SECTION VI

GEOLOGY REPORT

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The copy of this report (CJI, 2004) was provided to AREVA by WCS.
It is missing copies of several figures, all appendices, and one plate, as follows:

- Figures 6.5-1 through 6.6-7
- Appendices 6.2-1 through 6.6-7
- Plate 6.2-1

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GEOLOGY REPORT INTRODUCTION

The Waste Control Specialists LLC (WCS) facility in northwestern Andrews County was permitted in 1994 as a Class I hazardous waste landfill pursuant to 40 CFR Part 270, 30 TAC Chapter 305 (C) and (D) and 30 TAC Chapter 335.

The WCS site is located at the southwestern edge of the Southern High Plains, approximately 30 miles northwest of the City of Andrews (Figure 6.0-1). The WCS facility including the existing landfill, the RCRA permitted area, and the Flying W Ranch is shown on Figure 6.0-2. This part of Andrews County is a gently southeastward sloping plain with a natural slope of about 8 to 10 feet per mile. The immediate landfill vicinity is underlain primarily by the Late Tertiary/Quaternary-aged pedogenic Caprock caliche that overlies all pre-Quaternary strata in the High Plains. Quaternary Blackwater Draw eolian sands and younger windblown sands overlie the Caprock caliche in the northern and southern parts of the permitted area. Below the Caprock caliche are sands and sandstones that have been variously ascribed to the Tertiary Ogallala Formation, the Tertiary-aged sections of the Gatuna Formation, and the Cretaceous Antlers Formation. The sands and sandstones underlying the Caprock caliche 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 undifferentiated sands and sandstones of the Ogallala/Antlers/Gatuna Formations underlying the Caprock caliche and overlying the Dockum Group are herein referred to as the OAG hydrostratigraphic unit, or simply the OAG unit.

The WCS facility is located over a geologic feature referred to as the red bed ridge. The red bed ridge is a prominent buried ridge developed on the upper surface of the Triassic Dockum Group. The Dockum Group red beds are present beneath the entire WCS facility at depths ranging from about 8 feet over the crest of the red bed ridge to about 60 to 70 feet on the northern and southern boundaries of the permitted area. The lower part of the WCS landfill excavation lies within the upper 40 to 60 feet of the Dockum Group.

The OAG unit, which overlies the Dockum Group, is largely unsaturated over the crest of the red bed ridge beneath the WCS permitted area. The OAG unit is saturated to the northwest and east of the WCS permitted area including the extreme east central portion of the permitted area.

The Dockum Group is over 1,000 feet thick beneath the WCS facility. The first potential transmissive zones in the Dockum Group beneath the facility are discontinuous sandstones/siltstones at depths of up to 125 feet; however this zone has never yielded groundwater to monitor wells completed in the zone. Five monitor wells completed in the 125 foot zone have been dry since installation in 1996 and 1998. The next potential transmissive zone is a discontinuous sandstone/siltstone at a depth of about 180 feet. The uppermost continuous transmissive zone, which is the water bearing zone in which the facility's upgradient and downgradient monitor wells are screened, is a laterally continuous 10 to 30 foot thick sandstone/siltstone at a depth of about 225 feet. This unit is saturated and has very low permeability. The non-potable water supply for the WCS facility is obtained from the sandstone sections of the lower Dockum Group Santa Rosa Formation at a depth of about 1,140 to 1,400 feet below ground surface. A secondary supply is obtained from the lower Dockum Group Trujillo Formation sandstone at a depth of about 600 to 700 feet below ground surface. Potable water for the WCS facility is obtained by pipeline from Eunice, New Mexico.

1.0 REGIONAL PHYSIOGRAPHY AND TOPOGRAPHY

The WCS facility is located in west Texas, which lies within the southern portion of the North American Great Plains Physiographic Province. The site is situated in northwest Andrews County on the southwestern edge of the Southern High Plains, or the Llano Estacado (Figure 6.1-1). 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. It is bounded on the north by the southern escarpment of the Canadian River and on the east by the Caprock escarpment developed by the headward erosion of the upper tributaries of the Colorado, Brazos and Red Rivers. The western boundary is the Mescalero Ridge escarpment of the Pecos River valley. The southern boundary, which is not distinctly defined, blends into the Edwards Plateau. The Basin and Range Physiographic Province lies to the west of the Southern High Plains, and the Rolling Plains Physiographic Province lies to the east. The regional topographic slope is toward the southeast at about 8 to 10 feet per mile.

Mescalero Ridge, which defines the western edge of the Southern High Plains, is topographically expressed about 15 miles to the northwest of the site in western Lea County, New Mexico. The ridge is a nearly perpendicular cliff facing southwest with a relief of 100 to 150 feet.

The nearest surface water drainage feature to the WCS facility is Monument Draw in Lea County, New Mexico, a reasonably well-defined, southward-draining draw about 3 miles west of the WCS site. 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 facility 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).

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 permitted area, 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 facility. 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 landfill. Remnant deposits of a filled and now partially covered playa or salt lake basin are found about 2.5 miles east of the permitted area. Surface drainage from the area north and east of the WCS facility flows eastward into this basin.

Local topographic features outside the permitted area include Baker Spring to the west, small depressions or solution pans between Baker Spring and the permitted area, and a spring about 3 miles to the east on the western side of the partially covered playa or salt lake basin.

Baker Spring is located in Lea County, New Mexico, about 1925 feet west of the permitted area. Two surface draws empty into the Baker Spring depression. As discussed in Section 5.0 (Site Subsurface Soils Investigation), Baker Spring is the site of a former quarry area.

Brune (1981) indicates a historical spring (Scratch Spring) about 3 miles east of the permitted area, on the western side of the partially covered playa or salt lake basin. According to Brune (1981), the spring was dry in 1923 although the depression was reported to have water. The three small depressions, or solution pans, west of the permitted area are included in the discussion of local depressions in Section 4.3.1.3.

Other land uses within a few miles of the WCS facility include agricultural farming and ranching, drill sites for oil and gas wells (Railroad Commission records for an oil well located near the southwest corner of the permitted area indicate the well was completed in 1991, with the last recorded production in 1993); quarrying operations; 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 landfill site. 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 facility.

2.0 REGIONAL GEOLOGY

This section discusses the regional geology from ground surface to a depth of approximately 1400 feet, which includes the lowermost underground source of drinking water (USDW). The geologic deposits in the vicinity of the WCS facility have been mapped and evaluated in detail by Dr. T. M. Lehman and Dr. K. Rainwater in a recent report to the Andrews Industrial Foundation (Appendix 6.2-1). The evaluation in Appendix 6.2-1 is utilized to some extent in the following discussion of the regional geology. The Hobbs Sheet of the Geologic Atlas of Texas showing the area surrounding the proposed WCS landfill site is provided as Plate 6.2-1. Two regional cross sections developed by Terra Dynamics (1993) using oil and gas well logs are provided as Plate 6.2-2 and Plate 6.2-3. The locations of the cross sections are shown on Figure 6.2-1.

The geologic formations in the vicinity of the WCS facility comprise, from oldest to youngest, the Triassic Dockum Group, the Cretaceous Trinity Group Antlers Formation, the Late Tertiary Ogallala Formation, the Late Tertiary/Quaternary Gatuna Formation or Cenozoic Basin Fill, the Pleistocene windblown sand of the Blackwater Draw Formation, and Holocene windblown sands and playa deposits. A regional hard caliche, termed the Caprock caliche, developed on all pre-Quaternary formations before the Blackwater Draw windblown sands were deposited.

A stratigraphic column for the above units is provided in Figure 6.2-2. This stratigraphic column adopts the nomenclature of Lehman (1994a, 1994b) 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).

2.1 TRIASSIC DOCKUM GROUP

The Triassic Dockum Group disconformably overlies the Permian stratigraphic sequence within the region. The Dockum Group consists of five formations; the lowermost 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 facility. The Dockum Group consists of a series of fluvial and lacustrine mudstone, siltstone, sandstone, and silty dolomite deposits (McGowen et al., 1979),

which range up to approximately 1400 feet thick in the area of the Central Basin Platform. These sediments accumulated in a variety of continental depositional settings, including braided and meandering streams, alluvial fan deltas, lacustrine deltas, lacustrine systems, and mud flats (McGowen et al., 1979).

Figure 6.2-3 shows the inferred paleogeographic setting that existed during the deposition of the Dockum Group. McGowen et al. (1979) interpret that the Dockum Group accumulated in an inland fluvial-lacustrine basin. The terrigenous clastics of the Dockum Group deposited in the Permian Basin area were mainly derived from older sedimentary rocks that accumulated in Texas and New Mexico. In southeastern New Mexico and the Andrews County, Texas area, the sediments were derived from upland source areas to the south and west.

The lowermost part of the Dockum Group is the Santa Rosa Formation sandstone, which is about 200 to 250 feet thick. The Santa Rosa Formation comprises a lower sandstone member, a middle sandstone member, a middle shale member and an upper sandstone member (McGowen et al., 1979). The lower sandstone member, comprising 70 to 80 feet of medium- to fine-grained sandstone and some conglomerates, is characterized by overlapping thin, relatively broad, channel-fill sandstone bodies, which were deposited in an alluvial fan or a fan–delta system. The middle sandstone member is a coarse-grained meanderbelt sequence (McGowen and Garner, 1970; Levey, 1976, as referenced by McGowen et al., 1979) about 75 to 80 feet in thickness. The shale member overlying the middle sandstone is an olive-gray lacustrine claystone with plant material, and siltstone and sandstone lenses with a total thickness of about 75 feet. The upper sandstone is about 20 feet of very fine-grained sandstone overlain by about 10 feet of trough-fill, fine to medium-grained sandstone.

The Santa Rosa Formation sandstone is the lowermost formation used as a groundwater source in the area. The Santa Rosa sandstone yields brackish water from a depth of about 1,140 to 1,400 feet below ground surface from the central water supply well located between the ranch house immediately east of the WCS facility and the permitted landfill (Plate 6.2-2; the central well is named Great Western Drig. Scratch Royalty # 1-A).

The Tecovas Formation consists primarily of lacustrine claystone and siltstones between the Santa Rosa Formation sandstone and the Trujillo Formation sandstone. The Tecovas Formation is about 400 to 500 feet thick in the WCS area (Plates 6.2-2 and 6.2-3).

The middle sandstone of the Dockum Group is the Trujillo Formation sandstone. The Trujillo Formation is a fine-grained sandstone that is typically gray or greenish-gray in unweathered section. The Trujillo Formation Sandstone occurs at a depth of about 600 feet in the WCS area (see cross sections on Plates 6.2-2 and 6.2-3) and is about 100 feet thick.

Overlying the Trujillo Formation sandstone are the red or purple shales and siltstones of the Cooper Canyon Formation. The Cooper Canyon Formation has been historically referred to as the Chinle Formation in the Southern High Plains region (Appendix 6.2-1); however, the geologic evaluation by Texas Tech University provided in Appendix 6.2-1 indicates that the correct name for this unit is the Cooper Canyon Formation. There may be instances herein or elsewhere where Chinle is used instead of Cooper Canyon. For clarity, where this report uses the term Triassic red beds, red beds, or Chinle, the referenced formation is the Cooper Canyon Formation of the Dockum Group. The Cooper Canyon Formation has a thickness of the order of 500 feet in the WCS vicinity..

The Dockum Group is disconformably overlain in some areas of the Southern High Plains by Cretaceous rocks and in other areas by the Tertiary Ogallala Formation or the Tertiary/Quaternary Gatuna Formation. The Jurassic Period is not represented in the stratigraphic section of the area.

2.2 CRETACEOUS FORMATIONS

Cretaceous rocks were deposited in a shallow sea throughout the Texas Panhandle and eastern New Mexico (Nativ and Gutierrez, 1988). The entire Cretaceous stratigraphic section in this area comprises, from oldest to youngest, the Antlers, Walnut, Comanche Peak, Edwards, Kiamichi, and Duck Creek Formations (Appendix 6.2-1, Nativ and Gutierrez, 1988). The Walnut, Comanche Peak, Edwards, Kiamichi, and Duck Creek Formations are shown as the Fredricksburg Group on the Hobbs Geologic map sheet (Plate 6.2-1). The Comanche Peak

Formation is also mapped as the Fort Terrett Formation on the Hobbs sheet. The Cretaceous rocks dip southeastward at about 7 to 8 feet per mile (Nativ and Gutierrez, 1988).

The Cretaceous section thins and is absent in western Andrews County and southern Gaines County as shown on Figure 6.2-4 (Nativ and Gutierrez, 1988). However, Barnes (1976) indicates minor outcrops of the Cretaceous Fort Terrett (Comanche Peak) and Antlers Formations at Whalen Lake and Shafter Lake, 16 and 24 miles, respectively, east-southeast of the WCS facility, and in New Mexico about 1 mile west of the WCS facility (Plate 6.2-1). Lehman and Rainwater (Appendix 6.2-1) also indicate that a thick bed of limestone exposed in the floor of a gravel pit about one mile southeast of the permitted area is likely the Comanche Peak Formation. Lehman and Rainwater also determined that only the basal Cretaceous unit, the Antlers Formation, is present in the immediate vicinity of the WCS facility.

The Antlers Formation is the basal sand unit of the Cretaceous section in the Southern High Plains region. It is also referred to informally and in older literature as the Antlers Sand(stone), the Trinity Sand(stone), or the Paluxy Sand(stone). The Antlers Formation is a weakly cemented, fine- to medium-grained quartz sandstone and chert-pebble conglomerate. Regionally, the thickness of the Antlers Formation is considered to range from 0 to 60 feet (Fallin, 1989). The thickest areas occur in several linear belts trending southeastward, which represent filled channels that had been cut into the underlying Triassic red beds (Fallin, 1989). The Antlers Formation occurs as a buried erosional remnant along the crest of the red bed ridge underlying the WCS facility. Within 1 to 2 miles of the WCS facility, the Antlers Formation has a maximum thickness of 72 feet (Figure 6.2-5). Immediately below the permitted area, the Antlers Formation ranges in thickness from 0 feet in the southwest corner to about 20 feet in the area of the existing landfill.

2.3 TERTIARY OGALLALA FORMATION

The late Tertiary Ogallala Formation consists of fluviatile sand, silt, clay, and gravel capped by caliche (Barnes, 1976). The regional distribution of the Ogallala Formation and Ogallala aquifer has been the subject of considerable research and has been reviewed by numerous authors (e.g. Gustavson, 1996, Blandford et al., 2003). The sand deposits of the Ogallala Formation

consist of fine- to medium-grained quartz grains that are unconsolidated to weakly cohesive with localized silica-cemented lenses. Bed forms range from indistinctly bedded to massive to crossbedded. The sand intervals of the Ogallala Formation occur in various shades of gray and red.

Ogallala Formation silt and clay deposits are reddish brown, dusky red, and pink and contain caliche nodules. Gravels occur as basal conglomerates in intra-formational channel deposits, and consist primarily of quartz, quartzite, sandstone, limestone, chert, igneous rock, and metamorphic rock.

Within the Southern High Plains, the Ogallala Formation lies unconformably above either Triassic or Cretaceous rocks and occurs as an apron of coalescing alluvial fan lobes that extend eastward from the Rocky Mountains. The Ogallala alluvial outwash plain was dominated by braided streams and extends from South Dakota to the Texas Panhandle (Seni, 1980).

A depositional facies map of the Ogallala Formation, shown on Figure 6.2-6, and a structure contour map of the base of the Ogallala, shown on Figure 6.2-7, indicate the braided nature of the Ogallala depositional environment. The headward erosion of major rivers, such as the Pecos River in New Mexico and the Canadian, Colorado, and Brazos Rivers in Texas, and their various tributaries, has regionally modified the surface expression of the Ogallala Formation. Consequently, portions of the Ogallala Formation have been erosionally removed, exposing deeper, older stratigraphic units. The Ogallala Formation typically ranges from 9 to 200 feet in thickness in the south portion of the Southern High Plains and reflects the underlying paleotopography. In the area shown on Plate 6.2-1, the Ogallala Formation ranges from 0 to 100 feet in thickness (Barnes, 1976).

2.4 LATE TERTIARY/QUATERNARY GATUNA FORMATION

The Late Tertiary or Quaternary Gatuna Formation, which is part of the Cenozoic Basin Fill of the Pecos River valley, exists in the equivalent stratigraphic interval as the Ogallala Formation southwest of the red bed ridge in the vicinity of the WCS facility (Appendix 6.2-1). Some of these deposits southwest of the red bed ridge have been mapped as the Ogallala Formation

(Nicholson and Clebsch, 1961; Barnes, 1976), but Lehman and Rainwater (Appendix 6.2-1) conclude that these sediments may more logically be included with the Gatuna Formation, as suggested by Hawley (1993).

The Gatuna Formation and the rest of the Cenozoic Basin Fill occur as alluvial deposits in Monument Draw, New Mexico and in the Pecos River valley in general. The Pecos River valley and Monument Draw, New Mexico developed in response to subsurface dissolution of evaporites in the Pecos Trough and Monument Draw Trough of the Delaware Basin (Ashworth, 1990).

The Gatuna formation is quite thin in the WCS area, although it is about 60 feet thick in Monument Draw, New Mexico a few miles to the west where it was mapped by Nicholson and Clebsch (1961) as the Ogallala Formation. In the WCS area, the Gatuna Formation consists of 15 to 20 feet of coarse, red, cross-bedded, gravelly sand, with large boulders of sandstone and limestone.

2.5 LATE TERTIARY/QUATERNARY CAPROCK CALICHE

The pedogenic Caprock caliche is a thick, hard caliche unit that has developed over all pre-Quaternary formations in the Southern High Plains. The Caprock caliche is not considered a formal stratigraphic unit, and it is frequently considered part of and mapped as the Ogallala Formation (Appendix 6.2-1). The Caprock caliche in the vicinity of the WCS facility is hard, laminated and pisolitic, with chert pebbles (Appendix 6.2-1). It is typically 5 to 10 feet thick but can be as thick as 20 feet or more. In thick areas, nodules and layers of opal have formed as replacement mineralization. Where exposed at surface, the Caprock caliche is weathered and broken into rubble. The Caprock caliche is distinguished from caliches in overlying sediments by its hard, laminated and pisolitic form, compared to the lighter, softer, sandier and less dense younger caliches. In the immediate vicinity of the WCS landfill, the Caprock caliche is exposed at surface or covered by a thin veneer of windblown sand.

2.6 QUATERNARY BLACKWATER DRAW FORMATION

The Quaternary Blackwater Draw Formation was formerly referred to as windblown cover sand and is mapped as Qcs on Plate 6.2-1. The Blackwater Draw Formation forms an extensive cover over virtually all of the Southern High Plains. The windblown sands, silts, and clays were derived from the alluvial sediments in the Pecos River valley to the west (Holliday, 1989). Grain size of the eolian Blackwater Draw Formation in the Southern High Plains decreases from sand in the southwest to clay-size particles in the northeast. Several soil horizons have developed in the Blackwater Draw Formation, with varying degrees of caliche development. Regionally, the Blackwater Draw Formation ranges from 0 to 100 feet thick (Holliday, 1990).

2.7 QUATERNARY HOLOCENE AND PLEISTOCENE PLAYA DEPOSITS

Playa deposits mapped on the Hobbs Sheet (Plate 6.2-1) are both Holocene and Pleistocene in age. The older Pleistocene deposits are mapped as the Tahoka Formation (Qta), and the younger playa deposits, which are either Holocene or late Pleistocene, are mapped simply as playa deposits (Qp). Playa deposits typically range from 3 to 30 feet in thickness (Holliday et al., 1996).

The Tahoka Formation comprises lacustrine clays, silts, sands and gravels that are locally calcareous and selenitic. The clays and silts are indistinctly bedded, sandy and weakly coherent, and various shades of light gray and bluish gray. The sands are fine- to coarse-grained quartz, indistinctly bedded to massive, friable, gray, and grading to gravel at the margins of the deposits (Barnes, 1976). The deposits may also contain late Pleistocene molluscan and vertebrate fossils.

The late Pleistocene/Holocene playa deposits, mapped on the Hobbs Sheet as Qp, comprise sandy clay and silt in shallow depressions and are colored light to dark gray. The late Pleistocene deposits are usually covered by a thin deposit of recent sediments. The mapped playa deposits in the immediate vicinity of the WCS facility are Holocene/late Pleistocene.

2.8 HOLOCENE WINDBLOWN SAND

Windblown Holocene sands, mapped on the Hobbs sheet as Qsu, occur to the north and south of the WCS facility. The sands are partially stabilized by vegetation but can be seen in time-series aerial photographs to be undergoing transport as active dunes. The Holocene sands overlie the Pleistocene Blackwater Draw Formation and are typically 5 to 10 feet thick.

2.9 OAG UNIT AT THE WCS FACILITY

At the WCS facility, the Tertiary Ogallala Formation and the Late Tertiary/Quaternary Gatuna Formation occur in the same stratigraphic interval as the Cretaceous Antlers Formation (Appendix 6.2-1). The Ogallala Formation occurs to the northeast of the red bed ridge, on the Southern High Plains proper, while the Gatuna Formation occurs to the southwest of the red bed ridge, and the Antlers Formation occurs as an erosional remnant on the crest of the red bed ridge. The undifferentiated sands and sandstones of the Ogallala, Antlers, and Gatuna Formations overlying the Dockum Group red beds are referred to as the OAG unit. A schematic cross section shown on Figure 6.2-8 shows the stratigraphic relationships of the OAG unit. The local geologic and hydrogeologic situation is presented in more detail in Section 5.0 (Site Subsurface Soils Investigation) and Section 6.0 (Groundwater).

3.0 REGIONAL AQUIFERS

The High Plains aquifer of west Texas, considered to be the principal aquifer in west Texas, consists of water-bearing units within the Tertiary Ogallala Formation and underlying Cretaceous rocks (Nativ and Gutierrez, 1988). The High Plains aquifer is typically viewed hydrogeologically as a single, hydraulically connected aquifer system, and groundwater typically exists under both unconfined and confined conditions. The term Ogallala aquifer is frequently 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). However, the Ogallala and Cretaceous aquifers have been independently evaluated in the literature and will be addressed individually in the following discussion.

The Cenozoic Basin Fill alluvium and the Triassic Dockum Group are considered minor aquifers in this part of west Texas (TWDB, 2001) and will also be addressed below.

3.1 OGALLALA AQUIFER

The Ogallala aquifer, which consists of the Ogallala Formation, 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). The southern limit of the Ogallala aquifer is north of the red bed ridge at approximately the northern and eastern boundaries of the WCS permitted area.

Regionally, the Ogallala aquifer thickens to the north and west (Blandford et al. 2003) as shown on cross sections in Figures 6.3-1 and 6.3-2. The saturated thickness of the Ogallala aquifer ranges from a few feet to approximately 300 feet in the Southern High Plains (Nativ, 1988). 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, as illustrated on Figure 6.3-3. The average hydraulic conductivity of the Ogallala aquifer is about 10 feet/day, as illustrated in Figure 6.3-4, with higher values preferentially distributed in depositional channels (Figure 6.3-5). Assuming an average hydraulic gradient of 12.5 feet/mile and a porosity of 0.20, the average rate of flow in the 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). Regionally, the recharge rate to the Ogallala aquifer is estimated to be of the order of 0.35 inches/year (Mullican et al., 1997). Blandford et al. (2003) estimated predevelopment recharge at less than 0.083 inches/year. In a recent 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). 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 have remained reasonably stable over the last decades or even increased, indicating that recharge is the same or greater than discharge/pumping (Blandford et al., 2003). Water levels in three wells in Andrews County with a period of record of 40 to 50 years have remained stable over the entire period (Figure 6.3-6).

Water quality data for three Ogallala aquifer wells, located within two miles of the site, were obtained from a review of Texas and New Mexico state records for western Andrews County, Texas and eastern Lea County, New Mexico. These water well locations are provided in Table 6.3-1, and water quality data for these wells are provided in Table 6.3-2. The well locations are provided on Figure 6.0-2.

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 is not water bearing in the WCS permitted area (Figure 6.3-7).

3.2 CRETACEOUS AQUIFER (ANTLERS FORMATION)

The Cretaceous aquifer of the Southern High Plains is typically considered as part of the High Plains Aquifer (Nativ and Gutierrez, 1988). 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 in the subsurface, the Cretaceous aquifer is used in the Southern High Plains as a source of groundwater (Nativ and Gutierrez, 1988). The Cretaceous Antlers Formation has been identified in the vicinity of the WCS facility and in the subsurface immediately below the facility (Appendix 6.2-1); however, it is unsaturated but for a few isolated pockets and at the extreme east central portion of the permitted area (see Section 6.0).

3.3 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 facility. 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).

There are two water-bearing sandstone formations in the Dockum Group in the vicinity of the WCS facility. 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). The top of the Santa Rosa Formation sandstone is at 1,140 feet below ground surface at the WCS facility (Plate 6.2-2). The top of the 100-foot thick Trujillo Formation sandstone, the other Dockum Group water-bearing formation in the area, is at about 600 feet below ground surface (Plate 6.2-2).

The lower Dockum Group aquifer is recharged by precipitation where Dockum Group sediments are exposed at land surface (Bradley and Kalaswad, 2003). 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; Dutton and

Simpkins, 1986) 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 (Figure 6.3-8). 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). The regional hydraulic gradient of the lower Dockum aquifer, which is toward the southeast at approximately 15 feet/mile, is provided in Figure 6.3-9. Based on water levels encountered during logging of the two WCS non-potable water wells, 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 860 ft^2/day to about 30 ft^2/day and storativity, based on two values, is 0.0001 and 0.002 (Dutton and Simpkins, 1986). 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; Dutton and Simpkins, 1986). 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 (Figure 6.3-10). 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). 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.

3.4 CENOZOIC BASIN FILL AQUIFER

The Cenozoic Basin Fill aquifer, also referred to as the Pecos Alluvium aquifer (Jones, 2001), is a minor regional aquifer and is not present in the vicinity of the WCS facility. The Cenozoic Basin Fill alluvial deposits (Gatuna Formation) have been identified on the southwest slope of the permitted area (Appendix 6.2-1); however, they are not water bearing and do not constitute an aquifer.

4.0 ACTIVE GEOLOGIC PROCESSES

This section addresses the requirement to provide a description of the active geologic processes in the vicinity of the facility. Active geologic processes include flooding and submergence, faulting, seismicity, land surface subsidence, and the potential for surface erosion. Flooding is addressed by locating the facility out of a 100-year floodplain and submergence applies only to coastal zones. Faults, seismicity, land surface subsidence, and surface erosion are discussed in the following sections.

4.1 FAULTS

This section provides an analysis of faults in the vicinity of the facility at the regional and local scales. The requirements of 30 TAC 305.50(4)(F) and 30 TAC 305.50(10)(E) require delineation of all faults within 3000 feet of the facility, together with a demonstration that:

(i) the fault has not experienced displacement within Holocene time, or if faults have experienced displacement within Holocene time, that no such faults pass within 200 feet of the portion of the surface facility where treatment, storage, or disposal of hazardous wastes will be conducted; and

(ii) the fault will not result in structural instability of the surface facility or provide for groundwater movement to the extent that there is endangerment to human health or the environment.

The WCS site is situated over the north central portion of a prominent Paleozoic structural feature known as the Central Basin Platform. Faults are only known in the deep subsurface as interpreted from petroleum exploration activities. The faults are expressed in Paleozoic rocks at depths of thousands of feet. The deep faults lose their expression as stratigraphic offsets after early Permian (Wolfcampian) time. 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). 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

area of active regional tectonic stress and active faulting is the Rio Grande Rift that forms the eastern boundary of the Basin and Range Province. The Rio Grande Rift is over 200 miles west of the WCS area. There is no surface evidence of faulting within 3000 feet the WCS permitted area.

4.1.1 Regional Tectonic Setting and Faults

The WCS facility is located within the Permian Basin region of west Texas. The Permian Basin derives its name from the fact that it is underlain by extensive deposits of Permian sediments.

4.1.1.1 Tectonic Setting

The WCS site is situated over the north-central portion of a prominent structural feature known as the Central Basin Platform (Figure 6.4-1). 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 by two prominent 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 only mild structural deformation that produced broad regional arches and shallow depressions (Wright, 1979). The Central Basin Platform served intermittently as a slightly positive feature during the early Paleozoic (Galley, 1958). During the Mississippian and Pennsylvanian, the Central Basin Platform uplifted using ancient lines of weakness (Hills, 1985), and the Delaware, Midland, and Val Verde Basins began to form as 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). Highly deformed local structures formed ranges of mountains oriented generally parallel to the main axis of the platform (Wright, 1979).

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). 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 (Figure 6.4-2).

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). In Jurassic time, the area was again subject to erosion.

During Cretaceous time, a large part of the western interior of North America was submerged, and the west Texas/southeastern New Mexico region was part of a large continental shelf sea in which a thick sequence of Cretaceous rocks was deposited. The Cretaceous sequence of sediments comprised a basal clastic unit (the Trinity, Antlers or Paluxy sands) and overlying shallow marine carbonates.

Uplift 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 late Tertiary Ogallala Formation. The major episode of Laramide folding and faulting occurred in the late Paleocene. There have been no major tectonic events within the Permian Basin since the Laramide Orogeny, except for a period of minor volcanism during the late Tertiary in northeastern New Mexico and in the Trans-Pecos area. Hills (1985) 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).

4.1.1.2 Faults

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). The traces of these faults are shown on the Precambrian structure map provided in Figure 6.4-3. 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) (Figure 6.4-4).

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). The east-west and north-south regional cross-sections provided in Figures 6.4-5 and 6.4-6 illustrate this relationship. Figure 6.4-5 shows the draping of the Permian and Triassic sediments over the Central Basin Platform structure, located approximately 7000 feet beneath the present land surface. The faults that uplifted the platform do not appear to displace the younger Permian sediments. The northernmost fault on Figure 6.4-6, located at the Matador Uplift, terminates in lower Wolfcampian sediments.

A further comparison of the structure of the Devonian Woodford Formation to the structure of the younger Upper Guadalupe Whitehorse Group (Permian) (Figures 6.4-7 and 6.4-8) indicates that the faults in the Devonian section do not continue upward into the overlying Permian Guadalupe Whitehorse Group. The regional geologic and tectonic information does not indicate the presence of post-Permian faulting within the regional study area. In addition, the local information does not indicate Holocene displacement of faults within 3000 feet of the proposed WCS landfill site. The site-specific structural setting is discussed below.

