CHAPTER 2
SITE CHARACTERISTICS

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2. SITE CHARACTERISTICS

Waste Control Specialists LLC (WCS) controls approximately 14,000 acres of land in northwestern Andrews County. Within this property, WCS currently operates a commercial waste management facility on approximately 1,338 acres of land (the existing facility) and the remaining acreage is mostly undeveloped land. The WCS CISF will be located north and adjacent to the existing facility approximately 300 meters from the north edge of the rail loop as seen in Figure 2-1. The approximate coordinates for Phase I of the WCS CISF site are Latitude 32^{o} 27' 08" north longitude 103^{o} 03' 35" west longitude. The existing maximum and minimum elevations of the site are about 3520 feet and 3482 feet mean sea level (msl), respectively. Eunice, the closest population center, is located approximately 8 kilometers (5 miles) west at the cross-junction of New Mexico Highway 207 and 234. The WCS CISF is about 51 kilometers (32 miles) northwest of Andrews, Texas, and approximately 32 kilometers (20 miles) south of Hobbs, New Mexico. The nearest population center with an international airport is Midland-Odessa, located 103 kilometers (64 miles) southeast of the proposed WCS CISF.

More generally, the WCS CISF site is located at the southwestern edge of the Southern High Plains. This part of Andrews County is a gently southeastward sloping plain with a natural slope of about 8 to 10 feet per mile. A topographic map of the area is shown in Figure 2-2.

The WCS site has two approved Resource Conservation and Recovery Act (RCRA) permits from the TCEQ (HW-50398[2-33] and HW-50397[2-32]) and a Toxic Substances Control Act (TSCA) authorization from the United States Environmental Protection Agency (EPA). WCS also possesses radioactive material license (RML) R04100[2-30] and R05807[2-31] for low-level radioactive wastes (LLRW) and byproduct material, respectively.

2.1 Geography and Demography of Site Selected

The WCS CISF is situated in northwest Andrews County on the southwestern edge of the Southern High Plains. The entire WCS site is approximately 14,000 acres with all acreage being owned by WCS. The nearest population center of 25,000 or more is Hobbs, NM about 17.5 miles northwest of the WCS CISF.

Land uses within a few miles of the WCS CISF include agriculture, cattle ranching, drilling for and production from oil and gas wells, quarrying operations, uranium enrichment, municipal waste disposal, and the surface recovery and land farming of oil field wastes. Surface quarrying of caliche, sand and gravel is conducted in New Mexico, approximately one mile west of the WCS CISF. The oil field waste recovery facility is adjacent to this quarry. The Lea County, New Mexico municipal solid waste landfill is located adjacent to the state line to the immediate south and west of the WCS CISF. Uranium Enrichment Company (URENCO) operates a centrifuge technology, uranium enrichment facility about one mile to the southwest of the HW-50397 RCRA landfill location.

There are three counties (Andrews County, TX, Gaines County, TX and Lea County, NM) within a 15-mile radius of the WCS CISF. Andrews is the largest city within Andrews County. Andrews has a small population with no significant growth forecasted and is outside the 15-mile radius. Hobbs is the largest city in Lea County and is experiencing recent population growth rates on the order of 2% for 2013 to 2014; however, no significant growth is expected and Hobbs is outside the 15-mile radius. The 15-mile radius area around the WCS CISF is very low population with some industry and mostly ranch land and very little seasonal variation in the population. In the Environmental Report, Attachment A, the Socioeconomic Impact Assessment includes the most recent Census data and Figure 1.1-1 in Attachment A shows cities and towns with a 30 mile radius of the WCS CISF.

Except for a historical marker and picnic area approximately 5.5 km (3.3 mi) from the WCS CISF at the intersection of New Mexico Highways 234 and 18, there are no known public recreation areas or state or federal parks within 8 km (5 mi) of the WCS CISF.

The following nonindustrial water resources are located in the proposed WCS CISF vicinity:

- A manmade pond on the adjacent quarry property owned by Permian Basin Materials (Permian, 2016[2-28]).
- Baker Spring, an intermittent surface-water feature situated about 1.6 kilometers (1 mile) northeast of the WCS CISF that contains water seasonally.
- Several cattle-watering holes where groundwater is pumped by windmill and stored in aboveground tanks.

- Monument Draw, a natural shallow drainageway situated several kilometers southwest of the WCS CISF. Local residents indicated that Monument Draw only contains water for a short period of time following a significant rainstorm (LES, 2005[2-19]).

The nearest residential areas are due west of the WCS CISF in the city of Eunice, New Mexico, which is approximately 8 km (5 mi) away. The closest residence from the center of the WCS CISF is approximately 6 km (3.8 mi) away on the east side of Eunice, New Mexico.

2.2 Nearby Industrial, Transportation and Military Facilities

The only industrial facilities located within one mile of the WCS CISF boundary are URENCO USA, Permian Basin Materials and Sundance Services, Inc. (Figure 2-3). URENCO USA is a uranium enrichment facility that uses centrifuge technology to provide uranium enrichment services. WCS also operates several permitted and licensed facilities immediately south of the WCS CISF, including a RCRA landfill, a low-level radioactive waste facility and a byproduct materials landfill.

Permian Basin Materials operates a quarry and crushing operation, wherein caliche, sand and gravel are mined, crushed and screened for commercial sales and used in making concrete (Permian, 2016[2-28]). Sundance Services, Inc. provides oilfield waste disposal services. Sundance Services is authorized by the New Mexico Energy, Minerals and Natural Resources Department to operate the waste oil treating plant, and also manages produced water, solids and drilling muds. Sundance Services is also authorized to landfarm solids (Sundance, 2016[2-29]).

The Lea County (New Mexico) Municipal Landfill is located to the southwest and across New Mexico Highway 234 from WCS CISF. The Lea County Landfill is within 1 mile of the WCS CISF; however, it is over a mile from the location of the WCS CISF. This landfill disposes of municipal solid waste for the Lea County Solid Waste Authority under New Mexico Environmental Department Permit Number SW-98-08(P). The landfill services Lea County and its municipalities. The Lea County Municipal Landfill does not generate or receive hazardous waste (Lea, 2016[2-16]).

DD Landfarm, a non-hazardous oilfield waste disposal facility that closed in August 2013 and is undergoing decommissioning and post-closure monitoring, is located approximately 4 km (2.5 miles) west of the proposed WCS CISF.

The closest transportation facility is the Lea County Airport, which is approximately 18 miles from the WCS CISF.

There are no transportation or military facilities within a mile of the WCS CISF. Cannon Air Force Base is the closest at a distance of approximately 135 miles.

The existing WCS railroad is generally aligned parallel with and south of the proposed WCS CISF boundary.

Texas State Highway 176 is a two-lane highway with 3.6 m (12 foot) wide driving lanes, 2.4 m (8 foot) wide shoulders and a 61m (200 foot) wide right-of-way easement on each side. Access to the site is directly off of Texas State Highway 176.

2.3 Meteorology

2.3.1 Regional Climatology

The Weather Forecast Office at Midland, Texas covers the High Plains where the proposed WCS CISF is located. The climate of the WCS CISF in Andrews County, TX can best be described as "semi-arid continental" marked with four seasons. Summers are typically hot, dry weather with the relative humidity being generally low. July is the hottest month with high temperatures occasionally reaching above 100 degrees Fahrenheit. January is the coldest month, although the winters are not generally severe. Temperatures occasionally dip below 32 degrees Fahrenheit.

Precipitation levels are generally very low in this arid climate. The precipitation tends to be heavier in the summer and fall.

During the winter, the regional weather is often dominated by a high-pressure system in the central part of the western United States and a low-pressure system in north-central Mexico. The region is affected by a low-pressure system located over Arizona in the summer.

2.3.2 Local Meteorology

The Weather Forecast Office at Midland-Odessa, Texas covers the High Plains where the proposed WCS CISF is located. In addition to the weather forecast office in Midland, climatological data for atmospheric variables such as temperature, pressure, winds, and precipitation are also collected at stations in Jal, New Mexico; Hobbs, New Mexico; and Andrews, Texas. Table 2-1 indicates the distances and directions of these stations from the WCS CISF and the length of record for the reported data.

The Midland-Odessa monitoring station is the closest first-order National Weather Service station to the WCS CISF. First-order weather stations record a complete range of meteorological parameters for 24-hour periods, and they are usually fully instrumental and I operated by the National Weather Service (http://www.ncdc.noaa.gov/homr/).

2.3.2.1 Maximum and Minimum Temperatures

The Western Regional Climate Center (www.wrcc.dri.edu) has historic temperature data for Andrews, TX. The temperature data currently available spans from 1962 until 2010. The average maximum and minimum temperatures, the record high temperature and low temperature for each month, and the annual high and low temperature for these years is shown on Table 2-2. In Andrews, TX the average annual maximum temperature is 77.5 degrees Fahrenheit and the average annual minimum temperature is 49.6 degrees Fahrenheit.

The normal temperature range for the WCS CISF is 44.1 degrees Fahrenheit to 81.5 degrees Fahrenheit (mean monthly temperature). The off-normal maximum and minimum temperature is 30.1 degrees Fahrenheit and 94.6 degrees Fahrenheit (mean daily temperature). The extreme temperature minimum is -1 degree Fahrenheit and the maximum is 113 degrees Fahrenheit (Table 2-2).

2.3.2.2 Extreme Winds

Regionally wind speeds are usually more moderate, although relatively strong winds often accompany occasional frontal activity during late winter and spring months and sometimes occur just in advance of thunderstorms. Frontal winds may exceed 13 meters per second (30 miles per hour) for several hours and reach peak speeds of more than 22 meters per second (50 miles per hour).

Wind speed and direction data measured at the on-site WCS meteorological stations from 2010 to 2015 is shown on wind rose diagrams in Figure 2-4, Figure 2-5, Figure 2-6, Figure 2-7, and Figure 2-8. The data used to create the wind rose diagrams is located on compact discs in Attachment A. The wind roses show the percent of the time (rings) that the wind blows from each of the 16 directions (N, NNE, NE, … NNW) by the length of the bars. The shading of the bars also indicates the frequency of occurrence of wind speeds within the wind speed classes shown on the figures. The on-site data indicates that for this period from 2010 to 2015 the average wind speed ranged from 6.07 knots to 10.53 knots. The wind direction is predominantly from the south. The diagrams indicate that wind gusts in excess of 22 mph generally blow from the southwest or northeast.

2.3.2.3 Tornado and Sever Weather Conditions

Two F2 Class (wind speed from 113 to 157 mph) tornadoes have been recorded in Andrews County, TX from 1950 through 2015 according to data reported by NOAA. NOAA reports there were eight F1 Class (wind speed 73 to 112 mph) tornadoes recorded in Andrews County since 1950. No F4 or F5 tornados have ever been reported in the vicinity of the WCS CISF.

Tornados are classified using the F-scale with classifications ranging from F0-F5 as follows:

- F0-classified tornados have winds of 64 to 116 kilometers per hour (40 to 72 miles per hour)
- F1-classified tornados have winds of 117 to 181 kilometers per hour (73 to 112 miles per hour)
- F2-classified tornados have winds of 182 to 253 kilometers per hour (113 to 157 miles per hour)
- F3-classified tornados have winds of 254 to 332 kilometers per hour (158 to 206 miles per hour)

- F4-classified tornados have winds of 333 to 419 kilometers per hour (207 to 260 miles per hour)
- F5-classified tornados have winds of 420 to 512 kilometers per hour (261 to 318 miles per hour)

The WCS CISF is located about 805 kilometers (500 miles) from the coast. Because hurricanes lose their intensity quickly once they pass over land, a hurricane would most likely lose its intensity before reaching WCS and dissipate into a tropical depression.

Blowing sand or dust may occur occasionally in the area due to the combination of strong winds, sparse vegetation, and the semi-arid climate. High winds associated with thunderstorms are frequently a source of localized blowing dust. Most episodes of dust prevail for only six hours or less, when visibility is restricted to less than 0.5 mile. Statistical information is lacking on seasonal distribution intensity and duration of dust storms for the region. Recent data in Lubbock, Texas (110 miles northeast of the WCS CISF) indicates blowing dust an average of 12 times in the spring and 9 times during the remainder of the year (Bomar, 1995[2-4]).

2.3.2.4 Precipitation Exposure

The Western Regional Climate Center (www.wrcc.dri.edu) has historic precipitation data for Andrews, TX starting in 1914. The maximum observed 24-hour rainfall (from 1914 until 2012) amount at Andrews, TX is 7.6 inches in February 1914. Historic precipitation and snow data for Andrews, TX from 1914 to 2006 can be found in Table 2-3 and Table 2-4.

Rainfall records from the four (4) on-site meteorological stations on-site are included on compact discs in Attachment A.

Summer rains fall almost entirely during brief, but frequently intense thunderstorms. The general southeasterly circulation from the Gulf of Mexico brings moisture from these storms into the State of New Mexico, and strong surface heating combined with orographic lifting as the air moves over higher terrain causes air currents and condensation. Orographic lifting occurs when air is intercepted by a mountain and is forcefully raised up over the mountains, cooling as it rises. If the air cools to its saturation point, the water vapor condenses and a cloud forms.

As these storms move inland, much of the moisture is precipitated over the coastal and inland mountain ranges of California, Nevada, Arizona, and Utah. Much of the remaining moisture falls on the western slope of the Continental Divide and over northern and high-central mountain ranges. Winter is the driest season in New Mexico except for the portion west of the Continental Divide. This dryness is most noticeable in the Central Valley and on eastern slopes of the mountains. In New Mexico, much of the winter precipitation falls as snow in the mountain areas, but it may occur as either rain or snow in the valleys.

Snow loads for the WCS CISF are based on ASCE Design Criteria 7-10 (2010[2-40]) and are 10 pounds per square foot.

Data from the Midland-Odessa Weather Station indicate the relative humidity throughout the year ranges from 51.5 to 65 percent, with the highest humidity occurring during the early morning hours.

