAC simulations predicted deformations in the cover system components, the displacements at the ground surface due to these deformations do not result in any changes in sign in the slopes anywhere on that surface. Thus, the FLAC simulations predict that no ponding of surface water on that surface will occur; thus, the probability of elevated levels of water infiltration and the need for additional future maintenance of the cover to prevent that infiltration is low. Also, the FLAC code detected no failures due to slope instabilities during any of the described simulations. Finally, previous questions regarding FLAC implementation of plane stress elementary beam theory to simulate the mechanical behavior of the shotcrete linear under plane strain conditions were addressed in sufficient detail. The application also answered previous questions regarding the interpretation of several types of oscillations appearing in the numerical simulations. A detailed study indicated that these oscillations were not artifacts of numerical algorithms utilized in FLAC, but rather were an indication that the shear stresses at certain locations in the modeled shotcrete liner were exceeding the shear strength of the shotcrete. These considerations forced changes in the design of that liner, resulting in a reconfigured liner with maximum stresses below allowable limits.

Following review of the FLAC simulations, TCEQ staff determined that the reviewed computational results constitute a detailed study of the structural stability of the disposed waste and of the reduction of void space between the waste and its package within each canister.

The application describes simulations of the soil-structure interaction of the proposed disposal units due to an earthquake only after closure. The resultant changes in stresses, strains, and displacements in engineered components of the disposal unit based on the after-closure scenario in response to the earthquake appeared negligible. However, it is likely that the structurally stability of the backfill and canister stacks may be more vulnerable to compromise during a seismic event occurring during an operational phase. During such an event at the time of active operations, the lack of lateral confinement on an open canister stack face might lead to significant slippage between canisters accompanied by canister rotations and displacements. Thus, there is a concern regarding the protection of individuals during operations; such protection is required by the performance objective in 30 TAC §336.726. Therefore, a seismic analysis of such a scenario is needed. The Executive Director recommends a license conditions that requires the completion of appropriate seismic analyses demonstrating the structural stability of bulk and containerized waste during operational phases of the proposed disposal units. Further, the TCEQ has sufficient regulatory authority to require a licensee to perform additional studies, analyses, or to perform corrective action should a seismic event affect the facilities during operations.

Other proposed license conditions (see Sections 6.6, 6.7, and 6.8 of this EA) require that additional geotechnical and hydrogeologic verification and measurement be completed prior to construction. Analyses presented here regarding the FLAC simulations are contingent on the location of the subsurface water table and capillary fringe, and previously obtained geotechnical data. If the location of these hydrologic features or relevant geotechnical characteristics was to change significantly as a result of new information, so might TCEQ staff review and analysis regarding the structural stability of the disposed waste and backfill materials. The Executive Director recommends various license conditions to allow the Executive Director's observation, inspection and review of the geotechnical/hydrologic verification studies and measurements during excavation and construction, and the license provides that no waste may be disposed until the Executive Director has inspected the facility and has found it to be in conformance with the application and license.

2.3.7 Equivalency of Containment Barrier to Reinforced Concrete

Under the requirement of 30 TAC §336.730(b), "Wastes designated as containerized Class A, Class B, or Class C under §336.362(a) of this title or §336.702 of this title (relating to Definitions) shall be disposed of in the following manner: within a reinforced concrete container and within a reinforced concrete barrier, or within containment structures made of materials technologically equivalent or superior to reinforced concrete."

It is important to note that fiber reinforced shotcrete (FRS) is considered to be a type of reinforced concrete and sound shotcrete can have properties comparable to those of conventional reinforced concrete. On the other hand, it is clear that on a sufficiently resolved spatial scale FRS and conventional reinforced concrete have a different constitution. Consider two different FLAC simulations, one of a disposal unit with a containment barrier made of conventional reinforced concrete, one made with a containment barrier made of FRS. If both barriers were identically dimensioned, with identical compressive strengths, yield strengths, density, and moduli, the two FLAC simulations using even a high spatial resolution, would yield identical results. In other words, with FLAC, it is impractical to design and complete simulations, comparing conventional reinforced concrete and FRS, that account for their different micro-structures. While computer codes are available (i.e., discrete element codes) that can study the differences in material response due to differences in micro-structure, conventional design procedures for FRS do not attempt to account for such micro-structure. Therefore, the FLAC simulations in the application did not compare the response of a containment structure made of shotcrete to the response of a containment structure made of conventional reinforced concrete. Rather, the application has attempted to demonstrate that if a fiber reinforced shotcrete liner can be fabricated and constructed with the density and compressive and yield strengths stated, FLAC indicates that this liner will provide sufficient structural stability. Thus, as noted above, there is a necessity for a rigid adherence to the codes, standards, and procedures cited in the application as applicable to the shotcrete liner. Adherence to the codes, standards, and procedures is necessary in every aspect of facility design, construction, and operation.

Also, as noted above, the structural analysis in the application evaluated the concrete canisters with three increasingly detailed analyses: a rudimentary sizing based on elementary reinforced concrete design principles, a full SAP analysis, and an analysis of the canisters as components in an interacting system of components, using FLAC. The shotcrete liner was likely subjected to a similar rudimentary sizing analysis to include the shotcrete as a component in the FLAC simulations. However, a SAP analysis of the liner was not included in the application. While such an analysis may not be a necessary component in the design of the liner, the application makes no mention of why the SAP analysis was applied to one type of disposal unit component, but not another. Thus, the application proposes two different types of concrete that have been given different levels of analytical scrutiny.

The application provides attachments giving details of the strength and degradation of the concrete to be used in the concrete canisters but no similar details are given for the shotcrete. The application also does not address the question as to whether an elastomer coating should be applied to the shotcrete liner. In other words, demonstrations, other than FLAC simulations, of how FRS might be shown to be comparable to conventional reinforced concrete, were not included in the application.

2.3.8 Analyses of Structural Stability of the NCDU

TCEQ staff noted that no direct FLAC simulation of the structural stability of the uncontainerized waste in the FWF-NCDU was completed. The application argues that based on the computations simulating reduction in void ratio in the FWF-CDU, and based on the relative differences in the characteristic dimensions of the FWF-CDU and FWF-NCDU, that the computational results in the simulated CDU case could be assumed to apply also to the NCDU. If the void ratio in the emplaced of uncontainerized waste could be limited to the 0.15 value as assumed in the FWF-CDU simulations, then this assumption is reasonable. Reports included in Appendix 3.4-1, Attachment C of the application, documenting void ratios less than this value at other waste facilities, while supportive of the applicant's argument regarding the structural stability of the uncontainerized waste in the NCDU, cannot be considered conclusive. The justification presented in Appendix 3.4-1 regarding the FWF-NCDU depends on review of waste acceptance and emplacement procedures relevant to the uncontainerized or bulk waste that are presented in the application.

2.4 Disposal Unit Cover

Title 30 TAC §336.707(4) requires a description of the integrity and structural stability of the covers for the disposal units. In addition, 30 TAC §336.729(d) requires a demonstration that the covers accomplish the following:

- Minimize water infiltration;
- Direct percolating or surface water away from the disposed waste; and
- Resist degradation by surface geologic processes and biotic activity.

A description of the integrity and structural stability of the disposal unit covers is comprised of two aspects, a geo-mechanical analysis and a geo-hydrological analysis. The geo-mechanical aspect of the structural stability of the cover will be addressed in Section 2.3.6 of the EA. The geo-hydrological aspect of the cover design will be addressed in this section of the EA.

While the application has described the hydrological design features of the cover for the disposal units, there are remaining issues relating to the demonstration of the requirements in 30 TAC §336.729(d). A general description of the cover design is first presented below. Then, in order to consider the minimization of water infiltration, an analysis of the infiltration modeling described in the application is presented. This topic will also be relevant to the arguments concerning water management of Section 2.5.3 of the EA, and the Performance Assessment (PA) in Section 8.6 of the EA. Finally, issues and license conditions related to the cover design will be presented for each of the requirements of 30 TAC §336.729(d).

2.4.1 General Design of the Cover

The cover systems for the proposed CWF and FWF disposal units are an integral aspect of the long-term performance of these disposal units. Appendix 3.0-2 of the application includes a discussion of the disposal unit covers. For each unit the system is composed of three functional components, each of which contains several elements. The three components, listed from the top of the cover to the bottom, are an evapotranspiration cover (ET cover), a bio-barrier cover system, and a performance cover system.

The proposed ET cover will be comprised of the following elements:

- One-foot thick native conditioned layer seeded with xeric vegetation and surfaced with one-inch thick pea gravel mulch layer;
- Two-foot thick native fine material layer;
- Six-ounce per square yard geotextile fabric;
- One-foot thick sand filter material; and
- Six-ounce per square yard geotextile fabric.

The proposed bio-barrier cover contains:

- Three-foot thick bio-barrier (cobble) that drains to the Ogallala, Antlers, and Gatuña (OAG) Formations; and
- Red bed clay leveling fill (thickness varies).

The proposed performance cover consists of:

- Ten-ounce per square yard geotextile fabric;
- Two-foot thick lateral drainage layer that drains to the OAG;
- Geocomposite drain that drains to the OAG;
- Sixty-millimeter thick high density polyethylene (HDPE) geomembrane (FWF only);
- Three-foot thick low-permeability red bed clay performance cover;
- One-foot thick reinforced shotcrete layer;
- Red bed clay leveling fill (thickness varies); and
- Six-ounce per square yard geotextile fabric.

2.4.2 Infiltration Modeling

Before proceeding with the issues of the cover design, an overview of the infiltration modeling and its relation to the performance assessment will be introduced here. The infiltration modeling submitted in the application consists of simulations completed using the Hydrologic Evaluation of Landfill Performance (HELP) and the Variable Saturated Two-Dimensional Infiltration (VS2DI) computer programs. These simulations were reviewed to verify the amount of water infiltrating through the cover, determine its appropriateness for use in the performance dose modeling, and to estimate how infiltration might change over time. The calculated dose from the performance assessment provided in the application used an infiltration rate of approximately 1.0 millimeter per year. This section will summarize review the infiltration rate used in performance assessment and evaluate other factors that might further increase the infiltration rate.

Two computer software programs were used in modeling infiltration through the cover system, the HELP and the VS2DI models. HELP looks at one-dimensional flow through fully saturated materials, while VS2DI is a more realistic computer model incorporating two-dimensional flow through variably saturated porous media. These computer models were used in an almost complementary fashion with results from HELP being used as inputs into VS2DI. Conversely, the results from VS2DI were depicted as confirming the HELP results.

HELP is a quasi two-dimensional hydrologic model that uses water balance analyses in computing infiltration through various layers in and around landfills. Model inputs include climatologic data, soil characteristics, and the design parameters of the different layers. While the climatologic data suffices for modeling today's climate, discussion in Section 6.2 of the EA indicates that future climatology was not completely adopted in the infiltration models. There are similar concerns regarding the surficial soil characteristic inputs. However, both of these concerns will be discussed in Section 2.5.3 of the EA, which deals with water management in the future, i.e. after disposal. This section speaks to the design elements of the cover and its relation to water infiltration. An important factor in the design of the cover is the hydraulic conductivities of the layers.

Hydraulic conductivities can be modified to meet certain restrictive goals, i.e. reducing the movement of water. The modifications proposed to be implemented at the site included compaction of these materials and the selection of materials with desirable characteristics from nearby sources to be used in the cover. It was implicitly stated that values given for the hydraulic conductivities in the ET and bio-barrier covers come from literature values. Values for hydraulic conductivities in the performance cover were estimated from laboratory tests on thirty-three soil samples obtained during previous construction of the cover for a Resource Conservation and Recovery Act (RCRA) disposal landfill adjacent to the proposed site. The geometric mean of the conductivities of these samples was used to characterize them in the application. By using the geometric mean, the variability or spatial distribution of these conductivities was not accounted for. Of the thirty-three samples, twenty-five of these were obtained from the RCRA liner while the remaining eight were gathered from the cover. The application does not explain whether the twenty-five samples taken from the liner would represent hydraulic conductivities expected in a cover of the proposed disposal units.

Given these inputs, HELP simulations performed in the application indicate a 1.0 millimeter per year infiltration rate under current conditions. TCEQ staff performed sensitivity analyses to study the effects of varying hydraulic conductivities in the HELP simulations. This analysis looked at how slight variations in the parameters resulted in increased infiltration amounts. Outcomes from this analysis found that the hydraulic conductivities of the two lowest layers (layers 7 and 8) of the cover were most sensitive to variations of one order of magnitude.

A conservative value for infiltration rate of 3.4 millimeters per year was estimated independently based on the information provided in the application. TCEQ staff determined the probability of whether the hydraulic conductivities could vary by an order of magnitude. To that end, statistical analyses were performed on the eight samples submitted in the application. These samples were taken from a layer in the existing RCRA disposal unit cover. The application states that these samples were assumed to mimic the hydraulic conductivities of layer 7 in the proposed cover. In computing a representative hydraulic conductivity, the application states that a log-normal distribution of the hydraulic conductivities was assumed, as is common practice. However, the application then described calculation of the geometric mean of the samples, a statistic that is known to be biased low for a log-normal distribution. To be more conservative, verification performed by TCEQ staff used a mean variance unbiased estimator of the mean and a 90th percentile upper confidence limit of the mean in choosing a representative mean of the distribution. Both of these estimators produced higher hydraulic conductivities than the geometric mean, but still lower than two of the largest sample values. When these estimators for hydraulic conductivities were inserted into HELP, infiltration rates of 1.6 millimeters per year and 3.0 millimeters per year were obtained. Taking into account the impact of layer 8 of the proposed cover design, the hydraulic conductivity of layer 8 was doubled. The 90th percentile of the upper confidence interval of the mean for the hydraulic conductivities of layer 7 resulted in an estimated infiltration rate of 3.4 millimeters per year.

To validate results of a more conservative infiltration rate, Monte Carlo simulations were performed of the HELP model. This was accomplished by assuming that the hydraulic conductivities of layers 7 and 8 of the proposed disposal unit cover follow a log-normal distribution. Since these two layers have different hydraulic conductivity values, two different log-normal distributions were simulated, each with a mean at the layer's respective hydraulic conductivity value. Then, forty-five pairs of realizations from these log-normal distributions were input into their respective hydraulic conductivities in HELP to arrive at forty-five infiltration rates. The 95th percentile of these infiltration rates was calculated to be 2.6 millimeters per year.

VS2DI simulates two-dimensional flow through variably saturated media. A model domain is incorporated by the user representing a cross-section of the proposed facility. Hydraulic properties, such as hydraulic conductivities and van Genuchten parameters, were input along with initial and boundary conditions along the model domain. VS2DI then implements a finite difference code to solve Richard's equations for fluid flow. Like HELP, VS2DI used the same hydraulic conductivities, but unlike HELP, the VS2DI model presented in the application did not model soil-atmosphere interactions. Therefore, the VS2DI model presented in the application used water infiltration results from the HELP program. Specifically, the model domain in VS2DI did not include the ET and bio-barrier cover. Instead, VS2DI used the water infiltrating through these layers estimated by HELP as input to the initial and boundary conditions in VS2DI. Then the results from VS2DI provided in the application were compared to those of HELP.

It is also noted that a seepage face was used as the lower boundary condition in the VS2DI simulations provided in the application. This boundary condition does not appear to correspond to the boundary condition at the bottom of the cover system. A seepage face boundary condition would, for example, correspond to the interface between a fine-grained soil layer and a capillary break. As described by Scanlon et al. (Scanlon, 2002), a seepage face boundary results in an increase in water storage in the overlying soil and a decrease in the percolation rate. From a modeling standpoint, this has the effect of decreasing the amount of water leaving the cover and going into the disposed waste. A more appropriate lower boundary condition may be the unit gradient condition. (HELP assumes a unit gradient lower boundary condition). VS2DI does not include the unit gradient option for the lower boundary. Because of this limitation, only moderate consideration was given to VS2DI simulations. The Executive Director recommends a license condition to require the determination and sensitivity analyses of the lower boundary conditions used in the infiltration modeling to evaluate the effect of the lower boundary condition on percolation of water through the proposed cover system.

Long-term prediction of water infiltration into the disposed waste was performed by both of the models. However, instead of carrying out the computation to look at infiltration until peak dose is reached, the application incorporated different scenarios. These scenarios included a base case scenario, a scenario increasing the precipitation to 29 inches per year in anticipation of future climate change, decreasing the hydraulic conductivities of the clay layers to account for their degradation, a combination of the two, erosion of the ET layer, and preventing lateral drainage. Decreasing the hydraulic conductivities of the clay layers and increasing the precipitation to 29 inches per year resulted in the worst case scenario with an infiltration rate of eight millimeters per year. This rate was used in the performance assessment under future conditions.

2.4.3 Water Infiltration Assessment

Title 30 TAC §336.729(d) requires that the cover shall be designed to minimize water infiltration. The proposed cover implements three mechanisms designed to meet this requirement: evapotranspiration (ET), lateral drainage, and a series of low-permeability clay layers. The first mechanism employed is ET, which occurs in the proposed ET cover. The proposed ET cover is made up of three layers: a one-foot layer of native materials seeded with xeric vegetation, a two-foot layer of native fine material, and a one-foot layer of sand filter material contained by geotextile fabric. The application states that the purpose of these layers is to return any precipitation falling on the cover to the atmosphere via evaporation or transpiration. Hydraulic conductivities presented in the application and used in modeling the water infiltration through these layers are 1.2×10^{-4}, 1.5×10^{-6}, and 5.8×10^{-3} centimeters per second, respectively. These values were used for modeling presented in the application for both the FWF and the CWF and did not change for any of the long-term scenarios.

The application proposes the use of native fine materials in the evapotranspiration (ET) cover. The native fine material is assumed to be of a clayey nature. However, the use of clays in the cover can lead to desiccation if not constructed properly. Such desiccation may lead to an increase in crack width and/or the number of cracks in the ET cover. This, in turn, can lead to more water infiltration, rather than a minimization of water infiltration. Furthermore, for transpiration to be effective for plants on the cover, a more coarse material is required in order to allow easier access of water to roots. A more coarse material will also facilitate root growth while minimizing damage to the cover caused by root growth. The Executive Director recommends a license condition requiring additional thickness of the ET cover in order to support vegetation and reduce potential for erosion.

Regarding the modeling of the evapotranspiration layer, there are issues concerning the extent to which evaporation will occur during periods of lower temperature, lower humidity, and higher precipitation. Another concern is that the degradation of the fine native materials in the long-term in the ET layer is not addressed in the infiltration modeling presented in the application. Finally, the hydraulic conductivity of native fine material layer is 1.5×10^{-6} centimeter per second, a value that is more than one order of magnitude lower than the HELP model default value for this soil type of 2.5×10^{-5} centimeter per second and is lower than generally anticipated for soil placed to 85 percent of the Standard Proctor density, the specified minimum density for this layer. If the hydraulic conductivity of the native fine layer material was increased from 1.5×10^{-6} centimeters per second to the HELP model default value of 2.5×10^{-5} centimeter per second, the upper boundary flux used in the VS2DI would increase by a factor of 4.3 for the base case precipitation scenario and 1.7 for the increased precipitation scenario. The Executive Director recommends a license provision to verify site conditions that represent input parameters used in the HELP modeling and to provide sensitivity analysis on all relevant parameters, including thickness and hydraulic conductivities of the cover layers.

The second mechanism explained in the application to minimize water infiltration through the cover is lateral drainage. A lateral drainage layer is placed in between two low-permeability layers and acts as a moisture barrier conveying moisture to edge of the proposed disposal facility. The hydraulic conductivity utilized in modeling presented in the application for infiltration through this layer is 1.0×10^{-2} centimeters per second. In modeling this layer into the future, the hydraulic conductivity was lowered to 1.0×10^{-3} centimeters per second to account for future degradation as presented in the application. This had the effect of reducing any movement to the edge of the proposed disposal facility. While this increased the amount of infiltration, the net result was less than the higher infiltration scenario which included higher hydraulic conductivity of the clay layer and more precipitation available for infiltration. Additionally, degradation of the lateral drainage layer over the long-term should be considered in infiltration scenarios. The Executive Director recommends that the license provision for verification of site conditions that represent input parameters used in the HELP modeling also require the combination of scenarios to represent a conservative infiltration scenario

The application states that the final cover mechanism designed to minimize water infiltration is a series of low-permeability clay layers used to slow the movement of water in the performance cover. These clay layers comprise approximately three-fourths of the cover volume and are considered critical components in the proposed disposal unit cover. Hydraulic conductivities used in modeling the infiltration through these layers are 1.0×10^{-6} centimeters per second for "non-select" clay and 4.0×10^{-9} centimeters per second for "select" clay as presented in the application. To establish these values, the clays were partitioned into select and non-select categories based on the clay fraction. The higher the clay fraction, the less conductive a layer would be. These hydraulic conductivities were used for both the FWF and the CWF modeling provided in the application. To approximate the degradation of the select clay components in time, a hydraulic conductivity of 2.4×10^{-8} centimeters per second was used in the application.

If the low permeability clay layers are to resist desiccation and maintain a relatively low hydraulic conductivity, then there is a need for the clay barriers to be covered by a geomembrane and a sufficiently thick soil layer (Bonaparte, R., Daniel, D.E., and Koerner, R.M., 2002). Furthermore, because the cover systems for the CWF and FWF will be constructed incrementally, as depicted in Figures 4.1 to 4.17 of Section 4.2.6 of the application, leaving the compacted clay components of the cover systems exposed to environment for some time, measures should be implemented to reduce the potential for desiccation of the red bed clay in the performance cover. The red bed clay in the performance cover of the CWF may be especially vulnerable to desiccation as it will not be protected with an overlying geomembrane. White HDPE geomembranes, rather than black HDPE geomembranes, are preferable for placement over compacted clay barriers constructed in dry, hot climates. The white geomembranes will reduce temperatures and thus reduce problems with clay desiccation (Bowders, J.J., Daniel, D.E., Wellington, J., and Houssidas, V., 1997). A license condition pertaining to increasing the thickness of the layer above the low permeability clays is recommended.

2.4.4 Directing Water Away from the Disposed Waste

Title 30 TAC §336.729(d) requires that the cover shall be designed to direct percolating or surface water away from the disposed waste. A concern with the proposed cover design is that the lateral drainage layer in the performance cover is connected to the OAG formation. As discussed above, this drainage layer has a high hydraulic conductivity, and therefore, can drain infiltrating water away from the site. Conversely, the high hydraulic conductivity may create a path toward the disposed waste for rising water in the OAG. Given future higher water levels as a possibility in the OAG formation, as discussed in Section 6 of this report, there exists a chance that these higher water levels may encroach upon and/or into this drainage layer and over or through the disposal units. The site hydrogeologic conceptual model presented in the application indicates the potential of saturated conditions in the OAG materials in lateral contact with lower layers of the proposed cover materials. There is a possibility that OAG water might contribute to the overall water flux through the cover system. This increased flux could contribute to increases in peak doses computed by RESRAD which has been used for performance assessment in the application. The application has not addressed the possible hydrologic interaction between potentially saturated OAG materials and the cover materials in the proposed disposal units. The Executive Director recommends a license condition to demonstrate that groundwater flow from the OAG formation to the lateral drainage layer of the final cover will not affect the performance of the land disposal facilities.

2.4.5 Degradation by Surface Geologic Processes

Title 30 TAC §336.729(d) requires that the cover shall be designed to resist degradation by surface geological processes. The application describes two approaches for meeting this requirement. The first approach implements a design-oriented method in resisting surface geological processes. The second approach makes use of computer modeling in determining whether erosion will affect the site in the long-term.

Section 6, page 6-9 of the application states that erosion protection over the cover was calculated using the shear stress (tractive force) methods as prescribed in NUREG-1623, Design of Erosion Protection for Long-term Stabilization. This calculation is provided in Appendix 3.0-3.14 and addresses the requirement for the top layer of the final cover to minimize long-term water erosion. However, Appendix 3.0-3.14 is not included in the latest revision of the application. It is assumed that the proposed one-inch pea gravel replaced the previous design of a larger gravel size despite the lack of calculations determining its protection using the Shear Stress Method. Use of the Shear Stress Methods with a Probable Maximum Flood design basis and a rock durability score greater than 85 is important in reducing the possibility of localized erosion such as from gullying, minor channeling, or rilling. The Executive Director recommends a license condition requiring the submission of the calculations used to demonstrate erosion protection of the cover and implementation of a design for erosion protection using NUREG-1623 as a guide.

The application presents two computational methodologies to predict erosion at the site. Appendix 3.0-3.18 of the application uses the Universal Soil Loss Equation (USLE) in determining the average yearly erosion rate from wind and water. The application discusses the SWAT (Soil and Water Assessment Tool) computer program in Appendix 3.0-3.29 to estimate the yearly erosion at the site, and states that this verifies the results from the USLE.

Appendix 3.0-3.18 of the application provides calculations used to determine long-term soil loss from water and wind erosion using the USLE. Parameters used in this equation consist of a maximum slope at the site and its length, as well as factors, such as rainfall energy erosive factors, soil erodibility factors, vegetative cover and management factors, and conservation support factors. These factors depend on the location of the site, the classification of the soil, percent organic matter, and management of vegetation at the site. Results from this equation indicate a combined erosion rate from water and wind of 6.37×10^{-5} feet per year. It must be stated that limitations of the USLE include that its development applies mostly for agricultural purposes and that future climatological conditions are not accounted for. To address the limitation of the USLE, certain factors were varied in the equation, which resulted in a combined erosion rate from water and wind of 1.27×10^{-4} feet per year (roughly twice the base case). This analysis may not account for variation in future weather patterns or eventual degradation of the soil.

Appendix 3.0-3.29 describes the use of SWAT to model erosional processes at the site. SWAT uses a water balance technique to simulate the hydrologic cycle. This in turn can be used to estimate run-off volume and a peak run-off rate, which can be then used to calculate the run-off erosive energy variable. This flow of water and sediment between thirteen sub-basins was simulated for the 50,000 year period of analysis. These sub-basins were hydrologically connected in the modeling presented in the application, according to site specific topography (e.g., slope, elevation) and other characteristics, and each assigned geotechnical properties and other required inputs either from available data or from the literature. One of the sub-basins was identified with the FWF, another with the CWF. The total area of the modeled region presented in the application was 1.5

square kilometers. Climatological inputs were determined from a computerized weather generator capable of supplying daily wind speeds, precipitation levels, and solar radiation levels to the SWAT simulation. The SWAT computations utilized historical data from Hobbs, New Mexico in order to simulate the continuation of current erosional processes during the period of analysis. The computations also utilized climatological historical data from Wichita, Kansas to simulate erosional processes at the site due to predicted future climatic conditions throughout the period of analysis. The results indicate that the FWF and CWF have similar erosion rates of 7.1 x 10^{-6} feet per year and 3.28 x 10^{-5} feet per year for the current and the future climate conditions, respectively.

Predictive erosion modeling provided in the application is not based on erosion measured at the site. Erosion monitoring began in late 2006 and a license condition on erosion measurements on the site requires further installation and measurement of site-specific erosion. It should be noted that sufficient long-term data on erosion monitoring is necessary to confirm an erosion rate. Site data on erosion is not yet available to provide a measured erosion rate in the vicinity of the proposed disposal units. Additionally, erosion may develop outside the site boundaries and encroach upon the facility footprint at some point in the future. More discussion on SWAT application related to the performance assessment is given in Section 8 of the EA.

The table below shows the different erosion rates stated in the application. The rates are ordered from greatest to least and include the rate used in the performance assessment dose modeling presented in the application.

Table EA-2: Calculated Erosion Rates in the Application

Calculated Erosion Rate	Model Case
1.27 x 10^{-4} feet per year	Upper bound on current conditions - USLE
6.37 x 10^{-5} feet per year	Lower bound on current conditions - USLE
1.20 x 10^{-5} feet per year	Performance Assessment input value
3.28 x 10^{-5} feet per year	Wichita, Kansas conditions - SWAT
7.10 x 10^{-6} feet per year	Hobbs, New Mexico conditions - SWAT

This table shows an upper bound erosion rate that is 17 times the lowest erosion rate. Comparing the upper bound USLE with the performance assessment input indicates that a case where the erosion rate is three times that used in performance assessment is plausible. And, because future climate conditions and the other general concerns were not taken into account for this case, an even higher erosion rate could be considered. The Executive Director recommends a license condition that requires additional soil samples and sensitivity of erosion modeling, as well as development of a more flexible and sophisticated model.

2.4.6 Disposal Unit Cover Inconsistencies

Technical review of the cover design submitted in the application also indicated inconsistencies between several of the submissions related to design as follows: the engineering drawings found in Appendix 3.0-2, Sheets C1.19 and C2.44; Section 3.0 of the application; the engineering report in Appendix 3.0-1; the technical specifications found in Appendix 4.2.3, Specifications 31 05 19.13, 31 05 19.16, 31 24 00, 31 80 00, and 33 46 16.16; and the Construction Quality Assurance and Quality Control Plan (CQA/QC Plan) found in Appendix 4.2.3, Attachment A. Table EA-3 below consists of several examples. The Executive Director recommends a license condition to require that final engineering designs, specifications and calculations be submitted prior to commencement of major construction to address these issues.

Table EA-3: Application Information on Disposal Unit Cover Design

Layer	**Engineering Drawings**	**Section 3: Design or Engineering Report**	**Technical Specifications**	**CQA/QC Plan**
Native Fine Material Layer		Similar to existing and adjacent site soils (Section 3), compact to 85 percent of Standard Proctor density	Requirements for this layer are not included in the technical specifications	Requirements for this layer are not included in the CQA/QC Plan
Geotextile Fabric	6 and 10 oz/yd^2 geotextiles are shown		Requirements are presented for 8 and 16 oz/yd^2 geotextiles, but not the specified 6 and 10 oz/yd^2 geotextiles	
Bio-barrier		4 to 12-inch diameter cobbles	6 to 12 inch cobbles	
Lateral Drainage Layer		Minimum hydraulic conductivity = 1×10^{-4} cm/s; minimum specific gravity = 2.65	Minimum hydraulic conductivity = 1×10^{-1} cm/s; minimum specific gravity = 2.5	
Geocomposite Drain		10 oz/yd^2 weight of geotextile component of geocomposite in cover in Section 3	No specification for weight (oz/yd^2) of geotextile component of geocomposite in cover	

Layer	Engineering Drawings	Section 3: Design or Engineering Report	Technical Specifications	CQA/QC Plan
Geocomposite Drain			Test methods: carbon black (ASTM D 4218) and tensile properties (ASTM D 5035)	Test methods: carbon black (ASTM D 1248) and tensile properties (ASTM D 638/6693)
HDPE Geomembrane (60 mil)	60 mil geomembrane is shown		Requirements are presented for 80 mil geomembrane but not the specified 60 mil geomembrane	
HDPE Geomembrane (60 mil)			Peel strength ≥ 104 ppi	Peel strength ≥ 90 ppi (fusion) and 78 (extrusion)
Red Bed Clay Performance Cover		Maximum hydraulic conductivity of 4×10^{-9} cm/s in Section 3	Maximum hydraulic conductivity is not specified	Maximum hydraulic conductivity of 4×10^{-9} cm/s
Red Bed Clay Performance Cover		Compact to 95 percent of Standard Proctor density at optimum moisture content	Compact to 95 percent of Standard Proctor density at -4 to +1 percentage points of optimum moisture content	Compact based on test pad results, which require a Heavy Standard Proctor effort (Attachment 5-6)

References Section 2.4: Disposal Unit Cover

Bonaparte, R., Daniel, D.E., and Koerner, R.M. (2002). "*Assessment and Recommendations for Optimal Performance of Waste Containment Systems*," U.S. Environmental Protection Agency, National Risk Management Research Laboratory, Cincinnati, OH, EPA/600/R-02/099.

Bowders, J.J., Daniel, D.E., Wellington, J., and Houssidas, V. (1997). "Managing Desiccation Cracking in Compacted Clay Liners Beneath Geomembranes," *Geosynthetics '97 Conference Proceedings*, IFAI, Vol. 7, pp.527-540.

Scanlon, B. R., Christman, M., Reedy, R. C., Porro, I., Simunek, J., and Flerchinger, G. N., 2002, Intercode comparisons for simulating water balance of surficial sediments in semiarid regions: Water Resources Research, v. 38, p. 1323–1339.

2.5 Management of Water

Title 30 TAC §336.707(4) and (5) require the applicant to describe various natural and design features relating to the management of water. In addition, 30 TAC §336.729(e) and (f) require that the applicant demonstrate the following:

- Surface features direct surface water drainage away from the disposal units at velocities and gradients which will not result in erosion;
- The disposal site is designed to minimize the contact of water with waste during storage;
- The disposal site is designed to minimize the contact of standing water with waste during disposal; and
- The disposal site is designed to minimize the contact of percolating or standing water with wastes after disposal.

TCEQ staff reviewed relevant application materials to determine if satisfaction of each of these requirements has been demonstrated. Appendix 3.0-3 of the application describes the various natural and design features relating to the management of water at the proposed facility. An overall description of the surface water drainage is presented below followed by a discussion of the issues pertaining to each of the requirements.

2.5.1 Surface Water Drainage and the Disposal Units

A description of the surface water drainage at the disposal facility is presented in Volume 21, Appendix 3.0-3.1 of the application. This sub-section of the EA presents a discussion of the drainage upstream of the disposal units, followed by an overview of the drainage inside the units, and then, a discussion of the drainage outside the disposal units. An important consideration is whether or not surface features will direct surface water drainage away from the disposal units at velocities and gradients which will not result in erosion, as required in 30 TAC §336.729(e).

The application states that the drainage area upstream of the proposed facility is divided into three sub-basins, denoted Area 1, Area 2, and Area 3. These areas drain in parallel to the FWF and CWF disposal units. Area 1 consists of the western portion of the off-site run-off, Area 2 contains the central part of the off-site run-off, and Area 3 accounts for the eastern portion of the off-site run-off. Run-off from these areas is collected on the upstream (northern) boundaries of the disposal site by ditches and berms. Storm run-off from Area 1 contributes to run-off for Area 2, and run-off from Area 2 supplies run-off to Area 3. The ditches and berms were sized to account for the 100-year, 24-hour Precipitation Event with the amount of run-off for each area being calculated through the Rational Method.

The Rational Method may be used to predict the peak run-off for small areas from the formula $Q=CIA$, where C is the unitless run-off coefficient number, I is the intensity in inches per hour, and A is the area is acres. The coefficient number, C, accounts for the fraction of impervious ground cover in a unit area of land and may vary from about 0.30 for undeveloped land, to 1.00 for concrete. Lower values of C indicate higher infiltration, but less water run-off. A C value of 0.41 was used for each of the three sub-basins. The parameter *I* indicates the intensity of the rainfall and is based on the Intensity-Duration-Frequency (IDF) curves. The curves used in the application were determined from an application of a Texas Department of Transportation formula:

$$I = \frac{b}{(t_c + d)^e} \qquad (2.5.1\text{-}1)$$

The values for *b*, *d*, and *e* in equation 2.5.1-1 are 92, 9.8 and 0.804, respectively, and depend on the location of the rainfall event (i.e. Andrews County). The time of concentration, t_c, is most often defined as the time required for a particle of water to travel from the most hydrologically remote point in the watershed to the point of collection. There are several methods available for calculating this quantity. The application uses the Kirpich formula for this calculation. It is apparent from the formula given above that increases in the time of concentration, t_c, will result in a decrease in the rainfall intensity, *I*, used. The problem, then, is to determine a time long enough for maximum run-off to occur, yet short enough to establish a conservative estimate of the intensity. The times of concentration used in the application range from seven minutes to 20 minutes. The resulting intensities range from 5.9 to 9.4 inches per hour. The values for these parameters appear reasonable. Finally, Areas 1, 2, and 3 have areas of 15 acres, 13 acres, and 28 acres, respectively. From these intensities, areas, and run-off coefficients, peak run-off flows of 60, 40, and 99 cubic feet per second were calculated for Areas 1, 2, and 3, respectively.

Stormwater ditches and berms were then sized to convey this computed run-off around the facility to the dry creek bed to the south. However, there are several issues with the calculation of the surface water drainage ditches.

First, calculations used to determine the size of downstream ditches do not include upstream run-off from Area 1. As a consequence, the ditches may not have enough freeboard, and calculations for permissible shear stresses due to weight of water on the linings of the ditches may be underestimated. Such underestimation may result in the incorrect determination of permissible velocities for scour at bends in the ditches.

Secondly, the proposal to solely use berms for Area 1, and for a small area that drains to the Compact Waste Facility (CWF), may not minimize infiltration of water into disposed waste. A properly designed ditch can be used to control and divert off-site stormwater in an effective and expedient manner. Whereas, an ineffective use of a ditch could allow more time for water to pond behind the berm and infiltrate into the subsurface into the waste matrix. The Executive Director recommends a license condition that requires the design of a diversion ditch to include run-off from Area 1 and the Compact Waste Disposal Facility, that provides sufficient freeboard, and that uses riprap gravel to provide sufficient protection from scour.

The application states that drainage within the disposal unit is controlled with two design features. One feature accounts for storm run-off upstream of ledges located halfway up the disposal units. The other feature accounts for precipitation between these ledges and the bottom of the disposal unit. The feature for managing precipitation at the bottom of the disposal unit will be discussed below. The reason for the partitioning of the stormwater at this location was to separate the clean water from the contaminated water.

Section 3.6.1.2 of the application states that a ledge located just above the waste of each disposal unit will be used to collect stormwater from the areas between the surface and these ledges. This collected water will then be pumped to the surface and discharged into an unlined surface ditch. Calculation of the amount of stormwater that may be collected in the ledge is located in Appendix 3.0-3.19 of the application and was performed by multiplying the height of water during a 100-year, 24-hour Precipitation Event (6.1 inches) by the surface area between the ledge and the surface. A ditch within the ledge was sized to accommodate this volume of precipitation.

There are two issues with ditches on the ledge. First, there are four ledges in each of the disposal units. However, not every ledge contains the sized stormwater ditch. Because a ditch is not on every ledge, clean water may encroach into the disposal unit. The second issue is that there is a potential for water on the ledge to become contaminated due to airborne dispersion and waste handling activities on and near the ledge. The Executive Director recommends a license condition to require ledge ditches on all sides of the disposal unit that are sized to account for the 100-year, 24-hour Precipitation Event.

A description of the surface water drainage outside the disposal unit is addressed in Appendix 2.4.1 of the application. This appendix partitions the drainage area into nine sub-basins. These sub-basins cover the site from the northern playa upstream of the proposed facility to the point where stormwater discharge leaves the site to the southwest. A more detailed description of the site characteristics of the surface hydrology is discussed in Section 6.7 of the EA.

The sub-basin containing the proposed buildings and existing RCRA disposal unit were not characterized in Appendix 2.4.1. The application assumes that stormwater falling on this sub-basin is allowed to drain to the natural stream via sheet flow. However, the inclusion of staging and decontamination buildings in this sub-basin will increase the amount of impervious cover at the site. More impervious cover leads to concentrated flows and an increased amount of stormwater run-off. This could potentially increase erosion. No controls were discussed in the application to divert or convey stormwater run-off from the buildings and any discharge from the RCRA facility to natural stream drainage. The potential run-off from all sources (the buildings, the ditches, and the existing RCRA disposal unit) will necessitate the development of a sedimentation pond to control run-off and erosion.

Looking at the above issues together, an integrated stormwater management plan throughout the entire site is recommended. This plan should include appropriately sized stormwater ditches for every portion of the site that has been altered. Thus, a proposed license condition requires the development of a stormwater management plan and a sedimentation pond. This sedimentation pond could also be used as a sampling location for the detection of contamination of surface water.

2.5.2 Minimization of Water Contact with Waste

Title 30 TAC §336.729(f) states that the disposal site must be designed to minimize the contact of water with waste during storage and during disposal. Thus, the rule necessitates the same requirement for both staging and disposal activities. In this context, disposal occurs in the disposal unit and receipt and staging of waste occurs everywhere else. The application describes procedures and design features within the staging and decontamination buildings to reduce water contact with waste. However, as discussed above, the possibility exists of water contamination in areas outside of disposal area.

Contamination may occur in the ledges within the disposal unit during an unexpected meteorological event. This contaminated water, if not sampled, would then be discharged in the stormwater ditches north of the disposal units. Another scenario is that contaminated bulk soil will be dispersed due to wind during transport for disposal and subsequently be transported as suspended sediment in flow downstream to the dry creek. This possibility further reinforces the need for an integrated stormwater plan. Furthermore, 30 TAC §307.4(c) states that radioactive materials shall not be discharged in excess of the amount regulated by Chapter 336 of this title (relating to Radioactive Substance Rules). Thus, all run-off within the site should be managed and sampled in accordance with the radionuclide concentration limits stated in 30 TAC §336.359, Appendix B, Table II, Effluent Concentration Limits.

Title 30 TAC §336.729(f) states that the disposal site must be designed to minimize the contact of standing water with waste during disposal. The ability of the proposed design to meet this requirement is a function of the leachate collection system. Appendix 3.0-3.22 of the application discusses the leachate collection systems of the proposed disposal units. Each leachate collection system contains a six-inch PVC pipe placed in a sloped, gravel bed beneath the waste in each disposal unit. Water falling in the disposal unit during disposal will percolate to the gravel bed and then drain into the perforated pipe and then, into a sump. Pumps will then convey the wastewater up to the ledge above the disposed waste into a truck for transport to the leachate collection tanks.

TCEQ staff has reviewed this appendix and its related components and has two general concerns. First, it appears that due to the slope of the cell floor, leachate traveling along the floor would flow at an angle that is not perpendicular to the leachate pipe, as assumed in the appendix. The consequence being that some sections of pipe would not receive any of the flow, while other sections of pipe would receive more than that was designed. While this may or may not lead to the pipe being full, it would certainly increase the hydraulic head in the pipe. This violates the initial boundary conditions necessary for the application of Giroud's equation in calculating the leachate mounding in the leachate collection layer.

Secondly, Appendix 3.0-3.22 of the application indicates that a design basis used for the leachate collection system was the five-year, seven-day storm. While this design basis is consistent with that in RCRA, it is in conflict with statements in the application. Section 3 of the application states that a 100-year, 24-hour precipitation event will be used for the design basis of features used during operations. This design basis was determined by the 30 percent chance of the 100-year precipitation event being equaled or exceeded during the 35-year operating life of the facility. The leachate collection system qualifies as a design feature used during operations, and given that some section of the leachate collection system (including the sidewall) will be open to the environment during the 35-year operating life, it is good engineering practice to design this feature for the 100-year, 24-hour precipitation event. The Executive Director recommends a license condition to assess the design of the leachate collection system using the 100-year, 24-hour storm as the design basis and evaluate potential rise in hydraulic head to calculate mounding.

2.5.3 Minimization of Standing or Percolating Water after Disposal

Section 2.3.6 of the EA describes computations provided in the application that predict there will be no ponding of water on the disposal unit covers due to settlement and seismic excitation. However, other external factors not investigated in the application may affect whether standing or percolating water will be present at the site. Appendices 3.6-2 and 8.0-8 of the application present the evaluation of the cover system water balance using the HELP and VS2DI computer models. Two important external factors of the cover dealing with the climatology and the characteristics of the native vegetation after disposal will be discussed here.

The application indicates that climate change over the next 25,000 years might double the precipitation in the Andrews County area to that of Wichita, Kansas, today. In conjunction with this increased precipitation of 29.4 inches, the future climate study provided in the application indicates that temperatures would be lower. These factors would likely decrease the amount of evaporation from the current estimate given in the application. However, the infiltration models in the application do not account for these decreases in temperature and evaporation.

HELP input values were reviewed to assess the appropriateness of the soil characteristic parameters for the FWF and CWF disposal unit cover systems at the Andrews, Texas site. Several input parameters used in the HELP model simulations do not appear to be conservative with respect to the design of the cover system. Hydraulic conductivities were already mentioned in Section 2.4.3 of the EA. However, the maximum leaf area index is another important factor that plays a role in the transpiration of water from the upper layers of the cover. The maximum leaf area index is the one-sided leaf area per unit ground area. The maximum leaf area index was given a value of 2.0, which may be high considering the condition of the vegetation on the existing cover system or may be high or low given the future climate change.

To evaluate the effect of leaf area index and hydraulic conductivity on calculated percolation, TCEQ staff performed a sensitivity analysis and obtained the following result: if the hydraulic conductivity of the native fine layer material was increased to 2.5×10^{-5} centimeters per second (as discussed in Section 2.4.3 of the EA) and the leaf area index was decreased from 2.0 to 1.0, the upper boundary flux used in the VS2DI would increase by a factor of 4.8 for the base case precipitation. Regardless of the values input into HELP or VS2DI, there was no sensitivity analysis provided in the application. A license condition requires the verification of the infiltration modeling to account for the sensitivity of these parameters.

Finally, an important consideration when assessing the application's characterization of the engineered components of the proposed facility, as reviewed in this Section of the EA, are the ramifications of a license condition pertaining to a relocation of the boundaries of the proposed disposal units. This relocation requires the reconfiguration of the proposed units to maintain a sufficient depth to groundwater as required by 30 TAC §336.728(f). Any of the engineering design features and dimensions conditioning the analyses based on license conditions must be further reconciled with the relocated and reconfigured disposal units. The Executive Director has included license conditions that require submission of revised final engineering, design, drawings, specifications and calculations prior to commencement of major construction.

2.6 Design Considerations for Natural Events

Title 30 TAC §336.707(2) requires that the application describe the design basis for natural events at the facility and its relationship to the design criteria. Sections 3.7.1 and 3.2.1 of the application address this requirement. Included in Section 3.2.1 of the application is a table relating the various design requirements in 30 TAC Chapter 336 to a specific criteria by which a design basis was described. The application made use of four design bases under different natural events.

The first design basis presented in the application was the 100-year, 24-hour precipitation event. This accounted for active water management systems during operations and shall apply to controls for the collection, transfer, and storage of water at the site. Surface water controls were also sized for this design basis. The second natural event presented in the application was the Probable Maximum Precipitation Event. This design basis was used to determine long-term performance of the facility relating to the design of the cover. The third natural event presented in the application was the use of International Building Code (IBC) Wind and Snow Loads to design surface structures. This included a 90-mile per-hour wind load and a 20-pound snow load.

Finally, earthquakes were considered in the design basis for surface and sub-surface structures. Surface structures were designed for IBC Seismic Zone B or C. Sub-surface structures were analyzed using probabilistic seismic analyses and two-dimensional soil-structure interaction simulations utilizing design earthquakes developed from those analyses. The analysis of these site seismic response computations are described in Section 2.3 of the EA. Title 30 TAC §336.729(g) states that the design of the land disposal facility should incorporate safeguards, to the extent practicable, against hazards resulting from local meteorological conditions and geological phenomena.

2.7 Construction Codes and Standards

Title 30 TAC §336.707(3) requires that the application describe codes and standards relating to the design and construction of the land disposal facility. Section 3.2 of the application describes the extent of applicability of the standards in the design and construction of the facility and references Appendix 3.2, which contains a table of the codes and standards used in the application.

Table 3.2-1 (Reference Codes and Standards) of Appendix 3.2 of the application lists over 148 codes and standards (e.g., ASTM D1587-00, "Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes") prepared by various technical and industrial organizations including the American Association of State Highway and Transportation Officials (AASTHO), the American Concrete Institute (ACI), the American Institute of Steel Construction (AISC), the American Society for Testing and Materials (ASTM), the Concrete Reinforcing Steel Institute (CRSI), The American Petroleum Institute (API), the International Building Code (IBC), the National Electrical Code (NEC), and others.

Table 3.2-1 of the application does not reference locations in which specific engineering design, measurement, testing, or construction procedures relied on specific codes and standards listed in the table (or the specific sections of those codes or standards relied upon). It was not possible in the application review to ascertain (other from the code or standard title) what specific codes or standards were used. It may have been possible from each individual citation of a code and standard in the various engineering sections of the application to verify that each listed code and standard was utilized, and to clarify the exact nature of that utilization.

Section 3.2 of the application states that the list of codes and standards provided is not exhaustive; other standards may be added, deleted, or those listed may be superseded based on special design or manufacturer requirements. Because flexibility in the use or substitution of codes and standards during construction may be appropriate, the Executive Director recommends a license condition that requires any changes in the standards and codes must first be technically reviewed and approved by the Executive Director.

For example, TCEQ staff has a specific concern about the use of the API code 650 for the design of the leachate steel tanks. The application proposes to design the 500,000-gallon tanks to the API-650 welded atmospheric storage tank standard. The standard used provides a structurally adequate welded-panel atmospheric storage tank. The application further proposes to have the carbon steel weld panels given a corrosion resistant epoxy-type coating in the factory. However, field welding will burn-off the coating along either side of all of the welds, and field repair of those damaged areas will be required. This plan is not standard engineering practice. Welded, field-erected water storage tanks are given an internal corrosion resistant coating in the field after all welding and cleaning are done. Factory coatings are applied to bolted tank sections, or, alternatively, the bolted panel sections are galvanized. A detailed design of this tank has already been produced to the API-650 standard. Another equivalent and approved code is recommended in a license condition for inside coating and cathodic protection of the tanks.

2.8 Construction Methods and Features

Title 30 TAC §336.707(5) and 30 TAC §305.54(f) require a description of the disposal facility. In Volume 2, Section 4, the application described the construction of the disposal facility. Section 4 separates the construction into five subjects: construction management, federal facility waste disposal facility (FWF) construction, compact waste facility (CWF) construction, common facilities construction, and construction during operation.

The appropriate actions and hierarchy of the construction management are stated in Appendix 4.2.3. These actions provide plans for submitting and documenting daily construction activities. Also included in Appendix 4.2.3 is a description of the quality assurance to be used during construction of the facility. In supplementing/assuring these protocols, a proposed license condition requires written weekly reports and photographs to accommodate the Executive Director's inspection and observation of all excavation and construction activities and include a discussion of future construction activities.

Rule 30 TAC §336.716(f) requires that no waste shall be disposed of until the Executive Director has inspected the land disposal facility and has found it to be in conformance with the description, design, and construction described in the application for a license. The Executive Director recommends a license condition requiring a final geotechnical report and "as-built" construction drawings for review by the Executive Director. And, any changes from the design and construction of and corresponding proposed modification to the applicable disposal unit as depicted in the license application must be explained and submitted for review and approval by the Executive Director prior to continuation of further construction activities. Deviations may require an amendment of the license.

The application states that construction of the FWF will occur once a site survey has been performed and construction markers and other site controls are placed. The top formation, or the OAG, of sand, caliche and gravel mix will be excavated first, during which blasting through the caliche caprock is anticipated. Once excavation is complete, removal of the red bed clay will proceed until a depth of approximately 120 feet is reached. This process is proposed in the application to occur simultaneously in the

Federal Waste Facility for the Non-Containerized Disposal Unit (NCDU) and the Containerized Disposal Unit (CDU). A RCRA-style liner system is proposed to be installed at the bottom of the disposal units with a concrete barrier placed above that. Technical specifications contained in Appendix 4.2.3 will establish the standards for which the materials, testing procedures, and activities will be carried out.

The application states that construction of the CWF will follow nearly the same course as the FWF. The difference being that construction of the CWF is less complicated. The CWF is shallower than the FWF and does not require a RCRA liner. However, many of the activities and specification will be shared by both facilities.

The application states that the CWF and FWF disposal units will make use of facilities common to both. The administration buildings, TCEQ resident inspectors' office, and the guard house will serve both of the facilities and stormwater controls will similarly benefit both facilities. Construction of these surface stormwater controls will begin during initial excavation and extending as development proceeds. Construction of the building should be completed prior to receipt of waste.

Construction during operation will proceed as described above. The difference being that waste will be received as construction of an adjacent cell commences. A "segregation berm" between the newly excavated cell and the active cell will be utilized until the area is ready for operational use. However, since the segregation berm is between six and nine feet high, it is unclear what benefit this berm has for occupational safety. Nevertheless, personnel monitoring will not be required for construction personnel, and construction vehicles will not be subject to radiological surveys.

Pertaining to construction during operation and stormwater management, the application states that stormwater falling on a construction area will be managed as "clean stormwater rather than leachate." The proximity of the active construction areas to other operations areas after initial facility operation begins create a potential for stormwater to be contaminated. Additionally, due to the uncertainty in meteorological conditions during facility operations, any precipitation should be sampled and analyzed prior to release from an active construction area. A license condition has been proposed requiring that precipitation be sampled and managed in accordance with the radionuclide concentration limits stated in 30 TAC §336.359, Appendix B, Table II, Effluent Concentration Limits. Please see Section 2.5.2 of this EA for more discussion and requirements on the release of run-off surface water.

2.9 Vadose Zone Monitoring

An important aspect of the facility design is the vadose zone monitoring. This monitoring validates the design and construction of the facility and influences closure, post closure, and institutional control. Appendix 4.4-1 of the application states that the moisture content of the performance cover will be monitored. Soil moisture is difficult to monitor with automated time domain reflectometry in fine-grained sediments, such as those present at the site, because of potentially high conductivity. Because of this and other reasons, moisture content is not a very accurate predictor of water movement.

Matric potential generally has a large range of variation (0.1 to 80 meters) and can be used to more accurately monitor subsurface water movement in the vadose zone. Thus, in addition to the proposed monitoring of moisture content in the vadose zone, matric potential monitoring should be included to determine the direction of water movement (i.e. upward or downward), to avoid problems with monitoring moisture content in fine-grained sediments, and to provide a more sensitive indicator of subsurface water movement. Since these techniques only monitor vadose zone conditions intermittently, continuous monitors should also be employed. Heat dissipation sensors should be considered to continuously monitor subsurface water movement in the cover system.

Appendix 4.4-1 of the application depicts plans to use moisture sensors from Geokon Inc. (Model 4500 or equivalent). As previously noted, subsurface pressure should also be measured in addition to moisture content. Furthermore, it is a recommendation of TCEQ consultants to employ more commonly-used moisture sensors for vadose monitoring, such as those manufactured by Campbell Scientific. The relative merits of time domain versus frequency domain sensors should be examined, particularly if moisture content is to be monitored in fine-grained sediments.

Appendix 4.4-1 of the application does not specify the type of moisture sensors that will be installed 12 inches above the base of the low permeability red bed clay in the cover. It is recommended that both moisture sensors and pressure sensors should be installed. Additionally, sensors should be maintained to facilitate long-term and event-based monitoring at this location and not abandoned sensors, as stated in the application. Long-term, continuous monitoring is critical to assessing performance of the cover system at installation and into the future.

Appendix 4.4-1 of the application states that moisture content of the cover will be monitored by taking a direct, manual reading from an output device. This statement suggests that moisture content will not be continuously or automatically monitored and data electronically transferred. Monitoring single readings requiring manual operation may not be adequate for assessing cover performance and does not provide continuous assessment of performance. Manual readings would introduce the potential for inconsistencies due to human errors and differences in measurement techniques.

Additional monitoring of the cover should be considered such as electromagnetic induction monitoring that could be calibrated against moisture content or pressure head measurements (Reedy et al., 2003) and monitoring of vegetation using leaf area index and repeat photography over time.

The application states that neutron probe and electrical impedance wire systems will be used to monitor moisture content below the liner system. It is noted that neutron probes are highly reliable and extremely robust instruments. Care should be taken when installing neutron probe access tubes that there are no gaps between the outside of the tubes and the surrounding materials that might result in preferential flow. Additionally, there must be consideration of both the construction material of the neutron access probe access tubes and the type and strength of the neutron source used for the measurement. TCEQ staff recommends that access tubes be installed horizontally (Scanlon et al., 2005). Neutron logging has to be manually conducted. A continuous, automated monitoring system should also be included to supplement the neutron probe logging.

License conditions requiring moisture content and pressure head monitors are proposed to address these concerns. License conditions also require that the monitors be automated and continuous data transfer. Furthermore, the condition requires the monitoring system be maintained and not be abandoned so that it be used for long-term monitoring. A test plot for detailed monitoring of cover performance similar to those in the United States Environmental Protection Agency Alternative Cover Assessment Program should also be considered.

References Section 2.9: Vadose Zone Monitoring

Reedy et al., 2003. Reedy, R. C.; Scanlon, B. R. Soil water content monitoring using electromagnetic induction, J. Geotech. Geoenvironmental Engineering 2003, Nov 2003; 10.1061/ASCE1090-02412003129:111028, 1028-1039.

Scanlon et al., 2005. 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, v. 4, p. 55-71.

2.10 Construction Safety and Equipment

Rules 30 TAC §336.707(5) and 30 TAC §305.54(f) require the description of construction equipment and the safety associated with it. Section 4 of the application describes the construction equipment, its capabilities, and maintenance and storage of the equipment. Equipment used to excavate will include a backhoe and bulldozer for OAG removal. Side wall construction will be accomplished with skid-steer loaders, blade scapers, and vibratory compaction equipment. Sheepsfoot compactors will be used for placement of bulk waste and the cover. Haul trucks will be used to transport material to the staging areas. Finally, equipment used for concrete placement should include a concrete pumping machine, forms, screeds, screed rails, and steel supports.

Construction safety at the site will be accomplished through routine safety meetings, safety committees, and a WCS safety officer. Fall protection barriers will be instituted for surface elevations and traffic safety will be monitored by flaggers during construction and operation. Finally, a project-specific health and safety plan will be submitted to WCS for review and approval. This plan will address how the contractors will address the construction safety requirements established by the United States Occupational Safety and Health Administration (OSHA).

Section 3: Proposed Facility Operation and Management

3.0 General Introduction

In considering a disposal facility for licensing, the Commission reviews all of the aspects of the applicant's proposed management plan with the goal of ensuring that waste is received, handled, and disposal in a safe and responsible manner. This section reviews the organizational structure for both off-site and onsite functions, and the plan for a training program that will maintain an adequate complement of trained personnel to carry out the management plan. All aspects of the plan to analyze, consider, receive, handle and dispose waste are reviewed as well as plans for site security. Finally, the applicant's compliance history is considered.

3.1 Organizational Structure

Rule 30 Texas Administrative Code (TAC) §336.706(a)(2)(A) requires that an applicant, in demonstrating its qualifications, provide the entire organizational structure for both off-site and onsite functions, including a description of the lines of authority and assignment of responsibilities, whether in the form of administrative directives, contract provisions, or otherwise. Furthermore, an applicant should also provide a plan to maintain an adequate complement of trained personnel to carry out waste receipt, handling, and disposal operations in a safe manner. Those plans should include provisions for operating the facility in the event of unavailability of any contracted services or equipment.

TCEQ staff has reviewed the information provided in the application regarding the organizational structure. The application description of the facilities organizational structure is discussed in Section 10.0 of the application. The lines of authority and assignments of responsibility are discussed in Section 10.1.1 of the application. Waste Control Specialists, LLC (WCS) is registered in the State of Delaware and established to provide waste management services. The application lists the WCS corporate offices at Three Lincoln Centre, Suite 1700, 5400 LBJ Freeway, Dallas, Texas 75240.

The applications list the President and Chief Financial Officer as the executive in charge of site operations. The application states the following positions as reporting to the President: the Senior Vice-President of Licensing and Regulatory Affairs; the Senior Vice-President of Business Development; the Vice-President and General Manager; the Vice-President of Community Relations; the Director of Quality Assurance; the Director of Finance and Accounting; and the Director of Planning and Analysis. The application states that the Corporate Radiation Safety Officer is the chairperson of the Radiation Safety Committee for the proposed disposal facility and in that capacity has direct access to the President.

The application provides the reporting relationship and the lines of authority for the corporate organization. The reporting relationship for management positions supporting operational activities is provided for the key operating positions which report to the Vice-President and General Manager. URS Corporation has prepared and developed many portions of the low-level radioactive waste disposal application, which includes the reference design features, activities, and procedures for the proposed disposal activities. The application states that the design contractors are required to have a Quality Assurance (QA) Program that meets WCS's QA Program requirements. The application states that individual contractors are responsible for working under WCS's QA Program and procedures for qualification to support the design of the proposed disposal facility. During the licensing application phase, the application states that the design contractor's QA Program was evaluated and determined that it was acceptable. The application further states that the management of the facility design provided in the application, which was lead by URS Corporation, was accomplished by using a qualified design organization.

The application explains that contracted services were provided to perform the site characterization studies. WCS maintained full responsibility for the site characterization, design, quality assurance, construction, operation, and closure of the proposed disposal facility. The application again states these individual characterization contractors are responsible for working under the WCS's QA Program and procedures for qualification of existing data collected to support the site characterization.

The application states that WCS is responsible for the construction of the facility. Further discussion in the application indicates that a qualified construction contractor will be selected to construct the facility in accordance with approved design documents.

The application states that the Vice-President and General Manager position is responsible for the overall construction, operation, and administration of the proposed low-level radioactive waste disposal facility. In the discharge of these responsibilities, the application describes that the Vice-President and General Manager directs the following functional areas:

- Construction;
- Operations;
- Environmental health and safety
- Security;
- Quality assurance;
- Administrative services; and
- Human resources.

Analysis of the submitted information contained in the application provides a general management and functional structure of the organization. There does not appear to be a direct line of authority for the operation team personnel in Figure 10.3 of the application.

The application provides the qualifications of key personnel for the proposed disposal facility. The application explains that the proposed disposal facility will be staffed at sufficient levels prior to operation to allow for training, procedure development, and other pre-operational activities. Further, the application states that the responsible manager retains the ultimate responsibility and accountability for implementing the applicable requirements. The key positions identified in the application for the proposed disposal facility are the following:

- Vice-President and General Manager;
- Director of Operations;
- Director of Environmental Safety and Health;
- Radiation Safety Officer;
- Radwaste Manager;
- Director of Quality Assurance;
- Facility Quality Assurance Manager;
- Waste Acceptance Specialist;
- Radiation Technician(s);
- Operations Supervisor;
- Operator(s);
- Training Manager;
- Safety and Health Manager;
- Facility Operations Manager;
- Technical Support Manager;
- Security Manager;
- Director of Administrative Services; and
- Radiation Safety Supervisor.

The application lists the position of Vice-President and General Manager (GM) is responsible to the President of Waste Control Specialists, LLC. The application states that the GM is responsible for ensuring that the facility complies with all applicable regulatory requirements, selection of personnel for the key facility positions and, responsible for the protection of the facility personnel and the general public from radiation and chemical exposure. This position is also responsible for compliance with the facility license. The GM has the authority to approve and issue proposed disposal facility procedures.

The application states that the GM will be knowledgeable of the waste management processes, chemical safety, industrial safety, and the radiation protection program, and will conduct an assessment to ensure that the facility has a sufficient number of trained and qualified personnel prior to receipt of waste under the license. The application describes that the GM is expected to maintain direct links with the Radiation Safety Committee as well as the Radiation Safety Officer (RSO). A bachelor's degree (or equivalent) in an engineering or scientific field and ten years of responsible waste management experience is proposed to be required for the GM.

The application states that the Director of Operations reports to the GM and has the responsibility for managing engineering, construction, and operations of the facility. The Director of Operations position is proposed to require a bachelor's degree in an engineering or scientific field (or equivalent) and ten years of related experience.

The application states that the Director of Environmental Safety and Health reports to the GM and has the responsibility for the health, industrial safety, radiological safety, and environmental compliance programs. The Director of Environmental Safety and Health position is proposed to require a bachelor's degree in an engineering or scientific field (or equivalent) and ten years of related experience.

The application states that the Radiation Safety Officer (RSO) reports to the Director of Environmental Safety and Health. The RSO implements the radiation protection program and coordinates the proposed facilities to comply with the as low as reasonably achievable (ALARA) efforts. The RSO position is proposed to require a bachelor's degree in an engineering or scientific field (or equivalent) and ten years of related health physics experience. The list of responsibilities provided in the application assigned to the facility RSO does not appear to include all the responsibilities associated with an RSO as designated in a TCEQ radioactive material license. The RSO should be the licensee's primary contact with the agency and is the responsible individual on a license, not just the primary facility contact. The Executive Director recommends license conditions to clearly specifying duties associated with the draft license and identify that the RSO must be the primary contact between the licensee and agency.

As the primary contact with the agency, the RSO should be delegated the authority by the highest level of management to act for and on the behalf of the licensee in all matters relating to radiation safety and the radioactive material license. Delegation of such authority to the RSO was not evident in the information provided in the application. The application does not clearly provide the RSO position "shut-down" or "stand-down" authority over facility operations. The organizational structure presented in the application appears to impact the effectiveness of implementing the ALARA principle across facility operations. Therefore, the Executive Director recommends that a license condition require a resolution passed by the WCS's board of directors, and attested to by the secretary of the corporation, delegating to the RSO position the authority to act for and on behalf of the licensee in all matters relating to radiation safety matters and the draft radioactive material license and the authority to shut-down and stand-down operations.

The facility organizational chart depicts the Director of Environmental Safety and Health and the RSO on the facility organizational chart and describes the positions in the application. However, neither of these positions is indicated to have direct access to the President to convey information regarding health and safety issues, ALARA considerations, or rule and license condition violations. According to the lines of authority and communication on the organizational chart provided in the application, any information concerning radiation safety must pass through the Vice-President and General Manager position in order to reach the President. This lack of direct communication between the RSO and President is problematic. The Executive Director recommends revision to the organizational chart and description of the RSO position to establish a direct line of communication with the company president on all matters pertaining to radiation safety and compliance with conditions of the license and the applicable rules.

Mr. Guy Crawford, Ph.D. is designated as the RSO in the license application. Dr. Crawford has a doctor of philosophy in materials science and engineering. He has previously served as the RSO on a radioactive material license issued to an academic institution in Texas, and currently serves as the RSO on Radioactive Material License R04971, a radioactive waste storage and processing license co-located on the same site as the proposed disposal facility. In order to address the unique operations of the proposed low-level radioactive waste disposal facility, the Executive Director recommends a license condition requiring specified training for the RSO.

The application states that the Radwaste Manager reports to the Director of Operations and has the responsibility for managing the day-to-day operational activities of the proposed disposal facility. The Radwaste Manager position is proposed to require a bachelor's degree (or equivalent) in an engineering or science and ten years of related experience.

The application states that the Director of Quality Assurance reports to the President. This position is responsible for managing the proposed quality assurance program. The Director of Quality Assurance position is proposed to require, as a minimum, a bachelor's degree (or equivalent) and ten years of related quality assurance experience.

The application states that the Facility Quality Assurance Manager reports to the Director of Quality Assurance. This position is responsible for managing the Quality Assurance Program at the facility including audits, QA technical support and quality control. The Facility QA Manager position is proposed to require a bachelor's degree (or equivalent) and five years of related quality assurance experience.

The application states that the Waste Acceptance Specialist reports to the Technical Support Manager. This position coordinates the waste acceptance process. The Waste Acceptance Specialist position is proposed to require a bachelor's degree in an engineering or environmental field or five years of related waste management work experience.

The application states that the Senior Radiation Technicians report to the Radiation Safety Supervisor. The technicians will conduct surveys of the surface and landfill operations and support activities at the counting lab. The Senior Radiation Technician position is proposed to require an associate degree or two or more years of study in the physical sciences, engineering, or a health-related field. The application provides that

Senior Radiation Technicians will be required to complete at least four weeks of generalized training in radiation health.

The application states that the Operations Supervisor reports to the Radwaste Manager. This position manages the daily work activities of the Operators. The Operations Supervisor position is proposed to require a high school diploma or generally-equivalent diploma (GED) plus three years of operations experience.

The application states that Operators report to the Operations Supervisor. The Operators are responsible for operating equipment used to handle the waste. The Operator position is proposed to require have a high school diploma or GED.

The application states that the Training Manager reports to the Director of Human Resources. The Training Manager manages the coordination of the proposed training program. The Training Manager position is proposed to require a bachelor's degree in education or science or a minimum of ten years of professional training experience.

The application states that the Safety and Health Manager will report to the Director of Environmental Safety and Health. The Safety and Health Manager is responsible for direct management of the safety and health program and procedure implementation. The Safety and Health Manager is also, responsible for ensuring that the safety and health training is provided to employees and contractors working at the site. The Safety and Health Manager position is proposed to require a bachelor's degree in industrial or occupational safety or radiation safety, or a minimum of sixty hours of related college level study plus a minimum of four years of experience in the field of industrial and occupational safety.

The application states that the Facilities Operations Manager reports to the Director of Operations. The Facilities Operations Manager is responsible for maintaining an operating fleet of equipment for facility operations. The Facilities Operations Manager position is proposed to require an associate's degree in engineering or construction technology, or sixty hours of related study and six years of experience in operations and/or maintenance.

The application states that the Technical Support Manager reports to the Director of Operations. The Technical Support Manager is responsible for managing the facility planning and scheduling, the coordination of transportation of incoming and outgoing waste shipments, customer service, waste acceptance and data entry. The Technical Support Manager position is proposed to require a bachelor's degree in engineering or science (or equivalent) and five years of experience in the environmental industry or a related field.

The application states that the Security Manager reports to the Vice-President and General Manager. The Security Manager is responsible for managing the security staff and implementation of the facility security plans. The Security Manager position is proposed to require a bachelor's degree in a related field (or equivalent) and two years experience in security or law enforcement and a Texas State Security Certification.

The application states that the Director of Administrative Services reports to the Vice-President and General Manager. The Director of Administrative Services is responsible for managing procurement, records management, document control, and information technology activities. The Director of Administrative Services position is proposed to require a bachelor's degree in business administration or engineering or science (or equivalent) and five years of related work experience.

The application states that the Radiation Safety Supervisor (RSS) reports to the RSO. The RSS supervises and performs complex radiation protection and monitoring work relating to the operations of the Facility. The RSS position is proposed to require an associate's degree in health physics, radiation safety technology, physical science, or sixty hours of related study and three years experience in the field of health physics.

The application states that many of the staff and support jobs at proposed disposal facility allow for work experience to be used in place of academic credentials. Experience in place of a high school diploma or bachelors degree may not be a suitable alternate for many of the technical jobs that handle radioactive materials at the waste site. Experience that the staff brings to the job should be considered when deciding the suitability of the applicant and the job requirements. The Executive Directors recommends that appropriate education and training be consistently and uniformly maintained for each position on the technical and professional staff.

In order to ensure that contractors working on site are properly instructed and trained, a license condition which specifies that all persons, including contractors, who work within the confines of the low level waste disposal facility, take and successfully complete the licensee's basic radiation safety training course.

In addition to positions specified on the organization chart, the application refers to other positions which play a critical role in the administration or execution of the radiation safety program. The application has not provided the qualifications or training required for these positions. A draft license condition has been added to require all persons who have a role in the administration or execution of the radiation safety program to meet the qualifications and successfully complete the training required for the position of radiation safety technician.

3.2 Training Programs

Section 401.112(a)(10) of the Texas Health and Safety Code requires that the licensing agency evaluate an applicant's employee training program to ensure that the program will produce and support competent and technically qualified staff able to properly conduct all aspects waste disposal operations.

Title 30 (TAC) §336.706(a)(2)(B) requires that an applicant, in demonstrating their qualifications, provide a plan to maintain an adequate complement of trained personnel to carry out waste receipt, handling and disposal operations in a safe manner. Those plans should include provisions, including structure and level of detail, for operating the facility in the event of the unavailability of any contracted services or equipment. Minimum training and experience requirements for personnel filling key positions should be provided. The United States Nuclear Regulatory Commission NUREG-1199 recommends that the application provide the minimum number of persons to be assigned to common positions (NRC, 1991). Title 30 TAC §336.706(a)(2)(C) requires that the applicant provide a description of the personnel training program. Qualifications of the staff to engage in the proposed licensed activities should also be provided, including the minimum training and experience required based on responsibilities of each position.

Section 10.5 of the application states that the plan presented is capable of maintaining an adequate complement of trained personnel to perform disposal operations in a safe manner. The application states that it will require approximately 102 full-time employees to operate the proposed disposal facility in a safe manner and in compliance with regulatory requirements.

The application states that the employees at the facility can be separated into two main categories: the Facility Assigned Workers (FAW) and the Infrastructure Support Workers (ISW). The FAW are reported to be assigned to operating the proposed disposal facility. This means that the FAW be assigned to the overall licensed disposal facility, but may not work exclusively at the CWF or the FWF. The ISW may be working at the proposed disposal facility for some of their time and will also work throughout the larger WCS site complex, which will have several radioactive material licenses, hazardous waste permits, and other authorized activities going on concurrently. The Executive Director recommends that the roles and responsibilities be clearly communicated and understood for employees working under several different authorizations.

Personnel recruitment and retention are discussed in Appendix 10.5 of the application. In order to ensure an adequate workforce, the application states that recruitment for personnel will be sought on a local and national level. Recruitment is also sought from local colleges and universities. A competitive compensation structure is proposed in the application. This is proposed to include competitive salary and benefits, job and personal growth opportunities, cross training in multiple functions and skills, and a tuition reimbursement plan.

In the event that an adequate qualified workforce is not available to properly operate the proposed disposal facility, the application states that trained and qualified management and operating staff can be temporarily reassigned from the other operations at the larger site. The assumption that staff from other operations, authorized under different licenses and permits, would be trained and qualified to manage and operate a low-level radioactive waste disposal facility might be problematic. Additionally, the relocation of employees from other operations may affect the operations of other permitted and licensed facilities on the larger site. The Executive Director recommends a license condition to require a plan for utilizing staff from the larger site and that all replacement staff must complete Orientation Safety Training and have already received the document cross-training before being assigned to an alternative particular job.

The proposed training program described in Appendix 10.4 of the application is proposed to be designed to ensure that personnel associated with the facilities are trained and qualified to perform their respective jobs as described in their overall job assignment. The goal stated in the application is an operating environment that will establish a high level of performance. The application states that this high performance level is accomplished through management establishing high operating standards, communicating standards throughout the organization, providing sufficient resources, ensuring personnel are well-trained, closely monitoring performance, and holding workers and their supervisors accountable for their performance. The application states that personnel will be trained based on applicable regulatory requirements, facility procedures, plans, and identified tasks.

A high performance culture must be deep-rooted, character-driven, and have a focused plan for daily communication and feedback with improvement incentives. The application does not provide a discussion on or a plan to accomplish high performance in the daily, safe operations of the proposed disposal facility. The Executive Director recommends development of a clear plan to establish a site-wide safety and high-performance culture that is integrated into the daily operations of the proposed disposal facility.

The application states that the training department will be responsible for training coordination and performance reporting. Training coordination focuses on analyzing refresher training reports, planning training schedules, coordinating classes, reviewing class feedback, modifying the Training Records Database and providing training notifications for employees. The application states that coordination efforts are also provided to assist site subject matter experts (SMEs) in the development and/or modification of training courses.

The application states that all personnel are required to take the core training courses listed below. These courses are offered as computer-based training (CBT) and provided in the application as follows:

- Safety Orientation Training;
- General Employee Training (GET);
- Sexual Harassment Awareness Training;
- Preventing Workplace Violence Training;
- Contingency Plan and Emergency Information List Locations Training;
- Ergonomics Training;
- Hazard Communication Training;
- Blood-borne Pathogens Training; and

- Fire Extinguisher Training.

In addition to the core courses, the application states that some personnel will be required to take institutional training courses. These courses are standard training in the industry including hazwoper, confined space, hazardous waste supervisor training, radiation worker training, etc. These courses are offered as both CBT and classroom instruction.

The application describes job activity specific training (JAST) designed to address the training aspects that relate to the employee's specific work location. No formal lesson plans are provided in the application for JAST activities. The application states that documentation of personnel participation will be maintained as a sign-off record.

The application states that on-the-job training (OJT) and pre-planning/mock-up training are hands on operations by the worker. OJT allows workers to learn as they work and understand the relationships between steps executed in a particular order as a skill or procedure is learned. The application states that reading of pertinent procedures and equipment manuals is also assigned before the task is executed. Pre-planning and mock-up is reported to allow time to evaluate the job, determine the best way to do it, obtain the resources needed and safely execute the task.

There is limited information provided in the application of how practical training will be accomplished and maintained. Since the operation of a low-level radioactive waste disposal facility is unique and a new activity for WCS, the Executive Director recommends extensive pre-planning with mandatory mock-up or dry-runs for new tasks. Additionally, pre-planning must be combined with continuous communication with waste generators, processors, and transporter on changes in waste streams, packaging configurations, dose rate trends, and other important information that may affect operations and worker health and safety.

The application states that emergency response training is incorporated in core training and JAST training received by workers. Additionally, the application reports that CPR and First Aid courses will be required for those individuals selected to perform CPR and first aid functions.

The application states that visitors and contractors will be provided general orientation training before they are allowed to enter the facility. In addition to the general orientation, contractors will be required to complete additional training as needed to protect on-site and off-site employees, the environment and facility equipment. The application does not detail on how this program for non-employees will be accomplished.

The application provides that a performance checklist will be on file for all employees, off-site visitors, and contractors. The checklist will include the courses completed by the staff, visitors, and contractors, the date of completion and the signatures of the training instructors. The application states that training program development is accomplished by the Training Manager with implementation assistance from subject matter experts

(SMEs), managers, group/section leaders, supervisors, and outside contractors.

The application states that the Training Manager coordinates the training plan to provide employees with the training necessary for the safe and productive completion of their work responsibilities. The application states that the SMEs, in conjunction with the Training Manager will prepare lesson plans for all employees to address identified needs. It should be noted that a trainer should not fulfill their own training requirements by serving as their own instructor. There is no description in the application of how the Training Manager will receive necessary training to perform their job duties.

As discussed in the application, course evaluations will be used to evaluate the effectiveness of course content and to improve the training program. The proposed training program will also utilize the Training Records Database to track employee training participation in relation to mandatory job requirements. The application states that proper management of the Training Records Database aids managers in maintaining employee qualifications current with job requirements.

The application states that the training program consists of various course plans which are directed to the needs of individual personnel. These plans are reported to include training action plans, a needs assessment program, training course development, testing and verification training, training records, and training coordinating and performance reporting. The application describes courses offered as Computer Based Training (CBT) or classroom instruction and notes that in some instances a lesson plan may be used, but is not required. The application is not clear when lesson plans will be used. It should be clearly understood when lesson plans will be used and those trainings will be pursued another way.

As provided in the application, training action plans will be created to track training. The training action plans are proposed to consist of databases which are programmed with training requirements specific to job title and work location, and generates the appropriate list of requirements for each work classification. The application should clearly identify which individuals will be included in this database tracking. In order to ensure that necessary training has been completed, all employees, contractors, and visitors should be included in the training action plans database as well as the needs assessment program.

The application states that the needs assessment program provides a mechanism to identify hazards, training needs, and job task elements. The completion of the needs assessment training is proposed to ensure that mandatory requirements are met, as well as improving professional development needs. The application provides that the Training Manager provides training requirement reports to WCS line management.

The application describes that the training course development includes the delineation of the requirement(s) for the training, the preparation of the lesson plan, and review of the training material. The application states that the review of each of the courses will be accomplished by individuals with the appropriate technical background. This statement does not provide how a determination of appropriate technical background will be made.

The application states that other courses will be developed in various formats that include classroom instruction, video, examination, OJT, CBT, and Job Performance Measures (JPM). There should be enough detail in the training course description to evaluate the effectiveness of these proposed courses. Additionally, there are no lists, outlines or syllabi for any of the proposed training courses provided in the application.

The application states that testing and verification are used to assess the individual's knowledge of the task before they attempt to perform the task independently. Verification of training will be either from a written test or from a CBT course test. The application states that a score above 80 percent is required for verification of effective training on all written and CBT tests. In the event that a score above 80 percent on a written test is not achieved, the test will be reviewed with the employee to determine whether classroom training, on-the-job training, or both, are required to bring the employee's job knowledge up to the acceptance level.

The application states that training records are maintained both electronically and manually. The electronic versions of the training records are proposed to be retained as a database. The application proposes that the database will provide information on all training courses. The application also states that hard copy attendance records are maintained in each employee's training folder.

The training program and plan provided in the application describe proposed general training for on-site personnel, site visitors, and contractors. The content and level of information of the training courses cannot be determined because lists, outlines, or syllabi were not submitted for courses. The application provides a schedule for the training of on-site personnel. In order to ensure that necessary training has been completed, all employees, contractors, and visitors should be included in the training action plans database as well as the needs assessment program. The courses for site visitors were not clearly described in the application and not clearly distinguished from the courses taken by on-site personnel. The application will provide instruction to workers on respiratory protection as required by 30 TAC §336.321. The Executive Director recommends a license condition that requires all workers who may handle radioactive or otherwise hazardous material which could become airborne, successfully complete the respiratory protection training.

References Section 3.2: Training Programs

NRC, 1991. United States Nuclear Regulatory Commission, NUREG 1199. Revision 2, Standard Format and Content of a License Application for a Low-Level Radioactive Waste Disposal Facility, 1991.

3.3 Receipt, Inspection, and Acceptance of Waste

TCEQ rule at 30 TAC §336.707(6) requires that the license applicant submit specific technical information including a description of the types, chemical and physical forms, quantities, classification, and specifications of the radioactive material proposed to be received, possessed, processed, and disposed of at the land disposal facility to demonstrate that the performance objectives and the applicable technical requirements listed in Subchapter H of Chapter 336 of TAC 30 will be met. The applicant is also required to include performance criteria for form and packaging of the waste or radioactive material that will be received. The regulatory basis for this review by TCEQ can also be found in Texas Health and Safety Code §401.112(a)(8), the TCEQ rule 30 TAC §336.707(6), and 30 TAC§305.45(a)(8)(B)(ii). NUREG-1200, a United States Nuclear Regulatory Commission (NRC) document entitled "Standard Review Plan for the Review of a License Application for a Low-Level Radioactive Waste Disposal Facility" is also utilized for technical guidance.

3.3.1 Types of Waste Proposed for Acceptance

The application states that the Compact Waste Facility (CWF) will accept for disposal only stabilized low-level radioactive waste of Classes A, B, and C from commercial waste generators located within Texas and Vermont. No mixed waste or federal facility generated waste will be accepted at the CWF facility. According to the application, the historical trending and generator forecasts suggest that approximately 90 percent by volume of waste to be received at the CWF will be Class A, nine percent will be Class B, and one percent will be Class C. The CWF facility cumulative waste receipts over the facility lifetime are projected in the application to not exceed a maximum volume of 2,800,000 cubic feet (102,000 cubic yards).

The Federal Waste Facility (FWF) is proposed to accept Class A, B, and C low-level radioactive waste and mixed waste, a combination of wastes that are Class A, B, and C low-level radioactive waste and hazardous waste. Texas statute limits total volume of federal waste that is containerized to 3,000,000 cubic yards for the first five years. After five years, the lifetime capacity of the federal facility waste that is containerized may be increased by license amendment to a maximum limit of 6,000,000 cubic yards.

Mixed waste contains hazardous listed chemicals or exhibits hazardous characteristics as defined by 40 CFR Part 261. The application describes that most of the radioactive waste received from federal facilities will be stabilized and disposed in canisters at the Federal Waste Facility - Containerized Disposal Unit (FWF-CDU). However, the application requests authorization for a non-containerized unit, the FWF-NCDU, for waste received that is soil-like and rubble material from construction demolition and environmental restoration projects. The application states that the waste form proposed for disposal in the FWF-NCDU meets form stability requirements identified in Appendix 8.0-2 of the application.

Information on CWF waste streams, waste generators, and waste volumes is provided in Appendix 8.0-1 of the application. The information on FWF waste streams, generators, and waste volumes is provided in Appendix 8.0-2 of the application. Projected waste volumes and inventories for the CWF and FWF are described in Section 8.2 of the application.

Application Appendices 8.0-1 (for the CWF) and 8.0-2 (for the FWF) provide generic lists of the physical forms, chemical constituent data, anticipated volumes of waste, and the estimated concentration ranges. There has been no prior disposal of radioactive waste at the proposed low-level radioactive waste disposal site, although there has been disposal of certain exempted radioactive materials in an adjacent RCRA Subtitle C landfill owned and operated by WCS. Additionally, there is an active license (R04971) for processing and storage of radioactive waste at an adjacent facility. An inventory of radioactive material currently being stored at the adjacent RCRA Subtitle C facilities is not provided in the application.

3.3.2 Schematic Flow Diagrams and Process Flow

The pre-shipment authorization, receiving, inspection, and acceptance process flow can be found in the application in schematic flow diagram, Figure 5-1, as well as in schematic diagrams, Figure 5.3.2-1 and Figure 5.3.2-2, in the application.

The process flow below describes the steps proposed for disposal operations as discussed in the application. The operational procedures or standard operation procedures (SOPs), provided in the application are given in parenthesis below.

1. Generator Pre-Shipment Authorization
   - Waste Profile Approval (Procedure LL-OP-2.1)
   - Generator Certification (Procedure LL-OP-2.2)
   - Waste Shipment Authorization (Procedure LL-OP-2.3)

2. Shipment Receiving
   - Truck Arrives (no corresponding procedure)
   - Shipment Hold (no corresponding procedure)

3. Transport Check
   - Waste Receipt, Staging and Release Survey (Procedure LL-RS-10)
   - Arriving Vehicle Inspection (Procedure LL-OP-2.4)

4. Paperwork Check
   - Waste Shipment Compliance Verification (Procedure LL-OP-2.5)
   - Waste Classification Verification (Procedure LL-OP-2.6)

5. Shipment Off-loading
    - For Containerized Waste - Staging in the Container Staging Building (Procedure LL-OP-3.1)
    - For Bulk Waste - Waste Staging in the Bulk Staging Building (Procedure LL-OP-3.2)

6. Transport Vehicle Release (Procedure LL-OP-2.10)

7. Verification Sampling
    - Non-Destructive In-Situ Assay (Procedure LL-OP-4.0)
    - Sampling Contact Handled Waste (Procedure LL-OP-4.1)

8. Waste Acceptance for Disposal (Procedure LL-OP-2.7)

The procedures associated with these processes are found in Appendix 5.5 of the application. Procedures are also provided in the application for Electronic Waste Tracking (Procedure LL-OP-1.2), Acknowledgement of Waste Received (Procedure LL-OP-1.3), and Concrete Canister Receipt/Acceptance (Procedure LL-OP-5.1).

Compliance with the reviewed procedures in the application is specifically required by proposed license conditions. Procedures are the higher-tiered methods for facility operations as illustrated in Figure EA-3. Although there is flexibility given in the procedures as allowed by the issuance and performance of radiation work permits and other specific tasks at the proposed facility, the activities covered under procedures should be a complete collection of the standard operating instructions for the proposed facilities. These standard instructions comprise the unit operations that, in combination or used singly, make-up the sequence of work steps necessary for the formulation of a specific work instructions and radiation work permits. Due to the nature of the standard methods provided in procedures, it is necessary for proposed procedures and any subsequent amendments to procedures, to be reviewed for potential health and safety impacts. Amendments to procedures must be made in accordance with requirements in 30 TAC §305.62.

There is no mention in the procedures in the application that routine review and updates of the operational standards will be conducted. The Executive Director recommends that procedures and instructions be routinely reviewed to ensure they reflect the most current conditions. Operational programs should be continuously subject to improvement. Procedures should be reviewed and adjusted to improve operations and worker safety. The responsibility for updating each procedure, document control, and maintenance must be clearly defined. When a procedure is updated, processes and responsibilities for operator training must be clearly defined and documented. Backups for key operating personnel as well as chain of command during normal operations and emergencies should be clearly defined in the procedures.

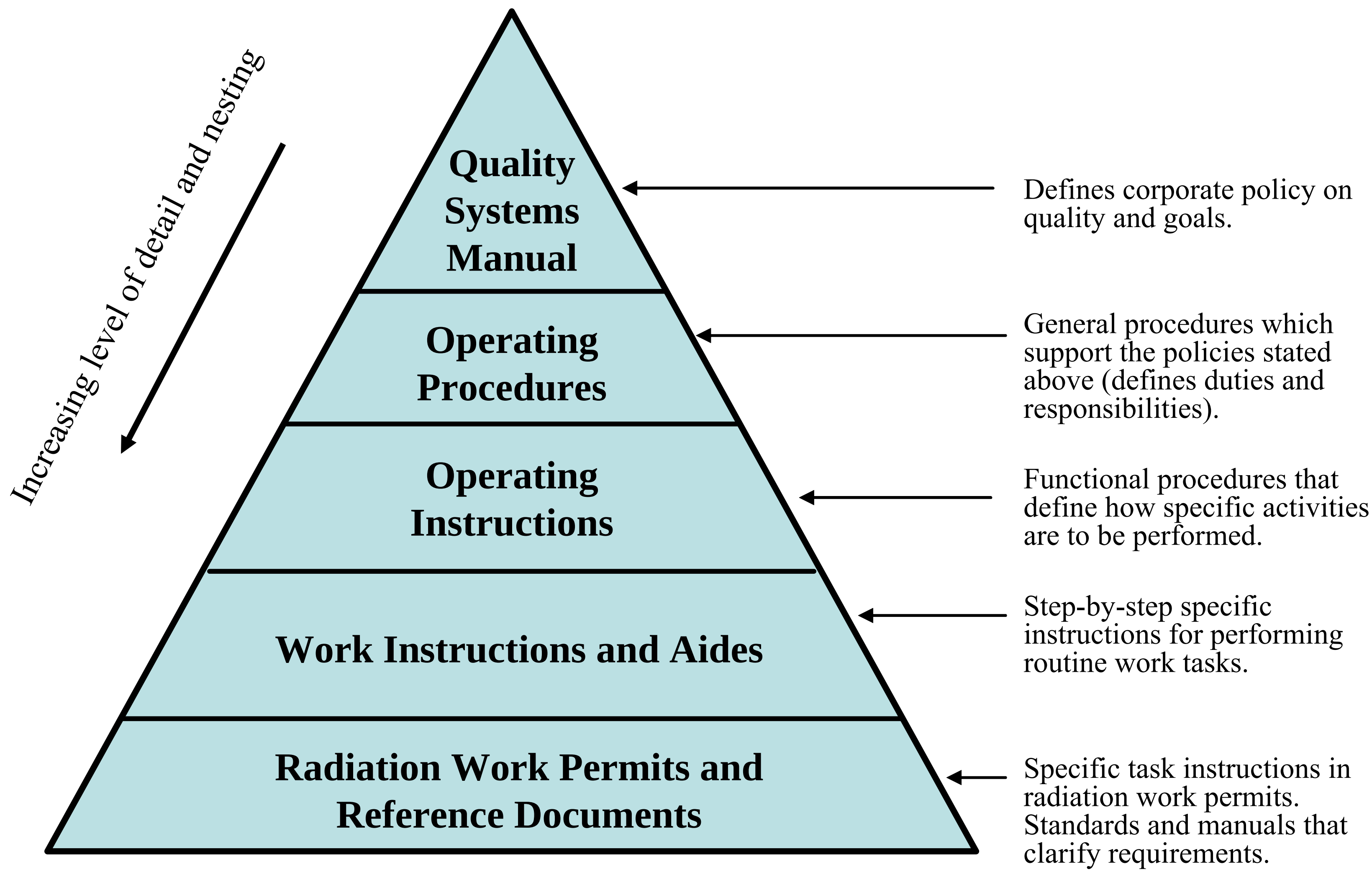

Figure EA-3: TCEQ Suggested Facility Operations Pyramid

Procedures for waste receipt, inspection, and acceptance for the CWF and FWF are spread across various sections of the license application. Procedures should be streamlined to focus on the specific activities being performed, and then properly consolidated and cross-referenced for better evaluation. The use of appendices and side-references in the procedures make them cumbersome and difficult to follow.

The application lacks specificity on the handling of commonly expected waste streams, having a predictable waste package and configuration. The procedures in the application do not address all the tiered steps needed to operate the type of full-service facilities proposed in the application. Procedures in the application are not specific on tasks and should be organized in the ISO 9000 or similar format. Procedures should be written in progressively increasing level of specificity from corporate quality/environmental/operations policy statement down to detailed SOPs for each specific operation following the ISO 9000 format. An example of the procedure that does not provide enough detail for evaluation is the large item evaluation processing. The inspection, rejection disposition process needs to be developed. It is necessary to clearly identify differences, if any, from the verification process mentioned in the following section of this EA.

More specific description and overview of the waste receipt, inspection methodology and operations are needed in Section 5.1 of the application. Reference was only made to the operation procedures listed in Appendix 5.5 of the application. The procedures are general and do not clearly identify roles, responsibilities, and chain of command, especially during an emergency or shipment rejection. A description of the waste acceptance operations is given under Section 5.2 of the application. The Executive Director recommends submission of updated and detailed procedures used for receipt and verification of waste packages and bulk wastes at the land disposal facilities. These procedures should include details on the handling of commonly expected waste streams with predictable waste package and configuration, should be organized in the ISO 9000 or similar format, and provide progressively increasing levels of specificity from general corporate quality/environmental/operations information down to detailed procedures for each specific operation. The procedures must provide detailed inspection, rejection, and disposition processes.

3.3.3 Pre-Shipment Approval and Manifesting

Sections 4 (Generator and Waste Approval Process) and Section 5 (Waste Receipt) of Appendix 5.2-1 of the application require each generator to obtain prior authorization from WCS for each waste shipment as described in the Procedure LL-OP-2.3, Waste Shipment Authorization. The application states that the waste generator must receive a written or electronic mail confirmation from WCS that the shipment has been approved. WCS requires all shipping information such as United States Department of Transportation (DOT) paper work, manifests and all supporting documentation for review. WCS verifies the shipment conforms to the Waste Profile Form (WPF), the waste classification, and the waste form. WCS also verifies that shipment is in compliance with applicable DOT, NRC, TCEQ and the United States Environmental Protection Agency (EPA) shipping requirements. The application states that a facility Waste Acceptance Specialist will coordinate with facility management, including the RadWaste Manager and Radiation Safety Officer, to verify that the facility can safely receive and manage the proposed shipment. The application states that a delivery schedule will be established with the generator or shipper, issue written authorization to the generator to allow shipment, and enter the appropriate information in the waste tracking database.

The application states that the shipper of waste intended for disposal will give the disposal facility 72 hours notice prior to shipment of waste. However, the application does not discuss how that notification will be conveyed to the TCEQ resident inspector. A license condition has been included to address pre-notification of shipment by both the waste shipper and the subsequent notice to the TCEQ.

The application states that for each new waste stream to be sent by an approved generator, a pre-shipment sample is sent to WCS for developing a waste profile using intrusive verification sampling and analysis. Once the pre-shipment sample is received, WCS will use either the in-house laboratory or an approved off-site laboratory to perform analyses for radiological classification, characterization, chemical and physical fingerprinting, and hazardous waste verification pursuant to 40 CFR Part 268. Additionally, any new waste stream planned for acceptance at the disposal facility must be reviewed and approved by the license amendment. The Performance Assessment must also be updated, reviewed, and approved to include any new waste stream information that is proposed for acceptance.