Two regional stratigraphic cross sections constructed in the vicinity of the WCS site using oil and gas well logs are shown as Plates 6.2-2 and 6.2-3. The locations of the cross sections are shown in Figure 6.2-1. These cross sections depict the major stratigraphic units that occur

within about 2000 feet below ground surface in the vicinity of the site. The stratigraphic units depicted on Plates 6.2-2 and 6.2-3 include the upper OAG 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 evaporites of the Rustler and Salado Formations. These cross sections do not indicate the presence of faulting in the upper 2,000 feet of sediments within 3 to 4 miles of the WCS site. The base of the underground source of drinking water (USDW) is the bottom of the Santa Rosa Formation at about 1,400 feet below ground surface in the vicinity of the WCS facility. The Santa Rosa Formation is the lowermost formation of the Triassic Dockum Group.

There is no evidence of displacement or offset of post-Permian sediments including Holocene sediments in the vicinity of the landfill. The WCS landfill excavation exposed the OAG unit, which includes the Caprock caliche, overlain by minor amounts of Blackwater Draw Formation and recent cover sand. The Blackwater Draw Formation typically has relatively well-developed soil horizons as well as calcic horizons. No offset or displacement was documented in the OAG unit, including the Caprock caliche, or the Blackwater Draw sediments, buried soil horizons, or the surface soil horizon.

4.1.2 Seismicity

The WCS facility 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 (EPRI, 1993). Crustal thickness in the vicinity of the WCS facility is approximately 30 miles (50 km), one of the three thickest crustal regions in North America (Mooney and Braile, 1989). In comparison, the crustal thickness of the Rio Grand Rift is as little as 7.5 miles (12 km) in places. Further, the seismic velocity of the crust in the Southern Great Plains implies that the crust is unusually intact and continuous in this region (EPRI, 1989).

The Central Basin Platform is an area of moderate, low intensity seismic activity based on observational data obtained from the National Geophysical Data Center of the National Oceanic and Atmospheric Administration (NOAA, 1992) and the U.S. Geological Survey (USGS) Earthquake Data Base available from the National Earthquake Information Center

(http://neic.usgs.gov/). Table 6.4-1 provides the historical seismic activity within 250 kilometers of the WCS facility (32.433°N, 103.05°W). Table 6.4-1 includes the data through 1992 from the NOAA data base, which was submitted in the original RCRA permit application, updated with information through 2003 from the national seismic data base operated by the USGS. The computer search for all recorded seismic activity within a 250 km (155 mile) radius of the proposed WCS landfill site provided a list of 188 seismic events (188 total with 68 suspected duplicates by Terra Dynamics (1993)) during the period from 1931 to 2003. Seismic activity for New Mexico and bordering areas, which includes Andrews County, is shown on Figure 6.4-9. With respect to seismicity in the WCS area, Sanford et al. (2002) indicate that a large fraction of activity in southeastern New Mexico and adjacent areas of west Texas is induced by oil and gas production, secondary recovery, or waste injection.

Figure 6.4-10 illustrates the largest earthquakes (moment magnitudes >3) from the same data set used to develop Figure 6.4-9. The largest earthquake in the vicinity of the WCS facility, referred to as the Rattlesnake Canyon earthquake with a magnitude of 5, occurred in 1992. The Rattlesnake Canyon earthquake was located by the seismograph stations monitored by the New Mexico Institute of Mining and Technology at latitude 32°17.80N and longitude 103°10.33W (Sanford et al., 1993), which is approximately 11 miles southwest of the facility. The USGS located the Rattlesnake Canyon earthquake at latitude 32°20.16N and longitude 103°06.06W, about 7 miles southwest of the WCS facility; however, Sanford et al. (1993) indicate that due to the uncertainty in the location reported by the USGS, the location reported by Sanford et al. (1993) is more accurate. The location of the Rattlesnake Canyon earthquake was approximately three miles east of the Paleozoic west platform fault (Figure 6.4-4). The Rattlesnake Canyon earthquake was interpreted by Sanford et al. (1993) as a reverse fault, with movement consistent with the approximately east-west maximum horizontal stress orientation reported by Zoback and Zoback (1991).

The seismic hazard at a particular geographic position is due to ground motion or shaking. Seismic hazard is based on historical seismic activity and frequently presented as Peak Ground Acceleration (PGA) maps. The maps present the probability of the PGA due to earthquakes exceeding a particular value of acceleration (expressed as a fraction or percent of gravitational

acceleration) over a particular time period. A PGA of greater than about 0.2 g is considered the acceleration level at which considerable damage can begin to occur to weakly built structures (Sanford et al., 2002). Figure 6.4-11 is a seismic hazard map of the western United States prepared by the USGS (http://geohazards.cr.usgs.gov/eq/, October 2002 revision). The map indicates that at the 90% probability level over a 50-year time period, the PGA of the southeastern New Mexico/Andrews County area would not exceed approximately 0.03 to 0.04 g (site specific search yields 0.0322 g). Figure 6.4-12 is a similar seismic hazard map of the western United States, which indicates that at the 98% probability level over a 50-year time period, the PGA of the southeastern New Mexico/Andrews County area would not exceed approximately 0.14 to 0.16 g (site specific search yields 0.1535 g). Golder Associates (1998) calculated the PGA at the WCS site for the Rattlesnake Canyon earthquake in the range of 0.06 to 0.07 g, which is well below the PGA of 0.2 g where considerable damage can begin to occur to weakly built structures (Sanford et al., 2002). Golder Associates (1998) indicate that these low estimated accelerations are "generally considered to be insignificant to well designed and constructed engineered structures or facilities."

4.1.3 Lineaments

Lineaments are relatively straight physiographic features typically identified by a review of surficial geologic maps, surface topography maps, LANDSAT images, and aerial photographs, including high altitude aerial photographs. Based on Landsat imagery, Finley and Gustavson (1981) identified more than 4600 lineaments throughout the Texas Panhandle, ranging in length from 1.2 miles up to 25 miles (Figure 6.4-13). Finley and Gustavson (1981) noted that the Landsat-identified lineaments fell into six categories: 1) stream segments, or short stream reaches commonly connecting at sharp angular junctions, 2) drainage lines, or linear valley trends independent of the orientation of stream segments within the trend, 3) scarps, or prominent topographic breaks, 4) playa alignments, 5) geologic contacts, or contacts between surficial materials with different reflectivities, and 6) tonal anomalies, or linear features that are not clearly a member of any of the previous categories and may be composites of previous categories.

Finley and Gustavson (1981) conclude that the development of physiographically-expressed lineaments is controlled or at least influenced by geologic structure. They further interpret that since few surface faults are mapped in the study area (91,500 square miles of the Texas Panhandle, including the Southern High Plains and most of Andrews County), joints rather than widespread faults are the likely geologic structural control on lineament development. Joints are fractures or partings in rocks along which movement has been negligible or absent (Dennis, 1972). The development of joints is an indication of the brittle behavior of rock, and is most evident in the Triassic and Permian sandstones within the area of the Southern High Plains. The poorly consolidated sediments of the Ogallala Formation do not exhibit well-developed jointing patterns. The Caprock caliche often exhibits an irregular, nearly orthogonal jointing pattern (Finley and Gustavson, 1981).

Finley and Gustavson (1981) suggest that minor or poorly developed jointing in the Pleistocene and Holocene deposits overlying the Caprock caliche may have offered preferred infiltration focus that could foster playa development at the intersection of joint sets, and that an area of increased joint density may localize playa-lake depressions.

Several mechanisms can account for the relationship between physiographically-expressed surface lineaments and susbsurface jointing. Joints form preferential planes that can be exploited by surficial and subsurface weathering processes. Joints offer paths of weakness and less resistance to erosional processes, allowing the development of surface drainage systems and linear stream segments in preferred orientations. Consequently, drainage systems in the Southern High Plains are often classified as lineaments, since their linear orientation is controlled by the joint systems that they exploit (Finley and Gustavson, 1981). Joints can be propagated upward into geologically younger sediments by many processes, including residual tectonic stresses (Price, 1966), crustal extension due to post-glacial rebound (Grisak and Cherry, 1975), shrinkage and differential compaction related to wetting and drying of clay-rich sediments, and differential compaction and dissolution of underlying materials (Finley and Gustavson, 1981). In the Southern High Plains, the orientation of joints and their associated surface lineations is controlled primarily by historical tectonic and structural trends (Finley and Gustavson, 1981). As shown in Figure 6.4-13, the dominant orientation for surface lineations in

the Southern High Plains is northwest to southeast, with a secondary orientation of northeast to southwest.

At the regional scale mapped by Finley and Gustavson (1981), Figure 6.4-13 shows a multicomponent northwest-southeast lineament approximately 3 to 4 miles in total length about 10 miles north of the WCS facility in Gaines County. The lineament is located in the approximate vicinity of Monument Draw, Texas (note: there are two Monument Draws in the WCS vicinity: one in Texas which starts between Hobbs and Eunice in New Mexico and heads eastward as a tributary to Mustang Creek in Texas; and one which starts west of Monument, New Mexico, continuing southeasterly and turning south around Eunice about 5 miles west of the Texas/New Mexico border). A second lineament at the regional scale identified by Finley and Gustavson (1981) lies in Andrews County, about 14 miles east of the WCS facility. This lineament appears to be the continuation of Monument Draw, Texas. The lineament map of Finley and Gustavson does not indicate the presence of Landsat-identified lineaments at the WCS facility.

Also at the regional scale, Bolden (1984) suggests that there are several regional-scale lineaments 200 to 330 miles in length in Trans-Pecos Texas and the Texas Panhandle oriented between 298° and 306°. The nearest of these to the WCS facility is a shorter offshoot line oriented approximately 345°, extending through Ward and Winkler counties in Texas into Lea County in New Mexico. The offshoot line appears to be defined by Monument Draw, New Mexico and its southern extension to the Pecos River through Winkler and Ward Counties, Texas.

At the local scale, lineaments were identified by Terra Dynamics in the vicinity of the WCS site based on an analysis of NASA color-infrared aerial photographs (Terra Dynamics, 1993). Terra Dynamics indicated the lineaments were related to linear drainage features and ground surface color tone anomalies. The lineaments were shown as straight lines on the color infrared imagery used by Terra Dynamics (Terra Dynamics, 1993, Figure VI.A.12). Terra Dynamics identified 5 northwest trending lineaments. The southernmost of these lineaments extended through the WCS facility. Terra Dynamics also identified two north trending lineaments between

the WCS site and Eunice. The lineament through the WCS site was described as an anomaly in the ground surface color tone on the color-infrared

Figure 6.4-14 is a 1983 color infrared photograph of the WCS area from the National High Altitude Program (note: the 1982 photograph included in the Terra Dynamics Geology report is not available from the EROS data center) and Figure 6.4-15 is a 1986 color infrared photograph of the same area at a slightly different scale. Four of the five northwest and north trending lineaments near the WCS site identified by Terra Dynamics are shown on Figure 6.4-15. The northernmost northwest-trending lineament identified by Terra Dynamics is off the photo approximately 8 miles to the north of the WCS site.

Golder Associates also conducted an analysis of the lineaments in the vicinity of the WCS facility and provided a summary of their evaluation in a draft document to WCS dated January 4, 1999. Lineaments identified by Terra Dynamics and Golder Associates are discussed below.

The southernmost northwest-trending lineament through the WCS facility, identified by Terra Dynamics, is represented by aligned zones of enhanced vegetation, shallow depressions and darker ground tones trending about 300° to 310°. The aligned depressions are most evident where the Caprock caliche is at or very near the surface. The tonal contrast in the center of the photo is where the Caprock caliche is either at ground surface or covered by only a thin veneer of windblown sand. The largest of the depressions, which may be considered a small playa about 15 acres in size, is located about one-half mile northeast of the existing landfill. The alignment of the playas at the WCS site likely results from their development at the intersection of joints, with the primary jointing direction trending 300° to 310°.

Part of the surface expression of the 300° to 310° lineament is a bench in the topography between Windmill Hill and the existing landfill. The bench alignment is coincident with the regional 300° to 320° alignment of lineaments in the Southern High Plains (Finley and Gustavson, 1981) that likely represents one of the primary jointing directions in the Southern High Plains. The bench overlies and is aligned with the red bed ridge and is topographically expressed for about 6000 feet with a relief of about 20 feet. The bench is on the southwest slope of the drainage divide between the Pecos River and the Colorado River. The bench has

developed as an erosional feature along the preferred jointing direction in the Southern High Plains. The bench projects to Baker Spring, to a notch in the topography about one-half mile northwest of Baker Spring, and parallels Mescalero Ridge, part of the Caprock escarpment to the northwest of Monument, New Mexico.

Two smaller lineaments oriented about 45° were identified by Golder Associates to the west and east of the permitted area. The westernmost 45° lineament, which is about 4000 feet in length, is a surface draw that empties into a depression at Baker Spring, New Mexico. The 45° lineament east of the permitted area is less developed. It extends through the ranch house area for a total length of about 4,500 to 5,000 feet, developing into a shallow draw southwest of the ranch house area. The north-trending lineaments identified by Terra Dynamics about 3 miles west of the WCS site in Lea County, New Mexico, may be related to tonal contrasts in the vicinity of Monument Draw, New Mexico.

The lineaments in the vicinity of the WCS facility do not have any geologic or geomorphic characteristics typical of active faults. There are no topographic shifts along the lineament, or any apparent offsets in local drainage, or any interruptions in the gradient of erosional terraces above Baker Spring (assuming Baker Spring comprises part of the lineament). The lineament in the vicinity of the WCS facility is considered to be an erosional feature.

4.2 LAND SURFACE SUBSIDENCE

This section addresses the potential for land surface subsidence due to ongoing geologic processes and human activities in the vicinity of the WCS facility. Subsidence can be defined as the sudden sinking or gradual downward settling of the earth's surface with little or no horizontal movement. Subsidence may be caused by natural geologic processes such as solution or compaction or by human activities such as subsurface mining or pumping of oil or groundwater.

4.2.1 Land Surface Subsidence due to Geologic Processes

No subsidence features related to geologic processes have been identified within the permitted area or the immediate vicinity of the site. The nearest active subsidence features to the WCS facility are the San Simon Swale, the San Simon Sink, the Wink Sink, and a sink northwest of Jal, New Mexico (Figure 6.4-16). The San Simon Swale and the San Simon Sink are located approximately 20 miles west-southwest of the WCS facility in Lea County, New Mexico. The San Simon Swale is a large (100 mi^2), northwest- to southeast-trending, elongate depression that overlies and is parallel to the inner margin of the Permian Capitan Reef (Figure 6.4-16). The San Simon Sink is located within the southern end of the San Simon Swale and covers an area of 0.5 mi^2. The sink is approximately 130 feet deep and is filled with 400 feet of alluvium deposited on top of Triassic red beds (Baumgardner et al., 1982). Subsidence was last recorded at the San Simon Sink approximately 50 years ago.

The Wink Sink, which formed in 1980, is located 2.5 miles northeast of Wink in southwestern Winkler County, Texas (Figure 6.4-16). The diameter of the Wink Sink is approximately 360 feet with an average depth of 80 feet (Baumgardner et al., 1982). In 1998, a sink developed 14 miles northwest of Jal, New Mexico. The sink was approximately 100 feet wide and 150 feet deep (Odessa American, 1998).

Like the San Simon Swale and the San Simon Sink, the Wink Sink and the sink northwest of Jal lie above the Capitan Reef. These surface subsidence features are believed to be caused by the collapse of solution cavities formed in the Permian Salado Formation that migrated upward over time in response to successive roof failures (Baumgardner et al., 1982). There appears to be a correlation between the location of the Capitan Reef, dissolution of salt in the Salado Formation, and the development of land surface subsidence features. Groundwater in the Capitan Reef is unsaturated with respect to sodium chloride, and the hydraulic head of groundwater in the reef is higher than the elevation of the Salado Formation. This allows relatively fresh water from the reef to move upward into the Salado Formation along fractures or other zones of permeability and dissolve salt. Denser brine then moves back down the same fracture system and a brine-density-flow cycle is set up that allows for development of solution cavities, successive roof collapses and eventual subsidence of the land surface (Baumgardner et al., 1982). Land subsidence features similar to those discussed above would not be

expected to form at or in the immediate vicinity of the WCS facility. The WCS facility is not located above the Capitan Reef, the eastern edge of which is about 15 miles west of the facility, and the eastern edge of the Capitan reef defines the eastern extent of salt dissolution associated with the reef (Baumgardner et al., 1982).

At the regional scale and over geologic time periods of millions of years, subsidence features such as the Pecos Trough and the Monument Draw Trough have developed in the region (Ashworth, 1990). The surface drainage systems of the Pecos River and Monument Draw, New Mexico have developed in response to the deep-seated subsidence in the Delaware Basin. The Pecos Trough, in the central part of the Delaware Basin, and the Monument Draw Trough, along the eastern margin of the Delaware Basin, developed through dissolution and removal of Permian evaporites (Ashworth, 1990). The Pecos and Monument Draw Troughs were subsequently filled with a thick sequence of Cenozoic alluvial deposits. The Monument Draw Trough extends southeastward from southern Lea County, New Mexico through Winkler County, Texas and into northern Ward County (Figure 6.4-16). The northern end of the trough is approximately 20 miles southwest of the WCS facility.

4.2.2 Land Surface Subsidence due to Human Activities

Subsidence features related to human activities are normally related to withdrawal of subsurface fluids such as oil and groundwater and compaction of overlying unconsolidated deposits or collapse of overlying consolidated sediments. No subsidence features related to human activities have been identified within the permitted area or the immediate vicinity of the site.

Oil production occurs throughout west Texas and southeast New Mexico. Oil production in the vicinity of the WCS facility is from consolidated sediments at depths greater than 3,000 feet (Terra Dynamics, 1993). There is no evidence of land subsidence related to withdrawal of oil within the permitted area or the immediate area surrounding the WCS facility. Literature review identified examples of land surface subsidence related to oil production, but these examples are confined to the Gulf Coast region of southeast Texas (Davis et al., 1989).

Land surface subsidence in response to groundwater withdrawal usually occurs due to consolidation of a thick sequence of unconsolidated or poorly consolidated sediments that form an interbedded aquifer-aquitard system (Freeze and Cherry, 1979). Such a system of unconsolidated or poorly consolidated sediments does not exist beneath the WCS facility. Groundwater at the WCS facility is obtained from sandstones in the Dockum Group at depths in excess of 600 feet. Dockum sandstones, mudstones, and siltstones are consolidated and are not subject to compaction upon fluid withdrawal. As such, land surface subsidence due to groundwater withdrawal at the WCS facility is not an issue.

4.3 EROSION

This section addresses the potential for surface erosion due to ongoing geologic processes in the vicinity of the facility. Lehman (Appendix 6.2-2) evaluated erosion on the Southern High Plains and in the vicinity of the WCS facility. Much of the following discussion is taken from Lehman (Appendix 6.2-2).

Erosion can be defined as a physical and chemical removal or wearing away of the material comprising the earth's surface. This ongoing process is driven by a natural attempt to attain and maintain an equilibrium state between inputs and outputs. Stated simply, erosion seeks to level topographic highs and fill in topographic lows at rates largely controlled by local climate, geology, vegetation and topography. The rate of erosion fluctuates as climatic conditions change over short time spans, but the equilibrium between natural inputs and outputs can be described as more or less stable for relatively long periods of time (Dunne and Leopold, 1978).

Erosion can be caused by water, wind, ice and gravity. The objectives of this section are to characterize the dominant erosional agents present in the vicinity of the WCS facility and to estimate the rates at which these processes proceed. To accomplish these objectives, a literature review was performed and photographs from the area were reviewed. The aerial photographs include stereo coverage for 1938, 1939, 1981, 1983 and 1986, as well as single photographs from 1949 and 1954. The photographs were reviewed to identify any possible landform changes attributable to erosional processes.

Regional Context

Lehman (Appendix 6.2-2) also conducted an assessment of the long-term erosion potential at the WCS facility. As indicated above, much of the following discussion is extracted from Appendix 6.2-2.

The Southern High Plains is a very stable geomorphic surface that presents a nearly featureless landscape with only subtle topographic relief, crossed by widely spaced dry valleys or draws. Short-duration high-intensity rainfall events (thunderstorms), sparse vegetation on thin soils, and the generally unconsolidated nature of the surficial sediments and strata bordering the Southern High Plains could result in enhanced potential for erosion of the land surface. However, sediment removal is limited by the low annual rainfall, low surface slope gradients, absence of an integrated drainage system, presence of indurated Caprock caliche at shallow depth, and land surface alteration by man (Finley, 1979 *in* Dutton et al., 1979).

Potential for surface erosion at the WCS facility was considered in terms of two separate topics: 1) processes and rates of erosion on the Southern High Plains surface itself and 2) processes and rates of erosion along the escarpment bordering the Southern High Plains. Estimates of the long-term potential for surface erosion at the site are based on previous studies conducted for the Southern High Plains region in connection with the assessment of the Waste Isolation Pilot Plant (WIPP) site in Eddy County, New Mexico and nuclear isolation feasibility studies for Deaf Smith County in the Texas Panhandle. Information gathered in connection with these sites is quite extensive and applicable to assessment of the WCS facility, owing to their similar geologic, physiographic and climatic setting.

4.3.1 Erosion of the Southern High Plains Surface

On the surface of the Southern High Plains, the dominant mechanisms by which sediment erosion and deposition occurs include 1) incision and aggradation via overland flow within the draws, 2) wind erosion and local deposition of dune sand or regional dust fall, and 3) deposition and deflation in playa and saline lake basins. Each of these processes as they relate to the WCS facility is discussed in the following sections.

4.3.1.1 Overland Flow

The WCS facility is situated on the southwestern side of an expansive divide between two draws that cross the Southern High Plains surface – 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 (Plate 6.2-1). Monument Draw, New Mexico flows intermittently southward from Lea County, New Mexico into Winkler County, Texas, but appears to terminate near the town of Wink and does not continue southward to the Pecos River. Flow in Monument Draw, Texas, however, continues eastward through Andrews County until it joins Mustang Draw, which is a tributary of the Colorado River.

The broad expanses between draws on the Southern High Plains do not exhibit an integrated drainage system. Topography in the immediate vicinity of the WCS landfill slopes to the southwest toward Monument Draw, New Mexico. However, because the immediate vicinity of the WCS facility, along with much of western and southern Andrews County, lacks an integrated drainage system due to low rainfall rates and an irregular hummocky surface mantle of permeable eolian sediment stabilized by sparse vegetation, most surface runoff collects in shallow surface depressions rather than contributing to Monument Draw, New Mexico. As such, local erosion by overland flow appears to be balanced with local deposition in internally-drained surface depressions, and local erosion would not be expected to affect the WCS facility.

Headward erosion of the draws was also evaluated. Monument Draw, New Mexico and Monument Draw, Texas are typical of the draws that cross the Southern High Plains surface. The most recent episode of incision and widening of these valleys began 20,000 years ago, and ended 12,000 years ago when sediment began aggrading in the valleys (Holliday, 1995). Filling of the valleys culminated about 3000 years ago, and little aggradation or downcutting has occurred in the past 3000 years. Estimated rates of recent incision (downcutting) in the modern draws range from 0.06 in/yr to 0.08 in/yr (Gustavson et al., 1980; Finley and Gustavson, 1980; Finley, 1981). The valleys average about 1542 feet in width, and the average maximum width is about 4000 feet (Holliday, 1995). If the valleys were initially incised and widened over a time span of 8000 years (20,000 to 12,000 years ago), then the flanks of the valleys retreated at an average rate of 1.18 in/yr to a maximum of 2.95 in/yr over that time span (assuming parallel slope retreat on either side of the valley axis). The WCS facility is about 3 miles east of

Monument Draw, New Mexico. If in the future this draw were to begin a renewed episode of incision and widening, it would take more than 160,000 years (at the average rate of 1.18 in/yr) for eastward retreat of the flank of Monument Draw, New Mexico to approach the WCS facility. These drainages have not widened their valleys for the past 12,000 years; hence, retreat of the valley flanks would require renewed downcutting in the lower reaches of Monument Draw, New Mexico, and would also likely require a return to climatic conditions that prevailed during the Late Pleistocene when the draws were incised (Lehman, Appendix 6.2-2).

4.3.1.2 Wind Erosion

Over the past 2 million years, most of the Southern High Plains surface experienced periods of wind erosion and deposition, alternating with periods of stabilization of the surface by vegetation, resulting in soil formation (Holliday, 1989). As a result, the Southern High Plains surface has experienced net aggradation (not erosion) resulting in deposition of the cover sands of the Blackwater Draw Formation that blankets most of the surface. Radiometric age determinations on ash beds and interbedded playa deposits demonstrate that deposition of the Blackwater Draw Formation began prior to 1.4 million years ago and continued until at least 100,000 to 50,000 years ago (Gustavson et al., 1991). Interbedding of the Quaternary Blackwater Draw Formation with radiocarbon-dated playa basin deposits suggests that deposition continued at least locally up to 3000 years ago (Gustavson et al., 1991; Holliday, et al., 1996). At least two recent episodes of regional eolian deposition younger than the Blackwater Draw Formation have also affected the southwestern part of the Southern High Plains in the vicinity of the WCS facility, and more localized episodes of eolian deposition have occurred on the down-wind side of lake basins and draws over the past 10,000 to 20,000 years. In local areas where wind has deflated the surficial sediments down to the resistant Caprock caliche, this has effectively halted further eolian deflation of the surface because the indurated Caprock caliche is relatively hard and deflation-resistant.

Surficial eolian deposits (including the Blackwater Draw Formation and younger windblown sediments) range from 0 to over 100 feet in thickness, and over much of the Southern High Plains surface average about 10 feet in thickness. As eolian deposition has taken place intermittently for at least the past 1.4 million years, this yields an average long-term net

accumulation rate of 0.000079 in/yr. This rate is comparable to measured rates of eolian dust accumulation on the High Plains today (Machenberg, 1986).

The land surface in the immediate vicinity of the WCS facility is topographically high and capped by the indurated Caprock caliche, but the surrounding area is blanketed by at least three successive layers of eolian sediment deposited over the past 2 million years. These eolian deposits are today partially stabilized by vegetation. If future conditions allow for increased sand mobility (increased aridity), the vicinity of the WCS facility will likely receive additional input of eolian sediment. The source area for local eolian sediment lies to the south and west of the WCS facility (upwind), in the alluvium of the Pecos River Valley, and providing future prevailing winds remain as today, these would potentially supply fresh windblown sand and dust to the area. It is unlikely that wind erosion could impact the WCS facility, and it is more likely that deposition of eolian sediment would further encroach on the surrounding area (Lehman, Appendix 6.2-2).

4.3.1.3 Development of Playa Basins

Small surface depressions (buffalo wallows) and a few established playa basins are present within a 6.2-mile radius of the WCS facility (Figure 6.4-15). 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 landfill. Remnant deposits of a filled and now partially covered playa or salt lake basin are found about 2.5 miles east of the permitted area. Surface drainage from the area north and east of the WCS facility flows eastward into this basin.

In general, the small surface depressions and established playa basins range in size from 33 feet to 1.5 miles in diameter, though most are less than 0.6 miles in diameter, and exhibit up to 33 feet of topographic relief. The basins originated 30,000 to 10,000 years ago, although some may be older, and have partially or completely filled with up to 3 to 65 feet of sediment since that time (Holliday et al., 1996). The basins formed within the eolian cover sands of the Southern High Plains (Blackwater Draw) and are considered to be formed primarily by wind erosion, and hence are larger and more numerous where the cover sands are thicker (Holliday et al., 1996). The basins typically hold water temporarily only after extended periods of rainfall,

and focused infiltration of water through the floors of the playas is considered the primary recharge mechanism for the unconfined High Plains aquifers (Gustavson et al., 1995; Mullican et al., 1997). Buffalo (and more recently, cattle) may also have played a role in enlarging the original depressions by transporting mud or dust out of the basins on their hooves and hides. Recent studies suggest that some larger playas, such as several near Amarillo in the northern panhandle of Texas, may be influenced by subsurface dissolution or Permian salts.

Playas and playa development have been the subject of considerable research since they were identified as internally-drained ephemeral surface water sources (e.g. Dumble, 1888). Gustavson et al. (1995) provide a review of the processes that form playas, concluding that no single process accounts for their origin. Gustavson et al. (1995) indicate that playas result from a number of different and intermittently active processes, which include eolian deflation and deposition, fluvial erosion and lacustrine and deltaic deposition, ground water recharge, pedogenesis, salt dissolution and subsidence, dissolution of soil carbonate, and animal activities. The origin of the playas in the vicinity of the WCS permitted area facility is most likely a result of the development of 'solution pans', or localized dissolution of the Caprock caliche at or near the ground surface. Gustavson et al. (1995) indicate that some playa basins probably began as solution pans on the Caprock caliche as early as the late Tertiary.

Development of playa basins does not result in substantial erosion of the surrounding landscape because topographic relief is low, and relatively small amounts of sediment removed from the surrounding watershed are concentrated in the basin and subsequently removed in part only by wind erosion when the lake is dry. The basins do not expand beyond an optimum diameter of several kilometers after they form and remain approximately fixed in diameter throughout their history (Holliday et al., 1996).

A number of irregularly-shaped salt lake basins occur on the Southern High Plains. The basins are currently groundwater discharge areas where large quantities of soluble salts have accumulated in lake waters and sediments (Gustavson et al., 1995). The solutes in the salt lakes and the evaporite minerals are derived from evaporation of the local groundwater (Wood et al., 1992). The origin of these basins has been attributed to several processes (summarized in Gustavson and Finley, 1985), including subsidence (Baker, 1915), deflation (Evans and

Meade, 1945), blockage of previously existing valleys (Reeves, 1966; Reeves and Parry, 1969) and accelerated erosion at intersections of lineaments representing the earth's regmatic shear pattern (Reeves, 1970). Gustavson and Finley (1985) conclude that development of some of the larger lake basins has been influenced by both dissolution-induced subsidence and deflation. Wood et al. (1992) showed that the salt lake basins could result solely from deflation in areas where the water table in the Ogallala aquifer was high due to underlying bedrock highs. The nearest salt lake basins to the WCS facility are Whalen Lake and Shafter Lake located to the east-southeast approximately 16 miles and 24 miles, respectively. A local depression about 2.5 miles east of the WCS permitted area, which contains Quaternary playa deposits (Tahoka Formation) partially covered by recent windblown sand, may be either a larger playa or a basin with a similar origin to the salt lake basins. Under any of the hypotheses of the origin of the salt lake basins, their development occurred over geologic time scales of millions to hundreds of millions of years. The salt lake basins are not an active geologic process that could affect the WCS facility.

