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TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

May 13, 2008

LaDonna Castañuela, Chief Clerk
Office of the Chief Clerk
Texas Commission on Environmental Quality
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Austin, Texas 78711-3087

2008 MAY 13 PM 4:27
CHIEF CLERKS OFFICE
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Re: TCEQ Docket No. 2008-0428-RAW
Application by Waste Control Specialists, LLC for new Radioactive Material License No. R05807

Dear Ms. Castañuela:

Enclosed for filing, please find the original and eleven copies of the Draft Environmental Analysis. By this letter, I am also providing a copy of the Draft Environmental Analysis to all persons on the attached mailing list.

Sincerely,

Don Redmond

Don Redmond
Staff Attorney
Environmental Law Division

cc: Mailing List

Enclosure

MAILING LIST
WASTE CONTROL SPECIALISTS, LLC
TCEQ DOCKET NO. 2008-0428-RAW

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Draft Environmental Analysis:

License Application Review for By-Product Waste Disposal from Waste Control Specialists LLC in Andrews County, Texas,

License No. R 05807

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY
2008 MAY 13 PM 4:27
CHIEF CLERKS OFFICE

Uranium and Technical Assessments Section
Radioactive Materials Division, Office of Permitting Remediation & Registration
Texas Commission on Environmental Quality
October 22, 2007

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APPENDIX G. ESTIMATING THE DOSE TO A WORKER DURING THE OPERATING PERIOD FROM RADON WHILE PLACING AND COMPACTING BY-PRODUCT WASTE

SUMMARY

Waste Control Specialists, LLC (WCS) has applied for a license to dispose of by-product material at a site located approximately 31 miles west of the City of Andrews, Texas, and six miles east of the City of Eunice, New Mexico on State Highway 176. WCS is a Delaware limited liability company. The company corporate offices are located in Dallas, Texas. The Texas Department of Health (predecessor of the Texas Department of State Health Services) received the Waste Control Specialists' by-product waste disposal license application on June 23, 2004. The application requested a radioactive material license, under the provisions of Title 25 of the Texas Administrative Code, Section 289.260, that would authorize the disposal of by-product material [as defined at 25 TAC §289.260(3)(B)] received from other persons.

The location of the proposed by-product disposal facility is depicted in Figure 1.3 of Section 1.0 of Volume 1 of the application. A closer view of the proposed facility with respect to other features at the WCS complex is depicted in Figure 3.17 of Section 3 of Volume 1 of the application. The proposed by-product disposal units will occupy approximately 16 acres. Including the supporting facilities surrounding the disposal units, the proposed by-product disposal facility will occupy approximately 36.39 acres.

A more detailed depiction of the proposed by-product material disposal facility with the perimeter fence, access gates, facility structures (e.g., guard house/counting lab, overhead inspection station, incoming container storage area, contact water tanks, outgoing container staging area, container decontamination building) and disposal units identified at the WCS complex is provided in Figure 3.18 of Section 3.0 of Volume 1 of the application.

The disposal area of the facility is indicated to be comprised of six (6) disposal units or cells (A through F) allowing for a total volume of 1,160,000 cubic yards (Section 3.2 of Volume 1) and total radioactivity of 24,530 curies.

1.0 INTRODUCTION

The Texas Department of Health (predecessor of the Texas Department of State Health Services) received the Waste Control Specialists' by-product waste disposal license application on June 23, 2004. The original application consisted of 7 volumes which grew to 15 volumes over the course of 17 revisions. Two of those revisions were major, constituting revisions to the entire application. The first major revision was submitted in response to an agency letter for more information sent to WCS in August 2005. That letter requested WCS to consolidate the application and remove unnecessary material. WCS completed a consolidation of the application in October 2005 with the application doubling in size. DSHS responded to that complete revision with a 61-page review letter in August 2006. WCS responded with a second major revision, Revision 13 in January 2007, which increased the number of volumes up to 15. Additional revisions and an omission correction were subsequently received. Staff review is based on the last major revision of the application: Revisions 13 through 17 (WCS, 2007).

The Technical Assessments program of the Texas Department of Health (TDH) began the review of the

WCS application in June 2004 under 25 TAC §289.260. TDH was re-organized on September 1, 2004 into the Texas Department of State Health Services (DSHS). In the newly formed DSHS, the Technical Assessments Group continued with the review until the 80th Texas Legislature passed, and the Governor signed, SB 1604, transferring regulatory authority for uranium/by-product waste disposal to the Texas Commission on Environmental Quality (TCEQ), effective July 1, 2007. The new Uranium and Technical Assessments Section of TCEQ continued the WCS review and the by-product waste disposal regulations at 25 TAC §289.260 remained in effect until the review was complete.

In addition to the reviewing agency, other state agencies were given an opportunity to review and comment on the WCS application because of possible areas of regulatory and/or mission overlap. In 2004, letters were sent to the Texas Department of Agriculture, Texas Parks & Wildlife Commission, Texas State Soil and Water Conservation Board, Texas Historical Commission, Railroad Commission of Texas, Bureau of Economic Geology (UT), and the Texas Commission on Environmental Quality inviting their review and comment on the WCS application (TDH, 2004a-g). Responses were received from four of the seven agencies.

1.1 STAFFING AND REVIEW AREAS

Staff expertise for the application review was divided into six review areas: operational health physics, environmental health physics, process engineering (accident analysis), civil engineering, geology/hydrology, and socioeconomics. Regulatory requirements for the review of the WCS application came from the Health and Safety Code Chapter 401.263, 25 Texas Administrative Code §289.260, and the National Environmental Policy Act of 1969 (USNRC, 1982). In response to the foregoing requirements, radiation staff developed an environmental analysis outline (e.g., TDH, 1991) that would permit agency reviewers to prepare an environmental analysis for the purpose of determining whether the subject activity would have a significant impact on the human environment. Individual technical review chapters were produced that addressed specific parts of the environmental analysis outline and which reflect the findings of review staff. Section management assigned various part of the previously mentioned outline to staff experts in engineering, health physics, etc (DSHS, 2006a). Thus, the NEPA-style environmental analysis outline found in the Texcor report (TDH, 1991) was modified for use in individual review chapters. Taken together, the staff final reports constitute an environmental analysis for the application as presented by this consolidated document.

The individual review areas are as follows.

- The geology and hydrology review addressed the majority of site characterization data pertaining to regional and site specific geology, and performance of the site in preventing radionuclide migration in the post-closure period. Based on staff review, specific license conditions related to verification of site characterization and post-closure performance are needed (TCEQ, 2007e). Certain monitoring wells that have been impacted by surface drainage need to be carefully watched after the surface drainage is modified in order to allow for monitoring data to be a true early

indicator of potential contaminant release. Specific license conditions were added to the draft license to address groundwater impact modeling and monitoring, and to verify presented characterization for the nearest water tables in the Dockum and Ogallala-Antlers-Gatuña (OAG) formations.

- The environmental health physics (EHP) addressed the review of the environmental and general population exposure impacts resulting from possible emissions or migration of radioactive materials during operations, closure, and after license termination. The review and evaluation of groundwater impacts and post-closure impacts related to groundwater were reviewed by the geological staff. For the most part, the applicant gave adequate responses to questions about dose assessment, baseline environmental measurements, and the routine environmental monitoring program (TCEQ, 2007b). The dose assessment for the general population resulting from routine operations suggested that any impacts would be negligible. Based on staff review, aspects of the applicant's monitoring program were addressed by the addition of specific conditions in the draft license.

- The operational health physics (OHP) review addressed the regulations in 25 TAC §289.260 and §289.252 that constitute the requirements for licensing and safely operating the facility during the operational and closure phases. In addition, OHP also completed a Safety Evaluation Report (SER) and assembled a draft license. The OHP review determined the need for numerous draft license conditions associated with the applicant's proposed Radiation Safety Program and the requirements of the regulations (TCEQ, 2007a). For example, draft conditions are proposed to address aspects of the radiological training program, the respiratory protection program, the bioassay program, parts of the monitoring and sampling program, and receipt of waste materials. The clarifying or limiting conditions are presented in the draft license. The SER is a report that documents the agency's identification and evaluation of the operation of the applicant's radiation safety program. The OHP review identified operational aspects of the applicant's radiation safety program that will be addressed through the addition of license conditions.

- The civil engineering addressed the review of the waste cell design and proposed construction, surface water controls and flooding, and erosion impacts (TCEQ, 2007d). This review indicated that specific license conditions were necessary for verifying geotechnical measurements, providing as-built construction drawings, operation of the leak detection system, minimization of infiltration of water into the OAG formation, and monitoring for unanticipated geological features during excavation of the by-product material disposal facility.

- The process engineering review concentrated on transportation issues, waste emplacement, impacts of accidents, decommissioning, and financial assurance. Based on staff review, specific license conditions were added to the draft license specifically in the area of water management and minimization of particulate air emissions in the waste cell (TCEQ, 2007c).

- An adjunct staff member reviewed WCS's socioeconomic report which examined the applicant's current status and near-term impacts on the county's and region's cultural, economic, governmental, and natural resources (DSHS, 2006b). The review elements included: uses of adjacent lands and waters; population distribution; minority and low-income populations; environmental justice; historic, architectural, and scenic resources; cumulative effects; environmental approvals and consultations; alternatives to the proposed action; benefits and costs; societal benefits and costs in the context of public policy; leadership and public opinion surveys; economic and social effects of construction and operation; financial costs to government; and commitment of mineral resources. All topics were found to have been satisfactorily addressed by the applicant.

1.2 REVIEW OF OTHER STATE AGENCIES AND THE PUBLIC

As mentioned above, other state agencies were invited to review and comment on the WCS by-product waste disposal application. These agencies represent other aspects of State Government that are responsible for protecting health, safety, and the environment of the State of Texas. Agencies assisting in the review included:

- The Texas Historical Commission (THC) responded to the Department's invitation to comment on WCS's application (THC, 2004). THC staff indicated that no historic properties would be affected by the construction and operation of the WCS facility.

- The Texas Parks and Wildlife Commission (TPWC) responded to the Department's invitation to comment on WCS's application and found that the impacts, if any, to local flora and fauna would be minimal (TPWC, 2004). This review provides attention to possible impacts on flora and fauna associated with the proposed WCS site.

- The Texas State Soil & Water Conservation Board (TSSWCB) responded to the Department's invitation to comment on WCS's application. The Andrews Soil and Water Conservation Board #246 indicated their concern about groundwater protection and their opposition to the project (TSSWCB, 2004).

- The Texas Department of Agriculture (TDA) responded to the Department's invitation to comment on WCS's application and indicated that they had no comment (TDA, 2004).

- Members of the public and others were invited to comment on the WCS application. In response to TDH's invitation to comment in 2004, no replies were received.

1.3 REQUIRMENTS FOR AN ENVIRONMENTAL ANALYSIS

An environmental analysis is required by Section 401.263(a) of the Texas Health and Safety Code which

states, in part, that: "If the commission is considering the issuance of a license to dispose of by-product material and it is determined that the licensed activity will have a significant impact on the human environment, a written environmental analysis shall be prepared." The commission has addressed the requirements of the Texas Health and Safety Code regarding the environmental analysis as follows:

- **An assessment of the radiological and non-radiological effects of the licensed activity on the public health must be made.** This topic is addressed in detail in the environmental health physics review (TCEQ, 2007b) and the geological review (TCEQ, 2007e) of this application. The environmental health physics (EHP) review examined environmental baseline information for the proposed site that included: climate and meteorology; air quality; population distribution; and radiological and chemical characteristics of all environmental media (air, soil, water, etc). The EHP review also examined the applicant's monitoring program and the radiological impacts of this facility during operations and in the post-closure period. The EHP review examined the operational radiological doses forecasted for the site workers and the nearest residence and found that the facility would operate well within the applicable dose limits. In the post-closure period, the reviewer found that the applicant had made provision for meeting the requirements for ultimate closure: control of radon flux, attenuation of ambient gamma radiation, and assuring that surface soils are decontaminated. The geological review (TCEQ, 2007e) examined non-radiological impacts on soil, sediment, surface water, and groundwater. Owing to the proposed depth of the by-product wastes (both radiological and non-radiological), impacts to soils and sediments were not anticipated. The only surface water adjacent to the site is the Baker Spring, and the top of the buried by-product wastes could be in communication with the Baker Spring through the OAG formation. After installation of the final cover on the disposal units, there should be minimal non-radiological impact on Baker Spring.

- **An assessment of any effect of the licensed activity on a waterway or groundwater.** This topic is addressed in detail in the geological review (TCEQ, 2007e). A requirement for licensing of a by-product waste disposal site is that radiological and non-radiological contaminants should be isolated and contained for 1,000 years or at least 200 years. No permanent streams exist on site, hence there will be no impact on any waterway. Groundwater (usable groundwater) does exist on site, but it is of sufficient depth so that any contaminants that may be mobilized from the waste disposal facility will not reach it in 1,000 years or at least 200 years.

- **Consideration of alternatives to the licensed activity, including alternative sites and engineering methods.** This topic is reviewed in detail in the process engineering review (TCEQ, 2007c). The licensee presented alternatives of no action, alternatives to the Andrews County site, alternative processes, and alternative methods of by-product disposal. The topic was satisfactorily addressed.

- **Consideration of decommissioning, decontamination, reclamation, and other long-term effects associated with a licensed activity, including management of by-product material.**

Decommissioning, decontamination, and reclamation as part of the overall closure plan was reviewed in detail in the process engineering review, Decommissioning and Financial Assurance (TCEQ, 2007c). Other procedural aspects of closure are reviewed in the operational health physics review (TCEQ, 2007a).

- Long-term effects are also examined in other reports: socioeconomics review (DSHS, 2006) reviewed for long-term effects on infrastructure, economics, and population distribution; environmental health physics (TCEQ, 2007b) looked at long-term radiological impacts from radon, ambient gamma, and soil radium; civil engineering (TCEQ, 2007d) discussed on-site erosion and post-closure subsidence; and geology (TCEQ, 2007e) reviewed for potential impacts on groundwater from migration of contaminants out of the by-product material disposal unit.

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1.4 REFERENCES

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Texas Department of Health. 1991. Environmental Assessment Related to the Texcor Industries, Inc. By-product Disposal Project, Kinney County, Texas. TBRC-EA-19. Austin, Texas. April 5, 1991.

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Texas Department of Health. 2004d. Letter from R. Ratliff, TDH to the Director, Railroad Commission of Texas (Surface Mining and Reclamation Division), dated July 2, 2004, requesting review and comment on mining aspects of WCS' application.

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Texas Historical Commission. 2004. Letter from F. Lawrence Oaks, State Historic Preservation Officer to R. Ratliff, TDH, dated July 19, 2004, responding to our request for review and comment on WCS's by-product waste disposal application (returned copy of our letter with "No Historic Properties Affected..." stamped on it).

Texas Parks and Wildlife Department. 2004. Letter from D. Allen, Wildlife Habitat Assessment Program to R. Ratliff, TDH, dated October 15, 2004, responding to our request for review and comment on WCS' by-product waste disposal application.

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U.S. Nuclear Regulatory Commission. 1982. Regulatory Guide 3.8: Preparation of Environmental Reports for Uranium Mills. Office of Nuclear Regulatory Research. Washington, D.C. *(Outline for environmental reports and direct reference to NEPA requirements.)*

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CHAPTER 2 GEOLOGICAL REVIEW

2.1 REGIONAL AND SITE GEOLOGY

State requirements at Title 25, Texas Administrative Code (TAC) §289.260(f)(1)(A)(ii) states that a license application for by-product material disposal shall include area/site characteristics including geology. The purpose of understanding the site characteristics is to ensure that the site features comply with 25 TAC §289.260(o)(2), to meet the broad objective of isolating the tailings and associated contaminants without ongoing active maintenance.

2.1.1 Regional Geology

2.1.1.1 Topography

WCS owns a tract of approximately 14,900 acres situated along the Texas-New Mexico border in Andrews County, Texas and Lea County, New Mexico. Within this property, on a 1,338 acre tract in Andrews County, WCS operates a permitted RCRA hazardous waste landfill (TCEQ Permit HW50358) and a licensed low level radioactive waste storage and treatment facility (TCEQ License L04971). This tract is also the site of the proposed by-product material disposal facility covered by this application, as well as federal and state low-level radioactive waste disposal facilities covered by a separate application.

The proposed WCS by-product disposal landfill site is situated at the western edge of Andrews County, Texas, (Figures 1 and 2) and lies atop the ridge locally forming the southwestern flank of the Southern High Plains. The elevations at the proposed facility range from about 3,415 to 3,500 feet above mean sea level. The Southern High Plains comprise a semi arid area of low relief, undulating plains, generally separated from the Pecos River valley to the west by a well defined escarpment, the Mescalero Ridge. In the vicinity of the proposed facility the transition is not so distinctly defined. To the north and east, the Southern High Plains are bounded by caprock escarpments resulting from headward erosion of the Canadian, Colorado, Brazos, and Red Rivers. To the south, the Southern High Plains blend into the Edwards Plateau, without a well defined boundary.

The ridge beneath the WCS site forms the surface water drainage divide for the Pecos and Colorado Rivers. The nearest drainage to the west is Monument Draw, in Lea County, New Mexico, about 3 miles distant and about 115 feet lower in elevation, with over half of the slope occurring in the first mile to the southwest of the proposed by-product facility. To the north and northeast the nearest continuous drainage is also named Monument Draw, and lies about 8 miles distant and less than 100 feet lower in elevation.

Local topographic features include a small dune field to the north and a number of shallow depressions (playas) around the proposed by-product disposal facility. The largest of these lies about 2,500 feet to the northeast, with a overall elevation difference on the order of about 20 feet. To the west about 2,000 feet is Baker Spring, an historic feature which commonly contains water filling a depression reported to have resulted from excavation by a now defunct sand and gravel operation. Another large, closed depression is

located about four (4) miles to the east. This feature essentially drains much of the eastern side of the WCS property, including some of the proposed disposal facility.

The topographic expression at the site is for the most part subdued, with longer, gentle slopes rather than short, steep, sharply defined features. This is most likely due to the large amount of windblown sands present. These sands are largely responsible for the above mentioned lack of a well defined escarpment in this area.

2.1.1.2 Structure

The WCS site is located over the north-central part of the Central Basin Platform, a large elevated block between the Delaware and Midland Basins, within the Tobosa Basin of southeastern New Mexico and west Texas. Prior to late Mississippian time this region, which was in the foreland of the Marathon-Ouachita orogenic belt, had only mild structural deformation, producing broad shallow depressions and regional arches.

During Mississippian and Pennsylvanian time the area was affected by the collision of the Gondwanaland and Laurasia continents, causing the Marathon-Ouachita orogeny. During this orogeny the Tobosa Basin was broken up into the various basins and uplifts forming the Permian Basin region (Figure 3). One of these uplifted regions formed the present day Central Basin Platform, along previously existing zones of weakness.

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 a downwarping that created a large landlocked basin that was filled with sediments accumulated in flood plains, 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.

The Laramide Orogeny uplifted the area to the west of the area 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 final uplift of the High Plains region in Miocene and later time.

Based on this geologic history presented in 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. The literature presents alternative views of the tectonic regimes and forces based on well log interpretations and seismic profiles, as none of the major faults are exposed at the surface. It is suspected that at least one of the bounding faults for the Central Basin Platform lies buried approximately 7,000 feet below the WCS site, but there has been no apparent activity along this fault since early Permian time. The applicant does note that one fault has been mapped west of the facility that appears to have been active in the late Permian.

The applicant has included cross sections indicating that no significant faulting occurs in the upper 2,000 feet of sediments within 3 to 4 miles of the WCS facilities. A 1992 earthquake beneath Rattlesnake Ridge, about 12 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.

2.1.1.3 Stratigraphy

The regional stratigraphy is well understood and accepted. Figure 4 depicts the stratigraphic column for the Central Basin Platform. The upper portion of the column above the Permian pertains directly to the WCS site; from oldest to youngest, the Triassic Dockum Group, consisting of the Santa Rosa, Tecovas, Trujillo, and Cooper Canyon Formations (in the site area), the Cretaceous Antlers, the Tertiary Ogallala and Gatuña, and the Quaternary Blackwater Draw and Playa Deposits.

Permian formations of primary interest in the region are the Rustler and Salado. These units contain large sections of evaporites, which are subject to dissolution when exposed to fresher water. Their dissolution is often accompanied by the collapse of the overlaying strata, and may create surface subsidence features. This geologic hazard is also covered in Section 1.3.4, Subsidence.

The Triassic Dockum consists largely of red beds, with two major sandstone units. The Dockum sediments accumulated in a large land-locked interior basin (Figure 5, shows early Dockum inferred paleogeography), and represent a fluvial-lacustrine basin environment, into which river systems transported sediment from highlands around the basin onto a weathered Permian surface (Bradley and Kalaswad,2003, McGowan et al, 1977, 1979, Granata, 1981). Typical depositional environments in such a system include braided and meandering streams, alluvial fan deltas, lacustrine sediments, lacustrine deltas, and mud flats. Atop the Central Basin Platform the Dockum can range up to 1,400 to 1,500 feet in thickness.

The basal unit of the Dockum, the Santa Rosa Formation, is a sandstone and conglomerate ranging from 200 to 250 feet thick. The Santa Rosa is overlain by the Tecovas Formation, a 500 to 550 foot thick sequence of lacustrine claystones and siltstones. The Tecovas is in turn overlain by the Trujillo Formation, a sandstone approximately 100 feet thick. The uppermost unit, the Cooper Canyon, lies atop the Trujillo, and consists of approximately 600 feet of red bed claystones and interbedded sandstones and siltstones.

The Jurassic was a period of non-deposition, leaving an unconformity surface, onto which the Cretaceous Antlers Formation was deposited. The Antlers consists of fine to medium grained sandstone and chert

pebble conglomerate, the thickest sections of which were deposited in erosional channels cut into the Cooper Canyon. Locally there are small outcrops of younger Cretaceous shales and limestones. Regionally, the Antlers is an irregular sheet deposit thinning to the northwest. The Antlers ranges from 0 to 60 feet in thickness (Fallin, 1989).

After Cretaceous time, there was another period of non-deposition and most of the Cretaceous rocks were eroded away. By the Tertiary mid-Miocene renewed deposition began, depositing the Ogallala Formation and probably at least the earliest sediments of the Gatuña Formation, partially equivalent formations deposited on opposite sides of the Red Bed Ridge, a buried ridge at the top of the Cooper Canyon.

The Ogallala is believed to have been deposited as fluvial and eolian sediments, sourced from highlands to the west, with deposition being controlled by the existing surface topography. Erosion related to the Pecos, Canadian, Brazos, and Colorado Rivers has modified the surface expression of the Ogallala through varying degrees of removal. The Ogallala is a major aquifer for the entire High Plains region. Over the Southern High Plains the Ogallala ranges from a feather edge in the south, near the WCS site, to over 800 feet in thickness northeast of Amarillo (Reeves, 1996). On the opposite side of the Red Bed Ridge, the Gatuña lies atop the red beds. The Gatuña has been mapped as a continuation of the Ogallala, and is also considered to be at least partially age-equivalent, but is considered by other authors to be a separate unit, as cited in the application (Hawley, 1993, and Lehman and Rainwater, 2000).

Overlying all pre-Quaternary units is a regional pedogenic caliche caprock. This is not truly a separate stratigraphic unit, and is often mapped as part of the Ogallala. The caprock caliche is formed by a subaerial pedogenic process that develops soils containing significant secondary calcium carbonate, and moves through a sequence of stages, culminating in a calcrete. The applicant has chosen to group all of these post-Triassic units under the term Ogallala-Antlers- Gatuña, or OAG, as they are all in hydrologic communication.

The Quaternary surface material in the region consists of windblown sands, with the Pleistocene sands termed the Blackwater Draw, the overlying Recent/Holocene sands are unnamed, and playa deposits, consisting of sandy clays and silts formed in shallow depressions, and subject to intermittent inundation and drying. The source of the Blackwater Draw sands is considered to be the Pecos River Valley, as demonstrated by the decrease in grain size from the southwest to the northeast across the Southern High Plains.

2.1.2 Site Geology

The site geology must demonstrate that 25 TAC §289.260(o)(14)(B) can be satisfied. This requires examination of the characteristics of the underlying soil and geologic formations to control transport contaminants and solutions. Such information is deemed to include extent, thickness, uniformity, shape, and orientation of underlying strata, as well as borehole information to allow determination of significant discontinuities, fractures, and channeled deposits of high hydraulic conductivity.

2.1.2.1 Structure

On the local scale, excavation of the RCRA hazardous waste landfill, directly adjacent to and south of the proposed by-product disposal facility, revealed two opposing reverse faults in the Triassic Dockum, one dipping to the south with about 20 feet of offset, the other dipping to the north with about 3 feet of offset. The applicant has studied the faults in detail (WCS Application, Attachment 4-1) and maintains they do not continue into the overlying Cretaceous Antlers Formation, and they do not meet the definition of a capable fault as defined in 25 TAC §289.260(c)(5). However, the ultimate cause for the faulting has not been determined, and the prevalence and extent of such faulting is undetermined. The applicant, in their fault study, also notes that numerous smaller faults were observed in the Cooper Canyon, and states that they pre-date the deposition of the Cretaceous Antlers sediments.

The applicant states that fractures and jointing in the red beds (Dockum) have also been studied (WCS Application, Attachment 4-1, Fault Study). These observations appear to be related to the excavation of the RCRA hazardous waste landfill. A review of the boring logs provided in the application indicates the Dockum to be fractured at depth as well. These logs either simply note that fractures are present, that fractures may also have associated black mineralization, that the fractures may be filled (noted as possible calcite with a question mark), or, in one instance as an open fracture (Boring B-54 at 63.5 feet depth). However, at no time is any indication of fracture size provided. Neither is any information on orientation consistently reported. The nature, density, and extent of fracturing is undetermined, and this type of information is necessary when attempting to model the potential flow of leachate and transport of radionuclides.

The applicant, on page 4 of Attachment 4-1 of the fault study makes an observation that weathering and alteration at the top of the Cooper Canyon appears to predate the faulting or folding, but on the next page notes that Liesegang banding is present, and then states that the alteration is clearly post-fracturing. It is unclear how the applicant is differentiating between fracturing, jointing and faulting, and their timing, as the two statements appear contradictory.

The occurrence in the Dockum of gypsum, as both rosettes and fracture fillings, was observed in the RCRA landfill extension excavation. Some fractures exhibit the presence of fibrous gypsum, which grows outward from a medial plane, referred to as antitaxial gypsum. This occurrence raises a controversy revolving around the possible modes of formation of antitaxial gypsum. The applicant contends that stress related to the dissolution of deeper evaporite horizons is not the only source of such gypsum.

The last issue relating to structure at the WCS site is that of the above mentioned salt dissolution. This is covered in more detail in Section 1.3.4.

2.1.2.2 Stratigraphy and Sedimentology

At the site specific level, the primary stratigraphic units of concern are the OAG, which includes the caliche cap, and the Cooper Canyon Formation. As proposed, the by-product disposal facility will remove

the OAG and waste will be disposed of totally within the Cooper Canyon.

Locally, the OAG consists of feldspathic and quartzitic sand and gravel with silts and clays, which in part may be calichified in the near surface. The basal portions appear to be more friable, being referred to in the WCS geology report as unconsolidated to semi-consolidated. In outcrop at Baker Spring, about 2000 feet to the west, the Antlers portion of the OAG exhibits cross bedding, indicating a higher energy depositional environment.

Differentiating between Ogallala and the Antlers is difficult because of their similar natures, but may sometimes be accomplished by the presence of colored chert pebbles in the Antlers. The thickness of the OAG is in part related to the Dockum surface, with the thickest deposits in topographic lows in the Dockum surface, and thicker sections more distant from the Red Bed Ridge crest. In the application there are inconsistencies in exactly how this occurs. The Antlers, which was deposited on a weathered Cooper Canyon surface, might be expected to be thickest where there were physical depressions or lows in that depositional surface. Instead, the mapping in the Lehman and Rainwater (2001) geology report shows the thickest Antlers in large part associated with the Red Bed Ridge crest, while to the north of the facility there is an extensive elongated area without Antlers, generally coinciding with a depression in the Cooper Canyon surface. While one might argue that the Antlers was eroded away and replaced with Ogallala, this makes it difficult to explain how the basal Antlers sands and shales would remain along the ridge crest, where they would be most exposed to weathering.

The application states that the Cooper Canyon Formation, into which the by-product materials will be placed, represents a combination of fluvial, lacustrine, and deltaic sediments. Of primary interest for the hydrogeological picture are four major siltstone/sandstone units, named for their approximate depths from the surface. They are referred to as the 80-Foot Sand (or Zone), the 125-Foot Sand (or Zone), the 180-Foot Sand (or Zone) and the 225-Foot Sand (or Zone). The presence of other, less continuous "stray" sands is hypothesized, as shown on the Hydrogeologic Conceptual Model cross sections.

The applicant has installed over 250 borings to gather information for the evaluation of the local stratigraphy. The application includes the boring logs. It has been noted that the 2001 By-product Investigation boring logs differ from logs of what appear to be the same boreholes that are included in the Low Level Radioactive Waste Facility application. It also appears some data from the logs in the application were used on maps included in the by-product disposal facility application. The explanation offered is that the original set of logs was inadvertently included in both of the applications, but the cores were relogged in the course of a subsequent internal data qualification process with no further explanation. Additional refinements were made to several boring logs included in the application for the 2003-2004, and the 2006 investigations. These two reports were sealed by the geologists. The refined versions are not sealed, which puts the validity of these logs in question. In addition, there are contradictions between the text of the Geology Report and the accompanying figures, as noted below. Such discrepancies make it difficult to determine exactly which interpretation the applicant has chosen.

The 80-Foot Sand, high up in the section, is well above the bottom of the proposed disposal landfill. A

release here is deemed less likely, and the sand appears to be highly restricted in lateral extent, based on the applicant's comment that individual sandstone/siltstone beds within the general interval are not readily correlatable between borings. Also, their isopach mapping (Figure 5-14a) shows it shaling out in all directions. Several discrepancies were noted between the boring log thicknesses and the data on the map; these served only to modify the general shape of the contours, not the overall concept. For these reasons it has not been studied to the extent that the other sands have.

The next zone, the 125-Foot Sand, roughly between 110 to 125 feet depth is described as a relatively continuous, dry sandstone containing silt. The applicant states the 125-Foot Sand "thins and is absent in western and northern areas of the proposed by-product material landfill." While borings indicate this is true for the western portion of the proposed by-product disposal site, it contradicts the 125-Foot Sand Isopach map for the northern area, as shown in Figure 5-14b. This particular unit also exhibits an extreme thickness fluctuation in the WCS Hydrogeologic Conceptual Model Cross Section B-B', Figure 6-6a.

The third zone is the 180-Foot Sand, and is described as a discontinuous, fine grained sandstone. Except for being absent in the northwest corner of the proposed by-product disposal site the 180-Foot Sand is shown as continuous beneath the by-product disposal facility (Figure 5-14c, the 180 Foot Isopach). This contradicts the text portion of the geology report. In the Groundwater section, Section 6.0, the report states both positions on continuity in the space of 5 pages. This zone is considered saturated under the northeast corner of the proposed by-product disposal site, but unsaturated elsewhere.

The most emphasis is placed on the lowest of the four zones, the 225-Foot Sand. This unit is fully saturated and is considered the uppermost aquifer for monitoring and regulatory purposes at the RCRA hazardous waste landfill directly to the south. It is described as fine grained sandstone with variable amounts of silt. The 225-Foot zone is separated from the water-bearing Trujillo Sand by 350 to 400 feet of claystone.

The most thorough attempt to unravel the complex stratigraphic situation presented by the Cooper Canyon appears to have been the 1993 work done by Terra Dynamics Incorporated (TDI) for the RCRA hazardous waste facility permit application (Terra Dynamics, Incorporated, 1993). This landfill was constructed further to the south and the study area eventually became the location for the proposed by-product disposal facility and the proposed low-level radioactive waste disposal facilities.

In the TDI report, which is included in the application as Attachment 5-3, Exhibit G, the writers integrated their observations obtained from their coring program to decipher the stratigraphy. They concluded that there are three stratigraphic sequences present, but spent most of their efforts on the lowest sequence, which contains the 225-Foot Sand. This sequence is interpreted from examination of sedimentary features in the cores to represent increased depositional activity. The study emphasized this sand, which is fully saturated, because it was considered the uppermost aquifer of concern for the RCRA facility. TDI arrived at a general concept of the depositional regime, but without making any statements about the size of individual sand bodies or their arrangement with respect to one another. Thus, while there may be a well defined, continuous sand bearing interval, the continuity of the internal component sands is not addressed.

This information is important for interpreting the hydrogeological model.

TDI also concluded that the depositional regime of the uppermost sequence, which includes the 125-Foot Sand, is similar to that of the lower regime. This suggests that the sand bodies in the 125-Foot Sand could be similar in nature. However, because the 125-Foot Sand is not considered an aquifer, it was not studied in equal detail.

The middle sequence, which would include the 180-Foot Sand, was interpreted as resulting from a more quiescent, lacustrine interval. However, fluctuating lake levels in this time period also led to sand and siltstone deposition, although to a lesser degree than during the other two sequences. Nevertheless, the stratigraphic variability can be striking, as shown by boring logs for two holes, about 35 feet apart. The two holes lie along the northwest edge of the proposed by-product disposal site. Boring B-98 has 13 feet of 180-Foot zone sandstone/siltstone, while MW-1 has none.

The lesser degree of interest in the sands other than the 225-Foot sand is evidenced by the lack of top and bottom of sand maps for those units. Such additional information may provide some insight into the location and size of stream channels, which might, in turn, aid in determination of sand geometry. However, without some general idea of the sizes of the fluvial systems involved, this is a difficult proposition. Terra Dynamics, in their 1993 geology report for the RCRA disposal facility, stated "...a number of cycles of predominantly mudstone and siltstone/sandstone deposition indicate the variable depositional history and complexity of the Dockum Group."

The concern over the degree of characterization is most critical for the 125-Foot Sand, as it lies about 12 to 15 feet beneath the bottom of the proposed by-product material landfill. Any release from the landfill will first encounter this sand and ultimately saturate it, making it imperative to have a good idea where the release may go, how far it may go, and at what rate.

Fractures are observable on the macro scale in the Cooper Canyon in the RCRA excavation. There appears to be two sets of subvertical, approximately orthogonal fractures, trending about N40E and N40W on a spacing of about one foot. These are said to likely be an expression of the regional jointing system discussed by Finley and Gustavson (Finley and Gustavson, 1981). Also noted are large, wavy, continuous low angle joints at roughly 30 to 60 degrees from the horizontal, which exhibit no regular spacing.

The boring logs often note that the cores exhibit fractures, but do not mention the size of the fractures, except for one described as open, at 63.5 feet depth in boring B-54. Some of these fractures are described as having dark mineralization associated with them, or even fillings of possible calcite and evaporites. Mineralized fractures would seem to indicate fluid transport has occurred at some point after the fracture formed. The presence, size, and orientation of fractures may have implications for fluid movement through the section.

At the WCS site, the upper Cooper Canyon exposure in the south wall of the RCRA landfill excavation contains fractures that are gypsum filled. This presents another controversial issue regarding the formation

of antitaxial gypsum, that is, gypsum that grows outward from a medial plane. It may be indicative of salt dissolution at depth, but the applicant believes this not to be the case, based on claims of restricted extent, both laterally and vertically, and lack of brecciation which might be expected to accompany dissolution subsidence. However, it is worth noting that Goldstein and Collins (1984) discuss the presence of gypsum veins cutting the bedding at 30 to 60 degree angles and their association with salt dissolution deformed strata within the Permian in the area of Caprock Canyon State Park in the Texas Panhandle. In addition, the core description for NMB-23 notes an evaporite seam (<1/4 inch) at 194 feet, and in B-32A/TP-26 another evaporite seam, approximately 1/8 inch thick, was observed at 154 feet, at an angle of 55 degrees from the horizontal. These two observations run counter to the claim of limited extent in the vertical sense.

Additional gypsum occurs as rosettes within the Cooper Canyon, but these occurrences do not imply salt dissolution. They are more of a free growing crystalline style that suggests formation in muds, possibly from warm, alkaline groundwater, according to the applicant. The application does not comment on whether the two forms of gypsum occur together or whether one or the other is more widespread, but they certainly indicate that the requisite conditions and components for the formation of gypsum existed in the Cooper Canyon.

After review of the geology portion of applicant's Geology Report, staff finds that such internal inconsistencies and contradictions taken in conjunction with the lack of detailed mapping for all of the Cooper Canyon sands indicate that the geologic characterization has not been verified. This will have further implications in trying to develop a thorough understanding of the hydrogeology. This is not meant to say that the site is unsuitable, but rather that further demonstration through verification studies and monitoring is necessary.

2.1.2.3 Soils

As noted above, the proposed design calls for removal of all material above the top of the Cooper Canyon followed by excavation of the landfill into the Cooper Canyon. Upon closure, a cover will be constructed over the waste material, and a cap will be built to specification essentially to grade. As such, the facility will be below what are conventionally thought of as soils, and impacts to the soils should not occur.

The applicant, in Appendix 2.C, Flood Plain Study, makes reference to the United State Department of Agriculture Soil Conservation Service report, Soil Survey of Andrews County. The applicant provides a listing of the named soils, and a map showing the distribution of those named soils present across the site.

Where the surficial soils become important is in consideration of surficial erosion, and whether the surface is aggrading or eroding. A report by Olig and Zacharaisen (URS Corporation) and Dr. Steven Forman (URS, 2007) based on the results of luminescence studies of soils samples from seven soil excavations is included in the application as Attachment 4-4 to the Geology Report.

The purpose of this report was to provide a detailed map of the surficial Quaternary sediments and

drainages, to collect and analyze soil samples from these taken from pits/trenches in these drainages, and age date them to help determine how pervasive erosion is locally. The process for age dating is referred to as optically stimulated luminescence dating.

The results of the analyses are interpreted to indicate that eolian deposition has been dominant for approximately the last 60,000 years at the site. Multiple periods of landscape stability are indicated by the formation of buried soils on the eolian sediments. It appears that wind erosion was occurring between 30,000 to 54,000 years ago.

This study focused on the areas of the WCS site that are more relevant to the low level waste disposal sites than to the proposed by-product disposal facility. Additionally, WCS has an erosion pin array set up in the same general area, known as the Ranch House Draw, to quantify erosion in the draw. The array has not been in operation long enough to have generated useful data. Unfortunately no similar array exists in the area of the proposed by-product disposal facility. At present, there is little evidence that soil is being removed through wind action, however with vehicular traffic and large piles of spoil and excavated material in the area this would be difficult to detect.

Staff has provided a draft license condition to install another erosion pin array to the west of the facility to develop data on possible wind and/or water erosion over the active life of the facility. The cap/cover design could then be modified to compensate for possible any increased erosion potential.

2.1.3 Geologic Hazards

At the proposed by-product material disposal site there are four potential geologic hazards that warrant consideration; flooding, erosion, seismic activity, and subsidence. All could be construed to be covered by §289.260(o)(2)(C), to minimize erosion, disturbance, and dispersion by natural forces over the long term.

2.1.3.1 Flooding

The proposed facility is built into a ridge crest, minimizing water run-on. The topography is subtle, but drainage appears good. The issue of flooding is covered in detail in Appendix 2.C, Flood Plain Study, and concludes that the facility does not lie within the 100 year flood plain. The study has been reviewed by a licensed engineer and found to be adequate; the entire flooding review can be found in Section 4.0 of the Civil Engineering Review.

2.1.3.2 Erosion

There are two primary issues to be addressed with regard to the erosion. Both are found in §289.260. The prevention of water erosion is addressed in §289.260(o)(8)(A), and wind protection is in §289.260(o)(8)(B). Staff believes, from a long term point of view in regard to the closed landfill, the potential for water erosion presents the greater concern of the two.

To the west of the proposed by-product disposal facility lies a broad, shallow draw which appears to have formerly drained the western part of the facility (Figure 4). The surface draw reflects the existence of a draw at depth in the top of the underlying Dockum Formation. The caprock caliche thins rapidly from the ridge top to the southwest in the vicinity of the draw, and this offers a potential avenue for increased erosion under future climatic conditions with increased rainfall. A potential mitigating solution was included in the report from Dr. Gibbons (Gibbons et al, 2007) in Revision 13, but this was removed in Revision 16. Staff believes that the proposed realignment and armoring of the upper reach of the draw is necessary as a preventative measure, as discussed in an Interoffice Memorandum, dated July 9, 2007 (Kuharic, 2007).

As noted in Section 1.1.1 of this review, the proposed by-product disposal facility sits atop the ridge defining the edge of the Southern High Plains. However, this area receives windblown sediments from the southwest, the prevailing wind direction, and does not appear to be eroding at present. The applicant has set up an erosion pin array to measure erosion in the Ranch House Draw to the southeast, however, the array has not been in place long enough to gather meaningful information, and this array is in a location where water erosion would be dominant. No similar array has been set up to the west of the proposed by-product disposal facility to determine wind erosion on the ridge top. Based on a luminescence study of the sediments in the Ranch House Draw area and from a borrow area to the north of the WCS facility (URS, 2007), the applicant states ages of the soils indicate no overall erosion has occurred for approximately 60,000 years. Staff believes that there has probably been localized erosion and redeposition so that on balance, there has been minimal erosion overall.

Nevertheless, Staff has provided a draft license condition to install another erosion pin array to the west of the facility to develop data on possible erosion over the active life of the facility. Armed with this type of data, the cap/cover design could be modified to compensate for possible erosion effects.

2.1.3.3 Seismicity

The hazard associated with seismic activity is referred to in 25 TAC §289.260(o)(8)(J), relating to location near a capable fault and associated design requirements. The application includes a report on seismic hazard evaluation (URS, 2004) and a section on Seismic Slope Analysis, which was reviewed by a licensed civil engineer. The report states there are no known Quaternary age faults within 100 kilometers (km) of the site, and on that basis the design is considered adequate.

The WCS facility lies within the Central Basin Platform, a region that has been tectonically stable for a very long time. Based on data from the National Geophysical Data Center, this area is considered to be one of moderate, low intensity seismic activity, as reported in the 1993 Terra dynamics geology report. The application provides a table of historic seismic activity within 250 km of the site. It is believed that a large percentage of this may be due to oil and gas production, secondary recovery, or waste injection, although some of the seismic activity may be a combination of overpressured reservoir fluids and tectonic activity. In any event, the largest earthquake recorded in the vicinity of WCS was the Rattlesnake Canyon earthquake, a magnitude 5.0 event recorded in 1992.

There is no explanation of why the Rattlesnake Canyon earthquake was not considered in the assessment that there have been no Quaternary faults within 100 km. WCS may consider it to be due to a reactivation of an older fault.

2.1.3.4 Subsidence

Subsidence features due to salt dissolution are known to exist in the region (refer to Figure 7). The applicant notes 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 form rather 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 WCS site, and Monument Trough Draw, 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 4 miles east of the site, whose origin is controversial, but may be related to salt dissolution.

The applicant offers a study evaluating salt dissolution in the vicinity of the WCS site by Holt and Powers (2007) as Attachment 4-2 of the Geology Report. Their conclusion is that there are no features in the area that are attributable to salt dissolution in the Rustler or Salado, based on accepted mechanisms of salt dissolution.

While the applicant contends that it is not an issue at the site, two regional cross sections contained in the application offer differing interpretations of the geology to the southwest of the site, based on geophysical log correlations. One interpretation indicates a persistent depression which could be explained by collapse due to salt dissolution at depth, except for the Santa Rosa top (Plate 2-3); the other interpretation does not show a continuous depression at all (Figure 6.4-27b). The cross sections do not extend deep enough below the Rustler-Salado interval to rule out dissolution of the underlying evaporites. In a July 10, 2007 draft memorandum to the TCEQ (Gustavson, 2007), Dr. Thomas Gustavson, former Bureau of Economic Geology (BEG) geologist and consultant for the TCEQ notes that there is contradictory evidence concerning salt dissolution near the site, and there remains uncertainty with respect to salt dissolution.

If the salt dissolution has occurred in a deeper horizon and has caused the depression of the overlying strata noted above, it is worth noting that no additional dissolution of the shallower evaporites is apparent. This may indicate that the depression is older and insufficient water is getting down to the Rustler-Salado section to cause major additional dissolution. If this is the case, the likelihood that salt dissolution would

impact the proposed by-product disposal facility during the period of regulatory performance seems remote. However, due to the fact that features such as the Wink or Jal Sinks formed quickly and they are of small enough scale to fit between the oil well logs used for the cross sections, there remains uncertainty.

2.2 HYDROGEOLOGY

Texas requirements at 25 TAC §289.260(f)(1)(A)(ii) states that a license application shall include site hydrologic characteristics. Texas requirements at 25 TAC §289.260(o)(2) requires that the application meets the broad objective of isolating the tailings and associated contaminants without ongoing active maintenance.

2.2.1 Regional Hydrogeology

As noted in Section 1.0, Geology, the proposed site lies atop the ridge that forms the southwestern extent of the Southern High Plains. The ridge forms a surface water divide between the Pecos and Colorado River, and according to the applicant, the ridge also acts as a groundwater divide.

Three aquifers are present regionally in the area of the north-south Texas – New Mexico boundary: the High Plains Aquifer, the Cenozoic Pecos Alluvium and the Dockum Group. Regionally, the High Plains Aquifer is the principal aquifer, consisting of the Tertiary Ogallala Formation and underlying Cretaceous water bearing units. The Cenozoic Pecos Alluvium, also called the Pecos Valley aquifer, is classified as a major aquifer by the Texas Water Development Board (TWDB). The Triassic Dockum Group aquifer is classified as a minor aquifer.

The High Plains Aquifer consists of the Ogallala Formation and Cretaceous Antlers Formation. The Ogallala Formation is the primary source of groundwater in the Southern High Plains. The Ogallala consists of sand, silt, clay and gravel capped by caliche. It was deposited as alluvial fans extending eastward from the Rocky Mountains. The Ogallala Formation underlies the Cretaceous Antlers Formation and unconformably overlies the Triassic Dockum Formation. In the Southern High Plains, the saturated thickness of the Ogallala ranges from negligible to approximately 300 feet, generally thickening to the north and west. Groundwater in the Ogallala is under water table conditions. Today, the principal sources of recharge to the Ogallala are playas, headwater creeks, and irrigation return flow. Discharge from the Ogallala occurs as springs, underflow, evapo-transpiration, and pumping. Irrigation from the Ogallala has made it possible to grow water intensive crops on the High Plains.

The Antlers Formation is generally a sandstone and conglomerate unit at the base of the Cretaceous in the Southern High Plains. It was deposited on erosional valleys in the top of the Dockum. The Antlers is considered part of the High Plains Aquifer.

The Cenozoic Pecos Alluvium/Pecos Valley Aquifer is represented by the Gatuña Formation, a Cenozoic basin fill alluvial deposit. The Gatuña extends over large portions of Eddy and Lea Counties in New Mexico and into Andrews, Winkler, and Loving Counties in Texas.

The Triassic Dockum Group underlies a large region in the Texas-New Mexico area (over 12,000 square miles of the Texas panhandle alone (Johns, 1989)). The Dockum is used as a replacement for, or in combination with, the Ogallala aquifer for irrigation, stock and municipal water. The Dockum consists of five formations that contain clays, shales, siltstones, sandstones, and conglomerates. Two water bearing formations in the lower Dockum constitute the Dockum aquifer. They are the 250 foot thick basal Santa Rosa Sandstone and the 100 foot thick Trujillo Formation, also a sandstone unit. They are used locally as water sources. The applicant uses water supply wells screened in the Trujillo and Santa Rosa. The Southeast well is screened in the Trujillo and the Central Well, a former oil well, is now screened in the Santa Rosa. Its proximity to the disposal facility may be a concern depending on the condition of the well plugging cement. The condition of this well should be closely examined.

2.2.2 Site Groundwater Hydrogeology

Texas requirements at 25 TAC §289.260(o)(14)(B) requires that the applicant provide information on the characteristics of the underlying soil and geologic formations to control transport of contaminants and information on the nature and current uses of groundwater at the site.

2.2.2.1 Physical Characteristics

WCS notes there are three aquifers are present at the site. The High Plains Aquifer (Ogallala and Cretaceous Antlers) and the Gatuña Formation overlie the Dockum Group at the 14,000 acre site (Fig. 2-8, Volume 7, WCS application). The 1976 Geological Atlas of Texas Hobbs Sheet shows the Ogallala Formation covering the majority of the site, with windblown sand covering the remainder. The extent of the Ogallala Formation in this area is under study while the stratigraphic relationship of the Ogallala and Gatuña Formations is worked out.

According to WCS, the Antlers Formation occurs as an erosional remnant on the crest of the Dockum redbed ridge, the Ogallala occurs to the north of the ridge, and the Gatuña occurs to the south of the ridge. WCS refers to the Ogallala (including the caprock caliche), Antlers and Gatuña formations as one unit, the OAG unit.

These two regional groundwater units, the OAG and the Dockum, are both of concern at the site. The applicant has proposed a dry line delineating an area where the OAG is not fully saturated from an area where the OAG is fully saturated, and maintains that the by-product material landfill is located in the "dry" area and thus OAG groundwater is not a concern.

In the Dockum Group Cooper Canyon Formation, as discussed in Section 1.2.2 of the Geology review, there are four (4) zones considered to be possible conductive horizons: the 225-Foot Sand, the 180-Foot sand, the 125-Foot Sand and the 80-Foot Sand. The sand zones are separated by claystone, considered by the applicant to be a uniform rock type throughout the Cooper Canyon.

The 225-Foot Sand is considered to be the uppermost aquifer, and the conceptual groundwater model is designed with this in mind. Use of this unit as the uppermost aquifer is a carryover from the RCRA hazardous waste permit. Use of this unit for this purpose carries some concerns with it. It is considered to be confined, that is, bounded above and below by aquitards, or units of lower hydraulic conductivity. The level to which water rises in monitoring wells constitutes the potentiometric surface, which can be mapped, and this potentiometric surface rises 125 feet above the top of the unit in one well shown on Fig. 6.6, the Hydrogeologic Conceptual Model. The level to which water rises in the aquitard is generally not a matter of concern. At the by-product facility, however, the proximity of the saturated claystone to the bottom of the excavation is critical. This sand unit ranges from 25 to 30 feet thick over the entire facility.

The 180-Foot Sand is considered by the applicant to be in part saturated and in part unsaturated. At the by-product facility the sand is thought to be unsaturated except for a small area in the northeast corner. This represents another case of dry line location moving through the sand, although how the degree of saturation changes over such a short distance is not explained. It is thinner than the 225-Foot Sand, and probably is not expected to have the same lateral continuity, based on its depositional environment. This sand ranges from 10 to 25 feet thick over most of the site, but at the southern and western sides of the by-product waste facility it is depicted as shaling out, i.e., transitioning from a siltstone/sandstone into a clay. This sand is not considered by the applicant to present a potential problem.

The 125-Foot Sand is proposed to have been deposited in a setting similar to that of the 225-Foot Sand, and so may have a greater lateral extent. It is considered to be dry, or, unsaturated in the facility area. In cross section it exhibits more vertical variability than the other sands, perhaps as a result of deposition in shifting channels. This sand immediately underlies the by-product material disposal facility, with perhaps 12 to 15 feet of vertical separation, and ranges in thickness from about 25 to 40 feet thick.

The uppermost unit is the 80-Foot Sand. It is considered to be dry, and appears to have a restricted lateral extent. The thickness of this unit ranges from 10 to 30 feet.

Data on the physical parameters of the individual sand units are difficult to obtain, even from the tables included in the application. Borehole numbers are given, along with sample depths, but these are never attributed to a given unit. Lacking a top of sand elevation table for each of the units, assigning the data to a particular sand is left to the reviewer's interpretation. The distribution of data is not consistent; hydraulic conductivity, moisture content, porosity, saturation are provided in varying combinations, but all of these are present about half of the time and sometimes only one or two are available. These data comprise some of the critical input parameters for both the conceptual model and mathematical modeling and the reviewers have no way of checking on their validity with certainty. Additional items which made the data difficult to interpret are whether the term void ratio is the same thing as porosity, and the applicant's use of the term permeability in the Summary of Geotechnical Results table really is supposed to be hydraulic conductivity. Clarification in the application is lacking.

2.2.2.2 Subsurface Site Investigation

The applicant has conducted various site investigations at the site. The presentation of the data related to the site investigations makes it difficult to review the data. The applicant has provided the groundwater elevations for all wells at the site in a single table, Table 6-3. This makes it necessary to search through the entire table to find water elevation for wells screened in the OAG formation or the 225-foot zone, for example. For ease of review, it would have been preferable to separate out the different zones in different tables. In addition, the applicant's system of a monitor well/piezometer name that differs from the reference boring names make it difficult to correlate borings with monitor wells and requires excessive reference back to the various volumes of the voluminous report to examine the results of the subsurface site investigation.

The application provides boring and completion logs for holes used in the site investigation, but these two activities do not always use the same hole. For example, in the By-product Material Facility Siting Investigation - 2001 (Attachment 5-1, Exhibit F) it appears that the applicant used mud rotary drilling to core holes for geologic information and description, then stepped out to drill an offset with an air rotary rig for a piezometer. These reference well logs do not provide northings and eastings, so the distance to offset is indeterminate. However, in the low-level radioactive waste disposal application also filed with the TCEQ these northings and eastings are available in a table. In some cases, the distance from the reference well to the piezometer is in the range of 40 to over 60 feet. Based on the nature of these sediments, large changes in the sand geometry may occur. This can be demonstrated by transferring the screened interval from the completion report over to the reference well boring log, and finding the screened intervals in claystones and less permeable rocks. Staff questions the validity of groundwater elevation from such wells unless the applicant can explain why the piezometer wells were screened as they are. There are no accompanying boring logs for the actual piezometer holes, although these should be readily available as they are part of the water well drilling report that the owner is supposed to have according to 16 TAC 76.700(1). It is unclear in the application how the screen depth of piezometers and monitoring wells are determined when no boring logs are available. The applicant has explained verbally that the field personnel can determine when the Dockum formation has been encountered by the color change of the dust in drilling from the OAG formation into the redbeds. This explanation is a plausible, if not very precise, method of locating the part of the section in which to set pipe and screen.

Another aspect of uncertainty in the water level elevations arises from the presence of what is referred to as "slough" in the bottom of some boreholes completed as piezometers. This consists of material that has fallen into the borehole and prevents the screened interval from extending to the bottom of the borehole, and means that a well bore may contain water, even when a measurement indicates the well to be dry. The "slough" can range from a foot or less up to ten feet in thickness. In these cases, the bottom elevation of the screen becomes critical. Staff believes the applicant should identify these borings on potentiometric surface maps, along with the relevant bottom of screened interval elevations. The applicant has, in September 2007 meetings, maintained that the method of well construction may provide some information that has not been properly evaluated by staff. However, the applicant did not include a caution in the application to this effect.

An additional difficulty in understanding both the geologic and hydrogeologic conceptual models arises

from how the applicant projects data from wells onto the cross section lines. At the request of Staff, the applicant provided a third cross section, Figure 2.25a, WCS Schematic Geologic Cross Section C-C', to depict the geology in a northwest to southeast direction. The applicant did not add the hydrogeologic data from those wells to the section, and once this was done, these data produced a picture of an erratic water level. The applicant has not provided an explanation for this behavior.

2.2.2.3 Hydrogeological Conceptual Model (HCM)

The applicant has developed a hydrogeologic conceptual model (Fig. 6.6, Volume 8) on the basis of site investigation data collected between 1992 and 2006. The conceptual model shows the buried red bed ridge composed of the Dockum Formation and flanked by OAG sediments. The proposed by-product material disposal unit intersects the 80-Foot Sand, which is shown to subcrop the OAG unit. The base of the landfill lies about 10 feet above the 125-Foot Sand, which may also subcrop the OAG unit to the south or southwest.

The applicant has proposed a "dry line," that is, a line on a map (application Fig. 6.2) that divides the area where OAG wells are currently dry (not containing water) from the area where OAG wells currently contain water, Figure 8. The applicant maintains that the proposed by-product landfill is on the dry side of the dry line. The dry line would be expected to move in response to variation in infiltration, due to rainfall variation, for example. The conceptual model (cross-sectional) representation of the dry line is a hook-shaped line that delineates the "dry" boundary of the transition zone beneath the OAG where the top of the Dockum may be saturated or not, depending on infiltration from the overlying OAG as it shifts in response to changing conditions. The size and location of the transition zone will obviously change in response to variations in infiltration. The hydrogeological conceptual model shows this area to underlie playa lakes, which are considered to be recharge features to the OAG and Dockum.

The applicant does not believe the dry line will migrate further to the south. A previous resistivity survey done on the site on file with the TCEQ (AGS, 2001) indicated potential saturation to the south of the existing dry line. However, this survey was not calibrated and the resulting interpretation of the data is open to question. A license condition will be added to require the survey to be rerun, the line extended, and the survey calibrated in order to verify that saturated conditions are not indicated by the survey.

The applicant represents the water table as extending downward from the surface to intersect the 180-Foot Sand (refraction of the water table). On the basis of water wells screened in the 180-Foot Sand, the southern portion of the 180-Foot Sand is dry, and the northern portion is under confined conditions, with the water table (potentiometric surface) rising about 50 ft. above the 180-Foot Sand, to within about 10 ft. of the base of the 125-Foot Sand. In the 180-Foot Sand, the model shows closely spaced equipotential lines between TP-21 and TP-60 in contrast to widely spaced equipotential lines in the remainder of the unit. The hydrogeological conceptual model shows the water table to continue moving downward toward the 225-Foot Sand, with closely spaced equipotential lines paralleling the 225-Foot Sand in the southward direction. The two wells in the 225-Foot Sand have confined conditions, with potentiometric surfaces at or above the top of the 180-Foot Sand. The reversal of the equipotential lines at the base of the 225-Foot

Sand is an unconventional representation of a hydrogeologic system. The cause of the tightening up of the equipotential lines is not explained.

The HCM also contains other unexplained inconsistencies. The 180-Foot zone is saturated in the northeast portion of the WCS facility area according to the applicant's mapping. However, on the hydrogeologic conceptual model cross section B-B' boring TP-55 is shown as completed in the claystone above the 180-Foot Sand, and is dry even though the completion lies below the hypothetical water table. Examination of the boring log for TP-55 indicates that it was considered dry in the 180-Foot Sand. It is unclear why it would be dry if it is in the saturated zone. Inconsistencies such as this make the model presentation confusing, difficult to interpret, and still in need for further verification.

Various sand bodies are indicated on the model, but they appear to be illustrative rather than based on data, since there are no well data indicated on the model. The depth and thickness of the Trujillo Formation, the bottom of the hydrogeological conceptual model, is based on a well located 4 miles off the cross section line, and its groundwater direction is based on regional data. The model shows the groundwater gradient in the 225-Foot Sand and the Trujillo Formation to be toward the south. Between the 225-Foot Sand and the Trujillo, groundwater movement is portrayed as downward, but above the 225-Foot Sand, it is shown to be lateral, upward and, under the transition zone, downward. According to Figure 5.5 in Freeze and Cherry (Groundwater, 1979), this sort of refraction is not to be expected.

The purpose of a conceptual model is to simplify the field geometry and organize the field data so the system can be analyzed more readily. It requires geologic cross sections, contoured structure maps showing the elevations of the base of sands and confining beds, isopach maps showing the thickness of sands and confining beds, hydrogeologic information such as water table and potentiometric maps for all sand bodies, maps and cross sections showing the hydraulic conductivity distributions of hydrogeologic units, among other information (from Anderson and Woessner, 2002). The applicant did not provide all this information in its application, and therefore it is unknown to what extent WCS possessed or used such data for the preparation of their conceptual model.

The applicant's conceptual model shows two types of sand units. Some of the sand units shown in the model are documented in well borings (e.g., 80-Foot Sand), whereas others, represented as interspersed throughout the Dockum, are not supported by data confirming their existence or location, and lack notation indicating their illustrative purpose. It would have been helpful to specify the illustrative nature of the sand units on the map legend. The applicant did confirm the speculative nature of such sands in their May 18, 2007 Response to Issues Identified as of April 3, 2007, Application Revision 16, but never updated the cross sections to reflect this.

The HCM shows that the proposed by-product material disposal unit will intersect the 80-Foot Sand, giving rise to the possibility that leachate from the disposal unit may infiltrate the 80-Foot Sand. A review of Figures 5.6 – 5.9 and related boring logs shows that 5 of 9 borings installed in the footprint of the by-product material disposal unit, all within the southern half of the disposal unit, intersect the 80-Foot Sand. Fig. 5-14a shows that the 80-Foot Sand extends to the southeast, and intersects the RCRA landfill. The

conceptual model shows the 80-Foot Sand intersecting the OAG formation, providing a potential pathway for leachate to migrate into this near-surface unit. In addition, the potential exists for contamination of the RCRA landfill. The applicant has not addressed this possibility.

As mentioned above, the HCM also shows the base of the by-product material disposal unit to be about 10 to15 feet above the top of the 125-Foot Sand. The proximity of these units means that leachate has the potential to migrate downward into the 125-Foot Sand. The HCM shows the 125-Foot Sand extending toward the OAG unit, but it appears to be unknown if the 125-Foot Sand actually intersects the OAG unit. It is important to know the geometry of the 125-Foot Sand and the extent of the interconnectedness of the 125-Foot Sand and the OAG unit.

The HCM shows the location of the dry line as being related to the location of playa recharge, but the Dockum is also recharged by infiltration through the OAG unit, and the dry line will migrate based on climatic conditions, particularly rainfall. Figure 6.2 of the application shows February-March 2006 groundwater elevations and the location of the dry line at that time. August 2007 groundwater elevations show that two wells adjacent to the by-product disposal facility that were dry in 2006 now contain between 1.7 and 5.0 feet of water, suggesting the dynamic nature of the dry line. The applicant maintains this is due to surface ponding of water related to drainage issues. This possibility will be addressed through a license condition.

Figure 6.2 (OAG Groundwater Elevations) and 6.2a (OAG Groundwater Saturated Thickness) show a number of soil borings and monitor wells used to present the groundwater data. The number of borings appears to indicate that there are numerous data points for the construction of these maps. However, many of the borings were installed several years ago, and were never converted to monitor wells. The map indicates that many of these locations are dry, when in reality, they were dry when drilled several years ago. Several borings/piezometers that were dry when originally installed now contain water, so it is incorrect to assume that the borings that were originally dry would necessarily be dry today, and to use them on a map as a "dry" data point for 2007 saturated groundwater thickness or groundwater elevation maps. It would be preferable to construct new maps without these data points, using only monitor wells or piezometers that can be measured or sampled, and determine groundwater elevations and the saturated thickness on the basis of current data points.

The site conceptual model indicates that the lateral extent of sand bodies is unknown, which is not in agreement with the isopach maps of the various sands. Examples are the southern extent of the 80-Foot Sand, the southern extent of the 125-Foot Sand, and the lateral continuity of the 180-Foot Sand. In the 180-Foot Sand, a steep hydraulic head drop over a short distance of sand may indicate that this sand is not continuous. It would be useful if the applicant had conducted shallow seismic surveys of the site to determine the continuity of the sands and incorporated this data into the model. If the sands are continuous, the head drop would indicate a higher velocity and therefore, a range in permeability of the sands, which is neither noted in the application, nor adequately addressed in the modeling.

A rationale for the representation of the potentiometric surface reversing at the base of the 225-Foot Sand

has not been explained by the applicant, as noted above.

The groundwater gradient in the Trujillo Formation is based on (unreferenced) regional data, and on depth information from the Central Well, located 4 miles distant from the cross section line associated with the hydrogeological conceptual model. It would be preferable to use a well located closer to the cross section line. It would also be preferable for the applicant to provide evidence to support the depth of the Trujillo and groundwater flow direction in the Trujillo. In addition, the applicant had not provided evidence to support the uneven spacing of the equipotential lines in the Trujillo. In summary, it appears that the nature of the Trujillo needs to be verified.

One major issue is the impact of fracturing in the Cooper Canyon formation. The degree of importance these fractures have to the groundwater modeling is not clear. The TCEQ has subject matter experts at the BEG assisting on the evaluation of this issue. One of the site investigations on which the conceptual model is based shows that the Dockum clay is significantly fractured at least down into the 225-Foot Sand. Modeling by the BEG personnel focuses on a 10 micron fracture aperture, but does consider a 100 micron fracture case. These are deemed most appropriate for the simple model employed, the 300 micron case being considered too conservative for the simple model.

The fracture apertures are important, as they are crucial to understanding flow and transport time for contaminants that would be released from the landfill over time. The applicant did have water samples from the 180-Foot and 225-Foot Sands age dated, with results indicating an age of approximately 15,000 years. However, the applicant assumes the water moved directly from the surface to the sample point by passing through the unsaturated zone. This seems unrealistic, and the logical assumption is that the water came from elsewhere than directly above the sample point. This further implies that either the Dockum is not as tight as thought, or some flow is moving faster through fractures. An argument can be made that any sample collected is primarily representing the water from the matrix, which would tend to provide an older average age and mask the presence of faster flow pathways, as the fractures would only represent a small percentage of the total volume (Scanlon, 2007). Further verification of the nature of fractures is needed.

2.2.3 Site Surface Water

Surficial water in the region of the site is almost all ephemeral in nature. All nearby natural streams are intermittent, as are the playas. The one surface feature that seems to be predominantly wet is Baker Spring, about 2,000 feet west of the proposed by-product site, although it has been noted that there is an excavation into the Dockum at this site that contains the water, and it has been reported as historically dry. Ranch House Draw, a drainage feature, lies directly south of the proposed waste disposal sites. This drainage appears to be choked with sand currently, and does not appear to be integrated with the Monument Draw (New Mexico) drainage. Other surface features that could be considered perennial are man made.

The nearest permanent flowing streams are the Pecos River in New Mexico, and on the Texas side one

may have to go as far as the North Concho River or Colorado River to find continuous flow.

The applicant concentrates the surface water study on the potential for run-on from precipitation and how to minimize this, both of which are reviewed in the Civil Engineering report. The playas are considered to be potential recharge points for the OAG, and water does not tend to remain in them for very long, as evidenced by the vegetation commonly found in them. The applicant also has a sampling plan for monitoring water quality in Baker Spring included in the application, as this is the only readily apparent surface water discharge point in the area.

A map identifying wetlands features in the vicinity of the WCS facility is included in the Low Level Radioactive Waste application, but this figure is not included in the by-product disposal site application. In the by-product facility application, Figure 2.53, Surface Water Bodies and Drainage Features, identifies the surface water features within a 5 mile radius.

2.2.4 Groundwater Protection

Texas requirements at 25 TAC §289.260(f)(1)(A)(iii) requires an application to include an environmental report that includes radiological and nonradiological impacts of the proposed project, including groundwater impacts. 25 TAC §289.260(o)(2)(B) requires that in selecting among alternative by-product material disposal sites, site features assure the isolation of tailings and associated contaminants without ongoing active maintenance, considering particularly hydrogeologic conditions conducive the immobilization an isolation of contaminants from usable groundwater sources.

According to 25 TAC §289.260(o)(9)(A) the primary groundwater protection standard is design standard for surface impoundments used to manage by-product material. The WCS application includes a disposal unit design that has been reviewed by a licensed civil engineer and the results of that examination are included in the Civil Engineering chapter. However, this regulation only stipulates that the liner prevent waste migration during the active life of the facility. Upon closure, no credit is given for the liner system and a hydrogeological evaluation is performed on the migration of contaminants out of the facility to the nearest water in order to evaluate the hydrogeologic and other environmental conditions conducive to continued immobilization and isolation of contaminants from usable groundwater sources and to evaluate whether there is reasonable assurance of effective containment of radiological hazards. Currently, groundwater conditions in the OAG indicate at least several feet of water in TP-42 and TP-43, to the north and south edges of the proposed site, respectively. With no credit given for the liner, including the cap, this raises the issue of the potential contact of groundwater with the waste material, which may not be all containerized. This presents a serious problem, as the applicant has done no modeling that indicates this would occur, and the potential dispersal of contaminants is not known.

The applicant maintains, in verbal communication from meetings held during September 2007, that misdirected runoff drainage has impacted these two wells, and that these high water level elevations do not indicate that the OAG water table is truly at that elevation. The license will be conditioned to require redirection of the affected drainages and continual monitoring of water level elevations to confirm this

explanation; as noted previously.

With regard to the shallow groundwater, a letter, dated September 13, 2004, from the Texas State Soil and Water Conservation Board presents comments from the Andrews Soil and Water Conservation District #246 board of directors, noting that two windmills and a storage tank were removed from WCS property just south of Highway 176. In addition, they comment on two other local windmills that were apparently used to produce shallow groundwater for local ranches. They express a concern that the shallow groundwater may not be adequately protected and the letter concludes with a statement expressing strong opposition to approval of the application (TSSWCB, 2004)

At the adjacent RCRA hazardous waste landfill, the 225-Foot Sand has been deemed the uppermost aquifer. The applicant has proposed this same unit be used for the by-product waste disposal facility. Staff has serious reservations on this point, and believes the 125-Foot Sand should be considered the uppermost sand of concern, although it is currently dry and thus not an aquifer. Although the applicant has reported this unit unsaturated at the by-product waste disposal site, they map it as a confined unit approximately 4,000 feet to the east. The 125-Foot Sand lies only 12 to 15 feet below the bottom of the by-product waste disposal excavation as designed, thus any release of contaminants will migrate into the 125-Foot Sand first, and will potentially reach the next unit, the 180-Foot Sand, later. This unit appears to be saturated only under the northeast corner of the by-product material disposal facility. Although it is presented as saturated only under the northeast corner of the by-product facility, the BEG modeling used it as the water table. Only after moving through the 180-Foot Sand would any release potentially continue moving downward to the 225-Foot Sand, which is fully saturated under the facility. Staff believes it is imperative to have the earliest possible warning of a release, and has drafted license conditions for the installation of 125-Foot Sand monitor wells around the by-product waste facility. If the 125-Foot Sand becomes saturated, it may be necessary to install 180-Foot Sand monitor wells. All of these monitor wells would be constructed in the same manner as existing monitor wells.

As the 125-Foot Sand is reported as unsaturated, a release would most likely tend to form a groundwater "mound" immediately below the release point and spread out from there. The application contains no base of sand maps for the 125-Foot Sand, so there is no way to known which direction this release might go, that is to say, there is no hydraulic gradient to drive the release in a particular direction initially. Staff recommends that these monitor wells be placed on a 200 foot spacing except, perhaps, along the west side, where the 125-Foot Sand appears to be absent. These wells should all be checked at least once every three (3) months during the operational life of the facility, and if liquid is detected a sample should be obtained and analyzed, in compliance with the facility sampling plan, provided as Procedure BP-EV-7.1.8., with the exception that where necessary sample containers will contain any preservative required for sample stabilization prior to sampling required by the analytical method to be used. Analysis should be preformed by an U.S. Environmental Protection Agency approved method, or an accepted equivalent method.

Depending upon the source of waste material going into the facility, metals and organic compounds not commonly found may occur. Under 25 TAC §289.260(o)(9)(D)(i) the agency will identify hazardous compounds; §289.260(o)(10)(G) expands the list of hazardous constituents to cover what would be likely

to occur. If the 125-Foot Sand is unsaturated, there is no groundwater background value to be determined. Therefore, the Staff proposes that for these new, non-radiological contaminants being introduced into the sand the regulatory limits imposed by 30 TAC Chapter 350, the Texas Risk Reduction Program, be used as protective concentration limits. These limits would apply to any compounds not specifically given limits by 25 TAC §289.260. These limits would also apply to any non-radiological contaminants in any sand. This can be accomplished by use of a license condition.

Groundwater impacts are addressed primarily through groundwater modeling. The by-product material landfill application contains four modeling studies. Exhibit A Matrix Dominated Flow is a calculation of downward movement to the 225-Foot Sand. Exhibit B Fracture-Matrix Dual Permeability Flow is a one-dimensional TOUGH2 model that considers fracture. Exhibit C Saturated Fracture Flow and Solute Transport is a SWIFT2 study of lateral flow in the 125-Foot Sand to a potential subcrop to surface units. Exhibit D OAG Groundwater Flow Model is a MODFLOW study of saturation in the OAG unit. The applicant did not provide a copy of a 3-dimensional TOUGH2 study (3 Dimensional Variably Saturated Groundwater Flow Model, Attachment 6-3) submitted and filed at TCEQ as part of another application, but that report was reviewed because it is relevant to the by-product material disposal facility application.

The Matrix Dominated Flow assumes a release from the bottom of the disposal facility, a 1.0 foot (ft) standing head of leachate, intergranular flow, no preferred pathways, and saturated conditions in the Dockum. The model assumes a 1.0 ft. standing head of leachate, whereas the process engineering section of this report indicates that the landfill may be the site of a 7 ft. head of leachate during its operational phase. The distance between the base of the landfill and the 125 ft. zone is modeled as 18 ft. but it appears to be 10 to 15 ft., and is probably subject to variation over its extent. There is no discussion of the assumption of "no preferred pathways," but in light of fracturing noted in boring logs, preferred pathways do need to be considered in a calculation of migration time. As stated elsewhere in this report, it is preferable to use a more conservative value of hydraulic conductivity than the geometric mean, given the heterogeneity of the sands at the site. It was not possible to evaluate the parameters used in the calculation: hydraulic conductivity was not found in the table cited (A-1). Furthermore, it was impossible to determine which intervals were used to calculate the hydraulic conductivities used for this model. In Table A-2, it is unclear which intervals were used for porosity data. It would have been helpful for the application to provide tables containing only the data used in the Matrix Dominated Flow model. The applicant did not provide an accurate reference to Holt report used in Table A-2, and the report is not listed in the application's table of contents, making it difficult to find. The title of Figure A-1 Generalized Geologic Column Modeled with TOUGH 2 is confusing; the text does not mention that TOUGH2 was used in this section of the report. These errors and/or oversights give the impression the report was not reviewed for quality control prior to submittal. The presentation of the data made review difficult, and the report's inconsistencies detract from the credibility of the report.

The Fracture-Matrix Dual Permeability Flow is a one-dimensional TOUGH2 model that studies the downward movement of water and dissolved solutes assuming an interconnected fracture and matrix system. It assumes the leachate from the by-product material landfill enters the fractured Dockum beneath the landfill and migrates downward under unsaturated conditions until it reaches the 180-Foot Sand, and

then under saturated conditions until reaching the 225-Foot Sand. However, a review of saturation data indicates that claystones and sandstones above the 180-Foot Sand range up to 100% (Attachment 5-5 Exhibit C). The BEG interpretation is that saturation does not drive fluid flow, but rather the matric potential does, and the BEG believes that the applicant has not adequately characterized this parameter (Scanlon, May 2007). Further transport modeling with additional data will be required. This will be addressed through a license condition. The model assumes fracture sizes of 10, 30 and 300 microns, but the applicant has not provided a rationale for the use of these fracture sizes. It would be preferable to provide references from studies of cores drilled at the site or at the least, references from geologic literature. It is worth noting that much of the data in the summary tables for this modeling in the by-product materials facility application and the low-level radioactive waste disposal facility application also filed with the TCEQ are not in agreement, and there is no explanation for why this is so.

Reviewing data collected for the matric potential study for the low-level radioactive waste disposal application identified three (3) wells in the immediate vicinity of the by-product disposal facility. The saturation data from these wells do not agree well with Attachment 5-5 data. It appears that there can be large variations over a short distance. A license condition for further matric potential verification is proposed, in an attempt to reconcile these data discrepancies, and determine the zone of saturation.

The Saturated Fracture Flow and Solute Transport study is an evaluation of groundwater flow and radionuclide transport using the SWIFT II flow and transport model. The study assesses flow and transport through the 125-Foot Sand, assuming the 125-Foot Sand becomes saturated and lateral flow occurs to a subcrop for the 125-Foot Sand on the slope of the red bed ridge. The study assumes fracture flow in the 125-Foot Sand, an average hydraulic conductivity of 5.24E-08 cm/s) for the 125-Foot Sand, and fracture apertures between 4.6 and 15.8 microns. It would have been preferable for applicant to provide an original table with hydraulic conductivity and porosity data for the 125-Foot Sand only. In addition, the applicant has not provided documentation that the fracture apertures selected for the model correspond to actual fractures in the 125-Foot Sand, although they are close to the 10 micron fracture used in the TOUGH 2 modeling.

The OAG Groundwater Flow Model is a MODFLOW study of saturation in the OAG unit and the movement of the dry line in response to recharge from precipitation. This study shows that recharge in the playas north and east of the proposed landfill has the largest impact on the location of the southern extent of the zone of saturation in the OAG, and as a result, WCS has proposed to fill these playas with excavated red bed material. However, the model was not able to simulate the dry conditions at PZ-36. It did not predict the apparent movement of the dry line due to increased precipitation, as evidenced by the recent presence of water in piezometer TP-42, on the north edge of the by-product disposal facility. This demonstrates the OAG must be a highly dynamic system, and is difficult to model. During the September 2007 meetings, the applicant stated that the water in TP-42 is from misdirected runoff from the Fernald canister storage area, and that it does not actually reflect movement of the dry line. In fact, the applicant believes the dry line to be more or less fixed at the mapped location. To address the uncertainty associated with the OAG dry line location with respect to the proposed by-product material license, a license condition has been proposed to redirect the drainage and both TP-42 and TP-43, and to monitor all OAG

wells and report the data on a monthly basis.

The 3D TOUGH2 model submitted and on file at the TCEQ, as part of the low-level radioactive waste disposal application, uses TOUGH2 to help determine water level elevation. One figure in the report presents the top of the water table intersecting the base of the by-product material landfill and extending across a portion of the by-product material landfill before descending to the east, as shown in Figure 9. It is unclear why this portion of the application was not submitted as part of the by-product material disposal application, since it has significant implications for the by-product material landfill. In effect, it shows that groundwater will be in contact with the by-product material, which shows that the site features do not assure isolation of the waste material because hydrogeologic conditions do not immobilize or isolate contaminants, but rather promote their mobilization. The modeling performed by TCEQ consultants confirms this. The applicant has provided a verbal explanation that some potentiometric surface data for the 225-Foot Sand was mistakenly used as the water table elevation and this caused the modeling to depict a surface at an elevation much higher than exists at the site. However, written information submitted on September 28, 2007 by the applicant, contradicts this explanation, once again confusing the issue. The applicant maintains that the model output was not meant for this purpose. TCEQ consultants have reached technical issues that the applicant's approach to determining saturation is not correct. However, 180-Foot Sand wells used for the potentiometric surface map indicate that the 180-Foot Sand is dry under the by-product material facility, although one well appears to be screened about six feet from the bottom of the unit. Owing to the tight nature of the zone, there is the possibility that water might not flow into the wells. Thus the location of the top of the saturated zone is unclear. A license condition will require the applicant to undertake additional geophysical/geotechnical investigations for verification purposes, to locate the top of the saturated zone more exactly.

The primary concern of review Staff in regard to transport through the various units relates to the presence and nature of fractures. The various boring logs and fractures seen in the RCRA landfill confirm the presence of fractures, even at depth. However, information on the nature and width of the fractures is lacking. Using a 300 micron fracture size along with other input parameters, the applicant calculates a period of at least 70,000 years for radionuclides to reach the 225-Foot Sand. In the narrative text the applicant cites the concept of critical flux in determining the movement through fractures, but their modeling uses the SWIFT II and TOUGH2 models. The mechanics of how these models incorporate this concept is unknown, but TCEQ consultants do not find a problem with the operation of the models.

The location of the Dockum formation water table and capillary fringe present a major concern because of the possibility that groundwater in contact with the waste may cause mobilization of contaminants. A stated above in the section on the Hydrogeological Conceptual Model, the water table is shown as line starting at the surface of the Dockum and dipping to the southwest, passing through the 180-Foot Sand and skimming across the top of the 225-Foot Sand. However, the 225-Foot Sand and a portion of the 180-Foot Sand are confined, and their potentiometric surfaces rise almost to the base of the 125-Foot Sand. An examination of saturation data suggests that claystones and siltstones of the Dockum are about 80% saturated from depths of about 70 feet to about 135 feet across the site, indicating that water is present at higher elevations than indicated on the Hydrogeological Conceptual Model. It appears that the location of

the water table and capillary fringe at this site are not well understood, leading to question about the site being adequately characterized. During September 2007 meetings, the applicant stated their belief that the true water table is deeper in the section and that the capillary fringe does not extend deeply upward into the Cooper Canyon, perhaps only a few meters.