3.3.4 Inspection and Acceptance of Waste Plan

This section discusses the receipt, inspection, and acceptance operations. The section following describes the analysis of the incoming waste. This information is necessary for making decisions regarding whether to forward the material for further processing or appropriate disposal operation. These issues are also an important factor in maintaining worker safety.

The application states that waste shipments will be received in a variety of sealed packages such as standard 55-gallon steel drums, cylindrical cask liners, rectangular steel boxes, intermodals, roll-offs, waste generator-designed canisters, or from a list of 400 radioactive material packages certified by the United States Department of Energy (DOE) for transport by road only. Waste received at the CWF will be stabilized prior to placement in the disposal cell using concrete canisters and grout. Large components that will not fit into concrete canisters will be stabilized by the generator prior to transport. It is not clear how large components will be accepted and placed in the disposal units.

The application states that shipments by rail are not planned for receipt of low-level radioactive waste. The application does not contain information for receiving, unloading, and possessing radioactive materials at a railcar unloading facility and does not provide necessary technical information to facilitate review. There are no processes or procedures for receipt, unloading, and handling of radioactive materials from railcars and the necessary transportation of waste to the disposal units. A technical review of processes and procedures would be necessary to evaluate the potential health and safety impacts of rail waste acceptance. The Executive Director recommends a license condition to prohibit the acceptance of waste shipped by rail for disposal.

The application states that transport check-in, weighing, vehicle inspections, and verification surveys will be completed in the common fenced area between the main facilities gate and the disposal facilities gates. The waste will remain on the vehicle to ensure waste destined for the CWF and FWF will not be commingled. Waste packages that enter the facility will be marked with individual bar codes and subsequent movements will then be tracked. After preliminary acceptance, the waste will be allowed to proceed into the appropriate disposal area. Waste containers with visible physical damage will not be accepted, and will be returned to the generator or transferred to an outside facility as directed by the generator. If needed, the damaged waste packages will be enclosed or placed in overpacks according to Procedure LL-OP-9.6, Overpacking Waste Containers.

The application states that the mechanisms for verification of incoming wastes upon receipt include visual inspection for conformance with the Waste Profile Form, review of the shipping manifest, and performance of radiological surveys for consistency with modeled external dosages. In some instances, sample collection and radiological analysis are performed in accordance with standard operating procedures in the Waste Analysis Plan.

Waste intended for disposal must be inspected by the TCEQ resident inspector prior to acceptance. Procedures provided in the application do not specifically address the notification, required inspection, and other communications that must be made to the TCEQ resident inspector. A license condition has been provided that addresses the notification and the inspection that must be incorporated into the disposal facility waste acceptance plan.

The application states that the waste items too large for disposal in canisters in the CWF will be evaluated on a case-by-case basis. The application states that extra large items may require extensive pre-planning taking several years; however, no details are provided to describe a common approach or method for consideration. The application does not include detailed procedures for common waste stream packaging configurations and large waste packages. Additionally, the application does not include detail for waste shipment tracking, or chain-of-custody, on-site. The Executive Director recommends license conditions to require detailed procedures for receipt, inspection and tracking of waste on-site and for the acceptance of large package waste shipments.

3.4 Waste Analysis Plan

Texas Health and Safety Code §401.218 requires that the applicant shall dispose of Class B and Class C low-level radioactive waste within a reinforced concrete container which will in turn be placed within a reinforced concrete barrier or within containment structures made of materials technologically equivalent or superior to reinforced concrete and in such a manner that the waste can be monitored and retrieved. The commission by rule may require a compact waste disposal facility license holder to dispose of certain Class A low-level radioactive waste that presents a hazard because of its high radiation levels in the manner required for Class B low-level radioactive waste and Class C low-level radioactive waste as above.

Texas Health and Safety Code §401.225(a) requires that on arrival of a shipment of low-level radioactive waste at the compact waste disposal facility or a federal facility waste disposal facility, the compact waste disposal facility license holder must determine that the waste complies with all laws, rules, and standards relating to processing and packaging of low-level radioactive waste before the waste is accepted for disposal at the facility. Texas Health and Safety Code §401.225(b) states that a person making a shipment of low-level radioactive waste that is in excess of 75 cubic feet shall give the compact waste disposal facility license holder written notice of the shipment at least 72 hours before shipment to the compact waste disposal facility or a federal facility waste disposal facility begins. The written notice must contain information required by the Texas Department of State Health Services (TDSHS).

The Waste Acceptance Plan (WAP) in the application provides a summary of the waste characteristics and waste form requirements, packaging criteria, categories of waste for receipt verification, generator and waste approval process, waste receipt process, discrepancy resolution, and if necessary, waste rejection in accordance with the standard operation procedures (SOPs). The WAP also establishes mechanisms for verification of incoming waste upon receipt, including visual inspection for conformance with Waste Profile Form and shipping manifest, radiological surveys for consistency with modeled external doses, and in some cases, sampling and radiological analyses.

Waste receiving, inspection, and acceptance process flow is presented in schematic form in Figure 5-1 of the application.

3.4.1 Waste Acceptance, Classification, and Rejection Process

The WAP in the application provides a summary of the acceptance criteria for the Compact Waste Facility (CWF), Federal Waste Facility - Containerized Disposal Unit (FWF-CDU), and Federal Waste Facility - Non-Containerized Disposal Unit (FWF-NCDU) facilities. The application proposes six waste streams for acceptance: bulk soil, bulk debris, container soil, container debris, high dose rate, and cask waste.

Waste certification and verification requirements and summary steps are provided in Table 5-2 of the application. Pre-shipment authorization must be obtained before waste is shipped. When the waste shipment is received, the application states that a comparison of the pre-authorization with the shipment manifest will be made before continuing the waste acceptance process.

The application states that components that are too large to go into canisters will be evaluated on a case-by-case basis. No specific details are provided. Specific pre-planning will take place before any large component is approved for disposal.

The application discusses documentation provided by waste generators, identifying the waste classification per 30 TAC §336.362(a). A Waste Profile Form (WPF) is prepared and includes the relevant radionuclides and associated activity concentrations. The application states that the WPF is used in the pre-approval process and verified when the shipment is received. Waste acceptance and classification procedures are found in Appendix 5.5 of the application

The application states that significant discrepancies discovered during the waste receipt inspection must be resolved before the waste is accepted for disposal. Discrepancies mentioned in the application may be related to manifests, shipping documents, waste analyses or external assays. Unresolved discrepancies, safety issues, regulatory violation, or license violations are identified in the application as resulting in the waste being rejected and returned to the generator ensuring compliance with applicable United States Department of Transportation (DOT) requirements. Discrepancies are classified by severity into minor, moderate, and major classes as described in Appendix 5.2-1 of the application. The application presents a scheme for tracking generator discrepancies individually and cumulatively. This scheme lists three minor discrepancies in a year by a generator as one moderate discrepancy. Each moderate discrepancy will result in a hold being placed on future shipments and a quality review is initiated. Three moderate discrepancies in a year will count as one major discrepancy. The application states that waste shipments will be rejected for any major discrepancy, the generator will be designated as non-compliant, and generator's identification number will be suspended. The application states that an on-site audit will be conducted of that generator prior to reinstatement. Procedure LL-P-2.2 in the application provides a list of conditions for suspension and remedial actions for waste generator reinstatement.

The application states that containers with visible physical damage will not be accepted and will be returned to the generator or transferred to an off-site facility as directed by the generator. A clear reference to a procedure for this rejection was not given in the application. It is important to clearly identify who is responsible for verifying that off-site facilities are properly licensed to receive rejected waste, and the methodology for initial qualification and on-going assessment. The Executive Director recommends a license condition that requires notification of the shipper and the Executive Director's resident inspector when it has been determined that a low-level radioactive waste shipment or part of a shipment cannot be accepted for disposal, that waste is returned to an authorized facility, and a detailed written procedure for this process.

3.4.2 Analysis/Inspection Techniques

The application states that radiological surveys and inspections will be done on the transport vehicle(s) and waste package(s) on all shipments. Additional inspections or sampling are stated to be completed as necessary. The application states that waste with high radiation fields (that is, greater than 100 millirem per hour), pathogenic hazards, or other occupational risks will not be subject to invasive sampling due to potential health concerns, including the ALARA standard. Waste acceptability for disposal is stated in Section 5.2 of the application to be determined by completion of inspections, radiological surveys, verification techniques, sampling, and analytical procedures.

Appendix 5.5 of the application discusses that waste generators must submit a Waste Profile Form and supporting information for review and approval before issuing the contract to accept waste. (Procedure LL-OP-2.1). The application states that each generator will characterize with sufficient precision radionuclide concentrations in each waste shipment in order to accurately classify it according to Tables I and II of 30 TAC §§336.362(a)(3)(D) and 336.362(a)(4)(E). Appendix 5.5 also states that information provided by the generator will be used to verify the waste shipment after it arrives at the facility (Procedure LL-OP-2.5.). Related procedures and application discussions on inspection and analysis of incoming waste shipments need more details. For instance, the application contains no discussion of statistically-based procedures capable of quantifying the quality of the waste acceptance procedures in terms of Type I and Type II decision errors. There are a variety of statistical techniques that can be used in waste acceptance decision-making. As part of these techniques, it is important to specify appropriate sampling and re-sampling rates, sampling frequencies, significance level, and minimum effect sizes and their associated power levels. The Executive Director recommends a draft license condition to require the submission of updated and detailed procedures used for verification of waste packages and bulk wastes at the land disposal facilities. Sampling procedures should include statistical techniques to assess decision errors in waste acceptance decision-making with sufficient details, including sampling rates, sampling frequencies, and significance levels.

3.4.3 Waste Characteristics

The application states that each waste stream is the result of a particular process or activity at each waste generator. The waste streams are segregated by waste class and then by waste group. Waste streams are classified in the application into three broad categories for the CWF: utility, non-utility, and reactor decommissioning. They are further grouped according source state (Texas or Vermont). The application further discusses 38 possible waste streams. Table 8.0-1-2, in Appendix 8.0-1 of the application gives a complete listing of these 38 possible waste streams acceptable at CWF.

It is proposed that the CWF will accept utility and non-utility waste. Most of the utility waste from nuclear power plants consists of protective clothing, filters, resins, and discarded non-fuel reactor components. The non-utility waste streams come from hospitals, universities, research institutions, and industries. Wastes are classified according the waste class types, namely Class A, B, and C low-level radioactive waste. WCS also lists 18 waste groups. Liquid waste requires solidification before shipping. Similarly, filter sludge, resins, and other residue materials containing liquids must be solidified or dewatered prior to shipping. The shipping manifests are required to contain details of physical and chemical forms of the waste. Any treatment of waste should be noted on the manifest. Chelating agents must also be listed by name and quantity, if it exceeds 0.1 percent by weight. The application provides a listing of possible physical forms of CWF waste streams in Table 8.0-1-3 of Appendix 8.0-1. Table 8.0-1-11 of this Appendix shows pre-treatment, chelating agent presence, transuranic and long half-life radioisotope information for each of the 38 CWF waste streams. The radiation condition data of the manifest gives the worker exposure rates, whether canister container is to be used, whether it is contact or remote handled type, and presence of high radioactivity. The application states that federal waste will be received from continuing operations, such as United States Department of Energy (DOE) production, research labs, and weapons facilities, and environmental restoration and cleanup at DOE sites.

Section 2.3 of the application WAP prohibits waste with free-standing liquids in excess of one percent by volume and bulk wastes with free-standing liquids in excess of 0.5 percent by volume. As a part of the Waste Profile Form, the generator is required to supply the supporting documentation used to determine the percent by volume of free-standing liquid in each waste.

The WAP for the proposed disposal facilities/units describes a plan to obtain, verify, and confirm the suitability of each waste shipment prior to contracting to receive the waste. Each shipment arriving at the facilities will be verified to be in conformance with regulatory and operation compliance for the designated disposal unit. The application states that safe handling procedures that maintain worker radiological exposures to "as low as reasonably achievable" (ALARA) criteria will be identified and used. However, the application does not provide how ALARA will be specifically achieved. The operational procedures, emergency preparedness features, radiation safety program and procedures, and ALARA design features are reviewed under Section 2.3 of this analysis.

The application states that each disposal unit will contain only those wastes that are authorized to be disposed in that unit. The Executive Director recommends a license condition that prohibits commingling of waste and requires the separation of operations to reduce the potential for commingling of waste. In order to ensure compliance with the WAP and with regulatory requirements, a draft license condition was established so that a TCEQ representative should inspect, and perform other analysis as deemed necessary, before waste acceptance.

The application states that components that are too large to go into canisters will be evaluated on a case-by-case basis. The application states that specific pre-planning will take place before any large component is approved for disposal. This is not consistent with statements made elsewhere in the application that only containerized waste will be disposed of in the CWF. The Executive Director recommends a license condition to address the review and approval of case-by-case component determinations.

Again, the SOPs provided in the application are not specific on some critical tasks and should to be organized in the ISO 9000 format or similar such format. Procedures should be written and organized in progressively increasing levels of specificity from broad corporate quality/environmental/operations systems manual down to detailed work instructions of each specific operation. Compliance with the reviewed procedures in the application is specifically required in a license condition. Although there is flexibility given in the procedures as allowed by the issuance and performance of radiation work permits and other specific tasks at the proposed facility, the activities covered under procedures are the collection of the basic operating instructions. These operating instructions comprise the unit operations that, in combination or used singly, make-up the sequence of work steps necessary for the formulation of a radiation work permit. Due to the nature of the standard methods provided in procedures, it is necessary for proposed changes to procedures to be reviewed for potential health and safety impacts. Changes to the procedures can be made in accordance with requirements at 30 TAC §305.62.

3.5 Interim Storage, Processing, and Handling of Waste

Title 30 TAC §336.707(5) requires the applicant to submit specific technical information needed for demonstration that the performance objectives and the applicable technical requirements of this subchapter will be met. The application shall include a description of the operation of the land disposal facility. The description shall include, waste emplacement; the procedures for and areas of waste segregation; methods and areas of waste storage; facilities for and methods of processing waste including improperly packaged shipments. Title 30 TAC §305.54(f) requires that the applicant for new licenses describe in the application how facility procedures for operation, will minimize, to the extent practicable, the generation of low-level radioactive waste, contamination of the facility, and the environment.

Title 30 TAC §336.708(a)(5) requires that the application include site-specific flow diagrams of waste processing and disposal operations, a description and accurate drawings of processing equipment, and any special handling techniques to be employed. Appendix 5.3.2 of the application provides a flow chart for each disposal area (CWF and FWF), with the majority of the steps being identical.

The application in Section 5.2.5 states that there will be no interim storage, or processing of wastes at the CWF or FWF. However, the waste backlog handling process described in the application could be considered interim storage. There is no information in the application concerning the interim waste storage requiring special handling or remediation, or waste handling procedures for which disposal has been intentionally deferred. Additionally, the application does not provide scenarios or reasons for a backlog of waste to occur. Since pre-shipment notification and approval is required prior to initiating any waste shipment, it is unclear why a backlog of waste shipments at the disposal facility would occur or why disposal of a waste shipment would be deferred other than in emergency or unusual conditions. In fact, the application states that the pre-approval method for waste is to help reduce the chance of a backlog. A detailed methodology for isolating, handling, and monitoring of interim storage, or backlogged waste, is not presented in the application. The Executive Director recommends a license condition to address the potential for interim storage of waste and requiring notification to TCEQ if waste cannot be disposed within 24 hours of receipt.

After waste has been accepted as specified in Procedure LL-OP-2.5, Waste Shipment Compliance Verification, the application states that the shipment is allowed to proceed to the specific disposal facility (either CWF or FWF). The CWF and FWF will have their own staging areas for incoming waste.

The application provides that the CWF and FWF have their own operational support areas for offloading and turnaround. Each one of these support areas includes staging buildings for offloading waste packages, and decontamination buildings for vehicle and equipment. Waste package will be off-loaded using pallet movers, lift trucks, or manual transfer techniques. Floor plans for these buildings are provided in Appendix 3.02 of the application.

After the transport check-in, weighting, vehicle inspections, and verification surveys are completed in the common fenced area between the main facilities gate and the disposal facilities gates, the application states that the waste will remain on the original shipment vehicle to ensure waste destined for the CWF and FWF will not be commingled. The application describes a process for marking waste packages with individual bar codes for tracking subsequent movements on-site. The application states that waste shipments received in shielded casks will not be barcoded. The application does not specify how waste received in shielded cask will be tracked, without using a barcode as noted in Section 5.7.1 of the application.

The application describes two types of waste shipments entering the CWF and FWF: contact-handled (CH) waste, including bulk waste and defined as having dose rate less than 0.1 rem per hour, and remote-handled (RH) waste, having a dose rate above 0.1 rem per hour at 30 centimeters. The application states that during normal staging operations, WCS personnel will not come into contact with waste, as all waste will remain inside the shipping containers. The application also provides an exception - CH waste packages and bulk packages that are opened for sampling or inspection. The application states that shielded or remote handled waste will not be staged, unloaded, or handled in operations support area but will be sent directly to the appropriate disposal unit.

The application states that waste packages or all other non-shielded waste packages will be staged in the container staging building. Procedure LL-OP-3.1, Waste Staging in the Container Staging Building, describes the process for waste staging. The Operations

Supervisor will direct unloading of waste containers into staging buildings. The design of the staging building presented in the application allows handling of a variety of shipment types and allows lifting equipment access to shipping media, including flat bed trailers, enclosed vans, and low-boy trailers. The application describes waste package transfers from transport vehicle to raised staging platform using dedicated lift trucks such as Toyota four-ton forklifts or equivalent, and waste drums and drums on pallet off-loaded using hydraulic lifts or with a drum grappler attachment to a forklift. If sampling is required, the waste packages will be transferred to sampling room, where the sampling is performed according to Procedure LL-OP-4.0, Non Destructive In-Situ Gamma Ray Spectroscopy or Procedure LL-OP-4.1, Sampling Contact Handled Waste.

The application describes a process for handling discrepancies in waste packages accepted for disposal based on the ability to resolve the discrepancy satisfactorily with the generator. Containers with visible physical damage will not be accepted for disposal and will be returned to the generator or transferred to an off-site facility as directed by the generator. Pending the appropriate action, the damaged waste packages will be enclosed or emplaced in overpacks according to Procedure LL-OP-9.6. Each disposal facility has separate operations support areas for off-loading, turnaround, staging, and decontamination. Staging and decontamination are performed in a separate building within each disposal facility. If during the staging process a waste package is damaged or a spill occurs, the package/spill will be contained and the area secured to limit contamination according to application Procedures LL-OP-9.6 and LL-OP-9.7.

3.6 Waste Disposal

Rule 30 TAC §336.707 requires the applicant to submit specific technical information to adequately demonstrate that the performance objectives and the applicable technical requirements of this subchapter will be met. The application shall include a description of the construction as well as operation of the land disposal facility. The operational details including detailed methods and procedures are required regarding waste emplacement, segregation, interim storage, and processing. The operational details including detailed methods and procedures are required on handling, segregation, and temporary storage of improperly packaged shipments. Title 30 TAC §305.54(f) requires the applicant describe how facility procedures for operation will minimize, to the extent practicable, the generation of low-level radioactive waste, contamination of the facility, and the environment.

3.6.1 Operating Procedures and Flow Diagram

Section 5.4 of the application provides an overview of the waste disposal operations. Section 5.3 of application provides a summary of the staging and handling of wastes. Operating procedures for these processes are provided in Appendix 5.5 of the application.

Operating procedures are provided in the application for the following activities:

- Waste Staging in Container Staging Building (Procedure LL-OP-3.1);
- Waste Staging in Bulk Staging Building (Procedure LL-OP-3.2);
- Disposal Pallet Assembly (Procedure LL-OP-3.3);
- Concrete Canister Receipt/Acceptance (Procedure LL-OP-5.1);
- Concrete Canister Placement (Procedure LL-OP-5.2);
- Placement of Contact Handled Waste in Canisters (Procedure LL-OP-6.1);
- CDU Waste Placement Cask CNS 21-300 Handling (Procedure LL-OP-6.2);
- CDU Waste Placement Cask CNS 8-120B Handling (Procedure LL-OP-6.3);
- Grouting and Canister Closure (Procedure LL-OP-6.4);
- Interim Cover Placement (Procedure LL-OP-8.1);
- Dust Suppression (Procedure LL-OP-9.1);
- Cask Inspections and Surveys (Procedure LL-OP-9.2);
- Container Decontamination (Procedure LL-OP-9.3);
- Transport Vehicle Decontamination (Procedure LL-OP-9.4);
- Decontamination Water Management (Procedure LL-OP-9.5);
- Overpacking Waste Containers (Procedure LL-OP-9.6);
- Spill Response (Procedure LL-OP-9.7); and
- Non-Routine Operations (Procedure LL-OP-9.8).

3.6.2 Containerized Waste Emplacement

The application states that all incoming contact-handled waste that is accepted for disposal is internally transported to the disposal cell by WCS trucks. The application states that remote-handled waste transported in casks will not be staged but directly placed in a disposal cell. Remote-handled waste shipments arriving in shielded casks will be directly disposed and will not be off-loaded or staged prior to final placement.

Section 5.4 of the application states that all the waste disposed of in CWF and FWF-CDU will be placed into concrete canisters. The application proposes the use of rectangular or cylindrical modular concrete canisters (MCC). The application states that rectangular canisters will be designed to hold B-25 boxes or other irregular shapes, while the circular canisters will be designed to hold drums and metal or polyethylene shipment cask liners. The number and type of empty MCCs to be placed and readied to accept waste, is based on the waste shipment scheduled. A forklift or crane will move empty MCCs into place in a staggered, nested array with 12-inch spacing between each MCC. Waste shipments will be off-loaded from the transport vehicle with a forklift or crane, using a quick release rigging, and then lowered into the MCC. The application states that a temporary lid will be placed on the MCC until the MCC is grouted (filling internal voids inside MCC with controlled low-strength materials). The Executive Director recommends that specific procedures be developed and used for off-loading and waste emplacement based on the type of waste disposal packages received and address the rigging needed for safe lifting.

The application proposes emplacement of the first tier of MCCs in the CWF on granular material and in the FWF-CDU on concrete pre-cast pads. The subsequent layers of

MCCs will be placed directly on the layer below, taking care to place similarly shaped MCCs over each other. The application states that rectangular canisters will be placed staggered on top of rectangular canister and the cylindrical canisters will be placed staggered on top of cylindrical canisters. The void space between MCCs is proposed to be filled with sand. The granular material base on which the first layer of MCC are to be placed is not described in the application. The Executive Director recommends that the designs, plans, and specifications for the sand used for the base on which the first layer of MCCs are placed be provided and include the material properties, characteristics, quality, layer thickness and placement method for both the base layer and materials used to fill void spaces between MCCs.

The application states that waste shipped by shielded cask will require additional precautions to ensure the amount of radiation doses to workers are maintained ALARA. However, the application does not provide details on what precautions are to be considered. Appendix 5.5.2-2, ALARA Design Features, included only a few examples of commercially-available equipment that could be used to support WCS ALARA goals.

The last paragraph on the Page 5-18 of Section 5.4 of the application reads:

> Waste shipment arriving at the LLRW facility in shielded shipping casks will require additional precautions to ensure radiation doses to workers are maintained ALARA. Appendix 5.5.2-2, "ALARA Design Features," provides a discussion on the ALARA design of the LLRW facility. Included are examples of commercially available equipment that will be used to support WCS ALARA goals. Two example cask handling Procedures LL-OP-6.2, "CDU Waste Placement Cask CNS21-300 Handling," and LL-OP-6.3, "CDU Waste Placement Cask CNS 8-120B Handling" are provided to better illustrate how these waste types may be handled.

In order for ALARA to be incorporated into operations involving shielded casks, sufficient detail in procedures is necessary to ensure that appropriate precautions can be taken. The application lacks details on what equipment will be used or what precautions will be followed regarding these operations with respect to ALARA.

Once a MCC has been filled with waste, the remaining internal voids will be filled with grout according to the Procedure LL-OP-6.4, Grouting and Canister Closure. The grout is proposed to be placed using a mobile pump truck or crane feed hopper. The application proposes to place grout in multiple layers to avoid floating. After the grouting inside a filled MCC is completed, the application states that either the next layer of MCC is placed on top or closed off with a pre-fabricated lid. Since permanent pre-fabricated lids are not planned for each filled MCC, then the precise placement of MCC layers is critical to maintain stability in the open disposal units.

The application states that some placement and grouting operations may require special planning for radiation dose control, and additional MCCs are likely to be placed in front of an empty MCC to provide additional shielding for high radiation field waste. The application does not provide details of what will trigger special planning or what scenario would be considered high radiation dose potential. The application does not clearly identify the types of "high radiation field waste" or situations which require special planning for radiation dose control during placement of MCCs. The application also does not provide specific action plans, and associated detailed procedures. The action plan provided in the application states that "additional MCCs are likely to be placed in front of an empty MCC to provide additional shielding for high radiation field waste." The Executive Director recommends that more specificity be provided on procedures for the operations involving waste packages that require special planning or have high radiation potential, detailed methodology for identifying the types of "high radiation field waste" and situations which require special planning for radiation dose control during placement of MCCs.

3.6.3 Segregation of Waste

Rule 30 TAC §336.730(a) requires that Class A low-level radioactive waste that does not meet the stability requirements of 30 TAC §336.362(b)(2) to be segregated from other wastes by placing the wastes in disposal units which are sufficiently separated from disposal units for the other waste classes so that any interaction between the disposal units shall not result in the failure to meet the performance objectives specified in 30 TAC §336.723.

The application states that since the waste placed in CWF will be in MCCs, the waste will meet the stability requirements of 30 TAC §336.362(b)(2). In Section 5.4, the application proposes to segregate waste by placing high activity Class A, B, and C low-level radioactive waste in MCCs, and placing stable low-activity Class A waste in canisters. It is not clearly stated in the application that different waste classes will not be intermixed within the same canister.

The application states in Appendices 5.2-1 and 5.5 that the FWF-NCDU will only accept Class A low-level radioactive waste that meet the stability and radiological requirements for bulk wastes per the Waste Acceptance Plan (WAP). However, bulk waste proposed for disposal in the FWF-NCDU is not anticipated to meet the stability requirements due to its physical form.

A particulate air emissions study should be provided to demonstrate that wind dispersal of the bulk waste placement will not affect the general public and individuals during operation, specifically in high-wind events that are known to occur in the site area. The Executive Director recommends a license condition that requires the submission of a particulate air emission study for the FWF-NCDU which is to include wind erosion of the exposed waste face as a mass air emissions rate factor in the air dispersion modeling; the study should evaluate high wind velocity events, consider maximum wind gusting velocities, and estimate the total annual mass loss of Class A bulk low-level radioactive waste from the FWF-NCDU, due to particulate air emissions, under anticipated average, and high-wind operating conditions. The Executive Director recommends that a conclusive engineering report include the information as given below:

- An evaluation of the expected effectiveness of water spraying, with and without chemical additives, in controlling particulate air emissions from the exposed waste face in the FWF-NCDU. The study should address the emissions control effectiveness during both average seasonal wind velocity and the highest wind velocity events taken from National Weather Service recorded data from the past 25 years for Midland/Odessa, Texas. The study should include an evaluation of the ability to apply water sprays in winds exceeding 25 miles per hour, given the tendency for wind erosion of the waste surfaces, and droplet entrainment at higher wind speeds. The evaluation should be based upon new testing, or documented performance testing under similar conditions from prior studies, which may include spraying systems manufacturers' performance data.

- A particulate air emissions study for the FWF-NCDU should include wind erosion of the exposed waste face as a mass air emissions rate factor in the air dispersion modeling. High wind velocity events should be taken from National Weather Service data for Midland/Odessa Texas from the past 25 years, and are to be used in computing wind erosion mass air emissions for one-hour, 24-hour, seven-day, 30-day, and annual averaging periods. Maximum wind gusting velocities and the frequency of wind gusting; as well as average sustained wind velocities should be considered in the analysis. Any credit taken for emissions control due to the sheltering effect of subsurface disposal must be validated by modeling, or by documented performance testing under similar conditions from prior studies. Any credit taken for emissions control by water spraying, with or without surfactants, of the exposed waste face must be consistent with the evaluation of this method as provided above. The study should include an estimate of the total annual mass loss of Class A soil and soil-like low-level radioactive waste from the FWF-NCDU, due to particulate air emissions, under anticipated average, and high wind operating conditions.

3.6.4 Covering of Emplaced Waste

In Section 5.4.4.3, the application states that: "Waste placement in both FWF and CWF will be placed within Dockum red bed clay at the site. The waste will be placed at an elevation of 25 to 40 feet below existing top surface of cover, which is well below the required five meters. In addition to this, there is a bio barrier as detailed in Figure 3.5.1-1 of Section 3." Rule 30 TAC §336.730(b) requires that containerized Class A, Class B, and Class C low-level radioactive wastes must be disposed within a reinforced concrete container and within a reinforced concrete barrier, or within containment structures made of materials technologically equivalent or superior to reinforced concrete; in such a manner that the waste can be monitored and retrieved; and 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.

3.6.5 Records of the Location Emplaced Waste

The application provides, in Section 5.4.4.2, the following to address records of emplaced waste:

> Data generated from the leachate collection system, along with operating records, waste manifest data, and sump and tank radionuclide concentration will be evaluated to identify locations in cells where unexpected radionuclide releases could be originating. Details on monitoring are provided in Section 7.2, and in Appendix 7.3.2, Early Warning and Corrective Action Plan. As each waste shipment is placed, its location in three dimensions within the cell is recorded. The location information, coupled with sump monitoring data and settlement data, is a means by which waste performance is monitored. Placing the waste in reinforced concrete canisters and fill internal voids with controlled low-strength materials (CLSM) grout assures that the waste will be retrievable should the need arise.

The application states that as each waste shipment is placed, its location within the cell is recorded in three dimensions. It is important that there be procedures that include identification of the responsible individual, the time, and location of waste emplacement in three dimensions within the disposal unit. There should be verification of the methodology on how filling the voids with CLSM grout provides assurance that the waste will be retrievable should the need arise. Rule 30 §TAC 336.740(f) requires the licensee to record: the date waste is received; the date waste is disposed; a traceable shipment manifest number; a description of any engineered barrier or structural overpack used for disposal; the location of disposal at the disposal site; the containment integrity of the waste containers; any discrepancies between manifest and waste received; the volume of any pallets, bracing, or other shipping materials that are disposed, and any evidence of damaged or leaking disposal containers or radiation or contamination levels in excess of DOT or NRC limits.

3.6.6 Management of Waste Generated On-Site

Operational activities, including waste sampling, could result in the generation of on-site waste. The application states that this waste will be packaged at the generation point, labeled, and transported to the staging building. This waste will then be evaluated according to the waste acceptance process. Any on-site generated waste must also meet the license condition prohibiting the commingling of federal facility waste and compact waste based on the constituents' originating source. If necessary to meet the WAP and license conditions, the waste will be shipped off-site for treatment. Procedures LL-OP-2.8 and LL-OP-2.9 can be found in the application. The handling of water from on-site decontamination activities is addressed in Procedure LL-OP-9.5. The application states procedures and administrative controls ensure that the waste generated within each facility will be disposed in the correct facility. Again, the Executive Director recommends a license condition prohibiting commingling of waste.

3.6.7 Other Parameters

Texas Health and Safety Code §401.218(b)(1-2) requires that the compact waste disposal facility license holder shall dispose of Class B and Class C low-level radioactive wastes within a reinforced concrete container which will then be placed within a reinforced concrete barrier or within containment structures made of materials technologically equivalent or superior to reinforced concrete and in such a manner that the waste can be monitored and retrieved. Rule 30 TAC §336.730(b)(2-3) requires that wastes designated as containerized Class A, Class B, or Class C low-level radioactive waste under 30 TAC §336.362(a) or §336.702 be disposed of in such a manner that the waste can be monitored and retrieved and 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.

Section 5.4 of the application states that the disposal unit designs for the CWF and FWF-CDU will have a reinforced concrete floor, sidewalls, and cap. The application provides that data generated from the leachate collection system, along with operating records, manifest data, and sump and tank radionuclide concentrations will be evaluated to identify areas where unexpected releases could have originated. The waste placement in both the FWF and CWF will be within the Dockum red bed clay and at a level between 25 and 40 feet below the existing top surface of the cover, providing at least five meters of intruder barrier. The proposed FWF-NCDU includes the same cover and liner elements as the CWF and FWF-CDU, with the exception of the reinforced concrete layer beneath and on the side walls of the disposal unit. In the FWF-NCDU, a liner system is used in place of the concrete layer. Figure 5.4.1-2-2 and 5.4.1-2-3 in the application illustrate proposed liner components for the FWF-NCDU.

Chelating agents are contained in some resin wastes that are proposed for disposal. Metal ions are bound by the chelating agents and the chelating agents are bound by the resins. The application states that metal-chelating agent complexes cannot be released from the resin unless the resin is treated with a strong acid or the resin degrades. The application concludes that resins are stabilized before disposal by dewatering or solidification, so the nuclide release rates from the waste form will be minimal. The application states that chelating agents, and other non-radiological substances identified in the proposed waste streams, will not affect the ability of the disposal facility to meet the performance requirements. The analysis of chelating agents in waste proposed for disposal is presented in Appendix 8.0-1 of the application. There is a limitation mentioned in the application of eight percent, by weight, on chelating agents. This limitation has also been incorporated as a draft license condition.

3.6.8 Non-Containerized Federal Facility Waste

The application proposes that Class A low-level radioactive waste from federal facilities that is soil-like, debris-like, or rubble type, be disposed in the FWF-NCDU. Soil-like waste that is transported in intermodals/roll-offs or reusable transport containers will be sent to the unloading area as described in Procedure LL-OP-7.1, Non-Canister Soil Placement. The application states that each soil-like, debris-like, or rubble type waste shipment will be inspected visually within the original shipping container to confirm the waste conforms to the waste profile. The application refers to specific tests that may also be completed prior to placement to ensure the material is consistent with the profile that was approved. The Executive Director recommends that procedures address the specific circumstances in which tests would be performed and the tests that might be considered related to non-containerized waste.

The application proposes unpackaged, non-soil-like low-level radioactive waste be transported to the FWF-NCDU on WCS-owned and operated trucks and emplaced in the disposal unit according to the Procedure LL-OP-7.2, Non-Canister Debris/Rubble Placement. The application states that unpackaged waste will be skip-loaded to the disposal unit for final placement and compaction as described in Procedure LL-OP-7.3, Non-Canister Compaction Testing. The application states that care will be taken to place the waste so that the overall stability of the disposal unit is assured. Because the application did not clearly demonstrate stability of proposed disposal of debris and rubble in the FWF-NCDU, the Executive Director recommends a license condition requiring that all debris and rubble be containerized.

Appendix 5.2.1-2 of the application states that if a waste stream, currently identified as stable and eligible for disposal in the FWF-NCDU, is later determined not to meet the stability requirements the applicant plans to place it in the FWF-CDU along with all other waste forms requiring structural stability. Void spaces within and between the waste and its package will be reduced to the extent practicable by the generator, prior to acceptance.

The application proposed that water be added to emplaced waste to enhance compaction and reduce fugitive dust emissions. A license condition is proposed to address minimizing the introduction of water into the disposal units. The optimum moisture levels for efficient compaction are in the range of five to 15 percent for most embankment fill. The application proposes to spread soil-like bulk waste in one-foot thick lifts and with an area of 10,000 square feet. Lifts are proposed to be compacted using static or vibratory compaction equipment to increase dry density. Shallow lifts ensure compaction is effective throughout the layer, and can be achieved in an efficient manner. The bulk waste disposal unit is to be constructed as a series of compacted soil lifts; each compacted to a specified minimum density based on modified Proctor testing values. Dry density values for soil-like waste are anticipated to range from 100 to 145 pounds per cubic feet. The Executive Director recommends a license condition to address the parameters and conditions for the disposal of soil and soil-like waste in the FWF-NCDU.

The application provides that Procedures LL-OP-7.1 and LL-OP-7.2 are proposed to be followed for waste emplacement operations. Some aspects of the FWF-NCDU operation provided in the application areas follows:

- Except for Group A-1 materials, soil-like waste will be compacted to 90 percent of modified Procter maximum density with moisture at plus or minus two percent range of optimum per ASTM D-1557 or AASHTO T180;
- Density is measured with nuclear density gauge measurements per ASTM D-2922 or AASHTO T310 for every 10,000 square feet of area but not less than one per lift;
- Sand cone density test will be done for 30 nuclear density gauge measurements;
- Additional tests could be performed if deemed necessary by the Operation Supervisor;
- Placement of soil-like waste under freezing conditions is prohibited;
- After the weather conditions become suitable again, the density measurements will be taken on already placed material before start of placement; and
- Emplaced soil-like waste will be reworked if nuclear density gauge results indicate unacceptable compaction after freezing conditions clear.

Although given as a method for waste compaction, the application does not explain the applicability of the American Association of State Highway and Transportation Officials methods (AASHTO) to low-level radioactive waste disposal. The application proposes that rubble will be incorporated into a soil-like waste matrix by spreading the rubble fraction across the lift area so that the material is evenly spread across the lift area without nesting. Following this rubble layer, it is proposed that soil-like material will be placed on top of the rubble base, finishing with compaction of the soil layer into the rubble base to create a composite lift of both materials. As with the soil-like material, the application provides that rubble will be inert, solid, and volumetrically stable. Appendix 5.2.1-2 of the application states that any interstitial voids between the rubble elements are filled by the granular soil-like waste as a result of compaction.

For rubble or debris wastes, the application describes that placement must be evaluated to ensure there is sufficient soil-like waste material available in order that both waste types can be placed together. If soil-like material is not available, clean fill material can be used in place of contaminated fill. These operational statements in the application for the disposal of rubble and debris lack detail. The application defines rubble-like waste as waste that can be emplaced and spread. Demolition items are categorized in the application as rubble if the maximum dimension of individual particles is less than six inches. The application mentions planned waste emplacement so that rubble and debris items are spaced so that nesting and bridging is precluded. The application proposes to allow individual waste container received at the FWF-NCDU containing random mixtures of soil-like waste, debris, and rubble. The application is not clear on how emplacement of heterogeneous debris items will ensure that void spaces are filled and how required compaction will be achieved.

The application presents a general emplacement scenario where debris items will be individually picked and placed, but indicates that there may be exceptions. However, these exceptions were not listed in the application and related procedures for waste emplacement with consideration of ALARA were not provided. The application states that heavy construction equipment will flatten ductile items to reduce voids and work irregular pieces into the underlying disposal layer, if appropriate. This flattening description lacks detail and oversimplifies necessary operations. Following this placement, that application states that remaining accessible voids will be filled with soil-like waste. The application does not provide information on judging or reaching accessible voids and what specialized equipment might be necessary. Because of concerns about the details for placement and disposal of debris and rubble in the FWF-NCDU, the Executive Director recommends a license condition that requires that debris and rubble be containerized.

3.6.9 Waste with Transuranic Radionuclides

Rules 30 TAC §336.733(b) specifies criteria for the disposal of wastes consisting of radionuclides with half-lives greater than 35 years and wastes consisting of transuranic radionuclides in concentrations of less than ten nanocuries per gram:

- All those wastes that are determined to be Class A low-level radioactive waste shall be placed in reinforced concrete canisters or equivalent containment structures to provide stability after disposal or shall meet stability requirements set forth in 30 TAC §336.362(b)(2); and
- Shall meet the minimum requirements for Class A low-level radioactive waste set forth in 30 TAC §336.362(b)(1).

Title 30 TAC §336.733(b) also states that the Executive Director may consider a request for an alternative to these criteria on a case-by-case basis.

The application proposes that the Executive Director use his case-by-case consideration for a broad scope request. The application presents an alternative method for disposal of some soil-like, debris-like, or rubble-like Class A low-level radioactive waste from Federal facilities at the FWF-NCDU in lieu of required containment structures meeting special criteria specified in 30 TAC §336.733(b). The alternative method proposed is open bulk waste disposal in lifts, in lieu of placement of waste in concrete canisters. This broad scope request is for a variety of possible waste types, including a range of radionuclide and hazardous constituents, heterogeneous physical configurations, and generation origins.

The application describes the alternative placement and densification of these wastes as involving compaction and water addition following embankment construction practices using heavy earthmoving machinery. The waste proposed to be disposed by this alternative would be limited to inert solids with relatively low concentrations of long lived radionuclides (half life greater than 35 years or transuranics), having minimal organic content and internal void volume. The description provided in the application does not address how organic content and void volume will be minimized. The application states that the waste would be subject to pre-disposal waste characteristics and post-placement density verification to ensure compliance with technical specifications. The application provides a generalized placement sequence consisting of placement, moistening, compaction, testing for density, and recompaction, if necessary.

The application refers to a proposed alternative to provide long-term waste disposal system performance equivalent to modular concrete canister disposal. The application states that the proposed alternative is possible because the waste being considered possesses inherent structural stability characteristics that allow placement and compaction to minimize void spaces using demolition/stabilization techniques for granular material and debris. The application states that Appendix 5.4.1-2 demonstrates long-term volumetric stability provided by this alternative is technically equivalent to concrete canister disposal as prescribed by 30 TAC §336.362 (b)(2). The statement that stability of the alternative is technically equivalent to concrete canister disposal is not supported by engineering analysis. The alternative presented in the application does not provide reasonable assurance that the alternative is as protective as concrete canister disposal.

The application states that low-level radioactive waste meeting the following requirements is allowed for the requested alternative in accordance with 30 TAC §336.733(b):

- Class A low-level radioactive waste under 30 TAC §336.362(a)(2);
- Minimum radioactive characteristics listed in 30 TAC §336.362(b)(1);
- May contain transuranic radionuclides with total concentrations below 10 nanocuries per gram;
- May contain radionuclides with half-lives greater than 35 years;
- Stability requirements of Class B and C low-level radioactive waste listed in 30 TAC §336.362(b)(2);
- Dose rates below 100 millirem per hour at 30 centimeters;
- Inert, volumetrically stable;
- Can be demonstrated to be compactable using conventional geotechnical methods; and
- Not classified as Class B or C low-level radioactive waste under 30 TAC §336.362(a)(2).

The application proposes to limit disposal under this alternative to soil-like Class A low-level radioactive waste to high volume, low-activity waste material. In the aggregate, the application states that the average mass concentration is less than two nanocuries per gram, and less than one percent of the Class A low-level radioactive waste limit. The majority of these radionuclides have half-lives greater than 35 years and an average radioactive concentration of 4.7 nanocuries per gram. The projected volume of soil-like waste proposed in the application for disposal in the FWF-NCDU is slightly less than 1,200,000 cubic yards, with a total radioactivity of approximately 7,000 curies.

The application states that specific acceptance criteria are implemented in the waste acceptance plan as provided in Appendix 5.2-1. Soil-like waste from each generator must meet these criteria for the waste to be accepted for disposal at the FWF-NCDU.

The application proposes to limit organic content to eliminate the potential for long-term biodegradation and to also limit cellulose and plastic materials that could contribute to rebound or creep mechanisms. While the proposed alternative process is tolerant of some organic or plastic materials, the application proposes to limit the presence of such materials to less than two percent as a placed average, using a combination of visual observation and analytical testing. It is not clear how visual observation could reliably and accurately determine presence of such low percentages of organics or plastic materials.

Although Table 5.4.1-2-2 of the application states that organic matter must be less than ten percent, the application also states a preference for organic content below five percent as a placed average, but no specifics are given to ensure this happens. The application states that biodegradable content will be monitored by operations personnel to ensure rubble is free of observable degradable content. The application does not provide information on how biodegradable content will be accurately monitored by personnel.

The application states that sizes of individual debris items may range up to several meters. This category of material is described in the application as distinct from rubble in that it cannot be dumped or spread as an aggregate material. These items are proposed for individual placement within a bulk lift so that internal and adjacent voids are minimized, and may require special orientation so that side voids will be available for backfilling during construction of the soil lift. The application states that this waste will not be placed in the same area as rubble material, but will be incorporated using established placement and bedding techniques developed by the construction/remediation industry.

The Executive Director does not consider that the application made sufficient demonstration to approve the general use of an alternative to concrete canisters or equivalent containment structures for bulk transuranic wastes or wastes with half-lives greater than 35 years. Therefore, the Executive Director recommends a license condition that prohibits disposal of waste in the FWF-NCDU consisting of radionuclides with half-lives of greater than 35 years and waste consisting of transuranic radionuclides in concentrations less than ten nanocuries per gram (<10 nCi/g). As provided in 30 TAC §336.733(b), the Executive Director may consider a licensee's request for an alternative from the canister requirement on a case-by-case basis.

3.6.10 Biodegradation Damage

Biodegradation occurs when microscopic organisms consume organic material. Biodegradation occurs when nutrients are available. Organic matter is the primary source of such nutrients. The application states that the potential for biodegradation and its effects on structural strength and stability are also limited because the organic content of stable bulk Class A low-level radioactive waste at the FWF-NCDU is limited.

The application proposes to limit the organic content in any single load based on American Association of State Highway and Transportation Officials T267. The application states that the use of this limit will control compromise of the structural strength and stability of soil-like waste and the stability and integrity of the FWF-NCDU cover system. The application does not explain the applicability of the American Association of State Highway and Transportation Officials T267 to low-level radioactive waste characteristics. The Executive Director recommends license conditions to limit the organic content of bulk materials received and the organic content of bulk materials that are disposed.

3.6.11 Radiation Damage

The application states that low concentrations of radionuclides, and therefore, only low radiation levels, will be present in the proposed FWF-NCDU. The projected radiation levels of the FWF-NCDU, will not exceed 300 rads per year, according to the application. Alpha, beta, and gamma radiation comprise virtually all of the radiation generated in the FWF-NCDU. The application states that alpha, beta, and gamma radiation does not create material damage to or jeopardize the structural stability of the disposal unit. Appendix 5.4.2-2 of the application discusses that while neutron radiation may cause changes that could produce physical changes leading to structural changes, levels of neutron radiation anticipated in waste to be disposed in the FWF-NCDU are low.

3.6.12 Chemical Changes

Land Disposal Restrictions (LDR) contained in federal regulations, 40 CFR Part 268, are incorporated by reference in Texas rules (30 TAC §335.431(c)). Regulation 40 CFR §268.42(d) subjects radioactive hazardous mixed wastes to the treatment standards in 40 CFR §268.40.

In order to accept mixed waste, the FWF-NCDU and FWF-CDU will need to obtain a separate Resource Conservation and Recovery Act (RCRA) permit, as a hazardous waste treatment, storage, or disposal facility. Under conditions of the RCRA permit, any hazardous waste must satisfy the requirements of LDRs, including treatment standards. Compliance with LDR treatment standards may be achieved by treating the hazardous waste to prescribed standards, treating the waste with a prescribed technology, or by demonstrating the waste form itself satisfies LDR treatment standards without treatment or processing.

As stated above, soil-like waste to be disposed of in the FWF-NCDU must satisfy LDR treatment standards in order to be acceptable for disposal. Thus, concerns about possible chemical changes occurring in the waste are mitigated by these requirements. LDR treatment standards produce physical or chemical changes in the waste to reduce the toxicity or mobility of hazardous constituents prior to disposal. Satisfying LDR treatment standards makes mixed waste with both a hazardous component and also a radioactive component acceptable for land disposal. The waste generator will be required to test each waste stream to verify its acceptability under LDR as a pre-condition for acceptance for disposal.

3.6.13 Thermal Cycling

Appendix 5.4.1-2 of the application states that the potential for freeze-thaw cycling of soil-like Class A low-level radioactive waste is limited. The application also states that the maximum and minimum temperatures observed in Andrews, Texas, over the 30 years between 1971 and 2000 are 102.8 °F (39.3 °C) and 13.7 °F (minus 10.2 °C), respectively. The application further states that the proposed FWF-NCDU includes the same cover and liner elements as proposed for the canister disposal unit, with the exception of the reinforced concrete layer beneath and on the side walls of the FWF-NCDU disposal unit.

The application states that site meteorological data extends back to January 2000 and contains six years of data. Appendix 2.3.1 of the application also includes meteorological data from four nearby, off-site weather stations as summarized in Tables 1 through 43. The additional off-site weather stations are located in the cities of Andrews and Midland, Texas and Jal and Hobbs, New Mexico, with the earliest records coming from Hobbs and Andrews in 1914. Temperature measurements taken on-site were not included in the tables; however, data from the nearby weather stations indicate that the temperature may range from a daily maximum of 116 degrees Fahrenheit (^{o}F) down to a daily minimum of negative 11 degrees Fahrenheit (^{o}F). The on-site data also indicates that the annual precipitation ranged from five inches to 30 inches of precipitation with an average of approximately 16 inches per year. Meteorological data from the nearby weather stations show similar ranges of precipitation. Data from these tables were used as parameters in the computer simulations discussed above.

3.6.14 Water Management

Section 5.4.1.4 of the application discusses generation, management and disposition of five categories of waste water. These are contact, non-contact (stormwater), decontamination area water, laboratory/emergency wash, and sanitary waste water streams. The application defines contact water as the water that is collected as leachate from active or closed disposal units, stormwater collected within active disposal units, decontamination facility wash water, intermodal staging area water, water from leachate/stormwater collection tanks.

The application points to Procedure LL-OP-2.8, Managing On-Site Generated Waste, for operations associated with contact water management on page 5-21 of Section 5. However, this procedure only provides details of roles and responsibilities of handling contact waste water and the documentation required. The application provides Procedure LL-OP-9.1, Dust Suppression, which involves using contact water from the waste disposal units for dust control. There is a potential for contact water to be entrained by the wind and can become a release pathway, therefore, it is recommended that contact water is not used for dust suppression. The Executive Director recommends a license condition prohibiting the use of contact waste for dust suppression.

The application contains other associated procedures for contact waste management: Procedure LL-OP-2.8-1, On-Site Generated Waste Profile Form; Procedure LL-OP-2.8-2, On-Site Generated Waste Compliance Review Form; and Procedure LL-OP-2.8-3, On-Site Generated Waste Tracking Form. The application does not provide details on waste water handling, transportation of waste water within the facility, and waste water storage tank system operation and control.

Section 5 of the application states that, if excess leachate is generated within disposal units, it will be managed in temporary storage vessels within the disposal units. The application further makes a general statement that if the leachate were to be removed from the landfill, it will be transferred to leachate collection tanks and managed according to Procedure LL-OP-2.8. The application states that leachate from closed disposal units will be transferred from the collection systems in each unit using a tank truck according to the methods described in Sections 3.5.4 and 3.5.5 of Appendix 3.0-1. Figure 5-3 of the application provides a schematic of the contact water management process flow.

Section 5.4 of the application considers as non-contact any water from buffer zones, non-excavated areas, excavated areas under construction, disposal units that have not yet received waste, access roads, and stormwater collected in secondary containment of the 500,000-gallon waste water storage tanks. The application proposes to dispose or discharge this water in accordance with Texas Pollutant Discharge Elimination System (TPDES) permit yet to be obtained. The application further states that this water may be used for dust suppression anywhere on-site, waste or fill material conditioning, or for compaction of waste in the FWF-NCDU.

The Executive Director recommends that specific procedures and process details be provided for the operations associated with the removal and on-site transport of water from the waste disposal units, waste water handling and transportation within the facility, the use and management of temporary storage vessels, and the management of non-contact water. The Executive Director also recommends license conditions for sampling water prior to reuse.

The decontamination building proposed for the disposal facility is equipped with a 12,000-gallon holding tank and associated recirculation/filtration system. The application states that the recirculation/filtration system will be operated continuously to remove solids and manage the radionuclide buildup in the water phase. Spent water filters will be placed in containers containing absorbent material to remove free liquids and profiled/managed according to Procedure LL-OP-2.8. The application proposed that water from these holding tanks will be removed using tank trucks and transferred to 500,000-gallon leachate tanks at least every six months.

The application states that the laboratory waste water consisting of analytical solutions and wash water will be collected in a 500-gallon holding tank and pumped to a mobile tank or direct haul truck for disposal at an adjacent RCRA facility. The application projects that liquid wastes generated in the laboratory will not contain radionuclides, and therefore, expects no liquid waste solutions containing radionuclides will be sent to the holding tank. However, the application also states such liquid wastes with a potential to contain radionuclides will be collected and disposed off-site separately.

The application states that the water generated by routine testing and flushing of eyewash and shower systems will be discharged into sewer system or to the environment in accordance with the TPDES permit to be obtained. Water generated during actual emergency use of equipment is proposed to be disposed according to a future TPDES permit. The Executive Director recommends that procedures are developed to assure that laboratory, eyewash and shower systems wastewaters will not contain radionuclides and provide response procedures should water from these systems or water used during emergencies become contaminated.

Regarding the water/leachate transfer system, the application states on page 5.25 of Section 5.4.1.4.4, "more detailed information on the equipment and design specifications are presented in detail in Sections 3.5.4 and 3.5.5 in Appendix 3.0-1." However, no such sections were found in Appendix 3.0-1 of the application. TCEQ staff did review the general description presented in Section 5.4.1.4.4 of the application. Detailed information was not presented in the application on the impact of rainwater/stormwater on the FWF-NCDU emplaced waste. Detailed information on process, equipment, process controls, procedures, and operational responsibilities concerning the FWF-NCDU leachate/water management system were not provided in the application. The Executive Director recommends a license condition requiring a water management study be submitted for review based on the following requirements:

- A pilot study must be conducted for the operation of the leachate/stormwater collection and management system at the proposed facility, specifically for the FWF-NCDU;
- Detailed documentation of water management system consisting of process diagrams, Process and Instrumentation (P&I) diagrams, control schematics,

equipment specifications, and detailed operation procedures prior to start of pilot study; and

- A detailed study with projected short-term and long-term impact of rainwater/stormwater on the FWF-NCDU disposal unit emplaned waste must be presented before the start of operations.

3.6.15 Electronic Record Keeping

Section 5.7-1 of the application proposes that electronic record keeping system will be used for tracking waste at low-level radioactive waste facilities as outlined in Procedure LL-OP-1.2, Electronic Waste Tracking System. It intends to use the database for tracking information on the waste profile, the manifest, waste package acceptance details, staging, and final disposal data. The application states that this system will be capable of maintaining and reporting on all mandatory records as specified in 30 TAC §336.740(i). Waste packages entering the facility not in shielded casks will be tagged with individual barcodes. Subsequent movement of each package is tracked through its unique barcode.

3.7 Mixed Waste Disposal

An applicant that is proposing to accept and dispose of mixed waste (a mixture of both low-level radioactive waste and hazardous waste), must submit a plan to meet the corresponding state and federal requirements for industrial and hazardous waste. The applicable requirements for hazardous waste are the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. 6901 et seq. and its corresponding regulations at 40 CFR Parts 266-271 and Texas Solid Waste Act, Texas Health and Safety Code Chapter 361 and its corresponding rules at 30 TAC Chapter 335. The statutes and rules require that an applicant must obtain both a radioactive material disposal license and a permit for disposal of hazardous waste in accordance with Texas Health and Safety Code §401.221 and 30 TAC §336.733(c) in order to accept mixed waste for disposal.

Section 5.6.1 of the application states that WCS intends to file an application for a hazardous waste permit in accordance with 30 TAC §335.2 There was limited information on treatment methods for meeting the land disposal restrictions provided in the application. The low-level radioactive waste disposal application did not provide a plan for compliance with 30 TAC §335. The Executive Director has a separate section of the TCEQ responsible for reviewing hazardous waste permits: the Industrial and Hazardous Waste Section of the Waste Permits Division. The Industrial and Hazardous Waste Section is conducting its technical review of the WCS application for a hazardous mixed waste permit for compliance with 30 TAC Chapter 335 during the summer of 2008. Therefore, the TCEQ Radioactive Materials Division staff did not review compliance with 30 TAC Chapter 335 requirements with regard to the hazardous component of mixed waste. The licensee may not dispose of mixed waste unless the licensee is specifically licensed under 30 TAC Chapter 336 and permitted permit under 30 TAC Chapter 335 for the disposal of mixed waste.

The application proposes to dispose of low-level radioactive waste and/or mixed waste. An applicant must submit a plan on how they will classify the waste in accordance with the waste classification criteria in 30 TAC §336.362(a). This requires consideration of the concentrations of long-lived radionuclides and concentrations of short-lived radionuclides. An application must also contain information on the waste characteristics in accordance with 30 TAC §336.362(b), which requires waste characteristics to meet certain minimum requirements for all classes of waste. These minimum requirements are intended to facilitate handling and to provide protection of health and safety of personnel at the disposal site. In addition, an applicant must demonstrate how the waste will be labeled, once it has been classified, in accordance with 30 TAC §336.362(c).

Section 5.6.2 of the application states that the FWF will only accept mixed waste for disposal if the waste, as shipped and received, is compliant with all applicable land disposal restrictions. There is no discussion provided in the application for classifying waste other than the statement that all wastes will be classified in accordance with 30 TAC §336.362. No reference is made to other parts of the application that may contain this information.

The Executive Director recommends license conditions that require the submission of a plan for the proper characterization and classification of the waste planned for disposal with a hazardous component.

Additionally, rule 30 TAC §336.229 prohibits the dilution of waste to change its waste classification. The rule states that no person shall reduce the concentration of radioactive constituents by dilution to exemption levels or to change the waste's classification or disposal requirements. Radioactive waste that has been diluted as a result of stabilization, mixing, or treatment, or for any other reason, shall be subject to the disposal regulations it would have been subject to prior to dilution. The Executive Director recommends a license condition stating the prohibition on dilution of waste.

3.8 Site Security

Section 401.112 of the Texas Health and Safety Code and 30 TAC §336.707(5) require that an application for a license to dispose of low-level waste include a description of the proposed physical security plans. Security operations are intended to protect the facility against vandalism, theft, tampering, sabotage or other illegal activities. These operations will also be involved in response to emergencies, radioactive material releases or fires. The security organization will consist of the Vice President and General Manager (GM), the Security Manager, the Director of Operations and Security Guards. The Security Manager will report to Director of Operations.

The WCS Security Plan is provided in Procedure LL-SP-100 of the application and is implemented through WCS Security Procedure LL-SP-1. Site security will be administered in accordance with Section 5.0 of Procedure LL-SP-1. Procedure LL-SP-2 addresses procedures to be followed to respond to incidents such as trespassing, theft, assault, bomb threat, sabotage, holding hostages and disruptions of the facility entrance. Site security will be provided through the entire duration of the licensing period, beginning with construction and ending with site closure. After completion of site closure, and surveillance periods, the custodial agency (e.g., the State of Texas or Federal Government) will assume responsibility for institutional control at the disposal site and will take over the security function.

The proposed security training for staff will occur in two segments. The first segment provides training to the on-site security staff. The training will include crime prevention and protection of WCS assets. The second segment provides security awareness training to all facility workers. The training proposed in the application emphasizes worker personal responsibilities in proper security practices.

The application states that the security manager is responsible for each segment of the security education and awareness program. Training for the on-site security staff will be initiated prior to starting assignment at the waste facility. Awareness training for all employees will be presented within 90 days of their initial employment. Periodic training will be presented to all staff within 90 days of each subsequent anniversary of employment. The application describes that the distribution of posters, pamphlets and checklists will be a part of on-going awareness training at the facility.

The site perimeter is proposed to be surrounded by a three-foot ranch type fence made of wooden poles and barbed wire. The disposal site will be surrounded by a chain link fence seven-foot high, which will be topped with three strands of barbed wire mounted on metal outriggers. The only public access discussed in the application will be through an entry gate which will be controlled at all times. Special security related equipment for the facility will be provided including motion detectors, passive alarm systems and radio communications. The list and location of the equipment are described in Appendix 5.5.4 of the application.

The application states that the main gate will be staffed 24 hours a day, seven days a week by a security officer. The demurrage to the staging area is proposed to be through a second gate controlled from the operations building. Other security measures proposed include the escort of all visitors by facility staff and control of the distribution of access keys to gates and buildings. The application states that no person will be allowed through the main entrance gate during non-working hours unless permission is received from the Security Manager or Director of Operations. During non-working hours the main entrance and the disposal site will be regularly patrolled by security staff. If unauthorized intrusion is discovered, the security guards will inform facility management and if necessary contact Andrews County Sheriff's Department. The application states that the facility security staff will work in close liaison with the Andrews County Sheriff's Department. The application states that the Sheriff's department will have the ultimate jurisdictional responsibility for handling any security incidents or illegal activities that may occur at the facility. The application states that the facility security force will work with the sheriff in responding to any incident involving a breach of security.

TCEQ staff has reviewed the physical security plan for the proposed low-level waste disposal facility according to United States Nuclear Regulatory Commission NUREG-1200, Standard Review Plan 8.7 (NUREG, 1994). The physical security plan, provided in Appendix 5.5.4 of the application, provides information on protection of the facility against potential acts of vandalism, theft, or sabotage. The proposed physical security measures provide design features of the surveillance equipment and layout of the equipment at the facility. The security procedures include cooperation between the security staff and Andrews County law enforcement personnel.

References Section 3.8: Site Security

NRC, 1994. United States Nuclear Regulatory Commission, NUREG-1200, Standard Review Plan for the review of a license application for a Low-Level Radioactive Waste Disposal Facility, Office of Nuclear Material Safety and Safeguards, Washington, D.C. April 1994.

3.9 Authorizations for Existing Facilities

Title 30 TAC §305.45(a)(5) require a description of the activities conducted by the applicant which require a permit or license from a regulatory authority. The application lists in Table 1.24 authorizations for existing facilities that are adjacent to the proposed low-level radioactive waste disposal facility. Radioactive Material License R04971, originally issued by the Texas Department of Health on November 30, 1997, authorizes possession and storage of radioactive material. Waste Control Specialists, LLC operates a permitted RCRA hazardous waste Subtitle C landfill (HW50358). The currently RCRA facility has a Texas Pollutant Discharge Elimination System (TPDES) discharge permit for processed waste associated its activities. A by-product material disposal facility license, R05807, was issued by the TCEQ on May 29, 2008 to WCS for a location immediately to the west of the proposed FWF. Jurisdiction over commercial storage and processing of radioactive material, disposal of by-product material, and source material recovery (uranium mining) were transferred from the Texas Department of State Health Services to the TCEQ by Senate Bill 1604, 80th Texas Legislature, 2007.

3.10 Applicant's Compliance History

Texas Health and Safety Code §401.112(a)(5) requires review of an applicant's compliance history to determine its regard for the regulatory process. TCEQ staff has reviewed the applicant's compliance history. The Consolidated Compliance and Enforcement Data System (CCEDS) Compliance History provided in the application in Appendix 1.23 is for the period from September 1, 2001 to August 31, 2006. WCS received a compliance rating of 1.59 and a classification of "Average" for this compliance period. Supporting documentation regarding the applicant's compliance history is also provided in the application. The applicant's current compliance history will be updated prior to issuance of a draft license. An analysis of the applicant's technical qualifications is provided in Section 4.1 of this document.

Section 4: Operational Radiation Protection Program

4.0 General Introduction

Section 401.112(a)(15) of the Texas Health and Safety Code requires consideration of worker monitoring and protection plans of an applicant for a low-level radioactive waste disposal facility license. A corresponding TCEQ rule, 30 TAC §336.707(8) requires an applicant to provide a description of the proposed radiation control program. Also, 30 TAC §336.706(a)(2)(B) requires a discussion of the technical qualifications of the applicant.

4.1 Technical Qualifications of Applicant

Texas Health and Safety Code §401.112(a)(5) requires the commission, in making a licensing decision on a specific license application to process or dispose of low level radioactive waste from other persons, to consider the applicant's qualifications, including financial and technical and compliance history. The applicant's financial qualifications are reviewed in Section 8.14.1 of this analysis. Please refer to Section 3.10 of this analysis for a discussion of the applicant's compliance history. Training and experience requirements for key personnel responsible for managing the operation of the facility are described in Section 3.2 of this analysis.

TCEQ staff has reviewed the applicant's technical qualifications provided in Section 10.2 of the application. WCS currently owns and operates a Resource Conservation and Recovery Act (RCRA) and Toxic Substance Control Act (TSCA) authorized landfill. RCRA Hazardous Waste Permit Number HW-50358 was originally issued on August 5, 1994. The RCRA Subtitle C landfill currently has 5,423,000 cubic yards of permitted disposal capacity. Historically, this facility has accepted hazardous waste authorized under its RCRA Subtitle C permit and low activity radioactive material authorized under exemptions granted by the Texas Department of State Health Services (TDSHS). The site was granted authorization under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) to receive waste resulting from a response action involving the off-site transfer of any hazardous substance, or pollutant or contaminant on March 27, 1997.

WCS also operates a Mixed Waste Treatment Facility (MWTF) for radioactive waste and hazardous waste that operates under a TCEQ permit and license. Storage and processing of radioactive waste and mixed waste were originally authorized under Radioactive Material License Number R04971 issued by the Texas Department of Health on November 30, 1997. License Number R04971 is currently under the jurisdiction of the TCEQ. WCS also maintains a Container Storage Area (CSA) with 36,760 cubic feet of waste storage capacity and a Low-Specific Activity (LSA) storage area with 1,500,000 cubic feet available for storage of low-specific radioactivity dry, solid radioactive waste in canisters. This authorization specifically allows the extended storage of by-product material from Silos 1 and 2 from the Fernald, Ohio site.

4.1.1 Recent Activities: Septic System Contamination

On August 24, 2005, the Texas Department of State Health Services (TDSHS) notified WCS that liquid sampled from the Administrative/Personnel Building septic system in April 2005 indicated elevated levels of americium and plutonium (WCS, 2007a). A Notice of Violation was issued by the TDSHS on November 3, 2005 (TDSHS, 2005). A review of all available analytical data indicated that analyses of fluid and solid samples collected by TDSHS from the WCS system resulted in a significant number of detectable concentrations of plutonium-239, and of other constituents. These detections began as early as April 2002 and generally persisted through analyses done on samples collected through July 2006. This was despite the fact that the WCS septic system was pumped on October 22, 2001. A chronology of this incident and a summary of the analytical data are presented by the applicant (WCS, 2007b).

On February 8, 2006, TCEQ inspectors took samples from the WCS septic system during the annual facility inspection. A Notice of Enforcement (NOE) regarding contamination of the septic system was sent to WCS by the TCEQ dated June 9, 2006 (TCEQ, 2006). During September 26-29, 2006, WCS excavated the soil above the septic tanks for access to each of the three tanks and removed four selected infiltrator panels to sample the soil in the drain field. Samples from the tanks and drain field were collected and analyzed. Contamination was detected in all three tanks and the drain field. Remediation of the contaminated septic system has not been conducted. A new septic system for the Administrative/Personnel Building has been installed and is monitored quarterly by WCS.

The Executive Director and WCS have resolved an enforcement action under the authority of Texas Water Code Chapters 7 and 27 and Texas Health and Safety Code Chapters 361 and 401. This proposed Agreed Order is entered into pursuant to Texas Water Code §§ 7.051 and 7.070. The Commission has jurisdiction of this matter pursuant to Texas Water Code §5.013 because it alleges violations of Texas Water Code Chapter 27, Texas Health & Safety Code Chapters 361 and 401, and the TCEQ rules.

The subject of the proposed order is notice of two violations alleged on or about November 8, 2005 and June 14, 2006 (TCEQ, 2008). WCS is alleged to have violated:

- Title 30 TAC §§331.6 and 336.203 by injecting radioactive wastes without authorization into or above a formation, located within one-quarter mile of the well that serves as an underground source of drinking water, and disposed of radioactive material without having a radioactive material disposal license. Specifically, WCS has allowed the introduction of radioactive materials, particularly americium-241, plutonium-239, and radium-226 into the facility administration building/laboratory septic system, as documented during investigations conducted on February 6, 2006 through February 9, 2006 and June 7, 2006; and

- Title 30 TAC §335.42(2) and (3) by causing, suffering, allowing, or permitting the collection, handling, storage, processing, or disposal of industrial solid waste in a manner as to cause the creation and maintenance of a nuisance or the endangerment of the public health and welfare. Specifically, the railcar unloading area had elevated amounts of metal contamination, as documented by an investigation conducted on June 7, 2006.

Analysis results from the septic system samples show an increase in the concentration of plutonium-239 over the time period from 2002 to 2006. This increase is consistent with a chronic pattern of radioactive material being disposed in the septic system. The increase in plutonium-239 released to the septic system peaked in 2005. This peak in concentration coincides with the WCS campaign to process low-level radioactive waste from the United States Department of Energy facility in Rocky Flats, Colorado.

Other transuranic radionuclides including americium-241and plutonium-238 were also detected in samples collected by TDSHS and in other samples collected during the excavation of the septic tanks and infiltrator panels in September 2006. It is noted that transuranics and other heavy metals tend to concentrate in the sediment portion of the septic tanks. It is also noted that this septic system was pumped on October 22, 2001.

During late July of 2007, WCS reported to TCEQ that samples taken from the newly installed septic system tested positive for radioactive contamination. However, the contents of the second septic system were sent to a publicly-owned wastewater treatment works before sample results were received.

4.1.2 Recent Activities: Unplanned Exposures

A second incident bearing on the applicant's technical qualifications involves unplanned intakes of radionuclides by WCS personnel while working in the Mixed Waste Treatment Facility (MWTF). An investigation of these intakes was initiated in June 2005 following a laceration injury to a worker in the MWTF. A series of urine and fecal samples were collected from the worker. The initial bioassay results confirmed an intake; however, the data was inconsistent with that expected for a laceration injury. It was determined that the exposure was due to inhalation and the bioassay sampling was expanded to include eight additional workers. Review of these data indicated the potential for intakes of radioactivity via inhalation and the bioassay program was expanded to include all workers on the site. A total of 95 individuals were included in the program. Forty-three (43) individuals exhibited measurable levels of transuranic radionuclides, predominantly plutonium-239 (WCS, 2008).

A chronology of this incident and a summary of the analytical data are presented in the application (WCS, 2007b). The root causes of the unplanned intakes were identified in a report from WCS dated December 8, 2005 (Kunihiro, 2005). It was determined that the root causes for the unplanned intakes were deficiencies in the respiratory protection program implementation and inadequacies in management review and oversight. Additional contributing causes were identified as improper maintenance and operation of the MWTF ventilation system, deficiencies in the timely evaluation of air sample data, air sampler locations not representative of the workers' breathing zone, air samples not collected or analyzed in a manner to ensure minimum detectable concentrations (MDC) at a level necessary for evaluating potentially significant exposures, and inadequacies in the bioassay assessment program.

An evaluation of the bioassay data and methodology was conducted by Dr. John W. Poston, Sr., Professor of Nuclear Engineering, Texas A&M University, under contract to the TCEQ. Dr. Poston's review highlighted that the facility placed a heavy reliance on the use of respiratory protection, rather than effective engineering controls to mitigate employee exposures. Also, WCS did not operate and maintain the MWTF ventilation system in a manner consistent with its design. Routine and preventative maintenance could have eliminated the degradation that occurred to the ventilation system. Lack of management oversight of the entire operation was also cited as a contributing factor to the employee exposures.

Dr. Poston prepared a report on dose reconstructions of the maximally-exposed individuals (Poston, 2008). Dr. Poston concluded that the potential doses were, in general, below the regulatory limits. In at least one possible scenario, the committed dose equivalent (CDE) value exceeded regulatory limit. Dr. Poston concluded that the exposure scenario (presented by WCS) was not realistic and was very unlikely to occur. In an attempt to provide better estimates of the CDE and the committed effective dose equivalent (CEDE) other models and combinations of models were evaluated. Based on the use of these models, it appears that all exposures were most likely chronic inhalation exposures resulting from loss of effective engineering controls at the facility over a period of time. Dr. Poston's reports are provided in Appendix C to this analysis. A comparison of the internal dose calculations between WCS and Dr. Poston is given in Appendix D to this analysis.

The applicant's proposed equipment, facilities, and procedures must be adequate to protect and minimize danger to the public health and safety and the environment in accordance with 30 TAC §336.207. More engineering and health physics controls are recommended. An increase in management oversight and direct accountability of the WCS radiation safety officer in daily operations are also recommended. Draft license conditions incorporate the Executive Director recommendations as follow:

- A bioassay program must be conducted for all employees. A baseline bioassay must be conducted on all employees. Thereafter, bioassays must be conducted monthly for occupationally-exposed workers and quarterly for administrative staff, managers and site contractors. Annual whole body counts, in addition to monthly urinalysis and fecal analysis will be employed. All radioisotopes for the land disposal facility must be evaluated in these bioassays.

- An annual report summarizing bioassay results for all employees is required. If any bioassay result exceeds ten percent of the occupational limit provided in 30 TAC Chapter 336, the Licensee shall notify the Executive Director within three days of receiving the results.

References Section 4.1: Technical Qualifications of Applicant

Kunihiro, 2005. Letter of December 8, 2005 from Dean Kunihiro, Senior Vice President, Licensing and Regulatory Affairs, Waste Control Specialists, LLC, to Jacqueline Hardee, Director, Waste Permits Division, Texas Commission on Environmental Quality. See enclosure: Root Cause Report, Unplanned Radiation Intake at the Mixed waste Treatment Facility.

Poston, 2008. J. W. Poston, Sr., Z. R. Bailey, B. A. Hrycushko, A Review and Analysis of the Bioassay Data Related to Worker Exposures at the Waste Control Specialists Facility. May 2008.

TCEQ, 2006. Texas Commission on Environmental Quality Notice of Violation dated June 9, 2006.

TCEQ, 2008. Texas Commission on Environmental Quality. Agreed Order signed by Rodney Baltzer, President of Waste Control Specialists, LLC, dated March 19, 2008. Docket Number 2006-0796-MLM-E.

TDSHS, 2005. Texas Department of State Health Services Notice of Violation dated November 3, 2005.

WCS, 2007a. Waste Control Specialists, LLC. Comprehensive Report Concerning Septic System Contamination and Personnel Internal Exposures at WCS and Corrective Actions. March 7, 2007. Section 2.1, Page 3.

WCS, 2007b. Waste Control Specialists, LLC. Comprehensive Report Concerning Septic System Contamination and Personnel Internal Exposures at WCS and Corrective Actions. March 7, 2007.

WCS, 2008. Waste Control Specialists, LLC. Evaluation of Internal Doses Using Bioassay Measurements for the 2005 MWTF Investigation of Intakes. January 2008.

4.2 Radiation Protection Program

Rule 30 TAC §336.708(8) requires the applicant to develop, document and implement a radiation protection program sufficient to ensure compliance with 30 TAC Chapter 336, Subchapter D. The applicant should provide a description for control and monitoring of contamination to personnel, vehicles, equipment, buildings, and the disposal site. Both routine operations and accidents should be addressed. The program description should also include procedures, instrumentation, facilities, and equipment. The regulations further require that the applicant use procedures based upon sound radiation protection practices to achieve occupational and public doses that are low as is reasonably achievable (ALARA). The following elements should be included in the ALARA program (NRC, 1983):

- Written management policy statement;
- Organizational structure separating the radiation protection group from the operational groups;
- Designation of a specific Individual responsible for the coordinating the ALARA program efforts;
- Training of employees in ALARA principles;
- Incorporation of ALARA principles in the design features of the facility and equipment;
- Incorporation of ALARA principles into operational procedures;
- Development of administrative controls on exposure below regulatory 1imits;
- Use of preplanning and mock-up training;
- Establishment of periodic reviews to determine the effectiveness of the ALARA program;
- Trend analysis of radiological parameters; and
- Radiation protection program audits.

TCEQ staff has reviewed the radiation safety procedures provided in the application. A written management policy statement is included in the application. The policy states that Waste Control Specialists, LLC is committed to the control of radioactive materials for which they are licensed and protecting their employees, the public, and the environment from unnecessary exposure to radiation. The application further states that some radiation exposure may be required to conduct company operations.

The organizational structure provided in the application is described as managers and supervisors at all organizational levels indicating their commitment to the implementation and continuous improvement of a Radiation Safety Program that is based upon the highest standards and best industry practices. The application states that management establishes and promotes realistic radiological performance goals to challenge employees to be innovative, creative, and to work together toward improving radiological safety performance. A safety culture must be deep-rooted, character-driven, and have a focused plan for daily communication and feedback with improvement incentives. The application does not provide a discussion on or a plan to accomplish highest standards in the daily, operations of the proposed disposal facility. The Executive Director recommends development of a clear plan to establish a site-wide safety and high-performance culture that is integrated into the daily operations of the proposed disposal facility.

The application indicates that the Vice-President and General Manager (GM) and the

Radiological Safety Supervisor (RSS) will be responsible for coordinating the ALARA program. The GM endorses the program by supporting the radiation safety plan, participating in the selection of ALARA goals and objectives, and providing support to the RSO and ALARA policies. The RSS provides support to the RSO's support of the radiation safety plan and oversight of the ALARA objectives.

The ALARA philosophy adopted requires that any exposure to ionizing radiation by occupational workers, members of the public or the environment be minimized to the extent that social, technical, economic, practical, and public policy considerations allows. The application describes that the Radiation Safety Committee oversees the application of ALARA principles through the Radiation Safety Plan. An ALARA training program in the principles of radiological safety and exposure control will be provided to all personnel who are expected to work with radiation or radioactive material, or expected to frequent the Radiologically Controlled Area. The Executive Director recommends the designation of a Restricted Area. The application also states that all personnel responsible for directing the activities of the individuals who work with radiation or radioactive materials, and all personnel who enter the radiation control area or work under the conditions of a radioactive materials license will be provided ALARA training.

The application states that the ALARA philosophy will be applied to proposed changes to facility and equipment design changes or maintenance work for radiological applications. The application states that changes to the facility includes radiation access control, shielding and decontamination equipment changes include instrumentation and controls, control of surface and airborne activity, liquid and gaseous effluents, radiological monitoring and waste generation. ALARA action levels are established when planning or evaluating a proposed design change, a planned maintenance or operations work activity.

The application states that the ALARA philosophy is implemented in preplanning and mock-up training before employing a process or procedure. Personnel who enter the radiation control area or work under the conditions of a Radiation Waste Permit will participate in an ALARA briefing before conducting the assigned task. The application provides that the Radiation Safety Technician is responsible for coordinating the following activities to insure that the operations will be handled with minimal exposure to operating personnel:

The application states that there will be confirmation that workers have reviewed and been trained to requirements and been approved for the specified activity, if appropriate. The following activities are described in the application:

- Pre-job radiation surveillance and assessment of the existing radiation levels and field distribution associated with the activity.
- Radiation monitoring and control during removal, handling, decontamination, packaging, storage, repair, and reinstallation (if appropriate) of any potentially contaminated items.
- Acceptance of the planned radiological cleanup, closure, post radiation

survey and activity, and return to operation of the component or system.

- Reporting, documentation, and proper disposition of the materials and records involved with the activity. Personnel exposures, radiation surveillance records, and demonstration of acceptable return to operation or restoration of the system or component.

Before entering the radiation control area, the application states that a worker will receive specific job training, briefings and/or mock-up training necessary to enable them to perform their work with a minimum radiation exposure. An assessment of the potential doses received by radiation operators were condensed and provided in Appendix 8.0-4 of the application. The application states that analysis of worker doses and recommendations for ALARA management of these doses were also incorporated into Appendix 8.0-4, "Worker Dose." Projections of doses were performed using analytical models and standard computer codes such as MicroShield® and the Residual Radiation Risk Assessment computer code (RESRAD).

The application discusses the establishment of administrative limits on contamination levels and worker doses to ensure that regulatory limits are not exceeded. Section 5.1.3 of the Radiation Safety Program in the application describes action limits to reduce radiation contamination levels and worker doses. Table 2 in Section 5.1.3, contains established derived limits. The goals and requirements of the Radiation Safety Program as stated in the application are accomplished through several layers of documentation. These are included in the application:

- Radiation safety program;
- Specific radiation safety implementing procedures;
- Project specific plans, hazards analyses, task instructions, permits, and forms

The application states that staff will review survey results monthly. The application describes that changes or trends should be identified and appropriate changes and corrective actions taken based on the review results. The application also states that a specific map will be used for each area where radiation surveys are to be performed. From the results of the survey data, trending dose rates can be observed. Due to the lack of details in the application, the Executive Director recommends greater oversight during the beginning of facility operations including review of procedures and provisions for maintenance of personnel monitoring and bioassays.

Due to the uniqueness of the operations and the role of the State of Texas as owner of a portion of the proposed facility, the regulatory agency should be included in the decision-making of radiation safety practices to ensure that compliance with 30 TAC Chapter 336 and performance objectives. The role of the Executive Director is to help ensure that the facilities radiation procedures and practices will achieve doses to workers and the general public as low as reasonably achievable. The Executive Director recommends that the radiation procedures and practices utilize operational and surveillance methods to assure that occupational doses will not be exceeded and that potential dose to workers and the general public are as low as reasonably achievable (ALARA).

Compliance with the reviewed procedures in the application is specifically required in the draft license. Procedures are the higher-tiered methods for facility operations. Although there is flexibility given in the procedures as allowed by the issuance and performance of radiation work permits and other specific tasks at the proposed facility, the activities covered under procedures are the collection of the basic operating standards. These operating standards comprise the unit operations that, in combination or used singly, make-up the sequence of work steps necessary for the formulation of a radiation work permit. Due to the nature of the standard methods provided in procedures, it is necessary for proposed changes to procedures to be reviewed for potential health and safety impacts. Changes to approved procedures must be made in accordance with requirements for amendment at 30 TAC §305.62.

Volume 29, Appendix 5.5.2-1, Procedure LL-RS-1 of the application is the radiation work permit (RWP) procedure. The application explains that the RWP describes what hazards exist in a restricted area. The permit explains what precautions need to be taken by workers when performing activities in a restricted area. The RWP is a combination of a radiation work permit and an industrial hazardous work permit. The combined permit, as suggested in the application, may cause confusion and misinterpretation about how to handle the hazards and what precautions should be implemented in the restricted area. Additionally, the use of work permits for administration and control of activities at the facility appears to be oversimplified. In order to conduct an effective program that utilizes radiation work permits, the radiological concerns of the program need to be differentiated from the routine operations of the program.

The application provides instruction on how to use the RWP. The instruction explains what information is provided in the RWP. It also explains what mechanism is in place to terminate the use of the permit. Management's responsibility and oversight while the RWP is in effect is discussed in the instruction. Personnel dosimetry for the workers, shielding calculations for the restricted area and ALARA review by operations and safety personnel are mentioned in the instruction. The application does not explain the posting and process for notifying of radiation work permit, outside of the restricted area. The posting and location of the radiation work permit is crucial to inform others of the activities underway. The application states that RWP records will be stored at WCS. The Executive Director recommends that the location of the stored RWP records be specified and that the responsible person of those records be identified.

4.2.1 ALARA and Respiratory Protection

State regulations require that an applicant for a license to dispose of low level waste insure that the doses to workers handling radioactive materials are ALARA. The procedures related to ALARA in the application are titled "Respiratory Protection" and identified as Procedure LL-HS-10.0, Revision 0, located in Appendix 5.5: Operational Procedures and Plans, of Volume 27 of the application; and Sections 6.8, 10.2 and 10.7 of Procedure LL-RSP-100 titled "Radiation Safety Program," Revision 0, located in Appendix 5.5.2-1: Radiation Safety Program and Procedures, of Volume 29 of the application.

The procedures were reviewed for compliance with the requirements in 30 TAC §336.321. Section 336.321(a)(3)(D)(i) requires that licensee's respiratory protection program contain written procedures regarding monitoring, including air sampling and bioassays. Procedure LL-HS-10.0 does not contain written procedures regarding monitoring, including air sampling and bioassays. Although such procedures may exist elsewhere in the application, there is no reference to such procedures in Procedure LL-HS-10.0 as being a part of the respiratory protection program.

Title 30 TAC §336.321(a)(3)(D)(ii) specifies that the licensee's respiratory protection program contain written procedures regarding supervision and training of respirator users. Section 4.1.2 of Procedure LL-HS-10.0 states that training will be provided to affected employees whose job requires them to use respiratory equipment. There is no cited section that pertains to procedures for supervision of respirator users. Because the application only provided a statement that training will be provided on use of respiratory equipment, the Executive Director recommends more specificity for those training procedures.

Title 30 TAC §336.321(a)(3)(D)(iii) specifies that the licensee's respiratory protection program contain written procedures regarding fit testing. Section 5.7 of Procedure LL-HS-10.0 in the application is titled to pertain to respiratory fit testing. This section states that employees will be fit tested at the time of initial fitting and at least annually thereafter. Reference is made to Appendix C as the job performance measures for conducting the fit test. Appendix C covers most of the elements expected in a fit test procedure. The Executive Director recommends that the procedures describe in detail the methods for checking the seal of the respirator under use conditions such as head and body movement expected during work activities.

Title 30 TAC §336.321(a)(3)(D)(iv) specifies that the licensee's respiratory protection program contain written procedures regarding respirator selection. The Executive Director recommends that written procedures describe the detailed process for selecting a respirator type (such as quarter face, half face, full face, supplied air, etc.) based on factors such as activities being performed and the conditions for planned use and reference procedure to the selection of respirator cartridges.

Title 30 TAC §336.321(a)(3)(D)(v) specifies that the licensee's respiratory protection program contain written procedures regarding breathing air quality. Section 5.2 of Procedure LL-HS-10.0 in the application addresses compressed breathing air and makes statements regarding the requirements for the air (which are the same as specified in rule at 30 TAC 336.321(c). The Executive Director recommends that the procedures address how the quality of breathing air will be determined in order to meet the stated requirements.

Title 30 TAC §336.321(a)(3)(D)(vi) specifies that the licensee's respiratory protection program contain written procedures regarding inventory and control. The Executive Director recommends that respirator inventory and control procedures be included as part of the general procedures for the respiratory protection program.

Title 30 TAC §336.321(a)(3)(D)(vii) specifies that the licensee's respiratory protection program contain written procedures regarding storage, issuance, maintenance, repair, testing, and quality assurance of respiratory protection equipment. Section 5.3 of Procedure LL-HS-10.0 of the application is titled to pertain to inspection, maintenance and care of respiratory equipment. Subsection 5.3.5.5 states that after (cleaning and) inspection respirators are stored in clean plastic bags. The Executive Director recommends that the procedure specify how storage of cleaned respirators will be maintained for subsequent use. Subsection 5.3.1 states that the Health and Safety Department will ensure that every employee is provided with a respirator that is clean, sanitary and in good working condition. Beyond that statement, there are no further instructions regarding the issuance of respirators. Subsection 5.3.3 identifies the Health and Safety Department with the responsibility to disassemble, clean, and perform maintenance on respirators. Subsection 5.3.5 describes the cleaning procedures. Subsection 5.3.7 states that Health and Safety Department is allowed to make repairs and replace parts missing from the respirator. However, no attempt will be made to replace components or to make adjustments or repairs beyond what the manufacturer recommends. Subsection 5.3.8 places the responsibility for test on the employee using the respirator. However, no specific instructions are provided in this subsection as to what tests are to be performed, or how they are to be performed, or a reference provided to where such tests and their performance are described elsewhere in this procedure or the application.

Title 30 TAC §336.321(a)(3)(D)(viii) specifies that the licensee's respiratory protection program contain written procedures regarding recordkeeping. Section 6.0 of Procedure LL-HS-10.0 of the application addresses records. However, it only states that records demonstrating performance of this procedure shall be created and retained in accordance with all applicable statutory and regulatory requirements; and supplemental WCS records management policies and procedures. As a procedure, the specific statutory and regulatory requirements should be specified to provide direction to the person executing the procedure. Section 6.4 of the procedure states that all records cited in this procedure will be provided upon request to employees, former employees, representatives designated by the individual employee, and representatives of Occupational Safety and Health Administration (OSHA). These records should also be available to review by the Executive Director and his staff upon request.

Title 30 TAC §336.321(a)(3)(D)(ix) specifies that the licensee's respiratory protection program contain written procedures regarding limitations on periods of respirator use and relief from respirator use. There does not appear to be any specification or limit on the time of use of a respirator, or on relief from respirator use in Procedure LL-HS-10.0. However, there is a statement in Section 10.7 of Procedure LL-RSP-100 of the application that specifies a limit on the amount of time that a person may be in a respirator (four hours without a break, and six hours total for a single day). Since Procedure LL-HS-10.0 is the stated procedure for respiratory protection, any limitation on time of use should be stated in Procedure LL-HS-10.0, or a reference contained in Procedure LL-HS-10.0 as to where such a limit is provided. With respect to relief from respirator use, 30 TAC §336.321(a)(4) requires that the licensee shall advise each respirator user that the user may leave the area at any time for relief from respirator use in the event of equipment malfunction, physical or psychological distress, procedural or communication failure, significant deterioration of operating conditions, or any other conditions that might require this relief. Such advice should be incorporated into the applicant's respiratory protection procedures as the means of communicating such to respirator users.

Title 30 TAC §336.321(a)(3)(E) specifies that "determination by a physician that the individual user is medically fit to use respiratory protection equipment before: (i) the initial fitting of a face sealing respirator; (ii) the first field use of non-face sealing respirators; and (iii) either every 12 months thereafter, or periodically at a frequency determined by a physician." This requirement is addressed in Section 5.6 of Procedure LL-HS-10.0 of the application. The procedure provided in the application commits to a medical evaluation and obtaining medical clearance before being allowed to wear a respirator and having the medical status of the respirator user reviewed at least annually. The Executive Director recommends that the procedure provide that the medical evaluation must be performed by a physician to determine that a user is medically fit to use respiratory protection equipment.

Volume 29 of the application in Appendix 5.5.2-1 contains numerous procedures. However, none of the procedures clearly communicate the pathway to follow for use of respiratory protection. For example, subsection 10.7, titled "Use of Respiratory Protection Equipment," is contained in the Radiation Safety Program (Procedure LL-RSP-100). The application states that "The Respiratory Protection Program (Procedure LL-HS-10.0) meets the requirements of Reference 2.1.2 Section (x), Reference 2.1.8 Chapter 336.321 (Use of Individual Respiratory Protection Equipment), and using the guidance from Reference 18.3.8 (ANSI Z-88.2-1992, Practices for Respiratory Protection)." This subsection then further states the following: "Prior to the use of respiratory protection equipment, each individual shall meet the requirements in Reference 18.3.8."

The Executive Director recommends that procedures clearly communicate the steps, conditions, and requirements for the use of respiratory protection.

The application states that documentation of radiation exposure to all individuals involved with the proposed disposal facility will be handled in accordance with 30 TAC

Chapter 336 requirements. The recording and reporting of occupational exposure data as described in the application are consistent with the recommendations of NRC Regulatory Guide 8.7 (NRC, 1983).

References Section 4.2: Radiation Protection Program

NRC, 1983. United States Nuclear Regulatory Commission, Regulatory Guide 8.7, Instructions for Recording and Reporting Occupational Radiation Exposure Data, Office of Nuclear Regulatory Research, Washington, D.C. June, 1992.

4.3 Quality Assurance and Quality Control

Title 30 TAC §336.707(7) require that the applicant must provide a description of the quality assurance program, tailored to disposal of low-level radioactive waste, developed and applied by the applicant for the determination of natural disposal site characteristics and for quality assurance during the design, construction, operation, and closure of the land disposal facility and during the receipt, handling, and emplacement of waste.

Quality Assurance (QA) is a program to be applied to the design, fabrication, construction, and testing of the structures, systems, and components of the waste facility. Also, a QA program should include information pertaining to the managerial and administrative controls to be used to assure safe operation of the waste facility. Quality assurance includes quality control, which comprises those QA actions related to the physical characteristics of a material, structure, component, or system, which provide a means to control the quality of the material, structure, component, or system to predetermined requirements.

The applicant must provide documentation which establishes a QA program for the design, construction, operation and closure of structures, engineered or natural systems, and components whose functions is required to meet the requirements of 30 TAC Chapter 336. NUREG-1293 lists 18 criteria that are essential to an effective QA Program (NRC, 1991). These are as follows:

- Organization;
- Quality Assurance;
- Design Control;
- Procurement Document Control;
- Instructions, Procedures, and Drawings;
- Document Control;
- Control of Purchased Material, Equipment, and Services;
- Identification and Control of Material, Parts and Components;
- Control of Processes;
- Inspection;
- Test Control;

- Control of Measuring and Test Equipment;
- Handling, Storage, and Shipping;
- Inspections, Test, and Operating Status;
- Nonconforming, Materials, Parts, or Components;
- Corrective Actions;
- Quality Assurance Records; and
- Audits, Surveillance, and Management Controls.

These criteria suggest how the applicant can establish and execute a working quality assurance program (NRC, 1991). TCEQ staff has reviewed the QA program provided in the application in accordance with the guidance provided by the United States Nuclear Regulatory Commission (NRC) documents NUREG-1200 (NRC, 1994), NUREG-1293 (NRC, 1991), NUREG-1199 (NRC, 1991) and NUREG-1383 (NRC, 1990). A brief description of the QA program is provided in Section 9.0 of the application. The QA plan is provided in Appendix 9.0 of the application. Quality assurance as it applies to facility design and facility operations are described in Appendix 9.0 and throughout the application. The QA requirements specific to environmental monitoring are located in Environmental Procedures in Appendix 5.5. Each of the 18 criteria of the QA plan listed above is described in sections throughout the application.

Each element of the QA plan presented in Appendix 9.0 of the application was reviewed against the criteria described in Section 4.3 of NRC Standard Review Plan 9.1 (NRC, 1994) for appropriate QA commitments. TCEQ staff reviewed the QA program to determine whether these commitments are tangible and whether the actions committed to by the applicant can be readily inspected against. There are some issues about the planned work routine during facility operations. The Executive Director recommends that quality-achieving and quality-assuring activities are clearly defined in the procedures, that instructions and procedures connect to QA activities, and that the responsibilities of the licensee's staff are well integrated into the operations. Program integration would assure adequate quality control of each function in the planned work routines. For example, the waste canister inspection and placement procedures rely on operators to perform both tasks manually, which increases the potential for unnecessary radiation exposure. During the canister placement, a WCS inspector is expected to review the operators' activities and perform other activities assigned to them simultaneously. Consequently, the inspector might be attending to another task and unable to provide their undivided attention during each segment of the operators' task.

Plan and procedures for assuring quality in facility operations is of fundamental importance. The QA plans and procedures need to be organized in a cohesive manner from different documents and submittals. In order to help provide a coordinated quality assurance program, the Executive Director recommends a license condition to require the creation of a Quality Assurance and Quality Control (QA/QC) manual as part of an effective program. This manual will assist in the effective operation of the QA/QC program and provide a mechanism to track and identify potential trends occurring in the routine operations of the proposed disposal facility.