4.3.2 Erosion of the Southern High Plains Escarpment

The escarpment bordering the Southern High Plains (the Caprock escarpment) on the west, north and eastern sides has developed over geologic time and continues to retreat by erosion. The WCS facility is about 10 to 15 miles southeast of Mescalero Ridge, where the western Caprock escarpment is topographically well defined. In the WCS vicinity, the Southern High Plains has begun to physiographically lose definition as an escarpment and become more of a gently southeastward sloping topography that indistinctly blends into the Edwards Plateau further to the southeast. Mescalero Ridge is retreating eastward and northward, away from the WCS area. The northward head-cutting of Monument Draw into Mescalero Ridge defines the southernmost extent of active erosion of the Caprock escarpment in the area. Although the WCS site does not appear to be located in an area where the Caprock escarpment would develop or retreat under existing physiographic conditions, the potential rates of erosion for the escarpment are instructive should erosional directions alter in the future, perhaps in response to deep-seated salt dissolution in the Pecos or Monument Troughs. A detailed discussion of escarpment erosion is provided by Dr. T. M. Lehman (Appendix 6.2-2). Parts of the discussion below are taken from Appendix 6.2-2.

The rate of the erosional retreat of the escarpment has been estimated based on projecting the original aerial extent of the Ogallala Formation relative to its present outcrop limit over the time elapsed since the end of deposition of the Ogallala Formation from 3 to 5 million years ago (Gustavson et al., 1980) (Figure 6.4-17). The present limit of the Ogallala Formation along the southwestern margin of the Southern High Plains is approximately 43 to 93 miles east of its postulated maximum limit along the eastern flank of the Guadalupe and Sacramento Mountains (Gustavson et al., 1980) (Figure 6.4-17). Assuming parallel slope retreat on both sides of the Pecos River Valley, the western escarpment of the Southern High Plains has retreated to the east 22 to 47 miles (relative to the present position of the Pecos River) owing to incision and widening of the Pecos River Valley following the end of Ogallala deposition. This results in an annual retreat rate of 0.275 to 0.59 in/yr if Ogallala deposition ended 5 million years ago, or an annual retreat rate of 0.47 to 0.98 in/yr if Ogallala deposition ended 3 million years ago (Lehman, Appendix 6.2-2).

This estimate is complicated by recognition that the Pecos River Valley has subsided in response to subsurface salt dissolution, and that downcutting and widening of at least the lower part of the Pecos River Valley must have occurred before or during deposition of the Ogallala Formation, because the alluvial fill of the lower Pecos Valley (Cenozoic Alluvial Fill or Gatuna Formation) is at least 13 million years old (as old as the basal sediments of the Ogallala Formation (Powers and Holt, 1993; Hawley, 1993). The youngest part of the Gatuna Formation is no older than 600,000 years. Hence, some or most of the eastward retreat of the Caprock escarpment in this area must have occurred prior to 600,000 years ago. If the present eastern limit of the Gatuna Formation marks the former position of the Caprock escarpment 600,000 years ago, then retreat of the escarpment for the past 600,000 years has been a maximum of 12.5 to 18.6 miles, and as little as 1.9 to 3.85 miles in other areas (based on Gatuna distributions shown by Kelley, 1980). This yields minimum and maximum annual retreat rates of 1.2 to 2 in/yr (Lehman, Appendix 6.2-2). A comparable estimated retreat rate of 1.6 in/yr was determined for widening of the Canadian River Valley, which is also incised into the High Plains surface along a belt of dissolution-induced subsidence active before, during, and after Ogallala deposition (Gustavson et al., 1980). The Canadian and Pecos Rivers are thought to have been affected by the same processes, and hence retreat rates may have been similar in both valleys.

A number of authors have produced similar estimates for the rate of retreat of the eastern escarpment of the Southern High Plains based on geomorphic history (Table 6.4-2). These estimates range from 1.6 in/yr to a maximum of 7.5 in/yr. Given that the original extent of the Ogallala Formation east of the Southern High Plains was as much as 2 to 3 times greater than its original extent west of the present Southern High Plains escarpment (Figure 6.4-17) and assuming that both western and eastern escarpments of the Southern High Plains retreated simultaneously, then the eastern escarpment must have retreated at least 2 to 3 times faster than the western escarpment, and perhaps as much as 6 times faster (Osterkamp and Wood, 1984).

A number of authors have determined modern erosion rates for the eastern escarpment of the High Plains (Table 6.4-2). These estimates are based on 2 to 4 years monitoring of erosion pins emplaced on varied slopes and soil types bordering the Southern High Plains escarpment, suspended sediment loads of streams draining the escarpment, and reservoir sedimentation rates. The erosion rates measured in these studies range from a low of 0.004 in/yr to a maximum of 28.5 in/yr. The maximum short-term erosion rate found in these studies (28.5 in/yr) was for headcut erosion of a vertical scarp in completely unconsolidated modern alluvium. These data were summarized by Gustavson and Simpkins (1989), who regarded a range of 0.4 to 1.2 in/yr as reasonable for modern erosion rates. Annual rainfall in the region where these studies were conducted (northeastern border of the Southern High Plains) is 18 to 20 in/yr, rather than the 12 to 14 in/yr received in western Andrews County, therefore the erosion rate measurements are higher than would be expected in the vicinity of the WCS facility.

As indicated in the opening paragraph of this discussion, erosional retreat of the Caprock escarpment does not appear to be occurring in the direction of the WCS area. However, assuming that conditions could physiographically lead, at some future time, to escarpment retreat toward the WCS area, Lehman (Appendix 6.2-2) estimates the time for escarpment retreat to approach the WCS area. Assuming the present closest position of the Caprock escarpment is approximately 22 miles to the west-southwest of the WCS facility (near Jal, New Mexico), and further assuming an average rate for erosional retreat of the escarpment estimated above (about 2 in/yr), it would require about 700,000 years for eastward retreat of the escarpment to reach the WCS vicinity. Alternatively, assuming escarpment retreat were to

occur along the eastern flank of Monument Draw, New Mexico, it would require 100,000 years at an average rate of about 2 in/yr for escarpment retreat to approach the WCS area. Escarpment retreat is, therefore, not considered to be an issue with respect to the WCS facility.

4.3.3 Erosional Features within the Permitted Area

Present-day erosional features within the WCS permitted area were identified using aerial photographs and topographic maps and field reconnaissance of the area. Physiographically, the WCS facility is located on a gently sloping plain with a regional slope toward the southeast at 8 to 10 feet per mile (Reeves, 1966). Local slope across the permitted area is to the southwest toward Monument Draw, New Mexico at approximately 50 feet per mile. Soils developed across the permitted area are typically shallow fine sandy loams with moderate to rapid permeability. The hazard of soil blowing is noted as moderate (Conner et al., 1974).

Erosional features developed within the permitted area include several subtle surface water drainage features located in the southeastern corner of the permitted area. These drainage features developed along the flanks of Windmill Hill and gather surface water runoff from Windmill Hill and the ranch house area. Drainage in these features is to the west-southwest.

Other erosional features identified within the permitted area include a topographic bench and several small depressions or playas. The bench runs through the center of the permitted area at an alignment of 300° to 320° and with a relief of approximately 20 feet. The bench developed as an erosional feature along the preferred jointing direction in the Southern High Plains. Four small depressions or playas are located on the northern half of the permitted area. The largest of these has a diameter of 1200 feet along its long axis, while the smallest is approximately 200 feet in diameter.

Terra Dynamics (1993) identified a subtle surface water drainage feature and five additional small depressions within the boundary of the landfill. These erosional features were removed during construction of the landfill and are no longer present within the permitted area.

The landforms within the WCS permitted area were evaluated using stereoscopically-paired aerial photographs from the 1938 and 1981 as well as NHAP color infrared aerial photographs from 1983 and 1986. The objective of this photo-geologic analysis was to determine where and how any possible changes in landforms had occurred due to erosion. The vertical exaggeration of the stereoscopic images was exploited to help detect any erosional changes in topography. Other characteristics compared between different sets of aerial photographs were shapes and sizes of drainageways and depressions or playas and observable changes in location or direction of these features.

Landforms on the WCS permitted area have remained virtually static for at least the last 70 years. No observable changes were detected in drainageway location, direction, shape or size or in the location, shape or size of the depressions or playas. The geologic interpretation is that active erosional processes have a relatively low impact in the permitted area, which is typical of this type of arid climate. This interpretation is consistent with Lehman (Appendix 6.2-2) who concludes that the present landscape of the Southern High Plains is in dynamic equilibrium. Local erosion by overland flow is balanced by local deposition when surface water runoff ponds in depressions and playas, and local wind erosion is balanced by local sediment deposition transported from upwind source areas. Lehman (Appendix 6.2-2) also concludes that the area is not subject to significant long-term erosion, but if anything, to slow aggradation due to addition of eolian sediment.

5.0 SITE SUBSURFACE SOILS INVESTIGATION

5.1 INVESTIGATION PROCEDURES

Site investigation activities were initiated in 1992 and have continued through 2003. During this period, seven (7) investigation events have been conducted for the purpose of characterizing the subsurface conditions. A total of 220 borings have been drilled and 109 monitor wells and piezometers installed. The site investigation activities included: the drilling of continuous cores and soil borings; geophysical logging; surface seismic surveys; and the installation of piezometers and monitoring wells. A summary of soil boring, well completion and selected geologic data is provided in Table 6.5-1. Soil boring locations, geologic logs and well completion logs are provided in Appendix 6.5-1. Geophysical logs are provided in Appendix 6.5-2. The locations of the borings in the area of the permitted boundary of the site are shown on Figure 6.5-1. The locations of the borings outside the permitted boundary of the site are shown on Figure 6.5-2.

5.1.1 1993 RCRA Site Investigation Activities

In 1993, Terra Dynamics, Inc. and Jack H. Holt and Associates, Inc. (JHA) conducted a hydrogeologic site investigation for the purpose of preparing the Geology Report of the initial Permit Application. A total of 59 borings was drilled in 1992 and 1993 to evaluate the hydrogeologic and geotechnical conditions at the site. Each of the borings was geologically logged from cores and grab samples. At nine boring locations, 14 monitor wells were completed. At each of the nine monitor well boring locations, the borings were geophysically logged. The results of the boring and monitor well installation were the basis for the evaluation of site hydrogeologic conditions presented by Terra Dynamics, Inc. in the original Permit Application.

JHA prepared a geotechnical and engineering analysis of the soil conditions in the area of the proposed landfill for the original Permit Application. The JHA report includes laboratory analyses from geotechnical testing, an analysis of foundation stability, and a slope stability evaluation.

5.1.2 1997 Weaver Boos Municipal Landfill Siting Investigation

In 1997 Weaver Boos Consultants, Inc. conducted a two phase investigation that included the drilling of 26 borings to the west and southwest of the RCRA landfill. With the exception of two borings that were located on adjacent property further west, the borings were located on WCS property in New Mexico. The purpose of the investigations was to evaluate subsurface conditions in the area of the proposed Lea County, New Mexico Sanitary Landfill. The first phase of the investigation was conducted for the purpose of locating the landfill. The second phase was conducted to evaluate the geologic conditions beneath the current area of the Lea County landfill that is currently in operation. The results of the geologic investigation were reported in a 1998 Solid Waste Landfill Application for a Permit in Lea County, New Mexico, which is presented in Appendix 6.5-3. This site has been permitted and is currently in operation.

5.1.3 1998 11(e)2 Siting Investigation

In 1998 numerous borings were drilled to evaluate a potential landfill location for the deposition of 11(e)2-defined materials. The field investigation activities were conducted by JHA in three phases and consisted of drilling 65 borings and constructing five monitor wells or piezometers. The first phase of the investigation is located to the west/southwest of the existing RCRA landfill and consisted of advancing 28 borings and installing monitor wells at three of the boring locations. These borings are identified with the nomenclature "A" series borings. The second phase borings are located to the north of the existing RCRA landfill and consisted of six borings. These borings are identified as the "B" series borings. To distinguish between the "B" series borings drilled in 1993, the year of the borings has been added to the nomenclature of the 1998 borings. The third phase borings are located to the west of the existing landfill in New Mexico and consisted of advancing 31 borings (NMB series) two of which were completed as monitor wells. The boreholes of the two monitor wells have also been geophysically logged. Two separate reports, dated 30 December 1998 and 11 February 2000 were prepared for these investigation activities. These reports are presented in Appendix 6.5-3.

5.1.4 RCRA Monitor Well Installation

Espey, Huston and Associates, Inc. (EHA) drilled nine borings and installed a total of 23 monitor wells in two phases around the existing RCRA Landfill. The first phase occurred in 1996 and included seven borings and the installation of 17 monitor wells. The second phase occurred in 1998 and included two borings and the installation of six monitor wells. The 23 monitor wells are nested and located at four upgradient and five downgradient locations. At each of the nine locations there are two wells screened into the upper and lower portion of the uppermost water-bearing "225 foot zone" siltstone unit. At each of the five downgradient locations an additional monitor well is screened in the dry 125-foot siltstone unit. EHA completed two separate reports for the well installation activities, these reports are presented in Appendix 6.5-3.

5.1.5 Texas Tech Piezometers

In 1999 Texas Tech University Water Resources Center drilled and installed 35 piezometers to investigate shallow subsurface conditions with particular interest in the location of groundwater occurrence on top of the red bed clay. The piezometers are located across the entire WCS property. A copy of this report is presented in Appendix 6.2-1.

5.1.6 2001 11(e)2 Siting Investigation

In 2001 Cook-Joyce, Inc. drilled and installed 12 monitor wells (PM series) and 13 piezometers (TP series) to evaluate the hydrogeologic conditions of an area in the eastern portion of the permitted boundary of the site. The purpose of the investigation was to further evaluate this area of the site for the potential location of an 11(e)2 landfill site. Seven of these borings were geophysically logged and the geophysical logs are presented in Appendix 6.5-2.

5.1.7 Additional Piezometers

In 2003 and 2004 two additional piezometers were installed on the WCS property and nine borings were drilled on adjacent property to the west in association with a geologic investigation conducted by Louisiana Energy Services (LES). Piezometer NMP-01 was installed in May of 2003 and is located on WCS property in New Mexico to the southwest of the RCRA landfill. The

purpose of installing the piezometer was to further evaluate the groundwater gradient in the "225 foot zone" uppermost groundwater-bearing unit. Piezometer TP-14 was installed in 2004 and is located to the east-northeast of the RCRA landfill and was installed in a depression or playa where groundwater was encountered above the red beds of the Dockum Group.

Nine borings were drilled across Section 32 in New Mexico adjacent to the WCS property. Six of these borings were advanced to the top of the red beds and three were advanced to approximately 250 feet below ground surface. The three deep borings were used in this report to supplement the site borings in determining the structure of the "225 foot zone" that is considered the upper most aquifer beneath the WCS site.

5.1.8 Additional Geologic Data

In addition to the geologic boring data and the monitor wells/piezometers that have been drilled and installed, two geophysical surveys have been performed, and the two non-potable water supply wells have been geophysically logged. The two geophysical surveys were conducted by Advanced Geological Services and Geological Associates in 2001 and include a total of eight lines, four resistivity and four seismic lines, that are located to the north-northwest of the RCRA landfill and to west of the landfill location in the area of the 2001 11(e)2 siting investigation. The results of these surveys are presented in Appendix 6.5-4.

The geophysical borehole logging conducted by Computalog, has been conducted in the site's two non-potable water wells which produce from the lower sandstones of the Dockum Group to evaluate the deeper stratigraphic conditions in the area of the site. The geophysical boring logs are presented in Appendix 6.5-2.

5.1.9 Survey Control

Survey control of the borings and wells has been conducted through several events since 1993. As surveying technologies evolved, various surveying techniques have been utilized for the different surveying events. In addition, survey control of the benchmarks used for the various events has changed. Due to the variations in the survey techniques and benchmark controls,

reported survey data on some of the boring logs and monitor well construction forms required adjustment. The adjusted elevations are presented in the tables in Appendix 6.5-1.

The survey of the initial 59 borings and wells that was conducted for the 1993 RCRA investigation used a benchmark elevation that has subsequently been adjusted. This survey data was collected using survey methodologies that do not possess the accuracy of subsequent surveys that utilized GPS surveying systems. Therefore, due to benchmark adjustments and comparisons to later surveys of the existing wells from this investigation, an adjustment to the elevations have been made. Based on these adjustments it is believed that the elevations presented in this report are within a reasonable degree of accuracy.

The survey data presented on the logs of the Weaver, Boos investigation for the Lea County Municipal Landfill project is limited. Of the two investigation activities conducted by Weaver, Boos, surveyed elevations are reported for the borings. However, horizontal control of the first phase was not presented but a boring location map was presented. The second phase borings were located with a local grid system with an undefined origin. To determine an approximate boring location, these borings were plotted on a U.S. Geological Survey (USGS) Topographic Map based on the submitted location maps and then compared to reported elevations to the elevations of the plotted locations on the topographic map. Based on the general concurrence of the two elevations, it is believed that the locations presented in this report are properly located within a reasonable degree of accuracy.

The six B-98 series borings conducted as part of the 1998 11(e)2 investigation were not surveyed. The locations of these boring are estimated in this report based on the boring location map prepared as part of the investigation. The elevations of these borings were estimated from elevations shown on the site topographic maps.

5.2 SUBSURFACE STRUCTURE

The site subsurface structural analysis is based on data compiled from all site investigation activities that includes 220 geologic borings (Table 6.5-1) and 17 geophysical logs. The structural interpretation derived from this information is summarized in five shallow geologic

cross-sections, A-A' through E-E'. A cross-section location map is provided as Figure 6.5-3. The five shallow cross-sections are provided as Figures 6.5-4 through 6.5-8. An isopach map of the overburden material is provided as Figure 6.5-9. A contour map of the top of the Dockum Group is provided as Figure 6.5-10. Structure maps of the top and bottom of the "225 foot zone", which is the upper most water-bearing zone, are provided as Figure 6.5-11 and 6.5-12.

The site subsurface data supports the regional structural analysis of horizontally configured intervals in descending order of recent wind blown sand and the Blackwater Draw Formation, caliche overburden material and undifferentiated materials of the Ogallala, Antlers and Gatuna (OAG) Formations overlying primarily silty claystone, siltstone and sandstone of the Dockum Group sediments. The contact of the OAG units and the Dockum is an erosional unconformity. Lithologic intervals within the Dockum Group range from discontinuous to laterally extensive. Based on the structure of the laterally continuous "225 foot zone", which is a siltstone in the Dockum Group, the local depositional framework indicates no evidence of faulting in the study area.

5.2.1 Surface and Shallow Strata

The surface and the shallow soil strata of the study area generally consist of, in descending order, windblown sands, unconsolidated and indurated caliche, sand and gravel. This zone overlies the Triassic age Dockum Group and is generally referred to as the overburden material. The overburden generally ranges in thickness from 8 to 70 feet in the study area. An isopach map of the overburden thickness is presented as Figure 6.5-9. Overall thickness of the overburden thins from the flanks of the red bed ridge to the top of the ridge where the overburden is the thinnest in the study area.

5.2.2 Dockum Group

The buried surface of the local Dockum Group indicates a paleotopographic expression as a ridge. The overburden OAG sediments, which range in age from Cretaceous to Tertiary, disconformably overlie the Dockum Group. The Dockum Group sediments are locally overlain by 8 to 80 feet of overburden deposits in the study area.

As shown in a map of the top of the Dockum Group (Figure 6.5-10), a buried ridge runs in a roughly northwest/southeast direction through the middle of the local study area. Three cross-sections (C-C', D-D', and E-E') run generally perpendicular to the axis of this ridge.

In the study area, the highest measured elevation of the buried ridge is 3453 feet msl. The north side of the ridge has relatively gentle relief of approximately 25 feet over 4200 feet (0.6% relief) in the study area. The south side of the ridge has considerably more relief. In the west central portion of the study area, along the Texas-New Mexico border, the top of red beds grades from an approximate elevation of 3450 to 3365 feet msl over 1800 feet (6.2% relief). In the south central to southeastern portion of the study area, the red bed ridge grades from approximately 3450 to 3375 feet msl over 4200 feet (1.7% relief).

Structure maps (Figure 6.5-11 and 6.5-12) of the top and bottom of the "225 foot zone" indicate a gentle dip to the south-southwest. The top of the "225 foot zone" dips at rate of about 1.3% to the southwest in the central part of the study area.

The dip in the "225 foot zone" is in contrast to the regional dip of Dockum Group that is toward the center of the Dockum Basin located to the north-northeast of the site. The localized dip could be due to variations in localized depositional activities and differential compaction.

5.2.3 Surface Structure

The topography of the study area generally slopes to the south-southwest. In the study area there are three general areas of varying slope. In the northern and central portions of the study area, the land surface is relatively flat but gently slopes to the south-southwest at approximately 10 feet over 3,000 feet. From the south central portion of the study area, surface grades increase to a drainage feature that is located in the southern portion of the site. The slope of the land surface from the south central portion of the site to the drainage feature is approximately 25 feet over a distance of 500 feet. This drainage feature slopes from east to west, at approximately 50 feet over a distance of 7,000 feet, where the drainage feature discharges from the site towards Monument draw.

Localized drainage depressions, such as playas or buffalo wallows, are located in the northern and central portion of the study area. The origin of these depressions or playas is discussed in Section 4.3.1.3.

One of the local depressions or playa areas was investigated by a series of four borings around the location of boring B-41. At this location, a depression in the surface of the Dockum Group corresponds to the overlying topographic depression. Both the depression in the surface of the top of the red bed and the overlying playa have relief of approximately four feet. However, the structure map of the top of the "225 foot" siltstone does not indicate a similar depression beneath the surface depression. Therefore, it is unlikely that the playa is due to the dissolution and slumping of underlying Dockum Group or deeper evaporite layers. The structural depression in the surface of the Dockum Group is probably a reflection of a small-scale paleotopographic depression scoured into the surface of the Dockum Group prior to the deposition of Ogallala Formation sediments.

The playas appear to be aligned generally in a pattern that parallels the red bed ridge near where the overburden material is thinnest. As discussed in Section 4.3.1.3, the playas near the ridge are likely due to dissolution of the near-surface caliche material.

The results of the coring and soil boring activity at boring B-41 suggest that partial dissolution of the shallow caliche cap may have occurred. The continuous core boring encountered only six feet of caliche cap, consisting primarily of calcium carbonate-cemented silt and sand. However, four exploration soil borings drilled along the outer rim of the playa (borings 41-N, 41-S, 41-E and 41-W) encountered a thickness of caliche cap ranging from 5.7 feet to 15.6 feet, with an average thickness of approximately 10.2 feet. This suggests that a portion of the caliche cap material at B-41 may have been dissolved at or near the surface, which is consistent with the playa development process discussed by Gustavson, et. al (1995).

Potential surface water infiltration and localized groundwater in the area of playas is supported by the presence of saturated conditions within the shallow sand and gravel immediately overlying the red beds in borings (B-41 and TP-14), located in two different playas. These two

playas are located in the center and the northern portion of the study area, respectively. However, cores and four soil borings surrounding location B-41 did not produce water.

The U.S. Geological Survey, NE Eunice sheet identifies the presence of a depression west of the study area as Baker Spring. However, there is also evidence that supports this feature is at least partially a result of past quarrying activities. As part of an investigation of the area, a pedestrian survey was conducted. A surface engineering control, or diversion berm, was identified above the quarry high wall. It appears that the berm had been constructed to divert surface water from the north and cause it to flow to the east of the former quarry area. Stockpiles of the overburdened silt and very fine sand material, which is typically not suitable for sand or gravel use, were identified in the area south of the quarry floor. In addition, the area of the quarry is littered with debris such as thick cable and other scrap metal components that appear to be parts of excavation equipment. It appears that the quarry floor has been excavated to the top of the redbed through the removal of the overlying sand and gravel reserves. The quarry floor is presently at a lower elevation than the natural drainage features that flow from the northwest and the northeast, and merge in the area of the quarry that formerly ran to the south. Both of these drainage features now allow surface water to flow into the old quarry floor, which causes ponding. The quarry floor is several feet below the outlet that would otherwise flow to the south. Therefore, the results of past quarrying activities allow surface water that formerly flowed through the natural drainage feature to be diverted and now pond in the quarry floor.

In an interview with the Plant Manager of the Wallach Quarry, which is located to the west of the Baker Spring/Quarry area, he stated that Baker Spring is not a naturally occurring feature but the result of past mining activities. He stated that Mr. Baker conducted mining operations of the sand and gravel materials above the red bed beginning in the 1940's and continued into the 1950's. He further stated that Baker did not have a crusher and at one time hauled the material to a crusher in the vicinity, which was owned by Wallach.

A search of historic aerial photographs identified a series photographs from 1939 that can be viewed in stereopair and a single aerial from 1949. These aerial photographs are presented in Appendix 6.5-5. The 1939 photos show a clean fresh face of the excavation and stockpiles of

mine spoil. The quarry floor appears to have regularly shaped excavation patterns with stockpiles and what appear to be ponds. The 1949 aerial photograph shows a network of roads, including a main road that leads south towards State Highway 234, in the area of the excavation.

Based on the investigation of the Baker Spring area, it is concluded that the feature is principally man-made and results from the historical excavation of gravel and caprock materials that are present above the red bed clay. As a result of the excavation, the quarry floor is topographically lower than the surrounding area. Following rainfall events, ponding on the excavation floor occurs. Because the floor consists of the very low permeability clay of the red bed, limited seepage of the ponded water occurs. Shading from the high wall and trees that have flourished in the mine spoil retard the natural evaporation rates and water stands in the pond for some time. It is suspected that during periods of ponding, a limited volume of surface water may infiltrate into the sands at the base of the excavated wall and is retained as bank storage. As the surface water level declines, the bank storage is discharged back to the excavation floor.

5.3 SUBSURFACE STRATIGRAPHY

The local subsurface stratigraphic framework is presented in five shallow geologic cross-sections (Figures 6.5-4 through 6.5-8). These cross-sections are based on the results of the site coring, soil boring and geophysical logging programs. Two hundred and twenty soil boring logs are presented in Appendix 6.5-1. Seventeen geophysical logs are provided in Appendix 6.5-2. A stratigraphic column is provided as Figure 6.2-2.

5.3.1 Surficial Materials

Two types of surface material overlie the study area. In the area of the red bed ridge in the central portion of the study area, a thin veneer of two feet or less of topsoil and wind blown sand is present at the surface. The topsoil consists of brown silty sand that contains sparse vegetation debris and roots.

Off the flanks of the red bed ridge, generally to the north and south, the sand content in the surface material increases with depth. This sand is associated with the Blackwater Draw Formation of Pleistocene age. 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.

5.3.2 Caliche

Within the local study area, the topsoil horizon is underlain by a variable sequence of calcium carbonate-cemented, calcrete duracrust capping material referred to as the Caprock caliche (or simply as 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).

A local surface exposure of the caliche was observed at Baker Spring. At this location, the caliche consists of: approximately six feet of white, highly fractured calcium carbonate-cemented feldspathic and quartzitic 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.

With the exception of the western extent of the study area, the caliche was observed to be laterally extensive throughout the area. The caliche encountered during the drilling program is similar to the caliche exposed at Baker Spring. Matrix color ranges from white to pinkish white, with varying degrees of cementation, hardness, fracturing and pisolitic concretions. 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. Open fractures and vugs were periodically observed within the caliche horizon.

5.3.3 OAG Unit

The unconsolidated or semi-consolidated sand and gravel unit that is located between the Caprock caliche and the underling red beds of the Dockum Group has been identified in past studies as various geologic formations including the Ogallala, the Antlers, and the Gatuna. For the purposes of this report, this material is considered one single hydrogeologic unit of undifferentiated Ogallala, Antlers, and Gatuna that is referred to as the OAG Unit. With the exception of some areas on the top of the red bed ridge, where the caprock extends to the top of the red bed, lower sand units of the OAG Unit are present across the site.

In a local surface exposure of the OAG Unit observed at Baker Spring, the sediments consist of approximately six feet of caliche-cemented silt, sand, and gravel, resting on top of approximately 15 feet of planar crossbedded and trough crossbedded sand and gravel. Sediment color ranges from pinkish tan to dark brown with red, pink, white, black and opaque quartzitic gravel clasts and granite cobbles. The base of the OAG Unit has a sharp and irregular contact with the underlying dusky red siltstone and claystone of the Dockum Group.

OAG sediments were encountered in numerous soil borings throughout the local study area. These sediments consist of unconsolidated to poorly consolidated fledspathic and quartzitic very fine to coarse sand and gravel with minor silt and clay content. For the purpose of general classification and cross-section preparation, the portion of the OAG Unit that has been cemented as part of the overlying caliche cap, is represented in the cross-sections as caliche.

The local thickness of the OAG Unit is partially related to the structure of the underlying red bed. The thickness of the OAG Unit generally increases off of the northern and southern flanks of the underlying red bed ridge. In the area of the ridge, the thickness of the OAG ranges from 0 to 30 feet. Off the flanks of the ridge, within the RCRA permitted area, the OAG thickness increases to as much as 70 feet. In addition, small-scale structural lows in the surface of the red bed generally contain an increased thickness of OAG Unit and an increase in gravel and sandy gravel near the contact with the underlying Dockum redbeds.

5.3.4 Dockum Group

The Dockum Group records a period of fluvial-deltaic and lacustrine deposition within a restricted continental basin during the Triassic (208 to 245 million years ago). The source areas of the Dockum Group include: the Llano Uplift area to the east; the Amarillo Uplift, Wichita Mountain Uplift and Arbuckle Mountain Uplift to the north and northeast; the Sierra Grande Arch and Sangre De Cristo Uplift to the northwest; the Sacramento Uplift to the west; and the Diablo Platform to the south (Figure 6.2-3).

In this report, the Dockum Group stratigraphic system proposed by Lehman (1994a, 1994b) is adopted as discussed in the Regional Geology section (Section 2.0).

The upper surface of the Dockum Group is irregular and indicative of the erosional, disconformable contact with the overlying OAG Unit.

The Dockum Group was penetrated to a maximum depth of 600 feet below ground level (WB-B-110) as part of the Weaver Boos Consultants, Inc. soil boring program for the Lea County municipal landfill investigation. In addition, the site's non-potable water supply well was geophysically logged through the entire thickness of the Dockum to a depth of 2,470 feet below ground level and a second well that does not fully penetrate the Dockum, was logged to a depth of 800 feet. Continuous cores, drill cuttings and geophysical logs were used to characterize the upper 600 feet of the Dockum Group at the site, which is considered the Cooper Canyon Formation by Lehman (1994a, 1994b).