Modeling efforts were pursued by subject matter experts on contract at the University of Texas - Bureau of Economic Geology (BEG). Based on the BEG work done to date, one issue remaining in this regard has to do with the transport time of contaminants released from the landfill to the 180-Foot Sand. The September 2007 meetings revealed that there seems to be more concern about this zone than the 225-Foot Sand. Modeling done at the BEG to date shows that there are combinations of fracture aperture, flux, sorption, and diffusion that yield a variety of flow regimes and range of travel times. The work appears to suggest that transport to the 180-Foot Sand can be rapid for uranium, but the attenuation, even with minimal fracture to matrix advection, is high (on the order of 8 orders of magnitude or more) (Nicot, 2007a),(Nicot, 2007b). Thus, while total containment of the waste is not complete for 200 years under this scenario, depending upon the leachate concentration, the concentration reaching the 180-Foot Sand is not significant, perhaps not exceeding the site background value. Under less extreme conditions, travel times exceed 200 years. One additional mitigating factor is that the basic assumption that these fractures are continuous over the entire transport distance is thought to be conservative.

2.3 GEOLOGICAL AND HYDROLOGICAL IMPACTS

2.3.1 Soil and Sediment Impacts

The proposed design for the by-product disposal facility includes removal of all overlying soils and sediments before excavation of the actual disposal units begins. Once the active operations cease and the cap/cover is in place, the possibility of impacts to the overlying sediments and soils is seen as remote. The possible exception to this would be if the OAG groundwater were eventually to inundate the facility, and contaminants could be dissolved into the groundwater which could in turn carry them to such a depth where plants and/or burrowing animals could encounter them. This, too, seems to be a remote possibility within the regulatory performance period minimum of 200 years.

The impact to subsurface soils would be contamination by components of a release, both radiologic and non-radiologic. Owing to the anticipated depth of the by-product disposal facility, these sediments are not expected to move or be exposed during the regulatory performance period.

2.3.2 Surface Water and Groundwater Impacts

Surface water impacts are not expected at the site. The only probable event would be a release that does migrate to the OAG via the 125-Foot Sand, and the applicant deems this unlikely, although no base of sand maps have been produced that would preclude this.

The primary surface feature that contains water on a long-term basis is Baker Spring. This feature is at the

base of the OAG and water collects in the excavated depression in the Dockum. As the OAG will be entirely above the level of the waste in the facility, it appears that Baker Spring will be very near to the elevation of the top of waste. Once the cap/cover is in place there should be very little, if any, communication between the two. However, as a license condition, Baker Spring will be monitored for evidence of contamination.

Impacts to groundwater will amount to the potential contamination of groundwater both beneath the facility (in the 125-Foot, 180-Foot Sands, which may become saturated, and the saturated 225-Foot Sand) and laterally as far as the groundwater can migrate.

The applicant believes there will be no lateral impact during the regulatory compliance period, and for minimal impact over the very long term. Staff has relied on the work of external consultants to verify modeling performed, and the use of draft license conditions to provide reasonable assurance that there will be no adverse effects over the period of regulatory compliance. Monitoring of the by-product disposal facility will be accomplished by a series of wells sampled on a periodic basis and additional monitoring and verification as required by draft license conditions, so that any release will be detected as early as possible.

The applicant did not address whether there are plans to check on the condition of the cement conditions behind pipe on the local oil/gas and water supply wells at the end of their operational life. Such cement jobs often deteriorate over the years, and a faulty cement job could provide a conduit for migrating contaminants to deeper strata, including the Trujillo or Santa Rosa Sandstones, which are water bearing in this area. This can be addressed through a license condition requiring logging to indicate cement condition and possible action to repair any problems.

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Waste Control Specialists. 2007. Cover letter from D. Kunihiro, WCS to G. Smith, TDSHS dated January 12, 2007, transmitting seven copies of Revision 13. Application was completely revised and updated, consisting of 15 binders (Volumes 1 through 12, and A, B, and C). Four minor revisions and an omission followed: Revision 14 - February 27, 2007; Revision 15 - May 4, 2007; Revision 16 - May 18, 2007; Revision 17 - June 4, 2007; a copy of omitted Table 3.1 - July 13, 2007, and a supplemental letter dated August 23, 2007.

WCS Application, Attachment 4-1, Fault Study.

WCS Application, Attachment 5-1, Exhibit F, By-product Material Facility Siting Investigation, 2001.

WCS Application Attachment 5-5, Exhibit B, Kleinfelder, Geotechnical Test Results, WCS Project, 2003.

WCS Application Attachment 5-5, Exhibit C, Kleinfelder, Geotechnical Testing Data and Results, WCS Project, 2005.

WCS Low Level Radioactive Waste Disposal Application, Attachment 6-2, Matric Potentials and Moisture Contents, Upper Cooper Canyon Formation, Daniel B. Stephens & Associates, Inc, for wells B-95, B-96, and B-98, January 8, 2007.

WCS Low Level Radioactive Waste Disposal Application Attachment 6-3, Volume 16, Senger, Rainer, Three Dimensional Variably Saturated Groundwater Flow Model.

WCS, 9/07, email file, Water Table data, submitted by Steve Cook to Susan Jablonski on September 28, 2007.

WCS, 10/07, email reports, Time Constant Narrative, and TOUGH2 Model Narrative, both submitted to Susan Jablonski, transmission date 10/01/07

CHAPTER 3 ENVIRONMENTAL HEALTH PHYSICS REVIEW

3.1 Climate and Meteorology

This section discusses the applicant's general climatic description and includes an evaluation of the climatic data to ensure that it provides an accurate representation of site conditions. The requirement to provide this data is listed in Texas Regulation 25 TAC §289.262(f)(1)(A)(ii) which states that the applicant must provide an environmental report that includes the results of a one-year preoperational monitoring program of area/site characteristics which includes meteorology, among other data. Meteorology is an important factor in the design and operation of a by-product facility. The data is used to develop an environmental monitoring program. Meteorological data is also required by the various computer models used to project the leaching through the cover system, transport of radon gas, and the potential transport and dispersion of radioactive particles by wind. These models are used to project potential dose to workers and to members of the public. In addition, various facility systems and facility designs must accommodate the estimated volumes of rain and the effects of cold and heat under which the facility will be subjected.

3.1.1 General Characteristics

The WCS site is identified by the National Oceanic and Atmospheric Administration (NOAA) and the Cooperative Institute for Research in Environmental Atmospheric Administration (CIRES) Climate Diagnostics Center as being in the Southeastern High Plains climatic region. The climate for this region is classified as semiarid and is characterized by warm, dry summers and mild, dry winters. Daily values of temperature and precipitation data were obtained based on records from seven National Weather Service (NWS) Cooperative Stations: (1) Hobbs, New Mexico; (2) Jal, New Mexico; (3) Andrews, Texas; (4) Pearl, New Mexico; (5) Ochoa, New Mexico; (6) Seminole, Texas; and (7) Odessa, Texas. Wind direction and speed measurements were obtained from the NWS "first-order" forecast office in Midland, Texas. Wind data was also taken from the onsite WCS weather station. The WCS station has 2-meter and 10-meter wind speed and direction instruments. This data is provided in Table 2.5 of the application (WCS, 2007) for years 2000 through 2003.

3.1.2 Temperature

Monthly air temperatures are provided in Table 2.1 of the WCS application (WCS, 2007) for the four New Mexico stations. Table 2.2 through Table 2.4 provide "Annual Climatic Means and Extremes" for the remaining three cooperative weather stations located in Texas. The warmest months are June and July and the coolest are November and December. The average annual minimum temperature from 01/01/1914 to 12/30/1997 is 49.5°F for Andrews, Texas and the average annual maximum temperature for this time period is 77.5°F. The record high for Andrews is 113°F on June 27, 1994 and record low of -1°F on February 02, 1985.

3.1.3 Precipitation

Tables 2.1 through 2.4 (WCS, 2007) provide a summary of monthly average precipitation. The annual average rainfall for all seven cooperative stations is 14.2 in. with Andrews, Texas reporting and average annual precipitation of 15.61 in. The peak precipitation occurs in August and September. Average annual snowfall is between 0.6 in. for Odessa, Texas and 8.0 in. for Seminole, Texas.

3.1.4 Relative Humidity and Surface Evaporation

Relative humidity for region, as recorded for the Amarillo, Lubbock, and Midland-Odessa, is about 72% at 6:00 a.m. and 44% at noon. Tables 2.10 and Table 2.11 (WCS, 2007) list gross lake surface evaporation rates (inches) for Andrews County and Lea County. The mean annual net lake surface evaporation rate for Andrews County is 70.91 inches (TWDB, 2002).

3.1.5 Winds

Figures 2.4 through 2.16 (WCS, 2007) provide monthly wind rose plots of the primary NWS in Midland/Odessa, Texas. Prevailing wind directions are from the south and south-southeast, and the average wind speed throughout the year is 4 to 10 knots, as measured by the onsite weather station.

3.1.6 Storms

Severe weather events that may affect the Southern High Plans of Texas include: flash floods; high winds; dust storms; tornadoes; hail; and occasional snow, ice, and fog. Twenty-one tornadoes have been reported during the 42-year period of record for Andrews County. Lea County, New Mexico, reported 81 tornadoes (Tornado Project, 1996a and 1996b). Approximately 9.8 percent of these tornadoes were classified as strong F2 or F3 tornadoes. The strongest tornado occurred in Andrews County and was classified as an F3 with wind speeds of 113 to 157 mph. The majority of the tornadoes were F0 with wind speeds of between 40 to 72 mph. More likely to affect the site would be high winds and flash floods. Thunderstorms are responsible for a large percentage of the severe weather across New Mexico. High winds also frequent the area. A pronounced summer maximum is evident and is associated with thunderstorms. The Spring and Fall months contain wind damage from dry microbursts, when lower level moisture is often lacking. March through May also have a large number of events that are related to Spring seasonal winds, when relatively strong jet stream winds are able to mix down to the surface. There are a significant number of wind events in the winter months of December through February associated with large scale weather systems. The Southeast New Mexico plains receive numerous flash floods as well. (NWSO Albuquerque, Severe Weather Climatology for New Mexico, 1959-1998)

3.1.7 Evaluation Findings

TCEQ has reviewed the summaries in the meteorology and climatology sections of the WCS application (WCS, 2007) for completeness and adequacy of basic data. The wind and atmospheric stability data was based on onsite data to help ensure that wind speed and direction are accurately assessed. Other summaries

are based on nearby representative stations with long record retention periods (i.e., NWS Cooperative Stations surrounding the site recorded data for 47 or greater years). TCEQ has also reviewed the general climatic description of the region for completeness and authenticity. Climatic parameters have been checked against standard references, such as the NOAA and CIRES data bases, for appropriateness with respect to location and period of record. Based on this review, the data presented by WCS reflects an accurate representation of site conditions.

The staff has reviewed topographic maps and topographic cross-sections presented by the applicant. The terrain presents a slight upward trend in the predominant wind direction. There are no large scale natural or man made features to significantly affect radon or particulate dispersion. Standard regulatory atmospheric diffusion models, such as the Gaussian Plume Model, which are used by the applicants in their off-site dose projections, should provide a reliable assessment when modeling transport of airborne radioactivity from this site.

3.2 Air Quality and Impacts

3.2.1 Regulatory Requirements

The applicant originally wrote the application using DSHS regulations which do not specifically address non-radiological air quality. However, the application chose to base the content of their application on regulatory guidance documents which do specify the need to include such information. These guidance documents include the Texas Department of Health (now the Texas Department of State Health Services) Regulatory Guide 1.1 (TDH, 1984), USNRC NUREG-1569 (NRC, 2003), and USNRC NUREG-1620 (NRC, 2003). NUREG-1569 says that existing levels of air pollution and their relationship to the proposed operations should be discussed. Present data on airborne particulates and radon-222 (ambient concentrations and flux measurements) should be collected from the proposed license area during the preoperational monitoring program; these data should cover at least one annual cycle.

3.2.2 Discussion

Data concerning air quality are provided in Section 2.8.1, "Baseline Characteristics," of the WCS application (WCS, 2007). Lea County, New Mexico, and Andrews County, Texas are both designated by the Texas Commission on Environmental Quality (TCEQ) as being in attainment of the National Ambient Air Quality Standards (NAAQS) for all criteria pollutants. However, the only pollutant routinely monitored near the site is particulate matter, PM_{10} and $PM_{2.5}$, which are monitored in Hobbs, NM, and Odessa, TX, respectively. WCS's application summary Table 2.13 (WCS, 2007) provides the results of this particulate monitoring for 2003 through 2005. The applicant states that the primary air pollutants generated during construction and operation will include particulate matter from transport vehicles and excavation activities and carbon monoxide from fuel combustion. Other criteria pollutants, volatile organics, and inorganic emissions are not expected to be released in significant amounts due to the nature of facility operation or the chemicals expected to be used onsite. The Socioeconomic Impact Analysis, provided in Vol. 6, Appendix 11.A, Table 2.10, of the application (WCS, 2000) says that the transportation

of by-product material to the WCS facility will not, in and of itself, negatively affect these attainment programs because (1) most of the shipments to the WCS site will be by rail, (2) truck routes will be dispersed through a number of different urban areas, and (3) Andrew County is in attainment of all National Ambient Air Quality Standards and has no (additional) constraints to the dispersion of air-born pollutants.

WCS has conducted environmental monitoring to establish the mean baseline values for radionuclides in air. The program included continuous air monitoring stations; four located onsite and one other in the City of Andrews, TX. The data was collected from 2001 through 2003 and is summarized in Tables 2.14 and 2.15 of the application (WCS, 2007).

Of primary concern at this site is the potential for release of radioactive particulate matter generated during placement of bulk waste or from wind disturbance causing suspension of loose waste material. Operational procedures should require that dust suppression be used and that bulk waste handling be suspended during high wind conditions. This should help to minimize the amount of dust created. In addition, WCS has performed computer modeling which projects the potential dose to workers from inhalation and ingestion of bulk waste to demonstrate that the dose to workers and to the public is within acceptable regulatory limits. TCEQ has conducted an independent analysis and has verified the validity of the WCS calculations to ensure the safety of workers and the public from the effects of radioactive dust. The TCEQ verification calculation for exposure to dust and radon are provided in Appendix E and F of this chapter.

3.2.3 Evaluation Findings

The staff has independently confirmed the applicant's projected ground-level concentrations for radiological contaminants. The values will not exceed established standards unless an accident occurs. WCS emergency response for accident preparedness is being evaluated in two separate TCEQ sections of this document. Please refer to the operational health physics chapter and the process engineering chapter of this assessment.

3.3 Population Distribution

3.3.1 Regulatory Requirements

Texas regulations at 25 TAC §289.260(o)(2)(A), "Technical Requirements," states that in selecting among alternative by-product material disposal sites or judging the adequacy of existing sites, the agency will consider the remoteness from populated areas. Texas regulation at 25 TAC §289.260(f) requires the submission of an environmental report to allow the agency to assess the impact of the proposed licensed activity on the environment. Guidance provided for the preparation of an environmental report specifies that the socioeconomic impact of a by-product disposal facility be addressed. There are no additional requirements in Texas regulations concerning what information must be provided in the area of population distribution. However, the applicant has used various regulatory guidance documents in developing their

application which specify including this information.

NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications," was used by the applicant to provide recommendations for what information should be provided for determining the population distribution. Section 2.3, "Population Distribution," of this guidance, states that the staff should review population data based on the most recent census, including maps that identify places of significant population grouping, such as cities and towns within an 80-kilometers (km) (50 miles) radius. The staff should review the basis for population projections. For commercial-scale operations, the staff should also review descriptive material giving significant population on visitor statistics for neighboring schools, plants, hospitals, sports facility, residential areas, and parks, within 3.3 km (2 miles) of the operations. The review should include appropriate available food production data in kg/yr for vegetables (by type and totals), meat (all types and milk, and any available future predictions for this production by local governmental, industrial, or institutional organizations with 3.3 km (2 miles) of the site boundary.

3.3.2 Discussion

A description of the demographics of the site is provided in Vol. I, Section 2.2, "Demography and Socioeconomics," of the application (WCS, 2000), which references a standalone demographic and socioeconomic report entitled, "Socioeconomic Impacts of the Waste Control Specialists Proposed By-product Material Waste Disposal Facility." This document is provided in Appendix 11.A. As part of its license application, WCS has hired Hicks & Company to conduct the socioeconomic assessment of the proposed by-product material disposal facility which includes a background demographic analysis of the region. Please note that for environmental health physics review purposes, only the demographic analysis and not the socioeconomic assessment will be reviewed in this chapter. The Socioeconomic assessment is to be handled in a separate chapter.

Vol. 6, Appendix 11.A, Section 1.1, "Demographic Profile of the Region of Interest," in the Hicks & Company report, shown in the application (WCS, 2007), provides population data based on the most recent 2000 U.S. Census. The report notes that the population density around the site region is extremely low with the combined population of the four counties (Andrew County, Gaines County, Winkler Count, Texas and Lea County, New Mexico) being 90,155 based on the 2000 U.S. Census data. This represents a 2.9% decrease over the 1990 population of 92,852 persons. The rate of decrease is counter to the trends for the states of Texas and New Mexico that exhibited population increases of 22.8 to 20.1%, respectively during the same decade. From 1990 to 2000, the Andrew County population decreased by 9.3%. The report states that based on projection made using historic data and considering the mature nature of the oil industry in the area, Andrew, Gaines, Winkler and Lea Counties are likely to grow more slowly than their respective states' growth rates. The Texas Water Development Board, 2004 projections project growth for Andrews County to be 19.7% between the years 2000-2010 but then only 5.9, 5.6, and 5.3 percent over the next three decades, respectively.

Vol. 6, Appendix 11.B, "Population Distribution Data," in the application (WCS, 2000), provides maps

that identify places of significant population groupings within an 80-km (50 mi) radius. Table 11.B.3, "Sector Population for Each Given Downward Wind Direction and Distance Interval," shows the estimated number of people living within an 80-km radius of the site. This table includes field observations but does not provide the level of detail necessary to perform individual dose calculations. The facility will be a commercial scale operation; however, the applicant did not provide descriptive material for significant population or visitor statistics for neighboring schools, plants, hospitals, sports facility, residential areas, or parks within 3.3 km of the operations. In addition, the applicant did not provide food production data for vegetables, meat, milk, and future predictions for this production by local governmental, industrial, or institutional organizations with 3.3 km of the site boundary. As previously stated, this review did not examine the distribution of low-income and minority populations based on the most recent census data available.

3.3.3 Evaluation Findings

The staff has reviewed the population distribution for WCS by-product waste disposal facility according to NUREG-1569. .The applicant did not provide information on significant population statistics, food production data, or information concerning the transient population. However, this data is primarily needed for performing dose assessment and in developing an emergency preparedness program for the site. Radiological impacts will be analyzed using highly conservative assumptions in lieu of the lack of site specific data. The staff concludes that the population data provided by the applicant are accurate and provide an acceptable representation of present and projected population densities.

3.4 BASELINE CHARACTERIZATION

3.4.1 Regulatory Requirements

Texas rules at 25 TAC §289.260(o)(28) and 25 TAC §289.260(f)(1)(A) require that prior to any major site construction, a preoperational monitoring program shall be conducted for one full year to provide complete baseline data on the site and its environs. The guidance provided in Regulatory Guide (RG), 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills," (NRC, 1980) was used by the agency as an applicable guideline in which to base the quality of the applicant's baseline monitoring program. RG 4.14, Section 1.1, "Preoperational Sampling Program," provides the methods and frequencies for collection various environmental media including: (1) air samples, (2) water samples, (3) vegetation, food, and fish samples, and (4) soil and sediment samples. In addition, ambient gamma radiation measurements are required to be taken at the site to establish background radiation levels prior to operation of the facility.

3.4.2 Description of Programs

Baseline radiological and chemical characteristics must be collected to provide initial levels of chemical and radiological parameters against which to measure or evaluate compliance with applicable standards and rules; to evaluate performance of control systems and procedures; to evaluate environmental impacts

of operation; and to determine any potential long-term effects of effluent releases from the site. Accordingly, the applicant carried out a pre-operational sampling program which establishes groundwater quality, soil characteristics, ambient gamma data, and vegetation data. The applicant sampled Baker Springs, the only surface water body mentioned in the application (WCS, 2007) to be near the site. However, two of the sampling events used the EPA 901.1 Method which does not appear to be sensitive enough for determining the very low levels of naturally occurring radionuclides in the surface water. One additional surface water sampling event will be required of WCS for Baker Springs using the EPA Modified sampling methods and DOE Methods provided at the bottom of Vol. 1, Table 2.28 (WCS, 2007). See Section 2.4, "Surface Water," of this chapter for additional information concerning Baker Springs. The applicant also did not take fauna samples of the primary herbivore in the area. Additional fauna sampling requirements are discussed in Section 2.7, "Animals," of this chapter.

The methods and results for determining baseline characteristics for each of the environmental media of concern are provided below. The values determined in the WCS's tables were compared to the NCRP Report No. 50, 25 TAC §289.202, "Table II Effluent Limits," and baseline data provided in NUREG-1790, "Environmental Impact Statement for the Proposed National Enrichment Facility in Lea County, New Mexico - Final Report" (LES, 2005). The National Enrichment Facility (NEF) is located within 2 miles of the WCS site and thus provides a convenient comparison point for the WCS data.

3.4.3 Air

WCS has conducted environmental monitoring to establish the mean baseline values for radionuclides in air. The program included continuous air monitoring stations; four (4) located onsite and one (1) in the City of Andrews, TX. The data was collected from 2002 through 2006 and are summarized in Vol. 1, Tables 2.21 and 2.22 of the application (WCS, 2007). Ambient radon-222 was measured with passive integrating devices based on alpha-track detectors. When comparing the WCS proposed baselines for environmental media values to the 25 TAC §289.202 regulatory effluent limits we find that all proposed baselines are well below the limits for air and water. In addition, the baseline ambient radon-222 concentrations obtained from 2002 through 2006 (Table 2.22) range from 0.0003 to 0.0044 pCi/L. This appears to be low when compared to natural background measurements from the United States at large of 0.016 to 0.75 pCi/L (Gesell, 1983). The NEF Environmental Impact Assessment did not provide baseline air readings for particulates and radon so no comparison could be made between the two facilities for this type environmental media.

3.4.4 Groundwater

Water quality data was collected from 1997 through 2003 from the 225-ft zone at the adjacent RCRA landfill and analyses for thirteen metals, certain organic chemicals, and total dissolved solids (TDS). This data is summarized in Vol. 1, Table 2.16 of the application (WCS, 2007). In 2005, additional groundwater sample analyses were conducted of newly installed monitoring wells at the site. The following radionuclides were detected in all or nearly all groundwater samples in 2005: radium-226, radium -228, uranium-233/234, uranium-238, thallium-208, and thorium-230.

Three groundwater monitoring wells were installed at the proposed NEF facility with one of the wells yielding water sufficient for sampling. WCS summarizes the results of the NEF groundwater sample detected constituents in Table 2.17 of the application (WCS, 2007). NEF tested for a full suite of volatile and semi volatile organics, pesticides, polychlorinated biphenyls, cyanide, and the following metals: antimony, arsenic, beryllium, cadmium, cobalt, lead, mercury, selenium, silver, and thallium (NRC, 2005).

The values in the WCS tables were compared to the EPA Drinking Water Standards, 25 TAC §289.202, "Table II Effluent Limits," and the NEF Final Report. Based on the comparison, WCS's baseline gross alpha and total uranium exceed the EPA Drinking Water Standards of 15 pCi/l and 30 µg/l, respectively. WCS was questioned concerning the results of the gross alpha and total uranium samples in the most recent DSHS letter dated April 3, 2007. Their response is listed under question 10 of the Environmental Health Physics section of the WCS NOD Questions and Responses enclosure to Revision 16 of the application (WCS, 2007). WCS states that the high groundwater gross alpha and total uranium values are most likely due to suspended solids left in the unfiltered samples. WCS states that future groundwater samples will be filtered to remove suspended solids prior to analysis. A license condition will be added to the draft license which will require that a years worth of approved sample data be used in developing "Control Charts." Please refer to Section 7.0 of this chapter, for additional information. Control charts will be used in determining when investigative actions and mitigation actions will be required based on environmental sample results. Filtered groundwater water analyses will be needed to develop the groundwater control chart and will need to be approved prior to the site disposing of waste.

In addition, the WCS application does not appear to address non-radiological sampling and analysis during the operational period. There is evidence to indicate that non-radiological hazards may be the most important factor to ensuring the protection of groundwater at the WCS site. In 1986 the EPA completed a study of the Maywood Chemical Company site in New Jersey (Maywood, 1983). The study found the presence of elevated concentrations of volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), metals, pesticides, and other hazardous substances. In late 1987 through the spring of 1988, EPA collected split samples of soil and groundwater. The data indicates the presence of radiological contaminates in the soil and non-radiological contaminates in the groundwater. It is important for WCS to establish a baseline for all non-radiological contaminates which may be introduced to the burial site. Future sampling during the operational period will need to account for all non-radiological hazardous constituents which may be present in the Maywood waste and in any future waste which might be disposed of at the site. Therefore, a suggested license condition has been added to Section 7.0 of this chapter to address non-radiological baseline and operational groundwater monitoring.

3.4.5 Surface Water

Surface water samples were obtained from Baker Spring in December 2004 and November 2006. This data is summarized in Table 2.28 of the application (WCS, 2007). WCS used EPA Method 901.1 to detect a majority of the radionuclides of concern, but it does not appear to provide the required sensitivity to detect to the expected environmental levels for these natural constituents. For example, thorium-234 had a

minimum detectable level of 168 pCi/L and the sample result was 38.6 +/- 90 pCi/L. However, using DOE EML HAS-300, WCS was able to detect thorium -228 and thorium-232 to MDL levels of 0.253 pCi/L and 0.183 pCi/L, respectively. Because of the reliance on EPA Method 901.1, only one sample result is available with sufficient sensitivity for the majority of the radionuclides of concern for Baker Springs. A suggested license condition has been added to Section 7.0 of this chapter for WCS to take one additional sampling event, using the EPA Modified Methods and DOE Methods, which are listed at the bottom of Table 2.26, "Pre-Operational Data for Baker Spring," (WCS, 2007) to characterize the radionuclide constituents at Baker Spring.

3.4.6 Soil and Sediment

Establishing baseline data for soils and sediments is important for comparison purposes if decontamination is needed. Vol. 1, Table 2.25, of the application (WCS, 2007), contains the results of soil samples taken at Stations 3, 6, 8, and 22. The locations of these stations are shown in Figure 2.54 of the application (WCS, 2007). The applicant states that the range of values for the detected radionuclides in 2005 is consistent with naturally occurring levels in soils but does not provide a reference which they used in making their determination. In addition to the by-product pre-operational soil samples, WCS collected soil depth profile samples at three sample points during the process and storage facility licensing process. The results of the depth samples are shown in Figure 2.55 of the application (WCS, 2007). The results, shown in Table 2.26, indicate relatively little change in soil concentration with depth. The depth profile samples were compared with the pre-operational data soil analyses and found to be in good agreement.

In comparing NEF's soil data with WCS's values, the two facility data sets differ by a factor of two or less which is within the error of the sampling and analyses method. Therefore, TCEQ accepts the soil data as a legitimate baseline data collection.

Sediment samples; however, were not taken of Baker Springs. Additional sediment samples will be requested in a license condition.

3.4.7 Vegetation

Pathway analysis of radionuclides in the food chain requires measurements of vegetative material ingested by man or livestock. WCS collected vegetation samples at stations 3, 6, and 8 during the pre-operational monitoring period. Table 2.27, in the application (WCS, 2007), shows the values and "frequency of detection" for these samples which were taken in 2005. Up to eight individual samples were analyzed for specific radionuclides. Only radiological parameters were analyzed (Table 2.27 and Table 2.E.4-1 through 2.E.4-2 of the application). In comparison, the total radium levels in vegetation is well below the allowable regulatory limit of 5 pCi/g, as required by 25 TAC §289.260(h)(6)(A)(ii).

3.4.8 Animals

Pre-operational fauna samples were not proposed nor were any taken during the study period. However,

fauna samples are proposed during the operational period. Therefore, pre-operational fauna sample data are needed to establish a baseline in which to compare the operational environmental sample data. The applicant will need to submit additional data for these parameters before beginning operations. This is a proposed license condition.

3.4.9 Ambient Gamma Radiation

WCS has placed fifteen Thermoluminescent Dosimeters (TLD), including one control TLD, at various locations, on and offsite. The TLD locations are shown in Vol. 1, Figure 2.55 of the application (WCS, 2007). TLDs are placed approximately one meter above the ground in cages or plastic holders which are attached to a fence, wall, or pole. TLDs are exchanged on a quarterly basis and handled in accordance with WCS Procedure BP-EV-7.1.6,"Thermoluminescent Dosimeters." BP-EV-1.1.0, "By-product Facility Radiological Environmental Monitoring Program," requires the off-site laboratory performing the TLD processing to have a program that meets applicable sections of ANSI N545, "Performance, Testing, and Procedural Specifications for Themoluminescence Dosimetry (Environmental Applications)." Results are reported with the control TLD results subtracted to give a gross exposure for the location. The variation between the pre-operational background and the control location TLD dose is evaluated for determining the net dose for a location. Application Table 2.20 (WCS, 21004) provides the pre-operational Ambient Gamma Radiation measurements for thirteen of the fifteen TLDs listed in the Environmental Monitoring Program.

In addition, readings for Stations 21, 22, and 23 jump significantly for the December 31, 2005 quarter and for subsequent quarterly readings at these stations. Since these three TLDs are closest to the stored Fernald canisters it can be assumed that the increase is due to gamma radiation from the canisters. The dose for the TLD at Station 22 provides further evidence of this since it has the highest dose equivalent and this TLD is located closest to the Fernald canister storage pad. Although these three data points are not usable for establishing gamma radiation baseline, they do provide assurance that the program will perform as expected and provide reliable data during the operational period. WCS provided the mean annual dose, in millirem, for four different TLD groupings: on-site (6 locations), perimeter (8 locations), near-site (5 locations), and City of Andrews (1 location). Doses corresponded to 56, 56, 57, and 49 millirem, respectively. These data demonstrate a fairly consistent correlation of the mean background between the site and offsite locations.

In addition, NUREG-1790, "Environmental Impact Statement for the Proposed National Enrichment Facility in Lea County, New Mexico - Final Report," Section 3.14.1, "Background Radiological Exposure," p. 3-69 (NRC, 2005) discusses background radiation in the area:

> The U.S. Department of Energy (DOE) established radiological monitoring programs in southeastern New Mexico prior to the Waste Isolation Pilot Plant project to determine the widespread impacts of nuclear testing at the Nevada Test Site on the background radiation. DOE estimated the annual dose of approximately 0.65 millisieverts (65 millirem) is received from atmospheric particulate matter, ambient radiation, soil, surface water and sediment, groundwater,

and biota (DOE, 1997). These values fall within expected ranges and do not indicate any unexpected environmental concentrations. In May 2004, direct background radiation was measured to be 8 to 10 microrad per hour (LES, 2005), which corresponds to 0.70 to 0.88 millisieverts (70 to 88 millirem) per year. The measured range falls within the average annual direct background radiation for the United States.

The WCS ambient background gamma radiation measurements, which range between 49 and 57 millirem per year, fall within the expected range for direct background radiation as listed in the NEF report (LES, 2005) and as estimated by the Department of Energy.

3.4.10 Agency's Baseline Data

Agency personnel have not collected environmental media samples. Agency samples are recommended to confirm analytical results reported by the applicant; however, they are not required. The agency has instead chose to ensure that the applicant's sample program provides independent, reliable data through the applicant's quality assurance program and use of certified laboratories for all radiological and chemical samples.

3.5 ENVIRONMENTAL MONITORING

3.5.1 Regulatory Requirements

An environmental monitoring program is required to be conducted at the facility under 25 TAC §289.360(o)(28) to evaluate: (1) compliance with applicable requirements, (2) performance of control systems and procedures, and (3) environmental impacts of operations; and (4) to detect potential long-term effects. The Agency will use TDH Regulatory Guide 1.1, "Guidelines for the Preparation of Environmental Reports and Safety Evaluation Reports for In-Situ Uranium Recovery Facilities," (TDH, 1984) for determining whether WCS has an adequate program. Section (A)(2) of this guidance states that the environmental monitoring program should be described, with attention given to: (1) types of samples to be collected, (2) sample locations and frequency, (3) analyses to be performed on each sample, (4) analytical sensitivity (detection threshold) for each analysis, and (5) criteria for investigating increases in concentrations for substances. In addition, Reg. Guide 1.1 (TDH, 1984) provides a table, in Appendix I, which gives additional guidance to the applicant for type, number, location, method, frequency of sampling and analysis, and types of analyses to use in their environmental monitoring program

3.5.2 Licensee's Program

The applicant's environmental monitoring program is provided in Vol. 1, Section 4.0, and Vol. 4, Appendix 4.B, Procedure BP-EV-1.1.0, "By-product Facility Radiological Environmental Monitoring Program" (WCS, 2007). In general, the applicant's program addresses the principal pathways by which radioactive contaminants enter the environment for the pre-operational, operational, and post operation periods for the life of the site (BP-EV-1.1.0, Tables 7, 8, and 9).

To ensure compliance with the requirements of 25 TAC §289.260(o)(28) the applicant must first ensure that the program establishes an accurate baseline for radiological and chemical characteristics for all environmental media. This is of primary concern for radionuclides in the environment. This is because the applicant is allowed to subtract the baseline (i.e., background) dose from the environmental TLD readings prior to comparing these readings to the 100 millirem per year annual allowable TEDE dose limit to the public. The methods which WCS has used to establish radiological and chemical baselines were previously discussed in Section 2.0, "Baseline Radiological and Chemical Characteristics," of this chapter.

Section 2.4, "Groundwater," of this chapter discussed problems with the applicant's groundwater gross alpha and total uranium results. These values were excessively high possibly due to them being unfiltered samples. WCS states that future groundwater samples will be filtered to remove suspended solids prior to analysis. The applicants Table 2.15, "Background Means Currently Established for the WCS Site," are also not approved at this time. The U-234 and U-238 standard deviations are large and indicate a potential problem with the sample method or analysis. In addition, background air samples results often exceed the minimum detectable level reported. It is likely that excessive dust loading on low volume air samples filters is preventing the samplers from collecting sufficient amounts of naturally occurring background radionuclides. Low volume air samples do not appear sensitive enough to detect the very low levels of naturally occurring radionuclides at the site. Therefore, Table 1, "Environmental Monitoring," requires that high volume air samplers be used, both on and offsite. A suggested license condition has been added to Section 7.0 of this chapter which requires that one full year of agency-approved sample data be used in developing "Control Charts." These Control Charts, which will be the basis for investigative and action levels at the site, will be based upon groundwater, air, and other environmental background measurements.

3.5.3 Agency's Program

The Agency may establish a confirmatory sampling and analysis program for the WCS facility. However, the draft license and any final license will have provisions which would require the applicant to provide duplicate samples with the Agency, upon request, for later analysis and comparison. The agency will also have the opportunity, per the draft license, to take environmental samples it deems necessary to verify the health and safety of the public and to protect the local environment.

3.5.4 Evaluation Findings

The staff has reviewed the preoperational environmental monitoring program for the Waste Control Specialist by-product waste disposal facility for adherence to the requirements of 25 TAC §289.260, §289.202 and according to Texas Department of Health (now the Texas Department of State Health Services) Regulatory Guide 1.1 (TDH, 1984), NRC RG 4.15 (NRC, 1980), and NUREG-1569 (NRC, 2003). The objective of the review was to ensure that the applicant's preoperational environmental monitoring program was adequate to characterize the site before construction and operation (i.e., to

determine existing levels of radiological and selected nonradiological constituents), in accordance with §289.260(o)(28).

In its review, the staff determined the following:

(1) The applicant provided a description of the preoperational environmental monitoring program and of a plan for taking corrective measures as required by 25 TAC §289.260(o)(28). The staff noted that the program covered at least a 12-month period and included the basic environmental data (e.g., monitoring direct radiation exposures, airborne constituents, groundwater in the saturated (i.e., 225 foot) and vadose zone (i.e., 125 foot sandstone), surface water, soil, and vegetation and biota) in accordance with the requirements of 25 TAC §289.260(o)(28). WCS will be required to take additional surface water, sediment, and fauna samples as per license conditions which will be added to the draft license. These conditions will be required to be met prior to the site beginning operations. Based upon the applicant's descriptions of the preoperational environmental monitoring program and data collected, and licensed conditions to complete this data set, TCEQ finds that the applicant's environmental monitoring program and baseline description is considered acceptable.

(2) Except as listed in Section 3.2, "Licensee Program," above, the applicant's methods, techniques, and procedures for monitoring radiation and for sampling environmental media are consistent with TDH RG 1.1, NRC RG 4.14, and NRC NUREG-1569 and are adequate for determining radiation exposure levels and for obtaining representative samples.

(3) Field and laboratory data are recorded in appropriate units, according to the requirements of 25 TAC §289.260(o)(29), and include appropriate descriptive statistics, statistical analysis, reporting levels, action levels, and regulatory limits. Maps were provided that show all sampling locations and their direction and distances with respect to the disposal units.

(4) The environmental monitoring program organization, lines of authority, staff qualifications, and training of personnel are in accordance with the requirements of 25 TAC §289.260(e) and the implementation guidelines of TDH RG 1.1.

(5) The quality assurance (QA) measures and quality control (QC) procedures include quality controls on the organizational structure, selection and training programs, equipment, instrument testing, and calibration procedures for field monitoring and sampling, sample handling, sample analysis, data reporting, administrative reviews, audits, and general environmental monitoring procedures. The QA/QC program with respect to environmental monitoring is adequate, meets the guidelines of RG 4.15, "Quality Assurance for Radiological Monitoring Programs – Effluent Streams and the Environment," and provides reasonable assurance that the applicant's preoperational environmental monitoring program was maintained according to acceptable standards.

(6) With the exception of the additional environmental monitoring requirements listed in Section 7.0, "Suggested License Conditions" of this chapter, the location of the sampling points, the type of

samples obtained, and the sampling frequencies for the pre-operational and operation periods, have been adequately justified by the applicant on the basis of site-specific data with regard to locations of critical pathways and their measured variability.

Therefore, the staff concludes that the applicant's preoperational environmental monitoring program meets the review criteria noted, thereby satisfying the requirements of 25 TAC §§ 289.202 and 289.260(o)(28).

3.6 RADIOLOGICAL IMPACT FOR PROPOSED OPERATIONS

3.6.1 Overview of Impact Assessment Method

Radiological limits for the public at a uranium or by-product waste disposal facility are described in 25 TAC §289.260. During operations, the radiological dose limit for a uranium/by-product facility for the public of 100 millirem/yr is provided in 25 TAC §289.202(n). This dose limits is from all exposure pathways except for a groundwater exposure pathway which is ruled by the limits in §289.260(q). The groundwater limits are essentially the drinking water limits for radium and alpha-emitters. Groundwater is usually controlled during operations by a liner and leak detection system to guard against groundwater impacts. If groundwater concentrations exceed the limits in 25 TAC §289.260(q), then the licensee must apply for an ACL amendment and a dose/risk evaluation must take place as outlined in NUREG-1620.

During the post-closure period of a tailings impoundment or a by-product waste disposal facility, a radiological assessment of long term performance is completed to examine soil concentrations, radon flux predictions and measurements, and gamma radiation limits. The radiation doses to a hypothetical onsite resident farmer are not calculated in the post closure period for a waste site because the soil, radon, and groundwater concentration limits are considered to be protective. The soil and radon concentration limits include:

- Soil limits for radium (Ra-226 or Ra-228) must be removed to 5pCi/g averaged over the first 15 cm of soil below the surface and 15 pCi/g in the subsequent 15 cm thick layers of soil after the first 15 cm layer (25 TAC §289.260(h)(6) and §289.260(0)(22));
- Radon flux limits for radon emanating through the disposal unit cover must be designed to reduce the radon flux to less than 20 pCi/m2/s (25 TAC §289.260(0)(16)(B))
- Radon flux measurements must be taken of the disposal unit cover system once the final cover is in place using the methodology cited in 25 TAC §289.260(o)(x); and
- Gamma radiation emanating through the disposal unit cover system from by-product waste must be reduced to background levels (25 TAC §289.260(0)(17))

Groundwater impact is controlled during the operational period by a waste liner and leachate collection systems. To protect groundwater during the post-closure period, an evaluation is performed by the TCEQ geological staff to determine the potential for migration of contaminants out of the waste trench to the nearest water supply within the regulation time frame of "1,000 yrs or to the extent reasonably achievable

and, in any case, for at least 200 yrs." This evaluation does not give credit for the site having a liner system and instead relies upon the natural characteristics of the soils under the site to impede the potential for migration of contaminants out of the waste trench to the nearest water supply.

During operation, the principal radiological impacts of the WCS project will arise from routine releases of contaminated soil, dust, and of gaseous Radon (Rn-222). Radon and its daughter radionuclides can escape from bulk waste material and through minute factures in the containerized waste forms, and be dispersed as determined by the local meteorological conditions. The applicant used a series of simplified equations which conservatively estimate the dose to workers and the public. These equations are simplified in that they do not account for the many removal mechanisms such as rainout and radioactive decay.

The applicant calculated the dose to on-site workers and dose to a member of the public in the future after the site is decommissioned using a mathematical model called RESRAD (RESidual RADiation) (Strenge and Bander, 1981). RESRAD was developed by Environmental Assessment Division Argonne National Laboratory, under contract for the United States Department of Energy (DOE). As part of the RESRAD quality assurance (QA) program, the RESRAD code has undergone extensive review, benchmarking, verification, and validation. The manual and code have been used widely by DOE and its contractors, the U.S. Nuclear Regulatory Commission, U.S. Environmental Protection Agency (EPA), U.S. Army Corps of Engineers, State agencies, industrial firms, universities, and foreign government agencies and institutions.

It is important to note that the groundwater pathway models implemented in the RESRAD code apply only to situations for which the hydrological strata can reasonably be approximated by a sequence of uniform, horizontal strata. For sites having more complicated strata, such as fracture zones, simple models may be used to provide reasonable estimates if a set of effective hydrogeologic flow parameters are used. However, the accuracy of the results predicted is determined by the accuracy of the effective input parameters used (Yu et al. 1986). There is documented evidence in the WCS application that fractures exist in the site's geologic layers. Various models were used by WCS to attempt to determine the effects of these fractures. Because the results of these models showed that fracture flow should not predominate within the substrata and that matrix flow (i.e., a uniform horizontal strata flow) should be the case, WCS did not adjust their RESRAD parameters to determine a set of effective hydrogeologic flow parameters for groundwater modeling. WCS did not attempt to calibrate RESRAD using inputs "matched" to observable outputs (e.g., tracer studies or groundwater age dating) but did modify the rate of infiltration of water through the facility cover, as discussed in Section 4.8.2.3 of this chapter. Additional information, concerning the fracture flow and matrix flow models, is presented in a geology chapter (Kuharic, 2007).

RESRAD Version 6.22 was used by TCEQ to perform an independent analysis of WCS's dose to on-site workers who are expected to place and compact the waste. TCEQ also performed an extensive review of WCS's calculation for a member of the public living at the site boundary during the operational period. This hypothetical situation assumes the worst case situation where a member of the public lives at the boundary of the site in the predominate down wind direction. Documentation of TCEQ verification calculations using RESRAD and through hand calculations are provided in Sections 4.8.1 and Appendices E, F, and G, of this chapter.

3.6.2 Waste Characterization

Texas regulation 25 TAC 289.260(o)(14)(A) requires that the applicant supply information concerning the chemical and radioactive characteristics of the waste solutions. WCS provides a waste characterization in Vol. 1, Section 1.1.2, of the application which describes the radioactive characteristics and provides a limited description of the chemical characteristics of the waste they anticipate receiving for disposal at their by-product site (WCS, 2007).

The site is designed to receive and dispose of by-product material. which is defined in Texas regulation 25 TAC 289.260(c)(4), as "tailings or wastes produced by or resulting from the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes." By-product material typically consists of two types: (1) uranium mill tailings and (2) thorium mill tailings. Uranium mill tailing contain residual uranium-238, uranium-235, and their daughter products along with other naturally-occurring radionuclides such as: thorium-230, radium-226 and its daughter products; and stable metals such as barium, cobalt, copper, lead, nickel, vanadium, and molybdenum. Thorium mill tailings differ from uranium mill tailings due to the much higher concentration of thorium radionuclides in the waste material. Potential material sources, characteristics, and where possible, estimated quantities the actual waste to be received are summarized below:

Uranium Mill Tailings – The primary radionuclides in the mill tailings are Ra-226, Th-230, Rn-222, and Pb-210. Ra-226 radioactivity is between 50 pCi/g to over 1,000 pCi/g.

Solution Mining Residues – Sludge-like materials resulting from the processing of uranium ore solutions from the in-situ uranium mining process. These residues contain small amounts of uranium, thorium and its decay daughters (Ra-226, Pb-210, and Th-230). Ra-226 is typically the primary radionuclide of interest and is present on the order of 200 pCi/g.

Uranium Mining and Milling Facility Decommissioning Wastes – Upon completion of operations and subsequent decommissioning of uranium mining and milling facilities, contaminated process piping, equipment, containers, and building material would be classified as by-product waste and could be received by the facility. The radionuclide constituent in this waste stream will resemble uranium mill tailings. However, this waste would contain significant hot spots due to the concentration of uranium and its daughter product during various phases of the uranium extraction process.

Thorium Milling Residues – Thorium from sites in Maywood, New Jersey and West Chicago, Illinois are currently undergoing remediation. This waste stream has a much higher concentration of thorium than does uranium mill tailing. For example, the Maywood, NJ site has surface soil concentrations of around 1981 pCi/g of Th-232 where uranium mill tailing have between 70-600 pCi/g Th-230. The inhalation dose conversion factor for Th-232 is over 10 times higher than the dose factor for Th-230 making Th-232 more hazardous if inhaled.

Niagara Falls Storage Site – The Niagara Falls Storage Site (NRSS) received mill residues from Mallinckrodt Chemical Works, St. Louis, Missouri and from other sources. Mallinckrodt extracted uranium from the very rich Belgian Congo uranium ores (35 percent to 60 percent uranium oxide). Processing of this high grade ore resulted in residues know as the K-65 residues. A total of approximately 11,000 m^3 of by-product material are stored at NFSS.

Fernald Environmental Management Plant – This DOE facility, located approximately 18 miles northwest of Cincinnati, Ohio, began operations in 1952 and produced high purity uranium metal for the nation's defense programs. Production operations ended in 1989 and Fernald was included on the National Priorities List established under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Fernald Silos 1 & 2 stored residues were generated from the processing of high assay uranium ores at the FMPC and Mallinckrodt Chemical Works (MCW) in St. Louis, MO. The ores processed at MCW and the FMPC came primarily from one mine located in the former Belgian Congo. Those ores contained relatively high concentrations of uranium in the range of 40 to 50 percent as well as high concentrations of radium. The refinery wastes, known as raffinates, contained a high concentration of the radioactive decay-chain products. Approximately 8,900 cubic yards of raffinates from the K-65 process were slurried into Silos 1 & 2. This waste was stabilized with a formulation of flyash, and Portland cement. The waste loading in the stabilized waste is expected to average from 17 to 30 weight percent K-65 material; therefore, 70 to 83 weight-percent of the final stabilized waste form will be inert, non-waste material additives. This waste has been transported to the WCS site for temporary storage pending final disposal.

3.6.3 Sources of Emissions

The description of the waste is provided in Section 1.1.3 and Tables 1.3 through 1.11 of the application (WCS, 2007). The source term for the impact assessment was broken down into two separate categories, operational period source term and post-operational period source term. The two separate source terms were chosen because the primary exposure pathways differ for the two time periods.

For operations, the applicant chose to use the Maywood Superfund site waste characterization data as their source term. The Maywood waste is believed to contain the highest radionuclide concentrations that would be disposed as bulk soil without the use of rigid waste containers. The Maywood waste also contains the highest thorium-232 concentrations of any of the waste streams considered. For the post-operational period, the applicant is using the Fernald Silo 1 and 2 waste canister radionuclide data. Even though the Fernald Waste is containerized and is held in a flyash and concrete matrix, WCS has chosen a more conservative approach and will not take credit for the container limiting any leaching of the waste within the 1,000 year evaluation period. The Fernald waste data was provided by DOE Fernald, Inc. in their Silos 1 & 2 waste characterizations.

During the operational period, the primary exposure pathways will be from wind blown dust and radon from the loose bulk waste. During the post-closure period, the waste will be covered by a thick cap. WCS

used the RESRAD dose assessment computer model to project the dose for a resident farmer scenario which assumes that a farmer builds his house over the buried waste and draws water for himself, for irrigation of vegetables, and for the raising of domestic milk and meat animals. The primary exposure pathways will be from leachate to groundwater, radon, and direct gamma exposure.

By-product waste will contain, in addition to uranium, significant amounts of radium-226 and radon-222. The principal concern associated with uranium mill tailings is from the production of radon-222 gas from the decay of Ra-226. Potentially large quantities of radon-222 will be released from the surface of the disposal lifts of waste during operation of the site. The release of radon will be mitigated during the post-closure period by the disposal facility cover which is designed to attenuate the flux of radon emanating from the waste material to levels which are below 20 pCi/m^2s. Radon-222 has a half life of 3.8 days and can rapidly give rise to its daughter radionuclides; polonium-218 (half-life: 3 min), lead-214 (half-life: 27 min), bismuth-214: (half-life: 20 min), polonium-214 (half-life:160 μsec), lead-210 (half-life: 22 yr), bismuth-210 (half-life: 5 days) and polonium-210 (half-life: 138 days). If radon emanates from the cover surface it will disperse into the air and decay to its daughter products. The daughter radionuclides of radon attach themselves to particles in the air or any other material close at hand.

3.6.4 Exposure Pathways

The applicant provides a pathway evaluation in Vol. I, Section 5.3, "Performance Assessment." Exposure pathways included: (1) airborne dust and radon, (2) external radiation from soil, (3) radon in the leachate collection system, (4) radon migration through the cover system; (5) gamma radiation through the cover, and (6) infiltration of rainwater into the cover system creating leachate which migrate to groundwater and subsequently contaminates a drinking water well (WCS, 2007). Depending of whether it is the operational or post-operational period, the applicant calculates exposures for four different receptor groups which include: (1) workers located within the disposal trench; (2) a receptor located at the by-product facility boundary (fence line), which is approximately 100 meters distant from the waste in the trench; (3) a member of the public at the boundary of the facility approximately 1,000 meters for the landfill; and (4) the resident nearest the facility who is located approximately 5.63 kilometers to the west. WCS assumes that the exposure will occur on the ground surface rather than the actual burial depth of approximately 85 feet. This would be a conservative assumption in all cases except for worker dose from Rn-222. This is because radon is heavier than air and may concentrate in the trench area due to the lower wind speed and potential bath tubbing effect.

For the workers, WCS divides up the airborne pathway into two additional routes of exposure and provides a separate analysis for each: (1) Pathway A1 – Windblown dust from an open waste cell; and (2) Pathway A3 – Airborne radon from an open waste cell. Simplified dose projection calculations were used for the air-dispersion analysis. These simplified calculations are considered by the agency to be an acceptable approach to use for this evaluation. The analyses of the doses resulting from these pathways are presented in this chapter in Section 4.8, "Radiological Assessment."

3.6.4.1 Airborne Impacts

The predominate wind direction, as determined from onsite meteorological data at the WCS site, is from the south as shown in Figures 2.4 through 2.16 of the application (WCS, 2007). Therefore, the highest concentration of suspended and deposited radionuclides should be found in the north sector. Tables 5.3.1.1-1 through 5.3.1.1-8 show input parameters and dose results for all operational airborne exposure pathways. A very important factor used in the windblown dispersion calculations is the resuspension factor. The resuspension factor is discussed in Section 5.3.1.1, "Resuspended Dust Inhalation," on p. 5-10 of the application (WCS, 2007). For estimating the dust concentration for the worker a resuspension factor of 1.7 E-7 m^{-1} was used. This factor is the geometric mean of the measured values for dust in the cab of a tractor during operation while mechanically disturbing soil. The choice of resuspension factor is conservative and its use in the calculation will ensure protection of workers. For calculation of doses to other receptors downwind, the applicant chose to use a resuspension rate for soil in an arid or semi-arid environment from Table 4.18 of the DOE report (DOE, 1994). A resuspension rate of 6.3E-10 s^{-1} was used. This is the geometric mean value of data taken from Nevada Test Site, Hanford, and an eroding agricultural field.

Maximum exposure to a worker is 136 millirem per year from pathway A1 (i.e., windblown dust from an open by-product cell). The radon pathway to workers is significantly less, 21 millirem per year, due to the effects of wind to carry away the radon before it has a chance to decay to its dose producing daughter products.

Due to the effects of dispersion, the projected dose to the site boundary resident and nearest resident are very low, approximately 0.18 millirem/yr at the facility fence line (100 m), 0.032 millirem/year at 1,000 m, and 9.0E-04 millirem/yr for the nearest resident. These doses are well below the 100 millirem/year allowed by Texas regulation.

3.6.4.2 Surface Water Impacts

The only surface water mentioned in the application near the project site is Baker Spring. Baker Spring is located to the northwest of the proposed site at the edge of an escarpment where the caprock ends. Surface water is present in Baker Spring most of the year. In the Baker Spring area, sand and gravel reserves have been excavated to expose the top of the red bed. Addition information concerning Baker Spring and surface water in the area is presented in a geology review chapter (Kuharic, 2007).

3.6.4.3 Soil and Sediments Impacts

The principal impacts on soils and sediments will be associated with the potential for spills of by-product bulk waste material. The most likely places for spills to occur would be: (1) at the rail yard when transferring material from the rail cars to another transportation vehicle, (2) during transportation of the waste to the trench area, and (3) spills during placement of the waste when it is moved from the transportation vehicle to the waste lifts within the trench. In addition to spills of bulk waste, there is a small chance that the Fernald Silo 1 & 2 waste containers could be dropped causing the container's

integrity to be compromised. However, based upon the design of the canisters and because the Fernald by-product waste has been solidified within the stainless steel containers, it is highly unlikely that a significant spill would occur from the Fernald canisters.

Another potential source of soil and sediment impact would be from liquid waste at the site. Unlike the low-level radioactive waste rules, there are no requirements in Texas law to limit the percentage of liquid in by-product waste and due to their large volume, bulk waste container may contain significant amounts of contaminated liquid. In addition, the site is capable of generating significant amounts of radioactive wastewaters from their leachate control system and through liquid generated during decontamination of contaminated vehicles and equipment. WCS's procedural requirements for leachate collection, site monitoring, spill cleanup, and surface reclamation would be used to prevent significant environmental impacts on soils or sediments. Please refer to chapters on operational health physics and process engineering for additional information concerning the applicant's wastewater control program.

WCS performed a dose calculation for determining the external gamma dose from waterborne sediments (Pathway Description W2) to individuals at the disposal facility fenceline (100 m), an individual at the WCS property boundary (1,000 m), and the nearest resident (5.6 km). The input data for this pathway are shown in Table 5.3.1.5-2 of the application (WCS, 2007). This data assumes that windborne dust accumulate in surface sediments over a 30 year period, the projected operating life of the facility. No losses or removal mechanisms are assumed. Even with these conservative assumptions the doses are all much less than 1 millirem/yr which is far below the 100 millirem/yr regulatory limit from 25 TAC §289.202(n)(1)(A).

3.6.8 Radiological Assessment

The WCS radiological assessment was considered over the operational and for the post-operational periods. During the operational period, the WCS assessment evaluates windblown dust from an open by-product waste cell and from airborne radon from an open waste cell. Dose projections are performed for an onsite radiation worker, receptor at the boundary of the by-product disposal facility, for a member of the public at the site boundary in the predominate wind direction, and for the nearest resident. The operational and non-operational periods will be considered separately in this chapter.

3.6.8.1 Operational Period Radiological Assessment

The operational period is considered to be the time between when the landfill first receives waste until the start of decommissioning of the facility. The exposure pathways evaluated for the operational period include:

- Resuspended dust inhalation from operations (A1)
- Radon gas inhalation (A3)
- Worker inadvertent soil ingestion (S1)

- External gamma from ground-deposited dust (S3)
- External gamma from waterborne sediments (W2)

3.6.8.1.1 Airborne Dust from an Open By-product Waste Cell (Pathway A1)

Dust will be generated at the site, primarily as a result of placing and compacting bulk waste material. This waste is typically uranium mill tailings, soil, and building debris which contains fine particles which can be easily suspended by air currents and carried downwind. Texas regulation 25 TAC §289.202(o)(30) requires that a system be designed and operated so that all airborne effluent releases are as low as is reasonably achievable. The primary means of accomplishing this will be by means of emission controls. To control dusting from diffuse sources, the applicant has develop Operating Procedure BP-OP-2.7, "Dust Suppression." This procedure outlines a system for fugitive dust suppression which uses a set of movable spray nozzles (e.g., Rainbird® Series Rain Guns®) and hand held spray nozzles to spray non-contact water over the waste, This system is designed for complete coverage of the active landfill area each day. Non-contact storm water or well water (i.e., water that has not been in contact with the waste and therefore does not contain radioactive contaminates above natural background levels) will be used to mitigate dust generation and continuous air monitoring will be conducted as part of the environmental monitoring program. Water sprays will be used to reduce contaminated dust to protect workers from inhaling the dust and should also limit the amount of contaminated particulates that can migrate beyond the boundaries of the landfill. However, conservative estimates of windblown dust are necessary to project doses to workers and the public. Methods to estimate dust generation are shown in Sections 4.8.1.1.1.1 and 4.8.1.1.1.2 of this chapter, below.

WCS used the Maywood Superfund site source inventory given in Table 5.2.1-1 of the application (WCS, 2007). Simplified dose projection calculations were used to estimate the dose for a facility worker and to determine the dose to a member of the public at 100 meters, 1,000 meters, and for the nearest resident. An uncovered area of bulk waste was assumed to be approximately 1,000 m^2. Other parameters used in the calculations are provided in Table 5.3.1.1-1 of the application (WCS, 2007).

3.6.8.1.1.1 Worker Dose

The methods used by WCS to calculate worker dose are described in Section 5.3.1.1 of the application (WCS, 2007). WCS calculated and summed the dose for all radionuclides to determine the dose to a by-product material facility worker dose from dust inhalation, direct exposure and soil ingestion during operation of the bulk waste landfill. WCS estimates that the total committed dose equivalent for a worker from airborne dust is 136 millirem per year (Table 5.3.1.1-1 of reference WCS, 2004). TCEQ's verification calculation for this exposure pathway is provided in Appendix F of this chapter. The TCEQ calculations used very conservative assumptions which resulted in an estimated dose to the worker from inhalation of dust to be 275 millirem/yr.

3.6.8.1.1.2 Disposal Facility Boundary and Nearest Resident Doses

The calculated doses for this pathway are summarized in Table 5.3.1.1-1 of the application (WCS, 2007). WCS used simplified dose projection equations to calculate the dose to a member of the public at the landfill boundary, 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. Input parameters, used by WCS 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 regulatory requirements then additional sampling and more specific site data is warranted to allow for less conservative but more accurate site data which may result in lower projected doses. Doses for persons at 100 m, 1000 m, and 5.63 kilometers were projected to be 1.79E-01, 3.16E-02, and 9.03E-04 millirem per year, respectively.

3.6.8.1.2 Airborne Radon Gas from Waste Cell (Pathway A3)

Pathway A3 evaluates the potential doses from radon emitted during operations from a waste cell. An exposed waste area of 1,000 m^2 was assumed based on exposing one eighth of a waste cell. A Ra-226 concentration of 84,660 pCi/g was used in the calculation. This maximum radium-226 concentration was taken from the Maywood waste inventory source term shown in Table 5.2.1-1 of the application (WCS, 2007). Simplified dose projection equations were used to calculate the radon concentration (i.e., a conservative box model for onsite workers) immediately above the exposed waste layer, at 100 meters, at 1,000 meters, and at the location of the nearest resident.

3.6.8.1.2.1 Worker Dose

Simplified dose projections equations were used to estimate the radon concentration near the ground surface. WCS chose to use a very low wind speed which allows for significant quantities of radon daughter products to form in the air which the worker would be exposed. A wind speed of 0.001 m/s is very low and should provide a conservative upper bound for the dose to a worker. Radon dose to a worker is estimated to be 21.2 millirem/year (Table 5.3.1.2-2 of reference WCS, 2004). TCEQ performed a verification calculation of the worker radon dose. This calculation is provided in Appendix G of this chapter. The TCEQ calculation uses a much larger exposed waste surface area and resulted in a higher worker radon dose of 563 millirem/yr. It should be noted as shown in Appendix G that the worker radon dose is highly dependent upon wind speed at the base of the landfill and varies from 563 millirem/yr at a wind speed of 3.1 m/s to 1,750 millirem/yr for a wind speed of 1.0 meters/second.

3.6.8.1.2.2 Disposal Facility Boundary and Nearest Resident Doses

The same input parameters, with the exception of wind speed, were used to determine the dose to the downwind receptors. A higher wind speed, of 3.1 m/s, was used for the facility boundary and off-site dose determinations. The higher wind speed is based on the WCS on-site weather station which shows an annual average wind speed of 6.04 knots (i.e., 3.11 m/sec) for the site. Based on WCS's calculations, the projected doses were determined to be 3.44 millirem/yr, 0.224 millirem/yr, and 1.81E-02 millirem/yr for

the disposal site boundary, resident at 1,000 meters and nearest resident, respectively.

3.6.8.1.3 Worker Inadvertent Soil Ingestion (Pathway S1)

In addition to the airborne dust and radon exposure pathways, WCS calculated the dose to a worker from ingestion of soil. The worker is estimated to receive 1.45 millirem/year from ingestion of soil (Table 5.3.1.3-2 of reference WCS, 2004). WCS states that a one time per year ingestion event occurs of 100 mg of Maywood bulk waste soil. However, this is a daily intake and so needs to be multiplied by a factor such as 240 work days per year. This higher ingestion rate is also used as a RESRAD 6.2 default value for soil ingestion which is 35 g/yr or 150 mg/day. When the higher yearly ingestion rate is used the dose to the worker is approximately 350 millirem/yr. The TCEQ verification calculation, shown in Appendix E of this document, calculated a soil ingestion dose of 475 millirem/yr to the worker. Even with the additional soil ingestion, the projected dose to a site worker is well below the 5,000 millirem/yr allowed by Texas regulation.

3.6.8.1.4 External Radiation from Ground-Deposited Dust (Pathway S3)

The external radiation from this soil pathway calculates the projected doses to persons due to direct gamma radiation exposure from wind deposited contaminated dust on the ground surface. The calculation uses the same pathway parameters as those used in pathway A1. WCS used simplified dose projection equations to calculate the downwind ground concentrations of deposited radionuclides and external radiation doses at: (1) the disposal facility boundary, (2) WCS site boundary, and (3) for the nearest resident. The calculated doses are shown in Table 5.3.1.4-1 of the application (WCS, 2007). They include doses of 1.03E-3 millirem/yr, 1.82E-4 millirem/yr, and 5.18E-6 millirem/yr for the disposal site boundary receptor, resident at the 1000 meters site boundary, and the west resident at 3.65 km, respectively.

3.6.8.1.5 External Gamma from Waterborne Sediments (Pathway W2)

This soil pathway calculates the projected doses to persons due to direct gamma radiation exposure from waterborne sediments on the ground surface in an uncontrolled area. The calculation assumes that the dust deposited on the ground surface is transported by water to a low-lying area where it accumulates during the entire 30-year operational period. The input data for Pathway W2 are shown in Table 5.3.1.5-1 (WCS, 2007). The external radiation dose from sediment over the 30 year period are shown in Table 5.3.1.5-2 (WCS, 2007). They include doses of 3.08E-2 millirem/yr, 5.45E-03 millirem/yr, and 1.56E-04 millirem/yr for the disposal site boundary receptor, resident at the 1000 meters site boundary, and the nearest resident at 3.65 km, respectively. These doses are well below the 100 millirem/year regulatory limit from 25 TAC §289.202(n)(1)(A).

3.6.8.1.6 External Gamma to Worker from Placement and Compaction of Bulk Waste

Although by-product material contains the uranium-238, uranium-235, thorium-232 decay chains consisting almost entirely of alpha and beta radiation, significant x-ray photon radiation is still emitted.

Ac-228, a daughter product in the Th-232 decay chain, gives off x-rays having energies of 0.91 and 0.96 MeV with probability of decay by this energy per disintegration of 27.7 and 16.6 percent, respectively. Since the Maywood Superfund Site waste contains large amounts of Th-232, the level of Ac-228 should be significant. Table 1 provides a list of other radionuclide daughter products which decay to emit high energy photons.

Table 1, Photon Emitting Radionuclides Contained in By-Product Waste

Radionuclide	Decay Series	Quantum Energy (MeV)	Probability of Decay (%)
Ac-228	Th-232	0.91	28
Ac-228	Th-232	0.96	17
Bi-211	U-235	0.351	14
Pb-212	U-238	0.239	45
Ra-224	Th-232	0.241	4
Ra-226	U-238	0.186	3
U-235		0.184	54

Based upon this information, the TCEQ conducted two separate calculations to determine the projected dose to a radiation worker due to handling and compacting waste in the disposal pit. The first method used RESRAD Version 6.3 and the second used the program MicroShield® (MicroShield, 2006). These calculations used the Maywood radionuclide characterization with the x-ray emitting radionuclides listed above in equilibrium with their parent (decay series) radionuclide. Both methods calculated significant external direct radiation doses to workers. The results of this study using RESRAD indicated that a worker could receive a dose of 40 millirem/yr where the dose using MicroShield® indicated a dose to the worker of 7.29 millirem/yr. These results are provided in Appendix A of this chapter. Since MicroShield® is the preferred method for calculating exposure, its results will be added to other sources of worker exposure in the final worker dose determination performed in Section 4.8.3 of this chapter.

3.6.8.2 Post Operational Period Radiological Assessment

The post operational period, also known as the closure period, is the period of primary interest in the assessing the long-term impacts from the site. A minimum period of 1,000 years after closure is typically used as the period of analysis to demonstrate the relationship of site suitability to the performance objective in 25 TAC §289.260(o)(16)(A). This regulation states that in disposing of by-product material, licensees shall place an earthen cover over the by-product material at the end of the facility's operations and shall close the waste disposal area in accordance with a design that provides reasonable assurance of control of radiological hazards will be effective for 1,000 years to the extent reasonably achievable and, in any case, for at least 200 years.

3.6.8.2.1 Radon Gas Attenuation Through the Cover

Texas regulations 25 TAC §289.260(o)(16)(B) and TAC §289.260(o)(20) require that the cover system limit releases of Radon-222 from uranium by-product materials and Radon-220 from thorium by-product materials to the atmosphere so as not to exceed an average release rate of 20 picocuries per square meter per second (pCi/m^2s) to the extent practicable throughout the effective design life of the cover system (i.e., 1,000 years to the extent reasonably achievable and, in any case, for at least 200 years). Radon gas attenuation was evaluated using the RAECOM model (Rogers et al., 1984). This model determines the radon flux and radium concentration in a uranium tailings and multilayer cover system and can be used to predict the radon flux though the WCS by-product material disposal facility cover system. Input parameters used for the radon calculator are provided in Tables 5.3.2.1-1 through 5.3.2.1-4 of the application (WCS, 2007). Because radon flux through soil is highly dependent upon its moisture content, 25 TAC §289.260(o)(17) states that in computing required by-product material cover thicknesses, moisture in soils in excess of amounts found normally in similar soils in similar circumstances shall not be considered. Using the proposed cover system without consideration of the 60 mil HDPE liner, the radon attenuation was calculated at a nominal exit flux of 0.022 pCi/m^2s which is well below the TCEQ and EPA standard of 20 pCi/m^2s set forth in 25 TAC §289.260 and 40 CFR 192. An independent analysis of the RAECOM model radon flux from the cover was performed by TCEQ and is provided in Appendix D, of this chapter. These results verified the conclusions of the applicant that the proposed cover system will reduce radon emanation to below the 20 pCi/m^2s regulatory limit.

Texas regulation 25 TAC §289.260(o)(16)(B) states that if the applicant will have a phased emplacement of the final radon barrier as part of their reclamation plan they will verify that radon-222 release rates for each portion of the pile or impoundment as the final radon barrier for that portion is emplaced. In Vol. I, Section 6.1.1.5, the applicant says that they will place an interim final cover over the waste but will not commence radon monitoring until the final cover is put in place at the time of final closure. Since the interim final cover does not include the entire disposal facility it will not have the same performance characteristics as the completed final cover system. In addition, significant levels of radon-222 are anticipated to emanate from the angled waste sidewall, which has no cover, and the active waste cells, which have a 2-ft non-select red bed clay cover. Therefore, rather then monitor radon flux at the top of the interim final cover, WCS will monitor radon using the environmental radon stations listed in Table 1, "Environmental Monitoring."

Texas regulations at 25 TAC §289.260(o)(21) state that near-surface cover materials may not include waste, rock, or other materials that contain elevated levels of radium. WCS discusses the types of soil which will be used in the near-surface cover material in Vol. 1, Section 3.2.10, "Finished Surface Grade," of their application (WCS, 2007). They will consist primarily of previously excavated natural non-select red bed clays, caliche boulders, cobbles and fines. In addition, evapotranspiration soil layers and rock mulch will be added to the top of the cover to support a natural vegetation surface. Where this surface cover material will be obtained and the required radiological properties of this material were not specified in the WCS application. However, WCS will be required to conduct tests of the final radon barrier to ensure it is effective in limiting releases of radon-222 to a level not exceeding 20 pCi/m^2s averaged over

the entire pile or impoundment. These tests will provide an adequate demonstration that any additional levels of radium in soils added to the surface of the cover are essentially the same as surrounding surface soils.

3.6.8.2.2 Gamma Attenuation Through the Cover

Texas regulation 25 TAC §289.260(o)(17) states that the direct gamma exposure from the by-product material should be reduced to background levels. Due to the relatively low gamma ray energies of the by-product waste and the low activity for waste having long half-lives, WCS calculated a very high gamma attenuation factor. The parameters used in this calculation are provided in Table 5.3.2.2-1 of the application (WCS, 2007). Based upon conservative assumptions, the cumulative attenuation for gamma emission at the top of the cover would be 4.30E-22 millirem/yr. Therefore, direct gamma exposure from by-product material would be reduced to levels well below background levels as required by 25 TAC §289.260(o)(17). To verify their calculations, TCEQ did an independent analysis using a program called MicroShield®. Using the parameters from the application, the TCEQ MicroShield® model yielded estimated surface dose rates of 3.83E-19 millirem/yr which are well below background levels. Parameters used in the TCEQ verification calculations along with the MicroShield® printout are provided in Appendix B of this chapter.

3.6.8.3 Infiltration of Water Through the Cover

The cover system for the proposed landfill has seven layer system, which consists of, from top to bottom: (1) an evapotranspiration layer composed of a 6 inch layer of sand, 0.76 m of fine grained native soil, and an erosion protection layer made up of ¾ inch of rock mulch; (2) 1.2 m of mixed caliche boulders, cobbles, and fines; (3) 2.5 m of non-select red bed fill material; (4) a 0.6 m capillary break/granular drainage layer; (5) a 60 mil HDPE liner; (6) a 0.9 m compacted red bed clay barrier performance cover; and (7) 0.5 m red bed non-select fill that provides a base for the performance cap.

Vol. I, Section 5.3.2.3, "Infiltration Through the Cover," of the application (WCS, 2007), discusses how WCS applied the computer model HELP (USAE, 1997) to estimate the infiltration rate of water into the landfill. The HELP model was developed by the U.S. Army Engineer Waterways Experiment Station under a cooperative agreement with the EPA to support RCRA and Superfund programs. HELP is used to estimate the amounts of runoff, evapotranspiration, drainage, leachate collection, and liner leakage that may occur in a cover system. WCS does not include a 60 mil HDPE liner in their HELP model calculations even though the liner will be placed in the final cover system. Manmade liner systems, which are highly impervious to water infiltration, are prone to puncturing and will deteriorate over time. Therefore, the cover system will rely primarily on the properties of the select material incorporated into its multilayer system (i.e., clay's having very low hydraulic conductivity) to minimize water infiltration.

Application Tables 5.3.2.3-1 through 5.3.2.3-6 (WCS, 2007) provides a list of HELP model input and output parameters for a 100 year simulation. The model incorporates eight separate layers in the cover system design and uses conservative soil parameter values for total porosity, field capacity, wilting point,

saturated hydraulic conductivity, drainage length, and drainage slope. In addition, in Volume 4, Section 5.0, "Appendices," of the application (WCS, 2007), WCS provides a CD of the Help Model input and output files. The primary purpose for using the HELP model is to provide a more accurate and defensible approximation of water infiltration though the cover for input to the WCS RESRAD model. RESRAD only provides a very simple cover system model which can not pattern the complex multilayered cover proposed by WCS for the by-product landfill. WCS chose to determine an infiltration rate at the base of the cover and input this infiltration rate into the RESRAD model by modifying two different parameters.

Using the HELP model, TCEQ performed an independent analysis for determining infiltration of water through the cover. Parameters used in the TCEQ verification calculations along with the HELP printout are provided in Appendix C of this chapter. The results provide evidence to verify the correctness of the applicant's conclusions and that it is reasonable to expect a 0.140 inches per year percolation/leakage rate through the combined cover and waste form.

3.6.8.2.4.1 Post Operational Leachate Migration

The applicant addresses leachate migration in Vol. I, Section 5.3.2.4, "Post-Operational Leachate Migration," and Attachment 6.2, Exhibit C, "Saturated Fracture Flow and Solute Transport," of the application (WCS, 2007). Reviews of the various models and methods used by WCS to determine post-operational leachate migration are covered in the geology chapter.

3.6.8.3 Combined Dose for All Pathways

As required by Texas Regulation 25 TAC §289.202(n)(1)(A), it must be demonstrated that the Total Effective Dose Equivalent (TEDE) to a member of the public will not exceed 100 millirem per year during the operational phase. This dose includes the pathways for: (1) airborne particulate ingestion and inhalation; (2) radon and radon daughter product exposure; and (3) consumption of vegetables, meat, and milk products contaminated by windblown radioactive particles and from deposition of radon daughter products. The groundwater exposure pathway is handled under 25 TAC §289.260(q) which provides a table of maximum concentration values to be used for groundwater protection if the waste cell develops a leak to groundwater once the site begins operations. This table includes values for combined radium-226 and radium-228 and for gross alpha-particle activity. These limits match the TCEQ and EPA drinking water limits for radium and alpha-emitters in groundwater.

The agency conducted independent projections of the direct gamma dose to a resident living directly above the by-product waste during the post-closure period. These results are provided in Appendix B, of this chapter. This dose due to direct radiation was projected to be insignificant (e.g., was determined to be 4.0E-16 millirem/yr). The dose due to radon is also anticipated to be insignificant as shown by the 100% attenuation of radon by the cover system. The 100% attenuation of radon is demonstrated using the RAECOM radon flux calculator. These verification results are provided in Appendix D, of this chapter.

As it turns out, the highest dose to a member of the public during the period which the facility is operating,

occurs to a person living at the WCS site boundary in the predominate downwind direction (e.g., to the North). TCEQ performed a verification calculation which included WCS exposure pathways A1, A3, S3, and W2, as listed in Tables 5.2.1-1 through 5.3.1.5-1 of the application (WCS, 2007). The following significant modifications were made to the WCS inputs for use in the TCEQ verification calculations:

- The area of exposed waste was increased by a factor of 20 times (i.e., 19,800 m^2 versus 1,000m^2). This area of exposed waste consists of the Vol.1, Figure 3.7, Active Waste Slope, (WCS, 2007) which has a 288 feet downward face and a 740 feet maximum width.
- A re-evaluation of the dust resuspension factor was performed which resulted in a more conservative value of 5.25E-9 s^{-1} versus the WCS value of 6.3E-10 s^{-1}.
- The shortest distance from the landfill to the site boundary was taken which was 777 meters as opposed to the 1,000 meters used in the WCS calculation.
- To verify the applicants' wind dispersion model, the agency used the Pasquill-Gifford wind dispersion model solved for the plume centerline dose. The TCEQ chose an atmospheric stability Class C. This resulted in a less conservative wind dispersion X/Q value of 3.42E-6 s/m^3 versus the 6.0E-5 s/m^3 valued used by WCS. Although the TCEQ's X/Q value is smaller then the WCS value, it is still believed to be a highly conservative and defensible value for use in the calculation.
- In the radon dose calculation for the site boundary resident, TCEQ included both the exposed area of waste (i.e., 19,800m^2), described above, and the maximum area of the landfill having waste with an interim cover over it (i.e., 6,870 m^2). The RAECOM model was used to determine the radon emanation rate for the exposed and interim cover wastes. WCS used a 1,000 m^2 area of exposed waste for their radon dose calculations.

Use of these highly conservative assumptions and parameters provides a realistic worst case estimation of the dose to the site boundary resident. Using the assumptions and parameters, the calculated dose to the critical member of the public was 9.54 millirem/yr. This result is below the 100 millirem/yr allowed by Texas regulations. These calculations are provided in Appendix F, of this chapter.

The following table summarizes these doses for the operational and post-operational period.

Table 2: WCS Calculated Doses for the WCS By-Product Facility
During Operational and Post-Operational Periods

PERIOD INTEREST	PATHWAY DESCRIPTION / RECEPTORS	A1 Airborne Dust from open by-product cell (millirem/ yr)	A3 Radon gas from open waste (millirem/ yr)	A6 Radon emanation through finis cover (millirem/yr	S1 Worker Inadvertent Ingestion (millirem/yr	S3 External Radiation from Offsite Soil (millirem/ yr)	W2 Surface water Transport of ground-deposited dust to low lying areas (millirem/yr)	TOTAL DOSE (millirem/ yr)
Operational Period	Worker[a]	1.36E+02	21.2	3.66E-04	1.45	N/A	N/A	1.59E+02
	By-Product Facility Boundary	1.79E-01	9.18E-02	2.15E-04	N/A	1.03E-03	3.08E-02	3.03E-01
	Site Boundary	3.16E-02	1.63E-02	3.8E-05	N/A	1.82E-04	5.45E-03	5.36E-02
	West Resident	9.03E-04	4.66E-04	1.09E-06	N/A	5.18E-06	1.56E-04	1.53E-03
Post-Operational	Resident Farmer	N/A	N/A	8.03E-02[c]	N/A	N/A	N/A	8.03E-02

a. Allowable worker dose is 5,000 millirem per year per 25 TAC §289.202(c)(2).
b. Allowable public dose is 100 millirem per year per 25 TAC §289.202(n)(1)(A).
c. Value is from WCS Application (WCS, 2007), Appendix 5.A - CD, Computer Model Data, p. 180, Pathway G3 - By-product Facility - Outdoor Occupancy 100%, All Pathways.