2.3.2.5 Thunderstorms and Lightning Strikes

The mean number of annual thunderstorm days for Hobbs, NM and Midland, TX is 25.5 and 36.4, respectively. No records are maintained for the frequency of thunderstorms and lightning at the proposed WCS CISF; however, the actual number of events can be expected to be similar to these regional data. For Andrews County, there are no reported lightning events from 1950 to 2016 that have caused deaths, injury, property damage or crop damage (http://www.ncdc.noaa.gov/stormevents/, accessed 2016).

2.3.2.6 Mixing Heights

Mixing height is defined as the height above the earth's surface through which relatively strong vertical mixing of the atmosphere occurs. G.C. Holzworth developed mean annual morning and afternoon mixing heights for the contiguous United States (Holzworth, 1972[2-14]). According to Holzworth's calculations, the mean annual morning and afternoon mixing heights at the WCS CISF are approximately 436 meters (1,430 feet) and 2,089 meters (6,854 feet), respectively. Table 2-5 shows the average morning and afternoon mixing heights for Midland-Odessa, Texas.

2.3.2.7 Air Quality

To assess air quality, the EPA has established maximum concentrations for pollutants that are referred to as the National Ambient Air Quality Standards (http://www3.epa.gov/ttn/naaqs/criteria). Table 2-6 presents a list of the NAAQS Air Quality Standards. Six criteria pollutants are used as indicators of air quality: ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, particulate matter, and lead (EPA, 2016[2-35]). Both Lea and Andrews Counties are in attainment for all of the EPA criteria pollutants [2-35].

2.3.3 On-Site Meteorological Measurement Program

Meteorological data have been collected on the WCS property from four (4) meteorological towers stations shown in Figure 2-4 and listed below:

- WCS stations on-site include Tower 1, which has been collecting data since March 2009, and it measures temperature, wind direction, wind speed, relative humidity at 2 and 10 meters, barometric pressure, solar radiation, and rain at 2 meters only. Data averages, unless otherwise noted, are based on available historic records from 2009-2015. WCS has sensors at both the 2-meter (lower) and 10-meter (upper) height intervals.

- The ER Tower has been collecting data since July 2009 and it measures temperature, wind direction, wind speed, relative humidity at 2 and 10 meters, barometric pressure, solar radiation, and rain at 2 meters only. Data averages, unless otherwise noted, are based on available historic records from 2009-2015. WCS has sensors at both the 2-meter (lower) and 10-meter (upper) height intervals.
- The WeatherHawk West Tower has been collecting data since March 2009 and it measures temperature, wind direction, wind speed, relative humidity, barometric pressure, solar radiation, and rain at roughly 10 feet. Data averages, unless otherwise noted, are based on available historic records from 2009-2015.
- The WeatherHawk East Tower has been collecting data since March 2009 and it measures temperature, wind direction, wind speed, relative humidity, barometric pressure, solar radiation, and rain at roughly 10 feet. Data averages, unless otherwise noted, are based on available historic records from 2009-2015.

2.3.4 Diffusion Estimates

For normal and off-normal conditions, an atmospheric dispersion coefficient is calculated using D-stability and a wind speed of 5 m/sec and a 100 m distance to the controlled area boundary. The controlled area boundary is farther than 100 m from the WCS CISF so use of 100 m is conservative. For accident conditions, a dispersion coefficient is calculated using F-stability and a wind speed of 1 m/sec. These atmospheric conditions are consistent with the guidance of NUREG-1536 [2-33] and NUREG-1567 [2-33]. The smallest vertical plane cross-sectional area of one Horizontal Storage Module (HSM) is conservatively used as the vertical plane cross-sectional area of the building: area = HSM Width * HSM Height = 9’8” x 15’ = 20,880 in^2 = 13.47 m^2.

The atmospheric dispersion coefficients can be determined through selective use of Equations 1, 2, and 3 of Regulatory Guide 1.145 [2-33] for ground-level relative concentrations at the plume centerline. For D-stability, 5 m/sec wind speed and a distance of 100 m, the horizontal dispersion coefficient, σ_y, is 8 m per Figure 1 of [2-33]. The vertical dispersion coefficient, σ_z, is 4.6 m per Figure 2 of [2-33]. The correction factor at these conditions is determined to be 1.122 per Figure 3 of [2-33].

For F-stability, 1 m/sec wind speed and a distance of 100 m, the horizontal dispersion coefficient, σ_y, is 4 m per Figure 1 of [2-33]. The vertical dispersion coefficient, σ_z, is 2.3 m per Figure 2 of [2-33]. The correction factor at these conditions is 4 per Figure 3 of [2-33].

With the three values of χ/Q determined, the higher χ/Q value of the first two (Equation 1 and Equation 2) is compared with the last one (Equation 3) and the lower of those two is evaluated as the appropriate atmospheric dispersion coefficient per guidance of Regulatory Guide 1.145 [2-33].

The parameters used and the calculated atmospheric dispersion coefficients are summarized in Table 2-7.

2.4 Surface Hydrology

2.4.1 Hydrologic Description

The WCS CISF is located in western Andrews County, Texas nearly at the Texas – New Mexico border, just north of Texas Highway 176 approximately 32 miles west of Andrews, Texas and 5 miles east of Eunice, New Mexico. There are no maps of special flood hazard areas for this location published by the Federal Emergency Management Agency (FEMA). The proposed WCS CISF is not located in wetlands per the National Wetlands Inventory (see Figure 2-9).The Site Location and Surrounding Topography Map, Attachment B Figure 1.1-1, shows the WCS CISF location with respect to the surrounding topography and drainage features and the WCS property boundary.

From a surface water perspective, the general area is characterized by ephemeral drainages, sheet flow, minor gullies and rills, internally-drained playas, and a salt lake basin (identified in Figure 1.1-1 as a Depression Pond in Attachment B). The salt lake basin is the only naturally-occuring, perennial (year-round) water body located near the WCS CISF; the internally drained salt lake basin is located approximately 5 miles from the eastern boundary of the WCS CISF and rarely has more than a few inches of water at scattered locations within the bottom footprint. Surface drainage from the WCS CISF does not flow into this basin. Other perennial surface water features are man-made, including various stock tanks (often replenished by shallow windmill wells) located across the area and the feature denoted as the Fish Pond on Figure 1.1-1, which is located at the Permian Basin Materials quarry (formerly Wallach Concrete) west of the WCS CISF and is also replenished by well water. In addition, Sundance Services, LLC operates the Parabo Disposal Facility for oil and gas waste west of the WCS CISF. Water collects periodically in excavated and/or diked areas at this disposal facility and in the active quarry areas at this property adjacent to and west of the WCS property in New Mexico.

The nearest surface water drainage feature to the WCS CISF is Monument Draw in Lea County, New Mexico, a reasonably well-defined, southward-draining draw about 3 miles west of the WCS CISF. The draw does not have through-going drainage and loses surface expression after it enters Winkler County, Texas. (Note: there are two surface drainage features named Monument Draw in the vicinity: Monument Draw, New Mexico, a south-flowing ephemeral stream in Lea County, New Mexico, and Monument Draw, Texas (same name), an east-flowing ephemeral stream in Andrews County, Texas). East of Monument Draw, New Mexico and south of the WCS CISF is a local topographic high known as Rattlesnake Ridge. This poorly defined ridge parallels the Texas-New Mexico border and crests about 125 feet higher than Monument Draw, New Mexico (Nicholson and Clebsch, 1961[2-27]).

The WCS permitted area is on the southwestern slope of the drainage divide between the Pecos River and the Colorado River. In the immediate vicinity of the WCS CISF, the slope is southwest toward Monument Draw, New Mexico at about 50 feet per mile. The maximum and minimum elevations of the permitted area are about 3490 feet and 3415 feet msl, respectively.

Small surface depressions (buffalo wallows) and a few established playa basins are present within a 6.2-mile radius of the WCS CISF. The largest of the surface depressions within the permitted area is a small playa about 15 acres in size approximately one-half mile northeast of the existing RCRA landfill. Remnant deposits of a filled and now partially covered playa or salt lake basin are found about 3 miles east of the permitted area. Surface drainage from the area north and east of the WCS CISF flows eastward into this basin.

Baker Spring is a manmade feature located at a historic quarry on WCS property about 2,510 feet west of the WCS CISF in Lea County, New Mexico. This feature was formed by excavation of the caliche caprock to the top of the underlying red bed clays. After periods of rainfall, the depression may hold water for an extended period; during dry cycles, the depression may be dry for extended periods.

The National and Oceanic and Atmospheric Administration's National Weather Service Office for Hobbs, New Mexico indicates that the minimum average annual precipitation recorded is 2.01 inches in 2011 and the maximum average annual precipitation recorded is 32.19 inches in 1941. The annual precipitation on average is approximately 14 inches.

The WCS CISF is located on the southwest-facing slope that transitions from the Southern high Plains to the Pecos Valley physiographic section. The Southern High Plains is an elevated area of undulating plains with low relief encompassing a large area of west Texas and eastern New Mexico. In Andrews County, the southwestern boundary of the Southern High Plains is poorly defined, but in this report is considered to be where the caprock caliche is at or relatively close to the surface, such as on and near the WCS CISF.

The main surface water drainage in the area is Monument Draw, an ephemeral stream about 3 miles west of the WCS CISF, in New Mexico. Ephemeral streams or drainage ways flow briefly only in direct response to precipitation in the immediate locality. Monument Draw is a reasonably well-defined, southward draining feature (although not through-going) that is identified on the USGS topographic maps that serve as the base map source for Attachment B Figure 1.1-1.

An ephemeral drainage feature, referred to as the Ranch House Draw crosses the WCS property from east to west, generally to the south of the WCS CISF, as shown in Figure 1.1-1 in Attachment B. This feature is discernible from the topographic relief depicted on Figure 1.1-1 in Attachment B, although it is much less pronounced than Monument Draw. This drainage feature is a relict drainage way that is choked with windblown sand and is not through-going to Monument Draw. Most of the drainage from the area of the WCS CISF is down slope toward the Ranch house Draw, with a small portion of the drainage from this area toward the southwest. Surface water eventually infiltrates into the windblown sands and dune fields to the south and southwest of the WCS CISF. There are no ephemeral drainages that cross the WCS CISF. Most of the immediate area of the WCS CISF is drained from northwest to southeast by sheet flow. Sheet flow is a term describing overland flow or down slope movement of water taking the form of a thin, continuous film.

Playas, or small, internally-drained basins, occur on the WCS property. The playas are dry most of the time. Some of the playas occasionally hold water after relatively large precipitation events; however, the ponded water rapidly dissipates through infiltration, evaporation, and plant uptake. An established playa basin is present on the eastern edge of the WCS CISF. Surface topography maps indicate approximately 10 feet of relief in the playa.

The combination of low annual precipitation, relatively high potential evapotranspiration, permeable surficial soils down gradient of the WCS CISF, and topographic relief results in well-drained conditions. The engineering design and construction of the WCS CISF will eliminate areas that might promote ponding. Diversion berms and a collection ditch will direct stormwater from upstream drainage areas around the WCS CISF.

There are no public or private surface water drinking-water supplies in the WCS CISF vicinity. Potable water supply for the WCS CISF will tie-in to existing potable water lines at WCS. There are scattered windmills in the general area that take water from isolated pockets of groundwater perched on top of the red bed clay. This water is utilized primarily for livestock watering.

The WCS CISF is located on the southwest-facing slope that transitions from the Southern High Plains to the Pecos Valley physiographic section.

2.4.2 Floods

The WCS CISF is not located in the 100-year flood plain. Attachment B presents the Flood Plain Study for WCS and in Appendix A on Figure II.F.4 in that report identifies the 100-year floodplain near the WCS CISF.

2.4.2.1 Flood History

The climate of the area is classified as semiarid, characterized by dry summers and mild, dry winters. Annual precipitation on average is approximately 14 inches and annual evaporation exceeds annual precipitation by nearly five times. The area is subject to occasional winter storms, which produce snowfall events of short duration.

Rainfall records from July 2009 through December 2015, provided by WCS from a weather station near the WCS CISF, indicate an average annual rainfall of 12.6 inches and a maximum twenty-four hour rainfall total of 3.62 inches (Attachment A). According to WCS personnel, surface water runoff has not overflowed roads or existing drainage features at the WCS site during this time frame.

2.4.2.2 Flood Design Considerations

There has been no history of flooding at the WCS CISF site and the WCS CISF is not located in the 100-year floodplain. Almost all of the surface water runoff from the storage area will leave the WCS CISF just north of the southeast corner of the storage area and will drain into the large playa southeast of the WCS CISF. A small amount of surface water runoff from the parking lot of the WCS CISF will drain southwest. Flow arrows on Figure 1.1.2-2 in Attachment B, Developed Drainage Area Map, provide the detailed drainage patterns for the WCS CISF.

The WCS CISF Drainage Evaluation and Floodplain Analysis (Attachment B) models the probable maximum flood (PMF) flow over the existing railroad and the proposed WCS CISF rail side track. At analysis Point 1, the peak discharge resulting from all modeled storm events flows over State Line Road. The maximum depth of flow over the road (during the 500-year and ARC III) is approximately 0.8 feet which is equivalent to elevation 3487.3 feet msl. The maximum depth of water on the WCS CISF storage pad for a 500 year flood is 1.1 inches and the velocity is 1.7 feet/s.

The peak discharge resulting from all modeled storm events flows over the railroad tracks at Analysis Point 2. The maximum depth of water over the rail (during 500-year and ARC III) is approximately 1.4 ft. which is equivalent to elevation of 3466.4 feet msl.

2.4.2.3 Effects of Local Intense Precipitation

The Flood Plain Study in Attachment B includes calculations for a Probable Maximum Precipitation (PMP) using a 500-year frequency storm event and the limits of the flood plain. The results from these additional storms that were modeled describe a flood plain that is still shallow and wide that is too distant from the WCS CISF to ever be any threat.

2.4.3 Probable Maximum Flood on Streams and Rivers

There are no streams or rivers on or in the vicinity of the WCS CISF. Monument Draw, an ephemeral stream, is the closest main surface water drainage and is about 3 miles west of the WCS CISF in New Mexico, so the WCS CISF would be unaffected by flooding on streams of rivers. While Monument Draw is typically dry, the maximum historical flow occurred on June 10, 1972 and measured 36.2 cubic meters per second (1,280 cubic feet per second).