The application states that quality standards can be expected to be achieved in everyday operations at the waste facility by requiring the president of WCS to be actively involved in the quality assuring activities to meet performance objectives of the facilities quality assurance plan. The application describes a proposed Quality Assurance Plan and its implementing procedures as the actions taken by WCS management and employees during the performance of quality affecting activities to ensure quality assurance requirements are consistently met.

The Quality Assurance (QA) program is based on line management and staff being responsible and held accountable for the quality of their assigned task. Both management and staff will be responsible for implementing activities and performance objectives of the program. The facilities QA staff will be responsible for oversight and management of the quality assuring activities in the day-to-day operations at the facility. WCS will be responsible for all quality assurance activities while task are performed by WCS personnel and contractors at the low-level radioactive waste disposal facility.

Disputes involving differences of opinion on quality matters or issues are brought to the attention of WCS line management and if necessary continue up the organizational chain until resolution of the matter has been addressed. The Executive Director recommends that the person performing quality-assuring functions have the appropriate and sufficient independence to effectively evaluate the various work activities at the proposed disposal facility.

Section 3 of the QAP provided in the application discusses how the contractor's control of design specifications, drawings, design criteria, and component performance will be an active part of the applicant's quality assurance process with contractors who design and construct components at the site. The contractors will submit quality control data, related to their materials and procedures, to the applicant to verify that the contractors operations are in agreement with WCS QA program. The application states that the QA Manager will review the contractor's QA Program and verify that the contractor's QA Program is acceptable for the contracted scope of work at the site. In the case where a contractor's QA Program conflicts with the WCS QA Program, the contractor would be required to adapt to the QA program as provided in the application.

The application discusses procurement document control in the QAP. The application describes a mechanism where the QA program will be responsible for controlling the sequence of actions to be performed in the preparation, review, approval, and control of procurement documents. The application states that qualified QC inspectors will be trained in verifying quality-affecting work and shall be trained and qualified in the specific inspection process and the quality requirements. Included in the discussion on procurement document control provided in the application, there is a policy statement specifying the applicant's right of access to the suppliers' facilities and records and states that procedures will be established for inspection and audit of these facilities.

The application states that standard operating procedures will be used when there is a need to perform activities in a certain way. This description includes the sequence of actions to be performed in the preparation, review, approval and control of instructions in the procedure. The application notes that changes to the procedures will be handled by the QA management. The updated procedures will be instituted after the instructions have been approved.

The application states that work assigned to areas of responsibility is performed using the current version of procedures, instructions, drawings and documents as described in Section 6 of the QAP. To minimize unintended use of obsolete or superseded documents, the application states that the QA Manager will authenticate and document the status of unused documents.

Control of purchased material, equipment and services is discussed in Section 7 of the QAP provided in the application. The application states that items of concern will be graded and categorized as QA-1, QA-2, or QA-3 designation depending on the items affect on maintaining regulatory control of activities at the waste site. For QA-1 and QA-2 projects, a Quality Assurance Project Plan (QAPP) is proposed to be instituted. The QA manager will concur with the designation of the category and forward the approved QAPP to document control for inclusion into the document control system.

A process in which a specified quality control cannot be determined by inspection or test is described in Section 9 of the QAP provided in the application. The application indicates that the QA Manager is responsible for verifying the implementation of special process work and verifying that the process instructions are being followed. The contractors (suppliers) selected to manage special processes have met the requirements specified in this procedure. The application states that this verification shall be documented and maintained.

Section 10 of the QAP provided in the application describes WCS inspections that will ensure that quality-affecting activities are in conformance with documented instruction, procedures and drawings. The WCS inspector will verify that exams, measurements and test of materials or products from suppliers meet the acceptance criteria established by the applicant. The Executive Director recommends that the QA program also assess how the licensee's needed procedures are evaluated to conform to QA requirements.

Section 11 of the QAP provided in the application discusses test control, which is a mechanism used to verify conformance of an item or software to specified requirements and to demonstrate satisfactory performance for service at the disposal facility. The application states that the test procedures demonstrate that suppliers' structures, systems and components will perform satisfactorily in service.

Control of measuring and test equipment at the proposed facility is discussed in Section 12 of the QAP provided in the application. The application explains that procedures to calibrate, label, and provide maintenance for all measuring and test equipment will be available through the QA program. The Executive Director recommends that the QA program indicate if the test control will include installation and preoperational testing of services or components, specify the standards used to calibrate instruments, and specify how the calibration would be documented.

Section 15 of the QAP provided in the application discusses how to handle nonconforming materials, parts or components. The application describes a mechanism, which is available to any facility staff member called the Nonconforming Item Report (NCIR). When an item is discovered that does not meet the requirements of the QA program, then the NCIR is initiated and passed on to WCS management. After review by management, the item is accepted, rejected, repaired or reworked in accordance with documented procedures.

Corrective action reports are discussed in Section 16 of the QAP provided in the application. The application states that procedures are available to correct equipment failures, malfunctions, deficiencies or nonconformance to reduce the quality-affecting work activity. All actions taken to correct the quality-affecting activity will be documented and reported to appropriate level of authority.

The application discusses quality assurance records in Section 17 of the QAP. Records are proposed to be organized and handled by a records specialist. The application states that the records specialist answers directly to the QA manager. The records will include operating logs, results of reviews, inspections, tests, audits, monitoring of task, performance, and material analyses.

References Section 4.3: Quality Assurance and Quality Control

NRC, 1990. United States. Nuclear Regulatory Commission, NUREG-1383, Guidance on the Application of Quality Assurance for Characterizing a Low-Level Radioactive Waste Disposal Site,. Office of Nuclear Material Safety and Safeguards, Washington, D.C., October 1990.

NRC, 1991. United States. Nuclear Regulatory Commission, NUREG-1199, Standard Format and Content of a License Application for a Low-Level Radioactive Waste Disposal Facility, Office of Nuclear Material Safety and Safeguards, Washington, D.C., January 1991.

NRC, 1991. United States. Nuclear Regulatory Commission, NUREG-1293, Rev.1., Quality Assurance Guidance for a Low-Level Radioactive Waste Disposal Facility, Office of Nuclear Material Safety and Safeguards, Washington. D.C., April 1991.

NRC, 1994. United States. Nuclear Regulatory Commission, NUREG-1200,.Standard Review Plan for the Review of a License Application for a Low-Level Radioactive Waste Disposal Facility, Office of Nuclear Material Safety and Safeguards, Washington, D.C., April 1994.

NRC, 1995. United States. Nuclear Regulatory, Commission, Licensing Requirements for Land Disposal of Radioactive Waste., Office of Nuclear Material Safety and Safeguards, Washington, D.C., March 1995.

4.4 Environmental Monitoring Program

State and federal statutes and rules require that license applications for proposed low-level radioactive waste disposal facilities provide a comprehensive monitoring program that will effectively detect and measure impacts of the facilities to the environment. The application states that guidance provided by United States Nuclear Regulatory Commission (NRC) in NUREG-1388 was used in development of the environmental monitoring plan). The required plan must encompass a series of steps or phases that will cover the life of the proposed facilities. The overall program must begin with the establishment of natural background radiation levels and chemical characteristics of the proposed site, and progress through baseline, pre-operational, construction, operational and post-operation phases. A reference used for developing environmental monitoring programs is the United States Department of Energy report, DOE/LLW-13Tg (DOE, 1983).

This section will review the Radiological Environmental Monitoring Program (REMP) program proposed in the application. NRC Regulatory Guide 4.18 states that the disposal site must not be located where nearby facilities or activities could adversely impact the ability of the site to meet the performance objectives or significantly mask the environmental monitoring program (NRC, 1983). The close proximity of the existing facilities at the WCS site raises concern that significant masking may occur. The Executive Director recommends a license condition that requires demonstration that the proximity of these adjacent facilities will not have an adverse impact on the ability of the low-level radioactive waste disposal facility to meet the performance objectives or cause significant masking.

4.4.1 Program Descriptions

Sections 401.112(a)(6) of the Texas Health and Safety Code, states that the commission, in making a licensing decision on a specific license application to process or dispose of low-level radioactive waste from other persons, shall consider background monitoring plans for the proposed site. Other requirements include:

- Texas Health and Safety Code §401.112(a)(11) states that the commission shall consider a monitoring, record keeping and reporting program;

- Texas Health and Safety Code §401.112(a)(17) states that the commission shall consider a monitoring program for applicants that includes pre-license and post-license monitoring of background radioactive and chemical characteristics of the soils, groundwater and vegetation;
- Title 30 TAC §336.708(a)(10) requires the application to include a description of baseline, operational, and long-term environmental monitoring programs, including radioactive and chemical characteristics, and the plan for taking corrective measures if migration of radionuclides or chemical constituents is indicated; and
- Title 30 TAC §336.708(a)(3) requires that the application include area and site characteristics including ecology, geology (including geotechnical features), seismology, soils, topography, hydrology, air quality, natural radiation background, meteorology, climatology, historical and cultural landmarks, archeology, demography, and current land uses.

The proposed Radiological Environmental Monitoring Program (REMP) can be found in Appendix 2.10.1-2 of the application. The application states that the data collected comprises the baseline dataset for the proposed site. In addition, the application contains a Non-Radiological Environmental Monitoring Plan, presented in Appendix 2.10.2-2. Both plans address the federal facility waste disposal facility (FWF) and Compact Waste Facility (CWF), and associated pre-operational monitoring, operational monitoring, and post-operational monitoring programs. Monitoring for chemical constituents is included in the application.

4.4.2 Natural Background Study

A Resource Conservation and Recovery Act (RCRA) hazardous waste management and disposal facility has been operated at the site since 1994 under permit number HW-50358. WCS has also been authorized for the storage and processing of radioactive waste under radioactive material license number R04971 since 1997. A by-product material disposal facility has been approved under license number R05807. These licenses and permits are currently under TCEQ regulatory jurisdiction.

The application estimates that 450,000 cubic yards of waste containing radioactive material have been disposed at the RCRA facility as of March 16, 2007. The estimate is based on one-half of the RCRA disposal cell volume of 900,000 cubic yards. One half of the RCRA disposal unit volume contains waste with exempt radioactive materials. According to the RCRA permit, the overall RCRA disposal capacity is 5,423,000 cubic yards.

According to Table 8.1.2-1 in the application, the current estimated inventory for the RCRA facility contains approximately:

- 20,000 curies of tritium (hydrogen-3);

- One curie of cesium (cesium-137);
- 17 curies of radium (radium-226) and decay products;
- 30 curies of thorium (thorium-232) and decay products;
- 92 curies of uranium (uranium-238) and decay products; and
- 28 curies of americium (americium-241).

There is currently no monitoring required for radioactive constituents at the RCRA facility. The Executive Director recommends a license condition to include monitoring of groundwater for radioactive constituents from the RCRA facility.

The application states that background samples were first collected in 1996 for radioactive material license R04971, including soil, groundwater, vegetation, and thermoluminescent dosimeter (TLD) sites. The application also states that the 1996 radiological study, in conjunction with site studies of the Waste Isolation Pilot Project (WIPP), the Pantex facility, and Louisiana Energy Services (LES) site, describes and quantifies area and site characteristics, including natural background. The application also states that groundwater data from the 1996 study demonstrates that radioactivity concentrations measured during the background and baseline phases were consistent with expected natural background. However, the 1996 study was not conducted for the full one-year interval, did not sample all stations consistently, and did not analyze for all constituents.

Natural background assessments occurring after 1994 could be affected by disposal and decontamination activities conducted at the site under the RCRA permit and TCEQ license. As noted above, the existing RCRA disposal facility contains large volumes of waste containing radioactive material that may have affected the radioactive background of the site. The processing and storage of radioactive materials at the existing licensed facility may also have affected radioactive background.

Based on review of the analytical data collected by the Texas Department of State Health Services on the site, there have been events of elevated radioactive measurements at the site. The first event identified in the application was discovered in 2001 when tritium was found in air samples associated with the processing facilities. The second event in 2005 involved a septic system that had been installed in 1996. The application states that the contaminants involved in the 2005 event were plutonium-238, plutonium-239, americium-241, radium-226, uranium-235, uranium-234, thorium-232, thorium-228, and thorium-230. WCS was issued a notice of violation for discharging radioactive material into a septic tank system on November 3, 2005 (TDSHS, 2005). WCS also received a notice of enforcement on June 9, 2006 (TCEQ, 2006).

A proposed license condition provides a Modified Natural Radiation Monitoring Program. Sampling stations for environmental monitoring were chosen at the perimeters of the WCS site property to potentially lessen the effects of operations currently being conducted at the facility.

4.4.3 Baseline Study

Operations of existing processing and disposal facilities at the proposed site have complicated the establishment of chemical and radiological monitoring baselines. The 1997 REMP was conducted as a one-time sampling event. The 1997 REMP contains baseline soil, baseline water, and baseline gamma radiation survey measurement (TLD Data). Also included in this section of the application are the results of sampling, from 1997 to 2004, performed by the Texas Department of State Health Services (TDSHS), formerly the Texas Department of Health. The TDSHS program consisted of six TLD sites, five soil sampling sites and two monitoring wells that were analyzed for the same constituents quarterly.

Table EA-4: TDSHS Environmental Monitoring Summary

Station Number	Sample Type	Location
01	TLD, soil, water	North of current administration building
02	TLD, soil	Northwest corner of site
03	TLD	East side of site
04	TLD, soil	At State Highway 176, Southeast of proposed disposal facility
05	TLD, soil	Southwest corner of site
11	TLD	Background in the City of Andrews
09	Soil, water	South of proposed disposal facility

Radiological Environmental Monitoring Summary Reports for years 2001 through 2005 describe the media and matrix for the program conducted during these years. The reports contain radioanalytical data for air, radon, soil, groundwater, vegetation, tissue, and TLDs collected by the State of Texas during these years. Also included in these reports were assessments of doses to members of the public resulting from the past waste management and disposal operations. It is unclear from the information submitted in the application if the samples and analyses were performed independently by the applicant for the same media and matrix.

The application provides groundwater monitoring data from chemical sampling performed at the RCRA facility between 1997 and April 2003. The data shows which chemical parameters were analyzed and from what well. These previous sampling programs did not use the same sampling frequencies or sample the same constituents. For instance, some of the wells were sampled four times during the interval, while others were sampled once. In 2000, positive results were found for many of the constituents. The application does not explain if a different analysis method was used. No explanation for the positive findings could be found in the text. Further, the current RCRA permit does not require sampling for radiological constituents.

Establishment of baseline monitoring parameters provides a benchmark for all subsequent monitoring performed at the site. The purpose of a benchmark is to serve as a critical value in decision rules used to ascertain exceedances of baseline. Without an accurate benchmark, decisions based on these rules are being made with unknown error rates.

For large sites where long-term monitoring will take place, such as at United States Department of Energy (DOE), Army Corp of Engineers, United States Environmental Protection Agency (EPA) and state remediation sites, a Data Quality Objective (DQO) Process, established by the EPA, is often used to establish performance or acceptance criteria, which serve as the basis for designing any of the monitoring plans for the facility for collecting data of sufficient quality and quantity to support the goals of each plan (pre-operational, operational, and post-operational). The DQO Process consists of seven iterative steps. This iterative nature of the DQO Process allows one or more of these steps to be revisited as more information on the problem is obtained. Each step of the DQO Process defines criteria that will be used to establish the final data collection design. The first five steps are primarily focused on identifying qualitative criteria, such as:

- The nature of the problem that has initiated the study and a conceptual model of the environmental hazard to be investigated;
- The decisions or estimates that need to be made and the order of priority for resolving them;
- The type of data needed; and
- An analytic approach or decision rule that defines the logic for how the data will be used to draw conclusions from the study findings.

The sixth step establishes acceptable quantitative criteria on the quality and quantity of the data to be collected, relative to the ultimate use of the data. These criteria are known as performance or acceptance criteria, or DQOs. For decision problems, the DQOs are typically expressed as tolerable limits on the probability or chance (risk) of the collected data leading one to an erroneous decision. For estimation problems, the DQOs are typically expressed in terms of acceptable uncertainty (e.g., width of an uncertainty band or interval) associated with a point estimate at a desired level of statistical confidence.

In the seventh step of the DQO Process, a data collection design is developed that will generate data meeting the quantitative and qualitative criteria specified at the end of step six. A data collection design specifies the type, number, location, and physical quantity of samples and data, as well as the quality assurance and quality control activities that will ensure that sampling design and measurement errors are managed sufficiently to meet the performance or acceptance criteria specified in the DQOs. The outputs of the DQO Process are used to develop a Quality Assurance Project Plan and for performing Data Quality Assessment.

Previous monitoring performed at the site, in addition to the proposed modified natural radiation monitoring program and the pre-operational environmental monitoring program as defined in license conditions, will be used to establish a modified baseline.

4.4.4 Pre-operational Monitoring Study

Rule at 30 TAC §336.731 requires a pre-operational monitoring program to provide basic environmental data on the disposal site characteristics as part of the application. The application should include information about the ecology, meteorology, climate, hydrology, geology, geochemistry, and seismology of the disposal site. Furthermore, for those characteristics that are subject to seasonal variation, data must cover at least a 12-month period.

The application states that the pre-operational program confirms compliance with environmental radiation dose standards and should account for all activities within the site boundaries, for the combined facilities. A matrix of sample media and locations on the outer perimeter of the site are established for evaluating overall site-wide and off-site environmental impacts from operations. Monitoring stations are established at the perimeter of the site for quarterly TLD and dose rate surveys. Groundwater samples are collected quarterly from wells at stations located around the disposal units. Air sampling stations will be located on all sides of each facility and one west of the facilities for continuous particulate air sample collection, which will be changed out weekly with analysis performed monthly on the weekly composite. Quarterly radon samples will be taken at the same locations. Soil samples collected on an annual basis within the site boundary. Vegetation samples will be collected annually from a location within the site boundary, depending on availability.

The proposed pre-operational program provided in license conditions requires the installation of 11 new monitoring well clusters. Each well cluster should monitor the OAG, the top of the 225-foot interval, the bottom of the 225-foot interval, and the 125-foot layer. If the thickness of the 125-foot layer exceeds 20 feet, then both the top and bottom of the 125-foot layer should be monitored. Six of the well clusters should be equally spaced across the northern boundary of the proposed FWF, and three clusters should be equally spaced across the northern border of the proposed CWF. In addition, a well cluster should be located equidistant from the northwest corner of the proposed FWF and monitor well FWF-20. A final cluster should be located equidistant from the northeast corner of the proposed FWF and monitor well FWF-17.

For water sampling, it is stated under the pre-operational and operation plan in the application that ASTM D 4448 – 85a (ASTM, 1992), a standard guide to sampling groundwater monitoring wells, is specified as the guidance used for sampling monitoring wells. The guide further states that, prior to sampling, wells are pumped down to the point at which the conductivity equilibrates. Samples are then acquired from the well by lowering and filling a sample bailer with well water and then transferring the water to a sample container.

According to ASTM D 4448 – 85, it is recommended that de-watering of a well too quickly can disrupt the natural flow system around the well. Thus, groundwater flow to the well may not be responding under natural condition and possibly cause contaminants that were not originally present to be drawn into the well. This is applicable in low water tables and slow flowing groundwater aquifers. Thus, it is recommended that an approved low-flow sampling method be attempted, such as ASTM D6771 – 02, Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations. There is also an EPA technical guidance on Low Flow Purging and Sampling (EPA, 1996). In addition, water levels must also be collected prior to sample collection. Discrete water levels provide snapshots into the changing groundwater conditions, which in turn may indicate changes in concentration of constituents. A groundwater sample will be collected both before any water is purged and after well purging is complete. The purpose of this sampling is to determine the efficiency of the purging method (whether low-flow or not) by age-dating the water to determine differences between the water standing in the well versus aquifer water. Each sample in each well will be age-dated and the results reported to the TCEQ in the annual REMP report. For the purpose of observing seasonal variations in water levels and potentiometric surfaces, an approved network of wells representative of each water-bearing zone will be continuously monitored using transducers where possible. This seasonable variability may affect the concentrations of contaminants in the groundwater zones; thus, it must be monitored to see these affects. The Executive Director recommends a license condition that requires and further details these groundwater monitoring procedures.

Aquatic eco-receptors, if present, and sediment should be sampled at least once in Baker Spring and all other playas during the pre-operational monitoring period. Three additional air monitoring stations are recommended to monitor air particulates, ambient gamma radiation via TLDs, and radon. Two of the three additional air monitoring stations are recommended to be located on the south side of the FWF and the third should be placed south of the proposed CWF.

All wells completed in the 125-foot and 225-foot layers have been included in the proposed monitoring programs in the draft license, including up-gradient and down-gradient wells identified in the RCRA landfill application, if water is present. All wells should be sampled quarterly. Future revisions to the REMP should use the recommended occupancy factor of 0.25 when calculating doses to members of the public (ANL, 1993).

The application states that a walk-over survey of the entire site was performed in 2005 yet the survey was not included in the application. A walk-over survey, following a 50-meter grid pattern should be conducted over the entire surface area of the proposed CWF and FWF facilities to establish gamma radiation measurement prior to operations. Surveys will be performed approximately one meter above the ground surface and as soon as practical.

TCEQ staff reviewed the environmental monitoring program described in the application for compliance with the requirements of 30 TAC §336.731. WCS stated in a June 1, 2007 meeting with TCEQ staff that they would begin pre-operational monitoring on that date. After establishing a modified natural radiation monitoring program as described previously, a pre-operational environmental monitoring program can be initiated.

4.4.5 Operational Monitoring

Title 30 TAC §336.731(b) requires a monitoring program during facility construction and operation. The monitoring program shall be capable of providing early warning of releases of radionuclides and chemical constituents before they leave the disposal site boundary.

The operational groundwater monitoring program for the FWF and CWF is presented in Section 6.3 of the Geology Report included in Appendix 2.6.1 of the application. The proposed operational groundwater monitoring program includes monitoring of the OAG, the 125-foot layer, and the 225-foot layer, and includes down-gradient monitoring locations at an approximate spacing of 150 feet in the 125-foot layer and the 225-foot layer. The application does not include sampling of the 180-foot layer in the monitoring program. A license condition is proposed to include monitoring of groundwater in the 180-foot layer.

A license condition is proposed to require well spacing on 150-foot centers to help assure that contaminates can be detected. This spacing on 150-foot centers applies to the entire perimeter for the Ogallala, Antlers, and Gatuña (OAG) and to the down-gradient well clusters as well as adding additional wells clusters to cover gaps in the well spacing proposed in the application. The license condition proposes well clusters completed in the OAG, the 125-foot layer, and the upper and lower 225-foot layer.

Soil, water, and biota are proposed to be sampled and analyzed under the REMP in Appendix 2.10.2-2 of the application. Analytes, methods, and schedules are described in Appendix 2.10.2-2 of the application. Analytes include volatiles, semi-volatiles, metals, and water quality parameters. The application states that analyte suites may be modified to correspond to waste materials received at the proposed land disposal facility.

The application states that prior to commencing operations, investigation and action levels will be determined for all active matrix/analyte combinations where the analyte is detected. Situations outside of those discussed in Appendix 2.10.1-2, are proposed to be evaluated on a case-by-case basis. A two-tiered action level system is proposed in the application to determine if environmental data recognized as above normal background will continue from the pre-operational phase. The first tier is the investigation level (IL) and the second tier is the action level (AL). Once the operational phase begins, the IL value will be updated periodically for all matrices. AL values will be updated if requirements change or as needed to ensure the IL and AL values are statistically different, and to provide a timely warning of potential regulatory exceedances or loss of containment.

Sampling of air, soil, and biota for the operational monitoring program will remain essentially the same as the pre-operational program. The TLD measurement approach for the operational monitoring program will remain unchanged from that of the pre-operational monitoring program. Also, a micro-Roentgen ambient radiation grid survey, utilizing a five-meter grid, will be performed over each disposal trench as it is filled and capped. Soil, biota, and vegetation will continue to be sampled through the off-site environmental indicator measurements.

License conditions propose the protocols, including sampling locations and frequencies for the pre-operational phase of the monitoring program. The license conditions do not distinguish between operational and post-operational monitoring requirements. The nature and extent of post-operations monitoring depends on the performance of the facility during the operational phase and also is dependent on the conditions at the site at the beginning of the post-closure period. The results of previous environmental monitoring at the time of site closure will need to be taken into account when developing the post-closure environmental monitoring program.

4.4.6 Post-operational Monitoring

Rule 30 TAC §336.731(c) requires a monitoring program through the post-operational phase of the disposal site. The monitoring program must be capable of providing early warning of releases of radionuclides and chemical constituents before they leave the disposal site boundary.

Once operations are completed, the site would undergo the following four closure, stabilization, and monitoring periods:

- **Site Closure and Stabilization Period** - This period begins at the end of the CWF and FWF operational period. During this period the site is stabilized for post-closure care. Activities during the site closure and stabilization period include site modification to improve drainage and minimize erosion; decontamination of surface facilities; demolition of structures and facilities no longer necessary; and installation of monitoring devices. The duration of the site closure and stabilization period should not be more than one or two years.

- **Post-Closure Observation and Maintenance Period** - This is an observation period that begins after site closure and lasts until the license for disposal facilities are transferred from the operator to the permanent custodian (state or federal governmental entity). This observation period normally lasts five years. Post-closure monitoring shall consist of quarterly sampling of all OAG wells, and radon evaluation at former air monitoring sites. Annual fauna samples are also taken.

- **Institutional Control Period** - Institutional controls begin when the license is transferred from the operator to the permanent government custodial agency as provided in 30 TAC §336.734. Institutional controls are designed to physically control access to the disposal facility. There are three types of controls:

  - Proprietary institutional controls which are put in place by the property owner, such as deed restrictions;
  - Governmental institutional controls, which are based on a government's or police powers, such as zoning, water well-use restrictions, and building permit requirements; and
  - Physical controls such as fences, markers, earthen covers, and radiological monitoring and maintenance for those controls. Active maintenance may also be required to maintain institutional controls and containment structures. Physical controls must be used in combination with ownership in fee simple title. At the end of the prescribed period of institutional control, the license will be terminated by the state agency in charge of oversight for the facility. The NRC specifies that the institutional control period will normally last 100 years. However, the institutional control period could last longer if radionuclides with long half-lives are disposed at the facility and if active or surveillance-type maintenance is required for a longer period to protect the public and inadvertent intruders from radiation at the site or the site will not be able to be released for unrestricted use.

- **Post-Closure Period** - This is the period of primary interest in the performance assessment process. A minimum period of 1,000 years after closure or the period where peak dose occurs, whichever is longer, is required as the period of analysis to capture the peak dose from the more mobile long-lived radionuclides and to demonstrate that the performance objective in 30 TAC §336.724 is met. During this post-closure period, physical access controls to the disposal site are assumed to be lost and site surveillance has ended.

The Post-Operational Radiological Environmental Program in the application states that once the site is closed, a reduced scope of the operational programs will be planned. The same pathways of exposure will be monitored, along with same analysis, but, the number of locations and sampling frequency will be reduced. As the final caps on the disposal cells are put into place, groundwater will become the major path of migration. Selection of actual locations will be based on the operations data. Perimeter monitoring is the main concentration of the post-operations monitoring will include off-site locations for quarterly TLD and dose rate surveys, groundwater will be collected on a quarterly basis from nine wells mostly located around the proposed disposal units. Air particulate continuous sampler filters will be changed out on a weekly basis and composited monthly for analysis. Quarterly radon measurements will be taken at the same locations. Surface soil samples will be collected and analyzed on an annual basis and vegetation samples will be taken mostly around the perimeter of the site with one in the southeast near rail unloading area.

The proposed frequency of sampling and extent of laboratory analyses during post-closure monitoring presented in the application is generally reduced from that conducted during operational monitoring. Post-operational monitoring data is anticipated to confirm that the land disposal facilities are performing as projected and as required. Monitoring is necessary to ensure that any migration of radioactive or hazardous constituents or any unexpected behavior of environmental media will be detected. The application states that in the event that such changes are detected, the sampling frequency and extent of laboratory analyses can be adjusted, as deemed necessary, and as authorized by TCEQ.

Groundwater monitoring will continue to provide data to support long-term impact evaluation. The application states that sampling may be continued at Baker Spring if water is present. Soil and vegetation will continue to be sampled through the off-site environmental indicator measurements. The sampling methods and laboratory analyses will be unchanged from those used for the operational monitoring program. The application additionally states that air monitoring methods and laboratory analyses will also remain unchanged, although methods may be technologically upgraded based on industry standards.

The application states that external gamma radiation limits will continue to be measured and recorded using TLDs and survey meter mapping. The control station in the City of Andrews is proposed to continue to provide background information. The application states that micro-Roentgen survey measurements will be performed at each TLD location, and dose rate mapping also will be conducted over the site and immediately adjacent areas. The on-site grid system used during operations for micro-Roentgen surveys will continue to be used during the post-closure period. The application states that a micro-Roentgen survey will be performed annually on a 50-meter grid to record external gamma radiation limits throughout the post-closure period. The application states that physical surveillance will be conducted periodically during the closure period and post-closure period. The site will be physically inspected for needed maintenance and repairs to ensure the integrity of the waste and safety for the post-closure work force. This includes inspection of remaining facilities, fences, disposal unit cover system, and monitoring for erosion by water or wind.

License conditions do not distinguish between operational and post-operational monitoring requirements. There is the potential for a reduced level of environmental monitoring during the post-closure period. The nature and extent of post-operations monitoring depends on the performance of the facility during the operational phase and also is dependent on the conditions at the site at the beginning of the post-closure period. Therefore, the license conditions make no assumption that reduced levels of monitoring in the future will automatically be acceptable. Post-operational monitoring requirements for the FWF will also need to be evaluated by the United States Department of Energy (DOE) at the facility decommissioning. Monitoring of some environmental media, such as groundwater, might not be reduced during the post-operational period due to the continued risk of migration of contaminants. The results of previous environmental monitoring at the time of site closure will need to be taken into account when developing the post-closure environmental monitoring program.

References Section 4.4: Environmental Monitoring Program

ANL, 1993. Argonne National Laboratories, Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil, ANL/EAIS-8, Section 29.2, page 97, April 1993.

EPA, 2006. United States Environmental Protection Agency Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4, EPA/240/B-06/001, February 2006

DOE, 1983. United States Department of Energy, DOE/LLW-13Tg, Low-Level Radioactive Waste Management Handbook Series, Environmental Monitoring for Low-Level Waste Disposal Sites, page 4-1, January 1983.

NRC, 1983. United States Nuclear Regulatory Commission Regulatory Guide 4.18, Standard Format and Content of Environmental Reports for Near-Surface Disposal of Radioactive Waste", Section.1.2.3, page 4.18-6, first paragraph, June 1983.

NRC, 1994. United States Nuclear Regulatory Commission, NUREG-1200, Standard Review Plan for the Review of a License Application for a Low-Level Radioactive Waste Disposal Facility, Sections 2.9-1, 4.4-1 and 5.3-1, April 1994.

Poston, 2008. Poston, John W., Review of Internal Exposures at Waste Control Specialists Facility. Report for Comment. May, 2008.

TCEQ, 2006. Texas Commission on Environmental Quality Notice of Enforcement dated June 9, 2006.

TDSHS, 2005. Texas Department of State Health Services, Notice of Violation dated November 3, 2005.

4.5 Air Quality Effects

The Executive Director recommends a license condition to require a particulate air emissions study and demonstration that wind dispersal of bulk waste will not affect the general public and individuals during operation and specifically address high-wind events that may occur in the site areas. The following particulate air emissions studies would need to be completed and submitted prior to the constructing the FWF-NCDU:

- An evaluation of the expected effectiveness of water spraying, with and without chemical additives, in controlling particulate air emissions from the exposed waste face in the FWF-NCDU. The study should address the emissions control effectiveness during both average seasonal wind velocity and high wind velocity events taken from National Weather Service recorded data from the past 25 years for Midland/Odessa, Texas. The study should include an evaluation of the ability to apply water sprays in winds exceeding 25 miles per hour, given the tendency for wind erosion of the waste surfaces, and droplet entrainment at higher wind speeds. The evaluation should be based upon new testing, or documented performance testing under similar conditions from prior studies, which may include spraying systems manufacturers' performance data.

- A particulate air emissions study for the FWF-NCDU should include wind erosion of the exposed waste face as a mass air emissions rate factor in the air dispersion modeling. High wind velocity events should be taken from National Weather Service data for Midland/Odessa Texas from the past 25 years, and are to be used in computing wind erosion mass air emissions for one-hour, 24-hour, seven-day, 30-day, and annual averaging periods. Maximum wind gusting velocities, as well as average sustained wind velocities should be considered in the analysis. Any credit taken for emissions control due to the sheltering effect of subsurface disposal must be validated by modeling, or by documented performance testing under similar conditions from prior studies. Any credit taken for emissions control by water spraying or surfactant of the exposed waste face must be consistent with the evaluation of this method as provided above. The study should include an estimate of the total annual mass loss of Class A soil or soil-like low-level radioactive waste from the FWF-NCDU, due to particulate air emissions, under anticipated average, and high wind operating conditions.

Section 5: Cultural Resources, Socioeconomic Impacts, and Ecological Assessments

5.0 General Introduction

Texas Health and Safety Code 401.112(a)(3) requires consideration of the socioecomonic effects on surrounding communities from the operation of a low-level radioactive waste disposal facility, including transportation impacts. The cultural resources and socioeconomic effects review and following analysis of the application were performed by TCEQ consultant, Cynthia Werner, Ph.D., Texas A&M University.

5.1 Historical, Cultural, and Archaeological Landmarks

Consistent with United States Nuclear Regulatory Commission (NRC) Regulatory Guide 4.18, Standard Format and Content of Environmental Reports for Near-Surface Disposal of Radioactive Waste, the application includes a survey of historic, archaeological, architectural, scenic, cultural and natural landmarks within a ten-kilometer radius of the proposed facility. The survey (conducted by Hicks and Company) and related correspondences can be found in Volume 33, Appendix 11.1.1, Attachment A, Appendix E, p. 349-403. The application summarizes its review of the National Register of Historic Places, the New Mexico Registered Cultural Properties, and the Registered Texas Historical Landmarks databases by stating that there are no significant historic (or architectural) sites within a ten-kilometer radius of the proposed facility. The nearest National Landmark is the Odessa Meteor Crater (located ten miles southwest of Odessa), which will not be "impacted or visually obstructed by the site". The application states that the nearest National Park is Carlsbad Caverns National Park, approximately 100 miles west of the site.

Volume 33, Appendix 11.1.1, Attachment A, Section 1.4.2, of the application presents the results of an archaeological survey conducted in 1994, of the 150-acre tract affected by facility expansion. This survey concluded that there were no archaeological resources on the site and the land is "not well suited for the presence and preservation of archaeological resources." The application notes that "[i]n the unlikely event that archeological resources are uncovered during construction, all work will cease and an archaeological reviewer at the State Historic Preservation Office will be notified to assess the site before work can proceed." In 2006, in compliance with the NRC guidelines, the Hicks Company reviewed site records for archaeological projects conducted within 10 kilometers (314 square kilometers) of the proposed facility. This review, presented in Appendix 11.1.1, Attachment A, Appendix E, of the application, revealed a total of eighteen known archaeological sites, including seven sites that are eligible for the National Register of Historic Places. The closest sites are between three and four kilometers from the proposed facility, and "although some of the sites may lie within the view shed of the proposed facility, it is unlikely that this would have an adverse effect on the site." Section 1.4.3 of Attachment A states that a site visit conducted by the Hicks

Company demonstrated that there are no scenic, cultural or natural landmarks that would be affected by this project and that "...the entire study area can be considered to have modest scenic quality that is pleasant to regard for its rural, undeveloped nature, but not dramatic, unique or rare."

Also, in Appendix E of Attachment A, the application states that WCS has received a "no historic properties affected" stamp of approval from both the New Mexico State Historic Preservation Officer (dated April 2, 2006) and the Texas Historical Commission (dated July 11, 2006). These stamps of approval indicate that the proposed facility is unlikely to have negative impacts on historic, architectural, cultural, or archaeological resources in the area.

The application has provided information to support the conclusion that there are no historic, architectural, cultural, archaeological, scenic and natural landmarks within a ten-kilometer radius of the proposed facility that would be negatively affected by the construction and operation of the facility.

5.2 Demography

Volume 33, Appendix 11.1.1, Attachment A, Section 1.0-1.1, of the application presents 2000 census data to characterize the population within the region of interest. The region of interest (defined as a 30 mile radius from the proposed facility) includes five towns: Eunice, New Mexico (six miles west, 2,569 residents); Hobbs, New Mexico (20 miles north; 28,475 residents); Jal, New Mexico (23 miles south, 2,020 residents); Andrews, Texas (30 miles southeast, 9,577 residents); and Seminole, Texas (32 miles northeast, 5,973 residents). The combined population of the four counties located within the region of interest (including portions of the county that extend beyond the 30 mile radius) is 90,155.

The application provides data regarding education levels, morbidity and mortality statistics, age distribution, ethnic and racial distribution, housing characteristics, income, poverty, and employment. Within the region of interest, 61.8 percent of the population has a high school degree or higher level of education, yet only 10.5 percent of the population has a bachelor's degree or higher level of education. This is lower than the Texas state averages of 72.2 percent and 21.4 percent respectively, and the New Mexico state averages of 76.3 percent and 21.4 percent respectively. The age structure of the population is comparable to that of Texas and New Mexico with 34.4 percent age 19 and under, 53.5 percent age 20-64, and 12.1 percent age 65 and over. Health statistics in the region of interest are comparable to the health statistics of both states with a few exceptions: Andrews County has a lower cancer rate and a higher infant mortality rate than the state averages, and Lea County has higher rate of smoking-related deaths and alcohol-related deaths than the New Mexico state average.

Demographic variables related to race/ethnicity and poverty are important for assessing potential issues related to environmental justice. The relevant demographic variables are summarized in Appendix 11.1.1, Attachment A, Section 1.1.7, of the application. Racial and ethnic minorities (defined as non-white groups) constitute 44.6 percent of the total population in the four counties located within the region of interest. This is lower than the Texas state average of 55.3 percent and the New Mexico state average 47.6 percent. Hispanics/Latinos are the largest minority group, at 39.4 percent of the total population, which is higher than the Texas state average of 32.0 percent and slightly lower than the New Mexico state average of 42.1 percent. With the exception of Blacks/African-Americans, who make up 3.3 percent of the population, other minority populations represent less than one percent of the population in the region of interest. Income and employment levels for the residents in the region are summarized in Appendix 11.1.1, Attachment A, Section 1.1.7 of the application. The median annual household income levels in the region of interest range from $29,799 in Lea County, New Mexico to $34,036 in Andrews County, Texas. These household income levels are slightly lower than the New Mexico state average of $34,133 and the Texas state average of $39,927. Each of the four counties in the region of interest has a higher poverty level than their respective state averages. In Lea County, New Mexico, 17.3 percent of households live below the poverty level, compared to the state average of 14.5 percent. In Texas, 13.9 percent of the households in Andrews County, 17.3 percent in Gaines County, and 14.4 percent in Winkler County live below the poverty level, compared to the state average of 12.0 percent. Unemployment rates range from 3.1 percent in Gaines County, Texas to 5.0 percent in Lea County, New Mexico, and are comparable to state averages of 3.8 percent in Texas and 4.4 percent in New Mexico. In all four counties, the poverty rate for Hispanics/Latinos and African-Americans is higher than that for Whites, and the unemployment rate for Hispanics/Latinos is higher than that for Whites. Appendix 11.1.1, Attachment A, Section 2.3.5.2, of the application states that in accord with guidance in NUREG-1748, Environmental Review Guidance for Licensing Actions Associated With NMSS Programs, 2003, regarding environmental justice, none of the census tracts within a four-mile radius of the proposed facility contain a minority population group, aggregate minority population, or low-income household percentage that exceeds its county or state counterparts by more than 20 percentage points, and none are comprised of more than 50 percent minorities or low-income households. The application has adequately described the population characteristics for the region of interest.

5.3 Current Land Uses

Volume 1, Section 2.2.1, of the application describes current land uses near the proposed facility. The proposed disposal facility is located within Andrews County, Texas, about one mile north of State Highway 176 and adjacent to the Texas-New Mexico border. Within a five mile radius of the site, the land is primarily used for oil production and livestock grazing. There is one oil well one half mile south of the proposed disposal facility and two producing wells approximately 1.5 miles north of the proposed disposal facility. There are no oil wells on the proposed disposal facility footprint and the application states that this due to the "absence of favorable conditions for oil production" in the immediate location of the footprint. As listed in the application, the following businesses and entities are located within two miles of the site: Wallach Quarry (crushed stone, sand and gravel), Sundance, Inc. (oil recovery and solids disposal), DD Landfarm (oil production waste), the Lea County Landfill, and the proposed LES enriched uranium facility. The nearest residence is 3.5 miles west of the proposed facility. A map on page 60 of Section 2.2.1 illustrates land use patterns in the immediate vicinity of the proposed disposal facility. The application states that the proposed facility is "compatible with current land uses" because it is "located adjacent to and in proximity to existing facilities that are currently used for the processing, storage or disposal of hazardous, low-level radioactive waste, mixed low-level radioactive waste, and municipal solid waste". In Appendix 11.1.1, Section 3.1.5, the application states that "[t]here is no reasonable potential for other highly valued land uses at the proposed site such as agriculture, recreation, residences, or industry." The application has adequately described the current land uses for properties near the proposed facility, and demonstrated that the proposed facility is compatible with current land uses.

5.4 Projected Population Growth

In Volume 33, Appendix 11.1.1, Attachment A, Section 1.1, the application presents U.S. census data and Water Development Board data for population projections for the affected region, as well as a qualitative description of planned development projects in the region. From 1990 to 2000, the population of the four counties that border the proposed facility decreased an average of 2.9 percent. This decrease is described as counter to trends for each respective state (22.8 percent and 20.1 percent increases for Texas and New Mexico respectively). However, population projections suggest that the region's population will increase continuously from 2000 to 2040. Although census data suggests that the region of interest is likely to increase 23.6 percent from 2000 to 2040, this level of increase is much lower than population projections for Texas and New Mexico (71.5 percent and 58.9 percent projected increases). Similarly, the Texas Water Development Board projects a 17.5 percent increase in population from 2000 to 2040 for the three counties within the region of interest, yet a 74.6 percent increase for the population within the State of Texas. Within the region, the U.S. census expects Andrews County to experience a slightly higher level of growth, at 24.5 percent, from 2000 to 2040. During the same time period, the Texas Water Development Board projects a 22.1 percent increase in population for Andrews County.

Regarding this license application, it is critical to consider how population projections are expected to vary by race/ethnicity. Most significantly, the application states that from 2000 to 2040, the Hispanic population is expected to increase 84.0 percent in Andrews County, 110.5 percent in Gaines County, and 49.7 percent in Winkler County. In comparison, the White/Anglo population is expected to decrease by 18.0 percent in Andrews County and 20.1 percent in Winkler County, while increasing only 5.3 percent in Gaines County. The rate of growth for both Anglos and Hispanics is lower than the state projections, at 4.1 percent and 181.9 percent respectively. As noted in Attachment A, Section 1.1 of the application, population projection data by race/ethnicity does not exist at the county level for New Mexico. According to Appendix 11.1.1, Attachment A, Section 2.3.5.4, of the application, "the increasing future proportion of Hispanic or low-income persons in proximity to an established facility would not appear to fall within the purview of the environmental justice provisions of NUREG-1748." This statement is accurate; however, the Executive Director recommends that an additional environmental justice analysis be conducted for any license amendments made after 2015 to ensure that the licensed facility does not disproportionately impact minority or low-income groups.

Volume 1, Section 2.2.2, of the application presents a contradictory summary statement regarding the impact of projected population growth on the ability of the proposed disposal facility to meet performance objectives. Specifically, the application states: "The Texas population forecast (i.e. Texas Water Development Board (TWDB) projections) projects a much smaller growth rate between 2000 and 2010 (3.9 percent versus 19.7 percent) and essentially no growth during the following decade. In the two decades following 2020, the population for Andrews County is expected to decline". This statement is not supported by the data described above (provided by Hicks and Company) which suggests that the population will continue to grow in the region of interest (albeit more slowly than the state averages). This contradictory statement is used in Volume 1, Section 2.2.2, page 10 of the application to conclude that population trends are unlikely "to adversely impact the ability of the WCS land disposal facility to meet the performance objectives". Volume 33, Appendix 11.1.1, Attachment A, Section 2.3.4.5 contains the only other statement in the application regarding the impact of projected population growth: "... the undeveloped land around the WCS facility is not well suited for residential development, and a considerable portion is owned by WCS." Although the application contains some contradictory information regarding population projections, the application adequately demonstrates that the proposed facility is located in a site where projected population growth is unlikely to impact the ability of the facility to meet performance objectives.

5.5 Future Developments in the Region of Interest

As stated in Volume 1, Section 2.2 of the application, the facility property includes approximately 14,900 acres, which helps limit development in the proximity of the proposed facility. Adjacent properties are used for oil production, cattle grazing, landfill, and uranium enrichment. The most significant development project in the region is the construction of the Louisiana Energy Service's National Enrichment Facility (NEF) on a neighboring property in Lea County, New Mexico (approximately one mile west of the proposed low-level radioactive waste disposal facility). Volume 33, Appendix 11.1.1, Attachment A, Section 2.5.1.6 indicates that "the NEF clearly represents a potential customer for the WCS waste disposal complex, subject to complying with Texas statutory requirements." Volume 32, Appendix 11.1.1, Section 2.1.1, of the application states that there is no other "significant business development" within a ten-mile radius of the proposed disposal facility.

According to the Andrews Economic Development Corporation website, other new and proposed developments in the broader region include a proposed high-temperature teaching and test reactor energy research facility at the Andrews branch of the University of Texas - Permian Basin; a new distribution center for the fiberglass and composites company, Composites One; a new steel tank manufacturing facility for an existing Andrews company, Palmer of Texas; a new oilfield supply center for existing company, Western Texas Pipe and Supply; and the new Andrews Business and Technology Center (for distance learning) (www.andrewsedc.com/current.html, access date June 26, 2007).

The NEF project may likely benefit the proposed disposal facility in terms of providing additional revenue. Given the size of the site property and the location of the proposed facility relative to other proposed developments, it is unlikely that future developments in the region will adversely impact the ability of the proposed facility to meet the performance objectives.

Volume 33, Appendix 11.1.1, Attachment A, of the application includes: an analysis of community perceptions towards the proposed facility; analysis of economic impacts during the construction and operation phases of the proposed facility; an analysis of transportation-related impacts; and an analysis of cumulative socioeconomic impacts. These perceptions and impacts are reviewed below.

5.6 Community Perceptions of WCS

The impact of a new development can be analyzed from two perspectives: the expected impacts based on professional analysis and the perceived impacts based on the opinions of local community members. Perceived impacts can include intangible things, such as changes in lifestyle and challenges to local values. Although perceived impacts may not be in alignment with expected impacts, they are crucial for gauging how a local community will respond to a new development. This is particularly important when it comes to low-level radioactive waste disposal facilities, given the power of public opinion to influence the siting process. In fact, every attempt to site a Class A, B, and C low-level radioactive waste disposal facility in the United States, since the United States Congress passed the Low-Level Radioactive Waste Policy Act in 1980, has been hampered due to negative public perceptions.

As part of the application and in response to requests from TCEQ, community perceptions were assessed and analyzed through two different surveys of residents within the Region of Interest. These surveys can be used to assess the extent to which the community supports the proposed facility and to understand the positive and negative impacts that local community members anticipate from the proposed facility. The first (Tier I) survey was based on a non-probability sample of 50 individuals, including 26 individuals who were targeted as “community leaders” (including local government officials, business owners, and church leaders). The majority of interviews were face-to-face interviews. Survey respondents were asked whether they believed the facility would bring economic development to the region, and they were asked to discuss any concerns they had about the proposed facility. The first survey generated both qualitative and quantitative data. The results of this first survey are summarized in Volume 33, Appendix 11.1.1, Attachment A, Sections 1.3.3.2 thru 1.3.3.5 of the application.

In the first survey, 68 percent of respondents "strongly" agreed, 22 percent "moderately" agreed, and eight percent "minimally" agreed that the proposed facility will bring economic development to the region. Only two percent disagreed strongly to this question. In response to a question about their concerns with the facility, 78 percent of respondents stated that they had "no concerns," four percent had "minimal" concerns, 12 percent had "moderate" concerns, and only six percent had "strong" concerns. When asked for their overall opinion, 70 percent of respondents "strongly" agreed with the development of the proposed facility, 20 percent "moderately" agreed, eight percent "minimally" agreed, and two percent "strongly" disagreed.

In the first survey, numerous qualitative statements were collected from respondents in support of the proposed facility. The following sentiments were expressed in favor of the facility:

- The facility will help diversify the local economy which is very dependent on oil and gas;
- Low-level radioactive waste is safer, more regulated, and more stable than the oil and gas industry, and people in this region are already used to dealing with hazardous industries;
- The facility will create new jobs and help keep young people in the area;
- WCS has played a positive role in the community by providing jobs and donating money to local causes.

While many respondents only had positive things to say about the facility, several respondents noted the following concerns:

- Regarding transportation safety, and whether shipments of waste will increase congestion on local roads and railroads;
- Regarding how the facility might affect safety of water and pasturage for human and livestock consumption; and
- Regarding WCS's ability to communicate risks to the public.

These findings are useful for understanding what local community members believe are the benefits and risks of the proposed facility.

As indicated by data in Appendix 11.1.1, Attachment A, Section 1.3.3.2, although the first survey provided some information about local community perceptions, the survey sample was not representative of the total population in terms of education, income, race/ethnicity, or gender:

- 59 percent of the respondents had completed college (or graduate school);
- 82 percent earned more than $50,000 a year;

- 82 percent of the respondents were White;
- 12 percent were Hispanic/Latino; and
- 71 percent were male.

This sampling bias makes it problematic to make generalizations about public perceptions towards the proposed facility based on survey results. In other words, any conclusions based on statistics generated from this survey are highly questionable and unscientific. This does not mean that the survey does not have some value. The results of this survey are best suited for understanding how the economic and political elite view the proposed facility, since the survey sample is biased towards the views of economic and political leaders in the community. These are individuals who are likely to have vested interests in the proposed facility (i.e. increased income for business owners, increased tax revenue for politicians). The survey can also be used to understand some of the positive and negative views towards the existing WCS facility and the proposed expansion.

The findings from the first survey adequately demonstrate that the economic and political elite in the community are in strong support of the proposed facility. This is further evidenced by letters of support from the Lea County Board of Commissioners (November 22, 2005); the City of Eunice (December 14, 2005); City of Jal (December 12, 2005); City of Hobbs (November 21, 2005); City of Lovington (November 28, 2005); County of Andrews (January 13, 1997 and November 8, 2003); City of Andrews (August 23, 2003 and January 29, 2004); Town of Tatum (November 25, 2005). These letters are contained in Volume 33, Appendix 11.1.1, Attachment A, Appendix B, of the application.

As part of the application and in response to TCEQ's request to gather opinions from a more representative sample of the population, a second (Tier II) survey was conducted by phone using a probability (or random) sample. The sample for the second survey included 605 adults who lived within selected zip codes of the Region of Interest. Survey questions were aimed at measuring awareness of the three different proposed nuclear facilities in the region (WCS' LLRW disposal facility, the NEF facility, and the reactor), to assess the level of support for these facilities, and to determine perceived positive and negative impacts of WCS. The design of this second survey is described in Volume 33, Appendix 11.1.1, Attachment A, and Section 1.3.3.6, of the application. Most of the questions generated quantitative data, but the questions about impacts were open-ended questions (generating qualitative responses which were then categorized and quantified).

In the second survey, respondents were first asked questions that assessed how familiar they were with WCS. Then, they were asked whether they supported the processing, storage and disposal of low-level radioactive waste by WCS. They were also asked an open-ended question about the positive and negative impacts the facility has had on the community, and they were asked to respond to a series of agree/disagree statements regarding their support for the proposed facility. The responses of the second survey participants are summarized in Volume 33, Appendix 11.1.1, Attachment A, Appendix

G, of the application. Of the total sample, 64 percent have heard of WCS (and 42 percent had heard positive things), and 36 percent have not heard of WCS. Within Andrews County, 81 percent of the respondents had heard of WCS and 69 percent had heard positive things. Overall, the general level of familiarity with WCS was much higher than that for the National Enrichment Facility (46 percent). Although the majority of respondents were familiar with WCS, only 23 percent of the total sample and 44 percent of respondents in Andrews County had "seen, read or heard anything recently" about WCS. When asked to describe what the Waste Control Specialists facility does, only 20 percent of all respondents and 31 percent of respondents in Andrews County specified "radioactive waste". An additional 34 percent of all respondents gave answers that related to waste storage while 37 percent of all respondents were unsure or did not provide an answer. It is clear that some respondents who are familiar with the name of WCS seem to think that WCS is a general landfill. For example, 117 respondents (19.3 percent) thought that WCS "picks up garbage and disposes of it" or "safely stores the waste we have all over the county." Some respondents also believe that WCS "regulates waste control" (3.3 percent) "deals with recycling" (0.3 percent), "takes care of our sewers" (0.5 percent) "disposes of batteries" (0.2 percent) and "keeps city clean" (0.3 percent).

When asked whether they favor or oppose "the disposal of low-level radioactive waste by Waste Control Specialists in Andrews County, Texas," 52 percent of respondents favor, 35 percent oppose, and 14 percent are unsure. This level of support is nearly identical to the support for the "storage" and "processing" of low-level radioactive waste at the Andrews facility, the enrichment of uranium by the NEF facility in Lea County, and the generation of electricity with a nuclear reactor in Andrews County. Within Andrews County, the level of support is noticeably higher with 65 percent of respondents in favor of the disposal of low-level radioactive waste and only 26 percent opposed. The application also emphasizes that 65 percent of the respondents who had seen, read or heard something about WCS and 68 percent of respondents who knew that WCS handled radioactive waste favored the disposal of low-level radioactive waste at the facility.

In response to the open-ended question about how WCS has positively affected the community, 40.2 percent of the respondents indicated that WCS has helped the economy and provided jobs, 4.5 percent indicated that WCS has donated a lot of money to schools and other community projects, and 4.8 percent answered that WCS has helped clean the environment. While 21.8 percent were unsure how to answer the question, 25.6 percent answered that they had not seen any positive impacts from WCS. In response to the open-ended question about how WCS has negatively affected the community, 56.9 percent had no concerns, 25.9 percent of respondents had concerns, and 17.2 percent were unsure or didn't provide an answer. Of those who had concerns, 22 respondents stated "one of these days that will leak into the water," 14 respondents stated that they "just didn't care for it," 12 respondents were concerned about "health dangers to the surrounding community," 12 felt that the issue was "controversial" and had "divided the community," nine felt that it would be "detrimental to the future," eight were concerned about "nuclear contamination" or "radiation," and three stated that it "didn't bring jobs or only brought in minimum wage jobs."

In Volume 33 Appendix 11.1.1, Attachment A, Section 3.1.1.4, the application provides some information on how the survey results vary by ethnicity and income. For example, 55 percent of Hispanics in Andrews County support the disposal of low-level radioactive waste, compared to 65 percent of all residents in Andrews County. Although the overall rate of support was lower, only 26 percent of Hispanics felt that their concerns outweighed the positive impacts of the facility. Hispanic females had slightly higher perceptions of risk, with 22 percent expressing concerns about accidents and other effects (compared to 18 percent in the total population). Among respondents with family incomes below $30,000, 48 percent agreed with a statement suggesting that the positive impacts of the proposed facility outweighed their concerns, 38 percent disagreed, and 14 percent were unsure.

Local community support for the proposed facility was found to be much lower in the second survey (52 percent) than in the first survey (82 percent). In response to these divergent results, in Volume 33, Appendix 11.1.1, Attachment A, Section 1.3.4.1.1, the application concludes "while the random survey indicates that concerns and perceptions of risk are higher among the general population than among community leaders, there appears to be substantial trust and support for the facility, even among potentially vulnerable groups." Another statement in Section 1.3.4.1.1 suggests that "the random sample results have clearly identified more concerns and somewhat higher levels of perceived risks among the general population of the region of interest (ROI) than the informal survey of opinion leaders. Nevertheless, a majority of the general population appears to hold positive, trusting and optimistic attitudes and perceptions about how the proposed facility would affect their lives. This perception appears strongest among the total respondents, but notably, is also strong among the potentially vulnerable minority and low-income groups in the ROI community." In Appendix 11.1.1, Attachment A, Section 1.3.4.9, the application explains the difference between the two surveys, emphasizing that there is an important link between knowledge about the facility and support for the disposal of low-level radioactive waste at the facility. For example, the application states that "Tier II survey results show that most residents with specific knowledge of the WCS facility are in favor of the project and anticipate economic benefits."

As noted in Appendix 11.1.1, Attachment A, Appendix G, the second survey has several strengths in terms of methodology. First, standard telephone survey methods were employed and in general the sampling strategy and sampling frame were adequate for this study. Second, the survey was more representative of the local community than the first survey in terms of gender and income, with only 48 percent of respondents as males, and only 39 percent of respondents with incomes of $50,000 or more per year. Third, using American Association of Public Opinion Research (AAPOR) guidelines, the contact rates, defined as the number of eligible persons who were contacted (i.e. who answered the phone), were very good.

Despite these strengths, there are still several issues of concern regarding the methodology. First, with regards to race/ethnicity, as indicated by data from Attachment A, Appendix G, pages 464-466, the sample was not more representative than the previous sample: 82 percent of the sample was White/Anglo and 13 percent of the sample was Hispanic/Latino. In comparison, census data from Volume 33, Appendix 11.1.1, Attachment A, Appendix, page 427, indicates that the population within the region of interest is 55.4 percent White and 39.4 percent Hispanic/Latino. One partial explanation for the low proportion of Hispanic respondents was suggested in a presentation of survey results by consultant Michael Baselice (on March 13, 2006 at the TCEQ office in Austin): In survey research, it is difficult to generate lists of telephone numbers that includes cell phones, and Hispanic residents may be more likely than Anglos to use cell phones exclusively. Second, the survey was conducted in a short time period (three days) relative to other phone surveys of this scale, and this is likely to have severely hampered the ability to convert "soft refusals" and "call backs" into completed surveys. In general, telephone surveys can be problematic for reaching low income and minority populations, hence extra efforts often have to be taken in order to convert soft refusals, call backs and language issues into completed interviews. In this particular case, there were "language" problems with 325 calls, and presumably, the vast majority of these were likely to be potential Spanish-speaking respondents (as opposed to deaf or hearing-impaired respondents). In the case of a language issue, the procedure is to call back with an interviewer who is able to conduct the interview in a foreign language. The survey report indicates that there were 38 Spanish callbacks on the first two days and "42 more" on the third day. As indicated on page 427 of Appendix G in Attachment A, only one of these callbacks was converted into a completed interview. What all this suggests is that some caution must be used when employing this sample to represent the entire Region of Interest. Although the sampling methodology was appropriate, it is likely that the sample under-represents minorities and low-income households.

A second overall problem with the survey methodology relates to how certain questions were asked. For example, the only open-ended questions about the positive and negative impacts of the WCS facility were phrased in a way that captured impacts that have already taken place, rather than perceived impacts of the proposed expansion. As noted in Appendix 11.1.1, Attachment A, Appendix G, pages 461-462, of the application, respondents were asked: "Please tell me in your own words any benefits or positive impacts the Waste Control Specialists facility has had on your community?" and "Please tell me in your own words any concerns or negative impact the Waste Control Specialists facility has had on your community. By using this wording, respondents were not asked to discuss perceived impacts from disposal of low-level radioactive waste. Another problem arises with agree/disagree statements that were phrased one way for half of the respondents, and phrased in reverse for the other half of the respondents. For example, half of the respondents were asked whether they agreed or disagreed with the following statement: "I am used to the storage and processing of low-level radioactive waste, so disposal of the same should work out fine" while the other half responded to this statement: "I am not used to the storage and processing of low-level radioactive waste, so the disposal of the same concerns me." The second statement starts with a negative ("not") and then asks respondents whether they agree or disagree. If they support the disposal of low-level radioactive waste at WCS, the person has to "disagree" with the statement because two negatives make a positive. For native English speakers, this is a complex mental operation that requires common agreement on logic and grammar. Common colloquialisms allow for and employ double negatives without generating a positive, and in Spanish two negatives are common and grammatically correct without generating a positive. The important element of the question is whether or not people are comfortable with the disposal of low-level radioactive waste. Ideally, the percent of people who responded positively to the first statement would be similar to the percent of people who responded negatively to the second statement. But, that is not the case. For the first statement, 55.4 percent agreed, 34.7 percent disagreed, and 9.9 percent were unsure. And, for the second statement, 53.0 percent agreed, 39.1 percent disagreed and 7.9 percent were unsure. The point here is that it is difficult to interpret what the results from such questions mean in terms of community perceptions.

The following paragraphs discuss several concerns with the conclusions stated in the application regarding community perceptions of the proposed facility. The first concern is that the application repeatedly emphasizes that the majority of survey respondents favor the disposal of low-level radioactive waste at the Andrews facility, while noting that the level of support was highest in Andrews County. The application, however, does not acknowledge that there are statistically significant regional variations. Throughout the application, findings for residents in Andrews are compared to the total survey sample. For the survey sample, residents were interviewed in Andrews County, Gaines County, and Lea County. Further analysis of the raw data presented in the application (the data in Appendix 11.1.1, Attachment A, Appendix G) indicates that support for the proposed facility is much lower in Gaines and Lea County. Table EA-4 presents that data.

While support for the facility is in the mid-60s for Andrews County, they are in the mid-40s for the other two counties, with the exception of waste processing which is supported by 51 percent of respondents from Lea County. These findings suggest a higher degree of regional heterogeneity than the survey summary or socioeconomic impact statement imply. These findings are also in sharp contrast to the findings of the first survey (which was biased towards leader views), where 84 percent of respondents in Lea County had no concerns about the facility and four percent had minimal concerns (discussed above). This further confirms that the any conclusions based on the first survey are highly problematic when used to generalize about the region of interest as a whole.

Table EA-5: Support for Storage, Processing and Disposal of Low-Level Radioactive Waste

	N	Favor	F-test	Post-hoc test		
Storage				G	A	L
Gaines	128	0.43			*	
Andrews	172	0.67	10.563*	*		*
Lea	305	0.49			*	
Processing						
Gaines	128	0.40			*	
Andrews	172	0.66	11.168*	*		*
Lea	305	0.51			*	
Disposal						
Gaines	128	0.44			*	
Andrews	172	0.65	8.762*	*		*
Lea	305	0.48			*	

* = Prob.. ≤ 0.01

A related concern is that conclusions drawn from the second survey tend to downplay differences by ethnicity and gender. As an example in Volume 33, Appendix 11.1.1, Attachment A, Section 1.3.3.6, page 59, the application notes that "the opinions of Hispanics did not differ significantly from the opinions of Anglos." However, at the α = .05 level, statistical tests suggest that the Hispanic proportions are approaching statistical significance with respect to storage (0.55 Anglos and 0.45 Hispanics, with a z of 1.63) and disposal (0.54 Anglos and 0.45 Hispanics, z of 1.46). An argument could be made that given the under-representation of Hispanics in the sample and concerns of environmental racism, one might relax statistical testing to the α = 0.1 level of significance in which case Anglo proportions are significantly different (and higher) than Hispanics. Furthermore, and more importantly, issues of environmental racism do not focus exclusively on Anglo/Hispanic comparisons, but rather Anglo/minority comparisons. Thus, more germane comparisons would be between Anglos and minorities (Hispanic, Black, and Other). If these comparisons are made, Anglo proportions in favor of storage and disposal are statistically significant (at the 0.01 level) and higher than the minority proportions Table EA-5 and EA-6 present the data related to comparison.

These findings suggest that minority perceptions are indeed significantly different that the majority Anglo populations. More specifically, not only do minority proportions in favor not reach even the minimal 50 percent thresholds, but also they are significantly lower than those of the majority Anglo population. What is interesting is these differences are discernable from a sample that significantly under-represents Hispanic and other minority populations. Such findings challenge the application statement in Appendix 11.1.1, Attachment A, Section 1.3.4.1.1, page 75, that support "is also strong among the potentially vulnerable minority and low-income groups in the ROI community."

Table EA-6: Support for Storage, Processing and Disposal of Low-Level Radioactive Waste (Anglo vs. Minority)

	Prop.	z-test
Storage		
Anglo Minority	0.55 0.42	2.413
Processing		
Anglo Minority	0.54 0.47	1.349
Disposal		
Anglo Minority	0.54 0.40	2.563

Table EA-7: Support for Storage, Processing and Disposal of Low-Level Radioactive Waste (Male vs. Female)

	Prop.	z-test
Storage		
Male Female	0.62 0.45	4.185
Processing		
Male Female	0.61 0.43	4.425
Disposal		
Male Female	0.62 0.45	4.185

Regarding gender, the socioeconomic impact statement in the application provides limited information on gender differences, only noting, in Appendix 11.1.1, Attachment A, Section 1.3.4.9, page 72, that women have greater perceptions of risk and men trust the regulatory system more. In examining the raw data, however, it appears that gender differences with respect to favoring storage, processing and disposal of low-level radioactive waste are even more pronounced than minority differences. Table EA-7 above displays gender variations in the proportion in favor of storage, processing and disposal, along with the z-test for significant differences. While the male proportions are all just over 60 percent, the female proportions are at best 45 percent and these differences are highly significant. Thus, as suggested by the academic literature, women, who are often the care-givers for children and elderly within households, are significantly less in favor of WCS than are men. Again, these figures suggest a considerable "gender gap" when it comes to storage, processing and disposal in the ROI, a finding that is not suggestive of homogeneity, but rather heterogeneity.

A third concern is that WCS suggests that the differences between the first survey and the second survey can be explained by different levels of knowledge. Repeatedly, as in Appendix 11.1.1, Attachment A, Appendix G. page 451 and as in Appendix 11.1.1, Attachment A, Section 1.3.4.11, page 73, the application notes that respondents who are "knowledgeable" about WCS have higher levels of support for the proposed facility. Statements in the application imply that those members of the community with more education are more knowledgeable and more supportive. For example, in Appendix 11.1.1, Attachment A. Appendix G, page 434, a summary of the survey results notes that "[w]omen, particularly Hispanic women, with less knowledge of the project, tend to perceive more risk." The problem with this assumption is that neither survey adequately assesses respondent's knowledge levels, and thus conclusions that relate knowledge to support are deceptive. For example, there are three questions in the second survey that are used to ascertain "knowledge": one questions asks if the respondent has ever heard of WCS, a second question asks if the respondent has recently "seen, read or heard anything about WCS," and the third questions asks about the source of any information recently "seen, read or heard." As stated in Appendix 11.1.1, Attachment A, Appendix G, page 434, the survey indicates that 23 percent of the respondents had recently seen, read or heard something about WCS. Of those who had recently seen, read or heard something, over 70 percent had read something in the newspaper, about 44 percent had heard something from another person, and about 17 percent had attended a public hearing. The problem is that none of the questions asked can really determine whether the respondent is well-informed about WCS. An individual who has heard something about WCS from the newspaper or from a friend is not necessarily knowledgeable about the risks and benefits of the proposed facility.

A related concern is the finding that most people in the community are not all that aware of what WCS does. As noted above, about 25 percent of respondents equate WCS with a local landfill or local waste management facility. This indicates that outreach activities in the community have room for improvement.

5.7 Job Creation

Local community members anticipate the creation of new jobs as one of the positive benefits of the proposed facility. Responses to a community opinion survey, contracted by WCS, are summarized in Appendix 11.1.1, Attachment A, Section 1.3.3.3, pages 47-48, of the application. In that survey nineteen of the fifty respondents "supported the project due to the possibility of additional employment and the need for economic diversification in the area." Several respondents added that "young people need jobs" in order "to stay around Andrews." Similarly, others noted a desire to "improve employment for the current population." One respondent acknowledged that some of the jobs will require special knowledge of waste management, yet "hopes that the local population can be trained to fill necessary positions." The perception that the proposed facility will create new jobs is supported by the perception that the existing facility has already benefited the community by providing new jobs. In the random sample survey contracted by WCS, 33.9 percent of the 605 respondents indicated that WCS has positively impacted the community already by "giving jobs," "helping the economy" or "bringing revenue." Appendix 11.1.1, Attachment A, Appendix G, page 461 indicates that an additional 10.8 percent of the respondents cite other positive impacts that WCS has already made within the community, such as bringing economic growth and donating money to local causes. The random survey did not include a question about expected impacts of the proposed disposal facility, and the survey results did not distinguish "job creation" responses from "helping the economy" responses.

Appendix 11.1.1, Attachment A, page 2 indicates that during the construction phase, the proposed facility is expected to generate 25 full-time construction jobs in 2008. A smaller number of construction workers may be hired in future years to expand the landfill, yet these numbers are not yet determined. The average weekly wages in Andrews County within the construction industry is $560. The application does not specify the wage rate for the construction workers, but indicates that the rate will be "below the average wage rate for all industries" (which is $615). According to the 2000 census, 2, 102 construction workers are employed in the four counties within the Region of Interest, so an additional 25 jobs represents a 1.19 percent increase in this sector. Due to the current boom in the oil and gas industry and the "specialized nature of the work," In Appendix 11.1.1, Attachment A. Section 2.2.1.5, pages 83-84, the application anticipates that "contractors will probably have to be imported to the area for the construction of the proposed facility," as occurred with the RCRA landfill expansion work in 2005. However, in Appendix 11.1.1, Attachment A, Section 2.2.1.11, page 88, the application notes that "local contractors (within the ROI) and workers will be hired for general construction activities if available".

According to Appendix 11.1.1, Attachment A, Section 2.3.1.1, WCS currently employees 107 workers at the Andrews County site. During the operation phase, WCS expects to hire an additional 75 employees to operate the new component of the facility. Table 10.5.1, in Volume 31, Appendix 10.5, of the application indicates that of the 75 new hires, 73 will be facility assigned workers (based primarily at the WCS facility in Andrews County) and 2 will be infrastructure support workers. Appendix 11.1.1, Attachment A, Section 1.1.9, page 33, states that, according to the 2000 census, there are 33,339 individuals employed in all sectors and 2,054 individuals employed in the "other services" sector in the four counties within the Region of Interest, so an increase of 75 jobs represents a 0.22 percent increase in the total number of jobs and a 3.65 percent increase to the jobs in the "other services" sector.

Tables A.24 in Appendix 11.1.1, Attachment A of the application provides information on the job qualifications and training information for three categories of WCS employees: Maintenance (five levels), Operator (five levels), and Technician (five levels). The Maintenance and Operator levels require a minimum high school education, while the

Technician positions require a minimum high school education at the lower levels and some college at the higher levels. Although the application lists job titles for the 75 new jobs, Tables 10.51 and 10.5.2 in Volume 31, Appendix 10.5 indicate that only some of the job titles correspond to the three job categories mentioned above, including 21 new technician positions and eight new operator positions. The application does not specify the educational requirements for the other 46 new positions, however, the list includes jobs such as “radiation safety officer” that are likely to require specialized education, jobs such as “security guards” and “truck drivers” that are less likely to require higher education, and jobs such as “waste acceptance specialist” and “sampler” where the minimum educational requirements are unclear. In Appendix 11.1.1, Attachment A, Section 2.3.1.8, page 93, the application indicates that they attempt to hire locally, but when “qualified individuals cannot be located in the surrounding areas, a wider search is employed to areas such as Lubbock, Texas, El Paso, Texas, Dallas, Texas, Albuquerque, New Mexico, Denver, Colorado and Los Alamos, New Mexico, depending on the qualifications needed.”

As stated in Appendix 11.1.1, Attachment A, Section 2.3.1.5, page 90, the new workers will earn an average salary of $40,000 per year. This is higher than the average wage in the region, and thus the new jobs are likely to “attract existing workers from most industrial sectors in the County, except for the oil and gas sector, where wages would remain relatively higher.” The application does not specify how the wages/salaries for the new jobs will vary from one position to the next. An impact study conducted in 1996 for an earlier WCS development estimated that approximately 62 percent of the new facility jobs would be filled by unemployed and underemployed workers in the Region of Interest, while 38 percent of the new facility workers would relocate to the area. It is implied that these numbers would apply to the current expansion as well, which means that 46-47 of the 75 jobs would go to locals. According to Appendix 11.1.1, Attachment A, Section 2.3.1.7, page 92, of the application, based on current WCS operations, it is anticipated that 49 percent of the new employees will live in Andrews County and 40 percent in New Mexico.

5.8 Indirect and Induced Economic Impacts

Economic growth in one sector of the economy spawns economic growth throughout the economy. Induced impacts refer to impacts on the local economy as individuals who are directly employed by a new development spend their new wages locally on goods and services such as housing, clothing and food. Indirect impacts refer to impacts on the local economy as the new business (or new component of a business) spends money on local goods and services.

Volume 33, Appendix 11.1.1, Attachment A, Section 2.2.1.7 of the application describes the use of multipliers from the Regional Input-Output Modeling System (RIMS II) to model indirect and induced economic impacts from the proposed facility within the region of interest. In addition, spatial allocation factor is used to indicate the distribution of indirect and induced economic impacts. Using RIMS II multipliers and spatial allocation methodology, the model estimates that the addition of 25 full-time construction workers will generate 27 additional indirect and induced jobs within the region of interest, and seven additional indirect and induced jobs outside the region of interest (in Lamesa and Odessa). In Appendix 11.1.1, Attachment A, Section 2.2.1.9, pages 86-87, the application anticipates that these new workers will commute from existing residences, and that "no substantial in-migration of population is expected for the Region of Interest as a result of the construction-related job growth." The model estimates that the addition of 75 full-time workers will generate an additional 61 indirect and induced jobs, including 46 in the immediate Region of Interest and 15 outside the region of interest (in Lamesa and Odessa). According to the model, this would include 23 jobs in Eunice, 16 jobs in Hobbs, three jobs in Andrews, and one job each for Seminole, Kermit, Lovington and Jal.

According To Appendix 11.1.1, Attachment A, Section 2.2.1.2, page 82, during the construction phase, which is limited to 2008 the proposed facility is expected to generate $4,650,000 in indirect and induced income and $18,000,000 in indirect and induced sales. During the operation phase, the proposed facility is expected to generate $16,735,000 per year in indirect and induced income and $21,164,500 per year in indirect and induced sales. As stated in Appendix 11.1.1, Attachment A, Section 2.2.1, page 82, according to the model, the distribution of this income and sales would occur in the same proportion as the distribution of jobs noted above.

As described in Appendix 11.1.1, Attachment A, Section 2.2.1, the analysis of economic and services impacts uses multipliers from the Regional Input-Output Modeling System (RIMS II) to model indirect and induced economic impacts from the proposed facility within the region of interest. Different multipliers are used for different economic sectors. The construction sector, for example, has relatively high multipliers due to extensive backward linkages. RIMS multipliers are commonly used in economic impact assessments, but it should be noted that the results are approximate estimates. In addition, RIMS II uses a simplified gravity model to understand the distribution of economic impacts. A simplified gravity model assumes that economic impacts will be distributed as a function of the population of regional cities and the inverse of the squared distance between these cities and the facility. The use of a simplified gravity model was originally developed for understanding economic impacts in urban areas, and may be less effective for understanding the distribution of economic effects in a rural region. For example, Appendix 11.1.1, Attachment A, Section 2.3.1.7, of the application notes that the allocation of impacts to Eunice (which are high because of its physical proximity to the site) may be overestimated because the "existing economic base of the small town would not likely sustain this level of impacts in the short run." The actual impacts will vary depending on actual residence patterns of WCS employees, actual profit earned by WCS, actual expenditure patterns by WCS, etc. In Appendix 11.1.1, Attachment A, Section 2.3.3.1, the application presents a comparison of actual residence patterns of existing 107 employees versus predicted residence patterns for additional 75 employees based on spatial allocation factors. The comparison provided in Table EA-8 clearly demonstrates how the spatial allocation factors can be problematic:

Table EA-8: Comparison of Actual Residence Patterns to Predicted Residence Patterns

City of Residence	Number of Existing WCS Employees	Percent of Existing WCS Employees	Spatial Allocation Factor	Percent of Future WCS Employees (as predicted)
Andrews, TX	59	55.14 percent	0.0523	5.23 percent
Eunice, NM	24	22.43 percent	0.3707	37.07 percent
Seminole, TX	1	0.09 percent	0.0152	1.52 percent
Kermit, TX	0	0 percent	0.0177	1.77 percent
Wink, TX	0	0 percent	0.0020	0.2 percent
Hobbs, NM	14	13.08 percent	0.2591	25.91 percent
Lovington, NM	0	0 percent	0.0233	2.33 percent
Jal, NM	7	6.54 percent	0.0124	1.24 percent
Lamesa, NM	0	0 percent	0.0092	0.92 percent
Midland/Odessa, TX	2	1.87 percent	0.2364	23.64 percent
Total	107	99.96 percent*	0.9983	99.83 percent*

* Totals do not equal 100 because some numbers have been rounded.

If residential patterns follow existing patterns rather than patterns suggested by spatial allocation factors, the estimated impacts for Andrews and Jal are grossly underestimated, while the estimated impacts for Eunice, Hobbs and Midland-Odessa are significantly overestimated. This problem would apply to spatial allocation estimates for indirect and induced job creation, indirect and induced earnings, indirect and induced output, and impacts on fiscal structures and community services.

5.9 Fiscal and Community Service Impacts

According to Appendix 11.1.1, Attachment A, Section 2.2.1.11, page 87 of the application, during the construction phase, the proposed facility will probably generate about $100,000 of additional sales tax revenue. The application notes that there will be additional community services expenditures associated with temporary construction workers and their families, but does not estimate the costs of these services.

Section 2.3.3, Attachment A, of Appendix 11.1.1 presents information regarding tax revenues associated with the proposed facility. During the operation phase, the proposed facility will provide additional income to local jurisdiction(s) in terms of property tax revenues, sales tax revenues, and gross receipts tax revenues. Property tax would not apply to the Compact portion of the WCS facility, because the facility (according to Section 401.205 of the Texas Health and Safety Code) would be conveyed to the State of Texas upon the issuance of the license and thus be tax-exempt. Property tax revenue would apply to the federal portion of the proposed disposal facility. The WCS property is currently valued at $12 million, which represents less than 0.1 percent of the tax basis for Andrews County. Of the $12 million in property, $1.2 million consists of tax-exempt RCRA assets. In lieu of the taxes that would be generated by the exempted assets, WCS makes an annual donation of approximately $30,000 to the Andrews Independent School District (ISD) Educational Foundation, a non-profit foundation that funds innovative teaching programs not funded by the Andrews Independent School District (ISD). While income from property tax revenues will benefit Andrews County, there will be no comparable benefits to surrounding counties in Texas and New Mexico. The socioeconomic impact assessment portion of the application does not include data on expected sales tax revenues that would be generated as a result of expansion of WCS facilities during the operation phase.

In accordance with House Bill 1567 of the 78th Regular Session of the Texas Legislature (and Section 401.244 of the Texas Health and Safety Code), the host county (Andrews County) will receive five percent of the gross receipts from (1) compact waste received at the compact waste disposal facility (CWF), and (2) any federal facility waste received at a federal facility waste disposal facility (FWF) licensed under Section 401.216. An additional five percent of gross receipts will go to the State of Texas. Gross receipts tax revenues are difficult to estimate because revenue will depend on actual waste volumes, types of waste received, and agreed price that will fluctuate with market values. Appendix 11.1.1, Attachment A, page 97, of the application estimates that the tax revenues will be between $3 million and $4 million per year, of which half would go to Andrews County. The information provided with the license application indicates that the gross receipts tax revenue will vary from a high of approximately $4.6 million per year from 2010-2014 (the initial years of operation) to a low of approximately $3.1 million per year from 2040-2044 (the final years of operation). Due to higher expected volumes of federal waste relative to Compact waste, the proportion of tax revenue from Compact waste varies from less than two percent to approximately 20 percent. Thus, as indicated in Table FIN 1-5, page 6, of the application, Andrews County would receive amounts ranging from $2.3 million per year to $1.55 million per year. These variations over the years primarily reflect declining volumes of waste received at the facility. Table 2.7 in Appendix 11.1.1, Attachment A, Section 2.3.3, indicates that in 2005, the projected revenue for Andrews County was $13,834,279, while the budgeted expenses were $17,019,451. Section 2.3.3 also indicates that an additional $1.55 to 2.3 million per year in tax revenue would thus represent anywhere from 11.2 percent to 16.7 percent increase to the existing tax revenue for the county. Since the gross receipts tax revenues will only accrue to the host county, neighboring counties in Texas and New Mexico will not benefit from this income.

Although seemingly negligible in comparison with fiscal benefits, Section 2.3.3 notes that the addition of 75 new employees is expected to increase local community services expenditures by $409,615 per year. WCS estimates that half ($204,808) will be borne by Andrews County, while the other half will be borne by neighboring counties. The application does not explain why Andrews County would bear half of the costs for community services expenditures. This is inconsistent with the spatial allocation figures that are used throughout the application to predict economic impacts, though it is an adequate approximation if expenditures were based on existing residential patterns (See Table EA-7 above). Given that neighboring counties will not benefit in terms of property tax or gross sales receipts tax revenues, these additional expenses could pose some problems to some governmental entities. The application notes that for Eunice and Jal in Lea County, "increased governmental expenditures for community services associated with population and employment increases within and near their jurisdictions may pose a challenge for local authorities." However Section 2.3.3 of the application notes that property taxes from the proposed NEF facility may offset these expenses.

5.10 Corporate Philanthropy

Appendix 11.1.1, Attachment A, Section 2.5.1.1, Table 2.1.7 summarizes charitable activities in which WCS has been involved. Since the facility opened in Andrews County, WCS has provided charitable support for projects in the local community. In 2004, WCS donated approximately $65,000 to the local community, in addition to $40,000 that was contributed to the Andrews Independent School District (ISD) Education Foundation. Since this section of the application also mentions "WCS' investment in the community through involvement of its employees in community organizations," it is unclear from the application whether all of these donations were made by the company, or whether some of the donations were made by individual employees of WCS. The application implies, but does not explicitly state, that contributions to the community will increase if the proposed facility is licensed. Whether corporate or individual, these charitable donations do not fall within the scope of "mitigations" as suggested by the application in Section 2.3.3, page 97.

5.11 Property Values

Appendix 11.1.1, Attachment A, Section 2.3.3.2, page 98, of the application suggests that, with the exception of Eunice, property values in the region of interest are unlikely to be affected by the proposed facility due to its relatively remote location. WCS predicts that Eunice "could realize some increase in land values within its corporate limits, especially for residential and commercial lots that are available for immediate development." The application does not provide any evidence to support or challenge this argument (such as comparable data from other waste sites), though the argument seems reasonable.

5.12 Transportation-Related Impacts

In an effort to assess the transportation-related impacts of the proposed facility, the application provides an analysis of perceived transportation risks, existing traffic patterns in Andrews and Lea Counties, and the anticipated increase of local traffic due to shipments of low-level radioactive waste.

Appendix 11.1.1, Attachment A, Section 2.4.4.1, of the application notes that survey respondents in the first survey "were not particularly worried about traffic generated by the proposed WCS LLW facility operation." In particular, respondents noted that there is already a high level of truck traffic due to the oil and gas industry. Respondents did note concerns about the potential development of a loop around Andrews that might negatively impact businesses by diverting traffic away from the downtown and the need for better cattle fencing on State Highway (SH) 176. Section 2.4.4.2 of Attachment A of the application notes that Texas chapters of the Sierra Club and Public Citizen have both cited concerns about the safety of transporting radioactive waste through Texas.

Again, it is problematic to make assumptions based on the findings from survey one due to the bias towards economic and political leaders. As noted in Appendix 11.1.1, Attachment A, Section 1.3.3.4, of the application, at least one respondent in the first survey did feel that "some roads are inadequate to handle boom traffic already." Unfortunately, the second survey did not have any questions that directly asked about traffic impacts of the proposed facility. As stated in Appendix 11.1.1, Attachment A, Appendix G of the application, however, when asked what they had seen, read, and heard recently, three respondents said that they had heard "about dangers of transporting nuclear waste" or "lots of trucks." And, when asked to mention any negative impacts that the facility has had on the community, six respondents mentioned the "future effects of the material driving through our community."

In Appendix 11.1.1, Attachment A, Section 2.4.2, the application provides information on average daily traffic, based on information from the Texas Department of Transportation. State Highway 176 is the road that leads from the city of Andrews to the WCS facility, and thus the primary route for waste trucks. There is an average of 2,250 vehicles on this road every day at the state line (where the facility is located) and an average of 1,250 vehicles on the road every day at the intersection of 1788 on the east side of Andrews. On the United States Highway (US) 385, the main north-south road into Andrews, the average daily traffic (ADT) ranged from 3,700 on the north side of town to 10,400 within the city. Data for the highways in New Mexico were gathered from the New Mexico Department of Transportation. In New Mexico, SH 176 had an ADT of 3,177 from Eunice to the intersection of US 62 west of Eunice. SH 18, the major north-south road that connects Hobbs and Eunice, had an ADT of 14,118 from Hobbs to Jal, a town south of Eunice. WCS anticipates that approximately 3,973 truckloads of waste per year. The application notes that low-level radioactive waste would be transported on three interstate highways in Texas (Interstate Highway (IH) -10, IH-20, and IH-30), but did not indicate which roads other than SH 176 would be used for waste shipments. However, the primary sources of commercial and federal low-level radioactive waste are identified in the transportation impact analysis presented in Volume 34, Appendix 11.7.1, Tables 11.7.1.1 and 12.7.1.2, of the application. According to this impact analysis the vast majority of the waste will be arriving from the east of the WCS facility. Waste that travels along IH-20 and IH-30 would then reach the site by traveling on US 385. The same would be the case for waste that enters Texas from IH-40. Waste shipped through Houston or San Antonio would arrive on IH-10 and then US-18, and thus enter from New

Mexico. WCS does not specify what proportion of the waste is likely to arrive on US-385 versus US-18. However, for SH 176, basic calculations can be made based on the data presented. The addition of 3,973 trucks per year will cause a slight increase to the volume of traffic on SH 176 (whether the trucks are coming from the east where there are typically 2,250 vehicles on the road each day or whether the trucks are coming from the west where there are typically 3,177 vehicles per day). There is no discussion of how increased traffic compares to the design volume of SH 176 or how it might affect the need for maintenance of these highways. As noted in Volume 33, Appendix 11.1.1, Attachment A, Section 2.4.6.2, of the application, currently, US-385 is scheduled for resurfacing and SH-176 is scheduled to be reconstructed within the city of Andrews. Within New Mexico, both SH-176 and US-18 are scheduled for road maintenance within the next three to four years.

In Appendix 11.1.1, Attachment A, Section 2.4.3, the application provides information on the expected impacts on traffic accidents. In 2003, there were 1,159 traffic accidents in Lea County. There is no comparable data presented for Andrews County. The application states that the increased traffic associated with the proposed facilities is likely to result in 123 additional accidents over the 35-year life of the facility.

In Section 2.4.4 of Attachment A, the application discusses the impacts on noise, air pollution and traffic congestion. This section notes that impacts on interstate highways are likely to be "negligible" due to existing high volumes of traffic. The section then notes that the facility is located in an area not immediately adjacent to populated areas, and concludes that "noise, air pollution and traffic congestion are expected to exhibit only minor increases similar to that experienced near any other small industrial center along a rural stretch of interstate highway. Operation of the proposed facilities at the proposed site is therefore not expected to have an undue impact on noise, air pollution and traffic congestion." In the subsequent section, the application adjusts this statement slightly by noting that "[n]egative impacts of increased noise, traffic and air pollution.... will be focused around the facilities where wastes are currently stored, the major routes identified above and the Region of Interest. Although these impacts will have real socioeconomic effects, primarily in terms of reducing the quality of life in the affected communities and transportation corridors, these effects are difficult to quantify and locate." In this case, the "affected communities" includes communities where wastes are stored and generated.

In Section 2.4.2 the application indicates that the proposed facility is also expected to receive approximately 450 shipments by rail annually. In the subsequent section, the application states that there are "no plans to use the existing rail infrastructure for receipt of bulk waste destined for the proposed radioactive waste facilities. Analysis considering impacts of rail should be considered within the context of possible future use of rail." Future possible impacts would include the possibility of increased delays at at-grade crossings and increased accidents at at-grade crossings. The Executive Director recommends a license condition to prohibit the acceptance of waste shipped by rail for disposal.

5.13 Local Water Supplies

Section 2.5.10 of the socioeconomic impact statement discusses impacts of the proposed facility on local water sources. The application states that the site is currently using about one million gallons of non-potable water per year, pumped from two local wells (central well and southeast well) completed in the Santa Rosa Formation and the Trujillo Formation of the Dockum aquifer. The application states that well water is used to maintain the firewater tank, for processing activities, and for dust suppression during both construction and landfilling operations. Water use will increase during the construction phase of the proposed facility to about 2.5 million gallons and an ongoing use rate of about two million gallons per year. In addition, WCS purchases potable water from the City of Eunice which is used in showers, bathrooms and the laboratory. The facility currently uses approximately 42,000 gallons of potable water per year for 115 persons, which represents about 0.03 percent of the water used by the City of Eunice. This includes water that WCS provides for the Lea County Landfill at no cost to Lea County. The addition of 75 new employees is likely to increase potable water use to 195,000 gallons per year. Appendix 11.1.1, Attachment A, Section 2.5.10, page 136, of the application states that "the projected increase in potable water needs for the low-level radioactive waste disposal facility will not add a significant burden to the City of Eunice water supply."

In 2000, Andrews County used 38,356 acre-feet of water, including 32,882 acre-feet for irrigated water and 3,394 acre feet for municipal water. In the next 50 years, municipal water needs are expected to increase slightly while irrigated water needs are expected to decline slightly. Although needs within Andrews County will not increase significantly, irrigated water needs from nearby counties will affect water availability in the region (according to the Texas Region F Water Plan). Municipal water needs are currently met by water obtained from the High Plains (Ogallala) aquifer. To meet future water needs, the city plans to develop new wells in northern Andrews County into the Dockum aquifer (the same aquifer used by WCS for non-potable water). Given that WCS receives all potable water from the City of Eunice and all non-potable water from the Dockum aquifer and the projected use by WCS is less than 0.2 percent of the City of Andrews water use in the year 2000, the application concludes that there is "no conflict between the planned expansion of the WCS disposal complex operations and the Regional Water Plan."

5.14 Local Ranching and Agriculture

Appendix 11.1.1, Attachment A, Section 2.6, of the application considers the potential impacts of the proposed facility on ranching and agriculture in the Region of Interest. First, the application considers whether there are pathways for radionuclide exposure for livestock and plants, and concludes that "the bio-barrier layer is designed to prevent root penetration" and "no exposures are expected from grass root intrusion into the waste." The application also notes that perceptions of risk of contamination are low in the local community, with only 10.7 percent of the respondents in a survey noting concerns about possible contamination effects.

5.15 Cumulative Impacts

The United States Nuclear Regulatory Commission's (NRC) Environmental Review Guidance for Licensing Actions Associated with NMSS Programs, NUREG-1748, provides guidance for assessing the cumulative impacts associated with a nuclear facility. Cumulative impacts are defined as "the impact on the environment which results from the incremental impact of action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions."

Appendix 11.1.1, Attachment A, Section 2.5.1.2, of the application describes efforts for complying with the above guidance. The application identifies four "proposed actions" that will affect the social and economic base of the Region of Interest: (1) the proposed WCS low-level radioactive waste component; (2) the proposed WCS byproduct materials disposal facility; (3) the proposed National Enrichment Facility; and (4) the proposed 2005 federal energy policy featuring a renewed reliance on nuclear energy. In addition to the approval of pending licenses for WCS and NEF, WCS identifies two "foreseeable future actions" including (1) the continued high price of crude oil and (2) the possible development by General Atomic Corporation and the University of Texas-Permian Basin of a high temperature test reactor in Andrews County.

In Section 2.5.1.3 the application states that, taken together, these actions are likely to have the following cumulative impacts: "(1) increased output, employment and income within the region; (2) increased property and sales tax base development and positive net fiscal impacts to communities, especially in Lea County, New Mexico; (3) increased potential for future nuclear materials disposal and processing related economic development in the Region; (4) increased truck and rail traffic within the Region, especially in Andrews and Eunice, and within the transportation corridors through which wastes would travel to the disposal complex; (5) increased community perceptions of risk associated with the transportation of wastes; (6) increased perceptions of risk and uncertainty associated with the notion that recent developments and decisions could foster a growing regional potential for the emergence of a nuclear material processing and disposal complex in southeast New Mexico and west Texas; and (7) a fluctuating demand for NEF construction-related social and community services over the eight-year construction period."

These cumulative impacts are further discussed in Section 2.5.1.6 of the application. While the byproduct material disposal component at WCS is only expected to generate 3 additional jobs, the construction of the National Enrichment Facility is expected to generate an average of 400 construction jobs per year for eight years, with a peak of up to 800 construction-related jobs with an average salary of $39,000, and an estimated 210 workers during the operation phase with an average salary of $50,100. Louisiana Energy

Services estimates that it will spend $1.2 billion during the construction phase of NEF, including about $390 million locally on goods, services and wages. During the operation phase, local spending by LES will generate an estimated $23.2 million in additional output, $5.6 million in additional earnings, and 173 indirect jobs. The application emphasizes that the proposed NEF site and the expanded WCS facility together "might represent potential propulsive industries that could, under the right unfolding of future circumstances, drive the eventual development in the Region of a growth pole centered on the processing and disposal of nuclear materials."

The application notes that these developments might bring some challenges to the Region of Interest. One challenge would be providing services for Eunice and Jal, in particular, during the eight-year construction phase of the NEF (which would coincide with the construction and initial operation phase of WCS): "A rapid influx of construction workers would increase the demand for temporary housing and a wide variety of local commercial and community services. In addition, those entities providing local social, educational and community services will be required to quickly upgrade their capabilities to deal with social problems and stresses typical of rapid growth situations, such as increased traffic congestion, school overcrowding, crime, alcohol and drug abuse, domestic violence and others. As noted Appendix 11.1.1, Attachment A, Section 2.4.1.1, the fiscal challenge to local communities will be how to program the rapid development of these needed capabilities in an affordable manner and in such a way that they can be efficiently scaled back as the construction phase ends and these service demands decrease." A second challenge will be the increased traffic due to these twin developments. During the peak years of the construction phase, there would be up to 800 construction workers commuting to the site for work. For NM 234, the expected increase of traffic would represent 40 to 50 percent of the design volume. Overall, as noted in Section 2.4.1.2 of the application, the cumulative effects of WCS and NEF operations "could represent a moderate level of effects in the vicinity of the two facilities on New Mexico Highway 18 and New Mexico Highway 234 in Eunice, and New Mexico and Texas State Highway 176 east of Eunice in Andrews County, in terms of an increased potential for congestion, noise and traffic accidents."