Table 3: TCEQ Verification Calculated Doses for the WCS By-Product Facility During Operational and Post-Operational Periods

PERIOD INTEREST	PATHWAY / RECEPTORS	External radiation to worker from handling and compacting waste (millirem/yr)	External radiation to resident farmer from radiation through cover system (millirem/yr)	RESRAD dose, including radon to worker for inhalation and ingestion pathways (millirem/yr)	Dose Resident (millirem/yr)	**TOTAL DOSE** (millirem/yr)
Operational Period	**Worker**[a]	7.29	N/A	1.31E+03	N/A	1.32E+03[c]
	Resident at Site Boundary[b]	N/A	N/A	N/A	9.54[d]	9.54
Post-Operational	**Resident Farmer**	N/A	4.06E-16	N/A	N/A[e]	4.06E-16

a Allowable worker dose is 5,000 millirem per year per 25 TAC §289.202(c)(2).
b. Allowable public dose is 100 millirem per year per 25 TAC §289.202(n)(1)(A).
c. From all pathways calculated in Appendix A, E, and G.
d. From all pathways calculated in Appendix F.
e. Besides the external dose to the resident farmer, the only other exposure pathways are from radon emanating through the cover and from use of contaminated groundwater. TCEQ addresses the radon and groundwater pathways by ensuring an adequate cover system design to limit radon emissions and by proper siting of the facility so that the natural soils preclude the migration of contaminates to a usable groundwater zone. Therefore, doses have not been calculated for these pathways.

3.7 EVALUATION FINDINGS

The staff's reviewed the sufficiency of information to satisfy 25 TAC §289.202 and 25 TAC §289.260 requirements. The applicant's projections of compliance with regulatory criteria have been compared with an independent staff assessment of these projections. The results provide reasonable assurance that the following conditions are met:

(1) Radiation exposure pathways will occur primarily through inhalation of airborne emissions, ingestion of food chain sources, and direct external exposure from handling of waste and from ground deposited particulates. The staff has reviewed the exposure pathways presented by the applicant for air, surface water, direct radiation, and other transfer mechanisms in accordance with NUREG-1569 and found them to be acceptable. The groundwater exposure pathway has been

reviewed by TCEQ Geologists and their findings sent to the file (Kuharic, 2007).

(2) The applicant calculated dose to workers and to the public for the operational phase of the project. WCS used computer spreadsheet calculations which employed a straight-line Gaussian plume model to predict radionuclide distribution and concentration for determining the movement of radioactive particulates and radon gas in the environment. RESRAD calculations, performed by the applicant, take into account radioactive decay and in-growth of daughter radionuclides and assess the three major exposure pathways of inhalation, ingestion, and direct external exposure.

(3) The staff concludes that the concentration estimates are conservative and defensible and are appropriate for the assessment of dose. In addition, use of these values in dose assessment related to performance objectives of 25 TAC §289.202(n)(1)(A) will lead to reasonably accurate and conservative values of dose. This conclusion is based on the use of conservative or justifiable input parameters in the modeling effort performed by the applicant and the independent analysis performed by the TCEQ staff.

(4) Normal offsite releases will be controlled by engineering and procedural controls (i.e., use of water sprays and termination of disposal activities during high wind conditions) so that impacts on individuals through the particular combination of pathways inherent at the access location of concern are within the limits specified in 25 TAC §289.202(n)(1)(A) and furthermore reduced to levels as low as reasonably achievable.

(5) In determining the distribution and concentration of radionuclides, the applicant has used realistic and reasonably conservative assumptions in the analysis and has discussed the uncertainties inherent in the modeling analysis.

(6) The relative concentration of radionuclides and doses to onsite workers and the critical member of the public were independently verified by the TCEQ staff. The TCEQ also conducted independent reviews of the WCS dose model results using HELP, RAECOM, MicroShield®, and RESRAD Version 6.3, computer models along with and EXCEL spreadsheet calculations.

(7) The staff's assessment included consideration of the applicant's commitments and proposed limiting conditions of operation, the applicant's proposed environmental monitoring program, the ease in which operations can be adjusted to eliminate or mitigate potential release of radioactivity, past environmental monitoring and disposal history at other onsite disposal areas, and the applicant's training and experience.

Based upon a review of the information provided by WCS, in their by-product disposal facility application, staff finds that the WCS application meets the appropriate environmental health physics regulatory requirements of 25 TAC §289.202 and 25 TAC §289.260, as discussed in this chapter. My review of this application indicates that issuance of a radioactive materials license to WCS to conduct by-product waste disposal operations at the Andrews County site would not be inimical to public health and safety and will

control radiological hazards to the environment (i.e., radioactive particulates, radon, and from direct gamma radiation exposure) during the time period of regulatory concern (i.e., for 1,000 years to the extent reasonably achievable and, in any case, for at least 200 years). Please note that the regulatory requirements listed in 25 TAC §289.260(f)(1)(A)(iii) , 25 TAC §289.260(o)(2)(B), and 25 TAC §289.260(o)(9)(A), dealing with groundwater protection, have been addressed in the geology chapter.

3.8 SUGGESTED LICENSE CONDITIONS

The following list of the applicant's commitments and/or limiting conditions of operations.

- General Provisions. The LICENSEE shall conduct the radiological and non-radiological environmental monitoring specified in Table 1 of this license to provide data to evaluate potential health and environmental impacts, and to facilitate the evaluation of long-term effects and the potential need for mitigation.

- Duplicate Samples and Other Environmental Samples. The Licensee shall provide the executive director an opportunity to obtain duplicate samples concurrent with the Licensee's data collection schedule. In addition, the Licensee shall allow the executive director the ability to obtain whatever environmental media sample(s) the executive director deems necessary to ensure the health and safety of the public and local environment.

- Evaluation of Data. The Licensee shall evaluate monitoring data using a two-tiered environmental monitoring response system (i.e., investigation and action levels) as described in Volume 4, Appendix 4.B, Procedure BP-EV-1.1.0, Section VIII of the Licensee's application. The results of the evaluation shall be included in the annual environmental monitoring report to the executive director.

- Transitional Monitoring Period. The Licensee shall provide for a transitional environmental monitoring period whenever program components, including sampling locations, equipment, techniques, or laboratories, are changed. This transitional period shall include parallel monitoring with both the old and new conditions for at least one sampling period or as directed by the executive director.

- Pre-operational Monitoring Period. The Licensee shall provide one full year of baseline data on the site and its environs prior to operations.

- Control Charts and Nonparametric Prediction Limits. The Licensee shall develop control charts and/or nonparametric prediction limits for all environmental media measurements which will be used to determine investigative limits and action limits for determining whether contamination may be migrating from the site as seen by increasing trends in the periodic analyses. For whichever statistical monitoring method is used, one year of executive director-approved

environmental media data will be required for each parameter under review. Prior to the start of by-product material disposal the executive director shall approve the specific methods, sample analyses for each baseline measurement which were incorporated into the charts, and the final control charts which contains all baseline environmental measurements (see WCS App., Vol. 4, Procedure BP-EV-1.1.0).

- Baker Spring Sampling Event. Prior to the disposal of by-product material at the facility, the Licensee shall conduct an additional surface water and sediment sampling event of the Baker Spring surface water feature using all EPA and DOE Methods shown at the bottom of Table 2.26, "Pre-Operational Data for Baker Spring."

- Pre-operational Fauna Samples. The Licensee shall conduct two (2) fauna sampling events at approximately six (6) month intervals and establish a baseline in which to compare these pre-operational fauna samples with fauna samples taken during the site's operational period. The Licensee shall analyze these fauna samples for the radionuclides and analytical methods listed in Table 2.25, "Pre-Operational Data Summary for Soil."

- Sampling of Non-Radiological Contaminants: The Licensee shall conduct quarterly baseline non-radiological contaminant sampling and analysis of all groundwater monitoring wells for a period of one year. All wells which yield sufficient water will be sampled for a full suite of volatile and semi-volatile organic compounds, pesticides, polychlorinated biphenyls, cyanide, and metals. The Licensee shall conduct operational non-radiological contaminant sampling and analysis, as required, as governed by the non-radiological hazardous constituents which are determined to be present in the by-product material which may be accepted for disposal in the by-product material disposal facility. Samples for these non-radiological constituents shall be performed in all 125-foot and 225-foot monitoring wells which are located at the perimeter of the by-product material disposal facility.

3.9 REFERENCES

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3.10 TABLE AND APPENDICIES

The following table and appendices are available online at <www.tceq.state.tx.us/goto/wcsbyproductapp/

TABLE 4: ENVIRONMENTAL MONITORING

APPENDIX A, "MICROSHIELD® CALCULATION OF THE DIRECT GAMMA DOSE RECEIVED BY A WCS WORKER PLACING AND COMPACTING BY-PRODUCT RADIOACTIVE WASTE"

APPENDIX B: "MICROSHIELD® CALCULATION OF THE DIRECT GAMMA DOSE RECEIVED TO A RESIDENT FARMER LIVING OVER THE WCS BY-PRODUCT RADIOACTIVE WASTE DISPOSAL SITE"

APPENDIX C: "HELP© MODEL CALCULATION FOR ESTIMATING RAIN WATER LEACH RATE THROUGH THE WCS BY-PRODUCT FACILITY COVER SYSTEM"

APPENDIX D: "RAECOM MODEL FOR ESTIMATING THE RADON EMANATION RATE THROUGH THE WCS BY-PRODUCT FACILITY COVER SYSTEM"

APPENDIX E: "RESRAD© CALCULATION FOR ESTIMATING THE DOSE TO A WCS WORKER PLACING AND COMPACTING BY-PRODUCT RADIOACTIVE WASTE"

APPENDIX F: "ESTIMATING THE DOSE TO A RESIDENT LIVING AT THE SITE BOUNDARY DURING THE OPERATING PERIOD IN THE PREDOMINATED WIND DIRECTION FROM THE WCS BY-PRODUCT RADIOACTIVE WASTE DISPOSAL SITE"

APPENDIX G: "ESTIMATING THE DOSE TO A WORKER DURING THE OPERATING PERIOD FROM RADON WHILE PLACING AND COMPACTING BY-PRODUCT WASTE"

CHAPTER 4.0 ADMINISTRATIVE AND OPERATIONAL HEALTH PHYSICS ASSESSMENT

The following details a review encompassing Revision Numbers 13, 14, 15, 16 and 17 of the WCS application. The review evaluates the applicant's compliance with the administrative provisions of Title 25 of the Texas Administrative Code, Chapter 289, Section 260 and all sections captured within the scope of Section 260. This review consists of three parts. The first part is a description of the applicant's requested activities and elements that will be employed to assure the safe execution of the proposed activity. The second part, beginning at Section 4.12, is a critique of the applicant's compliance with the requirements and provisions of Title 25 of the Texas Administrative Code (25 TAC), Chapter 289 (Licensing of Uranium Recovery and By-product Material Disposal Facilities), also referred to as the Rules, and Chapter 401 of the Texas Health and Safety Code pertaining to the disposal of by-product material. An evaluation of the procedures required under the Rules is based on guidance provided in Regulatory Guides and NUREGs published under the auspices of the U. S. Nuclear Regulatory Commission (NRC), and the experience and professional judgment of the review staff. The final part of this chapter is the finding of a review of the applicant's intended use of the requested radioactive material.

4.1 PROPOSED ACTIVITIES

Waste Control Specialists LLC (WCS) proposes to construct and operate a disposal facility for by-product material. WCS will receive by-product material from other persons and dispose of that material by shallow-land burial at a facility located in Andrews County, Texas over a projected 30 year lifespan for the facility.

The By-product Material Disposal Facility will be located on an approximately 36.39 acre site within a complex already operated by WCS. The complex is located in the western portion of Andrews County 30 miles West of Andrews, Texas on State Highway 176. Access to the site is from State Highway 176 due north along State Line Road, which parallels the Texas-New Mexico state line, for about one and a half miles. The proposed By-product Material Disposal Facility is one of several facilities at the WCS complex at this location. A radioactive waste processing facility and a hazardous waste treatment, storage and disposal facility are already located and in operation at the complex. Additional facilities planned for this complex include proposed disposal facilities for low-level radioactive waste and Federal radioactive waste. Figure 3.17 in Volume 1 of the application depict the proposed by-product material disposal facility in relationship to the other existing and proposed facilities.

4.2 AUTHORIZED ACTIVITIES

4.2.1 Facility Description

The main feature at the by-product material disposal facility will be the disposal cells. A total of six

(6) disposal cells, occupying approximately 16 acres of surface area, will be constructed over the life of the facility. The cells will be constructed as needed over the life of the facility. The cells will be excavated to a maximum depth of 100 feet below grade (§3.2, Vol. 1). Over the life of the facility a total volume of 1,169,000 cubic yards is expected to be developed.

Aside from the disposal cells, other features at the facility include a combination guard house/counting room (located near the entrance gate on State Line Road), an inspection station, a staging area for incoming shipments, a decontamination building, a staging area for outgoing empty containers and two contact-water storage tanks. These features comprise what WCS terms support functions (§3.7.1 and Figure 3.18, Vol. 1). A security fence is indicated to surround the perimeter of the facility when the disposal cells are constructed with toll gate barriers at the entrance gate on State Line Road and at the contractor entrance (§3.9.1, Vol. 1).

4.2.2 Receipt of By-product Material

WCS will receive by-product material from other persons at the by-product material disposal facility. By-product material will not be generated by WCS at this facility. However, by-product material may be received from WCS if the by-product material has first been received for processing at the facility licensed under Radioactive Material License No. L04971. Following processing at the facility licensed under Radioactive Material License No. L04871, the by-product material may then be transferred to the By-product Material Disposal Facility for disposal.

Receipt of by-product material at the By-product Material Disposal Facility is indicated to be via truck. However, WCS has indicated in the application that by-product material may also be shipped to the WCS complex and received at the railcar unloading facility under Radioactive Material License No. L04971, then transferred from railcar to trucks for ultimate delivery to the By-product Material Disposal Facility. It should be noted that the railcar unloading facility is not currently considered by the agency to be a part of License No. L04971 (per consultation with Hans Weger, Radioactive Waste Processing License Reviewer with the Uranium and Technical Assessments Section).

WCS provided procedures in the BP-OP-series that describes the by-product material acceptance criteria. WCS will require the generator/shipper of by-product material to have submitted characterization information of the by-product material in advance and to have received WCS approval for shipment of the by-product material to the facility for disposal before shipment is actually made or received at the By-product Material Disposal Facility.

As part of the requirements for acceptance of by-product material for disposal, WCS will require the generator/shippers to provide a certification that the by-product material offered for disposal (1) complies with the definition of by-product material given at 25 TAC §289.260(c)(4), (2) was not generated prior to 1978, or (3) was deemed by-product material by an act of the U.S. Congress. In addition to the requirement by WCS that the generator/shipper provide a characterization of the by-product material offered for disposal as to its radionuclide content and activity, and hazardous material

constituents, a license condition is recommended that would require that a characterization of the by-product material offered for disposal also identifies all chemical constituents and their concentration.

To address a concern regarding protecting workers from the potential for inhalation of airborne radioactivity, a license condition is recommended that requires bulk by-product material to be containerized. A discussion of the reason for this recommended condition is provided in the portion of this assessment pertaining to WCS's respiratory protection program. An additional concern that this recommended condition is intended to address is the potential for transfer of bulk material from the disposal cells to unrestricted areas. This concern is discussed in the process engineering review. And, this recommended condition is also intended to mitigate the potential for by-product material to impact groundwater is less than 200 years. A discussion of this concern is in the geology section of the environmental analysis.

4.2.3 Disposal Operations

Procedures describing the disposal operations are provided in the BP-OP-2.series of procedures in Appendix 3.7A of Volume 1 and the Procedures Manual. WCS will use a crane or a lift to remove containerized by-product material (e.g., Fernald canisters) from the transport vehicle for placement in the disposal cells. Uncontainerized by-product material will be off loaded from the transport vehicle onto an unloading skid. The off loaded noncontainerized by-product material will be moved into place on the working face of the disposal cell by dozer or other pusher. The uncontainerized by-product material will be spread on the working face and compacted.

WCS indicates in Procedure BP-OP-2.1 "By-product Material Disposal" that soil-like material will be excavated from previously placed by-product material and containerized by-product material placed in the excavations and encapsulated by the excavated by-product material. Since the license will not authorize non-containerized bulk by-product material, a draft license condition has been recommended to specify that clean soil be used to fill the void spaces between containers of by-product material.

4.2.4 Equipment Release

WCS will survey items (e.g., equipment, vehicles, containers, etc.) before releasing them from the by-product material disposal facility to unrestricted use. Items which exceed the limits specified at 25 TAC §289.202(ggg)(6) will not be released to unrestricted use. WCS will decontaminate items to be released to unrestricted use that exceed the surface contamination limits specified at 25 TAC §289.202(ggg)(6). Decontamination activities will be conducted in a dedicated building at the by-product material disposal facility. A license condition will reinforce the requirement that before any item leaves the By-product Material Disposal Facility for release to unrestricted use that it be surveyed and demonstrated to not exceed the surface contamination limits specified at 25 TAC §289.202(ggg)(6).

WCS may transfer equipment, vehicles and other items contaminated with by-product material in

excess of the limits specified at 25 TAC §289.202(ggg)(6) to other persons who possess a radioactive material license, issued by either an Agreement State or the NRC, that authorizes the possession of by-product material in an unsealed form.

4.3 ORGANIZATIONAL STRUCTURE

Waste Control Specialists LLC is registered in the State of Delaware. However, it maintains its corporate offices at Three Lincoln Centre, Suite 1700, 5400 LBJ Freeway, Dallas, Texas 75240. WCS has engaged Corporation Services Company, 701 Brazos Street, Suite 1050, Austin, Texas 78701 to represent it as its registered agent (§1.2.1, Vol. 1).

The corporate organizational structure for WCS is presented in Section 1.2 of Volume 1 and is depicted in Figure 1.2. Corporate organization relevant to radiation safety at the by-product disposal facility, consist of the following:

4.3.1 President and Chief Financial Officer

The President and Chief Financial Officer (CFO) of Waste Control Specialists LLC is stated to have the ultimate responsibility to ensure the compliance of the proposed by-product material disposal facility with all applicable regulatory requirements.

4.3.1.1 Vice-President of Licensing and Regulatory Affairs

This position reports directly to the President. The person occupying the position of Vice-President of Licensing and Regulatory Affairs is the person who signed the last application form (18 May 2007) and is designated in a resolution from the management committee of WCS to be authorized, empowered and directed to manage, direct or administer the company's activities with regard to application for a license. No further statement is made with respect the role that this position plays in the organization with respect to radiation safety or the operation of the by-product disposal facility.

4.3.1.1.1 Corporate RSO

This position is stated to report directly to the Vice-President of Licensing and Regulatory Affairs. The person occupying the position of Corporate RSO is not identified in the application, nor are the credentials for a person occupying this position provided. Furthermore, it is not stated in the application what role this position plays in the organization with respect to radiation safety or the operation of the by-product disposal facility.

4.3.1.2 Vice-President and General Manager (GM)

The GM reports directly to the President and CFO. The GM has direct responsibility for the operation of the facility and the selection of personnel for key facility positions. The GM is responsible for the

protection of facility personnel and the general public from radiation exposure, and is responsible for compliance with the facility licenses.

The organizational structure with respect to the proposed by-product material disposal facility is depicted in Figure 1.6 and the individual positions described in Section 1.2.5. A synopsis of the positions and their relevance to radiation safety is given below.

4.3.1.2.1 Director of Environmental, Safety and Health (EH&S)

The ES&H director reports directly to the GM. The ES&H director is responsible for the health, industrial safety, radiological safety and environmental compliance programs, including ensuring environmental monitoring, and the site security force. The description of the EH&S director position in Section 1.2.5.3 does not indicate it to be combined with the radiation safety officer position. However, Figure 1.6 shows the RSO in parenthesis for the director of ES&H block in the organizational chart. Thus, there is some confusion as to whether the two positions are actually separate or are combined.

4.3.1.2.1.1 Facility Radiation Safety Officer (RSO)

The facility radiation safety officer (RSO) position is described in Section 1.2.5.4, and appears as a parenthetical on the ES&H Director block on the organizational chart presented in Figure 1.6. The RSO is indicated to be the primary facility contact with the agency. The RSO is indicated to be responsible for ensuring that operations are conducted in accordance with ALARA, maintaining compliance with regulatory standards and adhering to radiation safety procedures. The RSO is stated to have the authority to shut down operations in an emergency or when unsafe conditions exist. The RSO is responsible for investigating environmental releases and employee exposures, ensuring that corrective actions are taken and reporting to the agency. Additional responsibilities include initiating and maintaining procedures that affect radiation safety, provides an annual review of the procedures, and guides the radiation safety training program. Responsibilities also include all aspects of the radiological monitoring and survey programs, and that the required records concerning the radiation protection program are properly maintained. The RSO is also indicated to manage the radiation safety organization, which includes the radiation safety supervisor and radiation safety technicians. Additional information concerning the RSO is provided in the Radiation Safety Program (BP-RSP-100) in Appendix 10.A of Section 10 of Volume 5, and the Procedures Manual.

WCS's list of responsibilities assigned to the facility RSO is not completely acceptable. In accordance with 25 TAC §289.252(f)(3(N) the RSO shall be the licensee's primary contact with the agency, not just the primary facility contact. Therefore, it is recommended that a condition be placed on the license specifying that the RSO shall be the licensee's primary contact with the agency. As the primary contact with the agency, the RSO should be delegated the authority by the licensee 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 application. Therefore, a draft

license condition has been recommended to require the licensee to provide a copy of a resolution passed by the board of directors and attested to by the secretary of the corporation delegating such authority to the radiation safety officer.

The facility organizational chart depicts the Director of Environmental, Safety and Health and Facility Radiation Safety Officer as occupying the same block in the organizational chart (Figure No. 1.6, Vol.1), although these are described in the narrative of the application as two separate positions. However, neither of these positions is indicated to have direct access to the President of WCS to convey information regarding health and safety issues, or rule or license condition violations. According to the lines of authority and communication on the organizational chart, any information concerning radiation safety must pass through the General Manager in order to reach the President. This lack of direct communication from the RSO to the company president is a cause for concern. A draft license condition has been recommended to require the Licensee to revise its organizational chart and description of the RSO position to specify that the RSO for the license has a direct line of communication with the President of WCS.

Mr. Guy Crawford, Ph.D. is designated as the RSO on the license application form. Mr. Crawford has a doctor of philosophy in materials science and engineering. Mr. Crawford has previously served as the RSO on a radioactive material license issued to one of the academic institutions in Texas, and currently serves as the RSO on Radioactive Material License No. L04971, a radioactive waste processing license issued to Waste Control Specialists LLC [Appendix 1.E, Attachment 1, Volume 4]. Mr. Crawford's education and work experience are considered acceptable for him to serve as the RSO for a license of this nature.

4.3.1.2.1 Quality Assurance Manager

The Quality Assurance Manager is stated to report to the Director of QA and is responsible for managing the WCS QA Program per Section 1.2.5.5. The Quality Assurance Manager Position is not depicted in Figure 1.6, however, the Director of QA is indicated to report directly to the GM. Procedure Radiation Safety Program Review BP-RS-1.2.1 identifies the QA Manager as having the primary responsibility for the audits of the radiation safety program.

4.3.1.4 Radiation Safety Committee

Although not depicted on the organizational chart, WCS also has a radiation safety committee (RSC). The RSC is comprised of the Corporate RSO, the RSO, Director of Operations, Director of ES&H, and the Quality Assurance Manager. The RSC is responsible for general review and oversight of facility and operational changes, policies, procedures and practices, compliance with applicable requirements, program performance, and a review of incidents and violations of regulations and license conditions. The RSC reports directly to senior management of WCS (§1.3.4, BP-RSP-100, Vol. 5).

4.4 ADMINISTRATIVE PROCEDURES

4.4.1 Corporate ALARA Policy

WCS has indicated that it embraces the concept of maintaining doses to employees, the public and the environment as low as reasonably achievable (ALARA). This is evidenced by a Radiation Safety Policy signed by Linda Beach for Rodney Baltzer (President). [Attachment 1, BP-RSP-100, Appendix 10.A, Section 10, Vol. 5]. This document should have been signed by the President of WCS, and not by a person not identified in the application. It is unknown from this application whether or not Ms. Beach has been delegated the authority to act for and the behalf of either WCS or the President of WCS to make statements or commitments.

Procedures for implementation of the ALARA program, entail reviews of facility and equipment design changes, access control, radiation shielding and geometry, process instrumentation and controls, airborne radioactivity, surface contamination, liquid and gaseous effluents, isolation and decontamination capability, workplace and worker radiological monitoring; establishment of action levels; and training and instruction. These procedures are described in the procedure titled "ALARA Program BP-RS-1.1.1. Additional procedural guidance is provided in the procedure titled "ALARA Exposure Data Review" BP-RS-1.1.2.

4.4.2 Personnel Qualifications and Training

WCS initiates a description of the training provided to personnel in Section 5.5 of BP-RSP-100 "Radiation Safety Program," Appendix 10.A, Section 10, Vol. 1. Additional information on the core training provided is given in a document title Training Plan, TRN-1.1 in Appendix 3.10.A of Vol. 5. Information on the specific training provided to radiation safety technicians is provided in procedure "Radiation Safety Technician Training Program" BP-RS-1.31.

4.4.2.1 Radiation Safety Officer (RSO)

WCS does not indicate any training to be provided to the RSO by WCS. Instead, WCS provides a commitment that the RSO shall have a Bachelors of Science or higher degree in Health Physics or a physical or biological science and at least five (5) years of practical health physics experience [§ 1.3.2, BP-RSP-100, Appendix 10.A, Section 10, Volume 5]. This is not considered to be sufficient for a license authorizing unsealed radioactive material. More appropriate criteria for the RSO, derived from the NRC's Regulatory Guide 8.31, is recommended to be placed as a condition on the license.

4.4.2.2 Radiation Safety Supervisor

The position of radiation safety supervisor (RSS) is described and the qualifications specified in Section 1.3.2 of the Radiation Safety Program BP-RSP-100. The RSS works under the supervision of the RSO and performs many of the duties for which responsibility is assigned to the RSO, as well as providing supervision of the activities of the radiation safety technicians.

4.4.2.3 Radiation Safety Technicians

Per Section 5.5 of BP-RSP-100, Radiation Safety Technicians are indicated to be employees with daily radiation safety, protection and control responsibilities. These individuals will receive an initial 8-hour classroom training, but will also have additional training of approximately 40 hours of classroom/module training and approximately 20 hours of hands-on training. The training is indicated to consist of the following:

- Radiation worker topics
- Dose calculations
- Shielding Calculations
- Counting statistics and analysis methods
- Regulatory compliance and enforcement
- Survey instrumentation, methods and documentation
- Radiation work permit development and implementation
- Other requirements for radiation safety technicians outlined in facility procedure BP-RS-1.3.1, "Radiation Safety Technician Training Program"

Qualifications for persons seeking an entry level radiation safety technician position are provided in the procedure BP-RS-1.3.1 "Radiation Safety Technician Training Program." Additional training and testing requirements are specified in the procedure. The training provided to persons seeking the radiation safety technician position with WCS appears appropriate from the technical perspective given the radionuclides and activity levels that could be encountered with this license.

4.4.2.4 Radiation Worker

Per Section 5.5 of BP-RSP-100 radiation workers are indicated to be those individual who frequent the restricted area. These workers are provided an 8-hour classroom training covering the following topics:

- Sources of radiation and biological effects of exposure to radiation
- Contamination control
- Occupational exposure limits
- Interpretation of radiological surveys and posting

- Radiation work permits
- Use of protective clothing and personal protective equipment
- Land disposal of wastes and other site-specific topics

Section 5.5.1 also indicates that radiation workers will receive 8-hours of training in the following topics:

- Fundamentals of radioactive materials and radiation
- Radiation versus contamination
- Biological effects of radiation
- Risks of occupational exposure
- Exposure limits and minimizing exposure
- Existing and potential areas of exposure and contamination
- Personnel dosimetry (internal and external)
- Use of protective clothing and equipment (PPE)
- Contamination control
- Methods of decontamination
- Rights and responsibilities of radiation workers
- Stop work authority
- By-product facility procedures
- Site specific lessons learned as well as industry events
- Federal and State regulations and license provisions for the protection of personnel from radiation and radioactive material
- Emergency response
- Radiation exposure reports available to workers
- Respiratory protection program
- Use of radiation work permits

This is unclear whether the radiation workers will receive eight (8) hours of training total covering the two (2) sets of topics listed, or will receive 16 hours of training covering both sets of topics. Given the topics to be covered, 16 hours is more appropriate. It is recommended that a condition be placed on the license to clarify the amount of time that should be devoted to initial training of radiation workers.

Radiation workers will be tested on the training and provided annual refresher training.

Section 5.5.1 of BP-RSP-100 contains a statement that reveals that WCS will allow individuals to avoid the training if they successfully pass a written exam that includes the basic radiation safety training principles and WCS facility/site specific information. This is not desirable. All employees should receive the same training. It is recommended that a condition be placed on the license requiring that all persons (employees and/or contractors) who work within the confines of the by-product

material disposal facility to take and successfully complete the licensee's basic radiation safety training course, without exception.

4.4.2.5 General Worker

Section 5.5.3 of BP-RSP-100 states that general workers will receive a briefing on the escort requirements, current radiological conditions, RWP requirements and operations expected to be encountered before entry to the restricted area.

4.4.2.6 Visitors

WCS will provide visitors with a briefing on the escort requirements, current radiological conditions, RWP requirements and operations expected to be encountered before entry is allowed to the restricted area (Section 5.5.3 of BP-RSP-100).

4.4.2.7 Females

WCS will provide specific instructions to female employees and visitors authorized to receive radiation exposure regarding prenatal exposure risks to the developing embryo and fetus. The instructions will include applicable information from the appendix to NRC Regulatory Guide 8.13. (Section 5.5.7 of BP-RSP-100)

4.4.2.8 Contractors

In order to ensure that contractors working on site are properly instructed, it is recommended that a condition be placed on the license to specify that all persons, including contractors, who work within the confines of the by-product material disposal facility to take and successfully complete the licensee's basic radiation safety training course, without exception.

4.4.2.9 Radiation Safety Trainers

WCS provides a commitment in Section 5.5 of BP-RSP-100 that trainers must have the prior teaching or training experience, adequate theory, practical knowledge and experience for the subject matter that they are assigned to teach. Furthermore, the trainers must have their qualifications approved by the RSO.

4.4.2.10 Other Personnel

Aside from the positions specified above, WCS introduces additional positions throughout the application who have a critical role in the administration or execution of the radiation safety program. In procedure BP-RS-2.4.3 "Internal Dose Assessment" the positions of Health Physicist and Dosimetry Radiation Safety Technician are introduced. However, WCS fails to provide the qualifications or

training required of persons who will fill these positions. A draft license condition has been recommended to require all persons who have a role in the administration or execution of the radiation safety program meet the qualification and training of at least the position of radiation safety technician.

4.4.3 Standard Operating Procedures

WCS has procedures for operational activities involving radioactive materials. (BP-RS-Series, Appendix 10.A, Section 10, Vol. 5) WCS also has procedures for development and revision of standard operating procedures (BP-ADM-1.1, Appendix 3.10.A, Vol. 4). The procedure for development and revision of standard operation procedures does not indicate that the RSO is involved in this process. Also, the procedure does not indicate that any new or revised standard operating procedure involving by-product material requires the approval of the commission, by amendment of the radioactive material license, before implementation of the procedure. It is recommended that a condition be placed on the license to stipulate that standard operating procedure development and revision be done under the supervision of the RSO and that any new or revised conditions be approved by the commission before adoption or implementation.

4.4.4 Radiation Work Permits

WCS employs radiation work permits (RWP) extensively [BP-RS-1.6.1, Appendix 10.A, Section 10, Vol. 5]. WCS not only uses an RWP for activities not specifically covered by an approved procedure, but also use them on a routine basis, even to the point of issuing a standing RWP (for up to a year). The concept of a standing RWP is unusual, that is, that an RWP is used when there is not a standard operating procedure, and if something is routinely done, then a standard operating procedure is developed. There is a concern that the use of a standing RWP is a means to circumvent the development of and obtaining the approval of the agency of a standard operating procedure. However, even in its expanded form, the RWP process provided by WCS may be acceptable. Although, if an activity is done routinely, or an RWP is needed for a year, or even months, then a standard operating procedure should be developed.

4.4.5 Audits

Audits will be conducted at least annually of the by-product facility radiation safety program. The audits will be conducted under the oversight of the WCS Quality Assurance Manager, with concurrence by the radiation safety committee (§1.3.3, BP-RSP-100, and BP-RS-1.2.1, Vol. 5). 25 TAC §289.202(e)(3) specifies that the review is to be completed at intervals not to exceed 12 months. This is not the same as performing an annual review or completing review audits at 12 month intervals. For clarification, it is recommended that a condition be placed on the license that reiterates the requirement of the rule, that is, that the audits and review be completed at intervals not to exceed 12 months.

Section 5.1.2 of BP-RS-1.2.1 states that activities conducted to evaluate specific components of the audit "may" include the items listed. The use of the term "may" is not definitive enough. The term "may" should be replaced with the term "shall." For clarification as to the commitment by WCS, it is recommended that a condition be placed on the license specifying that all of the items listed in Section 5.1.2 of procedure BP-RS-1.2.1 be conducted to evaluate specific components of an audit.

One of the items identified as "may" being done is the observation of radiation safety procedures as prescribed by license conditions, government regulation and by-product material facility procedures. Observation of the performance of the radiation safety procedures must be done in the audit of the radiation safety program. A recommended license condition requires that procedures be observed as a part of the audit process.

4.5 RADIATION SAFETY CONTROLS

4.5.1 Restricted Area Designation

WCS's procedures specify that restricted areas and/or radiologically controlled areas (both terms having the same meaning by WCS) will be designated within the confines of the By-product Material Disposal Facility (§7.4, BP-RSP-100, Appendix 10.A, Section 10, Vol. 5). Regarding the designation of restricted areas, WCS provided a statement in a letter dated May 18, 2007, that the entire By-product Material Disposal Facility will comprise the restricted area. To emphasize and make certain that it is clear what constitutes the restricted area, a draft license condition has been recommended to define and identify the restricted area as the entire By-product Material Disposal Facility within the confines of the security fence bounding the By-product Material Disposal Facility, as depicted in Figures 3.17 and 3.19 in Section 3 of Volume 1 of the January 12, 2007, application.

4.5.2 Postings

4.5.2.1 Restricted Area

WCS commits to posting the boundary of the restricted area. However, the commitments made in Section 7.5 of BP-RSP-100 and BP-RS-1.7.3 use different terminology, make different commitments as to how the postings will read, and, thus, have the potential to cause confusion regarding what postings are appropriate. Furthermore, neither provides sufficient specifics regarding the location of the posting. For purposes of simplification and clarity, a draft license condition has been recommended to specify the language on the posting, the visibility of the posting, the spacing of the posting, and the height of the posting.

4.5.2.2 Radiation Area

WCS provides standard procedures in BP-RS-1.7.3 for the posting of a radiation area.

4.5.2.3 Airborne Radioactivity Area

WCS will post an area as an Airborne Radioactivity Area if the concentration of airborne radioactivity equals or exceeds 10% of the appropriate DAC value for the waste stream involved. This is too nebulous. For this license application WCS should have provided the appropriate DAC for the waste streams that they contemplate receiving, that is, either uranium or thorium recovery by-product material, or a combination of both. Lacking such in the application, it is recommended that a condition be placed on the license specifying the total airborne radioactivity concentration which will require the posting of an area as an airborne radioactivity area.

4.5.3 Occupational Radiation Exposure

WCS has committed to, and provided procedures describing, monitoring for exposure and the determination of both external dose and internal dose for workers.

4.5.3.1 External Dose

WCS's procedures for assessing the external dose received by workers appears to be divided among numerous procedures (e.g., BP-RS-2.1.1, BP-RS-2.1.3, BP-RS-2.1.5, BP-RS-2.2.1, BP-RS-2.3.1) with additional information provided in Section 8.0 of BP-RSP-100 "Radiation Safety Program." This number of procedures makes it difficult to ascertain in an expedient manner the content of the external dose program for WCS's workers. This could result in difficulty for an inspector or for an employee of WCS to determine how the program works, what WCS has committed to in the program and what the responsibilities and duties of an employee are with respect to the execution of the program. A simpler, more succinct description would have been preferred.

Procedure BP-RS-2.1.1 titled "External Monitoring Program" is indicated to describe the applicant's program for monitoring the external dose received by workers at the proposed by-product disposal facility.

Section 4.1 titled "Prerequisites" contains a statement that reads as follows: "An individual requesting dosimetry ..." This statement implies that dosimetry will be issued only to persons who request dosimetry, as opposed to the concept that it is WCS's policy to issue dosimetry. This makes it appear that dosimetry is issued only on the action of, and at the request of, the employee, and not a proactive action on the part of the WCS to routinely provide personnel monitoring as part of its radiation safety program. However, Section 4.2.1 appears to clarify and alleviate the concern raised in Section 4.1 in that it states that "personnel dosimetry shall be provided to an individual who will enter Restricted Areas." However, to remove any ambiguity that the WCS's procedures may impart as to who will be provided personnel dosimetry, a recommended license condition specifies that WCS will provide dosimetry to all personnel who enter the By-product Material Disposal Facilitiy.

The procedure also describe the WCS's program for determining an individual's exposure from

previous employment, creation of dosimetry files, and instructions provided to employees on the use of dosimeters. The procedure contains a commitment to maintain the records and make them available for inspection by the licensing agency.

Although Section 6.2 does not specify the use of BRC Form 202-3 "Occupational Exposure Record for A Monitoring Period," or a similar form, as is required by 25 TAC, §289.202(rr)(3), Section 5.3.3 of BP-RS-2.5.1 specifies the use of BRC Form 202-3, or equivalent, for recording dose to employees.

Procedure BP-RS-2.1.1-4 "Dosimeter User Instructions" instructs the user that the assigned dosimeters must be worn at all times in all locations on the WCS By-product Facility where their use is required. However, the instructions fail to specify where use of dosimeters is required at the facility, or refer to another portion of the procedure or another procedure that would specify where the use of dosimeters is required at the facility. Ideally, the instructions to the dosimeter users should be revised to make it explicitly clear where dosimeters are to be worn at the by-product material disposal facility. A recommended license condition requires the Licensee to revise the Dosimeter User Instructions, identified in the application as BP-RS-2.1.1-4, to include an instruction to the users of personnel dosimetry that personnel dosimetry shall be worn at all times in the by-product material disposal facility.

Section 4.2.1 of procedure BP-RS-2.2.1 "Issue, Control, Collection and Processing of Dosimeters" specifies the use of a Landauer OSL "Pa" series for beta/gamma radiation monitoring, or an equivalent. This type of dosimeter is appropriate for the type of radiations emitted from the radioactive material requested in the application.

WCS makes a commitment in §4.2.7 of procedure BP-RS-2.2.1 "Issue, Control, Collection and Processing of Dosimeters" to obtain dosimetry from and have it processed by a vendor who is a participant in the National Institute of Standards and Technology's National Voluntary Laboratory Accreditation Program. This complies with 25 TAC, §289.202(p)(3).

Section 5.1.5 of procedure BP-RS-2.2.1 emphasizes the prohibition on sharing of dosimeters.

Section 5.2 of procedure BP-RS-2.2.1 appropriately commits to storing of dosimeters when not in use.

Although Section 5.2 of procedure BP-RS-2.2.1 addresses dosimeter control, the statements in Sections 5.2.1 and 5.2.2 imply that a control dosimeter is stored with un-issued dosimeters in a storage locker in a low-dose area. However, the instructions to workers in BP-RS-2.1.1-4 #3 directs workers to place dosimeters on the dosimeter field storage rack when not being worn. A location for the dosimeter field storage rack is not specified. Additionally, there is no mention in BP-RS-2.1.1 of a control dosimeter being placed with the issued dosimeters on the dosimeter field storage rack. However, in BP-RS-2.2.1, Section 5.2.3, there is a reference to a control dosimeter on each personnel badge rack, implying that a control dosimeter may be placed on the storage rack for the issued dosimeters. It is unclear in the procedure if the field storage rack and the personnel badge rack are one

and the same. A recommended license condition requires specification of the location of the issued dosimeter storage racks, the location of a control dosimeter on the issued dosimeter storage racks, and the exchange of the control dosimeter at the same frequency as the issued dosimeters.

4.5.3.2 Internal Dose

WCS describes the elements of its internal exposure and dose determination for employees in Section 8.4 of BP-RSP-100. This section refers to procedure BP-RS-2.4.1 "Internal Radiation Monitoring and Bioassay Samples," BP-RS-2.4.2 "Special Bioassay Sampling," and BP-RS-2.4.3 "Internal Dose Assessment" as specifying the requirements and instructions for monitoring of internal exposure and determination of dose.

4.5.3.2.1 Whole Body Counting

Section 5.1 of BP-RS-2.4.1 indicates that whole body counting will be performed on employees and contractors at the time of hire or working in a radiological area, performed annually, and upon termination, or when directed by the RSO. It is unclear whether or not the date from the whole body counting procedure will be used to determine the committed effective dose equivalent for personnel.

4.5.3.2.2 Bioassays

Section 5.3 of BP-RS-2.4.1 states that bioassays are indicated to be performed on employees and contractors at the time of hire or before working in a radiological area, performed quarterly and upon termination, if confirmed air sample results of greater than 10 DAC or greater, or as directed by RSO. Bioassays are indicated to be either urine or fecal (re: BP-RS-2.4.1, §5.5).

The assessment of internal dose is described in Procedure BP-RS-2.4.3 titled "Internal Dose Assessment." Section 1.0 of that procedure states that the procedure provides instruction for the assessment of dose due to the presence of radionuclides identified and quantified by radiobioassay, that is, radioanalysis of biological material.

WCS states that the dose from bioassay data will be assessed using a computer modeling program, such as CINDY (Computer-based Internal DosimetrY System). CINDY is indicated to have been developed by Battelle Pacific Northwest Laboratories, and marketed by Canberra. The application did not demonstrate how CINDY is an appropriate and NRC-approved methodology for assessing dose. An evaluation cannot be made as to the appropriateness or acceptability of the applicant's procedures with respect to how the dose will be determined. A contact with the NRC stated that NRC staff are not familiar with its application to by-product material and indicated that the approach should be evaluated and approved by the NRC.

Instead, it is recommended that WCS refer to NRC Regulatory Guide 8.9 (Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program), which in turn recommends referring to

NUREG/CR-4884 (Interpretation of Bioassay Measurements) to determine the intake from the bioassay data. In turn, reference is then made to following the recommendations in NRC Regulatory Guide 8.34 (Monitoring Criteria and Methods To Calculate Occupational Radiation Doses) to determine the dose from the intake estimate. Until such time as CINDY has been deemed acceptable by NRC staff, this reviewer recommends that a condition be placed on the license to require that the internal dose be derived using the accepted guidance documents, or that WCS retain a qualified, professional dosimetrist.

4.5.3.2.3 Air Sampling

WCS addresses monitoring for airborne radioactivity in a cursory manner in BP-RSP-100 Radiation Safety Program. This section makes a nebulous statement regarding the monitoring method having a minimum detectable activity equal to or less than the applicable DAC. However, a specific DAC value is not provided. The information contained in BP-RSP-100 is too general in nature to constitute a procedure. However, a reference is made to BP-RS-3.3.1 "Airborne Radioactive Material Survey Methods and Calculations" for the calculation of the MDA.

Procedure BP-RS-3.3.1 is fairly well written describing the use of low-volume and high-volume air sampling.. However, there are areas of concern in BP-RS-3.3.1 that should be addressed. Those are as are as follows:

- The definition of derived air concentration (DAC) given in Section 2.0 of this procedure references DAC values provided in Appendix B, Table I Column 3 of BP-RSP-100. There is no Appendix B in BP-RSP-100. Instead, this reference should be changed to either 25 TAC §289.202(ggg)(2)(F), or 30 TAC §336.359(d)(Table I)(Column 3).

- Section 4.2.1 specifies two air sample activity actions levels: 1 E -9 microcuries per cubic centimeter beta/gamma and 1 E -13 microcuries per cubic centimeter alpha. This reviewer is not certain as to the relevance of these values and why they are used by the applicant. Furthermore, the analytical procedure presented in this procedure does not appear to distinguish between beta/gamma counts and alpha counts.

- Section 4.2.10 states that air sampling equipment shall be selected depending on the type of monitoring to be performed. This procedure should be more specific as to the type of air sampling equipment to be used in a specific application.

- Section 5.1.2.13 refers to a Canberra iSOLO 300G counting instrument, and a PIPS detector. The Canberra web site does not list an iSOLO 300G as a model number for a product. Also, there are several types or series of PIPS detectors. The applicant must be more specific in identifying the type of counting instrument and detector combination to be used in order for agency review staff to determine the applicability of the referenced instrument/detector.

- The calculational procedures in Sections 5.2.3.6.4 and 5.2.4.2.5 appear to take into account filter collection efficiency, however, the determination of filter collection efficiency is not described in the procedure.

- Although instrument efficiency appears to be included in the calculations described in Sections 5.2.3.6.4 and 5.2.4.2.5, there does not appear to be a section in the procedure that describes how the instrument efficiency is determined.

Section 1.0 of Procedure BP-RS-3.3.1 states that air sampling is performed to determine the radionuclide DAC fractions to be used to calculate the committed effective dose equivalent (CEDE) of a worker's total effective dose equivalent (TEDE). This seemingly conflicts with statements in BP-RS-2.4.4, which indicates that the CEDE will be calculated based on whole body counting results, and that air sampling results will be used only if whole body counting results are not available (refer to clarity issue in section 4.5.3.2.1).

Section 4.2.9 in BP-RS-3.3.1 states that both low- and high-volume air samplers shall be calibrated every 6 months. This is more frequent than the annual calibration frequency recommended at Section 5.2 in NRC's Regulatory Guide 8.25, which is acceptable. However, the applicant's procedures fails to specify that the air samplers shall also be calibrated when the airflow meters have been repaired, modified, or damage is believed to have occurred. It is recommended that a license condition specify that the airflow meters also be calibrated when they have been repaired, modified or damage is believed to have occurred.

Procedure BP-RS-3.3.4 describes the calibration of high- and low-volume air samplers.

Procedure BP-RS-3.3.3 describes the calibration of lapel air samplers.

4.5.3.2.4 Lapel Air Samplers

Use of lapel air samplers is described in procedure BP-RS-3.3.3 "Use and Calibration of Lapel Air Samplers." Lapel air samplers are indicated to be calibrated every month or 200 hours of use. The calibration instruments are stated to be re-certified every 12 months. Instructions as to when a lapel air sampler should be used is not provided in this procedure.

4.5.3.2.5 Committed Effective Dose Equivalent

WCS indicates that the committed effective dose equivalent (CEDE) will be calculated from air sampling results [Procedure BP-RS-2.4.4]. However, an additional statement in the procedure indicates that the air sampling results or CEDE calculated therefrom should only be used if a whole body counter is not available and there is a suspected uptake. So it is not clear what will be used to

calculate the CEDE or how the CEDE will be calculated. While the CEDE could be derived from whole body counts, bioassay results or air sampling results, or combinations thereof, it is not clear from WCS's procedures exactly which method will be used or when it will be used to derive the CEDE. In any event, it seems appropriate that a calculation of the CEDE using either the whole body counting method or results from bioassays should be done by a professional dosimetrist.

4.5.3.3 Total Effective Dose Equivalent

Section 5.3.2 of BP-RS-2.5.1 commits to preparing a monthly exposure report of individual internal and external exposure. This section fails to provide specifics as to where the data is derived (i.e., reference to another procedure that describes the generation of the exposure data) to prepare the exposure report.

A commitment is provided in Section 5.3.4 of BP-RS-2.5.1 (Radiation Exposure Reporting) to preparing an annual exposure summary of the total internal and external exposure. Section 5.3.3 of BP-RS-2.5.1 specifies the use of BRC Form 202-3, or equivalent, for recording dose to employees, per the requirements of 25 TAC, §289.202(rr)(3). However, an annual summary for each individual radiation worker does not appear to be specifically stated in the procedure.

It does not appear that the contribution from radon is included in the preparation of the total exposure/dose. A draft license condition has been recommended to require that WCS monitor for occupational exposure to radon and include its contribution to assessing the total effective dose equivalent to workers.

4.5.4 Dose to Individual Member of the Public

4.5.4.1 External Dose

WCS will post dosimeters at the perimeter of the restricted area to measure the external exposure that an individual member of the public could receive if present at that location [Procedure BP-RS-1.5.2 "Radiation Exposure to the Public"]

4.5.4.2 Internal Dose

WCS will conduct daily air sampling along the boundary of the restricted area boundary of the facility downwind of work being performed within the restricted area [Procedure BP-RS-1.5.2 "Radiation Exposure to the Public"]. Air sampling will be conducted in accordance with procedure BP-RS-3.3.1 "Airborne Radioactive Material Survey Methods and Calculations" as the method for performing the air sampling.

4.5.4.3 Total Effective Dose Equivalent

WCS will calculate the total effective dose equivalent to an individual member of the public based on the results from the external and internal dose determinations.

4.5.5 Contamination Control Measures

4.5.5.1 Personnel

The measures taken by WCS to control contamination of personnel appears to be described in Procedures BP-RS-3.6.1 "Personnel Contamination Monitoring", BP-RS-3.6.2 "Personnel Decontamination", and BP-RS-3.6.4 "Whole Body Frisk."

Procedure BP-RS-3.6.1 "Personnel Contamination Monitoring" appears to describe the procedure for frisking personnel to determine if they have external radioactive contamination. However, this procedure fails to describe the following:

- When frisking will be performed. Ideally, a person should be frisked to check for external contamination whenever they leave the restricted area.
- Where frisking stations are located. Ideally, these should be at the exit points to the restricted area.
- How frisking is to be performed.
- Equipment, that is survey meter and detector combination, to be used to perform frisk.
- Procedure BP-RS-3.6.2 "Personnel Decontamination" describes the procedure for decontamination of hair, skin and clothing of personnel.

Procedure BP-RS-3.6.4, "Whole Body Frisk" describes the procedure for frisking personnel to determine if they have external radioactive contamination. For the most part this procedure covers the essentials of performing a frisk to determine if external contamination may be present on personnel. However, the procedure fails to describe when frisking will be performed. Ideally, a person should be frisked to check for external contamination whenever they leave the restricted area.

It is unclear from procedure BP-RS-3.6.1 that it relates to procedure BP-RS-3.6.4, or vice versa. Although, since the two procedures pertain to essentially the same thing, that is, surveys of personnel, it appears that they should relate to one another. However, neither procedure provides a reference to the other. As such, this can lead to confusion as to which procedure prevails.

To address the deficiencies of both procedures, it is recommended that a condition be placed on the

license to make it clear what survey needs to be performed on personnel exiting the restricted area, and when the survey should be performed.

4.5.5.2 Equipment and Materials Released from Facility

WCS will decontaminate containers and equipment prior to release from the By-product Material Disposal Facility. Waste generated during decontamination activities will be managed either as contact water (for wash water) or containerized and managed as facility generated waste.

4.5.5.3 Good Hygiene Practices

It is recommended that a condition be placed on the license requiring that the Licensee prohibit individuals from eating, drinking, smoking, or chewing within the confines of the By-product Material Disposal Facility.

4.5.6 Respiratory Protection Program

WCS states that they intend to receive bulk by-product material for disposal.

Procedures for handling bulk material, and environmental conditions at the site (relatively low humidity and windy conditions) made the prospect for suspension of the by-product material in the air a likelihood, and hence a respiratory problem. WCS indicated that the use of respirators was the method to be used to protect employees.

The procedures submitted by WCS pertaining to the use of respirators [BP-HS-1.24.1 Radiation Protection Program] does not comply with the requirements of 25 TAC §289.202(x)(1)(C). Therefore, WCS's respiratory protection program cannot be considered acceptable and they should be precluded from receiving and working with unsealed, that is, bulk by-product material.

4.5.7 Instrumentation and Calibration

WCS identifies a variety of portable survey instruments to be used in conducting alpha and beta/gamma count rates, gamma dose rates [BP-RS-3.1.1 Operation of Portable Survey Instruments] and scaler instruments for counting smears [BP-RS-3.1.3 Operation and Calibration of Scaler Instruments]. The instruments are appropriate for the uses indicated.

WCS indicates that they will use a licensed vendor to calibrate instruments for radiological monitoring [§9.1.2, BP-RSP-100]. Title 25 of the Texas Administrative Code, Section 289.202(p) specifies that instruments and equipment used for quantitative radiation measurements are to be calibrated by a person licensed or registered by the agency, another agreement state, a licensing state, or the United States Nuclear Regulatory Commission (NRC) to perform such service. It is recommended that a condition be placed on the license to reinforce this requirement or the rule.

4.6 ENVIRONMENTAL MONITORING

The environmental monitoring program is discussed in a Technical Report prepared by the Environmental Health Physicist of the Uranium and Technical Assessments Section of the Texas Commission on Environmental Quality. Thus, a discussion of the environmental monitoring program will not be repeated in the Safety Evaluation Report. The findings of the review conducted by the Environmental Health Physicist resulted in a license condition that details the specific parameters of the environmental monitoring program. The conclusions of that report are that the WCS's proposed environmental monitoring program, in conjunction with the license condition, is adequate to ensure protection of the health and safety of the public, and the environment.

4.7 ACCESS CONTROL AND SECURITY

The By-product Material Disposal Facility is indicated to be enclosed by a six-foot chain link fence with tollgate-type barrier bars to control access to the landfill area, as indicated in Section 3.9.1 of Volume 1, and as depicted in Figures 3.18 and 3.19 in Volume 1. Access is depicted to be through the entry road gate on the west side of the by-product material disposal facility, and a contractor gate on the northeast side of the facility.

WCS security personnel are on duty 24 hours a day, 365 days a year at the primary station at the access gate to State Line Road at the storage and processing facility guardhouse. Additional security are also present during normal operating hours at the guardhouse at the By-product Material Disposal Facility (§3.9.2, Vol. 1).

State Line Road is indicated by review staff to terminate at its north end at a cattle guard and a locked gate just to the north of the WCS property. However, Figure 3.17 in Vol. 1 depicts a road from the west intersecting Stateline Road at approximately the location to the By-product Material Disposal Facility entry gate. Information from TCEQ staff who have recently been to the site indicate that the road from the west is unimpeded. Thus, persons could arrive at the By-product Material Disposal Facility without going through the security measures at the entrance to State Line Road.

4.8 EMERGENCY PROCEDURES

WCS employs procedure BP-EP-1.0 "By-product Emergency Response to identify position responsibilities in the event of an emergency situation involving fire, weather, security or other types of emergencies (e.g., personnel injury, radioactive material spills and releases, etc.). General actions to be taken in the event of different types of emergencies are provided. A contact list is provided with the names, addresses and phone number of key personnel to contact in the event of an emergency. Copies of reporting documents are included in the procedure.

4.9 DECOMMISSIONING

Decommissioning requirements are discussed in detail in the Process Engineering Technical Report. In general, the applicant proposes to construct and fill the disposal cells in a sequential manner so that part of the decommissioning process involving closure of the disposal cells is on-going throughout the life of the facility. Upon completion of the operational life of the facility the applicant proposes to decontaminate equipment and items to be released from the facility to unrestricted use, or place items that do not meet the criteria for unrestricted use [that is, exceed the surface contamination limits specified at 25 TAC §289.202(ggg)(6)] into the last disposal cell, remove any soils at the facility that exceed the contamination limits specified at 25 TAC §289.202(eee)(4) and (6), that is, radium-226 or Ra-228 concentration shall not exceed 5 pCi/g averaged over the first 15 centimeters of soil below the surface, and shall not exceed 15 pCi/g averaged over any 15 centimeter thick soil layer more than 15 centimeters below the surface of the soil, and shall not exceed 30 pCi/g of natural uranium averaged over the top 15 centimeters of soil below the surface, and 150 pCi/g average concentration at depths greater than 15 centimeters, so that no individual member of the public will receive an effective dose equivalent in excess of 100 millirem per year. It is recommended that this is emphasized by a condition on the license.

WCS will close the cell in accordance with the specifications provided in the application, conduct a final survey to ensure that release criteria has been achieved, and request from the applicable regulatory agency confirmation that release criteria has been achieved, and request termination of the license. The Uranium and Technical Assessments Section staff have found the applicant's decommission plan to be acceptable at this time, but reserve the right to require the applicant/licensee to provide additional information or make revision to the closure plan in the future.

4.10 FINANCIAL SECURITY

Financial security requirements are discussed in detail in the Process Engineering Technical Report. The findings in that report are that $4,266,925 (2004 dollars) for decommissioning, $72,505 (2004 dollars) for five-years of post-operational surveillance, and $724,310 (2004 dollars) for long-term care would be sufficient to ensure decommissioning of the proposed by-product material disposal facility and provide the funds required by rule for long-term care. It is recommended that a condition be placed on the license that would require the adjustment of the amount of the funds to current dollar amounts by application of an inflation adjustment factor obtained from the agencyagency.

Section 289.260(m) of 25 TAC requires an annual review of the financial security to assure that sufficient funds are available for decommissioning, and to adjust the level of funding accordingly.

WCS has proposed a parent company guarantee as the method to be used for providing the financial security, and has agreed to use the agency-approved model of a parent company guarantee. A parent company guarantee is an accepted form of financial security under the provisions of 25 TAC Section 289.260, but not under TCEQ proposed rules for by-product disposal. If the proposed rules are

adopted, the licensee would need to provide financial assurance that complies with TCEQ requirements by June 1, 2008.

4.11 COMPLIANCE HISTORY

WCS has not operated a by-product material disposal facility before so there is no Agency compliance history that can be reviewed for this particular application. However, WCS has operated and currently operates a radioactive waste processing facility, licensed under the Department of State Health Services (Radioactive Material License No. L04971), and a RCRA storage, treatment and disposal facility, permitted under the Texas Commission on Environmental Quality, since 1997. There have been no actions by the DSHS against the applicant under License No. L04971 in the past six (6) years that have resulted in the assessment of administrative or civil penalties, or the revocation or suspension of the license. There is no indication in the TCEQ's Central Registry of the applicant having a less than average compliance history classification with respect to any of the permits issued to WCS by the TCEQ.

4.12 REGULATORY REQUIREMENTS

The following requirements and provisions of the Rules denoted by text in **bold** print, have been reviewed by the TCEQ Health Physics staff. Findings and comments of the applicant's compliance with the requirements and provisions of the Rules are denoted by text in normal print.

289.260(d) - Unless otherwise specified, an applicant for a license is subject to the requirements in §289.252(d) of this title.

The following documents the applicant's compliance with this provision:

Title 25 TAC §289.252(d)(1) - Applications for specific licenses shall be filed in a manner prescribed by the agency.

The applicant complied with that provision using Form 252-2, accompanied by Form 252-1 and supplemental information. The forms are located in the application in Volume 1 under the "Forms" tab.

Title 25 TAC §289.252(d)(2) specifies that each application shall be signed by the chief executive officer or other individual delegated the authority to manage, direct, or administer the licensee's activities.

The original application for this license was submitted using BRC Form 252-2 and was signed by Dean Kunihiro, Senior Vice President, and dated 21 June 2004. Subsequent applications forms (BRC Form 252-2) have been submitted on 13 April 2006, and 12 January 2007, all likewise signed by Dean

Kunihiro. The most recent application form (BRC Form 252-2) was dated 18 May 2007, and signed by Jeffrey M. Skov, Vice President of Licensing and Regulatory Affairs. All of these application forms are located under the "Forms" tab in Volume 1 of the application.

A Secretary's Certificate, signed by A. Andrew R. Louis, Secretary and dated March 29, 2005, provided a resolution from the management committee of Waste Control Specialists LLC that Dean Kunihiro was authorized, empowered and directed manage, direct and administer the Company's activities with regard to its application for by-product material. A similar resolution dated May 14, 2007, signed by A. Andrew R. Louis, Secretary, conferring on Jeffrey M. Skov the same authorization, empowerment and direction as for Mr. Kunihiro accompanied the application dated 18 May 2007. Therefore, this provision of the rules is considered to be met.

Title 25 TAC §289.252(d)(4) specifies that each application for a specific license, other than a license exempted from §289.204 of this title, shall be accompanied by the fee prescribed in §289.204.

A fee in the amount of $197,555, as prescribed by 25 TAC §289.204 (as of June 2004), was paid (see License Fee Form). That amount is appropriate for the use requested (i.e., disposal, as indicated in letter dated June 21, 2004, and section 1.1 (Volume 1) of the material accompanying the application) of by-product material as defined in 25 TAC §289.260(c)(4) (from BRC Form 252-2). Therefore, this provision of the rule has been met.

Title 25 TAC, §289.252(d)(5) specifies that each application shall be accompanied by a completed BRC Form 252-1 (Business Information Form).
Business Information Form (RC Form 252-1), signed by Jeffrey M. Skov, Senior Vice President, dated 5/18/07, was submitted. In previous revisions to the applications, the Business Information Form was also submitted with the dates of 1/12/07, 4/13/06; 9/15/04, and June 21, 2004, all signed by Dean Kunihiro, Senior Vice President. These forms are located in Volume 1, under the "Forms" tab of the application. Therefore, this provision of the rule has been met.

Title 25 TAC, §289.252(d)(6) specifies that each applicant shall demonstrate to the agency that the applicant is financially qualified to conduct the activity requested for licensure, including any required decontamination, decommissioning, reclamation, and disposal before the agency issues a license.

Section 289.260(d)(2) has a similar provision which will be used to address this provision for the applicant.

Title 25 TAC, §289.252(d)(7) specifies that if facility drawings submitted in conjunction with the application for a license are prepared by a professional engineer or engineering firm, those drawings shall be final and shall be signed, sealed and dated in accordance with the requirements of the Texas Board of Professional Engineers, 22 Texas Administrative Code,

Chapter 131.
This will be addressed by an identical provision under §289.260(f)(3).

Title 25 TAC, §289.260(d)(1) specifies that applications for specific licenses shall be filed in seven copies in a manner specified by the agency.

The applicant filed seven (7) copies of the application, and seven (7) copies of all revisions to the application. Therefore, this provision has been met.

Title 25 TAC, §289.260(d)(2) specifies that each applicant shall demonstrate to the agency that the applicant is financially qualified to conduct the licensed activity, including any required decontamination, decommissioning, reclamation, and disposal, before the agency issues or renews a license.

Senate Bill 1604, of the 80th Texas Legislature, effective June 17, 2007, contains a provision that affects the manner in which this provision is reviewed. The applicable text from the bill is as follows:

> Sec. 401.108. FINANCIAL QUALIFICATIONS. (a) Before a license is issued or renewed by the commission, the applicant shall demonstrate to the commission that the applicant is financially qualified to conduct the licensed activity, including any required decontamination, decommissioning, reclamation, and disposal, by posting security acceptable to the commission.

Consequently, the determination of compliance with §289.260(d)(2), that is financial qualification, is now determined by demonstrating compliance with the financial assurance requirements of §289.260(f) and (m). The review of the applicant's proposed method of financial assurance indicates that the applicant is proposing the use of a parent company guarantee. While this would be permissible under the provisions of 25 TAC, §289.260, it is not anticipated to be acceptable under the provisions of Subchapter L of 30 TAC 336, since Subchapter L holds applicants and licensees to the provisions of Subchapter S of 30 TAC 37, and Subchapter S does not allow for the use of a parent company guarantee. If the proposed rules are adopted, the licensee would need to submit financial assurance that complies with TCEQ requirements by June 1, 2008.

289.260(e) - A license application will be approved if the agency determines that the applicant has met the requirements of §289.252(e) of this title.

The requirements of 25 TAC §289.252(e) are as follows:

Title 25 TAC, §289.252(e)(1) specifies that the applicant and all personnel who will be handling the radioactive material are qualified by reason of training and experience to use the material in question for the purpose requested in accordance with this chapter in such a manner as to minimize danger to occupational and public health and safety and the environment.

The person designated by the applicant to serve as the radiation safety officer for the license is deemed qualified by reason of training and experience for the authorizations requested for this license. A more detailed analysis of the RSO's qualification is given in another section of this chapter [re: 25 TAC §289.260(e)(1)]. Additionally, a condition is recommended to ensure that future RSO designees by the licensee will also have sufficient and appropriate training and experience. The training and experience indicated by the licensee for persons who will be assisting the RSO in the execution of the radiation safety program and the radiation workers either are or will be sufficiently qualified for the duties and responsibilities which their positions entail. The qualifications and training of these positions will be discussed in more detail in another section of this chapter.

Title 25 TAC, §289.252(e)(2) requires that the applicant's proposed equipment, facilities, and procedures are adequate to minimize danger to occupational and public health and safety and the environment.

This will be determined after all of the information submitted by the licensee has been reviewed by the appropriate members of the review team, a consensus is reached by the members of the review team, and concurred with by Agency management, that the licensee has satisfactorily complied with all elements of the review and the operations of the licensee's proposed facility will not be inimical to the health and safety of the public.

Title 25 TAC, §289.252(e)(3) requires that the issuance of the license will not be inimical to the health and safety of the public.

This determination will be made after all of the information submitted by the licensee has been reviewed by the appropriate members of the review team, a consensus is reached by the members of the review team, and concurred with by Agency management, that the licensee has satisfactorily complied with all elements of the review and the operations of the licensee's proposed facility will not be inimical to the health and safety of the public.

Title 25 TAC, §289.252(e)(4) requires that the applicant satisfies any applicable special requirement in this section and other sections as specified in subsection (a)(2)(A) of this section, that is, §289.260.

The provisions of §289.260 will be identified in this review, and a statement of compliance status given at each provision's listing that is pertinent to this review.

Title 25 TAC, §289.252(e)(5) requires that the radiation safety information submitted for requested sealed source(s) or device(s) containing radioactive material is in accordance with subsection (v) of 25 TAC §289.252.

No sealed sources or devices are requested with this application. Therefore, this provision is not applicable.

Title 25 TAC, §289.252(e)(6) requires that the qualifications of the designated radiation safety officer (RSO) as specified in subsection (f) of 25 TAC §289.252 are adequate for the purpose requested in the application.

The qualifications of the proposed RSO will be evaluated under the provisions of 289.260(e)(1).

Title 25 TAC, §289.252(e)(7) requires the applicant to submit an adequate operating, safety, and emergency procedures manual.

The applicant's operating, safety and emergency procedures initially consisted of procedures located throughout the application. The May 18, 2007, letter included a Procedures Manual which consolidated the procedures into a single binder. The procedures are considered to be mostly adequate for the activities and uses requested in the application. A discussion of the various procedures that are radiation safety related is provided in other sections of this assessment.

25 TAC, §289.252(e)(8) requires that the applicant's permanent facility be located in Texas. As determined from the description provided in Section 1 of Volume 1 of the application, the applicant's facility is located in Texas. Therefore, this provision has been met.

25 TAC, §289.252(e)(9) specifies that the owner of the property is aware that radioactive material is stored on the property, if the proposed storage facility is not owned by the applicant. The applicant shall provide a written statement from the owner, or from the owner's agent, indicating such. This paragraph does not apply to property owned or held by a government entity or to property on which radioactive material is used under an authorization for temporary job site use.

Section 1.2.4.1 of Section 1 of Volume 1 of the application discusses ownership of the facility. According to the warranty deed provided as Attachment 2 in Appendix 1.D (Volume 2 of the application), WCS has 100% ownership of the surface estate. However, Exhibit "B" to that warranty deed sets out certain restrictions and encumbrances. The restrictions and encumbrances are as follows:

- Lease Agreement for Natural Gas Pipeline executed by Flying W Diamond Ranch to Texaco Producing, Inc.
- Terms, conditions, and stipulations contained in Easements and Rights-of-Way described in Schedule I.
- Reservations of all oil, gas and other minerals contained in Warranty Deed executed by Ethel S. Sims to Wayne May.

- Subject to the rights of Kid Kroger, pursuant to the terms and provisions of a grazing lease agreement.

The Easements and rights-of-Way specified in Schedule I include Section 25 for Sohio Petroleum Company and Southwest Public Service.

The responses in the applicant's letter dated May 18, 2007, provide explanations that resolve the restrictions and encumbrances noted above.

Section 1.2.4.2 of Volume 1 of the application indicates that WCS holds a majority of the mineral estate interest in the salient quadrants of Section 25. However, WCS does not hold 100% of the mineral estate interest. The application contains documents of WCS's efforts to purchase outright or exchange like-kind mineral interest with the mineral interest holders, or execute a surface use agreement with the mineral interest holders, or notification of WCS's intent to either file a deed notification on the subject area or initiate condemnation proceedings (re: Attachment 10, Appendix 1.D, Volume 2).

WCS also provides copies of legal opinions rendered on the practical result of failure to secure 100% of the mineral estate interest (re: Attachment 8, Appendix 1.D, Volume 2).

A condition will be placed on a license to address the issue regarding the mineral estate.

Title 25 TAC, §289.252(e)(10) specifies that there be no reason to deny the license as specified in subsection (d)(10) or (x)(7) of §289.252.

The provisions of subsections (d)(10) or (x)(7) of §289.252 are as follows:

289.252(d)(10) - Applications for licenses may be denied for the following reasons:

(A) **any material false statement in the application or any statement of fact required under provisions of the Texas Radiation Control Act (Act);**

(B) **conditions revealed by the application or statement of fact or any report, record, or inspection, or other means that would warrant the agency to refuse to grant a license on an application; or**

(C) **failure to clearly demonstrate how the requirements in this chapter have been addressed.**

289.252(x)(7) - In making a determination whether to grant, deny, amend, renew, revoke, suspend, or restrict a license, the agency may consider the technical competence and compliance history of an applicant or holder of a license. After an opportunity for a hearing, the agency shall deny an application for a license, an amendment to a license, or renewal of a license if the applicant's compliance history reveals that at least three agency actions have been issued against

the applicant, within the previous six years, that assess administrative or civil penalties against the applicant, or that revoke or suspend the license.

No grounds exist under the above provisions for denial of the license.

Title 25 TAC, §289.260(e)(1) specifies the qualifications of the RSO as follows:

(A) possession of a high school diploma or a certificate of high school equivalency based on the GED test; and

(B) training and experience necessary to supervise the radiation safety aspects of the licensed activity;

The RSO is indicated to be Guy Crawford, Ph.D. (re: Item 6 of application form, BRC Form 252-2, dated 18 May 2007). Dr. Crawford is currently the RSO on Radioactive Material License No. L04971, a radioactive waste processing license. Dr. Crawford has previously served as the RSO on an academic license. Both the academic license and L04971 involved managing unsealed radioactive material. Dr. Crawford's credentials are presented in Attachment 1 of Appendix 1.E of Volume 2 of the application. Dr. Crawford's academic credentials and work experience are considered sufficient, by this reviewer, to support his designation as the radiation safety officer for a license that would authorize the receipt from other persons and disposal of by-product material (as defined at Section 401.003(3)(B) of the Texas Health and Safety Code).

The applicant's criteria for RSO are presented in §1.3.2 of BP-RSP-100 of Section 10.A of Volume 5 of the application. The criteria specified is that the RSO have a bachelor's degree in health physics or a biological or natural science and five (5) years of practical health physics experience. This criteria is not entirely consistent with what this reviewer considers to be desirable. In addition to the criteria specified by the applicant, the RSO criteria should also include at least four (4) to six (6) weeks of specialized training in handling unsealed radioactive material. Additionally, the practical experience should include at least two (2) years of experience in working with unsealed radioactive material. This would be consistent with the RSO criteria provided in NRC's Regulatory Guide 8.31.

The following condition is proposed for inclusion on a license, if issued:

XX. The Licensee shall require the following qualifications of any person to be proposed by the Licensee to serve as the RSO for this license:

A. A bachelor's degree in the physical or biological sciences, industrial hygiene, or engineering from an accredited college or university or an equivalent combination of education and relevant experience in uranium recovery, radioactive waste processing, or processing of unsealed radioactive material facility radiation protection. Two (2) years of relevant experience is considered equivalent to 1 year of academic study.

B. At least one (1) year of work experience relevant to uranium recovery, radioactive waste processing, or processing of unsealed radioactive material operations in applied health physics, radiation protection, industrial hygiene, or similar work. This experience should involve actually working with radiation detection and measurement equipment, not strictly administrative or "desk" work. This experience should be in addition to any experience that is used to meet the educational requirement.

C. At least four (4) weeks of specialized classroom training in health physics specifically applicable to uranium recovery.

D. The RSO should attend refresher training on uranium recovery, radioactive waste processing, or processing of unsealed radioactive material facility health physics every two (2) years.

Title 25 TAC, §289.260(f)(1) requires that an application for a license shall include the following:

(A) for new licenses, an environmental report that includes the results of a one-year preoperational monitoring program, and the following:

The preoperational monitoring program will be addressed in the environmental health physics review.

(i) description of the proposed project or action;

The proposed project has been reviewed throughout this document.

(ii) area/site characteristics including ecology, geology, topography, hydrology, meteorology, historical and cultural landmarks, and archaeology;

Historical and cultural landmarks were included in the socioeconomic review. Ecology is considered to have been addressed in the context of the review and comments from the Texas Parks and Wildlife Department.

(iii) radiological and nonradiological impacts of the proposed project or action, including waterway and groundwater impacts and any long-term impacts;

This impact will be addressed in the geology and environmental health physics review.

(iv) environmental effects of accidents;

This will be addressed in the process engineering review.

(v) by-product material disposal, decommissioning, decontamination, and reclamation and impacts of these activities; and

This will be addressed in the process engineering review.

(vi) site and project alternative;

This will be addressed in the review by process engineering.

Title 25 TAC, §289.260(f)(1)(B) requires the inclusion of a closure plan for decontamination, decommissioning, restoration, and reclamation of buildings and the site to levels that would allow unrestricted use and for reclamation of the by-product material disposal areas in accordance with the technical requirements of subsection (o) of §289.260 in the application.

As an aid to evaluating this requirement, the following helps to identify what constitutes a closure plan:

Per 25 TAC §289.260(c)(7), a closure plan consist of a decommissioning plan, and may include a reclamation plan.

Per 25 TAC §289.260(c)(25), a reclamation plan is the plan detailing activities to accomplish reclamation of the by-product material disposal area in accordance with the technical criteria of this section. The reclamation plan shall include a schedule for reclamation milestones that are key to the completion of the final radon barrier, including as appropriate, but not limited to, wind blown tailings retrieval and placement on the pile, interim stabilization (including dewatering or the removal of freestanding liquids and recontouring), and final radon barrier construction. Reclamation of by-product material shall also be addressed in the closure plan.

Although a definition for decommissioning plan is not in the rules, the definition of decommission as found at 25 TAC §289.201(b)(25) defines decommission as: To remove a facility or site safely from service and reduce residual radioactivity to a level that permits the following: (A) release of the property for unrestricted use and/or termination of license; or (B) release of the property under alternate requirements for license termination.

This will be addressed in the review by process engineering.

Title 25 TAC, §289.260(f)(1)(C) requires the proposal of an acceptable form and amount of

financial security consistent with the requirements of subsection (m) of this section.

In Section 8.1.3.1 of Volume 1 (p. 8-2, Revision 17) the applicant makes a commitment to use the agency-approved model of a parent company guarantee as the method for providing financial security. This is acceptable under the review conducted under the provisions of 25 TAC Chapter 289. However, it is noted that since the program has transferred to the TCEQ from the DSHS at some point in time the applicant/licensee will need to comply with the provisions of 30 TAC Chapter 336, Subchapter L (proposed for adoption). Following adoption of Subchapter L, a change in the form of financial assurance used will likely be necessary.

The amount of the financial security is evaluated in the review by process engineering. The findings in that report are that $4,266,925 (2004 dollars) for decommissioning, $72,505 (2004 dollars) for five-years of post-operational surveillance, and $724,310 (2004 dollars) for long-term care would be sufficient to ensure decommissioning of the proposed by-product material disposal facility and provide the funds required by rule for long-term care. A condition is proposed for the license that would require the adjustment of the amount of the funds to current dollar amounts by application of an inflation adjustment factor derived from the U.S. Department of Labor's Bureau of Labor Statistics Consumer Price Index.

Title 25 TAC, §289.260(f)(1)(D) requires procedures describing the means employed to meet the requirements of subsections (g)(1) and (2) and (o)(15) of this section during the operational phase of any project.

§289.260(g)(1) - Daily inspection of any by-product material retention systems shall be conducted by the licensee. General qualifications for individuals conducting inspections shall be approved by the agency. Records of the inspections shall be maintained for review by the agency.

The applicant referenced Sections 3.8 and 3.11 in Volume 1 of the application as the part of the application to address the provisions of 25 TAC, §289.260(g)(1). Section 3.8 pertains to recordkeeping. This section does not provide the specifics for documenting the daily inspection of the by-product material retention systems. At a minimum, documentation of the daily inspections should include the date, the person performing the inspection, and for each item of inspection the findings of the inspector.

Section 3.11 specifies what will be inspected and what the inspector will observe for in the daily inspections of the disposal facility. It is noted that this inspection is limited only to the landfill, that is, disposal cells. In addition to the items listed, any stored by-product material on the facility site, for example, any containers of by-product material stored or staged on the receiving pad, and the contact water tanks should also be included in the daily inspection since they also comprise retention systems

for by-product material.

The application did not address the general qualifications for individuals conducting the daily inspections of the by-product material retentions systems. A draft license condition has been recommended to ensure that a qualified person conducts these inspections.

§289.260(g)(2) - In addition to the applicable requirements of §289.202(ww)-(yy) of this title, the licensee shall immediately notify the agency of the following:

(A) any failure in a by-product material retention system that results in a release of by-product material into unrestricted areas;

(B) any release of radioactive material that exceeds the concentrations for water listed in Table II, Column 2, of §289.202(ggg)(2) of this title and that extends beyond the licensed boundary;

(C) any spill that exceeds 20,000 gallons and that exceeds the concentrations for water listed in Table II, Column 2, of §289.202(ggg)(2) of this title; or

(D) any release of solids that exceeds the limits in subsection (h)(6) [soil and vegetation contamination limits] of this section and that extends beyond the licensed boundary.

The applicant's means of addressing the notification and reporting requirements of §289.202(ww) – (yy) and the notification events in §289.260(g)(2) could not be located in the application. Instead, the applicant indicated that these provisions were not applicable to a below ground by-product material disposal facility (re: Table 1, Section 1 of Volume 1 of the application). Unless agency management finds otherwise, the cited provisions are applicable and should be adhered to by the applicant.

Title 25 TAC, §289.260(f)(1)(E) requires that specifications for the emissions control and disposition of the by-product material be provided in the application.

The applicant provides procedures in procedures BP-OP-2.1 "By-product Material Disposal," BP-OP-2.2 "By-product Facility – Fernald Material Transfer and Disposal,"BP-OP-2.5 "By-product Facility – Non-Routine Operations," and BP-OP-2.6 "Managing On-Site Generated Waste at By-product Facility" to describe the disposition of by-product material. Procedure BP-OP-2.7 "Dust Suppression at the By-product Facility" provides the specifications (procedures) for control of fugitive by-product material emission from the disposal facility.

Title 25 TAC, §289.260(f)(1)(F) requires that for disposal of by-product material received from others, information on the chemical and radioactive characteristics of the wastes to be received, detailed procedures for receiving and documenting incoming waste shipments, and detailed waste acceptance criteria be provided in the application.

By-product material is by definition "tailings or wastes produced by or resulting from the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes. Underground ore bodies depleted by such solution extraction operations do not constitute "by-product material" within this definition" [re: 25 TAC §289.260(c)(4)].

The definition of "by-product material" can be extended, by act of the US Congress, to include other materials, for example, the materials from the Fernald, Ohio site.

Conversely, the definition of by-product material can be, and has been, limited by interpretation of the definition by the office of general counsel of the US NRC. That is, by-product material is limited to that material produced after 1978.

The process and procedures for acceptance of material for disposal at the by-product disposal facility are presented in the documents titled "By-product Material Acceptance Criteria" (BPAC), the "By-product Material Profile Approval Process" (BP-OP-1.1), and the "By-product Material Shipment Compliance Verification" (BP-OP-1.4) as presented in the By-product Material Disposal Facility Procedures Manual, dated May 2007.

Section 3.3 of the BPAC states that it is the generator's responsibility to ensure that the material is classified and characterized correctly. The generator is directed to identify and quantify the concentration of any hazardous constituent listed in 10 CFR Part 40, Appendix A, Criterion 13 that may be present in the by-product material. The BPAC states that by the generator's signature on the By-product Material Profile the generator is certifying that the by-product material was generated after 1978, and meets the definition of by-product material, or was deemed to be by-product material by act of the U.S. Congress.