2.4.4 Potential Dam Failures (Seismically Induced)

There are no dams on or in the vicinity of the WCS CISF. The WCS RCRA and LLRW facilities currently have five (5) manmade evaporation ponds which are partially above-grade. If a seismic event were to cause slope failure the ponds are designed to have the south wall fail and all water released would flow south away from the WCS CISF.

2.4.5 Probable Maximum Surge and Seiche Flooding

Surges and seiches are typically observed on lakes or seas. There are no surface bodies of water on or near the WCS CISF where such a phenomenon would be a safety concern at the WCS CISF. There are currently five evaporation ponds at the WCS site and they are designed with spillways on the south side so any seiche or surge would flow south away from the WCS CISF.

2.4.6 Probable Maximum Tsunami Flooding

The WCS CISF is located about 805 kilometers (500 miles) from the coast. The WCS CISF is sufficient distance from the coastline that tsunami flooding is not a hazard.

2.4.7 Ice Flooding

The WCS CISF is not located in an area where ice flooding is a concern. There are no streams or rivers on or in the vicinity of the WCS CISF. Monument Draw, an ephemeral stream, is the closest main surface water drainage and is about 3 miles west of the WCS CISF in New Mexico, so the WCS CISF would be unaffected by ice blockage and ice flooding.

2.4.8 Flooding Protection Requirements

The WCS CISF is not located in an area where flooding protection is required. There are no maps of special flood hazard areas for this location published by the Federal Emergency Management Agency (FEMA).

2.4.9 Environmental Acceptance of Effluents

There are no radioactive or other effluent releases associated with the proposed WCS CISF.

Stormwater runoff is not expected to contain any radiological effluents and WCS CISF stormwater runoff will be directed to the natural drainage system. Domestic wastes will be directed to above ground tanks on-site and the tanks will be periodically drained and all wastes will be transported off-site for disposal.

2.5 Subsurface Hydrology

The High Plains aquifer of west Texas, the principal aquifer in west Texas, consists of water-bearing units within the Tertiary Ogallala Formation and underlying Cretaceous rocks (Nativ and Gutierrez, 1988[2-26]). Hydrogeologically, the High Plains aquifer is viewed as a single, hydraulically connected aquifer system, and groundwater exists under both unconfined and confined conditions. The term Ogallala aquifer is used interchangeably with the High Plains aquifer, since regionally, the Ogallala Formation is the primary component of the High Plains aquifer (Dutton and Simpkins, 1986[2-8]). Regionally the sands, gravels and sandstones that have been variously ascribed to the Tertiary Ogallalla Formations, the Tertiary aged sections of the Gatuña Formation, and the Cretaceous Antlers Formation are distinct and independent. Locally, these units are situated in the same stratigraphic interval and hydrogeologically they represent a single hydrostratigraphic unit overlying the Triassic red beds, the distinctive red and purple mudstones, siltstones, and sandstones of the Triassic Dockum Group. The hydrostratigraphic unit of undifferentiated sands and sandstones of the Ogallala/Antlers/Gatuña is locally referred to as the OAG unit. However, the Ogallala and Cretaceous aquifers are evaluated independently in the literature and will be addressed individually in the discussion below.

The Cenozoic Alluvium aquifer and the Triassic Dockum Group aquifer are considered either major (Cenozoic Alluvium) or minor (Dockum Group) aquifers in this part of west Texas (Mace, 2001[2-20]) and will also be addressed below.

The shallowest water bearing zone is about 225 feet deep at the WCS CISF. Figure 2-10 is a groundwater contour map indicating the OAG unit is largely unsaturated beneath the WCS CISF. The nearest downgradient drinking water well identified in the hydrogeologic unit is located approximately 6.5 miles to the east of the proposed WCS CISF at a residence on the Letter B Ranch. The method of storage (dry cask), the nature of the canisters, the extremely low permeability of the red bed clay and the depth to groundwater beneath the WCS CISF preclude the possibility of groundwater contamination from the operation of the WCS CISF.

Ogallala Aquifer

The Ogallala Formation aquifer is the primary freshwater aquifer within the regional study area and serves as the principal source of groundwater in the Southern High Plains (Cronin, 1969[2-6]). The southern and eastern limits of the Ogallala aquifer lie to the north and east of the WCS CISF.

Regionally, the Ogallala aquifer thickens to the north and east of the currently permitted WCS facility (Blandford et al., 2003[2-3]) as shown on cross sections in Figure 2-11 and Figure 2-12. The saturated thickness of the Ogallala aquifer ranges from a few feet to approximately 300 feet in the Southern High Plains (Nativ, 1988[2-25]). Groundwater within the Ogallala aquifer is typically under water table conditions, with a regional hydraulic gradient toward the southeast ranging from approximately 10 feet/mile to 15 feet/mile. The average hydraulic conductivity of the Ogallala aquifer is about 10 feet/day with higher values preferentially distributed in depositional channels. Assuming an average hydraulic gradient of 12.5 feet/mile and a porosity of 0.20, the average rate of flow in the regional Ogallala aquifer is 43 feet/year.

The primary sources of recharge to the Ogallala aquifer are playas, headwater creeks, and irrigation return flow (Blandford et al., 2003[2-3]). Regionally, the recharge rate to the Ogallala aquifer is estimated to be of the order of 0.35 inches/year (Mullican et al., 1997[2-24]). Blandford et al., (2003)[2-3] estimated predevelopment recharge at less than 0.083 inches/year. In a 2003 numerical model of the Ogallala aquifer, prescribed recharge beneath irrigated lands was on the order of 1.25 to 2.25 inches/year, and recharge beneath non-irrigated agricultural lands ranged from 0.25 to 2.0 inches/year (Blandford et al., 2003[2-3]). Groundwater discharge from the Ogallala aquifer occurs naturally through springs, underflow, evaporation, and transpiration, but is also removed artificially through pumping. Throughout much of the Southern High Plains, groundwater discharge from the Ogallala aquifer exceeds recharge, and water levels have consistently declined. In some regions, however, water levels remained reasonably stable between 1960 and 2000 or even increased, indicating that recharge is the same or greater than discharge/pumping (Blandford et al., 2003[2-3]).

Water quality data for three Ogallala aquifer wells, located within two miles of the WCS CISF, were obtained from a review of Texas and New Mexico state records for western Andrews County, Texas and eastern Lea County, New Mexico.

Review of the water quality data indicates that the local Ogallala aquifer contains fresh to slightly saline water (TDS ≤ 3000 mg/L). The Ogallala Formation, if present, is not water bearing in the WCS area.

Cretaceous Aquifer (Antlers Formation)

The Cretaceous aquifer of the Southern High Plains is also considered to be part of the High Plains Aquifer (Nativ and Gutierrez, 1988[2-26]). The regional hydraulic gradient of the Cretaceous aquifer is toward the southeast, similar to the overlying and often hydraulically interconnected Ogallala aquifer.

The Cretaceous aquifer of the Southern High Plains consists of a basal unit (Trinity or Antlers Formation sandstone), an intermediate unit (Edwards Formation limestone), and an upper unit (Kiamichi/Duck Creek Formation sandstone and limestone). Where present and water bearing in the subsurface, the Cretaceous aquifer in the Southern High Plains is used as a source of groundwater (Nativ and Gutierrez, 1988[2-26]). The Cretaceous Antlers Formation has been identified in the vicinity of the WCS CISF and in the subsurface immediately below the WCS CISF; however, it is unsaturated but for a few isolated perched lenses.

Triassic Dockum Group Aquifer

The Dockum Group regionally consists of Triassic fluvial and lacustrine clays, shales, siltstones, sandstones and conglomerates. The Dockum Group consists of five formations, the lowermost of which is the Santa Rosa Formation, followed by the Tecovas, the Trujillo, the Cooper Canyon, and the Redonda Formations. Only the Santa Rosa, Tecovas, Trujillo and Cooper Canyon Formations are present in the vicinity of the WCS CISF. Water from the Dockum Group aquifer is used as a replacement for, or in combination with, the Ogallala aquifer as a regional source for irrigation, stock and municipal water (Dutton and Simpkins, 1986[2-8]).

There are two water-bearing sandstone formations in the Dockum Group in the vicinity of the WCS CISF. Both yield non-potable water with less than 5,000 mg/L total dissolved solids. The Santa Rosa Formation sandstone at the base of the Dockum Group is about 250 feet thick and is considered the best aquifer within the Dockum Group (Bradley and Kalaswad, 2003[2-5]). The top of the Santa Rosa Formation sandstone is at 1,140 feet below ground surface at the WCS CISF (Figure 2-13). The Trujillo Formation sandstone, the other Dockum Group water-bearing formation in the area, is about 100 feet thick. The top of the Trujillo Formation is about 600 feet below ground surface (Figure 2-13). About 450 feet of very low permeability Dockum Group fluvial and lacustrine clays separate the two formations.

The lower Dockum Group aquifer is recharged by precipitation where Dockum Group sediments are exposed at land surface (Bradley and Kalaswad, 2003[2-5]). However, most of the recharge to the sandstones in the lower Dockum Group (comprising the Santa Rosa and Trujillo Formation sandstones) is considered to have occurred during the Pleistocene (Dutton, 1995[2-7]; Dutton and Simpkins, 1986[2-8]) some 15,000 to 35,000 years before present. Topographically controlled groundwater basin divides were developed during the Pleistocene by the erosion of the Pecos and Canadian River valleys. Prior to the development of these groundwater basin divides, the lower Dockum aquifer was recharged by precipitation on its outcrop area in eastern New Mexico. However, since the development of the Pecos and Canadian River valleys, the lower Dockum aquifer in Texas has been cut-off from its recharge area. Without recharge, the lower Dockum aquifer experiences a net loss of groundwater from withdrawal by wells and by seepage (Dutton and Simpkins, 1986[2-8]). The regional hydraulic gradient of the lower Dockum aquifer, which is toward the southeast, is approximately 15 feet/mile. Based on water levels encountered during logging of the two deep wells at the WCS site, water levels in the lower Dockum aquifer range from 2,852 feet msl (Santa Rosa Formation) to 3,172 feet msl (Trujillo Formation). Transmissivity of the lower Dockum aquifer ranges from 3180 ft^2/day to about 10 ft^2/day and storativity, based on two values, is 0.0001 and 0.002 (Dutton and Simpkins, 1986[2-8]). Based on the transmissivity values noted above, an average thickness of 350 feet of combined Santa Rosa and Trujillo Formation sandstones, a porosity of 0.15, and a gradient of 15 feet/mile, the rate of groundwater flow is estimated to be between 17 feet/year and 0.6 feet/year.

The upper portion of the Dockum Group (Cooper Canyon Formation) serves as an aquitard in the regional and local study area (Nicholson and Clebsch, 1961[2-27]; Dutton and Simpkins, 1986[2-8]). This is supported by the fact that the hydraulic head of the lower Dockum aquifer is significantly lower than that of the overlying Ogallala aquifer throughout much of the regional study area. This relative head difference, approximately 200 to 300 feet in western Andrews County, suggests that the lower Dockum aquifer is receiving essentially no recharge from cross-formational flow (Nativ, 1988[2-25]). The primary limiting factors on recharge to the Dockum Group aquifer include the low-permeability aquitard characteristics of the upper Dockum Group and cut-off by the Pecos River Valley of historical recharge areas in eastern New Mexico.

Cenozoic Alluvium Aquifer

The Cenozoic Alluvium aquifer, also referred to as the Cenozoic Pecos Alluvium aquifer (Jones, 2001[2-15]), is regional in extent, but it is not present in the vicinity of the WCS CISF.

2.5.1 Salt Dissolution and Sink Holes

The proposed WCS CISF is located over Permian-age halite-bearing formations, and the possibility of dissolution and its effects on the long-term performance of the WCS CISF have to be considered. Robert M. Holt, PhD and Dennis W. Powers, PhD developed three conceptual hydrologic models of dissolution processes (shallow, deep and stratabound) based on experience and features found in the Delaware Basin west of the WCS CISF. Investigations showed that no features in the study area at and around the WCS CISF indicated any past dissolution, and the hydrologic systems at the site limit the potential for future dissolution and/or sinkholes. The full discussion and results of the study are detailed in “Evaluation of Halite Dissolution in the Vicinity of Waste Control Specialists Disposal Site, Andrews County, TX” and the report is located in Attachment F.

2.6 Geology And Seismology

2.6.1 Basic Geologic and Seismic Information

This section discusses the regional geology ascending from a depth of approximately 1400 feet, which includes the lowermost underground source of drinking water (USDW), to the ground surface. Figure 2-14 presents the Hobbs Sheet of the Geologic Atlas of Texas, 1:250,000 scale. The map shows surficial lithologic exposures, topography infrastructure and governmental boundaries in the area surrounding the WCS permitted area.

Two cross sections in the vicinity of the WCS CISF were created using boring logs from former site investigations. The locations of the cross sections are shown on Figure 2-15. Two cross sections in the vicinity of the WCS CISF are included as Figure 2-16 and Figure 2-17 and the associated boring logs are included in Attachment C.

The geologic formations of concern, beneath of the WCS CISF comprise, from oldest to youngest, the Triassic Dockum Group, the Cretaceous Trinity Group Antlers Formation, the Late Tertiary stratigraphic equivalent of the Ogallala Formation, the Late Tertiary/Quaternary Gatuña Formation or Cenozoic Alluvium (note that the Gatuña Formation and Cenozoic Alluvium are sometimes used interchangeably), the Pleistocene windblown sands of the Blackwater Draw Formation, Holocene windblown sands and playa deposits. A regional hard caliche pedisol, termed the Caprock caliche, developed on all pre-Quaternary formations before the Blackwater Draw sands were deposited.

A stratigraphic column for the above units is provided in Figure 2-13. This stratigraphic column adopts the nomenclature of Lehman (1994a[2-17], 1994b[2-18]) for the Dockum Group and includes the entire stratigraphic sequence typical of the Central Basin Platform of the west Texas Permian Basin (Bebout and Meador, 1985[2-2]).