Based on the results of the on-site drilling program, the Dockum Group consists primarily of reddish brown, maroon and purple siltstone and claystone with intervals of reddish tan and greenish gray siltstone and sandstone. The portion of the Dockum Group encountered during the on-site drilling program can be divided into five zones. The upper zone consists of primarily dry claystone that is interbedded with relatively thin discontinuous silty sandstone layers. The second zone encountered is a dry, fine-grained sandstone with minor amounts of silt. The third zone is similar to the upper zone and is made up of claystone interbedded with discontinuous silty sandstone layers. The fourth zone is a saturated, silty sandstone. The fifth zone is similar to the first and third zones and consists of claystones and siltstones.

The upper zone of claystone is encountered at the contact of the OAG unit and extends to an approximate depth of 125 feet below ground level. The landfill is excavated approximately 40 feet into the upper zone. The thickness of this zone is approximately 85 feet and generally consists of a red to purple, dry, very firm to consolidated clay or claystone. Based on numerous geotechnical tests that have been conducted on this zone, the claystone has a moisture content ranging from approximately 1.5 to 30%, a plasticity index (PI) of 15 to 50, a dry density of 116 to 144 pounds per cubic foot, percent passing the #200 sieve of 90 to 100%, and permeability of 10^{-9} to 10^{-8} centimeters per second (Table 6.5-2). Discontinuous stringers of sandstone with silt have been identified in some of the site borings and a dry sand lense was exposed just below the OAG-Dockum contact in the landfill sidewall during excavation. Generally these sandstone lenses occur at depths of 50 and 80 feet below ground level and consist of dry, fine-grained, gray to red sand with silt and clay. The sandstone lenses have PI values as low as 13, percent passing the #200 sieve are in the 70% range, and permeability values are in the 10^{-6} to 10^{-7} cm/sec range.

The second zone in the Dockum red beds is encountered at an approximate depth of 125 feet below ground level. This "125 foot zone" consists of a dry, gray to white, sandstone with silt. This zone is laterally continuous within the study area with the exception of the far western portion of the New Mexico borings. There are five monitor wells screened in this zone along the southern boundary of the existing landfill. These monitor wells have been dry since they were installed in 1996 and 1998. The upper and lower contact with the red bed claystone is transitional making a determination of the contact arbitrary.

The third zone is similar to the uppermost zone and consists of a dry, red to purple claystone with varying silt content. The third zone is approximately 100 feet in thickness. This zone is interbedded with discontinuous, dry, fine-grained, sandstone lenses. A discontinuous silty sandstone zone is encountered at an approximate depth of 180 feet below ground level.

The fourth zone is encountered at an approximate depth of 225 feet below ground level and ranges in thickness from approximately 10 to 30 feet. The zone consists of a saturated, gray to pink, fine-grained, sandstone with varying amounts of silt. This zone is the uppermost water-bearing zone that is continuous across the site and the existing groundwater monitoring system

for the landfill is completed into this zone. This zone has been tested in the field and the laboratory to determine the hydraulic conductivity and permeability. Hydraulic conductivity values range from 10^{-7} to 10^{-9} cm/sec. Laboratory porosity testing of the zone has been conducted with results that range from 8 to 18%.

Beneath the uppermost water-bearing zone is a claystone that is the lower confining unit. This claystone is similar to zone three. Few borings at the site have been advanced more than 10 feet into this zone. Two borings were advanced to a depth of approximately 600 feet in the area of the existing Lea County Landfill, located adjacent to the southwest corner of the study area. These borings indicate that the claystone is massively bedded to a depth of approximately 565 feet below ground surface where the claystone transitions into sandstone (likely the Trujillo Formation sandstone) that was reported to be saturated. Geophysical logging has been conducted on the site's two non-potable water supply wells. One of the supply wells, the central well, is located in the RCRA permitted area. The second supply well, the southeast well, is located approximately 3 miles to the southeast of the site just south of State Highway 176. The geophysical logs also suggest that this lower confining unit is massive, with possible silty or sandy claystone zones that are less than 10 feet in thickness. These zones occur between depths of 374 to 690 feet below ground surface in the southeast well and 400 to 600 feet below ground surface in the central well.

5.4 GEOTECHNICAL PROPERTIES OF THE SUBSURFACE SOILS

Geotechnical testing to evaluate the subsurface properties has been conducted as part of the numerous site investigation activities conducted since 1992. The results of the analyses are summarized in Table 6.5-2. The laboratory results of each of the geotechnical testing studies are provided in Appendix 6.5-6. The following is a list of the test methods used:

• Unified Soil Classification System	D-2487-90
• Sieve Analysis Including Minus No. 200 Hydrometer Analysis	D422-63
• Minus #200 Mesh	D1140
• Moisture Content	D2216-90
• Atterberg Limits including Liquid and Plastic Limits	D4318-84

• Unconfined Compression Tests – rock specimens	D2938-68
• Unconfined Compression Strength – clay soils	D2166-91
• Triaxial Compression Tests	D4767-88
• Unit Weight Tests	D2937-90
• Permeability Tests	D5084-91
• Moisture-Density Relationship – Standard Proctor	D698-91

Field hydraulic conductivity testing of the 225 foot uppermost water-bearing zone has been conducted at two locations: MW-1B and DW-36A. Rising head slug tests were conducted at each of these locations by removing a volume of water from the well and measuring the rate of recovery versus time. The resultant hydraulic conductivity values were calculated to be 6.0×10^{-8} cm/sec and 6.17×10^{-8} cm/sec for MW-1B and DW-36A, respectively. The slug test data and hydraulic conductivity calculations are presented in Appendix 6.5-7.

6.0 GROUNDWATER

6.1 LOCAL GROUNDWATER USAGE

An investigation to identify the locations of groundwater wells in the WCS vicinity was conducted by Banks Information Solutions, Inc. (Banks), and a pedestrian survey of the area was also conducted. In January 2004, Banks reviewed files at the TWDB and the TCEQ and the state of New Mexico files to identify well reports that had been submitted to the State within a 3-mile radius of the approximate location of the existing landfill. The results of the report identified a total of seven water wells within the search area. The nearest wells identified are located approximately 1.5 miles to the southeast and to the north of the landfill. Each of the wells identified was completed in the shallow overburden material of the OAG Unit.

In addition to the water well search, Banks also conducted a search of oil and gas wells within a 2-mile radius of the site. A total of 12 oil and gas wells were identified within the search area. Two of the locations were proposed locations but were not drilled; six locations have been plugged; two locations are described as shut-in oil wells; one is in production; and no information of one well was reported. However, the location of the well number 12, for which no information was presented, appears using a dry hole symbol and as a dry hole on the USGS topographic map of the area. The results of the Banks survey are presented in Appendix 6.6-1.

A pedestrian survey of the WCS property was conducted to inventory the locations of water wells. The results of the pedestrian survey identified an additional five wells (Figure 6.6-1) in the area of the uninhabited ranch house, located approximately one mile east of the landfill, that were not identified in the Banks search. Four of the wells are shallow wells completed into the overburden material. Two of the wells are located at the ranch house and two are located approximately 0.5 miles to the northeast of the ranch house. <u>The fifth well is </u>~~T~~the site's central well, used as a non-potable water source, corresponds with the location of well number 8 of the oil and gas search. This well was reported to have been converted to a water supply well. Based on the geophysical log of this well, the accessible depth of the central well is 2,470 feet below ground level.

6.2 FACILITY GROUNDWATER

In the study area, 104 piezometers or monitor wells have been installed to evaluate the local groundwater conditions. The well completion diagrams for these wells and piezometers are presented in Appendix 6.5-1.

6.2.1 Groundwater Occurrence

Groundwater was encountered in four units in the study area. The three upper zones, the OAG unit and a two discontinuous sandstone seams in the Dockum Group at approximately 80 and 180 feet below ground level, contained localized discontinuous lenses of groundwater. The fourth is the uppermost water-bearing zone or "aquifer" that is continuous across the site is located in the "225 foot zone".

If groundwater was encountered in the boring, the depth is noted on the geologic logs. Historic depth to groundwater measurements of the site's monitor wells and piezometers are presented in Table 6.6-2. The maximum and minimum stabilized groundwater elevations of these wells and piezometers are presented in Table 6.6-3.

OAG Unit

Saturated conditions were encountered in the OAG unit at seven of the total of 172 borings located in both the RCRA permitted area and the NMB series borings located immediately to the west. These isolated locations (B-41, TP-14, NMB-37, A-28, A-16, TP-05 and TM-09) are located in the area of the higher elevations of the red bed ridge. At each of these locations, the groundwater is unconfined. TP-14, A-16, TP-05 and TM-09 were completed as monitor wells.

Two of the locations with saturated conditions (B-41 and TP-14) are located in the area of localized depressions or playas. Boring B-41 was not completed as a piezometer but four additional borings were drilled around the edge of the depression to determine the extent of groundwater. All but one of these perimeter borings was dry, suggesting that the groundwater is an isolated occurrence.

Boring A-16, which was completed as a monitor well, indicates a thin lense of groundwater, that is approximately 1 foot thick, remains perched on top of the red bed. The geologic log of boring A-28, which is located topographically downgradient of A-16 based on the top of red bed elevation, also recorded saturated conditions in the OAG unit. Borings A-19 and B-20, that are located topographically side gradient of A-28, were not saturated.

Groundwater was also encountered in boring NMB-37. There are six borings that are generally located around NMB-37 that did not encounter groundwater. Therefore, the groundwater encountered in boring NMB-37 appears to be isolated and of limited lateral extent.

TP-05 and PM-09 are located near the eastern boundary of the permitted area. These two wells indicate the presence of groundwater and appear to be the edge of the zone of continuous saturation in the Ogallala aquifer to the east of the permitted area.

As part of Texas Tech 1999 investigation (Appendix 6.2-1), 35 borings were drilled of which 34 were completed as piezometers. The piezometers are located across the WCS property, which is approximately 23 sections (Figure 6.6-2). Groundwater was encountered in 17 of these piezometers. The location, thickness, and elevation of the groundwater at each of the locations are also shown in Figure 6.6-3. In addition, other boring and piezometer locations where groundwater was identified in the OAG Unit are shown on this ~~F~~figure. The occurrence of groundwater in the OAG Unit has been identified in three areas of the WCS property. The first, as previously discussed ~~are~~is the isolated occurrence~~s~~ of groundwater on the crest of the red bed ridge.

The second area is on the northwest portion of the WCS property outside the RCRA permitted boundary of the site. In this area, three piezometers (PZ-1, PZ-2, and PZ-16) indicated saturated conditions in the OAG Unit. The saturated thickness of the OAG unit in these piezometers ranges from 6 to 25 feet. To the southeast of these, ~~piezometers~~ piezometer PZ-5 is dry. Borings WB-4 and WB-8 are located to the south and also did not indicate the presence of groundwater. Based on the groundwater elevations of the three piezometers in this area, the groundwater flow direction is to the southeast.

The third occurrence of groundwater in the OAG Unit is generally to the east of the RCRA permitted boundary of the site. In this area, groundwater is present in the OAG at 14 piezometers locations with a saturated thickness ranging from 1 to 18 feet. Based on the groundwater elevations recorded from these 14 piezometers, the groundwater flow direction is to the east.

South of the permitted area the OAG Unit appears to be dry based on unsaturated conditions in 11 piezometers.

80 Foot Sandstone

The "80 foot" sandstone is a discontinuous saturated zone. Two wells are completed in this zone, PM-02 and PM-08. At these two locations groundwater is under confined conditions.

180 Foot Sandstone

The "180 foot" sandstone is a discontinuous saturated zone. Of tThe four wells completed in this zone, 4C, 5C, 6B1 and PM-09, indicate that the groundwater is under confined conditions.

Uppermost Aquifer

The uppermost aquifer at the site consists of the saturated "225 foot zone" in the Dockum Group. Currently there are nine sets of two nested monitor wells completed into the "225 foot zone". At each monitor location a monitor well is screened in the upper and lower portion of the "225 zone". The thickness of this zone at the existing monitor wells ranges from 26 to 30 feet. The two nested monitor wells at each location are completed with 15 feet of screen in the upper and lower portions of the water-bearing zone. The existing monitoring system of this zone consists of four upgradient monitor wells (MW-1A and B through MW-4A and B) and five downgradient monitor wells (DW-32A and B through DW-36A and B). In addition to the "225 foot" monitor wells, an additional supplemental monitor well (SW-32 through SW-36) has been completed in the unsaturated "125 foot zone" at each of the downgradient monitor well locations. The upgradient and downgradient wells are located on approximately 150-foot spacing.

Within the study area, there are currently 32 wells completed in the "225 foot zone" at 21 locations. The list of wells completed in the "225 foot zone" is shown on Table 6.6-1.

6.2.2 Monitor Well Groundwater Levels

Depth to groundwater measurements have been recorded in each of the site's monitor wells on a quarterly basis since the wells were installed. However, due to the low permeability of the "225 foot zone" and the withdrawal of groundwater for sampling purposes, static levels have not been achieved. Therefore, to determine the groundwater elevations needed to develop a gradient map of this zone, supplemental wells were used. The groundwater levels for the site monitor wells and the supplemental wells are presented in Table 6.5-1.

6.2.3 Limits of the Uppermost Aquifer

As previously discussed, the uppermost aquifer beneath the landfill ~~and~~ that is continuous across the site is the "225 foot zone". Structure maps of the top and the bottom of the uppermost aquifer are presented in Figures 6.5-11 and 6.5-12. This zone ranges in thickness from 11 to 30 feet in the study area.

6.2.4 Hydraulic Gradient

Based on the groundwater elevations from the wells and piezometers that were determined to be properly screened across only the "225 foot zone" and have stabilized groundwater levels, a table containing monthly gauging elevations was developed and is included as Table 6.6-2.

Horizontal Groundwater Gradient

Groundwater gradient maps have been constructed utilizing the semi-annual gauging events recorded in April 2003 and October 2003 (Figures 6.6-4 and 6.6-5). These two figures represent the groundwater elevation data collected during the spring and fall 2003 groundwater monitoring events. Included in the fall 2003 gradient map is the groundwater elevation for piezometer NMP-01, which was installed in May 2003.

The groundwater gradient maps for Spring and Fall 2003 are similar in both the direction and the magnitude of the gradient. The groundwater flow direction is to the south-southwest at an average gradient of 0.016 ft/ft across the site.

<u>Groundwater Velocity</u>

The velocity of the groundwater in the uppermost aquifer has been calculated based on the groundwater gradient, the hydraulic conductivity, and the porosity using the following expression:

$$\text{Groundwater velocity} = \frac{Ki}{\theta}$$

Two in-situ hydraulic conductivity tests have been conducted of the "225 foot zone" at monitor well locations MW-1B and DW-36A. The tests were conducted by lowering the water level in the wells and measuring the rate of recharge versus time. The resulting hydraulic conductivity values were calculated to be 6.0×10^{-8} cm/sec and 6.17×10^{-8} cm/sec for MW-1B and DW-36A, respectively. The geometric mean of the hydraulic conductivity as determined from the two field tests of the "225 foot zone" is 6.06×10^{-8} cm/sec. Five laboratory permeability tests were also conducted to evaluate the hydraulic conductivity of the "225 foot zone". The geometric mean of the hydraulic conductivity as determined from the five laboratory tests of core samples from the "225 foot zone" is 1.07×10^{-8} cm/sec. A geometric mean of the hydraulic conductivity in-situ and laboratory values (6.06×10^{-8} and 1.07×10^{-8} cm/sec) is 2.55×10^{-8} cm/sec.

The hydraulic gradient in the "225 foot zone" is approximately 0.016 ft/ft based on the 2003 groundwater gradient maps presented in Figures 6.6-4 and 6.6-5. A porosity value of 14% was used for calculation of velocity. This value is an average of four laboratory-determined porosity values. Porosity results for the core samples ranged from 8%-18%. These laboratory results are presented in Appendix 6.5-6.

The calculated groundwater velocity is:

$$\text{Groundwater velocity} = \frac{Ki}{\theta}$$

Hydraulic conductivity (K)	=	2.55×10^{-8} cm/sec
Hydraulic gradient (i)	=	0.016 ft/ft
Porosity (θ)	=	0.14

$$= \frac{2.55E-08 \text{cm/sec} \times 0.016 \text{ ft/ft} \times 86{,}400 \text{sec/day} \times 365 \text{day/yr} \times 1 \text{ft}/30.48 \text{cm}}{0.14}$$

Groundwater velocity = 0.003 ft/year

6.2.5 Gradient Variations

As previously discussed, the horizontal gradient of the "225 foot zone" is to the south-southwest at an average of 0.016 ft/ft based on two determinations in 2003. Over the past two years of monitoring groundwater levels, the groundwater gradient in the area of the landfill varies little between monitoring events from 0.015 to 0.017 ft/ft. The two in-situ hydraulic conductivity results at DW-36A and MW-1B are similar at 6.0×10^{-8} and 6.13×10^{-8} cm/sec. It should be noted that these in-situ hydraulic conductivity tests were able to be conducted on these wells because the groundwater recovered more rapidly following sampling events (i.e. over a period of 2 to 3 months) than in the remaining monitor wells. Therefore, if additional in-situ hydraulic conductivity tests were to be conducted on the remaining monitoring wells, these hydraulic conductivities would be expected to be less than the tests conducted. This would result in a decrease in the estimated groundwater velocity of the "225 foot zone".

~~The "225 foot zone" is under confined conditions with a hydraulic head of approximately 60 to 130 feet depending of the depth of the "225 foot zone" and location of the well point in relationship to the water level.~~

There does not appear to be communication between the "225 foot zone" and upper or lower water-bearing zones. Where present, the upper dscontinuous "180 foot" sandstone is mostly dry with only isolated lenses of groundwater. Where groundwater is present in the 180 foot ~~label~~-sandstone, the groundwater levels are significantly lower than the hydraulic head of the "225 foot zone". Therefore, it is unlikely that these two sandstone zones are in communication.

The first reported occurrence of groundwater beneath the "225 foot zone" is at an approximate depth of 600 feet below ground level. Although completion records of the site's southeast non-potable water supply well are not available, the total depth of the well has been measured at 850 feet below ground level. It is believed that this well is completed into the Trujillo Formation of the Dockum Group at about 600 feet below ground surface. The water level of the southeast supply well is at 290 feet below ground level. This water level is approximately 50 feet below the base of the "225 foot zone" and is approximately 150 feet below the hydraulic head of the "225 foot zone". The water level in the non-potable central supply well, which is believed to be completed in the Santa Rosa Formation between 1,140 and 1,400 feet below ground surface, is about 600 feet below ground surface. The very large hydraulic head differences between the "225 foot zone", the Trujillo Formation at 600 feet below ground surface, and the Santa Rosa Formation at 1,140 feet below ground surface indicates that there is virtually no vertical hydraulic communication in the Triassic Dockum Group in this area.

6.2.6 Conceptual Release Pathway

In the event of a breach of the landfill primary liner system, the following simplified conceptual model of the migration pathway is presented. If the leachate exits below the primary liner, the landfill's secondary landfill system would then prevent the leachate from migrating further.

In the event that the secondary liner system failed, the leachate collection system would collect leachate. The leachate collection system is designed to maintain a maximum leachate level of 1 foot in the base of the landfill.

The 1 foot of leachate would represent a minimal driving force for the downward migration of the leachate through the red bed claystone. With the approximate hydraulic conductivity of the

claystone of 1×10^{-9} cm/sec, or 2.8×10^{-6} ft/day, and at a thickness of 40 feet below the base of the landfill and assuming a vertical downward gradient of 1 and a porosity of 0.14, it would require approximately 5,400 years at a velocity of 0.00739 ft/year (as calculated below), which does not include the time necessary to saturate the claystone, for leachate to reach the "125 foot" sandstone. The "125 foot" sandstone is currently being monitored with the SW series monitor wells that are located along the southern boundary of the site.

$$\text{Velocity} = \frac{1E-09\text{cm/sec} \times 1\,\text{ft/ft} \times 86{,}400\text{sec/day} \times 365\text{day/yr} \times 1\text{ft}/30.48\text{cm}}{0.14}$$

=0.00739 ft/yr

The "125 foot" sandstone has an approximate permeability of 1×10^{-6} cm/sec, or 2.8×10^{-3} ft/day. Based on a thickness of 20 feet of this zone, it would require approximately 3 years for the leachate to migrate to the base of this zone and into the underlying claystone that has a permeability of approximately 1×10^{-9} cm/sec.

Assuming that the leachate would continue to move vertically through the underlying claystone, it would require approximately 13,500 years, at 0.00739 ft/yr, to reach the uppermost aquifer in the "225 foot zone" sandstone.

Totaling the estimated travel time through each of these three zones, it will require approximately 18,900 years for a release from the landfill to intersect the uppermost aquifer, at an approximate depth of 225 feet below ground level.

The groundwater velocity in the uppermost aquifer has been calculated to be 0.003 ft/year. Assuming that a water well was installed within 100 feet of the landfill into the uppermost aquifer and screened such that groundwater from this zone was harvested, it would require another ~~years~~30,000 years for the groundwater to intersect the well.

6.3 DETECTION MONITORING

As discussed in Section 6.2.6, it is estimated that it will require approximately 19,000 years for a release from the landfill to impact the groundwater and an additional 30,000 years for the affected groundwater to migrate to a well located within 100 feet of the landfill. However, a groundwater monitoring system is proposed. In the unlikely event that a release from the land disposal area were to occur and migrate to the uppermost water bearing zone or aquifer, the monitoring well system and the detection monitoring program are designed to provide a reliable indication of the presence of hazardous constituents in the ground water. The following sections describe the existing and proposed monitor well system, including well location, well design, and development; groundwater sampling procedures and frequency; detection monitoring parameters and analytical procedures; and data evaluation procedures.

6.3.1 Monitor Well Locations

Monitoring wells will be completed in the uppermost aquifer, which is located at an approximate depth of 225 feet below ground level at the downgradient limit of the waste disposal area. In addition, at each of the downgradient monitoring locations, supplemental observation wells will be completed in the upper dry sandstone/siltstone zone that occurs at an approximate depth of 125 feet below ground level.

Based on groundwater elevations measured in site piezometers completed in the uppermost aquifer, the groundwater gradient is to the south-southwest (Figure 6.6-4). The proposed detection monitoring system consists of 28 downgradient monitoring locations, including five locations at which monitoring wells have previously been installed (Figure 6.6-5). The location of the property boundary in relationship to the RCRA permitted boundary is shown on Figure 6.6-1. The location of borings in the area of the landfill are shown on Figure 6.5-1. The existing monitor wells are spaced on approximately 150-foot centers, and future monitor wells are proposed to be constructed at the same spacing. This spacing is appropriate for detection of a release, particularly in view of the extremely remote potential for a release to reach the uppermost aquifer. The point of compliance for the landfill monitoring system is also presented on Figure 6.6-6.

6.3.2 Monitor Well Design

Future monitor wells will be constructed in accordance with ASTM Method D5092, *Design and Installation of Groundwater Monitoring Wells in Aquifers*, and the requirements of the permit. The general specifications to which the existing monitor wells were constructed are presented in Table 6.6-4. Their construction provides for the collection of samples that are representative of ground-water quality at the point of compliance. The design and construction of future monitor wells are discussed below.

The monitor well boreholes will be drilled with air rotary techniques to a minimum depth of 1 foot into the confining redbed clay and claystone underlying the uppermost aquifer. The wells will be constructed with a minimum of 2-inch inside diameter (ID) flush threaded PVC casing, screen and end cap. The screen will be factory-slotted to 0.01 inches. The casing will be pre-cleaned and sealed for delivery on-site, or will be pressure washed prior to placement in the well. Casing centralizers will be placed in the borehole on approximately 50-foot centers to ensure proper placement of the filter pack and grout. A permanent mark or notch will be placed in the top of the casing at the surface for survey and groundwater gauging purposes. The top of the casing will be fitted with a seal cap.

At each location, the entire aquifer thickness will be screened with one or more wells having a screened interval no greater than 15 feet, resulting in a nest of wells at locations where the aquifer is greater than 15 feet in thickness. This manner of construction is consistent with the completion of the existing wells, and will be followed at future well locations. A properly sized, clean siliceous granular material (filter pack) will be placed in the annular space around the screen and will extend 2 to 3 feet above the top of the screen. A granular bentonite seal will be placed above the sand pack to a minimum thickness of 2 feet. Sufficient time will be allowed for the bentonite seal to be hydrated with native groundwater. In the event that the groundwater does not recharge to a thickness to hydrate the lower 2 feet of the bentonite seal within a reasonable time, deionized (DI) water may be used to hydrate the seal material. Samples of the DI water will be collected and analyzed for the parameters presented in Table 6.6-5. A cement bentonite grout will be placed above the bentonite seal to within 2 feet of the surface. Prior to construction of the surface completion, additional bentonite grout will be added if settlement occurs.

The well will be completed at the surface with a lockable steel protective casing, a concrete pad, and protective steel bollards. The concrete pad will extend into the annular space to the top of the cement bentonite grout and at the surface will be extend a minimum of 2 feet around the protective casing. The steel protective casing will be placed over the well casing and will extend a minimum of 2 feet below ground level. Protective steel bollards will be placed around the concrete pad and will extend to a minimum height of 4 feet.

Monitor well design and construction will be conducted under the supervision of a Texas Licensed Professional Geoscientist. A Texas Licensed Professional Geoscientist will submit a certification report within 60 days of installation of the proposed monitor wells. The certification report will include the following information:

- Name/number of the well;
- Intended use of the well;
- Date and time of the construction activities;
- A description of the drilling method;
- Surveyed location of the well and the ground surface and top of casing elevations;
- The diameter of the borehole and the casing diameter;
- The total well depth;
- A geologic boring log;
- The depth to the first saturated zone;
- Identification of well materials;
- The screen size and the screened interval;

- The volume of the sand filter pack, bentonite seal, and bentonite grout;
- Placement method of the filter pack, bentonite seal, and bentonite grout;
- Surface construction as built drawing, including a description of the protective casing, bollards, and the size of the concrete well pad; and
- Well development procedures.

The general design of the proposed monitor wells is shown on Figure 6.6-7.

6.3.3 Monitor Well Development

Newly installed monitor wells will be developed prior to the initial sampling event to repair borehole wall smearing that may have resulted from drilling and to remove fines from the well and filter pack. Well development will be conducted by a combination of surging, pumping, and bailing the groundwater in the well. Initially, the well will be surged using an inert surge plug of a diameter slightly less than the ID of the well casing. The surge plug will be moved up and down through the screened interval of the well to force groundwater across the filter pack and borehole wall. Groundwater will then be pumped from the bottom of the well to remove fines that have entered the casing. This procedure will be repeated until groundwater conditions stabilize based on visual observations of turbidity. Once the sample appears to be relatively free of sediment or the sediment content has stabilized, groundwater will be field-tested for pH and conductivity. Well development will be deemed complete after these field measurements have generally stabilized.

6.3.4 Groundwater Sampling Procedures

Prior to the collection of groundwater samples, the monitor well surface completion will be inspected to evaluate the integrity of the well. If the result of the inspection determines that general maintenance of the well is required, such action will be completed and noted in the Annual Groundwater Monitoring Report. (Note: if the integrity of the well has been

compromised such that the collection of a representative sample can not be performed, the a proposal for replacement of the damaged well will be submitted to TCEQ within ninety days of the date of the inspection that identified the deterioration.)

Until April 2003, the wells were generally purged prior to sampling. However, historically slow recharge of the uppermost aquifer precluded the groundwater from fully recovering between semi-annual sampling events. Purging the wells prior to sampling was discontinued in April 2003, as authorized by a permit modification approved by the TCEQ on February 26, 2003. Because groundwater is so slow to recharge, purging of the groundwater prior to sampling is not required to insure that "fresh groundwater" is available for collection during sampling and wells will not be purged prior to sampling.

Prior to the collection of a groundwater sample, the water level in the detection monitoring and supplemental wells (if present) will be gauged using an electric line tape and recorded to the nearest 0.01 foot. Groundwater samples will be collected using new, clean, dedicated or disposable bailers fabricated of inert materials or dedicated pumps. Measurement of pH, conductivity and temperature will be conducted and recorded in the field.

The groundwater samples will be placed in laboratory supplied containers that will include preservatives as required. The samples will be placed in cooled ice chests for storage and shipment to the laboratory under standard chain-of custody procedures.

The supplemental wells will be gauged during each groundwater sampling event. In the event that liquid is identified in the supplemental wells, a sample will be collected in the same manner as described for the detection monitoring wells.

6.3.5 Groundwater Sampling Frequency

An evaluation of groundwater recharge rates and the groundwater gradient in the water bearing zone of interest at the WCS site has been performed. The purpose of the evaluation was to estimate the amount of time necessary for "new" groundwater to be available for sampling based on site-specific conditions. "New" groundwater is desired to be sampled at each

monitoring event so that independent samples are collected for data evaluation purposes, as required by applicable regulations.

Assuming purging is not conducted before sample collection, the volume of groundwater removed to conduct the required laboratory analysis is approximately 3 gallons or 0.401 ft^3.

The radius of influence of this volume of removed water in the water-bearing zone of interest is estimated at 0.733 ft, as calculated below.

Volume (V) of water removed	=	0.401 ft^3
Water-bearing zone of interest screen length (h)	=	15 ft
Water-bearing zone of interest porosity (θ)	=	14 percent

$$= \frac{\sqrt{V}}{\sqrt{p?h}}$$

$$= \frac{\sqrt{0.401 ft^3}}{\sqrt{p \, x 0.14 x 15 ft}}$$

radius = 0.246 ft

In order for "new" and "independent" groundwater for a sampling event to occupy a well after a sampling event, groundwater must flow under natural conditions from the upgradient end of the radius of influence to the downgradient end, i.e., a total distance of 2 x 0.246 ft, or 0.492 ft. Another way to say this is that although one would expect water to refill the well from 360 degrees, only the water from upgradient is new water, or water that has not been sampled previously. Therefore, it takes water that moves twice the distance of the radius of influence to be new water.

The minimum time taken for "new" groundwater to occupy the sampling volume and provide an "independent" sample is about 164 years (0.492 ft divided by 0.003 ft/year) for a porosity of 0.14.

These calculations approximating site-specific conditions of the water-bearing zone of interest demonstrate that the interval between sampling events must be much longer than a year in order to collect independent samples from the monitoring wells at each sampling event.