In order to comply with 25 TAC §289.260(f)(1)(F) the chemical characteristics, not the hazardous constituents listed in 10 CFR Part 40, Appendix A, Criterion 13, of the by-product material must be identified. It is recommended that a condition be placed on the license to require the licensee to obtain or have the generator/shipper of the by-product material provide a chemical constituent profile of any by-product material offered for disposal, listing the chemicals contained in the by-product material and their concentration.

The applicant indicates that it will rely solely on the by-product material generator/shipper for determination that the material meets the requirements of by-product material. A draft license condition has been recommended to require the Licensee to engage in verification that the material received at the site is indeed by-product material.

Title 25 TAC, §289.260(f)(3) requires that facility drawings submitted in conjunction with the application for a license shall be prepared by a professional engineer or engineering firm. Those

drawings shall be final and shall be signed, sealed and dated in accordance with the requirements of the Texas Board of Professional Engineers, 22 Texas Administrative Code, Chapter 131.

This provision will be addressed in the civil and process engineering review.

Title 25 TAC, §289.260(g)(1) specifies that daily inspection of any by-product material retention systems shall be conducted by the licensee. General qualifications for individuals conducting inspections shall be approved by the agency. Records of the inspections shall be maintained for review by the agency.

Compliance with this provision was previously cited at 25 TAC, §289.260(f)(1)(D). Refer to comments at 25 TAC, §289.260(f)(1)(D) for a discussion of the applicant's compliance with this provision.

Title 25 TAC, §289.260(g)(2) requires compliance with the applicable requirements of §289.202(ww)-(yy)

Title 25 TAC, §289.202(ww)(1)(A) specifies a report to the agency by telephone immediately after its occurrence becomes known to the licensee, stolen, lost, or missing licensed radioactive material in an aggregate quantity equal to or greater than 1,000 times the quantity specified in subsection 25 TAC §289.202(ggg)(3) of this section, under such circumstances that it appears to the licensee that an exposure could result to individuals in unrestricted areas.

Title 25 TAC, §289.202(ww)(1)(B) specifies a report to the agency by telephone within 30 days after its occurrence becomes known to the licensee, lost, stolen, or missing licensed radioactive material in an aggregate quantity greater than 10 times the quantity specified in subsection (ggg)(3) of this section that is still missing.

Title 25 TAC, §289.202(ww)(2) specifies that within 30 days after making the telephone report, make a written report to the agency setting forth the following information:

(A) a description of the licensed source of radiation involved, including, for radioactive material, the kind, quantity, and chemical and physical form;
(B) a description of the circumstances under which the loss or theft occurred;
(C) a statement of disposition, or probable disposition, of the licensed source of radiation involved;
(D) exposures of individuals to radiation, circumstances under which the exposures occurred, and the possible total effective dose equivalent to persons in unrestricted areas;
(E) actions that have been taken, or will be taken, to recover the source of radiation; and
(F) procedures or measures that have been, or will be, adopted to ensure against a recurrence

of the loss or theft of licensed sources of radiation.

Title 25 TAC, §289.202(ww)(3) specifies that subsequent to filing the written report, the licensee shall also report additional substantive information on the loss or theft within 30 days after the licensee learns of such information.

Title 25 TAC, §289.202(ww) (4) specifies that the licensee shall prepare any report filed with the agency in accordance with this subsection so that names of individuals who may have received exposure to radiation are stated in a separate and detachable portion of the report.

Title 25 TAC, §289.202(xx)(1)(A) requires that the licensee immediately report by telephone to the agency, and shall confirm the initial notification report within 24 hours by telegram, mailgram, or facsimile to the agency, each event involving a source of radiation possessed by the licensee that may have caused or threatens to cause an individual to receive:

(i) a total effective dose equivalent of 25 rems (0.25 Sv) or more;
(ii) a lens dose equivalent of 75 rems (0.75 Sv) or more; or
(iii) a shallow dose equivalent to the skin or extremities or a total organ dose equivalent of 250 rads (2.5 grays) or more.

Each report filed with the agency will have the names of individuals who have received exposure to sources of radiation stated in a separate and detachable portion of the report.

Title 25 TAC, §289.202(xx)(1)(B) requires the licensee to immediately report by telephone to the agency, and shall confirm the initial notification report within 24 hours by telegram, mailgram, or facsimile to the agency, each event involving a source of radiation possessed by the licensee that may have caused or threatens to cause the release of radioactive material, inside or outside of a restricted area, so that, had an individual been present for 24 hours, the individual could have received an intake five times the occupational ALI. Each report filed with the agency will have the names of individuals who have received exposure to sources of radiation stated in a separate and detachable portion of the report.

Title 25 TAC, §289.202(xx)(6) requires the licensee to notify the agency as soon as possible but not later than four hours after the discovery of an event that prevents immediate protective actions necessary to avoid exposures to radioactive materials that could exceed regulatory limits or releases of radioactive materials that could exceed regulatory limits (events may include fires, explosions, toxic gas releases, etc.).

Title 25 TAC, §289.202(xx)(7) requires the licensee to notify the agency within 24 hours after the discovery of any of the following events involving radioactive material:

(A) an unplanned contamination event that:
- **(i) requires access to the contaminated area, by workers or the public, to be restricted for more than 24 hours by imposing additional radiological controls or by prohibiting entry into the area;**
- **(ii) involves a quantity of material greater than five times the lowest annual limit on intake specified in subsection (ggg)(2) of this section for the material; and**
- **(iii) has access to the area restricted for a reason other than to allow isotopes with a half-life of less than 24 hours to decay prior to decontamination.**

(B) an event in which equipment is disabled or fails to function as designed when:
- **(i) the equipment is required by rule or license condition to prevent releases exceeding regulatory limits, to prevent exposures to radioactive materials exceeding regulatory limits, or to mitigate the consequences of an accident;**
- **(ii) the equipment is required to be available and operable when it is disabled or fails to function; and**
- **(iii) no redundant equipment is available and operable to perform the required safety function;**

(C) an event that requires unplanned medical treatment at a medical facility of an individual with spreadable radioactive contamination on the individual's clothing or body; or

(D) an unplanned fire or explosion damaging any radioactive material or any device, container, or equipment containing radioactive material when:
- **(i) the quantity of material involved is greater than five times the lowest annual limit on intake specified in subsection (ggg)(2) of this section for the material; and**
- **(ii) the damage affects the integrity of the radioactive material or its container.**

Title 25 TAC, §289.202(xx)(2)(A) requires the licensee within 24 hours of discovery of the event, report by telephone to the agency, and shall confirm the initial notification report within 24 hours by telegram, mailgram, or facsimile to the agency, each event involving loss of control of a licensed source of radiation possessed by the licensee that may have caused, or threatens to cause an individual to receive, in a period of 24 hours:

(i) a total effective dose equivalent exceeding 5 rems (0.05 Sv);

(ii) a lens dose equivalent exceeding 15 rems (0.15 Sv); or

(iii) a shallow dose equivalent to the skin or extremities or a total organ dose equivalent exceeding 50 rems (0.5 Sv).

Each report filed with the agency will have the names of individuals who have received exposure to sources of radiation stated in a separate and detachable portion of the report.

Title 25 TAC, §289.202(xx)(2)(B) requires the licensee within 24 hours of discovery of the event, by telephone to the agency, and shall confirm the initial notification report within 24 hours by telegram, mailgram, or facsimile to the agency, each event involving loss of

control of a licensed source of radiation possessed by the licensee that may have caused, or threatens to cause the release of radioactive material, inside or outside of a restricted area, so that, had an individual been present for 24 hours, the individual could have received an intake in excess of one occupational ALI. This provision does not apply to locations where personnel are not normally stationed during routine operations, such as hot-cells or process enclosures. Each report filed with the agency will have the names of individuals who have received exposure to sources of radiation stated in a separate and detachable portion of the report.

Title 25 TAC, §289.202(xx)(6) requires the licensee to notify the agency as soon as possible but not later than four hours after the discovery of an event that prevents immediate protective actions necessary to avoid exposures to radioactive materials that could exceed regulatory limits or releases of radioactive materials that could exceed regulatory limits (events may include fires, explosions, toxic gas releases, etc.).

Title 25 TAC, §289.202(xx)(7)(A) requires the licensee to notify the agency within 24 hours after the discovery of any of the following events involving radioactive material an unplanned contamination event that

(i) requires access to the contaminated area, by workers or the public, to be restricted for more than 24 hours by imposing additional radiological controls or by prohibiting entry into the area;

(ii) involves a quantity of material greater than five times the lowest annual limit on intake specified in subsection 25 TAC §290.202(ggg)(2) for the material; and

(iii) has access to the area restricted for a reason other than to allow isotopes with a half-life of less than 24 hours to decay prior to decontamination.

Title 25 TAC, §289.202(xx)(7)(B) requires the licensee to notify the agency within 24 hours after the discovery of any of an event in which equipment is disabled or fails to function as designed when

(i) the equipment is required by rule or license condition to prevent releases exceeding regulatory limits, to prevent exposures to radioactive materials exceeding regulatory limits, or to mitigate the consequences of an accident;

(ii) the equipment is required to be available and operable when it is disabled or fails to function; and

(iii) no redundant equipment is available and operable to perform the required safety function.

Title 25 TAC, §289.202(xx)(8)(A) requires reports required by 289.202(xx)(6) and (7) shall be made by telephone to the agency. To the extent that the information is available at the time of notification, the information provided in these reports shall include:

(i) the caller's name and call back telephone number;

(ii) a description of the event, including date and time;
(iii) the exact location of the event;
(iv) the isotopes, quantities, and chemical and physical form of the radioactive material involved; and
(v) any personnel radiation exposure data available.

Title 25 TAC, §289.202(xx)(8)(B) requires reports required by 289.202(xx)(6) and (7) shall be followed up by a written report to the agency within 30 days of the initial report. The reports must include the following:
(i) a description of the event, including the probable cause and the manufacturer and model number (if applicable) of any equipment that failed or malfunctioned;
(ii) the exact location of the event;
(iii) the isotopes, quantities, and chemical and physical form of the radioactive material involved;
(iv) date and time of the event;
(v) corrective actions taken or planned and the results of any evaluations or assessments; and
(vi) the extent of exposure of individuals to radioactive materials without identification of individuals by name.

Title 25 TAC, §289.202(yy)(1)(A)requires the licensee to submit a written report within 30 days after learning of incidents for which notification is required by 289.202(xx).

Title 25 TAC, §289.202(yy)(1)(B) requires the licensee to submit a written report within 30 days after learning of doses in excess of any of the following:
(i) the occupational dose limits for adults [re: 289.202(f)]
(ii) the occupational dose limits for a minor [re: 289.202(l)]
(iii) the limits for an embryo/fetus of a declared pregnant woman [re: 289.202(m)]
(iv) the limits for an individual member of the public [re: 289.202(n)];
(v) any applicable limit in the license; or
(vi) the ALARA constraints for air emissions as required by 289.202(e)(4)

Title 25 TAC, §289.202(yy)(1)(C) requires the licensee to submit a written report when levels of radiation or concentrations of radioactive material in:
(i) a restricted are are in excess of applicable limits in the license; or
(ii) an unrestricted area has in excess of 10 times the applicable limit set forth 289.202, or in the license, whether or not involving exposure of any individual in excess of the limits in subsection (n) of this section

Title 25 TAC, §289.202(yy)(1)(D) requires the licensee to submit a written report when

levels of radiation or releases of radioactive material are in excess of EPA's generally applicable environmental radiation standards in 40 CFR §190, or of license conditions related to those requirements.

289.202(yy)(2) - report required by 289.202(yy)(1) shall describe the extent of exposure of individuals to radiation and radioactive material, including, as appropriate:

(A) estimates of each individual's dose;
(B) the levels of radiation and concentrations of radioactive material involved;
(C) the cause of the elevated exposures, dose rates, or concentrations; and
(D) corrective steps taken or planned to ensure against a recurrence, including the schedule for achieving conformance with applicable limits, ALARA constraints, generally applicable environmental standards, and associated license conditions.

Title 25 TAC, §289.202(yy)(3) specifies that reports filed in accordance with 289.202(yy)(1) shall include for each individual exposed: the name, identification number, and date of birth. With respect to the limit for the embryo/fetus in subsection (m) of this section, the identifiers should be those of the declared pregnant woman. Reports shall be prepared so that this information is stated in a separate and detachable portion of the report.

Title 25 TAC, §289.202(yy)(4) specifies that reports made in accordance with 289.202(yy)(1) will be made in writing to the agency.

No specific procedure was noted in the application or the Procedures Manual that addressed how the licensee would comply with the above notification and reporting requirements. However, since the rule is very explicit as to when a notification should be made and how it should be made, and when and how a report should be made, the rule can suffice as a procedure. The applicant will need to maintain a copy of the current rule in order to know when and how to comply.

Title 25 TAC, §289.260(g)(2)(A) requires the licensee to immediately notify the agency of any failure in a by-product material retention system that results in a release of by-product material into unrestricted areas.

Title 25 TAC, §289.260(g)(2)(B) requires the licensee to immediately notify the agency of any release of radioactive material that exceeds the concentrations for water listed in Table II, Column 2, of 25 TAC §289.202(ggg)(2) and that extends beyond the licensed boundary.

Title 25 TAC, §289.260(g)(2)(C) requires the licensee to immediately notify the agency of any spill that exceeds 20,000 gallons and that exceeds the concentrations for water listed in Table II, Column 2, of 25 TAC §289.202(ggg)(2).

Title 25 TAC, §289.260(g)(2)(D) requires the licensee to immediately notify the agency of any release of solids that exceeds the limits in25 TAC §289.202(h)(6) and that extends beyond the licensed boundary.

Title 25 TAC, §289.260(f)(1)(D) requires the applicant to provide procedures that describe the means to meet the requirements of 25 TAC, §289.260(g)(1) and (2). Please refer to the discussion on 25 TAC, §289.260(f)(1)(D) for specific comments on the applicant's addressing of the provisions of 25 TAC, §289.260(g)(1) and (2). It should be noted that the applicant has responded in Table 1-1, of Volume 1, that the provisions of 25 TAC, §289.260(g)(2) are not applicable to a below ground by-product material disposal facility.

Title 25 TAC, §289.202(g)(3) requires the licensee to notify the agency within 24 hours of the following:

(A) any spill that extends:

(i) beyond the wellfield monitor well ring;

(ii) more than 400 feet from an injection or production well pipe artery to or from a recovery plant; or

(iii) more than 200 feet from a recovery plant; or

The provisions of 25 TAC, §289.260(g)(3)(A) are applicable to a source material recovery site, and is thus, not applicable to this application.

(B) any spill that exceeds 2,000 gallons and that exceeds the concentrations for water listed in Table II, Column 2, of 25 TAC §289.202(ggg)(2).

The location in the application where this was addressed could not be located.

Title 25 TAC, §289.260(l)(3) requires that before transferring radioactive material to a specific licensee of the agency, NRC, an agreement state, a licensing state, or to a general licensee who is required to register with the agency, the licensee transferring the radioactive material shall verify that the transferee's license authorizes the receipt of the type, form, and quantity of radioactive material to be transferred.

The provisions of 25 TAC, §289.260(l)(3) pertain to licensees who transfer radioactive material to other persons. Given the nature of this application, that is, disposal of by-product material, compliance with this provision should not be a consideration. However, in Section 14.4 and 15.4 of the applicant's Radiation Protection Program (BP-RSP-100) in the Procedures Manual, statements are made that imply that the applicant has the intentions of transferring radioactive material to other persons. In that case, the application should address how the applicant will comply with the provisions of 25 TAC, §289.260(l)(3). However, the applicant does not include 25 TAC, §289.260(l)(3) in Table 1-1, nor can this reviewer find in the application where the applicant has described how it will comply with this provision.

Title 25 TAC, §289.260(m) – Financial Security Requirements

(1) **Financial security for decontamination, decommissioning, reclamation, restoration, disposal, and any other requirements of the agency shall be established by each licensee prior to the commencement of operations to assure that sufficient funds will be available to carry out the decontamination and decommissioning of buildings and the site and for the reclamation of any by-product material disposal areas.**

This provision requires that financial security be established prior to the commencement of operations. Therefore, the funds do not have to be established at this time, but may be provided at some time after the license is issued and the commencement of operations.

The amount of funds to be ensured by such security arrangements shall be based on agency-approved cost estimates in an agency-approved closure plan.

The closure plan shall be for

(A) decontamination and decommissioning of buildings and the site to levels that allow unrestricted use of these areas upon decommissioning; and

(B) the reclamation of by-product material disposal areas in accordance with technical criteria delineated in subsection (o) of this section.

A closure plan is provided in Section 6.1 of Volume 1. However, the closure plan is stated to be for expected closure procedures. As such, the plan appears to be more conceptual in nature than an actual plan submitted for agency approval.

Section 6.1.1 provides an "expected" sequence of closure activities. In a number of instances the sequence of event entails first the survey of an area/building and concrete, then the dismantling of the building and concrete and the placement of the building and concrete in the landfill (although not specified it is assumed that the landfill is the by-product disposal cell(s)). This seems to be a backwards sequence of events. If a facility or items are designated to be placed into the by-product cell for disposal, regardless of its state of contamination, then it is not logical to survey the item. Instead, once a building or structure is removed, then the concrete pad on which it rested should be surveyed, and decontaminated if necessary, if it is to be released to unrestricted use.

The sequence of closure activities specifies that items to be released will be surveyed. However, there is no specification of what constitutes the release criteria, or a reference to either the release criteria, or the procedures for making the determination that release criteria has been met.

Section 6.1.1.1 states that contact water will be transferred to an off-site wastewater treatment

unit for treatment and discharge. The contact water is considered to be by-product material. Unless the off-site wastewater treatment unit is licensed to receive by-product material the contact water cannot be transferred to them. This portion of the closure plan, and the operating procedure, will need to be addressed in future submissions of a closure plan.

Section 6.1.1.2 is titled to pertain to decontamination and disposition of facility equipment. This section makes reference to surveys being performed of soils under the concrete floor (of the contact water storage tanks) to determine if the soils are suitable for unrestricted release in accordance with applicable radiation safety procedures, with a reference to Appendix 10.A. Appendix 10.A consists of the applicant's Radiation Safety Plan (BP-RSP-100) and forty-nine procedures. The applicant is not specific as to which procedure(s) is/are applicable and will be used. Furthermore, the release criteria for equipment are not specified.

With respect to the staging area, the applicant states that the caliche will be removed and the soils underneath surveyed to ensure the area is suitable for unrestricted release as described in Section 6.1.1.2a. Section 6.1.1.2a describes the method for conducting area surveys, soil sampling, and the subsequent correlation of the soil sample analytical data with the survey readings to develop a relationship between the radiation survey results and the concentration of radium-226 and uranium in the soil. This section also identifies the release criteria as the limits specified at 25 TAC, §289.260(h)(6)(A)-(C), which are appropriate. This procedure is acceptable.

In conclusion, the application partially addresses the provisions of 25 TAC, §289.260(m)(1)(A) in an acceptable manner. The deficiencies regarding the sequence of performing surveys and decontamination/placement activities can probably be addressed by license condition. The statement that contact water will be transferred off-site to a wastewater treatment facility can be addressed by license condition prohibiting such transfer of water. The lack of specificity regarding the determination of release of equipment can be addressed by license condition by specifying the release criteria that will be applicable.

Compliance with the remainder of the provisions pertaining to the closure plan will be reviewed by process engineering.

Title 25 TAC, §289.260(m)(2) requires that the closure plan shall be submitted in conjunction with an environmental report that addresses the expected environmental impacts of the licensee's operation, decommissioning and reclamation, and evaluates alternatives for mitigating these impacts.

The applicant references Section 6.1 in Table 1-1 of Volume 1 of the application as containing the closure plan and states that environmental impacts are addressed. Volume 1 of the application proper is an overview of the application and would not ordinarily be considered to be an environmental report.

However, this could be a misinterpretation of the rule by the applicant. Section 289.260(f)(1)(A) of 25 TAC specifies that the application will include an environmental report that consists of the results of a one-year preoperational monitoring program; a description of the proposed project or action; area/site characteristics including ecology, geology, topography, hydrology, meteorology, historical and cultural landmarks, and archaeology; radiological and nonradiological impacts of the proposed project or action, including waterway and groundwater impacts and any long-term impacts; environmental effects of accidents; by-product material disposal, decommissioning, decontamination, and reclamation and impacts of these activities; and site and project alternative. The applicant did not provide a consolidated environmental report. Rather, the elements identified in the rule that should comprise an environmental report are scattered throughout the application. However, the applicant has met the intent of the rule to provide an environmental report.

Title 25 TAC, §289.260(m)(3) specifies that the security shall also cover the payment of the charge for long-term surveillance and control for by-product material disposal areas required by 25 TAC §289.260(n)(3).

Compliance with this provision will be addressed in the process engineering review.

Title 25 TAC, §289.260(m)(4) requires that the cost estimates must take into account total costs that would be incurred if an independent contractor were hired to perform the decommissioning and reclamation work.

Compliance with this provision will be addressed in the process engineering review.

Title 25 TAC, §289.260(n) - Long-term care and maintenance requirements.

Title 25 TAC, §289.260(n)(3) specifies that a minimum charge of $250,000 (1978 dollars) or more, if demonstrated as necessary by the agency, shall be paid into the Radiation and Perpetual Care Account to cover the costs of long-term care and maintenance. ... The total or unpaid portion of the charge shall be covered during the term of the license by additional security meeting the requirements of subsection (m) of this section.

If site surveillance, control, or maintenance requirements at a particular site are determined, on the basis of a site-specific evaluation, to be significantly greater (for example, if fencing or monitoring is determined to be necessary), the agency may specify a higher charge.

Compliance with this provision will be reviewed by process engineering.

Title 25 TAC, §289.260(o)(1) requires that by-product material handling and disposal systems

shall be designed to accommodate full-capacity production over the lifetime of the facility. When later expansion of systems or operations may be likely, capability of the disposal system to be modified to accommodate increased quantities without degradation in long-term stability and other performance factors shall be evaluated.

This provision pertains to mill sites (inferred from statement concerning designed to accommodate full-capacity production). Therefore, this provision is not applicable to this application.

Title 25 TAC, §289.260(o)(2) requires that in selecting among alternative by-product material disposal sites or judging the adequacy of existing sites, the following site features which would assure meeting the broad objective of isolating the tailings and associated contaminants without ongoing active maintenance shall be considered:

(A) remoteness from populated areas;

This provision is addressed in the socioeconomic review.

(B) hydrogeologic and other environmental conditions conducive to continued immobilization and isolation of contaminants from usable groundwater sources;

This provision will be addressed in the geology review.

(C) potential for minimizing erosion, disturbance, and dispersion by natural forces over the long term.

This provision will be addressed in the geology review.

Title 25 TAC, §289.260(o)(3) specifies that the site selection process shall be an optimization to the maximum extent reasonably achievable in terms of these site features.

An assessment of compliance with provision of subparagraph (A) will be determined in the agency's socioeconomic review.

Compliance with the provisions of subparagraphs (B) and (C) will be reviewed by primarily by geology.

Title 25 TAC, §289.260(o)(4) specifies that in the selection of disposal sites, primary emphasis shall be given to isolation of the by-product material, a matter having long-term impacts, as opposed to consideration only of short-term convenience or benefits (e.g., minimization of transportation or land acquisition costs). While isolation of by-product material will also be a function of both site and engineering design, overriding consideration shall be given to siting features.

Compliance with this provision will be addressed in the geology review.

Title 25 TAC, §289.260(o)(5) specifies that by-product material should be disposed of in a manner such that no active maintenance is required to preserve conditions of the site.

This provision will be reviewed by the civil engineering, geology and process engineering disciplines.

Title 25 TAC, §289.260(o)(6) specifies that the applicant's environmental report shall evaluate alternative sites and disposal methods and shall consider disposal of by-product material by placement below grade. Where full below grade burial is not practicable, the size of retention structures, and size and steepness of slopes associated with exposed embankments shall be minimized by excavation to the maximum extent reasonably achievable or appropriate given the geologic and hydrologic conditions at a site. In these cases, it shall be demonstrated that an above grade disposal program will provide reasonably equivalent isolation of the by-product material from natural erosional forces.

The applicant discusses site and project alternatives in Section 9 of Volume 1 of the application. This is evaluated in the agency's socioeconomic review.

The applicant proposes below grade disposal of by-product material (re: Section 1.1, page 1-3, Volume 1 of the application). Therefore, demonstration of compliance with this provision is not applicable.

Title 25 TAC, §289.260(o)(8) - The following site and design requirements shall be adhered to whether by-product material is disposed of above or below grade:

(A) **the upstream rainfall catchment areas shall be minimized to decrease erosion potential by flooding that could erode or wash out sections of the by-product material disposal area;**

(B) **the topographic features shall provide good wind protection;**

(C) **the embankment and cover slopes shall be relatively flat after final stabilization to minimize erosion potential and to provide conservative factors of safety assuring long term stability. The objective should be to contour final slopes to grades that are as close as possible to those that would be provided if by-product material was disposed of below grade. Slopes shall not be steeper than 5 horizontal to 1 vertical (5h:1v), except as specifically authorized by the agency. Where steeper slopes are proposed, reasons why a slope steeper than 5h:1v would be as equally resistant to erosion shall be provided, and compensating factors and conditions that make such slopes acceptable shall be identified;**

(D) a full self-sustaining vegetative cover shall be established or rock cover employed to reduce wind and water erosion to negligible levels;

(E) where a full vegetative cover is not likely to be self-sustaining due to climatic conditions, such as in semi-arid and arid regions, rock cover shall be employed on slopes of the impoundment system. The agency will consider relaxing this requirement for extremely gentle slopes, such as those that may exist on the top of the pile;

(F) the following factors shall be considered in establishing the final rock cover design to avoid displacement of rock particles by human and animal traffic or by natural processes, and to preclude undercutting and piping:

- **(i) shape, size, composition, gradation of rock particles (excepting bedding material, average particles size shall be at least cobble size or greater);**
- **(ii) rock cover thickness and zoning of particles by size;**
- **(iii) steepness of underlying slopes.**

(G) individual rock fragments shall be dense, sound, and resistant to abrasion, and shall be free from cracks, seams, and other defects that would tend to unduly increase their destruction by erosion and weathering action. Local rock materials are permissible provided the characteristics under local climatic conditions indicate similar long-term performance as a protective layer. Weak, friable, or laminated aggregate may not be used.

(H) rock covering of slopes may not be required where top covers are very thick (on the order of 10 m or greater); impoundment slopes are very gentle (on the order of 10h:1v or less); bulk cover materials have inherently favorable erosion resistance characteristics; there is negligible drainage catchment area upstream of the pile; and there is good wind protection

(I) all impoundment surfaces shall be contoured to avoid areas of concentrated surface runoff or abrupt or sharp changes in slope gradient. In addition to rock cover on slopes, areas toward which surface runoff might be directed shall be well protected with substantial rock cover (riprap). In addition to providing for stability of the impoundment system itself, overall stability, erosion potential, and geomorphology of surrounding terrain shall be evaluated to assure that there are no ongoing or potential processes, such as gully erosion, which would lead to impoundment instability;

(J) the impoundment shall not be located near a capable fault that could cause a maximum credible earthquake larger than that which the impoundment could reasonably be expected to withstand; and

(K) the impoundment should be designed to incorporate features that will promote deposition. Design features that promote deposition of sediment suspended in any runoff which flows

into the impoundment area might be utilized. The object of such a design feature would be to enhance the thickness of cover over time.

The above provisions will be addressed in the civil engineering review.

289.260(o)(9) - Groundwater protection.
The following groundwater protection requirements and those in paragraphs (10) and (11) of this subsection and subsection (q) of this section apply during operations and until closure is completed. Groundwater monitoring to comply with these standards is required by paragraphs (28) and (29) of this subsection.

(A) shall have a liner that is designed, constructed, and installed to prevent any migration of wastes out of the impoundment to the adjacent subsurface soil, groundwater, or surface water at any time during the active life (including the closure period) of the impoundment, unless exempted under 289.260(o)(9)(C).

For impoundments that will be closed with the liner material left in place, the liner shall be constructed of materials that can prevent wastes from migrating into the liner during the active life of the facility.

(B) The liner shall be:

(i) constructed of materials that have appropriate chemical properties and sufficient strength and thickness to prevent failure due to pressure gradients (including static head and external hydrogeologic forces), physical contact with the waste or leachate to which they are exposed, climatic conditions, the stress of installation, and the stress of daily operation;

With respect to the liner's ability to perform in the presence of prolonged exposure to radiation, an evaluation was made by both the applicant and agency review staff of the estimate dose that the liner would receive and the number of years to achieve a degradative dose of gamma radiation. A high density polyethylene (HDPE) synthetic liner is proposed for use in the by-product disposal cell. HDPE is considered to be adversely affected by radiation dose of 1,000,000 RADs. The applicant provides an analysis of the effect of radiation from the by-product material proposed for disposal on the HDPE liner (re: Appendix 3.2.E). The applicant references Table 5.3.2.2-1 in Section 5 (Volume 1) as identifying the radionuclides a concentrations used in their analysis. The applicant states that the concentrations in the table are representative of the Fernald waste (Silos 1 and 2). The radionuclides and concentrations are as follows:

U-238 85.34 pCi/g,
U-235 3.9 pCi/g,

Th-232 128 pCi/g,
Pa-231 4,041 pCi/g,
Ra-226 84,660pCi/g,
U-234 85.34 pCi/g,
Th-230 12,560 pCi/g,
Ac-227 7,670 pCi/g,
Po-210 84,660 pCi/g,
Pb-210 84,660 pCi/g,
Ra-228 128 pCi/g,
Ra-224 128 pCi/g,
Th-228 128 pCi/g.

A density of 1.6 g/cm^3 was assumed.

A waste form of one (1) square meter by 70-feet was assumed. Table 5.3.2.2-1 (Vol. 1) lists the radionuclides that are present in the Fernald waste and the concentration of each radionuclide. The table also depicts the calculated dose rate for each of the radionuclides, and sums the calculated dose rates to estimate a dose rate to which the liner would be subjected. The calculation is made from the center of the one-square meter by 70-foot column of waste. This method derives an estimated dose rate of 7.461 times 10^{-2} R/hr. That dose rate is then multiplied by the number of hours in a year to derive the estimated annual dose rate. The annual dose rate is then divided into 1,000,000 R to estimate the amount of time to achieve a dose of 1,000,000 R (re: Appendix 3.2.E, Vol. 3). The applicant's method of calculating the dose rate from the center of the waste column is considered to be a conservative approach to deriving the dose rate that would impact the liner.

In attempting to validate the applicant's estimate of the dose to the liner, this reviewer used MicroShield Version 6.02. A case was set up to replicate a waste volume of 70 feet deep, by 756 feet long by 125 feet wide (dimensions obtained from diagrams in Section 3 of Vol. 1). The waste was assumed to be comprised of the radionuclides used by the applicant from the Fernald waste. No consideration was given to shielding by the waste containers, and the density of the waste was assumed to be 1.6 g/cm^3. The scenarios for the case were run assuming no decay, decay for 200 years and decay for 1,000 years. The maximum dose achieved of the three cases was 2.5 time 10^{-2} mR/hr for the 200-year decay scenario. This is more than three orders of magnitude less than the estimate derived by the applicant. Hence, a deleterious effect from gamma radiation on the HDPE liner is considered to be negligible.

(ii) placed upon a foundation or base capable of providing support to the liner and resistance to pressure gradients above and below the liner to prevent failure of the liner due to settlement, compression, or uplift; and

(iii) installed to cover all surrounding earth likely to be in contact with the wastes or leachate.

(C) The applicant will be exempted from the requirement for a liner if the agency finds, based on a demonstration by the applicant, that alternate design and operating practices, including the closure plan, together with site characteristics will prevent the migration of any hazardous constituents into groundwater or surface water at any future time. In deciding whether to grant an exemption, the agency will consider:

(i) the nature and quantity of the wastes;

(ii) the proposed alternate design and operation;

(iii) the hydrogeologic setting of the facility, including the attenuative capacity and thickness of the liners and soils present between the impoundment and groundwater or surface water; and

(iv) all other factors that would influence the quality and mobility of the leachate produced and the potential for it to migrate to groundwater or surface water.

(D) A surface impoundment shall be designed, constructed, maintained, and operated to prevent overtopping resulting from normal or abnormal operations, overfilling, wind and wave actions, rainfall, or run-off; from malfunctions of level controllers, alarms, and other equipment; and from human error.

(E) When dikes are used to form the surface impoundment, the dikes shall be designed, constructed, and maintained with sufficient structural integrity to prevent massive failure of the dikes. In ensuring structural integrity, it shall not be presumed that the liner system will function without leakage during the active life of the impoundment.

The above provisions will be addressed in the civil engineering review.

289.260(o)(10) - By-product materials shall be managed to conform to the following secondary groundwater protection requirements:

(A) Hazardous constituents entering the groundwater from a licensed site shall not exceed the specified concentration limits in the uppermost aquifer beyond the point of compliance during the compliance period.

(B) Specified concentration limits are those limits established by the agency as indicated in (G) of this.

(C) The agency will also establish the point of compliance and compliance period on a site-specific basis through license conditions and orders.

(D) When the detection monitoring established under paragraphs (28) and (29) of this section indicates leakage of hazardous constituents from the disposal area, the agency will perform the following:

(i) identify hazardous constituents;

(ii) establish concentration limits;

(iii) set the compliance period; and

(iv) may adjust the point of compliance if needed in accordance with developed data and site information regarding the flow of groundwater or contaminants.

The above provisions are applicable during operations, after a leak is detected, thus not a part of the application review.

289.260(o)(12) - In developing and conducting groundwater protection programs, applicants and licensees shall also consider the following:

(A) installation of bottom liners. Where synthetic liners are used, a leakage-detection system shall be installed immediately below the liner to ensure detection of any major failures. This is in addition to the groundwater monitoring program. Where clay liners are proposed or relatively thin, in situ clay soils are to be relied upon for seepage control, tests shall be conducted with representative tailings solutions and clay materials to confirm that no significant deterioration of permeability or stability properties will occur with continuous exposure of clay to by-product material solutions. Tests shall be run for a sufficient period of time to reveal any effects that may occur;

(B) mill process designs that provide the maximum practicable recycle of solutions and conservation of water to reduce the net input of liquid to the by-product material impoundment;

This application does not pertain to a mill. Therefore, this provision is not applicable.

(C) dewatering of by-product material solutions by process devices and/or in situ drainage systems. At new sites, by-product material solutions shall be dewatered by a drainage system installed at the bottom of the impoundment to lower the phreatic surface and reduce the driving head of seepage, unless tests show by-product material solutions are not amenable to such a system. Where in situ dewatering is to be conducted, the impoundment

bottom shall be graded to assure that the drains are at a low point. The drains shall be protected by suitable filter materials to assure that drains remain free-running. The drainage system shall also be adequately sized to assure good drainage; and

(D) neutralization to promote immobilization of hazardous constituents.

Provision D applies only to mill tailings. Therefore, this provision is not applicable.

The above provisions will be addressed in the civil engineering review.

Title 25 TAC, §289.260(o)(13) requires that technical specifications shall be prepared for installation of seepage control systems. A quality assurance, testing, and inspection program, which includes supervision by a qualified engineer or scientist, shall be established to assure that specifications are met. If adverse groundwater impacts or conditions conducive to adverse groundwater impacts occur due to seepage, action shall be taken to alleviate the impacts or conditions and restore groundwater quality to levels consistent with those before operations began. The specific seepage control and groundwater protection method, or combination of methods, to be used shall be worked out on a site-specific basis.

This provision will be addressed in the civil engineering review.

Title 25 TAC, §289.260(o)(14) - In support of a by-product material disposal system proposal, the following information shall be supplied:

(A) the chemical and radioactive characteristics of the waste solutions;

(B) the characteristics of the underlying soil and geologic formations particularly as they will control transport of contaminants and solutions. This shall include detailed information concerning extent, thickness, uniformity, shape, and orientation of underlying strata. Hydraulic gradients and conductivities of the various formations shall be determined. This information shall be gathered by borings and field survey methods taken within the proposed impoundment area and in surrounding areas where contaminants might migrate to groundwater. The information gathered on boreholes shall include both geologic and geophysical logs in sufficient number and degree of sophistication to allow determining significant discontinuities, fractures, and channeled deposits of high hydraulic conductivity. If field survey methods are used, they should be in addition to and calibrated with borehole logging. Hydrologic parameters such as permeability shall not be determined on the basis of laboratory analysis of samples alone. A sufficient amount of field testing (e.g., pump tests) shall be conducted to assure actual field properties are adequately understood. Testing shall be conducted to make possible estimates of chemisorption attenuation properties of underlying soil and rock; and

(C) location, extent, quality, capacity, and current uses of any groundwater at and near the site.

Provision A will be addressed by the geology, civil engineering and environmental health physics chapters of this report. Provisions B and C will be addressed in the geology review.

Title 25 TAC, §289.260(o)(16) specifies that in disposing of by-product material, an earthen cover shall be placed over the by-product material at the end of the facility's operations and shall close the waste disposal area in accordance with a design that provides reasonable assurance of control of radiological hazards to the following:

(A) be effective for 1,000 years to the extent reasonably achievable and, in any case, for at least 200 years;

This provision will be addressed in the geology and civil engineering review.

(B) limit releases of radon-222 from uranium by-product materials and radon-220 from thorium by-product materials to the atmosphere so as not to exceed an average release rate of 20 picocuries per square meter per second (pCi/m2s) to the extent practicable throughout the effective design life determined in accordance with subparagraph (A) of this paragraph. This average applies to the entire surface of each disposal area over a period of at least one year, but a period short compared to 100 years. Radon will come from both by-product materials and cover materials. Radon emissions from cover materials should be estimated as part of developing a closure plan for each site. The standard, however, applies only to emissions from by-product materials to the atmosphere.

This provision will be addressed in the environmental health physics review.

Title 25 TAC, §289.260(o)(17) states that in computing required by-product material cover thicknesses, moisture in soils in excess of amounts found normally in similar soils in similar circumstances shall not be considered. Direct gamma exposure from the by-product material should be reduced to background levels. The effects of any thin synthetic layer shall not be taken into account in determining the calculated radon exhalation level. Cover shall not include materials that contain elevated levels of radium. Soils used for near-surface cover shall be essentially the same, as far as radioactivity is concerned, as that of surrounding surface soils. If non-soil materials are proposed as cover materials, the licensee shall demonstrate that such materials will not crack or degrade by differential settlement, weathering, or other mechanisms over the long term.

This provision will be addressed in the environmental health physics review.

Title 25 TAC, §289.260(o)(18) specifies that as soon as reasonably achievable after emplacement of the final cover to limit releases of radon-222 from uranium by-product material and prior to placement of erosion protection barriers or other features necessary for long-term control of the tailings, the effectiveness of the design and construction of the final radon barrier at limiting releases of radon-222 to a level not exceeding 20pCi/m2s averaged over the entire pile or impoundment shall be verified through testing and analysis, using the procedures described in Appendix B, method 115 of 40 CFR Part 61, or another method of verification approved by the agency as being at least as effective in demonstrating the effectiveness of the final radon barrier.

This provision will be addressed in the environmental health physics review.

Title 25 TAC, §289.260(o)(19) specifies that when phased emplacement of the final radon barrier is included in the applicable reclamation plan the verification of radon-222 release rates required in paragraph (30) of this subsection shall be conducted for each portion of the pile or impoundment as the final radon barrier for that portion is emplaced.

This provision will be addressed in the environmental health physics review.

Title 25 TAC, §289.260(o)(20) provides that within 90 days of the completion of all testing and analysis relevant to the required verification in paragraphs (30)(C) and (30)(D) of this subsection, the licensee shall report to the agency the results detailing the actions taken to verify that levels of release of radon-222 do not exceed 20 pCi per square meter per second when averaged over the entire pile or impoundment. The licensee shall maintain records documenting the source of input parameters, including the results of all measurements on which they are based, the calculations and/or analytical methods used to derive values for input parameters, and the procedure used to determine compliance. These records shall be maintained until termination of the license and shall be kept in a form suitable for transfer to the custodial agency at the time of transfer of the site to the state or federal government.

The applicant references sections 6.1.1.5 and 6.1.1.7 in Volume 1 as addressing the requirements of this provision. Section 6.1.1.5 makes no commitment as to a specific time when a report of the testing results will be made to the Agency. The only commitment made is in Section 6.1.1.7 which states that a final status radiation survey report will be prepared and provided to the TDSHS as required by 25 TAC 289.260(h)(18)(B). The reference to 289.260(h)(18)(B) does not demonstrate compliance with the provisions of 289.260(o)(20). However, lacking a commitment from the applicant, a recommended license provision specifies the performance standard. If the licensee fails to comply with the performance standard, a violation of the rule will be issued.

Title 25 TAC, §289.260(o)(21) requires that near-surface cover materials may not include waste, rock, or other materials that contain elevated levels of radium. Soils used for near-surface cover shall be essentially the same, as far as radioactivity is concerned, as surrounding surface soils. This is to ensure that surface radon exhalation is not significantly above background because of

the cover material itself.

This provision will be addressed in the environmental health physics review.

Title 25 TAC, §289.260(o)(22) stipulates that the design requirements for longevity and control of radon releases apply to any portion of a licensed and/or disposal site unless such portion contains a concentration of radium in land averaged over areas of 100 square meters (m2), that, as a result of by-product material, does not exceed the background level by more than:

(A) 5 picocuries per gram (pCi/g) of radium-226, or in the case of thorium by-product material, radium-228, averaged over the first 15 centimeters (cm) below the surface; and

(B) 15 pCi/g of radium-226, or in the case of thorium by-product material, radium-228, averaged over 15-cm thick layers more than 15 cm below surface.

The applicant indicates in Table 1-1 that Section 6.1.1.5 of Volume 1 addresses this provision. The §289.260(o)(22) provides that the radon flux limit applies to any portion of a disposal site where the radium concentration exceeds the limits specified in that section. However, Section 6.1.1.5 makes a commitment to determining the radon flux only on the disposal unit cap, and makes no mention of other areas at the disposal site. However, this may be inconsequential since the applicant provides a commitment in Section 6.1.1.2a (of Volume 1) to identifying those areas that exceed the limits specified at 25 TAC §289.260(h)(6)(A) – (C), and a commitment in Section 6.1.1.2b to cleaning up those areas that exceed the afore-stated limits.

Title 25 TAC, §289.260(o)(23) requires that the nonradiological hazards associated with the waste in planning and implementing closure shall also be addressed. The licensee shall ensure that disposal areas are closed in a manner that minimizes the need for further maintenance. To the extent necessary to prevent threats to human health and the environment, the licensee shall control, minimize, or eliminate post-closure escape of nonradiological hazardous constituents, leachate, contaminated rainwater, or waste decomposition products to groundwater or surface waters or to the atmosphere.

This provision will be addressed in the geology and environmental health physics review.

Title 25 TAC, §289.260(o)(24) - For impoundments containing uranium by-product materials, the final radon barrier shall be completed as expeditiously as practicable considering technological feasibility after the pile or impoundment ceases operation in accordance with a written reclamation plan, as defined in subsection (c)(25) of this section, approved by the agency, by license amendment. (The term "as expeditiously as practicable considering technological feasibility" includes "factors beyond the control of the licensee.") Deadlines for completion of the final radon barrier and applicable interim milestones shall be established as license conditions. Applicable interim milestones may include, but are not limited to, the retrieval of

windblown by-product material and placement on the pile and the interim stabilization of the by-product material (including dewatering or the removal of freestanding liquids and recontouring). The placement of erosion protection barriers or other features necessary for long-term control of the by-product material shall also be completed in a timely manner in accordance with a written reclamation plan approved by the agency by license amendment.

Reclamation plan - For the purposes of subsection (o)(16)-(27) of this section, "reclamation plan" is the plan detailing activities to accomplish reclamation of the by-product material disposal area in accordance with the technical criteria of this section. The reclamation plan shall include a schedule for reclamation milestones that are key to the completion of the final radon barrier, including as appropriate, but not limited to, wind blown tailings retrieval and placement on the pile, interim stabilization (including dewatering or the removal of freestanding liquids and recontouring), and final radon barrier construction. Reclamation of by-product material shall also be addressed in the closure plan. The detailed reclamation plan may be incorporated into the closure plan.

Closure plan - The plan approved by the agency to accomplish closure. The closure plan consists of a decommissioning plan and may also include a reclamation plan.

The applicant indicates in Table 1-1 of Volume 1 that this provision is addressed in Section 6.1.3 of Volume 1.

Compliance with this provision will be addressed in the process engineering review.

Title 25 TAC, §289.260(o)(27) requires that the licensee's closure plan shall provide reasonable assurance that institutional control will be provided for the length of time found necessary by the agency to ensure the requirements of paragraph (16) of this subsection are met.

The applicant indicates in Table 1-1 of Volume 1 that this provision is addressed in Section 7.0 of Volume 1 and Section 7.A of Volume 5.

Compliance with this provision will be addressed in the process engineering review.

Title 25 TAC, §289.260(o)(28) specifies that prior to any major site construction, a preoperational monitoring program shall be conducted for one full year to provide complete baseline data on the site and its environs. Throughout the construction and operating phases of the project, an operational monitoring program shall be conducted to measure or evaluate compliance with applicable standards and rules; to evaluate performance of control systems and procedures; to evaluate environmental impacts of operation; and to detect potential long-term effects.

The applicant states in Table 1-1 of Volume 1 that at least one years worth of preoperational environmental data has been obtained and will continue the environmental monitoring program during operations. Furthermore, the applicant references Section 4.2.1 of Volume 1 and Appendix 4.B of Volume 4 as addressing this provision.

Compliance with this provision will be addressed in the environmental health physics review.

Title 25 TAC, §289.260(o)(29) requires the licensee to establish a detection monitoring program needed for the agency to set the site-specific groundwater protection standards in paragraph (10)(D) of this subsection. For all monitoring under this paragraph, the licensee or applicant will propose, as license conditions for agency approval, which constituents are to be monitored on a site-specific basis. The data and information shall provide a sufficient basis to identify those hazardous constituents that require concentration limit standards and to enable the agency to set the limits for those constituents and compliance period. They may provide the basis for adjustments to the point of compliance. The detection monitoring program shall be in place when specified by the agency in orders or license conditions. Once groundwater protection standards have been established in accordance with paragraph (10)(D) of this subsection, the licensee shall establish and implement a compliance monitoring program. In conjunction with a corrective action program, the licensee shall establish and implement a corrective action monitoring program to demonstrate the effectiveness of the corrective actions. Any monitoring program required by this paragraph may be based on existing monitoring programs to the extent the existing programs can meet the stated objective for the program.

The applicant indicates in Table 1-1 of Volume 1 that a detection monitoring system has been implemented and that the detection monitoring will continue during the operating and post-operational periods. Additionally, the applicant indicates that Section 4.3 of Volume 1 addresses this provision.

Compliance with this provision will be addressed in the geology and environmental health physics review.

Title 25 TAC, §289.260(o)(30) specifies that systems shall be designed and operated so that all airborne effluent releases are as low as is reasonably achievable. The primary means of accomplishing this shall be by means of emission controls. Institutional controls, such as extending the site boundary and exclusion area, may be employed to ensure that offsite exposure limits are met, but only after all practicable measures have been taken to control emissions at the source.

The applicant indicates in Table 1-1 of Volume 1 that this provision is addressed in Section 5.3.1.1 of Volume 1, Appendix 3.7.A (BP-OP-2.7 and Sections 5.A and 5.C of Volume 4.

Compliance with this portion of this provision will be addressed in the process engineering review.

(A) **During operations and prior to closure, radiation doses from radon emissions from surface impoundments of by-product materials shall be kept as low as is reasonably achievable.**

The applicant indicates in Table 1-1 of Volume 1 that this provision is addressed in Sections 5.3.1.2 and 5.3.2.1 of Volume 1.

This portion of the provision pertains to operations. Therefore, it is not a part of the application review.

(B) **Checks shall be made and logged hourly of all parameters which determine the efficiency of emission control equipment operation. It shall be determined whether or not conditions are within a range prescribed to ensure that the equipment is operating consistently near peak efficiency. Corrective action shall be taken when performance is outside of prescribed ranges. Effluent control devices shall be operative at all times during drying and packaging operations and whenever air is exhausting from the uranium dryer stack. Drying and packaging operations shall terminate when controls are inoperative. When checks indicate the equipment is not operating within the range prescribed for peak efficiency, actions shall be taken to restore parameters to the prescribed range. When this cannot be done without shutdown and repairs, drying and packaging operations shall cease as soon as practicable. Operations may not be restarted after cessation due to off-normal performance until needed corrective actions have been identified and implemented. All such cessations, corrective actions, and re-starts shall be reported to the agency in writing within ten days of the subsequent restart.**

This portion of the provision pertains to drying and packaging of yellowcake. Since drying and packaging of yellowcake is not a part of this application, determination of compliance with this provision is not applicable.

(C) **To control dusting from by-product material, that portion not covered by standing liquids shall be wetted or chemically stabilized to prevent or minimize blowing and dusting to the maximum extent reasonably achievable. This requirement may be relaxed if by-product material are effectively sheltered from wind, as in the case of below-grade disposal. Consideration shall be given in planning by-product material disposal programs to methods for phased covering and reclamation of by-product material impoundments. To control dusting from diffuse sources, applicants/licensees shall develop written operating procedures specifying the methods of control that will be utilized.**

The applicant indicates in Table 1-1 of Volume 1 that this provision is addressed in Appendix 3.7A of Volume 4.

This portion of the provision will be addressed in the environmental health physics review.

(D) Uranium recovery facility operations producing or involving thorium by-product material shall be conducted in such a manner as to provide reasonable assurance that the annual dose equivalent does not exceed 25 millirems (mrem) to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ of any member of the public as a result of exposures to the planned discharge of radioactive materials to the general environment, radon-220 and its daughters excepted.

This portion of the provision is not applicable since this application does not involve the recovery of uranium.

(E) By-product materials shall be managed so as to conform to the applicable provisions of 40 CFR 440, as codified on January 1, 1983.

This portion of the provision is not applicable since it pertains only to mining operations, not by-product disposal.

Title 25 TAC, §289.260(o)(31) allows for applicants to propose alternatives to the specific requirements in subsections (m)-(p) of this section. The alternative proposals may take into account local or regional conditions including geology, topography, hydrology, and meteorology.

The applicant indicates in Table 1-1 of Volume 1 that this provision is not applicable since alternatives have not been proposed.

Compliance with this provision will be addressed in the process engineering review.

Title 25 TAC, §289.260(o)(32) specifies that the agency may find that the proposed alternatives meet the agency's requirements if the alternatives will achieve a level of stabilization and containment of the sites concerned and a level of protection for the public health and safety and the environment from radiological and nonradiological hazards associated with the sites, which is equivalent to, to the extent practicable, or more stringent than the level that would be achieved by the requirements of subsections (m)-(p) of this section and the standards promulgated by EPA in 40 CFR Part 192, Subparts D and E.

The applicant indicated in Table 1-1 of Volume 1 that this provision is not applicable since alternatives have not been proposed.

Compliance with this provision will be addressed in the process engineering review.

Title 25 TAC, §289.260(o)(33) specifies that all site-specific licensing decisions based on the criteria in subsections (m)-(p) of this section, or alternatives proposed by licensees/applicants shall take into account the risk to the public health and safety and the environment with due

consideration to the economic costs involved and any other factors the agency determines to be appropriate.

The applicant indicated in Table 1-1 of Volume 1 that this provision is not applicable since alternatives have not been proposed.

Compliance with this provision will be addressed in the process engineering review.

Title 25 TAC, §289.260(o)(34) Any proposed alternatives to the specific requirements in subsections (m)-(p) [m – Financial Security, n – Long-Term Care and Maintenance Requirements, o – Technical Requirements, and p – Land Ownership] of this section shall meet the requirements of 10 CFR 150.31(d).

> 10 CFR §150.31(d) - In adopting requirements pursuant to paragraph (b)(2) of this section, the State may adopt alternatives (including, where appropriate, site-specific alternatives) to the requirements adopted and enforced by the Commission for the same purpose if, after notice and opportunity for public hearing, the Commission determines that the alternatives will achieve a level of stabilization and containment of the sites concerned, and a level of protection for public health, safety and the environment from radiological and nonradiological hazards associated with the sites, which is equivalent to, to the extent practicable, or more stringent than the level which would be achieved by standards and requirements adopted and enforced by the Commission for the same purpose and any final standards promulgated by the Administrator of the Environmental Protection Agency in accordance with section 275. Alternative State requirements may take into account local or regional conditions, including geology, topography, hydrology and meteorology.

The applicant indicated in Table 1-1 of Volume 1 that this provision is not applicable since alternatives have not been proposed.

Compliance with this provision will be addressed in the process engineering review.

Title 25 TAC, §289.260(o)(35) specifies that no new site shall be located in a 100-year floodplain or wetland as defined in "Floodplain Management Guidelines for Implementing Executive Order 11988."

Compliance with this provision will be addressed in the geology and civil engineering review.

Title 25 TAC, §289.260(p) Land ownership of by-product material disposal sites.

(1) These criteria relating to ownership of by-product material and their disposal sites apply to

all licenses terminated, issued, or renewed after November 8, 1981.

(2) Unless exempted by NRC, title to land (including any affected interests therein) that is used for the disposal of by-product material or that is essential to ensure the long-term stability of the disposal site and title to the by-product material shall be transferred to the State of Texas or the United States prior to the termination of the license. Material and land transferred shall be transferred without cost to the State of Texas or the United States. In cases where no ongoing site surveillance will be required, surface land ownership transfer requirements may be waived. For licenses issued before November 8, 1981, NRC may take into account the status of the ownership of the land and interests therein, and the ability of a licensee to transfer title and custody thereof to the State.

(3) Any uranium recovery facility license

(4) For surface impoundments only, the applicant/licensee shall demonstrate a serious effort to obtain severed mineral rights and shall, in the event that fee simple title including all mineral rights cannot be obtained, provide notification in local public land records of the fact that the land is being used for the disposal of radioactive material and is subject to a NRC license prohibiting the disruption and disturbance of the tailings.

(5) If NRC, subsequent to title transfer, determines that use of the surface or subsurface estates, or both, of the land transferred to the state or federal government will not endanger the public health and safety or the environment, NRC may permit the use of the surface or subsurface estates, or both, of such land in a manner consistent with the provisions of this section. If NRC permits the use of such land, it will provide the person who transferred the land with the first refusal with respect to the use of such land.

Section 1.2.4.1 of Section 1 of Volume 1 of the application discusses ownership of the facility. According to the warranty deed provided as Attachment 2 in Appendix 1.D (Volume 2 of the application), WCS has 100% ownership of the surface estate. However, Exhibit "B" to that warranty deed sets out certain restrictions and encumbrances. The restrictions and encumbrances are as follows:

1. Lease Agreement for Natural Gas Pipeline executed by Flying W Diamond Ranch to Texaco Producing, Inc.

2. Terms, conditions, and stipulations contained in Easements and Rights-of-Way described in Schedule I.

3. Reservations of all oil, gas and other minerals contained in Warranty Deed executed by Ethel S. Sims to Wayne May.

4. Subject to the rights of Kid Kroger, pursuant to the terms and provisions of a grazing lease

agreement.

The Easements and rights-of-Way specified in Schedule I include Section 25 for Sohio Petroleum Company and Southwest Public Service.

Section 1.2.4.2 of Volume 1 of the application indicates that WCS holds a majority of the mineral estate interest in the salient quadrants of Section 25. However, WCS does not hold 100% of the mineral estate interest. The application contains documents of WCS's efforts to purchase outright or exchange like-kind mineral interest with the mineral interest holders, or execute a surface use agreement with the mineral interest holders, or notification of WCS's intent to either file a deed notification on the subject area or initiate condemnation proceedings (re: Attachment 10, Appendix 1.D, Volume 2).

WCS also provides copies of legal opinions rendered on the practical result of failure to secure 100% of the mineral estate interest (re: Attachment 8, Appendix 1.D, Volume 2).

This was previously discussed in this chapter. The issue of the restrictions and encumbrances has been addressed by the applicant in a May 18, 2007 letter.

4.13 INTENTED USE

A review of the applicant's intended use was conducted. This reviewer was reasonably assured that the requested radioactive material will be used as intended. Thus, an additional evaluation of a potential security risk is not needed.

As a review for intended use is deemed by the NRC to contain material that is "sensitive and non-publicly available" no details of the review are provided in this chapter.

4.14 CONCLUSION AND RECOMMENDATION

WCS has submitted a multitude of procedures addressing the receipt, handling and disposal of by-product material; the monitoring and assessment of radiation levels in and around the proposed facility; the tracking and estimation of exposure and dose to both workers and individual members of the public; organizational structure and protocols for maintaining exposure and dose as low as reasonably achievable; and provided a description of equipment used to handle , monitor and assess by-product material to assure that it is managed safely. Although the procedures are complex and seemingly convoluted for certain processes, the key to any successful radiation safety program is a commitment to radiation safety by management and the hiring and retaining of qualified and competent persons to manage and run the radiation safety program and facility. The recommended license conditions in conjunction with WCS's procedures and personnel should be capable of conducting an operation that will not be harmful to occupational health and safety.

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CHAPTER 5 CIVIL ENGINEERING ASSESSMENT

Staff review of the assigned civil engineering aspects of the By-Product Waste Disposal Application [1] by Waste Control Specialists LLC (WCS) in Andrews County, Texas, L05807, has determined that the proposed civil engineering design is a typical RCRA, Subtitle C, standard landfill design. As such it presents no insurmountable civil engineering challenges and should, in fact, prove straightforward to build and operate assuming acceptable standard procedures, practices, the application itself and license terms and conditions (if issued) are observed. Ongoing rigorous inspection during construction, operation, and closure will be necessary. The civil engineering design as currently presented should meet NUREG requirements, including life span; however, it is not realistic to believe maintenance will not be necessary after closure. Some inspection and maintenance during, and after, the termination period can reasonably be expected.

However, the application does contain unresolved issues which the applicant appears to resolve by further design revisions as the project proceeds.

Some of these issues include, but are not limited to:

- What constitutes the ground water level and does it really impact the geotechnical (or regulatory) aspects of the design? This issue from a civil engineering aspect needs further review by experienced geotechnical design engineers. The groundwater model is not calibrated to the site.

- The applicant states that observation during excavation of the landfill will be used to verify the soil design parameters and possibly require modifications to the design if conditions such as permeable soil stringers and excessive water are discovered. This would be considered good engineering practice but should be subject to TCEQ review.

- The operation (or possible closure) of leachate collection and leak detection systems after operational closure needs resolution. These systems may need to be operated even in the termination phase. This will not be conclusively known until their performance is assessed in the 5 year post closure period.

- Continued inspection and maintenance (earthwork and grading) after closure is expected to be necessary as maximum settlement is not projected until 50 to 500 years after closure.

- The applicant does not seem to have effectively addressed wind borne particulate issues. In particular, do the high west Texas winds pick up loose by-product product material in the landfill and disperse it around the site? If so, this has the potential of contaminating the entire site and would require all surface run off (including into OAG) to be handled differently than currently designed. This could also require both design modification and revisions to TPDES Permit.

- That the applicant does not consider this a complete final design is exemplified by WCS verbally stating on August 3, 2007, that they are considering a railroad loop encircling all the permitted sites by a raised (2' approximately) road bed. This would affect all surface drainage designs. WCS also indicated their intent to manage all facilities under 1 TPDES permit which might affect surface drainage and process design.

- The facility buildings are not designed. Their basic parameters are specified with the apparent intention to order prefabricated metal buildings of those dimensions and suitable to site specific soil and wind conditions. This is standard industry practice and suitable for the applicant's purposes and operational life of the facility.

5.1 DESIGN OF THE PROPOSED FACILITY

5.1.1 Description

This review is of civil engineering aspects of an application [1] by Waste Control Specialist LLC (WCS) to construct and operate a radioactive by-product material disposal facility on a tract of land owned by WCS. Specifically, the proposed by-product disposal facility will be located on within a 1,338 acre tract of land upon which WCS currently operates a facility to receive radioactive waste for storage and processing (DSHS License L04971). WCS is also authorized by TCEQ and EPA for the receipt, storage and treatment of hazardous waste, non hazardous industrial solid waste and waste containing PCBs. In addition, WCS operates a RCRA/TSCA landfill on the 1,338 acre tract, which is authorized by TCEQ and EPA for disposal of hazardous waste, industrial non hazardous waste and waste containing PCBs.

5.1.2 Location, Access and Site Features

The Waste Control Specialists, LLC., By-product Material Disposal Facility License Application (R05807) Volume 1, Figure 1.5, indicates the proposed by-product facility is located on WCS property entirely within Section 25, Block A-29, Public School Land, Andrews County, Texas. The by-product facility is further described by metes and bounds survey in Application Volume 2, Appendix 1 D, Attachment 6, as containing contains 36.39 acres. Based on the applicant's plotted location upon the Eunice NE, USGS, 7.5 minute topographic map, 1969 edition, photorevised to 1979; the approximate center of the by-product license is North 32 ° 26 ' 40 " Latitude, West 103 ° 03 ' 43 " Longitude, as characterized by the 1927 North American Datum.

The facility may be accessed by traveling approximately 32 miles, west north west from Andrews, Texas, on Texas State Highway 176 and then turning north onto State Line Road just inside the Texas - New Mexico border. The WCS facilities are located immediately north of SH 176. The proposed by-product facility will include a waste receiving and storage area, by-product landfill and necessary ancillary equipment and structures. The applicant states that the application is based upon the technical

requirements as specified in 25 Texas Administrative Code §289.260(o). The applicant further states in Volume 1, Section 1.0, page 1-1, that Table 1.1 is a cross reference between the requirements of 25 TAC §289.260 and the application location(s) satisfying said regulatory requirements.

The facility is adjacent to other WCS licensed facilities on approximately 23 contiguous square miles of WCS owned land. The adjacent facilities include a Class III radioactive waste processing and storage facility (L04971) and a hazardous waste treatment, storage and disposal facility (HW-50358). WCS has pending applications to receive low level radioactive waste and mixed low level from federal facilities and Texas - Vermont Compact low level radioactive waste. The By-product Facility is located east of, and adjacent to, the National Enrichment Facility currently under construction in New Mexico.

The proposed by-product disposal facility will be located on what is known as the red bed ridge, a broad gently sloping topographic high, generally oriented northwest-southeast, which drains to the southwest toward Monument Draw in New Mexico. The depth of the waste disposal and the low topographic surface relief around the landfill combined with the naturally occurring caprock will mitigate the potential for erosion impacting the by-product disposal facility.

Disposal in the proposed facility is reported to occur completely below the top of the Triassic Dockum red beds, a laterally extensive (tens to hundreds of miles) and very thick (greater than 1,000 feet) massive clay and sandstone/siltstone formation. Caprock caliche, sands and gravels of the undifferentiated Ogallala, Antlers and Gatuña formations (OAG) extend from the surface to the top of the red beds. In the immediate area of the by-product landfill, the OAG ranges in thickness from about 18 feet to approximately 32 feet.

The by-product disposal facility will be excavated through the caliche (OAG) overburden soil into the underlying red bed. The placement and disposal of waste will occur only within the red bed from about 18 feet below ground level to approximately 100 feet below ground level.

In the geotechnical report, the applicant reports the first water bearing saturated zone is approximately 90' below the bottom of the disposal facility and that due to the relative impermeability of this zone, sufficient quantities of water cannot be produced for domestic or industrial uses.

The applicant reports the first sandstone capable of providing usable quantities of water is the Trujillo Formation. The top of the Trujillo is approximately 600 feet below ground level and about 100 feet thick. The red beds extend to approximately 1,140 feet below ground level to the top of Santa Rosa sandstone. At the applicant's site, the Santa Rosa extends down to approximately 1,400 feet below ground level and is the base of the Triassic Dockum formation,

The applicant reports the Triassic Dockum red bed formation is composed primarily of hard, virtually impermeable clay interspersed in the upper portion with hard and relatively impermeable thin siltstone and sandstone stringers and layers. The landfill containment system will consist of the in situ red bed clays and siltstone/sandstone materials, three feet of recompacted select red bed clay, a 60 mil (defined as 1/1000th of an inch, or 0.001 inch thickness) high-density polyethylene (HDPE) geomembrane, a geonet leak detection

system, another 60 mil HDPE geomembrane, a geocomposite consisting of a geonet with a geotextile bonded to it, and two feet of protective granular soil. The applicant reports the hydraulic conductivity of the in situ clay has been demonstrated to range from approximately 10^{-8} centimeters per second (cm/sec) to 10^{-9} cm/sec. The reported hydraulic conductivity of the sandstone/siltstone zones generally range from approximately 10^{-7} cm/sec to 10^{-8} cm/sec. The hydraulic conductivity of the recompacted select red bed clay has been demonstrated to consistently range from approximately 10^{-8} cm/sec to 10^{-9} cm/sec.

The applicant reports the minimum cover thickness above the waste will be approximately 18' and exceeds the minimum requirement for an effective radon barrier. The cover minimizes surface water infiltration because of the low conductivity of the compacted red bed clay. A capillary break (granular drainage layer) is below the upper compacted clay layer, and placed over a 60 mil HDPE geomembrane on top of a 3 inches recompacted clay layer. The granular drainage layer is tied into the naturally occurring OAG layer on top of the red bed formation. The granular layer is intended to drain moisture away from the landfill into the OAG.

The nearest property line is over a half mile from the by-product material disposal facility. The nearest residence is approximately 3.5 miles from the disposal facility. The closest active commercial/industrial operations are over a half mile from the by-product facility.

5.1.3 Facility Design Features

The applicant's landfill cross sections in Vol. 1, Figure 3.6, indicate excavation will be approximately 100 feet below natural grade into the red bed clay and all waste will be disposed within Triassic Dockum formation. The excavation will have a constructed engineered liner consisting of 3 feet of select red bed clay compacted to a hydraulic conductivity of $1x10^{-7}$ cm/sec, or less. A 60 mil smooth high density polyethylene (HDPE) liner will be placed on top of the constructed soil liner. Then a geonet leak detection layer will be placed followed by another 60 mill smooth HDPE liner. A 10-ounce bonded geonet geotextile will then be placed as a leachate collection layer. Finally, a 2 feet layer of granular protective soil will be placed. The sidewalls will be similar except it will utilize a 6-ounce geotextile bonded to both sides of a geonet incorporating both leak detection and leachate collection into opposite sides of the same membrane. Also, an 8-ounce geotextile or 8 mil geomembrane will be utilized as ultraviolet protection until granular protective soil may be placed over the sidewall.

5.1.3.1 Slope Stability Analysis

The By-product Material Disposal Facility Stability of Excavation Slope Analysis is presented by the applicant in Volume 3, Appendix 3.2.A, Attachment 1. The analysis was prepared for Cook-Joyce, Inc. and sealed by Michael M. Shiflett, P.E., of the Fort Worth office of Kleinfelder dated January 9, 2007. The slopes were analyzed using SLOPE/W software [3] by Geo-Slope International. The computer modeling utilizes a conventional circular type failure plane.

The soil strength and properties used for the analysis are:

Material	Unit Weight PCF	Cohesion PSF	Friction ANGLE Degrees
Redbed Clay	135	260	36
Sand & gravel	125	0	38
Cemented soil	120	200	36

Conservative soil parameters were chosen from the laboratory test results of on site investigations by Kleinfelder.

Kleinfelder reports the subgrade was modeled as a cemented soil layer over the sand and gravel layer underlain by the red bed clay. Borings taken within the proposed By-product Landfill area show that about 12 feet to 29 feet of cemented sands and silts with layers of caliche and soft limestone overlie approximately 3 feet of silty sand and gravel underlain by the reddish brown sandy (red bed) clay. Since the cemented soil layer has lower soil strength parameter compared to the red bed clay material, and the thicker the weak material, the lower the factor of safety, the depth of the cemented soil layer was selected as 27 feet in their analysis in order to be more conservative.

The slope is 1:1 through the cemented soil and sand and gravel layers to a depth of 30 feet from existing ground surface to the red bed clay. The slope through the red bed clay is 2 Horizontal to 1 Vertical (2H:1V) to a depth of 100 feet below existing ground surface. A 50 feet wide horizontal bench will be constructed between the two slopes.

A minimum factor of safety of 1.51 was reported for the 1:1 slope through the cemented soil and sand and gravel.

A minimum factor of safety of 1.98 was reported for the 2H:1V slope in the red bed clay.

Kleinfelder reported Borings B35 and B36, about 100 feet north of the landfill excavation, indicate a sand and gravel layer. However, this layer is not encountered in other borings. The slope stability is recalculated with the following results in the event this sand and gravel layer is not present in all locations.

A minimum factor of safety of 1.63 was reported for the 1:1 slope through the cemented soil and sand and gravel

A minimum factor of safety of 1.98 was reported for the 2H:1V slope in the red bed clay.

Kleinfelder concludes these factors of safety meet or exceed the normally accepted value of 1.5. They further state that during excavation of the landfill, visual observation of the subgrade should confirm that:

- The cemented soil layer is indeed cemented, and the soil shear strength consists of both cohesion

and friction.

- The red bed clay is not jointed. If the clay is jointed, efforts should be made to protect the clay from drying and cracking.

5.1.3.2 Sidewall Liner Stability Analysis

The By-product Material Disposal Facility Sidewall Liner Stability Analysis is presented by the applicant in Volume 3, Appendix 3.2.A, Attachment 2. The analysis was prepared for Cook-Joyce, Inc. and sealed by Michael M. Shiflett, P.E., of the Fort Worth office of Kleinfelder dated January 9, 2007.

The analysis procedure verifies tensile stress by calculating shear forces in the HDPE liner system. It also verifies liner system stability using infinite slope stability analysis [4]. Cohesion in the waste is neglected to produce a conservative calculation. To insure conservative calculation, the calculations have considered as much as 6 feet of waste placed against the sidewall liner as opposed to normal operating practice of placing 2 feet to 3 feet of waste. Site specific interface friction values based on testing results of on site soils and specific proposed geosynthetic materials were used in the analysis.

Kleinfelder reports the impact of seepage and pore water pressure to the soil/geomembrane interface is not considered because of the very low permeability of the red bed clay and constructed clay liner at the cell sidewalls.

Kleinfelder reports the 60 mil textured HDPE geomembrane is stable on the clay liner interface by a factor of safety of 3.4.

Kleinfelder reports the geocomposite drain (double sided) and 60 mil HDPE (textured) geomembrane interface is stable by a factor of safety of 4.5.

Kleinfelder reports the 60 mil HDPE (textured) geomembrane is stable on the geocomposite (double sided) by a factor of safety of 4.5.

Kleinfelder reports the resistance of the geocomposite drain (double sided) is stable on the 60 mil HDPE textured geomembrane by a factor of safety of 4.5.

Kleinfelder reports the soil and waste is stable on the geocomposite drain (double sided) by a factor of safety of 1.5.

Kleinfelder reports all the factors of safety meet or exceed the minimum required value of 1.5.

Two feet of granular protective soil cover will be placed over the liner system. During construction this may be as much as three feet. Three feet of soil protective cover without waste support is analyzed for a conservative factor of safety.

Kleinfelder reports 3 feet of protective soil without waste support produces a factor of safety of 2.8 at the 60 mil HDPE (textured) geomembrane clay liner interface.

At interfaces 2, 3 and 4 [geocomposite drain (double sided) and HDPE (textured) geomembrane interface] the reported factor of safety is 3.7.

Kleinfelder reports since the calculated factors of safety exceed 1.5, the liner system is stable as designed.

5.1.3.3 Anchor Trench Design

The By-product Material Disposal Facility Anchor Trench Design Analysis is presented by the applicant in Volume 3, Appendix 3.2.A, Attachment 3. The analysis was prepared by Yanfeng Li, EIT, of the Fort Worth office of Kleinfelder dated January 11, 2007, and sealed by Brian Dudley, P.E., of Cook-Joyce, Inc. on January 12, 2007.

As it is much easier to observe and repair an anchor trench failure than a sideslope geomembrane liner failure; it is desirable to have the anchor trench fail first.

It is reported that the factor of safety against sideslope liner failure is 1.3 and is considered adequate.

The factor of safety against soil block failure due to the resulting shear forces is reported as 1.6 and is also considered adequate.

5.1.3.4 Seismic Slope Stability

The By-product Material Disposal Seismic Analysis is presented by the applicant in Volume 3, Appendix 3.2.A, Attachment 4, Exhibit 3. The analysis was prepared for Cook-Joyce, Inc. and sealed by Michael M. Shiflett, P.E. (TX # 43763), of the Fort Worth office of Kleinfelder dated January 12, 2007. The report was actually prepared for Cook-Joyce, Inc. by Kleinfelder California registered professional engineers Cristiano Melo (CA PE # 64025) and R. Jeffrey Dunn, Ph.D. (CA PE # 29128) and signed by Betsy Buchner. Unlike Texas, California professional engineering licensing requires demonstrated competency in earthquake resistant design. The use of California Licensed Professional Engineers with seismic experience is considered acceptable as Texas Licensed Professional Engineers are not required to demonstrate competency in this field. In additions, federal regulations such as NUREG recognize the equal validity of every state's Professional Engineering licensing. This report was partially based upon Seismic Hazard Evaluation and Development of Seismic Design Ground Motions For the WCS Waste Disposal Facility by URS Corporation dated July 28, 2004 [5].

Kleinfelder reported the purpose of the evaluation was to address 25 TAC §289.260(o)(8)(J), which states," The impoundment shall not be located near a capable fault that could cause a maximum credible earthquake larger than that which the impoundment could reasonably be expected to withstand".

Kleinfelder further states that they understand impoundment is synonymous with landfill for the purposes of this project. The maximum credible earthquake is typically defined as an earthquake with a 10% probability in 50 years (475 year return period).

Kleinfelder reports that the July 28, 2004 Seismic Hazard Evaluation and Development of Seismic Design Ground Motions for the WCS Waste Disposal Facility in Andrews County prepared by URS Corporation for this site states there are no known Quaternary age (younger than 1.6 million years) faults within 100 km of the site. Using probabilistic seismic hazards analysis, URS's report estimated the peak horizontal acceleration for a 2,500 year return period (2% probability of exceedance in 50 years) for this site is 0.05g, which is associated with an earthquake magnitude of M 5.5. The peak horizontal acceleration of 0.05g for this site is very low compared to more seismicly active areas such as California or Japan where anticipated peak horizontal accelerations can approach 1.0 g. Kleinfelder reports that the 0.05 g peak horizontal acceleration is considered a conservative value and is actually higher than the anticipated maximum credible earthquake.

Kleinfelder reports that due to the flatness of the final landfill slope configuration, the low seismicity of the site and the lack of Quaternary age faults within 100 kilometers of the site, it is Kleinfelder's professional opinion that the seismic slope stability of the final landfill closure surface should be more than adequate to handle the anticipated maximum credible earthquake for this site.

Furthermore, Kleinfelder states that performance studies of lined landfills in California subjected to larger earthquakes have indicated that both operating and closed landfill facilities have performed very well with minimal or no damage. This has included the lining, final cover and land leachate collection systems. This reinforces Kleinfelders conclusion that the WCS facility should withstand a design earthquake.

5.1.3.5 Pipe Analysis

The By-product Material Disposal Facility Pipe Analysis is presented by the applicant in Volume 3, Appendix 3.2.A, Attachment 5. The structural stability of the proposed leachate collection and leak detection systems was evaluated and sealed by Diana G. Dworaczyk, P.E., of Cook-Joyce, Inc. on May 16, 2007.

The evaluated piping included: 6-inch leachate collection (perforated HDPE DR7), 6-inch leachate collection cleanout riser (HDPE DR9), 20-inch leachate extraction riser (HDPE DR9), 24-inch leachate extraction sump (perforated HDPE DR9), 8-inch leak detection sump (perforated HDPE DR7), 8-inch leak detection riser (HDPE DR9) and 4-inch leak detection (perforated HDPE DR9). The piping was evaluated under both short term and long term structural and hydraulic loading of anticipated construction, operating and closure conditions [6,7].

Cook-Joyce, Inc. reports all pipe types and sizes specified are suitable for use, exhibiting acceptable factors of safety against wall crushing, ring deflection and buckling [6,7]. The pipes remain structurally

stable for both short term and long term assumed conditions. The pipes also provide adequate flow capacity with a factor of safety of 1.5.

5.1.3.6 Geotextile Analysis

The By-product Material Disposal Facility Geotextile Analysis is presented by the applicant in Volume 3, Appendix 3.2.D, Attachment 1. The Geotextile Analysis was reviewed by sealed by J. Brian Dudley, P.E., of Cook-Joyce, Inc. on May 16, 2007.

The geotextile function is to prevent clogging of the geonet drainage layer and to protect the geomembrane from puncture. The criteria for geotextile evaluation are: Soil retention; Long term flow performance at geocomposite drainage layer and leachate collection trench, and; Resistance to puncture and to protect the geomembrane.

Two geotextiles in the landfill do not require the above characteristics. One is the 8 ounce geotextile between the soil lateral drainage layer and the overlying clay fill which simply facilitates compaction of the clay fill on a granular subgrade. The other is the 8 ounce temporary ultraviolet light protective cover on the sideslopes which will be replaced in stages with protective soil cover as the waste level rises in the landfill.

The analysis and report states that all selected geotextiles meet the apparent opening size criteria and are acceptable. The analysis and report states all individual capacity reduction factors have been applied to the leachate collection system and a calculated factor of safety greater than 2.0 remains for the pipe trench geotextile.

The report further states the geomembrane/geotextile systems used in the design are adequately protective against liner puncture during construction and service life of the membrane with an operations loading factor of safety exceeding 3.0. The report concludes that the evaluated geotextile filter fabrics are adequate, protective of the geomembrane and can allow proper flow of the leachate without clogging based upon the three criteria analyzed: soil retention, long term flow performance at the leachate collection layer and the leachate collection trench.

5.1.3.7 Leachate Collection System Analysis

The By-product Material Disposal Facility Leachate Collection System Analysis is presented by the applicant in Volume 3, Appendix 3.2.D, Attachment 2. The proposed leachate collection was designed and sealed by Diana G. Dworaczyk, P.E., of Cook-Joyce, Inc. on May 17, 2007.

Cook-Joyce reports that the designed leachate collection system consists of a geocomposite and geonet over a HDPE geomembrane. The geocomposite is overlain by a 24-inch granular protective cover soil layer in all cells of the landfill. Each disposal unit slopes to the center and the leachate drains into a perforated leachate collection pipe located along the cell centerline. The leachate collection pipes drain

toward the leachate collection sump located at the north end of each cell. The leachate collection system should be designed, constructed and operated to collect and remove leachate from the disposal unit during its active life and the post-operational period to minimize leachate depth over the top liner [8,9].

The By-product Material Disposal Facility Leachate Collection System Analysis presented by the applicant is further supported by the Impingement Rate Analysis [10] in Volume 3, Appendix 3.2.D, Attachment 2, Exhibit 4. The Impingement Rate Analysis was also prepared and sealed by Diana G. Dworaczyk, P.E., of Cook-Joyce, Inc. on January 11, 2007.

The maximum simulated peak daily percolation rate is 1.99 inches per day during initial operation of the disposal unit A & B. The maximum simulated peak daily percolation rate during active operation, when disposal unit A & B are full and awaiting final cover placement, is 0.0861 inches per day.

The leachate collection system was designed with a HELP model [10] simulation with the 25 year, 24 hour rainfall of the wettest week of the wettest five years on record with no storm runoff and a range of sand characteristics. This produces a conservative design.

The HELP input and output modeling data is presented as a CD marked Revision 13, 12 January, 2007, Appendix 3.2.D, Attachment 2, Exhibit 4, Annex 6 in Volume 3.

5.1.3.8 Leak Detection System Analysis

The By-product Material Disposal Facility Leak Detection System Analysis is presented by the applicant in Volume 3, Appendix 3.2.D, Attachment 3. The Leak Detection System Analysis [11] was prepared and sealed by Kathy L. McGee, P.E., of Cook-Joyce, Inc. on May 17, 2007.