Finally, in Appendix 11.1.1, Attachment A, Section 1.3.3.4, the application considers whether cumulative effects will negatively impact ranching, agriculture and water use. The application concludes that there should be no impact on ranching or agriculture as the facilities will not affect surface waters, and the survey indicates that majority of respondents are not concerned about water or livestock contamination (and thus prices for agricultural products should not be affected). Regarding water usage, the application notes that "local municipal and industrial water supplies for the City of Eunice, New Mexico, could be stressed during the construction phase, and possibly the operation phase, of the proposed National Enrichment Facility. According to Appendix 11.1.1, Attachment A, Appendix G, page 454, the cumulative annual use of WCS and NEF would be 71.2 acre-feet per year, over 99 percent of which would be NEF water use. And, according to page 462 of Appendix G, substantial improvements to the City's water treatment, storage and distribution systems would likely be required to serve the construction and operations phases of the NEF project…" In Appendix 11.1.1, Attachment A, Section 2.4.2, page 109, the application further notes that the National Enrichment Facility will obtain its water supply from both the City of Eunice and the City of Hobbs.

5.16 Qualitative Summary of Economic Benefits and Costs

In accordance with NUREG 1569 guidelines, in Appendix 11.1.1, Attachment A, Section 2.5.2, the application provides a qualitative summary of potential social and economic costs and benefits from the proposed facility. According to the application, the economic benefits to the Region of Interest (and the broader community) would include:

- Tax revenues and contributions from WCS to be received by local, state, and federal governments and local school systems;
- Increase of economic diversity and cyclical stability;
- Increased knowledge of the Llano Estacado environment as a consequence of ecological research and environmental monitoring;
- Increased employment, output and income benefits in the region during construction and operation phases;
- Long-term economic benefits will accrue to residents of the Region, and the residents of those communities where low-level radioactive waste is temporarily being stored in less appropriate circumstances; and
- Long-term economic benefits to the entire nation as a result of facilitating a more secure, economically viable nuclear materials sector through the final resolution of the temporary storage of low-level radioactive waste.

The application also identifies the following economic costs to the Region of Interest:

- Minor impact on the local housing market, especially in Eunice, and very slight inflationary rentals or higher prices for other goods and services;
- Increased congestion of local streets and highways, especially in Eunice and Andrews central business districts;
- Noise, vehicle emissions, and temporary aesthetic disturbances from increased truck traffic;
- Temporary minor overloading of utilities, water supply, and sewage treatment facilities in Eunice;
- Very minor crowding of local schools, hospitals, or other public facilities, and overtaxing of community services;
- Very slight deterioration of aesthetic and scenic values along SH 176;
- Permanent removal of land at the WCS complex from alternative future uses
- Possible decrease in real estate values in areas adjacent to the proposed facility;

- Increased costs to local governments in Lea County and Andrews County for the services required by permanently employed workers and their families, with greatest impact on Eunice and Jal;
- Minimal impact to ranchers;
- Minimal drawdown on local aquifers; and
- Increased truck and rail traffic and associated congestion and delay.

The application concludes that the "the employment, output and income benefits (quantified above) that will be realized in the Region from construction and operation of the proposed facility should far outweigh the costs identified, providing a small but positive net economic impact from the construction and operation phases of the facility."

The qualitative summary of socioeconomic costs and benefits adequately describes the types of impacts the proposed facility is likely to have on the Region of Interest. However, the conclusion that the benefits will outweigh the costs is likely to be for certain individuals within the Region of Interest.

Given the multitude of factors involved that cannot be easily quantified as a whole, it is difficult to determine whether or not the majority of individuals in a Region of Interest are more likely to benefit from a proposed development. While some individuals will feel that they benefit from new job opportunities, new business opportunities, and expanded community services from new tax revenues, other individuals may feel that they are inconvenienced by increased traffic congestion or they may feel threatened by perceived risk from radiation contamination. The qualitative summary is based on the Region of Interest as a whole, and does not describe fully how the economic costs and benefits will be unequally distributed throughout different sub-regions within the Region of Interest. The sub-region that is very likely to benefit the most is Andrews County, while the sub-region that is likely to bear the greatest amount of costs is Lea County (in particular, the City of Eunice, but to a lesser extent, Jal and Hobbs). Andrews County will benefit more due to the gross receipts tax, which will provide between $1.5 and 2.3 million in tax revenue per year, representing an increase to the existing county budget ranging from 11.2 percent to 16.7 percent. In addition, Andrews County will receive property tax revenue from WCS.

These sources of income can easily offset the additional expenses incurred by community services (including schools) due the addition of new WCS employees and their families. In contrast, the City of Eunice will not receive any tax revenue from WCS, is likely to experience increased governmental expenditures for community services associated with population and employment increases. Although Eunice will benefit from jobs and indirect economic impacts, the proposed facility is not likely to create as many jobs as modeled by RIMS II spatial allocation factors. At the same time, residents of Eunice are likely to experience increased property values (both commercial and residential) due to their proximity to the WCS facility. Increased property values tend to have disproportionately negative impacts on low-income households (due to increased costs to rent homes and increased inability to purchase a new home).

Due to the proximity to the facility, residents of Eunice are also more likely to be negatively impacted by the noise and pollution associated with increased truck traffic on nearby highways. These findings are consistent with community perceptions. As noted above, only 48 percent of the respondents from Lea County favored the disposal of low-level radioactive waste at the WCS facility in Andrews County, compared to 65 percent of the residents in Andrews County. While some of these disproportionate impacts (such as tax revenue inequity) may be offset by the construction of the National Enrichment Facility, other problems (property values, challenges to community services, traffic-related impacts) may be compounded by NEF.

5.17 Ecological Assessment

Texas Health and Safety Code §401.231(7) and 30 TAC §336.708(a)(3) require that an application for a low-level radioactive waste disposal facility include information on the ecology of the area surrounding the proposed site. United States Nuclear Regulatory Commission (NRC) Regulatory Guide 4.18 states that a description and quantification of flora and fauna within five kilometers of the proposed disposal site (NRC, 1983).

The application describes and quantifies the flora and fauna from historical documents on the area ecology that contained data previously collected over a period of one year (Ortega et al., 1997). Additionally, the application provides more recent seasonal surveys of populations of vegetation, birds, mammals, reptiles and amphibians, and terrestrial invertebrates were conducted in March, April, and October 2004 (Reagan, 2004) and June and September 2006 (URS, 2007).

TCEQ staff reviewed the information provided in the application related to ecology. Appendix 2.91 of the application contains an ecological assessment. A summary of the assessment is provided in Section 2.2 of Appendix 11.1.1 of the application. Appendix 11.9.2 of the application presents a Baseline Ecological Survey Report that establishes pre-operational baseline conditions. These baseline conditions can be used to assess potential impacts and trends throughout the operating life of the disposal facility.

5.17.1 Terrestrial Ecology

The application describes three survey transects at each of six plots - three upwind reference plots and three downwind potentially affected plots. These plots were used to establish baseline conditions by quantifying plant species diversity and richness, evaluating abundance and diversity of mammal species, and qualitatively surveying reptiles, amphibians, and terrestrial invertebrates. Bird observations were conducted throughout areas surrounding the plots during morning and afternoon periods, and sightings were also recorded elsewhere on the site regardless of proximity to the plots. A winter bird census was also conducted in December 2006. Through habitat evaluations and the endangered species lists generated by the Texas Parks and Wildlife Department (TPWD) and the United States Fish and Wildlife Service (USFWS), nine threatened/endangered or otherwise protected species were identified as potentially occurring at the site. It is important that TPWD and/or USFWS personnel be contacted directly to obtain the threatened/endangered species determination. The Executive Director recommends a draft license condition to require written documentation from TPWD and/or USFWS regarding the likelihood of protected species occurring near the site.

Section 2.9.1 and Appendix 11.1.1 of the application also identifies and discusses game and other important species. Statistical comparisons of reference and potentially affected plots indicated their similarity and establish a basis for future comparisons during construction, operation, and closure phases of the proposed disposal facility. Surveys and other studies conducted on the site indicate that all expected functional components of the high plains prairie ecosystem are present. Based on the presence of exotic species, bare ground as a result of human activity, and a disproportionate abundance of overgrazing indicator species, such as snakeweed, prickly pear cactus, the application states that the establishment of an ecological services baseline condition of approximately 90 percent of optimal conditions is a reasonable estimate.

5.17.2 Aquatic Ecology

In addition to describing the terrestrial ecology, NRC Regulatory Guide 4.18 recommends that aquatic ecology also be addressed. However, Appendix 2.9.1 of the application states that no aquatic studies have been conducted because “there are no permanent and only occasionally ephemeral sources of surface water available on or in the vicinity of the site and these would not support aquatic species.” There has been water frequently observed in Baker Spring, less than one mile west-northwest of the site, over the past four years. Baker Spring is located behind the reported Ogallala, Antlers, Gatuña “dry line” and is cut into the Dockum red bed clay. Therefore, Baker Spring could receive groundwater from the OAG saturated zone. Water in Baker Spring could be present in all but the driest of times, thus supporting an aquatic community and would also be very attractive to wildlife. A barn owl was observed at Baker Spring during the March 2004 survey (URS, 2007). Although no aquatic surveys were conducted, the application speculates that amphibians, such as spadefoot toads, Texas toads, and invertebrates may be present. Baker Spring should be surveyed to establish baseline conditions and should be routinely monitored for site-related impacts. The Executive Director recommends a license condition that requires both the establishment of baseline environmental monitoring conditions in Baker Spring, including the identification of supported species, and routine sampling for determination of potential impacts to species and surface water and sediment quality.

Appendices 2.9.1 and 11.1.1 of the application states that there is confirmation that wetlands are not located in the vicinity of site. This statement is confusing as most playas are classified as isolated wetlands. The National Wetlands Inventory map dated

1990 identifies several wetland areas within a five-mile radius of the proposed disposal facility. Current internet mapping tools confirm numerous wetland areas in the vicinity of the site. Also, Appendix 11.9.2 of the application contains a survey of the two closest playas to the facility and identifies them as isolated wetlands. These two playas lie in a depression immediate adjacent to the proposed disposal facility. To address this issue, the Executive Director recommends a draft license condition for obtaining a site-specific "no jurisdiction" determination from the United States Army Corps of Engineers regarding site playas.

References Section 5.17: Ecological Assessment

NRC, 1983. United States Nuclear Regulatory Commission, Regulatory Guide 4.18: Standard Format and Content of Environmental Reports for Near-Surface Disposal of Radioactive Waste, Office of Nuclear Regulatory Research, Washington, D.C., June 1983

Ortega et al., 1997. Ortega, I.M., F.C. Bryant, R.D. Petit, and K. Rylander, Ecological Assessment of the Low Level Waste Repository, Andrews County, Texas. Final Report, 1997

Reagan, 2004. Reagan, D.P., Habitat Characterization and Rare Species Survey for the Proposed Low Level Waste Repository, Andrews County, Texas, 2004

URS, 2007. URS Supplemental Survey to Ecological Assessment of the Low Level Waste Depository, Andrews County, Texas, Final Report - Revision 1, March 2007

Section 6: Effects on a Waterway or Groundwater

6.0 General Introduction

Texas Health and Safety Code §401.113(c)(2) requires the TCEQ Environmental Analysis (EA) to include an assessment of any effect on a waterway or groundwater resulting from a proposed licensed activity. This section of the environmental analysis considers the site characteristics, climatology, meteorology, geology, and hydrology.

6.1 Site Location and Geography

State of Texas rule, 30 Texas Administrative Code (30 TAC) §336.710(3), require a description of the ownership of the land and fixtures that are part of the proposed disposal site. Title 30 TAC §336.730(f) also requires that the boundaries and locations of each disposal unit shall be accurately located and mapped by means of land survey. Section 2, Attachment C and Attachment D, Figure D-1 of the application includes a legal description of each proposed disposal: the 89.90 acre federal facility waste disposal facility (FWF), the 29.66 acre compact waste disposal facility (CWF), and the 3.29 acre area identified as a "common administrative area."

Section 2, Attachment C, Figure C-1 of the application includes a composite map depicting the surveyed outlines of the proposed waste management areas. A legal description of the proposed waste management areas is also provided in Section 1, Attachment B, Exhibit I which includes a General Warranty Deed for the 1,338.121 acres representing the RCRA-permitted area.

6.1.1 Surveys, Maps, Boundaries, and Surrounding Features

A survey map indicating the location of the proposed disposal units must be included with the application. The application includes a location map in Section 2, Attachment D which depicts the FWF and CWF outlines, roadways, the RCRA permit outline ("facility" boundary), and section lines in the immediate vicinity. Attachment D also includes a reference to the Survey, Block, and Section (Public School Land, Block 29, Section 25) for the proposed waste management areas listed above.

As required by 30 TAC §305.45(a)(6)(B), a location map must depict the approximate boundaries of the tract of land owned or to be used by the applicant and shall extend at least one mile beyond the tract boundaries sufficient to show the general character of the areas adjacent to the facility, including public roads, towns and the nature of development of adjacent lands. A location map was included in the application as Section 2, Attachment E. Section 2.1.3 of the application describes the access route from the nearest highway to the facility. In addition, the approximate latitude and longitude for the centroid of the proposed CWF and FWF disposal areas has been provided in Table 2.1.4-1 of the application.

As required by 30 TAC §305.45(a)(6), the application must include a map prepared by a licensed professional engineer or a registered surveyor which shows the facility and each of its intake and discharge structures and any other structure or location regarding the regulated facility and associated activities at a scale not less than one inch equal to one mile. The provided map must extend at least one mile beyond the tract boundaries. In addition, 30 TAC §336.708 requires that the application include site-specific environmental information, including topography, and Texas Health and Safety Code §401.233 requires consideration of natural site characteristics, which are defined to include the suitability of site topography. The application includes, in Section 2, Attachment F, two topographic maps labeled Figure F-1 and Figure F-2. The base maps are United State Geological Survey (USGS) 7.5-minute topographic maps and extend at least one mile beyond the facility boundaries as required. The topographic base maps underlying Figure F-1 is "Eunice NE, Texas - New Mexico," dated 1969 and photorevised in 1979. The base map for Figure F-2 is a composite map consisting of nine contiguous 7.5-minute USGS topographic base maps (including "Eunice NE"), the most recent of which is dated 1971 and some of which were photorevised in 1979.

Also required by the consolidated permits rules 30 TAC §305.45(a)(6), the application must include a map which shows the facility and each discharge structures and any other structure or location regarding the regulated facility and associated activities. The topographic maps provided in Section 2, Attachment F of the application do not include the location of all surface discharge structures and waste treatment and storage facilities. Although Volume 1, Table 1.24 (page 1-15) provides a list of all permits and authorizations for the existing facilities on the site, the application does not reference maps or figures depicting existing and proposed discharge structures, as well as each on-site facility consistent with this list.

The consolidated permits rules in 30 TAC §305.45(a)(6)(A) require a map which shows each well, spring, and surface water body or other water in the state within the map area at least one mile beyond the facility property boundary. The topographic maps included in Section 2, Attachment F of the application depict the location of all wells (water, oil and gas, disposal, etc.), springs and other surface water bodies, listed in public records or otherwise known to the applicant within one mile of the facility property boundary, and the purpose for which each water well is used (e.g., domestic, livestock, agricultural, industrial, etc.) and other requested features near the proposed disposal facility.

Section 2, Attachment F, Figure F-1 appears to list all water wells within one-mile of the proposed disposal facility, except for monitor wells and piezometers located on the site (as noted on the map), and for a second well at location "7," in New Mexico about a mile south of Baker Spring. Figure F-1 includes a reference to Banks Information Solutions, Inc. (Banks) survey. The Banks survey included in the application as Attachment 6-1 of the application provides additional information for the water wells depicted on the map. Figure F-1 of also depicts springs and other surface water bodies within one mile of the facility property boundary (to the extent that a USGS topographic map depicts these features). Among more prominent surface water features identified on Figure F-1 are Baker Spring in New Mexico, and an unnamed surface water body is shown approximately one-quarter mile southeast of Baker Spring (between Baker Spring and the proposed disposal facility). Another prominent surface water body is an apparent impoundment used as a stock tank and filled with water from windmill wells which is located just southeast of Windmill Hill, south of State Highway 176. In addition, Figure F-1 depicts the location of oil wells within one mile of the facility property boundary. Well location "15" as identified in the Banks survey is shown in Figure F-1 to be an "Abandoned Location/Not Drilled." The Texas Railroad Commission's data and the summary of the oil well information from the Banks survey show location 15 as a "dry hole" rather than an undrilled location as noted in Table 3-1a of the application. Figure F-1 does not indicate any gas wells or disposal wells within one mile of the facility property boundary.

It should be noted that the Banks survey provided in the application includes some, but not all of the *State of Texas Well Reports*. It does not include *State of Texas Well Reports* for at least 11 monitor well locations that are owned by the applicant. The information provided in the application in addressing this requirement is necessarily time-specific. As such, this would necessitate the periodic updating of well, spring and surface water body information from the site. A license condition is proposed to address the annual update of this information.

6.1.2 Adjacent Landowners

As required by 30 TAC §305.45(a)(6)(D), an application must include a map which shows the ownership of tracts of land adjacent to the facility and within a reasonable distance from the proposed point or points of discharge, deposit, injection, or other place of disposal or activity. In addition, 30 TAC §305.54(c) states that an application must include information on ownership of the land on which the proposed project will be located, ownership of the proposed facilities, buildings, structures, and equipment, and ownership of properties adjacent to the proposed site.

The adjacent property owner information is presented in Section 2, Attachment G of the application. Attachment G includes a map and cross-referenced list of adjacent landowners. The information provided on adjacent landowners is dated February 21, 2005. An updated list of adjacent landowners should be provided by the applicant prior to initiating public notice requirements related to the application.

6.1.3 Indian Lands

The application must include any other information reasonably required by the Executive Director to ascertain whether the facility will be constructed and operated in compliance with all pertinent state and federal statutes, including whether the facility is located on Indian lands. Section 2.1.7 (page 2-7) of the application states that the facility is not located on Indian lands. Section 2, Attachment G, Figure G-1 of the application also includes a list of adjacent landowners and a composite topographic map consisting of nine contiguous 7.5-minute USGS topographic maps.

6.1.4 Coastal Management Boundary

The application must identify the location of the proposed facility in relation to the Coastal Management Program boundary. As stated in the Section 2.1.8 (page 2-7) of the application, the proposed facilities are not located within the Coastal Management Program boundary. Figure 2.1.8-1 of the application indicates the location of the proposed disposal facility in relation to the Coastal Management Program.

6.1.5 Local Disposal Prohibition of Solid Waste

Texas Health and Safety Code §363.112 states that the applicant must document that the proposed facility is not located within an area in which a governing body of the county or municipality has prohibited the processing or disposal of municipal hazardous or industrial solid waste. The application states that the facility is not located in an area in which the governing body of the county or municipality has prohibited the processing or disposal of municipal hazardous waste or industrial solid waste.

6.1.6 International Boundary Proximity

As stated in Texas Health and Safety Code §401.217, the commission may not issue a license for a CWF facility or license the operation of a FWF if the disposal facility site is located in a county any part of which is located 62 miles or less from an international boundary. Section 2.1.10 of the application states that the land disposal facility is not located in a county within 62 miles or less from an international boundary. In addition, Figure 2.1.8-1 the application includes indicates the location of the proposed facility in relation to the nearest international boundary.

6.2 Climatology and Meteorology

Title 30 TAC §336.708(a)(3) states that the application must contain area and site characteristics including meteorology. Appendix 2.3.1 of the application describes characteristics of the meteorology at the site. Meteorology is an important factor in the design and operation of a low-level radioactive waste facility. Meteorological data is used to develop an environmental monitoring program, and is also required by the various computer models used to predict the cover infiltration, cover erosion, the potential transport of radon gas, and the potential transport and dispersion of radioactive particles by wind. These models are used to evaluate potential dose to workers and to members of the public. In addition, various facility systems and facility designs must accommodate the estimated volumes of rainfall and temperature effects.

Current meteorological data may be used in conducting short-term analyses for the development of an environmental monitoring program and computer modeling. However, future meteorological data must be utilized in predicting future performance of the site, such as erosion and infiltration. Consequently, future performance of the site becomes a factor when examining whether the site can meet the performance objectives.

The application states that site meteorological data extends back to January 2000 and contains six years of data. Appendix 2.3.1 of the application also includes meteorological data from four nearby, off-site weather stations as summarized in Tables 1 through 43. The additional off-site weather stations are located in the cities of Andrews and Midland, Texas and Jal and Hobbs, New Mexico, with the earliest records coming from Hobbs and Andrews in 1914. Temperature measurements taken on-site were not included in the tables; however, data from the nearby weather stations indicate that the temperature may range from a daily maximum of 116 degrees Fahrenheit (^{o}F) down to a daily minimum of negative 11 degrees Fahrenheit (^{o}F). The on-site data also indicates that the annual precipitation ranged from five inches to 30 inches of precipitation with an average of approximately 16 inches per year. Meteorological data from the nearby weather stations show similar ranges of precipitation. Data from these tables were used as parameters in the computer simulations discussed above.

A review of the compiled data shows that average temperature and precipitation readings from the six-year on-site record are within the ranges of the ninety-year record of averages from Andrews and Hobbs. The compiled data does not necessarily represent the meteorology at the site for the next 50,000 years. Appendix 2.3.3-1 discusses future climatology for the area based on the earth's orbital parameters and past geological and environmental histories. This analysis shows that estimates of future average annual precipitation is approximately 24.3 inches per year, and is predicted to occur 23,000 to 26,000 years in the future. The report also presents that site climatic conditions at this time will likely be similar to current conditions in Wichita, Kansas. Appendix 2.3.3-1, page 2.3.3.1-46, of the application states that "over the past 30 years, Wichita has experienced an average of 29.34 inches of precipitation annually." It should be noted that estimates of future average rainfall and temperature are within their current respective ranges, thus the averages given above are not inconceivable.

This climate analysis is useful to evaluate the effects of long-term climate change on the proposed low-level radioactive waste facility. The Executive Director recommends license conditions to require the use of future climatic conditions as parameters in predictive modeling to demonstrate that performance objectives can be met under future climatic changes.

The Texas Health and Safety Code §401.217 states that the commission may not issue a license for a compact waste disposal facility or license the operation of a federal facility waste disposal facility if the disposal facility site is located in a county in which the average annual rainfall is greater than 20 inches. Title 30 TAC §336.708 also requires that the site not be located in a county in which the average annual rainfall is greater than 20 inches. Currently, the average annual rainfall is approximately 16 inches for the county of Andrews. This is based on data submitted in the application and 30 years data from the National Weather Service. It should be noted that in 2004, over 30 inches fell on the site. This matches the total annual precipitation in the nearby weather stations. Furthermore, the Midland weather station recorded a 21-inch annual precipitation for 2007 and a 16-inch annual precipitation in 2006.

The impact of precipitation at this site over time is important as it affects infiltration, groundwater movement, erosion, and performance objectives over time, all of which are being modeled for 50,000 years into the future. Furthermore, it is precipitation that drives groundwater movement, erosion, and elements of the performance objectives. Therefore, computer models utilizing climatic parameters need to account for long-term climatic changes.

6.3 Geology

As required by Texas Health and Safety Code §§401.112, 401.231, 401.233, 30 Texas Administrative Code (TAC) §§336.708 and 336.728, a license application for low-level radioactive waste disposal must provide an evaluation of the site characteristics including the regional and site-specific geology.

The proposed disposal facility is located on approximately 14,900 acres in western Andrews County, Texas along the Texas-New Mexico state line. Within this property, on a 1,338 acre tract Waste Control Specialists, LLC operates a permitted RCRA hazardous waste landfill (TCEQ Permit HW50358) and a licensed low-level radioactive waste storage and treatment facility (TCEQ License R04971). The property is also the site of the recently licensed by-product material disposal facility covered by a separate application.

In Section 2.5, the application states that the proposed disposal facility is located near the southwestern edge of the Southern High Plains (see Figure 1-1 in Appendix 2.6.1) where surface elevations range from about 3,415 to 3,500 feet above mean sea level. The Southern High Plains comprise a low relief, undulating surface, generally defined to the west by the Pecos River Valley, and the Mescalero Ridge. In the vicinity of the proposed facility, however, the Mescalero Ridge is not well defined. To the north and east, the Southern High Plains are bounded by caprock escarpments resulting from headward erosion of the Canadian, Red, Brazos, and Colorado Rivers. To the south, the Southern High Plains transition into the Edwards Plateau, without a well defined boundary. The topographic expression at the site is mostly subdued, with long, gentle slopes.

The disposal site is described in Section 2.5 of the application as lying on a broad topographic ridge that forms a surface water drainage divide between the Pecos and Colorado Rivers. The nearest major drainage feature to the west is Monument Draw, which lies in Lea County, New Mexico, and flows to the south into the Pecos River (see Figure 2.5.6 in Section 2 of the application). To the north and northeast the nearest continuous drainage feature is also named Monument Draw, which flows to the east in

Andrews County, Texas and eventually into the Colorado River.

Section 2.5 of the application describes the local topographic features that include a small dune field to the north and a number of shallow depressions (playa lake basins) around the proposed disposal facility (see Figure 2.2.1-2 in Section 2 of the application). The largest playa lake basin lies approximately 2,500 feet to the northeast, with an overall basin relief of about 20 feet. Baker Spring (an historic feature which commonly contains water) is located approximately 2,000 feet west of the proposed facility in Lea County, New Mexico. Most surface drainage from the eastern side of the property is toward the large closed unnamed depression (see "Depression Pond" labeled in Figure 2.2.1-2 in Section 2 of the application) located approximately four miles east of the proposed facility.

6.3.1 Regional Structure

In Section 2.5.3 of the application, the proposed facility is located over the north-central portion of the Central Basin Platform, a large elevated block between the Delaware and Midland Basins, all of which was once within the Tobosa Basin of southeastern New Mexico and west Texas. Prior to late Mississippian time this region had only mild structural deformation, producing broad shallow depressions and regional arches (see Figure 2.5.5 of Section 2.5.3 of the application).

During late Mississippian and Pennsylvanian time the area was affected by the collision of the continents of Gondwanaland and Laurasia, causing the Marathon-Ouachita orogeny as stated in Section 2.5.3 of the Application. During this event the Tobosa Basin was broken up into the sub-basins and uplifts forming the Permian Basin region. One of these uplifted regions is the Central Basin Platform. Tectonic events in the late Mississippian uplifted the platform and subsequent Pennsylvanian and early Permian deformation compressed and faulted the area. Deformation ceased in the early Permian Wolfcamp, as evidenced by high angle faulting that terminates in Wolfcampian age sediments and the presence of younger strata draped over the preexisting structures.

A period of tectonic quiescence followed, during which erosion and gradual subsidence took place. An expanding sea eventually covered the area, depositing several thousand feet of evaporites, carbonates, and shales. During Triassic time the region underwent slow uplift and erosion followed by downwarping that created a large landlocked basin that was filled with sediments that accumulated in flood plain, deltaic and lacustrine environments. This was followed by another period of erosion during Jurassic time, and a final marine inundation by Cretaceous seas, resulting in the deposition of a basal clastic unit and overlying marine shales and carbonates.

According to Section 2.5.3 of the application, the Laramide Orogeny [when Rocky Mountains were formed] uplifted the area to the west of the Permian Basin and the Cretaceous sea retreated to the south and east. A major episode of folding and faulting took place in the Paleocene. Post-Laramide activity included a period of volcanism, Basin and Range extension in Trans-Pecos Texas and New Mexico, development of the Rio Grande Rift, and uplift of the High Plains region in Miocene and later time.

Based on this geologic history presented in Section 2.5.31 of the application, there has been no significant faulting since Permian time; only gentle regional tilting with some local folding and small scale faulting has occurred since. Section 4 of Appendix 2.6.1 of the application includes cross-sections (Figures 4-5 and 4.6) indicating that no significant faulting occurs in the upper 2,000 feet of sediments within three to four miles of the proposed facilities.

Also, in Section 4 of Appendix 2.6.1, however, it is cited that Hills (1970) postulated that later normal movement may have occurred by reactivation of these faults, but that the movement was not sufficient to noticeably displace the overlying Permian strata. Hills (1970) further postulated that late movement along the faults may have created a conduit for fresh water for dissolution of Permian evaporate beds. In addition, in Section 4 of Appendix 2.6.1 of the application, a 1992 earthquake (of magnitude 5) beneath Rattlesnake Ridge, between 7 to 19 miles southwest of the facility, demonstrates that the region is not totally without occasional seismic activity, although no surface expression of this fault movement has been noted.

Based on TCEQ and the Bureau of Economic Geology of The University of Texas (BEG) staff reviews of Appendix 2.6.1 (see lineaments shown on Figures 4-24 through 4-26), the faults and fractures in the vicinity of the WCS site do not appear to be active. However, the faults and fractures occur along the crest and parallel to the Dockum red bed ridge. Because the Dockum red bed ridge has been described in Appendix 2.6.1 of the application as a gentle fold resulting from dissolution-induced subsidence, some of these lineaments may reflect tension fractures that developed along the crest of the red bed ridge as a result of folding. Tension fractures being somewhat more open may be able to hold water longer and thereby account for the enhanced vegetation and development of erosional features such as playas along fractures.

In addition, TCEQ and the BEG staff examined the reverse fault that was discovered in one of the walls of the RCRA unit, now excavated and removed, presented in Figures 4-9, 4-10 and 4-11 in Appendix 2.6.1. Some of the overlying Createaceous formation (Antlers Formation) in the hanging wall of one of the faults appeared to have been gently folded, which might have indicated some post Cretaceous disturbance.

6.3.2 Regional Stratigraphy

For the following discussions, see Figure 2-2 in Appendix 2.6.1 of the application for a regional stratigraphic chart for the Central Basin Platform. According to information provided in Section 2.5.1 of the application, the Precambrian basement is overlain by marine Cambro-Ordovician platform carbonates and Silurian-Devonian carbonates and shales. These sediments are truncated unconformably by Permian deposits consisting of marine shales, limestones, sandstones, marls, and evaporates. Permian age deposits are unconformably overlain by the Triassic Dockum Group.

The Dockum Group, which was described as a series of fluvial and lacustrine mudstone, siltstone, sandstone, and silty dolomite strata (McGowen et al., 1979). Cretaceous sediments unconformably overlie the Dockum Group. Cretaceous strata were deposited as a shallow sea transgressed across the region. As the shallow sea retreated much of the Cretaceous section was eroded away prior to deposition of the overlying Tertiary Ogallala Formation.

Appendix 2.6.1 of the application describes the depositional facies of the Ogallala Formation as a series of fluvial valley fills with both valley fills and interfluves overlain by eolian sediments. However, Figure 2-6 of the application depicts the depositional facies of the Ogallala Formation as a series of overlapping alluvial fan lobes (Reference Seni,1980). Gustavson and Winkler (1988) and Gustavson (1996) have clearly shown that the Ogallala Formation is a series of fluvial valley fills. The application also identifies the Late Tertiary/Quaternary Gatuña Formation as part of the Cenozoic alluvium of the Pecos River valley, which overlies the Triassic Dockum Group southwest of the proposed disposal site.

The Quaternary Blackwater Draw Formation, which overlies the Tertiary Ogallala Formation, consists of windblown sands, silts, and clays. Section 2.6 of Appendix 2.6.1 of the application describes the only source area of the Blackwater Draw Formation at the proposed facility as being the Pecos River valley. Another possible source is the Blackwater Draw Formation along the western margin of the Southern High Plains (Gustavson, 1996). Along the western margin of the Southern High Plains there are many areas where the Blackwater Draw is only a few decimeters thick, in part because these areas were source areas for thicker sections of the formation to the east.

6.3.3 Site Stratigraphy

For the following discussions, see Figure 2.5.1 in Section 2 of the application for a site specific stratigraphic chart. As described in Section 2.5.2 and Appendix 2.6.1 of the application, the stratigraphy beneath the proposed disposal site consists of, from oldest to youngest, the Santa Rosa, Tecovas, Trujillo and Cooper Canyon Formations of the upper Triassic Dockum Group, the Cretaceous Antlers Formation and to a lesser extent the overlying Comanche Peak (Fort Terrett) Formation, the Tertiary Ogallala Formation, the late Tertiary/Quaternary Gatuña Formation, the eolian sands of the Pleistocene Blackwater Draw Formation, and the recent windblown sands which form a thin cover throughout the area.

The Dockum Group at the proposed disposal site consists of fluvial and lacustrine mudstones, siltstones, and sandstones of the Santa Rosa, Tecovas, Trujillo, and Cooper Canyon Formations derived from upland source areas to the southeast, south and west. In Appendix 2.6.1 of the application, it is stated that the Santa Rosa Formation is a groundwater source and provides non-potable water to the Central Industrial Well at the WCS facility from a depth of approximately 1,140 feet to 1,400 feet below ground surface. The well has a total open depth of approximately 2,465 feet. This total open depth extends into the Permian evaporate section beneath the proposed disposal site. The application does not include information describing the well construction or an evaluation of current well conditions. The Executive Director recommends a license condition requiring a complete evaluation of the construction and current condition of the Central Industrial Well.

The Tecovas Formation consists of approximately 400 to 500 feet of lacustrine claystone and siltstone. Overlying the Tecovas Formation is the Trujillo Formation consisting of approximately 100 feet of fine grained sandstone at a depth of approximately 600 feet below ground surface. The uppermost formation of the Dockum Group, beneath the proposed disposal facility, is the Cooper Canyon consisting of approximately 500 feet of lacustrine shales and mudstones with discontinuous fine grained sandstones and siltstones. Both Section 2.5.2 and Appendix 2.6.1 of the application identify four siltstone/sandstone units within the Cooper Canyon Formation, the 225-foot zone 180-foot zone, 125-foot zone and 80-foot zone. These permeable zones within the Dockum Group represent the most likely pathways for groundwater movement into or out of the proposed waste facility. It is important to correctly understand the lateral extent and stratigraphic connectivity of the permeable units observed in adjacent wells.

Appendix 2.6.1 of the application identifies the 225-foot zone as the uppermost aquifer beneath the proposed disposal facility. This sandstone is also identified as the uppermost aquifer by the RCRA hazardous waste permit adjacent to the proposed facility. The 225-foot zone ranges from 25 to 30 feet thick over the entire facility and is probably confined. The potentiometric surface for the 225-foot zone, which was derived from monitor well data, is shown to rise as much as 125 feet above the top of the unit as indicated by the hydrogeologic conceptual model presented in Figure 2.5.11 of Section 2 of the application. Figure EA-4 is provided as a conceptual cross-section of the proposed disposal site based on information reviewed in the application. Figure EA-4 provides a cross-sectional view across the proposed Federal Waste Facility, from north to south that is similar to one of the cross-section views provided in the application.

Appendix 2.6.1 of the application states that the sandstones and siltstones of the 225-foot zone are laterally continuous. The Dockum Group fine sandstones and siltstones are low-energy, low-gradient fluvial deposits laid down near the margin of a large lacustrine basin.

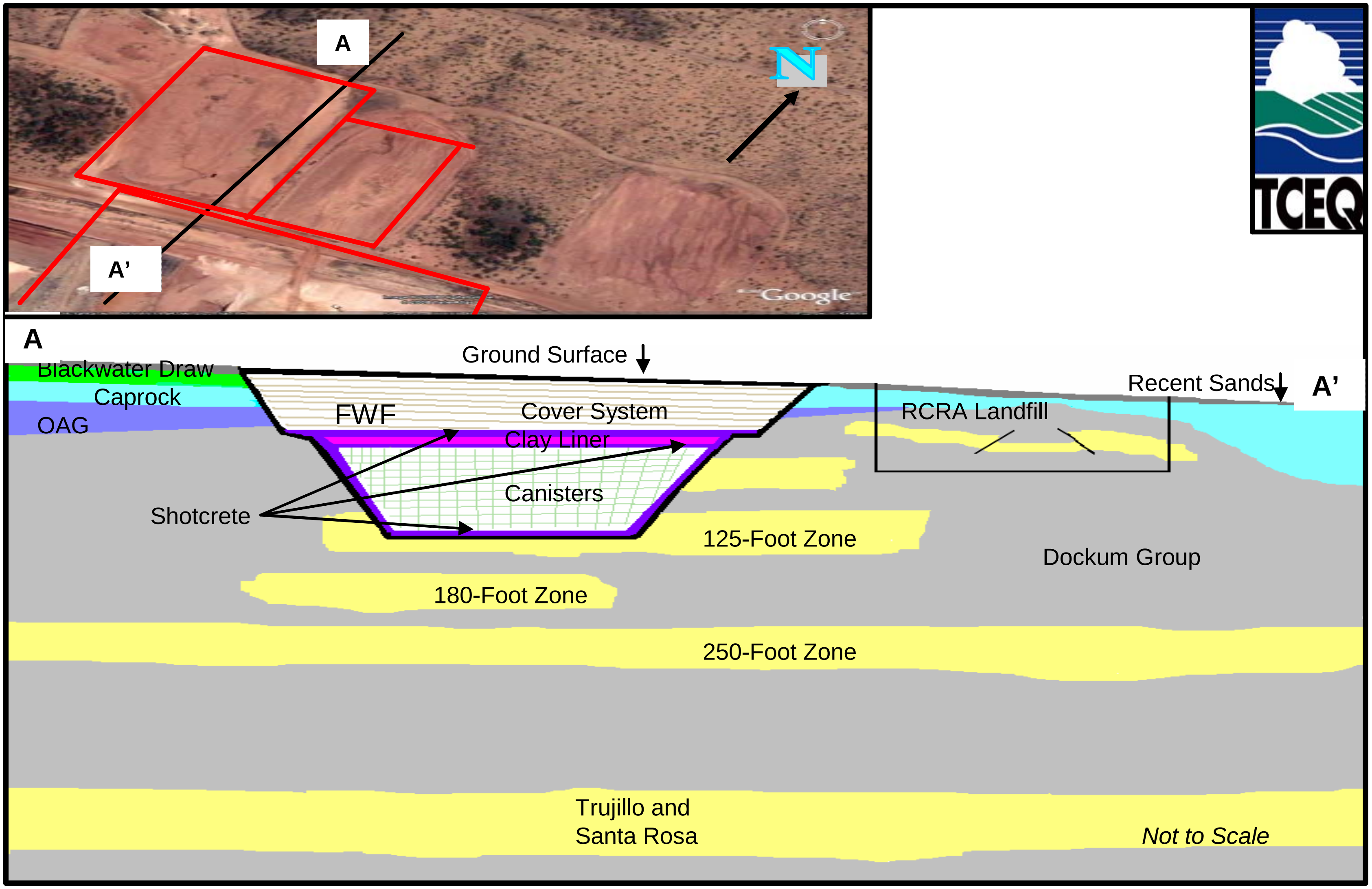

Figure EA-4: Conceptual Cross-Section of the Proposed Disposal Facility

According to TCEQ and BEG staff reviews, there appear to be correlation errors on cross-sections A-A', B-B', C-C' and E-E' in Appendix 2.6.1 of the application. On cross-section A-A', between wells B48 and TP04/PM06, there is approximately 50 feet of difference in elevation of the 225-foot zone between these two wells, which are only about 2,500 feet apart. Similarly, the cross-sections indicate approximately 50 feet of elevation change along the bottom of the 225-foot zone between wells B-48 and TP-04/PM-06. In addition, up to 55 feet of elevation difference along the top and bottom of the siltstones described as the 225-foot zone between wells A-22 and TP-04, which are approximately 4,500 feet a part has been noted. The siltstones and sandstones of the 225-foot zone in wells B-48, TP-04, and A-22 are only approximately 21 feet thick. It would be unusual to have 50 feet of elevation difference in a single stratigraphic unit comprised of siltstones and fine sandstones over a horizontal separation of only 2,000 to 4,500 feet. It is possible that the 225-foot zone is not a single depositional unit as is implied by the structure maps (Figures 5-11 and 5-12) and the cross-sections A-A' and B-B' (Figures 6-5a and 6-5b) provided in the Appendix 2.6.1 of the application.

The 180-foot zone is described in the application as a discontinuous sandstone/siltstone which is partly saturated beneath the proposed facility. This unit ranges from 10 to 25 feet in thickness across most of the proposed site. The unit has been described as continuous beneath the proposed disposal areas and thinning to zero along the southern and western boundaries of the proposed facility. The 180-foot zone has also been described as less continuous and not as well defined as the underlying 225-foot zone and the overlying 125-foot zone.

The 125-foot zone was probably deposited in a setting similar to that of the 225-foot zone, and is probably not saturated in the proposed facility area. In cross-section the 125-foot zone is more vertically variable than the other sands, perhaps as a result of deposition along shifting channels. This zone immediately underlies the western portion of the adjacent by-product material disposal facility and ranges in thickness from about 25 to 40 feet. Correlation of the 125-foot layer between wells B-32, B-4 and B-5 cross-section B-B' (Figure 5-5 in Appendix 2.6.1) indicate approximately 20 feet of elevation difference over a horizontal distance of 1,500 feet and approximately 30 feet of elevation difference over a horizontal distance of 2,000 feet between wells PM-03 and PM-12. The application also includes an isopach map of the 125-foot zone which reveals discrepancies in thickness at some borehole locations when random comparisons were made to the corresponding thickness data from borehole descriptions provided in Attachment 5-1, Exhibit A. For example: at boring location B-19, the boring log indicates a thickness of 0.0 feet, where the isopach map indicates a thickness of 32 feet; and at boring location B-22, the boring log indicates a thickness of three feet where the isopach map indicates a thickness of 12 feet.

The 80-foot zone is identified as the uppermost siltstone/sandstone within the

Cooper Canyon Formation beneath the proposed disposal facility. It is dry, and appears to have a restricted lateral extent. The thickness of this unit ranges from 10 to 30 feet. Correlation of the 80-foot zone between wells B-32 and B-22 cross-section C-C' (Figure 5-6 in Appendix 2.6.1) indicates approximately 30 feet of elevation difference over a horizontal distance of 1,000 feet. The application also includes an isopach map of the 80-foot zone (Figure 5-13 in Appendix 2.6.1), which indicates significant variation in thickness at several borehole locations when random comparisons are made to the corresponding thickness data from borehole descriptions provided in Attachment 5-1, Exhibit A. For example: at boring location B-12, the boring log indicates a thickness of 6 feet where the isopach map indicates a thickness of 11 feet; at boring location B-19, the boring log indicates a thickness of 15 feet where the isopach map indicates a thickness of 20 feet; and at boring location B-46, the boring log thickness could be interpreted as either 11 feet or four feet where the isopach map indicates a thickness of 30 feet.

Based on the information presented in Section 2.6.1 of the application, TCEQ staff and the BEG consider that it is more likely that the sandstone and siltstone bodies within the Dockum Group are not laterally extensive. Additionally, the 80-foot zone, 125-foot zone, and 225-foot zone isopach maps are probably more variable in thickness than indicated.

Data on the physical parameters of the individual sand units are difficult to obtain, even from the tables included in the application in Table 5-2 in Appendix 2.6.1. The distribution of data presented in the application is not consistent; hydraulic conductivity, moisture content, porosity, and saturation are provided in varying combinations, or not all parameters are provided, making validation and interpretation of data difficult. These data comprise critical input parameters for both the conceptual model and mathematical modeling, and should have been provided in a clear and unambiguous format. The Executive Director recommends license conditions to require additional site characterization of the subsurface to verify elevations of the top of the Cooper Canyon formation, verify saturated conditions, and verify the matric potential.

The application has combined the Ogallala, Antlers, and Gatuña formations into single hydrostratigraphic unit, termed the OAG. The OAG unit is present across the proposed disposal site and consists mainly of unconsolidated to poorly-consolidated very fine to coarse sand and gravel with minor amount of silt and clay. The OAG unit ranges in thickness from zero to 30 feet across the site. The thickness generally increases to the northeast and southwest along the flanks of the underlying Dockum red bed ridge. According to the application, the top of the OAG unit is marked by the caprock caliche.

In Appendix 2.6.1, Section 5 of the application states that the unconsolidated or semi-consolidated sands and gravels located between the caprock caliche and the underlying red beds of the Dockum Group has been identified as various geologic formations including the Ogallala, the Antlers, and the Gatuña. The caprock caliche does not overlie the Ogallala Formation, rather it is a soil that developed across stratigraphic boundaries and time lines (Gustavson, 1996). Attachment 6-7 of Appendix 2.6.1 of the application does state that the caprock caliche may be the result of the welding together or stacking of numerous calcic soils that developed in sediments of the Tertiary Ogallala and parts of the Quaternary Blackwater Draw Formations.

As described in Section 2.5.2 of the application, the caprock caliche is a hard, erosion resistant, pedogenic calcrete. In addition, the application indicates that the caprock caliche, in the vicinity of the proposed disposal site, is typically five to ten feet thick but may exceed 20 feet in some areas. The application also indicates the caprock caliche horizon is hard, laminated and pisolitic, contains chert pebbles, and is exposed or covered by a thin veneer of windblown sand in areas of the proposed disposal facilities.

According to TCEQ staff and the BEG review of Appendix 2.6.1 of the application, there are various definitions of caliche and caprock caliche. Descriptions and definitions of caprock caliche in the application include: calcium carbonate-cemented caliche referred to as the caprock caliche and the caprock observed at Baker Spring. At this location, the caliche consists of approximately six feet of calcium-carbonate cemented sand; overlying approximately 12 feet of massive caliche and very fine grained sand; resting on top of approximately six feet of silt, sand, and gravel, which becomes less cemented with depth. These definitions of the caprock caliche are not consistent with the definition used in most of the borehole logs at the proposed site, the definition used in the isopach map of the caprock caliche, or the definition used in recent literature describing calcretes and calcic soils on the Southern High Plains (Gustavson, 1996). The thickness of the caprock caliche from the isopach map given in the application could also be understated (Figure 5-9a in Appendix 2.6.1).

Regarding the chronostratigraphic position of the caprock caliche, the application indicates that the caprock caliche is developed on pre-Quaternary strata (see Appendix 2.6.1: Introduction; Section 2.3; and Section 2.5). The areas of development of the caliche caprock are not, however, limited to pre-Quaternary strata (Gustavson, 1996). Locally the caprock caliche is the "c" horizon of the modern soil. In these areas, the caprock caliche is actually forming in and incorporating Holocene sediments. Development of the caprock along the western margin of the Southern High Plains shows that Quaternary or Blackwater Draw-aged calcium carbonate and clastic sediment comprise or are welded onto the top of the caprock caliche. The relationship between the Caprock caliche (calcrete) and the stratigraphic units is presented in Appendix 2.6.1 of the application.

The application also states that the contact between the caprock and overlying eolian sand exposed in the on-site excavations represents a major disconformity over a period that may span many millions of years; and that the top of the caprock was eroded prior to Quaternary eolian deposition (Appendix 2.6.1, Section 4.3.1). The caprock calcrete is developed on all pre-Quaternary strata in the High Plains because the upper part of the calcrete is Quaternary in age. TCEQ staff and BEG state that the caprock calcrete is an accumulation of calcic soils including soils that developed on sediments of the Ogallala Formation and the Blackwater Draw Formation. Throughout parts of the site, the caprock calcrete is the calcic horizon of the current surface soil including locally the Blakeney-Conger, Faskin-Douro, and Kimbrough Series. Locally, the caprock calcrete is coeval with parts of the Ogallala Formation and all of the Blackwater Draw Formation (Gustavson and Holliday, 1998; Gustavson, 1996).

In many cases, sections of caliche containing gravel were not identified as part of the caprock in the application. However, the exclusion of caliche containing gravel from the caprock was not described consistently. In some instances, sections of caliche containing concretionary rings in micrite, silica concretions, growth rings around clasts (probably pisolites or broken and recemented calcrete), all of which are characteristic of the caprock, were omitted in the application. At some boring locations described in the application, the thickness of hard caliche was mapped as caprock and moderately hard caliche was not. At other locations described in the application, the thickness of moderately hard caliche was mapped as caprock. The Executive Director recommends the consistent use of terms in description of site geology.

Review comments by TCEQ and BEG staff have indicated that the areal extent of exposed caprock appears to be inconsistently illustrated in the application. The three-dimensional groundwater flow model depiction of the top layer properties of the proposed site (Appendix 2.6.1, Attachment 6-3, Figure 1) indicates several large areas of exposed caprock surrounded by the Blackwater Draw Formation. Mapped areas of the caprock presented in the application cover areas up to a few thousands of square yards and appear to be inconsistent with data depicted in the surficial geology map of the proposed site (Appendix 2.6.1, Attachment 4.3, Plate 1). In addition, the isopach maps provided in the application, using roughly the same data to illustrate thickness variations of strata overlying the caprock are dissimilar in detail (Appendix 2.6.1: Attachment 4.3, Plate 2; and Figure 2-10), and appear to contain several data plotting errors and extraneous contour lines, such as those noted south of the proposed Compact Waste Facility (CWF).

The inconsistent use of terminology and the spatial variability of the caprock caliche leads to uncertainty in prediction of the location of the dry line. The Executive Director recommends that a more accurate isopach map of the Caprock caliche be developed and that the depiction of the aerial extent of exposed caprock be consistent with the application materials.

The Blackwater Draw Formation consists of reddish brown, fine to very fine grained eolian sand with minor amounts of clay and caliche. The thickness ranges from zero to approximately 40 feet across the proposed facility. The thickness increases to the northeast and south of the proposed disposal units.

6.3.4 Tectonic Processes

As required by 30 TAC §336.708(a), the application must include site-specific environmental information (or reconnaissance level information when appropriate), which addresses and quantifies, to the extent practicable, area and site characteristics including geology and seismology. In addition, 30 TAC §336.728(i) requires that areas shall be avoided where tectonic processes such as faulting, folding, seismic activity, or vulcanism may occur with such frequency and extent to significantly affect the ability of the disposal site to meet the performance objectives of this subchapter or may preclude defensible modeling and prediction of long-term impacts.

The proposed disposal facility lies above the Central Basin Platform, a region that has been tectonically stable since the early Permian. The application states that this area experiences moderate to low intensity seismic activity based on data from the National Geophysical Data Center of the National Oceanic and Atmospheric Administration. The application provides a table of historic seismic activity within 250 kilometers of the site. Some of the seismic activity may be due to oil and gas production, secondary recovery, or waste injection, as well as to a combination of over-pressured reservoir fluids and tectonic activity. The application states that the closest areas of faulting that affect Quaternary strata are associated with the Basin and Range physiographic province with numerous Quaternary faults located approximately 200 miles west of the proposed facility (Appendix 2.6.1, Section 4.1). Following this, the application states that the closest Quaternary faults are in the Guadalupe Mountains about 100 miles southwest of the WCS site (Appendix 2.6.1, Section 4.1.1). There are also minor differences in distances to Quaternary faults described in other sections of the application (Appendix 2.6.1, Section 4.1.1.2). However, the largest earthquake recorded in the vicinity of the proposed disposal facility was the Rattlesnake Canyon earthquake, a magnitude 5.0 event recorded in 1992 and located approximately 12 miles southwest of the facility. This demonstrates that the region is not totally without occasional seismic activity, although no surface expression of this fault movement has been noted (TCEQ, 2007).

TCEQ staff and the BEG have reviewed Appendix 2.6.1, Section 4.1 of the application and note that a discussion of Quaternary faulting associated with the dissolution of underlying evaporite deposits is not included. Quaternary faulting is associated with the Wink sinks and related depressions to the south as well as the San Simon Swale to the west in New Mexico. Fault scarps and open fissures surround each of these features. Appendix 2.6.1 of the application states that abrupt elevation changes within the Permian evaporate section, southwest of the proposed facility may be related to general fault trends in the area. The study in Attachment 4-2 of Appendix 2.6.1 of the application states that the study was not extended to evaluate the possibility of faulting as a cause of the abrupt elevation changes noted.

The Executive Director recommends a license condition to require the verification and evaluation of the location of faulting nearest to the land disposal facility.

6.3.5 Regional Subsidence Features

In Section 2.5.6 of the application it is stated that subsidence features due to salt dissolution are present in the region of the proposed disposal facility. The application states that these all overlie the Capitan Reef, which is a permeable limestone reef that formed along the margin of the Delaware Basin in Permian time. Small scale features include the San Simon and Jal Sinks, both of which lie about 20 miles to the southwest of the WCS site, and the Wink Sinks, which lie about 40 miles to the south. Such features may develop suddenly, as opposed to a long-term gentle subsidence of a regional nature. Larger structures include the San Simon Swale, a large depression centered about 25 miles to the west and west-southwest of the site, and Monument Draw Trough, an elongate feature that begins about 35 to 40 miles south southwest of the site and extends in a south-southeasterly direction for roughly 25 miles. There are also two saline lakes east of the site, Shafter Lake and Whalen Lake, along with an unnamed depression about four miles east of the site, which may be associated with underlying Permian salt dissolution.

TCEQ staff and the BEG reviewed the stratigraphic cross-sections presented in Figures 6.4-27a and 6.4-27b in Attachment 4-2 of Appendix 2.6.1 of the current application. These cross-sections were based on geophysical well logs, which were also displayed on the cross-sections. It is also to be noted that these cross-sections were previously submitted under an earlier application version in 2006. These cross-sections presented data that may indicate thinning within the Rustler, Salado and Tansil interval and down-warping of overlying stratigraphic units, which could be interpreted as possible dissolution and subsidence in the vicinity of the proposed facility. However, it is noted that the same data sets were re-interpreted and presented on Figures 23 and 24, as well as on isopach maps presented in Figures 14 through 19, in Attachment 4-2 in Appendix 2.6.1 of the application. The re-interpretation of this data apparently resulted in the conclusions that there was no salt dissolution or subsidence. Because both interpretations are based on the same data set, the issue of whether or not salt dissolution has occurred in the subsurface remains uncertain. In addition, the application lacks a detailed description of the interval between the 225-foot zone of the Cooper Canyon Formation and the underlying Permian strata under and adjacent to the proposed disposal facility. The Executive Director recommends a license condition to require the boring and collection of core samples from the lower Dockum Group and salt-bearing section of the Salado Formation to provide additional information and verification that salt dissolution will not impact the land disposal facilities.

TCEQ staff and the BEG requested a discussion of the physical and geochemical environment under which antitaxial gypsum veins in Dockum Group sediments developed at the site following recognition of these features from exposures at the RCRA pit and as part of a review of an earlier version of the application. The issue of the origin of antitaxial gypsum veins is important because these veins occur commonly in strata that have subsided or collapsed over zones of salt dissolution in many areas beneath and adjacent to the High Plains of Texas (Gustavson and others, 1994). The RCRA pit lies near the location of a stratagraphic cross-section and structure, and isopac maps containing data that can be interpreted as evidence of salt dissolution and subsidence beneath the WCS site (Figures 6.4-27e, 6.4-27c, and 6.4-27b, and Plate 6.2-3 from an earlier 2006 version of the application). Consequently, it is important to fully understand the origin of these veins, because they may have resulted from dissolution-induced subsidence.

TCEQ staff and the BEG reviewed Attachment 4-2 Evaluation of Halite Dissolution in the Vicinity of Waste Control Specialists Disposal Site, Andrews County, Texas, in Section 4.1 of Appendix 2.6.1 of the application. Appendix A of Attachment 4-2 describes a possible alternate origin and environment of deposition of antitaxial gypsum veins. In Attachment 4-2 of Appendix 2.6.1 in the application, it is stated that the gypsum veins occur commonly in breccias and that saline springs are commonly present. In the Gustavson et al. (1994) model, one of the origins of antitaxial (satin spar) gypsum veins can be related to localized dissolution of relatively shallow halite. The model is based on mapping zones of salt dissolution over several thousand square miles using geophysical logs from exploration wells, continuous core through salt dissolution and collapse zones from seven wells, and extensive outcrop studies. Active salt dissolution zones beneath the Southern High Plains in many areas are more than 1,200 feet deep, similar to the depth to salt at the proposed facility. Antitaxial gypsum veins commonly occupy breaks along bedding planes, minor faults, and fractures that developed because of dissolution induced collapse. Antitaxial gypsum vein fillings are also characterized by a medial suture that contains fragments of wall rock that resulted from breaking open the fracture as collapse occurred, where fibrous gypsum appears to have a medial suture defined by fragments of wall rock). Saline springs, if they are present at all, are commonly tens of miles away laterally.

The lateral and vertical extent and the size and distribution of antitaxial gypsum veins observed at the proposed disposal facility cannot be reasonably extrapolated from limited exposures in the RCRA landfill excavation or from the limited number of shallow cores available. Therefore, the distribution of antitaxial gypsum veins above the Permian evaporate section beneath the proposed disposal facility should be further investigated.

Section 4.1.1.3 of Appendix 2.6.1 of the application states that the limited vertical and areal extent of the gypsum at the site indicates that unloading or regional scale dissolution are not likely potential causes of the gypsum veins. There is uncertainty in the lateral and vertical extent and the size and distribution of antitaxial gypsum veins observed at the proposed disposal facility that cannot be reasonably extrapolated from limited exposures in the RCRA landfill excavation or from the limited number of shallow cores available. Therefore, the distribution of antitaxial gypsum veins above the Permian evaporate section beneath the proposed disposal facility is uncertain.

The application concludes that the antitaxial gypsum in the veins exposed in the RCRA pit observed at the proposed facility may not be related to salt dissolution at depth because: (1) brecciated strata has not been observed; (2) gypsum veins are separated from Permian halite by over 1,500 feet of Dockum strata; (3) there are no saline springs close by; (4) Dockum aquifers contain relatively fresh water; and (5) borehole log interpretation in Section 4.1.1.3 of Appendix 2.6.1 of the application shows no evidence of salt dissolution. The Attachment 4-2 of Appendix 2.6.1 of the application also states that all of the various forms of gypsum found in the RCRA landfill excavation formed in shallow alkaline groundwater and the most likely setting was syndepositional.

Reference to an alternate explanation for the origin of antitaxial gypsum veins does not negate the possible formation above areas of salt dissolution. The distinctly different crystal forms and color variations noted in the application suggests gypsum formation in various depositional environments (Appendix 2.6.1, Figure 4-19c.). In addition, if the antitaxial gypsum veins were formed syndepositionally (i.e., within surficial desiccation cracks) fragments of wall rock along the medial suture (characteristic of antitaxial veins) would not be expected. The application shows fibrous gypsum with a well-defined medial suture line which appears to contain surrounding Dockum red bed material (Appendix 2.6.1, Figure 4-19c). Other samples of antitaxial gypsum from the RCRA excavation should be examined for the presence or absence of Dockum red bed material incorporated into the medial suture.

The Executive Director recommends license conditions requiring verification and study of uncertainty related to possible salt dissolution and faulting in the vicinity of the proposed disposal site: 1) verification that salt dissolution will not impact the land disposal facility by placing one boring and collecting core samples near the proposed land disposal facility from the lower part of Dockum formation group and into the salt-bearing section of the Salado Formation; and 2) further evaluation of the abrupt elevation changes noted within the Permian evaporate section southwest of the proposed disposal facility including potential impact on the overlying strata .

6.3.6 Resistivity Study

The surface resistivity data acquired along four transects north of the facility were provided in Attachment 5-4 of Appendix 2.6.1 of the application. The resulting data appear to be of good quality and relevant to Dockum red bed depth, OAG water saturation, and origin of the playa north of the site. Resistivity sections constructed along the transects show several interesting features, including a shallow resistive zone at the surface (dry, coarse deposits) except at the playa, where a shallow conductive zone suggests moist and finer-grained deposits at and near the surface. More resistive strata beneath this surface conductive layer are consistent with geophysical surveys across other High Plains playas that have been interpreted as possible evidence of collapse strata. The presence of a linear high-resistivity zone that connects the topographic lows could represent buried, coarser channel-type deposits, or it might be evidence of linear collapse features related to subsurface evaporite dissolution. Additional surface resistivity or electromagnetic data could address this ambiguity.

Beneath the surface resistive layer, at depths of ten feet or more on all resistivity lines, is a more conductive layer that could likely represent higher-water-content OAG strata. Evaluation of the data in the application shows the conductive layer thinning toward the proposed facility as the saturated zone thins, suggesting that these and similar electrical data could be helpful in further evaluation of shallow saturated conditions immediately near the proposed disposal facility. Follow-up boreholes at key locations should be logged to quantify saturation at and near the facility. The Executive Director recommends verification of resistivity data by completing a comprehensive resistivity or electromagnetic analysis of the area of the proposed disposal facility.

There should be demonstration that the large playa to the north of the proposed disposal facility (and the linear high resistivity feature upon which the low areas align) is not the result of subsurface dissolution and subsequent subsidence of overlying strata. If dissolution and subsidence is active in the area of the large playa, filling the playa may only temporarily solve the infiltration problem. The Executive Director recommends a license condition that requires that any modification to surface water characteristics of the watershed considered on the site area be approved as a license amendment.

6.3.7 Surface Drainage and Erosion

Attachment of Appendix 2.6.1 of the application includes information regarding surface drainage in the vicinity of the proposed disposal facility. The primary surface drainage on the site is Ranch House Draw, which crosses the southern portion of the proposed facility. Section 4 of Appendix 2.6.1 the application indicates that Ranch House Draw is currently blocked with eolian sand toward the western side of the proposed facilities area. Surface hydrologic analysis was provided in the application describing the limits of the 100-year, the 500-year, and the probable maximum precipitation event floods along Ranch House Draw and in Appendix 2.4.1 Attachment II F Flood Plain Study states unequivocally that Ranch House Draw drains into Monument Draw. A floodplain map, Appendix 2.4.1, Figure II F - 4 of the application, also illustrates the channel centerline.

Section 4 of Appendix 2.6.1 of the application states that the drainage system on the site is not currently integrated within itself or with Monument Draw, New Mexico. Section 4 of Appendix 2.6.1 of the application also states that Ranch House Draw and Monument Draw have not been integrated for at least 60,000 years and will not be integrated over the next 50,000 years. However, Section 2 of Appendix 2.4.1 of the application states there is a draw (Ranch House Draw) that crosses the southern portion of the proposed disposal facility and ultimately drains into Monument Draw. The flood plain analysis presented in Appendix 2.4.1, Attachment II F of the application indicates Ranch House and Monument Draws are integrated.

Attachment 4-3 to Appendix 2.6.1 of the application also states there is no evidence that a fully integrated, active channel system existed in the ranch house drainage for at least the past approximately 60,000 years. Appendix 2.6.1, Attachment 4-3, Section 2.2.2 of the application also states that the ranch house drainage presently extends for some 1,700 meters (5,550 feet) from its headwaters just south of the ranch house to a broad, multiple-channel area south of the federal facility waste disposal facility (FWF) where a deposit becomes fan-shape (Plate 1 of Attachment 4-3, Appendix 2.6.1). The drainage cannot be traced further downstream, either to the southwest or west in the historical imagery or in the field, as channels appear to be buried by dune sands. A review of aerial photographs indicates the Ranch House Draw drainage may have continued due west, connecting to a short section of paleochannel preserved west of the site (Plate 1 of Attachment 4-3, Appendix 2.6.1). If so, this paleochannel connection was completely buried by deposition of a large lobe of sand that may be a wind-shadow dune deposited on the leeward side of a small ridge to the south (Plate 1 of Attachment 4-3, Appendix 2.6.1). Regardless of where the Ranch House paleodrainage may have flowed, it is clear that the present drainage is no longer integrated with Monument Draw, New Mexico which is the closest significant drainage west of the site, and may not have been for some time.

The descriptions of surface hydrology and related erosion potential of Ranch House Draw in the application were compared. The analyses of surface hydrology provided in Appendix 2.4.1, Attachment II F of the application showed that the expected lateral extent of flood events under current climatic conditions cross areas delineated by surface mapping that were presumed to completely block discharge of the lower reach of Ranch House Draw. The calculated flood levels presented in Appendix 2.4.1, Attachment II F of the application are based on current precipitation rates and apparently do not consider the potential for higher precipitation rates in the future. These data also imply that discharge from Ranch House Draw may become integrated with Monument Draw in the future. In fact, Attachment II F of Appendix 2.4.1 of the application, which contains data referred to in the previous sentence, states that Ranch Draw and Monument Draw are integrated. If the Monument Draw base level is lowered by future erosion, headward erosion along Ranch House Draw may threaten the proposed disposal facility. There is some uncertainty in the potential for surface erosion at the proposed disposal facility.

A conservative erosion rate must be established for an input parameter for use in performance assessment. An average annual disposal unit cover and slope erosion rate of 2.3×10^{-3} centimeters per year was established for the proposed disposal facility using the revised universal soil loss equation. A slightly different erosion rate of 3.64×10^{-4} centimeters per year is also stated in the application in Appendix 2.6.1, Section 4. Additional values for soil loss as a result of 100-year, 500-year, and probable maximum precipitation events are also provided in the application. The Executive Director recommends a license condition requiring the submission of performance assessment modeling based on erosion and other scenarios that are consistent with site-specific data, provide sensitivity and uncertainty analyses, and evaluate site adequacy in meeting the performance objectives.

In Section 5.3.2 of Appendix 2.6.1 of the application, it is stated that the caliche caprock exposed at the WCS site can be used as evidence for long-term landscape stability. However, the Quartenary caliche caprock is shown to thin over the Dockum red bed ridge in geologic cross-sections in Appendix 2.6.1: Figures and Attachments 2-1 and 2-2. In addition, the caliche caprock exposed in the RCRA pit adjacent to the WCS site is only one to two meters thick with a short of section of pisolithic caliche suggesting the caprock has been eroded. Field observations in the vicinity of the WCS by Lehman, as stated in Attachment 2-1 of Appendix 2.6.1 of the application, showed that locally the Cretaceouse Antlers Formation was originally overlain by the caliche caprock, which was subsequently eroded along with an unknown amount of the Antlers Formation. Considering, too, that the Ogallala Group was deposited during large sedimentation, valley-filling events as described in Section 2.3 of Appendix 2.6.1 and described by Gustavson and Winkler (1990). The description provided in the application states that paleovalley-filled facies of the Tertiary Ogallala consisted of gravelly and sandy braided-stream deposited on top of an erosional surface and interbedded with and overlain by eolian sediments deposits of sand and loess. Thus, massive erosion followed by wind-blown depositional events has been occurring for over a million years at the site. These and the subsequent arguments below support the basis of TCEQ's requests for the determination of the most conservative erosion rates for modeling calculations. Even if it is suggested that even possible gradation is found to be occurring on a short-term basis as presented in Attachments 4-3 and 4-4 of Appendix 2.6.1 of the application, large erosion precipitation events could remove substantial amounts of cover from the landfill as suggested by the regional geologic history of the site.

Table 1 in Attachment 4-1 of Appendix 2.6.1 presents a regional summary of measured erosion rates for the High Plains. Short-term soil loss calculated using the Universal Soil Loss Equation ranged from 0.06 to 0.2 centimeters per year. In addition to suspended sediment loads of streams draining the escarpment and reservoir sedimentation rates, erosion pins emplaced on varied slopes and soil types and monitored for 2 to 4 years were used to calculate a mean soil erosion rate of 0.05 centimeters per year. These erosion rates were determined for areas with annual rainfall rates of 15 inches per year to as much as twenty two inches per year. In Section 4 of Appendix 2.6.1 of the application, it states that the maximum erosion rate measured at the Buffalo Lake site, which is near Canyon, TX, were 2.4 centimeters per year. The reported depth of erosion, 2.4 centimeters, was the average net erosion depth shown by erosion pins lying on zero to nine-degree slopes as the result of a ten-year return interval storm (Finley and Gustavson, 1983). During this storm, headcuts in the alluvial-colluvial material on the floor of a tributary to Tierra Blanca Creek migrated as much as twelve meters (40 feet) upstream (Finley and Gustavson, 1983).

In terms of site erosion rate characteristics, vertical wind loss (deflation) should also be considered. Vertical wind loss was discussed in earlier reports filed in support of the application. When determining cover erosion rates, both soil loss as a result of rainfall run-off, and soil loss as a result of wind erosion should be included. According to the Soil Survey of Andrews County, Texas (USDA, 1974) the Blakeney-Conger and Jalmar-Penwell soil associations in the vicinity of the proposed disposal facility exhibit moderate to severe blowing hazards, respectively. Operations at the proposed disposal facility may increase the potential wind dispersion and surface erosion.

An estimated surface erosion rate was used in the RESRAD modeling presented in Appendix 8.0-6 of the application. RESRAD is a computer model used to evaluate the transport of radionuclides to saturation (Pathway G1) and the transport through the 125-foot zone to a water well screened in the OAG unit (Pathway G2). RESRAD requires information on site characteristics, and all of the non-default parameters used to model Pathways G2 and G3 are given in Appendix 8.0-6, Tables 8.0-6.8-4 and 8.0-6.18-1 of the application. In both tables, the cover erosion rate is given as 1.2 x 10^{-3} centimeters per year. The source of this rate is not referenced, but is described as coming from an erosion study in a comment section of the tables. The application included Attachment 4-1 and Attachment 4-3 describing erosion at the proposed disposal site. These attachments do not describe a surficial erosion rate or a cover erosion rate of 1.2 x 10^{-3} centimeters per year. The erosion rate used in RESRAD cannot be verified as site-specific based on the information presented in the application. In addition, an average annual landfill cover and slope erosion rate of 2.3 x 10^{-3} centimeters per year was determined for the proposed disposal facility using the revised universal soil loss equation (Appendix 2.6.1, section 4, p. 4-39-42, and Table 4-1a). A slightly different erosion rate of 3.64 x 10^{-4} centimeters per year is also stated in the application in Appendix 2.6.1, Section 4. Additional values for soil loss as a result of 100-year, 500-year, and probable maximum precipitation events are also provided in the application.

Five erosion monitoring stations were installed at the site as stated in Section 4 of Appendix 2.6.1. A sixth station was installed in March 2007. Erosion measurements are to be made quarterly. The first measurement occurred in the fourth quarter of 2006. Erosion pin measurements for the last quarter of 2006 and first two quarters of 2007 were not included in this application.

As described previously, license conditions are proposed related to possible effects due to erosion at the site. The Executive Director recommends license conditions to address the measurement of erosion rates that would provide a site-specific value for modeling input parameters. Additionally, a license condition proposes the installation of a weather/climate station in the immediate proximity of erosion monitoring in Ranch House Draw and the locations of additional erosion pin arrays.

References Section 6.3: Site Geology

Finley, R. J., and Gustavson, T. C., 1983, Geomorphic effects of a 10-year storm on a small drainage basin in the Texas Panhandle: Earth Surface Processes and Landforms, v. 8, 63-77.

Gustavson, T. C., Hovorka, S. D., and Dutton, A. R., 1994, Origin of satin spar veins in evaporite basins: Journal of Sedimentary Research, v. A64, no. 1, p. 88-94.

Gustavson, T.C. 1996. Fluvial and Eolian Depositional Systems, Paleosols, and Paleoclimate of the Late Cenozoic Ogallala and Blackwater Draw Formations, Southern High Plains, Texas and New Mexico: University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 239, 62 p.

Gustavson, T. C., and Holliday, V. T., 1998, Cyclic eolian sedimentation and pedogenesis on a semiarid to subhumid grassland, Tertiary Ogallala and Quaternary Blackwater Draw Formations, Southwestern United States: Journal for Sedimentary Research, p. 622-634.

Gustavson, T. C., and Winkler, D. A., 1988. Depositional facies of the Miocene–Pliocene Ogallala Formation, northwestern Texas and eastern New Mexico: Geology, v. 16, p. 203-206.

McGowen, J.H., Granata, G.E., and Seni, S.J., 1979, Depositional Framework of the Lower Dockum Group (Triassic) Texas Panhandle: The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 97, 60 p.

TCEQ, 2007. Draft Environmental Analysis: License Application Review for By-Product Waste Disposal from Waste Control Specialists, LLC in Andrews County, Texas, License No. R05807.

USDA, 1974. United States Department of Agriculture (USDA), National Resource Conservation Service Soil Survey of Andrews County, Texas, 1974

6.4 Seismic Characteristics

Active, tectonic processes such as faulting, folding, seismic activity, or vulcanism, could prevent performance objectives from being met. For instance, severe local faulting, or severe local ground shaking due to an earthquake initiated on a regional fault, might damage the concrete layer proposed in the cover system in each disposal unit. If this were to occur, the requirements of 30 TAC §336.725 might not be met. Similarly, such tectonic processes might sufficiently damage, or deform, the engineered components of the proposed disposal units such that water could intrude into the disposed waste or such that on-going active maintenance or waste retrieval might be necessary. In such circumstances, the requirements of 30 TAC §336.727 might not be satisfied. Similarly, an earthquake occurring during any operational phase might cause the overturning of, and subsequent damage to, a stack of concrete canisters used for waste disposal in active disposal units. Resulting damage of concrete canisters filled with waste could result in the increased worker radiation exposure during operations. In such a case, the requirements of 30 TAC §336.726 might not be satisfied. Local vulcanism could render the site inoperable, or even inaccessible prior to closure (consider a large fall of volcanic ash). Regional vulcanism, accompanied by the formation of intrusive structures (e.g. dikes, sills) might cause significant subsurface deformations and consequent loss of stability for the entire site, so that 30 TAC §336.727 would not be satisfied.

6.4.1 Active and Inactive Geologic Processes

Section 4 of Appendix 2.6.1 of the application on the regional and local tectonic environment was reviewed. There is no apparent threat, either short-term or long-term, to the proposed disposal facility, from either folding or vulcanism. The proposed facility is sited in a tectonically stable region of Texas in which these tectonic processes cannot be expected to be active, even over the tens of thousands of years characterizing the period of analysis.

TCEQ staff also reviewed the analysis of the local faulting and fracture systems directly inferred from the observable expression of these systems in the exposed faces of the open excavations in the RCRA landfill, already present in the immediate vicinity of the proposed low-level radioactive waste disposal units. Section 4 of Appendix 2.6.1 of the application presents a geologic structural analysis of the faults in this system and concludes that the local system of faulting and fractures is due to tectonic activity occurring prior to the Tertiary Period. In Section 4 of Appendix 2.6.1 of the application, it is also concluded that there are no regulatory issues related to faulting at the WCS facility. The engineering ramifications of these conclusions are that the faults within RCRA landfill are no longer active and need no further consideration in any seismic hazard analysis or site seismic response computations. However, active tectonic threats to the proposed disposal facility that do need further evaluation include earthquakes initiated on any one of the several regional faults, identified in the application by a seismic hazard analysis, as potentially active. As discussed in another section of this analysis, a license condition is proposed to address the potential for regional faulting and the threat of subsidence due to salt dissolution.

Section 4.0 of Appendix 2.6.1 of the application states that the proposed site lies in a region with crustal properties that indicate minimum risk due to faulting and seismicity. Also, the application states that crustal thickness is the most reliable predictor of seismic activity and faulting in intracratonic regions. Crustal thickness in the vicinity of the site is approximately 30 miles, one of the three thickest crustal regions in North America. In comparison, the crustal thickness of the Rio Grand Rift (in southwestern Texas) is as little as 7.5 miles.

From the tectonic viewpoint, the site lies on the Central Basin Platform, an area of moderate, low intensity, seismic activity. Table 4-1 of Section 4.0 of Appendix 2.6.1 provides a listing of all historic seismic activity (through 2003) within 250 kilometers of the proposed disposal site. This list includes 188 different seismic events. The application identifies potentially active faults that need further consideration in a seismic hazard analysis. The list includes the largest earthquake in the vicinity of the site, the Rattlesnake Canyon event of 1992. This earthquake had a magnitude of 5.0 and had an epicenter located approximately 11 miles southwest of the facility. One of the primary measures of damage potential of an earthquake is the peak horizontal ground acceleration (PHGA). Peak horizontal ground acceleration is a first order measure of the regional potential for structural damage due to an earthquake. Various investigators have estimated the PHGA due to the Rattlesnake Canyon event to be in the range of 0.06 to 0.07 g, where g is the acceleration due to gravity of 9.8 meters per second per second. The data from Table 4-1, including the data on the Rattlesnake Canyon event, served as a basis for the probabilistic seismic hazard analysis presented in the application. Section 5.1.2 of Appendix 2.6.1 of the application concludes that the small calculated peak accelerations and minimal ground motion resulting from the probabilistic seismic analysis indicates that the WCS site is in a seismically stable zone.

Evaporite dissolution is an active regional geologic process, and may be occurring at the WCS site. It is a more common and potentially more relevant process than seismic activity, tectonism, or vulcanism. The Executive Director recommends a license condition to further study and verify possible salt dissolution at the proposed site.

6.4.2 Disposal Engineering Report

TCEQ staff reviewed the expected earthquake induced ground motions in the Appendix 3.0-1 of the application. The application concludes that peak horizontal ground accelerations expected to occur at the proposed site should be limited to 0.10 g (acceleration due to gravity). This conclusion was based on the examination of standard seismic hazard maps produced by the United States Geological Survey (USGS) for different regions of the United States. The 0.10 g estimate is commensurate with the PHGA estimated for the 1992 Rattlesnake Canyon event. There is a standard rule of thumb in earthquake engineering that damage to even poorly built above-ground structures (e.g., un-reinforced, adobe residential structures) will only occur for peak horizontal accelerations above 0.20 g (Kramer, S.L., 1996). Therefore, the potential for seismic damage to buried reinforced concrete canisters and other disposal unit components would be very small, if not negligible. However, the potential damage to above-ground components of the proposed disposal units (e.g., storage tanks for leachate collection water) might not be negligible.

In any case, although the potential for seismic damage to the proposed facilities, as indicated by the peak horizontal ground acceleration, can be considered low, the application contains a probabilistic seismic hazard analysis, and a seismic response analyses for both the federal facility waste disposal facility (FWF) and Compact Waste Facility (CWF) disposal units and the leachate collection storage tanks. The seismic response analysis for the disposal units, utilizing the FLAC computer code, is reviewed in Section 6.4.3 of this analysis. The seismic response analysis for the leachate collection storage tanks is reviewed in this section of the analysis.

6.4.3 Seismic Hazard Evaluation

TCEQ staff reviewed Appendix 2.5.2 of the application containing the seismic hazard analysis, including the probabilistic seismic hazard analysis, and the development of several design earthquakes. In Appendix 3.4-1 of the application, the design earthquakes were used as inputs to a series of two-dimensional seismic site response analyses using the computer code, Fast Lagrangian Analysis of Continua (FLAC).

Based on regional maps, site geotechnical data (including in-situ spectral analysis of surface waves to determine dynamic material properties), and a literature review, the application considers a suite of equivalent liner dynamic material models to characterize the cyclic dynamic response of the subsurface materials at the proposed disposal site. These models served as input to a series of one-dimensional seismic site response computations using a computer code, Response Spectrum and Acceleration Scaling (RASCALS), and that were presented in the application. These computations suggested that any seismically induced shaking expected to occur within the proposed disposal units would not cause loss of structural stability of the concrete canisters, the backfill materials, or any of the other engineered components of these units.

Appendix 2.5.2 of the application describes a probabilistic seismic hazard analysis. Two design earthquakes, the Whittier Narrows Earthquake, 1987, and the North Palm Springs Earthquake, 1986, were used in the analysis presented in the application. Both of these events have magnitudes of approximately 5.0. The design earthquakes served as input to the FLAC seismic site response computations mentioned above.

The application concludes that the FLAC computations constitute a sufficient demonstration that the proposed disposal site avoids tectonic processes occurring with such frequency and extent as to significantly affect the ability of the site to meet the performance objectives of 30 TAC §336.723. The application also states that the site characteristics or active tectonics at the site do not preclude defensible modeling and prediction of long-term impacts.

While the application's seismic analysis of the proposed disposal units (using the FLAC code) indicate that seismic events pose no threat to the structural stability of the units after closure, no seismic analysis of the proposed disposal units during operation has been presented in the application. This concern is addressed in a proposed license condition requiring a seismic analysis for active operational conditions. In addition, the TCEQ has sufficient regulatory authority to require a licensee to perform additional studies, analyses, or to perform corrective action should a seismic event affect the facilities during operations.

The Executive Director recommends a license condition that requires verification of the location of faulting nearest to the land disposal facility. However, this proposed condition is not related to any specific concerns regarding the seismic characteristics of the proposed site. Rather, this proposed condition is related to concerns regarding the occurrence of subsidence at the site due to salt dissolution. These concerns are discussed in Section 3.3.1 of this analysis.

References Section 6.4: Seismic Characteristics

Kramer, S.L., 1996. Geotechnical Earthquake Engineering, Prentice-Hall. Upper Saddle River, N.J., 1996

6.5 Natural Resources

As required by 30 TAC §336.708(a)(4), the application shall include site-specific environmental information (or reconnaissance level information when appropriate) which addresses and quantifies to the extent practicable an identification of the known natural resources at the site, whose exploitation could result in inadvertent intrusion into the wastes after removal of active institutional control. Section 2.8.1 of the application identifies and discusses petroleum, sand and gravel, caliche, surface water and groundwater as known and/or potential natural resources at the proposed disposal site. However, the application does not address uranium in the Dockum, which has been described as a minor potential commercial natural resource in Dockum channel-lag facies (BEG, 1979), and sulfur, which is shown to be another extractable natural resource in Andrews County, found in association with natural gas (USGS, 2001).

The license application indicates the primary land use within a five-mile radius of the proposed facility is grazing and ranching. Oil and gas exploration and production activities have also been conducted in the vicinity of the proposed disposal facility. Other businesses in proximity to the site include the Wallach Quarry (crushed stone, sand and gravel) and Sundance, Inc. (oil recovery and solids disposal), both located about one mile west of the facility. DD Landfarm is located approximately 2.5 miles west of the facility, and the Lea County Landfill is located approximately one mile southwest of the facility. In addition, construction of the Louisiana Enrichment Services (LES) uranium enrichment facility is currently underway in Lea County New Mexico. The LES construction site is approximately one mile west of the proposed disposal facility. Future water uses in the area will include, industrial, domestic, livestock, and agricultural purposes. Nearby towns include Andrews, approximately 30 miles east, and the City of Eunice, New Mexico, five miles west of the proposed disposal facility.

The nearest residence is situated approximately 3.5 miles west of the proposed disposal facility.

The license application states oil production has occurred in the area for over 75 years, and notes that a producing oil well is located on the site. The proposed facility, located within the Permian Basin, is surrounded by several active oil fields. Section 2.8.2 of the application indicates the proposed facility is flanked by the Fullerton field about ten miles to the east, the Penrose and Eunice South fields to the west, and a smaller field approximately five miles to the north. Section 2.2.1 of the application identifies three producing oil wells on the site, two wells approximately 1.5 miles north of the proposed facility and one well approximately one-half mile southwest of the proposed facility. However, the Section 2.8.2 application dismisses the future exploitation of petroleum at the proposed facility as “minimal to non-beneficial.” Section 2.8.1 of the application further states that the absence of producing oil wells on the proposed disposal facility supports the absence of favorable conditions for oil production, and that there is little evidence of significant oil and gas reserves.

Section 2.8.2 of the application does not specifically address the future exploitation of sand and gravel in the area, other than to state, “While the proposed WCS disposal facility is located in an area of known natural resources, the presence of these resources is not likely to result in failure of the proposed disposal facilities to meet the performance objectives, including the protection against inadvertent intruders and the protection of long-term facility stability.” Section 2.8.1 of the application states that the mining operation immediately west of the site includes crushing caliche. The application, however, dismisses the possibility of caliche mining at the facility, stating caliche is widely available over the entire Southern Plains Region, and there is no economic incentive for caliche mining at the facility. As noted in Appendix 2.6.1, Attachment 5-5 of the application, active caliche (and sand and gravel) mining has taken place since at least 1939 one-half mile west of the proposed facility in Lea County, New Mexico. Other areas of Lea County have active commercial mining of aggregate and stone. As noted during a site visit in March 2007, sand and caliche have also been mined onsite.

Section 2.4.1 of the application states that there are no perennial streams flowing through or adjacent to the site. Several surface water bodies, both ephemeral and perennial, have been identified within five miles of the facility area. The surface water features identified in the application include Baker Spring, various stock tanks and ponds, and playas. Section 2.4.2 of the application also states that there are no coastal high-hazard areas, surface water bodies, or wetlands present on the facility area, or within five miles of the facility area, as indicated on the Wetlands Inventory Map. The map provided in Appendix 2.4.2 of the application shows approximately six types of designated wetlands. Playa lakes are numerous in the area and are believed to form from natural depositional lows produced by deflation and/or hydrocompaction in surface eolian sands, developing in as little time as a few thousand years (BEG, 1990). In addition, a common practice on the High Plains is the excavation by machinery in order to deepen the central part of a playa to impound water for a stock tank (Gustavson, 2007).

Several subsurface investigations have been conducted to evaluate the presence of groundwater in the vicinity of the proposed disposal facility. Section 2.8.1 of the application states that the lack of potable groundwater resources in the Dockum Group, in the area, serves as a disincentive for additional resource exploration. Section 2.5.8.1 of the application states that on-site quality groundwater within the Dockum Trujillo and Santa Rosa formations has been estimated at less than 3,000 milligrams per liter for total dissolved solids. While this may be considered relatively poor quality, it should be noted that a total dissolved solids as high as 7,000 milligrams per liter is considered an acceptable maximum limit for livestock (TAMU, 1997). Given that rangeland (i.e., cattle grazing) is considered the predominant land use in the area, as noted in Section 2.2.1 of the application, this is an important consideration.

The Dockum Trujillo and Santa Rosa formations are considered to be part of the larger Dockum aquifer, designated a minor aquifer by the Texas Water Development Board (TWDB, 2006a). While the application addresses the Dockum aquifer in the sections relating to natural resource exploitation it does not mention the High Plains aquifer. The High Plains aquifer, which includes the Ogallala formation, has been designated a major aquifer by the Texas Water Development Board (TWDB, 2006b). The water wells and windmills identified in the application indicate shallow groundwater is or was present in the vicinity of the proposed disposal facility (USGS, 1969). Attachment 6-1 of the application includes a well search identifying 258 water wells within the designated 10-kilometer (6.2-mile) radius of the proposed facility. A ground survey identified the locations of 16 additional water wells near the proposed facility. Twelve water wells have been located within the boundary of the site area. Section 2.8.1 of the application also identifies three active water wells outside the proposed facility boundary on the site property.

In summary, petroleum, sand, gravel, caliche, surface water and groundwater are considered in the application. Based on the review of the application, these resources are currently being exploited in the site vicinity. The application lists natural resources that occur in the area, but did not evaluate less important ones such as uranium and sulfur. The exploration and production of these natural resources could be anticipated to take place into the future. Invasive technologies and methods could be used to extract these resources. It is to be noted that with the installation of the disposal unit cover system, sand, gravel, and caliche formations will be removed; thus, it is less likely that intrusion will occur after the cap is installed to access these materials.

References Section 6.5: Natural Resources

BEG, 1979. The University of Texas. Bureau of Economic Geology, "Depositional Framework of the Lower Dockum Group (Triassic), Texas Panhandle." McGowen, J.H., et. al. BEG Report of Investigations No. 97, 1979

BEG, 1990. The University of Texas. Bureau of Economic Geology (BEG).. "A Proposed Sequential Development of Lake Basins, Southern High Plains, Texas and New Mexico." Reeves, C.C., Jr. In "Geologic Framework and Regional Hydrology: Upper Cenozoic Blackwater Draw and Ogallala Formations, Great Plains." Diffendal, Robert F., Jr., et. al. Thomas Gustavson, ed. BEG publication SP0006, 1990

Gustavson, 2007. Gustavson, Thomas C., Personal communication, 2007

NM, 2001. State of New Mexico, Energy, Minerals, and Natural Resources Department. Mines, Mills and Quarries in New Mexico.

TAMU, 1997. Texas A&M University, Texas Agricultural Extension Service (TAES). "Water Quality - Its Relationship to Livestock." Faries, Floron C., Jr., et. al.

TWDB, 2006a. Texas Water Development Board, Minor Aquifers of Texas (map), 2006.

TWDB, 2006b. Texas Water Development Board, Major Aquifers of Texas (map), 2006.

USGA, 1969. United States Geological Survey 1969, photorevised 1979. "Eunice NE, Texas - New Mexico." 7.5-minute topographic map.

USGS, 2001. United States Geological Survey. *Mineral Industry Survey, Texas, 2000 Annual Estimate*, 2000

6.6 Groundwater Hydrology

Title 30 TAC §336.708(a) (3) requires that the application shall include site-specific environmental information (or reconnaissance-level information when appropriate) which addresses and quantifies to the extent practicable the following: area site characteristics including hydrology.

Natural site characteristics of low-level radioactive waste disposal sites provide the key assurance that radionuclides will safely be isolated as they decay over intervals lasting thousands of years. The United States Nuclear Regulatory

Commission (NRC) states in Title 10, Code of Federal Regulation (CFR), Section 61.7(b)(2) that: "A cornerstone of the system is stability−stability of the waste and the disposal site so that once emplaced and covered, the access of water to the waste can be minimized." Intrusion of groundwater into the proposed disposal units would increase the mobility of radionuclides and the likelihood of public exposure to radioactivity during the period of analysis. Thus, an application for low-level radioactive waste disposal must demonstrate compliance with a series of regulations regarding subsurface water conditions at the site.

Title 30 TAC §336.728(f) requires that the proposed disposal site shall provide sufficient depth to the water table so that groundwater, perennial or otherwise, shall not intrude into the waste. Consideration of the capillary fringe and fluctuations of the water table are necessarily captured by the requirement of a "sufficient" depth to the water table. Further guidance is given in United States Nuclear Regulatory Commission (NRC) NUREG-0902, which states:

> The sixth requirement, related to the depth of the water table, indicates that, with few exceptions, near-surface disposal of low-level radioactive wastes will be in unsaturated soil deposits. Exceptions could include dry disposal in engineered facilities or structures completely below, partially below, or completely above natural site grade. Alternatively, as indicated in the wording of the requirement, waste disposal may be below the water table at some sites if it can be conclusively shown that 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, however, should waste disposal occur within the zone marked by fluctuations of the water table; and
>
> At sites where disposal will be above the water table, seasonal fluctuations of the water table and capillary fringe both prior and subsequent to waste disposal must be considered. The bottoms of the disposal units must be, at all times, above the saturated zone in order to limit the water contacting the wastes to that small portion which infiltrates through covers in disposal areas (NRC, 1982).

Texas rule 30 TAC §336.728(f) requires a demonstration that the proposed disposal site provides sufficient depth to groundwater currently (as determined by data collected from an appropriate set of borings, monitoring wells, and piezometers), and also a demonstration that the site provides sufficient depth to groundwater at all times. An appropriate period of time, termed the period of analysis, is defined in 30 TAC §336.709(1). This rule states that a minimum period of 1,000 years after closure or the period where peak dose occurs, whichever is longer, is required as the period of analysis to capture the peak dose from the more mobile long-lived radionuclides. Due to the complexities of demonstrating site suitability into the future, a 50,000 year period of analysis was established. Thus, the proposed site must have sufficient depth to groundwater over that time period. Such a demonstration requires that the application provide prediction of the future evolution of site hydrologic conditions, using either analytical or numerical models calibrated to current site hydrologic conditions. The demonstration must also incorporate estimated temporal variations in relevant climatic factors and site boundary conditions. The Executive Director recommends a license condition requiring modeling to predict hydrologeological conditions ensuring future unsaturated conditions of the buffer zone, including sensitivity and uncertainty analyses of the OAG and Dockum water tables.

Predictive modeling should be considered an integral component of site characterization. The requirement of sufficient depth to groundwater dictates that any observed current depth to groundwater is sufficient only if appropriate predictive modeling, calibrated to that current depth, demonstrates that the groundwater will not cross the boundaries of the proposed disposal units within any time during the period of analysis.

Title 30 TAC §336.724, regarding protection of the general population from releases of radioactivity, requires a demonstration that the transport of radionuclides over relevant exposure paths not expose potential receptors to peak doses in excess of regulatory limits over the period of analysis. Therefore, site hydrogeologic characterization efforts must generate data of sufficient quantity, quality, and spatial resolution to support a realistic, but conservative assessment demonstrating compliance with this performance objective.

Title 30 TAC §336.728(g) requires a determination of whether or not the footprint of the disposal site is within the recharge area of any sole source aquifer in the State of Texas. 30 TAC §336.728(h) requires that the hydrogeologic unit used for disposal will not discharge groundwater to the ground surface within the disposal site. Surface water features sustained by groundwater discharge, such as perennial and ephemeral streams, springs, seeps, swamps, marshes, and bogs, must not be present at the proposed disposal site. This requirement should provide sufficient space within the buffer zone to implement remedial measures, if needed, to control releases of radionuclides before discharge to the ground surface or migration from the disposal site.

The integrated understanding of the past, current, and future hydrogeologic conditions derived from field site characterization efforts, laboratory measurements, literature reviews, and computational and other numerical studies, and as presented in the application to demonstrate compliance with the above regulatory requirements, is referred to as the site hydrogeologic conceptual model.

TCEQ staff has reviewed and assessed application materials describing field and laboratory site characterization data, literature reviews, and computational simulations and numerical studies, and the site hydrogeologic conceptual model. TCEQ staff's analysis of these materials recognizes the central importance of groundwater issues in the reviewed application requesting authorization to dispose of low-level radioactive waste in the near surface.

This section of the analysis consists of four main discussions. The first discussion is an analysis of the application's characterization of current hydrologic conditions in the Ogallala-Antlers-Gatuña (OAG) materials, the uppermost geologic formation at the proposed disposal site. The second discussion is an analysis of the characterization of current hydrologic conditions in the deeper geologic formation at the proposed site, the Dockum Group. The third discussion concerns the results of predictive modeling of the future hydrologic conditions in the OAG. The fourth discussion is an analysis of application materials relevant to the future hydrologic conditions in the Dockum Group.

6.6.1 Summary of the Site Hydrogeologic Conceptual Model

The two proposed waste disposal units, the Federal Waste Facility (FWF) and the Compact Waste Facility (CWF), are to be founded to depths of 120 and 85 feet, respectively, within fine-grained, stratified, subsurface materials known as the Cooper Canyon Formation of the Dockum Group, and referred to as the "Dockum." At the proposed site, this Group is overlain by approximately 10 to 30 feet of OAG materials, which extends from the top of the Dockum Group to the ground surface. Thus, once the proposed facility is constructed, the disposed waste will be below the OAG materials. The acronym used in the application, OAG, denotes that the composition of the formation overlying the Dockum consists of a mixture of materials that exist nearby as separate and distinct formations: the Ogallala, Antlers, and Gatuña.