Although it is estimated that a period of ~~64~~164 years will be required for independent groundwater to be available for sampling, the current groundwater sampling frequency of staggered semi-annual monitoring will be continued. Samples will be collected in the first month of the second and fourth quarters of the calendar year (April and October). The monitor well pairs at each of the downgradient locations will be sampled every other 6-month period. Therefore, as presently being conducted, the even numbered paired wells will be sampled in the first semi-annual sampling event and the odd numbered paired wells will be sampled in the second semi-annual sampling event.

As discussed in Section 6.3.7, data evaluation procedures do not involve comparison of downgradient monitoring data to background data. In addition, given the very slow rate of groundwater flow as previously discussed, any wells located upgradient of the waste management area are so far removed from the point of compliance in terms of time of travel that they are not likely to represent the same data population for the naturally-occurring parameters as that present along the point of compliance. Consequently, no sampling of the upgradient monitor wells is proposed.

6.3.6 Analytical Parameters

A list of the analytical parameters, analytical method, detection limit, and concentration limits is presented in Table 6.6-5. The parameters listed in Table 6.6-5 will provide a reliable and early indication of any groundwater contamination at the site. General water quality parameters of pH (field), conductivity (field), Total Organic Carbon (TOC), and total phenolics will provide useful information regarding the general quality of the groundwater and as general indicators of contamination. The list of analytical parameters was approved by the TCEQ in a permit modification authorization dated October 7, 2003.

The metal parameters that are currently being analyzed in the groundwater monitor wells include arsenic, cadmium, nickel, and selenium. These metals were selected based on an analysis of mobility of several metals that were identified in leachate samples collected from four landfill cells in March of 2002 (Table 6.6-6).

Of the eight RCRA metals, antimony, beryllium, chromium, and silver were not detected in any of the leachate samples and were therefore eliminated as reliable indicators of groundwater contamination. Each of the remaining metals was further evaluated in terms of mobility.

Mobility was evaluated in terms of the potential for transfer of the metal from the soil matrix to the groundwater matrix. The soil-leachate partition factor (Ksw), which represents the conventional three-phase equilibrium partitioning relationship among the soil, pore water, and pore vapor phases of the soil matrix, was used as the relative measure of mobility. Calculation of the soil-leachate partition factor is a function of a pH-dependent soil-water sorption coefficient (Kd). Soil-leachate partition factors were calculated for each metal using the Kd coefficients for pH levels of 5, 6, 7, and 8. The calculations are summarized on Table 6.6-7.

Concentration-weighted mobility factors were then calculated for soil pH values of 6, 7, and 8, since soils at the site were anticipated to fall within the neutral to alkaline range, using the maximum and average leachate concentrations as shown on Table 6.6-6. The calculations of concentration-weighted mobility factors are summarized on Table 6.6-8. The metals were then ranked, based on the concentration-weighted mobility factors. Table 6.6-9 provides the concentration/mobility rankings in descending order for the metals, based on maximum leachate concentrations, for soil pH values of 6, 7, and 8. The concentration/mobility rankings for the metals based on average leachate concentrations are provided in descending order in Table 6.6-10 for soil pH values of 6, 7, and 8.

Review of Tables 6.6-9 and 6.6-10 demonstrates that arsenic is the first or second-highest ranking constituent in both tables for all soil pH values. Therefore, arsenic was selected as a detection monitoring parameter. The top five highest ranking metals other than arsenic on Tables 6.6-9 and 6.6-10 for all three pH levels are identified below, together with the number of times the metal was in the top five.

Metal	Number of Top Five Occurrences
Nickel	6
Selenium	6
Barium	5
Cobalt	4
Cadmium	3

Of these five metals, WCS proposes to include nickel, selenium, and cadmium as detection monitoring parameters. Including arsenic, this yields a total of four metals proposed for the detection monitoring program. Cadmium was selected instead of cobalt and barium since these two metals have much higher acceptable levels in groundwater. The current maximum allowable concentrations of these constituents in groundwater are 1.5 mg/L for cobalt (TRRP Tier 1 Residential Groundwater PCL) and 2.0 mg/L for barium (EPA Maximum Contaminant Level), while the maximum allowable concentration of cadmium in groundwater is 0.005 mg/L.

The organic parameters for the groundwater monitoring program were selected based on a review of the waste characteristics, detected organic constituents in the landfill leachate, and the relative mobility of organic compounds. Table 6.6-11 identifies the organic constituents detected in the landfill leachate, their concentration, and data relative to environmental mobility for these parameters.

The specific organic parameters proposed for the detection monitoring program consist of the priority pollutant volatile organics, excluding methylene chloride, 2-chloroethylvinylether, acrolein, and acrylonitrile; plus acetone and carbon disulfide. In addition, WCS proposes to

include phenol, which is a semi-volatile (acid-extractable) organic, and 1,4-dioxane, which can be analyzed as a volatile or as a semi-volatile (base/neutral) organic.

Priority pollutants were identified by EPA under the NPDES program as the most prevalent chemicals in industry. Due to their prevalence and mobility, this subset of organic constituents has been determined to be a reliable indicator of ground water contamination at numerous federal Superfund sites. As a class, the volatile organic constituents are more mobile in the environment than the semi-volatile organic constituents. Many of the organic constituents detected in the leachate from the WCS landfill are volatile organics. Further, the priority pollutant volatile organics include chlorinated organic compounds that were not detected in these particular leachate samples, but are prevalent in commerce and in many areas of impacted ground waters across the country.

Other organic constituents detected in the landfill leachate would generally be less mobile than the proposed volatile organics, and if a release from the landfill were to occur and impact groundwater quality, volatile organics would be expected to be present. As such, the volatile organics will provide a reliable indication of any organic constituents that may reach groundwater at the site. However, since phenol exhibits a similar mobility (based on the Kd for this compound), this semi-volatile organic will also be included as a detection monitoring parameter.

Methylene chloride will not be included as a monitoring parameter due to its common detection as a laboratory contaminant. In addition, 2-chloroethylvinylether is not included since it is a constituent listed in Appendix VIII of 40 CFR Part 261, but was not included as a constituent in Appendix IX of 40 CFR Part 264. Acrolein and acrylonitrile are not included because the laboratory reporting limit for each of these constituents is 20 µg/L and the Appendix IX PQL for each is 5 µg/L. Acetone and carbon disulfide, which are not priority pollutants, are included in the proposed volatile organic monitoring parameters since they were detected in the landfill leachate. WCS proposes to analyze for 1,4-dioxane using EPA Method 8270 for semi-volatile organics, since this method has a significantly lower reporting limit than Method 8260. Table 6.6-12 identifies the detection monitoring parameters and the methods for chemical analysis of the parameters.

6.3.7 Data Evaluation and Response

The results of the groundwater analyses obtained for each monitoring event will be evaluated to assess whether any indication of contamination is evident. The volatile organic priority pollutants, carbon disulfide, acetone, 1,4-dioxane, and phenol do not occur naturally in soils and/or groundwater. Consequently, these parameters will be evaluated for indication of a statistically significant increase by direct comparison to the PQL values listed in Appendix IX of 40 *CFR* Part 264. These PQLs represent the lowest concentrations of analytes in ground waters that can be reliably determined within specified limits of precision and accuracy under routine operating conditions.

Due to the large number of organic constituents being monitored and the part per billion concentration ranges of the PQLs, there is a significant probability over time that one or more of these constituents will be reported in one or more samples due to artifacts of the sampling and analytical process, rather than as a result of the actual presence of the constituent in the groundwater. To verify a reported organic constituent is actually present in the groundwater, a resample event will be included as part of the procedure for determination of a statistically significant increase.

In the event that an apparent statistically significant increase is identified for any well in a given monitoring event, the well(s) will be resampled as soon as possible and the samples(s) will be analyzed for the parameter(s) for which apparent statistically significant increases were identified. If the resampling data also indicates a statistically significant increase, the increase will be considered to be confirmed, and the TCEQ Executive Director will be notified in writing within seven days of the confirmation. In addition, WCS will immediately sample the groundwater in all monitoring wells that exhibit a confirmed statistically significant increase, analyze these samples for the hazardous constituents listed in 40 CFR Part 264, Appendix IX, and comply with all other applicable requirements of 30 TAC §335.164(7).

The potential for metals to reach the uppermost water bearing zone or aquifer, if a release occurred from the landfill, is limited by sorption and other attenuation processes that metals undergo. These attenuation processes represent a significant reduction in the potential concentration of metals that could reach the uppermost water bearing zone at approximately

225 feet below ground surface. Given these migration-limiting circumstances applicable to metals, and the fact that other parameters not subject to the same degree of attenuation will be evaluated, metals data will not be evaluated statistically. WCS will evaluate the metals data qualitatively through review of graphs of concentration over time and include a discussion of the qualitative data evaluation in the annual groundwater monitoring report.

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TABLES

TABLE 6.3-1
WASTE CONTROL SPECIALISTS LLC
WATER WELLS WITHIN A 2-MILE RADIUS OF THE LANDFILL SITE IN 2004

State	Longitude W	Latitude N	Elevation (feet msl)	Owner	Total Depth (feet)	Date Drilled	Aquifer	Depth to Water (feet)	Measurement Date
TX	103.0444	32.4603	3491	Ed Tinsley	Unknown	00/00/40?	Ogallala	82.47	11/15/74
TX	103.0350	32.4275	3495	Bill Vance	Unknown	Unknown	Ogallala	78.55	12/10/65
TX	103.0314	32.4278	3477	Flying W Ranch	80	Unknown	Ogallala	Unknown	Unknown
NM	103.0845	32.4695	3552	Hard B. Tapp	Unknown	Unknown	Unknown	Unknown	Unknown
TX	103.0111	32.4437	3475	Ralph McWhorter	85	10/13/78	Ogallala	Dry	10/13/78
NM	103.0862	32.4751	3530	Seth Brown	Unknown	Unknown	Unknown	Unknown	Unknown
NM	103.0977	32.4674	3487	W&W.O. Stephens	Unknown	Unknown	Unknown	Unknown	Unknown
NM			3497	Paul Wallach	65	00/00/50	Triassic	36.39	Unknown
NM			3472	Parabo, Inc.	Unknown	00/00/85?	Ogallala	53.5	Unknown

TABLE 6.3-2
WASTE CONTROL SPECIALISTS LLC
SUMMARY OF WATER WELL GROUNDWATER-QUALITY CHARACTERISTICS IN WESTERN ANDREWS COUNTY, TEXAS AND EASTERN LEA COUNTY, NEW MEXICO

	Well No. 26-40-201	Well No. 26-40-201	Well No. 26-40-601	Well No. 26-40-601	Well No. 26-40-602	Parabo, Inc. MW-79*
Aquifer	Ogallala		Ogallala		Ogallala	Triassic
Well Depth (feet)	Unknown		Unknown		80	
Sample Date	10/09/80	05/22/96	10/09/80	08/01/74	10/10/90	01/28/87
Calcium (mg/L)	206	NR	62	60	78	340
Magnesium (mg/L)	17	NR	8	11	21	41.5
Sodium (mg/L)	92	NR	20	20	36	239
Bicarbonate (mg/L)	205	166	233	231	249	NR
Sulfate (mg/L)	196	150	19	15	39	359
Chloride (mg/L)	265	317.5	8	9	39	723
Nitrate (mg/L)	65.5	NR	23.2	24	4.07	NR
Fluoride (mg/L)	0.4	0.51	0.8	1	0.76	NR
Silica (mg/L)	53	34.3	44	39	43	NR
TDS (mg/L)	1070	NR	308	293	429	2386
Cond (mmhos/cm^3)	1250	1109	415	437	459	2450
pH	8.1	8.15	8.0	8.0	7.14	NR

mg/L = milligrams per liter
mmhos/cm = micromhos per cubic centimeter
NR Not Reported

* Terra Dynamics 1993

TABLE 6.4-1
WASTE CONTROL SPECIALISTS LLC
HISTORICAL SEISMIC ACTIVITY WITHIN 250 KM (155 MILE) RADIUS
FACILITY (322.433N, 103.05W)

DATE	LOCATION		DISTANCE	DISTANCE	INTENSITY	MOMENT MAGNITUDE
	LATITUDE (N)	LONGITUDE (W)	(MILES)	(KM)		
08/16/31	30.6	104.1	140	225	VIII	
08/16/31	30.6	104.1	140	225		
08/16/31	30.6	104.1	140	225		
08/16/31	30.6	104.1	140	225		
08/16/31	30.6	104.1	140	225		
08/16/31	30.6	104.2	143	230	VIII	
08/16/31	30.7	104.6	150	241		
08/16/31	30.7	104.6	150	241		
08/18/31	30.6	104.1	140	225		
08/18/31	30.7	104.6	150	241	V	
08/18/31	30.7	104.6	150	241		
08/19/31	30.6	104.1	140	225	V	
08/19/31	30.6	104.1	140	225	VI	
08/19/31	30.7	104.6	150	241	III	
08/26/31	30.6	104.1	140	225	III	
08/26/31	30.7	104.6	150	241	III	
11/03/31	30.7	104.6	150	241	III	
12/20/35	34.4	103.2	136	219	V	
01/08/36	32.4	104.2	67	108	II	
01/08/36	32.4	104.2	67	108	II	
02/02/49	32.4	104.2	67	108	IV	
02/02/49	32.4	104.2	67	108		
05/22/52	33	105	120	193	IV	
01/27/55	30.6	104.5	152	245	IV	
01/27/55	30.6	104.5	152	245	IV	
01/27/55	30.6	104.5	152	245	IV	
12/10/61	32.24	103.86	49	79		
12/10/61	32.26	103.86	48	77		
12/10/61	32.263	103.865	48	77		
03/06/62	31.08	104.55	128	206		
02/11/64	34.35	103.73	138	222		
11/08/64	31.9	103	37	60		
11/08/64	31.93	102.98	35	56		
11/21/64	31.9	103	37	60		
11/21/64	31.92	102.98	35	56		
02/03/65	31.9	103	37	60		
02/03/65	31.92	102.96	35	56		
08/30/65	31.92	102.98	35	56		
08/30/65	32	102.3	53	85	IV	
08/30/65	32.08	102.42	44	71	IV	
08/30/65	32.1	102.3	49	79	IV	
08/30/65	32.1	102.3	49	79		
08/14/66	31.7	103.1	50	80	VI	
08/14/66	31.92	102.98	35	56		
08/14/66	32	102.6	40	64	VI	
08/14/66	32	102.6	40	64	VI	
08/14/66	32.12	102.34	47	76	VI	
05/02/68	33.02	105.27	135	217		

TABLE 6.4-1
WASTE CONTROL SPECIALISTS LLC
HISTORICAL SEISMIC ACTIVITY WITHIN 250 KM (155 MILE) RADIUS
FACILITY (322.433N, 103.05W)

DATE	LOCATION		DISTANCE	DISTANCE	INTENSITY	MOMENT MAGNITUDE
	LATITUDE (N)	LONGITUDE (W)	(MILES)	(KM)		
05/02/68	33.02	105.27	135	217		
07/30/71	31.64	103.17	55	89	III	
07/30/71	31.7	103	50	80	III	
07/30/71	31.7	103.1	50	80	III	
07/30/71	31.72	102.996	49	79		
07/30/71	31.74	103.09	48	77		
07/31/71	31.59	103.12	58	93		
07/31/71	31.65	103.12	54	87	IV	
07/31/71	31.7	103.1	50	80	IV	
07/31/71	31.7	103.1	50	80	IV	
07/31/71	31.703	103.061	50	80		
09/24/71	31.6	103.2	58	93		
09/24/71	31.63	103.18	56	90		
07/26/72	32.68	103.98	56	90		
07/26/72	32.68	103.98	56	90		
10/02/74	31.98	100.71	140	225		
11/12/74	32.06	100.98	123	198		
11/28/74	32.3	104.1	61	98	IV	
11/28/74	32.31	104.14	63	102		4
11/28/74	32.31	104.14	64	103		
11/28/74	32.311	104.143	64	103		
11/28/74	32.63	104.01	57	92		
11/28/74	33.765	104.99	144	232		
12/30/74	30.92	103.11	104	167		
12/30/74	30.92	103.11	104	167		
08/01/75	30.57	104.49	154	248	II	
08/01/75	30.65	104.57	152	245		
08/01/75	31.42	104.01	89	144		5
08/01/75	31.425	104.012	89	143		
01/19/76	30.9	103.1	37	60		
01/19/76	31.9	103.077	37	60		
01/19/76	31.9	103.08	37	60		4
01/19/76	31.9	103.09	37	60	IV	
01/22/76	31.9	103.07	37	60	III	
01/22/76	31.9	103.07	37	60		3
01/22/76	31.9	103.07	37	60		
01/22/76	31.9	103.071	37	60		
01/25/76	31.9	103.08	37	59		4
01/25/76	31.9	103.09	37	60	V	
01/25/76	31.902	103.08	37	60	V	
01/25/76	31.93	103.09	35	56		
04/03/76	31.3	103.17	78	126		
04/21/76	32.21	103.1	16	26		
04/21/76	32.21	103.1	16	26		
05/01/76	32.27	103.14	12	19		
05/01/76	32.4	103.1	3	5		
08/05/76	31.57	103.02	60	97		
08/05/76	31.57	103.02	60	97		

TABLE 6.4-1
WASTE CONTROL SPECIALISTS LLC
HISTORICAL SEISMIC ACTIVITY WITHIN 250 KM (155 MILE) RADIUS
FACILITY (322.433N, 103.05W)

DATE	LOCATION		DISTANCE	DISTANCE	INTENSITY	MOMENT MAGNITUDE
	LATITUDE (N)	LONGITUDE (W)	(MILES)	(KM)		
09/17/76	31.4	102.5	78	126		
09/17/76	32.21	103.1	16	26		
09/17/76	32.21	103.1	16	26		
09/19/76	30.69	104.43	144	232		
12/19/76	32.259	103.08	12	19		
12/19/76	32.26	103.08	12	19		
04/07/77	32.23	103.07	14	23	IV	
04/07/77	32.23	103.07	14	23		
04/26/77	31.9	103.08	37	59		3
04/26/77	31.9	103.08	37	60		
04/26/77	31.902	103.083	37	60		
04/26/77	32	103.1	30	48		
06/07/77	32.85	100.9	128	206		
06/07/77	32.858	100.77	135	217		
06/07/77	33.058	100.749	140	225		
06/07/77	33.06	100.75	141	227		4
06/07/77	33.13	100.94	131	211		
06/08/77	32.7	100.72	136	219		
06/08/77	32.8	100.9	127	204		
06/08/77	32.858	100.77	135	217		
06/08/77	32.89	100.95	126	203		
06/17/77	32.346	100.4	154	248		
06/17/77	32.35	100.4	154	248		
07/22/77	31.8	102.7	48	77		
11/27/77	32.862	100.68	140	225		
11/27/77	33.03	101.08	121	195		
11/28/77	32.95	100.84	134	216		4
11/28/77	32.954	100.837	133	214		
11/28/77	32.96	100.88	131	211		
11/28/77	33.022	100.84	134	216		
02/18/78	31.35	104.56	115	185		
03/02/78	31.52	102.41	73	117		
03/02/78	31.55	102.5	69	111	V	
03/02/78	31.56	102.51	68	110		4
03/02/78	31.562	102.512	68	109	III	
06/16/78	32.87	100.99	123	198		
06/16/78	32.961	100.79	136	219		
06/16/78	32.99	100.88	131	211		
06/16/78	33.03	100.766	138	222		
06/16/78	33.03	100.77	138	222	V	
06/16/78	33.03	100.77	139	224		5
06/16/78	33.067	101.19	116	187		
06/16/78	33.1	101.2	117	188		
06/29/78	31.05	101.94	115	185		
07/05/79	32.9	101.31	105	169		
07/05/79	32.949	100.895	130	209		
07/05/79	32.95	100.89	130	210		3
07/05/79	33	100.92	130	209		

TABLE 6.4-1
WASTE CONTROL SPECIALISTS LLC
HISTORICAL SEISMIC ACTIVITY WITHIN 250 KM (155 MILE) RADIUS
FACILITY (322.433N, 103.05W)

DATE	LOCATION		DISTANCE	DISTANCE	INTENSITY	MOMENT
	LATITUDE (N)	LONGITUDE (W)	(MILES)	(KM)		MAGNITUDE
08/03/79	32.85	100.94	125	201		
08/03/79	32.851	100.74	137	220		
05/08/81	32.212	101.51	91	146		
11/10/81	32	100.67	142	229	III	
01/04/82	31.18	102.49	93	149		4
01/04/82	31.18	102.49	92	148		
01/04/82	31.182	102.492	92	148		
04/26/82	33.02	100.84	135	217		3
04/26/82	33.02	100.84	134	216		
04/26/82	33.021	100.844	134	216		
11/09/82	31.99	100.7	142	228		3
11/28/82	33	100.8	136	219		
11/28/82	33	100.84	135	217		3
11/28/82	33.003	100.842	134	216	IV	
09/11/84	31.991	100.697	140	225		
09/11/84	32	100.7	140	225		
09/19/84	32.027	100.688	140	225		
09/19/84	32.027	100.688	140	225		
09/19/84	32.03	100.69	142	228		3
12/04/84	32.26	103.56	31	50		3
12/04/84	32.266	103.556	32	51		
12/04/84	32.266	103.556	32	51		
01/25/86	32.06	100.73	139	223		3
01/25/86	32.064	100.733	137	220		
01/30/86	32.066	100.693	140	225	IV	
01/30/86	32.07	100.69	140	226		3
01/02/92	32.33	103.1	7/11*	11/18		5
01/02/92	32.336	103.101	7/11*	11/18	V	
08/26/92	32.17	102.71	27	44		3
06/23/93	31.35	102.51	82	132		3
04/14/95	30.28	103.35	149	240		6
04/14/95	30.3	103.35	148	238		3
04/14/95	30.3	103.35	148	238		3
04/14/95	30.3	103.35	148	238		3
04/14/95	30.3	103.35	148	238		3
04/14/95	30.3	103.35	148	238		2
04/14/95	30.3	103.35	148	238		3
04/14/95	30.3	103.35	148	238		2
04/14/95	30.3	103.35	148	238		3
04/14/95	30.3	103.35	148	238		3
04/14/95	30.3	103.35	148	238		2
04/15/95	30.27	103.32	150	241		4
04/15/95	30.3	103.35	148	238		2
04/16/95	30.3	103.35	148	238		2
04/16/95	30.3	103.35	148	238		3
04/16/95	30.3	103.35	148	238		2
04/17/95	30.3	103.35	148	238		3
04/21/95	30.3	103.35	148	238		3

TABLE 6.4-1
WASTE CONTROL SPECIALISTS LLC
HISTORICAL SEISMIC ACTIVITY WITHIN 250 KM (155 MILE) RADIUS
FACILITY (322.433N, 103.05W)

DATE	LOCATION		DISTANCE	DISTANCE	INTENSITY	MOMENT
	LATITUDE (N)	LONGITUDE (W)	(MILES)	(KM)		MAGNITUDE
06/01/95	30.3	103.35	148	238		4
07/06/95	30.3	103.35	148	238		3
07/06/95	30.3	103.35	148	238		3
11/12/95	30.3	103.35	148	238		4
04/15/98	30.19	103.3	Unknown	Unknown		4
03/01/99	32.57	104.66	93	150		3
03/14/99	32.59	104.63	92	148		4
03/17/99	32.58	104.67	94	151		4
05/30/99	32.58	104.66	94	151		4
08/09/99	32.57	104.59	89	144		3
02/02/00	32.58	104.63	91	147		3
02/26/00	30.24	103.61	155	249		3
06/02/01	32.33	103.14	9	14		3
11/22/01	31.79	102.63	52	83		3
09/17/02	32.58	104.63	92	148		4
09/17/02	32.58	104.63	92	148		3
06/21/03	32.67	104.5	85	137		4

Sources: National Oceanographic and Atmospheric Administration (1992)
United States Geological Survey (2004) http://neic.usgs.gov/

Definition of I Tremor not felt, or rarely felt only under especially favorable conditions
- II Tremor felt indoors by few people; may cause slight movement of liquids and suspended or delicate objects
- III Tremor felt indoors by several people; may cause swinging of suspended objects; movement may be appreciable on upper levels of tall buildings
- IV Tremor felt indoors by many people; causing dishes and windows to rattle; noticeable movement of delicate objects
- V Tremor felt by nearly all people; causes breakage of many delicate objects (dishes, glassware, etc); trees and bushes shaken slightly
- VI Tremor felt by all people, both indoors and outdoors; causes considerable breakage of delicate objects, movement of furnishings, slight cracking of chimneys and plaster wall material.
- VIII Fright, general alarm approaches panic; twisting fall of chimneys, columns, monuments and partial collapse of buildings, homes, etc.; moved, overturned very heavy furniture; sand and mud ejected in small amounts

Moment Magnitude: Moment Magnitude is the measure of total energy released by an earthquake, and is based on the area of the fault that ruptured in the earthquake.

* USGS location is at 7 miles: New Mexico Tech location is at 11 miles

TABLE 6.4-2
WASTE CONTROL SPECIALISTS LLC
EROSION RATE MEASUREMENTS AND ESTIMATES FOR THE SOUTHERN HIGH PLAINS

SOURCE		RATE ESTIMATE			BASIS FOR ESTIMATE
Short-term measurements of erosion rates on varied soil types, slopes, and vegetation densities					
		Minimum	Maximum	Unit	
1980	Finley & Gustavson	0.039	0.079	in/yr	Slope denudation for single thunderstorm
1980	Baumgardner	0.016	0.000	in/yr	Extrapolation from 9 years of water data
1981	Finley & Baumgardner	0.000	4.331	in/yr	Vertical scarp retreat
1981	Finley & Baumgardner	0.020	0.000	in/yr	Monitored erosion pins, mean rate
1981	Finley & Baumgardner	0.031	0.079	in/yr	Suspended sediment load
1981	Gustavson et al.	0.004	0.039	in/yr	Stream drainage basins
1981	Gustavson et al.	0.024	0.118	in/yr	Reservoir sedimentation
1981	Gustavson et al.	0.024	0.079	in/yr	Universal soil loss equation
1982	Simpkins et al.	0.106	0.311	in/yr	Monitored erosion pins, means, all slopes
1982	Simpkins et al.	1.142	3.425	in/yr	Retreat rates for vertical scarps only
1982	Simpkins et al.	0.000	2.087	in/yr	Erosion pins, maximum net erosion rate
1986	Simpkins	0.079	1.102	in/yr	Maximum rates, 2 to 4 years erosion data
1986	Simpkins	0.315	0.669	in/yr	Erosion rates, Ogallala caliche only
1986	Simpkins	2.638	28.504	in/yr	Erosion of unconsolidated alluvium only
1989	Gustavson & Simpkins	0.394	0.787	in/yr	Summary compilation of all data
Long-term qualitative estimates of erosion rates based on geomorphic histroy					
1980	Gustavson		5.118	in/yr	Caprock retreat, past 7,200 - 8,600 years
1980	Gustavson		7.087	in/yr	Caprock retreat, past 600,000 years
1980	Gustavson		4.331	in/yr	Caprock retreat, past 3 million years
1980	Gustavson		1.575	in/yr	Widening, Canadian River Valley, 0.6 million years
1982	Simpkins & Baumgardner		7.480	in/yr	Caprock retreat, maximum past 600,000 years
1984	Ostercamp & Wood		1.969	in/yr	Caprock retreat, past ca. 3 million years
1989	Gustavson & Simpkins	2.362	7.087	in/yr	Summary compilation of all data

TABLE 6.5-1

WASTE CONTROL SPECIALISTS LLC
BOREHOLE SUMMARY

		Boring ID		Boring ID		Boring ID		Boring ID
	1	B-1	16	B-16	31	B-31	46	B-42
	2	B-2	17	B-17	32	B-32	47	B-43
	3	B-3	18	B-18	33	B-33	48	B-44
1993 RCRA SITE	4	B-4	19	B-19	34	B-34	49	B-45
INVESTIGATION	5	B-5	20	B-20	35	B-35	50	B-46
Terra Dynamics/Holt	6	B-6	21	B-21	36	B-36	51	B-47
	7	B-7	22	B-22	37	B-37	52	B-48
	8	B-8	23	B-23	38	B-38	53	B-49
	9	B-9	24	B-24	39	B-39	54	B-50
	10	B-10	25	B-25	40	B-40	55	B-51
	11	B-11	26	B-26	41	B-41	56	B-52
	12	B-12	27	B-27	42	B-41E	57	B-53
	13	B-13	28	B-28	43	B-41S	58	B-54
	14	B-14	29	B-29	44	B-41N	59	B-55
	15	B-15	30	B-30	45	B-41W		
	60	WB-1	67	WB-8	74	WB-15	81	WB-107
1997 MUNICIPAL LANDFILL	61	WB-2	68	WB-9	75	WB-101	82	WB-108
INVESTIGATION	62	WB-3	69	WB-10	76	WB-102	83	WB-109
Weaver Boos	63	WB-4	70	WB-11	77	WB-103	84	WB-110
	64	WB-5	71	WB-12	78	WB-104	85	WB-111
	65	WB-6	72	WB-13	79	WB-105		
	66	WB-7	73	WB-14	80	WB-106		
	86	A-1	103	A-18	120	NMB-1	137	NMB-25
	87	A-2	104	A-19	121	NMB-2	138	NMB-26
	88	A-3	105	A-20	122	NMB-3	139	NMB-27
	89	A-4	106	A-21	123	NMB-4	140	NMB-28
	90	A-5	107	A-22	124	NMB-5	141	NMB-29
1998 11(e)2	91	A-6	108	A-23	125	NMB-6	142	NMB-30
Siting Investigation	92	A-7	109	A-24	126	NMB-7	143	NMB-31
Holt	93	A-8	110	A-25	127	NMB-10	144	NMB-32
	94	A-9	111	A-26	128	NMB-11	145	NMB-33
	95	A-10	112	A-27	129	NMB-12	146	NMB-34
	96	A-11	113	A-28	130	NMB-13	147	NMB-35
	97	A-12	114	B-1-98	131	NMB-14	148	NMB-36
	98	A-13	115	B-2-98	132	NMB-17	149	NMB-37
	99	A-14	116	B-3-98	133	NMB-19	150	NMB-38
	100	A-15	117	B-4-98	134	NMB-22		
	101	A-16	118	B-5-98	135	NMB-23		
	102	A-17	119	B-6-98	136	NMB-24		