The report states that WCS will routinely measure and record the amount of liquids removed from the leak detection sumps. During the active life and closure period of the By-product Material Landfill, the volume of liquid removed from each sump will be recorded on at least a weekly basis. During the post-operational period, the quantity of liquid removed from each sump will be recorded on a monthly basis or an alternate frequency approved by DSHS (now TCEQ). The recorded volume for each sump and each measurement period will be evaluated to determine if the Action Leakage Rate (ALR) is exceeded. To provide a conservative trigger level for initiation of the Response Action Plan, the ALR for the By-product Landfill has been established at 75% of the calculated leakage rate.

5.1.3.9 Liquids Removal System Analysis

The By-product Material Disposal Facility Liquids Removal System Analysis is presented by the applicant in Volume 3, Appendix 3.2.D, Attachment 4. The Liquids Removal System was sealed by J. Brian Dudley, P.E., of Cook-Joyce, Inc. on January 12, 2007.

The Liquids Removal analysis is to verify that the leachate sump is adequately sized for proper operation

of the leachate removal pumps and to identify representative pumps that have adequate pumping capacity and size to fit inside the riser and extraction pipes. The volume of the leachate collection sump and the leachate removal pump have been designed so that adequate capacity for leachate containment is provided without frequent cycling of the liquid removal pump. The pump is assumed to switch on when the liquid level rises to the midline of the 6" leachate collection pipe. Under this condition, leachate from the landfill floor geocomposite will always drain into the leachate collection trench and pipe without the leachate level rising above the landfill floor elevation. Pumps may vary from those analyzed so long as the clearance and pumping rate requirements are met.

5.1.3.10 Response Action Plan

The By-product Material Disposal Facility Response Action Plan is presented by the applicant in Volume 3, Appendix 3.2.D, Attachment 5, and is dated 21 June 2004, with revisions in September 2005, April 2006, and 12 January 2007.

The Response Action Plan is a site specific plan that is developed to address leakage that may occur through the primary liner to assure that it does not migrate out of the unit. The design of this liner system is consistent with the technical requirements and guidance applicable to hazardous waste landfills. The action leakage rate (ALR) is the maximum leakage rate that can be removed by the leak detection system (LDS) without the head on the secondary liner exceeding one foot. If the ALR is exceeded, then the RAP outlines the actions that should be implemented to reduce leakage rate below ALR, evaluate the effectiveness of these actions and, if necessary, modify the response to improve effectiveness. The RAP also requires a written preliminary assessment to be submitted to TCEQ within 30 days of WCS determining that the ALR has been exceeded. Within 60 days of initial notification, WCS will submit a detailed report on actions, responses, proposed responses and leak characterization. Further reports will follow on a quarterly basis as long as flow rate exceeds the ALR.

5.1.3.11 Landfill Contact Water Management

The By-product Material Disposal Facility Landfill Contact Water Management is presented by the applicant in Volume 3, Appendix 3.2.D, Attachment 6, is sealed by Stephen L. Cook, P.E., and is dated May 18, 2007.

The Landfill Contact Water Management will evaluate the water management capability during periods of rainfall in excess of the design storm. The excess water management capability will be evaluated elsewhere as a part of Process Engineering Review.

5.1.3.12 Stormwater Contained by Berm

The By-product Material Disposal Facility Storm Water Contained by Intercell Berm Analysis is presented by the applicant in Volume 3, Appendix 3.3.B, and was prepared and sealed by J. Brian Dudley, P.E., for Waste Control Specialists, LLC on January 12, 2007.

The control of stormwater within the disposal unit excavation is focused on containing and separating uncontaminated runoff from runoff that has been contaminated by contact with waste in the active operations area. The stormwater will be contained adjacent to the intercell berm which is located along the side of each landfill cell. Rainfall collecting in the area between the last constructed intercell berm and the rough cut excavation side slope will be treated as uncontaminated stormwater. Rainfall captured within active disposal units will be contained on the lined cell floor and collected through the leachate collection system. Sufficient volume will be maintained in the active cell between the waste and intercell berm to store runoff from the 100 year, 24 hour design storm. Prior to the time that waste placement in the active cell reaches a point in the cell which would reduce the storage volume below that required for storage of the design storm, the next cell shall be lined and certified for use.

The report concludes that for the 100 year, 24 hour design storm:

- Uncontaminated runoff can be contained within a 20 feet or larger offset between the toe of excavation and the toe of the intercell berm;
- The volume of stormwater contacting the waste disposal area can be contained within a 30 feet or larger offset between the waste and the toe of the intercell berm (except that a minimum 40 feet offset is required for Cell F berm);
- Contaminated water containment for waste offsets larger than either 30 feet or 40 feet (as stated above) is adequate as the intercell berm is not overtopped. This includes the condition where the cell is just beginning to receive waste and almost all of the cell is available for runoff containment.

5.1.3.13 Sprinkler Specifications

The By-product Material Disposal Facility Sprinkler Specifications is presented by the applicant in Volume 3, Appendix 3.3.C, and will be reviewed in Process Engineering.

5.1.3.14 Contact Water Tank Design

The By-product Material Disposal Facility Contact Water Tank Design Analysis is presented by the applicant in Volume 3, Appendix 3.3.D, and was prepared and sealed by Mark S. Day, P.E., of URS for Waste Control Specialists, LLC on January 5, 2007. The Contact Water Tank Design will be reviewed in Process Engineering.

5.1.3.15 HDPE Compatibility

The By-product Material Disposal Facility Landfill HDPE evaluation [12,13] of chemical and radiological compatibility is presented by the applicant in Volume 3, Appendix 3.2.E. For purposes of worst case evaluation, the significantly higher radionuclide content of the Fernald waste was used to determine the potential radiation exposure to the HDPE. Chemical compatibility was assessed using published literature.

The report states that HDPE will not have any significant changes in its physical properties or adverse effects due to gamma radiation from the waste for at least 200 years after closure and even up to 1,000 years. The report further states there should be no adverse effects to the HDPE from the beta radiation for more than 1,500 years. No published data was available for effects of alpha radiation on HDPE. The report concludes that the expected leachate should have no detrimental effect on the performance of the HDPE.

5.1.3.16 Stability of Final Cover

The By-product Waste Facility Stability of Final Cover, Transition and Waste Slope Analysis is presented by the applicant in Volume 3, Appendix 3.2.A, Attachment 6. The analysis was prepared for Cook-Joyce, Inc. and sealed by Yanfeng Li, P.E., of the Fort Worth office of Kleinfelder dated May 18, 2007.

The slopes were analyzed using SLOPE/W software[3] by Geo-Slope International. The computer modeling utilizes a conventional circular type failure plane.

The cross sections modeled were representative of the applicant's design. The slope for the final cover back to active disposal units is 2H:1V to a depth of 33 feet below final top cover. The slope for by-product waste operating face is assumed to be 4H:1V to a depth of 70 feet below top of red bed clay. A minimum of 100' horizontal separation will be maintained between the slopes.

The facility design indicates six layers in the 33' final cover as described previously. From top to bottom, the final cover layers are: 3 feet of fine-grained evapotranspiration layer cover soil, 4 feet of caliche material, 8 feet to 16 feet of non-select red bed clay material, 2 feet of lateral drainage sand, a 60 mil HDPE geomembrane, 3 feet of select red bed clay and 1.5 feet to 8 feet of non-select red bed leveling clay. The waste below these layers is expected to be a mixture of soil, concrete rubble and rock like materials.

Both red bed clay materials will be excavated on site and the select red bed clay will have larger particles such as silt stone and gravel removed. Both select and non-select red bed clay are to be compacted to at least 95% of Standard Proctor and will have a hydraulic conductivity of 1×10^{-7} cm/sec or less. The soil strength parameters were selected from lower values of triaxial test results in the report.

A minimum factor of safety of 2.3 was determined for the 4:1 by-product waste slope.

A minimum factor of safety of 2.1 was determined for the 2:1 final cover transition slope.

These factors of safety exceed the normally accepted value of 1.5 therefore they are acceptable..

5.1.4 Waste Retention Ponds or Waste Cells

The disposal unit is subdivided into approximately north-south oriented cells starting with Cell A on the east side and continuing alphabetically through Cell F on the western side. The six individual waste cells are sloped downward at 1% grade to the North and a 2% cross slope to their individual center line yielding a composite slope of 2.24% in a northerly direction. The North end of each cell has a leachate collection and a leak detection sump. The intercell berm top is a constant elevation 2 feet to 7 feet above the sloping cell floor. The berm is designed to prevent stormwater from entering adjacent cells.

When a cell is filled with waste; the top of the waste will be 18.5' to 34' below the surface of the landfill.

The constructed cover over the waste starts with a 3 feet thick compacted select red bed clay overlain with a 60 mil HDPE geomembrane. A 2-footgranular drainage layer will then be placed followed by two non-select red bed clay layers as grading and leveling fill. Then a barrier layer composed of mixed caliche boulders, cobbles and fines will be placed. Finally an evapotranspiration cover of sand filter, fine grained soil and a surface layer of rock mulch will be placed. Contours of top of waste, top of performance cover and final ground surface are depicted in Vol 1, Figures 3.3, 3.4 and 3.5.

5.2 INFRASTRUCTURE

The by-product disposal facility entry gate and guard house are approximately 6,800 feet North of SH 176 on an access controlled State Line Road and are in the northwest corner of the by-product disposal license area. Along the northern edge of the by-product facility arranged in linear fashion, are the overhead inspection station, incoming container staging area, two 60' diameter contact water tanks, concrete surfaced outgoing container staging area covered by a 80' wide, 30' high metal building with upper 14 feet enclosed and a 60 feet by 32 feet by 30 feet high metal container decontamination building with caliche access areas. The buildings are not actually designed but are roughly specified so that they may be ordered from a prefabricated steel building catalog. Typically, the building manufacturer provides turnkey design and erection services to fit the site specific conditions such as size, soil/foundation and wind resistant design. This is considered standard industry practice and the resultant buildings are satisfactory for the purposes specified.

Immediately to the south is the approximately 16 acre by-product landfill consisting of six side by side disposal units. Each unit is typically 125 feet x 756 feet and covers 2.2 acres except for the east and west end cells of 3.4 and 4.0 acres. The applicant reports a total waste disposal capacity of 1,169,000 cubic yards (CY). The applicant also reports that a waste acceptance rate of 39,000 CY/year would result in a life cycle of approximately 30 years. WCS made a verbal representation at a meeting on August 3, 2007, that some form of storm water collection / filtration system will be added to the contact water system at a future date.

5.3 CONSTRUCTION OF THE PROPOSED FACILITY AND QUALITY ASSURANCE PLAN

The By-product Waste Facility Construction Quality Assurance Plan is presented by the applicant in Volume 3, Appendix 3.2.B. The construction quality assurance plan prepared and sealed by J. Brian Dudley, P.E., of Cook-Joyce, Inc. on May 16, 2007.

The construction quality assurance plan (CQA) is to provide the controls to ensure that the by-product material landfill liner, leak detection and leachate collection systems, and final cover are properly built in accordance with the approved engineering design, TCEQ license requirements, acceptable industry practice, applicable technical data and the construction quality assurance plan.

Specific construction requirements in the plan include:

- Soils, equipment and construction methods (including elevations and grades) for fill, compacted clay liners, geosynthetics, protective and final cover systems, gravel, anchor trench backfill, erosion resistant and bio-intrusion barrier and evapotranspiration layer,
- Guidance for testing soils and geosynthetics,
- Reporting standards and documentation for Construction Certification Report.

The CQA requires that the low permeability clay liner and clay performance cover shall have continuous on site inspection during construction by a geotechnical professional or qualified engineering technician under direct supervision of the geotechnical professional. All field sampling and testing, both during construction and after completion of the low permeability clay liner and performance cover construction, shall be performed by geotechnical professional or a qualified engineering technician under his supervision.

The CQA requires that the low permeability clay liner and performance cover must possess a hydraulic conductivity no greater than $1x10^{-7}$ cm/sec, a liquid limit (LL) not less than 30, and a plasticity index (PI) not less than 15. The percent of soil fines passing the #200 sieve must be at least 30%. All of the soil material must pass the one inch sieve and shall not contain rocks or stones that total more than 10% by weight. TCEQ staff plans to be on site during liner construction.

5.4 SURFACE HYDROLOGY IN RELATION TO FLOODING

The land around the by-product material disposal facility excavation generally slopes from north to south. The northern side of the landfill is the only side to receive surface water runoff from off site drainage basins. A two foot high, twelve foot wide temporary diversion berm will direct surface water around the disposal facility during construction and operation. It has side slopes of 3H:1V. After the disposal facility

final cover is placed, a triangular diversion ditch will effectively be created serving the same function where the north edge of the crowned final disposal facility cover intersects the natural grade which is sloping downhill towards the landfill. There is a natural highpoint along the north edge of the landfill that creates a split in the diversion ditch directing some of the intercepted runoff to the east around the landfill and some of the intercepted runoff to the west around the disposal facility.

The upstream contributing basin is about 16.1 acres. This area is located north of the disposal facility excavation. There is a drainage divide that intersects the temporary perimeter berm and final landfill cover. A smaller portion of the upstream contributing drainage basin is diverted around the excavation to the east. This drainage basin is about 3.7 acres. The remaining 12.4 acres of upstream contributing drainage basin are intercepted by the temporary perimeter berm and diverted to the west around the excavation.

5.4.1 Flood Plain Study

The By-product Material Disposal Facility Flood Plain Study is presented by the applicant in Volume 2, Appendix 2.C, including Attachments A through C, and was prepared and sealed by Frederick H. Haas, P.E., for Waste Control Specialists, LLC on January 9, 2007.

A draw flowing from east to west crosses the southern portion of the WCS property north of State Highway 176 and south of the proposed by-product material disposal facility. The watershed contributing to this draw contains about 1350 acres. There is also a playa depression east northeast of the proposed by-product disposal facility near the northeast corner of WCS property. Approximately 680 acres drains into this depression.

The Federal Emergency Management Agency has published no flood hazard maps for this area.

The hydrologic analysis of these features was done using standard techniques including Soil Survey of Andrews County, USDA Soil Conservation Survey TR-55 *Urban Hydrology for Small Watersheds*, HEC-HMS and HEC-RAS.

The analysis indicates that runoff from a 100 year storm event which enters the playa depression does not exit the playa and therefore does not contribute to flow in the draw.

The 100 year analysis indicates flow from the draw will have a maximum depth of 1 foot over the site access road where six 29 inch by 18 inch corrugated metal arch culverts are located. The 100 year floodplain in the draw is shallow and wide with average depth about 1 foot and average width about 350 feet with a flow about 4 feet per second (fps).

There is no impact from a 100 year rainfall event on the proposed by-product material disposal facility as the northern limit of the 100 year floodplain is approximately 3,000 feet southeast of the proposed by-product disposal facility.

5.4.2 Control of Surface Water

The By-product Material Disposal Facility Control of Surface Water Run On During Operation and Surface Water Run On and Run Off at Post Closure Analysis is presented by the applicant in Volume 3, Appendix 3.3.A, and was prepared and sealed by Frederick H. Haas, P.E., for Waste Control Specialists, LLC on May 16, 2007.

The operational drainage analysis results in a depth of flow behind the berm of 0.5 feet for eastern drainage (7 cubic feet per second (cfs) with velocity of 0.6 fps) and a depth of flow of 0.6 feet (17 cfs and velocity of 0.9 fps) to the west. The capacity of the section behind the berm at depth of 2 feet is about 410 cfs which exceeds the calculated 100 year runoff of 17 cfs intercepted by the berm.

The post closure drainage analysis results in a depth of flow of 0.4 feet (7 cfs at 0.6 fps) to the east and a depth of flow of 0.5 feet (21 cfs at 1.1 fps) for the west drainage basin.

5.4.3 Erosion Protection

The By-product Material Disposal Facility Erosion Protection for Long Term Stability Analysis is presented by the applicant in Volume 3, Appendix 3.2.C. The Erosion Protection for Long Term Stability Analysis was prepared and sealed by Frederick H. Haas, P.E., for Waste Control Specialists, LLC on May 16, 2007.

The report analyzes the by-product landfill and the diversion ditches upstream of the landfill created by the slope of the final cover. The report states that the design conforms to the guidance outlined in *Design of Erosion Protection for Long-Term Stabilization Final Report,* U.S. Nuclear Regulatory Commission, T.L. Johnson, September, 2002 (NUREG-1623).

The report states that the land use for the area upstream of the disposal facility is undeveloped. The cover type in this area is desert shrub and the hydrologic condition is poor. The disposal facility will be covered with gravel rip rap and will eventually have vegetation growing through it such that the cover system will be similar to the surrounding soil group, cover type and hydrologic condition.

The HEC-HMS model for the disposal facility cover results in maximum Probable Maximum Flood (PMF) for the basins as follows: Basin N1 (draining north and east) 2 cfs, Basin N2 (draining north and west) 11 cfs, Basin S1 UP (upstream portion draining south) 48 cfs, Basin S1 DWN (downstream 2% slope portion draining south) 60 cfs, Basin E1 (draining east) 9 cfs, and Basin W1 (draining west) 20 cfs. The HEC-HMS model for the diversion ditches results in maximum PMP flow of 17 CFS diverted to the east and 62 cfs diverted to the west. The final cover of the disposal facility is crowned so there is runoff from the cover in all directions back to existing grade.

The calculations show that a representative rock size of 0.25 inches is adequate to protect the final cover.

A representative rock size of 0.5 inches is chosen for the rip rap over the final cover. This has a safety factor ranging from 2.7 to 9. A minimum thickness of 1.0 inches of rip rap is established by NUREG-1623. To facilitate construction the rip rap thickness may be increased.

Based on the Probable Maximum Flood, the flow velocity and hydraulic radius were estimated by Manning's equation and checked against NUREG-1623. NUREG-1623 recommends a maximum of 2.5 to 3.0 feet per second (FPS) and the calculated maximum PMF velocity was reported as 1.6 FPS. The calculated tractive forces for the PMF were less than the allowable tractive force for the 0.5" rip rap.

5.5 SUBSIDENCE MONITORING

The By-product Material Disposal Facility Settlement Analysis is presented by the applicant in Volume 3, Appendix 3.2.A, Attachment 4, Exhibit 1. The analysis was prepared for Cook-Joyce, Inc. and sealed by by Yanfeng Li, P.E., of the Fort Worth office of Kleinfelder dated May 18, 2007.

Typical landfill settlement is composed of mechanical and decompositional settlement. As the by-product disposal facility is expected to accept a combination of soil, concrete rubble and rock material; long term settlement due to decomposition will not predominate. The landfill is subdivided into approximately north-south oriented cells starting with Cell A on the east side and continuing alphabetically through Cell F on the western side. Cells A and B will first receive the Fernald canisters and then by-product waste, while cells C through F will only receive by-product waste. Therefore the two sets of cells will be analyzed separately.

Cells C through F will accept 70 feet of waste with 33 feet of cover resulting in a maximum design thickness of 103 feet of total fill. The mechanical settlement of cells C through F due to consolidation during filling is estimated as 4.6 feet. Settlement of bulk solid waste due to consolidation is estimated as 0.12 feet and creep settlement during filling is anticipated to be 0.62 feet. Postclosure creep settlement is estimated at 0.25 feet after 100 years, 0.33 feet after 200 years and approaching 0.45 feet after 500 years for cells C through F. Landfill postclosure creep settlement is usually defined at 100 years. For a more conservative estimate, the applicant utilized a postclosure creep settlement estimate at 200 years which produced a total mechanical settlement of 5.55 feet during operation and postclosure. Only 0.33 feet of this total mechanical settlement is anticipated 200 years after closure of cells C through F.

Decompositional settlement of cells C through F as a result of consolidation of voids inside containers is calculated at 0.26 feet and an additional 0.03 feet for consolidation of voids outside containers. Consolidation of waste inside containers is estimated at 0.25 feet yielding a total decompositional calculated settlement of 0.54 feet after 100 years.

Therefore total settlement for cells C through F, 100 to 200 years after disposal facility closure is projected to be 0.84 feet.

Cells A and B contain 13 feet of Fernald canisters, 5 feet of sand and 33 feet of cover. Waste is projected

to be placed on top of the canisters over a 9 year period at a theoretical rate of 0.5 feet per month. Mechanical settlement of cells A and B due to consolidation during filling is calculated to be 3.7 feet. Creep settlement during filling is projected to be 0.46 feet and postclosure creep settlement is calculated to be 0.29 feet. This yields a total mechanical settlement for cells A and B during operation and postclosure to be 4.45 feet. Since bulk solid waste is 90% of the waste volume in cells A and B; the postclosure mechanical settlement is estimated to be 0.26 feet with 4.0 feet of operational mechanical settlement.

Decompositional settlement of cells A and B is estimated to be 0.35 feet due to consolidation of voids inside containers and 0.08 feet due to consolidation of voids outside the containers. Settlement due to consolidation of waste inside the Fernald containers is projected to be 0.7 feet yielding a total decompositional settlement of 1.13 feet.

Total mechanical and decompositional settlement of Cells A and B is calculated to be 5.13 feet of which total settlement after closure of cells A and B is projected to be 1.4 feet.

Kleinfelder (page 14) further states, "Based on the field investigation and laboratory tests results from Reference 6, the on site clay soil that serves as the landfill foundation has relatively high strength (from triaxial tests and unconfined compression tests) and low moisture content. Based on the consolidation test results from Reference 7, the on site clay is overconsolidated.

The settlement will be elastic settlement in short term and the long term plastic settlement may not occur. Actually, there will be some elastic rebound during excavation and also elastic settlement in the short term when the waste and cover are being placed. Long-term plastic settlement after the closure of the disposal facility will not occur.

Obviously, some inspection combined with earthwork fill and grading may be anticipated in the termination phase.

5.6 REGULATORY REQUIREMENTS

Texas regulations at Title 25 Texas Administrative Code Chapter (TAC) 289, Subchapter F, Rule §289.260, Licensing of Uranium Recovery and By-product Material Disposal Facilities imposes specific design requirements upon license applications. Specific regulatory requirements applicable to this review are as follows:

- Texas rule at Title 25 TAC § 289.260(f)(3) states, "Facility drawings submitted in conjunction with the application for a license shall be prepared by a professional engineer or engineering firm. Those drawings shall be final and shall be signed, sealed and dated in accordance with the requirements of the Texas Board of Professional Engineers, 22 Texas Administrative Code, Chapter 131."

In general, this requirement has been met. Some sealed signatures have been annotated for "licensing purposes" in consideration that the design is ongoing. All seals have been signed and dated by currently licensed Texas Professional Engineers except for two California licensed Professional Engineers sealing the Seismic - Earthquake evaluation. This evaluation was also sealed by a Texas licensed Professional Engineer. This is understandable as Texas has no Professional Engineer earthquake competency requirement whereas such competency is part of California's Professional Engineer Licensing Requirement. Also, acceptance of an out of state Professional Engineering License is required under Federal (and hence NUREG) Regulations. Therefore the intent of 25 TAC §289.260(f)(3) has been satisfied.

- Texas rule at Title 25 TAC § 289.260(o)(5) states, "By-product material should be disposed of in a manner such that no active maintenance is required to preserve conditions of the site."

  This raises an issue about potential subsidence. Although the design has been revised to reduce the effects of subsidence after closure; there is still the possibility of subsidence in the central area of the landfill several hundred years or more after closure which might result in a shallow depression collecting water. This could then cause further subsidence. A second issue is the final disposition of the leachate collection and leak detection systems which is not addressed in the application.

  Some fill and grading will be expected at any landfill 50 to 500 years after closure and that this design is a reasonable attempt to minimize future earthwork in the license termination phase.

  Final disposition of the leachate collection and leak detection systems should depend upon their performance and necessity to be determined in the post closure period. If these systems are not properly closed then they could become a conduit for Radon gas to escape. Also, if not properly closed and sealed, the HDPE pipe cannot be expected to last through the license termination phase due to the effects of the sun's radiation.

- Texas rule at Title 25 TAC §289.260(o)(8)(A) states, "The following site and design requirements shall be adhered to whether by-product material is disposed of above or below grade: (A) the upstream rainfall catchment areas shall be minimized to decrease erosion potential by flooding that could erode or wash out sections of the by-product material disposal area;"

  The surface hydraulics are reviewed above, and show that the consultant minimized the possibility of erosion due to flooding by diversion of surface water; hence this requirement is satisfied.

- Texas rule at Title 25 TAC §289.260(o)(8)(B) states, "The following site and design requirements shall be adhered to whether by-product material is disposed of above or below grade: (B) the topographic features shall provide good wind protection;"

  The proposed disposal fcaility is below grade with a final top slope of 1% to 2% at or near grade to

prevent ponding and to match existing slopes. It is covered with riprap to prevent water erosion (a more severe condition than wind) as described in 4.3, above. This requirement is satisfied.

- Texas rule at Title 25 TAC §289.260(o)(8)(C) states, "The following site and design requirements shall be adhered to whether by-product material is disposed of above or below grade: (C) the embankment and cover slopes shall be relatively flat after final stabilization to minimize erosion potential and to provide conservative factors of safety assuring long term stability. The objective should be to contour final slopes to grades that are as close as possible to those that would be provided if by-product material was disposed of below grade. Slopes shall not be steeper than 5 horizontal to 1 vertical (5h:1v), except as specifically authorized by the agency. Where steeper slopes are proposed, reasons why a slope steeper than 5h:1v would be as equally resistant to erosion shall be provided, and compensating factors and conditions that make such slopes acceptable shall be identified;"

  The proposed disposal facility is below grade with a top slope of 1% to 2% at grade to prevent ponding and to match existing slopes. It is covered with rip rap to prevent water erosion (a more severe condition than wind) as described in 4.3, above. This requirement is satisfied.

- Texas rule at Title 25 TAC §289.260(o)(8)(D) states, "The following site and design requirements shall be adhered to whether by-product material is disposed of above or below grade: (D) a full self-sustaining vegetative cover shall be established or rock cover employed to reduce wind and water erosion to negligible levels;"

  As referenced above, the cover will be approximately 0.5 inch diameter rock rip rap with native vegetation eventually growing through it. The voids between the rock rip rap and the native vegetation will both encourage deposition of wind borne material and are erosion resistant. This requirement is satisfied.

- Texas rule at Title 25 TAC §289.260(o)(8)(E) states, "The following site and design requirements shall be adhered to whether by-product material is disposed of above or below grade: (E) where a full vegetative cover is not likely to be self-sustaining due to climatic conditions, such as in semi-arid and arid regions, rock cover shall be employed on slopes of the impoundment system. The agency will consider relaxing this requirement for extremely gentle slopes, such as those that may exist on the top of the pile;"

  As referenced above, the cover will be approximately 0.5 inch diameter rock riprap with native vegetation eventually growing through it. The surface is also an extremely gentle slope. This requirement is satisfied.

- Texas rule at Title 25 TAC §289.260(o)(8)(F) states, "The following site and design requirements shall be adhered to whether by-product material is disposed of above or below grade: (F) the

following factors shall be considered in establishing the final rock cover design to avoid displacement of rock particles by human and animal traffic or by natural processes, and to preclude undercutting and piping:

(i) shape, size, composition, gradation of rock particles (excepting bedding material, average particles size shall be at least cobble size or greater);
(ii) rock cover thickness and zoning of particles by size; and
(iii) steepness of underlying slopes.

- The By-product Material Disposal Facility Erosion Protection for Long Term Stability Analysis is presented by the applicant in Volume 3, Appendix 3.2.C and was referenced in 4.3, and 6.5 - 6.7, above. Human and animal traffic was considered to be negligible due to the remoteness of this arid location. The thickness, sizing and grading of the rip rap to prevent erosion was adequately demonstrated. Undercutting and piping is not an issue in this below grade design. This requirement is satisfied.

- Texas rule at Title 25 TAC §289.260(o)(8)(G) states, "The following site and design requirements shall be adhered to whether by-product material is disposed of above or below grade:(G) individual rock fragments shall be dense, sound, and resistant to abrasion, and shall be free from cracks, seams, and other defects that would tend to unduly increase their destruction by erosion and weathering action. Local rock materials are permissible provided the characteristics under local climatic conditions indicate similar long-term performance as a protective layer. Weak, friable, or laminated aggregate may not be used;"

  The By-product Material Disposal Facility Erosion Protection for Long Term Stability Analysis is presented by the applicant in Volume 3, Appendix 3.2.C and was referenced above. These aggregate qualities are addressed in this referenced analysis. This requirement is satisfied.

- Texas rule at Title 25 TAC §289.260(o)(8)(H) states, "The following site and design requirements shall be adhered to whether by-product material is disposed of above or below grade: (H) rock covering of slopes may not be required where top covers are very thick (on the order of 10 meters or greater); impoundment slopes are very gentle (on the order of 10h:1v or less); bulk cover materials have inherently favorable erosion resistance characteristics; there is negligible drainage catchment area upstream of the pile; and there is good wind protection;"

  The design cover varies from approximately 5.5 to 10 meters thick and the slopes are very gentle with adequate erosion protection; hence this requirement is satisfied.

- Texas rule at Title 25 TAC §289.260(o)(8)(I) states, "The following site and design requirements shall be adhered to whether by-product material is disposed of above or below grade: (I) all impoundment surfaces shall be contoured to avoid areas of concentrated surface runoff or abrupt or sharp changes in slope gradient. In addition to rock cover on slopes, areas toward which surface

runoff might be directed shall be well protected with substantial rock cover (riprap). In addition to providing for stability of the impoundment system itself, overall stability, erosion potential, and geomorphology of surrounding terrain shall be evaluated to assure that there are no ongoing or potential processes, such as gully erosion, which would lead to impoundment instability;"

As referenced in 4.0 through 4.3, above, there are no impoundments on this site and drainage adheres to these requirements. The nearest existing gully draining from the site is across State Line Road from the proposed landfill. The native caliche caprock is resistant to erosion. This requirement is satisfied.

- Texas rule at Title 25 TAC §289.260(o)(8)(J) states, "The following site and design requirements shall be adhered to whether by-product material is disposed of above or below grade: (J) the impoundment shall not be located near a capable fault that could cause a maximum credible earthquake larger than that which the impoundment could reasonably be expected to withstand"

  The Seismic Slope Stability Analysis is referenced in 1.3.4, above. The July 28, 2004 Seismic Hazard Evaluation and Development of Seismic Design Ground Motions for the WCS Waste Disposal Facility in Andrews County prepared by URS Corporation for this site states there are no known Quanternary age (younger than 1.6 million years) faults within 100 km of the site. It is reported that due to the flatness of the final landfill slope configuration, the low seismicity of the site and the lack of Quaternary age faults within 100 kilometers of the site, it is Kleinfelder's professional opinion that the seismic slope stability of the final landfill closure surface should be more than adequate to handle the anticipated maximum credible earthquake for this site. This requirement is satisfied.

- Texas rule at Title 25 TAC §289.260(o)(8)(K) states, "The following site and design requirements shall be adhered to whether by-product material is disposed of above or below grade: (K) the impoundment should be designed to incorporate features that will promote deposition. Design features that promote deposition of sediment suspended in any runoff which flows into the impoundment area might be utilized. The object of such a design feature would be to enhance the thickness of cover over time."

  Due to the rather flat and arid terrain of the entire area, coupled with often high wind velocities, little deposition may be expected other than that caught by voids in rock rip rap and native vegetation. The site is designed to prevent erosion as referenced in 4.0 to 4.3, above. As the cover thickness is not expected to decrease over time, this requirement is considered satisfied.

- Texas rule at Title 25 TAC §289.260(o)(9)(A) states, "Groundwater protection. The following groundwater protection requirements and those in paragraphs (10) and (11) of this subsection and subsection (q) of this section apply during operations and until closure is completed. Groundwater monitoring to comply with these standards is required by paragraphs (28) and (29) of this

subsection. (A) The primary groundwater protection standard is a design standard for surface impoundments used to manage by-product material. Unless exempted under paragraph (9)(C) of this subsection, surface impoundments (except for an existing portion) shall have a liner that is designed, constructed, and installed to prevent any migration of wastes out of the impoundment to the adjacent subsurface soil, groundwater, or surface water at any time during the active life (including the closure period) of the impoundment. If the liner is constructed of materials that may allow wastes to migrate into the liner during the active life of the facility, impoundment closure shall include removal or decontamination of all waste residues, contaminated containment system components (liners, etc.), contaminated subsoils, and structures and equipment contaminated with waste and leachate. For impoundments that will be closed with the liner material left in place, the liner shall be constructed of materials that can prevent wastes from migrating into the liner during the active life of the facility."

The liner system designed for this facility is a typical RCRA Subtitle C design to prevent migration of wastes and is reviewed in detail in several subsections of above sections 1.3 Facility Design Features and 3.0 Construction of Proposed Facility. The civil engineering aspects of this design satisfy the applicable parts of this regulation. Groundwater monitoring itself will be in the geological review.

- Texas rule at Title 25 TAC §289.260(o)(9)(B) states, "Groundwater protection. The following groundwater protection requirements and those in paragraphs (10) and (11) of this subsection and subsection (q) of this section apply during operations and until closure is completed. Groundwater monitoring to comply with these standards is required by paragraphs (28) and (29) of this subsection. (B) The liner required by subparagraph (A) of this paragraph shall be:
  - (i) constructed of materials that have appropriate chemical properties and sufficient strength and thickness to prevent failure due to pressure gradients (including static head and external hydrogeologic forces), physical contact with the waste or leachate to which they are exposed, climatic conditions, the stress of installation, and the stress of daily operation;
  - (ii) placed upon a foundation or base capable of providing support to the liner and resistance to pressure gradients above and below the liner to prevent failure of the liner due to settlement, compression, or uplift; and
  - (iii) installed to cover all surrounding earth likely to be in contact with the wastes or leachate."

The liner system designed for this facility is a typical RCRA Subtitle C design of appropriate material, foundation and cover to prevent migration of waste and is reviewed in detail in several subsections of above sections 1.3 Facility Design Features and 3.0 Construction of Proposed Facility. Therefore, the civil engineering (liner) aspects of this design satisfy the requirements of this regulation. Groundwater monitoring itself will be in the geological review.

- Texas rule at Title 25 TAC §289.260(o)(12)(A) states, "In developing and conducting groundwater protection programs, applicants and licensees shall also consider the following: (A) installation of bottom liners. Where synthetic liners are used, a leakage-detection system shall be installed immediately below the liner to ensure detection of any major failures. This is in addition to the groundwater monitoring program conducted as provided in paragraph (29) of this subsection. Where clay liners are proposed or relatively thin, in situ clay soils are to be relied upon for seepage control, tests shall be conducted with representative tailings solutions and clay materials to confirm that no significant deterioration of permeability or stability properties will occur with continuous exposure of clay to by-product material solutions. Tests shall be run for a sufficient period of time to reveal any effects that may occur;"

  The recompacted clay and synthetic liner system designed for this facility is a typical RCRA Subtitle C design and is reviewed in detail in several subsections of above sections 1.3 Facility Design Features and 3.0 Construction of Proposed Facility. The liner system includes a leakage detection system reviewed in 1.3.8 above and compatibility of HDPE liner is in 1.3.15 above. The civil engineering (liner) aspects of this design satisfy the requirements of this regulation. Groundwater monitoring itself will be in the geological review.

- Texas rule at Title 25 TAC §289.260(o)(12)(C) states, "In developing and conducting groundwater protection programs, applicants and licensees shall also consider the following: (C) dewatering of by-product material solutions by process devices and/or in situ drainage systems. At new sites, by-product material solutions shall be dewatered by a drainage system installed at the bottom of the impoundment to lower the phreatic surface and reduce the driving head of seepage, unless tests show by-product material solutions are not amenable to such a system. Where in situ dewatering is to be conducted, the impoundment bottom shall be graded to assure that the drains are at a low point. The drains shall be protected by suitable filter materials to assure that drains remain free-running. The drainage system shall also be adequately sized to assure good drainage;"

  As reviewed above in 1.3.5 through 1.3.12, this design has a collection and removal system for liquids in the waste cells which satisfies this regulatory requirement. Waste material entering the landfill is expected to already be or will be solidified. Dewatering is further reviewed in process engineering.

- Texas rules at Title 25 TAC §289.260(o)(13) states, "Technical specifications shall be prepared for installation of seepage control systems. A quality assurance, testing, and inspection program, which includes supervision by a qualified engineer or scientist, shall be established to assure that specifications are met. If adverse groundwater impacts or conditions conducive to adverse groundwater impacts occur due to seepage, action shall be taken to alleviate the impacts or conditions and restore groundwater quality to levels consistent with those before operations began. The specific seepage control and groundwater protection method, or combination of methods, to be used shall be worked out on a site-specific basis."

The civil engineering aspects of this regulation are satisfied by the landfill leachate collection and removal system and leak detection system design and construction quality assurance plan as reviewed in the above sections 1.3.8 and 3.1.

- Texas rule at Title 25 TAC §289.260(o)(14) states, "In support of a by-product material disposal system proposal, the applicant/licensee shall supply the following information:

  (A) the chemical and radioactive characteristics of the waste solutions;
  (B) the characteristics of the underlying soil and geologic formations particularly as they will control transport of contaminants and solutions. This shall include detailed information concerning extent, thickness, uniformity, shape, and orientation of underlying strata. Hydraulic gradients and conductivities of the various formations shall be determined. This information shall be gathered by borings and field survey methods taken within the proposed impoundment area and in surrounding areas where contaminants might migrate to groundwater. The information gathered on boreholes shall include both geologic and geophysical logs in sufficient number and degree of sophistication to allow determining significant discontinuities, fractures, and channeled deposits of high hydraulic conductivity. If field survey methods are used, they should be in addition to and calibrated with borehole logging. Hydrologic parameters such as permeability shall not be determined on the basis of laboratory analysis of samples alone. A sufficient amount of field testing (e.g., pump tests) shall be conducted to assure actual field properties are adequately understood. Testing shall be conducted to make possible estimates of chemisorption attenuation properties of underlying soil and rock; and
  (C) location, extent, quality, capacity, and current uses of any groundwater at and near the site."

- The applicant made an attempt to satisfy the waste classification of an unknown waste stream by utilizing known characteristics of the Fernald containers and general uranium mill tailings. Further discussion of waste characterization will be in process engineering review. The civil engineering aspects of the site subsurface conditions were characterized by standard civil and geotechnical engineering test procedures. The civil engineering aspects of this requirement were satisfied. Further evaluation of subsurface conditions will be in geological review.

- Texas rule at Title 25 TAC §289.260(o)(16)(A) states, "In disposing of by-product material, licensees shall place an earthen cover over the by-product material at the end of the facility's operations and shall close the waste disposal area in accordance with a design that provides reasonable assurance of control of radiological hazards to the following: (A) be effective for 1,000 years to the extent reasonably achievable and, in any case, for at least 200 years;"

The earthen cover system (especially as described in 1.3.16, and 4.3, above) with synthetic and recompacted clay liners is in a low seismic activity region, with gentle natural final cover grades and rock riprap to reduce erosion, can generally be expected to meet this regulatory requirement The HDPE liners and HDPE pipe may also reasonably be expected to satisfy this requirement as reviewed in 1.3.15 as long as they are properly protected from the sun and construction or operational accidents as described in the applicant's procedures. Settlement, however, is expected to require some fill and grading of the final cover of approximately 1 foot, 50 to 200 years after closure, as reviewed in 5.0 above. This requirement is satisfied as reasonably as can be expected of any man made design.

- Texas rule at Title 25 TAC §289.260(o)(35)(A) states, "No new site shall be located in a 100-year floodplain or wetland as defined in "Floodplain Management Guidelines for Implementing Executive Order 11988."

  FEMA has not published a floodplain map for this remote area. Consequently, the applicant (see 4.1 above) conducted a 100 year floodplain analysis. The results of this analysis indicate the site is approximately 3,000 feet northwest of a calculated 100 year floodplain. It is TCEQ understanding that the Army Corps of Engineers does not currently consider the nearby Playa Lakes to be wetlands. This site satisfies this regulatory requirement, although the Corps determination has not been included in this application.

5.7 REFERENCES

Waste Control Specialists. 2007. Cover letter from D. Kunihiro, WCS to G. Smith, TDSHS dated January 12, 2007, transmitting seven copies of Revision 13. Application was completely revised and updated, consisting of 15 binders (Volumes 1 through 12, and A, B, and C). Four minor revisions and an omission followed: Revision 14 - February 27, 2007; Revision 15 - May 4, 2007; Revision 16 - May 18, 2007; Revision 17 - June 4, 2007; and a copy of omitted Table 3.1 - July 13, 2007.

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NUREG-1623, Design of Erosion Protection for Long-Term Stabilization Final Report, U.S. Nuclear Regulatory Commission, T.L. Johnson, September 2002

CHAPTER 6 PROCESS ENGINEERING REVIEW

The following technical chapter represents the process engineering review of the commercial by-product material disposal license application, L05807, originally submitted by Waste Control Specialists, LLC (WCS) on June 24, 2004 to the Texas Department of Health, Bureau of Radiation Control (TDH). Subsequent to the original application, WCS submitted 17 application revisions to the newly formed Texas Department of State Health Services (TDSHS). Effective June 17, 2007 the subject regulatory program of 25 TAC §289.260, and related programs, were transferred to the Texas Commission on Environmental Quality (TCEQ). The process engineering review of license application L05807, Revision 17, dated June 4, 2007 (WCS 2007), has been performed under the regulatory requirements, as applicable, of 25 TAC §289.252, and 25 TAC §289.260.

6.1 PROCESS OPERATIONS

6.1.1 Introduction

WCS owns approximately 14,900 acres of land, most of which lies adjacent to the Texas-New Mexico state line in Andrews County, Texas, with a smaller tract lying in Lea County, New Mexico. WCS began acquiring this property in 1994. In Andrews County, Texas, a 1,338 acre tract of the 14,900 acres owned is currently the site of a RCRA facility, operated under TCEQ Permit No. HW-50358, originally issued in 1994; and a radioactive waste storage and treatment facility operated under TCEQ license L04971, originally issued in 1997 by the TDH. Container storage buildings and pads, and a treatment building are authorized units in both the RCRA permit and the low level radioactive materials license, while there is no reference to this fact in either the permit or the license. Acquisition of the land, and construction of the existing facilities then predate the submission of the original by-product material license application by 10 years, and 5-8 years, respectively.

The proposed commercial by-product material disposal facility occupies approximately 36 acres of land within the 1,338 operating tract in Andrews County, and is located just north of the existing RCRA landfill. The by-product material disposal facility consists of a 16-acre, 6-cell, sub-grade landfill; a truck receiving and waste staging area; a paved and covered waste vehicle marshaling area; a decontamination building, with sumps, transfer pumps, and piping; and two 500,000-gallon contaminated water/wastewater storage tanks, with secondary containment, transfer pumps and piping.

The disposal facility generally conforms to RCRA Subtitle C design standards, and is to be operated as a landfill, rather than as an impoundment. Free liquids present in incoming wastes are proposed to be solidified prior to disposal (which is a RCRA requirement), or to be solidified in place (which is not an acceptable RCRA practice) in the landfill cell using cement and flyash. Water enters the landfill as rainfall, and as service water utilized in the dust suppression spray system. Accumulated water is removed from completed landfill cells using the leachate collection system. Water removed by the leachate collection system in landfill cells containing waste is pumped to the two 500,000-gallon tanks, and subsequently is transferred to an undefined wastewater treatment plant to be located near the existing waste treatment

building. Ultimate disposal of treated wastewater would require a permitted outfall, under the TPDES permit program administered by the TCEQ. Wastewater treatment and discharge are not within the scope of this license application.

Process flow of by-product material begins with truck shipments directly to the landfill site, and with rail shipments into the existing rail yard that require trans-shipment by truck to the landfill. Inspection, and some limited waste preparation/treatment are accomplished in the receiving/marshalling area at the landfill site. Waste is then trucked down an access ramp into the sub-grade landfill for dumping/placement. The Fernald DOE facility waste canisters are a unique by-product material waste, and are placed by a crane into the first cell of the landfill located at the eastern perimeter of the excavation. Wastes which follow are primarily soil-like wastes, and various types of debris, such as demolished concrete structures and shredded piping and building wall panels. The total waste capacity of the landfill is approximately 1,169,000 cubic yards. WCS is projecting a 30-year service life for the disposal facility, which averages 39,000 cubic yards per year of by-product material disposal.

The disposal facility is constructed in stages, with the intent to have no more than three cells active at any given time. Cap construction also proceeds in stages, as cells are filled and the active waste face advances toward the western perimeter of the landfill excavation. Leachate removed from active cells, and any sludges produced in the associated wastewater treatment plant become by-product material wastes produced by the ongoing site operations. Decommissioning, after 30 years of active operations, also produces wastes which must be managed as by-product materials either by disposal in the final cell of the landfill itself, or by shipping final residuals offsite to another licensed facility. WCS has plans to add pozzalonic agents, such as flyash and Portland cement, to incidental free liquids found during inspections of incoming wastes, and occurring in the landfill cells as a result of phase separation. WCS relies upon dust suppression techniques, utilizing water sprays, possibly with the addition of foaming and wetting agents; and upon a claimed wind sheltering effect of the sub-grade landfill design as engineered controls for the effective abatement of wind erosion and dispersal of by-product material particulates.

6.1.2 Process Facilities

Process related facility drawings and reports furnished in the WCS application have been properly stamped, signed, and dated by the following Texas registered professional engineers, as required by 25 TAC §289.260(f)(3):

Stephen L. Cook, Cook-Joyce, Inc., P.E. No. 42203 (Chemical, expiration date 9/30/07)
Mark S. Day, URS, P.E. No. 93463 (Civil, expiration date 3/31/08)
J. Brian Dudley, Cook-Joyce, Inc., P.E. No. 59831 (Civil, expiration date 3/31/08)
Diana G. Dworaczyk, Consultant, P.E. No. 63724 (Civil, expiration date 12/31/07)
Kathy L. McGee, Cook-Joyce, Inc., P.E. No. 57783 (Chemical, expiration date 6/30/08)

6.1.2.1 Landfill

The WCS application proposes a disposal facility design that generally follows the design and operating standards of a RCRA Subtitle C landfill. As a process unit, the landfill essentially functions as a large, high density polyethylene (HDPE) lined waste container, with a sump and pump system in each cell for removing separated liquids or leachate above the primary liner. In the case of by-product material, leachate will be water containing dissolved and suspended solids leached or transported from the soil-like waste, with some of the heavy metal species being radioactive. Leachate, therefore, is also by-product material waste.

The double liner system also provides a leak detection function for the upper, primary HDPE liner, by installing a drain layer and collection sump and pump system under the primary liner, and above the secondary liner. Below the secondary HDPE liner is 3 feet of re-compacted native (redbed) clay having a maximum permeability of $1x10^{-7}$ cm/sec. This clay layer would presumably prevent a leak through both HDPE liners from reaching the sub-soils for 30 years, which corresponds to the standard 30-year post-closure care period for RCRA landfills. RCRA rules require that leachate be removed at such a frequency and rate as to avoid exceeding 12 inches of static liquid head over the primary liner, as a leakage attenuation technique. Although RCRA rules clearly do not apply to a by-product material landfill (or surface impoundment), WCS has adhered to the RCRA leachate removal requirements, and has outlined a RCRA-compliant response action plan in Appendix 3.2.D, Attachment 5, which generally addresses the investigation and evaluation of any leaks encountered during the operational period, and discusses the limited ability to actually make repairs to the primary HDPE liner.

The WCS application proposes a 5-year post-closure care period, but does not discuss any intent to include monitoring the levels in the leachate and leak detection sumps and removing any accumulated liquids during this period. Ongoing post-closure maintenance is to be avoided, according to 25 TAC §289.260(n)(2). The WCS application also does not discuss feasible corrective actions, if any exist beyond cap maintenance, to be taken if the leak detection system would indicate significant breaching of the upper liner after closure. The WCS application may be considering the RCRA Subtitle C landfill design to be a benchmark for by-product material waste disposal.

It is important to note that a RCRA landfill is subject to a 30 year post-closure surveillance and detection monitoring period, while the time horizon for by-product material is 1,000 years, with a 200-year minimum period of non-detection of releases. HDPE liners should be assumed to have failed in any analysis of potential release to the groundwater over these longer time horizons (Lee 2006), and ultimately it is the site-specific sub-surface conditions (geology, hydrogeology) that must be relied upon for groundwater protection. The RCRA double HDPE liner design is useful during operations for detecting leaks through the primary HDPE liner, dewatering the landfill cells, and for providing at least the capability to remove water during a short-term post-closure care period. It is always desirable to minimize static liquid head on a liner, regardless of the material. Therefore, the RCRA design seems to be a reasonable approach, from a cost and performance standpoint, for the 30 year operational period, and for the proposed 5-year post-closure care period (prior to deeding the property to the State of Texas) of the

proposed by-product material disposal unit. The RCRA design also meets the requirement under 25 TAC §289.260(o)(12)(A) to have a leak detection system under a synthetic liner, and meets the requirement under 25 TAC §289.260(o)(12)(C) to provide for dewatering of by-product material solutions (at new sites).

The detailed review of the design of the landfill is the subject of the civil engineering chapter, and the sub-surface conditions analysis is the subject of the geology/hydrogeology chapter. The acceptability of the RCRA design as stated in this report is limited to the analysis of the proposed landfill as a process unit. Ultimate acceptability of the proposed design depends upon the civil engineering, and the geology/hydrogeology reviews as well.

The technical requirements under 25 TAC §289.260(o) primarily address groundwater protection for surface impoundments at uranium recovery sites. The rules presume operations based upon conventional milling at open pit mines, where surface impoundments often involved constructing embankments above grade to take advantage of topographic features. The rule at 25 TAC §289.260(o)(9)(C) provides an opportunity for applicants to request an exemption from the liner requirements stated in 25 TAC §289.260(o)(9)(A), based upon an adequate demonstration that a proposed alternative is adequately protective. A surface impoundment is a wastewater and/or sludge lagoon that is utilized as an operating unit at a uranium recovery site, and typically contains free liquids during operations. A surface impoundment also is required under 25 TAC 289.260 (o)(12)(C) to have a drainage system for dewatering the contents in order to minimize the static liquid head on the liner, although there is no stated maximum value for static liquid head (RCRA rules require 12 inches as a maximum static head).

After uranium recovery operations have ceased, surface impoundments must either be completely remediated, and the site reclaimed, or the free liquids removed or solidified, as required by 25 TAC §260(o)(24), and the unit closed as a landfill. Clearly these rules do not expressly address a commercial by-product material disposal landfill at a non-uranium-recovery site. However, these are the rules that must be applied at this time. It may be inferred from these rules that the WCS application could have been based upon a surface impoundment approach, with the disposal of wastes containing free liquids, provided a liner leak detection system, and a drainage system for dewatering have been installed. However, the Fernald DOE waste is containerized, and it would be poor practice to in effect submerge the canisters and risk corrosion. In addition, the volume of water, or free liquids, in a sludge lagoon reduces the available disposal capacity, and would not reduce the static liquid head on the liner to the extent possible in a landfill designed and operated to RCRA standards. Furthermore, the application indicates that the majority of the forecasted wastes to be received will be soil-like, with some additional quantities of demolition debris; and as discussed above, the Fernald wastes are containerized.

Regarding construction at or above grade, as generally is the case with surface impoundments, the application advises that the soils overlying the redbed formation are porous, and therefore would not provide immobilization of a leak breaching the liner system; and that, furthermore, the sheltering effect of a subsurface design from wind dispersal of particulates is significant, and would be lost in an at-grade or above grade design. Therefore the intent to operate generally as a below-grade RCRA landfill seems

reasonable and appropriately conservative for this application, all things considered.

The disposal facility may be seen as a unit operation, and it is useful to analyze the mass balance issues of this unit operation in an evaluation of the overall hydraulic balance of the proposed facility. The WCS application unfortunately provides only a fragmented, incomplete picture of the hydraulic mass balance for contact water (also referred to as contaminated water, and wastewater) for the total facility. This information is partially presented on Figure 3.24A, Contact Water Process Flowsheet, and in the related Table 3.1, Contact Water Flow Rates; with some additional information given in Appendix 3.2.D, Attachment 6, Landfill Contact Water Management. Figure 3.24A does not show the front-end input streams to the landfill of rainfall capture, or water to the dust suppression spray units; and only covers the rainwater contacting emplaced wastes. Evaporation to the atmosphere from the landfill is not mentioned, and appears to have been neglected (which is reasonable) in the mass balance studies. Design appendices 3.3B, Storm Water Contained by Intercell Berm, and 3.2.D, Attachment 6, Landfill Contact Water Management, use attenuated "run-off" values of the 5-year, 25-year, and 100-year 24-hour rainfalls; and of the selected 8-consecutive-day rainfall, in the scenarios studied.

The concept of run-off being less than incident rainfall in a lined pit having limited soil-like waste content, which has been subjected to water sprays for dust control, is questionable (i.e., it is more conservative to assume emplaced waste does not absorb a significant portion of the incident rainfall), and is not considered to be consistent with a worst-case scenario. The pump-out rate from the leachate sumps is 230 gallons per minute (gpm), while the incident rainfall capture rate from a 100-year, 24-hour rainfall, for example, is 834 gpm, average, using worst-case conditions from the application of 321,200 ft^2 of capture in the horizontal plane (assumes the toe of the emplaced active waste face is just projecting into a new cell), and a more conservative 100-year, 6-inch rainfall in 24 hours at 100% run-off (rather than the 4.3 inches computed as run-off in the application). The 230 gpm pump-out rate from the leachate collection sump is calculated in Appendix 3.2.D, Attachment 4, Liquids Removal, based upon the area of Cell A alone, and a 25-year, 24-hour storm.

The application provides no discussion of the rationale for sizing the pumps for this lesser requirement. It could be inferred that as a practical matter, the size of the pump that can be inserted in the riser is limited, as is the flow into the sump, and designing to the 100- year, 24-hour rainfall rate over 321,200 ft^2 is impractical, and presumably occurs infrequently. It appears that significant static liquid heads could exist in the active cell for several days until the water from a worst-case rainfall scenario has been pumped out. It also appears that the intercell berm could be over-topped, contaminating the (assumed) clean captured storm water in the adjacent inactive cell. One possible practice could be to use portable pumps in addition to the leachate sump pump, taking suction from the pond of water formed in the cell, to reduce the pump-out time, and hence reduce the time period of elevated static liquid heads on the liner.

Appendix 3.2.D, Attachment 6, Landfill Contact Water Management, utilizes an historical highest 8-consecutive-day rainfall period from May, 1992 for Hobbs, New Mexico as an extended rainfall period scenario for studying the potential for contaminated water accumulation in the landfill and in the two 500,000-gallon tanks. Both the landfill and the two 500,000-gallon tanks are assumed to be empty at the

start of the 8-day period. It is assumed that the emplaced waste is able to absorb around 30% of the 13 inches of rain (the balance being "run-off") that fell during this historical period. Both the assumptions of the landfill and two 500,000-gallon tanks being empty at the start of the 8-day period, and the waste being able to absorb and hold a substantial portion of the incident rainfall do not appear consistent with evaluating a worst-case scenario. Furthermore, the Hobbs historical daily rainfall data provided in the application show two relatively recent daily rainfall amounts which exceed the stated 6-inch 100-year value used in the application: 7.5 inches fell on September 15, 1995, and 6.87 inches fell on September 28, 2004. The 3-day period from September 15-17, 1995 of 7.5 inches, .80 inches, and .65 inches, respectively, appears to create a more severe scenario for maximum accumulation of water in the landfill than either the 100-year, 24-hour scenario, or the 8-consecutive-day scenario studied in the application.

The summary spreadsheet entitled "Landfill Water Analysis" in Appendix 3.2.D, Attachment 6, does not provide a data column for static liquid head on the landfill liner, which is in fact the critical parameter of interest in evaluating rainwater accumulation. Therefore it does not appear that the WCS application has evaluated the worst case potential rainfall scenario, and impacts have not been reported based on the critical parameter of static liquid head developed over the landfill liner system. There appears to be a possibility of over-topping the intercell berm under a more severe worst-case scenario than studied in the application. The maximum height of the intercell berm corresponds to a static liquid head on the liner of approximately 7 feet at the low, north-end of the sloped cell bottom.

The "non-contact", uncontaminated rainwater captured in newly constructed cells, and captured at the perimeter bench constructed at the top of the redbed, have not been evaluated on a hydraulic-balance basis. Furthermore, there is a concern that wind-dispersed waste could potentially be re-deposited in the inactive cells, and on the perimeter bench, thereby also contaminating that portion of the captured incident rainfall. The WCS application proposes to use only uncontaminated water, which is either recycled non-contact rainwater, or primary source well water, for dust suppression within the landfill area. This practice avoids wind drift loss of contaminated water spray droplets, if contaminated water were to be used, while adding to the volume of wastewater to be managed from the active landfill cells. Non-contact captured rainwater needs to be included in the hydraulic balance study for the facility, particularly because of the potential for "non-contact" water to contact re-deposited waste resulting from wind erosion and dispersal. There is an additional concern that cross-contamination could occur between the by-product material landfill and the adjacent Federal low level waste landfill due to wind erosion and dispersal. The potential for cross-contamination is unknown, and has not been addressed in the WCS application.

The process flow diagram of Figure 3.24A also shows an unloading platform used by trucks at the operating area within the landfill. The platform has a sump for collecting water from the dust suppression spray nozzles used while the trucks are dumping bulk by-product material waste. The wastewater is removed from the sump, presumably using a portable pump or a vacuum truck, and trucked to the two 500,000-gallon tanks. The quantity of this wastewater produced per unit time has not been provided in the application. It would appear to be a relatively small amount.

6.1.2.2 Contaminated Water Storage Tanks

By-product material waste solids remain in the active landfill cells, while contaminated water is removed by the leachate collection system, and pumped to the two 500,000-gallon wastewater storage tanks. There are no storage tanks for uncontaminated water. Uncontaminated water to be used for dust suppression would need to either be stored in-place in inactive landfill cells, stored in-place at the perimeter sump formed by the back-sloped, excavated redbed bench; or pumped to tank trucks using portable pumps. Contaminated water flows forward to the two 500,000-gallon storage tanks that are located just north of the landfill perimeter. Figure 3.2.4A, Contact Water Process Flowsheet, shows 3,000-gallon tank trucks and/or a 250 gpm portable pumping unit being used for the transfer from the leachate sump pump discharge to the two 500,000-gallon tanks.

The locations of the tank trucks during loading, and the portable tank and pumping unit are not shown on any layout drawings. It would appear that they need to be spotted at grade just north of the landfill excavation perimeter, and will not be on spill controlled pads (which could lead to contaminated soils at this location). There is also a flow stream for the water removed from the landfill leak detection sumps, which is expected to be a minor stream with a pump-out rate of 10 gpm. Sump pumps to be utilized are an electric-motor driven, submersible design on castors, with integral level sensors and switches. They may be moved from cell to cell as needed. Flow of water into the leachate sumps in completed, active cells can be expected to be highly variable, since rainfall is the primary inflow source.

As discussed in section 1.2.1 above, major rainstorms could overwhelm the leachate sump pump-out rate of 230 gpm and turn the cell into a temporary water impoundment. It may be advisable to consider employing supplemental pumping, utilizing portable pumps, for example, placed between the intercell berm and the toe of the waste, in order to avoid high liquid static heads (greater than 12 inches) above the primary liner during high rainfall periods.

The WCS application provides a draft-quality P&ID for the two 500,000-gallon wastewater storage tanks in Figure 3.26, Tanks BPT-1 and BPT-2. Level instrumentation for the prevention of tank overfilling is interlocked with the inlet valves in the lines from the decontamination building sumps, and with the tank truck unloading pumps; but is not interlocked with either the inlet valves (these are manual valves) or the portable, diesel engine-driven pump unit associated with the transfer of leachate from the landfill. Narrative information in the application indicates that this latter interlocking is omitted as a practical matter, and operator observation of the tank levels will be required to prevent overfilling. Polyethylene piping, or hose/tubing, which is corrosion resistant in this service, is to be used for the transfer lines from the decontamination building and from the portable pumping unit at the landfill. Piping within the secondary containment of the tanks is shown as carbon steel, which is likely to have a relatively significant corrosion rate in water service (KTM 2007).

The transfer line to the "off-site" wastewater treatment plant is double-walled polyethylene. Non-metallic pipe or tubing, lined carbon steel pipe, or stainless steel pipe is preferred for water service to avoid the probable significant corrosion rates of bare carbon steel pipe in wastewater service (Tuthill 2007). The

lines within the secondary containment should be PVC or FRP, for example (stainless steel being costly by comparison), and not bare carbon steel. Corrosion failure of pressure piping creates a hazardous situation.

The double-walled HDPE line to the wastewater treatment plant is a conservative design, and would avoid leakage from line failures which could contaminate soils outside of the secondary containment structure of the two 500,000-gallon tanks. There is no indication in the application that winter freeze protection of any above-ground water transfer lines has been considered, or provided as applicable. There is no indication in the application that suspended solids loading from the influent water has been considered, and it seems likely that the two 500,000 gallon tanks will accumulate settled solids, or sludge, during ongoing operations. The tanks are designed with access ports for clean-out if solids do accumulated to significant levels. Influent wastewater at the treatment plant may need to be pre-filtered. It appears that the wastewater flow management portion of the overall facility has only been designed to the conceptual level, and will require significant additional design development to address all functional requirements.

The two 500,000-gallon tanks are intended to be sized to conservatively contain the volume of captured rainfall in the worst case 100-year, 24-hour rainfall scenario of 6 inches of incident rainfall, attenuated to 4.3 inches of "runoff" (which has been questioned previously in this report as not being consistent with a worst-case scenario), as described Appendix 3.2.D, Attachment 6, of the application. This strategy assumes that both tanks are essentially empty at the start of the 100-year storm (which also seems to be inconsistent with a worst case scenario). Since the inflow is 230 gallons per minute (gpm), average, and the outflow is 150 gpm maximum, the tank system will accumulate inventory at the rate of 80 gpm until the landfill has been pumped out. There would be a several day time period required to actually do a net transfer of the 100-year storm quantity at 230 gpm, unless additional pumps (as previously suggested in this report) are employed at the landfill. It can be seen that the landfill becomes a temporary impoundment by necessity during higher rainfall events.

As discussed previously in this chapter, the requirements under 25 TAC §289.260(o) address impoundments, and accumulating water, or free liquids in a landfill cell is not expressly prohibited. The critical factor in being able to manage the wastewater is the flow rate and operational reliability of the ultimate disposal process, which is given in the WCS application as being 150 gpm maximum to an offsite and undefined treatment plant, requiring a TPDES permit for the outfall. A higher pump-out rate from the landfill to the two 500,000-gallon tanks would only be beneficial to the extent that there is available storage volume in the tanks, since the 150 gpm feed-forward rate to the wastewater treatment plant becomes the rate-limiting parameter.

An alternative to a wastewater treatment plant would have been one or more waste disposal wells, permitted under the TCEQ UIC program. It would appear that the treatment plant utilizes one or both of the 500,000 gallon tanks as operational front-end surge, so that if the treatment plant is out of service, flow to it from the two 500,000-gallon tanks must stop. It would be useful for the application to address a more stringent worst-case scenario in evaluating the potential challenges to the tank system as designed; involving, for example, a starting tank inventory (assume the wastewater treatment plant has been out of service for a period of time), and a more severe 24-hour rainfall (e.g., 7.5 inches recorded in Hobbs on

September 15, 1995) with no percolation into the emplaced wastes.

The WCS application proposes to design the two 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, and WCS may not want to do a redesign to either the API or AWWA bolted tank standard (and a bolted tank may come at a higher cost). What is needed in the application is a certifying statement from the coating and tank manufacturers that this factory applied coating can be adequately repaired in the field in this situation. It is expected that the manufacturer will be able to provide a procedure and materials for making the repairs, and will offer a performance warranty. These water tanks require high-integrity internal coatings because bare carbon steel tanks in water service will experience relatively high general and pitting-type corrosion rates, particularly if the pH is nearly neutral or slightly acidic, and there is dissolved oxygen and significant levels dissolved solids (Tuthill 2007).

6.1.2.3 Decontamination Building

The WCS application provides a conceptual P&ID for the decontamination building in Fig. 3.27, Decontamination Building Sump. Waste transport vehicle and waste container washing is to be carried out in this building. There are two sumps in the sloped concrete grade slab of this building, each having a 30 gpm sump pump, and associated level control instrumentation. The handheld water spray units are not shown on Fig. 3.27, or on Fig. 3.24A, Contact Water Process Flowsheet (which in fact does not show any of the primary water input streams to the flow system). Narrative information in the application indicates that each spray unit flows at about 15 gpm, which is a reasonable value.

The clean supply water to the spray units becomes contaminated wastewater, and is collected in the sumps for transfer to the two 500,000-gallon tanks. The transfer lines are HDPE, which will be corrosion resistant. It is not clear if these lines are above or below ground. There is no indication in the application that freeze protection of any above ground water transfer lines has been considered, and provided as applicable. This is a simple operation. However, it would be useful if the application had estimated the total flow of wastewater from the decontamination building as a component stream in a complete hydraulic balance study for average and worst-case operating conditions.

6.1.2.4 Facility Wastes

Facility wastes are wastes generated onsite during operations and closure. Since the WCS application proposes a commercial by-product material waste disposal landfill, and is therefore not of the complexity of a uranium recovery facility, facility wastes generated during operations are limited to primary source water and captured rainwater that have become contaminated with by-product material by contacting the wastes transported to the site. The terms "contact water," "contaminated water," and "wastewater" are used interchangeably in the application, and in this report, to refer to this type of facility waste. Captured storm water that has not contacted by-product material waste is not considered to be wastewater in the application, and presumably may be discharged under a storm water permit without treatment, or reused in the dust suppression system. However, there is some question about the potential for wind erosion and dispersal of by-product material (and possibly low level waste from the adjacent Federal landfill) during operations (see section 1.4 below), and therefore it is possible that rainfall captured anywhere within or near the excavation could become contaminated.

Wastewater is generated within the disposal facility, and also in the decontamination building; and flows forward to the two 500,000-gallon tanks, and subsequently is metered at 150 gpm (maximum) to a dedicated wastewater treatment plant. Ultimate disposal is via a TPDES permitted outfall. Management of captured rainfall and the resulting wastewater is a primary concern of the process engineering review of the WCS application, and has been evaluated in some detail in the above sections at 1.2. The application does not discuss the issue of sludge that may be produced in the wastewater treatment plant, and settled solids that may accumulate in the two 500,000-gallon tanks. It seems reasonable that treatment sludge and tank solids could be placed in the by-product material disposal facility.

Decommissioning wastes consist of materials and residuals resulting from the decontamination and/or demolition of facility buildings and foundations, piping, and ancillaries. Some of the materials and residuals are contaminated with by-product material, and use is to be made of the final landfill cell, to the extent practicable, in their disposal. Any contaminated decommissioning waste materials and residuals remaining after full closure of the landfill are to be transported to an offsite licensed facility for disposal. Certain equipment is to be decontaminated and reused, utilizing the decontamination building prior to its demolition. This equipment will generally include various types of vehicles used during operations and closure. Materials not contaminated with by-product material may be disposed of in appropriately permitted conventional landfills.

During the 5-year post closure care period proposed in the application, there is no mention of monitoring landfill sump levels, or removing accumulated liquids. It would appear that the options are to do nothing (which seems to be the intent, since actions are not discussed in the application), to pump to a tank truck for offsite transport, or to pump to a tank truck for onsite treatment, if a treatment plant is still in existence. Use of the submersible pumps would require temporary electrical power, and opening the capped risers would vent radon gas. The performance of the landfill cap is the key to avoiding ongoing accumulations of water in the landfill sumps after closure, assuming the landfill cells are substantially dewatered prior to closure. It would be useful for the application to clarify the intent, if any, to monitor and removed liquids

during this 5-year period. The civil engineering review addresses landfill cap design, and related landfill design issues.

The WCS application has not included any waste disposal wells in the overall wastewater management strategy. As discussed above, the ultimate disposition of wastewater generated on-site is to the undefined treatment plant and TPDES outfall to the surface waters. It is noted that without at least one waste disposal well, or a treatment plant with outfall, the landfill cannot operate beyond a short term period without accumulating large volumes of captured rainfall, contacting the waste and becoming wastewater beyond the storage capacity of the two 500,000- gallon tanks. Solar evaporation, even in a somewhat dry location such as Andrews County, cannot be relied upon for effecting ultimate disposal of accumulated water. Evaporation of impounded water results in an increase in dissolved solids, which in turn causes the evaporation rates to drop-off significantly in accordance with Raoult's Law . In addition, worst-case rainfalls will occur over relatively short time periods, and can accumulate in the landfill to unmanageable levels before even effective solar evaporation (e.g., in shallow lagoons with mixing and/or spraying) could measurably reduce the volume. The WCS application does not take credit for any evaporation from the landfill in the hydraulic balance studies, which is seen as appropriate in a conservative analysis. Certainly some evaporation will take place, particularly from the dust suppression system. However, quantification of the evaporation rate would be difficult.

6.1.2.5 Engineering Controls for Particulate Air Emissions

The requirements under 25 TAC §289.260 (o)(30) state that all airborne releases are to be as low as is reasonably achievable by the primary means of applied emissions controls. Section 5.0 of the WCS application states "Windblown dispersion is expected to be minimal" due to the assumed abatement effect of the sub-grade landfill design (which is preferred by 25 TAC §289.260(o)(6)), and the use of water sprays (with chemicals) for dust suppression. This section of the application also states "...active disposal area will be sheltered during the operational period from high winds and extreme weather conditions." Dust control at landfill and construction sites using water sprays and water spreader trucks, with and without the use wetting and foaming agents, is common practice, and is considered a first line of defense in reducing nuisance dust emissions due to mechanical disturbances of exposed soils (WDEQ 2006). However, it is common practice at construction sites to stop work at high wind speeds, due to wind erosion and the inability of water spray suppression to be effective in controlling dust emissions (WDEQ 2006). Therefore, water spray dust suppression is only effective part of the time. At higher wind speeds, when such abatement is needed the most, it becomes an ineffective method due to the wind entrainment of sprayed droplets, and due to the effect of the wind in the drying and eroding of waste surfaces.

The application indicates that emplaced wastes will not be given a clean soil cover (in order to conserve disposal volume), and wind erosion could work directly on waste surfaces. The application does propose the cessation of waste dumping and placement operations when winds reach 25 mph. However, the already emplaced waste is always available for wind erosion and dispersion, 24 hours a day, 7 days a week. The application does not provide any testing data, or reference data for similar operations that could help quantify the potential air emissions control efficiencies of the water spray system for the full range of site-

specific wind conditions. It would be useful for the application to provide more information on the expected performance of the water spray dust suppression system for the site-specific winds and landfill design.

Appendix 11.D of the application intends to provide modeling evidence of the abatement effectiveness of the "sheltering" of the waste from wind dispersal in the sub-grade landfill design. The application states the analysis as "...modeling both pit source and surface area source to determine the advantage of completely below grade landfilling." Table 4-1, WCS-Air Modeling-Unit Impacts-ug/m^3, indicates, for example, that ground-level concentrations (GLC) at the WCS property boundary, for an assumed unit mass emissions rate of 1 lb/hr released at 20 feet below grade (i.e., "pit" release), are 18%, 35%, and 52% respectively of the 1-hour, 24-hour, and annual average GLC values for surface release of 1 lb/hr of particulates. The model used was the EPA AERMOD area source model, which utilized a year of meteorological data from the Midland National Weather Service (NWS) station. Therefore, it is reasonable to conclude from the unit emissions rate modeling results that sub-grade release of fugitive particulates leads to significantly lower off-property ground-level impacts than surface release for the meteorological conditions modeled.

However, Appendix 11.D also predicts actual GLCs by computing actual mass emission rates of particulates for various waste moisture and wind speed conditions, utilizing EPA AP-42 emissions factors computation methods (EPA 1995) found in Section 13.2.4, Aggregate Handling and Storage Piles (for waste dumping), and found in Section 11.9, Western Surface Coal Mining (for waste spreading). Dosages relating to the source terms inherent in the actual GLCs, where unit GLCs are multiplied by these actual emission rates to determine actual GLCs, are also computed and found to be acceptable for members of the public at the fence line and beyond. The modeling results in Appendix 11.D are generally consistent with the results of other modeling done under the environmental health physics (EHP) portion of the application, which is the subject of the EHP review report. Regarding AP-42, Section 13.2.4, for waste dumping, the application does not discuss the rationale for selecting this computational method, and it appears that the method may have been misapplied.

Equation (1) in Section 13.2.4 is an empirical relationship which holds for wind speeds of 1.3-15 mph, and for material moisture contents of .25-4.8%. The WCS application uses this equation for wind speeds of 5-25 mph, and waste moistures of 5-15%. There is no discussion in the application for choosing these wind speed and moisture parameter ranges. It does not seem reasonable that a 25 mph wind speed is the maximum speed that could occur at the waste face within the proposed landfill, when surface winds are known to reach speeds in excess of 50 mph in Andrews County seasonally. These parameters then do not seem to represent reasonably foreseeable worst-case conditions of waste dryness and higher wind speeds, and would seem to understate actual worst-case mass emission rates when used in the computations. It is reasonable to expect that a worst-case scenario at the proposed landfill location could be, for example, waste in the range of 1-5% moisture, and wind speeds in the range of 40-50 mph impacting the emplaced wastes. Additional research would appear to be needed into estimating potential worst-case winds in the sub-grade landfill proposed for this site. However, it also seems likely that the AP-42 equation utilized by the WCS application is inapplicable to such worst-case conditions, as it is to most of the lesser conditions

examined in the WCS application.

AP-42 does address wind erosion in Section 13.2.5, Industrial Wind Erosion, which appears to be a discussion more applicable to this situation than Section 13.2.4. For example, Section 13.2.5.2 states: "Because erosion potential has been found to increase rapidly with increasing wind speed, estimated emissions should be related to the gusts of highest magnitude." Section 13.2.4.3 also states: "Worst-case emissions from storage pile areas occur under dry, windy conditions." Regarding AP-42, Section 11.9, the WCS application has utilized an emissions factor equation for bulldozing (spreading) at a surface coal mine, taken from Table 11.9-1, Emission Factor Equations for Uncontrolled Open Dust Sources at Western Surface Coal Mines. However, it is noted that this equation does not incorporate wind speed as a parameter (uses moisture content, and silt content). In this same Table 11.9-1, there is a factor for active storage pile wind erosion which is a direct function of wind speed, and it would appear to produce a very significant emission rate for probable worst-case wind speeds within the landfill at the proposed Andrews County site.

A study conducted by the Wyoming Department of Environmental Quality in the Powder River Basin coal mining region (WDEQ 2006) states: "It is generally accepted that for wind speeds greater than thirteen miles per hour, wind erosion increases with the cube of wind speed." The South Dakota Department of Environment & Natural Resources states that high air pollution levels occur from dust emissions when wind gusts reach 40 mph to 70 mph, and when average hourly wind speeds are greater than 20 mph (SDDENR 2007). Predictive models have also been developed for wind erosion analysis (WERU 2007). However in the WCS application, Appendix 11.D, mass emissions computations do not appear to utilize any factors based upon wind erosion, which seems to be the most significant factor that needs to be included in estimating worst-case mass emissions of by-product material waste particulates. Consequently, it is reasonable to conclude that worst-case mass emissions may have been understated, perhaps significantly, as presented in Appendix 11.D, and therefore actual off-property GLCs (and doses) may have been understated.

The studies conducted by WCS and their consultants in support of this application may have benefited from applying the "defense-in-depth, in-depth configuration design" approach to this facility (Brodeur 2003), which is a method intended to avoid the limitations of reliance solely upon predictive models in demonstrating performance (e.g., the validity of the air dispersion modeling results depends upon the validity of the separately determined, and hand-calculated actual mass emissions rates). In any case, it would be useful for the application to provide a referenced study, which may include additional modeling, of the worst-case wind speeds predicted to impact, and potentially erode and disperse the emplaced waste (at its highest elevations) within the proposed landfill, considering tri-axial dimensional aspect ratios of the landfill, topographical site features, and known (worst-case) meteorological data. This would allow wind erosion to be appropriately evaluated as a potential air emissions factor, and the sub-grade landfill design to be thoroughly evaluated as an emissions control method.

6.2 IMPACTS OF ACCIDENTS

6.2.1 Introduction

The WCS application provides an accident analysis in Appendix 11.C, Accident Analysis Report, which also includes a report entitled "Accident Analysis Scenarios for By-product Material and Other Radioactive Material Facilities at Waste Control Specialists." The discussions in both narratives are relatively brief, and generally determine that there are no highly probable accident scenarios producing significant environmental impacts either in the operation of by-product material disposal facility, or in the transport of waste to the site. The requirement for an analysis of the environmental effects of accidents is given at 25 TAC §289.260(f)(1)(A)(iv).

6.2.2 Facility Accidents

The WCS application has determined that the only significant weather related event is a tornado, which is evaluated from available statistical data as being of extremely low statistical probability for the Andrews County location. Potential damage and downwind transport of significant masses of soil-like by-product material from straight-line winds and wind gusts are not discussed, although the occurrence of high wind speed events in the area of Andrews County has been extensively studied and documented by the National Weather Service (NWS 2007c). Damage from flooding is presented as not being a problem, due to the intended design of diversion berms, and final surface contouring at the landfill site. Container breach and waste release potential from handling accidents, and from transport (offsite and onsite) vehicle fuel tank explosion and fire are examined and found to be "extremely remote/unlikely." A crane malfunction with a suspended Fernald waste canister is examined and found to pose an "insignificant" dose impact upon the public. Railcar unloading and trans-shipment potential accidents are not addressed in the application, and reference is made to this issue being addressed and authorized by the application and licensing under a separate licensing action.

NUREG-1569 guidance does not indicate that applicants must perform exhaustive examinations of all possible accident scenarios. However, all site-specific circumstances and conditions are to be examined for reasonably probable accident scenarios. The WCS application does not discuss the co-management of RCRA wastes, which may include reactive and ignitable materials, and radioactive wastes in the existing railcar receiving area, waste storage areas, or waste treatment building. The potential for fire and explosion involving RCRA wastes, as such an event may impact by-product material in the railcar receiving area, appears to be a scenario that should at least be examined for being reasonably probable.

6.2.3 Transportation Accidents

Transportation accidents have only been addressed in the application to the extent of the above scenario of truck vehicle fuel tank fire and explosion, and the national statistics on highway truck accidents. Railcar transportation accidents are not addressed in the accident analysis report, although there is a rail transport discussion in the socioeconomic study contained in Appendix 11.A, Socioeconomics Impacts Report.

According to the application, most of the wastes are to be shipped to the Andrews site by rail, and are to be containerized. The rail route seems to require a routing through southeastern New Mexico. It would be useful for the application to at least provide available information on the condition of the railroad line in this remote and final leg of shipment, and evaluate the potential accident scenarios at rural tracks and crossings that may experience a significant increase in traffic due to the by-product material shipments.

6.3 DECOMMISSIONING AND FINANCIAL ASSURANCE

6.3.1 Introduction

The closure plan is discussed in Section 6.0 of the WCS application, and the closure/decommissioning cost estimate is contained in Appendix 6.A. Since this is a new application for a commercial by-product material landfill, and not a uranium recovery operation, there is no groundwater restoration anticipated. Section 7.0 proposes a 5-year post-closure care period, prior to the transfer of the by-product disposal facility property to the State of Texas for long-term surveillance. The requirements for decommissioning/closure plans, and financial assurance/security are addressed under 25 TAC §289.260(d)(2), (f)(1)(A)(v), (f)(1)(B&C), (h)(5-11, 13-21), (m)(1-9), (n), and (o)(16-27), and the application appears to generally meet the applicable requirements.

6.3.2 Surface Decommissioning, Decontamination, and Reclamation

The closure plan is based upon utilizing the final, fully constructed cell of the landfill for disposal of contaminated demolition debris, soils, and other residuals prior to completion of the final cap. The decontamination building is utilized for the decontamination of certain vehicular equipment before being demolished itself. The two 500,000-gallon wastewater storage tanks have their final contents pumped to the wastewater treatment plant, and are demolished. The concrete of the secondary containment structure is broken-up, with the tank and concrete debris being disposed of in the landfill. The closure plan for the landfill is based upon a conservative assumption of closure at a point in time when the last two cells are not filled with by-product waste, and clean soil is needed to bring this area up to the elevation necessary for construction of the last segment of the final closure cap. The time required to complete closure is estimated to be in the range of 8-11 months, which is well with the 24 month limit stated in 25 TAC §289.260(h)(13).