The WCS CISF is located over the north-central portion of a prominent subsurface structural feature known as the Central Basin Platform. The Central Basin Platform is a deep-seated horst-like structure that extends northwest to southeast from southeastern New Mexico to eastern Pecos County, Texas. The Central Basin Platform is flanked on three sides by regional structural depressions known as the Delaware Basin to the southwest and the Midland Basin to the northeast, and by the Val Verde Basin to the south.

From the Cambrian to late Mississippian, west Texas and southeast New Mexico experienced mild structural deformation that produced broad regional arches and shallow depressions (Wright, 1979[2-36]). The Central Basin Platform served intermittently as a slightly positive feature during the early Paleozoic (Galley, 1958[2-9]). During the Mississippian and Pennsylvanian, the Central Basin Platform uplifted between ancient lines of weakness (Hills, 1985[2-13]), and the Delaware, Midland, and Val Verde Basins began to subside, forming separate basins.

Late Mississippian tectonic events uplifted and folded the platform and were followed by more intense late Pennsylvanian and early Permian deformation that compressed and faulted the area (Hills, 1963[2-12]). Highly deformed local structures formed ranges of mountains oriented generally parallel to the main axis of the platform (Wright, 1979[2-36]).

This period of intense late Paleozoic deformation was followed by a long period of gradual subsidence and erosion that stripped the Central Basin Platform and other structures to near base-level (Wright, 1979[2-36]) forming the Permian Basin. The expanding sea gradually encroached over broad eroded surfaces and truncated edges of previously deposited sedimentary strata. New layers of arkose, sand, chert pebble conglomerate and shale deposits accumulated as erosional products along the edges and on the flanks of both regional and local structures. Throughout the remainder of the Permian, the Permian Basin slowly filled with several thousand feet of evaporites, carbonates, and shales.

From the end of the Permian until late Cretaceous, there was relatively little tectonic activity except for periods of slight regional uplifting and downwarping. During the early Triassic, the region was slowly uplifted and slightly eroded. These conditions continued until the late Triassic, when gentle downwarping formed a large land-locked basin in which terrigenous deposits of the Dockum Group accumulated in alluvial flood plains and as deltaic and lacustrine deposits (McGowen, et al., 1979[2-21]). In Jurassic time, the area was again subject to erosion.

During Cretaceous time, a large part of the western interior of North America (including west Texas and southeastern New Mexico) was submerged by a large continental shelf sea. A thick sequence of Cretaceous rocks was deposited over most of the area. Locally, the Cretaceous sequence of sediments was comprised of a basal clastic unit (the Trinity, Antlers, or Paluxy sands) and overlying shallow marine carbonates.

Uplift from the west and southward and eastward–retreating Cretaceous seas were coincident with the Laramide Orogeny, which formed the Cordilleran Range west of the Permian Basin. The Laramide Orogeny uplifted the region to essentially its present position, supplying sediments for the nearby late Tertiary Ogallala Formation. The major episode of Laramide folding and faulting occurred in the late Paleocene. There have been no major tectonic events in North Americas since the Laramide Orogeny, except for a brief period of minor volcanism during the late Tertiary in northeastern New Mexico and in the Trans-Pecos area. Hills (1985)[2-13] suggests that slight Tertiary movement along Precambrian lines of weakness may have opened joint channels which allowed the circulation of groundwater into Permian evaporite layers. The near-surface regional structural controls may be locally modified by differential subsidence related to groundwater dissolution of Permian salt deposits (Gustavson, 1980[2-10]).

The Central Basin Platform is an area of moderate, low intensity seismic activity based on data obtained from the U.S. Geological Survey (USGS) Earthquake Data Base available from the National Earthquake Information Center (http://neic.usgs.gov/). Typical of the central U.S., there is a marked absence of mapped Quaternary faults and few of the known earthquakes can be associated with a specific geologic structure. In the 2014 U.S.G.S. National Hazard Maps, the site area was characterized as one of relatively low seismic hazard.

2.6.2 Vibratory Ground Motion

The WCS CISF lies in a region with crustal properties that indicate minimum risk due to faulting and seismicity. Crustal thickness is the most reliable predictor of seismic activity and faulting in intracratonic regions. Crustal thickness in the vicinity of the WCS CISF is approximately 30 miles (50 km), one of the three thickest crustal regions in North America (Mooney and Braile, 1989[2-22]). In comparison, the crustal thickness of the Rio Grande Rift is as little as 7.5 miles (12 km) in places.

In 2016, WCS completed a Probabilistic Seismic Hazard Evaluation using Nuclear Regulatory Commission (NRC) guidance for the WCS CISF. The Seismic Hazard Evaluation (Attachment D) was prepared under the technical supervision of Dr. Ivan Wong, head of Seismic Hazards Group, AECOM, Oakland, CA and the analysis was performed consistent with the professional standards of the Texas Board of Professional Geoscientists.

The objectives of the Seismic Hazard Analysis were to (1) estimate the levels of ground motions that could be exceeded at a specific annual frequency (or return period) at the site by performing a probabilistic seismic hazard analysis (PSHA), (2) incorporate the site-specific effects of the near-surface geology on the ground motions, and (3) develop Design Response Spectra (DRS) at the ground surface for the site and corresponding histories.

Significant earthquakes (moment magnitude [**M**] > 5.0), however have occurred in the site region including the 1992 **M** 5.0 Rattlesnake Canyon earthquake about 30 km from the WCS CISF. Some occurrences of induced seismicity have also proven to be spatially correlated to active hydrocarbon production in the region. Typical of the central U.S., there is a marked absence of Quaternary faults and few of the known earthquakes can be associated with a specific geologic structure. In the 2014 U.S. Geological Survey (USGS) National Hazard Maps, the site area was characterized as one of relatively low seismic hazard.

Spectral-analysis-of-surface-wave (SASW) surveys were performed at the WCS CISF by the University of Texas at Austin to obtain shear-wave velocity (V_s) profiles down to the Trujillo sandstone at a depth of about 600 feet.

To estimate ground motions, four Next Generation of Attenuation (NGA)-West2 ground motion prediction models for the western U.S. (WUS) and the EPRI (2013) [2-35] models for the central and eastern U.S. (CEUS) were utilized. For the NGA-West2 models, a time-averaged shear wave velocity (V_s) in the top 100 feet (V_s30) of 760 m/sec was used. The EPRI (2013) [2-35] ground motion models are defined for hard rock or a V_s30 of 2,830 m/sec and greater. To address the epistemic uncertainty on which models are appropriate, both the NGA-West2 and EPRI (2013) [2-35] models were used in the PSHA weighted 0.60 and 0.40, respectively.

Based on the PSHA and the inputs of the seismic source model and ground motion models, seismic hazard curves for both firm and hard rock were calculated. The absence of late-Quaternary faulting and the low to moderate rate of background seismicity, even that associated with petroleum recovery activities, results in relatively low seismic hazard at the WCS site. The largest contributor to the hazard at the WCS CISF is the background seismicity (the Southern Great Plains seismic source zone and Gaussian smoothing).

A site response analysis was performed to estimate ground motions at the WCS CISF incorporating the site-specific geology. The hazard curves were weighted based on the weights assigned to the NGA-West2 and EPRI (2013) [2-35] ground motion models and a 10,000 year return period horizontal Uniform Hazard Spectrum (UHS) was calculated. A 10,000-year return period vertical UHS was also calculated using the NRC V/H ratios. On Table 3 in Attachment D is the horizontal and vertical UHS for a return period of 10,000 years. The ground surface design response spectrum peak horizontal acceleration for 0.01 seconds is 0.25 g and the vertical is 0.175 g.

Historic and recent seismic activity for the Texas regional area from 1973 to 2015 can be seen on Figure 2-18.

2.6.3 Surface Faulting

Two types of faulting were associated with early Permian deformation. Most of the faults were long, high-angle reverse faults with several hundred feet of vertical displacement that often involved the Precambrian basement rocks (Hills, 1985[2-13]; Bebout and Meador, 1985[2-2]). The second type of faulting is found along the western margin of the Central Basin Platform where long strike-slip faults, with displacements of tens of miles, are found (Hills, 1985[2-13]). All of the major faulting in the vicinity of the Central Basin Platform occurred in response to tectonic forces active before the global plate tectonic reorganization that created the North American continent (Bally et al., 1989[2-1]). The Paleozoic faults exhibit low natural microseismicity as a result of passive response to relatively low levels of tectonic stress in the trailing edge of the westward-drifting North American plate. The closest Quaternary faults are in the Guadalupe Mountains (Muehlberger, 1979[2-23]), about 100 miles southwest of the WCS CISF.

The large structural features of the Permian Basin are reflected only indirectly in the Mesozoic and Cenozoic rocks, as there has been virtually no tectonic movement within the basin since the Permian (Nicholson and Clebsch, 1961[2-27]). The Central Basin Platform is located approximately 7000 feet beneath the present land surface and the Permian and Triassic sediments drape over the top of the Platform structure. The faults that uplifted the platform do not appear to displace the younger Permian sediments. The northernmost fault, located at the Matador Uplift, terminates in lower Wolfcampian sediments.

The regional geologic and tectonic information does not indicate the presence of significant post-Permian faulting within the regional study area. Permian period with basin subsidence matching sediment accumulation. Post-Permian activity in the entire Permian Basin consisted of localized tectonic pulses. The basin has remained stable for the last 200 million years (Seismic Hazard Evaluation Attachment D).

Two regional stratigraphic cross section constructed in the vicinity of the WCS CISF using oil and gas well logs are shown as Figure 2-11 and Figure 2-12. The locations of the cross sections are also shown on the figures. These cross sections depict the major stratigraphic units that occur within about 2000 feet below ground surface in the vicinity of the WCS CISF. The stratigraphic units depicted on Figure 2-11 and Figure 2-12 include the upper Ogallala Antlers Gapuña unit of a few tens of feet in thickness, the underlying Triassic red beds of the Dockum Group with a thickness of 1,000 to 1,500 feet, the underlying Permian Dewey Lake Formation red beds, and the Permian evaporates of the Rustler and Salado Formations. These cross sections do not indicate the presence of significant faulting in the upper 2,000 feet of sediments within 3 to 4 miles of the WCS CISF.

The closest areas of faulting that affect Quaternary strata are faults associated with the Basin and Range physiographic province. Tectonically, Basin and Range faulting is associated with crustal extension and thinning in southwestern North America due to right lateral shear between the Pacific plate and the North American plate. This extension is the cause of the Rio Grande Rift, which is an area with numerous Quaternary faults located approximately 200 miles west of the WCS CISF.

The closest Quaternary faults listed in the United States Geological Survey (USGS) Quaternary Fault and Fold Database (http://earthquakes.usgs.gov/qfaults) are faults that are associated with the range-front of the Guadalupe Mountains and are located along the southwestern base of the mountain range. The closest Quaternary fault is an unnamed fault at the base of the Guadalupe Mountains, listed as fault No. 907 in the database and located approximately 104 miles southwest of the WCS CISF in Guadalupe Mountains National Park in Culberson County, Texas. This fault is a down-to-the-west range-bounding normal fault, with the most recent deformation estimated at less than 1.6 million years ago (Ma) (http://earthquakes.usgs.gov/qfaults). A second fault associated with this region is the Guadalupe Fault listed as fault No. 2058 and located 108 miles west of the WCS CISF in Chaves and Otero Counties, New Mexico. This fault may be the re-activation of a late Tertiary Basin and Range fault. The age of the faulted deposits have not been studied, but the oldest faulted strata are believed to be as old as the penultimate glaciation based on the stratigraphic sequence present, placing the oldest age of deformation at approximately 130 thousand years ago (ka). The most recent deformation of this fault is believed to be less than 15 ka. There are additional Quaternary faults located south of the two faults listed, along the southwestern base of the Guadalupe Mountains in Texas.

The next closest area of Quaternary faulting listed on the USGS Quaternary Fault and Fold Database is the Alamogordo fault, which is divided into three sections. The sections of the Alamogordo fault closest to the WCS CISF are fault Nos. 2045b and 2045c on the USGS Quaternary Fault and Fold Database. These faults are located approximately 170 miles west of the WCS CISF in Otero County, New Mexico. The Alamogordo fault is the range-bounding structure of the Sacramento Mountains. The faults are down-to-the west faults, much like those associated with the Guadalupe Mountain range. The most recent deformation is listed as less than 130 ka in the USGS Quaternary Fault and Fold Database. There is no surface evidence of quaternary faulting within the WCS property.

During landfill excavation activities at WCS an apparent southward-dipping reverse fault in a sandstone in the upper portion of the Triassic red beds of the original RCRA landfill excavation were located in 2004. Since regulatory criteria address the age of faults and the age of any geologic units affected or displaced by faulting, a geologic investigation of the fault was undertaken. The southeast wall of the RCRA landfill was extended about 200 feet to the southeast in May and June 2004, yielding about 60 feet of vertical geologic exposure along a length of about 400 feet. Two benches with subvertical walls were exposed. The relationship between faulting in the Triassic red beds and the overlying Cretaceous Antlers Formation was carefully evaluated to determine if any displacement of the younger Cretaceous deposits had occurred. The Triassic red beds are separated from the overlying Cretaceous Antlers Formation sands and gravels and from a layer of reworked altered clay by a distinct and mappable parting near the top of the gray altered layer of red beds. None of the observed fault planes or slip surfaces in the Triassic red beds in the extensively mapped section cross or offset the parting. In addition, the bedding in the Antlers Formation is continuous where observable and not calichified, and in particular, there are no indications that the Cretaceous-aged Antlers Formation was affected by the faulting in the Triassic red beds. Photos, figures and further details are included in the WCS LLRW License [2-30].