TABLE 6.5-1

WASTE CONTROL SPECIALISTS LLC
BOREHOLE SUMMARY

		Boring ID		Boring ID		Boring ID		Boring ID
1999 Texas Tech University Investigation	151	PZ-1	160	PZ-10	169	PZ-19	178	PZ-28
	152	PZ-2	161	PZ-11	170	PZ-20	179	PZ-29
	153	PZ-3	162	PZ-12	171	PZ-21	180	PZ-30
	154	PZ-4	163	PZ-13	172	PZ-22	181	PZ-31
	155	PZ-5	164	PZ-14	173	PZ-23	182	PZ-32
	156	PZ-6	165	PZ-15	174	PZ-24	183	PZ-33
	157	PZ-7	166	PZ-16	175	PZ-25	184	PZ-34
	158	PZ-8	167	PZ-17	176	PZ-26	185	PZ-35
	159	PZ-9	168	PZ-18	177	PZ-27		
1999 11(e)2 Siting Investigation CJI	186	TP-01	190	TP-05	194	TP-09	198	TP-13
	187	TP-02	191	TP-06	195	TP-10	199	PM-9
	188	TP-03	192	TP-07	196	TP-11	200	PM-12
	189	TP-04	193	TP-08	197	TP-12		
Additional CJI Investigations	201	NMP-01	204	LES-B2	207	LES-B5	210	LES-B8
	202	TP-14	205	LES-B3	208	LES-B6	211	LES-B9
	203	LES-B1	206	LES-B4	209	LES-B7		
1996 - 98 RCRA MW Installation Espey, Huston & Associates, Inc.	212	B-1	215	B-4	218	B-34		
	213	B-2	216	B-32	219	B-35		
	214	B-3	217	B-33	220	B-36		

TABLE 6.5-1

WASTE CONTROL SPECIALISTS LLC
BOREHOLE SUMMARY

		MW/PZ	Ref. Boring		MW/PZ	Ref. Boring
1993 RCRA Site Investigation Terra Dynamics/Holt	1	7G	B-4	8	9G1	B-21
	2	4G1	B-5	9	9G2	B-21
	3	4G2	B-5	10	9G3	B-21
	4	4G3	B-5	11	5E	B-30
	5	4C	B-7	12	5C	B-39
	6	2G	B-10	13	6B1	B-48
	7	11D	B-20	14	6B2	B-48
1998 11(e)2 Siting Investigation Holt	15	A-16	A-16	18	NMB-23	NMB-23
	16	A-22	A-22	19	NMB-24	NMB-24
	17	A-24	A-24			
1996-98 RCRA Monitor Well Installation Espey, Huston & Associates, Inc.	20	DW-32A	B-32	32	MW-2A	B-2
	21	DW-32B	B-32	33	MW-2B	B-2
	22	DW-33A	B-33	34	MW-3A	B-3
	23	DW-33B	B-33	35	MW-3B	B-3
	24	DW-34A	B-34	36	MW-4A	B-4
	25	DW-34B	B-34	37	MW-4B	B-4
	26	DW-35A	B-35	38	SW-32	B-32
	27	DW-35B	B-35	39	SW-33	B-33
	28	DW-36A	B-36	40	SW-34	B-34
	29	DW-36B	B-36	41	SW-35	B-35
	30	MW-1A	B-1	42	SW-36	B-36
	31	MW-1B	B-1			
1999 Texas Tech University Investigation	43	PZ-1	PZ-1	61	PZ-19	PZ-19
	44	PZ-2	PZ-2	62	PZ-20	PZ-20
	45	PZ-3	PZ-3	63	PZ-21	PZ-21
	46	PZ-4	PZ-4	64	PZ-22	PZ-22
	47	PZ-5	PZ-5	65	PZ-23	PZ-23
	48	PZ-6	PZ-6	66	PZ-24	PZ-24
	49	PZ-7	PZ-7	67	PZ-25	PZ-25
	50	PZ-8	PZ-8	68	PZ-26	PZ-26
	51	PZ-9	PZ-9	69	PZ-27	PZ-27
	52	PZ-10	PZ-10	70	PZ-28	PZ-28
	53	PZ-11	PZ-11	71	PZ-29	PZ-29
	54	PZ-12	PZ-12	72	PZ-30	PZ-30
	55	PZ-13	PZ-13	73	PZ-31	PZ-31
	56	PZ-14	PZ-14	74	PZ-32	PZ-32
	57	PZ-15	PZ-15	75	PZ-33	PZ-33
	58	PZ-16	PZ-16	76	PZ-34	PZ-34
	59	PZ-17	PZ-17	77	PZ-35	PZ-35
	60	PZ-18	PZ-18			

TABLE 6.5-1

WASTE CONTROL SPECIALISTS LLC
BOREHOLE SUMMARY

		MW/PZ	Ref. Boring		MW/PZ	Ref. Boring
1999 11(e) 2 Siting Investigation CJI	78	PM-01	TP-05	91	TP-02	TP-02
	79	PM-02	TP-05	92	TP-03	TP-03
	80	PM-03	TP-05	93	TP-04	TP-04
	81	PM-04	TP-04	94	TP-05	TP-05
	82	PM-05	TP-04	95	TP-06	PM-09
	83	PM-06	TP-04	96	TP-07	PM-12
	84	PM-07	PM-09	97	TP-08	TP-08
	85	PM-08	PM-09	98	TP-09	TP-09
	86	PM-09	PM-09	99	TP-10	TP-08
	87	PM-10	PM-12	100	TP-11	TP-09
	88	PM-11	PM-12	101	TP-12	TP-12
	89	PM-12	PM-12	102	TP-13	TP-13
	90	TP-01	TP-01			

		MW/PZ	Ref. Boring		MW/PZ	Ref. Boring
Additional Investigations CJI	103	NMP-01	NMP-01	106	LES-MW2	LES-B9
	104	TP-14	B-T3A	107	LES-MW3	LES-B3
	105	LES-MW1	LES-B7			

TABLE 6.5-2 WASTE MANAGEMENT AREA SUBSURFACE CONDITIONS

Waste Control Specialists LLC Landfill Project,

Boring Number	Depth Below Grade	Stratum	USC Symbol	Moisture Content (%)	Atterberg Limits: Liquid Limit	Atterberg Limits: Plasticity Index	Dry Density (PCF)	Percent Passing #200	Unconfined Compressive Strength (TSF)	Permeability: Horizontal	Permeability: Vertical	Percent Porosity
MARCH 1993												
B-1	5.0	Tan sandy silt		6.8								
	15.0	Reddish tan silty sand		3.5								
	55.0	Reddish brown silty clay		11.9								
	62.0	Red silty clay	CL	7.8	39	23	133	96.9				
	64.0	Reddish brown silty clay	CL							1.63×10^{-9}	2.06×10^{-9}	
	70.0	Red silty clay	CL	8.3	46	27						
	72.5	Red brown silty clay	CH	8.9	54	33	137	97.0	27.8			
	76.0	Reddish brown silty clay					133					
	81.0	Red brown silty clay	CL	8.7	45	27	135	99.8				
	82.0	Red silty clay		9.0								
	88.0	Red silty clay	CL	8.1	39	23						
	94.0	Red silty clay		5.0								
B-2	7.0	Tan cemented sand		12.7								
	42.5	Red silty clay	CL	7.9	49	27	135	99.8			4.54×10^{-9}	
	48.0	Red silty clay	CH		51	32						
	50.0	Red silty clay		10.6								
	60.0	Red silty clay		11.0								
	70.0	Red silty clay	CL	8.6	44	26						
	75.0	Red silty clay	CH	8.4	53	30	136	97.8	32.6		$<1.00 \times 10^{-9}$	
	81.0	Red silty clay		9.7								
B-3	2.0	Tan limestone w/silt layers		2.5			115					
	7.0	Tan limestone w/silt layers		0.7			116					
	13.0	Tan limestone w/silt layers		1.3			114					
	17.0	Light gray clayey silt		5.9								
	18.0	Red silty clay		17.4								
	22.0	Red silty clay		12.6			120					
	26.0	Red silty clay	CL	9.1	45	28		92.5				
	32.0	Red silty clay		9.8	42	25						
	36.0	Red silty clay		8.6			124					

TABLE 6.5-2 WASTE MANAGEMENT AREA SUBSURFACE CONDITIONS

Waste Control Specialists LLC Landfill Project,

Boring Number	Depth Below Grade	Stratum	USC Symbol	Moisture Content (%)	Atterberg Limits		Dry Density (PCF)	Percent Passing #200	Unconfined Compressive Strength (TSF)	Permeability		Percent Porosity
					Liquid Limit	Plasticity Index				Horizontal	Vertical	
	44.0	Red silty clay		8.9			125					
	48.0	Red silty clay	CL	7.7	46	25	138	99.1				
	49.0	Red silty clay	CH	8.6	53	29	132	99.6			4.20×10^{-9}	
	57.0	Red silty clay		8.2								
	62.0	Red siltstone		5.0								
	68.0	Red siltstone		5.0								
	70.0	Reddish brown silty clay		5.0								
	71.0	Reddish brown silty clay		5.5				74.7				
	75.0	Red siltstone		5.5				74.7				
	80.0	Reddish brown silty clay		7.4							3.20×10^{-6}	
	90.0	Reddish brown silty clay		4.0								
	93.0	Purple silty clay		6.9								
	95.0	Purple silty clay		7.1								
B-3	99.5	Purple silty clay		16.0								
B-4	42.0	Red brown silty clay	CH	7.3	52	30	128	98.9			2.32×10^{-9}	
	68.0	Red brown silty clay	CL	7.9	46	26	134	99.1		1.10×10^{-8}	1.35×10^{-9}	
	75.0	Red silty clay w/gray streaks		11.8				87.0				
	80.0	Red silty clay		10.1								
	86.0	Red silty clay		8.7								
	95.0	Reddish brown silty clay		9.2								
	98.0	Gray and red siltstone		1.8								
	105.0	Reddish brown silty clay		11.2								
	110.0	Reddish brown silty clay		20.7								
	118.0	Reddish brown silty clay		21.6								
	125.0	Reddish brown silty clay		21.9				90.9				
	130.0	Reddish brown silty clay		24.5								
	137.0	Reddish brown silty clay		22.5								
	145.0	Reddish brown silty clay		18.3								
	150.0	Reddish brown silty clay		19.9								
	155	Reddish brown silty clay		17.1								

TABLE 6.5-2 WASTE MANAGEMENT AREA SUBSURFACE CONDITIONS

Waste Control Specialists LLC Landfill Project,

Boring Number	Depth Below Grade	Stratum	USC Symbol	Moisture Content (%)	Atterberg Limits		Dry Density (PCF)	Percent Passing #200	Unconfined Compressive Strength (TSF)	Permeability		Percent Porosity
					Liquid Limit	Plasticity Index				Horizontal	Vertical	
	160.0	Reddish brown silty clay		14.8								
	165.0	Reddish brown silty clay		11.2								
	170.0	Reddish brown silty clay		11.7								
	179.0	Reddish brown silty clay		11.5								
B-4	185.0	Reddish brown silty clay		12.5								
	190.0	Light gray & red siltstone		14.6								
	195.0	Light gray & red siltstone		5.0								
	208.0	Tan siltstone									2.06×10^{-8}	
B-5	50.0	Reddish purple silty clay	CL	8.1	49	30		98.8			3.75×10^{-9}	
	58.0	Light gray siltstone									5.60×10^{-8}	
	60.0	Light gray siltstone									7.26×10^{-8}	
	84.0	Red siltstone									8.92×10^{-8}	
B-6	5.0	Tan limestone		2.3								
	17.0	Red silty clay		10.0								
	22.0	Red silty clay		8.0								
	27.0	Red silty clay		6.3			116					
	31.0	Red silty clay		11.5								
	35.0	Red silty clay		12.2								
	40.0	Red silty clay		5.2								
	45.0	Red-gray siltstone		6.0								
	50.0	Red-gray siltstone		3.3	30	13	118					
	54.0	Red-gray siltstone		9.4								
	60.0	Red silty clay		8.2								
	65.0	Red silty clay		6.8								
B-6	70.0	Red silty clay		9.7								
	75.0	Red silty clay		14.1	61	40						
	80.5	Gray siltstone		11.7			119	41.2				
	85.0	Gray siltstone		5.1			126					
	91.3	Red-gray siltstone		3.2			124					
	95.0	Red-gray siltstone		4.0								

TABLE 6.5-2 WASTE MANAGEMENT AREA SUBSURFACE CONDITIONS

Waste Control Specialists LLC Landfill Project,

Boring Number	Depth Below Grade	Stratum	USC Symbol	Moisture Content (%)	Atterberg Limits Liquid Limit	Atterberg Limits Plasticity Index	Dry Density (PCF)	Percent Passing #200	Unconfined Compressive Strength (TSF)	Permeability Horizontal	Permeability Vertical	Percent Porosity
	99.5	Red silty clay		9.3								
B-7	5.0	Limestone w/silt layers		7.1								
	12.0	Tan cemented sand & gravel		4.4								
	17.0	Tan sandstone		1.2								
	22.0	Tan sandstone		1.8								
	27.0	Tan sand & gravel		3.2			118					
	32.0	Light gray clayey silt		17.6								
	35.0	Red silty clay		9.9								
	37.0	Red silty clay	CL	9.5	36	21	122	92.2	25.7			
	55.0	Red silty clay		8.8								
	60.0	Red silty clay		6.2			130					
	65.0	Red silty clay		7.2								
	70.0	Red silty clay		8.2				92.2	33.7			
	75.0	Red silty clay		7.8								
	80.0	Red silty clay	CL	7.6	44	30	128					
B-7	85.0	Red silty clay		5.8								
	90.0	Red silty clay		10.1								
	95.0	Red silty clay		7.7				91.2				
	100.0	Red silty clay		8.4								
	105.0	Red silty clay		5.7								
	110.0	Gray siltstone		4.0			106					
	115.0	Gray siltstone		4.8			107					
B-8	1.0	Brown silty sand		4.5								
	5.0	Tan sandy silt w/gravel		6.1								
	10.0	Tan sandy silt w/gravel		3.1								
	15.0	White-gray sand		2.3								
	24.0	Yellowish-red brown silty clay		10.3								
	27.0	Red silty clay		10.1								
	41.0	Red silty clay		7.7								

TABLE 6.5-2 WASTE MANAGEMENT AREA SUBSURFACE CONDITIONS

Waste Control Specialists LLC Landfill Project,

Boring Number	Depth Below Grade	Stratum	USC Symbol	Moisture Content (%)	Atterberg Limits: Liquid Limit	Atterberg Limits: Plasticity Index	Dry Density (PCF)	Percent Passing #200	Unconfined Compressive Strength (TSF)	Permeability: Horizontal	Permeability: Vertical	Percent Porosity
	46.0	Tan siltstone		5.4								
	51.0	Tan siltstone		6.6								
	56.5	Red silty clay		7.2								
	64.0	Gray siltstone		4.5								
	67.0	Gray siltstone		3.9								
	72.0	Red silty clay		10.1								
	78.0	Red silty clay		6.4								
B-8	82.0	Red silty clay		7.3								
	87.0	Red silty clay		9.2								
	92.0	Red silty clay		8.4								
	97.0	Red silty clay		7.4								
B-9	3.0	Tan sandy silt		3.8								
	10.0	Tan sandstone		10.4								
	15.0	Tan sandstone		8.2								
	20.0	Tan limestone		6.1					78.6			
	26.0	Tan sandy silt		9.2								
	32.0	Tan sandy silt		12.3								
	37.0	Reddish brown silty clay		13.1								
	42.0	Red silty clay		7.9								
	47.0	Red silty clay		9.1								
	50.0	Red silty clay	CH	10.6	51	29	128	99.2			3.76×10^{-9}	
	59.0	Purple silty clay		13.3								
	65.0	Light gray sandy siltstone		4.0								
	70.0	Light gray sandy siltstone		2.0								
	74.0	Light gray siltstone									2.58×10^{-8}	
	75.0	Light gray sandy siltstone		5.6					57.9			
	76.0	Light gray siltstone									3.91×10^{-8}	
	80.0	Light gray sandy siltstone		7.7								
B-9	85.0	Light gray siltstone		6.2								
	90.0	Red brown silty clay		11.2								
	95.0	Red brown silty clay		12.1								
	100.0	Red brown silty clay		10.1								

TABLE 6.5-2 WASTE MANAGEMENT AREA SUBSURFACE CONDITIONS

Waste Control Specialists LLC Landfill Project,

Boring Number	Depth Below Grade	Stratum	USC Symbol	Moisture Content (%)	Atterberg Limits: Liquid Limit	Atterberg Limits: Plasticity Index	Dry Density (PCF)	Percent Passing #200	Unconfined Compressive Strength (TSF)	Permeability: Horizontal	Permeability: Vertical	Percent Porosity
B-10	3.0	Tan silt		4.2								
	13.0	Tan sandstone		8.3								
	18.0	Tan sandstone		9.2								
	23.0	Tan sandstone		6.9								
	28.0	Tan sandy silt		3.0								
	34.0	Tan sandy silt		12.7								
	39.0	Red silty clay		10.1								
	44.0	Red silty clay		8.0								
	49.0	Red silty clay		14.6								
	54.0	Red silty clay		13.3								
	59.0	Tan siltstone		11.5								
	64.0	Reddish brown silty clay		3.9								
	69.0	Reddish brown silty clay		3.1								
	75.0	Reddish brown silty clay		3.8					49.7			
	80.0	Red silty clay		4.7								
B-11	2.0	Tan limestone w/silt		4.0			104					
	23.0	Red-gray silty clay		8.2								
	27.0	Red-gray silty clay		9.6								
	31.0	Red-gray silty clay		8.7								
	36.0	Red-gray silty clay		13.9			130					
	40.0	Red-gray silty clay		8.1			135					
	47.0	Reddish brown silty clay		6.4			136					
	51.0	Reddish brown clay	CL	5.6	46	24		92.6				
	57.0	Reddish brown clay		8.7								
	62.0	Reddish brown clay		7.4								
	68.0	Reddish brown clay		9.7								
	73.0	Reddish brown clay		15.4				91.5				
	79.0	Reddish brown clay		10.3								
	84.0	Gray siltstone		3.5								
	89.0	Gray siltstone		4.1								

TABLE 6.5-2 WASTE MANAGEMENT AREA SUBSURFACE CONDITIONS

Waste Control Specialists LLC Landfill Project,

Boring Number	Depth Below Grade	Stratum	USC Symbol	Moisture Content (%)	Atterberg Limits		Dry Density (PCF)	Percent Passing #200	Unconfined Compressive Strength (TSF)	Permeability		Percent Porosity
					Liquid Limit	Plasticity Index				Horizontal	Vertical	
	95.0	Gray siltstone		3.3				91.6				
	99.0	Gray siltstone		6.0								
	105.0	Red silty clay		8.3								
	109.0	Red silty clay		11.2								
B-12	1.0	Tan limestone w/silt		6.7								
	7.0	Tan limestone w/silt		10.8								
B-12	13.0	Tan siltstone		4.7								
	18.0	Tan limestone		1.8								
	24.0	Tan limestone		2.6			109					
	28.0	Tan sand & gravel		1.4								
	33.0	Whitish gray silty clay		35.1			126					
	36.0	Gray-red silty clay		16.3								
	41.0	Gray-red silty clay	CH	8.9	54.0	38	129		21.3			
	46.0	Gray-red silty clay		11.8								
	51.0	Dark red silty clay		9.1			128	94.0				
	57.0	Dark red silty clay		7.3								
	60.0	Dark red silty clay		5.4								
	64.0	Dark red silty clay		6.3								
	70.0	Dark red silty clay		5.3								
	74.0	Dark red silty clay	CL	8.7	46.0	27	132	88.7		2.89×10^{-9}	3.55×10^{-9}	
	80.0	Dark red silty clay		6.4			138					
	85.0	Dark red silty clay		5.8								
	90.0	Dark red silty clay		8.3								
	95.0	Dark red silty clay		7.9			134					
	99.5	Dark red silty clay		7.1				86.1				
B-13	4.0	Tan sandy silt		8.3								
	10.0	Tan sandy silt		7.7								
B-13	16.0	Tan limestone		6.5								
	21.0	Tan limestone		1.4								
	27.0	Tan limestone		1.7								
	32.0	Gray-red silty clay		11.3								

TABLE 6.5-2 WASTE MANAGEMENT AREA SUBSURFACE CONDITIONS

Waste Control Specialists LLC Landfill Project,

Boring Number	Depth Below Grade	Stratum	USC Symbol	Moisture Content (%)	Atterberg Limits Liquid Limit	Atterberg Limits Plasticity Index	Dry Density (PCF)	Percent Passing #200	Unconfined Compressive Strength (TSF)	Permeability Horizontal	Permeability Vertical	Percent Porosity
	37.0	Red silty clay		16.2								
	41.0	Red silty clay	CH	12.6	52.0	33						
	45.0	Red silty clay		12.0								
	51.0	Red silty clay		12.2					30.2			
	56.0	Red silty clay		12.6								
	61.0	Red-gray silty clay		7.8								
	68.0	Red silty clay	CH	10.9	52.0	30	133	99.1				
	74.0	Red silty clay	CH	7.4	55.0	32	135	99.4	17.6		1.77×10^{-9}	
	80.0	Red silty clay		10.6								
	84.0	Red silty clay		7.1								
	90.0	Red silty clay		10.3								
	99.5	Red silty clay		8.6								
B-14	51.0	Gray sandy siltstone		2.3								
	75.0	Reddish brown silty clay						95.8				
	99.5	Reddish brown silty clay						99.0				
B-16	23.5	Reddish brown silty clay						97.8				
	50.0	Reddish brown silty clay						94.6				
	65.0	Purple silty clay	CL								1.76×10^{-8}	
	66.0	Reddish purple silty clay	CL	7.9	46.0	27	135	98.8	36.7			
	75.0	Tan sandy siltstone						2.2				
	80.0	Tan sandy siltstone									1.93×10^{-6}	
	85.0	Tan sandy siltstone									7.64×10^{-7}	
	100.0	Reddish brown silty clay						93.7				
B-17	7.5	Tan weathered limestone		0.5								
	17.0	Tan weathered limestone		6.6								
	25.0	Tan siltstone		3.1				18.1				
	30.0	Tan siltstone		7.0								
	32.0	Tan siltstone		6.9								

TABLE 6.5-2 WASTE MANAGEMENT AREA SUBSURFACE CONDITIONS

Waste Control Specialists LLC Landfill Project,

Boring Number	Depth Below Grade	Stratum	USC Symbol	Moisture Content (%)	Atterberg Limits		Dry Density (PCF)	Percent Passing #200	Unconfined Compressive Strength (TSF)	Permeability		Percent Porosity
					Liquid Limit	Plasticity Index				Horizontal	Vertical	
	40.0	Reddish brown silty clay		10.1								
	46.0	Reddish brown silty clay		10.2								
	52.0	Reddish brown silty clay		7.7				91.6				
	58.0	Reddish brown silty clay		9.0								
	64.0	Reddish purple silty clay		8.6								
	70.0	Reddish purple silty clay		5.4								
	75.0	Reddish purple silty clay		9.0								
	81.0	Reddish purple silty clay		8.4				97.1				
B-17	86.0	Reddish purple silty clay		10.0								
	92.0	Reddish purple silty clay		10.3								
	97.0	Reddish purple silty clay		6.5								
	102.0	Tan-gray siltstone		4.8				70.2				
	108.0	Tan-gray siltstone		2.3								
	112.0	Tan-gray siltstone		2.3								
	116.0	Tan-gray siltstone		1.9								
	122.0	Reddish brown silty clay		7.4								
	125.0	Reddish brown silty clay		8.1								
B-18	6.0	Tan weathered limestone		8.4								
	16.5	Tan weathered limestone		5.5								
	28.5	Tan sand & gravel		6.2								
	35.0	Reddish brown silty clay		16.7								
	39.0	Reddish brown silty clay		13.0								
	40.0	Reddish brown silty clay	CH	8.3	53.0	34.0	138.0	99.6	13.9			
	45.0	Reddish brown silty clay		10.1								
	50.5	Reddish brown silty clay		11.1				94.6				
	61.0	Reddish brown silty clay		9.2								
	65.0	Reddish brown silty clay		9.3								
	72.0	Reddish brown silty clay	CL	7.8	47.0	27.0	136.0	98.7	22.5		1.11×10^{-9}	
	77.0	Reddish brown silty clay		7.7				90.0				
B-18	81.0	Reddish brown silty clay	CH	8.9	51.0	29.0	130.0					
	85.5	Reddish brown silty clay		11.0								
	92.0	Reddish brown silty clay		8.1								

TABLE 6.5-2 WASTE MANAGEMENT AREA SUBSURFACE CONDITIONS

Waste Control Specialists LLC Landfill Project,

Boring Number	Depth Below Grade	Stratum	USC Symbol	Moisture Content (%)	Atterberg Limits: Liquid Limit	Atterberg Limits: Plasticity Index	Dry Density (PCF)	Percent Passing #200	Unconfined Compressive Strength (TSF)	Permeability: Horizontal	Permeability: Vertical	Percent Porosity
	99.0	Reddish brown silty clay		14.5				94.2				
B-19	5.0	Tan weathered limestone		1.9								
	13.0	Tan sand & gravel		1.9								
	21.0	Reddish brown silty clay		21.5								
	26.0	Reddish brown silty clay		14.6								
	31.0	Reddish brown silty clay		12.7								
	36.0	Reddish brown silty clay		13.2								
	40.0	Light gray sandy siltstone		5.2								
	45.5	Light gray sandy siltstone		4.2								
	51.0	Light gray sandy siltstone		4.0								
	58.0	Reddish brown silty clay		11.4								
	65.0	Reddish brown silty clay		6.6								
	70.0	Reddish brown silty clay		10.3								
	75.0	Reddish brown silty clay		17.4								
	80.0	Reddish brown silty clay		10.0								
	85.0	Reddish brown silty clay		13.1								
	90.0	Reddish brown silty clay		16.1								
B-19	99.5	Reddish brown silty clay		16.5								
B-25	56.0	Red clayey sandstone									4.41×10^{-7}	
	71.0	Reddish brown silty clay	CH	6.8	52.0	30.0	139.0				2.30×10^{-9}	
B-26	50.0	Reddish brown silty clay	CL	8.7	44.0	25.0	133.0	97.8				
	73.0	Reddish brown siltstone								7.18×10^{-7}	7.86×10^{-7}	
	80.0	Reddish brown silty clay	CL	7.7	46.0	27.0	137.0	99.6	40.5		2.75×10^{-9}	
B-29	60.0	Tan siltstone									3.72×10^{-8}	
	76.0	Reddish brown silty clay	CH	7.5	55.0	34.0	131.0	98.3				
B-30	70.0	Reddish brown silty clay			46.0	29.0						
	74.0	Reddish brown silty clay	CL								3.05×10^{-9}	

TABLE 6.5-2 WASTE MANAGEMENT AREA SUBSURFACE CONDITIONS

Waste Control Specialists LLC Landfill Project,

Boring Number	Depth Below Grade	Stratum	USC Symbol	Moisture Content (%)	Atterberg Limits		Dry Density (PCF)	Percent Passing #200	Unconfined Compressive Strength (TSF)	Permeability		Percent Porosity
					Liquid Limit	Plasticity Index				Horizontal	Vertical	
	76.0	Reddish brown silty clay	CH	9.3	51.0	29.0	136.0	98.7			5.48×10^{-9}	
	80.0	Reddish brown silty clay		2.5			144.0					
	90.0	Light gray siltstone								5.87×10^{-7}	6.42×10^{-7}	
B-31	30.0	Reddish brown silty clay	CL	7.1	47.0	30.0	139.0	99.2				
	74.0	Reddish brown & purple silty clay		8.6	42.0	26.0	135.0	98.9			3.05×10^{-9}	
B-34	40.0	Reddish brown silty clay		8.7	50.0	31.0	138.0	99.5				
	70.0	Reddish brown silty clay		7.7	46.0	30.0		98.2				
	80.0	Reddish brown silty clay		7.3	52.0	31.0		99.9			1.65×10^{-8}	
B-35	32.0	Reddish brown silty clay		31.1								
	35.0	Reddish brown silty clay	CH	22.5	73.0	50.0		99.8				
	40.0	Reddish brown silty clay		12.0								
	45.0	Reddish brown silty clay		10.0								
	50.0	Reddish brown silty clay	CL	8.5	46.0	31.0	132.0	99.4				
	55.0	Reddish brown silty clay		11.1								
	60.0	Reddish brown silty clay		8.8								
	70.0	Reddish brown silty clay	CL	7.6	36.0	23.0						
	75.0	Reddish brown silty clay		5.7								
	76.0	Reddish brown silty clay	CL	8.7	39.0	25.0	129.0	97.9	38.7		2.15×10^{-9}	
	85.0	Reddish brown silty clay		12.2			130.0					
B-39	36.0	Reddish brown silty clay	CH	8.4	54.0	31.0	136.0	96.1				
	40.0	Reddish brown silty clay		12.5								
	45.0	Reddish brown silty clay	CL	12.0	48.0	29.0	124.0	98.9	26.6			
	50.0	Reddish brown silty clay		9.4								
	55.0	Reddish brown silty clay		8.0								
B-39	60.0	Reddish brown silty clay	CL	6.4	35.0	20.0		98.9				
	65.0	Reddish brown silty clay		7.6			142.0					
	70.0	Reddish brown silty clay		7.5								
	71.0	Dark red silty clay	CL								6.75×10^{-9}	

TABLE 6.5-2 WASTE MANAGEMENT AREA SUBSURFACE CONDITIONS

Waste Control Specialists LLC Landfill Project,

Boring Number	Depth Below Grade	Stratum	USC Symbol	Moisture Content (%)	Atterberg Limits		Dry Density (PCF)	Percent Passing #200	Unconfined Compressive Strength (TSF)	Permeability		Percent Porosity
					Liquid Limit	Plasticity Index				Horizontal	Vertical	
	72.0	Reddish brown silty clay	CL	7.7	48.0	30.0		95.5				
	82.0	Reddish brown silty clay		7.6								
	85.0	Reddish brown silty clay		7.5								
	90.0	Reddish brown silty clay		7.6			139.0					
B-40	60.0	Reddish brown silty clay	CH	8.6	51.0	32.0	138.0	95.4				
	80.0	Reddish brown silty clay	CL	7.6	39.0	26.0	131.0	97.1				
	91.5	Reddish brown silty clay					145.0					
	99.5	Reddish brown silty clay		8.3								
B-41	40.0	Reddish brown & purple silty clay		16.4	36.0	27.0	128.0	97.3	28.2			
	50.0	Reddish brown & purple silty clay		8.3	52.0	30.0	136.0	99.4				
	80.0	Reddish brown & purple silty clay		7.1	48.0	30.0	129.0	98.7		3.77×10^{-9}	4.44×10^{-9}	
B-42	41.0	Reddish brown silty clay	CL	12.8	43.0	28.0	127.0	99.7				
	43.0	Reddish brown silty clay	CL	9.8								
	45.0	Reddish brown silty clay		6.1								
	50.0	Reddish brown silty clay		6.2								
	55.0	Reddish brown silty clay		6.5								
	60.0	Reddish brown silty clay	CL	7.1	43.0	25.0	140.0	92.3				
	65.0	Reddish brown silty clay		6.7								
	70.0	Reddish brown silty clay	CH	8.6	50.0	31.0	137.0	99.7				
	75.0	Reddish brown silty clay		10.1								
	80.0	Reddish brown silty clay		7.0								
	85.0	Reddish brown silty clay		6.9								
B-43	28.0	Reddish brown silty clay		17.2			114.0					
	40.0	Reddish brown silty clay		12.5								
	45.0	Reddish brown silty clay		7.9								
	55.0	Reddish brown silty clay	CL	9.5	45.0	28.0		98.9	18.7			