The methodology and scope of the closure plan appear to be reasonable. The closure cost estimate has a grand total figure of $4,266,925 (2004), which includes recommended contingencies (NRC 1988) of 15% for the estimate itself, and 10% for contract administration of third party closure. The estimate further includes the minimum long term surveillance fund fee of $250,000 (1978), $724,310 (2004), required by 25 TAC §289.260(n)(3). The cost estimate appears to be based upon reasonable unit costs for labor, materials, and professional services. Labor productivity, and certain labor rates are based upon data taken from R.S. Means, which is the recognized source for commercial construction cost data, by region. Additionally, labor effort and cost information provided by a well-known demolition contractor is utilized in the estimate. The closure cost estimate total as proposed appears to be reasonable, and the scope of the

closure plan appears to be complete. Costs will need to be escalated to the current year of financial posting if a license is to be issued.

The post-closure care plan is based upon a proposed 5-year environmental monitoring, inspection and maintenance period performed by WCS, prior to the transfer of ownership of the property to the State of Texas. Environmental monitoring, as described in the application in Section 4.0, Environmental Monitoring Program, continues during the 5-year period. The plan does not mention monitoring of the levels in the leachate collection and leak detection sumps, or removing accumulated liquids. In order to prevent the possible transport of radon gas through the risers from the sumps, these risers would need to be sealed at the surface after closure. As noted previously in this report, it would be useful for the application to clarify whether any further level monitoring and/or sump liquids removal is contemplated during the 5-year post-closure care period.

The requirements under 25 TAC 289.260 (n)(2) state a preference to avoid any post-closure ongoing maintenance. Section 7.0 of the WCS application contains an estimated cost of $14,500 per year, for each year of the proposed 5-year post-closure care period. This relatively small annual cost would appear to only really be able to cover inspections and environmental monitoring. Actual required maintenance would seem to need to be in addition to the stated annual estimate. It would be useful for the application to discuss the potential magnitude of, for example, repairs to the landfill cap for subsidence. Consequently the $14,500 per year estimate may not be adequate. The proposed 5-year period post-closure care period appears to be reasonable in terms of scope and duration.

6.4 ALTERNATIVES

6.4.1 Introduction

The requirements for the analysis of project alternatives are given at 25 TAC §289.260(f)(1)(A)(vi), and (o)(2, 3, 6, 31-34). Section 9.0 of the WCS application contains the alternatives analysis report for the commercial by-product material disposal facility. It appears that WCS initially began acquiring property in Andrews County around 1993-94, apparently for the purpose of constructing a commercial RCRA landfill. RCRA permit HW-50358 was issued to WCS by the TNRCC, the predecessor agency of the TCEQ, in 1994. A radioactive waste storage and treatment facility followed, and the TDH, predecessor agency to the DSHS, issued license L04971 in 1997 for this purpose. Waste storage buildings, pad areas, and a waste treatment building (partitioned into RCRA treatment and low level radioactive waste treatment sides) are shared by these two operations. The original license application for the proposed commercial by-product material disposal facility, L05807, was submitted to the TDH on June 24, 2004.

6.4.2 The Alternative of No Action

The WCS application makes a case for both a Texas, and a national need for additional disposal capacity for by-product material waste. The uranium recovery industry in Texas is in a significant period of growth due to the price of yellow cake now being above $100 per pound. A local, within the state disposal service

would be a benefit to this growth, by providing a lower cost, lower risk alternative to out-of-state long-distance transport of by-product material waste. The application further emphasizes that the Fernald waste canisters are already stored onsite, and disposal onsite would also reduce costs and risks compared to having to transport this waste to, for example, Utah. The rationale for rejecting the no-action alternative is considered to be reasonable and valid.

6.4.3 Alternatives to the Andrews County Site

The WCS application lists the advantages of the Andrews County site as including local public support, relative remoteness, relatively low rainfall, favorable hydro-geologic characteristics, and an existing compatible use (i.e., the L04971 facility). The application also states that other locations in other Texas counties would encounter "intense opposition" to the project. However, there is no specific information on what, if any, other geographical locations either in the State of Texas, or in any other states, were in fact examined and studied as possible locations for the WCS by-product material waste disposal facility. The WCS site in Andrews County already represents a substantial capital investment in land, operating facilities, and related supporting infrastructure (over $30 million, according to a statement in Section 8.0 of the application) that was initiated a decade prior to the submission of the application for license L05807. Therefore, the economic momentum, or financial advantage, of the Andrews County site appears to be at least one of the more significant factors in its selection, if not the primary factor. It would be useful if the WCS application would also discuss the importance of this economic momentum factor, and how it may have precluded any serious, in-depth studies of alternative locations.

The WCS application does not discuss potential negative factors associated with the proposed Andrews County site. While long-term historical annual rainfall averages 14 inches to 15 inches, National Weather Service (NWS) data for Midland shows actual annual rainfall amounts of 32.1 inches, 23.5 inches, 21.4 inches, and 22.5 inches respectively for the years 1986, 1991, 1992, and 2004 (NWS 2007a). Storms in the area can result in large short term rainfall amounts, such as 3.5 inches of rain in one hour at Midland in May 2007 (MWT 2007). High wind speeds resulting in dust storms are also not uncommon in the area. On June 27, 2007, the NWS center at Midland reported a high-wind event that affected a large area of west Texas and southeast New Mexico. Winds of 93 mph were measured at Midland, and wind speeds in excess of 70 mph were reported near the Lea County, New Mexico – Texas state line, which would essentially represent the vicinity of the proposed WCS site (NWS 2007b). However, the accident analysis report of the WCS application, in Appendix 11.C, has only evaluated the probability of a tornado at the proposed site (ignoring straight line wind storms), and the wind dispersion study in Appendix 11.D appears to ignore wind erosion as a contributing factor to particulate mass emissions rates.

A recent study by the U.S. Geological Survey (Reheis 2003) shows the Andrews County area to be in the highest dust emissions zone in the southwestern United States. Studies by the United States Department of Agriculture, Wind Erosion Research Unit (WERU) also show the Andrews County site to be within the primary wind erosion region of the United States (WERU 2003). Furthermore, as detailed in the geology review report of the WCS application, the fact that the redbed, or Dockum, formation is listed as a minor Texas aquifer in various published handbooks and reports (TWDB 2001) is not mentioned in the

application. It seems reasonable to conclude that there has been no alternative site selection process carried out specifically for this proposed by-product material commercial disposal facility. As stated in the paragraph above, economic momentum, and not selection from among studied alternative locations, seems to have pre-determined the Andrews County location. It is then unclear, based upon the alternatives analysis presented in the application, whether a proper balance has been struck between the site features and the economic advantage of the site, while considering the risks to public health and safety and the environment as required by 25 TAC §289.260(o)(33).

6.4.4 Alternative Processes

This is not a uranium recovery operation, and there really is not a chemical, or physical-chemical, process involved with this application. However, it would have been useful for the application to have discussed the rationale for not installing one or more waste disposal wells at this site, and instead, installing an off-site, and as yet undefined, wastewater treatment plant. The wastewater treatment plant is flow, or hydraulically, coupled to the by-product material wastewater storage tanks. It would also be useful for the application to include basic information on the treatment plant, such as any front-end surge capacity it may have; the design, if any for redundancy (such as a dual-train design); the sludge residuals produced, which may need to be managed back into the by-product material waste disposal facility; and the status of design and permitting activities for coordination with the start-up of the by-product material waste disposal facility.

6.4.5 Alternative Methods of By-product Waste Disposal

The WCS application discusses alternative designs, and an alternative location within the boundaries of the property owned. It seems that the proposed redbed ridge location on the WCS property is really the only on-property location where the overburden thickness above the redbed clay formation is shallow enough to make the proposed landfill construction within the redbed economically feasible, and to make the landfill operationally feasible once constructed. Above-grade disposal is discussed, and rejected because of the unsuitability of the surface soil layer, potentially higher landfill cap erosion rates after closure, and potentially greater fugitive waste particulate air emissions rates. Below-grade waste placement is, in fact, preferred by the rules (25 TAC §289.260(o)(6)). Sub-surface disposal above the redbed is discussed, and is rejected also due to unsuitability of the soil layer above the redbed clay formation. Given these conditions, the selected design of disposal entirely within the redbed formation seems to be the reasonable choice.

Section 1.2.1 of this report discusses the landfill design as essentially conforming to RCRA Subtitle C design standards for hazardous waste landfills. The WCS application has not discussed why this RCRA design has been proposed, versus other landfill designs. WCS may be considering the RCRA design to be something of a benchmark standard, and it is similar to the landfill design used in the Monticello, Utah Mill Tailings Repository (Sandia 2001). However, it would still be useful for the application to discuss the rationale for the proposed RCRA-type landfill design, along with other design alternatives considered, including any considerations for designing and operating a surface (or sub-surface) impoundment instead

of a landfill. It is noted that an impoundment also requires a liner system (unless successfully exempted), a leak detection system where a synthetic liner is used, and a drainage system, and would ultimately need to be closed, with solid wastes in place, as a landfill. In addition, an impoundment-type operation is likely to develop higher static liquid heads over the liner system, which would increase the potential of release to the groundwater. The selection of the RCRA landfill design and operating standards does appear to represent good engineering practice in this case, from the standpoint of process functionality.

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10 CFR 40, Appendix A

40 CFR Part 264, Subpart N - Landfills

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CHAPTER 7 SOCIOECONOMIC ASSESSMENT

7.1 USES OF ADAJACENT LANDS AND WATERS

7.1.1 Evaluation Findings

DSHS has conducted its review of the site characterization information concerned with uses of adjacent lands and waters near the facility.

The applicant has acceptably described the present and projected land use, including residential, commercial, agricultural, industrial, grazing and recreational uses. Appropriate information on the location and extent of each type of use has been provided. Water data have been provided.

The description of the location in relation to adjacent land uses have been described in a method acceptable for determination of likely impacts of the proposed facility.

7.1.2 Land Use

Nearby towns include Andrews, approximately 30 miles east, and the City of Eunice, New Mexico, 6 miles west of the facility. The nearest residence is situated approximately 3.5 miles west of the facility.

Land use within one mile of the existing facility and proposed landfill is limited to cattle grazing. The majority of the land within five miles of the facility is used for grazing and ranching activities. Other businesses in proximity to the WCS property 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 (oil production waste) is located approximately 2.5 miles west of the facility, and the Lea County Landfill is located approximately one mile southwest of the facility. These land uses appear compatible with the industrial operations planned by WCS.

7.1.3 Water Use

Data on present and projected water use estimates have been provided. Water will be used for dust suppression during construction. WCS currently uses non-potable water pumped from wells and all other water is purchased from and supplied by the City of Eunice.

Future water uses in the area will include, industrial, domestic, livestock, and agricultural purposes. A constructed wetlands project and sports complex is being developed within the City of Andrews, thirty miles east of the WCS facility.

Senate Bill 1 was passed by the 75th Texas Legislature in 1997 to address Texas water issues. To implement this planning process, the Texas Water Development Board (TWDB) created 16 planning

regions across the state. Andrews County is in Region F, which covers 32 west Texas counties. The applicant reviewed the Region F Water Plan, adopted in 2001, to assess the WCS impact on water issues in the region.

On a regional basis, future water demands in Region F exceed the currently available supplies beginning in 2000. Most of these needs are attributed to large irrigation demands that cannot be met with available ground water sources. Other needs are due to limitations of contractual agreements, infrastructure, water quality and/or growth. The WCS facility operations are not specifically mentioned in the Region F Plan. The applicant states that the proposed WCS facility component would use about 52,000 gallons (approximately 0.16 acre-feet) per year from the City of Eunice, reportedly a fraction of the annual water use proposed by the National Enrichment Facility (NEF) in Eunice, New Mexico. The applicant notes that the cumulative annual use of WCS and NEF from the City of Eunice and the City of Hobbs would amount to about 71.2 acre-feet per year, over 99% of which is NEF water use. These accumulated demands may require the construction of additional water supply capital improvements, and associated expansion of utility debt and debt service, on the part of the Cities of Eunice and Hobbs. WCS does not contribute to Eunice, NM, in the form of contributions or taxes that might offset capital improvement expenses; however, because the majority of the demands will come from NEF water use, it would seem that Eunice would expect to address those costs with NEF rather than WCS. The City of Eunice has been offered the opportunity to comment on the WCS costs to local government.

7.1.4 Other Nuclear Fuel Cycle Facilities

The applicant has identified and located other nuclear fuel cycle facilities located or proposed within an 80-km [50-mi] radius of the site. A nuclear materials enrichment facility, mentioned earlier in this report, has been licensed by the U.S. Nuclear Regulatory Commission. This will operate at a site a few miles west of the WCS on New Mexico Highway 234. An existing transuranic waste disposal site, the Waste Isolation Pilot Project (WIPP), is located in southeast New Mexico, about 50 miles from the WCS facility, between Carlsbad and Jal, New Mexico. Discussions were underway in 2006 between the University of Texas – Permian Basin and General Atomic Corporation concerning the possible location in Andrews County of a high temperature nuclear test reactor.

7.1.5 Conclusion

Based on the information provided in the application, and the detailed review conducted of the characterization of uses of adjacent lands, the staff concludes that the land use information is acceptable and has provided a description of the affected environment containing sufficient data to aid the TCEQ in its conduct of an independent analysis. Note that additional assessment of water resources and uses will be addressed in geology review chapter.

7.2 POPULATION DISTRIBUTION

7.2.1 Evaluation Findings

TCEQ has conducted its review of the site characterization information concerned with population distribution and food production near the facility. This section of the report will address population information and environmental justice.

The applicant has acceptably described the population distribution using population data from generally accepted sources. A map showing the location of significant population centers, within an 80-kilometer radius [50-mile] of the approximate center of proposed operations, is provided. A table and accompanying map providing population in pie-shaped wedges, centered on each of the 16 compass points, is included. Nearest residence distances are noted for each sector. This information has been referred to technical assessments for evaluation of environmental health physics.

7.2.2 Population Data

The cities of Andrews, Texas and Eunice, New Mexico are the closest population centers to the site at distances of about 30 miles southeast and six miles west, respectively. Other population centers are at distances from the site as follows:

- Hobbs, Lea County, New Mexico: 20 miles north
- Jal, Lea County, New Mexico: 23 miles south
- Lovington, Lea County, New Mexico: 39 miles north-northwest
- Seminole, Gaines County, Texas: 32 miles east-northeast
- Denver City, Gaines County, Texas: 40 miles north-northeast

Based on a description of the methodology and sources, population data have been appropriately projected for the proposed life of the facility as shown in the following excerpted tables from the application's submission.

Table 5, Population and Population Projections for Counties in the Region of Interest

Year	Lea County, NM	Andrews County, TX	Gaines County, TX	Winkler County, TX	Region of Interest	New Mexico	Texas
1970	49,554	10,372	11,593	9,640	81,159	1,016,000	11,196,730
1980	55,993	13,323	13,150	9,944	92,410	1,302,894	14,229,191
1990	55,765	14,338	14,123	8,626	92,852	1,515,069	16,986,510
2000	55,511	13,004	14,467	7,173	90,155	1,819,046	20,851,820
2010	60,702	14,264	16,422	7,694	99,082	2,091,675	24,330,643
2020	62,679	15,255	18,228	8,058	104,220	2,358,278	28,005,792
2030	64,655	15,845	19,580	8,059	108,139	2,624,881	31,830,579
2040	66,631	16,192	20,637	7,958	111,418	2,891,483	35,761,159

Source: U.S. Census Bureau, 2002.

The Texas Water Development Board projections for population growth in Andrews, Gaines, and Winkler Counties in Texas are presented below in Table 6 excerpted from the application.

Table 6, Texas Water Development Board Population Projections for Texas Counties in the Region of Interest

Year	Andrews County, TX	Gaines County, TX	Winkler County, TX	Region of Interest in Texas	Texas
1970	10,372	11,593	9,640	31,605	11,196,730
1980	13,323	13,150	9,944	36,417	14,229,191
1990	14,338	14,123	8,626	37,087	16,986,510
2000	15,796	15,380	9,282	40,458	20,864,990
2010	17,314	16,603	10,042	43,959	24,542,579
2020	18,472	17,262	10,599	46,333	28,802,922
2030	18,998	17,300	10,764	47,062	32,791,383
2040	19,290	17,369	10,875	47,534	36,436,265

Source: Texas Water Development Board, 2004. *2002 State Water Plan Population Projections for 1990-2050 by County.*

The population projection data for the State of New Mexico is based on the 2000 U.S. Census as shown in the applicant's Table 7. The data shows a growth in the population of Lea County to 66,631 in 2040, a 20.0% increase over the 2000 population of 55,511 persons. This is consistent with the State of Texas' projected growth.

Table 7, New Mexico Population Projections for Lea County, New Mexico

Year	Lea County, New Mexico
1970	49,554
1980	55,993
1990	55,765
2000	55,511
2010	60,702
2020	62,679
2030	64,655
2040	66,631

Source: U.S. Census Bureau, 2000.

It appears likely that population growth as projected for the area can be accomplished without involvement of the site area due to the land mass available in the region and the land holdings of WCS. Note that other areas of the staff technical report will address population exposures.

7.2.3 Minority and Low-Income Populations

The applicant has provided acceptable information on minority and low-income populations, schools, industrial facilities, sports facilities, residential areas, and parks within 3.2 km [2 mi] of the proposed facility.

The applicant has also provided population projections by ethnicity in the application. The DSHS Center for Health Statistics has prepared a "Demographic Analysis for the Andrews County WCS Site" (2005) that evaluates population characteristics including ethnicity to confirm the findings of the applicant.

7.2.4 Environmental Justice

The application was reviewed with attention to whether or not there are disproportionately high adverse impacts on minority or low-income populations residing within Lea and Andrews counties that may warrant further examination for environmental justice concerns. The evaluation was performed using the most recent population and economic data available from the U. S. Census Bureau for that area and was done generally in accordance with the procedures contained in NUREG-1748 (NRC, 2003) guidance. This guidance was endorsed by the NRC's Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions (FR, 2003). Attention was given to the current population estimates and projections due to the age of the Census data.

7.2.4.1 Procedure and Evaluation Criteria

Census data from the 2000 decennial census were obtained from the U. S. Census Bureau for minority and low-income populations residing within several counties in the area of the proposed facility. These data were obtained at a census tract (CT) level, and include (for minority populations) percentage totals within each census tract for each individual minority population group (i.e., Black or African-American, American Indian /Alaska Native, Asian, Native Hawaiian and Other Pacific Islanders, Hispanic or Latino) This information may be found in the application, Tables 1-8, A.4A, and A.4B.

For the low-income analysis (defined in NUREG-1748 as those households below the US Census Bureau poverty level), only the total percentage of individuals and families below the poverty level was obtained. This is shown in Table 1-13 of the application. The low-income data used in the evaluation was for 1999. The minority and low-income population percentage data were then compared to their counterparts for their respective counties. These comparisons were made pursuant to the "20%" and "50%" criteria contained in Appendix C to NUREG-1748, to determine: (1) if any individual census tract contained a minority population group, aggregate minority population, or low-income household percentage that exceeded its county or state counterparts by more than 20 percentage points; and (2) if any census tract was comprised of more than 50% minorities (either by individual group or in the aggregate) or low-income households.

7.2.4.2 Results of Environmental Justice Analysis

The largest minority group is Hispanic or Latino, accounting for 42.1% of the total population in New Mexico and 32.0% in Texas. In Lea County, N.M., Hispanics comprise the highest percentage of a minority population with 39.6%. In Andrews County, Texas, Hispanic or Latino is the largest minority group as well with 40.0% of the population. Based on a review of the census tract data, it was determined that CT 9503 in Andrews County had a minority population of 61.4% with 58.2% of the population being Hispanic or Latino. Within Lea County, New Mexico, four census tracts, CT 1, CT 2, CT 3, and CT 4, all have minority populations greater than 50% (the Hispanic populations alone exceeded 59% in these tracts). Three of the four census tracts contained minority populations exceeding the NUREG-1748 "20%" criteria (NRC, 2003) because their percentages were 20 percentage points or more higher than Lea County's minority population (including Hispanic) of 45.98%. Lea County census tracts 1, 3, and 4 consisted of 70.0, 79.4, and 79.0% minority.

No county is comprised of more than 50% of low-income households. However, based on an analysis of the census tract data, there are several individual census tracts where the percentage of families below the poverty level exceeds 50% for a given race category. More than 50% of Black or African-American families were living below the poverty level in Lea County CTs 2, 3, and 8, Andrews County CT 9501, and Gaines County CT 9502. More than 50% of American Indian/Alaska Native families were living below the poverty level in Lea County CTs 2 and 5.02. More than 50% of Asian families were living below the poverty level in Andrews County CT 9502. All of these areas are in the urbanized parts of the relevant counties and are not adjacent to the proposed facility.

The only census tracts in the Region of Interest that fall within the five-mile radius are Census Tract 9501 in Texas and Census Tract 8 in New Mexico.

7.2.4.3 Environmental Justice and Transportation Effects

With respect to transportation routes in locations with high minority populations, based on a review of the census tract data, it was determined that CT 9503 in Andrews County had a minority population of 61.4% with 58.2% of the population being Hispanic or Latino. Two highways in Andrews County that are potential waste shipment routes include U.S. 385 and SH 176, which traverse this census tract. Within Lea County, New Mexico, four census tracts, CT 1, CT 2, CT 3, and CT 4, in the City of Hobbs, all have minority populations greater than 50% (the Hispanic populations alone exceeded 59% in these tracts). Three of the four census tracts contained minority populations exceeding the NUREG-1748 "20%" criteria (NRC, 2003) because their percentages were 20 percentage points or more higher than Lea County's minority population (including Hispanic) of 45.98%. Lea County census tracts 1, 3, and 4 consisted of 70.0, 79.4, and 79.0% minority. One principal roadway, which is a potential waste shipment route, is N.M. 18, which traverses or comes close to these census tracts.

With respect to transportation routes through census tracts with low-incomes, Census data confirms that two census tracts (3 and 4) in Hobbs, New Mexico have median household incomes below the 2006 H.H.S. Poverty Guideline of $20,000. N.M. 18, a potential waste shipment route, traverses or comes close to these two census tracts.

The applicant contends that no direct impacts such as displacements would result from construction of the proposed project. Any indirect impacts would be distributed throughout the community to those populations that are not immediately adjacent to the facility. The positive economic benefits would be more or less distributed throughout the community in the same manner, as well. Therefore, based on this limited analysis of the data, the applicant generally concluded that no disproportionately high or adverse direct or indirect effects to minority or low-income communities are anticipated as a result of the proposed facility. However, transportation effects will be considered in greater depth in the engineering sections of the Technical Report. Pending those findings, an environmental justice statement can be finalized by the staff.

State population projections indicate an increasing number of minorities will be present in the Region of Interest. Although the issuance of the license considers only current population, the department may wish to consider additional environmental justice analyses be performed in the case of major amendments to the license which might result in unforeseen and disproportionate impacts. This is consistent with NRC policy for Environmental Reviews which notes that non-radiological and socioeconomic evaluations are done for controversial or precedent setting licensing actions or in cases, including issuance of an amendment that would authorize or result in (i) a significant expansion of a site, (ii) a significant change in the types of effluents, (iii) a significant increase in the amounts of effluents, (iv) a significant increase in individual or cumulative occupational radiation exposure, (v) a significant increase in the potential for or consequences from radiological accidents, or any other licensing action for which the Commission determines an Environmental Report is necessary. (10 CFR §51.60)

Additionally, attention should be given to evaluating the impacts of this license as predicted and as actually experienced to assure that impacts resulted as anticipated and did not result in disproportionate impacts that should be mitigated.

7.2.5 Food Production

Food production data (e.g., vegetables, meat, milk) have been described; this information has been referred to technical assessments for evaluation of environmental health physics. In terms of socioeconomic impacts, food production has limited impact on Andrews County economy when compared with other Texas counties.

The 2002 Census of Agriculture (USDA, 2002) reports that Andrews County had 169 farms in 2002, down 3 percent from 174 farms in 1997. These farms amounted to 803,998 acres in 2002 and 832,603 acres in 1997, also down 3 percent. The average size farm in the county was 4,757 acres in 2002 and 4,785 acres in 1997.

The market value of agricultural production was $8,671,000 in 2002 and $9,908,000 in 1997, down 12 percent. Crop sales accounted for $2,240,000 of the total value in 2002, while livestock sales accounted for $6,432,000 of the total value. Andrews County is not a leading agricultural producer in Texas, ranking 212th out of 254 counties in market value of agricultural products statewide in 2002.

Source: United States Department of Agriculture, Texas Agricultural Statistics Service, Census of Agriculture, County Profile for Andrews County, 2002.

7.2.6 Conclusion

Based on the information provided in the application, and the detailed review conducted of the characterization of population distribution for the facility, the staff concludes that the information is acceptable and provides a description of the affected environment containing sufficient data to aid the TCEQ with its conduct of an independent analysis.

7.2.8 References

NRC. Regulatory Guide 3.46, "Standard Format and Content of License Applications, Including Environmental Reports, for *In Situ* Uranium Solution Mining." Washington, DC: NRC, Office of Standards Development. 1982.

NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." Washington, DC: NRC. 2001.

7.4. HISTORIC, ARCHITECTURAL AND SCENIC RESOURCES

7.3.1 Evaluation Findings

TCEQ has conducted its review of the site characterization information concerned with regional historic, architectural, and scenic resources near the facility. The licensee has acceptably described these resources. Final evaluation of the historic resources is pending confirmation from the Texas Historical Commission. The applicant has stated in a June 15, 2006, letter that this will be forthcoming.

7.3.2 Historic Resources

A listing of all nearby areas and properties included or eligible for inclusion in the National Register or National Natural Landmarks was provided by the applicant. A map showing all historic landmarks and places with respect to the facility was included. A record of the investigation of places and properties with historic, scenic, and cultural significance was provided. As part of the application in Appendix H, a map showing National Register Properties, National Natural Landmarks, National Parks, New Mexico Registered Cultural Properties, Recorded Texas Historical Landmarks, and Texas State Archaeological Landmarks located within a 10 km radius was presented.

A letter from the state historic preservation officer addressing any issues related to the properties that might be affected by the facility is included from New Mexico and is expected from the Texas Historical Commission pending additional work being done by the applicant as stated in June 15, 2006 correspondence. Upon receipt of this letter, a finding on Historical Resources can be finalized by staff. The expected letter, when received, will supersede the Texas Historical Commission letter from F. Lawrence Oaks, State Historic Preservation Officer to R. Ratliff, TDH, dated July 19, 2004, responding to the department's request for review and comment on WCS's by-product waste disposal application. Mr. Oaks returned copy of the request letter with "No Historic Properties Affected..." stamped on it.

The applicant conducted investigations within 10 kilometers of the proposed project site to determine whether historic resources that are listed in or eligible for listing in the National Register of Historic Places (NRHP) or that are designated as New Mexico Registered Cultural Properties (NMRCP) or Registered Texas Historical Landmarks (RTHL) are present in the vicinity, and if so, whether the proposed project would impact listed or eligible historic resources.

The applicant's search of the Texas Historical Commission's (THC) files indicates that there are no previously identified NRHP or RTHL historic resources in the construction or staging areas of the project. Thus, the project would not directly impact any historic resources. The THC search also indicates that there are no previously identified NRHP or RTHL historic resources within 10 km of the proposed project site. According to a search of the on-line database of New Mexico Registered Cultural Properties and communication with the NMRCP coordinator at the New Mexico Historic Preservation Division done by the applicant's consultants, WCS determined there are no previously identified NMRCPs within 10

kilometers of the proposed project site.

7.3.2 Architectural Resources

The applicant's project architectural historians reviewed current and historical maps of the area within a radius of 10 kilometers of the project site, to identify buildings or structures 50 years old or older. The architectural historian conducted the field investigations on March 8, 2006. The investigation consisted of driving all public roads within the 10 km study area to visually identify buildings, structures and objects that meet criteria for historic significance and integrity. Photographic and written documentation was gathered on four properties that appeared to be 50 years old or older. Additional photos were taken of properties that did not appear to be historic in order to provide an overview of the character of the building stock in the vicinity of the historic-age properties.

Following the field investigations, project architectural historians compiled an evaluation context for the study area and conducted analysis to determine whether any of the historic-age properties meet the criteria for listing in the NRHP or for being registered as RTHLs or NMRCPs. The findings of this analysis were summarized in letter reports submitted to the THC and the NMHPD for their comments. The letter reports concluded that none of the historic-age properties represent significant themes in local, state or national history, are not associated with significant persons and do not represent significant trends in architecture or design. They further conclude that since no significant historic resources are present in the 10 km study area, the project has no potential to adversely impact historic resources. Copies of the letter reports are provided in Appendix H of the application, including the signed "no historic properties" letter from NMHPD. A response from the THC is pending. (Note that these coordination letters were specifically requested by TCEQ so the low-level radioactive waste disposal project is referenced therein, but the analysis and coordination is pertinent and included for reference.)

Additionally, the applicant has stated that in the event historic resources would be affected by the non-emergency stages of remediation, professional architectural historians will be consulted to determine whether remediation efforts would impact significant historical resources and to identify ways of avoiding impacts.

7.3.2 Scenic Resources

The application was reviewed for the aesthetic and scenic quality of the site in accordance with the U.S. Bureau of Land Management Visual Resource Inventory and Evaluation System.

According to the U.S. Department of Interior (1986) and the Bureau of Land Management (1994), visual resources consist of landscape or visual character, and visual sensitivity and exposure. A study area's landscape features include landform, vegetation, water resource features, color, adjacent scenery, scarcity, and cultural modifications (that either add to or detract from visual quality). The overall impression of an area, composed of the elements above, is referred to as the "visual character". For this analysis, the visual character of the area is focused on the perspective of residents living in close proximity to the facility who

would be affected by changes to the existing visual resource, and the perspective of the driving public (along roads within 10 kilometers of the proposed site). However, since the closest residence is approximately 4 miles away from the facility, the majority of the analysis is geared toward the driving public.

The applicant's environmental team analyzed whether or not the following features exist or are likely to exist within 10 kilometers of the facility: landform (elevated views, hilltops), vegetation (woodlands), water (stream crossings, bridges, wetlands, water bodies), color (notable changes in color of the landscape), adjacent scenery (pastoral scenes, wildlife viewing potential), scarcity (known scarcity of wildlife habitat, vegetation, or cultural resource), and cultural modifications (urbanized areas, historic structures, visual detractors).

In accordance with the DOI and BLM guidance, a photo inventory of the scenic qualities of the proposed facility was conducted during the week of May 9-13, 2005. This study area included views from as much as 15 miles from the proposed project. Views were captured to illustrate three zones: foreground-middle ground, background, and seldom-seen.

A photo inventory within the WCS complex in its current condition was compiled as well as images of the by-products material waste in storage. Casks currently stored on the surface are scheduled for burial when the license is issued; therefore their visual impact is short-lived.

It was determined that the visual resources study area does not contain notable representations of any of the landscape features, although the relative lack of visual obstructions to a vast view of this section of the West Texas/East New Mexico landscape could be considered the "visual character" of the area. Overall, 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. Facilities geared towards resource extraction, the Lea County landfill, and oil well pump jacks exist in the project area, which have an equal or higher impact on the visual landscape than the proposed facility. Visual contrast with the existing landscape would be more apparent during construction. Since the proposed primary waste storage facilities are underground, there would be minimal contrast with existing visual resources

7.3.2 Conclusion

Based on the information provided in the application, and the detailed review conducted of the characterization of regional historic, architectural, and scenic resources, the staff concludes that the information is acceptable and provides a description of the affected environment containing sufficient data to aid the DSHS in its conduct of an independent analysis. Findings on Historical resources are pending as noted in this report.

7.3.2 References

NRC. NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." Washington, DC: NRC. 2001.

U.S. Bureau of Land Management. "Visual Resource Management." U.S. Bureau of Land Management Manual—8400. Washington, DC: U.S. Department of the Interior. http://lm0005.blm.gov/nstc/rrm/8400.html. 2000.

7.4 CUMULATIVE EFFECTS

Guidance directing evaluation of cumulative effects comes from U.S. Nuclear Regulatory Commission's *Environmental Review Guidance for Licensing Actions Associated with NMSS Programs NUREG 1748* (NRC, 2003a). In that document, cumulative impact is defined as "the impact on the environment which results from the incremental impact of the 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."

Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. (40 CFR §1508.7). To determine cumulative impacts, the guidance recommends following CEQ guidelines as outlined in "Considering Cumulative Effects Under the National Environmental Policy Act" (CEQ, 1997).

Based on those guidance documents, cumulative socioeconomic impacts of the WCS complex operations (including existing operations, the proposed low-level radioactive waste disposal facilities, and the proposed by-product material disposal facility) were evaluated by the applicant as summarized in this section.

7.4.1 Socioeconomic Resources Affected by the Combined WCS Disposal Complex

The socioeconomic resources affected by the cumulative effects of the WCS disposal complex are the people, businesses, government services and other organizations of the Region. The operations will have a cumulative effect on the transportation corridors through which wastes will be brought to the disposal complex. Social impacts include roles of WCS-related associates as residents, employees, and employers. Government services and infrastructure may be impacted incrementally as additions to the WCS operations occur and cumulative effects develop.

For the Region, the demographic characteristics of the residents in terms of ethnicity, income, employment and education have been profiled in the application, with attention to projections for the future. For the transportation corridors through which wastes might travel to the complex from potential clients, demographic characteristics will be quite different from the Region and highly variable between specific corridors, and it is assumed that impacts will be distributed rather evenly; however, a full analysis of

transportation will be done by civil engineers and reported in a separate Technical Report. Presumably, cumulative effects on government services and infrastructure will be offset by tax revenues from the WCS complex growth and development.

7.4.2 Past, Proposed, and Reasonably Foreseeable Future Actions

WCS located a processing and disposal complex in Andrews County, beginning in the 1990's, and its development affected the socioeconomic situation of the Region. WCS discussed this in its application. Comparison is also given to the nature of this complex and its impacts in comparison to development and periodic fluctuation of the Region's hydrocarbon resources. These developments and their impacts on the Region's social and economic development are summarized in Sections 1.3.1 and 1.3.4 of the application.

Proposed and foreseeable actions that would affect the Region's socioeconomic resources include: (1) the possible approval by the TCEQ of the pending WCS low-level radioactive waste disposal component license application; (2) the possible approval by the TCEQ of the pending WCS by-product material disposal facility license application; (3) the development of the National Enrichment Facility; (4) implementation of the 2005 federal energy policy including a renewed reliance on nuclear energy; and (6) the possible location in Andrews County of a high temperature test reactor.

7.4.3 Cumulative Socioeconomic Effects

Cumulative socioeconomic effects likely to arise as a result of the proposed and reasonably foreseeable actions identified in the application include changes in (1)output, employment, and income within the Region and (2) in property and sales tax base development and fiscal impacts to communities. Another impact is the increased potential for future nuclear materials disposal and processing-related economic development in the Region. Also anticipated are increases in (1) 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 and in (2) community awareness of transportation of wastes within the area. There is additional awareness that 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. Also a fluctuating demand for NEF construction-related social and community services over the eight-year construction period is anticipated.

7.4.4 Socioeconomic Relationships

Cumulative socioeconomic effects will be based on existing social and economic relationships that have evolved in the Region as a result of the long history of development of the hydrocarbon resource base. These social and economic relationships and their implications for the current social structure, character of the Region and resilience in the face of potential facility impacts have been described in Sections 1.3.1 and 1.3.4 of the application. In short, the community is accustomed to risks, both environmental and economic, as has been experienced by them with the oil and gas industry over the past decades. The

community desires diversification and an industry that is less subject to dramatic swings in production and pricing.

New and growing employment and business opportunities for community residents may arise from the potential development of a new science and technology-intensive radioactive materials processing and disposal sector in the Region. New community fiscal resources, including contributions for education, may be realized from the WCS complex development.

7.4.5 Employment and Income Cumulative Impacts

The WCS complex will have cumulative impact on employment as presented in Table 8 excerpted from the application.

Table 8. Estimated Cumulative Impacts on Direct and Indirect and Induced Employment and Income Associated with the WCS Complex Operation

	Direct Employment	**Indirect and Induce Employment**	**Direct Income**	**Indirect and Induced Income**
Existing WCS Complex (2004)	107	49	$8,260,400	$1,817,288
Low-Level Radioactive Waste Component	37	17	$2,856,400	$643,600
By-product Material Disposal Component	3	1	$231,600	$50,952
Estimated Cumulative Impacts	147	67	$11,348,400	$2,511,840

Source: WCS, 2004c.

Note that the by-product disposal operations impacts are relatively small when compared to the other operations of WCS. However, when taken as an increment to development of the waste disposal complex, they have significance in terms of continuing the progression toward a nuclear processing and waste disposal-based advanced technology economic sector for the Region.

The clustering of related industries, such as nuclear materials processing, in a region can give rise to agglomeration economies that accelerate economic development. Agglomeration economies are cost savings in an economic activity that result from enterprises or activities locating near one another. Clustering of related activities create cost savings by increasing the efficient use of information where contact between buyers and sellers is facilitated, by spreading of the costs of public services, and by the development of specialized input suppliers serving a number of companies in the surrounding area. In that

the community leadership has expressed support for new nuclear-related development initiatives and a there appears to be a cultural acceptance of such initiatives and entrepreneurial enterprises, this region may find one cumulative effect of the WCS complex to be the fostering of the future nuclear-related economic development. The nuclear material processing and waste disposal sector represented by the existing WCS complex and proposed additional components has emerged as a factor in the regional economy and represents a seed of a potential new growth sector.

7.4.6 Cumulative Socioeconomic Impacts of Other Past, Present and Future Actions

The licensure in the immediate vicinity of the WCS complex of Louisiana Energy Service's (LES) National Enrichment Facility (NEF) as a gas centrifuge uranium enrichment plant could represent a substantial cumulative impact.

Cumulative socioeconomic effects for the Region, including the National Enrichment Facility effects, are presented in Table 9 below excerpted from the WCS application.

Table 9. Estimated Cumulative Impacts on Direct and Indirect and Induced Employment and Income Associated with the WCS Complex Operation and the National Enrichment Facility

	Direct Employment	Indirect And Induced Employment	Direct Income	Indirect and Induced Income
Existing WCS Complex (2004)	107	49	$8,260,400	$1,817,288
Low-Level Radioactive Waste Component	37	17	$2,856,400	$643,600
By-product Material Disposal Component	3	1	$231,600	$50,952
National Enrichment Facility	210	173	$10,500,000	$5,600,000
Estimated Cumulative Impacts	357	240	$21,848,400	$8,111,840

Source: WCS 2004c; NRC, 2004.

Again, the impact of the by-product disposal facility is relatively small; however, the possibility that the proposed NEF location in combination with the WCS disposal complex could form the basis for a development of a nuclear complex would constitute a substantial cumulative socioeconomic effect.

Potential cumulative socioeconomic effects could be that these two facilities might represent potential propulsive industries that could drive the eventual development of the Region centered around the

processing and disposal of nuclear materials.

In terms of other future actions that might contribute to regional cumulative socioeconomic effects, as noted in Sections 2.1.6 and 2.5.4 of the application, discussions were underway in 2006 between the University of Texas – Permian Basin and General Atomic Corporation concerning the possible location in Andrews County of a high temperature nuclear test reactor.

An important past action in the Region that has added to cumulative socioeconomic impacts in the Region is the Waste Isolation Pilot Plant, or WIPP. The WIPP is the world's first underground repository licensed to safely and permanently dispose of transuranic radioactive waste left from the research and production of nuclear weapons. It is located 26 miles southeast of Carlsbad. Over the next 35 years, WIPP is expected to receive about 37,000 shipments of waste from locations across the United States and will result in cumulative transportation impacts. Other contributions to cumulative socioeconomic impacts within the Region is WIPP's professional and technical workforce.

7.5 ENVIRONMENTAL APPROVALS AND CONSULTATIONS

7.5.1 Evaluation Findings

Staff has conducted its review of the environmental approvals and consultations for the proposed facility.

The applicant has identified the environmental approvals and consultations obtained or required for the proposed facility. The applicant has provided a summary of permits and licenses obtained for the proposed facility that identifies the type of permit (license), the granting authority, the assigned number, and the current status (if appropriate). These are shown in the following table excerpted from the application.

Table 10. WCS Authorizations for Existing Facilities

	Relevant Program and/or Law	Permit /License No.	Government Agency*
1	Texas Solid Waste Disposal Act (TSWDA)	HW-50358[1]	TCEQ
2	Wastewater disposal under Texas Water Code	TPDES 0403	TCEQ
3	Underground Injection Control under Texas Injection Well Act	None	
4	Texas Clean Air Act (TCAA)	HW-50358[3]	TCEQ
5	Texas Uranium Surface Mining & Reclamation Act	None	
6	Texas Surface Coal Mining & Reclamation Act	None	
7	Hazardous Waste Management program under the TSWDA	HW-50358	TCEQ
8	National Pollution Discharge Elimination System (NPDES) program under the Clean Water Act (CWA)	TPDES 0403	TCEQ
9	Prevention of Significant Deterioration (PSD) program under Clean Air Act (CAA)	None	
10	Non-attainment program under the CAA	None	
11	National Emission Standards for Hazardous Pollutants (NESHAP) preconstruction approval under the CAA	None	
12	Ocean dumping permits under the Marine Protection Research Sanctuaries Act	None	
13	Dredge or fill permits under Section 404 of the Clean Air Act	None	
14	Texas Radiation Control Act (TRCA)	L04971[4]	TCEQ
15	Other relevant environmental permits/licenses	TSCA Authorization[5]	EPA

TCEQ – Texas Commission on Environmental Quality
EPA – U.S. Environmental Protection Agency
[1]Original permit issued August 5, 1994.
[2]TPDES permit issued December 2, 1999, discharge commenced April 2001.
[3]Air authorization currently in RCRA permit. New Source Review Permit application filed on July 9, 2004 and currently being processed by TCEQ.

[4]Radioactive Materials License for processing and storage issued November 30, 1997. A By-product Material Disposal License Application is currently pending with the TDSHS.
[5]TSCA Authorization issued December 2, 1994 and reauthorized November 22, 1999.

Meetings held with environmental and citizens' groups are documented in the list excerpted from the application. However, summaries of the meetings were not provided. Several meetings held in public forums have been observed by staff and therefore, evidence exists that issues surrounding the WCS application have been voiced in public. Presumably, these same kinds of issues have been discussed in various meetings with other organizations.

7.5.2 Chronology of Meetings, Hearings and Public Participation

In addition to maintaining an office in Andrews to facilitate public inquiries and access, below is a list of specific "outreach" presentations that have been made after submission of the license application to explain WCS and its waste disposal initiatives to organizations in the local communities and other parts of the state.

WCS Outreach Presentations		
GROUP	**SUBJECT**	**DATE**
Andrews Community Leaders	WCS Strategic Plan	2/11/2005
Andrews/Hobbs Community Leaders	LA overview	8/10/2004
Carlsbad, NM Economic Development Committee	LA overview	8/19/2004
NM legislative committee	Radioactive waste overview	7/22/2005
Andrews Lions Club	Radioactive waste overview	3/29/2005
Eunice Rotary Club	Radioactive waste overview	4/28/2004
TCEQ Public Meeting	LA process and overview	3/31/2005
Texas A&M engineering students	Radioactive waste overview	3/21/2005
Air and Wastes Management Association	Radioactive waste overview	10/20/2005

7.5.3 Conclusion

Based on the information provided in the application and the detailed review conducted of the environmental approvals and consultations for the facility, the staff concludes that the environmental approvals and consultations list permits licenses, approvals and other entitlements that must be obtained in connection with the proposed action and describe the status of compliance with these requirements. A list of public meetings and interactions was provided.

7.5.5 Reference

NRC. NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." Washington, DC: NRC. 2001.

7.6 ALTERNATIVES TO THE PROPOSED ACTION

Alternatives to the proposed action are discussed in Site and Project Alternatives - Section 9.0 of the license application.

The proposed WCS by-product material landfill is located on an approximately 15,400-acre tract of land located in West Texas. WCS considered an alternative location on the property that is owned by WCS, but WCS believed the alternative location was not as desirable as the proposed location based on operational and economic considerations. The alternative location considered is approximately one mile to the southeast of the currently proposed landfill location.

In addition, WCS considered a design to dispose of the by-product material near and above the surface. However, WCS noted that this design had the potential for impacting the undifferentiated Ogallala, Antlers and Gatuña sands and gravels near the surface at the landfill site.

The No-Action Alternatives that are relevant would be: (1) to locate the proposed by-product material disposal facility elsewhere; and (2) to not develop a by-product material disposal facility at all.

In either case, the facility would not be located at the WCS complex in Andrews County and the relatively minor socioeconomic benefits and costs would not occur in the Region of Interest. If the proposed by-product material disposal facility were located elsewhere, the socioeconomic benefits and costs would be different depending on the specific circumstances of the alternative location. If an entirely new site were developed, the impacts would be substantially greater than those estimated here, as an entirely new facility would need to be constructed rather than the addition of an incremental disposal landfill cell such as is proposed for the existing WCS facility. If the facility were located at an existing disposal site, the magnitude and character of the potential socioeconomic impacts would depend upon the specific circumstances of the existing disposal site to be used, and would need to be determined individually for each such specific alternative site.

The applicant notes that the primary national significance of the No-Action Alternative is that existing stores of by-product materials would remain in their present locations or be transported to an alternative disposal site. The first alternative would be unsatisfactory from the perspective of a national energy policy that emphasizes the further development of nuclear energy in that it would delay the resolution of the nuclear material waste disposal issue. Development of an alternative disposal site elsewhere in the nation would entail socioeconomic impacts at the selected location.

7.7 BENEFITS AND COSTS

7.7.1 Evaluation Findings

DSHS has conducted its review of the cost-benefit analysis for the facility. Financial information has been provided based on actual data and model projections.

DSHS has reviewed societal benefits and costs in the context of public policy and social costs and expectation as expressed by community leadership and community surveys conducted by the applicant's consultants. Thorough examination of these issues indicates contemplation of the numerous social and political issues has occurred in public forum and in popular press as well.

7.7.2 Societal Benefits and Costs in the Context of Public Policy

Possible conflicts between the proposed action and federal, state, regional and local land use and public policy have been identified, described, and documented. Issues raised in the Texas Senate Natural Resources Hearing of February 1, 2005, have been acknowledged. Testimony from public officials has been noted. Current and future societal benefits and costs have been compared in terms of establishing a precedent for future actions that might have cumulative impacts for the region. This section summaries the presentation of this information by the application.

7.8 PUBLIC POLICY

7.8.1 Federal Policy

In April, 2005, the Bush Administration reiterated its nuclear energy policy and in subsequent Energy Policy Act passed in 2006. The expansion of nuclear energy in the United States is a major component of our national energy policy. The development of the WCS facility for the safe, permanent disposal of by-product materials would be consistent with the administration's national energy policy emphasis on nuclear energy.

7.8.2 State Policy

At the level of State energy policy direction, in 2003, the Governor of the State of Texas issued Executive Order RP 29 relating to the creation of the Texas Energy Planning Council. The Council recommended a study of the role nuclear energy should play in supplying Texas' future energy needs. The Plan does not speak directly to the issue of radioactive waste disposal, but does not include any provision that would be in conflict with the proposed facility.

7.8.3 Texas Legislature Considerations

Elected officials have given consideration to radioactive waste policy during the past 25 years in an effort to provide for the safe disposal of radioactive waste generated within the state and to address disposal possibilities for accepting radioactive waste from other states. The WCS application for by-product disposal, as well as the low-level radioactive waste application pending at TCEQ, has been the subject of legislative policy debate. Due to the importance Legislators have given this topic, this technical report will include significance legislative actions and discussions.

The Texas Senate Natural Resources hearing held February 1, 2005, examined the WCS waste business issues in terms of state policy in depth. A video transcript of that hearing is available at http://www.senate.state.tx.us/avarchive/ram.php?ram=00002032. This section summarizes that testimony to memorialize the policy issues and statements of elected officials.

The hearing was convened to consider the need for further changes to the State's policy on radioactive waste disposal. Witnesses were called by invitation. Public testimony was not taken. No legislation was passed as a result of this hearing.

Senator Duncan presented a comprehensive history of the statutes and regulations concerning by-product material waste. He continued his presentation by noting that the Legislature considered the importation of radioactive waste into Texas in the previous session, but did not give adequate attention to by-product material waste. Among the policy issues that Senator Duncan suggested needed further consideration were the following: Should Texas agree to be the Nation's first and last resort for disposal of by-product material? If so, what level of compensation to the State is appropriate? And, to what extent should the State and which agency in the State should regulate this activity?

The next group of witnesses represented WCS. George Dials, speaking for the company, noted that WCS has 120 people on their payroll in Texas. The company has a $4 million annual payroll in Andrews County where 100 of the company's employees live and work. He urged the State to adopt policies that would allow WCS to continue to grow and bring jobs and prosperity to west Texas. Mike Woodward, speaking for the company, noted that the community fully supported the project after analyzing it carefully. He noted that it was very unusual – indeed an asset -- to have a community that did not have a "NIMBY" (not in my back yard) attitude about such a facility. Mr. Dials continued with a discussion of transportation issues. In response to a question from Senator Duncan, Mr. Dials said that WCS was not currently pursuing waste from the nearby LES facility, but would not rule out doing so at the proper time if State law permitted.

Senator Jackson pondered the need to continue the Texas Low-Level Radioactive Waste Compact that was adopted by the Texas Legislature in 1997. The compact limits the amount of waste that Texas is obligated to receive for disposal. Senator Jackson suggested that the new direction that the Legislature was heading made the compact irrelevant.

The third group of witnesses was the local banker and the Mayor from Andrews Texas. Russell Shannon, speaking for the Andrews Industrial Foundation, noted that the facility had almost unanimous support in the community. He noted that some members of the Andrews community were concurrently attending a meeting concerning a uranium enrichment plant to learn more about that facility. He expressed concern about the slow process and urged the Senators to adopt laws that would expedite the licensing of the by-product material facility. He also noted that the community had been courting WCS for a decade but had not seen any compensation in the way of mitigation or compensation fees. He mentioned that WCS did not pay local school taxes, but contributed to a local educational foundation in an amount equal to school taxes. He endorsed Senator Duncan's call for increased regulatory oversight and urged the State to conduct frequent public hearings in Andrews County to keep the citizens informed.

Andrews City Mayor complimented WCS for always keeping him informed. He felt that their open communication was a definite asset. The Mayor referred to the citizens of Andrews as important resources in that they are open-minded and smart about industrial activities. He acknowledged that five or six persons in the County probably opposed the WCS facility, but thousands supported it. He said that all benefits to the City were indirect; no direct compensation was paid to the City of Andrews. But, in the long term he believed that the project will bring hope and prosperity to the people of Andrews.

The fourth panel was a group of engineers from the Department of Energy's uranium enrichment plant in Fernald, Ohio. They discussed highly technical details about the waste product, noting that it was declared "by-product material" waste by an act of the Congress. In response to questions from Senator Duncan, they noted that the waste to be shipped to Andrews County for storage at the WCS facility would remain the property of the DOE until it was disposed in the WCS by-product material disposal facility. If a facility is not available in Texas in two years, then the DOE will be obligated to remove the waste to another place for either storage or disposal. The engineers were not able to define where the waste will be taken in that instance.

The final panel was a group of state regulatory officials and an analyst from the Legislative Budget Board. In response to questions from the Committee Chairman, Senator Armbrister, the panelists described their roles in the regulation of the WCS facility. The analyst noted that he had not considered the amount of revenue that the State of Texas could receive under differing scenarios of storage and disposal of by-product material waste.

In summary, the hearing attendees speaking on behalf of Andrews reported support for the WCS facility in Andrews County, noting the qualitative benefits they believe the WCS operations will bring to Andrews. However, from a statewide viewpoint there are lingering questions about the amount and types of radioactive waste that the State Legislators might be willing to accept for disposal and the appropriate levels of compensation to the State treasury if the State should agree to accept these types of waste. In addition, the Legislators were in agreement that the regulation of this industry needed further review and a determination needed to be made about which agency in Texas should take the lead in regulating the industry.

7.8.4 Local Policy

Although WCS has coordinated with organizations in Andrews, no meetings have taken place with regional or state planning organizations or councils of government (the nearest Metropolitan Planning Organization is in Midland/Odessa).

Local land use and public policy with regard to by-product material waste disposal has been promulgated in a series of resolutions by local governments in support of the WCS facilities development. In 1997, and again in 2003, the Andrews County Commissioners voted unanimously to endorse the development of a low-level radioactive waste facility in Andrews County, noting that, "...the addition of these waste streams added to the WCS facility's capabilities is a welcomed type of business within our local and regional economy." In 2004, the Mayor and City Manager of the City of Andrews, the County Judge, the President of the Andrews Industrial Foundation, President of the Chamber of Commerce and other local business leaders signed letters to the state's governor and U.S. senators supporting the proposal to send waste materials from the U. S. Department of Energy – Fernald Facility in Ohio, to the licensed facility of WCS for storage in Andrews County. Appendix B of the application contains Resolutions.

Andrews is the only municipality in Andrews County. The WCS site is roughly 30 miles due west of the city of Andrews; hence, local land use regulations and/or comprehensive plans do not apply to the facility as this is well beyond the City of Andrews' extra-territorial jurisdiction (ETJ). Andrews County has not adopted countywide zoning nor does it have other regulatory ordinances that would apply.

The Andrews Industrial Foundation, a privately funded group formed decades ago to help attract companies to the city, has expressed support for the WCS facility because it is seen as bringing jobs and people to Andrews.

The new City of Hobbs Comprehensive Plan addresses long-term policies that will guide future development. It includes an economic development chapter that provides a set of strategies for both strengthening the local tax base and diversifying the economy. The strategies include supporting the development of the NEF Facility in Eunice, working to identify and recruit businesses into the area that would provide associated goods or services for the NEF facility or its workers, and also working to support the establishment of a Uranium Waste Treatment facility within 5-10 miles of the proposed NEF site to provide safe treatment of the waste and also provide additional jobs in Lea County.

7.8.5 Conclusion

It would appear from these sources that the proposed WCS by-product disposal facility is in conformance with stated local public policy with respect to land use, economic development and radioactive waste disposal issues.

7.9 LEADERSHIP AND PUBLIC OPINION SURVEY FINDINGS

Public opinion surveys, both in the form of scientific and informal surveys, and community leadership activities were provided by the applicant as documentation of scoping and public opinion documentation. These surveys and activities express primarily positive levels of support for the WCS operations relating to radioactive waste disposal.

Media coverage, including radio, newspaper, television, and Internet reported both factually and editorially and examined ramifications of the radioactive waste disposal issue. Press coverage included local, regional, state and national coverage and perspectives.

Regarding the planned disposal of radioactive materials by WCS in a facility to be licensed in Andrews County, the details and issue appear to have been well publicized, although communications in Spanish were limited. The company solicited the opinions of regional and local residents. The licensing agency participated in informal public meeting with residents.

Results of a random sample public opinion survey were examined by the licensing entity. The majority of persons interviewed in random and non-random samples approved of disposal. Elected officials had opportunities to legislate changes to policy that would have changed the course of WCS's activities, but did not. Local elected officials endorsed the project through resolutions, testimony and other public statements. An opportunity for a public hearing will be published by the licensing entity and testimony will be taken and considered as statutes require.

Therefore, it can reasonably be concluded that the public and leadership have had adequate exposure to the issue and opportunity to express opinion and legislate changes as desired. Furthermore, an opportunity for persons affected will be provided through hearing process.

Public Opinion Surveys, State and Community Leadership Positions, and Media Coverage will be discussed in greater detail in the next sections.

7.10 PUBLIC OPINION SURVEYS

7.10.1 Random Survey

WCS contracted with Baselice & Associates, Inc., a national research organization, to conduct a random telephone survey of public attitudes toward the WCS plan for a facility and operations related to disposal of radioactive waste. The survey included open-ended questions related to the public's understanding of WCS and perceived positive and negative impacts of WCS in Andrews County.

The firm conducted a survey of residents over the age of 18 in zip code areas that extended to 56 miles from the site. The area included the cities of Eunice, NM, and Andrews, TX, as well as other surrounding communities. The survey was conducted January 21-23, 2006. The sample preparation determined a

geographically representative sample of respondents as well as representative of gender. Hispanics constitute 35% of the Census population in the survey area, although 13% of the respondents were Hispanic. Baselice & Associates provided a discussion to explain that the disproportionate number of Hispanic responders may be a function of the prevalent use of cells phones (no land line numbers available for calling) or due to other factors unique to that population group. However, it appears that reasonable attempts were made to include all ethnicities in the survey. The opinions of the Hispanics interviewed did not differ significantly from the opinions of Angles. Hispanics (65%) were more apt than Anglos (54%) to agree with the statement "The WCS facility has had a positive impact on the community."

Survey Specifics:

Total sample respondents = 605
Margin of error = +/- 4.1%
Andrews County respondents = 172
Margin of error = +/- 7.4%

FINDINGS: RADIOACTIVE WASTE OPINIONS		
RESPONDENTS	**FAVOR DISPOSAL**	**OPPOSE DISPOSAL**
Andrews County	65%	26%
Survey Area	52%	35%

The random survey indicated there is a higher level of support among respondents who know more and specific information about the actual activities of WCS.

7.10.2 Non-representative Survey

An informal community survey was also conducted by WCS's consultants through onsite interviews conducted by planners. This survey was not representative of the population diversity in the Region of Interest (ROI) with respect to gender, ethnicity, educational level, and income. Specifically, 82% white, 71% male, 82% over the age of 40, 82% with an annual income of over $50,000 (15% of those with annual income over $100,000), and 59% college graduates were surveyed. However, findings are included as indicating the level of community support for the operations with the disclaimer that the study was not a scientific survey. The findings of support among this survey sample is somewhat consistent with the findings of the random survey in that there is a higher level of support among respondents who are more knowledgeable about the company and radioactive waste disposal.

7.10.3 Community Leadership Position

Community Leadership has consistently supported the development of a radioactive waste sector by WCS. Testimony at legislative hearings, resolutions, letters of endorsement, conversations and interviews document this support. These have been made available in the application.

7.11 MEDIA COVERAGE

Pros and cons of WCS's radioactive waste disposal plans for licensure and state policy were well aired through press, television and radio as illustrated by the references shown in this section. Examination of the many articles did not reveal significant aspects that were not at some time considered in public debate, community survey, conversations or legislative hearings.

Therefore, through media coverage, it can be reasonably concluded that the public and elected officials have been adequately made aware of the controversial and non-controversial issues related to radioactive waste disposal. This coverage served to provide an awareness of the issue so that persons had opportunity to do their own due diligence in formulating their policies and opinions.

A sampling of articles include:

Andrews County News. 2005. "TCEQ panel hears mostly support for WCS." April 6, 2005.

Barnes, Melanie. 2005. "Don't let Texas be dumping ground for toxic waste." April 2, 2005. Dallas Morning News.

Blaney, Betsy. 2005. "Former oil town eyes radioactive waste: Officials like idea of cash, jobs from storage, but is it safe?" MSNBC.com. http://www.msnbc.msn.com/id/7709778

Blaney, Betsy. May 2, 2005. "Waste no one else wants is welcome: Radioactive material from Fernald going to Texas." The Associated Press. http://news.enquirer.com/apps/pbcs.dll/article?AID=/20050502/NEWS01/505020359/1056/news01

Campbell, Bob. 2004. "Geologists argue over Andrews waste dump." The Midland Reporter-Telegram. Mywesttexas.com
http://www.mywesttexas.com/site/printerFriendly.cfm?brd=2288&dept_id=475626&newsid=12860308

KGBT4 – TV Harlingen, Texas. 2005. "Tons of uranium by-product waste headed to West Texas."

Nelson, Dave. "Battle lines shape up in waste war: Second company makes move in Andrews County." Avalanche-Journal http://www.lubbockonline.com/news/092896/battle.htm

7.12 ECONOMIC AND SOCIAL EFFECTS OF CONSTRUCTION AND OPERATIONS

DSHS has conducted its review of the economic and social benefits of construction and operation proposed at the facility. The applicant has acceptably described anticipated economic and social benefits of construction and operation of the facility using models, actual experience and business plans and industry-wide comparison.

7.13 SOCIOECONOMIC BENEFITS

7.13.1 Construction Phase

Construction phase benefits were estimated by the applicant using WCS estimates on expenditures and models for projecting indirect and induced impacts.

Total by-product material disposal facility construction costs to begin operations are estimated by WCS to be $500,000. Also note, additional construction costs will be incurred during the operation phase of the new facility to enlarge the landfill cell as needed. WCS has estimated that six construction workers will be needed to build the initial phase of the by-product disposal facility. In the applicant's analysis, estimated impacts are spatially distributed over the entire Region of Interest.

Total direct, indirect and induced economic impacts arising from the construction of the proposed by-product material disposal facility component are estimated using average values for output and employment and income multipliers for the construction sector. Direct employment of construction workers during the construction phase of the project is estimated by WCS to be six employees. A total direct, indirect and induced employment impact of 14 jobs is anticipated.

Total direct, indirect and induced personal income arising from the construction of the by-product disposal facility results in $125,000 of wages and salaries per year. Direct, indirect and induced income from construction of the proposed facility is projected to be $318,750.

Expenditures associated with the construction phase of the proposed by-product material disposal facility component will have a short-term impact on retail sales in the region.
The total effect on the retail sector was estimated as $52,750 of associated retail sales.

7.13.2 Social Impacts during Facility Construction Phase

No new residents are expected to move into the area during the facility construction phase. For specialized services, workers and equipment operators are anticipated to commute from outside of the Region of Interest. Given the relatively short period of time (four months) required for construction, it is expected that there will be short-term positive social impacts resulting from increased income to local individuals and businesses. Increased traffic will affect local roadways over the time period. With the experience of oil and gas operations and maintenance, the use of heavy trucks on the highways is not unusual or

unexpected.

7.13.3 Operation Phase

A set of output, employment and earnings multipliers for the Region of Interest was derived by averaging the BEA RIMS II multipliers for the Andrews, Texas Metropolitan Statistical Area (Andrews County, Texas) and the Hobbs, New Mexico Metropolitan Statistical Area (Lea County, New Mexico). These two Metropolitan Statistical Areas comprise the majority of the Region of Interest. In the study conducted by the applicant, the WCS disposal facility is represented by the Waste Management and Remediation Services sector (562000; 1997 NAICS Code 562).

In 2004, the WCS facility employed 107 workers at the Andrews County site under current operations. Direct employment at the new by-product material component of the facility during the operating phase is predicted to include an additional three workers. An additional 2.4 indirect and induced workers in the Region of Interest are expected. Total employment generated in the Region of Interest by the operation of the new by-product material facility component is therefore estimated at 5.4 jobs.

A direct annual income impact of approximately $150,000 is expected for the operational phase of the by-product material disposal facility. Total annual income effects are estimated at $158,935.

7.13.4 Tax Revenues

WCS state and local taxes, donations and contributions in 2005 are summarized in Table 11 below excerpted from the application. The total amounted to almost $1.5 million dollars.

Table 11, WCS 2005 Taxes, Donations and Contributions (dollars)

Tax Type	State	Andrews	Total
Property Taxes			
Hospital district		22,123.27	22,123.27
School district		150,269.28	150,269.28
Roads		6,193.06	6,193.06
Other		35,429.27	35,820.55
Total Property Tax		**214,014.88**	**214,014.88**
Payroll Tax	383,729.70		
State Fees	419,040.91		
Franchise Tax	60,768.10		
Sales Tax (direct pay only)	327,541.88	66.00	
Total tax paid (mandatory)	1,191,080.59	214,080.88	1,405,161.47

Andrews Education Foundation donation		24,343.79	24,343.79
Social Contributions		56,280.00	56,280.00
Total donations (voluntary)		80,623.79	80,623.79
Grand Total	**1,191,080.59**	**294,704.67**	**1,485,785.26**

Source: WCS, 2006.

In 2005, the existing WCS facility paid approximately $214,080 in taxes to local Andrews County jurisdictions, including Andrews County, Andrews Independent School District, and Andrews Hospital District. WCS is planning significant investments relating to several outstanding licenses and projects. Therefore, WCS expects the property tax base to increase over the next few years.

A summary of the 2005 Andrews County budget by major fund of expenditure is presented in Table 12 excerpted from the application.

Table 12, 2005 Andrews County Budget Summary by Fund

	General Fund	Road & Bridge	Debt Service	Total
Projected Revenue	$11,535,977	$2,298,302	$0	$13,834,279
Budgeted Expenses	($14,382,568)	($2,636,883)	$0	($17,019,451)
Variance	($2,846,591)	($338,581)	$0	($3,185,172)

Source: Andrews County Budget, 2005.

7.13.5 Industry-wide Standard

Relatively few radioactive waste disposal sites of any kind operate in the United States. Therefore, little actual experience with an industry-wide standard of financial impact or contribution is available. In lieu of standardized information, the applicant provided a "Summary of Economic Impacts Associated with the EnergySolutions Waste Disposal Facility in Tooele County, Utah" to lend relevance to the discussion of tax revenues and contributions. Excerpted from the application is this information:

EnergySolutions (formerly Envirocare of Utah) owns a nuclear waste facility in Utah's West Desert, in Tooele County. In 1988, Envirocare began disposing of naturally occurring radioactive material (NORM). Since then, the company has received licenses and permits to accept Class A low-level radioactive waste, including such things as contaminated soils, tools and equipment from nuclear power plants (Envirocare, 2006). On February 3, 2006, Envirocare announced it was changing its name to EnergySolutions and acquiring BNG America, the U.S. arm of a British waste company. It has also acquired Scientech D&D (Associated Press, 2006).

EnergySolutions provides over 400 direct jobs, and indirectly supports another 1,200 jobs in the Utah economy. Many of these jobs are skilled professional positions. The average annual wage of EnergySolutions employees is higher than the Utah average (Envirocare, 2006). According to the Utah Department of Workforce Services (2006a), in the third quarter of 2005, the average monthly wage for employees in the private waste management and remediation service sector was $5,238; in 2004, the average monthly wage in Tooele County was $2,852 (Utah Department of Workforce Services, 2006b).

Most of EnergySolutions's revenue comes from out of state. EnergySolutions spends a majority of this revenue is Utah, including taxes, fees, payroll, and procurement of goods and services (Envirocare, 2006). According to Matt Lawrence, Tooele County Commissioner, the West Desert industries have an important role on the economic well-being of Tooele County (Lawrence, 2004). According to Charlie Roberts, Mayor of Tooele City, "besides providing jobs and taxes to Tooele County, Envirocare purchases water, fuel, and personal protective clothing among other things from local businesses" (Envirocare, 2006). On average, the company provides 25 percent of Tooele County's budget (Envirocare, 2006).

The company is a major contributor to the Tooele County community. It sponsored the Utah State Firefighter's Museum in Tooele honoring firefighters throughout the state. The company has also supported the Tooele County Fair & Stock Show, Children's Justice Center, Women's Shelter, Senior Citizens Center, and the Tooele School District (Envirocare, 2006). Additionally, Envirocare was the title sponsor of the PGA Tour's Utah Classic for at least two years. Charities benefiting from this tournament include Utah Boys & Girls Ranch, Huntsman Cancer Institute, Kirilenko's Kids, and the First Tee of Salt Lake City (Kragthorpe, 2005).

Property values in Tooele County nearly tripled during Envirocare's first 12 years of operation. According to the Tooele County Board of Realtors, the average home price in 1987 was $50,500. In 2000, the average home sold for $131,500 (Envirocare, 2006).

While the arrangements between the waste companies with Tooele County and Andrews County are unique to one another, the example provided does indicate that over time, positive economic impacts may result from the operation of such waste sites. Increases in tax contributions, elevation of property values and increased and enhancing interactions on a social level may be expected to result given the Tooele County example.

7.13.6 Qualitative Summary of Economic Benefits and Costs

In developing a qualitative summary of economic benefits and costs associated with the construction and operation of the by-products materials disposal facility reference has been made to the NUREG 1569 guidance document (NRC, 2003b). That guidance indicates that a summary should include potential social and economic benefits from the proposed facility that could affect various political jurisdictions or public and private interests. Some of these benefits might reflect transfer payments or other values that may partially, if not fully, compensate for certain services as well as external or environmental costs, and this

fact should be reflected in the designation of the benefit.

For the proposed by-product material disposal facility at the WCS complex, economic benefits would include:

- Tax revenues and contributions from WCS to be received by local, state, and federal governments;
- Incremental increases in economic diversification and cyclical stability;
- Increased knowledge of the Llano Estacado environment as a consequence of ecological research and environmental monitoring activities associated with license application, plant operation and technological improvements from applicant research programs;
- Employment, output and income benefits that will be realized from construction and operation of the proposed facility;
- Long-term economic benefits will accrue to the residents of the Region, and the residents of those communities where by-product material wastes are temporarily stored in less appropriate circumstances;
- Additional long-term benefits will accrue 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 by-product material wastes.

For the proposed by-product material disposal facility at the WCS complex, economic costs might include:

- Temporary external costs or diseconomies during facility construction could include very minor impact on the local housing market, especially in Eunice, NM, 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 alternate future uses;
- Possible decrease in real estate values in areas adjacent to the proposed facility; and
- Increased costs to local governments in Lea County NM and Andrews County TX for the services required by the permanently employed workers and their families. The communities of Eunice and Jal are most likely to be affected by very minor incremental costs and for the long term.

The economic benefits and costs associated with the construction and operation of the by-products materials disposal facility summarized would primarily impact the residents of Lea County NM and Andrews County TX. Eunice and Jal, NM and Andrews TX would be the communities most affected by the very minor cost and benefit impacts noted. Absolute levels of economic costs and benefits are very

small because of the limited scale of the proposed disposal operations. In terms of net impacts, the employment, output and income benefits that will be realized in the Region from construction and operation of the proposed facility should outweigh the costs identified, providing a small, but positive net economic impact from the construction and operation phases of the facility.

For Post-Operative Phase Socioeconomic Impacts, see separate Technical Report containing decommissioning and closure information.

2.1.1 Reference

NRC. NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." Washington, DC: NRC. 2001.

7.14 FINANCIAL COSTS TO GOVERNMENT

A 1996 study estimated that the proposed WCS component would require a total of $71,000 in increased local government expenditures – the proportion of local taxing authority budgets allocable to WCS employees and children. This represents $1,919 per WCS employee hired for the proposed radioactive waste disposal component. Assuming this proportion to be applicable to the 3 new employees expected for the operational phase of the by-product material disposal facility, the associated increased local government expenditures would be $5,757.

WCS's application assumed that the estimated $5,757 increase in annual expenditure impact to Andrews County would be entirely distributed to the existing governmental jurisdictions within the County. They further assume that an additional $5,757 additional annual expenditure impact would be expected for the remainder of the Region of Interest. The total of $11,514 annual governmental expenditure impact attributed to the operational phase of the proposed by-product material facility is distributed geographically throughout the Region and is shown in Table 2-8 of the application.

The county judges of Lea County, NM, and Andrews County, TX, and the mayors of cities of Hobbs and Eunice, NM, and Andrews, TX, have been given an opportunity to review the estimates of fiscal impacts and provide comments. When received, these responses will be provided by the applicant as indicated in the June 15, 2006, letter to the DSHS.

7.15 COMMITMENT OF MINERAL RESOURCES

Issuance of the disposal license will require commitment of mineral resources in the form of ownership by the applicant or by deed restriction. The applicant has provided an explanation of mineral resources owned and being acquired by WCS and has provided valuation of those resources by an appraiser.

The surface estate of the proposed area to be licensed for disposal is owned in fee simple by Waste Control Specialists LLC and WCS owns a majority interest in the underlying mineral estate. WCS is making a

serious effort to obtain the remaining interests in order to ensure the long-term stability of the disposal site as required by 25 *TAC* §289.260(r)(2).

If 100% of the mineral estate cannot be secured in fee, then WCS intends to propose, as provided by 25 *TAC* §289.260(q)(31), to file in the deed records of Andrews County a deed restriction notification that the land is being used for the disposal of by-product material waste and is subject to certain restrictions prohibiting the disruption and disturbance of the waste.

The primary minerals of interest beneath the WCS property are oil and gas. Accordingly, WCS proposes to utilize surface use agreements that restrict oil and gas exploration and production activities from occurring within areas to be utilized for the disposal of by-product material waste, described by metes and bounds and identified in the deed records of Andrews County. As part of the surface use agreement, WCS will designate, as necessary, appropriate locations for the exploration and production of mineral resources. WCS has provided an affidavit from T. Verne Dwyer, landman, concerning the value of mineral rights in Section 25, Andrews County, Texas.

The WCS application reports that there has never been any production of oil or gas from Section 25 so there is no reliance on income from this section by anyone. The WCS area has been subject to numerous seismic exploration programs with no new drilling resulting. There is a producing oil and gas well on the WCS property, just south of the proposed by-product disposal facility. ~~There has been no indication that Section 25 has been seriously considered for mineral development. The only new leasing activity in close proximity to the site has been in Lea County, New Mexico, on state and federal tracts. The state and federal leases covering these tracts indicate an average lease bonus price of less than $50 per net acre.~~

WCS paid Exxon-Mobil $225 per net mineral acre for their mineral interest based on a method of pricing that has long been accepted by the industry (3 times the lease bonus price per net acre ($75)). WCS has purchased mineral interests in Section 25 from one of the largest oil companies in the country, Exxon-Mobil, indicating that the company did not view the area as a promising oil or gas prospect.

WCS now owns 100% of the surface rights and approximately 67% of the mineral rights in Section 25, Block A-29, PSL Survey, Andrews County, Texas. An Appraiser retained by WCS has concluded that the value of the minerals not owned by WCS would, in 2005, be less than the original $225 per net acre, most likely in the $100 per net acre range. This appraisal is found in the application, Appendix F. It is the appraiser's opinion that the price of $225 per net acre was the fair market value of the tracts that are involved in WCS's area of interest.

7.16 CONCLUSION

The applicant has provided an acceptable analysis of probable costs consistent with the facility with actual data, models and industry-wide experience.

The applicant has included analyses of:

- tax revenues
- creation of temporary and permanent jobs and accrued payroll
- incremental increases in regional productivity of goods and services

The applicant has addressed impacts on:

- housing
- noise and congestion,
- infrastructure (e.g., schools, water supply, transportation links)
- land acquisition
- recreation
- access to land or water
- aesthetics
- historic, scenic, or cultural interests
- costs to provide government services for any additional population

The applicant has acceptably identified and considered the extent and longevity of the effect of construction and operation on individuals.

The applicant has presented a comparison of the societal benefits and costs to society that acceptably justifies the proposed facility and operations.

The applicant has acceptably described anticipated economic and social effects of resources committed at the facility covering the affected environment and the extent of activities.

The applicant has acceptably identified, for each resource committed, who is affected, to what extent, and the expected duration of the effect. Overall, the applicant has demonstrated that its analysis of resources committed as a result of the construction and operation of the proposed facility is supported by properly interpreted data, calculations, and model results.

Based on the information provided in the application and the detailed review conducted of the benefit-cost analysis for the facility, the staff concludes that the benefit-cost analysis is acceptable and considers economic, technical, and other benefits and costs of the proposed action and alternatives.

Overall, the applicant has demonstrated that the analysis of the economic and social benefits from the construction and operation of the proposed facility are supported by actual data, calculations, and model results.

Based on the information provided in the application and the detailed review conducted of economic and social benefits of construction and operation of the WCS, the staff concludes that the economic and social benefits of construction and operation provide an analysis that balances the impacts of proposed actions.

The applicant has provided an acceptable analysis of probable benefits consistent with the facility design and industry-wide experience (Tooele County data) as an example of the potential benefits.

7.18 REFERENCES

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RADIOACTIVE MATERIAL LICENSE

LICENSE NUMBER	AMENDMENT NUMBER
R 05807	INITIAL DRAFT

91. A. The Licensee shall conduct the following radiological and non-radiological environmental monitoring program until the license is terminated.

Sample	Station Location Reference	Location[7]	Method	Frequency	Type of Analysis[5]
Air Particulate	1 3 4 6 7 8 9 P11 26 27 P30 P31 P32	East of guard house Northwest of RCRA landfill North of RCRA landfill Northwest facility fence line North fence line center of RCRA permit area Southeast rail yard Control station 3.5 mi. east of TX/NMex state line, south of Hwy 176 East of by-product facility and west of Federal facility (operational only) About center of east edge of RCRA permit area (north of old ranch house) Southeast of facility operational area (upwind prevalent wind direction)(future) North of by-product facility (operational only) Southwest of facility (approximately 1.4 mile west of Texas/New Mexico border (future) North of rail road spur (operational only)	high-vol. sampler	Continuous[6]	Analyze samples monthly or as required due to dust loading from each location for: gross alpha, gross beta Alpha isotopic[1], Monthly Composite Gamma Isotopic[2], Liquid Scintillation[3]
Radon	1 3 4 6 7 8 9 P11 26 27 P30 P31 P32	East of guard house Northwest of RCRA landfill North of RCRA landfill Northwest facility fence line North fence line center of RCRA permit area Southeast rail yard Control station 3.5 mi. east of TX/NMex state line, south of Hwy 176 East of by-product facility (operational only) About center of east edge of RCRA permit area (north of old ranch house) Southeast of facility operational area North of by-product facility (operational only) Southwest of facility (approximately 1.4 mile west of Texas/New Mexico border North of rail road spur (operational only)	track-etch detector	quarterly	radon

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Sample	Station Location Reference	Location[7]	Method	Frequency	Type of Analysis[5]
Surface water	18	West of by-product facility (Baker Spring)	grab	semi-annual when sufficient water is present	Analyze samples from each location for: gross alpha, gross beta Alpha isotopic[1], Gamma Isotopic[2], Liquid Scintillation[3]
Sediment	18	West of by-product facility (Baker Spring)	grab	annual	Analyze samples from each location for: gross alpha, gross beta Alpha isotopic[1], Gamma Isotopic[2], Liquid Scintillation[3]
		Standing water in by-product waste pit.	grab	quarterly	
Ground water[9]	9	Control station 3.5mi. east of TX/NMex state line, south of Hwy 176	Grab	Quarterly	Analyze samples from each location for: gross alpha, gross beta Alpha isotopic[1], Gamma Isotopic[2], Liquid Scintillation[3]
	11A	Southeast of by-product facility	grab	quarterly	
	11B	South of by-product facility	grab	quarterly	
	11C	Southwest corner of by-product facility	grab	quarterly	
	11D	West of by-product material landfill	grab	annually	
	11E-G	East of by-product material landfill	grab	quarterly	
	3A	North of by-product facility	grab	quarterly	
	FWF-9	East of by-product facility and west of Federal facility (operational only)	grab	quarterly	
	A-16	OAG well located southeast of compact facility	grab	quarterly	
	A-22	Well in the "225-foot zone" located southeast of the compact facility and A-16	grab	annually	
	A-24	Well in the "225-foot zone" located southeast of the compact facility and east of A-22	grab	annually	
	5E-A	Well in the "225-foot zone" located south of the by-product facility	grab	annually	
	6B2	Well in the "225-foot zone" located in the northern perimeter of the federal facility	grab	annually	
	MW3A	Well in the "225-foot zone" located north of the by-product facility	grab	annually	
	DW35A	Well in the "225-foot zone" locate south of the RCRA landfill	grab	annually	
	PM-01	OAG well located in northeast portion of RCRA permit area	grab	annually	
	PM-03	Well in the "225-foot zone" located in the northeast portion of RCRA permit	grab	annually	

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Sample	Station Location Reference	Location[7]	Method	Frequency	Type of Analysis[5]
		area			
	PM-06	Well in the "225-foot zone" located northeast of compact facility	grab	annually	
	PM-07	OAG well located in eastern portion of RCRA permit area, northwest of old ranch house	grab	quarterly	
	TP-14	OAG well located northeast of federal facility	grab	quarterly	
	TP-18	OAG well located just outside the northeast corner of federal facility	grab	quarterly	
	TP-19	OAG well located north of the compact facility	grab	quarterly	
	TP-20	OAG well just north of RCRA permit area, between stations 7 and 16	grab	quarterly	
	TP-31	OAG well located at Bakers Springs	grab	quarterly	
	TP-46	OAG well located south of the federal facility	grab	quarterly	
	Vadose Zone Wells	All wells completed in the "125-foot zone" located along all sides of the by-product landfill.[10]	grab	quarterly[4]	
Vegetation	3	Northwest of RCRA landfill	grab	spring and autumn	Analyze samples from each location for: gross alpha, gross beta Alpha isotopic[1], Gamma Isotopic[2], Liquid Scintillation[3]
	6	Northwest facility fence line			
	8	Southeast rail yard			
	9	Control station 3.5 mi. east of TX/NMex state line, south of Hwy 176			
Soil	3	Northwest of RCRA landfill	grab	quarterly	Analyze samples from each location for: gross alpha, gross beta Alpha isotopic[1], Gamma Isotopic[2], Liquid Scintillation[3]
	6	Northwest facility fence line			
	8	Southeast rail yard			
	9	Control station 3.5 mi. east of TX/NMex state line, south of Hwy 176			
	22	Northwest corner, by-product facility fence line			
	26	About center of east edge of RCRA permit area (north of old ranch house)			
Fauna	General Site Area	Primary herbivore	grab	annually	Analyze samples from each location for: gross alpha, gross beta Alpha isotopic[1], Gamma Isotopic[2], Liquid Scintillation[3]
Closed disposal unit sumps		Liquid, if present	grab	monthly	Analyze samples from each location for:
		Exterior surface of standpipe cover	wipe	monthly	
		Monitoring system sump	wipe	monthly	

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Sample	Station Location Reference	Location[7]	Method	Frequency	Type of Analysis[5]
					gross alpha, gross beta Alpha isotopic[1], Gamma Isotopic[2], Liquid Scintillation[3] Also record level in sumps and volume of any leachate pumped.
Meteoro-logical	Onsite Met. Station	2 meters	reading	10 minute averages[8]	precipitation, barometric pressure, solar radiation scalar wind speed and direction, temperature, relative humidity, standard deviation scalar wind direction
Meteoro-logical	Onsite Met. Station	10 meters	reading	10 minute averages[8]	vector wind speed and direction, scalar wind speed and direction, temperature, relative humidity, standard deviation vector and standard deviation scalar wind direction
Direct radiation	1 3 4 6 7 8 9 P11 12 13 14 15 16	East of guard house Northwest of RCRA landfill North of RCRA landfill Northwest facility fence line North fence line center of RCRA permit area Southeast rail yard Control station 3.5 mi. east of TX/NMex state line, south of Hwy 176 East of by-product facility and west of Federal facility (operational only) Southwest of facility (approx. 1.2 mile west of Texas NM border)[4] Southwest corner of property line. North of proposed Federal facility Northwest corner of Texas – NM border Northeast corner of RCRA permit area	TLD (for all locations)	quarterly (for all locations)	Direct gamma radiation measurements taken at each location.