2.6.4 Stability of Subsurface Materials

In the area of the WCS CISF, surficial materials consist of topsoil, recent windblown sand and sands of the Blackwater Draw. A thin veneer of two feet or less of topsoil and windblown sand is present at the surface. The topsoil consists of brown silty sand that contains sparse vegetation debris and roots. The Blackwater Draw consists of sand that is reddish brown, fine to very fine grained, with minor amounts of clay and nodules of soft sandy caliche. Surficial material is underlain by a variable sequence of calcium carbonate-cemented caliche referred to as the caprock caliche. The caprock caliche forms the resistant beds of the Caprock escarpment along the western and eastern margins of the Southern High Plains (Gustavson and Finley, 1985[2-11]). A local surface exposure of the caprock was observed at Baker Spring. At this location, the caliche consists of: approximately six feet of white, highly fractured calcium carbonate cemented feldspathic and quarzitic silt and very fine grained sand; overlying approximately 12 feet of white and pinkish white, massive caliche with extensive concretionary nodule growths (i.e., pisolites) and feldspathic and quartzitic silt and very fine grained sand; resting on top of approximately six feet of pinkish white, calcium carbonate-cemented feldspathic and quartzitic silt, sand and gravel which becomes less cemented with depth. The lower six feet of caliche appears to be well-to-poorly cemented calcium carbonate. The caliche has an irregular basal contact and indicates a gradational transition into primarily uncemented sands and gravels below. The caliche horizon contains varying amounts of feldspathic and quartzitic silt, sand and gravel fragments with a general trend of decreased cementation and increased silt, sand and gravel content with depth.

The WCS CISF subsurface conditions were explored with eighteen soil borings (Geotechnical Engineering report from Geoservices in Attachment E). The boring locations and depths were selected by GEOservices and surveyed by WCS personnel (Attachment E Figures 3, 4, and 5). The soil test borings were advanced using a Cannon skid rig (air rotary) and a CME-55 track rig. N-values were recorded in the field and noted on the boring logs. Soil samples collected during drilling were sent to a lab for visual classification and laboratory testing including: Atterberg Limits; Natural Moisture Content; Particle Size Analysis; Resistivity of Soil; Consolidated Undrained Triaxial Test; Standard Proctor Moisture-Density Tests; California Bearing Ratio; and Consolidation.

At the surface of each of the eighteen soil test borings, residual soils were encountered to auger refusal and/or boring termination depths ranging from 25 to 45 feet below the existing surface elevation. The N-values of the standard penetration resistance test (SPT) were used to evaluate the relative consistency or density of the subsurface. The N-values for the subsurface materials ranged from 4 bpf to 100 blows per 1 inch of penetration, indicating a relative density of very loose to very dense. The relative density of the subsurface materials were most commonly medium dense to very dense. The standard penetration resistance values have likely been inflated due to the caliche.

The natural moisture content of the subsurface materials ranged from 2.5 to 9 percent. Atterberg limits testing on three selected residual samples revealed liquid limits (LL) ranging from 26 to 20 percent and each sample was non-plastic. Wash 200 tests performed on eight soil samples revealed 24 to 45 percent finer than the 200 sieve.

2.6.5 Slope Stability

The WCS CISF site and surrounding area is nearly flat, so there is little possibility of landslides. Settling or slumping is unlikely because the geologic strata are well consolidated and surface soils have low moisture content. The semi-arid climate helps maintain low moisture content of the soils. Surface water is absent except during infrequent rainstorms.

2.6.6 Volcanism

There is minimal seismic and no volcanic activity near the WCS CISF. There is no evidence of tectonic or volcanic activity near the WCS CISF in the recent past.

2.7 Summary Of Site Conditions Affecting Construction And Operating Requirements

The WCS CISF site is located on the southwestern edge of the Southern High Plains, approximately 32 miles northwest of the City of Andrews. This part of Andrews County is a gently southeastward sloping plain with a natural slope of about 8 to 10 feet per mile. The finished grade of the WCS CISF `is expected to be sloped gently with an anticipated elevation of 3,485 feet above msl. The WCS CISF site is currently undeveloped and the existing land surface is fairly flat with an average slope of 0.8 percent (%). The existing maximum and minimum elevations of the site are about 3520 feet and 3482 feet msl, respectively. The cover type is desert shrub. The existing WCS railroad is generally aligned parallel with and south of the proposed WCS CISF site boundary.

The entire WCS CISF, including the access road, is above the 100-year flood elevation. The northern most limit of the 100-year floodplain is approximately 4,000 feet southeast of the WCS CISF while the northernmost limits of the 500-year and PMP floodplains are 3965 feet and 3895 feet southeast of the WCS CISF, respectively.

A probabilistic seismic hazard analysis was performed to determine the design basis ground motion at the WCS CISF. The peak ground acceleration for a 10,000 year return period is 0.26 g.

Subsurface soils at the WCS CISF are suitable for supporting conventional foundations under both the static and dynamic loading conditions. There is no potential for liquefaction, collapse, or excessive settlement of these soils. There are no slopes, natural or manmade, close enough to the proposed WCS CISF facilities that their failure would adversely affect these facilities.

Canisters contained in storage overpacks will be used to store canisters containing spent fuel and GTCC waste. The canisters are drained of all liquid prior to being shipped to the WCS CISF. Therefore, liquid releases cannot result from operation of the WCS CISF.

The shallowest water bearing zone is about 225 feet deep at the WCS CISF. The method of storage (dry cask), the nature of the storage casks, the extremely low permeability of the red bed clay and the depth to groundwater beneath the WCS CISF preclude the possibility of groundwater contamination from the operation of the WCS CISF.

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Table 2-1
Weather Stations Located Near the WCS CISF

Station	Distance and Direction from Proposed WCS CISF	Length of Record[1]	Station Elevation (meters)
Hobbs, New Mexico	32 kilometers (20 miles) north of WCS CISF	29 (1981-2010)	1,115
Jal, New Mexico	50 kilometers (31 miles) south of WCS CISF	29 (1981-2010)	947
Andrews, Texas	51 kilometers (32 miles) east of WCS CISF	29 (1981-2010)	967
Midland-Odessa, Texas	103 kilometers (64 miles) southeast of WCS CISF	29 (1981-2010)	1,118

Note:

1. Years of compiled data for climatological analysis.

Table 2-2
Summary of Maximum and Minimum Temperatures for Andrews, TX
Period of Record: 1962 to 2010

MONTH	MEAN MONTHLY TEMPERATURE		MEAN DAILY MAX. TEMPERATURE		MEAN DAILY MIN. TEMPERATURE		HIGHEST DAILY MAX. TEMPERATURE		LOWEST DAILY MIN TEMPERATURE	
	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
January	6.7	44.1	14.5	58.1	-1.1	30.1	29.4	85.0	-17.8	0.0
February	9.2	48.6	17.2	63.1	1.1	33.9	31.7	89.0	-18.3	-1.0
March	13.3	56.0	21.8	71.3	4.8	40.6	36.1	97.0	-13.3	8.0
April	18.2	64.7	26.8	80.2	9.4	49.0	37.2	99.0	-5.0	23.0
May	22.7	72.9	31.0	87.8	14.5	58.1	41.7	107.0	0.6	33.0
June	26.6	79.8	34.3	93.8	18.7	65.7	45.0	113.0	8.3	47.0
July	27.5	81.5	34.8	94.6	20.2	68.3	43.9	111.0	13.9	57.0
August	26.7	80.0	33.9	93.0	19.5	67.1	41.1	106.0	12.2	54.0
September	23.3	73.9	30.4	86.8	16.1	61.0	40.0	104.0	3.3	38.0
October	18.3	64.9	26.1	79.0	10.4	50.8	38.3	101.0	-5.6	22.0
November	11.8	53.2	19.4	67.0	4.1	39.4	33.9	93.0	-11.7	11.0
December	7.6	45.6	15.3	59.5	-0.2	31.7	27.2	81.0	-17.2	1.0
Annual	**17.5**	**63.5**	**25.3**	**77.5**	**9.7**	**49.4**	**45.0**	**113.0**	**-18.3**	**-1.0**

Source: www.wrcc.dri.edu

Table 2-3
Andrews, TX Period of Record Precipitation Data (1914-2006)

Precipitation CM (INCHES)	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	ANNUAL
Average	1.24 (0.49)	1.50 (0.59)	1.70 (0.67)	2.41 (0.95)	4.19 (1.65)	4.88 (1.92)	5.74 (2.26)	4.78 (1.88)	5.72 (2.25)	3.78 (1.49)	1.58 (0.62)	1.35 (0.53)	38.86 (15.30)
Maximum	11.40 (4.49)	6.40 (2.52)	8.46 (3.33)	13.67 (5.38)	14.91 (5.87)	18.06 (7.11)	30.23 (11.90)	14.00 (5.51)	20.17 (7.94)	16.16 (6.36)	8.00 (3.15)	7.80 (3.07)	78.66 (30.97)
Minimum	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.36 (0.14)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.36 (0.14)
Max 24 Hr	5.61 (2.21)	2.54 (1.00)	4.70 (1.85)	6.30 (2.48)	7.62 (3.00)	9.40 (3.70)	19.30 (7.60)	6.10 (2.40)	8.90 (3.50)	5.21 (2.05)	5.33 (2.10)	3.94 (1.55)	19.30 (7.60)

Source: Reference [2-30]

Table 2-4
Andrews, TX Period of Record Snow Data (1914-2006)

Snow CM (INCHES)	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	ANNUAL
Average	3.33 (1.31)	1.52 (0.60)	0.08 (0.03)	0.15 (0.06)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.08 (0.03)	1.45 (0.57)	1.98 (0.78)	8.59 (3.38)
Maximum	25.40 (10.00)	17.78 (7.00)	2.54 (1.00)	6.35 (2.50)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.54 (1.00)	35.56 (14.00)	13.97 (5.50)	52.07 (20.50)
Minimum	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Max 24 Hr	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 2-5
Average Morning and Afternoon Mixing Heights for Midland-Odessa, Texas

	Winter	Spring	Summer	Fall	Annual
Morning	290 meters (951 feet)	429 meters (1,407 feet)	606 meters (1,988 feet)	419 meters (1,375 feet)	436 meters (1,430 feet)
Afternoon	1,276 meters (4,186 feet)	2,449 meters (8,035 feet)	2,744 meters (9,003 feet)	1,887 meters (6,191 feet)	2,089 meters (6,854 feet)

Source: Reference [2-14]

Table 2-6
EPA National Ambient Air Quality Standards

Pollutant	EPA Standard Value	Standard Type
Carbon Monoxide (CO)		
8-hour Average	9 ppm	Primary
1-hour Average	35 ppm	Primary
Nitrogen Dioxide (NO_2)		
Annual Arithmetic Mean	0.053 ppm (2)	Primary and Secondary
Ozone (O_3)		
8-hour Average	0.070 ppm (3)	Primary and Secondary
Lead (Pb)		
Quarterly Average	1.5 g/m^3 (1)	Primary and Secondary
Particulate (PM_{10})		
24-hour Average	150 $\mu g/m^3$	Primary and Secondary
Particulate ($PM_{2.5}$)		
Annual Arithmetic Mean(5)	12.0 $\mu g/m^3$	Primary
Annual Arithmetic Mean(5)	15.0 $\mu g/m^3$	Secondary
24-hour average(5)	35 $\mu g/m^3$	Primary and Secondary
Sulfur Dioxide (SO_2)		
3-hour Average	0.5 ppm	Secondary
1-hour Average	75 ppb (4)	Primary

Notes

1. In areas designated nonattainment for the Pb standards prior to the promulgation of the current (2008) standards, and for which implementation plans to attain or maintain the current (2008) standards have not been submitted and approved, the previous standards (1.5 $\mu g/m^3$ as a calendar quarter average) also remain in effect.
2. The level of the annual NO_2 standard is 0.053 ppm. It is shown here in terms of ppb for the purposes of clearer comparison to the 1-hour standard level.
3. Final rule signed October 1, 2015, and effective December 28, 2015. The previous (2008) O_3 standards additionally remain in effect in some areas. Revocation of the previous (2008) O_3 standards and transitioning to the current (2015) standards will be addressed in the implementation rule for the current standards.
4. The previous SO_2 standards (0.14 ppm 24-hour and 0.03 ppm annual) will additionally remain in effect in certain areas: (1) any area for which it is not yet 1 year since the effective date of designation under the current (2010) standards, and (2) any area for which implementation plans providing for attainment of the current (2010) standard have not been submitted and approved and which is designated nonattainment under the previous SO_2 standards or is not meeting the requirements of a SIP call under the previous SO2 standards (40 CFR 50.4(3)), A SIP call is an EPA action requiring a state to resubmit all or part of its State Implementation Plan to demonstrate attainment of the require NAAQS.
5. Averaged over 3 years

Table 2-7
Atmospheric Dispersion Coefficients

Parameter	Normal/Off-Normal	Accident
Stability	D	F
$\overline{U_{10}}$ (m/sec)	5	1
A (m^2)	13.47	13.47
σ_y (m)	8	4
σ_z (m)	4.6	2.3
M	1.122	4
Equation 1 of [2-33] (sec/m^3)	1.635E-03	2.806E-02
Equation 2 of [2-33] (sec/m^3)	5.766E-04	1.153E-02
Equation 3 of [2-33] (sec/m^3)	1.542E-03	8.650E-03
χ/Q (sec/m^3)	1.542E-03	8.650E-03