TABLE 6.5-2 WASTE MANAGEMENT AREA SUBSURFACE CONDITIONS

Waste Control Specialists LLC Landfill Project,

Boring Number	Depth Below Grade	Stratum	USC Symbol	Moisture Content (%)	Atterberg Limits: Liquid Limit	Atterberg Limits: Plasticity Index	Dry Density (PCF)	Percent Passing #200	Unconfined Compressive Strength (TSF)	Permeability: Horizontal	Permeability: Vertical	Percent Porosity
	65.0	Reddish brown silty clay		9.3			135.0					
	70.0	Reddish brown silty clay	CL	5.8	39.0	26.0						
	75.0	Reddish brown silty clay		6.8			143.0					
	80.0	Reddish brown silty clay	CH	10.3	51.0	30.0		99.1	42.4			
	85.0	Reddish brown silty clay		8.2								
B-43	90.0	Reddish brown silty clay		8.3			138.0					
	95.0	Reddish brown silty clay		11.9								
B-46	30.0	Reddish brown silty clay		13.5								
	40.0	Reddish brown silty clay		14.8								
	45.0	Tan silty sandstone		4.8								
	50.0	Tan silty sandstone		2.9			130.0					
	55.0	Reddish purple silty clay		10.4	51.0	35.0		99.0				
	65.0	Reddish purple silty clay		12.2								
	70.0	Reddish purple silty clay		9.7			137.0					
	74.5	Dark red w/gray silty clay		10.5			125.0					
	80.0	Reddish brown silty clay	CL	10.9	49.0	30.0	132.0	98.7	24.3			
B-47	70.0	Reddish brown silty clay			46.0	29.0						
	82.0	Reddish brown silty clay	CH	7.9	52.0	29.0	131.0	96.3			7.66×10^{-9}	
B-52	41.0	Reddish brown & purple silty clay		8.7	49.0	30.0		96.3				
	70.0	Reddish brown & purple silty clay		8.3	47.0	28.0	127.0	98.6			5.78×10^{-9}	
B-54	54.0	Reddish brown silty clay	CL	8.5	47.0	28.0	133.0	98.3				
	73.0	Reddish brown silty clay	CL	7.6	46.0	25.0	130.0	99.7	37.3			
	109.0	Reddish brown silty clay		11.4			133.0					
B-55	33.0	Reddish brown silty clay	CL	8.6	39.0	25.0	133.0	94.3				
	48.0	Gray siltstone		5.1			138.0					

TABLE 6.5-2 WASTE MANAGEMENT AREA SUBSURFACE CONDITIONS

Waste Control Specialists LLC Landfill Project,

Boring Number	Depth Below Grade	Stratum	USC Symbol	Moisture Content (%)	Atterberg Limits: Liquid Limit	Atterberg Limits: Plasticity Index	Dry Density (PCF)	Percent Passing #200	Unconfined Compressive Strength (TSF)	Permeability: Horizontal	Permeability: Vertical	Percent Porosity
	78.0	Reddish brown/gray sandstone									2.72×10^{-7}	
7 February 2000												
A-12	58-59	Redbed		5.2	28	13	121.4	98.2			5×10^{-9}	
	70-71	RedBed		4.8	25	10	144.2	65.5			1.7×10^{-8}	
	83.5-84.5	Sandstone		6.3		NP	124.0	30.9			3.95×10^{-6}	
A-14	85-86	Sandstone		3.4		NP	138.8	33.5			7.65×10^{-7}	
A-16	57.5-58.5	Redbed		8.8	47	29	135.8	97.8			5.7×10^{-9}	
A-17	81-82	Redbed		6.8	31	15	131.6	98.9			3.7×10^{-9}	
A-19	69-70	Siltstone		2.1	26.0	11.0	136.7	82.4	136.0			
A-21	58.5-59.5	Redbed		6.4	25	10	144.5	97.9			5.7×10^{-9}	
	76-77	Redbed		5.3	26	11	146.4	89.9			8.2×10^{-9}	
A-22	75-76	Sandstone		2.5		NP	122.0	29.3	47.0			
	82-83	Redbed		6.0	32	16	143.2	99.5	70.0			
	90-91	Siltstone		3.6	22	8	137.8	89.2	89.0			
A-24	58-59	Redbed		7.0	31	15	142.9	98.2	89.0			
	72-73	Redbed		4.1	24	9	148.4	90.0	120.0			
A-26	40-45	Sandstone		5.5	31	15		53.0				
	55-60	Redbed		6.3	32	16		90.1				
	75-80	Redbed		7.6	40	23		93.2				
A-27	45-50	Redbed		9.6	41	24		97.2				
	65-70	Redbed		7.7	34	18		98.6				
	85-90	Redbed		4.7	26	11		79.0				

TABLE 6.5-2 WASTE MANAGEMENT AREA SUBSURFACE CONDITIONS

Waste Control Specialists LLC Landfill Project,

Boring Number	Depth Below Grade	Stratum	USC Symbol	Moisture Content (%)	Atterberg Limits		Dry Density (PCF)	Percent Passing #200	Unconfined Compressive Strength (TSF)	Permeability		Percent Porosity
					Liquid Limit	Plasticity Index				Horizontal	Vertical	
30 December 1998												
B-23	35'	Purple silty clay		10.1	48.0							
	42'	Reddish brown silty clay		5.9								
	52'	Reddish brown silty clay		5.9								
	65'	Reddish brown silty clay		7.4								
	75'	Purple silty clay		8.5								
	80'	Reddish brown silty clay		3.4								
	90'	Reddish brown & purple silty clay		12.9	37.0							
	98'	Reddish brown & purple silty clay		15.4	48.0							
B-24	33'	Reddish silty sandy clay		4.8	26.0							
	40'	Light tan sandstone		1.7								
	50'	Red Bed & reddish brown sandy silty clay		10.3	42	24						
	71'	Light tan sandy silty clay		3.6								
	75'	Reddish brown silty clay		6.6								
	85'	Reddish brown silty clay		11.4								
	90'	Reddish brown silty clay		10.9	49	30						
	95'	Reddish brown silty clay		10.7								
B-25	34'	Light brown sandstone		2.5			125.3				3.1×10^{-6}	
	41'	Reddish brown silty clay		8.9	44	26						
	50'	Reddish brown silty clay		11.7								
	60'	Dark purple silty clay		9.8								
	81.5'	Purple reddish brown silty clay		13.4	41	24						
	92'	Purple reddish brown silty clay		10.4								
B-26	57'	Reddish brown silty clay		12.7								
	70'	Purple brown silty clay		12.1				99.0				

TABLE 6.5-2 WASTE MANAGEMENT AREA SUBSURFACE CONDITIONS

Waste Control Specialists LLC Landfill Project,

Boring Number	Depth Below Grade	Stratum	USC Symbol	Moisture Content (%)	Atterberg Limits		Dry Density (PCF)	Percent Passing #200	Unconfined Compressive Strength (TSF)	Permeability		Percent Porosity
					Liquid Limit	Plasticity Index				Horizontal	Vertical	
	78'	Reddish brown silty clay		8.0	34	18	136.0				2.3×10^{-9}	
	79'	Reddish brown silty clay		9.3				93.7				
	89'	Reddish brown silty clay		11.3				97.9				
	99'	Reddish brown silty clay		9.9				97.5				
B-27	39'	Reddish brown silty clay		9.4	41	24						
	43'	Tan silty clayey sandstone		6.2	25	10						
	47'	Tan sandstone		1.2			137.3				1.8×10^{-6}	
	48'	Tan sandstone		3.0								
	61'	Purple silty clay		6.6	30	14						
	75'	Light reddish brown silty clay		11.1								
	84'	Reddish brown silty clay		11.1								
	91'	Dark reddish brown silty clay		19.9								
B-28	25'-30'	Reddish brown & purple silty clay		4.0	61	40						
	31'	Reddish brown silty clay		4.1				95.4				
	61'	Brown silty clay		10.5				97.9				
	63'	Purple & dark reddish brown silty clay		10.6	45	27						
	72'	Purple reddish brown silty clay		10.7								
	81'	Dark purple silty clay		15.4								
	94'	Reddish brown silty clay		9.7				96.2				
	100'	Reddish brown silty clay		9.6								
B-29	25'-27'	Purple & reddish brown silty clay			65	44						
	38'	Light brown silty clay		11.1				98.6				
	46'	Reddish brown silty clay		12.4								

TABLE 6.5-2 WASTE MANAGEMENT AREA SUBSURFACE CONDITIONS

Waste Control Specialists LLC Landfill Project,

Boring Number	Depth Below Grade	Stratum	USC Symbol	Moisture Content (%)	Atterberg Limits		Dry Density (PCF)	Percent Passing #200	Unconfined Compressive Strength (TSF)	Permeability		Percent Porosity
					Liquid Limit	Plasticity Index				Horizontal	Vertical	
	54'-60'	Dark purple & reddish brown silty clay		11.3	49	30		99.5				
	63'	Dark reddish brown & light tan silty clay		11.5								
	71'	Reddish brown silty clay		9.1								
	80'	Dark reddish brown silty clay		11.5				95.8				
B-29	87'	Purple & reddish brown silty clay			40	23						
	90'	Dark reddish brown silty clay		15.4								
	97'	Purple silty clay		13.4				98.7				
	--	Compacted standard proctor sample (Red brown silty clay mix)		16.7			107.9				2.9×10^{-9}	
B-30	15'-20'	Purple & red silty clay			63	42						
	61'	Reddish brown silty clay		8.9			136.5				1.4×10^{-9}	
	64'	Purple & reddish brown silty clay		11.5	47	29		98.1				
	75'	Reddish brown silty clay		5.9	37	20	138.9				5.0×10^{-9}	
	76'	Reddish brown silty clay		11.1								
	84'	purple silty clay		13.5								
	96'	Purple & reddish brown silty clay		13.7								
B-31	40'	Reddish brown silty clay		10.7								
	52'	Red bed purple & reddish silty clay		9.8	44	26						
	61'	Light reddish brown silty clay		10.2			129.0				6.4×10^{-9}	
	67.5'	Dark reddish brown silty clay		11.5								

TABLE 6.5-2 WASTE MANAGEMENT AREA SUBSURFACE CONDITIONS

Waste Control Specialists LLC Landfill Project,

Boring Number	Depth Below Grade	Stratum	USC Symbol	Moisture Content (%)	Atterberg Limits		Dry Density (PCF)	Percent Passing #200	Unconfined Compressive Strength (TSF)	Permeability		Percent Porosity
					Liquid Limit	Plasticity Index				Horizontal	Vertical	
B-31	74'	Reddish brown silty clay		7.3			141.5				1.4×10^{-9}	
	80'	Reddish brown silty clay		10.6			131.3					
	81'	Reddish brown silty clay		15.3								
	95'	Purple reddish silty clay		15.8								
B-32	23'	Tan clayey sandstone		7.4								
	24'	Tan sandstone		3.8								
	30.5'	Light tan sandstone		6.4								
	39.7'	Light tan clayey silty sand		6.2								
	43.8'	Light brown sandstone		5.3			112.7				1.53×10^{-5}	
	49.5'	Tan sandstone		4.7								
	55'	Reddish brown silty clay		11.5								
	73'	Reddish brown silty clay		11.7								
	80'	Reddish brown silty clay		8.4								
	88'	Light reddish brown silty clay		6.2								
	43.8'	Light brown sandstone		5.3							Pending	

24 October 2001

TP-01	40-43'	Clay		9.8	49	32						
TP-01	138-139'	Clay		9.2	45	26						
TP-01	221-222'	Sandstone		3.2								
TP-02	30-40'	Sandstone		4.8								
TP-02	122-123'	Sandstone		4.9				14.0				
TP-03	30-40'	Sandstone		2.8								
TP-03	65-70'	Clay		5.0	26	13						0.13
TP-03	144-145'	Clay		6.9	37	19						0.17
TP-03	216-217'	Sandstone		8.3								0.08
TP-08	50-60'	Clayey Sand	SC	11.9	21	4		26.0				0.18
TP-08	105-106'	Clay	CL	11.9	41.0	25.0		99.0				
TP-12	20-30'	Clayey Sand	SC	16.9	34	12	139.0	21.0				
TP-12	48-50'	Clay	CL	8.9	46	32		99.0				
TP-13	20-22'	Clayey Sand	SC	10.3	27	10	137.0	46.0				

TABLE 6.5-2 WASTE MANAGEMENT AREA SUBSURFACE CONDITIONS

Waste Control Specialists LLC Landfill Project,

Boring Number	Depth Below Grade	Stratum	USC Symbol	Moisture Content (%)	Atterberg Limits: Liquid Limit	Atterberg Limits: Plasticity Index	Dry Density (PCF)	Percent Passing #200	Unconfined Compressive Strength (TSF)	Permeability: Horizontal	Permeability: Vertical	Percent Porosity
TP-13	65-75'	Clay with Sand	CL	8.7	36	20		81.0				
29 November 2001												
TP-04	25-30'	Clayey Sand with Gravel	SC	10.6	26	8		12.0				
TP-04	65-70'	Clay	CL	6.8	45	29		95.0				
TP-04	115-120'	Sandstone		1.2								
TP-04	155-160'	Clay	CL	6.0	45	27		99.0				
TP-04	220-225'	Sandstone		4.0								
TP-05	40-45'	Sandstone		1.2								
TP-05	75-80'	Clay	CL	9.6	44	27		98.0				
TP-05	110-115'	Sandstone		1.8								
TP-05	155-160'	Clay	CL	7.9	43	25		97.0				
TP-05	235-240'	Sandstone		6.9								
PM-09	35-40'	Clayey Sand	SC	19.2	24	7		16.0				
PM-09	70-75'	Clay	CL	8.0	44	31		91.0				
PM-09	115-120'	Clay	CL	5.7	41	27		97.0				
PM-09	160-165'	Clay	CL	7.1	41	26		99.0				
PM-09	210-215'	Clay with Sand	CL	7.2	38	22		75.0				
August 2003												
B-21	108-109'	Sandstone		0.6			112					
B-21	219-220'	Sandstone		2.1			140					0.13
B-4	208-209'	Sandstone		2.3			136					0.17
NMB-23	251-252'	Sandstone		2.7			149					0.08
NMB-24	220-221'	Sandstone		1.0			135					0.18
A-22	248-249'	Sandstone		4.3			129					

TABLE 6.6-1
WASTE CONTROL SPECIALISTS LLC
MONITOR WELL AND PIEZOMETER SUMMARY

1993 RCRA Site Investigation
Terra Dynamics/Holt

MW/PZ	Reference Boring	Screen Interval (Feet BGS)	Completion Zone
7G	B-4	185-215	225
4G1	B-5	145-175	Other
4G2	B-5	190-220	Other
4G3	B-5	237-242	Other
4C	B-7	161-191	180
2G	B-10	225-250	Other
11D	B-20	232-257	Other
5E	B-30	145-155	Other
5C	B-39	173-193	180
6B1	B-48	191-201	180
6B2	B-48	262-272	225

1998 11(e)2 Siting Investigation
Holt

MW/PZ	Reference Boring	Screen Interval (Feet BGS)	Completion Zone
A-16	A-16	27-37	OAG
A-22	A-22	245-255	225
A-24	A-24	257-267	225
NMB-23	NMB-23	251-261	225
NMB-24	NMB-24	210-230	225

TABLE 6.6-1
WASTE CONTROL SPECIALISTS LLC
MONITOR WELL AND PIEZOMETER SUMMARY

1996 - 1998 RCRA Monitor Well Installation
Espey, Huston and Associates

MW/PZ	Reference Boring	Screen Interval (Feet BGS)	Completion Zone
DW-32A	B-32	212.5-227.5	225
DW-32B	B-32	229.5-244.5	225
DW-33A	B-33	215-230	225
DW-33B	B-33	230-245	225
DW-34A	B-34	218-233	225
DW-34B	B-34	232-247	225
DW-35A	B-35	218-233	225
DW-35B	B-35	233-248	225
DW-36A	B-36	223-238	225
DW-36B	B-36	238-253	225
MW-1A	B-1	241-256	225
MW-1B	B-1	255.5-270.5	225
MW-2A	B-2	245-260	225
MW-2B	B-2	258-273	225
MW-3A	B-3	249-264	225
MW-3B	B-3	264-279	225
MW-4A	B-4	252-267	225
MW-4B	B-4	267.5-282.5	225
SW-32	B-32	117-127	125
SW-33	B-33	135.5-145.5	125
SW-34	B-34	108-118	125
SW-35	B-35	113-123	125
SW-36	B-36	105-119	125

TABLE 6.6-1
WASTE CONTROL SPECIALISTS LLC
MONITOR WELL AND PIEZOMETER SUMMARY

1999 Texas Tech Univ. Investigation
Texas Tech Univ.

MW/PZ	Reference Boring	Screen Interval (Feet BGS)	Completion Zone
PZ-1	PZ-1	91-106	OAG
PZ-2	PZ-2	78-93	OAG
PZ-3	PZ-3	52-67	OAG
PZ-4	PZ-4	100-115	OAG
PZ-5	PZ-5	70-85	OAG
PZ-6	PZ-6	55-70	OAG
PZ-7	PZ-7	45-60	OAG
PZ-8	PZ-8	49-64	OAG
PZ-9	PZ-9	56-71	OAG
PZ-10	PZ-10	70-85	OAG
PZ-11	PZ-11	55-70	OAG
PZ-12	PZ-12	65-80	OAG
PZ-13	PZ-13	65-80	OAG
PZ-14	PZ-14	61-76	OAG
PZ-15	PZ-15	70-85	OAG
PZ-16	PZ-16	65-80	OAG
PZ-17	PZ-17	75-90	OAG
PZ-18	PZ-18	61-76	OAG
PZ-19	PZ-19	95-110	OAG
PZ-20	PZ-20	86-101	OAG
PZ-21	PZ-21	55-70	OAG
PZ-22	PZ-22	105-120	OAG
PZ-23	PZ-23	92-107	OAG
PZ-24	PZ-24	75-90	OAG
PZ-25	PZ-25	30-45	OAG
PZ-26	PZ-26	35-50	OAG
PZ-27	PZ-27	35-50	OAG
PZ-28	PZ-28	55-70	OAG
PZ-29	PZ-29	70-85	OAG
PZ-30	PZ-30	25-40	OAG
PZ-31	PZ-31	44-59	OAG
PZ-32	PZ-32	78-93	OAG
PZ-33	PZ-33	65-80	OAG
PZ-34	PZ-34	30-45	OAG
PZ-35	PZ-35	110-125	OAG

TABLE 6.6-1
WASTE CONTROL SPECIALISTS LLC
MONITOR WELL AND PIEZOMETER SUMMARY

1999 11(e)2 Siting Investigation
CJI

MW/PZ	Reference Boring	Screen Interval (Feet BGS)	Completion Zone
PM-01	TP-05	52-57	OAG
PM-02	TP-05	113.5-123.5	80
PM-03	TP-05	219-229	225
PM-04	TP-04	53-58	OAG
PM-05	TP-04	126-131	125
PM-06	TP-04	217-227	225
PM-07	PM-09	45-55	OAG
PM-08	PM-09	80-90	80
PM-09	PM-09	197-207	180
PM-10	PM-12	18-23	OAG
PM-11	PM-12	125-135	125
PM-12	PM-12	180-190	Other
TP-01	TP-01	225-240	225
TP-02	TP-02	110-120	125
TP-03	TP-03	212-227	225
TP-04	TP-04	217-227	225
TP-05	TP-05	218228	225
TP-06	PM-09	110-120	Z-4
TP-07	PM-12	140-150	Z-4
TP-08	TP-08	110-120	125
TP-09	TP-09	110-120	125
TP-10	TP-08	80-100	Z-2
TP-11	TP-09	60-70	Z-2
TP-12	TP-12	47-57	OAG
TP-13	TP-13	32.5-42.5	OAG

Additional Investigations
CJI

MW/PZ	Reference Boring	Screen Interval (Feet BGS)	Completion Zone
NMP-01	NMP-01	222-227	225
TP-14	B-T3A	46-51	OAG
LES-MW1	LES-B7	214-229	Other
LES-MW2	LES-B9	217-232	225
LES-MW3	LES-B3	221-236	Other

TABLE 6.6-2
WASTE CONTROL SPECIALISTS
JANUARY-APRIL 2002
GROUNDWATER ELEVATIONS

Well ID	TOC Elevation (ft)	Date	DtW (ft)	Date	DtW (ft)	Date	DtW (ft)	Date	DtW (ft)
DW32A	3461.52	1/22/2002	215.49	2/25/2002	211.18	3/26/2002	227.28	4/19/2002	224.86
DW32B	3461.46	1/22/2002	200.11	2/25/2002	195.19	3/26/2002	235.37	4/19/2002	228.07
DW33A	3464.99	1/22/2002	222.57	2/25/2002	219.99	3/26/2002	230.34	4/19/2002	228.78
DW33B	3465.12	1/22/2002	211.41	2/25/2002	207.48	3/26/2002	239.11	4/19/2002	229.91
DW34A	3468.70	1/22/2002	198.62	2/25/2002	195.51	3/26/2002	222.94	4/19/2002	214.52
DW34B	3468.94	1/22/2002	201.52	2/25/2002	197.65	3/26/2002	238.67	4/19/2002	225.91
DW35A	3467.86	1/22/2002	191.54	2/25/2002	189.91	3/26/2002	205.04	4/19/2002	198.37
DW35B	3467.95	1/22/2002	191.49	2/25/2002	189.88	3/26/2002	204.11	4/19/2002	198.13
DW36A	3467.59	1/22/2002	190.86	2/25/2002	189.12	3/26/2002	205.36	4/19/2002	198.10
DW36B	3467.93	1/22/2002	190.98	2/25/2002	189.27	3/26/2002	204.41	4/19/2002	198.00
NMB-23	3467.85	1/21/2002	139.97	2/22/2002	138.79	3/26/2002	137.72		
NMB-24	3439.15	1/21/2002	116.19	2/22/2002	116.16	3/26/2002	116.13		
MW1A	3480.79	1/21/2002	151.11	2/22/2002	148.48	3/26/2002	146.25		
MW1B	3480.61	1/21/2002	142.02	2/22/2002	140.89	3/26/2002	139.81		
MW2A	3481.72	1/21/2002	158.58	2/22/2002	156.50	3/26/2002	154.62		
MW2B	3481.93	1/21/2002	190.58	2/22/2002	185.22	3/26/2002	180.40		
MW3A	3483.04	1/21/2002	154.56	2/22/2002	152.98	3/26/2002	151.50		
MW3B	3483.10	1/21/2002	153.81	2/22/2002	152.26	3/26/2002	150.81		
MW4A	3484.70	1/21/2002	139.78	2/22/2002	139.05	3/26/2002	138.35		
MW4B	3484.74	1/21/2002	139.63	2/22/2002	138.94	3/26/2002	138.22		
A-22-99	3460.00	1/21/2002	168.69	2/22/2002	167.91	3/26/2002	167.56		
A-24-99	3464.20	1/21/2002	158.09	2/22/2002	159.26	3/26/2002	159.61		
6B-2	3487.07	1/21/2002	137.61	2/22/2002	136.43	3/26/2002	135.90		
7G	3448.57	1/21/2002	138.35	2/22/2002	138.04	3/26/2002	137.61		
TP-01	3485.38	1/22/2002	98.5	2/22/2002	98.50	3/26/2002	98.31		
TP-02	3436.14	1/22/2002	122.62	2/22/2002	122.62	3/26/2002	122.63		
TP-03	3487.98	1/22/2002	225.81	2/22/2002	223.78	3/26/2002	221.58		
TP-04	3489.05	1/22/2002	133.85	2/22/2002	134.07	3/26/2002	134.04		
TP-05	3488.35	1/22/2002	119.72	2/22/2002	119.62	3/26/2002	119.51		
PM-03	3487.99	1/22/2002	119.73	2/22/2002	119.77	3/26/2002	119.63		
PM-06	3489.59	1/28/2002	134.08	2/22/2002	134.26	3/26/2002	134.27		

TABLE 6.6-2
WASTE CONTROL SPECIALIST
MAY - JULY 2002
GROUNDWATER ELEVATIONS

Well ID	TOC Elevation (ft)	Date	DtW (ft)	Date	DtW (ft)	Date	DtW (ft)	Date	DtW (ft)
DW32A	3461.52	5/1/2002	223.75	5/29/2002	225.52	6/25/2002	223.1	7/30/2002	220.06
DW32B	3461.46	5/1/2002	224.98	5/29/2002	226.72	6/25/2002	219.16	7/30/2002	209.78
DW33A	3464.99	5/1/2002	227.92	5/29/2002	230.56	6/25/2002	228.46	7/30/2002	225.67
DW33B	3465.12	5/1/2002	225.68	5/29/2002	228.92	6/25/2002	221.65	7/30/2002	215.95
DW34A	3468.70			5/29/2002	215.93	6/25/2002	209.18	7/30/2002	203.28
DW34B	3468.94	5/1/2002	220.85	5/29/2002	224.37	6/25/2002	215.48	7/30/2002	207.44
DW35A	3467.86			5/29/2002	199.11	6/25/2002	196.13	7/30/2002	193.73
DW35B	3467.95			5/29/2002	198.91	6/25/2002	196.02	7/30/2002	193.71
DW36A	3467.59			5/29/2002	199.50	6/25/2002	195.92	7/30/2002	193.16
DW36B	3467.93			5/29/2002	199.39	6/25/2002	195.98	7/30/2002	193.26
NMB-23	3467.85	5/6/2002	136.37	5/28/2002	135.65	6/24/2002	134.78	7/29/2002	133.22
NMB-24	3439.15	5/6/2002	116.13	5/28/2002	115.92	6/24/2002	115.81	7/29/2002	115.54
MW1A	3480.79	5/6/2002	143.8	5/28/2002	142.62	6/24/2002	141.46	7/29/2002	140.21
MW1B	3480.61	5/6/2002	138.48	5/28/2002	137.94	6/24/2002	137.42	7/29/2002	136.90
MW2A	3481.72	5/6/2002	152.38	5/28/2002	151.26	6/24/2002	150.14	7/29/2002	148.86
MW2B	3481.93	5/6/2002	174.86	5/28/2002	172.11	6/24/2002	169.13	7/29/2002	165.08
MW3A	3483.04	5/2/2002	149.72	5/28/2002	149.58	6/24/2002	148.46	7/29/2002	147.37
MW3B	3483.10	5/2/2002	149.22	5/28/2002	148.89	6/24/2002	147.82	7/29/2002	146.77
MW4A	3484.70	5/2/2002	137.57	5/28/2002	137.43	6/24/2002	136.93	7/29/2002	136.42
MW4B	3484.74	5/2/2002	137.46	5/28/2002	137.30	6/24/2002	136.86	7/29/2002	136.43
A-22-99	3460.00	5/6/2002	167.7	5/30/2002	169.00	6/24/2002	168.45	7/30/2002	167.81
A-24-99	3464.20	5/6/2002	159.61	5/30/2002	160.56	6/24/2002	159.47	7/30/2002	158.81
6B-2	3487.07	5/6/2002	135.49	5/29/2002	138.37	6/24/2002	136.92	7/30/2002	136.00
7G	3448.57	5/6/2002	142.56	5/29/2002	138.84	6/25/2002	137.9	7/30/2002	137.70
TP-0001	3485.38	5/6/2002	98.16	5/30/2002	98.18	6/24/2002	98.66	7/30/2002	98.32
TP-0002	3436.14	5/6/2002	122.61	5/30/2002	122.53	6/24/2002	122.54	7/30/2002	122.55
TP-0003	3487.98	5/6/2002	218.66	5/30/2002	216.77	6/24/2002	214.78	7/30/2002	211.38
TP-0004	3489.05	5/6/2002	134.86	5/30/2002	133.64	6/24/2002	133.67	7/30/2002	133.54
TP-0005	3488.35	5/6/2002	119.32	5/30/2002	119.31	6/24/2002	119.34	7/30/2002	119.45
PM-0003	3487.99	5/6/2002	119.43	5/30/2002	119.41	6/24/2002	119.44	7/30/2002	119.51
PM-0006	3489.59	5/6/2002	134.27	5/30/2002	134.20	6/24/2002	134.22	7/30/2002	134.23