According to the site hydrogeologic conceptual model presented in the application, there appear to be two water tables in the immediate vicinity of the proposed disposal facility. The first is a water table present within the OAG materials above the proposed FWF and CWF disposal units. The characterized saturated conditions in the OAG can be described as a "perched" water table as these conditions appear to extend downward only to the contact of the OAG and Dockum materials. While the data presented in the application indicate that the OAG water table currently lies outside the lateral boundaries of the proposed disposal units, the precise current lateral extension of that water table remains uncertain.

The second water table is in the Triassic red bed materials forming the upper reaches of the Dockum Group and has continuous lateral extension across the entirety of the proposed site while exhibiting a variable depth beneath the OAG materials. The conceptual model presented in the application describes this water table as everywhere beneath the bottom of the proposed disposal units. The application states that the second water table is no closer than 14 feet from the bottom of the deeper of the proposed units, the FWF disposal unit. According to the application, this second water table would not intersect either of the FWF and CWF. Saturated conditions in the form of a capillary fringe usually exist above a water table in fine grained materials; the estimated depth of 14 feet given in the application apparently accounts for the capillary fringe above the lower water table.

The site hydrogeologic conceptual model describes saturated conditions as existing everywhere below the second water table, throughout the depth of the Dockum Group and beyond, into deeper formations. However, because of the lateral extent of the proposed disposal facility, there is some uncertainty in the precise depth of that water table across that extent, especially in areas near the boundaries of the facility where characterization data becomes relatively sparse. Therefore, the Executive Director recommends license conditions requiring additional characterization and verification of unsaturated conditions, including additional borings and a resistivity study. In addition, during construction activities, license conditions require the licensee to evaluate and assess subsurface features such as fractures, faults, collapse features and groundwater flow and perform geotechnical studies to verify original conditions.

The application presents a predictive numerical model to estimate the future location of the OAG water table. After approximate calibration to current OAG conditions, the OAG predictive model was used to develop simulations of the evolution of those conditions in response to future climate change. These simulations indicated that without some form of modification of the local site topography (in the application this modification is termed “playa intervention”) that the lateral extent of the OAG groundwater will increase and intersect the lateral boundaries of the proposed FWF disposal unit within the period of analysis. The playa intervention proposed in the application would consist of filling playas in the immediate vicinity of the proposed disposal units with clay excavated from the units (to reduce recharge into the playas) and grading the surfaces of the filled playas to direct surface water away from the disposal units. The Executive Director recommends a license condition to require predictive modeling on the future location of the Dockum water table to demonstrate that the land disposal facilities and buffer zones will remain unsaturated at all times.

6.6.2 Summary of Hydrology Information

Section 6 of Appendix 2.6.1 of the application includes a description and tabulation of all the data collected in the effort to describe and quantify the ground water hydrology at the proposed disposal site. Paragraph 6.2.6 of Section 6 describes the site hydrogeologic conceptual model developed in the application from the site characterization data.

The site characterization data were collected during numerous investigation activities that have been conducted at the site since 1992 to the present. The application reports investigations including a RCRA landfill site characterization, four by-product material disposal facility siting studies, an OAG hydrogeology investigation, and investigation activities related to the proposed FWF and CWF facilities. The application states that approximately 250 borings were drilled and 150 monitor wells and piezometers were installed on the larger site area. While hydrologic data from these investigative efforts were not all collected in the immediate vicinity of the proposed FWF and CWF, they were all utilized in the development of the site hydrogeologic conceptual model that was presented in the application.

The current site hydrogeologic conceptual model is presented in Section 6.2.6 of Appendix 2.6.1 of the application. The analysis of future climate changes is presented in Volume 5, Appendix 2.3.3-1 of the application. The application presents attempts to use predictive numerical models to characterize the evolution of the current site hydrogeologic conceptual model due to these climate changes in Paragraph 6.2.6a of Section 6 of Appendix 2.6.1 of the Geology Report and in Volume 16, Appendix 2.6.1, Attachment 6-3, of that report.

Paragraph 6.2.6.2 of Section 6 of Appendix 2.6.1 of the Geology Report also presents modeling results (based on the current site hydrogeologic conceptual model) assessing groundwater flow and solute transport in the subsurface Dockum red bed materials using fracture flow conceptualizations and the computer code TOUGH2. The technical review of this portion of the application was completed by the University of Texas - Bureau of Economic Geology (BEG) at the request of the TCEQ (Appendix A).

6.6.3 Subsurface Structure and Stratigraphy

In Volume 9, Appendix 2.6.1, Paragraphs 5.2 and 5.3 of Section 5, the application depicts the subsurface geologic structure and stratigraphy at the disposal site. For the purposes of this section of the Environmental Analysis (EA) only the salient features of this structure and stratigraphy are described.

At the proposed site, the dominant subsurface structure is the Dockum Group. This structure is composed of four different formations, the upper one of which is denoted the Cooper Canyon Formation. The Cooper Canyon Formation extends to a depth of 600 feet below the site and consists of interbedded, largely horizontal, and somewhat discontinuous, layers of sandstone embedded in a claystone, siltstone matrix referred to in the application as "red bed materials" or the "red beds".

The Cooper Canyon formation is immediately underlain by the Trujillo Formation, followed by the Tecovas and Santa Rosa Formations. The Trujillo and Santa Rosa Formations are both water bearing units while both the Cooper Canyon and Tecovas formations function as aquitards within the Dockum Group. Within the boundaries of the proposed disposal site the Cooper Canyon Formation is overlain by a surface deposit of windblown sands (the Blackwater Draw Formation), caliche materials, and a deposit of unconsolidated sands and gravels that is referred to in the application as the OAG. The contact between the OAG and the underlying Cooper Canyon Formation consists of an erosional surface that forms a buried, south-easterly trending ridge ("the red bed ridge"). The proposed FWF and CWF disposal units are to be located in the Dockum red bed materials below this ridge and below the surficial OAG material. Numerous playa depressions within the OAG can serve as recharge areas for these surficial materials.

Figure 5-10 of Section 5 in the application is a contour map showing both the elevations of the top of the Dockum red bed ridge and the footprints of both proposed disposal units. The contours indicate the trend of the crest of this ridge across the site. This figure also shows the lateral boundaries of the proposed disposal site. Figure 5-10b of Section 5 in the application gives a three-dimensional depiction of the buried Dockum red bed ridge and indicates the location of both proposed disposal units on or near the crest of that ridge.

At a depth of 225 feet in the Cooper Canyon Formation, the application reports that there is a layer with a nominal thickness of 30 feet. Other layers discussed in the application, somewhat less continuous than the 225-foot layer, are at approximate depths of 80, 120, and 180 feet, interbedded within the Dockum red bed materials. There is a water table within the Dockum red bed materials, currently beneath the bottom of each of proposed disposal units but above the 225-foot layer. There is also a water table in the OAG materials above the upper Cooper Canyon materials. Thus, the site hydrogeologic conceptual model described in the application is largely a depiction of hydrologic conditions within and above the 225-foot layer across the lateral boundaries of the proposed disposal site.

6.6.4 Subsurface Hydrogeologic Properties

As an integral component of the site hydrogeologic site conceptual model the application presents multiple measurements and estimates of hydraulic conductivity, porosity and other hydrologic and geotechnical properties in each of the materials present within the Dockum Group, down to, and including the 225-foot layer. Hydraulic conductivity, effective porosity, and distribution (or adsorption) coefficients, are of particular interest. In saturated porous media, according to Darcy's Law, the average linear groundwater velocity, $\bar{v}$ is proportional to the hydraulic conductivity, K and inversely proportional to the effective porosity, η_e:

$$\bar{v} = \frac{K}{\eta_e} \nabla \varphi \qquad (6.6\text{-}1)$$

where $\nabla \varphi$ is the hydraulic gradient estimated at spatial locations from hydraulic head measurements in available monitoring wells or piezometers. The average linear groundwater velocity, $\bar{v}$, is a conservative estimate of the velocity of dissolved contaminants that are moving, or advected, with the groundwater. If the transport of the contaminant of interest is affected by adsorption onto the porous media, simple models of the equilibrium state of the adsorption process indicate that the velocity of the contaminant will be retarded with respect to $\bar{v}$. The contaminant will effectively be transported with a lower velocity than the moving groundwater. Thus, if adsorption is ignored, $\bar{v}$, is a conservative estimate of the speed at which the contaminant will move through the porous media. If the distribution coefficient, k_d relating the contaminant and the geochemistry of the porous medium is known the retarded velocity, v_r of the contaminant can be estimated as:

$$v_r = \frac{\bar{v}}{1 + \left(\frac{\rho_b}{\eta_e}\right) \cdot k_d} \qquad (6.6\text{-}2)$$

The symbol ρ_b denotes the bulk density of the porous media. Equation (6.6-2) indicates that as the distribution coefficient increases, the retarded velocity of the contaminant decreases.

It is apparent from Equations (6.6-1) and (6.6-2) that uncertainties in any of the parameters K, η_e or k_d will affect the estimated velocity of the groundwater and, therefore, the speed at which radionuclides dissolved in the groundwater are transported. For example, from Equation (6.6-1) a doubling of the hydraulic conductivity would double the groundwater velocity; a halving of the effective porosity would also double the groundwater velocity. From Equation (6.6-2) a doubling of the distribution coefficient will approximately halve the estimated speed at which radionuclides are being transported. It should be noted that compared to the typically large measured ranges of K and k_d, porosity only varies between 0 and 1, so that large absolute variations in η_e cannot occur. Still, the effect of a halving an effective porosity on the groundwater velocity is not unrealistic. Due to uncertainties in the measured porosity of the materials in the 225-foot materials, changes in porosity of such magnitude should be considered.

The above considerations are relevant to the performance assessment of the proposed disposal site. The application presents a performance assessment completed using the Residual Radiation Risk Assessment Computer Code (RESRAD). Section 8.10 of this EA gives an analysis of this performance assessment. In a performance assessment, the time needed for each radionuclide in the disposal unit inventory to be transported through all porous media between the disposed waste and the receptors of interest affects the time history of the dose received by that receptor. Thus, in the performance assessment values of K and η_e in each of the separate Dockum materials, as well as the k_d values characterizing the adsorption between each radionuclide of interest and those media, are significant parameters. The role of all of these parameters in the performance assessment, including k_d, is discussed in Section 8.10.

TCEQ staff performed an independent analysis using RESRAD (also described in Section 8.10), and including sensitivity and uncertainty studies, indicating that relatively small deviations in the values described in the application may result in peak doses in excess of regulatory limits during the period of analysis. As described in Section 8.10, no site specific values of k_d were determined as part of the site characterization described in the application.

Values of k_d are different for each radionuclide depending not only on the geochemistry of each porous material that radionuclide encounters during its transport, but also on the pH (measure of alkalinity/acidicity) and Eh (oxidation/reduction potential) of the groundwater and temperature conditions. Furthermore, the relationship indicated in Equation (6.6-2) assumes a simple linear relationship between the equilibrium concentration of a dissolved radionuclide in the groundwater and the equilibrium concentration of the contaminant adsorbed onto the porous medium. At elevated concentration levels, this simple linear relationship may not be valid. After a certain amount of radionuclide is adsorbed from the water onto the surface of the porous medium the capacity for further adsorption begins to diminish. At higher concentration levels, the amount of adsorption will also depend on the instantaneous value of the concentration, so that the sorption process is characterized by a non-linear relationship, not be a single coefficient. A consequence is that use of the distribution coefficient to model the actual geochemical process may overestimate the amount of radionuclide adsorbed onto the porous media and thus, according to Equation (6.6-2), overestimate the retardation in the transport velocity of affected radionuclides. Such radionuclides will be estimated to arrive at the location of water well later than their actual arrival, so that the dose at that well due to those radionuclides would be underestimated. In the absence of site-specific information regarding all the parameters affecting the adsorption process, tabulated literature values of k_d may not suffice in performance assessment computations.

Section 6.6.20 of the EA contains an extended discussion of spatial uncertainty in hydrogeologic characterization problems. Section 6.6.20 also discusses the use of geostatistical techniques for estimating the spatial distributions of hydrogeologic parameters, such as hydraulic conductivity and porosity from spatial realizations of these parameters obtained during site characterization. The geostatistical techniques explicitly recognize and quantify this spatial uncertainty. Also, Section 6.6.17 of the EA contains a description of the evaluation of the presence and flow of water in the OAG materials immediately above the top of the Dockum based on geostatistical and spatial analytic concepts.

6.6.5 Hydraulic Conductivities in the Subsurface

The application describes the determination of hydraulic conductivities in the Dockum materials using three different methods: (1) slug tests in the 225-layer; (2) laboratory tests of samples from the 225-layer, the other sandstone-like layers (at depths of 125 and 180 feet), and from the claystone materials between these layers; and (3) age-dating techniques. The conductivities measured from these methods are presented below with discussion of the spatial distribution of these conductivities.

Volume 15, Attachment 5-8 presents the results of 22 slug tests completed in the 225-foot layer. The horizontal conductivities determined from these tests are described in Volume 9, Appendix 2.6.1, Section 6, of the application:

> The hydraulic gradient in the 225-foot zone is approximately 0.015 to 0.016 ft/ft. Based on the 2006 groundwater gradient map presented in Figure 6.4 long term water level recovery in the 225-foot zone wells has provided a total of 22 estimates of the field horizontal hydraulic conductivity of the 225 zone. The calculated values and Hvorslev plots are provided in Attachment 5-7. The results are primarily in the range of 10^{-8} to 10^{-9} centimeters per second, with one value in the 10^{-7} range. The geometric mean of the field analyses for horizontal hydraulic conductivity is 7.37 x 10^{-9} centimeters per second, the harmonic mean is 5.04 x 10^{-9} centimeters per second, and the arithmetic mean or average is 3.59 x 10^{-8} centimeters per second. The arithmetic mean value of 3.59 x 10^{-8} centimeters per second is used to calculate the groundwater velocity as it is the conservatively largest average value for the 225-zone. A porosity value of 15% (0.15) was used for the calculation of velocity.

The application describes how the above Equation 6.6-1, was utilized to determine a preliminary conservative estimate of the horizontal transport velocity of radionuclides in the 225-foot zone of 0.004 feet per year (approximately 200 feet in 50,000 years). The largest of the 22 reported conductivities, described above as "with one value in the 10^{-7} range" corresponds more precisely to a value of 5.99×10^{-7} centimeters per second. This maximum value is over one order of magnitude larger than the arithmetic mean value of 3.59×10^{-8} centimeters per second used in the application "to calculate the groundwater velocity as it is the conservatively largest average value for the 225-zone". If the maximum conductivity, rather than the arithmetic mean is used in the computation of a groundwater velocity (keeping other parameters fixed), then a groundwater velocity of 0.613 feet per year (30,650 feet in 50,000 years) is calculated. This value is 16.6 times higher than the velocity computed using the arithmetic mean.

As conceptualized in the performance assessment using RESRAD, the water well used by the receptor of interest can only be located within a small volume of the subsurface materials of the 225-foot zone at the proposed disposal site. A subset of the hydraulic conductivities presented in the application were measured at large distances from the location of the water well modeled in RESRAD, compared to the characteristic dimensions of that small volume. Therefore, the hydraulic conductivities may not represent the conditions in the modeled well location.

If sufficient measurements of hydraulic conductivity in the 225-foot layer were available and the locations of these measurements provided sufficient spatial coverage of the area immediately outside of, and within the footprint of one of the disposal units, then a contour map of the hydraulic conductivity in the 225-foot zone could be constructed. Unless the actual spatial distribution of hydraulic conductivity in the 225-foot zone had a random spatial distribution, a contour map of conductivities constructed from sufficient samples from that actual spatial distribution would likely exhibit some structure, i.e., contiguous areas of low hydraulic conductivity and contiguous areas of high hydraulic conductivity. The relative location of the receptor of interest within this contoured conductivity structure would be of interest. If likely transport pathways from a disposal unit to the receptor location were completely contained within a "high" in the mapped hydraulic conductivity, then the range in conductivity values measured at all locations, or some average of these conductivities would not be relevant in estimating a travel time to that receptor. In this context, perhaps the maximum of the measured values (e.g., 5.99×10^{-7} centimeters per second) would be a more representative conductivity. Since the capture zone of the drinking water well might span several different conductivity contours, it would warrant consideration.

The application provides no analysis of the spatial distribution of the 22 slug test results. The application provides no explicit argument, based on correlations between materials exercised in each slug tests, that the results of each of the 22 tests contain information relevant to the problem of estimating doses to a receptor using the water well of interest. A plotting by TCEQ staff of the 22 slug test locations shows their spatial distribution to be characterized by several clustering of tests. It could be argued that the 22 tests contain redundant information. Further, giving equal weight to each of the 22 measurements in the computation of the various averages reported in the application may give too much importance to upgradient or distant values.

In geostatistical terms, the application has treated estimating a single hydraulic conductivity for the site as a zero-dimensional problem. The information available in the spatial configuration of the slug test locations has not been utilized in any manner. Furthermore, the application has addressed this issue as one in global estimation. But, this issue is more similar to one of block or point estimation (Isaaks and Srivastiva, 1989a). For example, in a block problem the geostatistical technique of block kriging is used to estimate the mean of a small volume of material embedded in a larger global volume containing a spatial distribution of samples, some perhaps located within the block, otherwise located outside of it. The actual conductivity estimation problem of interest is more like a block estimation problem than a global estimation one.

The application represents hydraulic conductivity of the 225-foot layer using zero-dimensional statistical estimators developed from the available sets of conductivity measurements. From the geostatistical point of view this representation, while allowing for heterogeneity in the spatial distribution of hydraulic conductivity, assumes that this heterogeneity has a random spatial distribution (i.e., unstructured) over each spatial scale of possible interest. The application does not provide information to support this assumption or identify the set of spatial scales of possible interest.

A significant percentage of the slug tests were conducted in materials upgradient of the proposed disposal units (materials not traversed by radionuclide transport pathways) or in materials laterally distant from likely pathways to the receptor of interest. In the absence of correlation arguments in the application, conductivities measured in such locations may not be relevant to performance assessment.

Measurements of hydraulic conductivity over the widest possible area would be useful in addressing other hydrogeologic problems associated with the proposed disposal site. For instance, predicting the evolution of the groundwater table in the Dockum materials over the period of analysis would require reasonable estimates of hydraulic conductivity over a large area without the need for small scale spatial resolution of the conductivity field. Radionuclide transport, however, is an inherently local problem. Hydraulic conductivity distributions adequate for solving one problem may not be adequate for solving another. It appears that the spatial resolution in hydraulic conductivity described in the application is incommensurate with the spatial scale of the performance assessment.

At the time the 22 slug tests were conducted in the 225-foot layer, at least 11 other wells in the 225-foot layer were available for slug testing. Slug testing in all 33 of the available wells would have provided a larger and more resolved spatial sampling of the hydraulic conductivity field in the 225-foot layer. There is no discussion in the application as to how the subset of tested wells was selected from the total available. Therefore, it is apparent that these wells were not initially located as the solution to an experimental design problem intended to estimate the spatial conductivity field in the 225-foot layer, relevant to a receptor in a performance assessment, in an optimum manner. It appears that the wells were constructed for other purposes (monitoring of groundwater) and only subsequently selected as loci for slug tests.

Because these 22 wells served as monitoring wells, some were sampled during their period of recovery. Such perturbations from an otherwise undisturbed recovery may have rendered the subsequent analysis of the recovery data inaccurate. For all but two of the slug tests, the application did not contain sufficient data for an independent analysis of the slug tests reported in the application.

In addition, because of the existence of fractures in the subsurface Dockum materials, the reported slug tests may not provide representative conductivities in a fractured porous media. Special equipment and procedures may be needed to generate and interpret slug test data in such media.

TCEQ staff constructed confidence limits on the mean hydraulic conductivities, assuming log-normality of the population. The 95th percentile Upper Confidence Limit was 1.00 x 10^{-8} centimeters per second. The 5th percentile Lower Confidence Limit was 4.56 x 10^{-9} centimeters per second. These limits will be compared to similar limits computed for conductivity measurements listed in Table 5-2 for samples from the 125 and 180- foot layers.

Section 6 of Appendix 2.6.1 of the application also describes the results of laboratory measurements of the vertical hydraulic conductivities on samples obtained from the 225-foot layer:

> The laboratory hydraulic conductivity tests provide estimates of the vertical hydraulic conductivity of the 225-foot zone. The laboratory tests on six 225-foot zone core samples listed in Table 5-2 range from 3.0 x 10^{-9} to 4.2 x 10^{-7} centimeters per second, with geometric, harmonic and arithmetic means of 2.14 x 10^{-8}, 9.73 x 10^{-9}, and 8.31 x 10^{-8} centimeters per second, respectively. By inspection the horizontal to vertical anisotropy is about 0.4 to 1,

> based on comparison of the horizontal and vertical values for each of the calculated means. The apparent anisotropy is relatively small (and the reverse of what is likely the larger scale anisotropy of the Dockum Group as a whole) and not significant.

The referenced Table 5.2 appears to contain laboratory measurements of vertical hydraulic conductivity from only five samples from the 225-foot materials, not six. Also, while Table 5.2 does indicate that six measurements of horizontal hydraulic conductivity were made on core samples from the Dockum, none of these samples were from the 225-foot layer.

Section 6 of Appendix 2.6.1 of the application continues:

> Because anisotropy is minimal, it is reasonable to aggregate all measured hydraulic conductivities into a single data set for averaging and analysis. The logs of these conductivities were tested for normality using a Liffiefors test. At the 95 percent confidence level, we do not reject the assumption that the logs of the values were drawn from a normal distribution.

While the application describes the results of a hypothesis test of the available data to determine the appropriateness of applying statistical estimation of the parameters of a lognormal distribution, no such test was applied to the earlier described slug test results. The application makes no statement regarding the distribution of the slug test conductivities. If the laboratory conductivity measurements are limited to five samples rather than the 12 referred to in the application, the log-normality of the available samples likely cannot be tested. With such a small sample size the Type II error rate of the Lilliefors test (or any other test of normality) is too high to render acceptance of the null hypothesis (at any level of confidence) very useful. Thus, the reported 95 percent confidence level for the conductivities measured in cores taken from the 225-foot zone may not be useful.

The five samples listed in Table 5-2 were taken from locations at a large lateral distance from the footprint of either the FWF or CWF. The five values reported in Table 5-2 may not be representative of that portion of the 225-foot layer of interest. To reinforce these spatial considerations, the highest vertical conductivity reported in Table 5-2 is for a sample reported to be from a stratum of sandy silt. The measured conductivity for this sample was 4.2×10^{-7} centimeters per second. The four lower conductivities reported in the table were all in samples with a different texture (i.e., silt, siltstone, sandy siltstone). The 225-foot layer is heterogeneous but hydraulic connectivity within each of these textures is likely. Radionuclides following a pathway of least resistance to their movement might be able to find connectivity in the sandy silt within that 225-foot layer.

Table 5-2 in Appendix 2.6.1 of the application also lists hydraulic conductivities measured in 39 samples obtained from the 125 and 180-foot layers. The application gives no statistical analysis of these conductivities or any narrative summary of them. TCEQ staff performed a statistical analysis of these conductivities, but did not perform a textural comparison of the materials in the 225-foot layer and these other layers to determine if the statistical analysis might contain useful information applicable for describing the conductivity of the 225-foot layer. The application also did not pursue such a textural comparison.

The geometric mean of the 39 measured vertical hydraulic conductivities was 4.58×10^{-8} centimeters per second. TCEQ staff notes this is almost one order of magnitude higher than the geometric mean of the 22 slug tests conductivities presented in the application. TCEQ staff also constructed confidence limits on the mean assuming log-normality from the available 39 measurements. The 95th percentile Upper Confidence Limit was 2.48×10^{-5} centimeters per second and the 5th percentile Lower Confidence Limit was 3.45×10^{-7} centimeters per second. Both of these limits are significantly higher than the corresponding limits presented above for the slug test conductivities. Given the limited set of lab conductivities in the 225-foot materials, any demonstration that the aggregated materials sampled from the 125 and 180-foot layers are comparable to the materials in the 225-foot layer would be useful. It might allow the conductivities from the more extensive data set to be extrapolated to the 225-foot layer. The application attempts no such extrapolation nor explains why such an extrapolation might be inappropriate.

Any demonstration that the 125-foot and 180-foot materials were similar to those in the 225-foot layer would need to explain the significant differences in the conductivities (representative by the presented confidence limits) in the slug test results and the laboratory results provided in the application. The fact that this difference is manifested might not necessarily indicate a textural dissimilarity in the materials. The slug tests exercise porous media over a much larger volume than do the laboratory tests (i.e., the "support" of these measurements are different). It can generally be expected that hydraulic conductivities measured over similar materials, but over different "support" will be different. The application does not address this issue. It is possible that the differing hydraulic conductivity measurements reflect variations with depth in the effects of the subsurface fracture system.

Table 5-2 in Appendix 2.6.1 of the application also lists vertical hydraulic conductivities measured in 45 samples obtained from the 125 and 180 foot-layers. Table 5-1a in Appendix 2.6.1 of the application gives a short statistical summary of these vertical conductivities. The table is titled "Confidence Intervals about Claystone Geometric Mean Hydraulic Conductivities." This title may misrepresent the presented limits. In statistical analysis, confidence intervals are usually constructed to contain a population parameter with a stipulated probability (confidence). The geometric mean is not a population parameter, rather it is a point estimator of a population parameter. For lognormal populations, interval estimators are available for each of the two parameters, median and mean. Neither of these intervals can correctly be characterized as confidence limits on the geometric mean.

Table 5-1a in Appendix 2.6.1 of the application lists the 95th percentile Upper Confidence Limit (UCL) as 5.5 x 10^{-9} centimeters per second and the 5th percentile Lower Confidence Limit (LCL) is given as 3.0 x 10^{-9} centimeters per second. These estimates were used in the performance assessment in the application to characterize the RESRAD simulated behavior of the materials above the 225-foot layer.

Hydraulic conductivities measured in samples with small “support”, obtained in fractured porous media, may exhibit smaller conductivities in samples from similar materials with larger “support.” It may be larger subsurface volumes that dictate the “effective” in-situ hydraulic conductivity in site-specific flow field. The application does not evaluate the available claystone laboratory conductivity measurements relative to these possibilities.

Appendix 2.6.1, Paragraph 6.2.6.b of the application reports estimates of the bulk effective hydraulic conductivities of the Dockum materials on the basis of groundwater age-dating using radioactive isotopes and groundwater samples taken from both the 180-foot and 225-foot layers. The calculated effective bulk hydraulic conductivities of the upper Cooper Canyon Formation using the estimated age dates were 2.50 x 10^{-9} and 3.9 x 10^{-9} centimeters per second. These conductivities are similar to those reported in the application for the slug tests in the 225-foot layer and for the lab measurements conductivities in the claystone samples. However, these are bulk measurements that cannot be assigned a specific location in space. The materials in the upper Cooper Canyon Formation might be expected, locally, to exhibit conductivities both higher and lower than these estimates.

6.6.6 Measured Porosities in the Subsurface

Table 5-2 of Appendix 2.6.1 of the application lists 37 laboratory measurements of porosity from samples taken from a variety of locations in the Dockum materials. Porosity was measured for each of the five samples obtained from the 225-foot layer. In reference to estimates of groundwater velocity in the 225-foot layer, the application notes that a porosity value of 15 percent (0.15) was used for calculation of velocity. This value is an average of five laboratory-determined porosity values. Porosity results for the core samples ranged from 8 percent to 20 percent. The application computed a groundwater velocity from Equation (6.6-1) using a porosity value of 0.15 percent (an average of only five laboratory measurements). If instead, the lowest porosity measurement of 0.08 percent was utilized in that computation, the estimated groundwater velocity would be almost doubled.

Thus, the entire previous discussion of the importance of spatial variability in hydraulic conductivity could be repeated regarding the importance of the spatial variability of porosity. Porosity also plays an important role in estimating radionuclide transport. Table 5-2 of Appendix 2.6.1 of the application indicates that five porosity measurements were made on samples from the 225-foot zone. These measurements may not be sufficient to establish a conservative value of effective porosity useful in RESRAD.

Furthermore, as discussed in Section 8.10 of this EA, RESRAD also requires an estimate of the total porosity in each of the modeled geologic layers. The application gives no indication of how the input values for total porosity were determined and how they are related to the measured effective porosity values in Table 5-2. Regarding effective and total porosity, the text Physical and Chemical Hydrogeology (Domenico and Schwartz, 1990) notes:

> Effective porosity implies some connectivity through the solid medium, and is more closely related to permeability than is total porosity… effective porosity can be over one order of magnitude smaller than total porosity, with the greatest difference occurring for fractured rocks.

If the subsurface materials at the proposed site are sufficiently fractured, any standard rule of thumb relating effective and total porosity, and utilized in the determining RESRAD inputs in the application, may not be applicable.

The above considerations of how independent changes in porosity and conductivity might affect estimates of average linear groundwater velocity perhaps should be considered only in the context of a possible relationship between K and η_e. The text Groundwater, (Freeze and Cherry, 1979a) notes:

> The porosity η_e can be an important controlling influence on hydraulic conductivity, K. On sampling programs carried out within deposits of well-sorted sand or in fractured rock formations, samples with higher η_e generally also have higher K. Unfortunately, the relationship does not hold on a regional basis across the spectrum of possible rock and soil types. Clay-rich soils, for example, usually have higher porosities than sandy or gravelly soils but lower hydraulic conductivities.

The application gives no discussion of the relationship between porosity and hydraulic conductivity.

There are techniques for estimating hydraulic conductivity from porosity and grain-size analyses. Such techniques could be utilized to either extend the set of available hydraulic conductivities to locations where conductivity measurements are not available or to generate “duplicate” conductivities for comparison and interpretive purposes. The Executive Director recommends license conditions requiring grain size analysis and determination of porosity values as part of the installation of wells.

6.6.7 Further Investigation of Hydrogeologic Properties in the Dockum Group

The Executive Director recommends additional in-situ and laboratory measurements of hydraulic conductivity in the Dockum materials in the immediate down-gradient vicinity of, and within the footprint of, the proposed disposal units, in order to characterize the hydraulic conductivity field of specific interest to a performance assessment.

A fundamental step in understanding and predicting the behavior of flow systems in fractured media involves the identification and location of hydraulically significant fractures. The geometry of the void space affects both the flow properties and the physical properties of the rock mass, such as the elastic and electric properties. Because the relationship between geophysical properties of a rock mass and the hydrological properties of the fractures is not unique, it is usually necessary to make direct measurements of flow properties from wells drilled in the subsurface. As stated in Applied Hydrogeology by Fetter:

> Wells located in a fracture trace, or especially at the intersection of two fracture traces, have a statistically significant greater yield than wells not located on a fracture trace. The same relationship is apparently true for wells located on lineaments, as opposed to those not on lineaments (Fetter, 1980).

As stated by the National Research Council in their study of rock fractures and fluid flow:

> Fractures in the subsurface are zones of anomalous physical properties that can be detected remotely by various means, ranging from simple extrapolation of surface observations to sophisticated seismic and electromagnetic soundings (NRC, 1996).

The Executive Director recommends development of a set of new borings and wells to be used initially for the purpose of completing tests capable of measuring the hydraulic conductivity in those Dockum materials of greatest relevance to the performance assessment. In determining the spatial placement of new wells, the possible fracture and faults will be first investigated within, and immediately down-gradient of both of the units; and wells should then be installed where the possible fractures or lineaments have been located and if possible in the intersection of two or more fractures. During the boring of new wells core samples should be obtained so that laboratory measurements of porosity in the 225-foot layer materials can be generated. These samples should also be utilized in the completion of site specific determination of distribution coefficients, k_d, for a suite of radionuclides, including those of greatest interest in the performance assessment. Batch contact tests, rather than column tests, should be used to estimate the sorption isotherm over an appropriate range of concentrations.

In particular, given that most of the fault and fracture traces of the Dockum are buried, a spatial extrapolation of known fault and fracture planes needs to be performed. To assist in the determination of new well locations, the existing fracture and fault planes in the RCRA pit, shown on Figures 4-11 in Appendix 2.6.1 of the application, should be extended and extrapolated until they are located underneath, adjacent, and immediately down-gradient of proposed units. The Executive Director recommends that surface, single-borehole, or borehole-to-borehole geophysics will be used across the footprint of the proposed disposal facility, adjacent on all four sides, and immediately down-gradient of the units to verify the extrapolations. Additionally, a plan for the placement of these monitoring wells must be developed. Monitoring wells should be installed where possible faults, fracture, or lineament are found, and if possible, where the maximum number of these features is intersected.

Slug tests involve only one well and are conducted in formations that exhibit generally low hydraulic conductivities. Hydraulic properties determined by slug tests are representative only of the material in the immediate vicinity of the tested well. To capture early time response, the Executive Director recommends that a pressure transducer or an electronic data logger be utilized in slug tests. It is also recommended that the well be pressurized both continuously and by a pulse.

The period of each of the hydraulic tests in any new set of wells should be of sufficient length to allow an accurate determination of the hydraulic conductivity of the subsurface materials exercised by the test. Appropriate tests should be completed in all of the new wells. It is recommended that none of the new wells be used as sampling stations until hydraulic conductivity testing is complete in each well.

Additionally, appropriate statistical analysis of the resulting measured hydraulic conductivities is recommended to be completed. In particular, the resulting test data should be used to estimate effective hydraulic conductivities of particular interest in the performance assessment. The resulting data should also be used to construct and estimate the spatial distribution of hydraulic conductivities over the entire site within the subsurface Dockum materials.

The statistical analysis of the hydraulic tests is recommended to be compared to the statistical analyses presented in the application for the samples from the 125-foot, 180-foot and 225-foot layers. The entire set of available data should be used to investigate the spatial distribution of hydraulic conductivities over the convex hull of all measurement locations. The Executive Director recommends license conditions that require development of a performance assessment maintenance plan and collection of additional data in support of performance assessment.

6.6.8 Characterization of Water Table in the OAG

Figure 6-3a of the application characterizes the water table in the OAG materials across the site; it shows contours of the saturated thickness of water in the OAG and the footprints of the CFW and FWF. Water in the OAG is resting on the top of the eroded surface of the underlying Dockum red bed ridge such that the saturated thickness of the OAG water generally decreases nearer to the crest of that buried ridge. The "0" contour shown on the figure (the locus of zero saturated thickness) is referred to as the "OAG dry line" and represents an estimate of the current lateral extent of saturated conditions in the OAG. Note that to the north and east of that OAG dry line the saturated thickness generally increases; at the extreme northern boundary of the site, the saturated thickness reaches 25 feet. Saturated conditions in the OAG exist continuously to the north of the buried Dockum red bed ridge, giving the impression that the buried ridge might function more or less as a natural dam, impeding the flow of OAG water to the south.

Examination of the elevation contours on Figure 5-10 of the application indicates that the OAG water flow should tend to parallel the elevation contours (to the southeast) of the buried Dockum red bed ridge. If the saturated thickness of the water in the OAG was to increase, this flow would be perpendicular to those contours, and hence toward the footprint of the proposed disposal units. Figure 5-10 of the application shows saturated conditions exist in the OAG immediately adjacent to the northeast corner of the boundary of the proposed FWF. Under predicted future increases in rainfall and decreases in evapotranspiration, the OAG dry line might further encroach upon the boundaries of one, or both, of the disposal units in the CWF and FWF.

A visual comparison of Figures 5-10 and Figure 6-3a of the application indicates that the OAG dry line differs from the elevation contours characterizing the top of the Dockum. This may be an indication of the uncertainties associated with the use of interpolation algorithms to contour data, both OAG elevation data and top of Dockum measurements. TCEQ staff notes the problematic intersection of the top of Dockum contours by the OAG dry line following that locus from west to east as depicted figures provided in the application. Locally, the direction of the OAG dry line appears to be topographically upgradient. The opposite is expected, especially if the water in the OAG is near equilibrium. The application makes no explicit note of this.

TCEQ staff analysis resulted in concerns about how the available spatial resolution of the top of the Dockum red bed ridge might obscure deviations of the actual OAG dry line from the dry line represented in Figure 6-3a. A proposed license condition requires verification of the elevations of the top of the Dockum Group with sufficient spatial resolution to support any modeling of the OAG dry line, or water table in the Dockum Group, relying upon these elevations.

As observed in Paragraph 6.2.1 of Section 6 of Appendix 2.6-1 of the application, the precise location of the OAG dry line is dependent on the amount of precipitation and recharge, primarily through playa infiltration, that reaches the OAG unit. In Paragraph 6.2.1, the application states "during relatively wet conditions, such as from late 2003 until early 2005, the dry line likely migrated southward as infiltration from the largest playa in the vicinity reaches the OAG unit and mounds. During dry or drought conditions, the dry line will likely migrate northward, retreating down the northward slope of the buried ridge". Here the application is noting significant lateral expansion of the OAG saturated conditions, as described in the latest revision of the application, relative to the characterization of those conditions in earlier revisions. In some directions, and relative to that earlier characterization, the OAG dry line appears to have moved several thousands of feet toward the proposed disposal units.

The location of the OAG dry line shown in Figure 5-10 of the application is based on an interpretation of OAG well data contained in Table 6-2. Such an interpretation involves a judicious assessment of the quality and redundancy of the available OAG water level data, the selection and weighting of an appropriate subset of that data, consideration of the estimated elevation contours of the Dockum red bed ridge, and the application of an appropriate interpolating contour algorithm. Differing combinations of these factors will result in different constructions of the OAG dry line. Therefore, the construction of the OAG dry line presented in the application is just one possible interpretation of the available data. An independent interpretation of the available OAG well data could result in OAG dry line constructions significantly closer, in some areas, to the proposed units than the OAG dry line shown in Figure 5-10 of the application.

6.6.9 Recent Characterization Data on Water Table in OAG

The apparent transient character of saturated OAG conditions is further illustrated by OAG water level data recently submitted after the final revision to the application (WCS, 2007a). This data indicates that several OAG wells previously dry now contain several feet of water. Consequently, the OAG dry line may have moved considerably closer to the boundaries of the proposed units relative to the current dry line depicted in Figure 5-10 that was constructed without consideration of recent data. TCEQ staff constructed a revised OAG dry line considering the recent data which moved the dry line closer to the proposed facilities. In some directions, the difference between the two dry lines is over one thousand feet. Thus, it appears that because of transient saturated conditions of the OAG, the dry line indicated in Figure 5-10 of the application may not be a depiction of current conditions at the site.

The precipitation rates on the actual site are recorded in the application from 2000 through late 2006. The most recent measurements from late 2006 to present are not yet available. These rates are of potential use for interpreting the current dynamics of the OAG system. The National Weather Service website indicates that the recent precipitation in Andrews County may be no more than four inches above normal during the period when recent data on OAG well levels were measured (NWS, 2007a). However, Appendix 2.3.3-1 of the application estimates that future rainfall rates at the site will be at least as severe as the precipitation events occurring both during the period 2003-2005, and more recently. This suggests that the future OAG dry line, in response to wetter climatic conditions, could move beyond the lateral extension of the dry line implied by the recent OAG data, thus increasing the possibility of intrusion into the proposed disposal units. This is plausible since OAG wells, shown in the recent data to contain significant levels of water, are outside of the predicted future OAG dry lines presented in the application.

The application does not depict the pre-2003 locus of the OAG dry line. Therefore, a visual, or more quantitative, comparison of that locus to the OAG dry line shown in Figure 6-3a of the application is not possible. TCEQ staff considers the statement in the application about the significant impact of the increased precipitation during 2003-2005 to be an important hypothesis regarding the response time of the OAG materials to increased recharge. The application provides no explicit support for this hypothesis. It may be that a numerical simulation using the pre-2003 and post-2005 OAG monitoring well data is possible. Such a simulation is discussed in TCEQ staff analysis later in this section.

Analysis of the most recent OAG data indicate that the OAG dry line could possibly extend further to the south, approaching the boundary of the proposed CWF disposal unit in the vicinity of monitor wells TP-19 and TP-30 as shown on Figure 6-3 of the application. Furthermore, the elevation data for the Dockum red bed ridge indicate the OAG dry line could extend further to the south approaching the boundary of the proposed CWF disposal unit. Monitor wells have not been installed between the OAG dry line, as established using the PZ-36 monitor well location, and the northern boundaries of the proposed by-product material and

FWF disposal units, a distance of more than 2,000 feet. Although the application indicates the OAG unit is dry at monitor well PZ-36, the lack of data between PZ-36 and the northern boundaries of the elevation of proposed units suggests the location of the dry line within the OAG has not been fully evaluated within this area. Uncertainty remains about the current location of the OAG dry line as depicted in the application. More recent data may indicate that saturated conditions within the OAG formations may exist within the boundary of the FWF disposal site.

The precise location of the OAG dry line relative to the boundaries of the proposed disposal units is a critical issue. The OAG dry line may intersect the boundaries of one, or both, of the disposal units either currently, or in the future. This would raise the question of whether or not the proposed disposal facility provides sufficient depth to groundwater since the proposed units would then be below OAG groundwater. Furthermore, difficulties during construction might arise depending on the extent of OAG saturated conditions, requiring dewatering procedures, additional shoring of engineering excavations, or modifications in the design of the disposal unit liner and cover systems. A second critical issue regarding sufficient depth to groundwater involves the interaction between the OAG water table and the water table in the underlying Dockum red bed materials. The dynamics of this interaction allow that, even if the OAG dry line were to maintain the location indicated in the application, saturated conditions in the Dockum Group may eventually intersect the boundaries of one or both of the proposed disposal units. License conditions are proposed to address the proximity of OAG groundwater to the proposed disposal units and the uncertainty in the current characterization of groundwater as presented in the application.

One of these proposed license conditions recommended by the Executive Director requires a relocation of the FWF. This proposed condition requires that the northernmost edge of the FWF be relocated at least 50 feet further from the OAG dry line and that a revised design, reflecting this relocation, must be submitted to the Executive Director. A related proposed license condition requires an individual buffer zone for both the CWF and the FWF in a lateral perimeter of at least 100 feet around all disposed waste. This surface buffer zone has the primary function of allowing adequate monitoring for early detection of a release and for any necessary remedial activities. Since detection of saturated conditions in the buffer zone will trigger cessation of waste disposal operations and immediate notification of the Executive Director, this zone provides additional protection to the proposed FWF regarding uncertainties in the current, or any future, locus of the OAG dry line. An additional proposed license condition will address concerns regarding the uncertain location of current and future saturated conditions in the Dockum red bed materials beneath the proposed disposal units. This proposed license condition requires the maintenance of an individual vertical buffer zone for both the CWF and the FWF under the lowest point of disposed waste adequate to allow monitoring for early detection of releases and to allow for remediation, if necessary. To aid in the maintenance of a vertical buffer zone under the FWF, a license condition is proposed to modify the bottom elevation of the disposal units in the FWF to 3,370 feet mean sea level.

A license condition requires water level elevations to be monitored in all OAG wells during facility construction in order to monitor the movement of the OAG dry line. If any water level elevations are found to be higher than the top of the Dockum, this proposed condition requires that excavation and construction cease in order to re-sample, verify, or otherwise perform tests.

The Executive Director recommends license conditions designed to accurately determine if unsaturated conditions are present within the boundaries of the proposed CWF and FWF, and immediately outside the buffer zones defined for each of the proposed units. A series of borings must be used to verify unsaturated conditions prior to construction, with annual verification also required. Degree of saturation measurements to a depth of at least one foot into the Dockum will be required. The proposed conditions also require saturation measurements and matric potential measurements in borings within Dockum materials. The measurements at a depth of one foot into the Dockum provide additional data regarding the current state of saturated conditions in the OAG, while measurements within one foot of the bottom of each of the proposed disposal units provide additional data regarding saturated conditions in the lower Dockum red bed materials. Each of these proposed conditions would require that saturated conditions measured in any of the specified locations force cessation of waste disposal operations to accommodate additional sampling, verification, or testing.

Finally, a proposed license condition requires that any necessary modifications in the design or construction of the disposal units, resulting from re-evaluation of the subsurface water conditions, including saturated conditions in the OAG materials, be submitted to the Executive Director for review.

6.6.10 Resistivity Survey and the OAG Dry Line

Attachment 5-2 to Appendix 2.6.1 of the application contains the results of resistivity surveys completed during site characterization efforts. TCEQ consultants at the BEG reviewed these surveys regarding the current position of the OAG dry line as presented in the application.

The BEG notes that:

> The position of the OAG dry line as depicted in the license application includes a northward excursion from a point near the northwest corner of the proposed federal facility waste disposal facility. The principal justification for the northward excursion away from the proposed facility is the boreholes (T-1 and T-2)

reported to be dry between the planned facility and the dry well PZ-36 at the north property boundary. The surface resistivity data acquired along four transects (T1, T2, T3, T4) north of the facility appear to be of high quality and, because resistivity responds to parameters such as clay content and moisture content, are relevant to issues such as Dockum red bed depth, OAG water saturation, and origin of the playa north of the proposed facilities. Most of resistivity line T1 and all of line T2 fall between the dry line and the proposed by-product material landfill and the federal facility waste disposal facility, yet do not appear to have been used to estimate the position of the dry line.

In general, the resistivity-depth cross-sections constructed along each of the transects show several interesting features, including a shallow resistive zone at the surface (dry, coarse deposits) underlain by a more conductive layer that is likely to represent higher-water-content OAG strata at depths of ten feet or more. This conductive layer generally thins toward the proposed facilities, suggesting that electrical data could be helpful in establishing more confidence in the position of the dry line. Line T1, for example, notes a "zone of increased water saturation" that lies between the depicted dry line and proposed facilities. Absent any OAG monitor wells over a large area between the proposed federal facility waste disposal facility and PZ-36, it is hard to justify the inferred OAG dry area between the depicted dry line and the facility with the geophysical data that suggest the possible presence of elevated moisture contents within the OAG zone in the same area.

Thus, it appears that that the characterization of saturated conditions using resistivity studies in the OAG materials, as described in the application, could be further developed. A license condition requires verification of the previous resistivity study to re-establish, as closely as possible the original study, and extend the survey to the south across the land disposal facility. This proposed condition requires that borings be installed and logged to calibrate the resistivity survey. If the completed survey were to indicate that the OAG dry line was located over the proposed disposal units then additional sampling, verification, or testing would be required.

6.6.11 Characterization of Water Table in the Dockum Red Bed

The site hydrogeologic conceptual model is presented in Appendix 2.6.1, Section 6, Paragraph 6.2.6 of the application. According to this model, there are two water tables in the immediate vicinity of the proposed facility. The second water table is located within these Dockum red bed materials beneath the water table in the OAG.

These subsurface conditions are depicted in Figure 6-5b of the application. This figure shows the subsurface hydrologic conditions on a north-south trending cross-section B-B′ through the eastern edge of the FWF. The water table in the OAG is shown to be within 100 feet (laterally) from the northern edge of the FWF and above the proposed depth of emplaced waste. Figure 6-5b of the application shows a deeper water table in the Dockum red bed materials that is within 70 feet of the bottom of the FWF. In addition, the thickness of the capillary fringe resting on top of that water table is not shown in this figure, so that the actual distance between saturated conditions in the Dockum red bed materials and the bottom of the northern edge of the FWF must be less than 70 feet. Figure 6-5b also shows that the depth to the lower water table in the Dockum decreases continuously in the northerly direction. Eventually, the water table portrayed in Figure 6-5b intersects the upper water table in the OAG at an elevation of 50 feet above the bottom of the proposed FWF disposal unit. The hydrologic conditions at the site are three-dimensional. Thus, the spatial relationships of the water tables in the OAG and in the Dockum red bed materials to each other, and to the boundaries of the proposed disposal units, could be examined on any vertical cross-section through that surface.

For instance, Figure 6-5a shows this spatial relationship on a north-south trending cross-section A-A′ through the western edge of the proposed FWF disposal unit. The water table in the OAG is at a greater lateral distance from the northern edge of that unit (approximately 2,000 feet) in Figure 6-5a than in Figure 6-5b. The lower water table in the Dockum red bed materials, without capillary fringe, is shown to be within approximately 50 feet of the bottom of that unit. Figure 6-5a also shows the depth to the lower water table in the Dockum continuously decreases to the north until intersecting the water table in the OAG, again at an elevation above the bottom of the proposed FWF disposal unit.

The cross-section of greatest interest is the one on which saturated conditions are a minimum distance to the disposal unit boundaries. The Executive Director recommends that a cross-section be developed for the line through the disposal units where the distance to saturated conditions below the units is at the minimum. The cross-section in Figure 6-5b may be close to this minimizing cross-section since the closest approach of saturated conditions in the OAG is near the northeastern corner of the FWF. However, the application does not identify the cross-section in Figure 6-5b as the minimizing cross-section. The minimizing cross-section may occur elsewhere due to the direction of the subsurface flow in the Dockum red bed.

Appendix 3.4-1 of the application states:

> The location/elevation of the capillary-saturation zone above the groundwater table within the proposed disposal-unit sites was interpreted utilizing moisture content and matric-potential data. Based on these interpretations, the top of the capillary zone is closest to, but at least 14-feet below, the invert of the northern portion of the FWF disposal unit. At the southern portion of the FWF and CWF units, the distance between the top of the capillary fringe and the disposal-unit inverts is greater.

Details of this cited interpretation are not given in the application. Such an interpretation might first involve establishing the cross-section through the FWF on which the distance from the unit boundary to the water table is a minimum, and then appending to that distance an estimate of the thickness of the capillary fringe. Ground elevations indicated in Table 6-2 of the application suggest that the lower water table achieves a minimum distance from the bottom of the FWF disposal unit on a cross-section between those indicated on Figures 6-5a and 6-5b.

The minimum distance of saturated conditions from the bottom of the proposed FWF disposal unit is also addressed in Paragraph 6.2.6 of Section 6 of Appendix 2.6.1 of the application as follows: "Based on matric potential and moisture content data, the water table beneath the northern parts of the FWF and CWF is interpreted to be at approximately elevation 3,300 to 3,320, and the capillary fringe in this area extends no higher than elevation 3,340 feet msl [mean sea level]." Since design specifications locates the bottom of the FWF disposal unit at 3,360 feet mean sea level, this interpretation would place the capillary fringe of the lower water table between 20 and 40 feet below the bottom of the disposal unit. The discrepancy between the 20 foot and 14 foot nearest to buried waste estimate is not addressed in the application.

The application does not explain the appropriateness of utilization of the groundwater elevation data from monitoring well 6-B2, screened in the 225-foot layer and located in boring B-48, in determining either the 14-foot or 20-foot minimum distances. Table 6-2 of the application shows the most recent water elevation in this monitoring well as 3,339 feet mean sea level. On the other hand, the hydrograph for this well in Appendix 2.6.1, Attachment 5-8 of the application indicates that water level in this well should recover to an elevation of 3,350 feet within the near future. If elevation data from this well played a significant role in the interpretation of the minimum distances, then the posting of the 3,339-foot measurement, rather than the historic stabilized elevation of 3,350 feet, is questionable. This 11-foot difference may be significant. Also, the application makes no reference to the recent 135-foot decrease in the groundwater elevation in well 6-B2 indicated in the hydrograph.

The application makes no explicit statements regarding the locus of saturated conditions in the Dockum red bed during the period of analysis. Section 6 of Appendix 2.6.1 of the application does state:

> The zone of fluctuation of the water table and capillary fringe below the FWF and CWF is most likely about a foot, similar to the variation of water levels in the 180-foot zone wells, and unlikely to be more than five or six feet, based on the variation of water levels in the 225-feet zone.

It appears that this statement is intended to characterize the dynamics of groundwater in the Dockum red bed over the entire period of analysis. Also, the application further states that "the similarity of the upward fluxes in the saturated zone and in the unsaturated zone indicates an approximate water balance can be achieved and the hydrogeologic system can be approximated as a steady-state system." The application does not explain how any deduction of the presence of a steady-state system in the Dockum red bed, developed from an examination of groundwater data collected over recent years, might apply over the entire period of analysis. Also, the basis for such a deduction is not explicitly given.

Several license conditions are proposed related to hydrogeologic conceptual model, including modeling to demonstrate that the buffer zone will be unsaturated at all times. This proposed license condition requires that the modeling incorporate representative current and future climatic parameters into appropriate numerical computer models.

Other proposed license conditions requiring that the measurement of the degree of saturation within one foot of the bottom of each of the proposed disposal units in specified locations both inside and outside of the buffer zones have been previously discussed. These proposed conditions will address concerns regarding uncertainties in the current depth to saturated conditions at the proposed disposal site.

6.6.12 Groundwater Dynamics in the Dockum Red Bed

Groundwater dynamics in the subsurface of the proposed disposal site are complex and cannot be deduced from simple arguments or representations. Carefully considered analytical or numerical models are able to predict how the current subsurface conditions will evolve into the future. Therefore, the following analyses of the subsurface dynamics, while based on elementary principles, are considered heuristic, indicative of the possible future configurations of the OAG and Dockum water tables, but not conclusive or constituting strong constraints on their future evolution.

These heuristic arguments are consistent with the reasoning incorporated into Figures 6-5a and 6-5b of the application. For example, these arguments assume that the continuity in the 225-foot layer is complete, as shown over the width of the Dockum red bed materials in these figures. The application only implicitly recognizes the continuity of the 225-foot layer depicted in these figures as an idealization. A more realistic characterization of the continuity of that 225-foot layer is depicted in the predictive numerical modeling in Attachment 6-3 of Appendix 2.6.1. Different problems may require different conceptual models but the application is not explicit regarding this issue.

Figures 6-5a and 6-5b provided in the application have contours of the hydraulic potential (head) fields superimposed on the cross-sections. The application states that these potential fields have been estimated from the available water level measurements. These two figures indicate water flow with an upward component in most of the subsurface materials above the 225-foot layer and predominantly horizontal flow within the 225-foot layer. These components of the flow field suggest that the water table in the Dockum red bed materials is currently moving both laterally toward the proposed disposal units, and upward, toward the ground surface. That is, hydrologic conditions in the subsurface are not in equilibrium. The figures in the application suggest that the lower water table in the Dockum could continue to move upward until the vertical gradient in hydraulic head is diminished.

The groundwater elevation data in Table 6-2 of the application clearly indicate a vertical gradient in some subsurface localities. These data show that in its northernmost portions the 180-foot layer is confined, like the 225-foot layer in its northernmost portions. The recently measured hydraulic head in these layers in those locations is above the top surface of these layers. The data provided in Table 6-2 show that the measured head in the 180-foot layer, while above the top of that layer, is less than the elevation of the recently measured hydraulic head in the 225-foot layer. Thus, an upward, vertical gradient is indicated. Assuming the potentiometric surface in the 225-foot layer is constant into the future, the water table in the Dockum red bed would achieve equilibrium when it reached the locus of that surface. At that time, the vertical gradient of the hydraulic head in the Dockum red bed materials would be essentially zero and vertical flow would cease.

Future increases in rainfall could be expected to raise the water table in the OAG and increase the hydraulic heads in the deeper underlying Dockum red bed materials, in particular, the hydraulic head in the 225-foot zone. Such an increase might induce further upward movement in the lower water table in the Dockum since a new equilibrium would be approached. Such analyses suggest that the current locus of the water table in the Dockum red bed, as shown in Figures 6-5a and 6-5b of the application, might move upward and toward the bottom of the proposed disposal units over some future period of time.

Both Figure 6-5a and Figure 6-5b provided in the application show an area labeled “Area Where Water Table is Refracted Downward.” A notation inside the labeled area denotes each of these areas as a “transient zone.” The dashed water table shown on the figures, directly beneath the proposed disposal units, bifurcates near the northern end of the cross-section, forming lines constituting the lateral boundaries of the indicated area. The curved, parabolic portion of that boundary (the southern boundary) connects with the southern most lateral extension of the water table in the OAG. It is this locus that represents the application’s estimate of the current location of the water table in the Dockum red bed materials. The more linear portion of the boundary of the “transient area,” forming the northern boundary of that area, continues upward from the bifurcation point on each figure where it eventually intersects that water table in the OAG.

Here, what remains to be discussed are the points of intersection of the lower water table with the water table in the OAG shown in both Figures 6-5a and 6-5b. In Paragraph 6.2.6 of Section 6 of Appendix 2.6.1, the application states:

> Figures 6-5a and 6-5b illustrate the hydrogeologic conceptual model of the WCS site using schematic cross-sections through the landfills. The unconfined groundwater (water table) in the OAG north of the proposed FWF is the uppermost part of the hydrogeologic system. Recharge to the OAG occurs by infiltration from playas. Inter-playa recharge is quantitatively negligible as most inter-playa infiltration is returned to the atmosphere by evapotranspiration. Beneath areas where the OAG unit is permanently saturated (such as the north end of the cross-sections) the Triassic red bed will be saturated over their full depth; and
>
> Bear (1972) discusses and mathematically demonstrates the refraction of a phreatic surface (water table) at a discontinuity in permeability. In the case of the OAG at the WCS site, the phreatic surface (i.e., water table in the OAG) intersects two media with significantly different hydraulic conductivities. The two different media are the OAG unit sands and gravels and the underlying Dockum red bed claystones. Where the refraction occurs will be where the Dockum red bed beneath the OAG are permanently saturated over their full depth. This area is north of the large playa. Beneath the large playa (Figure 6-5b) the Dockum red bed are saturated immediately below the OAG, unsaturated for about the next 100 feet and again saturated at depth as the permanent water table in the underlying Dockum red bed is approaches. In areas where the OAG is saturated but underlain by unsaturated red bed, water movement from the OAG to the Dockum red bed will

be primarily vertical, similar to a recharge pond over unsaturated material.

Based on Figures 6-5a and 6-5b provided in the application, the Dockum red bed materials are saturated over their full depth to the left of the point of intersection between the two water tables on the northern side of that point. The intersection point of the two water tables identifies the estimate of that portion of the OAG which is permanently saturated.

Since the mathematical solution attributed to Bear (Bear, 1972a) is a steady-state solution, predictive of the geometric relationships between static water tables existing across a discontinuity in hydraulic conductivity, the points of intersection shown on Figures 6-5a and 6-5b can be identified as an estimate of some past steady-state locus of the OAG dry line. Hence, the current location of that dry line, as depicted in Figure 6-3a, can be considered to be a transient perturbation from that steady-state locus. It is important to note that the location of the points of intersection on both Figures 6-5a and 6-5b are not necessarily based on historical water level measurements from the OAG. These features of the conceptual model can be considered schematic.

The important implication here is that if, in response to future climate changes, the long-term steady-state locus of the OAG dry line were to move towards the southern end of the cross-sections shown on Figures 6-5a and 6-5b, Bear's solution predicts that the refracted surface of the lower water table would, eventually, also move toward the southern end of each cross-section. If the lateral relocation of the steady-state locus is sufficient, then the lower water table in the Dockum must eventually intersect the lateral boundary of the proposed FWF disposal unit.

The parabolic boundary of the hatched area in Figures 6-5a and 6-5b depicts the dynamic response of the hydrologic system to a sudden change in the OAG dry line as the system attempts to equilibrate to that change. If the dry line were to remain in its current location, the transient zones shown in the figures would vanish and the parabolic boundaries would straighten and resemble the current linear boundaries of those zones. If climate changes cause the future steady-state OAG dry line to move to the current location of the transient OAG dry line as indicated in Figure 6-3a, then the point of intersection of the lower water table with the water table in the OAG would be only 100 feet from the northern edge of the FWF disposal unit. In that case, at some future time, the refracted water table as it descends into the Dockum red bed might intersect the northern, vertical boundary of that unit.

The current locus of the transient OAG dry line is attributed in the application to an above-average rainfall, during the period of 2003-2005. If this above-average rainfall is similar in magnitude to the annual future rainfall predicted by the future climate change models presented in the application, then the above described transformation of the locus of the past steady-state OAG dry line locus is quite possible. The Executive Director recommends that the transient nature of the OAG dry-line under wetter conditions be addressed as part of the site conceptual model.

6.6.13 Illustrative Analog: A Reservoir-Dam System

The OAG-Dockum red bed ridge hydrologic system as presented by the application can be compared to a water reservoir (the water in the OAG) existing behind an engineered dam (the Dockum red bed ridge). A discussion of such a system can be found in the text by *Soil Mechanics for Unsaturated Soils* (Fredlund and Rahardjo, 1993a). The dynamic response of a reservoir-dam system is depicted to a sudden increase in the depth of the reservoir, determined from numerical analyses using the finite element method. Here, the sudden increase in the depth of the reservoir is to be considered analogous to a rise in water levels in the OAG due to a future change in climate.

Figure 16.7 in the text by Fredlund and Rahardjo shows the evolution of the water table in the dam. This figure is reproduced here as Figure EA-5. The figure shows a current water table (labeled t = 0) at equilibrium with a reservoir depth of four meters, and a succession of water table loci induced by a sudden rise of reservoir depth to 10 meters, as the system seeks a new equilibrium configuration. Figure EA-5, aside from differences in scale, is very similar to Figures 6-5a and 6-5b in the application. Figure EA-5 shows an area analogous to the “transient zone” indicated on Figures 6-5a and 6-5b, created in response to the sudden increase in reservoir depth. This area is decreasing with time, as the parabolic boundary of that zone transforms into a more linear, equilibrium position. It is important to note that in Figures 6-5a and Figures 6-5b in the application, the slope of the red bed ridge is a great deal shallower than the slope of the corresponding side in the reservoir-dam analog. Thus, only a small rise in the saturated thickness of the OAG is needed to induce a large horizontal movement (lateral expansion) of the OAG dry line. The application is stating that such a small rise and corresponding large horizontal movement in the dry line occurred following the heavy rainfall during the 2003-2005 period. In Figure EA-5 a rise of six meters in the reservoir level induces the horizontal motion of the top of the reservoir water as shown in the figure.

Figure EA-5 shows that the water table in the dam takes 19,656 hours (2.24 years) to return to an equilibrium configuration in response to the sudden increase in reservoir depth. Due to differences in scale and material properties, this does not imply that the water table in the Dockum red bed shown in Figures 6-5a and 6-5b of the application, in response to a sudden lateral expansion of the saturated conditions in the OAG materials would require that same period of time to equilibrate to a future equilibrium configuration. However, Figure EA-5 suggests, that if the current position of the OAG dry line is a sudden perturbation from a steady-state position (as suggested in the application) then the current locus of the water table (corresponding to the t=0 locus in Figure EA-5) might be expected, at some future time to relocate (corresponding to the t =19,656 hour locus in Figure EA-5). If so, then examination of the site hydrogeologic conceptual model in Figure 6-5b suggests that, at some point in the future, the lower water table, after achieving its new equilibrium position, will intersect the boundaries of the FWF disposal unit. It can be concluded that the features of the reservoir-dam system suggest the plausability of the hyrdrogeologic conceptual model presented in Figures 6-5a and 6-5b of the application. This system also suggests that, due to future predicted increases in precipitation, that the potential for upward movement in the lower water table in the Dockum requires a careful examination.

There are several interesting features of the system depicted in Figure EA-5. In this figure, the ten meter water level remains constant even as water flows from the reservoir into the dam to feed the expanding water table. Thus, the point of intersection of the new reservoir water level with the dam surface remains fixed during the evolution of that water lower table. In essence, the reservoir is assumed to be infinite; loss of water from the reservoir into the dam interior does not lower the depth of reservoir. Thus, the system analyzed by Fredlund and Rahardjo shown in Figure EA-5 may be subtly different than the system depicted in the hydrogeologic model in Figures 6-5a and 6-5b of the application.

In the system described in the application the lateral expansion of the OAG dry line (attributed to heavy rainfall during the period 2003-2005) is not instantaneous, nor is that expansion (i.e., rise) necessarily constant. Assuming the expansion occurs over a period of two years, that period could only be considered instantaneous relative to the time significant changes in saturation occur in the underlying Dockum red bed materials. Also, it is not clear if the saturated conditions in the OAG behave as if supported by an infinite supply of water. Expansion of saturated conditions in the Dockum red bed underlying the OAG, induced by the lateral expansion of the OAG dry line, may remove sufficient water from the OAG to cause a retraction in the extent of the OAG dry line so that a final equilibrium, steady-state configuration is achieved. Thus, the steady-state locus of that OAG dry line may underestimate the lateral extension of that dry line during its transient evolution to that steady-state.

The finite-element analyses performed by Fredlund and Rahardjo assumed that the reservoir-dam system was responding with a no flow condition applied, and maintained, on the bottom boundary of the dam. The site hydrogeologic conceptual model presented in the application characterizes the bottom surface of the 225-foot layer as a no flow boundary. Therefore, it might be expected that the flow fields in the reservoir-dam system and the system above the 225-foot layer, shown in Figures 6-5a and 6-5b, might be similar. Figures 16.8(a) and (b) and

Figures 6.10(a) and (b), in Fredlund and Rehardjo (reproduced here as Figures EA-6(a), EA-6(b), and EA-7(a) and EA-7(b)), depict the hydraulic head and velocity fields in the reservoir-dam system at two different times following the sudden increase in reservoir depth. The no flow boundary is depicted on Figures EA-6(b) and EA-7(b). The similarities between the hydraulic head fields in these figures and the hydraulic head fields in Figures 6-5a, and Figures 6-5b, are evident. Examination of the velocity fields in Figures EA-6(b) and EA-7(b) shows that while vertical components of flow are present on these figures at some locations, they are generally small (the velocity fields on Figures 6-5a and Figures 6-5b must be inferred from the head fields via the application of Darcy's Law). Immediately above the bottom boundary of the dam, the velocity fields are everywhere dominated by horizontal flow. As discussed below, such horizontal flow does not characterize the velocity field implied by the site hydrogeologic conceptual model, immediately above the 225-foot layer. This indicates that the characterization of the bottom of the 225-foot layer as a no flow boundary in the conceptual model is questionable.

The reservoir-dam problem from Fredlund and Rehardjo is a two-dimensional problem. On any cross-section parallel to that shown in Figure EA-5 from the text, conditions are identical. The hydrologic conditions at the proposed disposal site are three-dimensional. Because of the curvilinear nature of the OAG dry line on all sets of parallel cross-sections through that site, conditions are different, including the component of flow perpendicular to that cross-section. Thus, the reservoir-dam analogy must be considered with some care.

6.6.14 Characterization of the Lower Water Table in the Dockum

The application does not describe how the available site characterization data was used to determine the particular configuration of the lower water table as shown on Figures 6-5a, and Figures 6-5b. Table 6-2 of the application documents the history of ground water elevations recorded in dozens of monitoring wells and piezometers designed to measure these elevations over the thickness of the Dockum red bed materials from the ground surface down to the bottom of the 225-foot layer. However, a measurement of the height of water in a monitoring well, or piezometer, once that height has stabilized, does not necessarily give an indication of the location of the water table. That height is only a measure of the hydraulic head at a location corresponding to the well point of a piezometer or with the middle of the screen in a monitoring well.

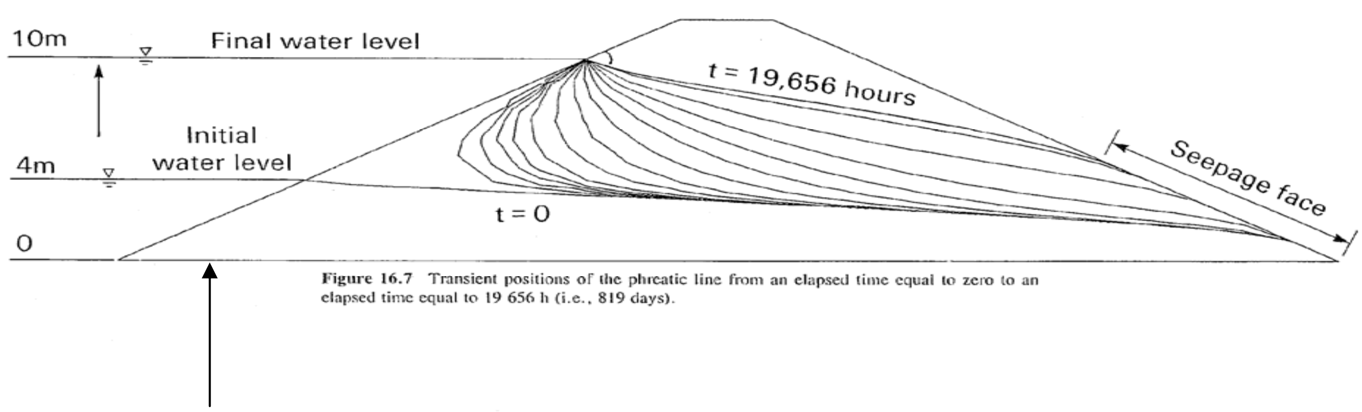

Figure EA-5: Changing locations of water table in reservoir-dam system in response to sudden rise in reservoir depth
(From: *Soil Mechanics for Unsaturated Soils*, by Fredlund and Rahardjo, 1993, John Wiley and Sons).

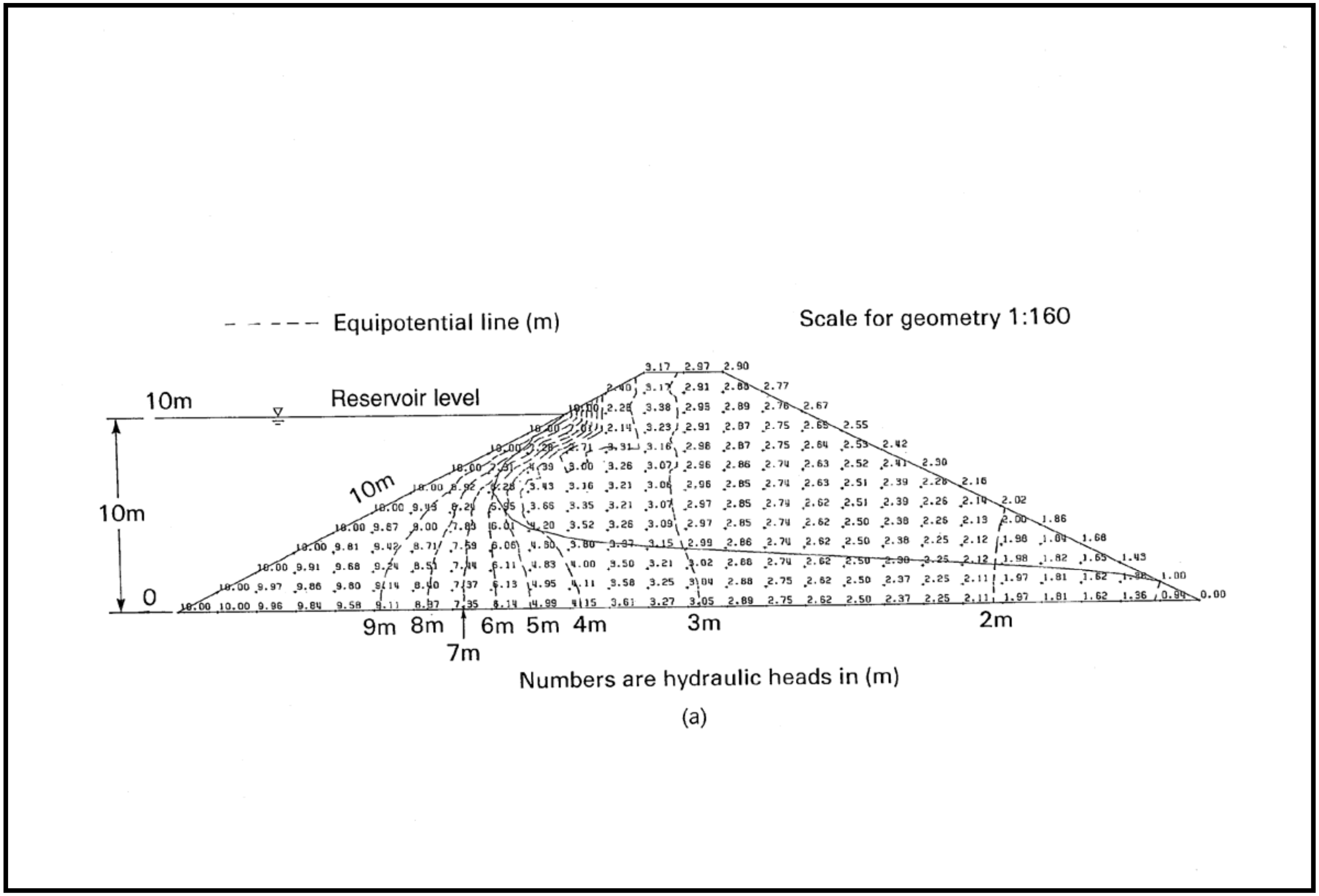

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Figure EA-6(a): Hydraulic head field in reservoir-dam system soon after rise in reservoir depth
(from *Soil Mechanics for Unsaturated Soils*, by Fredlund and Rahardjo, 1993, John Wiley and Sons).

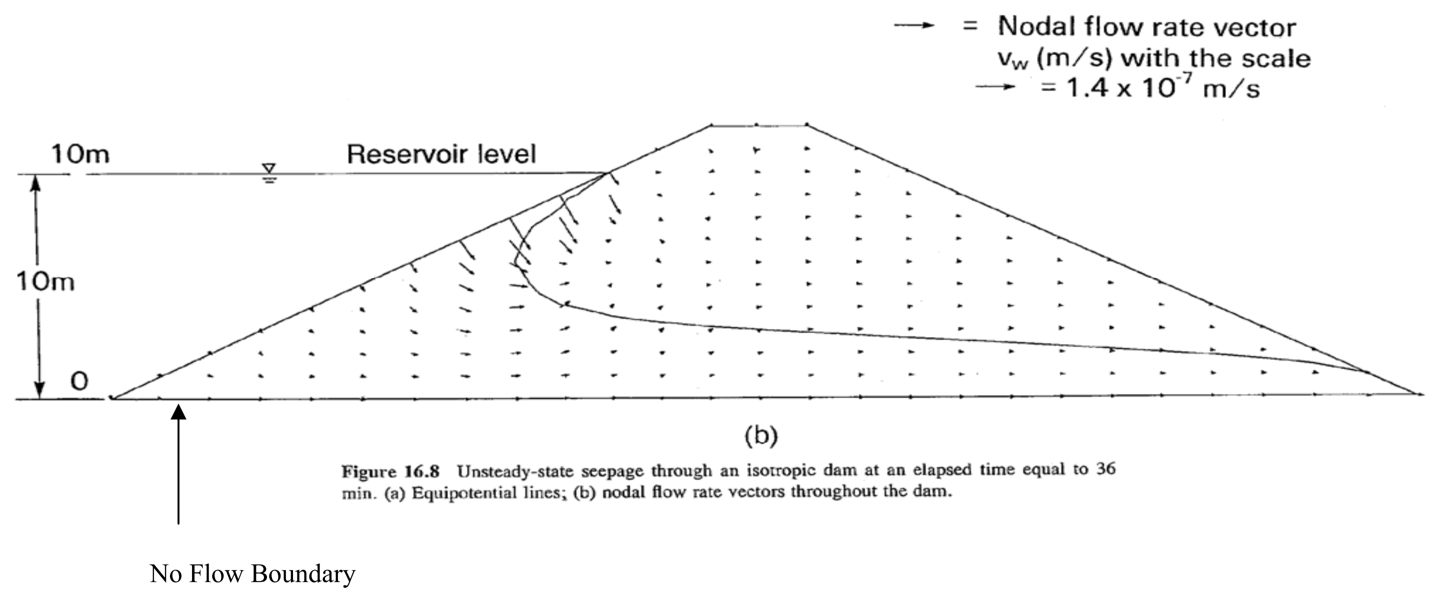

Figure EA-6(b): Velocity field in reservoir-dam system soon after rise in reservoir depth
(from *Soil Mechanics for Unsaturated Soils*, by Fredlund and Rahardjo, 1993, John Wiley and Sons).

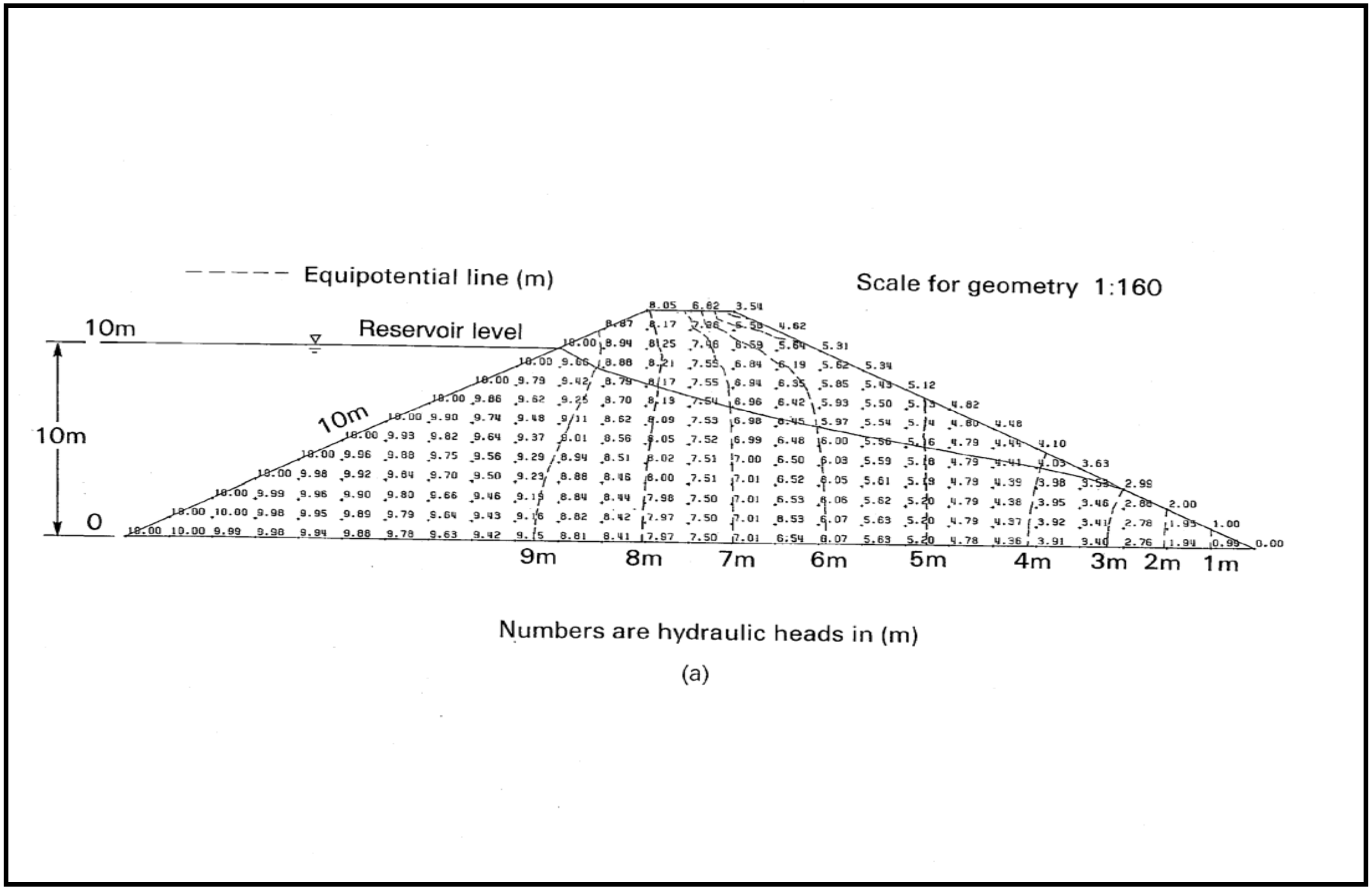

Figure EA-7(a): Hydraulic head field in reservoir-dam system near final equilibrium
(from *Soil Mechanics for Unsaturated Soils*, by Fredlund and Rahardjo, 1993, John Wiley and Sons).

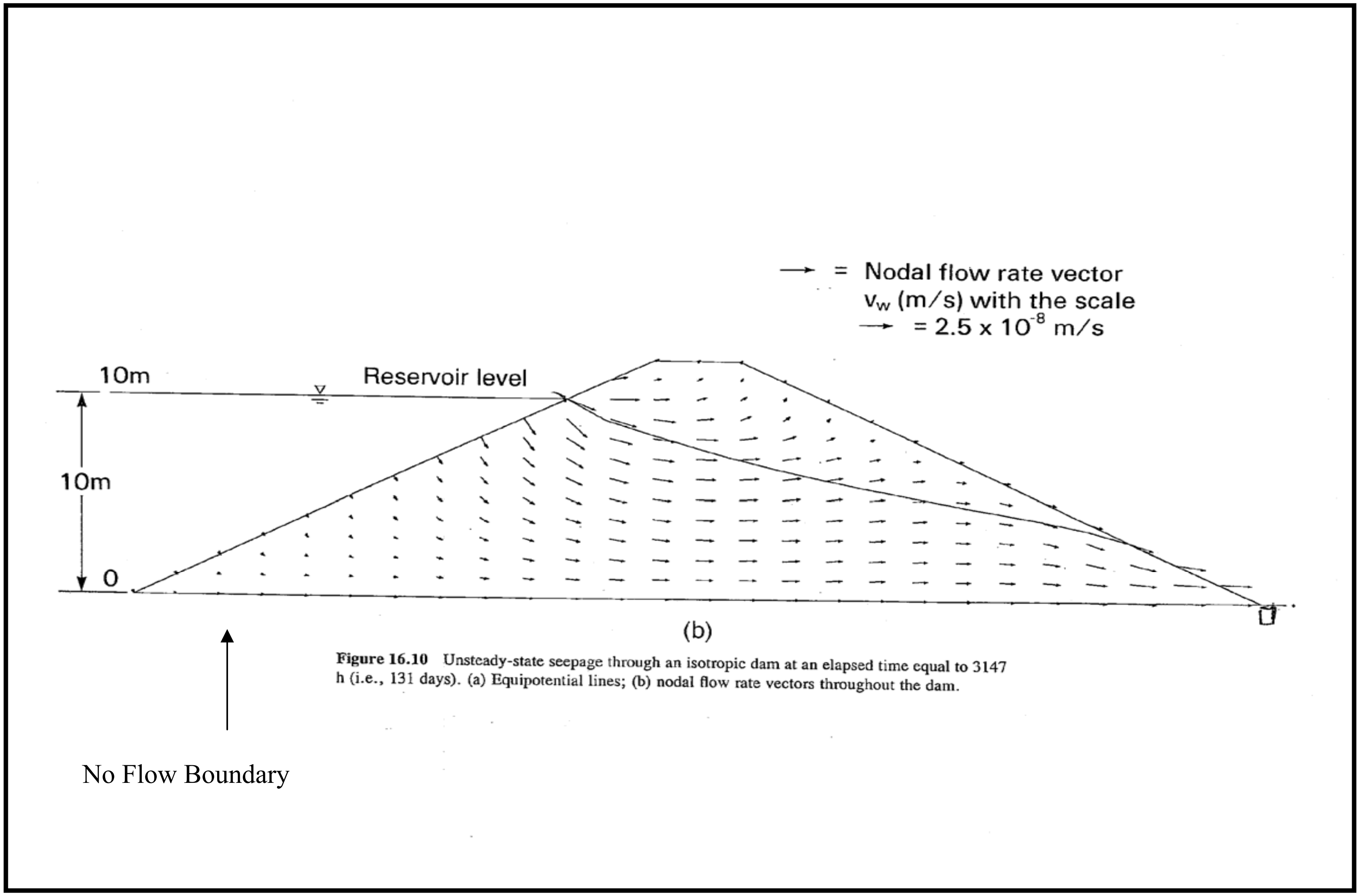

Figure EA-7(b): Velocity field in reservoir-dam system near final equilibrium
(From: *Soil Mechanics for Unsaturated Soils*, by Fredlund and Rahardjo, 1993, John Wiley and Sons).

The depth to the water table can be directly determined by noting the first appearance of water at the bottom of the piezometer or well as the depth of the piezometer or well is slowly increased (to give time for water to appear at that depth). If monitoring wells are quickly drilled to pre-established depths, so that specific locations or formations can be monitored once the wells are completed at those depths, then the location of the water table might be missed. This is particularly true if piezometers or wells are placed in low conductivity materials so that water only collects slowly in these devices.

The application gives no specific indication that the water table was directly measured in any of the claystone materials separating the siltstone layers in the Dockum Group. Yet the site hydrogeologic conceptual model, as depicted on Figures 6-5a and 6-5b of the application, indicates the locus of the water table traversing these materials. The application does not clearly explain why the water table in these materials could not be directly inferred in the field.

There are other methods which indirectly measure the location of the water table. It appears that the site characterization efforts described in the application targeted specific depths for monitoring, such as the 225-foot layer, the 180-foot layer, and the 120-foot layer. Boring logs associated with monitoring wells and piezometers could give an indication of the depth of the water table. In-situ measurement techniques relying on the water table as a locus of zero gage pressure can also be used to delineate that locus, however, it is not clear from the application if such techniques were considered.

Section 6 of Appendix 2.6.1 of the application does not give an explicit and detailed description of how the available well logs and well and piezometer water elevation data were used to determine the current locus of the water table in the Dockum red bed. In order to construct a first order approximation to the current locus of the lower water table, TCEQ staff used the elevation data from the 225-foot layer as recorded in Table 6-2.

6.6.15 Lower Water Table as a Surface in Three-Dimensions

The current water table in the Dockum red bed materials is a surface embedded in three-dimensional space. The shape of the water table surface cannot be inferred solely from an examination of the cross-sections depicted on Figures 6-5a and 6-5b. These figures do make it clear that to an observer standing on the bottom of the proposed FWF disposal unit, the water table in the Dockum red bed would appear at an elevation higher than the observer as the observer looked northward, and at a lower elevation when looking toward the south. The water table in the Dockum red bed would also appear at a higher elevation as that observer looked also to both the west and east. As previously noted, that same observer, looking downward, would see the saturated conditions in the Dockum red bed approximately 14 to 20 feet below, and looking upward, and would see the saturated conditions in the overlying OAG.

The three-dimensional aspects of the current saturated conditions at the proposed site are not discussed in Section 6.0 of Appendix 2.6.1 of the application. They are evident, however, in a series of figures included in Appendix 2.6.1, Attachment 6-3. Figures 2 and 3 of Attachment 6-3 show the location of the current water table on four different cross-sections through the proposed disposal site; two north-south sections and two east-west sections. From Figure 1 of Attachment 6-3 and recalling that the bottom of the FWF unit is at elevation of 3,360 feet mean sea level, the outline of proposed disposal units on each of these cross-sections in Figures 2 and 3 in the same attachment can be constructed.

The proposed location of the disposal units is on the axis of an unsaturated zone bounded on three sides by saturated conditions whose elevation exceeds that of the bottom of the FWF and bounded on the bottom by saturated conditions approaching possibly within 14 feet. Figure 6 from Attachment 6-3 of the application is a three-dimensional depiction of the current locus of the water table in the Dockum red bed. All of these cited figures approximate current conditions. Under predicted future increases in rainfall as provided in the application, the width, depth, and length of the unsaturated zone in which the proposed units are to be founded could be expected to decrease.

Figure EA-8 shows a contour map of that approximation, again with the boundaries of the FWF unit appended. Figure EA-9 shows the surface map of that approximation with the boundaries of the bottom surface of the proposed FWF disposal unit appended. In constructing these maps, the historical stabilized elevation of 3,350 feet in monitoring well 6-B2 was used as the relevant datum, rather than the most recent elevation of 3,339 feet for that well shown in Table 6-2 of the application.

While the maps in Figures EA-8 and EA-9 overestimate the elevations of the lower table, they may approximate the location of that water table at some future time as the subsurface conditions attempt to equilibrate to the current, measured, potentiometric field. Also, this overestimation may be ameliorated somewhat by the fact that the data in Table 6-2 of the application does not account for the thickness of any capillary fringe. Figure EA-9 explicitly shows the three-dimensional character of the lower water table in the Dockum, and the location of the proposed FWF disposal unit above the lowest elevation of that water table, flanked on three sides by water at higher elevations. Figure EA-8 indicates that a 3,340 foot elevation contour partitions the footprint of FWF unit into two roughly equal areas. Another 3,340 foot contour to the left of this contour indicates that a higher head elevation (approximately 3,350 feet) may exist near the western boundary of the unit.

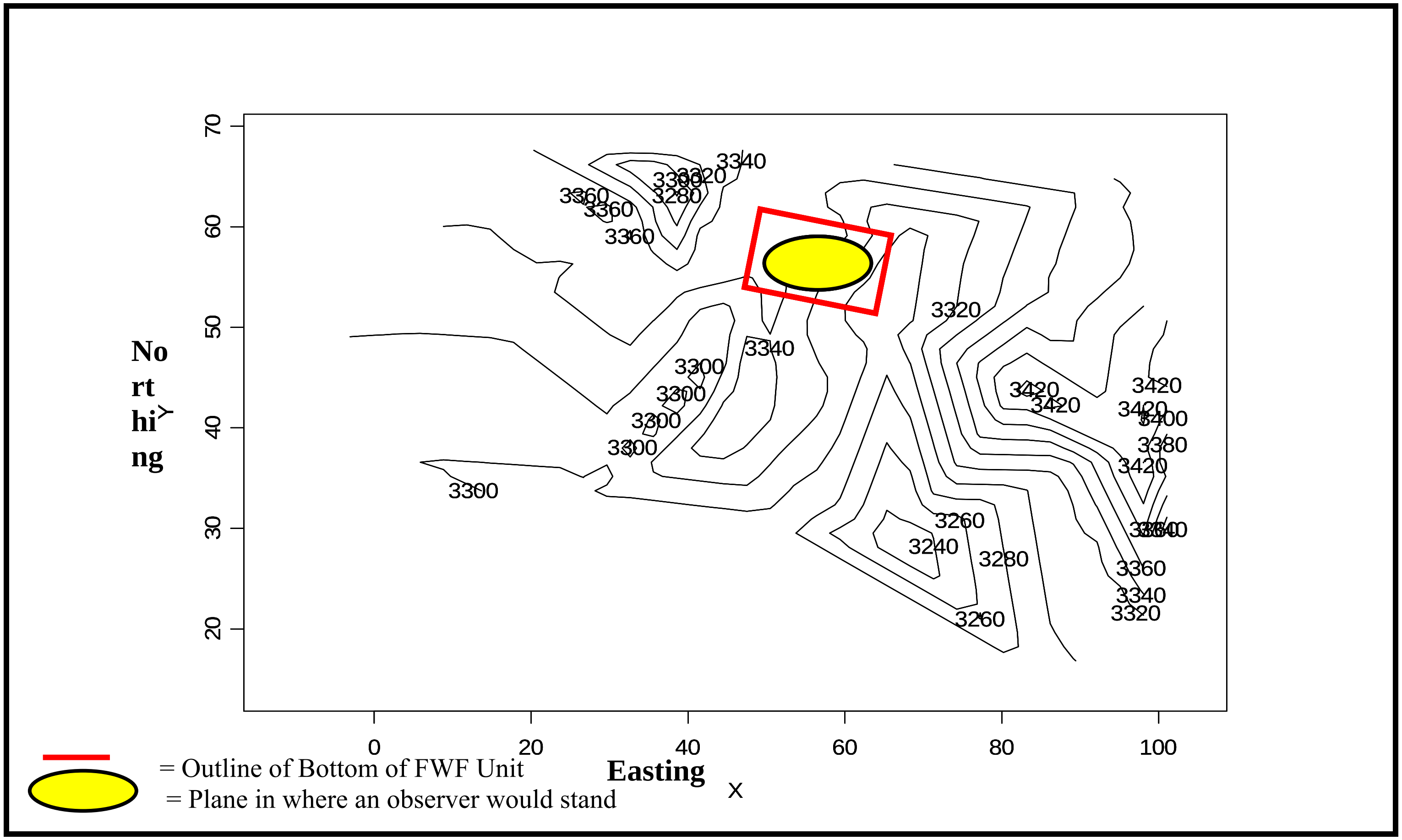

Figure EA-8: Approximate Contours of Saturated Conditions in Dockum Red Bed Materials (X,Y in Hundreds of Feet)
Note: Bottom of the FWF Unit Specified by Four Points (X,Y): (48,52); (52,61); (64,56); and (60,48).

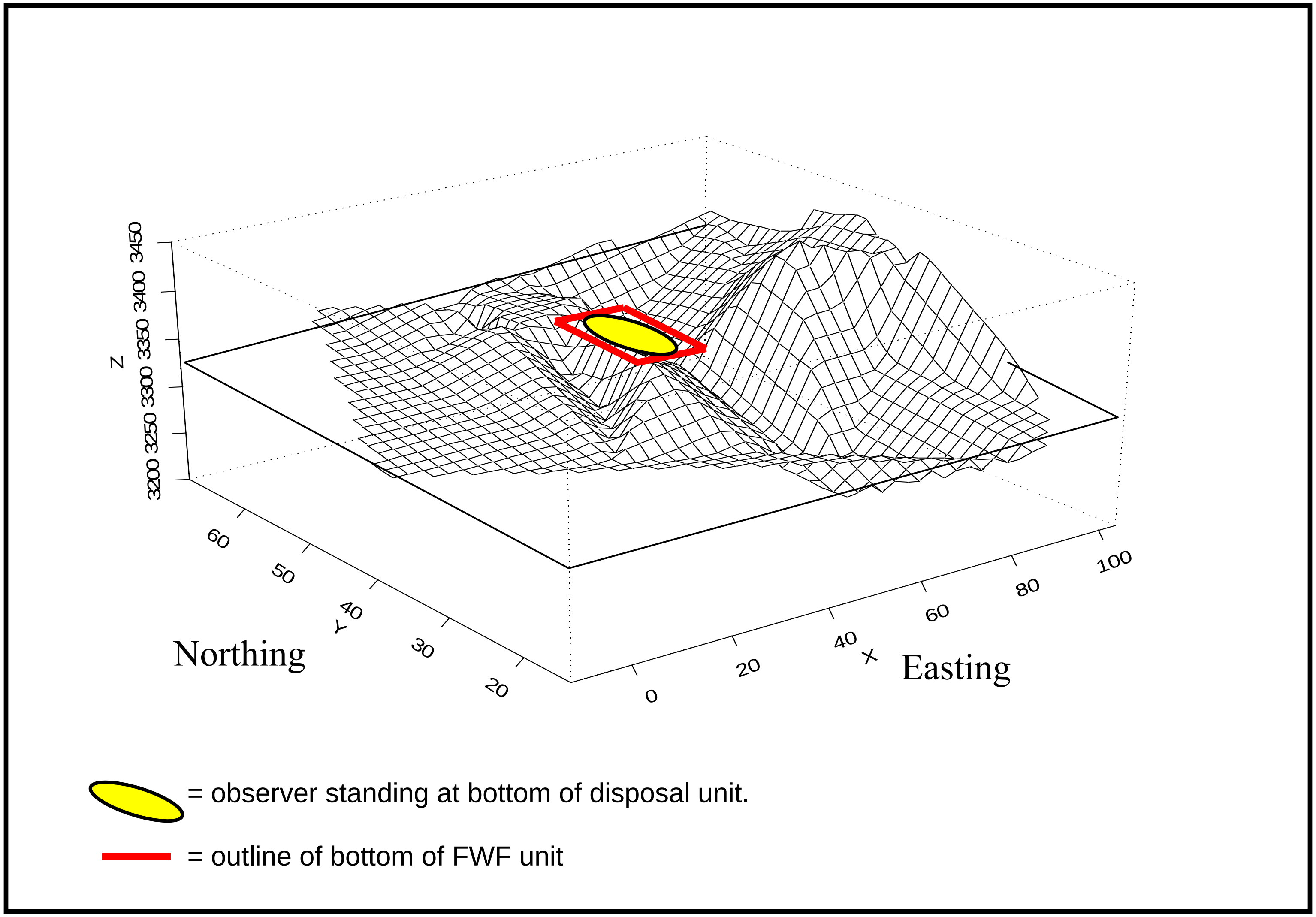

Figure EA-9: Approximate Locus of Saturated Conditions in Dockum Red Bed Materials (X, Y in hundreds of feet).
Note: Bottom of the FWF unit located at elevation Z=3,360, Four Corners of Bottom at (48,52), (52, 61), (64,56) and (60,48).