Figure 2-1
WCS Facility Site Plan

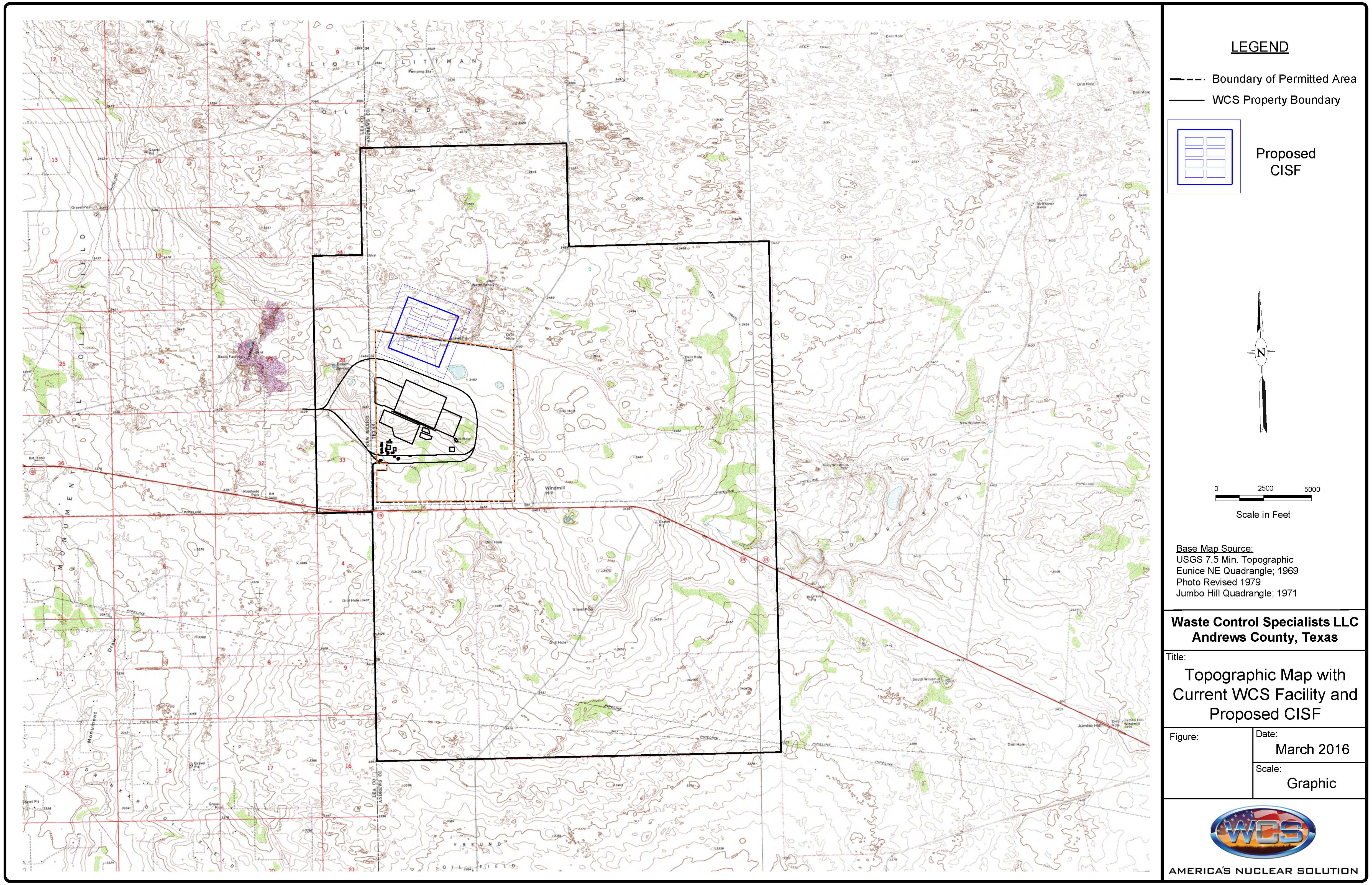


Figure 2-2
WCS Facility Site Plan

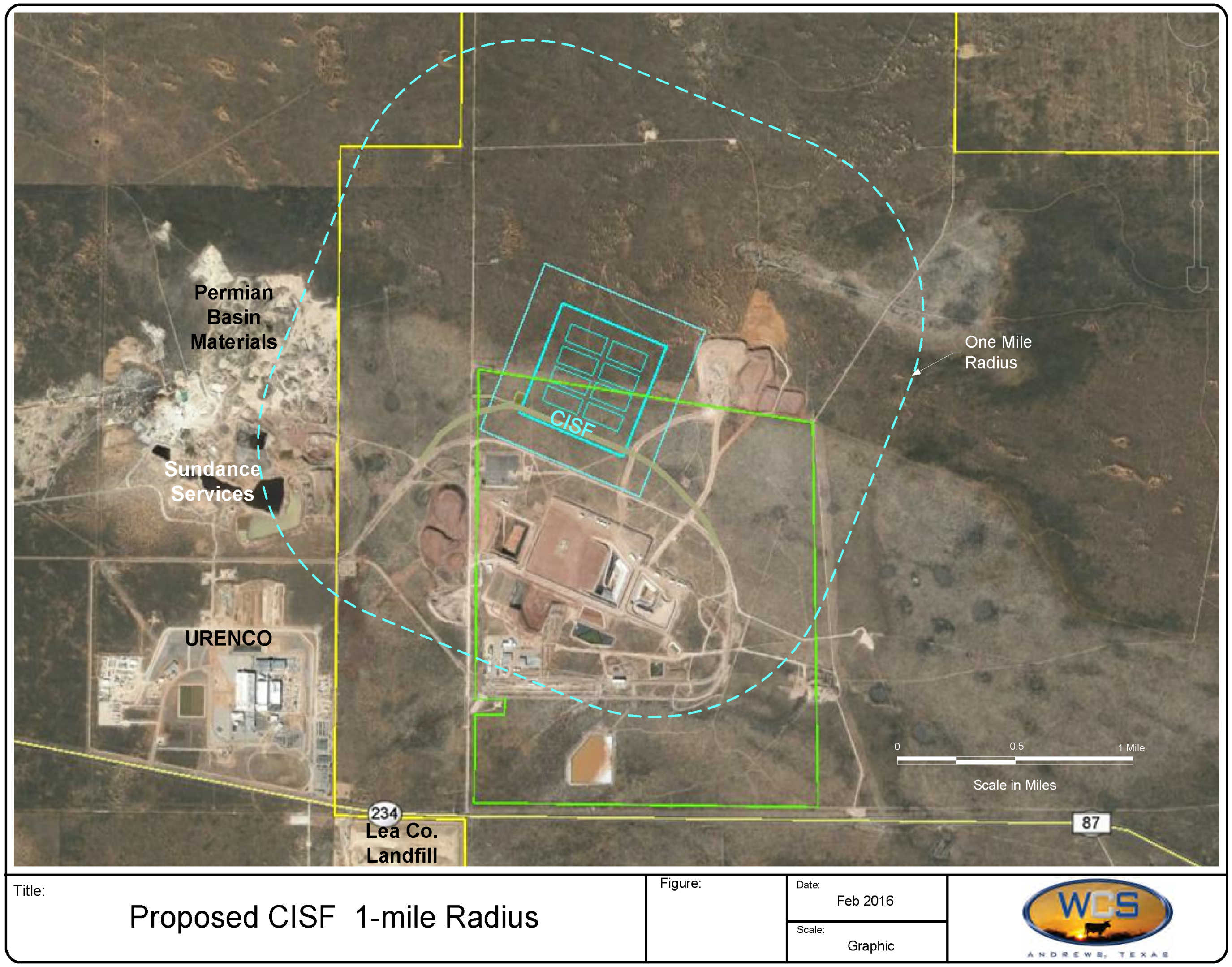
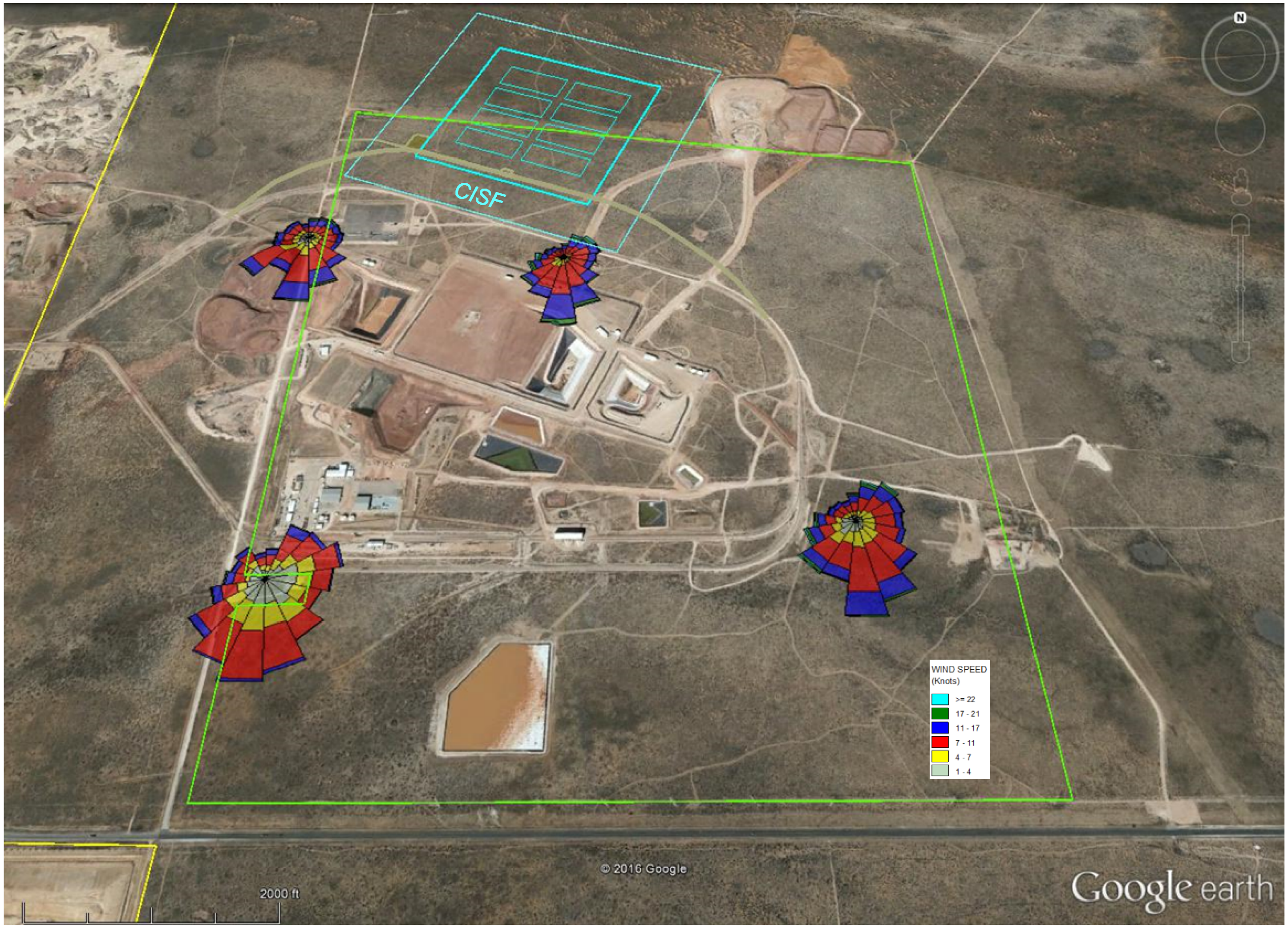
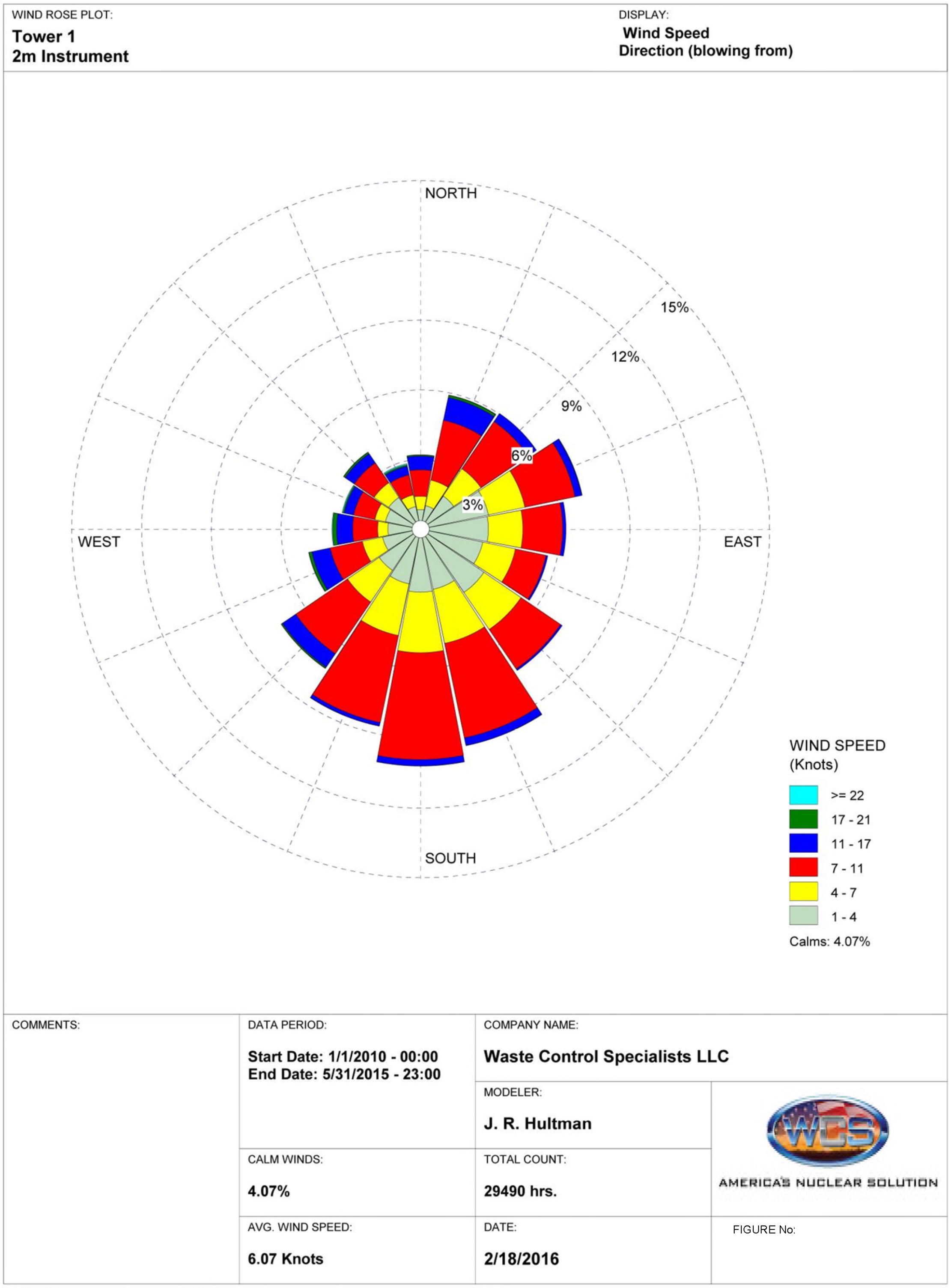