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Sample	Station Location Reference	Location[7]	Method	Frequency	Type of Analysis[5]
	17	Southeast corner near Hwy 176			
	18	Northeast corner, by-product facility fence line			
	19	North of proposed Federal facility			
	21	Northeast corner, by-product facility fence line.			
	22	Northeast corner, by-product facility fence line.			
	23	West of by-product facility			
	24	Southeast corner, by-product facility fence line.			
	25	Old ranch house on east edge of RCRA facility			
	26	About center of east edge of RCRA permit area			
	28	Approximately 1000 feet east of Station 8			
	P30	North of by-product facility (operations only)			
	P31	Southwest of facility (approximately 1.4 mile west of Texas/New Mexico border (future)			
	P32	North of proposed rail road spur (operations only)			

1. Alpha isotopic analyses performed if gross alpha exceeds investigation limit (IL). Analyses will include radium, thorium, and uranium using the EPA and DOE modified analytical method used for the appropriate baseline analyses.
2. Gamma isotopic analyses includes long-lived and primordial isotopes (Pb-210, Bi-212, Pb-212, Bi-214, Pb-214, Ac-228, Ra-228 (Ac-228), Th-234, U-235, U-238).
3. Liquid scintillation analysis for primordial and man-made isotopes may be performed as designated by the RSO.
4. Compositing of groundwater from any and all 125-ft vadose zone wells is permitted to obtain a sufficient groundwater sample volume for analysis.
5. Unless noted otherwise, analysis frequency is same as sample collection frequency.
6. Air particulate filters shall be replaced weekly or more frequently if excessive loading develops.
7. Refer to Figure 4.1, "By-Product Disposal Facility Environmental Monitoring Locations." Some locations may vary due to construction of disposal units or other facility features.
8. 90% data retrieval.
9. Groundwater samples shall be collected in accordance with SWI No. 1.8 (January 10, 1995).
10. The Licensee shall conduct operational non-radiological contaminant sampling and analysis, as required, as governed by the non-radiological hazardous constituents which are determined to be present in the by-product material which may be accepted for disposal in the by-product material disposal facility.

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B. Duplicate Samples and Other Environmental Samples. The Licensee shall provide the executive director an opportunity to obtain duplicate samples concurrent with the Licensee's data collection schedule. In addition, the Licensee shall allow the executive director the ability to obtain any environmental media sample(s) the executive director deems necessary.

C. Evaluation of Data. The Licensee shall evaluate monitoring data using a two-tiered environmental monitoring response system (i.e., investigation and action levels) as described in Volume 4, Appendix 4.B, Procedure BP-EV-1.1.0, Section VIII of the Licensee's application. The results of the evaluation must be included in the annual environmental monitoring report to the executive director.

D. Transitional Monitoring Period. The Licensee shall provide for a transitional environmental monitoring period whenever program components, including sampling locations, equipment, techniques, or laboratories, are changed. This transitional monitoring period must include parallel monitoring with both the old and new conditions for at least one sampling period or as directed by the executive director.

E. Pre-operational Monitoring Period. The Licensee shall provide one full year of baseline data on the site and its environs prior to operations. **The Licensee shall consult with the TCEQ to ensure that the proper samples, methods and analyses are used for determining the baseline data, as required by the executive director.** (Although they have a year's worth of data for certain media (i.e., groundwater) the sample analysis method is some cases were deficient (e.g., did not filter water samples) so they should get with us to determine what they did wrong prior to obtaining this data. - RAB)

F. Control Charts and Nonparametric Prediction Limits. The Licensee shall develop control charts and/or nonparametric prediction limits for all environmental media measurements which will be used to determine investigative limits and action limits for determining whether contamination may be migrating from the site as seen by increasing trends in the periodic analyses. For whichever statistical monitoring method is used, one year of data is required for each parameter under review. Prior to the disposal of by-product material, the Licensee shall submit a report to the executive director that includes the control charts or prediction limits, baseline measurements, methods, and analyses for determining investigative limits and action limits. The Licensee shall follow any action limits, investigative limits, or method required by the executive director for determining whether contamination may be migrating from the disposal facility. (see WCS App., Vol. 4, Procedure BP-EV-1.1.0).

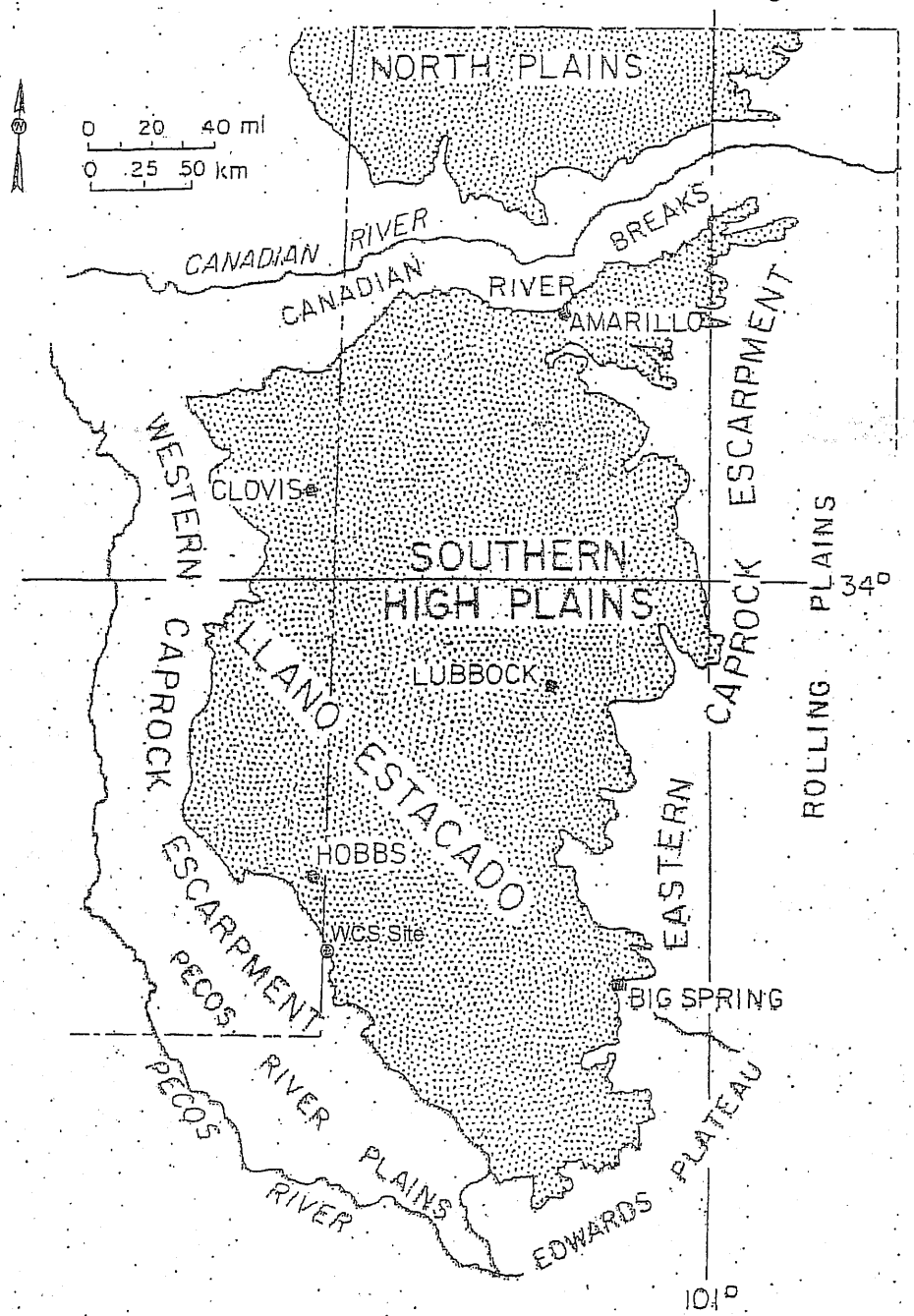
G. Baker Spring Sampling Event. Prior to the disposal of by-product material, the Licensee shall conduct an additional surface water and sediment sampling event of the Baker Spring surface water feature using all EPA and DOE Methods shown at the bottom of Table 2.26, "Pre-Operational Data for Baker Spring."

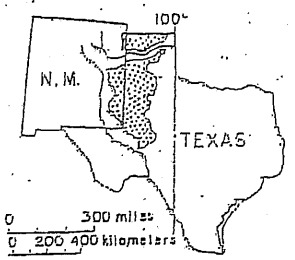
H. Pre-operational Fauna Samples. The Licensee shall conduct two (2) fauna sampling events at approximately six (6) month intervals and establish a baseline in which to compare these pre-operational fauna samples with fauna samples taken during the site's operational period. The Licensee shall analyze these fauna samples for the radionuclides and analytical methods listed in Table 2.25, "Pre-Operational Data Summary for Soil."

I. Sampling of Non-Radiological Contaminants: The Licensee shall conduct quarterly baseline

DRAFT

Figure 1 Site Location





Source: Finley and Gustavson, 1981

Date: 1/12/07
File: WCS_Fig2.19.fh11

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WCS Site Location on the Southwestern Edge of the Southern High Plains

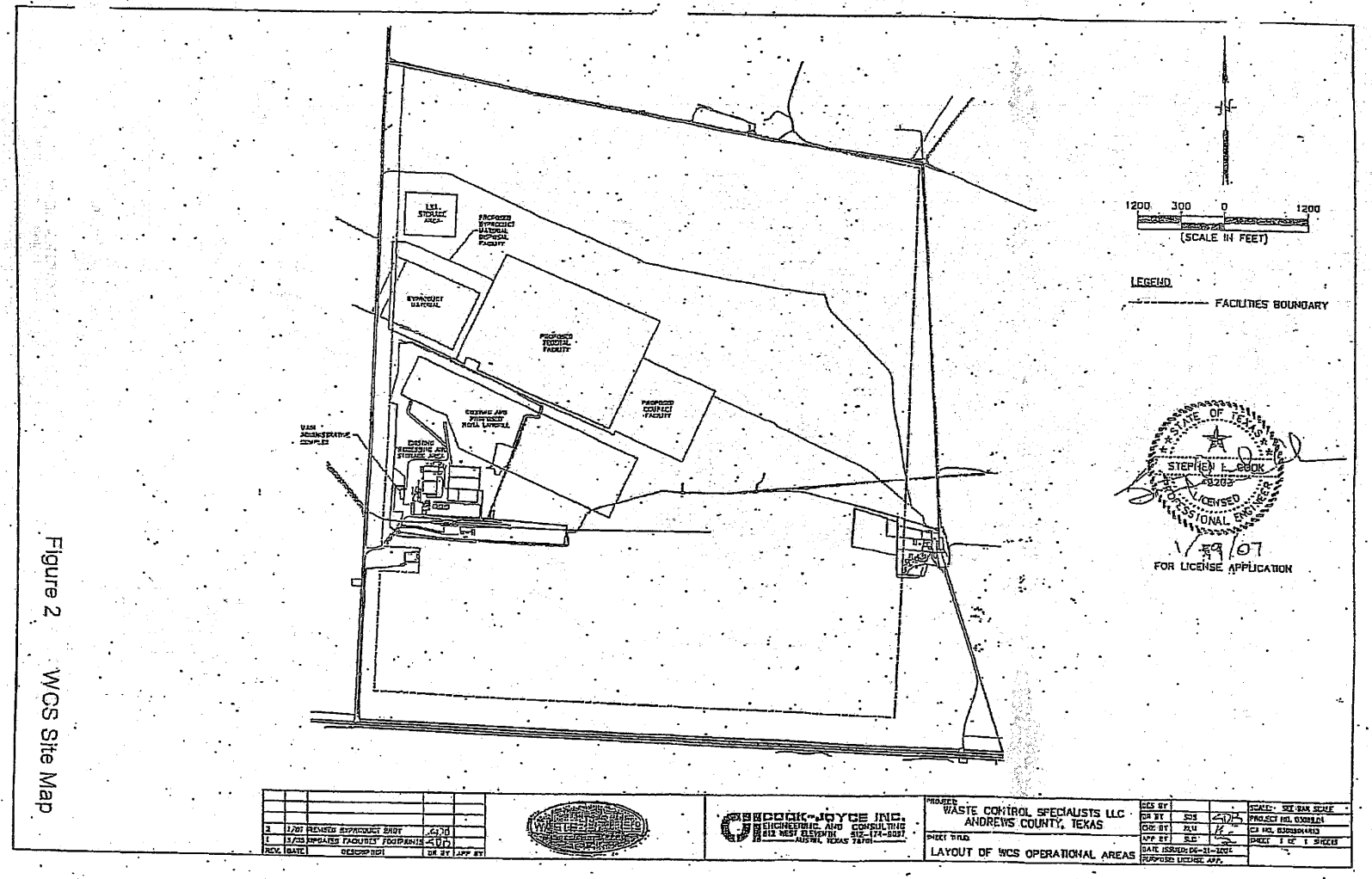
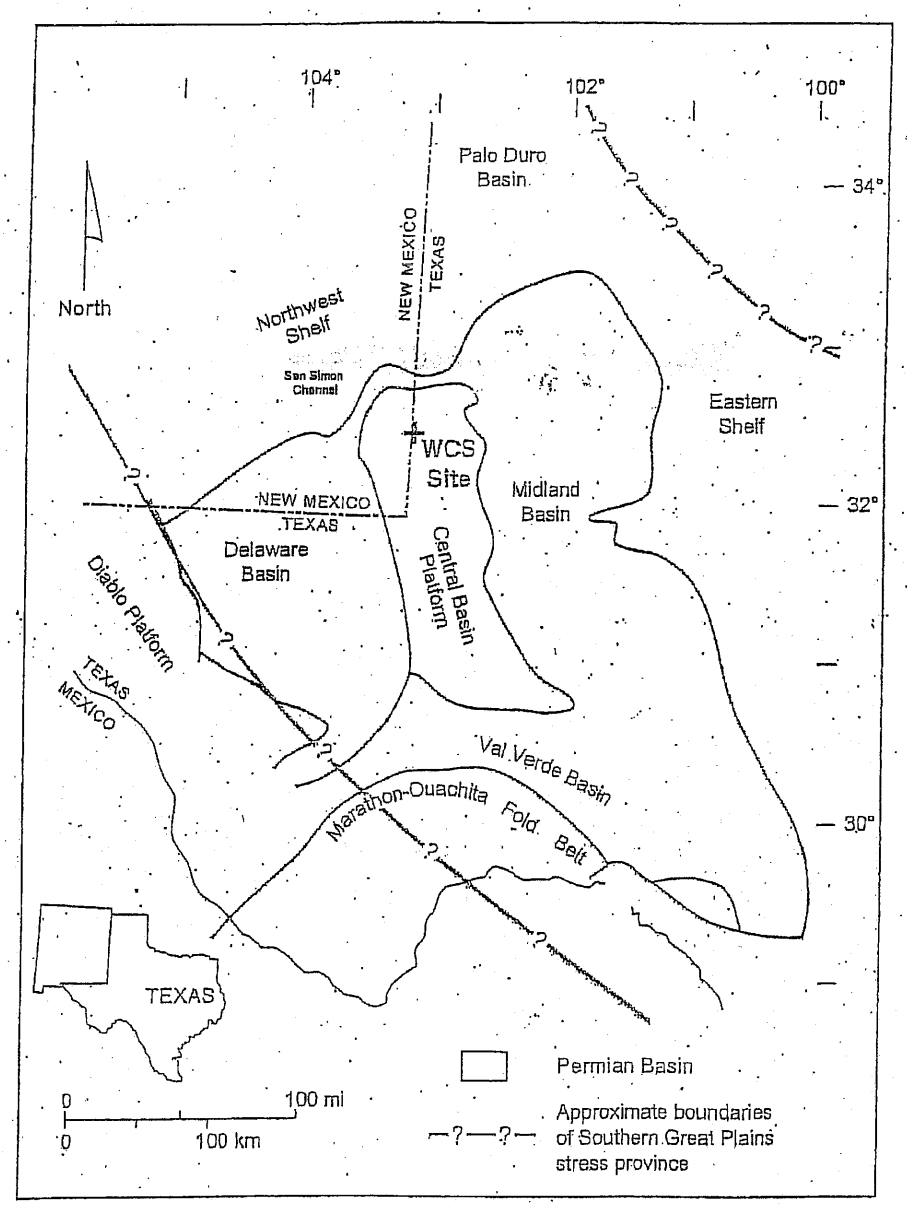


Figure 2 WCS Site Map

Figure 3 Permian Basin Features



Modified from Hills, 1984; Frezel et al., 1988; Dutton et al., 2003; URS (Wong et al.), 2004 Attachment 4-2b

Date: 1/12/07 File: WCS_Fig2.20.fh11	Geologic and Seismotectonic Setting of the WCS Site
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COOK-JOYCE INC. ENGINEERING AND CONSULTING 812 WEST SEVENTH AUSTIN, TEXAS 78701-2000 (512) 474-9097 FAX (512) 474-9483	

Figure 4 Stratigraphy

Years BP	SYSTEM/SERIES		GROUP	FORMATION
.0.01	QUATERNARY	RECENT/HOLOCENE		Windblown Sand / Playa Deposits
		PLEISTOCENE		Blackwater Draw or Tahoka / Gatuna
1.6	TERTIARY			Ogallala (5-13 my)
66	CRETACEOUS	COMMANCHEAN	Washita	Duck Creek
(millions)				Kiamichi
			Fredericksburg	Edwards
				Comanche Peak
				Walnut
			Trinity	Antlers
144	JURASSIC			
208	TRIASSIC		DOCKUM	Redonda
				Cooper Canyon
				Trujillo
				Tecovas
				Santa Rosa
245	PERMIAN	OCHOA		Dewey Lake
				Rustler
				Salado
		GUADALUPE	WHITEHORSE	Tansill
				Yates
				Seven Rivers
				Queen
				Grayburg
			SAN ANDRES	Glorieta
		LEONARD	CLEAR FORK	U. Clear Fork
				Tubb Sd.
				L. Clear Fork
			WICHITA	Wichita-Abo
		WOLFCAMP	WOLFCAMP	
286	PENNSYLVANIAN	CISCO	CISCO	
		CANYON	CANYON	
		STRAWN	STRAWN	
		ATOKA	ATOKA	
320	MISSISSIPPIAN	MERAMEC		Mississippian Lime
		KINDERHOOK	KINDERHOOK	
360	DEVONIAN	UPPER	WOODFORD	Woodford Shale
		LOWER	DEVONIAN	
408	SILURIAN	U. NIAGARAN		Upper Silurian Shale
		L. NIAGARAN	FUSSELMAN	
		ALEXANDRIAN		
438	ORDOVICIAN	UPPER	MONTOYA	
		MIDDLE	SIMPSON	
		LOWER	ELLENBURGER	
505	CAMBRIAN			
570	PRECAMBRIAN			Igneous and Metamorphic Rocks

------ Denotes Unconformity

Source: Modified from WTGS, 1976; Bebout & Meador, 1985; Nativ and Gutierrez, 1988

STATE OF TEXAS
5/16/07
GERALD E. GRISAK
GEOLOGY
No. 617
LICENSED
PROFESSIONAL GEOSCIENTIST

Date: 5/18/07
File: WCS_Fig2.21.ai11

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Regional Stratigraphic Chart of the Central Basin Platform

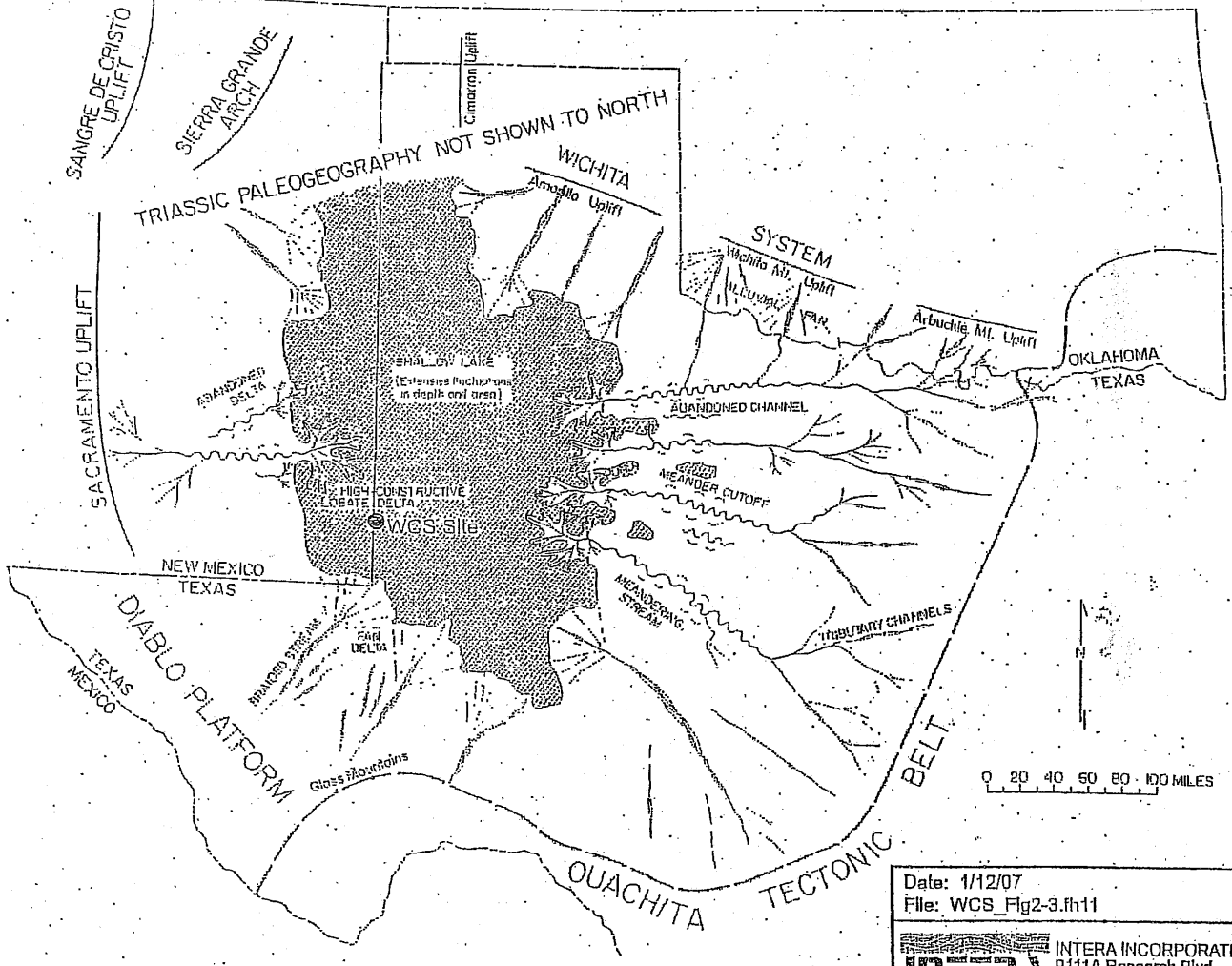

Figure 5 Early Dockum Basin Paleogeography

Source: McGowen et al., 1979

Date: 1/12/07 File: WCS_Fig2-3.fh11	Inferred Paleogeography of Dockum Sedimentation
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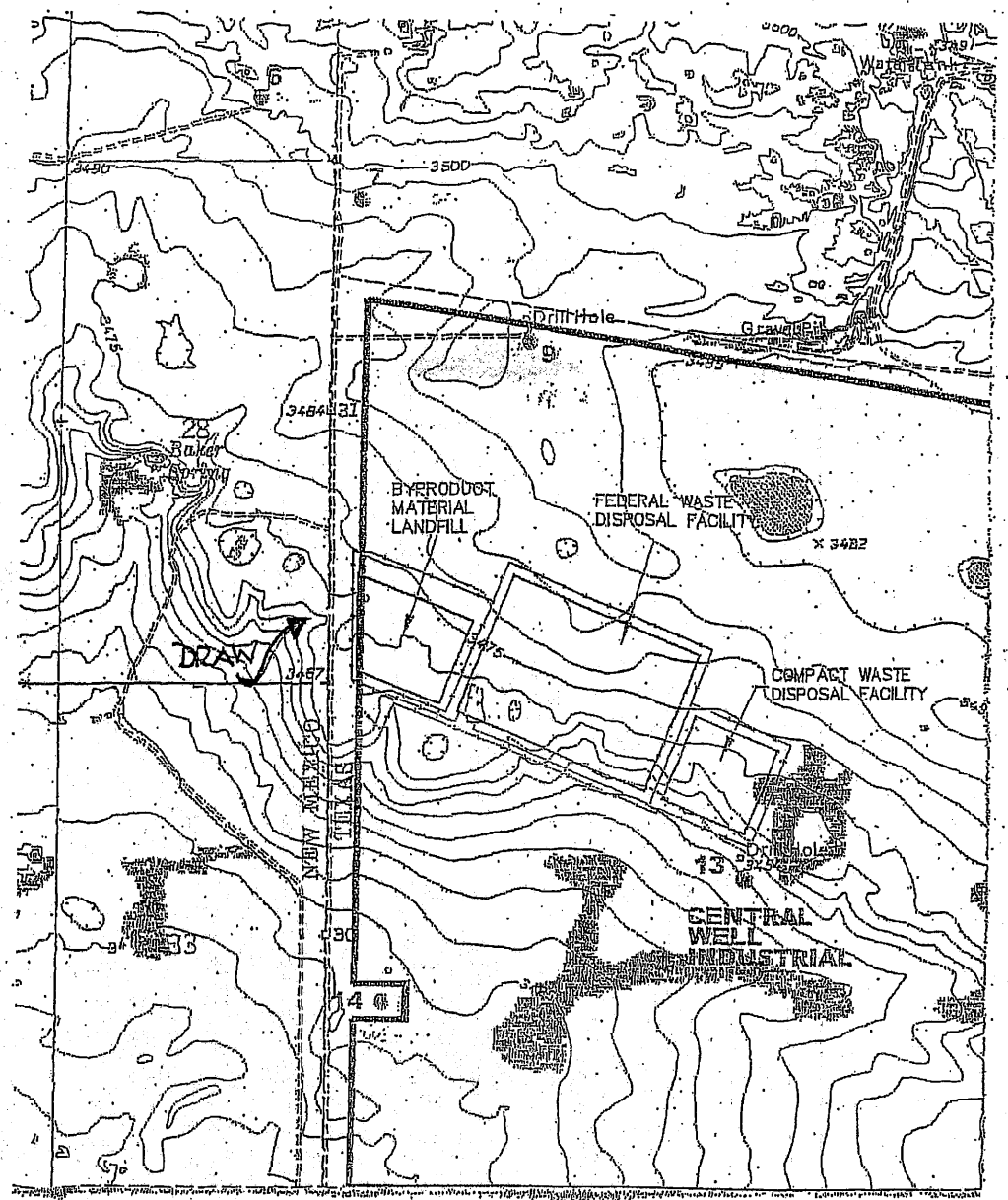
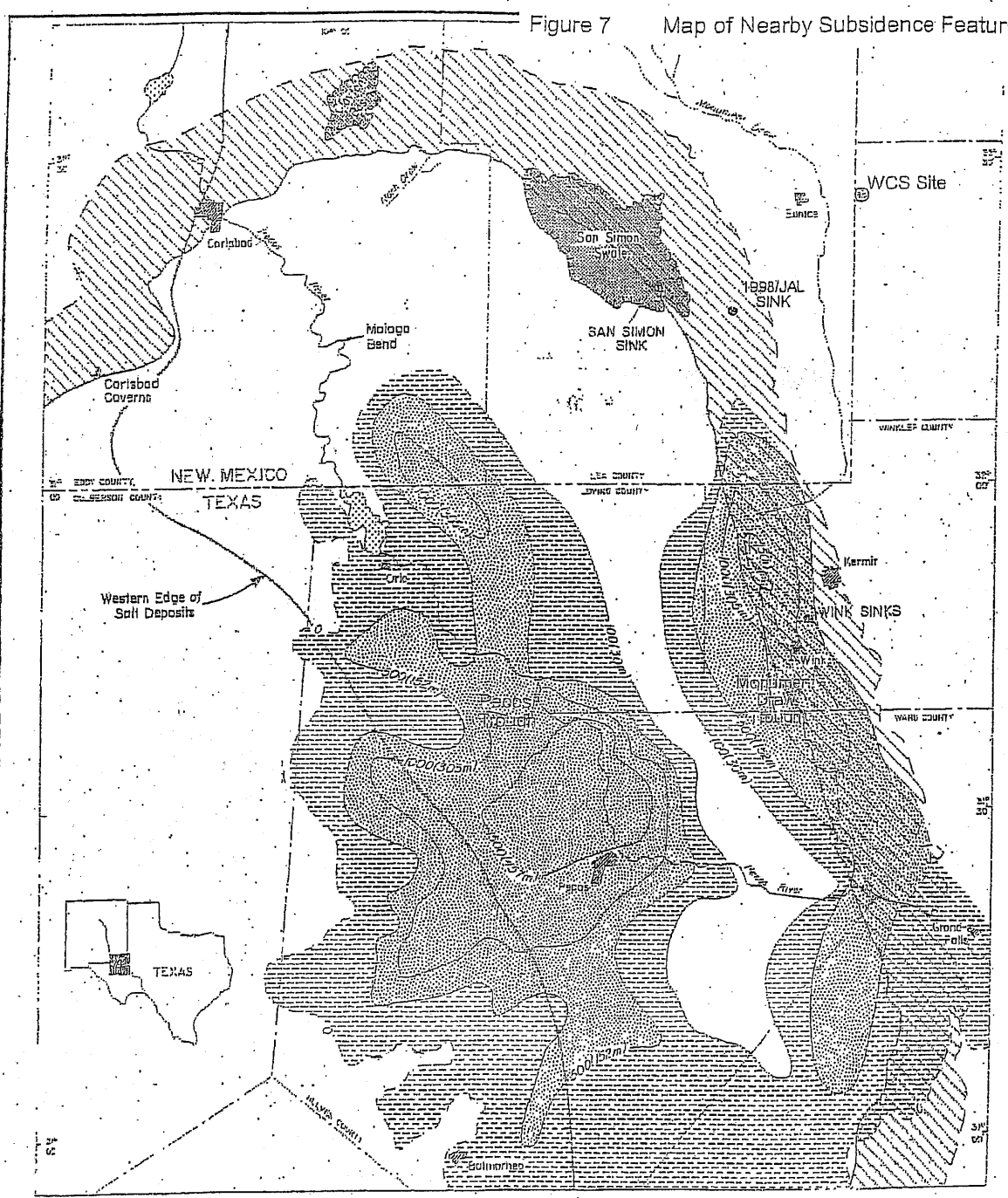
Figure 6 Draw with Potential Erosion Concerns and Baker Spring



BASE MAP SOURCE:
U.S.G.S. 7.5 MIN. TOPOGRAPHIC
EUNICE NE QUADRANGLE; 1969
PHOTOREVISED 1979

Figure 7 Map of Nearby Subsidence Features



Source: Baumgardner et al., 1982

Date: 1/12/07
File: WCS_Fig4-17.fh11

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Map of Nearest Subsidence Features

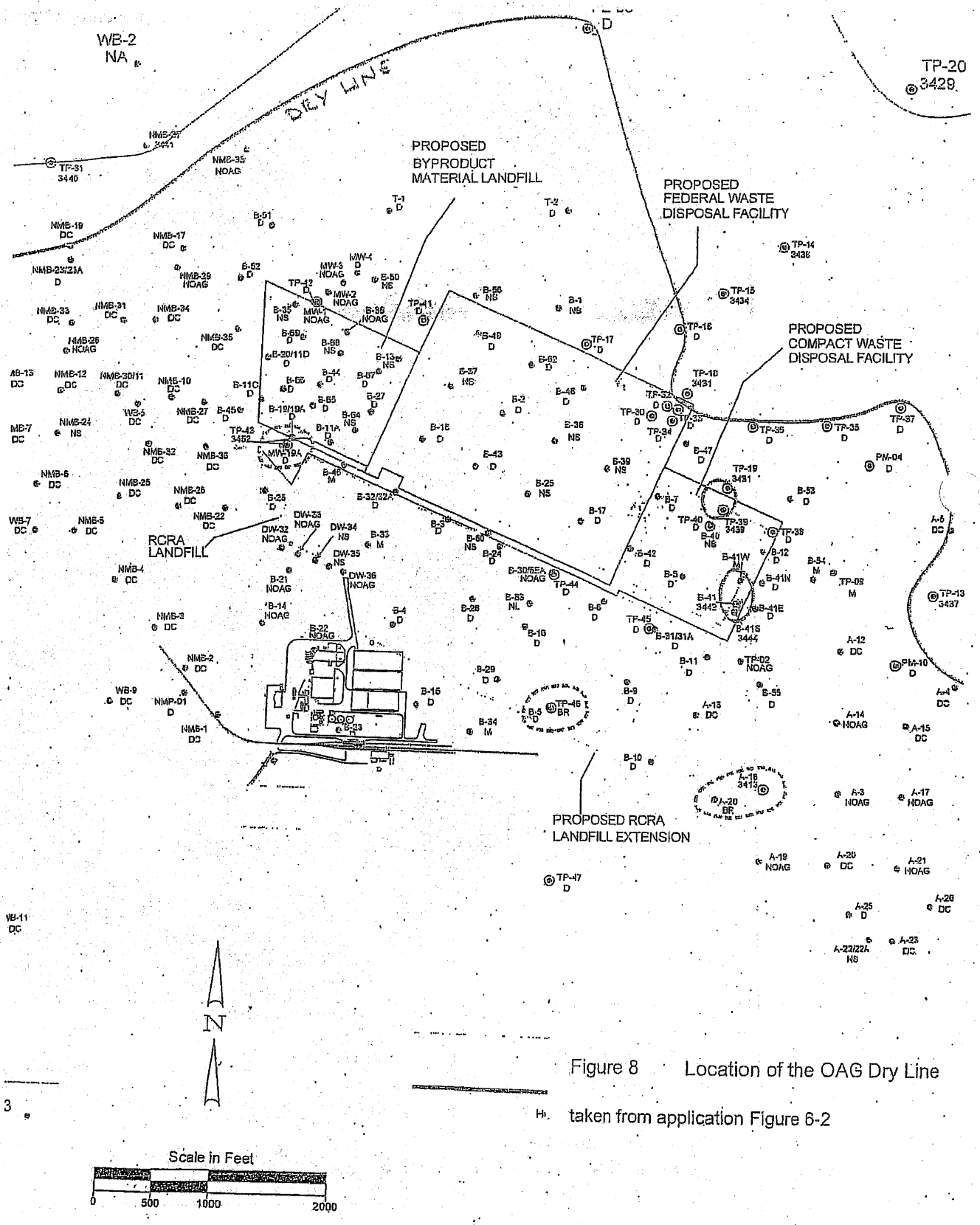


Figure 8 Location of the OAG Dry Line

taken from application Figure 6-2

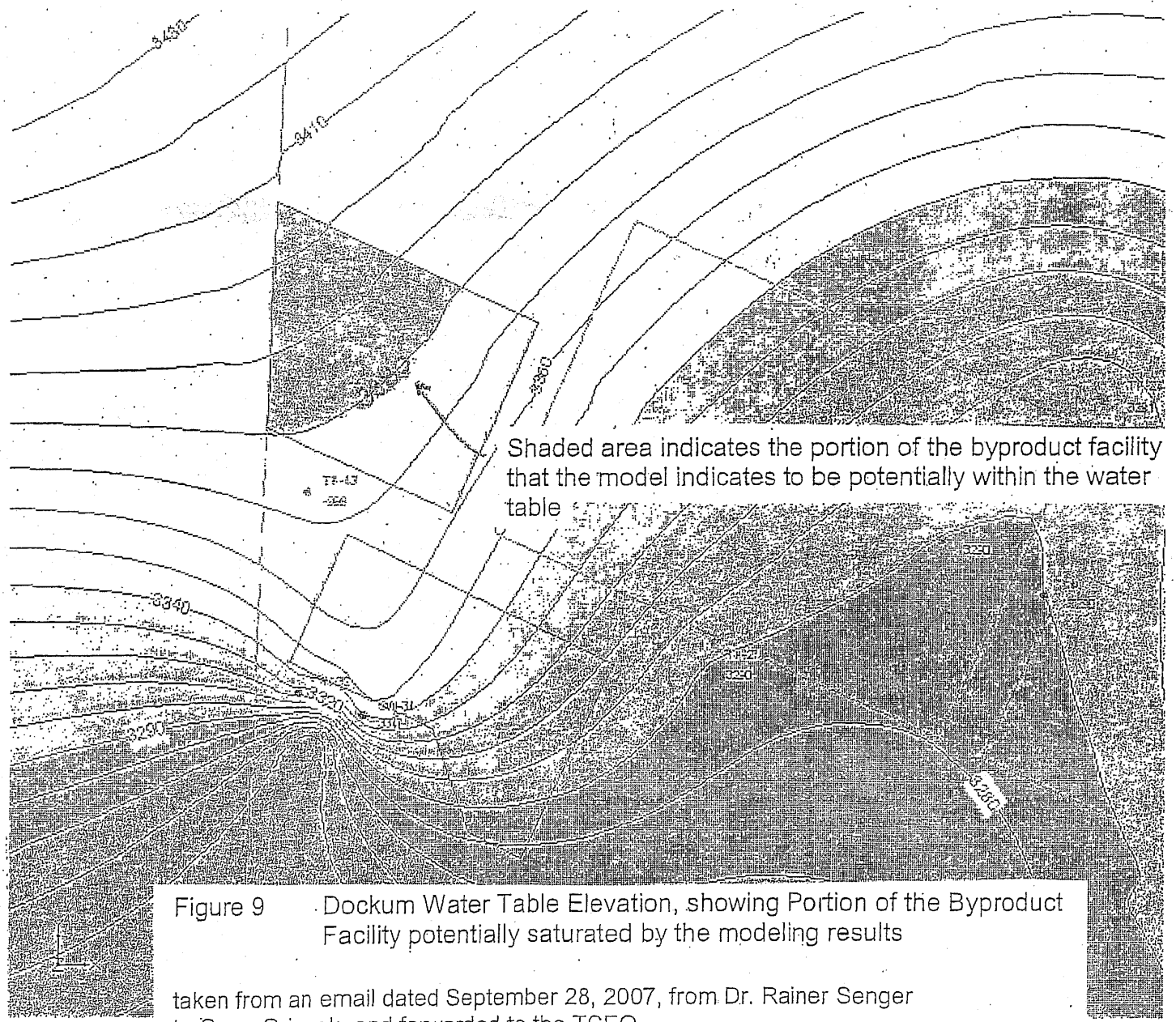


Figure 9 Dockum Water Table Elevation, showing Portion of the Byproduct Facility potentially saturated by the modeling results

taken from an email dated September 28, 2007, from Dr. Rainer Senger to Gerry Griseak, and forwarded to the TCEQ

APPENDIX A

TCEQ VERIFICATION CALCULATION

MICROSHIELD® CALCULATION OF THE DIRECT GAMMA DOSE RECEIVED BY A WCS WORKER PLACING AND COMPACTING BY-PRODUCT RADIOACTIVE WASTE

DIRECT GAMMA RADIATION DOSE CALCULATION

Calculation: Dose to a WCS worker involved in placing and compacting byproduct waste.

Assumptions:
a. All waste is worst case Fernald Silo 1&2 source term for radionuclides except for Maywood source term for Ra-226, Th-230, Th-232, and U-238.
b. Waste is homogeneous.
c. Waste is 21.3 m in height and has the larger Maywood source term waste volume of 894,000 m^3.
d. The waste area is a square with the exposure point of concern being 1 m off the waste surface.

Determine Maywood and Fernald Silos 1 & 2 Total Curies for Each Radionuclide (to convert pCi/g provided in the application to total Ci for each of the Maywood and Silos 1 & 2 waste radionuclides for use in MicroShield© program).

Radionuclide	pCi/g[1]	Total (m^3)[2]	Total Wt (g)[3]	Total Curies[4]
Ac-227	7670	894000	1.43E+12	10971.168
Pa-231	4040	894000	1.43E+12	5778.816
Pb-210	84660	894000	1.43E+12	121097.664
Ra-226	493	894000	1.43E+12	705.1872
Ra-228	128	894000	1.43E+12	183.0912
Th-228	128	894000	1.43E+12	183.0912
Th-230	367	894000	1.43E+12	524.9568
Th-232	1981	894000	1.43E+12	2833.6224
U-234	85	894000	1.43E+12	121.584
U-235	4	894000	1.43E+12	5.7216
U-236	4	894000	1.43E+12	5.7216
U-238	367	894000	1.43E+12	524.9568
Po-210	84660	894000	1.43E+12	121097.664
Ra-224	128	894000	1.43E+12	183.0912

1. Concentration provided in Table 5.2.1-1 of the WCS application.
2. Maywood Waste Volume of 894,000 m3 is provided in Table 5.3.1.4-1 of the application.
3. Total weight = Total volume (m^3)* density of 1.6 g/cc*1E6 cc/m^3.
4. Total Curies = Total weight in g * pCi/g * 1E-12 Ci/pCi

Add Total Curies for each radionuclide to table in MicroShield© (See MicroShield© printout WCS Worker Dose Worst Case.ms6 for details concerning additional parameters used in the calculation.

Total Exposure from p. 2 of the printout: 1.00E-02 mR/hr

Determine Annual Worker Exposure = Exposure Rate with Buildup (mR/hr) * Fraction of Year Exposed * 365 d/yr *24 hr/d

Where
Exposure Rate = 1.002E-02 mR/hr
Fraction of Year Exposed = 0.083 from Table 5.3.1.5-1.

Annual Worker Exposure = 7.29E+00 mR/yr approximately equal to **7.29E+00 mRem/yr**

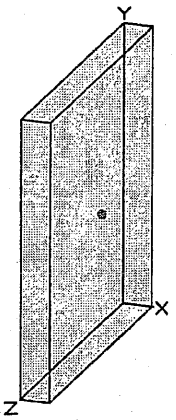
Conclusions: The Annual worker exposure calculated above is relatively high but is below the allowed Federal and State Radiation Worker limit of 5, 000 mRem per year. The calculation is highly conservative since it uses the Maywood waste volume which is much larger than actual Fernald Silos 1 & 2 waste volumes. Only 23% of the waste volume would be made up of Fernald waste and the remaining would be Maywood waste which has a much lower curie content. Therefore, since the final dose calculated is well below the allowed worker dose and due to the high level of conservatism in the calculation, it appears that workers would be able to handle and compact the waste without exceeding any regulatory limits.

MicroShield v6.02 (6.02-00097)
Texas_State_Dept._Health

Page : 1
DOS File : WCS Worker DoseV2.ms6
Run Date : July 27, 2007
Run Time : 11:08:25 AM
Duration : 00:00:03

File Ref: Log # 2004-06-087
Date: 7/27/2007
By: KJS
Checked:

Case Title: Worker Dose
Description: Standing on bare waste. Maywood source concentrations
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	2.1e+3 cm	69 ft 10.6 in
Width	2.1e+4 cm	672 ft 6.9 in
Height	2.1e+4 cm	672 ft 6.9 in

Dose Points

	X	Y	Z
# 1	2230 cm	10300 cm	10300 cm
	73 ft 2.0 in	337 ft 11.1 in	337 ft 11.1 in

Shields

Shield Name	Dimension	Material	Density
Source	8.95e+11 cm³	Concrete	1.6
Air Gap		Air	0.00122

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included
Library : Grove

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ac-227	1.1000e+004	4.0700e+014	1.2289e-002	4.5468e+002
Pa-231	5.7800e+003	2.1386e+014	6.4571e-003	2.3891e+002
Pb-210	1.2100e+005	4.4770e+015	1.3518e-001	5.0015e+003
Po-210	1.2100e+005	4.4770e+015	1.3518e-001	5.0015e+003
Ra-224	1.8300e+002	6.7710e+012	2.0444e-004	7.5642e+000
Ra-226	7.0500e+002	2.6085e+013	7.8759e-004	2.9141e+001
Ra-228	1.8300e+002	6.7710e+012	2.0444e-004	7.5642e+000
Th-228	1.8300e+002	6.7710e+012	2.0444e-004	7.5642e+000
Th-230	5.2500e+002	1.9425e+013	5.8651e-004	2.1701e+001
Th-232	2.8300e+003	1.0471e+014	3.1615e-003	1.1698e+002
U-234	1.2200e+002	4.5140e+012	1.3629e-004	5.0428e+000
U-235	5.7200e+000	2.1164e+011	6.3901e-006	2.3643e-001
U-236	5.7200e+000	2.1164e+011	6.3901e-006	2.3643e-001
U-238	5.2500e+002	1.9425e+013	5.8651e-004	2.1701e+001

Buildup
The material reference is : Air Gap

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
.015	1.200e+15	6.015e-276	8.747e-22	5.159e-277	7.503e-23
0.02	7.485e+11	7.745e-122	1.548e-24	2.683e-123	5.363e-26
0.03	1.989e+13	1.316e-38	7.799e-22	1.304e-40	7.729e-24

OS File : WCS Worker DoseV2.ms6
Run Date: July 27, 2007
Run Time: 11:08:25 AM
Duration : 00:00:03

ergy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.04	3.187e+11	1.728e-20	4.040e-18	7.644e-23	1.787e-20
0.05	1.818e+14	1.282e-10	6.865e-08	3.416e-13	1.829e-10
0.06	2.905e+11	3.210e-10	2.347e-07	6.375e-13	4.662e-10
0.08	1.562e+12	8.571e-07	6.341e-04	1.356e-09	1.003e-06
0.1	3.642e+12	2.689e-05	1.640e-02	4.114e-08	2.510e-05
0.15	3.205e+12	4.015e-04	1.313e-01	6.612e-07	2.163e-04
0.2	1.270e+12	6.888e-04	1.305e-01	1.216e-06	2.303e-04
0.3	1.698e+13	5.654e-02	4.724e+00	1.073e-04	8.960e-03
0.4	3.700e+11	4.098e-03	1.939e-01	7.984e-06	3.779e-04
0.5	1.219e+09	3.304e-05	1.031e-03	6.486e-08	2.024e-06
0.8	4.741e+10	7.609e-03	1.081e-01	1.447e-05	2.056e-04
TOTALS:	1.430e+15	6.940e-02	5.306e+00	1.317e-04	1.002e-02

APPENDIX B

TCEQ VERIFICATION CALCULATION

MICROSHIELD® CALCULATION OF THE DIRECT GAMMA DOSE RECEIVED TO A RESIDENT FARMER LIVING OVER THE WCS BY-PRODUCT RADIOACTIVE WASTE DISPOSAL SITE

DIRECT GAMMA RADIATION DOSE CALCULATION

Calculation: Dose to a resident farmer living on top of waste during post-closure period.

Assumptions:
a. All waste is worst case Fernald Silo 1&2 source term for radionuclides except for Maywood source term for Ra-226, Th-230, Th-232, and U-238.
b. Waste is homogeneous.
c. Waste is 21.3 m in height and has the larger Maywood source term waste volume of 894,000 m^3.
d. The waste area is a square with the exposure point of concern being 1 m off the waste surface.
e. The cover still exists over the site which is 6.55 m thick and has a density of 1.6 g/cc.

Determine Maywood and Fernald Silos 1 & 2 Total Curies for Each Radionuclide (to convert pCi/g provided in the application to total Ci for each of the Maywood and Silos 1 & 2 waste radionuclides for use in MicroShield© program).

Radionuclide	pCi/g[1]	Total (m^3)[2]	Total Wt (g)[3]	Total Curies[4]
Ac-227	7670	894000	1.43E+12	1.10E+04
Pa-231	4040	894000	1.43E+12	5.78E+03
Pb-210	84660	894000	1.43E+12	1.21E+05
Ra-226	493	894000	1.43E+12	7.05E+02
Ra-228	128	894000	1.43E+12	1.83E+02
Th-228	128	894000	1.43E+12	1.83E+02
Th-230	367	894000	1.43E+12	5.25E+02
Th-232	1981	894000	1.43E+12	2.83E+03
U-234	85	894000	1.43E+12	1.22E+02
U-235	4	894000	1.43E+12	5.72E+00
U-236	4	894000	1.43E+12	5.72E+00
U-238	367	894000	1.43E+12	5.25E+02
Po-210	84660	894000	1.43E+12	1.21E+05
Ra-224	128	894000	1.43E+12	1.83E+02

1. Concentration provided in Table 5.2.1-1 of the WCS application.
2. Maywood Waste Volume of 894,000 m3 is provided in Table 5.3.1.4-1 of the application.
3. Total weight = Total volume (m^3)* density of 1.6 g/cc*1E6 cc/m^3.
4. Total Curies = Total weight in g * pCi/g * 1E-12 Ci/pCi

Add Total Curies for each radionuclide to table in MicroShield® (See MicroShield© printout WCS Worker Dose Worst Case.ms6 for details concerning additional parameters used in the calculation.

Total Exposure from p. 2 of the printout: 5.27E-22 mR/hr

Determine Annual Worker Exposure = Exposure Rate with Buildup (mR/hr) * Fraction of Year Exposed * 365 d/yr *24 hr/d

Where
Exposure Rate = 5.583E-19 mR/hr
Fraction of Year Exposed = 1.0 due to living onsite.

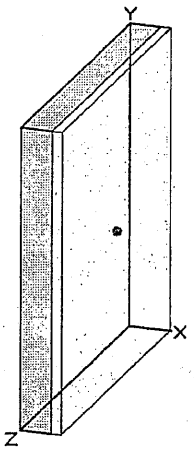
Annual Worker Exposure = **3.83E-19 mR/yr** approximately equal to **3.83E-19 mRem/yr**

Conclusions: The annual resident farmer exposure calculated, shown above, is very low and is below well below the 100 mrem/yr dose allowed by Federal and State Regulations. The calculation is highly conservative since it uses the Maywood waste volume which is much larger than Fernald Silos 1 & 2 waste volumes. Only 23% of the waste volume would be made up of Fernald waste and the remaining would be Maywood waste which has a much lower curie content. Therefore, since the final dose calculated is well below the allowable public dose and due to the high level of conservatism in the calculation, it appears that the resident farmer (aka, member of the public) would be protected due to shielding provided by the disposal unit cover.

Log # 2004-06-0878
File Ref:
Date: 7/27/2007
By: DJS
Checked:

Page : 1
DOS File : WCS Resident Dose.ms6
Run Date: July 27, 2007
Time: 11:26:14 AM
Duration : 00:00:03

Case Title: Worker Dose
Description: Standing on bare waste. Silo 1 2 concentrations
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	2.1e+3 cm	69 ft 10.6 in
Width	2.1e+4 cm	672 ft 6.9 in
Height	2.1e+4 cm	672 ft 6.9 in

Dose Points

	X	Y	Z
# 1	2890 cm	10300 cm	10300 cm
	94 ft 9.8 in	337 ft 11.1 in	337 ft 11.1 in

Shields

Shield Name	Dimension	Material	Density
Source	8.95e+11 cm³	Concrete	1.6
Shield 1	655.0 cm	Concrete	1.6
Air Gap		Air	0.00122

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included
Library : Grove

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ac-227	1.0971e+004	4.0593e+014	1.2256e-002	4.5348e+002
Pa-231	5.7788e+003	2.1382e+014	6.4558e-003	2.3886e+002
Pb-210	1.2110e+005	4.4807e+015	1.3529e-001	5.0056e+003
Po-210	1.2110e+005	4.4807e+015	1.3529e-001	5.0056e+003
Ra-224	1.8309e+002	6.7743e+012	2.0454e-004	7.5680e+000
Ra-226	7.0519e+002	2.6092e+013	7.8781e-004	2.9149e+001
Ra-228	1.8309e+002	6.7743e+012	2.0454e-004	7.5680e+000
Th-228	1.8309e+002	6.7743e+012	2.0454e-004	7.5680e+000
Th-230	5.2496e+002	1.9424e+013	5.8646e-004	2.1699e+001
Th-232	2.8336e+003	1.0484e+014	3.1656e-003	1.1713e+002
U-234	1.2158e+002	4.4985e+012	1.3582e-004	5.0255e+000
U-235	5.7216e+000	2.1170e+011	6.3919e-006	2.3650e-001
U-236	5.7216e+000	2.1170e+011	6.3919e-006	2.3650e-001
U-238	5.2496e+002	1.9424e+013	5.8646e-004	2.1699e+001

Buildup
The material reference is : Shield 1

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	1.201e+15	0.000e+00	3.986e-22	0.000e+00	3.419e-23
0.02	7.484e+11	0.000e+00	3.909e-25	0.000e+00	1.354e-26

DOS File : WCS Resident Dose.ms6
Run Date: July 27, 2007
Run Time: 11:26:14 AM
Duration : 00:00:03

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.03	1.988e+13	0.000e+00	2.297e-23	0.000e+00	2.276e-25
0.04	3.186e+11	2.857e-279	9.758e-25	1.263e-281	4.316e-27
0.05	1.819e+14	3.589e-177	1.822e-21	9.560e-180	4.852e-24
0.06	2.907e+11	7.914e-136	2.089e-23	1.572e-138	4.150e-26
0.08	1.562e+12	1.274e-98	2.671e-22	2.016e-101	4.227e-25
0.1	3.640e+12	1.442e-83	2.877e-21	2.207e-86	4.401e-24
0.15	3.204e+12	1.454e-68	1.388e-20	2.395e-71	2.285e-23
0.2	1.270e+12	1.282e-61	1.279e-20	2.262e-64	2.258e-23
0.3	1.698e+13	1.114e-51	2.258e-19	2.114e-54	4.284e-22
0.4	3.699e+11	1.295e-47	4.495e-21	2.523e-50	8.759e-24
0.5	1.219e+09	7.013e-46	1.238e-23	1.376e-48	2.430e-26
0.8	4.745e+10	4.547e-36	3.271e-22	8.649e-39	6.222e-25
TOTALS:	1.431e+15	4.547e-36	2.628e-19	8.649e-39	5.274e-22