The saturated conditions in the Dockum red beds may be more extensive than depicted in Figures 6-5a and 6-5b of the application, and possibly more extensive than shown in Figures EA-8 and EA-9 due to a capillary fringe. A capillary fringe will exist along the entire arc defined by the bottom of the water table in the OAG, the parabolic locus defining the boundary of the transient zone, and the top of the water table conditions extending to the southern end of each cross-section.

6.6.16 Characterization of Capillary Fringe in the Dockum Red Bed

A precise determination of the location of the top of the capillary fringe in the Dockum red bed materials would involve completing measurements of the degree of saturation in samples collected from a high density sampling program in the Dockum red bed materials. A locus between interpolated surfaces defined by saturated samples and unsaturated samples would approximate the top of the capillary fringe. Thus, the distance between that locus and the actual top of the capillary fringe would be dependent on the distance between vertical locations in the sampling grid. More importantly, as noted above, apparently accurate measurements of degree of saturation in materials such as those in the Dockum red beds, is problematic, so that a high sampling density might still result in a somewhat uncertain locus for the top of the capillary fringe.

The application did not include a program of sampling and laboratory measurement of degree of saturation to locate the top of the capillary fringe above the lower water table. The application does describe a program of sampling and laboratory testing designed to estimate the thickness of capillary fringe that could, in a general sense, be supported by the various sediment types. Thickness of the capillary fringe that a sample from a given location could support was not an indication that a capillary fringe with that thickness was present at that location, only that materials with a texture similar to that sample, in a homogenous porous medium of such materials, could support such a thickness. Thus, that sampling and testing program could possibly provide some upper bound estimate of the thickness of the capillary fringe that could exist at the site.

6.6.17 Soil Retention Curve and Moisture Content Study

Volume 16, Appendix 2.6.1, Attachment 6-2 of the application summarizes laboratory studies of the matric potential and moisture contents of 90 core samples from nine boreholes, to depths 150 feet below the land surface in the vicinity of the land disposal facility. The laboratory derived moisture retention curves measurements obtained from these samples have several potential uses: (1) develop constitutive equations (i.e., van Genuchten parameters) for site sandstone, siltstone, and claystone materials, of possible use in numerical simulations of unsaturated flow at the proposed disposal site; (2) develop estimates of possible capillary fringe thicknesses in these same materials; (3) to estimate water fluxes; and (4) to determine whether or not capillary conditions exist in the subsurface under gravitational equilibrium.

Presumably these data were used in the interpretation of the minimum distance of saturated conditions from the boundaries of the proposed disposal units provided in the application (i.e., 14 to 20 feet). Comments were developed by the University of Texas - Bureau of Economic Geology (BEG), consultant to the TCEQ, regarding Attachment 6-2 (BEG, 2007b). In their review, the BEG describes concerns with the methodology used to measure matric potential. While matric potential may be directly measured from cores, the method presented in the application indirectly estimated matric potential from saturation measurements and moisture retention measurements. The BEG identified potential sources of error from this approach, including:

- Measuring saturation and moisture retention in different soil samples rather than a direct measurement in the core sample of interest;
- Uncertainty in measured moisture retention used for converting measured moisture content to matric potential; and
- Resolution of moisture content moisture retention data.

BEG states the following in their review of the application:

> The application references Scanlon et al. (2002) for the methodology for measuring matric potential; however, the Scanlon et al. publication only refers to methods that measure matric potential or water potential directly on soil samples in the laboratory (e.g., dew point potentiometer, filter paper) or matric potential or water potential in the field (heat dissipation sensors, electrical resistance sensors). None of these approaches were used by the applicant; and
>
> The applicant also states that water fluxes were estimated by calculating differences in matric potential from the equilibrium line and multiplying by hydraulic conductivity. They indicate that the plots of matric potential relative to the equilibrium line indicate the direction of water movement; however, more recent studies (Walvoord et al., 2002, Scanlon et al., 2003) indicate that this is not quite true and the actual matric potential gradient is the important gradient to consider.

Regarding Attachment 6-2 of the application, the BEG also questions the appropriateness and introduction of uncertainty of matric potentials estimates.

Regarding a relevant profile from Andrews County found in the literature that was utilized in the application, the BEG notes that profile is restricted to a depth of nine meters and was not drilled in the immediate vicinity of the proposed disposal facility. Further, the BEG recommends that "additional profiles should be drilled in the vicinity of the proposed site using these methods to evaluate long-term subsurface water movement."

In the review of the results reported in Attachment 6-2 of the application, the BEG used an alternative least squares curve fitting software to the one that was used in the application (i.e., the RETC code) to estimate the air entry pressures, and therefore to estimate capillary fringe thicknesses (BEG, 2007b). These thicknesses ranged from 0.3 to 20 meters (from one to 60 feet). While the application concludes in Attachment 6-2 that water in the unsaturated zone at the proposed site was not under gravity equilibrium, such equilibrium was apparently assumed in the predictive modeling described in Volume 16, Appendix 2.6.1, Attachment 6-3.

To address concerns regarding the verification of the full vertical extent of saturated conditions beneath the proposed disposal units several license conditions have been proposed. A proposed condition requires the use of in-situ measurement techniques, prior to the commencement of major construction, to verify the matric potential of the subsurface Dockum Group in order to locate more definitively the top of the zone of saturation beneath the proposed disposal units.

In order to protect the FWF against any uncertainties in the current or future locus of the top of saturated conditions in the Dockum, an additional license condition requires that the bottom elevation of the relocated FWF be no lower than an elevation of 3,370 feet (instead of the 3,360 foot elevation described in the application). As mentioned previously, another proposed license condition requires the maintenance of an individual buffer zone for both the CWF and FWF under the lowest point of disposed waste. The primary function of this buffer zone is to provide for early detection monitoring of releases and to allow adequate space for remediation activities, if necessary. Since the proposed license condition also requires cessation of waste disposal operations when saturated conditions are detected within the buffer zone, additional protection against any uncertainties in the locus of saturated conditions beneath the proposed units is created.

6.6.18 225-Foot Layer as a Groundwater Divide

A salient feature of the hydraulic potential contours shown on the two Figures 6-5a and 6-5b in the application is the abrupt change in direction of these contour lines as they exit the bottom of the 225-foot layer. These lines imply that groundwater flow, everywhere below the bottom of the 225-foot layer, has a strong downward component. In essence, this feature of the site hydrogeologic conceptual model constitutes a groundwater divide. Groundwater flow is upward or horizontal above this divide, and downward below it. This groundwater divide features prominently in the numerical modeling described in Volume 16, Appendix 2.6.1, Attachment 6-3, of the application. In this modeling effort, the bottom of the 225-foot layer is used as a boundary to the numerical grid and a no flow condition is implemented on this boundary.

This feature of the site hydrogeologic conceptual model presented in the application is a problematic conceptualization of the subsurface flow field. Even if a subsurface locus characterized by a zero vertical velocity component were to exist in the three-dimensional velocity field, that locus would likely be a curvilinear surface. There is no justification given in the application of why the locus should be identical to the bottom of the 225-foot layer. It is true that such an approximate identification might serve as a convenient implementation of a simple boundary condition in a numerical model defining the bottom of the 225-foot layer as a grid boundary. However, it appears that the implementation of such an approximation as a no flow boundary condition in the numerical modeling provided in the application, may have contributed to the apparent inability to calibrate that model to current hydrological conditions as depicted in Figures 6-5a and 6-5b in the application.

Finally, the empirical support for the equipotential lines below the 225-foot layer depicted on Figures 6-5a and 6-5b of the application appears to consist predominately of hydraulic head measurements made in only three monitoring wells, despite that the application states that approximately 250 borings were drilled and 150 monitor wells and piezometers were installed. The locations of the three wells, if projected onto the cross-sections depicted in these two figures, are thousands of feet from the equipotential contours depicted on the northern ends of these cross-sections.

Table 6-2 in the application shows only two monitoring wells screened below the 225-foot layer, monitoring wells 2G and 4G3. Well 4G3 is located in Boring B-5, within the footprint of the existing RCRA landfill near the southeast corner of that disposal unit. Monitoring well 2G, located in boring B-10, outside of existing RCRA landfill, is several hundred feet to the east of the southeast corner of that disposal unit. The third well is shown on Figures 6-5a and 6-5b. The monitoring well is located in the lower Trujillo Aquifer (hundreds of feet below the 225-foot layer), approximately 2,500 feet southeast of the eastern edge of the proposed FWF unit. Despite this large distance, the application projects this measurement onto the cross-sections in the two figures to assist in the contouring of the equipotential lines below the 225-foot layer.

Table 6-2 of the application shows the most recent hydraulic head measurement in 4G3 is 3,195 feet. The most recent measurement of hydraulic head in monitoring well 4G2, screened in the 225-foot layer, and apparently in the same boring (boring B-5) as 4G3, is 3,283 feet. Thus, the monitoring data do indicate a downward gradient in the vicinity of boring B-5. Despite the relative proximity of 4G2 to the cross-section shown in Figure 5-6b, the measured head of 3,195 feet in well 4G3 is not projected onto this cross-section. On the other hand, the most recent hydraulic head measurement in well 2G (over 500 feet to the east of 4G3) is 3,290 feet. Unlike in Boring B-5, there is no monitoring well screened in the 225-foot layer above well 2G, so that no direct determination of the vertical gradient at that boring location can be made. It is this head measurement which is apparently projected onto the cross-section in Figure 5-6b of the application to assist in the construction of the lower equipotential lines. Because there was no explicit explanation in the application of how the equipotential lines were constructed, TCEQ staff inferred the above data was used as described.

Volume 19, Appendix 2.6.1, Section 6, of the application describes upward, vertical hydraulic gradients measured in the majority of nested well sets screened in the 225-foot layer. Such gradients suggest an upward flow of groundwater into the 225-foot layer from below.

Simple conservation of mass calculations applied to areas in the 225-foot layer bounded by near vertical equipotential lines as presented in the application indicate that mass is not conserved within these area elements. According to the application, the 225-foot layer is the most conductive and most continuous conduit in the upper Dockum Group. Groundwater in the immediate vicinity of this layer, above and below, should tend to flow towards it. Also, given the relative hydraulic conductivities in the materials above, in, and below the 225-foot layer, the theory of steady-state saturated flow across discontinuities in hydraulic conductivity predicts that the nearly vertical equipotential contours in the 225-foot layer should be refracted immediately below that layer at an angle approximately 90 degrees counterclockwise from the direction shown on Figures 6-5a and 6-5b (Freeze and Cherry, 1979b). Assuming continuity of these equipotential lines below the 225-foot layer, they would begin to parallel those shown on Figures 6-5a and 6-5b, only at some distance below the bottom of that layer, if at all. If so, then the actual current hydrogeologic conditions would be characterized by a large additional volume of water with an upward velocity component. The implications of this relative difference for the future evolution of the water table in the Dockum red bed materials might be significant.

The assumed continuity of the 225-foot layer might suggest a horizontal flow in this layer that may not actually be present. In turn, that suggested horizontal flow might be interpreted to support the presence of a no flow boundary condition on the bottom of that layer. Furthermore, that horizontal flow is suggested by a refraction analysis driven by the assumed and idealized discontinuity in hydraulic conductivity. In the site hydrogeologic conceptual model of the application, this discontinuity in conductivity exists across the boundary of the assumed continuous and homogeneous 225-foot layer and the assumed continuous and homogeneous claystone materials above that boundary. The horizontal flow is dependent on such idealizations. Since that same flow is inconsistent with the vertical gradients measured in the nested monitoring wells in the 225-foot layer, as well as with simple mass conservation analyses applied to this layer, a different conceptualization of the flow in this layer might be needed.

The numerical modeling described in Attachment 6-3 of Appendix 2.6.1 of the application relies on a more realistic depiction of the sediments in the neighborhood of the 225-foot depth in the Dockum red bed materials. This depiction suggests a porous medium with a more complicated structure than the idealizations portrayed in Figures 6-5a and 6-5b of the application. The discontinuity in the 225-foot layer, evident in this depiction, suggests a flow structure near the 225-foot depth that may not strongly support such flow. Furthermore, the numerical simulations described in Attachment 6-3 provide a significant indication that some other condition other than a no-flow condition exists on the bottom boundary of the 225-foot layer.

6.6.19 Predictive Modeling of the OAG Dry Line

United States Nuclear Regulatory Commission NUREG-0902 states that "the bottoms of the disposal units must be, at all times, above the saturated zone in order to limit the water contacting the wastes to that small portion which infiltrates through covers in disposal areas" (NRC, 1982b). Thus, TCEQ staff's review of the numerical modeling regarding the evolution of the two water tables present at the proposed disposal site, in response to future climate changes, is central to this section of the EA.

Figure 6-3a of Appendix 2.6.1 of the application shows the current depiction of the saturated thickness of the OAG materials, including the contour of zero saturated thickness (i.e., the OAG dry line). Paragraph 6.2.6a of Section 6 of Appendix 2.6.1 of the Geology Report describes the use of the numerical code, Modular Flow Code (MODFLOW) to predict the evolution of the OAG dry line in response to changes in future climatic conditions.

The application summarizes Paragraph 6.2.6a as follows:

> This section discusses the relationship between saturated conditions in the OAG, the dry line, the landfill boundaries and infiltration in the larger playa north of the landfills and the smaller playas north and in the vicinity of the landfills. A three-dimensional steady-state model of the OAG groundwater flow system was developed to investigate the relationship between recharge and the aerial extent of saturated OAG in the vicinity of

> the site under current and future conditions. The base of the model is the upper paleo surface of the Dockum Formation. The model was calibrated to February-March 2006 water levels. Precipitation in 2004 and 2005 was significantly above normal; therefore the infiltration rate obtained from the calibration is conservatively high. Long term steady-state infiltration is likely somewhat lower. Playa-focused recharge was applied to locations that are topographic depressions and/or show vegetative evidence that they are playas or otherwise low areas collecting and allowing infiltration during higher precipitation events. Recharge of 0.1 millimeters per year (0.004 inches per year) was applied to the inter-playa areas, consistent with data from the literature.

The numerical simulation of several different scenarios is described in Paragraph 6.2.6a of the application. These simulations feature modifications in current playa recharge rates based on differing models of future climate change. One of the climate models is based on statistical characterization of historical rainfall data available from six different precipitation measurement stations within the region (the standardized precipitation index (SPI) approach). The second climate model is based on known variations in the parameters characterizing the earth's orbital eccentricity and variations in the location and direction of the earth's rotational axis. The use of these models and changes in future climatic conditions at the proposed disposal site constructed from these models, are described in Volume 6, Appendix 2.3.3-1 of the application. These models provided estimates of higher annual precipitation rates and decreased evapotranspiration rates which served as inputs to the OAG predictive modeling.

Pages 6-20 through 6-24 of Paragraph 6.2.6a in the application describe the modeling grid, boundary conditions, and procedures used to calibrate the model to the current site hydrogeologic conceptual model. During the calibration process, the OAG hydraulic conductivities and recharge rates were varied so that the OAG dry line computed by the MODFLOW code could be matched to the OAG dry line presented in the application. The application states that the computed and measured OAG dry lines are reasonably matched and that measures of the quality of the calibrated model (e.g., residuals between computed and recent OAG water elevations) indicate an adequate calibration. Based on groundwater elevation data from Table 6-2, and the more recent OAG data submitted to the TCEQ, there is a question whether or not the target OAG dry line of the calibration effort was an adequate representation of the actual, current OAG dry line. Moreover, the representation of the transition from "dry" to "wet" in the OAG is more accurately conceptualized as a zone rather than a distinct line.

There are differences in the current OAG dry line shown in Figure 5-10 and the current OAG dry line implied by recent OAG data collected at the proposed disposal facility after the submittal of the application. This recent data indicates that the actual dry line may be closer to the boundaries of the proposed units than the target dry line utilized in the MODFLOW simulations. It follows that predictions of the future locus of that dry line using a target dry line conditioned by the recent data as an initial condition, might result in a future locus with a greater lateral extension in the direction of the proposed disposal units.

6.6.20 Initial Conditions and Boundary Conditions

The application appears to be implying that the target OAG dry line was an anomaly, in the sense that it was an aerial extension of a more retracted and representative steady-state dry line. That is, the application appears to be arguing that the target OAG dry line is a transient response to a perturbation in the annual rainfall. The application concludes "therefore the infiltration rate obtained from the calibration is conservatively high. Long term steady-state infiltration is likely somewhat lower." The application seems to imply that predictive modeling using the calibrated MODFLOW as an initial state somehow has a conservative character. Predictive modeling generates an evolving OAG dry line in response to future infiltration, recharge, and evapotranspiration rates, as estimated by climate change models. The prediction of the future OAG dry line at no point relies on the current infiltration rate chosen during calibration of the initial model. If the predictive modeling uses the current state of the OAG dry line as the initial state, then any prior "steady-state" locus of that dry line (pre- 2003) seems irrelevant.

The general head boundary (GHB) condition applied during the calibration modeling computes the mass flux from each finite difference cell at the bottom of the modeled OAG materials as a function of the difference between the hydraulic head in the OAG (a variable in that cell) and the hydraulic head at a point in the 225-foot layer directly below that cell. The hydraulic head in the 225-foot layer below any cell of interest is not a modeling variable, but is to be estimated, via interpolation, from the monitoring well data for those OAG grid cells within the convex hull of the available monitoring well locations in the 225-foot layer. However, since the areal extent of the domain modeled in the MODFLOW simulations extends beyond that convex hull, extrapolation of the available hydraulic head was apparently used in the modeling described in the application. This allowed the application of the GHB condition to cells also outside of that convex hull. The application gives no details of this extrapolation, although spatial extrapolation of data over small distances relative to the average distances between available data points may be problematic.

Boundary conditions similar to the GHB condition referenced in the application are often used in groundwater modeling. During review of the OAG predictive modeling, TCEQ staff relied on the MODFLOW implementation of the general head boundary conditions as described in the text Applied Groundwater Modeling (Anderson and Woessner, 1992a). Often, boundary conditions of this type are used to simulate the flux between an unconfined aquifer and a confined aquifer, when the two aquifers are separated by an aquitard. This aquitard would be a saturated unit with a hydraulic conductivity of several orders of magnitude less than both of the bounding aquifers. In applying this type of boundary condition the formation between the aquifers (the aquitard) is assumed saturated.

The site hydrogeologic conceptual model presented in the application depicts the Dockum red bed materials immediately below the transient extension of the OAG water from a steady-state locus, as unsaturated. The hydraulic conductivity of unsaturated materials is always less than the hydraulic conductivity of saturated materials. Furthermore, that same conceptual model posits a large component of horizontal flow in the Dockum red bed between the OAG (the unconfined aquifer) and the 225-foot layer (the confined aquifer) as well as a conductivity contrast between the Dockum red bed "aquitard" and 225-foot layer of only one order of magnitude or less. Therefore, it appears that simulating the actual flux across the boundary between saturated OAG materials and the underlying unsaturated Dockum red bed materials by a general head boundary condition is questionable.

Implementation of the GHB, as described in the application, requires that a conductivity be computed for the saturated materials separating the location of the assumed known hydraulic head and the location point within the boundary cell at which the unknown hydraulic head is to be computed. Thus, use of the GHB condition requires that a single hydraulic conductivity be assigned, characterizing the Dockum red bed materials over a distance of approximately 180 feet. The thickness of the Dockum red bed "aquitard" cannot be considered to be small. Furthermore, the application gives no details of how this averaging was accomplished, although the various lenses within the Dockum red bed materials have different hydraulic conductivities. Also, whatever this conductivity, it is likely larger than the unsaturated hydraulic conductivity that will be present in the Dockum red bed materials immediately under a substantive portion of the laterally expanding, saturated OAG conditions.

If the use of the GHB condition assumed the heads at points in Dockum red bed materials nearby the bottom of the OAG grid are equal to the head in the 225-foot layer directly below these points, then the assumed influence on the OAG flux of the 225-foot layer over such a large vertical distance would be lessened. Also, this conceptualization of the GHB condition avoids an averaging of variably conductivities over the complete thickness of the Dockum red bed materials. However, this conceptualization seems to imply that, above some depth in the Dockum red bed materials, the hydraulic head achieves a constant value equal to that in the 225-foot layer. Such a condition is certainly not descriptive of the current site hydrogeologic conceptual model. In that model, shallow Dockum red bed materials are unsaturated. Over the time (unspecified) that it might take for steady-state conditions to be achieved, the hydraulic heads currently descriptive of the 225-foot layer could change. If the time needed for steady-state conditions to be achieved in response to future climate changes is small, the application provides no discussion of those relative times.

Furthermore, because implementation of the GHB condition assumes saturated conditions in the Dockum red bed materials below the bottom of the numerical grid, it seems likely that implementation of that boundary condition during the calibration process would overestimate the mass flux out of the OAG materials. Therefore, the lateral extension of saturated conditions in the OAG materials would be artificially limited. If so, calibration of the computed OAG dry line to the target OAG dry line might require an exaggerated influx of recharge water into the top of the finite difference grid.

It is possible, that as the entire thickness of the Dockum red bed materials approaches saturation, the hydraulic head in the 225-foot layer (the driver of OAG flux in MODFLOW's formulation of the GHB condition) will increase, in response to increases in the saturated depth of the overlying OAG materials. This increase would result in a decrease in the flux from the bottom of the OAG materials. This analysis suggests that the flux from the bottom of the OAG is a function of time. Over whatever time needed for a steady-state locus of the OAG dry line to be achieved, during segments of that time, the actual flux out of the OAG may be less than that simulated by use of the GHB condition.

In the numerical simulations described in Attachment 6-3 of Appendix 2.6.1 of the application, the OAG-Dockum red bed contact is an internal, rather than an external boundary. These simulations give a less idealistic treatment of flow conditions across this boundary. The simulations provided in the application could allow a comparison of the spatial and temporal variation in flux across on that internal boundary to the flux computed using an assumed GHB conditions on the modeled external boundary. The application has not pursued this comparison.

The MODFLOW grid features an internal no flow boundary corresponding to an elevation contour of 3,438 feet on the top of the Dockum red bed ridge. The application justifies this location for such a boundary by noting that the OAG dry line determined from the calibration process does not have a southern extension sufficient to intersect that internal boundary, and therefore it is, in fact, a no flow boundary. As noted, the use of the general head boundary condition may have significantly limited the lateral extension of the computed OAG dry line, therefore, the stated justification for the location of the internal no flow boundary may be insufficient. The simulations should have incorporated a study of the effect of the location of the internal no flow boundary on the lateral extension of the OAG dry line.

It seems that the MODFLOW simulations could have proceeded more cautiously by first applying a no flow condition to the bottom boundary of the finite difference grid during all predictive simulations. Computations enforcing this condition and utilizing recharge rates fixed by the climate change estimates would overestimate the lateral extension of the future OAG dry line since the flux from the bottom of the OAG materials would vanish and all recharge water would remain within the OAG. Results of these computations would provide a stronger test of an appropriate location for an internal no flow boundary.

The modeling described in the application did not study the effects on the locus of steady-state dry line of differing boundary conditions and recharge rates. For this reason, the results shown in Figures 6-5l, 6-5m, and 6-5n, cannot be considered conclusive. The Executive Director recommends license conditions that require additional predictive modeling studies that also incorporate appropriate sensitivity investigations studies. It has been noted that the numerical simulations of the future location of the OAG dry line are steady-state simulations. Several observations regarding this aspect of the simulations are needed.

6.6.21 Steady-state Computations as Predictive Simulations

Figures 6-5l, 6-5m, and 6-5n of the application show results of the submitted predictive modeling of the response of the OAG dry line to future climate changes. These figures show simulations of nine different scenarios, including the response of the OAG dry line to future climate changes following playa intervention. In these simulations playa intervention is simulated by significantly decreasing the recharge (below recharge rates otherwise corresponding to anticipated increases in future rainfall) into those playas, and perhaps other topographical lows, that are to be filled with Dockum red bed clay excavated from the proposed disposal units.

Section 6.2.6a of the application gives interpretations of these simulations. Figure 6-5l indicates that under future wetter climate conditions, and without playa intervention, the OAG dry line will exhibit a lateral extension closer to the northern edge of the proposed FWF unit and closer to the eastern boundary of the proposed CWF unit. Figures 6-5m and 6-5n indicate that with playa intervention (and different assumptions regarding the attenuation in recharge due to that intervention), the future locus of the OAG dry line will everywhere be further from the boundaries of the proposed disposal units than the current locus discussed previously (as shown in Figure 6-3a).

All the described simulations are the results of steady-state numerical modeling. In these simulations MODFLOW computes only a final, equilibrium, state of the groundwater in the OAG materials. Other information of interest was not provided in the applications. If the mathematical equations representing a dynamic system have a steady-state solution, a computed approximation to that solution is not associated with an elapsed time. Information about that elapsed time can, however, be provided by a transient analysis of the system. A transient analysis of that system allows a study of the configuration of the system at all times. But, in a transient analysis the steady-state will only be approached, in the limit, as time approaches an infinite value. In practice, the transient analysis is completed until a time at which the response of the system is no longer displaying a significant variation. That time is then considered an estimate of the time needed for the system to achieve steady-state.

Since the application presents only steady-state analyses of the future response of the OAG dry line to climate change, the application cannot, and does not, make any statements regarding the time period within which the equilibrium configurations shown in Figures 6-5l, 6-5m, and 6-5n are achieved. Therefore, TCEQ staff can only assume that the final configurations of the dry line shown on these figures occur within the period of analysis. Thus, without playa intervention, Figure 6-5l must be interpreted as indicating that during the period of analysis, saturated conditions will exist in the OAG materials above the proposed FWF unit.

Also, dynamic systems that ultimately achieve a steady-state might oscillate about that state as it is asymptotically approached. Only a transient simulation of such systems can study such oscillations. The application makes no statements regarding the possibility that the groundwater in the OAG materials may, at some finite time, "overshoot" a final steady-state locus that does not intersect the disposal unit boundaries. That is, within the immediate vicinity of the proposed disposal units, future increases in playa recharge could result in OAG water levels higher than steady-state levels because the "downstream" topography cannot immediately accommodate increases in lateral flow. Eventually, such levels might subside to steady-state values, but not before encroachment in the direction of the units has subsisted for some time.

TCEQ staff notes that the steady-state modeling of the OAG dry line did not utilize direct measurements of the saturated OAG conditions, but relied solely on hydraulic conductivities, non-uniquely determined from the MODFLOW calibration to that current OAG dry line. A transient simulation attempting to predict the evolution of that dry line over the period of analysis would explicitly incorporate that directly measured information as an initial condition.

Furthermore, the modeling described in the application appears to have assumed that the Dockum red bed materials beneath the OAG formation will eventually become saturated. The assumption of such conditions, implied by the use of the general head boundary condition, will result in the same steady-state configuration as the simulation of a system in which conditions on that same boundary are allowed, in time, to transition from unsaturated to saturated conditions over an appropriate period of time. In other words, the application is modeling a system in which the effects of a variable flux on the bottom of the OAG materials is irrelevant. There appears to be no warrant for such an assumption; such identification can only be validated by transient simulations.

The above discussion of general head boundary conditions suggest that saturated conditions in OAG materials will outrun the occurrence of saturated conditions at depth, resulting in a significant reduction of downward water flux relative to that resulting from a numerical simulation applying such a boundary condition.

Plots of the velocity fields characterizing the flow of groundwater in the OAG would be a useful interpretative tool. These velocity fields are available as optional output from any MODFLOW simulation. However, the application presents no discussion or graphical presentation of the groundwater velocities within the saturated materials enclosed by the simulated OAG dry line. The direction of the groundwater flow indicated on such plots could be compared to the top-of Dockum elevation contours presented in the application, serving as an assessment of the accuracy and consistency of these representations.

The simulated velocity fields would also provide useful quantitative information of how OAG groundwater actually flows away from the recharged playas. The application gives no description of this crucial aspect of the hydrologic behavior in the immediate vicinity of the proposed disposal units described. The objective of the playa intervention program suggested in the application is to modify the groundwater flow in the OAG materials by filling in the playas with clay materials from the excavated disposal units. Therefore, it seems reasonable that current velocity fields in the vicinity of these playas would be given a prior characterization. The steady-state velocity fields corresponding to the future OAG dry lines depicted in Figures 6-5l, 6-5m, and 6-5n, were also not included in Section 6.2.6a of the application. The steady-state velocity fields associated with the simulations of the effects of playa intervention would give information about how the modified playas actually perturb the natural groundwater flow in the OAG materials. These velocity fields were also not provided in the application.

Given the current near proximity of the groundwater in both the OAG and the Dockum red bed materials to the proposed disposal units, it is clear that a more detailed spatial resolution of that proximity is needed. The actual current position of the OAG dry line (and water table in the Dockum red bed) is not identical to the nominal position that any actual site characterization provides. The actual position of the OAG dry line and the actual velocity field of OAG groundwater depend on many factors; the actual elevations of the top of the Dockum red bed ridge being one of the most important. A site characterization can only provide an estimation of those actual elevations.

Any mapping of the OAG dry line based on monitoring well data from the OAG materials must consider the control exerted on that dry line by the elevation contours of the underlying Dockum red bed ridge. These contours have been established in the application from a grid of sampling points used to measure the top of the Dockum. Several important observations can be made regarding the representation of this lower surface.

First, the representation of the top of the red bed ridge presented in the application is not the only representation that can be generated from the same available data set. TCEQ staff has applied an interpolating algorithm to that data and obtained a contoured surface differing from that given in the application. The significance of these differences is relative to desired resolution in the location of the current OAG dry line. Repetition of this mapping exercise using other algorithms would generate additional representations of the ridge contours. Thus, the representation given in the application of the top of the Dockum red bed ridge is neither canonical nor unique. The actual shape of that ridge, as represented by a contour map of actual elevations is unknown; the single representation given in the application can be considered only to be an estimate characterized at every point in space with some uncertainty.

Second, the representation of the top of red bed ridge given in the application was determined using a sampling grid with a characteristic distance between grid points of hundreds of feet. Thus, vertical and horizontal variations in the subsurface elevations, present at a spatial scale with characteristic dimensions smaller than that of the sampling grid, cannot be resolved by the sampling grid utilized and therefore, will not be reflected in contour maps generated using data collected over that grid. Small scale depressions, spires, embayments, and dendritic features, often noted via visual observation on outcropping rock surfaces, cannot be accounted for in the characterization of the top of the red bed ridge presented in the application. Such information, if available, might significantly influence interpretations of saturated conditions in the OAG materials. For example, the weight given to a dry OAG well might be altered significantly if it was known that the bottom of that well was located on a small-scale, local maximum in the surface topography, and therefore possibly in the immediate vicinity of saturated conditions.

On the other hand, small scale topographical features at the ground surface at the proposed site can be resolved by direct visual observation. One can visually observe the ground surface at the site and note small depressions not otherwise detectable from grid points hundreds of feet distant. Thus, the spatial scales informing interpretations of the surface topography and of the top of the red bed ridge are incommensurate. The application argues, perhaps rightly, that several such small surface depressions, indicated from well data to contain water, are separated from the OAG dry line, so that line does not extend laterally to those depressions. Thus, these pockets of OAG groundwater are to be considered as unconnected. A similar spatial resolution of the top of the Dockum might provide evidence of connections between OAG saturated conditions.

The point is that because of the proximity of the OAG dry line to the proposed units, small variations in the estimated location of the top of the Dockum red bed ridge, variations usually of little practical significance, can here be significant.

Third, geostatistical procedures exist for quantifying the uncertainty in mapped spatial phenomenon, for providing multiple contour maps from a single data set (for comparison purposes) and even for providing contour maps of the uncertainty associated with any particular estimated map. Thus, regarding the estimation of any specific elevation contour of the Dockum red bed ridge as presented in the application, geostatistical procedures can sometimes be used to construct, say, 95 percent and 5 percent confidence contours, so that the any particular actual ridge elevation contour will be known to be within the two constructed contours, with a 90 percent probability. The Executive Director recommends that geostatistical procedures be used to quantify uncertainty associated with the contouring that was provided from the data set.

Fourth, the application does not describe the specific contouring algorithms used in the construction of the top of the Dockum contour map from the available data. Many of the commonly used contouring algorithms (e.g., inverse distance squared, ordinary kriging) are smoothing, interpolating algorithms. This dictates that the surfaces generated by their application contain maximum and minimum elevations exactly equal to the maximum and minimum elevations present in the data set supporting the interpolation. It is almost certain that actual elevations, at some unsampled locations, have elevations greater than the sampled maximum or less than the sampled minimum. The interpolated surface fails to capture the more extreme variation in topography characterizing the actual sampled surface. This consideration suggests that the use of interpolating algorithms for studying the top of the Dockum may not be appropriate.

Fifth, as noted, the maps of the groundwater velocity fields, available from the submitted OAG MODFLOW modeling, could potentially be compared to the submitted estimated elevations of the top of the Dockum red bed ridge. The simulation directions of the OAG groundwater flow, once compared to the estimated elevation contours for the red bed ridge, would provide check on both the estimates of the location of the OAG dry line and on the estimated top of the ridge.

Sixth, the MODFLOW simulations are dependent on the characterization of the OAG-Dockum contact constituting the bottom boundary of the numerical grid. Limited spatial resolution in the elevations characterizing this boundary (especially in portions of the grid corresponding to site locations at which spacing between available borings is large, such as to the north of the proposed units), will result in uncertainties in the computed OAG saturated conditions.

In addition, given this proximity, the sensitivity of any simulated OAG dry lines to the size of the finite difference grid cells used in the MODFLOW simulations could be of importance. The computed dry lines are only approximations to an exact steady-state solution to a governing system of partial differential equations. Presuming that the MODFLOW algorithm could, potentially, converge to that exact solution, it is expected that the discretization error in the approximate solution decreases as the size of the grid cells decreases. The application has not demonstrated that the discretization errors associated with their completed MODFLOW simulations are small. Replicating these simulations with a smaller grid size might result in significant changes in the computed OAG dry lines.

Seventh, the use of 100-foot grid cells in the MODFLOW simulations assures a minimum uncertainty of ±50 feet in the lateral resolution of the OAG dry line. Considering the nearness of that line to the FWF disposal unit, as described in the application, uncertainty of this magnitude cannot be considered negligible. MODFLOW simulations using a refined grid might show an OAG dry line with a greater lateral extension. The application should have explored this possibility.

Finally, and eighth, the grid size of 100 feet used in the MODFLOW simulations is smaller than the average distance between borings used to construct the map of the thickness of the OAG used in the MODFLOW simulations of the OAG dry line. This discrepancy is largest in the northern portions of the numerical grid. The application gives no discussion supporting the effect of this discrepancy on the resulting simulations, or whether the use of such a grid size constitutes sound modeling practice.

If it is assumed that the maps in the application of the elevations of the top of ridge are accurate, then these maps (especially Figure 5-10b) indicate that the top of the ridge may be the best on-site location for the proposed disposal units. Figure 5-10b seems to suggest that rising water levels in OAG materials north of the ridge might not induce water flow to the south, and up the ridge, exacerbating saturated conditions within the footprint of the proposed units. Rather, flowing groundwater might be channeled to the west and east of the crest of the ridge, and then down-gradient from the disposal units. Figure 5-10b suggests that if there is sufficient capacity in the OAG materials for groundwater transport around the ridge, to the east and west of the ridge, then the rise of OAG water toward the crest of the ridge crest will be limited. Study of the velocity fields in the OAG materials, predicted by numerical modeling, would provide information regarding groundwater flow in the vicinity of the ridge. The sensitivity of this groundwater flow to differing estimates of the ridge geometry would also be of interest.

Again assuming it is accurate; Figure 5-10b suggests that water would crest that ridge, inundating the footprint of the FWF disposal unit, only when a sufficient flow of groundwater around the ridge fills the thicker OAG sediments overlying the lower Dockum materials to the south of the ridge. Recharge conditions under which this would occur would be of great interest.

6.6.22 Additional Review of the OAG Modeling

The TCEQ requested that the BEG review the OAG modeling presented in the application. In their report to the TCEQ (BEG, 2007c), regarding playa recharge rates used in the OAG modeling the BEG states:

> The recharge rates used in the OAG model for current conditions are not conservative. The applicant used a maximum recharge of 1 inch/yr to represent playa-focused recharge; however, they indicated that a literature review suggested recharge rates up to 8 inches/year. One of the most direct methods of estimating playa focused recharge is to measure the distribution of bomb pulse tritium beneath a playa. Recharge estimates using this approach for playas in the vicinity of Lubbock and Amarillo ranged from 3 to 5 inches/yr. If the applicant wants to use a specific recharge rate for playas in the vicinity of the proposed facility, then such recharge rates should be estimated using the subsurface distribution of tritium. One cannot rely on model calibration using hydraulic heads to estimate playa focused recharge because this approach is only sensitive to the ratio of recharge to hydraulic conductivity and the same hydraulic head distribution can be obtained using different values of playa recharge as long as the ratio of recharge to hydraulic conductivity is kept constant. The recharge value of 1 in/yr is similar to the median recharge rate obtained for agricultural lands in the southern High Plains.
>
> The OAG modeling should include sensitivity analyses that evaluate variations in playa focused recharge up to the maximum values reported in the literature. Hydraulic heads can be matched by also increasing the hydraulic conductivity and maintaining a uniform recharge/hydraulic conductivity ratio. The resultant simulations will demonstrate the sensitivity of the position of the dry line to variations in playa-focused recharge. Modeling of proposed future conditions in the application should consider the impact of increased recharge beneath the playas as a result of elevated precipitation. Simulations of future conditions included evaluation of the impact of climate change on the system; however, the applicant should also consider the potential impact of regional land use change. If rangeland is converted to cropland, previous studies indicate that recharge rates would be increased regionally. Estimates of median recharge rates beneath non-irrigated cropland in the southern High Plains are about 1 inch/yr.

> The applicant should consider the impact of such changes or discuss why analysis of such a scenario is not realistic.

The BEG's conclusions regarding the boundary conditions are similar to those of TCEQ staff:

> Some of the boundary conditions chosen by the applicant are questionable and their impact on the simulation results is unclear. The applicant should present sensitivity analyses on the side and bottom boundary conditions. A regional change in recharge could impact heads on the side boundaries and then could impact fluxes and water levels in the domain of interest. It is possible that the dry line will not move southward in case of increased recharge but this conclusion cannot be confidently derived from the application. A no-flow bottom boundary is possibly more conservative than the GHB boundary used by the applicant but another sensitivity analysis would be needed to understand its impact on water levels and the position of the dry line. Examination of the water budget (not provided by applicant) would also help in forming one's opinion. If the boundary conditions do have a large impact on the results, the suggested approach is to construct a larger model (maybe using data from the Ogallala GAM) that would provide more accurate information for the side boundary conditions, especially when modeling impact of future wetter climate.

Thus, based on TCEQ staff and BEG concerns regarding the MODFLOW simulations of the locus of the OAG dry line, these simulations are considered to be inconclusive. Therefore, the Executive Director recommends several license conditions addressing these concerns. One of these conditions requires that, prior to the commencement of major construction, verification of the elevations of the top of the Dockum Group within the site area with sufficient spatial resolution be completed to support any modeling relying upon these elevations. A second proposed license condition requires the completion of predictive numeral modeling studies of future unsaturated conditions in the buffer zone. This modeling must incorporate sensitivity studies and uncertainty analyses of the location of the OAG dry line and of the lower water table in the Dockum Group.

6.6.23 Playa Intervention

The MODFLOW simulations of the future locus of the OAG dry line model the effects of a program of playa intervention apparently intended to reduce infiltration in playas within the immediate vicinity of the proposed site. The ultimate effect of the reduced infiltration would be to limit the lateral extent of saturated conditions in the OAG.

However, the application presents few details regarding the geometry, construction, or engineering design of the reconfigured playas. As sketched in the application, the program of playa intervention appears to involve the re-contouring of over one square mile of the proposed site by filling selected, existing playas and depressions with Dockum red bed materials excavated from the proposed disposal units. Such a program constitutes a substantive reconfiguration of the natural site characteristics. Reliance in the long-term on such a reconfiguration seems to imply that the natural characteristics of the proposed disposal site are not sufficient to prevent intrusion of groundwater into the disposed waste.

The simulations of the effects of playa intervention, as represented in Figures 6-5m and 6-5n, apparently assume both that the future depth of the saturated thickness in OAG materials outside the boundaries of the finite difference grid remain at current levels, and that all precipitation not infiltrating the filled in playas, and other topographic lows, is eliminated via evapotranspiration. In reality, increased future rainfall (and decreased evapotranspiration) in areas to the north and west of the grid should induce an increase in saturated thickness in OAG materials in those areas. In turn, additional mass flux, above that allowed in simulations, should occur across the western and northern boundaries of the grid. Such flow of water should contribute to an additional increment in lateral extension of the computed OAG dry line. Furthermore, it is possible that some precipitation falling on areas in which intervention has been completed will generate surface flows. Some of this flow could, especially as contoured surfaces in intervened areas are modified by long term erosion, recharge OAG materials in other areas and thus contribute to increases in saturated thickness in the OAG.

Paragraph 6.2.6a of the application makes reference to MODFLOW simulations in which the effects of head increases of five feet along grid boundaries utilizing lateral general head boundary conditions are simulated (although no graphical display of the results are given). Apparently, such simulations are intended to account for increases in saturated thickness in OAG materials outside the grid boundaries and due to increased future rainfall. It is not clear if the five foot increase is intended as a bound on the maximum saturated thickness induced in the OAG water table by future increased rainfall. If so, the application does not present any analysis to support the use of such a bound. On the other hand, if this increase is not intended as a bound on that maximum future thickness, then it is not clear how the referenced simulations would be conclusive.

Also, the simulations of the effect of a rising OAG water table in areas outside the boundaries of the grid apparently utilized the same general head boundary condition on the bottom boundary of that grid as the previously reviewed of simulations, and are therefore subject to the same criticisms as discussed above (i.e., possible underestimation of the lateral extent of the OAG dry line).

The TCEQ requested comments from the BEG regarding the planned playa intervention. Regarding the calibration of the MODFLOW simulation to the current OAG dry line the BEG concluded:

> Groundwater model calibration based on head data alone cannot be used to estimate recharge rates. Model calibration based on head data can only provide information on the ratio of recharge to hydraulic conductivity. The reliability of recharge estimates based on groundwater model calibration depends on how well the hydraulic conductivity of the sediments is known. Because hydraulic conductivity can vary a lot and is generally highly uncertain, recharge rates estimated from groundwater model calibration are generally not highly reliable. Model sensitivity analyses should be conducted to evaluate the impact of recharge rates ranging from 0.5 to 8.6 in/yr beneath the playas on system performance with respect to the proposed low-level radioactive waste disposal facility (BEG, 2007d).

As noted, the application does not present these recommended sensitivity analyses. The hydraulic conductivities resulting from the calibration process were used, without variation, in the submitted simulations of the future OAG dry line. Thus, one implication of the BEG's comments is that the response of the dry line locus to deviations in the spatial distributions and magnitudes of the calibrated hydraulic conductivities, was not adequately explored.

Based on the BEG's comments regarding the uncertainty in recharge rates, it appears that data currently available might form the basis for a numerical study of the actual recharge rates characterizing the proposed disposal site. The application has hypothesized that the currently observed locus of the OAG dry line (as shown in Figure 6-3a) is a transient perturbation, due to heavy rainfalls during the period 2003-2005, from a long-term, steady-state configuration. Suppose the pre-2003 dry line locus can be reconstructed from the available groundwater elevation data for the OAG monitoring wells and boreholes. Then, a series of transient MODFLOW computations, each utilizing the pre-2003 dry line as an initial condition could be completed. Each simulation would use a different recharge rate to estimate the response of that dry line over a two year period. Each simulation would also use the spatial distribution of hydraulic conductivities generated during the steady-state OAG calibration runs to characterize the OAG materials. Thus, a series of post-2005 OAG dry line loci would be generated. A comparison of each of these simulated dry lines with the OAG dry line depicted in Figure 6-3a would allow a determination of which of the utilized recharge rates might best approximate actual recharge conditions. Furthermore, if all of those rates were outside the range of rates cited by the BEG, the appropriateness of utilizing a general head boundary condition on the bottom of the OAG grid could be evaluated.

Regarding the proposed playa modifications, the BEG has stated:

> The ability of the proposed modifications to reduce recharge through the playa is questionable. The fill material is clay rich and likely to shrink and swell similar to clays in most playa floors. Although before the 1960s playas were generally considered to behave like evaporation ponds and groundwater recharge beneath playas was considered negligible (Mullican et al., 1997), many site specific studies conducted since that time have shown that clays in playa floors do not restrict recharge and that groundwater recharge occurs in the annular region surrounding playas and also through shrink/swell cracks in clays within playa floors (Wood and Sanford, 1995, Scanlon and Goldsmith, 1997). The modifications proposed by the applicant are unlikely to reduce recharge through the playas, because the fill material will also shrink and swell allowing preferential flow through the fill material.

If any modified playas are considered to be engineered structures, then as suggested in 10 CFR §61.7, the modified playas can only be considered to function effectively for a limited time period. This time period is considerably shorter than the period of analysis. Therefore, any computational simulations assuming reduced recharge in filled playas over a simulation time exceeding the effective life time of those modified playas cannot be considered as acceptable. The OAG dry line simulations submitted in the application are steady-state simulations, so that the simulation time is not known. It appears that computer simulations of the effects of playa intervention need to be transient simulations, accounting for reduced playa recharge over the limited effective lifetime, followed by a longer time period over which that recharge is increased to the current, higher level.

Title 30 TAC §336.727 requires that "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." Given the inevitable deterioration in the level of effectiveness of the modified playas (due to cracking and erosion), regardless of the initial level of effectiveness that the planned intervention can establish, it seems that long-term stability of the disposal site (the intended goal of playa intervention) relative to this regulatory requirement would require technical evaluation when, and if, the details of that intervention are finalized.

Concerns regarding the program of playa intervention alluded to in the application are addressed in a proposed license condition limiting any future modifications of the surface water characteristics of the watershed at the proposed disposal site to those specifically allowed in the license. Modifications allowed do not include the program of playa intervention described here. Thus, the proposed license condition requires that any future implementation of playa intervention would require written approval from the Executive Director. Furthermore, such future implementation may necessitate the development of additional license conditions regarding custodial care and ownership arrangements for any modified playas.

6.6.24 Predictive Modeling of the Water Table in Dockum Red Bed

The current site hydrogeologic conceptual model presented in the application posits saturated conditions within 14 feet of the bottom of the proposed FWF disposal unit. A complete characterization of the ground water hydrology at the proposed disposal site requires predictive analysis of the evolution of those saturated conditions. This requires that an appropriate numerical or analytic model be selected, calibrated to current site hydrogeologic conditions, and then utilized to simulate the evolution of those saturated conditions, over the period of analysis, in response to future climate changes. Volume 16, Appendix 2.6.1, Attachment 6-3 describes an apparent attempt to complete such a predictive analysis.

Attachment 6-3 describes a three-dimensional, transient, variably saturated modeling of the evolution of subsurface hydrogeology at the proposed disposal site using the computer code, Transport of Unsaturated Groundwater and Heat (TOUGH2). The application does not address whether this modeling effort is an attempt to calibrate the TOUGH2 code to the current site hydrogeologic model, or if this effort was only intended as a series of computations exploring physical and computational mechanisms. If the latter, then the TOUGH2 simulations could still be viewed as a necessary, but only preliminary step in a process leading to calibration and predictive analysis.

Alternatively, Attachment 6-3 can be interpreted as an extraction of useful information about the hydrologic behavior of the proposed site from a failed calibration attempt. At any rate, the first page of Attachment 6-3 states "At this stage, the model is not used for calibration purposes but only to evaluate the hydraulic behavior of the system". This statement indicates that a calibrated model was not constructed and consequently no predictive simulation of the evolution of the water table in the Dockum red beds was completed. Still, the computational results described in Attachment 6-3 exhibit several features deserving of comment.

Figure 1 of Attachment 6-3 shows the top surface of the three-dimensional finite difference grid used in the TOUGH2 simulations. Figures 2 and 3 show cross-sections through that grid showing the depth of that grid. The bottom of the grid corresponds to the bottom of the 225-foot layer at the proposed disposal site. The entire grid is comprised of approximately 128,000 cells. The total volume of material spanned by the grid is approximately 28 x 10^9 cubic feet. Thus the average volume of material represented by each cell is approximately 220,000 cubic feet. A cubic cell with this volume would be roughly 60 feet on each side. Assembling of the input data for the TOUGH2 simulations consists in assigning each of these 128,000 cells a series of parameter values including sediment type (sandstone, siltstone, claystone), a constitutive equation (i.e., equation of state) characterizing the saturated and unsaturated conductivity of that cell, a density, an effective porosity, and initial degree of saturation. For example, the application states that "to test this conceptual model, the 3D numerical model used the interpolated water table as initial hydrostatic conditions for the saturated zone". The locus of that water table is indicated on each of the figures in Attachment 6-3 and is denoted as "w.t." on Figures 2 and 3.

Furthermore, the required estimates of these parameters, and their spatial distribution, must be based on actual examination and measurement of only a very small volume of the sampled materials obtained during site characterization. TCEQ staff estimates the ratio of the volume of materials actually sampled and characterized (via boring logs, core samples) to be less than 0.00000001. In order to assign necessary parameter values to each of the cells in the three-dimensional finite-difference grid the modeling effort has resorted to a geostatistical, interpolation procedure called indicator kriging. Thus, several comments regarding geostatistics and kriging procedures are warranted.

While the ratio of 0.00000001 may seem quite low, it is typical of volume ratios associated with the characterization of many sites. For example, the introduction to the text Geostatistics: Modeling Spatial Uncertainty states "Geostatistics aims at providing quantitative descriptions of natural variables distributed in space or in time" (Chiles and Delfiner, 1999a). As examples of such "natural variables" the text cites: depth and thicknesses of a geological layer, porosity and permeability in a porous medium, soil properties in a region, and rainfall over a catchment area.

The text by Chiles and Delfiner continues:

> These variables exhibit an immense complexity of detail that precludes a description by simplistic models such as constant values within polygons, or even by standard well-behaved mathematical functions. Furthermore, for economic reasons these variables are often sampled very sparsely. In the petroleum industry, for example, the volume of rock sampled typically

> represents a minute fraction of the total volume of a hydrocarbon reservoir. The following figures, from the Brent field in the North Sea, illustrate the orders of magnitude of the volume fractions investigated by each type of data: Cores, 0.000000001; Cuttings, 0.000000007; Logging 0.000001. Thus, the decision to invest large amounts of money in the development of a new oil field is ultimately based on a very judicious use of "a set of assays from a hopefully very carefully chosen and prepared group of samples which can weigh in aggregate less than 5 to 10 kilograms.

Thus, in many site characterization efforts the collected data sites are inherently sparse and spatial uncertainties in any finalized characterization can be expected.

The example cited by Chiles and Delfiner illustrates the notion of spatial uncertainty, how it affects development decisions, and how descriptions of spatial phenomena are subject to uncertainty. The point is that the spatial phenomena that are the target of the site characterization effort described in the application are subject to spatial uncertainty. A "doubling" of the site characterization effort in terms of the volume of sampled material will only double the ratio of the volume of sampled materials to the total volume of the site to be characterized; substantial uncertainties will remain in any contours or surfaces of spatial phenomenon constituting a site characterization. Thus, that characterization can be considered only an estimate of subsurface phenomenon, and not a definitive description. While it is true that locally, via higher density sampling, the uncertainty in the characterization of a particular spatial phenomenon (e.g., OAG dry line) can be reduced, it cannot be eliminated.

Chiles and Delfiner characterize the science of geostatistics as follows:

> Geostatistics provides the practitioner with a methodology to quantify spatial uncertainty. Statistics come into play because probability distributions are the meaningful way to represent the range of possible values of a parameter of interest. In addition, a statistical model is well suited to the apparent randomness of spatial variations. The prefix "geo" emphasizes the spatial aspect of the problem. Spatial variables are not completely random but usually exhibit some form of structure, in an average sense, reflecting the fact that points close in spaced tend to assume close values. G. Matheron (1965) coined the term *regionalized variable* to designate a numerical function, z(x) depending a continuous on space index, x, and combining a high irregularity of detail with spatial correlation. Geostatistics can then be defined as the application of probabilistic methods to regionalized variables.

Thus, in the application of geostatistics to characterize each of the parameters cited above (i.e., sediment type, density, porosity), each parameters would be considered to be a regionalized variable with a spatial distribution explicitly recognized as an estimated quantity at every location. In addition there is an assumed uncertainty in the value of that estimated parameter at every location (whether a sampled location or not). Geostatistical estimation techniques (i.e., various types of linear and non-linear kriging procedures) cannot only be used to generate spatial maps of estimated parameters but also to generate spatial maps of the uncertainty associated with each of these estimated parameters.

Analogous to the repeated random sampling from a specified univariate probability distribution (e.g., using a random number generator to repeatedly generate "n" numbers from a specified normal distribution), a geostatistical interpolation procedure can, from a single set of characterization data, generate multiple spatial maps (called "realizations"), and the maps of the uncertainties associated with each of those maps, for a *single* spatial variable.

Thus, Figures 2 and 3 of Attachment 6-3 show, on various cross-sections, a single three-dimensional realization of the regionalized variable, sediment type, developed from the application of a geostatistical interpolation procedure called indicator kriging. Each grid cell in the 3-D finite difference grid has been assigned an estimated sediment type (claystone, sandstone, siltstone) based on the sediment type actually observed at known locations in boring logs and in core samples. Using indicator kriging an unlimited number of realizations of the regionalized variable, sediment type, all possible, and all consistent with the available characterization data, could be generated.

In Attachment 6-3, the maps of the spatial uncertainty in the estimated sediment type at each location on the cross-sections are not given, nor are additional realizations depicting other possible realizations of sediment type and also consistent with the available data, shown. This is not necessarily meant as a criticism of the submitted modeling procedure. There are many non-geostatistical interpolation algorithms; assignment of parameter values over a computational grid only requires that some interpolation procedure be used. If that modeling effort had exercised a non-geostatistical procedure in order to complete the assignment task it could not have been faulted for not generating additional mapped realizations for selected parameters or for not generating and exploring uncertainty maps associated with each realization; for non-geostatistical procedures such maps are not possible.

TCEQ staff notes that kriging procedures, as interpolation procedures, enjoy advantages over non-statistically based interpolation procedures only if certain so-called "stationarity" assumptions are satisfied. In Attachment 6-3 the application makes no reference to such assumptions.

The character of the geostatistical realization of a regionalized variable is seen by examining the structure of the 225-foot layer shown on the north-south cross-section on Figure 2 of Attachment 6-3. The bottom of that layer corresponds approximately to an elevation of 3,210 feet on the figure. The kriged realization of the 225-foot layer consists primarily of siltstone materials with some interbedded claystone materials. In only several cells does the realization indicate the presence of sandstone materials. Thus, the kriged realization of the 225-foot layer, while exhibiting more continuity in sediment type than the 180-foot layer depicted on the north-south cross-section of Figure 2, exhibits significantly less continuity than the highly idealized 225-foot layer depicted on Figure 6-5b .

The depiction of the 225-foot zone on Figure 6-5b is clearly an idealization compared to the realization of that layer on Figure 2. In fact, one might be tempted to say the depiction on Figure 6-5b is not really supported by the available sediment data; few, if any, actual geologic formations exhibit such continuity. In geostatistical terms, one could say that the "realization" of the 225-foot sandstone on Figure 6-5b, while being a possible realization based on the available data, is a realization that is very improbable. Yet, it is that improbable realization that is offered on Figure 6-5b as an important component of the site hydrogeologic conceptual model.

As noted previously, such a realization serves the modeling goal of creating a continuous conduit for radionuclide transport in the 225-foot layer so that travel times to receptors in that layer will be minimized and so that peak doses to those receptors maximized. To allow for a conservative analysis of an important transport pathway, the idealization shown on Figure 5-6b, while less realistic than the realization on Figure 2, is still appropriate to consider.

If numerous realizations of the 225-foot layer were generated using indicator kriging, only a very few, if any, would resemble the "realization" of that layer shown in Figure 6-5b. If numerous realizations of the entire subsurface sediment distribution were generated, probable none of them would resemble the "realization" of the totality of these sediments as shown on Figure 6-5b. Based on the available data, that larger spatial realization is just too improbable. Most of these realizations would likely resemble the single realization shown on Figure 2 more than they would resemble the idealization noted on Figure 6-5b as the "WCS Hydrogeologic Conceptual Model B-B' ."

Consideration of the more realistic portrayal of the 225-foot layer generated by indicator kriging suggests that the character of subsurface flow in the neighborhood of a depth of 225 feet in the red bed materials may be more nuanced than the flow in that layer implied by the idealization of the 225-foot sandstone shown in Figures 6-5a and 6-5b. The more realistic portrayal suggests considerably less continuity in the layer and suggests components of flow that are more complex than the flows implied by the equipotential fields superimposed on these figures. Considering the relative proximity of the 225-foot materials to the lower water table (and the proposed disposal units for that matter), it is possibly these more complex flows that affect the evolution of this water table.

This entire discussion underscores the facts that there are an infinite number of ways to assign the necessary parameters to all the cells in the computational grid. For each of these realizations a predictive simulation of the evolution of the saturated conditions in the Dockum red bed materials could, at least conceivably, be completed. Each simulation could be considered as a realization of "the evolution of the lower water table." The variety in these evolutions would simply be a manifestation of the many uncertainties associated with the submitted site characterization. The closest approach of the water table in the Dockum red beds to the disposal units, and the elapsed time associated with that approach would be different in each simulation. Perhaps, in some subset of the simulations the water table would intersect the boundaries of one of the proposed disposal units. The application does not include a single realization of the evolution of the lower water table.

As noted, the modeling effort described in Attachment 6-3 might be viewed as an initial conceptualization, with the potential for accommodating additional complexities, if needed. If so, that initial conceptualization does not account for the effects of fracturing on the evolution of the lower water table. Thus, a concern might be that saturated conditions, propagating inside one or more critically configured discrete fractures, might intersect disposal unit boundaries prior to the arrival of saturated conditions in the unfractured matrix of the Dockum red bed materials (if they arrive at all). If so, then this concern cannot be addressed by the modeling effort described in Attachment 6-3 of the application.

Thus, following Chiles and Delfiner, it should always be kept in mind that due to spatial uncertainties, models (whether conceptual or numerical) have their limits and represent reality only up to a certain point. It is common in site characterization work to use interpolation and extrapolation techniques to extend the available measurements into unsampled volumes of the subsurface so that the spatial distribution of the parameters of interest can be estimated. Frequently these techniques assume the spatial continuity of the parameters of interest, so that the parameter values are often conceptualized as being lines or surfaces in three dimensions. This assumed continuity is often extended to the lines and surfaces resulting from the mathematical differentiation of the parameter values.
Of course, utilization of these continuity assumptions may be problematic. This is evident in any attempt to fit a continuous functional form (i.e, a curve or surface) to actual data: there is always some deviation in data points from the continuous curve or surface. In this regard, geostatistical procedures have another useful characteristic: they can provide models of spatial phenomena without requiring these phenomena to be continuous in space.

As noted by Chiles and Delfiner:

> No matter what we do and how carefully we work, there is always a possibility that our predictions and our estimates of uncertainty turn out to be completely wrong, because for no foreseeable reason the studied phenomenon, at unknown places, is radically different than anything observed. In geostatistical parlance this is called the "risk of radical error."

As the ratio of the volume of observed material to volume of material to be characterized decreases, the risk of radical error increases. Subjectively, it seems that at sites with subsurface fracture systems the risk of such error may increase by an additional increment.

In this regard, TCEQ staff notes that Paragraph 6.2.6.1 (Matrix Dominated Flow and Diffusion-Dominated Transport) of Section of the Geology Report describes a series of TOUGH2 flow and transport simulations that incorporate a modeling of the influence of subsurface fractures on flow and transport in the Dockum red bed materials. On the other hand, the TOUGH2 simulations described in Attachment 6-3 do not simulate the effects of fracturing. If the application considers the effects of fracturing on radionuclide transport to be of potential significance then it seems like that same fracturing might also significantly affect the evolution of saturated conditions in the Dockum red beds (or even the locus of the OAG dry line). On the other hand, if the computations described in Section 6.2.6.1 were indicative that the effects of fracturing were not significant relative to the evolution of the lower water table, no reference is made in Attachment 6-3 to such an indication. From this point of view, it appears that the application contains several differing and uncoordinated models.

Partly on the basis of the above discussions involving inherently sparse data sets and spatial uncertainties in site characterizations relying on such data sets, possibly exacerbated when fracturing is present, the Executive Director has proposed additional license conditions. One of these proposed conditions requires that during excavation and construction of the disposal site frequent written reports and photographs of construction and excavation activities be provided and that particular attention be directed to fractures, faults, and any evidence of collapse features or groundwater flow or any other unanticipated geologic features. Another proposed condition requires that during excavation and construction that geotechnical studies be performed, allowing observation by the Executive Director, to verify original geotechnical conditions by continuously monitoring parameters and features such as soil moisture, slope stability, and permeable soil stringers. This proposed condition should provide for a finer, local, spatial resolution of important features of the proposed site relative to the resolution described in the application.

6.6.25 Upscaling and TOUGH2 Analysis

Fluid flow in porous media is governed by partial differential equations. These equations depend on spatially distributed parameters, such as hydraulic conductivity or porosity, which can be considered to be regionalized variables. Unfortunately, it is usually impossible to measure the parameters directly at the spatial scale we need them for a description of the flow (Chiles and Delfiner, 1999c). Laboratory measurements of hydraulic conductivity, for example, investigate core sized volumes, volumes that are very small compared with the size of the modeling grid (here, approximately 60 feet by 60 feet by 60 feet). Thus a shift, or upscaling, of laboratory derived values to volumes characterizing that grid is needed. This may not be as simple a matter as linear averaging over a larger volume, for example. The general upscaling problem is this: find the physical characteristics of a fictitious homogeneous medium which, at a higher scale, behaves like the real heterogeneous medium. This involves the equations of the problem as well as the spatial distribution of the parameter. Attachment 6-3 of the application gives no discussion of how the upscaling problem was solved for any of the parameters assigned to the computational grid.

Prior to the commencement of predictive modeling using the TOUGH2 code the model must be calibrated to the current site hydrogeologic conceptual model. Practically, this entails assigning current values of each of the parameters noted above to each of the approximately 128,000 grid cells. This is a tedious and complex task.

Based on review of Figures 1 through 11 of the application, it appears that the TOUGH2 computations preceded in stages. The first stage involved assigning a sediment type (claystone, siltstone, sandstone) to each grid cell. Since "sediment type" is a categorical variable, rather than an interval variable (e.g., a real number), assigning each cell a categorical value required the use of an algorithm capable of interpolating categorical data. Indicator kriging has many attributes, especially if applied in situations in which its supporting assumptions can be validated. From a practical point of view, one of its primary attributes is that it can be used in the interpolation of categorical data, and for that reason the technique was used in the TOUGH2 simulations.

Visual inspection and laboratory testing of cores from the Dockum red bed materials can be used to classify the Dockum red bed sediments in many different ways. Perusal of the Soil Retention Curves and Moisture Content Study submitted with the application, or even perusal of the submitted drilling logs, indicate that the observed sediments in Dockum red bed materials could be partitioned into numerous categories and that each category would manifest differing hydrologic behaviors. In assigning parameter values to each of the 128,000 cells it has been assumed that there are only three categories of sediment type, and each of these sediment types has apparently been tagged with its own constitutive equation (e.g., van Genuchten equation characterizing conductivity as a function of moisture content) and density. If one accepts the simplification that thickness of capillary fringe is texture dependent, then the reduction of the sediment variability to three categories implies that the Dockum red bed sediments have been approximated as consisting of only three different textures.

The choice of only one sediment type would not render a sufficient incorporation into the TOUGH2 modeling of the site hydrogeologic conceptual model. On the other hand, the use of many sediment types might be more consistent with available characterization data but would introduce additional uncertainties in the pretense inherent in characterizing the hydrologic behavior of each of these types.

Following the implementation of the indicator kriging procedure each cell in the numerical grid was characterized by a sediment type, a hydrogeologic constitutive equation, and a density. All other input parameters were computed in stages. The first stage resulted in the computation of the hydraulic heads and degree of saturation in every cell, given the locus of the lower table, as represented by the current site hydrogeologic conceptual model, and under the assumed constraint of gravitational equilibrium, everywhere. This strategy resulted in the simulation of a capillary fringe. The second stage used transient TOUGH2 analysis to create an enlarging zone of saturated conditions in the OAG grid cells in response to appending recharge rates (scaled partially to the results of the MODFLOW calibration simulations) to grid cells on the top surface of the grid corresponding to playa and depression locations. The computational results were monitored, at different simulation times, to assess the location of the simulated OAG dry line relative to the dry line stipulated by the current site hydrogeologic conceptual model. During these staged computations a no flow condition, consistent with the current site hydrogeologic conceptual model, was enforced over the entire bottom boundary of the numerical grid.

If, at some simulated time, the lateral extent of the computed OAG dry line, the locus of the water table (with appended capillary fringe), and the vector field characterizing the flow of water in Dockum red bed materials, were judged to be a reasonable match to those same elements as represented in the current site hydrogeologic conceptual model, then the TOUGH2 computations could be considered to be calibrated. The calibrated model's increased recharge rates, representative of future climate changes, could then be applied to the upper grid boundary, and the evolution of the site hydrogeologic conditions could be simulated.

Regardless of whether the TOUGH2 computations could be successfully calibrated, or whether an effort at calibration was even attempted, the results of the staged computations still provide information about the hydrologic behavior of the proposed site.

The north-south section depicted in the top half of Figure 9 of Attachment 6-3 of the application shows the simulated saturated conditions in the Dockum red bed materials after the first computational stage described above. This cross-section is roughly through the eastern edge of the proposed FWF disposal unit; this cross-section is basically that shown on Figure 6-5b on which the current site hydrogeologic conceptual model is depicted. Using the information in Figure 1 of the Attachment the boundaries of the FWF unit can be superimposed onto Figure 9 (recall the bottom elevation of the FWF unit is at 3,360 feet). The envelope of these saturated conditions, indicating the top of a simulated capillary fringe, is shown on Figure 9 to be above the dashed line locating the current locus of the water table in the Dockum red bed materials. Thus, Figure 9 shows a capillary fringe closer to the boundaries of the proposed unit, in both the lateral and vertical directions, than the initial locus of the water table. Comparing the top of the saturated conditions and the dashed line on Figure 9, the thickness of the capillary fringe at any point can be estimated.

Figure 8 on Attachment 6-3 of the application is a representation of saturated conditions, following the first stage of computation, on an east-west cross-section passing roughly through the middle of both the proposed FWF and CWF disposal units.

Figure 8 and Figure 9 on Attachment 6-3 of the application show simulated saturated conditions at the proposed disposal site, on two cross-sections of interest, without accounting for the effects of playa recharge. In that regard, the simulations might be considered incomplete.

Regarding Figure 10, in Attachment 6-3, the application states:

> Development of a shallow perched water table is indicated in Figure 10, showing the transient simulation results after 1,000 years in terms of saturation (top) and hydraulic head (bottom) below the water table. Also shown are the computed water flux vectors, indicating preferential recharge through the playa and development of a perched water table in the OAG and fully saturated conditions in the underlying conditions.

Figure 10 shows simulated saturated conditions on the same north-south cross-section shown in Figure 9 (along the eastern edge of the FWF unit), after recharge of the OAG cells has continued for almost 1,000 years (see the legend on upper left hand corner of cross-section) so that water is encroaching further on the boundaries of the proposed FWF, especially from the lateral direction. The figure shows a developing saturated zone corresponding to the "transient zone" depicted on Figure 6-5b, thus serving to qualitatively validate that feature of the site hydrogeologic conceptual model. Examination of the "water flux" vectors on Figure 10, indicate that although some features on the figure correspond to those shown on Figure 6-5b representing the current site hydrogeologic conceptual model, the simulated flux vectors almost no where exhibit a vertical component implied by the equipotential lines of that conceptual model. This is an indication that calibration of the TOUGH2 simulation to the conceptual model is not succeeding.

Figure 11 of Attachment 6-3 of the application shows simulated saturated conditions on the same north-south cross-section following a recharge period of 5,000 years. Superposition of the boundaries of the proposed FWF disposal unit onto Figure 11 indicate that the simulated saturated conditions continue to encroach on the boundaries of that unit; in fact, the figure shows that saturated conditions have intruded into the unit from the lateral direction.

It is important to note that Figure 11 does not depict a simulation of saturated conditions in the Dockum red bed materials at a time 5,000 years into the future. They are a simulation of saturated conditions at the current time; the TOUGH2 code needed 5,000 years of simulated time to generate saturated conditions in the OAG, under estimated current recharge rates, somewhat similar to the observed OAG conditions.

Regarding the simulated field of water fluxes depicted on Figure 11, the application states:

> The simulated hydraulic heads at depths indicate a significant water level decline due to the prescribed discharge along the initial water table. The model indicates some small upward gradient from the 225-foot layer beneath the site (Figure 11), but it is much less than the observed gradient (Fig. 6-5a and 6-5b of Appendix 2.6.1). The simulated upward flow is not enough to maintain the initial water table.

The application is noting that Figure 11 shows the appearance of a lens of unsaturated conditions in the water table. This lens almost separates the saturated subsurface into disjoint domains. The water fluxes also fail to exhibit the needed vertical component needed to match those of the conceptual model. Thus, one interpretation of Figure 11 is that it suggests that a calibration of the TOUGH2 model, using the indicated input parameters, would not be possible.

The application states the following regarding Figure 11: "with continued downward infiltration, the unsaturated zone beneath the perched water table in the OAG will be resaturated with time". Thus, the simulation validates the description of the dynamic hydrologic behavior in the Dockum red bed inferred earlier from consideration of the theoretical solution by Bear and of Fredlund and Rehardjo's numerical simulation of the reservoir-dam system.

Also regarding Figure 11, the application states that "the observed downward gradient indicating recharge to the 225-foot zone in the northern part and the steep upward gradient in the central part could not be reproduced even when assuming anisotropic permeabilities for the different hydrostratigraphic units". Thus, there was an apparent attempt to calibrate the simulation to the flow field indicated by the conceptual model by exploring the effects of anisotropic hydraulic conductivities (despite the fact that elsewhere in the application the conductivities, based on laboratory data, are deemed isotropic).

These observations made in the application suggest that the no-flow condition applied on the bottom boundary of the numerical grid, rather than anisotropies in permeabilities, may be responsible for a simulated vertical gradient that "is much less than the observed gradient" and for a simulated upward flow that "is not enough to maintain the initial water table." Intuitively, the application of a vertical flux with an appropriate magnitude and spatial variation, on the bottom boundary would increase the simulated vertical gradient and possibly sustain the initial water table. Certainly, the calculations incorporating a no flow condition over the entire bottom of the numerical grid did not result in computational results matching the site hydrogeologic conceptual model.

The problem of accurately characterizing the flux boundary condition on the bottom of the 225-foot layer is a difficult one. Not only does that flux vary spatially along the bottom of any model cross-section but that spatial variability is likely a function of the location of that cross-section. In Figures 6-5a and 6-5b, the application indicates a no flow boundary on each of the two depicted cross-sections; since the horizontal distance between these cross-sections is several thousand feet, it seems possible that the current spatial distribution of flux on the bottom boundary of each these cross-sections are likely not identical. Thus, the characterization of the flux conditions on the bottom of the 225-foot layer as constant in space may be an oversimplification.

It seems that the ultimate purpose of the TOUGH2 numerical simulations, once completed, would be to study the evolution of the hydrologic behavior in the Dockum red bed materials. It is expected that the current locus of the lower water table will evolve with time. It seems reasonable to have a similar expectation regarding the flux boundary condition on the bottom of the 225-foot layer. If so, then it might be anticipated that those expected temporal variations in flux significantly influence the evolution of the lower table. Thus, the application's characterization of the flux conditions on the bottom of the numerical grid as constant in time may also be problematic. Proposed license conditions require predictive numerical or analytic modeling to address modeling site boundaries.

The TOUGH2 simulations described in the application in Attachment 6-3 indicate that the spatial extent of the site hydrogeologic conceptual model should be extended. Selection of the 225-foot layer as the bottom of the numerical grid constitutes the placement of grid boundary too close to the subsurface volume in which the evolving water table and saturated conditions within the Dockum red bed materials are to be studied. Thus, even small errors in characterizing the flux along that boundary, both in space and in time, may significantly effect the evolution of the "near by" water table. On the cross-section shown on Figure 6-5b, directly beneath the bottom of the FWF disposal unit the water table is only 50 feet or so above the 225-foot layer. Even a moderate vertical flux applied on the boundary at that point would be expected to influence the nearby water table.

The Executive Director recommends license conditions that require predictive modeling, whether numerical or analytical. If that required modeling were to take a form similar to the simulations presented in the application, then additional site characterization extending the spatial extent beyond the characterization given in the application, might be required.

In modeling practice there are several strategies that can be pursued to avoid the propagation of uncertainties in grid boundary conditions into the interior region of that grid where the phenomenon of interest is located (Anderson and Woessner, 1992a). These strategies usually involve the use of an initial grid with boundaries sufficiently removed t interior domain of interest so the interior is not unduly influenced by conditions applied to those boundaries. In the procedure termed "telescopic mesh refinement" (TMR), an initial grid with coarse grid spacing is fitted to regional (distant) boundaries and boundary conditions for models covering successively smaller geologic areas are defined from the regional scale simulation. Thus, any further predictive simulations might incorporate TMR as an effective computational strategy.

Attachment 6-3 of the application describes an interesting TOUGH2 simulation of the time needed for the hydrologic conditions at proposed site to evolve from an assumed previous state of complete saturation in the Dockum red bed materials to a configuration similar to that currently observed. This simulation is only intended as an exploratory tool, so that it is necessarily simplistic in some respects. For example, in this simulation a no flow condition was again applied on the bottom of the 225-foot layer. The simulation shows (see Figure 13 in Attachment 6-3) that after approximately 14,000 years the hydrologic state of the system is roughly similar to that portrayed by the site hydrogeologic conceptual model. If this simulation had utilized a grid with a bottom boundary at depth, say at 600 feet, and assumed a no flow condition on that boundary, then the spatial and temporal variability of the flux on the bottom of the 225-foot layer, now an internal surface within the numerical grid, could be studied. Information from that simulated flux, rather than a no flow boundary condition, could then be applied to the bottom of the 225-foot layer, now serving as the lower grid boundary in a second simulation.

6.6.26 Additional Analysis of TOUGH2 Simulations

The University of Texas - Bureau of Economic Geology (BEG) also completed a technical review of the TOUGH2 Three-Dimensional (3D) simulations being discussed here (Appendix A). This effort included a review of materials prepared by the applicant after submittal of the final revision of the application. These materials present several brief arguments as to why the hydrogeologic system at the proposed site has been in a state of quasi-steady-state equilibrium for some time and will remain in such a state throughout the period of analysis. None of these arguments were explicit in the application materials, nor did these arguments cite references deriving, describing, or otherwise supporting the use of a "time constant" analysis prominently featured in these arguments. In their review regarding the TOUGH2 simulations and the more recently submitted materials the BEG stated "TOUGH2 3D models do provide insight into the behavior of the natural system but should be better calibrated and better constrained to provide arguments to the unproven applicant's contention that the system is and has been at steady-state for tens of thousands of years" (Appendix A). In their review, the BEG rendered other opinions regarding the TOUGH2 3D modeling supporting the independent analysis of TCEQ technical staff as presented above.

Paragraph 6.2.6.2 of the application describes several TOUGH2 two-dimensional (2D) simulations of fluid flow and radionuclide transport and travel times in modeled fracture systems between the bottom of the proposed disposal units and saturated conditions in the Dockum red bed materials. The application does not formally integrate these simulations into the development of the site hydrogeologic conceptual model. Thus, an analysis of these simulations is not given in this section of the analysis. As they stand these simulations are considered to be more relevant to performance assessment issues. However, for completeness, a summary of the BEG's review of these simulations is given here.

The BEG states:

> TOUGH2 2D transport modeling by the applicant addressed subsurface-parameter uncertainty in a relatively thorough fashion except for one variable: assumed top-boundary fluxes of approximately 0.01 inch/yr are too low. Simulations performed for and presented in this report with top flux increases to 0.1 and 1 inch/yr lead to much less conservative results, decreasing breakthrough time from approximately 14,000 years (applicant's base case) to <5,000 years (flux x10) and <1,000 years (flux x100) for Tc-99. Chloride's breakthrough time, used as a marker for the

> byproduct facility, also decreases from >1,000 years (applicant's base case) to <200 years in other cases. Note that cases in which simulation results do not meet concentrations suggested by regulations do not necessarily invalidate the site.
>
> Because the 2D model used in the simulations is so conservative, a more realistic conceptual model consistent with site geology and hydrology would probably yield results that would be less extreme than some of those presented in this analysis. It is, however, the applicant's charge to develop such models, for example, by modeling the bottom liner (as applicable), by evaluating fracture extent and connectivity, and by better understanding the source (leachate chemical composition was obtained with no credit given to containers; in addition, high water flux is also likely to translate into a much lower radionuclide concentration)."

Thus, based on the BEG's review, the TOUGH2 transport simulations provided in the application may not be adequate representations of either the subsurface fracture system at the proposed site or of the transport of radionuclides within that fracture system. Section 8.6 of this EA provides a detailed analysis of the performance assessment provided in the application and includes a discussion of proposed license conditions designed to adequately model the transport of radionuclides in the subsurface of the proposed disposal site.

References Section 6.6: Groundwater Hydrology

Anderson and Woessner, 1992a, Applied Groundwater Modeling, Page 129.

Bear, J., 1972a. Dynamics of Fluids in Porous Media. Chapter 7: Solving Boundary and Initial Boundary Problems. Page 268. Dover.

BEG, 2007b. University of Texas. Bureau of Economic Geology, Review of Matric Potentials and Moisture Contents, Upper Cooper Canyon Formation (Attachment 6-2). Letter Report to TCEQ.

BEG, 2007c, University of Texas. Bureau of Economic Geology Playa Recharge Comment. Letter Report to TCEQ.

Chiles and Delfiner, 1999a. Geostatistics: Modeling Spatial Uncertainty. Chapter 1: Introduction.

Domenico and Schwartz, 1990. Physical and Chemical Hydrogeology. Chapter 2: The Origin or Porosity and Permeability.

Fetter, 1980. Applied Hydrogeology.

Fredlund and Rahardjo, 1993a. Soil Mechanics for Unsaturated Soils. Chapter 16: Two-and Three-Dimensional Unsteady-State Flow and Nonisothermal Analyses.

Freeze and Cherry, 1979a. Groundwater. Chapter 2: Physical Principles.

Freeze and Cherry. 1979b. Groundwater. Chapter 8: Groundwater Resource Evaluation.

Isaaks and Srivastava, 1989. An Introduction to Applied Geostatistics. Chapter 10: Global Estimation.

NRC, 1982. United States Nuclear Regulatory Commission NUREG-902: Site Suitability, Selection and Characterization.

NRC, 1996. National Research Council: Rock Fractures and Fluid Flow.

NWS, 2007a. National Weather Service. Precipitation Analysis. http://www.srh.noaa.gov/rfcshare/precip_analysis_new.php.

USEPA, 2007a. United States Environmental Protection Agency, Region 6. www.epa.gov/Region06/6wq/swp/ssa/solesource.htm.

WCS, 2007a. 40 Select OAG Wells: Groundwater Elevations. Submittal from Waste Control Specialists, LLC to TCEQ, August 10, 2007.

6.7 Surface Hydrology

Title 30 TAC §336.708(a)(3) states that the application must contain area and site characteristics relating to surface hydrology. Furthermore, 30 TAC §336.728(d) requires that waste disposal must not take place in a 100-year floodplain. These two requirements were addressed in a floodplain study in Appendix 2.4.1 of the application. This appendix shows the location of the 100-year, 500-year, and Probable Maximum Floodplain. This appendix also includes its supporting data as well as inputs and outputs for the computer models used for the determination of the floodplains. A brief overview on surface water features will be presented followed by a discussion on the modeling used in this floodplain study to represent the surface water hydrology and resulting floodplains at the site. Finally, issues with surface water hydrology and license conditions addressing these issues will be discussed.

Figure 2 in Appendix 2.4.1-2 notes ten playas, three stock ponds, one spring, and one “depression pond” all within a five-mile radius of the facility. The applicant has stated that the spring and depression pond are fed by subsurface flows in addition to surface flows indicating a high water table. The other playas and stock ponds are all fed by surface flows, which will then contribute to subsurface water flows.

Appendix 2.4.1 consists of the floodplain study used to describe the surface water hydrology at the site. The floodplain study describes the watershed characteristics, hydrology and hydraulics at the site, and a sensitivity analysis of the parameters used. The floodplain study uses the US Army Corps of Engineer Hydrological Engineering Center Hydrologic Modeling System (HEC-HMS) to simulate precipitation events on a given watershed and quantify the peak flow at a control location. This sub-section will discuss the methodology used in the application in determining the surface water hydrology.

The watershed containing the proposed disposal facility is approximately three square miles. The watershed is comprised of nine sub-basins, each draining to a pair of culverts crossing State Highway 176 at the southwest corner of the site. From the culverts, stormwater ultimately drains to Monument Draw in New Mexico and then back east to the Pecos River. Drainage at the site will be conveyed to the culverts via a dry creek south of the facility running east to west. An exception might include the northernmost basin, which has all stormwater flow draining to the playa to the north of the facility. Most of this flow in this sub-basin is contained in the playa and will contribute to subsurface flow, except under Probable Maximum Precipitation (PMP) event where the stormwater will flow to the dry creek bed.

The slope of the watershed ranges from 0.5 percent to 4.5 percent with an average slope being 1.0 percent. Most of the site slopes toward the south until the area around the creek bed which slopes to the west. Soil on the site is comprised of those classified as Hydrologic Groups A, B, and C. Soils will range from high infiltration rates (Group A) to low infiltration rates (Group D). Thus, soils at the site are mostly comprised of high to moderately low infiltration rates. Vegetation on the site was considered to be desert brush with a coverage ranging from good in the south to fair at the north. The slope, hydrologic group, and vegetative cover all produce a run-off curve number used in the HEC-HMS computer program.

Using the HEC-HMS computer program and the above watershed characteristics, a hydrologic analysis of the watershed was performed. Precipitation events used to simulate precipitation include the 100-year, 500-year, and Probable Maximum Precipitation. The SCS dimensionless unit hydrograph method was then used to measure watershed response to the different precipitation events. The SCS dimensionless unit hydrograph requires a curve number, acreage of the sub-basins, and a lag time

Curve numbers were developed from the Hydrologic Groups of soils, land use, and cover type as presented above. Another factor used to characterize the curve number was the Antecedent Moisture Condition (AMC). The AMC indicates the level of moisture present at the soil prior to a precipitation event. AMC I indicates a dry soil, whereas AMC III indicates a moist soil. As the level of AMC increases, more run-off can be expected. In determining the curve numbers, the application anticipates a soil condition represented by AMC I. This correlates to a curve number of 60, the lowest curve number applicable. This curve number was applied to all but one sub-basin, which used a curve number of 62. Sensitivity of the AMC was incorporated into the floodplain study and will be discussed below.

The lag time used in the computer simulations were estimated as six-tenths of the time of concentration, where the time of concentration is defined to be the time required for a particle of water to travel from the most hydrologically remote point in the watershed to the point of collection. The lag times for the model range from 30 to 86 minutes, which given the size of the sub-basins appears appropriate.

Thus, each sub-basin is given acreage, curve number, and a lag time, which generates a hydrograph. These hydrographs represent the amount of flow as a function of time. The hydrographs can then be combined with other sub-basins creating hydrographs with higher peak flows. Additionally, hydrographs can be routed via stream reaches. That is, the hydrographs can be offset in time to account for the flow to reach some downstream control point and then combined with a merging hydrograph from another sub-basin to produce characteristic hydrograph at that point. This was performed in the hydrologic analysis for points along the stream bed. Flows from these points were then inserted in the hydraulic model to determine the height of a given floodplain.

The United States Army Corps of Engineers Hydrological Engineering Center River Analysis System (HEC-RAS) was used to perform one-dimensional steady or unsteady flow along the dry creek bed south of the facility. HEC-RAS used the 100-year, 500-year, and PMP precipitation event flows from HEC-HMS to determine floodplain elevations along the stream. Cross-sections of the creek bed were input into the model along with the Manning's n values used to account for the roughness of the channel/stream. The culverts under State Highway 176 were used as the starting point of the model. Different starting water surface elevations were input into the model to investigate sensitivity of the simulated floodplains. Results indicated a shallow and wide floodplain. However, neither of the 100-year, 500-year, or PMP floodplains encroaches upon the proposed disposal facilities.

Various scenarios were used in modeling the surface water hydrology and floodplains to determine its sensitivity. The effects of developing the proposed low-level radioactive waste disposal facilities and by-product disposal units were investigated. Development of these disposal units results in a faster lag time, different curve numbers, and possibly different drainage areas. These changes produce higher peak stormwater run-off rates. Also, as discussed above, the AMC were adjusted to produce more stormwater run-off. The effect on the floodplain of all these scenarios is minimal and does not result in an encroachment of the floodplain in the disposal units.

The Executive Director recommends several license conditions related to surface hydrology and water management. An integration of the stormwater management plan discussed in Section 2.3 of the EA into the surface water models must be performed to account for the proposed stormwater controls and pond required by the proposed license. Future climatic conditions, which include increased annual precipitation rates, and presumably increased 24-hour rainfall amounts, must be considered for each of the precipitation events listed above. Additionally, any alteration in drainage patterns on the site must be accounted for.

6.7.1 Proposed Lining of the Playa

Appendix 2.6.1 (WCS, 2007a) of the application indicates that a nearby playa just north of the facility will be filled with red bed clay from the excavations in order to reduce infiltration into the waste matrix over the next 50,000 years. This proposed "lining" of the playa will effectively alter the surface water characteristics of the area's watersheds. While this will not drastically change the extent of the floodplains noted above, it will increase the amount of flow in a previously unaffected basin and contribute to other aspects of surface processes going on within that basin. This increase in flow could lead to downstream gully erosion, which could possibly encroach onto the landfill or onto the playa which is being re-engineered. Analysis and mitigation of these surface processes have also not been adequately demonstrated. The Executive Director recommends a license condition restricting modification of playas or other alterations that may affect surface water flow on the site.

The proposed lining of the playas presents additional concerns. Appendix 2.6.1 of the application has indicated that the area north and northeast of the proposed landfills will be filled with excavated and compacted red beds and contoured to promote surface water drainage to the east. Primarily is the issue of whether the ability of the proposed modifications will reduce recharge through the playas. The fill material is clay rich and likely to shrink and swell similar to clays in most playa floors and will be subjected to numerous freeze-thaw cycles. This has the potential of allowing preferential flow through the fill material. Furthermore, lining the playas may require maintenance to sustain optimum water content. The application does not address how active maintenance will be conducted in perpetuity in the filled playas. Active maintenance following closure must be avoided in accordance with 30 TAC §336.727. Further, TCEQ staff considers the lining of the playa an engineered barrier pursuant to 30 TAC §336.702(9).

6.7.2 Surface Hydrology Conditions

Appendix 2.4.1, page 2-1 of the application states that Ranch House Draw ultimately drains into Monument Draw, New Mexico. Floodplains resulting from 100-year, 500-year and Probable Maximum Precipitation (PMP) events as well as the channel center line are shown to drain off of the WCS facility (Figure II.F.4 in Appendix 2.4.1) This statement and the floodplain map are contradicted in Appendix 2.6.1, Attachment 4-3, p. 2-7, which claims that the present (Ranch House) drainage is no longer integrated with Monument Draw, New Mexico.

Similarly, page 2-2 of the same appendix of the application describes the soil units at the site. These units are, which are taken from the U.S. Soil Conservation Service Soil Survey of Andrews County, Texas and outlined in Figure II.F.2 in Appendix 2.4.1, do not correspond with surficial geologic units depicted on the Map of the Surficial Geology in Appendix 2.6.1, Attachment 4-3, Plate 1. A license condition was inserted to distinguish between the two inconsistencies.

6.8 Geotechnical Characteristics

The applicant must use site-specific environmental information (or reconnaissance-level information when appropriate) to describe and quantify, to the extent practicable, the area and site soils and geotechnical and geochemical properties. Quantified descriptions of the geotechnical properties must be sufficient to support all necessary engineering and modeling computations. The applicant's characterization of natural radiation background must be sufficient to support all necessary current and future environmental monitoring programs conducted at the proposed site.

TCEQ staff review of the application's description and quantification of the geotechnical, soils, and geochemical characteristics of the proposed site (as described in 11 different appendices and attachments) are discussed first. A review of the characterization of natural radiation background described in the application is presented in Section 4.4.2 of this Environmental Analysis (EA).

Certain site features that might be classified as "geotechnical" are not discussed in this section of the EA. For example, the characterization of the subsurface faulting and fracture system presented in the application is reviewed in Section 6.4.1. Also, certain aspects of how the moisture and saturation measurements collected during site characterization relate to apparent uncertainties in the site hydrogeologic conceptual model are discussed in Section 8.6 of this EA. Also Section 8.6 includes a detailed discussion of uncertainties in site characterization processes due to inherently sparse data sets. These sections of the EA describe possible sources of uncertainty in the characterization of the geotechnical properties of subsurface materials at the proposed disposal site, as described in the application.

Partly on the basis of these discussions incorporated into other sections of this EA, and partly based on the previously discussed proposed license condition dictating a relocation of the that facility, the Executive Director has proposed additional license conditions that involve the geotechnical characterization of the proposed site. One of these proposed conditions requires that during excavation and construction of the disposal site the TCEQ be provided with frequent written reports and photographs of construction and excavation activities and that particular attention be directed to fractures, faults, and any evidence of collapse features or groundwater flow or any other unanticipated geologic features. Another proposed condition requires that during excavation and construction that various geotechnical studies be performed, allowing observation by the Executive Director, to verify original geotechnical conditions by the continuous monitoring of parameters and features such as soil moisture, slope stability, and permeable soil stringers. This proposed condition should provide for a finer, local, spatial resolution of important features of the proposed site relative to the resolution described in the application.

This section of the EA provides a review of geotechnical properties described in those sections of the application not associated with the subsurface fracture system or directly with the site hydrogeologic conceptual model.

6.8.1 Geotechnical Investigation

In order to support numerical simulations of the structural stability of the wastes and backfill materials using the computer code FLAC (Fast Lagrangian Analysis of Continua), the application describes a completed 300-foot boring and extensive geotechnical testing of claystone and sandstone cores collected at 15 foot intervals from this boring. The testing and associated analyses of the test data are described in the different attachments to Volume 23, Appendix 3.4-1.

TCEQ staff reviewed the boring log for the 300-foot boring. TCEQ staff also reviewed the laboratory results of nine triaxial compression tests and 18 unconfined compression tests completed on cores from this boring. These tests provided strength and stress-strain characterizations, as well as moisture content measurements and unit weights for the Dockum red bed materials in which the proposed disposal units are to be founded. Also reviewed were a series of triaxial compression tests performed on samples of remolded Dockum red bed clay material which is to be used for the construction of a clay liner in the proposed disposal units. These tests were used by the applicant to characterize the strength and stress-strain behavior of the remolded clay. Densities, void ratios, and degree of saturation were also determined for the clay samples. TCEQ staff also reviewed the submitted analysis of the effect of the subsurface system of fractures in the Dockum red bed materials on strength and stress-strain behavior measured on the unfractured core samples.

All laboratory tests appeared to be completed according the relevant ASTM standards. The application contains sufficient information to allow verification of the elasto-plastic material models of the natural Dockum red bed materials and the remolded clay (used as inputs to FLAC) constructed by the applicant from the reviewed geotechnical testing. These models, in conjunction with associated completed sensitivity analyses, produced numerical simulations that were supportive of the structural stability of the waste and backfill materials in the proposed disposal units after closure (see Section 2.3.6 of this EA for a review of these simulations).

6.8.2 Geotechnical, Soils, and Geochemical Data

Volumes 9 through 16 of the application include a description and tabulation of all of the data collected in support of the site conceptual model. This data includes geotechnical, soils, and geochemical information. These data were collected during numerous investigation activities that have been conducted at the proposed disposal site since 1992 to the present. The investigations include a RCRA landfill site characterization, four by-product material landfill siting studies, an OAG hydrogeology investigation, and investigation activities related to the proposed FWF and CWF. While all these data were not collected in the immediate vicinity of the proposed FWF and CWF, they were all utilized in arguments given in the application in the development of a site-wide conceptual model as well as a site hydrogeologic conceptual model.