Figure 2-3
Proposed WCS CISF 1-mile Radius



Title:	Date:	
Wind Rose Location Map	2/18/2016	AMERICA'S NUCLEAR SOLUTION

Figure 2-4
Wind Rose Location Map

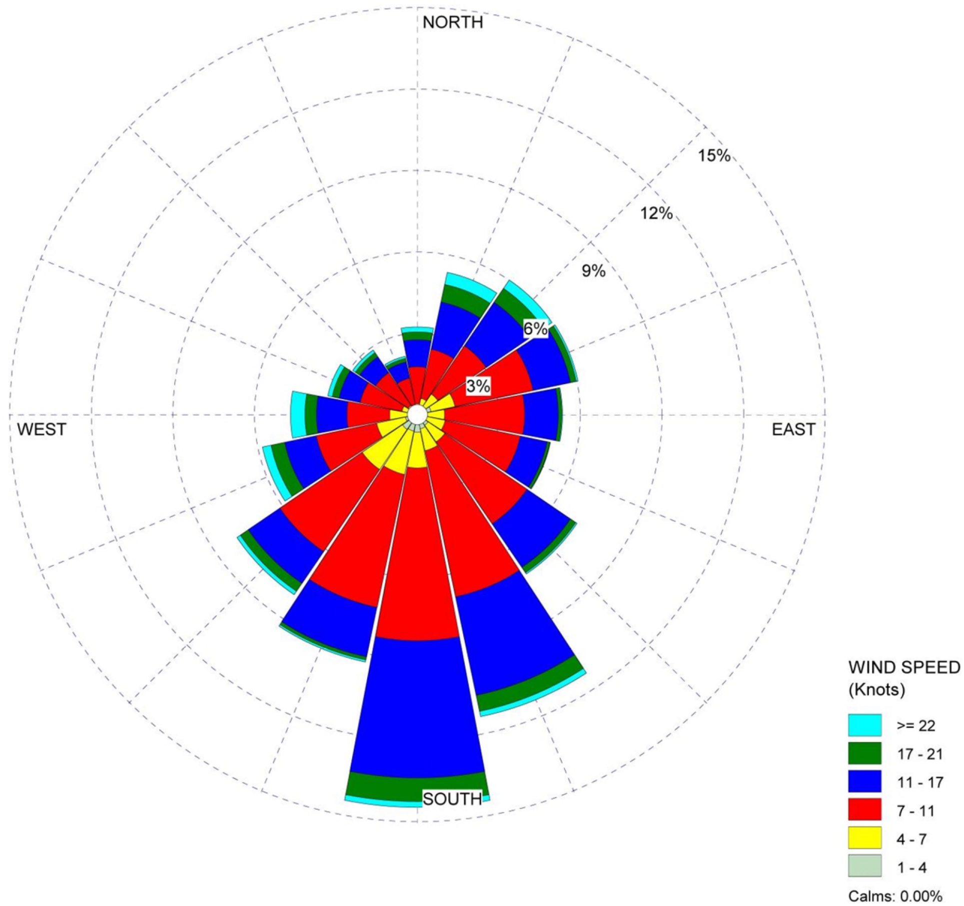


WRPLOT View - Lakes Environmental Software

Figure 2-5
WCS Wind Rose Plot: Tower 1

WIND ROSE PLOT:
ER Tower
2m Instrument

DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:

DATA PERIOD:
Start Date: 1/1/2010 - 00:00
End Date: 5/31/2015 - 23:00

COMPANY NAME:
Waste Control Specialists LLC

MODELER:
J. R. Hultman

AMERICA'S NUCLEAR SOLUTION

CALM WINDS:
0.00%

TOTAL COUNT:
48524 hrs.

AVG. WIND SPEED:
10.53 Knots

DATE:
2/18/2016

FIGURE No:

WRPLOT View - Lakes Environmental Software

Figure 2-6
WCS Wind Rose Plot: ER Tower

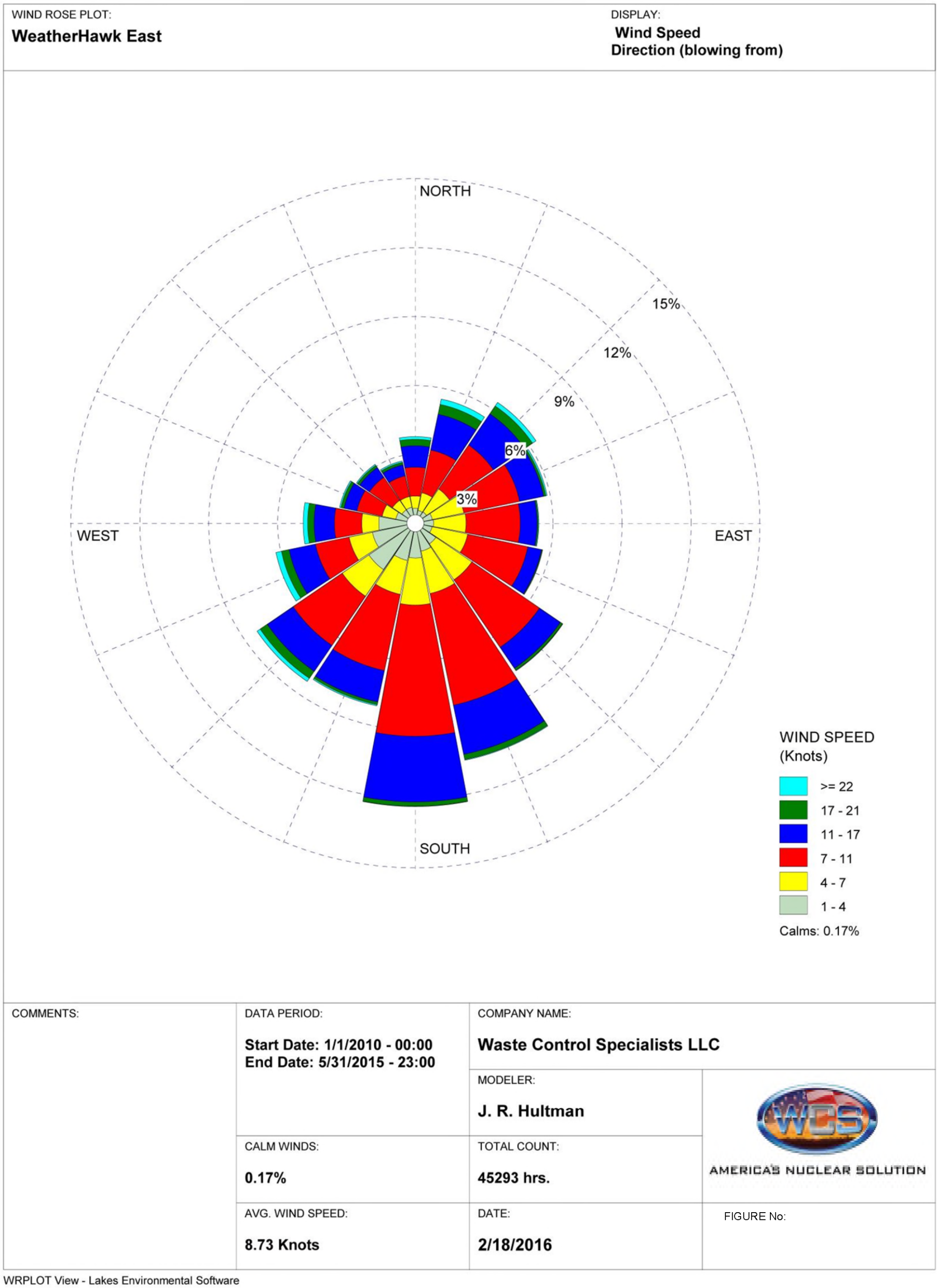
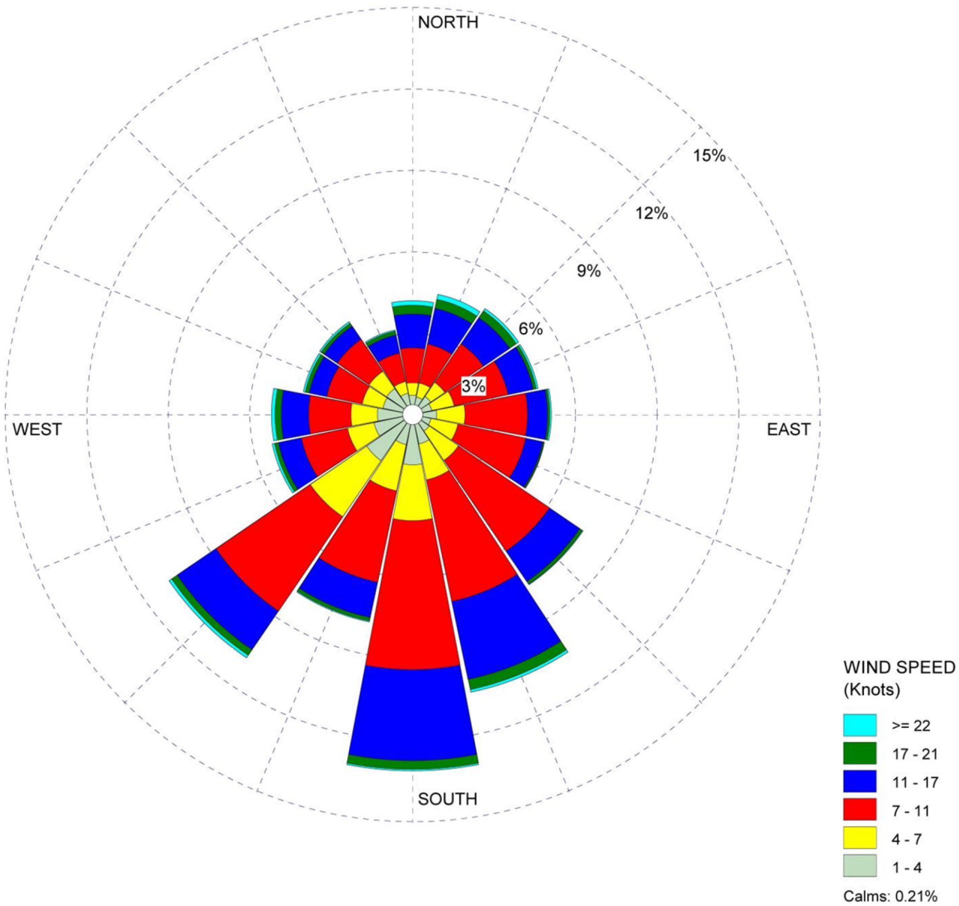


Figure 2-7
WCS Wind Rose Plot: WeatherHawk East

WIND ROSE PLOT:
WeatherHawk West

DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	Start Date: 1/1/2010 - 00:00 **End Date: 5/31/2015 - 23:00**	**Waste Control Specialists LLC**	
		MODELER: **J. R. Hultman**	AMERICA'S NUCLEAR SOLUTION
	CALM WINDS: **0.21%**	TOTAL COUNT: **48500 hrs.**	
	AVG. WIND SPEED: **8.81 Knots**	DATE: **2/18/2016**	FIGURE No:

WRPLOT View - Lakes Environmental Software

Figure 2-8
WCS Wind Rose Plot: WeatherHawk West

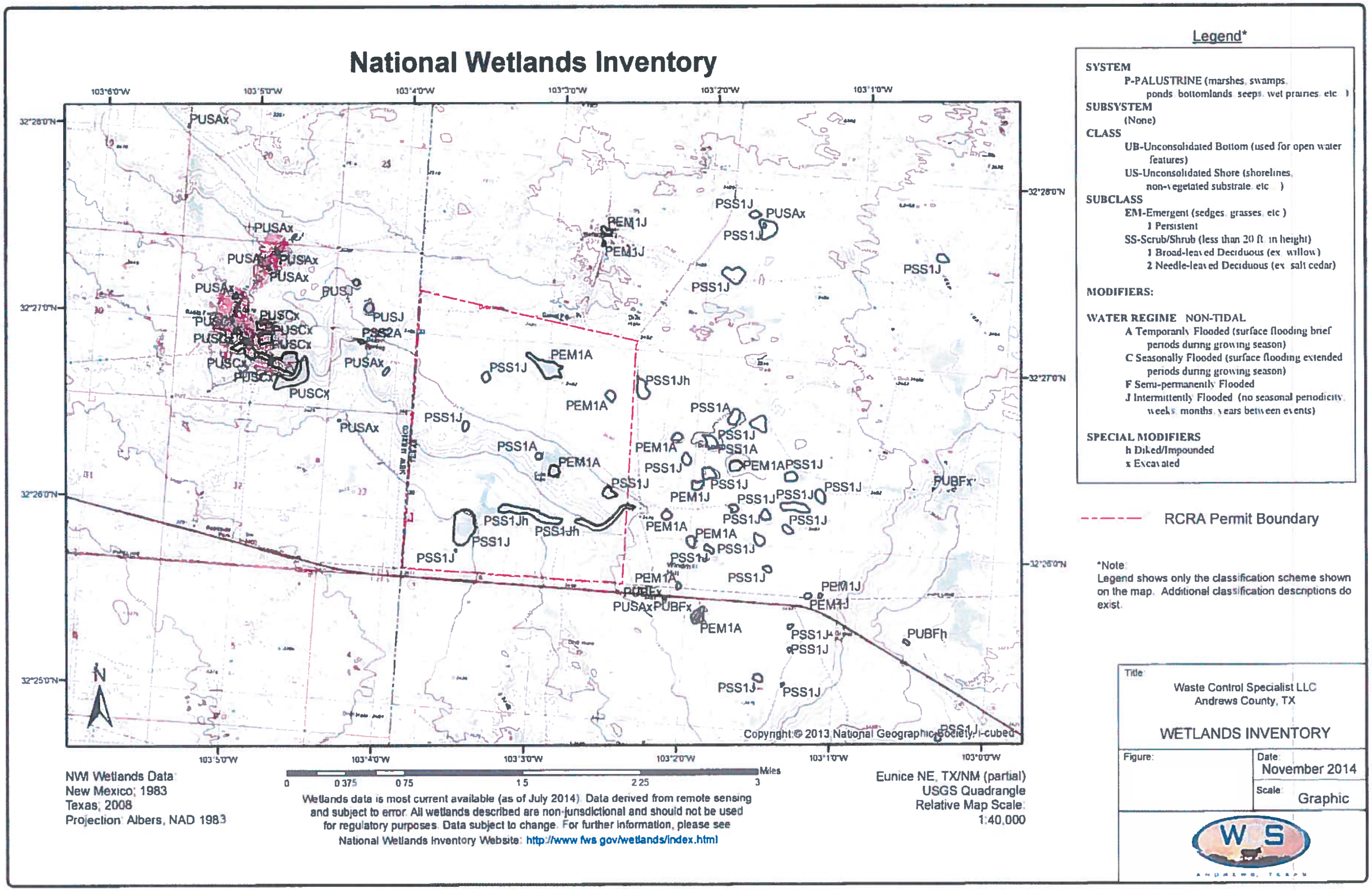


Figure 2-9
Wetlands Inventory

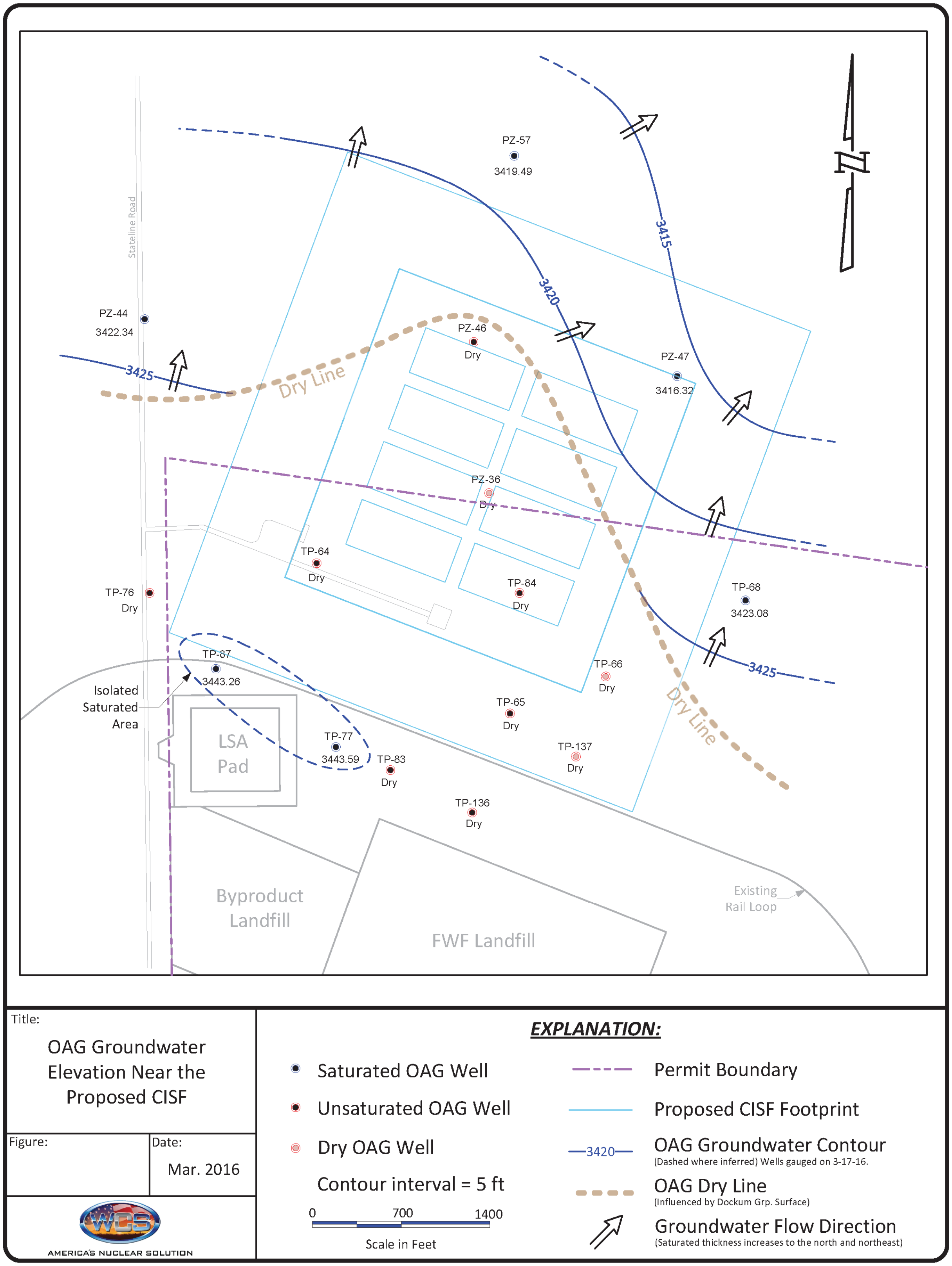


Figure 2-10
OAG Groundwater Elevation Near the Proposed WCS CISF

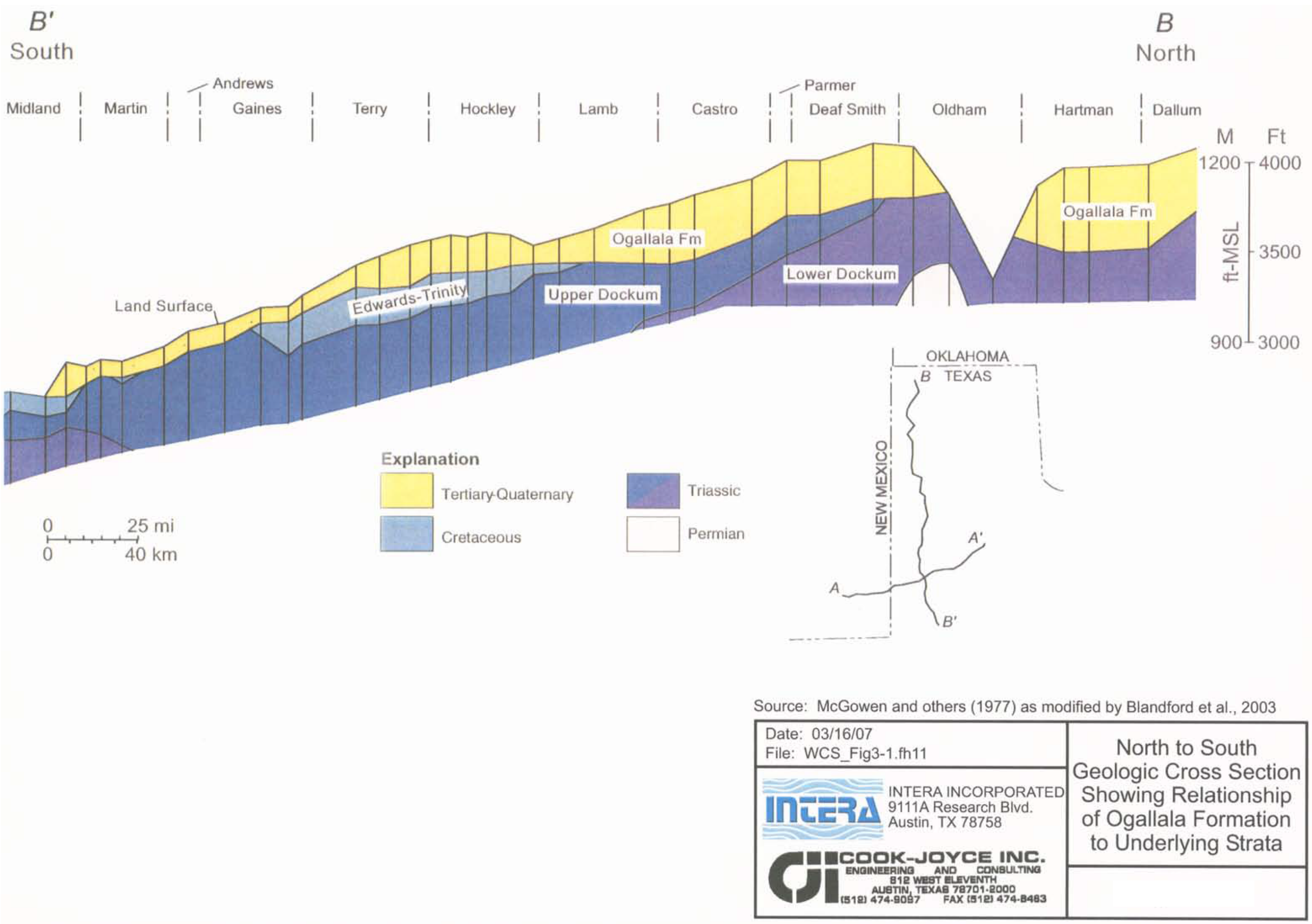


Figure 2-11
West to East Geologic Cross Section Showing Relationship of Ogallala Formation to Underlying Strata

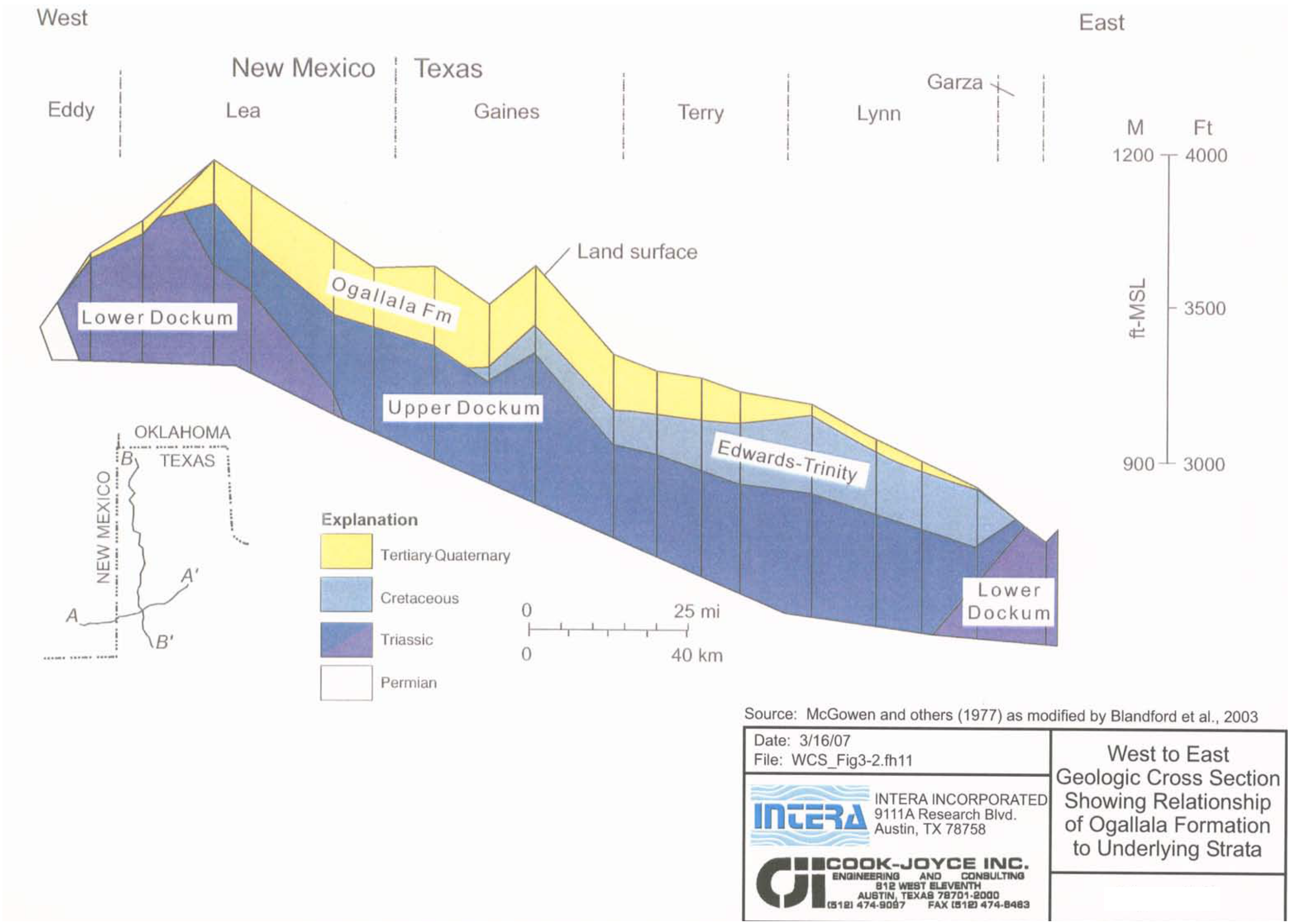
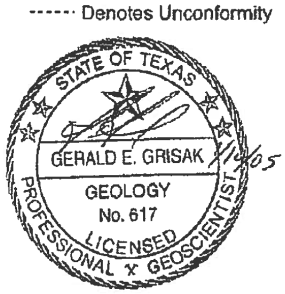


Figure 2-12
North to South Cross Section Showing Relationship of Ogallala Formation to Underlying Strata

Years BP (millions)	SYSTEM/SERIES		GROUP	FORMATION	
0.01	QUATERNARY		RECENT/HOLOCENE	Windblown Sand	Playa Deposits
			PLEISTOCENE	Blackwater Draw or Tahoka	
1.6	TERTIARY			Ogallala	Gatuna
66	CRETACEOUS		COMMANCHEAN	Duck Creek	
				Kiamichi	
				Edwards	
				Comanche Peak	
				Walnut	
				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



Date: 02/06/04
File: WCS_Fig6.2-2.ai

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Stratigraphic Column
Central Basin Platform

Figure 2-13
Stratigraphic Column Central Basin Platform