APPENDIX C

TCEQ VERIFICATION CALCULATION

HELP© MODEL CALCULATION FOR ESTIMATING RAIN WATER LEACH RATE THROUGH THE WCS BYPRODUCT FACILITY COVER SYSTEM

```
**********************************************************************
**********************************************************************
**                                                                  **
**                                                                  **
**          HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE            **
**               HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)         **
**               DEVELOPED BY ENVIRONMENTAL LABORATORY              **
**                 USAE WATERWAYS EXPERIMENT STATION                **
**          FOR USEPA RISK REDUCTION ENGINEERING LABORATORY          **
**                                                                  **
**                                                                  **
**********************************************************************
**********************************************************************

PRECIPITATION DATA FILE:    C:\HELP3\WCS\WEATHER5.D4
TEMPERATURE DATA FILE:      C:\HELP3\WCS\TEMP5.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\WCS\SOLAR5.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\WCS\EVAP5.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\WCS\SOIL5.D10
OUTPUT DATA FILE:           C:\HELP3\WCS\OUTPUT5.OUT

TIME:  13:33     DATE:   7/25/2007

**********************************************************************

     TITLE:  WCS LEACHING OF RAIN WATER THROUGH COVER.

**********************************************************************

     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
            COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER   1
          THICKNESS                     =      1.00   INCHES
          POROSITY                      =      0.4170 VOL/VOL
          FIELD CAPACITY                =      0.0450 VOL/VOL
          WILTING POINT                 =      0.0180 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.0676 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =  0.999999978000E-02 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 10

THICKNESS	=	30.00	INCHES
POROSITY	=	0.3980	VOL/VOL
FIELD CAPACITY	=	0.2440	VOL/VOL
WILTING POINT	=	0.1360	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1621	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.119999997000E-03	CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 1

THICKNESS	=	6.00	INCHES
POROSITY	=	0.4170	VOL/VOL
FIELD CAPACITY	=	0.0450	VOL/VOL
WILTING POINT	=	0.0180	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0459	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999978000E-02	CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 1

THICKNESS	=	48.00	INCHES
POROSITY	=	0.4170	VOL/VOL
FIELD CAPACITY	=	0.0450	VOL/VOL
WILTING POINT	=	0.0180	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0451	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999978000E-02	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 15

THICKNESS	=	96.00	INCHES
POROSITY	=	0.4750	VOL/VOL
FIELD CAPACITY	=	0.3780	VOL/VOL

WILTING POINT	=	0.2650	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3780	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.170000003000E-04	CM/SEC

LAYER 6

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 2

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4370	VOL/VOL
FIELD CAPACITY	=	0.0620	VOL/VOL
WILTING POINT	=	0.0240	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0620	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.579999993000E-02	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	500.0	FEET

LAYER 7

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	36.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

LAYER 8

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 15

THICKNESS	=	18.00	INCHES
POROSITY	=	0.4750	VOL/VOL
FIELD CAPACITY	=	0.3780	VOL/VOL
WILTING POINT	=	0.2650	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3752	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.170000003000E-04	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 1 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	62.20	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	16.000	ACRES
EVAPORATIVE ZONE DEPTH	=	26.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.711	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	10.367	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	3.418	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	67.273	INCHES
TOTAL INITIAL WATER	=	67.273	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM AMARILLO TEXAS

STATION LATITUDE	=	35.00	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	67	
END OF GROWING SEASON (JULIAN DATE)	=	317	
EVAPORATIVE ZONE DEPTH	=	26.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	6.90	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	52.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	50.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	55.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	58.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR AMARILLO TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.46	0.57	0.87	1.08	2.79	3.50
2.70	2.95	1.72	1.39	0.58	0.49

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR AMARILLO TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
35.40	39.60	46.40	56.50	65.50	74.90
78.60	77.00	69.70	59.20	45.40	38.30

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AMARILLO TEXAS
AND STATION LATITUDE = 35.23 DEGREES

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.75	856680.062	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	14.724	855175.875	99.82
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000388	22.509	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 8	0.441610	25648.689	2.99
CHANGE IN WATER STORAGE	-0.416	-24144.463	-2.82
SOIL WATER AT START OF YEAR	67.273	3907189.000	
SOIL WATER AT END OF YEAR	66.857	3883044.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.071	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT

PRECIPITATION	22.37	1299249.870	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	21.756	1263614.120	97.26
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000805	46.741	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 8	0.168636	9794.350	0.75
CHANGE IN WATER STORAGE	0.445	25840.707	1.99
SOIL WATER AT START OF YEAR	66.857	3883044.500	
SOIL WATER AT END OF YEAR	67.302	3908885.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.712	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	17.07	991425.812	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	17.997	1045249.370	105.43
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.002457	142.683	0.01
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 8	0.093440	5427.008	0.55
CHANGE IN WATER STORAGE	-1.020	-59250.711	-5.98
SOIL WATER AT START OF YEAR	67.302	3908885.250	
SOIL WATER AT END OF YEAR	66.282	3849634.500	

CHANGE IN WATER STORAGE	1.407	81727.648	5.70
SOIL WATER AT START OF YEAR	68.488	3977789.250	
SOIL WATER AT END OF YEAR	70.269	4081204.250	
SNOW WATER AT START OF YEAR	0.394	22892.311	1.60
SNOW WATER AT END OF YEAR	0.021	1204.840	0.08
ANNUAL WATER BUDGET BALANCE	0.0000	-0.474	0.00

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ANNUAL TOTALS FOR YEAR 55

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.91	982133.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	17.695	1027724.940	104.64
DRAINAGE COLLECTED FROM LAYER 6	0.0000	1.563	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.164049	9527.960	0.97
AVG. HEAD ON TOP OF LAYER 7	0.0001		
PERC./LEAKAGE THROUGH LAYER 8	0.205425	11931.077	1.21
CHANGE IN WATER STORAGE	-0.990	-57524.785	-5.86
SOIL WATER AT START OF YEAR	70.269	4081204.250	
SOIL WATER AT END OF YEAR	69.299	4024884.250	
SNOW WATER AT START OF YEAR	0.021	1204.840	0.12
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.241	0.00

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ANNUAL TOTALS FOR YEAR 56

RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	21.841	1268513.000	99.91
DRAINAGE COLLECTED FROM LAYER 6	0.0038	219.901	0.02
PERC./LEAKAGE THROUGH LAYER 7	0.388464	22562.018	1.78
AVG. HEAD ON TOP OF LAYER 7	0.0079		
PERC./LEAKAGE THROUGH LAYER 8	0.771741	44822.738	3.53
CHANGE IN WATER STORAGE	-0.756	-43926.457	-3.46
SOIL WATER AT START OF YEAR	69.102	4013446.750	
SOIL WATER AT END OF YEAR	68.346	3969520.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.021	0.00

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ANNUAL TOTALS FOR YEAR 100

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.06	1397404.870	100.00
RUNOFF	0.009	527.974	0.04
EVAPOTRANSPIRATION	20.429	1186507.370	84.91
DRAINAGE COLLECTED FROM LAYER 6	0.0000	1.551	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.192858	11201.181	0.80
AVG. HEAD ON TOP OF LAYER 7	0.0002		
PERC./LEAKAGE THROUGH LAYER 8	0.306690	17812.535	1.27
CHANGE IN WATER STORAGE	3.315	192554.844	13.78
SOIL WATER AT START OF YEAR	68.346	3969520.250	
SOIL WATER AT END OF YEAR	71.661	4162075.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.585	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.45	0.60	0.86	1.04	2.89	3.36
	2.69	2.90	1.71	1.61	0.60	0.48
STD. DEVIATIONS	0.39	0.44	0.62	0.78	1.59	1.65
	1.37	1.79	1.15	1.38	0.61	0.48
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.001
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.001	0.000	0.000	0.000	0.002	0.010
	0.000	0.002	0.000	0.000	0.000	0.003
EVAPOTRANSPIRATION						
TOTALS	0.579	0.704	0.932	1.098	2.619	3.395
	2.964	2.576	1.749	1.005	0.649	0.575
STD. DEVIATIONS	0.335	0.368	0.546	0.690	1.176	1.330
	1.386	1.470	0.983	0.594	0.362	0.339
LATERAL DRAINAGE COLLECTED FROM LAYER 6						
TOTALS	0.0029	0.0025	0.0026	0.0024	0.0027	0.0029
	0.0031	0.0032	0.0032	0.0033	0.0031	0.0030
STD. DEVIATIONS	0.0148	0.0131	0.0138	0.0128	0.0120	0.0114
	0.0124	0.0132	0.0135	0.0145	0.0143	0.0149
PERCOLATION/LEAKAGE THROUGH LAYER 7						
TOTALS	0.0207	0.0190	0.0209	0.0205	0.0219	0.0224
	0.0240	0.0243	0.0231	0.0221	0.0207	0.0208
STD. DEVIATIONS	0.0268	0.0239	0.0265	0.0268	0.0290	0.0293
	0.0307	0.0305	0.0285	0.0287	0.0276	0.0273

PERCOLATION/LEAKAGE THROUGH LAYER 8

TOTALS	0.0223	0.0200	0.0204	0.0202	0.0223	0.0217
	0.0227	0.0224	0.0226	0.0238	0.0228	0.0231
STD. DEVIATIONS	0.0287	0.0256	0.0252	0.0235	0.0252	0.0248
	0.0268	0.0274	0.0269	0.0279	0.0263	0.0284

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 7

AVERAGES	0.0707	0.0667	0.0642	0.0621	0.0661	0.0738
	0.0768	0.0787	0.0803	0.0808	0.0781	0.0741
STD. DEVIATIONS	0.3622	0.3512	0.3398	0.3239	0.2943	0.2889
	0.3034	0.3240	0.3414	0.3548	0.3629	0.3652

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	19.19	(3.698)	1114578.5	100.00
RUNOFF	0.002	(0.0110)	127.34	0.011
EVAPOTRANSPIRATION	18.845	(3.3019)	1094524.50	98.201
LATERAL DRAINAGE COLLECTED FROM LAYER 6	0.03491	(0.13349)	2027.309	0.18189
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.26044	(0.30414)	15126.493	1.35715
AVERAGE HEAD ON TOP OF LAYER 7	0.073	(0.278)		
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.26430	(0.28535)	15350.405	1.37724
CHANGE IN WATER STORAGE	0.044	(1.3412)	2548.86	0.229

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	4.02	233481.594
RUNOFF	0.101	5839.2324
DRAINAGE COLLECTED FROM LAYER 6	0.00341	197.90884
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.003646	211.78358
AVERAGE HEAD ON TOP OF LAYER 7	2.592	
MAXIMUM HEAD ON TOP OF LAYER 7	4.665	
LOCATION OF MAXIMUM HEAD IN LAYER 6 (DISTANCE FROM DRAIN)	49.8 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.006766	392.96970
SNOW WATER	1.05	61002.2969

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3103
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1315

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 100

LAYER	(INCHES)	(VOL/VOL)
1	0.0483	0.0483
2	6.8416	0.2281
3	0.6488	0.1081
4	4.2334	0.0882
5	36.2880	0.3780
6	1.8611	0.0775
7	15.3720	0.4270
8	6.3679	0.3538
SNOW WATER	0.000	

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APPENDIX D

TCEQ VERIFICATION CALCULATION

RAECOM MODEL FOR ESTIMATING THE RADON EMANATION RATE THROUGH THE WCS BYPRODUCT FACILITY COVER SYSTEM

Uranium Mill Tailings Cover Calculator

(last updated 2 Jul 2004)
Requires Netscape 3.0, Internet Explorer 3.0 or higher. JavaScript must be enabled.
For educational purposes only. No warranty.

.Determine the radon flux through a multi-layer soil cover of an uranium mill tailings pile and/or optimize the cover for a given flux.

(For calculating radon flux from bare and/or water covered tailings, see the Uranium Mill Tailings Radon Flux Calculator)

Select activity unit first, then enter the parameters and click the "Calculate" button below. **HELP**
Layer 1 is the tailings layer.
Numbers can be entered in exponential notation: $5 \cdot 10^{-6} = 5e\text{-}6$

Activity unit: (•) pCi ( ) Bq

Input Data

Layer Data HELP

Layer No.	Thickness [m]	Ra-226 Activity Conc. [pCi/g]	Rn-222 Emanation Fraction	Porosity	Moisture Cont. [dry wt_%]	Fraction Passing #200 Mesh (75 µm) *)	Rn-222 Eff. Diff.Coeff *) [m^2/s]
1	21.33	84660	0.3	0.3	12		
2	.457	0	0	0.29	12		
3	.914	0	0	0.29	12		
4	2.44	0	0	0.475	12		
5	1.22	0	0	.417	3		
6	1.52	0	0	0.397	3		
7	.762	0	0	.398	10		
8	2.54E-2	0	0	.417	3		

Options HELP

0 Entrance Radon flux to Layer 1 [pCi/m^2s]
0 Surface Radon conc. at top of system [pCi/L]
0 Layer No. to be optimized *)

0	Surface flux constraint for optimization [pCi/m^{2}s]
0.01	Surface flux convergence criterion (fraction)
48.3	Annual Precipitation [cm] (Note: This is for the Amarillo Region which is 19 in/yr versus 16 inches for Andrew's area to account for potentially wetter climate in the future.)
198.12	Annual Lake Evaporation [cm]
45.72	Depth to Water Table [m]

*) optional

RESULTS

---------- Input Parameters ----------

Number of Layers: 8
Radon Flux into Layer 1: 0 pCi/m2s
Surface Radon Concentration: 0 pCi/L
Bare Source Flux (Jo) from Layer 1: 28371 pCi/m2s
Specific Bare Source Flux from Layer 1: 0.335 pCi/m2s per pCi_Ra-226/g

Layer No.	Thickness [m]	Ra-226 [pCi/g]	Emanation Fract	Porosity	Moisture [dry wt_%]	Diff Coeff [m2/s]
1	21.33	84660	0.3	0.3	12	166.3E-9
2	0.457	0	0	0.29	12	108.9E-9
3	0.914	0	0	0.29	12	108.9E-9
4	2.44	0	0	0.475	12	2.255E-6
5	1.22	0	0	0.417	3	4.814E-6
6	1.52	0	0	0.397	3	4.624E-6
7	0.762	0	0	0.398	10	1.691E-6
8	0.025	0	0	0.417	3	4.814E-6

-------- Results of Radon Diffusion Calculation --------

Layer	Thickness	Exit Flux	Exit Conc.	MIC

No.	[m]	[pCi/m2s]	[pCi/L]	
1	21.33	12004	92.29E6	0.441
2	0.457	1615.	11.63E6	0.413
3	0.914	54.36	29.43E3	0.413
4	2.44	6.275	3.894E3	0.735
5	1.22	2.658	2.278E3	0.916
6	1.52	0.786	947.7E0	0.909
7	0.762	0.566	5.450E0	0.698
8	0.025	0.566	0E0	0.916

Total cover radon retention: 100.0%

Exit Flux is less than 20 pCi/m2s which meets the Texas Regulatory requirement as set forth in 25 TAC §289.260 and 40 CFR 192.

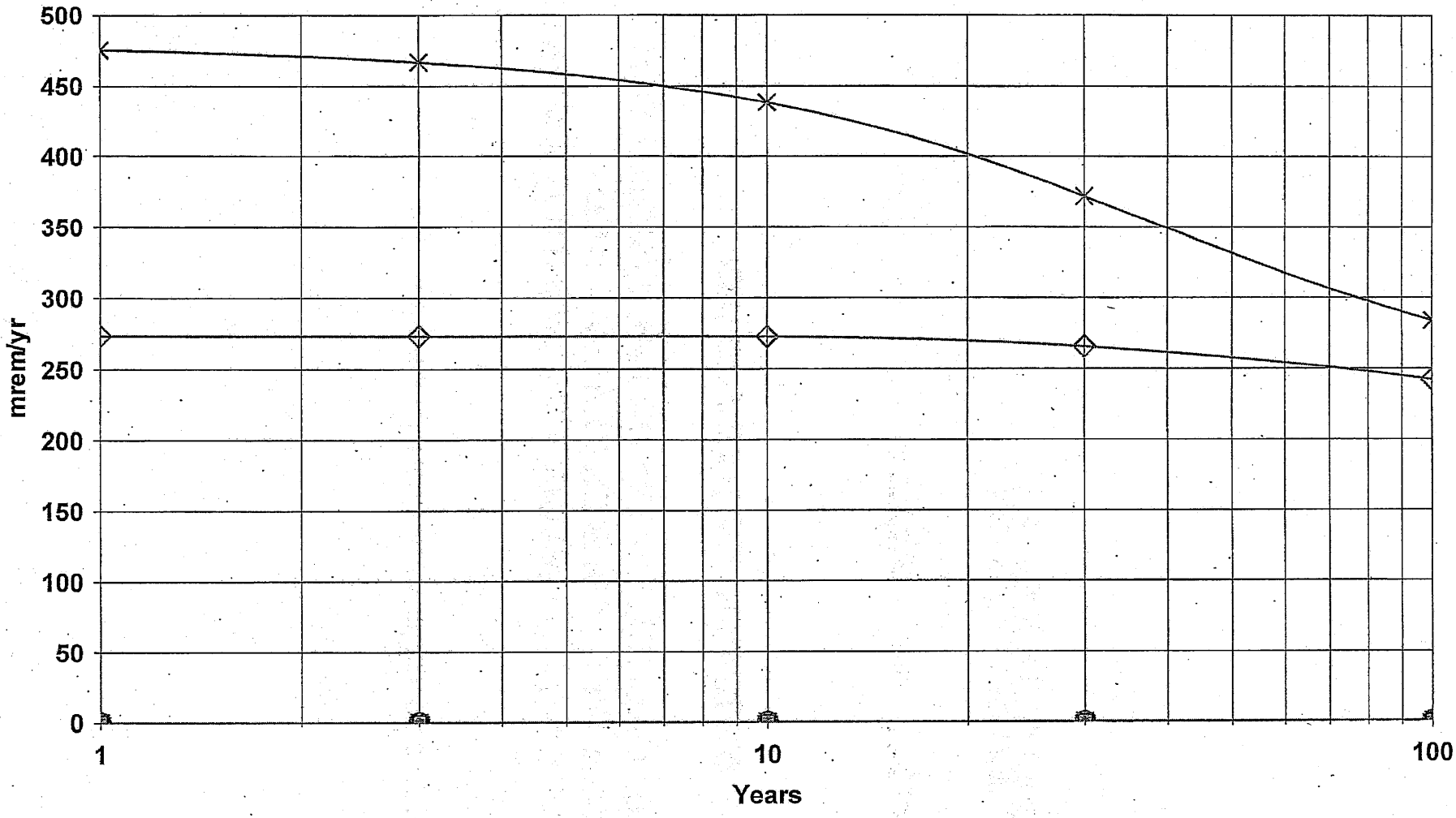
APPENDIX E

TCEQ VERIFICATION CALCULATION

RESRAD© CALCULATION FOR ESTIMATING THE DOSE TO A WCS WORKER PLACING AND COMPACTING BY-PRODUCT RADIOACTIVE WASTE

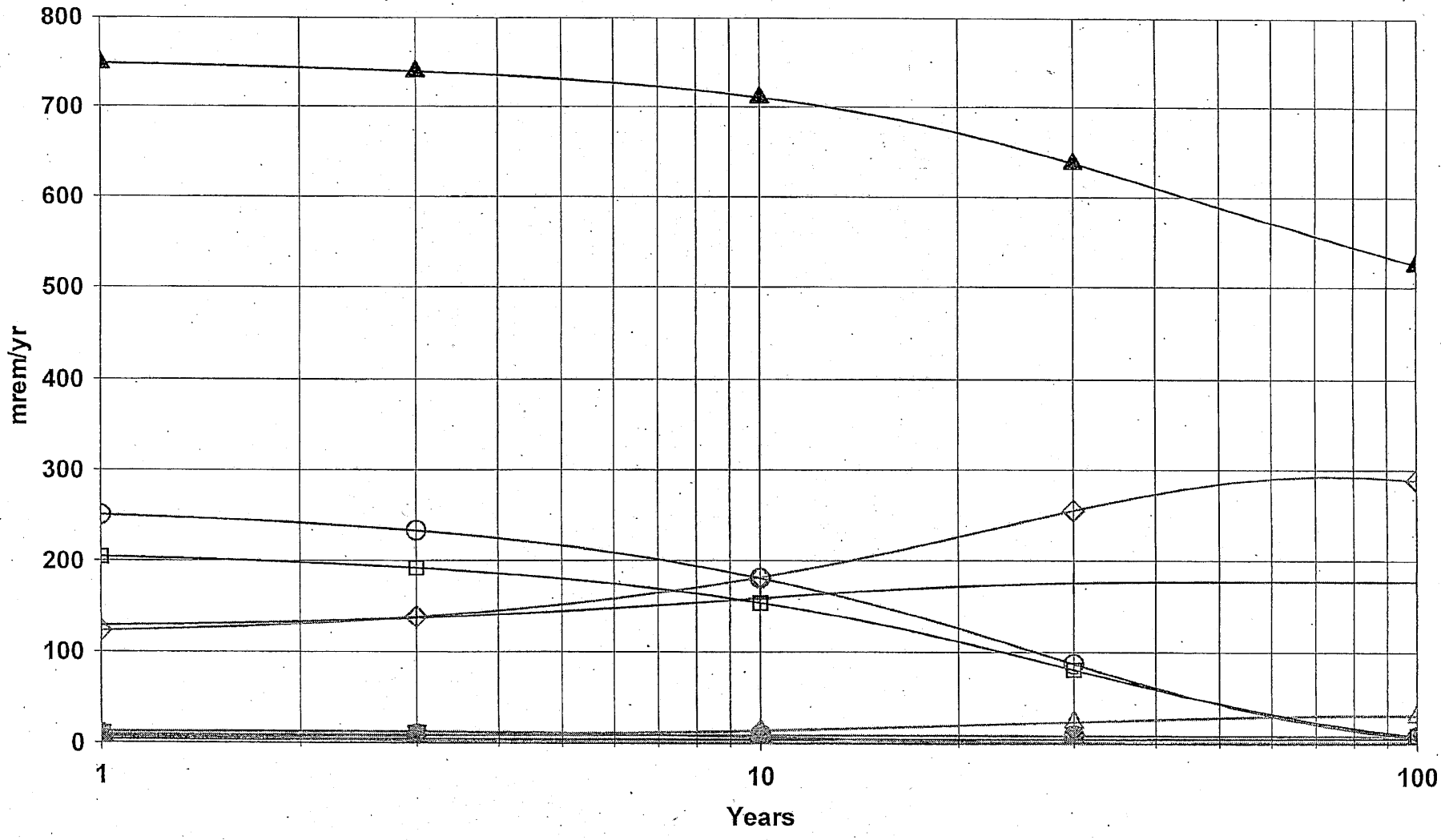
(Inhalation and Ingestion pathways only)

DOSE: All Nuclides Summed, Component Pathways



WCS BP Worker TCEQ Par.RAD 07/18/2007 07:58 GRAPHICS.ASC

DOSE: All Nuclides Summed, All Pathways Summed



WCS BP Worker TCEQ Par.RAD 07/18/2007 07:58 GRAPHICS.ASC Includes All Pathways

Summary : RESRAD Default Parameters WCS Worker Scenario
File : WCS BP Worker TCEQ Par.RAD

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Dose Conversion Factor (and Related) Parameter Summary
File: FGR 13 MORBIDITY

Menu	Parameter	Current Value	Base Case*	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Ac-227+D	6.724E+00	6.700E+00	DCF2(1)
B-1	Pa-231	1.280E+00	1.280E+00	DCF2(2)
B-1	Pb-210+D	2.320E-02	1.360E-02	DCF2(3)
B-1	Ra-226+D	8.594E-03	8.580E-03	DCF2(4)
B-1	Ra-228+D	5.078E-03	4.770E-03	DCF2(5)
B-1	Th-228+D	3.454E-01	3.420E-01	DCF2(6)
B-1	Th-230	3.260E-01	3.260E-01	DCF2(7)
B-1	Th-232	1.640E+00	1.640E+00	DCF2(8)
B-1	U-234	1.320E-01	1.320E-01	DCF2(9)
B-1	U-235+D	1.230E-01	1.230E-01	DCF2(10)
B-1	U-238	1.180E-01	1.180E-01	DCF2(11)
B-1	U-238+D	1.180E-01	1.180E-01	DCF2(12)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Ac-227+D	1.480E-02	1.410E-02	DCF3(1)
D-1	Pa-231	1.060E-02	1.060E-02	DCF3(2)
D-1	Pb-210+D	7.276E-03	5.370E-03	DCF3(3)
D-1	Ra-226+D	1.321E-03	1.320E-03	DCF3(4)
D-1	Ra-228+D	1.442E-03	1.440E-03	DCF3(5)
D-1	Th-228+D	8.086E-04	3.960E-04	DCF3(6)
	Th-230	5.480E-04	5.480E-04	DCF3(7)
	Th-232	2.730E-03	2.730E-03	DCF3(8)
D-1	U-234	2.830E-04	2.830E-04	DCF3(9)
D-1	U-235+D	2.673E-04	2.660E-04	DCF3(10)
D-1	U-238	2.550E-04	2.550E-04	DCF3(11)
D-1	U-238+D	2.687E-04	2.550E-04	DCF3(12)
D-34	Food transfer factors:			
D-34	Ac-227+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(1,1)
D-34	Ac-227+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,2)
D-34	Ac-227+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,3)
D-34				
D-34	Pa-231 , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(2,1)
D-34	Pa-231 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-03	5.000E-03	RTF(2,2)
D-34	Pa-231 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(2,3)
D-34				
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(3,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(3,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(3,3)
D-34				
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(4,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(4,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(4,3)
D-34				
D-34	Ra-228+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(5,1)
	Ra-228+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(5,2)
	Ra-228+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(5,3)
D-34				

Dose Conversion Factor (and Related) Parameter Summary (continued)
File: FGR 13 MORBIDITY

Menu	Parameter	Current Value	Base Case*	Parameter Name
D-34	Th-228+D , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(6,1)
D-34	Th-228+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(6,2)
D-34	Th-228+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(6,3)
D-34				
D-34	Th-230 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(7,1)
D-34	Th-230 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(7,2)
D-34	Th-230 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(7,3)
D-34				
D-34	Th-232 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(8,1)
D-34	Th-232 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(8,2)
D-34	Th-232 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(8,3)
D-34				
D-34	U-234 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(9,1)
D-34	U-234 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(9,2)
D-34	U-234 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(9,3)
D-34				
D-34	U-235+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(10,1)
D-34	U-235+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(10,2)
D-34	U-235+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(10,3)
D-34				
D-34	U-238 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(11,1)
D-34	U-238 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(11,2)
D-34	U-238 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(11,3)
D-34				
D-34	U-238+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(12,1)
D-34	U-238+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(12,2)
D-34	U-238+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(12,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Ac-227+D , fish	1.500E+01	1.500E+01	BIOFAC(1,1)
D-5	Ac-227+D , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(1,2)
D-5				
D-5	Pa-231 , fish	1.000E+01	1.000E+01	BIOFAC(2,1)
D-5	Pa-231 , crustacea and mollusks	1.100E+02	1.100E+02	BIOFAC(2,2)
D-5				
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(3,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(3,2)
D-5				
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC(4,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(4,2)
D-5				
D-5	Ra-228+D , fish	5.000E+01	5.000E+01	BIOFAC(5,1)
D-5	Ra-228+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(5,2)
D-5				
D-5	Th-228+D , fish	1.000E+02	1.000E+02	BIOFAC(6,1)
D-5	Th-228+D , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(6,2)
D-5				
D-5	Th-230 , fish	1.000E+02	1.000E+02	BIOFAC(7,1)
D-5	Th-230 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(7,2)
D-5				

Dose Conversion Factor (and Related) Parameter Summary (continued)
File: FGR 13 MORBIDITY

Menu	Parameter	Current Value	Base Case*	Parameter Name
D-5	Th-232 , fish	1.000E+02	1.000E+02	BIOFAC(8,1)
D-5	Th-232 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(8,2)
D-5				
D-5	U-234 , fish	1.000E+01	1.000E+01	BIOFAC(9,1)
D-5	U-234 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(9,2)
D-5				
D-5	U-235+D , fish	1.000E+01	1.000E+01	BIOFAC(10,1)
D-5	U-235+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(10,2)
D-5				
D-5	U-238 , fish	1.000E+01	1.000E+01	BIOFAC(11,1)
D-5	U-238 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(11,2)
D-5				
D-5	U-238+D , fish	1.000E+01	1.000E+01	BIOFAC(12,1)
D-5	U-238+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(12,2)

*Base Case means Default.Lib w/o Associate Nuclide contributions.

Summary : RESRAD Default Parameters WCS Worker Scenario
File : WCS BP Worker TCEQ Par.RAD

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	4.200E+04	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	2.000E+00	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	not used	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	5.000E+03	3.000E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)	not used	3.000E+02	---	T(7)
R011	Times for calculations (yr)	not used	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Ac-227	9.250E+02	0.000E+00	---	S1(1)
R012	Initial principal radionuclide (pCi/g): Pa-231	9.250E+02	0.000E+00	---	S1(2)
R012	Initial principal radionuclide (pCi/g): Pb-210	3.483E+03	0.000E+00	---	S1(3)
R012	Initial principal radionuclide (pCi/g): Ra-226	4.930E+02	0.000E+00	---	S1(4)
R012	Initial principal radionuclide (pCi/g): Ra-228	7.590E+02	0.000E+00	---	S1(5)
R012	Initial principal radionuclide (pCi/g): Th-228	7.590E+02	0.000E+00	---	S1(6)
R012	Initial principal radionuclide (pCi/g): Th-230	3.670E+02	0.000E+00	---	S1(7)
R012	Initial principal radionuclide (pCi/g): Th-232	1.981E+03	0.000E+00	---	S1(8)
R012	Initial principal radionuclide (pCi/g): U-234	1.680E+03	0.000E+00	---	S1(9)
R012	Initial principal radionuclide (pCi/g): U-235	7.679E+01	0.000E+00	---	S1(10)
R012	Initial principal radionuclide (pCi/g): U-238	3.670E+02	0.000E+00	---	S1(11)
R012	Concentration in groundwater (pCi/L): Ac-227	not used	0.000E+00	---	W1(1)
R012	Concentration in groundwater (pCi/L): Pa-231	not used	0.000E+00	---	W1(2)
R012	Concentration in groundwater (pCi/L): Pb-210	not used	0.000E+00	---	W1(3)
R012	Concentration in groundwater (pCi/L): Ra-226	not used	0.000E+00	---	W1(4)
R012	Concentration in groundwater (pCi/L): Ra-228	not used	0.000E+00	---	W1(5)
R012	Concentration in groundwater (pCi/L): Th-228	not used	0.000E+00	---	W1(6)
R012	Concentration in groundwater (pCi/L): Th-230	not used	0.000E+00	---	W1(7)
R012	Concentration in groundwater (pCi/L): Th-232	not used	0.000E+00	---	W1(8)
R012	Concentration in groundwater (pCi/L): U-234	not used	0.000E+00	---	W1(9)
R012	Concentration in groundwater (pCi/L): U-235	not used	0.000E+00	---	W1(10)
R012	Concentration in groundwater (pCi/L): U-238	not used	0.000E+00	---	W1(11)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.600E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	3.100E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R013	Precipitation (m/yr)	4.830E-01	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	not used	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	not used	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	not used	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	not used	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	not used	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	not used	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	not used	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	not used	2.000E-02	---	HGWT
R014	Saturated zone b parameter	not used	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	not used	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	not used	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	not used	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	not used	2.500E+02	---	UW
R015	Number of unsaturated zone strata	not used	1	---	NS
R015	Unsat. zone 1, thickness (m)	not used	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	not used	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	not used	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	not used	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	not used	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	not used	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	not used	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Ac-227				
R016	Contaminated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	not used	2.000E+01	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	not used	2.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.537E-03	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for Pa-231				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.825E-03	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R016	Distribution coefficients for Pb-210				
R016	Contaminated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	not used	1.000E+02	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	not used	1.000E+02	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	9.145E-04	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for Ra-226				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	not used	7.000E+01	---	DCNUCU(4,1)
R016	Saturated zone (cm**3/g)	not used	7.000E+01	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.305E-03	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R016	Distribution coefficients for Ra-228				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(5)
R016	Unsaturated zone 1 (cm**3/g)	not used	7.000E+01	---	DCNUCU(5,1)
R016	Saturated zone (cm**3/g)	not used	7.000E+01	---	DCNUCS(5)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.305E-03	ALEACH(5)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(5)
R016	Distribution coefficients for Th-228				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(6)
R016	Unsaturated zone 1 (cm**3/g)	not used	6.000E+04	---	DCNUCU(6,1)
R016	Saturated zone (cm**3/g)	not used	6.000E+04	---	DCNUCS(6)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.527E-06	ALEACH(6)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(6)
R016	Distribution coefficients for Th-230				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(7)
R016	Unsaturated zone 1 (cm**3/g)	not used	6.000E+04	---	DCNUCU(7,1)
R016	Saturated zone (cm**3/g)	not used	6.000E+04	---	DCNUCS(7)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.527E-06	ALEACH(7)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(7)
R016	Distribution coefficients for Th-232				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(8)
R016	Unsaturated zone 1 (cm**3/g)	not used	6.000E+04	---	DCNUCU(8,1)
R016	Saturated zone (cm**3/g)	not used	6.000E+04	---	DCNUCS(8)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.527E-06	ALEACH(8)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(8)
R016	Distribution coefficients for U-234				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(9)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(9,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(9)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.825E-03	ALEACH(9)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(9)
R016	Distribution coefficients for U-235				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(10)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(10,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(10)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.825E-03	ALEACH(10)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(10)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for U-238				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(11)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(11,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(11)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.825E-03	ALEACH(11)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(11)
R017	Inhalation rate (m**3/yr)	1.140E+04	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	2.500E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	not used	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	1.700E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	6.000E-02	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	not used	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	not used	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	not used	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6.300E+01	---	DIET(4)
R	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.650E+01	3.650E+01	---	SOIL

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R018	Drinking water intake (L/yr)	not used	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	not used	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	not used	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	not used	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	not used	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	not used	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	not used	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	not used	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	not used	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	not used	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	not used	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	not used	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	not used	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	not used	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	not used	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
C14	DCF correction factor for gaseous forms of C14	not used	0.000E+00	---	CO2F

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	suppressed
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	suppressed
4 -- meat ingestion	suppressed
5 -- milk ingestion	suppressed
6 -- aquatic foods	suppressed
7 -- drinking water	suppressed
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	active

Summary : RESRAD Default Parameters WCS Worker Scenario
File : WCS BP Worker TCEQ Par.RAD

Contaminated Zone Dimensions

Area:	42000.00 square meters
Thickness:	2.00 meters
Cover Depth:	0.00 meters

Initial Soil Concentrations, pCi/g

Ac-227	9.250E+02
Pa-231	9.250E+02
Pb-210	3.483E+03
Ra-226	4.930E+02
Ra-228	7.590E+02
Th-228	7.590E+02
Th-230	3.670E+02
Th-232	1.981E+03
U-234	1.680E+03
U-235	7.679E+01
U-238	3.670E+02

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 5.000E+03 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02
TDOSE(t):	7.534E+02	7.484E+02	7.396E+02	7.108E+02	6.379E+02	5.255E+02
M(t):	1.507E-01	1.497E-01	1.479E-01	1.422E-01	1.276E-01	1.051E-01

Maximum TDOSE(t): 7.534E+02 mrem/yr at t = 0.000E+00 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	1.469E+02	0.1950	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.128E+02	0.1498
Pa-231	0.000E+00	0.0000	3.081E+01	0.0409	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.404E+01	0.1116
Pb-210	0.000E+00	0.0000	1.913E+00	0.0025	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.094E+02	0.2779
Ra-226	0.000E+00	0.0000	1.061E-01	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.925E+00	0.0079
Ra-228	0.000E+00	0.0000	1.062E+00	0.0014	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.448E+00	0.0125
Th-228	0.000E+00	0.0000	5.290E+00	0.0070	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.322E+00	0.0057
Th-230	0.000E+00	0.0000	2.878E+00	0.0038	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.689E+00	0.0022
Th-232	0.000E+00	0.0000	7.827E+01	0.1039	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.688E+01	0.0622
U-234	0.000E+00	0.0000	5.330E+00	0.0071	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.988E+00	0.0053
U-235	0.000E+00	0.0000	2.270E-01	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.723E-01	0.0002
U-238	0.000E+00	0.0000	1.041E+00	0.0014	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.271E-01	0.0011
Total	0.000E+00	0.0000	2.739E+02	0.3635	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.795E+02	0.6365

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.598E+02	0.3448
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.149E+02	0.1524
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.113E+02	0.2805
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.031E+00	0.0080
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.051E+01	0.0140
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.611E+00	0.0128
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.567E+00	0.0061
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.252E+02	0.1661
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.317E+00	0.0124
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.993E-01	0.0005
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.868E+00	0.0025
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.534E+02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	1.417E+02	0.1893	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.088E+02	0.1454
Pa-231	0.000E+00	0.0000	3.534E+01	0.0472	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.741E+01	0.1168
Pb-210	0.000E+00	0.0000	1.853E+00	0.0025	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.028E+02	0.2710
Ra-226	0.000E+00	0.0000	1.142E-01	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.821E+00	0.0091
Ra-228	0.000E+00	0.0000	2.448E+00	0.0033	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.596E+00	0.0128
Th-228	0.000E+00	0.0000	3.682E+00	0.0049	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.008E+00	0.0040
Th-230	0.000E+00	0.0000	2.878E+00	0.0038	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.691E+00	0.0023
Th-232	0.000E+00	0.0000	7.885E+01	0.1053	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.989E+01	0.0667
U-234	0.000E+00	0.0000	5.320E+00	0.0071	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.980E+00	0.0053
U-235	0.000E+00	0.0000	2.267E-01	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.721E-01	0.0002
U-238	0.000E+00	0.0000	1.039E+00	0.0014	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.256E-01	0.0011
Total	0.000E+00	0.0000	2.734E+02	0.3653	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.750E+02	0.6347

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.505E+02	0.3347
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.228E+02	0.1640
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.047E+02	0.2734
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.935E+00	0.0093
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.204E+01	0.0161
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.690E+00	0.0089
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.569E+00	0.0061
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.287E+02	0.1720
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.301E+00	0.0124
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.988E-01	0.0005
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.865E+00	0.0025
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.484E+02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	1.317E+02	0.1781	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.012E+02	0.1368
Pa-231	0.000E+00	0.0000	4.389E+01	0.0594	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.376E+01	0.1268
Pb-210	0.000E+00	0.0000	1.738E+00	0.0023	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.902E+02	0.2572
Ra-226	0.000E+00	0.0000	1.295E-01	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.522E+00	0.0115
Ra-228	0.000E+00	0.0000	3.579E+00	0.0048	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.877E+00	0.0120
Th-228	0.000E+00	0.0000	1.784E+00	0.0024	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.458E+00	0.0020
Th-230	0.000E+00	0.0000	2.878E+00	0.0039	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.696E+00	0.0023
Th-232	0.000E+00	0.0000	8.083E+01	0.1093	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.575E+01	0.0754
U-234	0.000E+00	0.0000	5.301E+00	0.0072	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.966E+00	0.0054
U-235	0.000E+00	0.0000	2.260E-01	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.718E-01	0.0002
U-238	0.000E+00	0.0000	1.035E+00	0.0014	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.226E-01	0.0011
Total	0.000E+00	0.0000	2.731E+02	0.3693	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.664E+02	0.6307

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.329E+02	0.3149
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.377E+02	0.1861
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.920E+02	0.2596
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.652E+00	0.0117
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.246E+01	0.0168
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.241E+00	0.0044
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.574E+00	0.0062
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.366E+02	0.1847
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.267E+00	0.0125
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.978E-01	0.0005
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.858E+00	0.0025
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.396E+02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	1.021E+02	0.1437	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.843E+01	0.1103
Pa-231	0.000E+00	0.0000	6.907E+01	0.0972	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.123E+02	0.1580
Pb-210	0.000E+00	0.0000	1.389E+00	0.0020	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.521E+02	0.2139
Ra-226	0.000E+00	0.0000	1.756E-01	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.364E+01	0.0192
Ra-228	0.000E+00	0.0000	2.458E+00	0.0035	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.545E+00	0.0064
Th-228	0.000E+00	0.0000	1.412E-01	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.154E-01	0.0002
Th-230	0.000E+00	0.0000	2.878E+00	0.0040	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.721E+00	0.0024
Th-232	0.000E+00	0.0000	8.796E+01	0.1237	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.040E+01	0.0990
U-234	0.000E+00	0.0000	5.234E+00	0.0074	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.916E+00	0.0055
U-235	0.000E+00	0.0000	2.238E-01	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.709E-01	0.0002
U-238	0.000E+00	0.0000	1.022E+00	0.0014	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.122E-01	0.0011
Total	0.000E+00	0.0000	2.727E+02	0.3836	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.381E+02	0.6164

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.806E+02	0.2540
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.814E+02	0.2552
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.534E+02	0.2159
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.381E+01	0.0194
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.003E+00	0.0099
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.566E-01	0.0004
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.600E+00	0.0065
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.584E+02	0.2228
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.151E+00	0.0129
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.947E-01	0.0006
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.835E+00	0.0026
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.108E+02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	4.934E+01	0.0774	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.789E+01	0.0594
Pa-231	0.000E+00	0.0000	1.118E+02	0.1753	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.430E+02	0.2242
Pb-210	0.000E+00	0.0000	7.324E-01	0.0011	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.018E+01	0.1257
Ra-226	0.000E+00	0.0000	2.582E-01	0.0004	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.286E+01	0.0358
Ra-228	0.000E+00	0.0000	2.333E-01	0.0004	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.124E-01	0.0006
Th-228	0.000E+00	0.0000	1.007E-04	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.224E-05	0.0000
Th-230	0.000E+00	0.0000	2.879E+00	0.0045	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.842E+00	0.0029
Th-232	0.000E+00	0.0000	9.407E+01	0.1475	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.136E+01	0.1275
U-234	0.000E+00	0.0000	5.049E+00	0.0079	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.777E+00	0.0059
U-235	0.000E+00	0.0000	2.190E-01	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.692E-01	0.0003
U-238	0.000E+00	0.0000	9.857E-01	0.0015	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.831E-01	0.0012
Total	0.000E+00	0.0000	2.656E+02	0.4164	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.723E+02	0.5836

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.724E+01	0.1368
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.548E+02	0.3995
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.091E+01	0.1268
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.312E+01	0.0362
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.457E-01	0.0010
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.829E-04	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.721E+00	0.0074
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.754E+02	0.2750
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.826E+00	0.0138
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.882E-01	0.0006
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.769E+00	0.0028
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.379E+02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	3.868E+00	0.0074	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.970E+00	0.0057
Pa-231	0.000E+00	0.0000	1.347E+02	0.2563	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.536E+02	0.2923
Pb-210	0.000E+00	0.0000	7.799E-02	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.538E+00	0.0162
Ra-226	0.000E+00	0.0000	3.115E-01	0.0006	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.933E+01	0.0558
Ra-228	0.000E+00	0.0000	4.611E-05	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.148E-05	0.0000
Th-228	0.000E+00	0.0000	9.731E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.951E-16	0.0000
Th-230	0.000E+00	0.0000	2.884E+00	0.0055	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.469E+00	0.0047
Th-232	0.000E+00	0.0000	9.466E+01	0.1801	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.242E+01	0.1568
U-234	0.000E+00	0.0000	4.450E+00	0.0085	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.329E+00	0.0063
U-235	0.000E+00	0.0000	2.079E-01	0.0004	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.667E-01	0.0003
U-238	0.000E+00	0.0000	8.677E-01	0.0017	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.893E-01	0.0013
Total	0.000E+00	0.0000	2.420E+02	0.4605	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.835E+02	0.5395

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.838E+00	0.0130
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.883E+02	0.5486
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.616E+00	0.0164
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.964E+01	0.0564
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.276E-04	0.0000
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.768E-15	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.353E+00	0.0102
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.771E+02	0.3369
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.779E+00	0.0148
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.747E-01	0.0007
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.557E+00	0.0030
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.255E+02	1.0000

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr)/(pCi/g) 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02
Ac-227+D	Ac-227+D	1.000E+00	2.808E-01	2.708E-01	2.518E-01	1.952E-01	9.431E-02	7.393E-03
Pa-231	Pa-231	1.000E+00	1.197E-01	1.194E-01	1.190E-01	1.175E-01	1.132E-01	9.949E-02
Pa-231	Ac-227+D	1.000E+00	4.494E-03	1.326E-02	2.981E-02	7.863E-02	1.623E-01	2.122E-01
Pa-231	∑DSR(j)		1.242E-01	1.327E-01	1.488E-01	1.961E-01	2.755E-01	3.117E-01
Pb-210+D	Pb-210+D	1.000E+00	6.067E-02	5.876E-02	5.511E-02	4.405E-02	2.323E-02	2.474E-03
Ra-226+D	Ra-226+D	1.000E+00	1.129E-02	1.127E-02	1.123E-02	1.109E-02	1.071E-02	9.485E-03
Ra-226+D	Pb-210+D	1.000E+00	9.473E-04	2.800E-03	6.322E-03	1.692E-02	3.619E-02	5.063E-02
Ra-226+D	∑DSR(j)		1.223E-02	1.407E-02	1.755E-02	2.801E-02	4.690E-02	6.011E-02
Ra-228+D	Ra-228+D	1.000E+00	1.151E-02	1.019E-02	7.988E-03	3.404E-03	2.976E-04	5.878E-08
Ra-228+D	Th-228+D	1.000E+00	2.334E-03	5.676E-03	8.422E-03	5.822E-03	5.531E-04	1.093E-07
Ra-228+D	∑DSR(j)		1.385E-02	1.587E-02	1.641E-02	9.226E-03	8.507E-04	1.681E-07
Th-228+D	Th-228+D	1.000E+00	1.266E-02	8.814E-03	4.271E-03	3.381E-04	2.410E-07	2.330E-18
Th-230	Th-230	1.000E+00	1.244E-02	1.244E-02	1.244E-02	1.244E-02	1.244E-02	1.243E-02
Th-230	Ra-226+D	1.000E+00	2.445E-06	7.330E-06	1.707E-05	5.091E-05	1.453E-04	4.510E-04
Th-230	Pb-210+D	1.000E+00	1.372E-07	9.511E-07	4.920E-06	4.080E-05	2.806E-04	1.706E-03
	∑DSR(j)		1.245E-02	1.245E-02	1.246E-02	1.253E-02	1.286E-02	1.459E-02
Th-232	Th-232	1.000E+00	6.237E-02	6.237E-02	6.237E-02	6.237E-02	6.237E-02	6.236E-02
Th-232	Ra-228+D	1.000E+00	7.080E-04	2.015E-03	4.196E-03	8.730E-03	1.180E-02	1.210E-02
Th-232	Th-228+D	1.000E+00	9.757E-05	5.984E-04	2.377E-03	8.840E-03	1.439E-02	1.493E-02
Th-232	∑DSR(j)		6.318E-02	6.498E-02	6.894E-02	7.994E-02	8.856E-02	8.939E-02
U-234	U-234	1.000E+00	5.546E-03	5.536E-03	5.516E-03	5.446E-03	5.250E-03	4.619E-03
U-234	Th-230	1.000E+00	5.597E-08	1.678E-07	3.908E-07	1.165E-06	3.322E-06	1.028E-05
U-234	Ra-226+D	1.000E+00	7.335E-12	5.129E-11	2.705E-10	2.400E-09	1.976E-08	1.975E-07
U-234	Pb-210+D	1.000E+00	3.091E-13	4.602E-12	5.279E-11	1.318E-09	2.737E-08	6.015E-07
U-234	∑DSR(j)		5.546E-03	5.536E-03	5.516E-03	5.447E-03	5.253E-03	4.630E-03
U-235+D	U-235+D	1.000E+00	5.199E-03	5.189E-03	5.170E-03	5.104E-03	4.921E-03	4.331E-03
U-235+D	Pa-231	1.000E+00	1.266E-06	3.791E-06	8.813E-06	2.610E-05	7.309E-05	2.118E-04
U-235+D	Ac-227+D	1.000E+00	3.178E-08	2.200E-07	1.133E-06	9.268E-06	6.141E-05	3.360E-04
U-235+D	∑DSR(j)		5.200E-03	5.193E-03	5.180E-03	5.140E-03	5.056E-03	4.879E-03
U-238	U-238	5.400E-05	2.686E-07	2.681E-07	2.672E-07	2.638E-07	2.543E-07	2.238E-07
U-238+D	U-238+D	9.999E-01	5.090E-03	5.081E-03	5.062E-03	4.998E-03	4.819E-03	4.241E-03
U-238+D	U-234	9.999E-01	7.859E-09	2.354E-08	5.472E-08	1.621E-07	4.539E-07	1.316E-06
U-238+D	Th-230	9.999E-01	5.287E-14	3.697E-13	1.950E-12	1.729E-11	1.423E-10	1.420E-09
U-238+D	Ra-226+D	9.999E-01	5.198E-18	7.787E-17	9.062E-16	2.381E-14	5.669E-13	1.846E-11
U-238+D	Pb-210+D	9.999E-01	1.755E-19	5.404E-18	1.342E-16	9.974E-15	6.150E-13	4.724E-11
	∑DSR(j)		5.090E-03	5.081E-03	5.063E-03	4.998E-03	4.819E-03	4.242E-03

The DSR includes contributions from associated (half-life ≤ 180 days) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 5.000E+03 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02
Ac-227	1.780E+04	1.846E+04	1.986E+04	2.561E+04	5.302E+04	6.763E+05
Pa-231	4.027E+04	3.768E+04	3.360E+04	2.550E+04	1.815E+04	1.604E+04
Pb-210	8.242E+04	8.510E+04	9.072E+04	1.135E+05	2.152E+05	2.021E+06
Ra-226	4.087E+05	3.555E+05	2.849E+05	1.785E+05	1.066E+05	8.317E+04
Ra-228	3.611E+05	3.151E+05	3.047E+05	5.419E+05	5.878E+06	2.974E+10
Th-228	3.948E+05	5.673E+05	1.171E+06	1.479E+07	2.075E+10	*8.195E+14
Th-230	4.018E+05	4.016E+05	4.012E+05	3.989E+05	3.887E+05	3.428E+05
Th-232	7.914E+04	7.694E+04	7.253E+04	6.255E+04	5.646E+04	5.594E+04
U-234	9.015E+05	9.032E+05	9.064E+05	9.180E+05	9.518E+05	1.080E+06
U-235	9.616E+05	9.628E+05	9.652E+05	9.728E+05	9.889E+05	1.025E+06
U-238	*3.361E+05	*3.361E+05	*3.361E+05	*3.361E+05	*3.361E+05	*3.361E+05

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Ac-227	9.250E+02	0.000E+00	2.808E-01	1.780E+04	2.808E-01	1.780E+04
Pa-231	9.250E+02	75.0 ± 0.1	3.166E-01	1.579E+04	1.242E-01	4.027E+04
Pb-210	3.483E+03	0.000E+00	6.067E-02	8.242E+04	6.067E-02	8.242E+04
Ra-226	4.930E+02	90.4 ± 0.2	6.026E-02	8.298E+04	1.223E-02	4.087E+05
Ra-228	7.590E+02	2.261 ± 0.005	1.659E-02	3.014E+05	1.385E-02	3.611E+05
Th-228	7.590E+02	0.000E+00	1.266E-02	3.948E+05	1.266E-02	3.948E+05
Th-230	3.670E+02	1.000E+02	1.459E-02	3.428E+05	1.245E-02	4.018E+05
Th-232	1.981E+03	84.3 ± 0.2	8.939E-02	5.594E+04	6.318E-02	7.914E+04
U-234	1.680E+03	0.000E+00	5.546E-03	9.015E+05	5.546E-03	9.015E+05
U-235	7.679E+01	0.000E+00	5.200E-03	9.616E+05	5.200E-03	9.616E+05
U-238	3.670E+02	0.000E+00	5.091E-03	*3.361E+05	5.091E-03	*3.361E+05

*At specific activity limit

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide	Parent	THF(i)	DOSE(j,t), mrem/yr					
(j)	(i)		t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02
Ac-227	Ac-227	1.000E+00	2.598E+02	2.505E+02	2.329E+02	1.806E+02	8.724E+01	6.838E+00
Ac-227	Pa-231	1.000E+00	4.157E+00	1.226E+01	2.757E+01	7.273E+01	1.501E+02	1.963E+02
Ac-227	U-235	1.000E+00	2.441E-06	1.689E-05	8.703E-05	7.117E-04	4.715E-03	2.580E-02
Ac-227	∑DOSE(j)		2.639E+02	2.628E+02	2.605E+02	2.533E+02	2.374E+02	2.032E+02
Pa-231	Pa-231	1.000E+00	1.107E+02	1.105E+02	1.101E+02	1.087E+02	1.047E+02	9.203E+01
Pa-231	U-235	1.000E+00	9.719E-05	2.911E-04	6.767E-04	2.004E-03	5.612E-03	1.626E-02
Pa-231	∑DOSE(j)		1.107E+02	1.105E+02	1.101E+02	1.087E+02	1.047E+02	9.204E+01
Pb-210	Pb-210	1.000E+00	2.113E+02	2.047E+02	1.920E+02	1.534E+02	8.091E+01	8.616E+00
Pb-210	Ra-226	1.000E+00	4.670E-01	1.380E+00	3.117E+00	8.343E+00	1.784E+01	2.496E+01
Pb-210	Th-230	1.000E+00	5.035E-05	3.491E-04	1.806E-03	1.497E-02	1.030E-01	6.260E-01
Pb-210	U-234	1.000E+00	5.194E-10	7.732E-09	8.869E-08	2.215E-06	4.599E-05	1.011E-03
Pb-210	U-238	9.999E-01	6.439E-17	1.983E-15	4.926E-14	3.660E-12	2.257E-10	1.734E-08
Pb-210	∑DOSE(j)		2.118E+02	2.060E+02	1.951E+02	1.618E+02	9.886E+01	3.420E+01
Ra-226	Ra-226	1.000E+00	5.564E+00	5.554E+00	5.535E+00	5.468E+00	5.281E+00	4.676E+00
Ra-226	Th-230	1.000E+00	8.974E-04	2.690E-03	6.266E-03	1.868E-02	5.334E-02	1.655E-01
Ra-226	U-234	1.000E+00	1.232E-08	8.617E-08	4.544E-07	4.032E-06	3.320E-05	3.318E-04
Ra-226	U-238	9.999E-01	1.908E-15	2.858E-14	3.326E-13	8.737E-12	2.080E-10	6.774E-09
Ra-226	∑DOSE(j)		5.565E+00	5.557E+00	5.541E+00	5.487E+00	5.335E+00	4.842E+00
Ra-228	Ra-228	1.000E+00	8.739E+00	7.736E+00	6.063E+00	2.584E+00	2.259E-01	4.461E-05
Ra-228	Th-232	1.000E+00	1.403E+00	3.991E+00	8.311E+00	1.729E+01	2.338E+01	2.396E+01
Ra-228	∑DOSE(j)		1.014E+01	1.173E+01	1.437E+01	1.988E+01	2.361E+01	2.396E+01
Th-228	Ra-228	1.000E+00	1.771E+00	4.308E+00	6.393E+00	4.419E+00	4.198E-01	8.297E-05
Th-228	Th-228	1.000E+00	9.611E+00	6.690E+00	3.241E+00	2.566E-01	1.829E-04	1.768E-15
Th-228	Th-232	1.000E+00	1.933E-01	1.185E+00	4.708E+00	1.751E+01	2.850E+01	2.958E+01
Th-228	∑DOSE(j)		1.158E+01	1.218E+01	1.434E+01	2.219E+01	2.892E+01	2.958E+01
Th-230	Th-230	1.000E+00	4.566E+00	4.566E+00	4.566E+00	4.566E+00	4.565E+00	4.562E+00
Th-230	U-234	1.000E+00	9.403E-05	2.819E-04	6.565E-04	1.957E-03	5.581E-03	1.727E-02
Th-230	U-238	9.999E-01	1.940E-11	1.357E-10	7.155E-10	6.347E-09	5.223E-08	5.210E-07
Th-230	∑DOSE(j)		4.567E+00	4.567E+00	4.567E+00	4.568E+00	4.571E+00	4.579E+00
Th-232	Th-232	1.000E+00	1.236E+02	1.236E+02	1.236E+02	1.236E+02	1.235E+02	1.235E+02
U-234	U-234	1.000E+00	9.317E+00	9.300E+00	9.266E+00	9.149E+00	8.820E+00	7.761E+00
U-234	U-238	9.999E-01	2.884E-06	8.638E-06	2.008E-05	5.949E-05	1.666E-04	4.831E-04
U-234	∑DOSE(j)		9.317E+00	9.300E+00	9.266E+00	9.149E+00	8.820E+00	7.761E+00
U-235	U-235	1.000E+00	3.992E-01	3.985E-01	3.970E-01	3.920E-01	3.779E-01	3.326E-01
U-238	U-238	5.400E-05	9.859E-05	9.841E-05	9.805E-05	9.681E-05	9.334E-05	8.214E-05
U-238	U-238	9.999E-01	1.868E+00	1.865E+00	1.858E+00	1.834E+00	1.769E+00	1.556E+00
U-238	∑DOSE(j)		1.868E+00	1.865E+00	1.858E+00	1.834E+00	1.769E+00	1.557E+00

THF(i) is the thread fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02
Ac-227	Ac-227	1.000E+00	9.250E+02	8.920E+02	8.294E+02	6.430E+02	3.106E+02	2.435E+01
Ac-227	Pa-231	1.000E+00	0.000E+00	2.889E+01	8.346E+01	2.445E+02	5.205E+02	6.866E+02
Ac-227	U-235	1.000E+00	0.000E+00	2.552E-05	2.237E-04	2.270E-03	1.604E-02	8.970E-02
Ac-227	∑S(j):		9.250E+02	9.209E+02	9.128E+02	8.874E+02	8.312E+02	7.111E+02
Pa-231	Pa-231	1.000E+00	9.250E+02	9.233E+02	9.199E+02	9.081E+02	8.751E+02	7.690E+02
Pa-231	U-235	1.000E+00	0.000E+00	1.622E-03	4.847E-03	1.595E-02	4.613E-02	1.352E-01
Pa-231	∑S(j):		9.250E+02	9.233E+02	9.199E+02	9.081E+02	8.752E+02	7.692E+02
Pb-210	Pb-210	1.000E+00	3.483E+03	3.373E+03	3.164E+03	2.529E+03	1.334E+03	1.420E+02
Pb-210	Ra-226	1.000E+00	0.000E+00	1.507E+01	4.372E+01	1.299E+02	2.868E+02	4.050E+02
Pb-210	Th-230	1.000E+00	0.000E+00	2.443E-03	2.151E-02	2.214E-01	1.624E+00	1.009E+01
Pb-210	U-234	1.000E+00	0.000E+00	3.364E-08	8.924E-07	3.111E-05	7.126E-04	1.620E-02
Pb-210	U-238	9.999E-01	0.000E+00	5.215E-15	4.162E-13	4.882E-11	3.437E-09	2.765E-07
Pb-210	∑S(j):		3.483E+03	3.388E+03	3.208E+03	2.659E+03	1.622E+03	5.571E+02
Ra-226	Ra-226	1.000E+00	4.930E+02	4.921E+02	4.904E+02	4.845E+02	4.679E+02	4.143E+02
Ra-226	Th-230	1.000E+00	0.000E+00	1.589E-01	4.757E-01	1.576E+00	4.647E+00	1.459E+01
Ra-226	U-234	1.000E+00	0.000E+00	3.272E-06	2.938E-05	3.237E-04	2.845E-03	2.910E-02
Ra-226	U-238	9.999E-01	0.000E+00	6.753E-13	1.818E-11	6.671E-10	1.753E-08	5.911E-07
Ra-226	∑S(j):		4.930E+02	4.923E+02	4.909E+02	4.861E+02	4.726E+02	4.289E+02
Ra-228	Ra-228	1.000E+00	7.590E+02	6.719E+02	5.266E+02	2.244E+02	1.962E+01	3.875E-03
Ra-228	Th-232	1.000E+00	0.000E+00	2.248E+02	6.001E+02	1.380E+03	1.909E+03	1.959E+03
Ra-228	∑S(j):		7.590E+02	8.968E+02	1.127E+03	1.605E+03	1.929E+03	1.959E+03
Th-228	Ra-228	1.000E+00	0.000E+00	2.164E+02	4.078E+02	3.076E+02	2.954E+01	5.838E-03
Th-228	Th-228	1.000E+00	7.590E+02	5.283E+02	2.560E+02	2.026E+01	1.444E-02	1.396E-13
Th-228	Th-232	1.000E+00	0.000E+00	3.692E+01	2.460E+02	1.113E+03	1.883E+03	1.959E+03
Th-228	∑S(j):		7.590E+02	7.816E+02	9.097E+02	1.441E+03	1.913E+03	1.959E+03
Th-230	Th-230	1.000E+00	3.670E+02	3.670E+02	3.670E+02	3.670E+02	3.669E+02	3.666E+02
Th-230	U-234	1.000E+00	0.000E+00	1.511E-02	4.524E-02	1.499E-01	4.414E-01	1.381E+00
Th-230	U-238	9.999E-01	0.000E+00	4.677E-09	4.199E-08	4.626E-07	4.063E-06	4.148E-05
Th-230	∑S(j):		3.670E+02	3.670E+02	3.670E+02	3.671E+02	3.673E+02	3.680E+02
Th-232	Th-232	1.000E+00	1.981E+03	1.981E+03	1.981E+03	1.981E+03	1.981E+03	1.981E+03
U-234	U-234	1.000E+00	1.680E+03	1.677E+03	1.671E+03	1.650E+03	1.590E+03	1.399E+03
U-234	U-238	9.999E-01	0.000E+00	1.038E-03	3.104E-03	1.022E-02	2.955E-02	8.667E-02
U-234	∑S(j):		1.680E+03	1.677E+03	1.671E+03	1.650E+03	1.590E+03	1.399E+03
U-235	U-235	1.000E+00	7.679E+01	7.665E+01	7.637E+01	7.540E+01	7.270E+01	6.398E+01
U-238	U-238	5.400E-05	1.982E-02	1.978E-02	1.971E-02	1.946E-02	1.876E-02	1.651E-02
U-238	U-238	9.999E-01	3.670E+02	3.663E+02	3.650E+02	3.603E+02	3.474E+02	3.057E+02
U-238	∑S(j):		3.670E+02	3.663E+02	3.650E+02	3.604E+02	3.474E+02	3.058E+02

THF(i) is the thread fraction of the parent nuclide.

RESCALC.EXE execution time = 4.10 seconds

APPENDIX F

TCEQ VERIFICATION CALCULATION

ESTIMATING THE DOSE TO A RESIDENT LIVING AT THE SITE BOUNDARY DURING THE OPERATING PERIOD IN THE PREDOMINATED WIND DIRECTION FROM THE WCS BY-PRODUCT RADIOACTIVE WASTE DISPOSAL SITE

(Pathways include dust suspension, radon gas, and external radiation from deposited dust.)

TCEQ verification calculations for estimating dose to a resident living at the site boundary in the predominant down wind direction from the site.

Airborne dust from open byproduct waste cell

Maywood waste byproduct source term with natural dust suspension from waste cell

Equations:

Dose(mrem/yr) = Air.conc(Ci/m3) x breathing.rt(m3/yr) x frac.yr.exposed x DCF.inh(mrem/Ci) x resuspension factor(m-1) x waste.conc(Ci/m3) x active depth(m)

Air.conc = Waste.source(Ci/s) x X/Q(s/m3) (offsite)

Waste.source(Ci/s) = Waste.conc(Ci/m3) x active.depth(m) x resusp.rt(1/s) x waste.area(m2)

X/Q (s/m3) = wind.freq / (2 x pi x wind.spd(m/s) x sigma.y(m) x sigma.z(m))

Formula Geometric Mean $\left(\prod_{i=1}^{n} a_i\right)^{1/n} = \sqrt[n]{a_1 \cdot a_2 \cdots a_n}$

Resuspension rate (1/s)= DOE-HDBK-3010-94, Table 4-18, geometric mean of Nevada TS an Eroding field 1E-11, 1E-9, 2E-9, 2E-7, and 1E-6 s-1

Parameters:

Byproduct waste volume (m3)	**894,000**	1,169,000 cy
Area of exposed waste (m2)	**19,800**	Vol. I, Figure 3.7 worst case active waste slope(288ft) x disposal area width(740ft)
Average wind speed (m/s)	**3.1**	WCS weather station, avg 6.04 knots
Active depth for suspnsn. (m)	**0.001**	particles > 1 mm not suspended.
Resuspension rate (1/s)	**5.25E-09**	DOE-HDBK-3010-94, Table 4-18, GM of NTS, Hanford, eroding field
Inhalation rate (m3/yr)	**8,400**	RESRAD default
Distance to site boundary receptor (m):	**777**	Stortest distance from Northern edge of waste area to the north site boundary.
Wind frequency annual avg.	**0.13**	Wind frequency from the predominate wind direction from the South
Sigma-y	**88**	for a conservatively stable Pasquilll C stability class, Cember 1996, p. 493.
Sigma-z	**55.00**	for a conservatively stable Pasquilll C stability class, Cember 1996, p. 494
X/Q (s/m3)	**1.38E-06**	Pasquill-Gifford ground level, plume centerline. Adj for wind freq in N, NNE, NNW dirs, Bevelacqua 1999, p357.
Fraction of yr exposed	**1.000**	8,760 hr/yr

Maywood Bulk Waste Nuclide	Waste Conc Ci/m3	Surface Conc Ci/m2	Site Boundary Air Conc Ci/m3	FGR #11 DCF-inh. Sv/Bq	FGR #11 DCF-inh. mrem/Ci	Site Boundary Dose mrem/yr
Pa-231		0.00E+00	0.00E+00	3.47E-04	1.28E+12	**0.00E+00**
Ac-227		0.00E+00	0.00E+00	1.81E-03	6.70E+12	**0.00E+00**
Ra-226+D	7.89E-04	7.89E-07	1.13E-16	2.32E-06	8.58E+09	**8.16E-03**
Pb-214	7.89E-04	7.89E-07	1.13E-16	2.11E-09	7.81E+06	**7.42E-06**
Bi-214	7.89E-04	7.89E-07	1.13E-16	1.78E-09	6.59E+06	**6.26E-06**
Pb-210	7.89E-04	7.89E-07	1.13E-16	3.67E-06	1.36E+10	**1.29E-02**
Po-210	7.89E-04	7.89E-07	1.13E-16	2.54E-06	9.40E+09	**8.93E-03**
Ra-228+D	3.17E-03	3.17E-06	4.55E-16	1.29E-06	4.77E+09	**1.82E-02**
Ac-228	3.17E-03	3.17E-06	4.55E-16	8.33E-08	3.08E+08	**1.18E-03**
Th-228	3.17E-03	3.17E-06	4.55E-16	9.23E-05	3.42E+11	**1.30E+00**
Ra-224	3.17E-03	3.17E-06	4.55E-16	8.53E-07	3.16E+09	**1.21E-02**
Pb-212	3.17E-03	3.17E-06	4.55E-16	4.56E-08	1.69E+08	**6.44E-04**
Bi-212	3.17E-03	3.17E-06	4.55E-16	5.83E-09	2.16E+07	**8.24E-05**
Tl-208	1.14E-03	1.14E-06	1.64E-16	0.00E+00	0.00E+00	**0.00E+00**
Th-230	5.87E-04	5.87E-07	8.42E-17	8.80E-05	3.26E+11	**2.30E-01**
Th-232	3.17E-03	3.17E-06	4.55E-16	4.43E-04	1.64E+12	**6.26E+00**
U-234	5.87E-04	5.87E-07	8.42E-17	3.58E-05	1.32E+11	**9.37E-02**
U-235+D	2.70E-05	2.70E-08	3.87E-18	3.32E-05	1.23E+11	**4.00E-03**
Th-231	2.70E-05	2.70E-08	3.87E-18	2.37E-10	8.77E+05	**2.85E-08**
U-238+D	5.87E-04	5.87E-07	8.42E-17	3.20E-05	1.18E+11	**8.37E-02**
Th-234	5.87E-04	5.87E-07	8.42E-17	9.47E-09	3.50E+07	**2.48E-05**
Pa-234m	5.87E-04	5.87E-07	8.42E-17	0.00E+00	0.00E+00	**0.00E+00**

Projected Dose to Resident at Site Boundary (mrem/yr) 8.04E+00

A3 ***Radon gas from byproduct without interim cover***

Doses to Resident Site Boundary during operations

Fernald Silo 1 & 2 source term

Reference for radon flux equations - NUREG/CR-3533, April 1984

Equations:

Radon.flux(pCi/m2-s) = Radium.conc(pCi/cm3) x emanation.coef x sqrt(rn.decay(s-1) x diffusion.coef(cm2/s)) x 10,000 cm2/m2

Radon.source(pCi/s) = Radon flux(pCi/m2-s) x area(m2)

Air.conc.wrkr(pCi/m3) = radon.source(pCi/s) / [sqrt(waste.area(m2)) x wind.speed(m/s) x vertical.mixing(m)] (box model)

Air.conc.offsite(pCi/m3) = radon.source(pCi/s) x X/Q(s/m3) (Gaussian plume)

Radon.dose(mrem/yr) = Air.conc(pCi/m3) x 0.001(m3/L) x frac.yr.exposed x dose.fctr(mrem/yr per pCi/L)

Parameters:

Ra-226 activity concentration(pCi/g)	**8.47E+04**	Maximum bulk waste byproduct source term, Maywood
Area of exposed waste (m2)	**6,870**	Vol.1, Figure 3.7, Active Waste Slope which has a 288 ft downward face and a 740 ft maximum width
Radon Dose Conv. Factor	**46**	mrem/yr per pCi/L, outdoor, 10% eq., reference 10 CFR 20
Thickness of waste (m)	**21.33**	for use in RAECOM model on Wise-Uranium web site.

Average wind speed (m/s)	3.1	WCS weather station, avg 6.04 knots
Distance to receptor (m):	777	Stortest distance from Northern edge of waste area to the site boundary.
Wind frequency annual avg.	0.13	Wind frequency from the predominate wind direction from the South

Calculations:

Sigma-y	88	for a conservatively stable Pasquiill C stability class, Cember 1996, p. 493.
Sigma-z	55.00	for a conservatively stable Pasquiill C stability class, Cember 1996, p. 494
X/Q (s/m3)	1.38E-06	Pasquill-Gifford ground level, plume centerline. Adj for wind freq in N, NNE, NNW dirs, Bevelacqua 1999, p357.
Fraction of yr exposed	1.000	8,760 hr/yr
Radon flux (pCi/m2-s)	1.65E+02	using RAECOM model from Wise-Uranium web site
Radon source (pCi/s)	1.13E+06	
Air conc. Site Boundary (pCi/m3)	1.57E+00	

Projected Dose to Resident at Site Boundary (mrem/yr) 7.20E-02

A3b ***Radon gas from byproduct waste with interim cover***

Doses to Resident Site Boundary during operations
Fernald Silo 1 & 2 source term
Reference for radon flux equations - NUREG/CR-3533, April 1984

Equations:

Radon.flux(pCi/m2-s) = Radium.conc(pCi/cm3) x emanation.coef x sqrt(rn.decay(s-1) x diffusion.coef(cm2/s)) x 10,000 cm2/m2
Radon.source(pCi/s) = Radon flux(pCi/m2-s) x area(m2)
Air.conc.wrkr(pCi/m3) = radon.source(pCi/s) / [sqrt(waste.area(m2)) x wind.speed(m/s) x vertical.mixing(m)] (box model)
Air.conc.offsite(pCi/m3) = radon.source(pCi/s) x X/Q(s/m3) (Gaussian plume)
Radon.dose(mrem/yr) = Air.conc(pCi/m3) x 0.001(m3/L) x frac.yr.exposed x dose.fctr(mrem/yr per pCi/L)

Parameters:

Ra-226 activity concentration(pCi/g)	8.47E+04	Maximum bulk waste byproduct source term, Maywood
Area of exposed waste (m2)	6,870	Vol. I, Figure 3.7 worst case interim covered area(100ft) x disposal area width(740ft)
Radon Dose Conv. Factor	46	mrem/yr per pCi/L, outdoor, 10% eq., reference 10 CFR 20
Thickness of waste (m)	21.33	for use in RAECOM model on Wise-Uranium web site.
Average wind speed (m/s)	3.1	WCS weather station, avg 6.04 knots
Distance to receptor (m):	777	Stortest distance from Northern edge of waste area to the site boundary.
Wind frequency annual avg.	0.31	Wind frequency from the predominate wind direction from the South

Calculations:

Sigma-y	88	for a conservatively stable Pasquiill C stability class, Cember 1996, p. 493.
Sigma-z	55.00	for a conservatively stable Pasquiill C stability class, Cember 1996, p. 494
X/Q (s/m3)	3.29E-06	Pasquill-Gifford ground level, plume centerline. Adj for wind freq in N, NNE, NNW dirs, Bevelacqua 1999, p357.
Fraction of yr exposed	1.000	8,760 hr/yr
Radon flux (pCi/m2-s)	3.22E+00	using RAECOM model from Wise-Uranium web site
Radon source (pCi/s)	2.21E+04	
Air conc. Site Boundary (pCi/m3)	3.05E-02	

Projected Dose to Resident at Site Boundary (mrem/yr) 1.40E-03

S3 **External radiation from offsite soil (contaminated by dust deposition)**

Doses to Site Boundary & Nearest Resident during operations
Maywood waste is the source term, natural wind suspension of dust, like Pathway A1

Equations:

Dose(mrem/yr) = Ground.conc(Ci/m2) x frac.yr.exposed x DCF.surf(mrem/yr per Ci/m2)
Ground.conc(Ci/m2) = Air.conc(Ci/m3) x deposition.velocity(m/s) x time(s)
Air.conc = Waste.source(Ci/s) x X/Q(s/m3) (offsite)
Waste.source(Ci/s) = Waste.conc(Ci/m3) x active.depth(m) x resusp.rt(1/s) x waste.area(m2)
X/Q (s/m3) = wind.freq / (pi x wind.spd(m/s) x sigma.y(m) x sigma.z(m))

Parameters:

Bulk waste volume (m3)	894,000	1,169,000 cy
Area of exposed waste (m2)	19,800	1/8 of a cell exposed
Average wind speed (m/s)	3.1	WCS weather station, avg 6.04 knots
Active depth for suspnsn. (m)	0.001	particles > 1 mm not suspended
Resuspension rate (1/s)	5.25E-09	DOE-HDBK-3010-94, Table 4-18, GM of NTS, Hanford, eroding field
Dust deposition velocity (m/s)	0.01	EPA, typical
Inhalation rate (m3/yr)	8,400	RESRAD
Deposition time (s)	3.156E+07	1 year
Unit conversion	1.168E+23	converts Sv-m2/Bq-s to mrem-m2/Ci-yr
Distance to receptor (m):	777	Stortest distance from Northern edge of waste area to the site boundary.
Wind frequency annual avg.	0.13	Wind frequency from the predominate wind direction from the South

Calculations:

Sigma-y	88	for a conservatively stable Pasquiill C stability class, Cember 1996, p. 493.

Sigma-z	55.00	for a conservatively stable Pasquill C stability class, Cember 1996, p. 494
X/Q (s/m3)	1.38E-06	Pasquill-Gifford ground level, plume centerline. Adj for wind freq in N, NNE, NNW dirs, Bevelacqua 1999, p357.
Fraction of yr exposed	1.000	8,760 hr/yr

Waywood Bulk Waste	Bulk Conc	Surface Conc	Site Boundary Air Conc	Site Boundary Grnd Con	FGR #12 DCF-surf.	Site Boundary Dose
Radionuclide	Ci/m3	Ci/m2	Ci/m3	Ci/m2	Sv-m2/Bq-s	mrem/yr
Ra-226	7.89E-04	7.89E-07	1.13E-16	3.57E-11	6.44E-18	2.69E-05
Pb-214	7.89E-04	7.89E-07	1.13E-16	3.57E-11	2.44E-16	1.02E-03
Bi-214	7.89E-04	7.89E-07	1.13E-16	3.57E-11	1.41E-15	5.88E-03
Pb-210	7.89E-04	7.89E-07	1.13E-16	3.57E-11	2.48E-18	1.03E-05
Po-210	7.89E-04	7.89E-07	1.13E-16	3.57E-11	8.29E-21	3.46E-08
Ra-228+D	3.17E-03	3.17E-06	4.55E-16	1.43E-10	0.00E+00	0.00E+00
Ac-228	3.17E-03	3.17E-06	4.55E-16	1.43E-10	9.28E-16	1.56E-02
Th-228	3.17E-03	3.17E-06	4.55E-16	1.43E-10	2.35E-18	3.94E-05
Ra-224	3.17E-03	3.17E-06	4.55E-16	1.43E-10	9.57E-18	1.60E-04
Pb-212	3.17E-03	3.17E-06	4.55E-16	1.43E-10	1.43E-16	2.40E-03
Bi-212	3.17E-03	3.17E-06	4.55E-16	1.43E-10	1.79E-16	3.00E-03
Tl-208	1.14E-03	1.14E-06	1.64E-16	5.17E-11	2.98E-15	1.80E-02
Th-230	5.87E-04	5.87E-07	8.42E-17	2.66E-11	7.50E-19	2.33E-06
Th-232	3.17E-03	3.17E-06	4.55E-16	1.43E-10	5.51E-19	9.23E-06
U-234	5.87E-04	5.87E-07	8.42E-17	2.66E-11	7.48E-19	2.32E-06
U-235	2.70E-05	2.70E-08	3.87E-18	1.22E-12	1.48E-16	2.11E-05
Th-231	2.70E-05	2.70E-08	3.87E-18	1.22E-12	1.85E-17	2.64E-06
U-238	5.87E-04	5.87E-07	8.42E-17	2.66E-11	5.51E-19	1.71E-06
Th-234	5.87E-04	5.87E-07	8.42E-17	2.66E-11	8.32E-18	2.58E-05
Pa-234m	5.87E-04	5.87E-07	8.42E-17	2.66E-11	1.53E-17	4.75E-05
					Projected Dose to Resident at Site Boundary (mrem/yr)	4.62E-02

W2 Surface water transport of ground-deposited dust to a low-lying area
Based on ground deposited dust in Pathway S3

Operational time, Byproduct 30 yr

Projected Dose to Resident at Site Boundary over 30 year buildup time (mrem/yr) 1.39E+00

TOTAL DOSE DUE TO ALL PATHWAYS

	Pathway	Dose Summary (mrem/yr)
Airborne dust from open byproduct waste cell	A1	8.04
Radon gas from uncovered active waste slope	A3a	0.07
Radon gas from byproduct waste with interim cover	A3b	0.00
External radiation from offsite soil (contaminated by dust deposition)	S3	0.05
Surface water transport of ground-deposited dust to a low-lying area	W2	1.39
TOTAL PROJECTED DOSE TO RESIDENT AT SITE BOUNDARY:		9.54

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Uranium Mill Tailings Cover Calculator

(last updated 2 Jul 2004)
Requires Netscape 3.0, Internet Explorer 3.0 or higher. JavaScript must be enabled.
For educational purposes only. No warranty.

Determine the radon flux through a multi-layer soil cover of an uranium mill tailings pile and/or optimize the cover for a given flux.

(For calculating radon flux from bare and/or water covered tailings, see the Uranium Mill Tailings Radon Flux Calculator)

Select activity unit first, then enter the parameters and click the "Calculate" button below. HELP
Layer 1 is the tailings layer.
Numbers can be entered in exponential notation: $5 \cdot 10^{-6} = 5e\text{-}6$

Activity unit: (•) pCi ( ) Bq

Sample Data

Input Data

Layer Data HELP

Layer No.	Thickness [m]	Ra-226 Activity Conc. [pCi/g]	Rn-222 Emanation Fraction	Porosity	Moisture Cont. [dry wt_%]	Fraction Passing #200 Mesh (75 µm) *)	Rn-222 Eff. Diff.Coeff *) [m^2/s]
1	21.33	493	0.3	0.3	12		
2							
3							
4							
5							
6							
7							
8							

Options HELP

0 Entrance Radon flux to Layer 1 [pCi/m^2s] *)

0	Surface Radon conc. at top of system [pCi/L] *)
0	Layer No. to be optimized *)
0	Surface flux constraint for optimization [pCi/m^{2}s] *)
0.01	Surface flux convergence criterion (fraction) *)
48.3	Annual Precipitation [cm] *)
198.12	Annual Lake Evaporation [cm] *)
45.72	Depth to Water Table [m] *)

*) optional

Calculate Reset Form HELP

Results

```
----------------  Input Parameters  ----------------

 Number of Layers:  1
 Radon Flux into Layer 1:  0 pCi/m2s
 Surface Radon Concentration:  0 pCi/L
 Bare Source Flux (Jo) from Layer 1:  165.2 pCi/m2s
 Specific Bare Source Flux from Layer 1:  0.335 pCi/m2s per
pCi_Ra-226/g

Layer Thickness  Ra-226   Emanat  Porosity  Moisture  Diff Coeff
 No.      [m]     [pCi/g]  Fract             [dry wt_%]  [m2/s]
  1     21.33     493      0.3      0.3        12        166.3E-
9


--------  Results of Radon Diffusion Calculation  --------
```

> See also:

- Unit Converter
- Uranium Mill Tailings Radon Flux Calculator
- Uranium Radiation Properties · Uranium Radiation Exposure
- Uranium Decay Calculator
- Radon Individual Dose Calculator
- Uranium in Soil Individual Dose Calculator
- Uranium Mine and Mill Resident Individual Dose Calculator
- Nuclear Fuel Population Health Risk Calculator (collective dose)

Uranium Mill Tailings Cover Calculator

(last updated 2 Jul 2004)
Requires Netscape 3.0, Internet Explorer 3.0 or higher. JavaScript must be enabled.
For educational purposes only. No warranty.

Determine the radon flux through a multi-layer soil cover of an uranium mill tailings pile and/or optimize the cover for a given flux.

(For calculating radon flux from bare and/or water covered tailings, see the Uranium Mill Tailings Radon Flux Calculator)

Select activity unit first, then enter the parameters and click the "Calculate" button below. **HELP**
Layer 1 is the tailings layer.
Numbers can be entered in exponential notation: $5 \cdot 10^{-6} = 5e\text{-}6$

Activity unit: ◉pCi ○Bq

Sample Data

Input Data

Layer Data HELP

Layer No.	Thickness [m]	Ra-226 Activity Conc. [pCi/g]	Rn-222 Emanation Fraction	Porosity	Moisture Cont. [dry wt_%]	Fraction Passing #200 Mesh (75 µm) *)	Rn-222 Eff. Diff.Coeff *) [m^2/s]
1	21.33	165.2	0.3	0.3	12		
2	.61	0	0	0.29	12		
3							
4							
5							
6							
7							
8							

Options HELP

0 Entrance Radon flux to Layer 1 [pCi/m^2s] *)

0	Surface Radon conc. at top of system [pCi/L] *)
0	Layer No. to be optimized *)
0	Surface flux constraint for optimization [pCi/m^{2}s] *)
0.01	Surface flux convergence criterion (fraction) *)
48.3	Annual Precipitation [cm] *)
198.12	Annual Lake Evaporation [cm] *)
45.72	Depth to Water Table [m] *)

*) optional

Calculate Reset Form HELP

Results

```
---------- Input Parameters ----------

 Number of Layers:  2
 Radon Flux into Layer 1:  0 pCi/m2s
 Surface Radon Concentration:  0 pCi/L
 Bare Source Flux (Jo) from Layer 1:  55.36 pCi/m2s
 Specific Bare Source Flux from Layer 1:  0.335 pCi/m2s per
pCi_Ra-226/g

Layer Thickness  Ra-226   Emanat  Porosity  Moisture  Diff Coeff
 No.      [m]    [pCi/g]  Fract             [dry wt_%]  [m2/s]
  1     21.33     165.2    0.3      0.3        12        166.3E-
9
  2     0.61      0        0        0.29       12        108.9E-
9
```

> See also:

- Unit Converter
- Uranium Mill Tailings Radon Flux Calculator
- Uranium Radiation Properties · Uranium Radiation Exposure
- Uranium Decay Calculator
- Radon Individual Dose Calculator
- Uranium in Soil Individual Dose Calculator
- Uranium Mine and Mill Resident Individual Dose Calculator
- Nuclear Fuel Population Health Risk Calculator (collective dose)

APPENDIX G

TCEQ VERIFICATION CALCULATION

ESTIMATING THE DOSE TO A WORKER DURING THE OPERATING PERIOD FROM RADON WHILE PLACING AND COMPACTING BY-PRODUCT WASTE

TCEQ verification calculations for estimating dose to a resident living at the site boundary in the predominant down wind direction from the site.

A1 Airborne dust from open byproduct waste cell

Maywood waste byproduct source term with natural dust suspension from waste cell

Equations:

Dose(mrem/yr) = Air.conc(Ci/m3) x breathing.rt(m3/yr) x frac.yr.exposed x DCF.inh(mrem/Ci) x resuspension factor(m-1) x waste.conc(Ci/m3) x active depth(m)

Air.conc = Waste.source(Ci/s) x X/Q(s/m3) (offsite)

Waste.source(Ci/s) = Waste.conc(Ci/m3) x active.depth(m) x resusp.rt(1/s) x waste.area(m2)

X/Q (s/m3) = wind.freq / (2 x pi x wind.spd(m/s) x sigma.y(m) x sigma.z(m))

Parameters:

Byproduct waste volume (m3)	894,000	1,169,000 cy
Area of exposed waste (m2)	19,800	Vol. I, Figure 3.7 worst case active waste slope(288ft) x disposal area width(740ft)
Average wind speed (m/s)	3.1	WCS weather station, avg 6.04 knots
Active depth for suspnsn. (m)	0.001	particles > 1 mm not suspended
Resuspension rate (1/s)	6.30E-09	10 times the DOE-HDBK-3010-94, Table 4-18, GM of NTS, Hanford, eroding field
Inhalation rate (m3/yr)	8,400	RESRAD default
Distance to site boundary receptor (m):	777	Stortest distance from Northern edge of waste area to the site boundary.
Wind frequency annual avg,	0.322	Combined S, SSW, and SSE directions which may all contribute to the dose at the resident location
Sigma-y	120	Pasquill B stability class, Cember 1996, p. 493.
Sigma-z	103.00	Pasquill B stability class, Cember 1996, p. 494
X/Q (s/m3)	1.34E-06	Pasquill-Gifford ground level, plume centerline. Adj for wind freq in N, NNE, NNW dirs, Bevelacqua 1999, p357.
Fraction of yr exposed	1.000	8,760 hr/yr

Maywood Bulk Waste Nuclide	Waste Conc Ci/m3	Surface Conc Ci/m2	Site Boundary Air Conc Ci/m3	FGR #11 DCF-inh. Sv/Bq	FGR #11 DCF-inh. mrem/Ci	Site Boundary Dose mrem/yr
Pa-231		0.00E+00	0.00E+00	3.47E-04	1.28E+12	0.00E+00
Ac-227		0.00E+00	0.00E+00	1.81E-03	6.70E+12	0.00E+00
Ra-226+D	7.89E-04	7.89E-07	1.32E-16	2.32E-06	8.58E+09	9.50E-03
Pb-214	7.89E-04	7.89E-07	1.32E-16	2.11E-09	7.81E+06	8.64E-06
Bi-214	7.89E-04	7.89E-07	1.32E-16	1.78E-09	6.59E+06	7.29E-06
Pb-210	7.89E-04	7.89E-07	1.32E-16	3.67E-06	1.36E+10	1.50E-02
Po-210	7.89E-04	7.89E-07	1.32E-16	2.54E-06	9.40E+09	1.04E-02
Ra-228+D	3.17E-03	3.17E-06	5.29E-16	1.29E-06	4.77E+09	2.12E-02
Ac-228	3.17E-03	3.17E-06	5.29E-16	8.33E-08	3.08E+08	1.37E-03
Th-228	3.17E-03	3.17E-06	5.29E-16	9.23E-05	3.42E+11	1.52E+00
Ra-224	3.17E-03	3.17E-06	5.29E-16	8.53E-07	3.16E+09	1.40E-02
Pb-212	3.17E-03	3.17E-06	5.29E-16	4.56E-08	1.69E+08	7.50E-04
Bi-212	3.17E-03	3.17E-06	5.29E-16	5.83E-09	2.16E+07	9.59E-05
Tl-208	1.14E-03	1.14E-06	1.90E-16	0.00E+00	0.00E+00	0.00E+00
Th-230	5.87E-04	5.87E-07	9.80E-17	8.80E-05	3.26E+11	2.68E-01
Th-232	3.17E-03	3.17E-06	5.29E-16	4.43E-04	1.64E+12	7.29E+00
U-234	5.87E-04	5.87E-07	9.80E-17	3.58E-05	1.32E+11	1.09E-01
U-235+D	2.70E-05	2.70E-08	4.51E-18	3.32E-05	1.23E+11	4.65E-03
Th-231	2.70E-05	2.70E-08	4.51E-18	2.37E-10	8.77E+05	3.32E-08
U-238+D	5.87E-04	5.87E-07	9.80E-17	3.20E-05	1.18E+11	9.75E-02
Th-234	5.87E-04	5.87E-07	9.80E-17	9.47E-09	3.50E+07	2.88E-05
Pa-234m	5.87E-04	5.87E-07	9.80E-17	0.00E+00	0.00E+00	0.00E+00
				Projected Dose to Resident at Site Boundary (mrem/yr)		9.36E+00

A3 Radon gas from byproduct without interim cover

Doses to Resident Site Boundary during operations

Fernald Silo 1 & 2 source term

Reference for radon flux equations - NUREG/CR-3533, April 1984

Equations:

Radon.flux(pCi/m2-s) = Radium.conc(pCi/cm3) x emanation.coef x sqrt(m.decay(s-1) x diffusion.coef(cm2/s)) x 10,000 cm2/m2

Radon.source(pCi/s) = Radon flux(pCi/m2-s) x area(m2)

Air.conc.wrkr(pCi/m3) = radon.source(pCi/s) / [sqrt(waste.area(m2)) x wind.speed(m/s) x vertical.mixing(m)] (box model)

Air.conc.offsite(pCi/m3) = radon.source(pCi/s) x X/Q(s/m3) (Gaussian plume)

Radon.dose(mrem/yr) = Air.conc(pCi/m3) x 0.001(m3/L) x frac.yr.exposed x dose.fctr(mrem/yr per pCi/L)

Parameters:

Ra-226 activity concentration(pCi/g)	8.47E+04	Maximum bulk waste byproduct source term, Maywood
Area of exposed waste (m2)	6,870	Vol. I, Figure 3.7 worst case interim covered area(100ft) x disposal area width(740ft)
Radon Dose Conv. Factor	46	mrem/yr per pCi/L, outdoor, 10% eq., reference 10 CFR 20
Thickness of waste (m)	21.33	for use in RAECOM model on Wise-Uranium web site.
Average wind speed (m/s)	3.1	WCS weather station, avg 6.04 knots

Distance to receptor (m):	777	Stortest distance from Northern edge of waste area to the site boundary.
Wind frequency annual avg.	0.322	Combined S, SSW, and SSE directions which may all contribute to the dose at the resident location

Calculations:

Sigma-y	120	Pasquill B stability class, Cember 1996, p. 493.
Sigma-z	103.00	Pasquill B stability class, Cember 1996, p. 494
X/Q (s/m3)	1.34E-06	Pasquill-Gifford ground level, plume centerline. Adj for wind freq in N, NNE, NNW dirs, Bevelacqua 1999, p357.
Fraction of yr exposed	1.000	8,760 hr/yr
Radon flux (pCi/m2-s)	2.84E+04	using RAECOM model from Wise-Uranium web site
Radon source (pCi/s)	1.95E+08	
Air conc. Site Boundary (pCi/m3)	2.61E+02	

Projected Dose to Resident at Site Boundary (mrem/yr) 1.20E+01

A3b Radon gas from byproduct waste with interim cover

Doses to Resident Site Boundary during operations
Fernald Silo 1 & 2 source term
Reference for radon flux equations - NUREG/CR-3533, April 1984

Equations:

Radon.flux(pCi/m2-s) = Radium.conc(pCi/cm3) x emanation.coef x sqrt(rn.decay(s-1) x diffusion.coef(cm2/s)) x 10,000 cm2/m2
Radon.source(pCi/s) = Radon flux(pCi/m2-s) x area(m2)
Air.conc.wrkr(pCi/m3) = radon.source(pCi/s) / [sqrt(waste.area(m2)) x wind.speed(m/s) x vertical.mixing(m)] (box model)
Air.conc.offsite(pCi/m3) = radon.source(pCi/s) x X/Q(s/m3) (Gaussian plume)
Radon.dose(mrem/yr) = Air.conc(pCi/m3) x 0.001(m3/L) x frac.yr.exposed x dose.fctr(mrem/yr per pCi/L)

Parameters:

Ra-226 activity concentration(pCi/g)	8.47E+04	Maximum bulk waste byproduct source term, Maywood
Area of exposed waste (m2)	6,870	1/4 of a cell exposed
Radon Dose Conv. Factor	46	mrem/yr per pCi/L, outdoor, 10% eq., reference 10 CFR 20
Thickness of waste (m)	21.33	for use in RAECOM model on Wise-Uranium web site.
Average wind speed (m/s)	3.1	WCS weather station, avg 6.04 knots
Distance to receptor (m):	777	Stortest distance from Northern edge of waste area to the site boundary.
Wind frequency annual avg.	0.31	Combined S, SSW, and SSE directions which may all contribute to the dose at the resident location

Calculations:

Sigma-y	120	Pasquill B stability class, Cember 1996, p. 493.
Sigma-z	103.00	Pasquill B stability class, Cember 1996, p. 494
X/Q (s/m3)	1.29E-06	Pasquill-Gifford ground level, plume centerline. Adj for wind freq in N, NNE, NNW dirs, Bevelacqua 1999, p357.
Fraction of yr exposed	1.000	8,760 hr/yr
Radon flux (pCi/m2-s)	1.65E+03	using RAECOM model from Wise-Uranium web site
Radon source (pCi/s)	1.13E+07	
Air conc. Site Boundary (pCi/m3)	1.52E+01	

Projected Dose to Resident at Site Boundary (mrem/yr) 6.98E-01

S3 External radiation from offsite soil (contaminated by dust deposition)

Doses to Site Boundary & Nearest Resident during operations
Maywood waste is the source term, natural wind suspension of dust, like Pathway A1

Equations:

Dose(mrem/yr) = Ground.conc(Ci/m2) x frac.yr.exposed x DCF.surf(mrem/yr per Ci/m2)
Ground.conc(Ci/m2) = Air.conc(Ci/m3) x deposition.velocity(m/s) x time(s)
Air.conc = Waste.source(Ci/s) x X/Q(s/m3) (offsite)
Waste.source(Ci/s) = Waste.conc(Ci/m3) x active.depth(m) x resusp.rt(1/s) x waste.area(m2)
X/Q (s/m3) = wind.freq / (pi x wind.spd(m/s) x sigma.y(m) x sigma.z(m))

Parameters:

Bulk waste volume (m3)	894,000	1,169,000 cy
Area of exposed waste (m2)	19,800	1/8 of a cell exposed
Average wind speed (m/s)	3.1	WCS weather station, avg 6.04 knots
Active depth for suspnsn. (m)	0.001	particles > 1 mm not suspended
Resuspension rate (1/s)	6.30E-09	DOE-HDBK-3010-94, Table 4-18, GM of NTS, Hanford, eroding field
Dust deposition velocity (m/s)	0.01	EPA, typical
Inhalation rate (m3/yr)	8,400	RESRAD
Deposition time (s)	3.156E+07	1 year
Unit conversion	1.168E+23	converts Sv-m2/Bq-s to mrem-m2/Ci-yr
Distance to receptor (m):	777	
Wind frequency annual avg.	0.322	

Calculations:

Sigma-y	120	Pasquill B stability class, Cember 1996, p. 493.
Sigma-z	103.00	Pasquill B stability class, Cember 1996, p. 494

X/Q (s/m3) 1.34E-06 Pasquill-Gifford ground level, plume centerline. Adj for wind freq in N, NNE, NNW dirs, Bevelacqua 1999, p357.
Fraction of yr exposed 1.000 8,760 hr/yr

Waywood Bulk Waste Radionuclide	Bulk Conc Ci/m3	Surface Conc Ci/m2	Site Boundary Air Conc Ci/m3	Site Boundary Grnd Con Ci/m2	FGR #12 DCF-surf. Sv-m2/Bq-s	Site Boundary Dose mrem/yr
Ra-226	7.89E-04	7.89E-07	1.32E-16	4.16E-11	6.44E-18	3.13E-05
Pb-214	7.89E-04	7.89E-07	1.32E-16	4.16E-11	2.44E-16	1.18E-03
Bi-214	7.89E-04	7.89E-07	1.32E-16	4.16E-11	1.41E-15	6.85E-03
Pb-210	7.89E-04	7.89E-07	1.32E-16	4.16E-11	2.48E-18	1.20E-05
Po-210	7.89E-04	7.89E-07	1.32E-16	4.16E-11	8.29E-21	4.02E-08
Ra-228+D	3.17E-03	3.17E-06	5.29E-16	1.67E-10	0.00E+00	0.00E+00
Ac-228	3.17E-03	3.17E-06	5.29E-16	1.67E-10	9.28E-16	1.81E-02
Th-228	3.17E-03	3.17E-06	5.29E-16	1.67E-10	2.35E-18	4.58E-05
Ra-224	3.17E-03	3.17E-06	5.29E-16	1.67E-10	9.57E-18	1.87E-04
Pb-212	3.17E-03	3.17E-06	5.29E-16	1.67E-10	1.43E-16	2.79E-03
Bi-212	3.17E-03	3.17E-06	5.29E-16	1.67E-10	1.79E-16	3.49E-03
Tl-208	1.14E-03	1.14E-06	1.90E-16	6.01E-11	2.98E-15	2.09E-02
Th-230	5.87E-04	5.87E-07	9.80E-17	3.09E-11	7.50E-19	2.71E-06
Th-232	3.17E-03	3.17E-06	5.29E-16	1.67E-10	5.51E-19	1.07E-05
U-234	5.87E-04	5.87E-07	9.80E-17	3.09E-11	7.48E-19	2.70E-06
U-235	2.70E-05	2.70E-08	4.51E-18	1.42E-12	1.48E-16	2.46E-05
Th-231	2.70E-05	2.70E-08	4.51E-18	1.42E-12	1.85E-17	3.07E-06
U-238	5.87E-04	5.87E-07	9.80E-17	3.09E-11	5.51E-19	1.99E-06
Th-234	5.87E-04	5.87E-07	9.80E-17	3.09E-11	8.32E-18	3.01E-05
Pa-234m	5.87E-04	5.87E-07	9.80E-17	3.09E-11	1.53E-17	5.53E-05
					Projected Dose to Resident at Site Boundary (mrem/yr)	5.37E-02

W2 Surface water transport of ground-deposited dust to a low-lying area
Based on ground deposited dust in Pathway S3

Operational time, Byproduct 30 yr

Projected Dose to Resident at Site Boundary over 30 year buildup time (mrem/yr) 1.61E+00

TOTAL DOSE DUE TO ALL PATHWAYS

	Pathway	Dose Summary (mrem/yr)
Airborne dust from open byproduct waste cell	A1	9.36
Radon gas from uncovered active waste slope	A3a	12.00
Radon gas from byproduct waste with interim cover	A3b	0.70
External radiation from offsite soil (contaminated by dust deposition)	S3	0.05
Surface water transport of ground-deposited dust to a low-lying area	W2	1.61

TOTAL PROJECTED DOSE TO RESIDENT AT SITE BOUNDARY: 23.72

ERRATA

Draft Environmental Analysis: License Application Review for By-Product Waste Disposal from Waste Control Specialists LLC in Andrews County, Texas, License No. R 05807, October 2007

EA-1. Facility capacity is 1,169,000 cubic yards. Agency calculations indicate that the possession limit should be 24,530 curies, no change. Phrase "...radionuclides with half-lives greater than 30 days..." is not added to the EA. The phrase is used in Draft License Condition 67 and does not need to be repeated in the Draft EA. (4th paragraph of the Summary section of EA)

EA-2. The following should be substituted in Section 1 of the Introduction, first paragraph, last sentence. Application Dated: January 12, 2007. Letters dated: February 27, 2007, with Attachments A and B; May 4, 2007, including revisions to the application and a Procedures Manual dated May 2007; and June 4, 2007, with revisions to the application.

EA-15 Section 4.5.3.2.3 of the EA, first paragraph, fourth bullet, remove the second sentence, that is, "The Canberra web site does not list an SOLO 300G as a model number for a product." And, change the following sentence to read "There are several types or series of PIPS detectors."

EA-18 Section 4.5.6 of the EA, third paragraph, change "BP-HS-1.24.1" to "BP-HS-2.24.1"

EA-37. Section 7.2.4.3 of the EA, third paragraph, last 2 lines, delete: "However, transportation effects will be considered in greater depth in the engineering sections of the Technical Report. Pending those findings, an environmental justice statement can be finalized by the staff." and substitute "Transportation effects will be considered in greater depth in the engineering sections of the EA, but no environmental justice statement is required or being developed."

EA-38. The following should be added to section 7.3.2 Historic Resources, 2nd paragraph: Communications were received from both Historical Commissions stating that no historic properties will be affected by this project. Letters containing that information are found in Appendix H of Appendix 11A, Socioeconomic Report, of the License Application, Volume 6.

EA-39. Numbering for the following sections in the EA should be changed from X to Y:

HISTORIC, ARCHITECTURAL AND SCENIC RESOURCES should be changed from 7.4 to 7.3

Architectural Resources should be changed from 7.3.2 to 7.3.3
Scenic Resources should be changed from 7.3.2 to 7.3.4
Conclusion should be changed from 7.3.2 to 7.3.5
References should be changed from 7.3.2 to 7.3.6

EA-40. Section 7.4.1 of the EA, second paragraph, second line to the end, delete: "For the transportation corridors through which wastes might travel to the complex from potential clients, demographic characteristics will be quite different from the Region and highly variable between specific corridors, and it is assumed that impacts will be distributed rather evenly; however, a full analysis of transportation will be done by civil engineers and reported in a separate Technical Report. Presumably, cumulative effects on government services and infrastructure will be offset by tax revenues from the WCS complex growth and development." and substitute "For the transportation corridors through which wastes might travel to the complex from potential clients, demographic characteristics will be quite different from the Region and highly variable between specific corridors, and it is assumed that impacts will be distributed rather evenly. However, transportation issues will be reviewed in engineering sections of the EA. Cumulative effects on government services and infrastructure will be offset by tax revenues from the WCS complex growth and development

Staff. Section 4.5.3.2.1 of the Environmental Analysis, last sentence, change "date" to "data."