During these investigations, approximately 250 borings were drilled and 150 monitor wells and piezometers were installed. The application gives spatial locations of each boring, well, and piezometer. The large number of geotechnical, soils, and geochemical data collected from these borings and wells include continuous cores and soil borings, geophysical logs, and a large variety of laboratory measurements. Geotechnical laboratory tests performed on collected samples included measurements of density, grain size characteristics, water content, porosity, degree of saturation, percent swell, Atterberg Limits, permeability, and Shear Strength. Liner and cover certification tests during the RCRA investigation generated over 30 estimates of hydraulic conductivities (both horizontal and vertical) for linear and cover materials. A summary of these geotechnical results is given in Section 5, Table 5-2 of Appendix 2.6.1. Table 5-3 of Appendix 2.6.1 of the application summarizes data on the mineralogy of the claystone materials in which the proposed units are to be founded.

The hydrologic data collected during these investigations and their application to the development of a site hydrogeologic model are not discussed in this section of the EA (see section 8.6).

6.8.3 Dynamic Geotechnical Properties

Volume 8, Appendix 2.5-2 of the application describes a series of in-situ surface wave tests for characterizing the shear wave velocity within the upper 150 feet of the Dockum red bed materials in which the proposed units are to be founded. The application also describes analytic procedures for transforming the results of these in-situ tests into estimates of the variation in shear modulus and material damping in these materials. These geotechnical data were required in the submitted seismic analyses of the site and in the FLAC simulations of the seismic response of the proposed disposal units.

6.8.4 Moisture Potential Measurements

Volume 16, Appendix 2.6.1, Attachment 6-2 of the application describes laboratory measurements of moisture retention curves and moisture content from core samples obtained from nine different borings in the vicinity of the FWF unit. Because these geotechnical measurements played a significant role in the development and analysis of the site hydrogeologic conceptual model presented in the application, TCEQ staff's review of these data are given in Section 6.6 of this EA.

6.8.5 Surficial Geology at WCS Site

Attachment 4.3 of Appendix 2.6-1 of the application includes a report, intended to supplement the presented on-site erosion study that contains multiple characterizations of the soils and other surficial materials at the proposed disposal site. This report gives geomorphic and pedogenic descriptions of the site soils as determined from surficial mapping, study of the United States Department of Agriculture (USDA) Soil Conservation Service mapping of soils in Andrews County, review of stratigraphic studies completed in other areas of the Southern High Plains, and visual inspection and measurement of six different soil pits excavated at the proposed site. The analysis of soil data, erosion and subsidence studies are given in Section 6.8 of this analysis. This review resulted in several proposed license conditions that are described in that section.

6.9 Soil Conditions

As required by Texas Health & Safety Code §401.111, §401.231, Title 30 Texas Administrative Code (30 TAC) §336.708, and 30 TAC §336.728 a license application for low-level radioactive waste disposal must provide an evaluation of soil conditions at the proposed disposal facility.

The General Soil Map provided in the Soil Survey of Andrews County, Texas (USDA, 1974) indicates two general soil associations in the vicinity of the proposed disposal facility, the Blakeney-Conger association and the Jalmar-Penwell association, which consist of one or more soil series. The Blakeney-Conger association is described as rapidly permeable to moderately permeable fine sandy loam and loam with a soil blowing hazard classified as moderate. The Jalmar-Penwell association is described as moderately permeable to rapidly permeable fine sand with a soil blowing hazard classified as severe.

Section 2.6.2 of the application states that Andrews County is characterized by moisture-deficient soils and that the mean annual soil moisture is within the lowest range in Texas. This section of the application also states that the soil moisture deficit is a mitigating factor with respect to downward migration of fluids that could result from precipitation contacting spilled fluids. However, the Blakeney soils are described as well-drained with medium internal drainage and moderately rapid permeability (USDA, 1974). The Conger soils are described as well-drained with medium internal drainage and moderate permeability (USDA, 1974). According to the application, soils in the immediate vicinity of the proposed disposal area represent a thin (less than 18 inches) layer of Blakeney-Conger Series loam/clay-loam underlain by caliche or laminated caliche. Soil maps provided as Figure 2-10 of the application indicate non-caliche soil cover ranging from zero to 29 feet overlying the area including the proposed disposal area footprints; and a calcic soil (caliche) cover ranging from five to 35 feet overlying this area as noted in Figure 5-9a of the application. Together, the estimates of soil cover in the vicinity of the proposed disposal area range from five to 38 feet.

Section 2.6.2 of the application also characterizes the caliche as having generally low permeability. This characterization is based on several lines of evidence including the caliche being strongly cemented as described in soil boring logs provided in Appendix 2.6.1, Attachment 5-1 of the application. Many of the boring logs provided in Attachment 5-1 describe the caliche variously as fractured, crumbly, vuggy, and, in some cases, moderately soft. The Andrews County Soil Survey (USDA, 1974) describes caliche in the Blakeney-Conger series as ranging from strongly cemented to weakly cemented. Additionally, observations of Baker Spring, areas north of the proposed disposal facilities, and the trench excavated across a lineament at the site have documented numerous karst (dissolution) features in the caliche, including vugs, solution-enlarged fractures, solution cavities, and pipes.

Several studies conducted by the National Research Council (NRC, 2001; NRC, 2001a; NRC, 2001b; NRC, 2001c; and NRC, 2001d) indicate there are key technical reasons for soil clean-up/remediation difficulty including the following:

- Physical heterogeneity, which makes groundwater migration pathways difficult to predict;

- Migration of contaminants to inaccessible regions, such as clays or small pores in aggregates;
- Sorption of contaminants to subsurface materials;
- Difficulties in characterizing the subsurface, making knowledge of the subsurface incomplete; and
- Presence of non-aqueous phase liquids (NAPL), creating long-term continuous sources in the subsurface.

There are concerns related to soils at the site with regard to the ability to remediate spills. A contaminant is anticipated to move quickly from the surface to the top of the caliche. Once on top of the caliche, it will follow the top of the caliche until it can find a way through cracks, fractures or other features. Contaminants could possibly migrate along improperly or breeched well bores to the underlying vadose zone, to the groundwater of the OAG, and then possibly continue to the Dockum formations. Such a release at the surface has already occurred from the septic system and its associated drain field near the current Administration and Personnel buildings at the WCS site. There are many remediation cases that the TCEQ has regulated that involve similar soils and groundwater in cities such as Odessa, Midland, and Levelland. In addition, if a contaminant is discovered in a groundwater monitoring well, it will be difficult to identify the source or sources, if multiple sources are present.

The Executive Director recommends license conditions addressing the monitoring and remediation of soils including installation of spill control and monitoring measures from the surface to the top of the caliche caprock around areas at the surface where a spill or leak could possibly occur to facilitate remediation of these possible spills; and conduct tracing studies to determine the proper location and installation of monitor wells around these surface structures.

References Section 6.9: Soil Conditions

NRC, 2001. National Research Council Conceptual Models of Flow and Transport in the Fractured Vadose Zone, 2001

NRC, 2001a. National Research Council Conceptual Models of Flow and Transport in the Fractured Vadose Zone. Introduction. Page 9, 2001

NRC, 2001b. National Research Council Conceptual Models of Flow and Transport in the Fractured Vadose Zone. Preface, page ix, 2001

NRC, 2001c. National Research Council Conceptual Models of Flow and Transport in the Fractured Vadose Zone. Executive Summary. Page 4, 2001

NRC, 2001d. National Research Council Conceptual Models of Flow and Transport in the Fractured Vadose Zone. Chapter 1. Page 39, 2001

USDA, 1974. United States Department of Agriculture, National Resource Conservation Service Soil Survey of Andrews County, Texas, 1974

Section 7 Alternatives to the Proposed Activity

7.0 General Introduction

Section 401.112(a)(4) of the Texas Health and Safety Code requires the TCEQ to consider the need for alternatives to the proposed activity, including an alternative siting analysis prepared by the applicant. A state rule, 30 TAC §336.708(a)(7) requires the applicant to provide site-specific environmental information regarding project alternatives, including a discussion of the alternatives considered by the applicant for processing and disposal of waste.

Section 11.3 of the application contains a discussion of alternatives to the proposed project. The information presented in the application was reviewed. In performing the review, TCEQ staff utilized appropriate federal guidance documents (NRC, 1987).

7.1 Need for Facility

The Low-Level Radioactive Waste Policy Amendments Act of 1985, codified at 42 U.S.C. §§2021b-2021j (1985), states that each state shall be responsible for providing for disposal of low-level radioactive waste generated within the borders of that state, except for certain types of low-level radioactive waste generated by the federal government. Each state has the option to provide its own disposal facility or to participate in "Compacts" and arrange for use of disposal facilities in other states. The State of Texas currently is the host state in a Compact with Vermont known as the Texas Low-Level Radioactive Waste Disposal Compact, as authorized by Texas Health and Safety Code, Chapter 403.

There is currently no in-state disposal facility available to accept low-level radioactive waste generated in Texas. Most of the waste generated in Texas is either being stored temporarily at the generator's facility or at other licensed storage facilities, or it is shipped out-of-state for disposal. Low-level radioactive waste generators in Texas have recently relied on the disposal facility near Barnwell, South Carolina, and the disposal facility near Clive, Utah (formerly Envirocare) both of which are owned by EnergySolutions. The Clive facility is only authorized for commercial disposal of certain types of Class A low-level radioactive waste and naturally-occurring radioactive material (NORM) waste. The Barnwell facility also has restrictions on the types and quantities of waste it will accept but has previously accepted Class A, B, and C low-level radioactive waste from Texas and Vermont generators. The Barnwell facility is the host site for the Atlantic Interstate Low-Level Waste Management Compact, accepting waste from the states of South Carolina, Connecticut and New Jersey. Effective July 1, 2008, the Barnwell facility has closed to the receipt and disposal of out-of-compact commercial low-level radioactive waste.

The application also requests authorization to dispose of low-level radioactive waste and mixed low-level radioactive waste, that is, waste with a hazardous component and a radioactive component, generated by the federal government. This majority of federal facility waste is generated by the United States Department of Energy (DOE) as part of its remediation activities. There are DOE facilities currently accepting federal facility waste for disposal at DOE-owned and controlled sites including the Hanford, Washington site and the Nevada Test Site (NTS). The Hanford disposal facility can only accept radioactive waste generated in the environmental cleanup of the Hanford Reservation. The NTS currently accepts Class A, B, and C low-level radioactive waste from other DOE facilities, and certain types of mixed low-level radioactive waste.

7.2 Alternative of No Action

The application provides a no action alternative to the proposed project by stating:

> The No-Action Alternative was essentially precluded during the recent Texas state legislative session when a LLRW disposal facility in the State of Texas was accepted.

Section 11.3.2 of the application evaluated the following alternatives for disposition of waste to determine whether a disposal facility is necessary for the State of Texas: Viable alternatives for disposition of the waste include joining an existing Compact for disposal of Texas-generated waste in another state; or disposal of waste in existing facilities in Utah or South Carolina. The application concludes that efforts over the past years indicated that these were not viable options.

Additional alternatives to constructing a disposal facility in Texas not discussed in the application include:

- On-site decay in storage for low-level radioactive waste generated by medical and research institutions. This alternative is currently available in Texas for the waste produced by generators of short-lived radionuclides, but would not be practical for generators of long-lived radionuclides. This alternative would require additional storage capacity by the affected waste generators.

- Storage of low-level radioactive waste generated by Texas and Vermont nuclear power plants in special structures built on-site. In 1981, the United States Nuclear Regulatory Commission recommended that such storage should be limited to five years (NRC, 1981), but because of delays in development of disposal capacity by the states, a longer period of on-site storage is allowed, providing that the power plant operator has obtained a separate license for that purpose (NRC, 1991). A Texas nuclear power plant is already utilizing on-site storage for large components under the end of operational life of the plant.

- Disposal of low-level radioactive waste at the source of generation. A major drawback of this alternative is that many facilities that produce low-level radioactive waste are located in densely populated areas that are technically unsuitable for waste disposal.

7.3 Alternative Sites

Section 401.112(a)(4) of the Texas Health and Safety Code requires consideration of the applicant's alternative siting analysis. Section 11.2 of the application contains a description of the site selection process. The site selection process describes the siting criteria and site suitability requirements. Section 11.2.1 of the application also contains a site selection report. The site selection process and the site selection report only addresses the proposed Andrews County, Texas facility. The application does not provide an alternative siting analysis. Also, the site selection report is dated February 4, 2004. Much of the information contained in this report is out-of-date or inconsistent with information presented in other sections of the application.

Title 10, Code of Federal Regulations (CFR), §61.7(c)(1) states:

> During the preoperational phase, the potential applicant goes through a process of disposal site selection by selecting a region of interest, examining a number of possible disposal sites within the area of interest and narrowing the choice to the proposed site. Through a detailed investigation of the disposal site characteristics the potential applicant obtains data on which to base an analysis of the disposal site's suitability.

7.4 Alternative Methods of Processing and Disposal

TCEQ rule 30 TAC §336.708(a)(7) requires that an application for a low-level radioactive waste disposal facility include a discussion of alternatives considered for processing and disposal of the waste. Section 11.3.1 of the application presents alternate techniques of waste processing and reduction at the site of waste generation. Alternatives identified in the application included:

- Methods may be employed to reduce waste at the point of generation. The feasibility of incineration and super-compaction to minimize the amount of waste requiring disposal was evaluated.

- Waste generators who produce wastes containing low concentrations of short-lived radionuclides (less than 300 days half-life) may dispose of those wastes based on their non-radiological characteristics. This alternative allows waste to be disposed of in Class I municipal landfills or in hazardous waste disposal facilities.

Section 11.3.2 of the application evaluated waste disposal alternatives as follows:

- Shallow (near-surface) land disposal
- "Enhanced" shallow land disposal
- Above-ground vaults
- Below-ground vaults
- Above-ground modular concrete canisters
- Above/below-ground modular concrete canisters
- Earth-mounded concrete bunkers
- Mined cavities
- Unlined augured holes
- Lined augured holes

A description of these alternative technologies is contained in a report prepared jointly by the Texas Low-Level Radioactive Waste Disposal Authority and Rogers and Associates Engineering Corporation in 1987 (TLLRWDA, 1987). The final designs selected in the application are a modified "below-ground vault with modular concrete canister" design and modified shallow land disposal design for non-containerized waste.

The basic elements of the design presented in the application were enhanced to include two additional important features: 1) a thicker more robust cover design; and 2) an enhanced monolithic internal structure using reinforced concrete canisters with minimal void space in the disposal cell. The cover design is described in detail in Section 3.5 of the license application. The "monolithic" cell design is described in detail in Section 3.0 of the application.

References Section 7.0: Alternatives to the Proposed Activity

NRC, 1981. Storage of Low-Level Wastes at Power Reactor Sites. GL81-38. United States Nuclear Regulatory Commission Executive Director of Operations, Washington, D.C. November 10, 1981.

NRC, 1987. United States Nuclear Regulatory Commission, NUREG-1300, Environmental Standard Review Plan for the Review of a License Application for a Low-Level Radioactive waste Disposal Facility, Office of Nuclear Material Safety and Safeguards, Washington, D.C, April 1987.

NRC, 1991. Staff memo from L. J. Cunningham and P. Lohaus to M. R. Knapp et al dated January 31, 1991. United States Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation and Office of Nuclear Material Safety and Safeguards, Washington, D. C.

TLLRWDA, 1987. Low-Level Radioactive Waste Disposal Facilities: Conceptual Designs and Assessments, Five-volume report prepared jointly by the staff of the Texas Low-Level Radioactive Waste Disposal Authority and Rogers and Associates Engineering Corporation. February 1987.

Section 8 Long-term Effects

8.0 General Introduction

Texas Health and Safety Code §401.113(4) requires a consideration of the long-term effects associated with activities, including decommissioning, decontamination, and reclamation impacts, including the management of low-level radioactive waste, to be conducted under the license. This section of the environmental analysis will consider the current ownership of the proposed low-level radioactive waste disposal facilities, institutional ownership and control of the facilities, financial assurance and the performance assessment.

8.1 Ownership of Proposed Low-Level Radioactive Waste Disposal Facilities

Under 30 TAC §336.710, the institutional information in the application shall include:

> (1) A certification by the State or federal government which will own the disposal site that the State or federal government is prepared to accept transfer of the license when the provisions of §336.721 are met and will assume responsibility for custodial care after site closure and post-closure observation and maintenance;
>
> (2) Evidence that arrangements have been made for assumption of ownership in fee by the State or federal government before the commission issues a license where the proposed disposal site is on land not owned by the State or federal government;
>
> (3) A description of the ownership of the land and fixtures that are part of the proposed disposal site. A plat plan describing the site and identifying the ownership of the surface and subsurface estates must be included. Where portions of the site have been leased or will be leased to others, the terms of the lease agreement must be described; and
>
> (4) A description of the contractual terms and conditions of any agreement for the management or operation of the proposed disposal site.

If an applicant cannot reach a surface use agreement and cannot otherwise obtain fee simple title to the mineral estate of the land on which the facility or facilities are proposed to be located, the applicant may petition the commission to request the attorney general to institute condemnation proceedings as provided under Texas Property Code, Chapter 21, to acquire fee simple interest in the mineral rights as provided under 30 TAC §336.808(c) and Texas Health and Safety Code §401.204(c).

8.1.1 Undivided Ownership of Surface Estate

Waste Control Specialists, LLC (WCS or applicant) has demonstrated undivided ownership of the surface estate where the compact waste disposal facility (CWF) and the federal facility waste disposal facility (FWF) are proposed to be located. General warranty deeds are provided for the applicant's property in Texas and New Mexico, including metes and bounds descriptions for those tracts of land (WCS, 2007a). Survey descriptions of the land in the referenced warranty deeds are also provided (WCS, 2007b).

The general warranty deeds are subject to certain restrictions and encumbrances, including easements and rights-of-way through the area where the disposal facilities are proposed to be located (WCS, 2007c). Two of these restrictions and encumbrances are of special interest. A right-of-way and easement through Section 25 was granted to Sohio Petroleum Company (Sohio) for purposes of constructing and operating a fuel gas pipeline; however, the pipeline was never constructed. Sohio was dissolved as a business entity and British Petroleum (BP) obtained Sohio's interests. WCS has contacted BP in an effort to seek written confirmation that the easement has been abandoned. The application states that BP is in the process of executing a quitclaim deed, which would convey BP's interests in the right-of-way and easement to WCS. Upon receipt and recording, WCS will provide the quitclaim deed to the TCEQ. The second right-of-way and easement through Section 25 was granted to Southwestern Public Service for construction and operation of an electric power line which runs North/South along the Texas-New Mexico border adjacent to the proposed land disposal facilities. The public utility will be able to operate and maintain the power line without accessing or intruding upon the disposal facilities.

8.1.2 Ownership of Mineral Estate

Under Texas Health and Safety Code §401.204(a), an application for a compact waste disposal facility license may not be considered unless the applicant has acquired the title to and any interest in land and buildings as required by commission rule. WCS does not own all of the mineral interests underlying the proposed land disposal facilities. In a petition dated November 29, 2005, WCS is requesting that the TCEQ request that the attorney general institute condemnation proceedings to acquire fee simple interest in the outstanding mineral rights (TCEQ Docket No. 2005-1994-RAW). A licensing order has been drafted stating the application will be conditionally granted upon a demonstration by WCS that the applicant has acquired free and clear title to and all interests in land and buildings, including the surface and mineral estates, of the proposed disposal site, by either having acquired an undivided ownership of the buildings, surface estate, and mineral estate in fee simple through purchase or completed condemnation. The licensing order provides that the license may not be issued, signed, or granted and has no effect until the ownership demonstration required above has been approved by the Executive Director.

An ownership report for Section 25, Block A-29, Public School Survey, Andrews County, Texas was prepared by T. Verne Dwyer of Midland, Texas on February 14, 2007 (WCS, 2007d). WCS currently owns approximately 88 percent interest in the mineral estate as of the date of this report. WCS owns 100 percent working interest in the leasehold estate, except for the Northwest Quarter (NW/4) of Section 25, where they own 81.25 percent. WCS also provides a table showing net mineral acres purchased or acquired by like-kind exchange (WCS, 2007d). This table, along with supporting documentation of correspondence with the remaining mineral owners, demonstrates that WCS has made a good faith effort to obtain fee simple interest to the mineral estate in accordance with 30 TAC §336.808(c).

There are 13 outstanding mineral interest owners identified in Section 25 as of July 2, 2008. WCS currently owns an interest of 73.7 percent in the Northeast Quarter (NE/4) of Section 25, 90.1 percent in the Northwest Quarter (NW/4) of Section 25, and 96.2 percent in the South Half (S/2) of Section 25 (Woodward, 2008). By letters dated February 21, 2006 (Dwyer, 2006) and July 19, 2006 (Woodward, 2006), WCS offered the remaining mineral rights owners $225.00 per net mineral acre for their interests. WCS has also offered like-kind minerals exchanges with the owners in an effort to acquire the remaining mineral interests.

On November 29, 2005, WCS filed a petition with the Office of the Chief Clerk of the TCEQ to request that the commission request the Texas Attorney General to institute condemnation proceedings in order to acquire fee simple interest in the remaining mineral rights (Woodward, 2005). This petition was filed pursuant to Section 401.204(c) of the Texas Health and Safety Code and 30 TAC §336.808(c) which provide that if an applicant cannot reach a surface use agreement with a private landowner, the attorney general shall, on request of the commission, institute condemnation proceedings as provided under Chapter 21, Property Code, to acquire fee simple interest in the mineral right. On March 15, 2007, WCS filed a supplement to its November 29, 2005 petition (Woodward, 2007). WCS contends that a condemnation proceeding will be necessary for WCS to obtain fee simple interest in the mineral estate in accordance with Section 401.204(a) of the Texas Health and Safety Code and 30 TAC §336.808(a).

Numerous title defects were identified for the Section 25 mineral estate. WCS has not provided an abstract of title for Section 25 (Kunihiro, 2006). Remaining title defects are identified in William Burford's supplemental title opinion letter dated February 2, 2007 (Burford, 2007a). By letter dated February 5, 2007, Mr.

Burford also provides an updated list of potential claimants to Section 25 mineral interests if the title defects remain uncured (Burford, 2007b). WCS has made a good faith effort to cure all title defects concerning the Section 25 mineral estate; however, all remaining title defects must be cured before WCS can provide evidence that arrangements have been made for assumption of ownership in fee by the State or federal government. Clear title must be demonstrated before the commission issues a license where the proposed disposal site is on land not owned by the State or federal government in accordance with 30 TAC §336.710(2). WCS has also committed to initiating a legal proceeding in Andrews County District Court to quiet title to WCS' mineral interests in Section 25 (Baltzer, 2007). WCS must quiet title to the mineral rights it already owns to eliminate any potential claimants to the Section 25 mineral interests currently owned by WCS.

WCS has not acquired title to the mineral estate in accordance with Texas Health and Safety Code §401.204. WCS must demonstrate fee simple ownership of the mineral estate on the real property on which the proposed land disposal facilities are located prior to receipt and disposal of waste in the CWF and the FWF. Under 30 TAC §336.207(4), an application may be approved if the commission determines that the applicant has acquired the title to and any interest in land and buildings, including the surface and mineral estates, on which the facility or facilities are to be located by either having acquired:

> (A) An undivided ownership of the buildings, surface estate, and mineral estate in fee simple through purchase or completed condemnation; or
>
> (B) An undivided ownership of the buildings and surface estate, along with an exemption, granted by the commission in accordance with federal law for use of a surface use agreement, in lieu of acquiring fee simple title to the mineral estate.

Because WCS has submitted a request to the commission to request the Attorney General to initiate condemnation proceedings to acquire outstanding mineral interests and the mineral interests have not yet been acquired, the Executive Director recommends a licensing order that conditions final issuance of the radioactive materials license upon acquisition of the mineral estate in accordance with 30 TAC §336.207(4).

References Section 8.1: Ownership of Proposed Low-Level Radioactive Waste Disposal Facilities

Baltzer, 2007. Letter of March 16, 2007 from Rodney A. Baltzer, President, Waste Control Specialists, to Jacqueline Hardee, Director, Waste Permits Division, Texas Commission on Environmental Quality. Response Document to

TCEQ June 30, 2006 letter, Revision 12a. Attachment 1, Page 1-9, Response to Comment No. 1.

Burford, 2007a. Letter of February 2, 2007 from William B. Burford to Waste Control Specialists, LLC regarding Title Opinion No. 33,825. Volume 3, Appendix 1.4, Attachment B, Exhibit J.

Burford, 2007b. Letter of February 5, 2007 from William B. Burford to Waste Control Specialists, LLC regarding Title Opinion No. 33,825. Volume 3, Appendix 1.4, Attachment B, Exhibit J.

Dwyer, 2006. Letter of February 21, 2006, from T. Verne Dwyer to Andrews Royalty, Inc. Offer of Like/Exchange for Mineral Interests and Purchase Mineral Interest. Volume 3, Appendix 1.14, Attachment B, Exhibit A.

Kunihiro, 2006. Letter of March 31, 2006 from Dean Kunihiro to Jacqueline Hardee with attached WCS Responses to Second Technical Notice of Deficiency. Attachment 1, Page 20 of 25, Response to Comment No. 18.

WCS, 2007a. Waste Control Specialists, LLC Application for License to Authorize Near-Surface Land Disposal of Low-Level Radioactive Waste. March 16, 2007. Volume 1, Attachment B.

WCS, 2007b. Waste Control Specialists, LLC Application for License to Authorize Near-Surface Land Disposal of Low-Level radioactive Waste. March 16, 2007. Volume 1, Attachment B, Figures B-1 and B-2.

WCS, 2007c. Waste Control Specialists, LLC Application for License to Authorize Near-Surface Land Disposal of Low-Level Radioactive Waste. March 16, 2007. Volume 1, Section 1, Attachment 1, Exhibit I; and Volume 1, Section 1, Attachment B, Exhibit N, Figure 1.B-2.

WCS, 2007d. Waste Control Specialists, LLC. Application for License to Authorize Near-Surface Land Disposal of Low-Level Radioactive Waste. March 16, 2007. Volume 1, Attachment B, Exhibit N−1.

Woodward, 2005. Letter of November 29, 2005 from Michael L. Woodward to Glenn Shankle with attached Petition to the Commission to Request the Attorney General to Institute Condemnation Proceedings. Volume 4, Appendix 1.19, Attachment B, WCS' Supplement to the Petition to the Commission to Request the Attorney General to Institute Condemnation Proceedings.

Woodward, 2006. Letter of July 19, 2006 from Michael L. Woodward to Ashley Crawford. Offer of Like/Exchange for Mineral Interests and Purchase Mineral Interest. Volume 3, Appendix 1.14, Attachment B, Exhibit A.

Woodward, 2007. Letter of March 15, 2007 from Michael L. Woodward to Glenn Shankle with attached Supplement to the Petition to the Commission to Request the Attorney General to Institute Condemnation Proceedings. Volume 4, Appendix 1.19, Attachment B.

Woodward, 2008. Letter of July 3, 2008 from Michael L. Woodward to Mark Vickery with Second Supplement to the Petition to the Commission to Request the Attorney General to Institute Condemnation Proceedings.

8.2 Institutional Ownership

Disposal of low-level radioactive waste received from other persons may be permitted only on land owned in fee by the State or federal government in accordance with 30 TAC §336.734. The applicant must include certification by the State or federal government which will own the disposal site that the State or federal government is prepared to accept transfer of the license after proper closure of the site and will assume responsibility for custodial care after proper closure and post-closure in accordance with 30 TAC §336.710. The applicant must also include evidence that arrangements have been made for assumption of ownership in fee by the State or federal government before the commission issues a license.

8.2.1 Certification by the State

To satisfy the institutional ownership and control requirements for the CWF, the applicant must include a certification by the State demonstrating that there will be assumption of ownership in fee of the land at license issuance, acceptance of the license after proper closure, and responsibility for custodial care during the 100 year institutional control period. On November 28, 2005, WCS submitted a request for TCEQ certification related to future transfer of license and ownership of WCS' proposed CWF (Dials, 2005a). Other supporting documents filed with the request for certification include sample deed restrictions and a proposed agreement of covenants and restrictions (WCS, 2007a). Pursuant to Texas Health and Safety Code §401.209, on June 12, 2008, Executive Director Glenn Shankle certified that the TCEQ on behalf of the State of Texas will accept transfer of title in fee simple to the land and mineral rights, buildings and compact waste associated with the proposed compact waste disposal facility in Andrews County, Texas. A copy of the signed certification is provided in Appendix A.

8.2.2 Certification by the Federal Government

To satisfy the institutional ownership and control requirements for the FWF, the application must include a certification by the federal government demonstrating that there will be assumption of ownership in fee of the land at license issuance and responsibility for custodial care during the 100 year institutional control period. If the site is owned by the United States Department of Energy (DOE), the license does not need to be transferred. The DOE is considered "self-regulated" under the Atomic Energy Act and is not required to obtain a license from the state for its own work involving materials under the Act. The agreement signed by the United States Secretary of Energy required under 30 TAC §336.909(2) may be used to satisfy the requirements of 30 TAC §§336.734 and 336.710 if it also states that the federal government is prepared to accept ownership of the land on which the federal facility waste is disposed at license issuance and that the DOE will be responsible for custodial care of the site. To date, the DOE has not provided the required certification. Please see the following section on exemption requests for additional analysis of this issue.

8.2.3 Exemption Requests

WCS submitted a request for two exemptions from TCEQ rules with the original application in August 2004 (WCS, 2007a). The first is a request for exemption from the federal facility land ownership requirements set forth in 30 TAC §336.734(a) which states that disposal of waste received from other persons may be permitted only on land owned in fee by the State or federal government. The second is a request for exemption from the mineral ownership requirements. WCS submitted a subsequent request for exemption on March 15, 2007 (WCS, 2007b). A subsequent request replaces WCS' original request for exemption and withdraws the request for exemption dealing with surface-use agreements (Woodward, 2007c).

Federal ownership of the site for the proposed FWF must be demonstrated at license issuance prior to commencement of waste disposal operations. WCS requests an exemption from this requirement to allow WCS to own the property on which federal facility waste is disposed. WCS would then transfer the property on which federal facility waste is disposed to the federal government upon decommissioning. WCS states in their exemption application that the rule requirement is in conflict with Section 401.205(b)(2) of the Texas Health and Safety Code, also cited as the Texas Radiation Control Act or "TRCA," which provides that all required right, title, and interest in land and buildings be conveyed on decommissioning of the licensed federal facility waste disposal activity. Section 401.205(b)(4) of the TRCA requires that before accepting federal facility waste, the CWF license holder shall submit to the commission a written agreement, signed by an official of the federal government, stating that the federal government will assume all required right, title, and interest in land and buildings acquired under commission rules under Section 401.204 for the disposal of federal facility waste. Additional rule requirements can be found at 30 TAC §§336.710 and 336.909(2). WCS submitted a request for a written agreement and certification to United States. Department of Energy (DOE) Secretary Bodman on

November 28, 2005 (Dials, 2005). WCS has not yet obtained a written agreement from the DOE (Baltzer, 2007). The draft license includes a prohibition of acceptance of federal facility waste until such an agreement from the DOE Secretary of Energy is provided. A letter signed by James Rispoh with the DOE, dated March 3, 2008 states:

> The Department cannot, at this time, provide the requested assurance that it will assume all rights, title, and interest in the land, buildings and waste located at the facility upon decommissioning. There are a number of issues that must be addressed before such an agreement can be considered, and before it can be signed by the Secretary (DOE, 2008).

The authority to convey all required right, title, and interest in the FWF to the federal government upon decommissioning rather than upon licensure is contingent upon the granting of the proposed exemption by the TCEQ. In support of the exemption request allowing WCS ownership during the operational phase of federal facility waste disposal, WCS contends: that the exemption is consistent with state law, citing Texas Health and Safety Code Section 401.205(b)(2); that the exemption is consistent with federal law, citing as precedent the consideration and approval by the State of Utah and the United States Nuclear Regulatory Commission of the Envirocare exemption; that WCS' protection of the FWF during the operational phase of the facility will be the equivalent of the protection afforded by ownership by the federal government; that WCS and the State of Texas will control egress and ingress to the facility; that state resident inspectors will provide oversight of the facility; that WCS will record restrictive covenants for the property to prohibit excavation, construction, or other uses of the federal facility or land on which the federal facility will be located; that conveyance or transfer of the license to a third party will require the consent of the TCEQ; and that financial assurance in an amount sufficient to guarantee closure, post-closure care, corrective action, and institutional control will be sufficient to enable transfer of ownership to the federal government.

An exemption from the federal facility land ownership requirements set forth in 30 TAC §336.734(a) may be granted by the commission; however, acceptance of federal facility waste by WCS should be prohibited by license condition until the DOE provides an acceptable written agreement stating that the federal government will assume all right, title and interest in land and buildings for the disposal of federal facility waste in accordance with 30 TAC §336.909(2). The Executive Director has included a draft license condition prohibiting the acceptance of federal facility waste until a written agreement, acceptable to the Executive Director, is provided from the United States Secretary of Energy.

One issue related to the exemption request is whether the exemption from federal ownership requirements is compatible with federal law. WCS states that their request for exemption is somewhat similar to Envirocare of Utah's (Envirocare) request for exemption from governmental land ownership requirements. In that case, the Utah Department of Environmental Health allowed Envirocare to dispose of low level radioactive waste on private property that would never be conveyed to the State or federal government. The U.S. Nuclear Regulatory Commission (NRC) determined that granting the Envirocare exemption did not justify revoking Utah's agreement state status since Utah's regulations provided control of the disposal site equivalent to the control required in 10 CFR §61.59 (Federal Register, 1995). WCS states in their request for exemption that the NRC's decision in the Envirocare matter established precedence on the issue of a licensure applicant's exemption from the requirement of governmental ownership of low-level radioactive waste disposal facilities.

It is difficult to concur with the WCS' analysis that the Envirocare matter establishes precedent. The NRC stated in their policy issue statement SECY-95-152, dated June 13, 1995, that the Envirocare site could be one-of-a kind because of its unique properties (NRC, 1995). Thus, the exemption granted to Envirocare should not be considered as a precedent. NRC staff also stated in this policy paper that if any other State desires to use an exemption provision, a case specific evaluation could be conducted, as was done for the State of Utah. This evaluation has not been conducted by the NRC for the proposed WCS exemption request. Granting WCS' exemption request over objection from the NRC would seem to contradict established NRC policy. This could possibly jeopardize the State of Texas' agreement state program and might also subject the TCEQ to litigation as was the case for the Envirocare exemption. The Executive Director will submit the notice, draft license, draft Environmental Analysis and supporting documents to the NRC to allow an opportunity for the NRC to weigh in on the licensing and exemption decisions.

References Section 8.2: Institutional Ownership and Control of Proposed Low-Level Radioactive Waste Facilities

Baltzer, 2007. Letter of March 16, 2007 from Rodney A. Baltzer, President, Waste Control Specialists, to Jacqueline Hardee, Director, Waste Permits Division, Texas Commission on Environmental Quality. Response Document to TCEQ June 30, 2006 letter, Revision 12a. See Attachment 1, Page 1-2, Response to Comment No. 1.

Dials, 2005b. Letter of November 28, 2005 from George E. Dials, President and Chief Operating Officer, Waste Control Specialists, LLC, to Dr. Samuel W. Bodman, Secretary of Energy. Volume 5, Appendix 1.21.1, Attachment 3.

DOE, 2008. United States Department of Energy. Letter of March 3, 2008 from James A. Rispoh, Assistant Secretary for Environmental Management, to Rodney A. Baltzer, President, Waste Control Specialists, LLC.

Federal Register. Thursday, February 2, 1995. Volume 60, No. 22, Pages 6570 - 6574.

NRC, 1995. United States Nuclear Regulatory Commission. June 13, 1995. Policy Issue (Notation Vote), SECY-95-152, regarding Land Ownership Requirements for Low-Level Waste Sites.

WCS, 2007a Waste Control Specialists, LLC. Application for License to Authorize Near-Surface Land Disposal of Low-Level Radioactive Waste. March 16, 2007. Volume 5, Appendix 1.19.2, Attachment B.

WCS, 2007b. Waste Control Specialists, LLC Application for License to Authorize Near-Surface Land Disposal of Low-Level Radioactive Waste. March 16, 2007. Volume 5, Appendix 1.19.2, Attachment A.

Woodward, 2007. Letter of March 15, 2007 from Michael L. Woodward to Glenn Shankle with attached Request for Exemption. Volume 5, Appendix 1.19.2, Attachment A.

8.3 Site Closure and Decommissioning

Title 30 TAC Chapter 336 Subchapter H describes requirements regarding site closure and decommissioning that must be satisfied in a low-level radioactive disposal application. Title 30 TAC §336.708(11) requires that the application include a decommissioning and site closure plan that contains design features which are intended to facilitate disposal site closure and to eliminate the need for ongoing active maintenance after closure and an estimated date of site closure. Title 30 TAC §336.719 requires that an application amend the license for closure to the TCEQ before final closure or as otherwise directed by the commission. Title 30 TAC §336.730(h) requires that closure and stabilization measures as set forth in the approved site closure plan be carried out as each disposal unit is filled and covered. Title 30 TAC §§336.708(11), 336.718, 336.719, and 336.730(h) require that the application include a complete decommissioning and closure plan. Title 30 TAC §§336.729(b) and 336.730(i) require that the application demonstrate the compatibility of the site closure plan with the facility design and operation. Title 30 TAC §336.727, requires that the application demonstrate that the closure of the facility will meet long-term stability requirements and will eliminate, to the extent practicable, the need for ongoing active maintenance of the site. Title 30 TAC §336.729(b), requires that closure provide reasonable assurance that the performance objectives will be met.

8.3.1 Decommissioning and Site Closure Plan

Appendix 6.1.1-1 of the application contains the format and general description of a proposed Decommissioning and Site Closure Plan. The contents of this plan follow the format as laid out in United States Nuclear Regulatory Commission NUREG-1757, Volume 1. This NUREG categorizes the decommissioning of facilities into seven groups, Group1 through Group 7. This categorization is based on the amount of residual radioactivity, the location of the material, and the complexity of the activities needed to decommission the site. The FWF and CWF may be considered a Group 4 or Group 5. Group 4 is described as facilities using licensed material in a way that resulted in residual radiological contamination of building surfaces, soil, or a combination of both. Group 5 is similar except that groundwater was included in the media being contaminated. Regardless, the contents for both are the same and are as follows:

Site Description

- Executive Summary
- Facility Operating History
- Facility Description
- Radiological Status of the Facility
    - Dose Modeling
    - Environmental Information
    - ALARA Analysis

Program Organization

- Planned Decommissioning Activities
- Project Management and Organization
- Health and Safety Program during Decommissioning
- Environmental Monitoring and Control Program
- Radioactive Waste Management Program
- Quality Assurance Program
- Facility Radiation Survey
- Financial Assurance
- Restricted Use
- Alternate Criteria Decommissioning Plan Update

For each of the topics listed above, the decommissioning and site closure plan provides a general description of what can be expected to be submitted upon closure. The details relevant to each topic are contained in other sections of the application. It is important to note that the decommissioning and site closure plan is a document that may be viewed independently from the application. Changes in the site conditions must be reflected in the decommissioning and site closure plan.

Before final closure of the site, the licensee is required to submit an application to amend the license for closure and include final revision and specific details of the disposal site closure plan originally submitted as part of the application. The Executive Director recommends that the closure plan provide additional details and describe of the activities to be performed with sufficient description of analyses and procedures in closing the site.

Closure cost estimates were developed in the application to estimate the costs to close the facility at various times into the future. Cost estimates included specific activities to be carried out should the facility close unexpectedly. Based on review of the cost estimates, a more detailed plan to decommission and close the facility is necessary. Therefore, a license condition is proposed requiring a detailed decommissioning and site closure plan prior to construction. This plan must include a description of the activities, methods, analyses, etc., required to close and decommission this facility to account for at least one year of activity to be updated periodically. A decommissioning and site closure plan could be developed for *n* years of activity to be updated every *n* years, where *n* is between one and five.

Title 30 TAC §336.719 requires that an applicant submit an amendment to the license regarding closure before final closure. Updates or amendments to the decommissioning and site closure plan must state any newly developed information on site characteristics, additional testing performed on the backfill and waste, proposed revision of plans for decontamination of surface facilities and stabilization of the site for post-closure care.

Furthermore, 30 TAC §336.730(h) requires that closure and stabilization measures, as set forth in the approved site closure plan, be carried out as each disposal unit is filled and covered. Section 6.1.1 of the application indicates that the major closure activities of cover placement and site stabilization will be completed in phases for the majority of the waste disposal units by qualified operations personnel during the 35-year operating period. Therefore, a proposed license condition requires review and revision, if necessary, of the decommissioning and site closure plan following closure of each disposal unit. The application indicates in Figures 4-8 and 4-9 in Section 4 of the application indicate that closure will commence on the first disposal unit at between year four and year eight of facility operations. A proposed license condition requires license amendment for any periodic or final revisions made to the decommissioning and site closure plan.

The decommissioning and site closure plan provided in the application does not include information on decommissioning and closure relating to "mixed wastes." In accordance with 30 TAC 336.733(c), the applicant has requested a permit under 30 TAC Chapter 335, to authorize the receipt, storage, processing, and disposal of industrial solid wastes, including mixed wastes. If a permit is issued to authorize these activities in accordance with 30 TAC Chapter 335, the applicant must close the facility in accordance with the provisions of the industrial solid waste permit.

8.3.2 Compatibility of Facility Design Procedures

Rule at 30 TAC §336.729(b) requires compatibility of the disposal site design and operation with the disposal site closure plan. Title 30 TAC §336.730(i) additionally requires that active waste disposal operations not affect completed closure and stabilization measures. These rules require that the site design and operations be mutually complementary with the site closure plan.

Title 30 TAC §336.729(b) requires that the site design and operations be compatible with the site closure plan. Thus, the site design features should facilitate the execution of decommissioning and site closure plan and the planned operations should facilitate closure.

Factors determining the compatibility of site design are: the stability of the waste and the backfill; the integrity of the concrete barriers; precipitation withdrawal procedures; and the final cover system construction material specifications and placement procedures. Stability of the waste, backfill and concrete barrier, after closure, is discussed in Section 2.1 of the EA. License conditions are recommended regarding leachate collection and testing of the construction material to assure that the cover design is compatible with the closure plan.

Section 6.1.2 of the application provides a summary of the facility design and procedures related to disposal site closure and stabilization of the site after closure. It is required that the site closure plan should be compatible with the design facilities and operations. Thus, the site closure plan must do the following:

- Eliminate to the extent practicable long-term disposal site maintenance;
- Prevent inadvertent intrusion, minimize occupational exposures;
- Utilize disposal site monitoring; and
- Ensure that sizing of the required buffer zones are adequate to allow for monitoring and potential mitigative measures.

Section 6.1.2 of the application indicates any surface drainage features active during operations will be filled to allow storm run-off to drain away from the facility at velocities that will minimize erosion. Erosion protection will be accomplished through a surface layer of durable rocks. Each of these features will alleviate the need for active maintenance due to erosion of the site after closure. Section 6.1.2 of the application also indicates that inadvertent intrusion will be prevented through the incorporation into the facility design of a shotcrete liner, a bio-barrier, security fences, and durable markers.

Also, Section 6.1.2 indicates that occupational exposures during operations will be minimized because an isolation berm is one of the engineered components in the facility design. However, it is unclear if the berm provides adequate protection to workers in the event a disposal cell must be closed during operations. The Executive Director recommends a license condition to address the issue of worker safety in the construction area during the closure of a facility.

Appendix 6.1.2-1 indicates that monitoring of the disposal units will be provided during closure and post-closure. This will be accomplished through visual inspection, weather monitoring, settlement monitoring, infiltration monitoring, leachate monitoring, radiological environmental monitoring, and non-radiological environmental monitoring. The frequency of monitoring decreases as time progresses. Monitoring must be at a frequency sufficient to detect developing defects in the cover and liner systems, and to ensure that the original design assumptions regarding water content remain valid. Thus, The Executive Director recommends license conditions that require specified monitoring frequency and continued operation of all vadose zone monitoring instruments after closure.

The Executive Director also recommends that the effects of on-going operations be considered in evaluating closure and long-term stabilization. The application does not address whether activities implemented during operations, such as compaction of bulk waste material, or the movement of this waste in trucks, will affect the stability of slopes in the closed cells. A license condition is proposed to address the impact of ongoing disposal activities on closed disposal unit stability.

8.3.3 Long-term Stability Requirements

Rule 30 TAC §336.727 requires the closure of the facility to meet long-term stability requirements and eliminate, to the extent practicable, the need for ongoing active maintenance of the site. Section 6.1.2 of the application presents three features of the engineering design that facilitate the long-term stability of the disposal units and the minimization of the need for ongoing maintenance. These features are the structural stability of the waste and backfill, the erosive resistance of the cover, and the minimization of infiltration through the disposal unit cover systems.

An analysis of the structural stability of the site is concerned with whether or not the natural materials within the immediate vicinity of the disposal units and engineered components and disposed wastes in these units maintain their initial configuration after being subjected to varying forces and processes. Appendix 3.4-1 of the application presents an analysis of the structural stability of the site using the continuum mechanics computer code Fast Lagrangian Analysis of Continua (FLAC). A review of this analysis is given in Section 2.3.6 of the EA. The FLAC simulations studied the stresses, strains, and deformations in the natural materials, wastes, and engineered components of the disposal units during the soil-structure interactions induced by settlement, waste placement, excavation of nearby units, degradation of the concrete canisters, and seismic events. These simulations indicated that over the expected life of the engineered components the stresses, strains, and deformations induced by these processes would be negligible. The simulations indicate that the expected settlement in the waste and backfill materials should not affect the performance of the cover or its ability to convey storm run-off. However, the effects of salt dissolution, which is discussed in Section 3.0 of the EA, were not modeled. Therefore, concerns over the stability of the site from salt dissolution or subsidence will be addressed in proposed license conditions.

The application states that the proposed design provides sufficient long-term protection against erosion through the adoption of the recommendations in of the United States Nuclear Regulatory Commission NUREG-1623 and numerical simulations using the computer code SWAT. A description of these simulations is given in Appendix 3.0-3.18 of previous revisions of the application; however, this description was not included in the latest revision of the application. A proposed license condition will require a description of erosion modeling used as the basis for facility design.

Long-term drainage at the site is a function of the structural stability of the site, the erosion at the site, and the infiltration through the disposal unit cover systems. A review of the structural stability modeling provided in the application indicated that ponding due to settlement would not be a problem. Subsidence from salt dissolution was not addressed in the assessment provided in the application of long-term disposal site stability. There is uncertainty regarding site-specific erosion rates presented in the application. Also, the capacity for the drainage layer to direct moisture away from the disposal site may be insufficient. Thus, the long-term stability of the site may be affected by these and other factors. License conditions are proposed to address these concerns.

8.3.4 Demonstrating that Performance Objectives are Met

Title 30 TAC §336.729(b) requires that land disposal facilities be closed to provide reasonable assurance that the performance objectives will be met. These objectives are: protection of the general population, protection of individuals from inadvertent intrusion, protection of individuals during operations and stability of the disposal site after closure.

Dose modeling results presented in the application for the post-closure and institutional control period indicate that the maximum dose to the maintenance worker on-site is 0.4 millirem per year, the maximum dose to the individual at the site boundary is 1.1 millirem per year, and the maximum dose to the nearest resident is 0.0052 millirem per year. The RESRAD modeling presented in the application is not consistent with the site conceptual model, which indicates saturated conditions within 14 to 20 feet of the proposed disposal units. The RESRAD model in the application designates saturated conditions at the 225-foot layer. To address uncertainty in the range of site conditions, both current and future, draft license conditions that require an updated PA and development of a new performance assessment model based on verification of site parameters incorporating current and future site conditions.

Protection from inadvertent intrusion into buried waste is provided by either sufficient depth to waste burial or by an intruder barrier. Design features help ensure the stability of the waste and backfill material. The engineered components of the cover systems also serve to minimize infiltration and provide long-term stability of the disposal unit. The engineered components of the cover system, such as a concrete barrier help protect against inadvertent intrusion.

Section 6.1.2 of the application states that protection to individuals during operations will be provided by an isolation berm. The application also states "during the operational period, the perimeter berm, drainage channels, and final cover over closed cells will be routinely monitored in accordance with the operations monitoring program. Should excessive erosion be identified during this period, the erosion will be repaired and control features modified…." It is unclear the method by which the cover will be monitored, including erosion, on closed disposal units while operations are ongoing. Additionally, potential exposure originating from nearby open disposal units was not identified as a consideration in the closure discussion of the application.

Section 6.1.2 of the application states that stability of the disposal site after closure will be accomplished by the following:

- Design features ensuring the stability of the waste and the backfill;
- The integrity of the concrete barriers;
- The incorporation of effective precipitation withdrawal procedures;
- Erosion resistant cover layers; and
- Adherence to final cover system construction material specifications and placement procedures.

Section 5.3.3 of this analysis discusses the long-term stability of the site. Uncertainty regarding the stability of the site after closure remains with regards to salt dissolution, erosion modeling, and the future location of the water table.

8.3.5 Waste Generated During Closure Period

An applicant proposing to dispose of low-level radioactive waste must not only consider waste characteristics during operations but must also consider waste that will be generated during the closure period. The waste characteristic information should be the same as that provided for operational waste, namely, information on the physical, chemical, and radiological characteristics. During the closure period, waste can be expected to be generated from decontamination and decommissioning of surface structures and equipment. This waste may include personal protective equipment (PPE), tools, debris from demolition of buildings and structures, soil, concrete, and equipment that cannot be decontaminated. Additional information should be provided on closure costs and any impacts from closure activities.

TCEQ staff has reviewed the information submitted in the application on waste generated during closure. Section 8.2.3 of the application states that routine operating procedures and decontamination procedures prior to closure will ensure that no residual radioactive contamination is present above regulatory limits and that no waste will be generated during closure. Routine operating procedures and decontamination procedures cannot be relied upon to ensure that no contamination will remain after decommissioning; it is likely that waste will be generated during closure. This waste must be managed appropriately and the estimates of the volume of waste to be disposed in the CWF and in both the FWF-CDU and FWF-NCDU must be adjusted accordingly.

Before final closure of the proposed disposal site, an application for license amendment must be submitted for closure. This closure amendment application must include a final revision and specific detail of the disposal site closure plan. The Executive Director recommends license conditions to address closure requirements and waste generated during closure from decontamination activities.

8.4 Post-Closure and Institutional Control

Title 30 TAC §336.720(a) states that following completion of closure, the licensee shall observe, monitor, and carry out necessary maintenance and repairs at the disposal site until the site closure is complete. Furthermore, 30 TAC §336.731(c) states that the licensee shall maintain a monitoring system, which should be capable of providing early warning of release of radionuclides and chemical constituents before they leave the disposal site boundary. The intent of post-closure is to allow a period of time for the licensee to conduct surveillance and maintenance of the site and facilities in preparation of transferring the site to the designated custodial agencies. Following that, monitoring and maintenance will be conducted by the custodial agency during institutional control. Appendices 6.1.2-1 and 7.1.1 of the application present a post-closure plan which contains a discussion on the monitoring system and the activities to be performed during post-closure. Appendix 7.2.2 of the application contains a similar plan to be implemented during institutional control.

Appendices 6.1.2-1 and 7.1.1 of the application contain the post-closure plans required in rule. The post-closure period for the CWF will continue for five years. The FWF will dispose of mixed waste and will require a Resource Conservation and Recovery Act (RCRA) permit. Due to these RCRA requirements, the FWF is proposed to have a post-closure period of thirty years since it is planned to accept mixed low-level radioactive waste. Section 7 of the application separates the post-closure plan into two parts: post-closure monitoring and post-closure care.

8.4.1 Post-Closure Monitoring

In Appendix 6.1.2-1, the application states that most of the environmental sampling can be terminated or reduced in the post-closure monitoring period, except for groundwater monitoring. The application states that the remaining monitoring that will be performed consists of surface surveillance and visual walkovers, meteorological data collection, leak detection in the FWF, air sampling, soil and vegetation sampling, and external gamma radiation level monitoring.

The surveillance monitoring proposed in the application consists of periodic walkovers conducted to visually inspect the need for maintenance on the surface of the facilities. These walkovers will check for evidence of erosion, subsidence, settlement, and intrusion. Settlement will be monitored by annually surveying settlement markers placed on the disposal units after closure.

The application proposes that leak detection will monitor performance of the leachate collection system monthly for the first two years of post-closure. After these two years, leak detection will occur on a quarterly basis for years three to five and semi-annually thereafter. If the amount of leachate in the leak detection system exceeds the pump operating level, then the leachate is pumped out and disposed of off-site. Monitoring of the leak detection system will then be conducted for two consecutive months and then decreased to quarterly and semi-annually thereafter. The leachate collection system will pump leachate from both facilities on an as-needed basis. This leachate will be sampled and analyzed to determine the disposition, and then disposed of off-site.

Groundwater monitoring will be provided by the system of groundwater wells discussed in Appendix 2.10.1-2 of the application. Air, soil and vegetation will also be sampled per Appendix 2.10.1-2 of the application. External gamma radiation levels will be measured and recorded using thermoluminescent dosimeters. Meteorological data will be collected on an annual basis during closure, post-closure, and institutional control.

The application proposes to abandon the infiltration monitoring system and decrease the monitoring frequency of leak detection. Abandonment of infiltration monitoring is addressed in Section 2.8 of this analysis. A license condition is also proposed to address the monitoring requirements. Infiltration monitoring coupled with a constant frequency of leak detection would be useful in predicting future performance of the disposal system. A license condition is proposed to conduct leak detection monitoring on a monthly basis during post-closure.

Appendix 7.3.2 of the application discusses the early warning release program and the plan for taking corrective measures. This program establishes investigation limits and action limits used in deciding whether an investigation or a corrective action should be taken.

During post-closure, several maintenance activities will take place. Appendix 7.1.1 of the application lists these activities as:

- Operating the leachate collection system until the permit is terminated;
- Maintaining the integrity and effectiveness of the final cover by repairing the cap from effects of erosion, settlement, subsidence or other events;
- Maintaining and monitoring the leak detection system;
- Maintaining and monitoring the groundwater monitoring system; and
- Protecting and maintaining the surveyed benchmarks and fencing surrounding the facilities.

The application does not consider these activities as active maintenance.

8.4.2 Institutional Control

Appendix 7.2.2 of the application contains the institutional control plan. Institutional control is the period in which a custodial agency will maintain and monitor the site for a maximum period of 100 years to assure that performance objectives are being met. Activities to be performed on site include site surveillance and site care. Institutional control of the CWF will be conducted by the State of Texas. Institutional control of the FWF will be conducted by the United States Department of Energy.

The application states that monitoring of the site during institutional control is similar to that during post-closure. The only difference being that frequency of monitoring will occur on a quintennial basis for the first 20 years and on a decennial basis thereafter. However, there appears to be a discrepancy in the proposed monitoring frequency of the periodic walkovers. Appendices 7.2.2, 6.1.2-1, and Section 7 of the application indicate that walkovers will occur on a semi-annual, biennial, and quintennial basis, respectively. A license condition is proposed to require walkovers on a semi-annual basis during institutional control. Furthermore, the same monitoring conducted during post-closure should also be conducted during institutional control. That is, infiltration monitoring and leak detection should continue at the same frequency of post-closure.

Care during the institutional control period cannot be construed to be active maintenance per 30 TAC §336.727. Thus, activities to be conducted during institutional control include the following passive activities:

- Repairing fences;
- Repairing or replacing monitoring equipment;
- Reestablishing vegetation;
- Repairing erosion, subsidence, or other damages to the cover; and
- Maintaining the grounds of the site by mowing grass and removing deep-rooted vegetation.

8.5 Corrective Action

In accordance with 30 TAC §336.738(a) an application to dispose of low-level radioactive waste must address unplanned events that pose a risk to public health, safety, and the environment that may occur after the decommissioning and closure of the compact waste facility (CWF) or federal facility waste disposal facility (FWF). An application to dispose of low-level radioactive waste must include a plan for taking corrective action, as outlined in 30 TAC §336.731(d) which states, if migration of radionuclides and chemical constituents indicate that the performance objectives in 30 TAC Chapter 336 Subchapter H may not be met, including but not limited to 30 TAC §336.723. The corrective action plan should identify all possible system failures, including most costly corrective action scenarios, and the appropriate corrective measures and how they will be implemented. The plan should also include cost estimates for the full range of potential failures. A sampling and analysis plan, through appropriate statistical methods, should identify action levels prompting a graded approach for corrective action for both radionuclides and chemical constituents in air, surface water, groundwater, soil, and leachate. In addition, the plan should also describe, by modeling or calculations, the impacts to workers or any member of the public from a potential release and how the performance objectives including, but not limited to, 30 TAC §336.723 will continue to be met.

The application must address unplanned events, through modeling, that may occur after site closure and potentially harm human health or the environment. Unplanned events include, but are not limited to, geological phenomena, such as earthquakes, and accidents and/or failure of the disposal system components that leads to a release of radioactive material into the environment. These events should be evaluated, modeled, and quantified to determine the impacts, if any, to the environment or nearby receptors.

Appendix 3.4-1 of the application included an analysis of unplanned events and failures of the disposal system components. Conclusions on seismic events and failures of the disposal system components can be found in Section 6.4.2 of the application. Appendix 7.3.2 of the application contains possible failure scenarios of the disposal system. TCEQ staff's analysis of possible failure scenarios requiring corrective action can be found in Section 8.5.1 below. Section 8.0, Appendix 8.0-3 and Appendix 8.0-6 of the application contains information and modeling addressing long-term performance of the disposal site. TCEQ staff's analysis of long-term performance can be found in Sections 8.6, 8.11, 8.12, and 8.13 of the EA.

TCEQ staff has reviewed the analyses of unplanned events submitted in the application. Section 7.3.1 of the application states that releases to the atmosphere can only occur if all of the cover system components fail and, furthermore, that releases to groundwater can only occur if all of the cover system components fail plus the shotcrete and clay liner fail. Releases could occur by other means. For example, groundwater could potentially intrude into the waste from below the disposal unit or from the side, leaving the cover intact. This potential situation is further discussed in Section 8.11 of the EA. After approximately 500 years, it is assumed that the cover and liner system, and canisters have failed and reliance is placed on site characteristics for continued isolation of the radioactive waste (NRC, 2000). The application references Sections 7.4 and 7.5 of Appendix 7.3.2, apparently addressing corrective action costs and independent failures of the cover system and the clay liner, respectively. However, Sections 7.4 and 7.5 of Appendix 7.3.2 are not in the current application and either do not exist or have been removed by the applicant upon revision.

8.5.1 Corrective Action Plan

TCEQ staff has reviewed the Corrective Action Plan submitted in the application. Sections 5.3.8 and Appendix 7.3.2 of the application provide general information on potential failures and the resulting corrective measures. The application states that a specific corrective action plan will be developed once a failure is discovered and that any corrective action taken will be of a scale and method appropriate to the situation. There is no discussion of, or reference to, potential impacts to workers or members of the public from a failure or release in Appendix 7.3.2 of the application. Although not specifically delineated for to radioactive waste, the United States Environmental Protection Agency (EPA) publication, RCRA Corrective Action Plan, is an example of an acceptable guide and outline for addressing corrective measures (EPA, 1994).

The application's methodology for identifying possible corrective action scenarios contained an error in the conversion of units from cubic feet to cubic yards affecting the percentage of excavated materials from the failure scenario that would need to be shipped off-site for disposal. The determination of the most costly corrective action scenario is driven by the cost associated with the chosen percentage of excavated material that would need to be shipped off-site. Appendix 7.3.2 of the application assumes that only 20 percent of the waste excavated in a failure scenario in the FWF-NCDU will need to be transported to the federal Nevada Test Site as the most costly corrective action scenario. There is no discussion provided in the application regarding the assumption that 20 percent of the waste that is expected to be generated by the necessary corrective action will be disposed off-site in a correction action scenario. When the application provides more detailed cost estimates for corrective action in Appendix 7.3.3, it assumes no amount of excavated material would need to be shipped off-site for disposal. Rule 30 TAC §336.738 states that the amount for corrective action financial assurance will be determined by the Executive Director. Additional analysis of these cost estimates for the possible corrective action scenarios can be found in Section 8.14.6 below.

Appendix 7.3.2 of the application references the Radiological Environmental Monitoring Plan (REMP) and discusses statistical methods for deciding if a release from the disposal units has occurred. Leak detection and leachate management are discussed in the application, but are not mentioned in the REMP to indicate the frequency of monitoring that is proposed.

References Section 8.5.1: Corrective Action Plan

EPA, 1994. United States Environmental Protection Agency, EPA/520-R-94-004., RCRA Corrective Action Plan. U.S. OSWER Directive 9902.3-2A. Office of Solid Waste, Washington, D.C., May 1994.

8.5.2 Wastewater/Leachate Management

Appendix 7.3.2 of the application states that during the operational period leachate will be managed under a Texas Pollutant Discharge Elimination System (TPDES) permit and that during the post-closure period all leachate will be disposed off-site, thereby not requiring a TPDES permit. Section 5.4.1.4.3.5 of the application further discusses leachate management during operations and states that Texas Department of State Health Services (TDSHS) will provide radionuclide concentration limits for the TCEQ Wastewater Permitting Section in accordance with 25 TAC §289.101(h). The application does not mention compliance with 30 TAC §336.359, Appendix B, Table II, Effluent Concentration Limits. In addition, the application does not contain detail on sampling and analysis of wastewaters during operations.

All leachate and wastewater containing radionuclides must be managed in accordance with the effluent concentration limits at the release point at the boundary of the restricted area specified in 30 TAC §§336.314 and 336.359, Appendix B, Table II at any time, if water is intended to be discharged to the environment. Although the application states that leachate will be managed under a TPDES permit, there is no discussion about treatment methods for leachate that contains both radioactive and hazardous constituents in preparation for possible discharge. Additionally, both radioactive and hazardous constituents planned for acceptance into the disposal units may be soluble and cannot be removed by conventional treatment methods. However, no discussion was provided on possible treatment for soluble radioactive constituents. Most treatment methods generate a secondary waste stream, such as a spent resin, so that information on sampling and disposal of these secondary waste streams is necessary.

The application does not provide any information on action levels for the leachate that will initiate an investigation to determine the nature, extent, and cause of elevated radionuclide concentrations.

Therefore, the Executive Director proposes license conditions to require the applicant to manage all wastewaters and leachate in accordance with a TPDES permit, requirements of 30 TAC §336.359, Appendix B, Table II, Effluent Concentration Limits, and conditions of the draft license. Additional conditions require the initiation of an investigation if concentrations of radionuclides in the leachate are greater than 50 percent of the limits established in 30 TAC §336.359, Appendix B, Table II, Effluent Concentration Limits.

8.6 Performance Assessment

The applicant's analysis of Performance Assessment (PA) should address all potential exposure scenarios and pathways, and the resulting radiological impacts to nearby receptors. The essential elements of the PA include a description of the site and the engineered system proposed for disposal, an understanding of the events likely to affect long-term facility performance, a description of the processes controlling the movement of radionuclides from the disposal units to the environment, a computation of doses to members of the public resulting from releases, and an evaluation of the uncertainties in the computational results.

Performance assessment (PA) for a low-level radioactive waste disposal facility is a quantitative analysis used for demonstrating compliance with the performance objectives of 30 TAC §336.723. These performance objectives are 30 TAC §336.724, Protection of the General Population from Releases of Radioactivity, 30 TAC §336.725, Protection of Individuals from Inadvertent Intrusion, 30 TAC §336.726, Protection of Individuals during Operations, and 30 TAC §336.727, Stability of the Disposal Site after Closure. In meeting the performance objectives in 30 TAC §§336.724, 336.725, 336.726, and 336.727, the applicant shall provide the following information:

- Data used for demonstrating compliance with performance objectives;
- How data was collected;
- Development of conceptual model(s);
- Defining scenarios and pathways;
- Selection of appropriate mathematical model(s) and code(s);
- Calibration of the model(s)/code(s) and the data output from execution of the code(s);
- Sensitivity and uncertainty analyses; and
- Determination of site adequacy in meeting the performance objectives.

As part of demonstrating that performance objectives can be met, an application must provide site-specific data related to area and site characteristics including ecology, geology, seismology, soils, topography, surface hydrology, hydrogeology, air quality, natural background radiation, meteorology, climatology, and demographics. The data used for demonstrating compliance must be representative of current conditions and sufficient for modeling future conditions. Data collected must be obtained from site-specific environmental monitoring in all media and from characterization investigations. Monitoring data must be collected, analyzed, and reported following the appropriate quality assurance/quality control (QA/QC) and chain of custody protocols for the given analytical method. In the absence of site-specific data, literature values may be used if they can be demonstrated to be conservative and representative of site conditions.

A detailed description of the disposal system along with all available data should be used to develop the site-specific conceptual model taking into account important site features and processes. The conceptual model should include only the conservative assumptions or conditions that cannot be refuted by site-specific information or data. The term conceptual model refers to a model that represents all of the major atmospheric and hydrogeological characteristics of the site, as well as the influence of the components of the disposal system, such as impermeable barriers or concrete thickness. Eventually, the conceptual model is put into a form that can be mathematically modeled. Various levels of complexity should be considered depending on the purpose of the analysis. For instance, the initial screening assessments may be simple and conservative. Depending upon the model results, less conservatism may be appropriate and greater detail may be necessary to model the true complexity of the natural and/or engineered system. All conceptual model assumptions and their technical bases should be discussed in the license application along with how the models incorporate or account for important disposal site features and processes.

Part of the demonstration of meeting performance objectives includes modeling of current and future scenarios and choosing the appropriate pathways for each scenario. Scenarios and pathways analysis should cover a broad range of situations beginning with a conservative bounding analysis that serves as a point of departure in which only the most unlikely scenarios are eliminated. Justification should be provided for those scenarios and pathways that are deemed implausible and therefore eliminated from further evaluation. Scenario conservatism should provide reasonable assurance that the performance objectives in the above TCEQ rules will be met.

Modeling of current and future scenarios should be performed with mathematical models or computer codes that are capable of representing the site conceptual model. The model or code should adequately account for the design structure and site characteristics, while simulating the migration of radionuclides and potential doses to workers and members of the public. If both mathematical models and computer codes are used, a description should be provided in the application on how the two were integrated and the assumptions used.

Models or codes should be calibrated by replicating site-specific measurements. The calibration should demonstrate that the model or code accurately describes current physical conditions at the site. This is done by trial-and-error adjustment of parameters and then verified by performing model runs of the site.

Parameter sensitivity analysis is conducted in order to identify those parameters that have the greatest effect on dose. Parameter analysis is dependent on physical parameters including variability between and within sub-populations of data, factors influencing variability, the range of parameter variation, and how the variability affects the final result. The results should explain how the conceptual model and parameter values provide a reasonable simulation of the proposed land disposal facility's ability to maintain radionuclide releases within acceptable limits for a range of site conditions.

Performance assessment results should be compared to the regulatory requirements in 30 TAC §336.723 and provide that the site meets the performance objectives. Use of models and codes inherently introduces uncertainty in the results. This uncertainty becomes important when modeling gives results near regulatory limits, possibly rendering the modeling results ambiguous in a regulatory context. This may necessitate selection of a different, more flexible model or code to help facilitate less ambiguous results.

In addressing uncertainty, the application should include a discussion on specific variables, parameters, and models that have the greatest effect on dose.

Quantification of uncertainty involves either a deterministic or probabilistic approach. A deterministic approach is a single estimate of performance, usually a conservative bounding estimate. If performance is measured against a single estimate, uncertainty is addressed by providing reasonable assurance that this estimate conservatively bounds performance. A probabilistic approach is used for more complex analyses that involve a large number of parameters. In a probabilistic approach, each parameter is assumed to be a random variable characterized by a probability distribution function. From the available set of distribution functions, sets of parameter values are repeatedly generated and used as input into the code to generate a distribution of output values. The peak value of the output distribution representing dose is used as the best representation of dose to the average member of the impacted group. The peak of the mean doses over time must be less than the performance objective of 25 millirem per year total effective dose equivalent (TEDE) and 95 percent of the doses at any discrete time should be less than 100 millirem per year TEDE.

Section 8.1.1 of the application states that dose calculations relied on site characteristics, such as meteorology, geology, hydrology data, and also waste inventory information. The two proposed waste disposal units, federal facility waste disposal facility (FWF) and compact waste facility (CWF), are to be founded to depths of 120 and 85 feet, respectively, within fine-grained, stratified, subsurface materials known as the Dockum Group. At the proposed site, the Dockum Group is overlain by approximately 10 to 30 feet of Ogallala, Antlers, and Gatuña (OAG) materials, which extends from the top of the Dockum Group to the ground surface. Thus, once the proposed facility is constructed, the disposed waste will be at an elevation lower than the OAG formation. The acronym used in the application, OAG, denotes that the composition of the formation overlying the Dockum consists of a mixture of materials that exist nearby as separate and distinct formations: the Ogallala, Antlers, and Gatuña.

According to the site hydrogeologic conceptual model presented in the application, there appear to be two water tables in the immediate vicinity of the proposed disposal facility. The first is a water table present within the OAG materials above the elevation of the proposed FWF and CWF disposal units. The characterized saturated conditions in the OAG can be described as a "perched" water table as these conditions appear to extend downward only to the contact of the OAG and Dockum materials. While the data presented in the application indicate that the OAG water table currently lies outside the lateral boundaries of the proposed disposal units, the precise current lateral extension of that water table remains uncertain.

The second water table is in the Triassic red bed materials forming the upper reaches of the Dockum Group and has continuous lateral extension across the entirety of the proposed site while exhibiting a variable depth beneath the OAG materials. The conceptual model presented in the application describes this water table as everywhere beneath the bottom of the proposed disposal units. The application states that saturated conditions are no closer than 14 feet from the bottom of the deeper of the proposed FWF disposal units. According to the application, this second water table would not intersect either of the FWF and CWF. Saturated conditions in the form of a capillary fringe usually exist above a water table in fine grained materials; the estimated depth of 14 feet given in the application apparently accounts for the capillary fringe above the lower water table.

The site hydrogeologic conceptual model describes saturated conditions as existing everywhere below the second water table, throughout the depth of the Dockum Group and beyond, into deeper formations. However, because of the lateral extent of the proposed disposal facility, there is some uncertainty in the precise depth of that water table across that extent, especially in areas near the boundaries of the facility where characterization data becomes relatively sparse.

The application presents the results of a numerical model intended to estimate the future location of the OAG water table. After approximate calibration to current OAG conditions, the OAG predictive model was used to develop simulations of the evolution of those conditions in response to future climate change. These simulations indicated that without some form of modification of the local site topography (in the application this modification is termed "playa intervention") that the lateral extent of the OAG groundwater will increase and intersect the lateral boundaries of the proposed FWF disposal unit within the period of analysis. The playa intervention proposed in the application would consist of filling playas in the immediate vicinity of the proposed disposal units with clay excavated from the units (to reduce recharge into the playas) and grading the surfaces of the filled playas to direct surface water away from the disposal units.

The application contains no explicit prediction of the future location of the second water table in the Dockum Group. Additional discussion on the site conceptual model and groundwater hydrology can be found in Section 6.6 of this analysis.

Table 8.3-1 of Section 8.3 of the application provided analysis of 27 different scenarios during normal operations, ten different scenarios during the institutional control period, 25 different scenarios during the post-institutional control period, and 12 accident scenarios for demonstrating compliance with performance objectives of 30 TAC §336.723. Section 8.1.1 of the application states that appropriate scenarios and pathways were selected based on site geology, hydrology, demographics, design, and disposal site characteristics.

Of the 27 different performance assessment scenarios provided in the application, five different groundwater scenarios were evaluated. The scenario descriptions provided in the application are outlined below. The groundwater pathway scenarios are given greater consideration in the EA due to the significance of this pathway as the main contributor of dose to a receptor. As described in the application, the pathway listed below include the assumptions for each pathway used in the RESRAD modeling provided in the application.

Pathway G1 – This scenario assumed leaching and groundwater transport through the red beds to a well screened in the OAG formation above the red beds. This pathway was included in the detailed analysis. It evaluates the potential doses from leaching of radionuclides from the disposal units and their transport to groundwater. Leaching of the radionuclides from the buried waste is assumed to occur in the presence of water that may enter the disposal units through the cover system. The contaminated leachate is assumed to migrate horizontally through the red beds to a local depression in the red bed surface south of the disposal units. The leachate travels horizontally through the red beds to a location where the red beds discharge to the overlying alluvial materials of the OAG formation approximately 460 meters for the CWF and 1,250 for the FWF. The leachate flows into a localized region of perched water above the red beds. It is further assumed that an individual screens a well in the zone of perched water and withdraws water for drinking and livestock watering.

Pathway G2 – Leaching and groundwater transport through the 125-foot zone to a well screened above the red beds. This pathway was included in the detailed analysis. This pathway considers the potential doses from leaching of radionuclides from the disposal units and their transport to groundwater. Leaching of the radionuclides from the buried waste is assumed to occur in the presence of water that may enter the disposal units through the cover system. The contaminated leachate is assumed to migrate horizontally through the sandstone of the 125-foot zone. The zone is assumed to be continuous across the site. While the 125-foot zone appears to be unsaturated at all locations, it is assumed to provide a pathway with greater hydraulic conductivity than the red bed clay. Leachate is assumed to travel horizontally through the sandstone to a point where it subcrops to the OAG formation and enters a region of perched water on top of the red beds approximately 1,000 meters for the CWF and 1,100 meters for the FWF. This pathway is included because it represents a very conservative approach to modeling radionuclide transport away from the disposal units through a shallow zone of higher permeability than the red beds.

Pathway G3 – Leaching and groundwater transport to a well screened in the 225-foot waterbearing zone. This pathway was included in the detailed analysis. It evaluates the potential doses from leaching of radionuclides from the disposal units and their transport to groundwater in the 225-foot layer. Leaching of the radionuclides from the buried waste is assumed to occur in the presence of water that may enter the disposal units through the cover system. The contaminated leachate is assumed to migrate downward through the red beds to the sandstone layer at a depth of about 225 feet. It is assumed that an individual screens a well in the 225-foot formation and withdraws water for drinking and livestock watering. This formation was selected as the primary groundwater pathway because it is the shallowest sandstone zone that is both continuous and fully saturated across the site. It is the same formation in which groundwater monitoring wells will be installed. Like the previous pathway, the potential exposures assumed in pathway G3 are also unrealistic because it is unlikely that a domestic well would be screened in the 225-foot zone. The hydraulic conductivity of the formation is very low (less than 1.0E-7 cm/s). One estimate of the pore water velocity in the formation is about 0.007 ft/yr. The expected yield from a well in the 225-foot formation (a few gallons per day) is too low to supply the water needs of a residence, much less crop irrigation. It is more likely that a domestic well would be screened in deeper formations, such as the Trujillo sandstone at 600-foot depth or the Santa Rosa Formation at depths of 1,000 feet or more. However, in order to conservatively estimate the potential groundwater doses, the 225-foot zone was assumed to provide enough water for drinking and livestock watering.

Pathway G4 – Leaching and groundwater transport to a well screened in the Trujillo sandstone at a depth of 600 feet. This pathway was eliminated from the detailed analysis because it is bounded by Pathway G3. Pathway G4 considers the potential doses from leaching of radionuclides from the disposal units and their transport to groundwater at a depth of about 600 feet. Leaching of the radionuclides from the buried waste is assumed to occur in the presence of water that may enter the disposal units through the cover system. The contaminated leachate is assumed to migrate downward through the red beds and sandstone interbeds to a depth of about 600 feet. It is assumed that an individual screens a well in the 600-foot formation and withdraws water for drinking and livestock watering. Potential radionuclide concentrations in the Trujillo will be lower than the concentrations in the overlying 225-foot zone because the additional travel time from the 225-foot zone to the Trujillo sandstone will result in more time for radioactive decay and more dilution as the radionuclides migrate downward. Any potential radionuclide concentrations in the 600-foot zone would be lower than in the 225-foot zone and would occur at a later time. Therefore, Pathway G4 is always bounded by Pathway G3.

Pathway G5 – Leaching and groundwater transport to a well screened in the Santa Rosa formation. This pathway was eliminated from the detailed analysis because it is bounded by Pathway G3. Pathway G5 considers the potential doses from leaching of radionuclides from the disposal units and their transport to groundwater in the Santa Rosa Formation at a depth of approximately 1,100 feet. Leaching of the radionuclides from the buried waste is assumed to occur in the presence of water that may enter the disposal units through the cover system. The contaminated leachate is assumed to migrate downward through the red beds and siltstone/sandstone interbeds to the Santa Rosa formation at a depth of 1,000 feet or more. It is assumed that an individual screens a well in the Santa Rosa formation at this depth and withdraws water for drinking and livestock watering. Potential radionuclide concentrations in the Santa Rosa will be lower than the concentrations in the overlying 225-foot zone because the additional travel time from the 225-foot zone to the Santa Rosa will result in more time for radioactive decay and more dilution as the radionuclides migrate downward. Any potential radionuclide concentrations in the Santa Rosa would be lower than in the 225-foot zone and would occur at a much later time. Therefore, Pathway G5 is always bounded by Pathway G3.

The application states that, in the analysis of these scenarios, the determination was made that pathway's G4 and G5 were eliminated from consideration in the quantitative analysis using RESRAD because they were bounded by the more conservative scenario, G3. The information provided in the application on scenario G1 states that contaminated leachate was unable to travel sufficiently far to reach a receptor during a 100,000 year simulation period. Thus, the shallow horizontal transport pathway through the red bed material was not a credible scenario. The application states that Pathway G2 was also eliminated for the same reasons as Pathway G1.

RESRAD is designed to calculate vertical transport of radionuclides through an unsaturated zone to a water table. In order to model horizontal transport the flow parameters have to be input as an unsaturated zone.

All of the scenarios presented in the application simulate a site where the depth to saturated conditions is 225 feet below the ground surface. However, the scenarios in the application do not include a scenario in which saturated conditions are much closer to the proposed disposal units. TCEQ staff compared the scenarios to site-specific data presented in other sections and reports in the application. This comparison indicates that the RESRAD results presented in the application do not reflect saturated conditions above the 225-foot layer described in other sections of the application. Due to this concern, the Executive Director recommends a draft license condition that requires an annually updated performance assessment which must incorporate site specific data, including additional data as specified in pre-construction requirements of the draft license.

Section 8.1.1 of the application presents the use of different computer codes to simulate the following processes: water infiltration; erosion; radionuclide release and transport; human uptake of radionuclides; and external radiation exposure.

The Residual Radiation Risk Assessment computer code (RESRAD) was used in the application for assessing human uptake of radionuclides as part of performance assessment. RESRAD was presented in the application as the model chosen for conducting the performance assessment and providing demonstration that dose limits are not exceeded. RESRAD incorporates the use of a one-dimensional sorption-desorption ion-exchange leaching model to simulate the transport of radionuclides (DOE, 2001). While this transport model may be conservative, it does not take into account the possible geochemical interactions that may occur between the disposed waste and different materials affecting pH in the disposal units. The RESRAD modeling presented in the application calculates infiltration internally by use of a modeled relationship between input variables - precipitation, evapotranspiration, irrigation, and run-off. Hydrologic Evaluation of Landfill Performance (HELP) was used for determining a range of infiltration rates, that were used in RESRAD by use of the input values described above to determine infiltration. TCEQ staff's evaluation of the use of the HELP model can be found in Section 2.4 of this EA.

Section 6 of Appendix 2.6.1 of the application did provide simulations of radionuclide transport in a fractured vadose zone using the TOUGH2 computer code. An independent analysis of these simulations is provided in Appendix B to this document. Because the application did not demonstrate how the simulations were not incorporated into the dose modeling related to performance assessment, the Executive Director proposes a draft condition requiring an updated performance assessment prior to accepting waste to incorporate modeling that simulates site-specific conditions.

Microshield is a computer model used in the application to determine worker doses during operations. Microshield allows the user to input variables such as time exposed to radionuclides, distance from the source of exposure, shielding to reduce potential doses, source geometry, and the resulting worker doses from a given scenario. In addition, the application used the Soil Water Assessment Tool (SWAT) model for determining current and future erosion of the site. TCEQ staff's analysis on the SWAT results and erosion can be found in Sections 2.4.5, 6.3.8, and 8.11 of the EA.

Section 8.1.1 of the application states that although calibration of models and codes is normally used for complex groundwater models, calibration is not necessary for the simple models used for the PA. The application further states that the models used for the PA provide input parameter values that accurately reflect the current and expected conditions at the site during and after disposal operations. It appears that the models used for PA were not calibrated and used hydrological input parameter values that potentially are not representative of current or future site conditions, specifically, the location of saturated conditions. The Executive Director recommends that models be calibrated.

Section 8.1.1 of the application states that in meeting the performance objectives, a wide range of site data was collected and analyzed to conclusively demonstrate that all the regulatory performance objectives will be met. The application further states that radiation exposure to workers, the public, and intruders will be below all applicable regulatory limits and that the site characteristics, facility design, and operation will be protective of the surficial environment and groundwater. Because the application does not delineate exactly the information input into models and the assumptions used in conducting the PA, uncertainty exists in the use of the RESRAD code, the chosen parameter values, and the calculated radiation doses to the public. Additionally, the site characteristics, facility design, and operation presented in the application contain uncertainty. TCEQ staff attempted to address this uncertainty by conducting independent uncertainty analyses, using RESRAD, on parameters that have the greatest effect on dose. The results of these uncertainty analyses are discussed in Section 8.11 of this EA.

The Executive Director recommends license conditions that require submission of an updated PA prior to accepting waste. This will provide some reasonable assurance that the modeling results use the appropriate level of conservatism in evaluating doses to members of the public. Additionally, the PA is required to be updated annually to reflect changes in conditions, assumptions, received waste, or any other information that could impact facility performance.

References Section 8.6: Performance Objectives

DOE, 2001. United States Department of Energy, Users Manual for RESRAD Version 6. ANL/EAD-4. Version 6. Environmental Assessment Division, Argonne National Laboratories, Argonne, Illinois, July 2001.

8.7 Impacts From Nearby Facilities or Activities

In accordance with 30 TAC §336.728(k), the disposal site will not be located where nearby facilities or activities could adversely impact the ability of the site to meet the performance objectives of 30 TAC §336.723 or significantly mask the environmental monitoring program. If activities involving radioactive material were previously performed on the site, there must be an evaluation of the contribution of those activities that may impact the ability of the site to meet performance objectives.

An applicant proposing to dispose of low-level radioactive waste must consider and evaluate impacts from nearby activities or facilities that could affect the ability of the site to meet the performance objectives of 30 TAC §336.723. The evaluation should include descriptions of the activities, and if they involve radioactive materials, the effects on the environmental monitoring program. If the nearby activities include processing or disposal of radioactive materials, additional dose modeling may be necessary. In addition, an applicant should demonstrate that current and future exploitation of natural resources will not impair the sites ability to meet the performance objective of 30 TAC §336.725, relating to protection from inadvertent intrusion.

The information submitted in Section 8.1.2 of the application evaluates five off-site nearby facilities and two on-site facilities. The five off-site facilities include a quarry, a municipal solid waste landfill, an oil recovery and solids disposal operation, a processing/disposal facility for oil production wastes, and a uranium enrichment facility. The two on-site facilities owned and operated by Waste Control Specialists, LLC, were the RCRA landfill and the recently licensed by-product material disposal facility.

The evaluation provided in the application states that the potential impacts are minimal from the quarry and the Lea County, New Mexico municipal solid waste landfill. The reason cited for that determination is that these facilities do not handle or dispose of radioactive material. There is no evaluation included in the application that eliminates potential radioactive material that either has or could be disposed at the municipal solid waste landfill. Section 8.1.2 of the application states that the oil recovery and solids disposal operation and the oil production waste processor were determined to have no impact because, although they handle oil waste containing naturally-occurring radioactive materials (NORM), the facilities are not located in close enough proximity (one mile and 2.5 miles, respectively). The evaluation presented in the application in Section 8.2.1 further states that the uranium enrichment facility, located one-half mile to the west, will have no impact because routine operations will not generate significant air emissions and liquid effluents will be collected in an on-site impoundment. The application proposes installation of an air monitoring station between the two facilities to detect any airborne releases. The Executive Director recommends a license condition to evaluate potential impacts of any off-site surface impoundments.

The two on-site facilities currently operating on the site area were evaluated and dose modeling was included in the application. The RCRA landfill has accepted radioactive material for disposal that has been previously exempted under 25 TAC Chapter 289. The application in Section 8.1.2 states that the analysis for the RCRA landfill used a radionuclide inventory based on cumulative exempt materials disposed to date in that facility with an additional projection of inventory anticipated until the end of facility life. The by-product material disposal facility has been recently licensed but has not been constructed yet. The evaluation of this facility presented in the application uses the radionuclide concentrations of Silos 1 and 2 Fernald waste, from the DOE remediation of the Fernald, Ohio site, as the inventory for dose modeling the facility and states that these concentrations are the highest known concentrations in this category of waste. Section 8.1.2 of the application states that RESRAD modeling was used to evaluate the 225-foot groundwater pathway, consistent with the PA methodology, and that both facilities showed no groundwater doses for the first 10,000 years after disposal site closure.

TCEQ staff has reviewed the information submitted in the application for demonstrating compliance with the requirements of 30 TAC §336.728(k). It appears that both the RCRA and the by-product material disposal facility RESRAD analyses used conservative estimates of the radionuclide inventories. The evaluation presented in the application for the two on-site facilities does not take into account the possibility that the current or future location of saturated conditions at the site may impact the results.

The Executive Director recommends license conditions that require submission of an updated PA. In addition, it is recommended that effects, if any, from nearby facilities be evaluated as part of the PA, including the impact of any radioactive material in the Lea County landfill and any impoundment planned for the uranium enrichment facility. Additionally, the PA is required to be updated annually to reflect changes in conditions, assumptions, received waste, or any other information impacting performance of the disposal facility.

8.8 Source Term

Source term is characterized by the composition and magnitude of total radioactive material received over facility life, including chemical and physical properties of the radioactive material. The disposal zone, defined as a belowground region within which radionuclides are present in above site background concentration, is the common source term and starting point for all pathways evaluated in performance assessment.

In accordance with 30 TAC §§336.707(6) and 305.45(a)(8)(B)(ii), an application to dispose of low-level radioactive waste must describe the types, chemical and physical forms, quantities, classification, and specifications of the radioactive material proposed to be received, possessed, processed, and disposed of at the land disposal facility. The application should provide sufficient information about the wastes projected to be disposed of at the disposal site to allow for defendable modeling of potential radiological impacts associated with waste disposal. This description must include any prior disposal containing radioactive material at the site. This description must also include performance criteria for form and packaging of the waste or radioactive material that has been previously received and will be received.

8.8.1 Types, Forms, and Quantities of Radioactive Waste

A person proposing to possess, process, and dispose of low-level radioactive waste must provide information on the types, chemical and physical forms, and quantities of waste that will be accepted over the life of the facility. The description should be based on studies or surveys of waste generators. The waste characterization information should provide the following:

- Volumes of waste;
- Types of waste streams;
- Presence of chelating agents;
- How the waste will be classified (Class A, B, C, or containerized Class A) in accordance with 30 TAC §336.362;
- Information on the chemical characteristics;
- Whether the waste must be processed or packaged to meet Land Disposal Restrictions (LDRs) and stability requirements;
- Total radioactivity; and
- A radionuclide inventory for dose modeling.

In addition, an applicant should provide the previously mentioned information for any radioactive waste that has been previously disposed at the site.

TCEQ staff has reviewed the source term information provided in the application. For the Compact Waste Facility (CWF) waste inventory, Appendix 8.0-1 of the application states that waste volume and radioactivity projections were made using TCEQ report, "Texas Compact Low-Level Radioactive Waste Generation Trends and Management Alternatives Study," August 2000; the Texas Low-Level Radioactive Waste Authority (TLLRWDA) application, 1996; and unreferenced U.S. Nuclear Regulatory Commission (NRC) publications. Waste projections are based on a period of 35 years to include all nuclear power reactor decommissioning waste from the Texas Compact. The application states that the CWF will have an operating life of 35 years. The application is requesting the receipt of an estimated volume of 2,800,000 cubic feet of waste with a total associated radioactivity of 4,700,000 curies at the CWF. No mixed waste will be disposed in the CWF. Appendix 8.0-1 of the application states that waste received in the CWF will be classified in accordance with the classification system in 30 TAC §336.362(a). Waste stream types are provided in the application, as well as the physical characteristics of the waste proposed to be received, that fall into three broad categories: utility, non-utility, and decommissioning. The waste characterization information, from references cited in the application, may be outdated and does not necessarily reflect projections based on current waste management practices.

For the federal facility waste disposal facility (FWF) waste inventory, Appendix 8.0-2 of the application states that waste volume and radioactivity projections were made using the United States Department of Energy (DOE) report, "The Current and Planned Low-Level Waste Disposal Capacity Report," Revisions 1 and 2 (DOE 1998 and 2000, respectively). This DOE report estimates a volume of 57,000,000 cubic feet of radioactive waste generated over a 70-year period.

The application projections assume that generation of this volume would occur over a 35-year period due to accelerated clean-up projections by the DOE. The total radioactivity for this projected volume is 16,400,000 curies. Appendix 8.0-2 also states that waste generated by the DOE falls into three broad categories: waste from continuing operations, waste from environmental restoration activities, and waste from other DOE programs. The application is requesting the entire inventory of projected DOE waste for disposal into the FWF inventory, including both low-level radioactive waste and mixed low-level radioactive waste.

The FWF presented in the application will have two separate disposal units; the FWF - Containerized Disposal Unit (FWF-CDU) and the FWF - Non-Containerized Disposal Unit (FWF-NCDU). The application proposes acceptance of Class A bulk low-level radioactive waste and mixed low-level radioactive waste, in the form of soil, rubble, and debris, in the FWF-NCDU. Appendix 8.0-2 of the application states that wastes classified as hazardous must meet land disposal restrictions criteria, including treatment as required, prior to disposal. The application discusses nine treatment technologies that may be employed for meeting land disposal restrictions.

The application provides limited discussion on how stability requirements will be met for bulk waste disposed in the FWF-NCDU that has been treated to meet the land disposal restrictions. Stability of bulk waste is discussed further in Section 2.3.1 of this analysis. The Executive Director recommends a license condition to require placement of rubble and debris in concrete canister.

Also included in the requested waste streams for the FWF, the application proposes acceptance of uranium hexafluoride conversion waste (UF_6) from the DOE for disposal. The application does not describe whether the site is proposing to accept UF_6 waste from existing DOE stockpiles or from an adjacent uranium enrichment facility, Louisiana Energy Services' National Enrichment Facility (LES-NEF), or both. There is no discussion in the application on the assurance or certification requirements for DOE taking ownership of the LES-NEF waste prior to disposal. The NRC is currently evaluating disposal of depleted uranium (DU) as low-level radioactive waste, including its correct classification and methods necessary for evaluation of long-term performance. Appendix 8.0-6 of the application states that since the waste canisters in the disposal units will be filled with grout, a high pH (alkaline) environment will be created in the disposal units. High pH and the existence of potentially saturated conditions in the disposal units in the future may potentially lead to greater mobilization of the UF_6.

The Executive Director recommends license conditions to require additional information on the physical, chemical, and radiological characteristics of waste proposed to be received for disposal. Additionally, the Executive Director recommends a draft license that prohibits the disposal of UF_6 waste.

8.8.2 Waste Characteristics

Based on guidance in United States Nuclear Regulatory Commission NUREG-1199, the following information on waste characteristics should be provided:

- A discussion of the potential for receipt of Compact and non-Compact waste, as well as the conditions for such waste receipt;
- An identification of the major individual waste streams that constitute the majority of the waste volume and activity;
- An identification of the waste streams that constitute the remaining waste volume and activity. These waste streams may be identified in terms of typical waste streams generated by a number of generators (e.g., a waste stream consisting of low-activity waste generated by hospitals);
- Information on the physical, chemical, and radiological characteristics of each waste stream so identified above. This information should include:
  - Annual volumes;
  - Waste class;
  - Average concentrations of the principal radionuclides constituting the waste stream;
  - The chemical and physical form;
  - The presence of chelating agents;
  - Packaging characteristics (e.g., whether the waste will be disposed in a high-integrity container); and
  - Solidification agent. Descriptions of the chemical and physical form should provide information important to an estimation of release rates (e.g., whether the waste stream consists of activated metals, sealed sources, and ion-exchange resins);
- For the information discussed above on waste volumes, an estimate of trends, for example, whether the waste stream will be generated at a constant annual rate, or only occasionally. Waste streams only expected to be generated at a future time (e.g., waste streams associated with decommissioning of a nuclear power plant) should be specifically identified;
- For major generators, any plans to alter waste generation rates (e.g., in volume reduction, decommissioning plans) over the first five years of the operational life of the disposal facility;
- A presentation and discussion of any limitations that will be imposed on waste receipt, form, packaging, or other characteristics that would influence assessments of disposal facility performance. Such limitations could potentially include limitations on total site inventories of radionuclides of concern (e.g., carbon-14, hydrogen-3,

technetium-99, or iodine-129), or requirements on the structural stability of certain Class A low-level radioactive wastes. These proposed limitations will be incorporated into the land disposal facility license as conditions of operation; and

- A summary of the total projected waste volume and radioactivity for each year of the operational life.

An application for low-level radioactive waste disposal should contain information on waste characteristics of the waste proposed to be received for disposal. An application should include information on waste characteristics, including the number and types of waste streams that constitute the majority of the volume and radioactivity of the waste. Detailed information must be provided on the physical, chemical, and radiological characteristics of the waste. Important characteristics include annual volumes, classification of the waste (Class A, B, C, or containerized Class A), total radioactivity and radionuclide concentrations, chemical constituents and the presence of chelating agents, type of packaging (i.e., drum, high integrity container (HIC), etc.), and any stabilization agents or treatment methods that might have an effect on the mobility of radionuclides.

For establishing trends in waste generation, information on generation rates and future projections should be provided in the application. For example, timing of decommissioning of the nuclear utilities in the Texas Compact should be provided. In order to ensure long-term facility performance, information on conditions or limitations for acceptance of certain types of wastes or certain types of radionuclides should be discussed. This might include radioactivity or inventory limits for more mobile radionuclides or restrictions on receipt of waste containing chelating agents.

An applicant should also demonstrate that the waste meets the structural stability requirements of 30 TAC §336.362(b)(2). These additional requirements are found in 30 TAC §336.733(b) and specify that radionuclides with half-lives greater than 35 years and transuranics in concentrations less than ten nanocuries per gram must be placed in reinforced concrete canisters or equivalent containment structures. The use of concrete canisters is to provide stability after disposal, or the compliance with stability requirements in 30 TAC §336.362(b)(2) must be demonstrated by an alternative method. The Executive Director may consider a request for an alternative from this special criterion on a case-by-case basis.

TCEQ staff has reviewed the information provided in the application on waste characteristics. Information is provided on Compact and non-Compact waste receipt. Section 8.2.2 of the application states that waste proposed for receipt that is generated outside the Texas Compact will require approval from the Texas Low-Level Radioactive Waste Compact Commission. The application discusses the waste streams proposed to be received for disposal in the CWF and the FWF and provides information on the types and numbers of different waste streams, physical characteristics, chemical characteristics, and radiological characteristics. All of the waste streams discussed are also classified as Class A, B, C low-level radioactive waste, or containerized Class A in accordance with 30 TAC §336.362.

The application provides a brief discussion on structural stability of waste destined for the FWF-NCDU and states that Class A low-level radioactive waste not classified as "Class A containerized" may be disposed of without a concrete canister, provided that the waste is exempted from the canister requirement and meets the structural stability requirements of 30 TAC §336.362(b). Appendix 8.0-1 of the application further states that stable Class A low-level radioactive waste consisting of soil, debris, or rubble that can be compacted to a stable condition will be disposed without concrete canisters in the FWF-NCDU.

Appendix 8.0-1 of the application states that one of the proposed waste streams, ABSLIQD, for the CWF is aqueous and organic liquids primarily in the form of liquid scintillation fluid. The application further states that the liquids must either be packed in an adequate amount of absorbent or solidified with concrete or grout and that this waste stream is not considered a listed hazardous chemical. Although not all, many commonly used scintillation fluids contain toluene and/or xylene, both of which exhibit hazardous characteristics prior to treatment. In addition, it is not clear in the application as to what the treatment method will be for this waste stream prior to receipt for disposal in the CWF. Packing hazardous liquids in an adequate amount of absorbent will not meet the requirement in 30 TAC §336.362(b)(1)(d). If the waste stream exhibits a hazardous characteristic it may not be disposed in the CWF. The application does provide a list of treatment methods to meet land disposal restrictions and states that waste will be treated by the generator prior to disposal, but does not clearly address waste acceptance criteria for waste that has not been treated by the generator to meet the land disposal restrictions.

The decontamination and decommissioning pressurized-water reactor or decontamination and decommissioning boiling-water reactor waste stream represents waste from the decommissioning and decontamination of nuclear power reactors within the Texas Compact. Appendix 8.0-1 of the application states that these waste streams are not amenable to compaction and no treatment is necessary to meet the waste acceptance criteria. There is no basis for the statement provided in the application that compaction or treatment is not necessary for all decontamination and decommissioning waste. No discussion is provided on how reactor components, such as reactor vessels or steam generators, will be managed for receipt and emplaced in the disposal unit to maintain overall unit stability. No discussion is provided in the application on limitations that would be imposed on waste receipt, other than the waste must meet land disposal restrictions prior to receipt for disposal. Calculations and analyses were provided in the application for the amount of chelating agents projected in the CWF (6.1

percent of the total waste volume) and FWF-CDU (1.4 percent of the total waste volume).

The Executive Director recommends license conditions to address disposal of larger components, such as, reactor vessels and steam generators, and to limit the maximum weight percent of chelating agents contained within waste.

8.9 Operations under Normal and Accident Conditions

Operations at the land disposal facility must be conducted in compliance with the standards for radiation protection is set out in 30 TAC Chapter 336 , Subchapter D, except for releases of radioactivity in effluents from the land disposal facility, which shall be governed by 30 TAC §336.724. Radiation exposures shall be kept as low as is reasonably achievable (ALARA). An application should provide analyses of the protection of individuals during operations including assessments of expected exposures due to routine operations and likely accidents during handling, processing, storage, and disposal of waste. The analyses shall provide reasonable assurance that exposures will be controlled to meet the requirements of 30 TAC Chapter 336 Subchapter D.

Rule 30 TAC §336.708(8) requires an application to contain details on developing, documenting and implementing a radiation protection program sufficient to ensure protection of workers and the public and to maintain radiation doses that are ALARA. The applicant should provide a description for control and monitoring of contamination to personnel, vehicles, equipment, buildings, and the disposal site. Both routine operations and accidents should be addressed. The program description should also include procedures, instrumentation, facilities, and equipment.

The Radiation Safety Program is provided in Section 5.5.2 of the application. This program provides that radiation workers will receive eight hours of classroom training. The technical topics of this training are provided in the application. Radiation workers will require more than eight hours of training time to master the topics listed in the application. In addition to this initial training, the application states that monthly safety meetings and Radiation Safety Officer (RSO) safety audits should be conducted. Monthly safety meetings should be mandatory for all workers and audits should be conducted on all aspects of the Radiation Safety Program.

In order to establish a respiratory protection program that meets the requirements of 30 TAC Chapter 336, Subchapter D, the following procedures need to be developed and submitted to the Executive Director for review. The procedures must include:

- Air monitoring;

- Personnel breathing zone monitoring;
- Medical surveillance;
- Respiratory protection program audits;
- Maintaining breathing quality;
- Training on the use of respirators;
- Fit-testing;
- Respirator selection;
- Inventory and control;
- Storage and issuance;
- Maintenance, repair, testing, and quality assurance;
- Record keeping; and
- Periods of respirator use and relief from respirator use;

Title 30 TAC §336.321(a)(3)(D)(ii) specifies that the licensee's respiratory protection program contain written procedures regarding supervision and training of respirator users. Section 4.1.2 of Procedure LL-HS-10.0 states that training will be provided to affected employees whose job requires them to use respiratory equipment. With respect to the supervision of respirator users, there is no cited section that pertains to procedures for supervision of respirator users. Because the application only provided a statement that training will be provided on use of respiratory equipment, the Executive Director recommends more specificity for those training procedures.

Title 30 TAC §336.321(a)(3)(D)(iii) specifies that the licensee's respiratory protection program contain written procedures regarding fit testing. Section 5.7 of Procedure LL-HS-10.0 in the application is titled to pertain to respiratory fit testing. This section states that employees will be fit tested at the time of initial fitting and at least annually thereafter. Reference is made to Appendix C as the job performance measures for conducting the fit test. Appendix C covers most of the elements expected in a fit test procedure. The Executive Director recommends that the procedures describe in detail the methods for checking the seal of the respirator under use conditions such as head and body movement expected during work activities.

The application states that operations would use National Institute for Occupational Safety and Health (NIOSH) certified equipment and provides a description of the types of equipment that might be used. The Executive Director recommends that the type and number of respirators used to reduce concentration of airborne contaminants be specified for the different areas of the waste disposal operations for normal and emergency use at the facilities.

The application states that training on the use of respirators will be conducted by the Health and Safety Department. The training will include respirator selection, fit-testing, medical evaluation, hazards to respirator users, and competency in donning and removing the respirator. The application indicates that the health and safety manager will designate a competent person to administer the fit-testing procedure. The Executive Director recommends that air monitoring procedures identify the hazards in potentially contaminated work areas at the site and the method for determining the proper selection of respiratory equipment. The application states that the Health and Safety Manager will manage the respiratory program.

Section 5.1 of the application states that respirator selection for work areas will be determined on a case-by-case basis. During respirator training, the users should be informed that they may leave the work area at any time for relief from respirator use in the event of equipment malfunction, physical or psychological distress, procedural or communications failure, significant deterioration of operating conditions, or any other condition that might necessitate such relief. The application did indicate that the worker must have completed a valid fit-test prior to being allowed to wear a respirator. The application also explained that workers will not be assigned to tasks requiring respirator use until a physician has determined that they are physically able to perform the work and wear a respirator. The Executive Director recommends that the respiratory protection procedures specify the limitations on the period of respirator use and state that respirator users are encouraged to seek relief.

Breathing air systems are proposed to be available at the disposal facility. Title 30 TAC §336.321(a)(3)(D)(v) specifies that the licensee's respiratory protection program contain written procedures regarding breathing air quality. The application addresses compressed breathing air and makes statements regarding the requirements for the air (which are the same as specified in rule at 30 TAC §336.321(c). The application proposes to use Grade D air for the breathing air systems. The application states that the breathing air system will be checked "for air quality and content at least quarterly as described in CGA 7.1-1997". The air systems will be equipped with necessary safety and standby devices to minimize contamination of the air system. The Executive Director recommends that the procedures specify how it will be determined that the breathing air quality meets the stated requirements. The Executive Director recommends that the respirator protection procedures specify how respirators will be inventoried and controlled.

Title 30 TAC §336.321(a)(3)(D)(vii) specifies that the licensee's respiratory protection program contain written procedures regarding storage, issuance, maintenance, repair, testing, and quality assurance of respiratory protection equipment. The application states that inspection, maintenance and storage of respiratory equipment will be handled by the Health and Safety Department. The respirators will be cleaned and disinfected in accordance with manufacturers' instruction using automated cleaning equipment. The respirators will be periodically inspected and parts checked for signs of wear. When signs of wear have been observed the worn parts will be changed according to manufacturers' instructions. The application explains that respirators will be stored in a convenient, clean, and sanitary location. The application explained that repairs to the respirator would be limited to replacing components and making adjustments recommended by the manufacturer. Any major repairs to the respirator would be handled by authorized service dealers or the manufacturer. The Executive Director recommends that the respiratory protection procedures specify the location that respirators will be stored, the frequency that respirators will be inspected, and any training that may be required by the manufacturer for repair or service of respirators.

The application indicates that all respirator users would be required to take appropriate training and fitting before using the respirators. Section 4.1.2 of the application indicates that training will be provided for affected employees. There was no indication of how the training would be performed. Also, refresher training was discussed, but no list, outline, or syllabus of the training was provided in the application to understand what will be included in the refresher training. The application states that record keeping will be handled by the Health and Safety Department. All records related to equipment inspections, respiratory protection surveys, job performance fit test and training will be available for review by all interested parties. The records of respirator equipment and the respiratory program should be available to the Executive Director's staff upon request.

Section 336.321(a)(3)(D)(ix) specifies that the licensee's respiratory protection program contain written procedures regarding limitations on periods of respirator use and relief from respirator use. There is a statement in Section 10.7 of Procedure LL-RSP-100 provided in the application that specifies a limit on the amount of time that a person may be in a respirator (four hours without a break, and six hours total for a single day). Since Procedure LL-HS-10.0 is the stated procedure for respiratory protection, any limitation on time of use should be stated in Procedure LL-HS-10.0, or a reference contained in Procedure LL-HS-10.0 as to where such a limit is provided. With respect to relief from respirator use, 30 TAC §336.321(a)(4) requires that the licensee shall advise each respirator user that the user may leave the area at any time for relief from respirator use in the event of equipment malfunction, physical or psychological distress, procedural or communication failure, significant deterioration of operating conditions, or any other conditions that might require this relief. The user should be informed during respirator training that the respirator user may leave the work area at any time for relief from respirator use in the event of equipment malfunction, physical or psychological distress, procedural or communications failure, significant deterioration of operating conditions, or any other condition that might necessitate such relief. Such advice should be incorporated into the applicant's respiratory protection procedures as the means of communicating such to respirator users.

Appendix 5.5.2-1 and Appendix 5.5.2-2 of the application provide the personnel monitoring procedures proposed for the low-level radioactive waste disposal facility. TCEQ staff reviewed the procedures provided in the application. Procedure LL-RS-17, Internal Radiation Monitoring and Bioassay Sampling, was specifically reviewed. The Executive Director recommends that procedures should note specific gravity corrections. It is recommended that a baseline bioassay be conducted on all employees working in restricted areas. Because contamination has been found in unrestricted areas, a license condition is proposed for baseline bioassays on all employees.

Procedure LL-RS-2, Contamination Survey Techniques, was reviewed. The contamination limits (1,000 disintegrations per minute) for step-off pads is excessive. Step-off pads are traditionally clean areas and should not exhibit significant contamination. The Executive Director recommends a license condition to address contamination control related to step-off pads. Procedure LL-RS-4, Documentation of Radiological Surveys provided is proposed to address step-off pad use. The application did not contain a signature line on Form LL-RS-4-1, Radiological Survey Report. Procedures LL-RS-5, Radiological Area Postings and Procedure LL-RS-6, Control of Airborne Radiation Areas were reviewed. The phrase "up-to-date radiological surveys" should be clarified in procedures.

Procedure LL-RS-7, Personnel Contamination Monitoring and Procedure LL-RS-9, Release of Items from Controlled Areas was reviewed. Both of these procedures did not contain signature lines for the individual conducting the surveys. Procedure LL-RS-10, Radioactive Material Receipt, Staging, and Release Surveys, was also reviewed. Section 4.2.6, Page 5 of the procedure states that "100% surveys will be performed." The Executive Director recommends that the procedure specify if 100 percent of vehicles will be surveyed or 100 percent of each vehicle will be surveyed. Procedure LL-RS-16, titled Issue, Collection and Processing of Dosimeters, is provided in the application. The procedure should contain information warning visitors of the potential for discharge of the pocket dosimeter if it is dropped or mishandled.

Procedure LL-RS-17, Bioassay Sampling, was reviewed. As noted previously, it is recommended that all employees have radiological baseline bioassays established. This procedure references quarterly urinalysis. Fecal analysis frequency was not specified in the application. In addition, Form LL-RS-17-3 in Procedure LL-RS-17 should contain a signature line.

8.10 Protection of Individuals During Operations (Performance Objective): Releases of Radioactivity During Accidents and Unusual Operational Conditions

The application must provide information regarding the types, significance, and magnitudes of releases of radioactivity associated with accidents or unusual operational conditions in order to demonstrate meeting the performance objective stated in 30 TAC §336.724. The information should be sufficient to enable analysis of projected radiological impacts to any individual. The analysis must clearly demonstrate that the radiation protection standards in Chapter 336 Subchapter D are met.

Guidance from the United States Nuclear Regulatory Commission (NRC) recommends, at a minimum, that the following categories of accidents be addressed in analysis of operating conditions (NRC, 1983):

- Waste spillage;
- Equipment failure or site worker error;
- Fire and chemical reactions;
- Mishaps involving transport vehicles;
- Nearby site accidents;
- Accidents caused by natural events; and
- Accidents due to design or operations.

An analysis of postulated facility accidents involving radioactive materials was presented in the application. Appendix 8.0-5 of the application provides accident or unusual conditions scenarios that were analyzed. The scenarios cover the operational phase of the disposal facility. The application regards some accidents as unlikely because regulatory requirements or operating procedures and facility design are judged to preclude their occurrence or otherwise limit the release of radioactivity.

The application regards accidents involving mishaps of transport vehicles on the facility to be similar to fire or explosion accidents. Tornadoes, wind storms, and unusual rainfall are expected to produce nominal dose to the worker, the general public or residents. The application states that the blast effects from an explosion are likely to be a much greater concern to a worker than the radiation dose at ten meters from accident.

The application provided analysis of radiological impacts of selected scenarios and estimated doses at ten meters, 100 meters, and 6,000 meters. The ten-meter estimate represents the distance to the nearest worker that could be exposed in an accident scenario. The 100-meter estimate represents the distance to the nearest access point for an individual member of the public. The 6,000-meter scenario represents an estimated dose to the nearest resident.

The application analyzed and dismissed the potential for a release of radiation to the environment as a result of a tornado or flooding. The tornado scenario was dismissed based on evidence from United States Department of Energy (DOE) guidance entitled DOE-STD-1021-93, Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components (DOE, 1994). Appendix 2.3.1 of the application states that two tornados were reported in Andrews County in the last ten years. Therefore, there is a possibility that a tornado could impact the site.

The application dismisses the flooding scenario because the low-level radioactive waste facility is located near the high point of the local topography and above the 100-year flood plain which minimizes the potential for run-on. However, Appendix 2.3.1 of the application states that there have been 12 flash floods reported in Andrews County in the last ten years. Although run-on might be managed during operations, a flash flood could possibly inundate the disposal unit and submerge waste.

The application did not consider accidents near the facility that could affect operations and safety. There was no analysis of the possible impact of brush fires or fires at nearby facilities, such as the fire that previously occurred in the RCRA landfill. A discussion of nearby accidents can be found in Procedure LL-ERP-100 of the application. This procedure discusses postulated accidents involving fire, explosion, material release, vehicle and equipment accidents, and natural events at the facility. So, although there is a procedure addressing the emergency response of these types of accidents, there is no analysis of the potential impact to workers and members of the public.

For each type of accident considered in the application, a bounding accident was selected for analysis that would have the greatest potential for adverse impact on the population both on-site and off-site. The methodology used to model the impact is based on United States Nuclear Regulatory Commission, NUREG/CR-4370 (NRC, 1986). The guidance methodology included release fractions, accident probabilities and dispersion factors.

The results presented in the application are summarized in the Table EA-9. Tables EA-9, EA-10, and EA-11 show the results of hypothetical accidents at the CWF and FWF. The accidents involve the release and dispersion of radioactive material. The results show the exposure to workers, the exposure at the site boundary, and exposure to the nearest resident. The information provided in the application used simplified dose projection equations to calculate the dose to worker, site boundary, and nearest resident. The equations contain Pasquill-Gifford dispersion factors which are used to estimate the concentration of radionuclides at a point downwind from the facility. Input parameters provide a conservative dose estimate for the site. In general, it is better to first approach these types of calculations using conservative parameters to ensure that projected doses are well below the regulatory requirements. If the projections are near the

Table EA-9: Accidents and Unusual Conditions Scenarios

Scenario	Accident or Unusual Operational Condition	Exposure Pathways		Maximum Estimated Dose			Appendix 8.0.3 Reference Sec. 8.0-5
		On-site Workers	Off-site Person and Resident	On-site Workers (10 meters)	Off-site Person (100 meters)	Off-site Resident (6,000 meters)	
Container Breach	A defective drum received on-site results in radionuclide release.	airborne	airborne	(CWF) 23 millirem/ container	(CWF) 2.18×10^{-2} millirem/ container	(CWF) 3.36×10^{-6} millirem/ container	page 9
				(FWF) 674 millirem/ container	(FWF) 2.74 millirem/ container	(FWF) 3.36×10^{-6} millirem/ container	page 9
Equipment Failure	Crane malfunction suspends waste container in air.	dose	dose	90 millirem/ hour	0.89 millirem/ container	7.54×10^{-3} millirem/ hour	page 15
Fire or Explosion	Fire or explosion occurs in a container	airborne	airborne	(CWF) 158 millirem/ drum	(CWF) 2.20 millirem/ drum	(CWF) 3.99×10^{-3} millirem/ drum	page 12
				(FWF) 179 millirem/ drum	(FWF) 2.48 millirem/ drum	(FWF) 4.51×10^{-3} millirem/ drum	page 12
Explosion	Explosion occurs in a container	airborne	airborne	nominal	(FWF) 6.17 millirem/ drum	(FWF) 9.49×10^{-4} millirem/ drum	page 13
Accidents caused by natural events.	Destruction of contaminated structure coupled with tornado or severe winds	airborne	airborne	nominal	nominal	nominal	page 14
Flooding	Unusual rainfall	N/A	N/A	nominal	nominal	nominal	page 15

Table EA-10: Doses from Accidents at the CWF involving a Radiation Worker, Individual at the Site Boundary, and Nearest Resident

	WCS Estimate (in millirem)			**TCEQ Estimate (in millirem)**		
	At 10 meters	At 100 meters	At 6,000 meters	At 10 meters	At 100 meters	At 6,000 meters
Container Drop	2.39	2.18×10^{-2}	3.36×10^{-6}	2.38	2.25×10^{-2}	3.33×10^{-6}
Container Explosion or Fire	158	2.20	3.99×10^{-3}	158	2.20	4.0×10^{-4}

Table EA-11: Doses from Accidents at the FWF involving a Radiation Worker, Individual at the Site Boundary, and Nearest Resident

	WCS Estimate (in millirem)			**TCEQ Estimate (in millirem)**		
	At 10 meters	At 100 meters	At 6,000 meters	At 10 meters	At 100 meters	At 6,000 meters
Container Drop	674	2.47	3.79×10^{-4}	671	2.45	3.76×10^{-4}
Container Explosion	674	6.17	9.49×10^{-4}	6.64×10^{3}	6.10	9.38×10^{-4}
Container Fire	179	2.48	4.51×10^{-3}	152	2.13	3.86×10^{-3}

regulatory requirements then additional sampling and more specific site data is warranted to allow for less conservatism. More accurate site data may result in lower projected doses. Table II below shows the results presented in the application and the results calculated by TCEQ staff. The results are slightly different, but are in good agreement with one another.

Appendix 8.0-5 of the application discusses possible accident scenarios at the Compact Waste Facility (CWF) and the Federal Waste Facility - Containerized Disposal Unit (FWF-CDU) and Federal Waste Facility – Non-Containerized Disposal Unit (FWF-NCDU)). The worst-case accident involves a fire at the CWF and a container breach at the FWF and the airborne release of radioactive material from a 55-gallon drum in that building. When this scenario occurs at the

CWF, the inhalation dose at a distance of 100 meters (perimeter of the facility site) from the accident location would be 2.2 millirem. The worst-case accident at the FWF, the container breach, would produce an inhalation dose at a distance at 100 meters of 2.7 millirem. The application assumes that only one 55-gallon drum is involved in each of the accident scenarios. More than one drum in the accidents discussed would be very improbable. The application assumes that any omitted factors, such as the energy released from the explosion, immersion in an airborne plume, breach or rupture of more than one drum would not increase the exposure to affected individuals.

TCEQ staff reviewed the information provided in the application relating to accident analysis and release of radioactivity on-site and off-site. TCEQ staff re-calculations efforts generally agreed with the submitted results. The results, although they appear to be calculated accurately, are not representative of all the potential accident scenarios at the CWF and FWF. The application did not specify whether the accident scenarios were staged at the FWF-CDU or FWF-NCDU. The application does not contain a number of conceivable and credible accidents that should be modeled for a low-level radioactive waste disposal facility. Not all the inherent uncertainties associated with the quantitative dose estimates were clearly defined or discussed in the application. The application did provide impacts of the accidents considered in the application on the site that would be minor. The analyses of that narrow range of accidents did indicate that radionuclides could potentially be released to the environment beyond the site boundary but with limited impact.

The Executive Director recommends license conditions to provide some assurance that accidents and unplanned releases of radioactive material are minimized and, in the event they do occur, that they are responded to appropriately. There should be modeling and dose estimates of accidents where a larger shipment than a single 55-gallon drum at the CWF, the FWF-CDU, and the FWF-NCDU are completely destroyed and radionuclides become airborne. A single shipment of 55-gallon drums of low-level radioactive waste can contain over 100 drums. Possible accidents should include a breach of other types of containers such as a HIC or a liner, a building fire or explosion in an area where waste is staged, and accidents and/or fire involving a full transportation vehicle moving within the disposal facility.

Calculations and modeling should be performed for the dose to workers, persons near the perimeter of the facility and off-site residents possibly affected by airborne particulates or debris containing radionuclides in more appropriate worst-case accident events at the CWF, the FWF-CDU, and the FWF-NCDU. Also, the calculations should include the external exposure to the affected population as well as any internally deposited dose from the airborne component and deposited radionuclides that may be ingestion.

References Section 8.10: Protection of Individuals During Operations (Performance Objective): Releases of Radioactivity During Accidents and Unusual Operational Conditions

DOE, 1994. United States Department of Energy, DOE-HDBK-3010-94, Airborne Release Fractions/Rates and Respirable Fractions for Non-Reactor Nuclear Facilities., Washington, D.C., December 1994.

NRC, 1983. United States Nuclear Regulatory Commission Regulatory, Guide 4.18, Standard Format and Content of Environmental Reports for Near-Surface Disposal of Radioactive Waste, Office of Nuclear Material Safety and Safeguards, Washington, D.C. June, 1983.

NRC, 1986. United States Nuclear Regulatory Commission, NUREG/CR-4370, Suggested State Requirements and Criteria for a Low-Level Radioactive Waste Disposal Site Regulatory Program. Washington, D.C., January 1986

8.11 Protection of Individuals During Post-Closure, and Institutional Control Period (Performance Objective): Releases to the Environment

In accordance with 30 TAC §336.724, the applicant must demonstrate that concentrations of radioactive material which may be released to the general environment in groundwater, surface water, air, soil, plants, or animals shall not result in an annual dose above background exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, or 25 millirems to any other organ of any member of the public. Effort must be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable (ALARA).

Pathways analyzed in demonstrating protection of the general population from releases of radioactivity including air, soil, groundwater, surface water, plant uptake, and exhumation by animals 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 that there is reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits specified in 30 TAC §336.724. A minimum period of 1,000 years after closure or the period where peak dose occurs, whichever is longer, is required as the period of analysis to capture the peak dose from the more mobile long-lived radionuclides and to demonstrate the relationship of site suitability to the performance objective in 30 TAC §336.709(1) and to the performance objective in 30 TAC §336.724.

An application proposing to dispose of low-level radioactive waste must demonstrate meeting the performance objective of 30 TAC §336.724 which requires a demonstration that concentrations of radioactive material released to the environment shall not result in a dose that exceeds 25 millirems to the whole body, 75 millirems to the thyroid, or 25 millirems to any other organ of any member of the public. In addition, effort shall be made to maintain releases of radioactivity in effluents to the general environment ALARA. In demonstrating compliance, an applicant should develop and use a defensible methodology. This is accomplished by providing a useful decision-making framework for evaluating and defending the appropriateness of data, assumptions, models, and codes used for the performance assessment (NRC, 2000).

An application must identify and analyze relevant pathways that may lead to exposures to the general public from releases of radioactivity. These pathways include air, soil, groundwater, surface water, plant uptake, and exhumation by burrowing animals. The pathways should be evaluated by using calculations or benchmarked computer codes that allow site-specific information to be used. Variability in the data should be addressed by using methods that determine sensitivity of certain parameters and a measure of the uncertainty in the results. Uncertainty can be addressed by using statistical methods, such as Monte Carlo analysis. The mean peak dose for any given scenario must be less than the annual regulatory limit of 25 millirem. Additionally, a minimum period of 1,000 years after closure or the time when the peak dose occurs, whichever is longer, is required as the period of analysis to capture the peak dose from the more mobile radionuclides and to demonstrate the relationship of site suitability to the performance objectives.

8.11.1 Comparison of RESRAD Simulations

TCEQ staff has completed a review and analysis of the materials in the application demonstrating compliance with the performance objective of 30 TAC §336.724, Protection of the General Population from Releases of Radioactivity. The main component of this demonstration is a series of computer simulations using the Residual Radiation Risk Assessment computer code (RESRAD) to estimate peak doses over relevant exposure pathways over 100,000 years. An important part of the TCEQ staff's analysis was the use of RESRAD to not only attempt to replicate the computational results presented in the application, but also to explore the implications of remaining uncertainties in a subset of important RESRAD input parameters. This section of the EA discusses and compares RESRAD simulations completed by TCEQ staff and those presented in the application.

Using identical or similar input parameters to those described in the RESRAD simulations in the application, TCEQ staff was able to replicate the important features of the computed outputs of those simulations. When TCEQ staff utilized the capabilities of RESRAD for completing sensitivity and uncertainty analyses to explore the implications of conservative, but still realistic alterations in the magnitudes and variation of these input parameters, computed peak doses within the period of analysis were not below regulatory limits. The input parameters in question include the source term concentrations, the hydraulic conductivity in the saturated zone, and the erosion rate. The last two of these parameters are given an extensive discussion in this EA. The hydraulic conductivity discussion can be found in Section 6.6.4 of this EA. A discussion of erosional modeling and its role in performance assessment is the concluding paragraph of this section of the EA.

The site hydrogeologic conceptual model implemented in the performance assessment in the application is different, in several respects, from the site hydrogeologic conceptual model presented in the application. TCEQ staff asserts that this difference is indicative of the inherent hydrogeologic complexities of the proposed disposal site and that further site characterization work, beyond that presented in the application is needed to narrow these differences. Also, RESRAD can only simulate the erosion of the disposal cover through an input erosion rate that assumes that rate is constant over the entire period of analysis, which was modeled for 100,000 years. If an acceptable time-history of that erosion rate could be developed, a code capable of implementing a variable rate might give a more realistic simulation of the time at which peak doses occur.

This is not to say that RESRAD is an unsophisticated modeling program. For example, it is capable of modeling sites with multiple layers and of performing sensitivity and Monte Carlo based uncertainty analyses between both correlated, and uncorrelated, input parameters. Effective modeling with RESRAD requires previous experience in its application and extensive knowledge of radionuclides, dose and risk analysis, contaminant transport processes, and statistical analysis. However, the RESRAD code was developed for use as a regulatory screening tool. Its primary intended use was to develop soil cleanup levels at sites having soils contaminated with radionuclides.

While screening tools may be successfully used to simulate processes at complex sites, the usefulness of such tools is compromised when their outputs are on either side of, but close to, regulatory limits. In such cases the importance of inevitable uncertainties in input parameters is magnified, rendering the meaning of model outputs ambiguous. In such cases, the use of non-site specific or default values of input parameters may be inappropriate. Models that can incorporate more realistic, albeit more complex, modeling of the relevant input parameters and radionuclide transport processes, coupled with more focused site characterization efforts, must be considered. Sole reliance on the RESRAD code may interfere in arriving at an appropriate assessment of the performance of the proposed disposal units. The Executive Director also recommends license conditions that require additional, focused, site characterization work to be completed.

The TCEQ performed independent analysis using the RESRAD code to investigate the model used and the results from its use in the application for performance assessment. The performance assessment simulations conducted by TCEQ staff evaluated the resident farmer or resident intruder. This is consistent with the bounding scenario presented in the application. The resident farmer scenario assumes that at the end of the institutional control period a resident intruder moves on site and installs a well in the saturated zone located beneath the proposed disposal units. The scenario also assumes the resident intruder is a possible receptor over the following pathways: external exposure, drinking water, plant consumption, meat consumption, milk consumption, inhalation, soil ingestion, and inhalation of radon. The resident intruder scenario studied in the application assumed a depth of 225 feet to saturated conditions in the Dockum at which point the intruder completes a drinking water well. Appendix 8.0-6 of the application states that irrigation was eliminated from consideration as a sub-pathway because the characteristics of the 225-foot layer limit it's yield of water to a few gallons a day. The performance assessments simulations completed by TCEQ staff assumed these same conditions. Figure EA-10 is an illustration of the resident intruder scenario used in RESRAD simulations.

The site hydrogeologic conceptual model presented in the application (and reviewed in Section 6.6 of this EA) describes a water table at a significant, but variable height above the 225-foot layer and also discusses the possibility of an additional saturated thickness, in the form of a capillary fringe, above that water table. The hydrogeologic cross-section modeled in the application for RESRAD may not be as conservative, with respect to contaminant transport and performance assessment demonstration, as the actual hydrogeologic conditions indicated by the conceptual model in the application. Saturated conditions existing closer to the proposed disposal units could potentially decrease the travel time of the radionuclides from the disposal units to the receptor and increase the dose above regulatory limits.

TCEQ staff reviewed the groundwater scenarios provided in the application related to performance assessment. The Pathway G2 analysis presented in the application using RESRAD assumes a 1,000-meter horizontal distance from the base of the disposal units to a well located in the OAG, where the 125-foot layer subcrops to the OAG. The subcrop of the OAG in the 125-foot zone has not been explicitly characterized in the application. Based on the geology maps provided in the application in Figures 6-5A and 6-5B, it appears that the 125-foot zone outcrop in the OAG contact may be closer than the estimated 1,000-meter distance used in the Pathway G2 scenario. This difference in distance could potentially decrease travel times and result in doses to a receptor through the use of the OAG well.

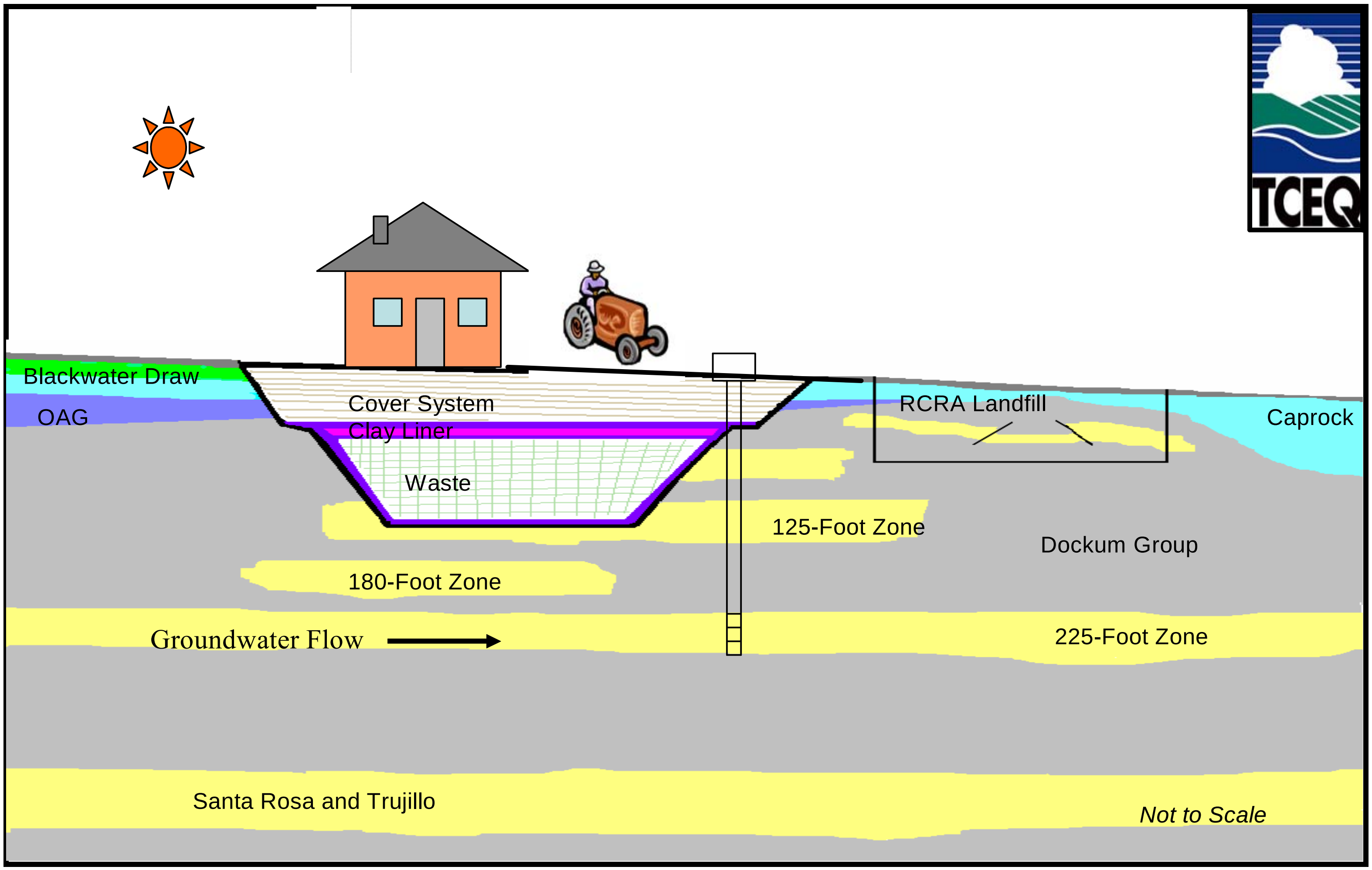

Figure EA-10: Resident Intruder with Well Scenario

Another significant difference between the performance assessment presented in the application and the independent performance assessments simulations involves source term concentrations. TCEQ staff simulations used source term concentrations that were independently calculated and 20 to 25 percent higher than presented in the application. Table 8.0-6.3-1 in the application states that a volume increase factor of four was used in RESRAD modeling for the Compact Waste Facility (CWF) and the Federal Waste Facility – Containerized Disposal Unit (FWF-CDU) and a volume increase factor of one was used in RESRAD modeling for the Federal Waste Facility – Non-Containerized Disposal Unit (FWF-NCDU). This volume increase factor was described in the application to account for the contributing volumes of grout, backfill, and concrete proposed in the CWF and FWF-NCDU.

TCEQ staff used a different approach than presented in the application by using the actual volumes of grout, backfill, and concrete in the CWF and FWF-NCDU. The source term used by TCEQ staff in the dose modeling was developed from information provided in the application in the following way:

$$C_i = \frac{(A_i)(10^{12})}{(V_s + V_g + V_c + V_w)} \qquad (8.10\text{-}1)$$

Where,

C_i = Concentration of the *ith* radionuclide in pCi/g,
A_i = Activity of the *ith* radionuclide in curies,
V_s = Volume of sand in the disposal unit in grams,
V_g = Volume of grout in the disposal unit in grams,
V_c = Volume of concrete in the disposal unit in grams, and
V_w = Volume of waste in the disposal unit in grams

Several other parameter values used in independent dose modeling differed from those provided in the application, such as, evapotranspiration coefficient, run-off coefficient, erosion rate, and distribution coefficients. In the RESRAD code, the evapotranspiration coefficient, the run-off coefficient, irrigation rate, and precipitation determine the infiltration rate through the waste disposal units. The application describes the determination of the infiltration rates used in performance assessment. TCEQ staff also rates. Both the independent dose modeling and the modeling presented in the application estimated infiltration rates using the Hydrogeologic Evaluation of Landfill Performance (HELP) and Variably Saturated Two-Dimensional (VS2DI) computer codes and incorporated the estimated rates generated into RESRAD simulations. The procedures and methods used by TCEQ staff for estimating infiltration rates are described in Section 2.4.2 of this EA.

TCEQ staff analysis indicates estimated hydraulic conductivities of the cover layers in their HELP simulations greatly impacts infiltration rates into the disposed waste. The underestimation of cover hydraulic conductivities would underestimate the infiltration rates used as input to RESRAD. The RESRAD simulations presented in the application utilized an infiltration rate of approximately one millimeters per year. TCEQ staff evaluation of the HELP simulations indicate a higher infiltration rate, by at least a factor of three, than the estimated rate presented in the application. This higher infiltration rate of three millimeter per year was used in the independent RESRAD simulations. Increases in infiltration rates allow more water to contact disposed waste, thus increasing potential leaching of radionuclides.

The site hydrogeologic conceptual model presented in the application indicates the presence of saturated conditions in the OAG materials in lateral contact with cover layer materials (see Section 6.6 of this EA). Thus, there is a possibility that OAG water might contribute to an increase in the lateral water flux into the disposal units and contribute to increases in peak doses computed by RESRAD. The RESRAD code does not directly estimate the magnitude of such a flux or directly account for the effect of such a flux. One treatment of such a flux involves the use of another code that estimates the lateral flux and using that estimate to incrementally increase the infiltration rate input into RESRAD. The information provided in the application did not address the possible hydrologic interaction between saturated OAG materials and the cover materials in the proposed disposal units. This type of event could result in greater influx of water into the units than that estimated solely from an infiltration rate determined by precipitation.

A sensitivity analysis was provided in the application and the results illustrated in Table EA-12. The information provided in the application concluded that the range of values used for parameter sensitivity analysis did not result in any doses greater than five millirem per year.

Sensitivity and uncertainty analysis using the RESRAD code of the saturated zone hydraulic conductivity (i.e., the hydraulic conductivity in the 225-foot layer) were not provided in the application. Variations in the magnitude and in the variability of the saturated hydraulic conductivity in the 225-foot layer should be explored. Section 6.6.4 of this EA provides a discussion of estimated spatial distribution of hydraulic conductivity and the reasons why this distribution may be important for the purposes of performance assessment. A primary focus of that EA section is the relatively small dimensions of the subsurface volume influencing contaminant transport to the receptor of interest in the performance assessment, relative to the spatial resolution of the available measurements of hydraulic conductivity in the 225-foot layer.

Table EA-12: WCS Sensitivity Parameters

Condition	Parameters Varied
Baseline	All parameters at baseline values
High Infiltration	Infiltration eight times baseline value
Enhanced leaching in the waste disposal zone - k_d	Decreased to one-tenth of baseline value
Enhanced transport in the Dockum red bed - k_d	Decreased to one-tenth of baseline value
High erosion rate	Up to maximum rate from SWAT analysis
Red bed clay hydraulic conductivity	Red bed clay conductivity six times baseline value (95th percentile) to 7.57 x 10^{-3} m/yr
Chelated metals in CWF and FWF-CDU	Red bed k_d decreased to zero for Co, Cr, Fe, Mn, Ni, Cs, Sb, Sr, Np, U, Pu, Am, Cm

Based on an analysis of the measured site-specific saturated zone hydraulic conductivities presented in the application, a value of 0.02 meters per year was used in the dose modeling. Simulation of the resident intruder scenario using RESRAD resulted in doses less than the 25 millirem per year regulatory limit for both the CWF and FWF.

TCEQ staff conducted a sensitivity analysis on the saturated zone hydraulic conductivity used in RESRAD and presented in the application to determine its affect on peak dose. The additional sensitivity simulations performed independently varied the value from 0.02 meters per year to 0.8 meters per year for the CWF and 0.02 meters per year to 0.06 meters per year for the FWF. Simulations using a saturated zone hydraulic conductivity greater than 0.7 meters per year for the CWF and 0.05 meters per year for the FWF resulted in doses greater than the 25 millirem per year regulatory limit. Based on sensitivity analysis, once hydraulic conductivity in the saturated zone was increased one or more orders of magnitude, the RESRAD results were sensitive to the distribution coefficients for the more mobile radionuclides, such as carbon-14, technetium-99, iodine-129.

Distribution coefficients, k_d, are input into the RESRAD code for each radionuclide projected in the waste zone, the unsaturated zone, and the saturated zone. A comparison of the k_d values provided in the application and those used in the independent analysis was performed. The more mobile long-lived radionuclides projected in the source term generally have the greatest impact on dose. Literature k_d values for carbon-14, technetium-99, iodine-129 used in the independent analysis are consistent with the k_d values provided in the application, with the exception of carbon-14. TCEQ staff used a carbon-14 k_d value of 1.0 for the saturated zone, while the value provided in the application was 5.0.

The k_d range for carbon-14, technetium-99, iodine-129 was also affected by infiltration rate and resulted in some peak doses greater than the 25 millirem per year in the sensitivity analysis. This further emphasizes the importance of accurate site-specific saturated zone hydraulic conductivities and k_d values to ensure appropriate conservatism in modeling. Section 6.6 of this EA provides additional discussion of k_d values used in the application for performance assessment.

8.11.2 Comparison of Uncertainty Analyses Using RESRAD

Assessing long-term site performance requires demonstration that the performance objectives will be met over time. Uncertainty in performance assessment generally comes from model uncertainty and parameter uncertainty. To reduce uncertainty, the use of appropriate models and site-specific values as inputs are important for providing reasonable assurance that regulatory limits will not be exceeded.

RESRAD was presented in the application as the model chosen for conducting the performance assessment and providing demonstration that dose limits are not exceeded. To address the uncertainty in the RESRAD modeling, independent uncertainty analyses were performed on key parameters to determine if the peak of the mean doses over time exceeds the 25 millirem per year performance objective and if a plot of the upper 95th percentile of doses at each discrete time were less than 100 millirem per year for total effective dose equivalent (TEDE).

The estimated erosion rate can play an important role in the results of the performance assessment. During the uncertainty analyses completed by TCEQ staff, the effect of the estimated erosion rate on peak doses was studied for a large range of erosion rates because the application presents several different erosion rates that could occur at the site over the next 50,000 years. The RESRAD simulations over a 100,000 year period indicated that even if very low erosion rates were assumed, computed doses were monotonically increasing after the period of analysis all the way out to 100,000 years. These doses computed over 100,000 years due to erosion were significantly larger than any peak doses from groundwater pathways computed in the RESRAD simulations during the 50,000 year period of analysis. This indicates that if, for such low erosion rates, the RESRAD simulations could be extended beyond the 100,000-year simulation period, peak doses due to long-lived radionuclides in the inventory would occur after this time period. This could not be done since RESRAD is limited to a maximum simulation period of 100,000 years. Alternative models could be capable of estimating the peak dose that could occur from on-going erosion into the future.

Conversely, manually increasing the erosion rates between RESRAD simulations generates peak doses above regulatory limits, occurring within the 100,000-year period that RESRAD can model. If high enough erosion rates were used as inputs to RESRAD, then peak doses in excess of regulatory limits would occur within the period of analysis. These simulations present the implications of uncertainty in what might be a realistic, but still conservative, range of erosion rates that could be used as inputs to RESRAD. It is important to determine such a range using computer programs capable of simulating erosion over long time periods. There is an extended discussion of erosion modeling and its role in the performance assessment following this comparison of uncertainty analyses.

The application provides an uncertainty analysis of RESRAD modeling in Appendix 8.0-7. The uncertainty analysis provided in the application evaluates uncertainty in precipitation, run-off coefficient, evapotranspiration coefficient, erosion rate, hydraulic conductivity of red bed materials, contaminated zone distribution coefficient and unsaturated zone distribution coefficient. The application does not provide an uncertainty analysis on the saturated zone hydraulic conductivity. The application discusses that the cover erosion rate was positively correlated (0.9) with precipitation, run-off was positively correlated (0.9) with precipitation, and evapotranspiration was negatively correlated (-0.9) with precipitation. The parameter ranges and types of distributions presented in the application uncertainty analysis are presented in Table EA-13.

The results of the uncertainty analysis provided in the application are as follows:

> For the CWF, the only doses within the first 10,000 years were from the long-lived, mobile radionuclides carbon-14, chlorine-36, iodine-129, and technetium-99. The maximum dose at year 10,000 was 0.948 millirem per year, primarily from chlorine-36 and carbon-14. From among the 300 estimates, the smallest peak dose from any 100,000-year simulation was 0.553 millirem per year. The peak doses at the 50^{th}, 90^{th}, and 95^{th} percentiles were 0.602, 1.18 and 1.24 millirem per year, respectively. The maximum peak dose from any 100,000-year simulation was 1.35 millirem per year.

Table EA-13: WCS Parameters for RESRAD Uncertainty Analyses

Parameter	Range	Distribution	Comment
Precipitation (m/yr)	0.41 – 0.74	Uniform	From climate study
Run-off coefficient	0.0482 – 0.0682	Uniform	From HELP output
Evapotranspiration coefficient	0.9887 – 0.9975	Uniform	From HELP output
Erosion rate (meters/year)	$0 – 2.2 \times 10^{-5}$ (Mode 1.2×10^{-5})	Triangular	From zero to max. rate from SWAT analysis
Redbed conductivity (centimeters/second)	4.0×10^{-9} – 2.4×10^{-8}	Uniform	Baseline to 95th percentile of measured values
Contaminated zone k_d	0.1x baseline to 10x baseline	Log-uniform	Varies leach rate
Unsaturated zone k_d	0.1x baseline to 10x baseline	Log-uniform	Varies retardation factors in red beds

For the FWF-CDU, the maximum dose within the first 10,000- year period was 1.15 millirem per year. The dose was almost entirely from technetium-99, although carbon-14, chlorine-36, and iodine-129 also contributed slightly to the total. From among the 300 estimates, the smallest peak dose from any of the 100,000-year simulations was 1.08 millirem per year. The peak doses at the 50th, 90th, and 95th percentiles were 1.16, 1.18, and 1.18 millirem per year, respectively. The maximum peak dose from any 100,000-year simulation was also 1.18 millirem per year.

For the FWF-NCDU, the maximum dose within the first 10,000 years was 3.55 millirem per year. The dose was almost entirely from technetium-99, although carbon-14, chlorine-36, and iodine-129 also contributed slightly. From among the 300 estimates, the smallest peak dose from any of the 100,000-year simulations was 3.45 millirem per

> year. The peak doses at the 50th, 90th, and 95th percentiles were 3.57, 3.58, and 3.58 millirem per year, respectively. The highest peak dose from any 100,000-year simulation was also 3.58 millirem per year.
>
> All doses within the first 100,000 years were below the 25 millirem per year dose limit in the performance objective. The only radionuclides to reach the well within 100,000 years were carbon-14, chlorine-36, iodine-129, and technetium-99.

To address the uncertainty in the RESRAD modeling, an independent uncertainty analyses was performed on key parameters. TCEQ staff conducted uncertainty analyses on precipitation, evapotranspiration coefficient, run-off coefficient, saturated zone hydraulic conductivity, unsaturated zone hydraulic conductivity, distribution coefficient, k_d of carbon-14 in the saturated zone, distribution coefficient k_d of technetium-99 in the saturated zone, and the cover erosion rate. The parameter ranges and types of distributions are provided in Table EA-13. Precipitation was negatively correlated with evapotranspiration (-0.7 coefficient), precipitation was positively correlated with run-off (0.7 coefficient), and precipitation was positively correlated with cover erosion rate (0.7 coefficient) for both the CWF and FWF.

TCEQ staff took an incremental approach in the uncertainty analyses by increasing the range of values defining the uniform distribution characterizing the saturated zone hydraulic conductivity, until the analysis resulted in either the peak of the mean doses over time exceeding the 25 millirem per year performance objective or the upper 95th percentile of doses at each discrete time exceeding 100 millirem per year total effective dose equivalent (TEDE). Table EA-14 lists TCEQ parameters for RESRAD Uncertainty Analysis.

For the CWF, TCEQ staff allowed RESRAD to make 300 estimates for a single repetition using Latin Hypercube sampling. Six individual cases were evaluated in the uncertainty analysis, each incorporating a higher saturated hydraulic conductivity range. The ranges and results of the independent analyses are provided in Table EA-15.

For the CWF, the 95th percentile dose for CWF Case 3 of the independent analysis is very near the recommended 100 millirem per year limit. For CWF Case 4, the peak of the mean doses exceeds 25 millirem per year and the dose at the 95th percentile exceeds 100 millirem per year. All doses occur at approximately 2,000 years. A slightly larger than a one-order of magnitude increase in saturated zone hydraulic conductivities, relative to those utilized in the performance assessment in the application, is producing peak doses that are very near to exceeding regulatory limits.

Table EA-14: TCEQ Parameters for RESRAD Uncertainty Analyses

Parameter	Range	Distribution	Comment
Precipitation (meters/year)	0.30 – 0.80	Uniform	Current is 0.41[1]
Evapotranspiration coefficient	0.90 – 0.99	Uniform	Application value = 0.9975 TCEQ = 0.97
Run-off coefficient	0.04 – 0.8	Uniform	Application value = 0.048 TCEQ = 0.75
Saturated zone hydraulic conductivity (meters/year)	0.01 – 0.2[2]	Uniform	Range of laboratory test results[1]
Unsaturated zone hydraulic conductivity (meters/year)	0.0016 – 0.0025	Uniform	Range of laboratory test results[1]
Distribution coefficient (k_d) of C-14 in the saturated zone (cubic centimeter/gram)	0.1 – 5.0	Uniform	Default = 0[3] Sand = 5.0 Clay = 1.0
Distribution coefficient (k_d) of Tc-99 in the saturated zone[4] (cubic centimeter/gram)	0 – 1.0	Uniform	Default = 0[3] Sand = 0.1 Clay = 1.0
Cover erosion rate (meters/year)	1.2×10^{-5} – 3.6×10^{-4}	Uniform	Min = Application value Max = 10x TCEQ derived value

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Notes:
1 – Site-specific data as provided in the application
2 – Parameter range only for the CWF. Range was varied in two cases for the FWF from 0.001 to 0.60 meters per year
3 – RESRAD Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil, 1993
4 – Uncertainty performed only for the FWF

Table EA-15: TCEQ Uncertainty Analysis Cases for the CWF

Analysis Case	Minimum Saturated Zone Hydraulic Conductivity (meters/year)	Maximum Saturated Zone Hydraulic Conductivity (meters/year)	Peak of the Mean Doses (millirem/year)	Dose at the 95th Percentile (millirem/year)
Baseline	0.001	0.02	0.87	4.6
CWF 1	0.005	0.05	2.28	12.4
CWF 2	0.01	0.20	8.73	47
CWF 3	0.04	0.40	18.30	99
CWF 4	0.06	0.60	27.30	149
CWF 5	0.08	0.80	36.50	198

Table EA-16: TCEQ Uncertainty Analysis Cases for the FWF

Analysis Case	Minimum Saturated Zone Hydraulic Conductivity (meters/year)	Maximum Saturated Zone Hydraulic Conductivity (meters/year)	Peak of the Mean Doses (millirem/year)	Dose at the 95th Percentile (millirem/year)
FWF 1	0.04	0.40	20	134
FWF 2	0.06	0.60	31	201

For the FWF, TCEQ staff allowed RESRAD to make 200 estimates with a single repetition using Monte Carlo sampling. Two cases were evaluated for the FWF. The ranges and results of the FWF independent analysis are provided in Table EA-16 above.

For the FWF, peak of the mean doses in FWF Case 1 of the independent analysis does not exceed 25 millirem per year. However, the dose at the 95th percentile exceeds 100 millirem per year. The peak of the mean dose occurs at year 1,565 and the dose at the 95th percentile occurs at year 860. The range of hydraulic conductivities producing these doses partially spans the estimated range of conductivities reported in the application based on site-specific data. The FWF Case 1 range of values exceeds the value utilized in the resident intruder scenario presented in the application slightly more than a single order of magnitude. The peak of the mean doses in FWF Case 2 of the independent analysis exceeds 25 millirem per year and the dose at the 95th percentile exceeds 100 millirem per year. The peak of the mean dose occurs at year 1,565 and the dose at the 95th percentile occurs at year 860.

8.11.3 Erosion Modeling and Performance Assessment Using RESRAD

One of the input parameters to RESRAD is the average yearly rate of erosion that will occur during the period of analysis. In general, there are three methods available for estimating such a rate. First, the erosion rate can be estimated from geomorphologic studies of past regional erosion rates. Such rates can be used as estimates of future rates if it can be assumed both that local erosional processes are similar to regional ones and that those processes remain relatively constant during the future period of analysis. Second, the erosion rates can be estimated from site-specific monitoring of current erosional processes. If such monitoring can be continued over a sufficient length of time and it can be assumed, again, that current processes will remain relatively constant during the future period of analysis, then the erosion rate determined during the monitoring period might be used as a proxy for the rate occurring during the period of analysis. Third, estimates of current site climatological, geological, and geotechnical conditions can be used as inputs to computer programs that attempt to predict the future time-history of erosional processes at the site. The first two methods are generally capable of generating a single rate. It is that rate then, which is assuming to continue, invariable, over the period of analysis. One of the advantages of the third method, the use of computer models, is that certain models, to some degree can simulate the temporal variation in erosional processes, although the uncertainty in such simulations is expected to increase with the length of simulated time.

Because of the inherent uncertainty in all of these methods for estimating local erosion rates over a long time period, it is best if all three of these methods were to be applied to study the erosional processes at the proposed site. This is the approach presented in the application. The geomorphologic erosional studies cited in the application and the site specific monitoring study currently being conducted, both described in the application, are discussed elsewhere in this EA. The geomorphical and computational studies provided the main basis for the erosion rates used in the RESRAD simulations presented in the application and in the simulations completed by TCEQ staff. This paragraph of the EA discusses the computer modeling of erosional processes described in the application and possible alternative modeling approaches.

Prior to a discussion of this computer modeling it is useful to present an analysis of erosional processes as they relate to the performance assessment.

Erosion is a pervasive geologic process which acts to alter the topography of the ground surface. At any particular location and time the elevation of the ground surface will be either increasing (aggrading), or decreasing (degrading). A major concern at the proposed disposal site is that during the period of analysis erosive processes might degrade the thickness of the protective cover system sufficiently to result in external doses in excess of regulatory limits due to an increased exposure to disposed radionuclides.

As described in the application, the proposed cover systems have been designed to mitigate the effects of degrading erosive processes. In a long-term, degrading geologic environment, any engineered structure can be considered only temporarily effective in mitigating the degradation of the materials below it. The application attempts to estimate the time history of the elevation of the ground surface at the proposed disposal sites, as that elevation is affected by erosion. That estimate must be completed over the specified 50,000 year period of analysis (a long "term" relative to the expected lifetime of engineered structures made of concrete or earthen materials). Even if the topography at the proposed site is determined to be degrading, if the erosion rate is low enough, significant doses due to external exposure might occur after the designated period of analysis. On the other hand, if the topography continues to degrade over a period long relative to the period of analysis, even at very low rates, eventually the buried waste will be exposed, and any long-lived radionuclides will generate possibly excessive doses, albeit after the period of analysis. This phenomenon was exhibited in the RESRAD simulations completed by TCEQ staff, as discussed above.

One of the required inputs to RESRAD is a single erosion rate, assumed by the code to be constant over the simulated period of analysis. An estimated total change in elevation (estimated by any of the three methods) over the entire period of analysis, at the location of a disposal unit, divided by the length of the period of analysis, provides an average erosion rate characterizing that entire period. In general, the erosion rate can be expected to be variable over the period of analysis, so that the instantaneous value of that variable rate is also of interest. If, early during the period of analysis, erosion rates are high relative to later rates, then significant doses might be expected to occur at earlier times than predicted from the use of the average erosion rate. If the earlier erosion rates are significantly higher than that average rate, then doses that might otherwise occur after the period of analysis might now occur during that period. Furthermore, since during that shorter period of time radionuclides will have decayed less than otherwise expected and will remain significantly above regulatory limits. Thus, the estimated time history of site erosion, not just an average rate over the period of analysis, is of interest.

Appendix 3.0-3.18 describes calculations used to estimate long-term erosion rates at the proposed disposal site using the Universal Soil Loss Equation (USLE). Inputs to this equation include a maximum slope at the site and the length of that slope, a factor characterizing the energy of the expected rainfall, a factor characterizing erosive potential, a factor characterizing soil erodibility, and vegetative and soil management factors. These factors depend on the location of the site, the classification of the soil, the percent organic matter in the soil, and the management practices applied to the soil. The application describes how, through the exercise of reasonable variations in the described factors, a combined erosion rate from water and wind of 6.37×10^{-5} feet per year was estimated.

It must be noted that the USLE has several limitations. To address these limitations the application made an attempt to study the sensitivity of the computed results to the input factors. On the basis of this study the application estimates that a reasonable upper bound from the USLE would be 1.27×10^{-4} feet per year (roughly twice the base estimate). The application does not address whether the sensitivity analysis actually accounts for variation in what might be important parameters, such as weather patterns and degradation of the input soil characteristics.

Also, to address limitations in the USLE based analysis the application describes computer modeling of the long-term erosional processes at the site. While the application states that consideration was given to several different codes including CREAMS and EPICS, the computer code Soil Water Assessment Tool (SWAT) was chosen. The application gives no discussion of the comparative process that resulted in the selection and use of SWAT.

Appendix 3.0-3.29 describes the use of SWAT to model erosional processes at the site. The flow of water and sediment between thirteen sub-basins was simulated for a 50,000-year period. These sub-basins were hydrologically connected, according to site specific topography (e.g., slope, elevation) and other characteristics, and each assigned geotechnical properties and other required inputs either from available data or from the literature. One of the sub-basins was identified with the FWF, another with the CWF. The total area of the modeled region was 1.5 square kilometers. Climatological inputs were determined from a computerized weather generator capable of supplying daily wind speeds, precipitation levels, and solar radiation levels to the SWAT simulation. The SWAT computations utilized historical data from Hobbs, New Mexico in order to simulate the continuation of current erosional processes during the period of analysis. The computations also utilized historical data from Wichita, Kansas to simulate erosional processes at the site due to predicted future climatic conditions. Since the Wichita climatic conditions were applied over 50,000 years, a case could be made that the SWAT simulations developed from those conditions were the best available estimate for consideration given in the application.

SWAT is limited by only allowing for analysis for a 10,000-year period. Because SWAT has this limitation, the application describes how the computations were completed by splicing together five consecutive SWAT runs, each of 10,000 years.

SWAT computed the annual amount of erosion in each of the sub-basins for each year during the period of analysis. However, apparently SWAT had no capability for integrating these erosional increments over the simulation time. The application includes an Excel spreadsheet that accomplished this integration for each of the modeled sub-basins. Thus, the spreadsheet provided a time-history of the estimated elevation change in each of the modeled sub-basins including the FWF and the CWF. These time histories indicated that while erosion rates were variable in the modeled sub-basins over the period of analysis that variability was small enough so that an average erosion rate for the FWF and CWF sub-basins would accurately summarize erosional processes in these sub-basins over the period of analysis. Division of the total elevation changes for the FWF and CWF sub-basins by the period of analysis of 50,000 years resulted in estimated average erosion rates of 7.1×10^{-6} feet per year, and 3.28×10^{-5} feet per year, respectively. As noted in the application, these rates are comparable to the estimations developed from the use of the Universal Soil Loss Equation. However, apparently the computation of erosional processes within each sub-basin in SWAT relies on the use of the USLE or some modification of it. Perhaps it should be expected that results from the two methods would be comparable.

While the SWAT model incorporates more complexities than the USLE, and in many respects provides a more realistic treatment of erosional processes, it too, like any model has its limitations. SWAT is a lumped parameter model, meaning it computes a single annual loss (or gain) in sediment in each modeled sub-basin. While the modeled sub-basins have connectivity to one another, and are assigned an area, they have no modeled extension in two-dimensional space. Therefore, differential erosion, resulting in changes in elevation within each of the sub-basins, on a spatial scale smaller than the areas of each modeled sub-basin cannot be simulated with SWAT.

Perhaps more importantly in the SWAT simulations described in the application, annual erosional changes in each sub-basin were computed, but these changes were apparently not utilized to alter the initially input slopes or elevations of those sub-basins. Thus, the computed erosional changes had no “feedback” on the simulated erosional processes. For example, the SWAT calculations for the Upper-Bound Climate (Wichita) indicate that after 25,000 years of simulation time, differences in total erosion range from two inches to twelve inches over the different modeled sub-basins. However, these seemingly significant changes are not utilized to modify the elevations of the sub-basins, so that these changes do not affect erosional time-histories after 25,000 years. While this seems counter to a subjective understanding of how erosional processes actually unfold, especially over long periods of time, the application gives no indication if this feature of the SWAT computations are a limitation of SWAT or a characteristic reasonably enforced on the simulations after an interpretation of the unfolding results. In a similar manner, the SWAT simulations assumed that despite the estimated erosion occurring within each sub-basin, the drainage divide separating the modeled sub-basins from other nearby, unconnected basins, maintained its location during the 50,000-year simulation time. The application provides no explanation for this feature of the computations. Any simulation capable of allowing a change in divide location (if any such change is judged significant) would alter the precipitation falling on the modeled sub-basins. Such "feedback" would likely affect the time-history of the erosion within each of the sub-basins.

The limitations in the simulations of site erosional processes presented in the application have been described above. There are computer models that attempt to model erosional processes on a continuous spatial scale (i.e., non-lumped parameter models), and on smaller spatial scales than does SWAT. Also these models "feedback" computed erosional changes so that elevation changes occur during each simulated time period. The application gives no explicit consideration of such models or of their possible limitations or advantages relative to the challenges of estimating erosion rates useful for completing a performance assessment for the proposed site.

As of the last revision of the application, no site-specific erosion monitoring results have been submitted to the TCEQ. Also, it is not yet clear if monitoring results will be recorded over a sufficient period of time to provide useful estimates of local erosion rates over the period of analysis. Thus, as of yet, there is no site-specific erosional data available to assist in the validation of the USLE and SWAT simulations. This situation necessitates focus on the importance of erosion modeling and the use of modeling results in performance assessment.

To address uncertainty in the range of site conditions, both current and future, the Executive Director recommends license conditions that require the an annually updated PA that is representative of current and future site conditions. The effects, if any, from nearby facilities will be evaluated as part of the PA. This will help provide reasonable assurance that the modeling results use the appropriate level of conservatism in evaluating doses to members of the public. Additionally, the PA is required to be updated annually to reflect changes in conditions, assumptions, received waste, or any other information impacting performance of the facility.

References Section 8.11: Protection of Individuals During Post-Closure, and Institutional Control Period (Performance Objective): Releases to the Environment

DOE, 2001. United States Department of Energy, ANL/EAD-4. Version 6, Users Manual for RESRAD Version 6. Environmental Assessment Division, Argonne National Laboratories, Argonne, Illinois., July 2001.

NRC, 2000. United States Nuclear Regulatory Commission, NUREG-1573, A Performance Assessment Methodology for Low-Level Radioactive Waste Disposal Facilities. Office of Nuclear Material Safety and Safeguards, Washington, D.C., October 2000.

8.12 Protection of Individuals During Post-Closure, and Institutional Control Period (Performance Objective): Long-Term Stability

In accordance with 30 TAC §336.727, the applicant must provide information on how the disposal facility will be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required. In accordance with 30 TAC §336.709(4), the applicant must provide analyses of the long-term stability of the disposal site and the need for ongoing active maintenance after closure shall be based upon analyses of active natural processes such as erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal units and adjacent soils, and surface drainage of the disposal site. The analyses must provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.

An application must provide information on how the disposal facility and the engineered features will provide long-term stability for isolating the waste and preventing or limiting environmental releases of radionuclides. Natural site characteristics contribute to the overall disposal system performance by providing a stable environment for waste disposal and by attenuating the movement of radionuclides off-site through the environment (NRC, 2000). The minimum characteristics of an acceptable disposal site are specified by the site suitability requirements of 30 TAC §§336.708 and 336.728. The requirements emphasize site stability, in connection with engineered barriers; waste isolation, in terms of rates of radionuclide mobilization and transport; and long-term performance, with respect to defensible modeling of future site behavior. The siting requirements in 30 TAC §336.728 require the need to avoid sites where the frequency, rate, and extent of geologic processes, such as erosion, mass wasting, and tectonic processes will adversely affect performance of the disposal facility or preclude defensible modeling of long-term performance. In addition, these requirements are intended to eliminate, to the extent practicable, areas having characteristics that are known to, or highly likely to, have active geologic processes. This means that sites should be selected where natural processes are occurring at consistent and definable rates, such that performance assessment models will represent both present and future site conditions.

Engineered features should be demonstrated to last a minimum of 300-500 years. The 500-year time frame corresponds to the period when the hazard from high-activity, short- and intermediate-lived radionuclides contained in Class B and C low-level radioactive waste is greatest. Additionally this time period is when the need for achieving long-term stability of engineered features, such as multi-layered covers, concrete canisters, high integrity waste containers (HICs), stabilized waste forms, and intruder barriers to Class C low-level radioactive waste is greatest. The main design function of these engineered features is to limit infiltration of water into the waste so as to minimize leaching of radionuclides to the environment, and to provide protection to an inadvertent intruder. Demonstration of long-term stability through site characteristics and engineered features provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure and that only surveillance, monitoring, and minor custodial care will be required.

TCEQ staff has reviewed the information submitted in the application for demonstrating compliance with the performance objective of long-term stability of the disposal site. The analysis encompasses multiple disciplines including geology, site characterization, and engineering design. TCEQ staff's analyses on erosion, mass wasting, salt dissolution, slope failure and geologic processes affecting long-term stability can be found throughout Section 6.0 of this analysis. TCEQ staff's analysis of engineering design related to settlement of wastes and backfill can be found in Sections 2.3.1, 2.3.8, and 3.6.9 - 3.6.14. TCEQ staff's analysis on infiltration and surface drainage can be found in Section 2.4. Engineered features to limit infiltration (lining of the playas) can be found in Section 2.3 and 6.7 of this analysis.

The Executive Director recommends license conditions have been developed to address engineering design, infiltration, and surface water management in order to provide reasonable assurance that long-term stability will be achieved.

References Section 8.12: Protection of Individuals During Post-Closure, and Institutional Control Period (Performance Objective): Long-Term Stability

NRC, 2000. United States Nuclear Regulatory Commission, NUREG-1573, A Performance Assessment Methodology for Low-Level Radioactive Waste

Disposal Facilities, Office of Nuclear Material Safety and Safeguards, Washington, D.C., October 2000.

8.13 Post-Institutional Control Period (Performance Objective): Inadvertent Intrusion

In accordance with 30 TAC §336.725, an applicant must demonstrate how design, operation, and closure of the land disposal facility shall ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste at any time after active institutional controls over the disposal site are removed. In accordance with 30 TAC §§336.725 and 336.709(2), the applicant must provide analyses of the protection of individuals from inadvertent intrusion including demonstration that there is reasonable assurance that the waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion will be provided.

An application must demonstrate how the disposal facility design ensures protection of any individual that might inadvertently intrude into the waste or occupy the site after the institutional control period. Protection from inadvertent intrusion is demonstrated by proper waste classification and segregation to meet the requirements of 30 TAC §336.362 relating to waste classification and waste stability and 30 TAC §336.730 relating to segregation of waste and intruder barriers. Waste classification and segregation ensures that the longer-lived and higher radioactivity wastes are disposed in such a manner that they either decay to negligible levels or the waste is contained in a stable form for a minimum of 300 years. Class A low-level radioactive waste should be sufficiently segregated from Class B and C low-level radioactive waste so that any interaction between Class A wastes and other waste will not result in failure to meet the performance objectives. Segregation of Class A low-level radioactive waste is not required if it meets the structural stability requirements in 30 TAC §336.362(b)(2).

An engineered barrier is defined as a man-made structure or device that is intended to improve the land disposal facility's ability to meet the performance objectives in 30 TAC §336.723. Engineered barriers are designed to inhibit water from contacting the waste, limit release of radionuclides to the environment, and mitigate the doses to an inadvertent intruder. The physical components that constitute an engineered barrier may range from geosynthetic membranes to natural soils to concrete containment systems. Examples of physical engineered barriers include surface drainage systems, cover systems, concrete secondary barrier, HICs, and backfill.

Similarly, an intruder barrier is defined as sufficient depth of cover over the waste that inhibits contact with waste and helps to ensure that radiation exposures to an inadvertent intruder meet the performance objectives, or engineered structures that provide equivalent protection to the inadvertent intruder. Although similar to the engineered barrier, the intruder barrier is designed specifically to provide protection to an individual inadvertently intruding into the waste. This can be demonstrated in one of two ways in accordance with 30 TAC §336.730(b)(3). The waste may be disposed of at a depth greater than five meters or disposed with intruder barriers that are designed to protect against inadvertent intrusion for at least 500 years.

Additionally, an applicant should demonstrate through modeling or calculations the impacts to any individual inadvertently intruding into the disposal unit and contacting the waste. This is accomplished by analyzing intruder scenarios, such as an intruder resident or intruder driller. Assumptions for these scenarios should be conservative and justifiable.

TCEQ staff has reviewed the information submitted in the application regarding protection of individuals from inadvertent intrusion. The information in the application provides a brief discussion on how their design, operations, and closure will ensure protection of inadvertent intruders. Section 8.0-6 of the application states that the depth of waste burial is the primary means of intruder protection. The proposal is to bury the waste at a depth of 12.3 meters in the Compact Waste Facility (CWF) and a depth of 12.8 meters in the federal facility waste disposal facility (FWF). Section 8.5 of the application also states that the layered cover system will alert an intruder that they have disturbed an engineered feature. In addition, a 12-inch concrete barrier will be placed at the waste cover interface.

Operational features proposed in the application are classification of waste, placement of Class B and C, and containerized Class A low-level radioactive waste in concrete canisters, and prohibition of greater than Class C low-level radioactive waste. Further, Section 8.5 of the application states that wastes will not be segregated by waste class because all waste will meet the stability requirements. Based on review of the application, uncertainty exists as to whether all Class A low-level radioactive waste will meet the stability requirements. Uncontainerized waste containing transuranics with half-lives greater than 35 years, proposed for the FWF-NCDU, is described as soil, rubble, and debris. This does not provide a stable waste form. Additional TCEQ staff analysis on waste stability can be found in Section 2.3.1 of this analysis.

Section 8.5 of the application states that environmental features contributing to intruder protection are the remote location and the lack of abundant potable water sources. It further states that groundwater is not readily available at the site except in very low quantities from the 225-foot layer or at greater depths. This is inconsistent with the information that is provided in the geology section of the application. Appendix 2.6.1 of the application indicates there are 275 water wells, including wells completed in the Ogallala-Antlers-Gatuña (OAG) materials, within six miles of the site and that 12 of those wells are within the site boundary.

Intrusion analysis was conducted and is consistent with the methodology recommended by the United States Nuclear Regulatory Commission in NUREG/CR-4370. All the analyses assume institutional controls have failed. The first analysis, involving the intruder discoverer, evaluates exposures to an individual that spends a minimal amount of time on the site, such as a transient. The application concludes that doses were negligible because of the large cover thickness so no quantitative evaluations were conducted.

The next analysis is of the intruder constructor, in which exposures to an individual that constructed a house or other structure on the former disposal site are evaluated. The application concludes that doses were negligible because of the large cover thickness; no quantitative evaluations were conducted. The intruder driller scenario was evaluated quantitatively. This scenario assumes a drilling crew enters the site and drills a water well through the disposed waste and into the 225-foot sandstone and a portion of the waste is exhumed in the drill cuttings. The drilling crew is exposed to the contaminated drill cuttings. The scenario also assumes that once the well is completed and the cuttings pit is covered, the drilling crew leaves. Appendix 8.0-6 of the application presents the maximum dose for the intruder driller scenario as 6.7 millirem per year.

The intruder resident scenario is an extension of the intruder driller scenario, in which, after the well is drilled a resident moves on-site and uses water from the well for drinking and watering livestock. In addition, the resident receives external exposure from the drill cuttings. Appendix 8.0-6 of the application states that irrigation was eliminated from consideration as a sub-pathway because the characteristics of the 225-foot sandstone limit it's yield of water to a few gallons a day. Table 8.3-3 of Section 8.3.2 of the application states the maximum dose to the intruder resident is 4.6 millirem per year.

To address uncertainty in the range of likely site conditions, both current and future, the Executive Director recommends license conditions that require the applicant to submit an updated performance assessment that is representative of current and future site conditions prior to construction. The effects, if any, from nearby facilities will be evaluated as part of the performance assessment. This will provide some reasonable assurance that the modeling results use the appropriate level of conservatism in evaluating doses to members of the public. Additionally, the PA is required to be updated annually to reflect changes in conditions, assumptions, received waste, or any other information impacting performance of the facility.

8.14 Financial Qualifications and Financial Assurance

Title 30 TAC §§336.735, 336.736, 336.737, and 336.738 require that the applicant has the financial qualifications, the financial assurances, liability coverage, and funding for closure, institutional control and corrective action. Financial assurance shall be based on cost estimates approved by the Executive Director. TCEQ staff reviewed proposed cost estimates for the various activities requiring financial assurance provided in the application to establish the amounts of financial assurance recommended by the Executive Director. In some instances, the Executive Director will recommend amounts higher than estimated in the application. An evaluation of the cost estimates in the application is described below.

Additionally, TCEQ staff and consultants at CH2M HILL, Inc. reviewed the demonstration of requirements for financial qualifications provided in the application. Title 30 TAC §336.735 requires that the applicant show that it either possesses the necessary funds or has reasonable assurance of obtaining the necessary funds, or 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. This information was generally presented in Section 12 of the application. Additional information related to financial qualifications was provided in attachments submitted under confidential cover. Therefore, this EA will not discuss the details of the information submitted as confidential.

There are two criteria for financial qualification and assurance. First, the applicant must possess the necessary funds or have reasonable assurance of obtaining the necessary funds, or a combination of the two. Second, these funds must cover the estimated costs of conducting all licensed activities over the planned operating life of the facility.

In meeting the first criteria, the applicant's parent company, Valhi, Inc., provided a commitment letter to finance the development and construction costs, initial operating costs, and corrective action requirements of the proposed disposal facility. The following are the financial assurance amounts presented in the application for projected costs and funding:

1st year Closure	$ 46.2 million
2nd year Closure	$ 50.8 million
Unplanned Closure	$ 62.9 million
Post-Closure	$ 9.9 million
Corrective Action	$ 22.0 million
Institutional Control	$ 20.7 million

Table EA-17 represents the proposed total financial assurance amounts that were provided in the application.

Table EA-17: WCS Proposed Financial Assurance

Scenario	Total Financial Assurance Cost
1st Year Closure	$ 98.8 million
2nd Year Closure	$ 103.4 million
Unplanned Closure	$ 115.5 million

Section 12 of the license application indicates that the applicant's cash flow will be sufficient to cover their funding needs and operating expenses throughout the operating life of the facility. The application provides financial statements and a financial model to predict the profitability of this venture thus providing reasonable assurance of obtaining the necessary funds.

Consultants to TCEQ, CH2M Hill evaluated financial qualifications pertaining to the financial model presented in the application. The applicant's business plan for the proposed disposal facilities is presented in a financial model that was submitted as confidential with the application. Additionally, the rates for the Texas Compact waste must be established by rule by the TCEQ, which will maintain the rates based on the actual expenses for operating the CWF. CH2M HILL conducted a sensitivity and impact analysis to evaluate the changing of some of the assumptions in the financial model presented in the application.

8.14.1 Issues with Financial Qualifications

The application provides a financial commitment and a business model to demonstrate financing of the proposed project. However, escalating construction costs due to: a higher inflation rate (a construction cost index may be more appropriate than the consumer price index to apply as a cost inflator for construction activities); higher hauling, excavation, and land clearing rates; and a contingency factor greater than 10 percent could all affect assumption used in the business model. Potential specific issues related to financial qualifications are as follows:

- The sufficiency of the projected working capital allowance for the first year of operations;
- Escalation in construction costs requiring additional financial assurance, or affecting assumptions made in the business model; and
- Risks due to company financial losses and financial performance in a declining market.

8.14.2 Liability Coverage and Funding for Closure

Title 30 TAC §336.736 requires financial assurance for closure and stabilization to be submitted to the TCEQ 60 days prior to the initial receipt of waste. Additionally, the rule requires the licensee of an operating facility provide financial assurance for bodily injury and property damage to third parties caused by sudden and non-sudden accidental occurrences. The Executive Director recommends a license condition addressing potential bodily injury and property damage.

The application commits to provide an insurance policy for bodily injury and property damage to third parties in the amount of $5.0 million per occurrence and $10.0 million in the aggregate.

WCS currently holds general liability, property, auto, and worker's compensation insurance. The application indicates that current policies are sufficient to cover the most-likely monetary damages that may arise, but no specifics were given as to whether these policies will cover potential injury to any property or person. The application indicates that there is no insurance coverage relating to risks incurred from the transportation of hazardous or radioactive materials. Instead, the application states that the transportation company or waste generator would be responsible for this risk and that low-level radioactive waste during transportation on public roads.

The Texas Department of Transportation requires transportation providers to have coverage of $5.0 million for the transportation of hazardous or radioactive materials. However, the application does not address insurance coverage for the transportation of radioactive materials within the facility. The application does not address whether the transportation company's insurance policy would remain in effect within the facility or if a separate policy would be necessary for transportation of materials within the facility.

Section 12 of the application states the intent to use a Letter of Credit in the amount of $65.7 million to demonstrate compliance for financial assurance for closure. The amount was based on an unplanned closure scenario occurring in year 12 of operations. The application presents three different unplanned closure scenarios to determine the maximum closure cost in Appendix 6.1.5-2 of the application. The first two scenarios consider the amount needed for closure if operations were to cease after the first or the second year. The third scenario presented in the application considers the amount for closure required in year 12, representing the estimated highest closure costs. Closure cost estimates were developed for each of these scenarios: at year one - $46.2 million, at year two - $50.8 million, and at year 12 - $62.9 million.

It appears from review of the application that the method used to compute the cost estimates for each of the scenarios was developed to consider variable amounts required as more waste is emplaced. For instance, as disposal units in each of the facilities are opened, developed, and closed, the costs would vary based on the stage of completion of the disposal units. And, because the phases of the FWF-NCDU, FWF-CDU, and CWF do not coincide, the calculations to estimate costs at each year are complicated. The application presents a methodology that simplifies these computations by normalizing the unit costs for each facility at any given time, and then computing a total cost by multiplying this normalized unit cost by a given quantity, and then summed over each line item cost.

Using Table 6.1.5-2-2 for the CWF as an example, around year 14, a new disposal unit would be excavated and developed with an additional airspace volume of approximately 260,000 cubic yards. Should an unplanned closure event occur as the excavation of this disposal unit is completed, then the amount of fill required to close the facility would include both this newly excavated unit and the remaining airspace in the existing unit, approximately 533,000 cubic yards. Cost estimates reviewed in the application only include cost of fill for the remaining airspace, 210,000 cubic yards, and not the cost to fill in the newly excavated disposal unit. This difference in quantity was computed and added to the cost estimates.

An assumption used in the application in applying the methodology to compute the total cost for each scenario is that the costs vary with time. For instance, as each disposal unit is excavated, developed, filled with waste, and then closed, the costs to close these units vary with the activity required to perform the appropriate tasks. The application partitions the costs of these tasks into fixed and variable costs. If variable costs contain some fixed costs then this method tends to underestimate costs at the beginning of the life of the facility.

Normalized unit quantities may not approximate the unit quantities under a worst case, unplanned closure event. Perhaps, a more appropriate approach would be to use actual costs of closure of the facility at varying times. Then, apply a sensitivity analysis to these costs to determine an upper bound for a highest cost closure scenario.

On-site or staged waste must be considered in an unplanned closure scenario. Although quantities and unit costs were stated in the application, this requirement was not addressed in cost estimates. Furthermore, Appendix 7.3.2 of the application states that all leachate pumped after final site closure will be shipped off-site for disposal. Thus, the disposal of leachate must also be considered in an unplanned closure event, but was also not addressed in the application or cost estimates. Additionally, Resource Conservation Recovery Act (RCRA) rules at

Title 30 TAC §335.178 state that a third party would be required to dispose of the maximum volume of authorized storage capacity at an off-site waste disposal facility. The Executive Director recommends a consistent approach for cost estimates for the low-level radioactive waste disposal facility.

Appendix 6.1.5-2 of the application estimates quantities for off-site disposal received at the FWF and CWF are 1,200 cubic yards and 151 cubic yards, respectively. The costs associated with off-site disposal for the FWF and CWF as stated in Appendix 7.3.2 of the application are $1,992 per cubic yard and $19,202 per cubic yard, respectively. The total cost for off-site disposal of staged waste during an unplanned closure event would be $5,300,000.

The application did not include discussion or cost estimates for treatment and disposal of leachate in an unplanned closure event. Additionally, the application did not include cost estimates regarding leachate in the general closure discussion. Although Appendix 7.3.2 of the application states that all leachate pumped after final site closure will be shipped off-site for disposal, the application did not provide estimates for this off-site disposal of leachate.

In determining the amount of leachate destined for off-site disposal, it can be estimated that the five 500,000 gallon tanks for the FWF and the two 500,000 gallon tanks for the CWF were assumed to be full for a total of 3,500,000 gallons. This is consistent with the total amount of 2,500,000 gallons of leachate for the FWF at closure presented in the RCRA application pertaining to this facility. There was no discussion of the potential for leachate with both hazardous and radioactive components in the RCRA application. In recognition of the use of concrete canisters in the FWF-CDU and CWF, only the fraction of leachate attributable to the FWF-NCDU was considered in TCEQ staff analysis. Because this fraction of leachate could contain hazardous and radioactive waste components, one could expect the cost for the off-site disposal activity to be considered in both applications. The cost associated with disposing of non-radioactive leachate was accounted for in the RCRA application at $1.00 per gallon. The $1.00 per gallon could be assumed to be an estimate for deep well injection of non-radioactive leachate off-site. However, with radioactive and hazardous constituents as a mixed waste, leachate would not be authorized for deep well injection at any known commercial waste disposal facility. Therefore, the leachate as a liquid mixed waste would need to be treated in order to allow for possible land disposal.

The cost associated with treatment and disposal of liquid mixed waste was researched by TCEQ staff. Potential unit costs for the disposal of low-level radioactive leachate ranges from $34 per gallon to $58 per gallon. And, the potential unit cost to treat and dispose of mixed waste leachate was found to be as high as $158 per gallon. While the potential unit cost for mixed waste leachate disposal could be much higher than the combined unit costs of low-level radioactive leachate and hazardous leachate separately, an average unit cost of $46 per gallon was selected for estimating off-site disposal costs associated with the fraction of leachate expected from the FWF-NCDU. Since the possibility exists that water will come into direct contact with the waste in the FWF-NCDU, which makes up four out of the twenty cells in the FWF, it is assumed that one-fifth ($^{4}/_{20}$) of the 2,500,000 gallon leachate could have radioactive contamination. The cost estimate for the off-site disposal of the 500,000 gallons of leachate at $46 per gallon is $23,000,000. The total cost estimate for the off-site disposal of all the on-site or staged waste is $28,300,000.

Because the cost to dispose of the leachate is not insignificant, the costs may be verified in the following fashion. Any leachate destined for disposal would first need to be solidified with cement or fly ash and then disposed of at an off-site disposal facility. The solidifying of the leachate with cement requires a water content of approximately 0.3. This indicates that mixing the cement with leachate would result in an increase in volume in gallons to be disposed of by a factor of 3.33. Converting these gallons to cubic yards becomes equivalent to disposing of 1.38 percent of the initial volume of waste in gallons. Multiplying this volume by the cost to dispose of solid low-level radioactive waste off-site ($1,992 per cubic yard) results in a unit cost of approximately $28. Adding the minimum cost to solidify the leachate at approximately $10 per gallon produces a cost of $38 per gallon, which is within the $34 to $58 per gallon range given above.

While it is possible for the leachate to be treated at an on-site treatment plant, thereby lowering the disposal costs of leachate, there was no indication in the application of such a plant being constructed, operated, decommissioned, or costed. Furthermore, such a plant would require a thorough review of the process and its removal efficiency, construction plans, operating procedures, sampling plan, radiation safety, decommissioning, and cost. These plans must take into consideration the proposed composition of leachate and any resulting dose, commingling of its radioactive waste, whether the treated stream can be discharged under a TPDES permit, and whether the proposed treatment system will be able to meet the corresponding discharge limitations. Additional information would also include time and cost of a pilot study, proposed leachate flow rates as a function of time, and accounting for third party operation and decommissioning of such a plant.

The Executive Director recommends closure financial assurance that includes the cost for off-site disposal of leachate and staged waste resulting in an amount higher than that estimated in the application. However, if the licensee were able to demonstrate lower costs estimates associated with authorized construction, operating, decommissioning and disposal of secondary waste streams, the Executive Director would consider a reduction in the required financial assurance amount. The application did not provide details for how this on-site treatment might be accomplished.

Overall, general comments regarding hauling costs, contingency, and escalation factor rates that were discussed in the previous sections apply to the closure cost estimates. Closure costs must accurately reflect current conditions and address concerns listed above. The closure costs under the three scenarios were updated to account for these concerns and are as follows: year one closure cost of $51,612,000, year two closure cost of $57,431,000, and an unplanned closure cost at year twelve of $71,534,000. Including the off-site disposal cost of leachate at $28,300,000, the total closure at year one, year two, and an unplanned closure event at year twelve would be $79,912,000, $85,731,000, and $99,834,000, respectively. The initial cost for unplanned closure will be based on the year one estimate of $79,912,000 with the requirement that the cost estimate be updated the following year. Thereafter, the cost for closure will be based on the submittal frequency of the closure cost estimates. Closure cost estimate submitted every *n* years would require the maximum amount of unplanned closure over the next *n* years, where *n* is between one and five years.

8.14.3 Funding for Post Closure and Institutional Control

Title 30 TAC §336.737 requires adequate funds be provided for surveillance, monitoring, any required maintenance, and other care of the disposal site on a continuing basis during the institutional control period. While 30 TAC §336.737 addresses institutional control requirements, post-closure will also be discussed in this section as the issues for both are similar. Section 12 of the application states that a Letter of Credit is intended to be used to demonstrate financial assurance for post-closure and institutional control. The costs for post-closure and institutional control proposed in the application are $9.9 million and $20.7 million, respectively.

Plans for post-closure and institutional control were included in Appendices 7.1.1 and 7.2.2 of the application. A review of these plans is included in Section 5.4 of the EA. From these plans annual costs for post-closure and institutional control were developed and are included in Appendices 7.1.3 and 7.2.3 of the application. Finally, a method used to determine total cost from these annual costs as a function of time for post-closure and institutional control is described in Appendix 12.1.4-3 of the application.

The method used to calculate the total costs makes use of the fact that the post-closure and institutional costs vary in time. In determining the total cost of post closure and institutional control as a function of time, the application partitions the costs into fixed and variable costs. Fixed costs are constant through time, while variable costs are increased each year as more waste is disposed. The rationale stated in the application for this method is that less monitoring would be needed for the initial stages of waste disposal should post-closure commence earlier than expected and the remaining volume of the disposal unit not be used for the disposal of wastes. Some costs, such as, for site walkovers are given as variable costs, but in reality, a certain percentage of this variable cost is actually fixed like the cost for contractor mobilization. Similarly, a certain amount of costs related to sampling/monitoring locations would remain fixed, regardless of the amount of waste disposed.

Overall, the same general comments regarding hauling costs, contingency, and escalation factor rates that were discussed in the previous sections apply to the post-closure and institutional control cost estimates. Post-closure and institutional control cost estimates must accurately reflect current conditions and address concerns. A license condition is proposed requiring $10,256,000 for the cost of post-closure and $21,000,000 for the cost of institutional control.

8.14.4 Funding for Corrective Action

Title 30 TAC §336.738 requires financial assurance for corrective action to address unplanned events that pose a risk to public health, safety, and the environment that may occur after decommissioning and closure of the disposal facility. Section 12 of the application states a Letter of Credit is intended to be used to demonstrate financial assurance for corrective action. The application provides a cost for corrective action of $22.0 million, described as a worst case scenario.

Appendix 7.3.2 of the application evaluates a stated “worst case” scenario by selecting one of five scenarios to determine the cost for corrective action. Each scenario presented a failure of the liner at different locations within the disposal facility. The five failure locations described in the application were at the center of the FWF-CDU, the center of the CWF, the side slope of the FWF-CDU, the center of the FWF-NCDU, and the side slope of the FWF-NCDU. For each of these scenarios, various corrective action tasks were identified in the application. These tasks included cover excavation, waste excavation, liner repair, canisters/waste replaced, backfill replaced, and cover replacement. Additional tasks described in the application included the cost to dispose of the degraded liner, the contaminated backfill, and a certain amount of excavated waste. The application stated that the scenario which contributed the largest volume of waste was selected as the “worst case” scenario.

Appendix 7.3.2 of the application identifies the selected corrective action configuration as a failure in the center of the FWF-NCDU. The application states that this failure would result in excavation of 157,000 cubic yards of waste and disposal unit cover material. In Appendix 7.3.2 of the application, a significant portion of the costs for corrective action included the cost to dispose the excavated waste at an off-site disposal facility. The application assumes that 20 percent of any waste excavated would be disposed at an off-site disposal facility at a cost of $1,992 per bank cubic yard. However, Appendix 7.3.3 of the application, which contains the detailed cost estimates of the selected scenario, assumes zero percent of waste excavated requiring off-site disposal. In that scenario all material excavated from the failed disposal liner scenario, including soils outside the original disposal unit, are capable of being re-worked, compacted, and disposed in the original volume to the repaired disposal unit.

The application does not provide a discussion of why a failure involving Class A low-level radioactive waste constitutes a more costly scenario than one involving higher radioactivity waste. First, the class of waste disposed in the FWF-CDU will most likely be Class B and C low-level radioactive waste rather than Class A low-level radioactive waste. The cost to dispose of Class B and C low-level radioactive waste off-site would likely be considerably higher than the $1,992 per bank cubic yard estimated in the application.

Further, there is no analysis provided in the application to support the assumption that only 20 percent of the waste excavated from the FWF-NCDU liner failure scenario will require disposal off-site. Appendix 7.3.2 of the application states that the cost to dispose of one bank cubic yard of FWF waste is $1,992 while the cost to dispose of one bank cubic yard of CWF waste is $19,202. The application's assumptions are based on estimates for disposal of federal waste at the Nevada Test Site for federal facility mixed waste and for disposal of compact waste at the Energy Solutions Barnwell facility. The application does not provide how the cost estimates for off-site disposal can be relied upon or the assumption of access to these disposal locations justified.

The corrective action cost estimate provided in the application did not include costs for remediation of soil or groundwater that may be contaminated should the liner fail. Nor, did it include costs associated with the development of analyses, design, plans, or procedures required to carry out corrective action. Further, the cost for a third party to conduct this corrective action is not included in the presented estimate. Appendix 7.3.2 of the application states that "the cost to excavate and replace/reconstruct the waste and cover system was estimated to total $8.3 million." Appendix 7.3.2 of the application states that the cost to dispose of waste at an off-site facility will be $1.7 million for a total of $10.1 million. These numbers are based on page 7 of 8 in the attachment to Appendix 7.3.2. However, there is a unit conversion error in the determination of the off-site disposal costs. (The application uses cubic feet instead of cubic yards resulting in a 27 times multiplication error.) A recalculation of the cost presented in the application using corrected units to dispose of 20 percent of the excavated waste at an off-site facility was $46.9 million, rather than $1.7 million estimated in the application.

Overall, the same general comments regarding hauling costs, contingency, and escalation factor rates that were discussed in the previous sections apply to the corrective action cost estimates. These estimates must be annually re-evaluated to accurately reflect current conditions. A corrective action financial assurance amount of $25,300,000 has been proposed as a license condition for the first year of operations. To address corrective action scenario requiring off-site disposal of waste, the Executive Director recommends the proration of the $46.9 million for the off-site disposal of waste over the 15-year license term. This recognizes that the cost estimate for corrective action will increase as more waste is disposed over the term of the license. Table EA-18 was developed to estimate how the corrective action costs would change as a function of time over the 15-year license term.

Table EA-18: Schedule of Corrective Action Costs

Year of Operation	Corrective Action Cost
Year 1	=$25.3M
Year 2	=$25.3M + $3.35M = $28.65M
Year 3	=$25.3M + $6.70M = $32.00M
Year 4	=$25.3M + $10.05M = $35.35M
Year 5	=$25.3M + $13.40M = $38.70M
Year 6	=$25.3M + $16.75M = $42.05M
Year 7	=$25.3M + $20.10M = $45.40M
Year 8	=$25.3M + $23.45M = $48.75M
Year 9	=$25.3M + $26.80M = $52.10M
Year 10	=$25.3M + $30.15M = $55.45M
Year 11	=$25.3M + $33.50M = $58.80M
Year 12	=$25.3M + $36.85M = $62.15M
Year 13	=$25.3M + $40.20M = $65.50M
Year 14	=$25.3M + $43.55M = $68.85M
Year 15	=$25.3M + $46.90M = $72.20M

The following are the updated amounts required for financial assurance under the first year of the license:

Closure	$ 79,912,000
Post-Closure	$ 10,256,000
Corrective Action	$ 25,300,000
Institutional Control	$ 21,000,000
Total for financial assurance in 1st Year	$ 136,468,000