TABLE 6.6-2
WASTE CONTROL SPECIALIST
AUGUST - SEPTEMBER 2002
GROUNDWATER ELEVATIONS

Well ID	TOC Elevation (ft)	Date	DtW (ft)	Date	DtW (ft)	Date	DtW (ft)
DW32A	3461.52	8/27/2002	216.59			9/12/2002	215.82
DW32B	3461.46	8/27/2002	203.85			9/12/2002	201.13
DW33A	3464.99	8/27/2002	223.44			9/12/2002	222.26
DW33B	3465.12	8/27/2002	212.69			9/12/2002	211.30
DW34A	3468.70	8/27/2002	232.59	8/28/2002	231.75	9/11/2002	224.64
DW34B	3468.94	8/27/2002	248.03	8/28/2002	247.47	9/11/2002	240.94
DW35A	3467.86	8/27/2002	226.54	8/28/2002	225.17	9/11/2002	209.22
DW35B	3467.95	8/27/2002	217.99	8/28/2002	216.94	9/11/2002	207.93
DW36A	3467.59	8/27/2002	222.3	8/28/2002	220.18	9/11/2002	206.85
DW36B	3467.93	8/27/2002	217.89	8/28/2002	216.54	9/11/2002	206.19
NMB-23	3467.85	8/27/2002	131.18			9/12/2002	130.22
NMB-24	3439.15	8/27/2002	115.29			9/12/2002	115.28
MW1A	3480.79	8/27/2002	139.28			9/12/2002	138.91
MW1B	3480.61	8/27/2002	136.42			9/12/2002	136.27
MW2A	3481.72	8/27/2002	147.87			9/12/2002	147.41
MW2B	3481.93	8/27/2002	163.09			9/12/2002	161.38
MW3A	3483.04	8/27/2002	146.51			9/12/2002	146.19
MW3B	3483.10	8/27/2002	145.94			9/12/2002	145.63
MW4A	3484.70	8/27/2002	136.14			9/12/2002	136.07
MW4B	3484.74	8/27/2002	136.07			9/12/2002	135.99
A-22-99	3460.00			8/28/2002	168.64	9/12/2002	168.33
A-24-99	3464.20			8/28/2002	158.59	9/12/2002	157.38
6B-2	3487.07	8/27/2002	137.73			9/12/2002	137.02
7G	3448.57	8/27/2002	139.13			9/12/2002	138.38
TP-0001	3485.38			8/28/2002	98.32	9/12/2002	98.40
TP-0002	3436.14			8/28/2002	122.57	9/12/2002	122.57
TP-0003	3487.98			8/28/2002	208.46	9/12/2002	206.72
TP-0004	3489.05			8/28/2002	133.51	9/12/2002	133.46
TP-0005	3488.35			8/28/2002	119.35	9/12/2002	119.41
PM-0003	3487.99			8/28/2002	119.45	9/12/2002	119.51
PM-0006	3489.59			8/28/2002	134.24	9/12/2002	134.24

TABLE 6.6-2
WASTE CONTROL SPECIALIST
NOVEMBER - DECEMBER 2002
GROUNDWATER ELEVATIONS

Well ID	TOC Elevation (ft)	Date	DtW (ft)	Date	DtW (ft)	Date	DtW (ft)
DW32A	3461.52	10/29/2002	220.98	11/25/2002	218.38	12/20/2002	215.43
DW32B	3461.46	10/29/2002	205.32	11/25/2002	200.45	12/20/2002	196.77
DW33A	3464.99			11/25/2002	224.51	12/20/2002	222.41
DW33B	3465.12			11/25/2002	212.56	12/20/2002	209.97
DW34A	3468.70			11/25/2002	212.04	12/20/2002	207.48
DW34B	3468.94			11/25/2002	219.71	12/20/2002	212.96
DW35A	3467.86			11/25/2002	199.27	12/20/2002	197.06
DW35B	3467.95			11/25/2002	199.13	12/20/2002	196.99
DW36A	3467.59	10/29/2002	202.91	11/25/2002	199.03	12/20/2002	196.59
DW36B	3467.93	10/29/2002	202.75	11/25/2002	199.05	12/20/2002	196.64
NMB-23	3467.85	10/29/2002	127.62	11/25/2002	126.32	12/19/2002	125.29
NMB-24	3439.15	10/29/2002	115.21	11/25/2002	115.38	12/19/2002	115.38
MW1A	3480.79	10/29/2002	137.78	11/25/2002	137.18	12/19/2002	136.65
MW1B	3480.61	10/29/2002	135.6	11/25/2002	135.06	12/19/2002	134.57
MW2A	3481.72	10/29/2002	146.08	11/25/2002	145.33	12/19/2002	144.65
MW2B	3481.93	10/29/2002	158.35	11/25/2002	156.58	12/19/2002	155.12
MW3A	3483.04	10/29/2002	146.32	11/25/2002	145.34	12/19/2002	144.61
MW3B	3483.10	10/29/2002	145.72	11/25/2002	144.78	12/19/2002	144.05
MW4A	3484.70	10/29/2002	136.1	11/25/2002	135.64	12/19/2002	135.27
MW4B	3484.74	10/29/2002	135.94	11/25/2002	135.57	12/19/2002	135.19
A-22-99	3460.00	10/29/2002	168.02	11/25/2002	169.71	12/20/2002	168.97
A-24-99	3464.20	10/29/2002	159.64	11/25/2002	161.84	12/20/2002	160.39
6B-2	3487.07	10/29/2002	135.81	11/25/2002	140.59	12/19/2002	138.64
7G	3448.57	10/29/2002	138.8	11/25/2002	139.26	12/20/2002	137.91
TP-0001	3485.38	10/29/2002	98.32	11/25/2002	98.38	12/20/2002	98.31
TP-0002	3436.14	10/29/2002	122.58	11/25/2002	122.6	12/20/2002	122.59
TP-0003	3487.98	10/29/2002	200.04	11/25/2002	193.87	12/20/2002	188.35
TP-0004	3489.05	10/29/2002	133.55	11/25/2002	133.86	12/20/2002	133.8
TP-0005	3488.35	10/29/2002	119.34	11/25/2002	119.45	12/20/2002	119.39
PM-0003	3487.99	10/29/2002	119.43	11/25/2002	119.54	12/20/2002	119.5
PM-0006	3489.59	10/29/2002	134.26	11/25/2002	134.29	12/20/2002	134.29

TABLE 6.6-2
WASTE CONTROL SPECIALISTS
JANUARY - APRIL 2003
GROUNDWATER ELEVATIONS

Well ID	TOC Elevation (ft)	Date	DtW (ft)	GW Elevation (ft)	Date	DtW (ft)	Date	DtW (ft)	GW Elevation (ft)
DW32A	3461.52	1/28/2003	210.31	3251.21	2/28/2003	206.55	3/31/2003	203.07	3051.90
DW32B	3461.46	1/28/2003	192.15	3269.31	2/28/2003	189.19	3/31/2003	186.67	3085.60
DW33A	3464.99	1/28/2003	218.99	3246.00	2/28/2003	215.53	3/31/2003	212.37	3037.09
DW33B	3465.12	1/28/2003	206.77	3258.35	2/28/2003	204.63	3/31/2003	202.56	3057.93
DW34A	3468.70	1/28/2003	202.06	3266.64	2/28/2003	198.81	3/31/2003	196.23	3073.66
DW34B	3468.94	1/28/2003	205.57	3263.37	2/28/2003	201.43	3/31/2003	198.56	3068.95
DW35A	3467.86	1/28/2003	194.57	3273.29	2/28/2003	192.93	3/31/2003	191.57	3083.36
DW35B	3467.95	1/28/2003	194.51	3273.44	2/28/2003	192.88	3/31/2003	191.55	3083.52
DW36A	3467.59	1/28/2003	193.91	3273.68	2/28/2003	192.14	3/31/2003	190.73	3084.72
DW36B	3467.93	1/28/2003	194	3273.93	2/28/2003	192.25	3/31/2003	190.85	3084.83
NMB-23	3467.85	1/27/2003	123.86	3343.99	2/28/2003	122.80	3/27/2003	121.98	3223.07
NMB-24	3439.15	1/27/2003	115.48	3323.67	2/28/2003	115.41	3/27/2003	115.31	3208.43
MW1A	3480.79	1/27/2003	135.81	3344.98	2/28/2003	135.15	3/27/2003	134.54	3211.10
MW1B	3480.61	1/27/2003	133.89	3346.72	2/28/2003	133.26	3/27/2003	132.73	3214.62
MW2A	3481.72	1/27/2003	143.59	3338.13	2/28/2003	142.69	3/27/2003	141.91	3197.12
MW2B	3481.93	1/27/2003	152.96	3328.97	2/28/2003	151.31	3/27/2003	149.96	3180.66
MW3A	3483.04	1/27/2003	143.63	3339.41	2/28/2003	142.76	3/27/2003	142.06	3198.22
MW3B	3483.10	1/27/2003	143.08	3340.02	2/28/2003	142.24	3/27/2003	141.56	3199.30
MW4A	3484.70	1/27/2003	134.84	3349.86	2/28/2003	134.35	3/27/2003	133.96	3216.39
MW4B	3484.74	1/27/2003	134.77	3349.97	2/28/2003	134.26	3/27/2003	133.89	3216.59
A-22	3460.00	1/27/2003	169.04	3290.96	2/11/2003	175.89	3/28/2003	169.00	3115.11
A-24	3464.20	1/27/2003	160.63	3303.57	2/11/2003	168.26	3/28/2003	159.58	3136.36
6B-2	3487.07	1/27/2003	137.24	3349.46	2/11/2003	142.61	3/27/2003	138.31	3206.15
7G	3448.57	1/27/2003	138.93	3309.64	2/11/2003	145.09	3/31/2003	138.04	3310.96
TP-01	3485.38	1/27/2003	98.31	3387.07	2/28/2003	98.21	3/28/2003	98.30	3288.87
TP-02	3436.14	1/27/2003	122.59	3313.55	2/28/2003	122.59	3/27/2003	122.53	3191.02
TP-03	3487.98	1/27/2003	184.78	3303.20	2/28/2003	181.81	3/28/2003	179.69	3126.48
TP-04	3489.05	1/27/2003	133.82	3355.23	2/28/2003	133.76	3/28/2003	133.80	3221.49
TP-05	3488.35	1/27/2003	119.40	3368.95	2/28/2003	119.31	3/28/2003	119.36	3249.68
PM-03	3487.99	1/27/2003	119.52	3368.47	2/28/2003	119.42	3/28/2003	119.45	3249.12
PM-06	3489.59	1/27/2003	134.29	3355.30	2/28/2003	134.31	3/28/2003	134.30	3220.98

TABLE 6.6-2
WASTE CONTROL SPECIALISTS
MAY-AUGUST 2003
GROUNDWATER ELEVATIONS

Well ID	TOC Elevation (ft)	Date	DtW (ft)	Date	DtW (ft)	GW Elevation (ft)	Date	DtW (ft)
DW32A	3461.52	4/24/2003	200.49	5/21/2003	197.91	3263.61	6/18/2003	195.38
DW32B	3461.46	4/24/2003	188.89	5/21/2003	183.21	3278.25	6/18/2003	181.64
DW33A	3464.99	4/7/2003	211.67	5/21/2003	210.92	3254.07	6/18/2003	208.35
DW33B	3465.12	4/7/2003	202.09	5/21/2003	201.84	3263.28	6/18/2003	199.89
DW34A	3468.70	4/7/2003	195.71	5/21/2003	194.84	3273.86	6/18/2003	193.12
DW34B	3468.94	4/7/2003	197.69	5/21/2003	196.75	3272.19	6/18/2003	194.68
DW35A	3467.86	4/7/2003	191.26	5/21/2003	190.93	3276.93	6/18/2003	189.92
DW35B	3467.95	4/7/2003	191.22	5/21/2003	190.94	3277.01	6/18/2003	189.89
DW36A	3467.59	4/7/2003	190.43	5/21/2003	190.49	3277.10	6/18/2003	189.27
DW36B	3467.93	4/7/2003	190.54	5/21/2003	190.63	3277.30	6/18/2003	189.41
NMB-23	3467.85	4/24/2003	121.38	5/21/2003	120.85	3347.00	6/12/2003	120.42
NMB-24	3439.15	4/24/2003	115.36	5/21/2003	115.28	3323.87	6/12/2003	115.13
MW1A	3480.79	4/24/2003	134.15	5/21/2003	133.75	3347.04	6/10/2003	134.16
MW1B	3480.61	4/24/2003	132.42	5/21/2003	132.21	3348.40	6/10/2003	154.31
MW2A	3481.72	4/24/2003	141.33	5/21/2003	140.79	3340.93	6/12/2003	140.39
MW2B	3481.93	4/24/2003	148.03	5/21/2003	147.78	3334.15	6/12/2003	146.98
MW3A	3483.04	4/7/2003	141.92	5/21/2003	141.66	3341.38	6/12/2003	141.17
MW3B	3483.10	4/7/2003	141.41	5/21/2003	141.15	3341.95	6/12/2003	140.70
MW4A	3484.70	4/7/2003	133.95	5/21/2003	133.78	3350.92	6/12/2003	133.55
MW4B	3484.74	4/7/2003	133.83	5/21/2003	133.73	3351.01	6/12/2003	133.48
A-22	3460.00	4/24/2003	169.11	5/22/2003	169.13	3290.87	6/12/2003	170.55
A-24	3464.20	4/24/2003	159.38	5/22/2003	159.15	3305.05	6/12/2003	159.33
6B-2	3487.07	4/24/2003	137.42	5/22/2003	136.74	3350.33	6/12/2003	140.68
7G	3448.57	4/24/2003	139.62	5/22/2003	138.11	3306.01	6/18/2003	138.99
TP-01	3485.38	4/24/2003	98.24	5/21/2003	98.49	3386.89	6/9/2003	98.45
TP-02	3436.14	4/24/2003	122.62	5/21/2003	122.63	3313.51	6/12/2003	122.64
TP-03	3487.98	4/24/2003	177.48	5/21/2003	175.22	3312.76	6/12/2003	173.30
TP-04	3489.05	4/24/2003	134.67	5/19/2003	134.36	3354.69	6/12/2003	133.97
TP-05	3488.35	4/24/2003	122.49	5/19/2003	123.28	3365.07	6/9/2003	123.30
PM-03	3487.99	4/24/2003	124.81					
PM-06	3489.59	4/24/2003	135.52					
NM-P01	3429.61	4/24/2003	dry	5/19/2003	137.03	3292.58	6/10/2003	136.38

TABLE 6.6-2
WASTE CONTROL SPECIALISTS
SEPTEMBER - DECEMBER 2003
GROUNDWATER ELEVATIONS

Well ID	TOC Elevation (ft)	Date	DtW (ft)	GW Elevation (ft)	Date	DtW (ft)	Date	DtW (ft)
DW32A	3461.52	7/21/2003	192.58	3073.56	8/27/2003	189.79	37879.00	190.86
DW32B	3461.46	7/21/2003	179.94	3099.88	8/27/2003	178.28	37879.00	177.81
DW33A	3464.99	7/21/2003	205.47	3051.17	8/27/2003	202.6	37879.00	201.30
DW33B	3465.12	7/21/2003	197.91	3067.32	8/27/2003	195.98	37879.00	195.74
DW34A	3468.70	7/21/2003	191.42	3084.16	8/27/2003	189.88	37879.00	188.76
DW34B	3468.94	7/21/2003	192.70	3081.56	8/27/2003	190.95	37879.00	189.90
DW35A	3467.86	7/21/2003	188.85	3089.09	8/27/2003	187.75	37879.00	187.23
DW35B	3467.95	7/21/2003	188.84	3089.22	8/27/2003	187.74	37879.00	186.95
DW36A	3467.59	7/21/2003	188.10	3090.22	8/27/2003	186.96	37879.00	186.08
DW36B	3467.93	7/21/2003	188.23	3090.29	8/27/2003	187.12	37879.00	186.52
NMB-23	3467.85	7/18/2003	119.87	3227.56	8/27/2003	119.26	37879.00	119.18
NMB-24	3439.15	7/18/2003	114.97	3209.05	8/27/2003	114.74	37879.00	114.67
MW1A	3480.79	7/14/2003	134.82	3211.81	8/20/2003	134.89	37873.00	134.72
MW1B	3480.61	7/14/2003	140.74	3185.56	8/20/2003	134.86	37873.00	134.41
MW2A	3481.72	7/18/2003	139.97	3201.36	8/27/2003	139.57	37873.00	139.45
MW2B	3481.93	7/18/2003	145.79	3189.16	8/27/2003	144.6	37873.00	144.52
MW3A	3483.04	7/18/2003	140.58	3201.29	8/27/2003	140.02	37873.00	140.06
MW3B	3483.10	7/18/2003	140.14	3202.26	8/27/2003	139.57	37873.00	139.52
MW4A	3484.70	7/18/2003	133.34	3217.81	8/27/2003	133.11	37873.00	133.08
MW4B	3484.74	7/18/2003	133.31	3217.95	8/27/2003	133.05	37873.00	133.11
A-22-99	3460.00	7/17/2003	169.06	3120.39	8/11/2003	174.19	37879.00	171.86
A-24-99	3464.20	7/17/2003	158.89	3145.98	8/11/2003	163.46	37879.00	162.51
6B-2	3487.07	7/18/2003	138.2	3208.19	8/11/2003	143.17	37873.00	140.24
7G	3448.57	7/18/2003	140.31	3310.67	8/11/2003	145.61	37873.00	144.30
TP-0001	3485.38	7/17/2003	98.63	3288.30	8/27/2003	98.65	37880.00	98.60
TP-0002	3436.14	7/17/2003	122.68	3190.82	8/27/2003	122.67	37879.00	122.60
TP-0003	3487.98	7/17/2003	170.27	3144.41	8/27/2003	166.71	37880.00	165.92
TP-0004	3489.05	7/17/2003	133.98	3221.10	8/27/2003	133.76	37880.00	133.51
TP-0005	3488.35	7/17/2003	121.61	3243.44	8/27/2003	120.7	37880.00	120.32
PM-0003	3487.99				8/21/2003	126.43	37879.00	123.48
PM-0006	3489.59				8/21/2003	141.92	37875.00	134.86
NM P01	3429.61	7/14/2003	136.67	3156.56	8/20/2003	136.46	37873.00	136.36

TABLE 6.6-2
WASTE CONTROL SPECIALIST
OCTOBER-DECEMBER 2003
GROUNDWATER ELEVATONS

Well ID	TOC Elevation (ft)	Date	DtW (ft)	Date	DtW (ft)	Date	DtW (ft)
DW32A	3461.52	10/15/2003	189.19	11/19/2003	186.67	12/12/2003	186.71
DW32B	3461.46	10/15/2003	179.07	11/19/2003	177.02	12/12/2003	177.14
DW33A	3464.99	10/30/2003	198.27	11/19/2003	197.11	12/12/2003	197.05
DW33B	3465.12	10/30/2003	192.93	11/19/2003	192.08	12/12/2003	191.96
DW34A	3468.70	10/15/2003	189.61	11/19/2003	188.10	12/12/2003	188.13
DW34B	3468.94	10/15/2003	193.28	11/19/2003	189.44	12/12/2003	189.21
DW35A	3467.86	10/30/2003	186.14	11/19/2003	185.79	12/12/2003	185.62
DW35B	3467.95	10/30/2003	186.17	11/19/2003	185.81	12/12/2003	185.84
DW36A	3467.59	10/15/2003	189.92	11/19/2003	185.39	12/12/2003	185.35
DW36B	3467.93	10/15/2003	189.92	11/19/2003	185.53	12/12/2003	185.42
NMB-23	3467.85	10/29/2003	118.48	11/17/2003	118.22	12/12/2003	118.07
NMB-24	3439.15	10/29/2003	114.48	11/17/2003	114.55	12/12/2003	114.32
MW1A	3480.79	10/29/2003	134.68	11/17/2003	133.67	12/8/2003	133.7
MW1B	3480.61	10/29/2003	134.39	11/17/2003	132.32	12/8/2003	132
MW2A	3481.72	10/15/2003	140.62	11/17/2003	140.88	12/12/2003	140.67
MW2B	3481.93	10/15/2003	145.83	11/17/2003	144.76	12/12/2003	144.25
MW3A	3483.04	10/30/2003	139.26	11/17/2003	138.04	12/12/2003	138.96
MW3B	3483.10	10/30/2003	138.84	11/17/2003	138.63	12/12/2003	138.47
MW4A	3484.70	10/15/2003	134.43	11/17/2003	132.94	12/12/2003	132.35
MW4B	3484.74	10/15/2003	134.45	11/17/2003	132.85	12/12/2003	132.78
A-22-99	3460.00	10/30/2003	168.31	11/20/2003	168.46	12/12/2003	168.22
A-24-99	3464.20	10/30/2003	158.76	11/20/2003	158.04	12/12/2003	147.76
6B-2	3487.07	10/30/2003	137.23	11/20/2003	136.74	12/12/2003	136.47
7G	3448.57	10/30/2003	138.87	11/20/2003	138.38	12/12/2003	135.02
TP-0001	3485.38	10/30/2003	98.56	11/17/2003	98.64	12/12/2003	98.67
TP-0002	3436.14	10/30/2003	122.66	11/17/2003	122.7	12/12/2003	122.73
TP-0003	3487.98	10/30/2003	161.31	11/17/2003	159.78	12/12/2003	159.55
TP-0004	3489.05	10/30/2003	133.82	11/17/2003	133.89	12/12/2003	133.92
TP-0005	3488.35	10/30/2003	120.31	11/17/2003	120.17	12/12/2003	120.11
PM-0003	3487.99	10/17/2003		11/17/2003	120.29	12/12/2003	120.22
PM-0006	3489.59	10/30/2003		11/12/2003	134.8	12/12/2003	142.63
NM P01	3429.61	10/29/2003	136.21	11/17/2003	136.34	12/8/2003	136.31

TABLE 6.6-2
WASTE CONTROL SPECIALISTS LLC
TEXAS TECH GROUNDWATER LEVELS

Well ID	TOC Elevation	Date	DtW	Date	DtW	Date	DtW
	(ft)		(ft)		(ft)		(ft)
PZ-1	3542	3/99	75	2001	75.69	12/17/2003	75.89
PZ-2	3519	3/99	68	2001	78.03	12/17/2003	77.55
PZ-3	3491	3/99	57	2001	58.04	12/17/2003	57.96
PZ-4	3513	4/99	na	2001	dry	12/17/2003	dry
PZ-5	3492	3/99	dry	2001	81.87	12/17/2003	83.97
PZ-6	3465	3/99	62	2001	63.98	12/17/2003	63.66
PZ-7	3455	3/99	dry	2001	69.21	12/17/2003	69.03
PZ-8	3490	3/99	dry	2001	dry	12/17/2003	69.9
PZ-9	3483	3/99	54	2001	55.15	12/17/2003	56.29
PZ-10	3484	3/99	74	2001	73.93	12/17/2003	74.15
PZ-11	3449	3/99	61	2001	62.53	12/17/2003	63.71
PZ-12	3429	3/99	60	2001	60.27	12/17/2003	60.88
PZ-13	3468	3/99	56	2001	56.20	12/17/2003	56.54
PZ-14	3484	3/99	59	2001	61.24	12/17/2003	61.37
PZ-15	3447	3/99	dry	2001	dry	12/17/2003	dry
PZ-16	3520	3/99	68	2001	68.57	12/17/2003	68.58
PZ-17	3465	4/99	83	2001	83.66	12/17/2003	83.75
PZ-18	3481	4/99	64	2001	65.14	12/17/2003	65.17
PZ-19	3432	4/99	dry	2001	dry	12/16/2003	dry
PZ-20	3440	3/99	dry	2001	dry	12/16/2003	dry
PZ-21	3401	4/99	dry	2001	dry	12/16/2003	dry
PZ-22	3393	4/99	dry	2001	dry	12/16/2003	dry
PZ-23	3412	4/99	dry	2001	dry	12/16/2003	dry
PZ-24	3416	4/99	dry	2001	dry	12/16/2003	dry
PZ-25	3410	3/99	dry	2001	dry	12/16/2003	dry
PZ-26	3433	3/99	36	2001	38.03	12/16/2003	38.61
PZ-27	3405	3/99	dry	2001	dry	12/16/2003	dry
PZ-28	3375	3/99	dry	2001	dry	12/16/2003	dry
PZ-29	3384	3/99	dry	2001	dry	12/16/2003	dry
PZ-30	3416	4/99	dry	2001	dry	12/16/2003	dry
PZ-31	3461	3/99	dry	2001	dry	12/16/2003	dry
PZ-32	3484	3/99	71	2001	70.70	12/16/2003	70.83
PZ-33	3474	3/99	62	2001	63.05	12/16/2003	63.67
PZ-34	3432	3/99	3432	2001	35.23	12/16/2003	35.29

TABLE 6.6-3
WASTE CONTROL SPECIALISTS LLC
MAXIMUM AND MINIMUM GROUNDWATER ELEVATIONS OF THE "225-ZONE"

Well ID	TOC Elevation (msl)	Date	Maximum DtW (ft)	Minimum GW Elev. (msl)	Date	Minimum DtW (ft)	Maximum GW Elev. (msl)
DW32A	3461.52	5/29/2002	225.52	3236.00	11/19/2003	186.67	3274.85
DW32B	3461.46	3/26/2002	235.37	3226.09	11/19/2003	177.02	3284.44
DW33A	3464.99	5/29/2002	230.56	3234.43	12/12/2003	197.05	3267.94
DW33B	3465.12	3/26/2002	239.11	3226.01	12/12/2003	191.96	3273.16
DW34A	3468.70	8/27/2002	232.59	3236.11	12/12/2003	188.13	3280.57
DW34B	3468.94	8/27/2002	248.03	3220.91	12/12/2003	189.21	3279.73
DW35A	3467.86	8/27/2002	226.54	3241.32	12/12/2003	185.62	3282.24
DW35B	3467.95	8/27/2002	217.99	3249.96	12/12/2003	185.84	3282.11
DW36A	3467.59	8/27/2002	222.3	3245.29	12/12/2003	185.35	3282.24
DW36B	3467.93	8/27/2002	217.89	3250.04	12/12/2003	185.42	3282.51
NMB-23	3467.85	1/21/2002	139.97	3327.88	12/12/2003	118.07	3349.78
NMB-24	3439.15	1/21/2002	116.19	3322.96	12/12/2003	114.32	3324.83
MW1A	3480.79	1/21/2002	151.11	3329.68	11/17/2003	133.67	3347.12
MW1B	3480.61	1/21/2002	142.02	3338.59	12/8/2003	132	3348.61
MW2A	3481.72	1/21/2002	158.58	3323.14	9/12/2003	139.45	3342.27
MW2B	3481.93	1/21/2002	190.58	3291.35	12/12/2003	144.25	3337.68
MW3A	3483.04	1/21/2002	154.56	3328.48	11/17/2003	138.04	3345.00
MW3B	3483.10	1/21/2002	153.81	3329.29	12/12/2003	138.47	3344.63
MW4A	3484.70	1/21/2002	139.78	3344.92	12/12/2003	132.35	3352.35
MW4B	3484.74	1/21/2002	139.63	3345.11	12/12/2003	132.78	3351.96
A-22-99	3460.00	2/11/2003	175.89	3284.11	12/12/2003	168.22	3291.78
A-24-99	3464.20	8/11/2003	163.46	3300.74	12/12/2003	147.76	3316.44
6B-2	3487.07	2/11/2003	142.61	3344.46	5/6/2002	135.49	3351.58
7G	3448.57	2/11/2003	145.09	3303.48	12/12/2003	135.02	3313.55
TP-01	3485.38	12/12/2003	98.67	3386.71	5/6/2002	98.16	3387.22
TP-02	3436.14	12/12/2003	122.73	3313.41	3/27/2003	122.53	3313.61
TP-03	3487.98	1/22/2002	225.81	3262.17	12/12/2003	159.55	3328.43
TP-04	3489.05	5/6/2002	134.86	3354.19	9/12/2002	133.46	3355.59
TP-05	3488.35	6/9/2003	123.30	3365.05	5/30/2002	119.31	3369.04
PM-03	3487.99	8/21/2003	126.43	3361.56	2/28/2003	119.42	3368.57
PM-06	3489.59	12/12/2003	142.63	3346.96	1/28/2002	134.08	3355.51
NMP-01	3429.61	1/28/2002	136.67	3292.94	10/29/2003	136.46	3293.15

The MW and DW series wells are not static (equilibrated) groundwater measurements.
PM-12 had groundwater in it only once. It has been dry since 2/2002.

TABLE 6.6-4 UNIT GROUNDWATER DETECTION MONITORING SYSTEM

Waste Management Unit/Area Name						
Well Number(s)	MW-1A	MW-1B	MW-2A	MW-2B	MW-3A	MW-3B
Hydrogeologic Unit Monitored	225	225	225	225	225	225
Type- point of compliance (POC), background (BG), observation (Observ)	BG	BG	BG	BG	BG	BG
Up or Down Gradient (UG, DG)	UG	UG	UG	UG	UG	UG
Casing Diameter and Material	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC
Screen Diameter and Material	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC
Screen Slot Size (in.)	0.010"	0.010"	0.010"	0.010"	0.010"	0.010"
Top of Casing Elevation (ft, MSL)	3480.79	3480.72	3481.93	3481.93	3483.04	3483.10
Grade or Surface Elevation (ft, MSL)	3477.5	3477.4	3478.7	3478.8	3480.0	3480.1
Well Depth (ft,)	257	271.5	261	274	265	280
Screen Interval, From(ft) To(ft)	241 256	255 270	245 260	258 273	249 264	264 279
Facility Coordinates (e.g., lat/long or company coordinates)						
32º26'	47.18"	47.23"	48.07"	48.12"	48.88"	48.93"
130º03'	46.00"	45.50"	44.20"	44.09"	42.73"	42.63"

TABLE 6.6-4 UNIT GROUNDWATER DETECTION MONITORING SYSTEM - continued

Waste Management Unit/Area Name						
Well Number(s)	MW-4A	MW-4B	DW-32A	DW-32B	6W-32	DW-33A
Hydrogeologic Unit Monitored	225	225	225	225	225	225
Type- point of compliance (POC), background (BG), observation (Observ)	BG	BG	POC	POC	Observ	POC
Up or Down Gradient (UG, DG)	UG	UG	DG	DG	DG	Dg
Casing Diameter and Material	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC
Screen Diameter and Material	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC
Screen Slot Size (in.)	0.010"	0.010"	0.010"	0.010"	0.010"	0.010"
Top of Casing Elevation (ft, MSL)	3484.70	3484.74	3461.52	3461.46	3461.45	3464.99
Grade or Surface Elevation (ft, MSL)	3481.6	3481.5	3481.5	3458.4	3458.5	3462.0
Well Depth (ft,)	268	283.5	228.5	244.5	128	231
Screen Interval, From(ft) To(ft)	252 267	267.5 282.5	212.5 227.5	229.5 244.5	117 127	215 230
Facility Coordinates (e.g., lat/long or company coordinates)						
32º26'	49.81"	49.86"	26.60"	26.56"	26.64"	26.15"
130º03'	41.39"	41.29"	47.52"	47.42"	47.63"	45.84"

TABLE 6.6-4 UNIT GROUNDWATER DETECTION MONITORING SYSTEM - continued

Waste Management Unit/Area Name						
Well Number(s)	DW-33B	SW-33	DW-34A	DW-34B	SW-34	DW-35A
Hydrogeologic Unit Monitored	225	125	225	225	125	225
Type- point of compliance (POC), background (BG), observation (Observ)	POC	Observ	POC	POC	Observ	POC
Up or Down Gradient (UG, DG)	DG	DG	DG	DG	DG	DG
Casing Diameter and Material	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC
Screen Diameter and Material	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC
Screen Slot Size (in.)	0.010"	0.010"	0.010"	0.010"	0.010"	0.010"
Top of Casing Elevation (ft, MSL)	3465.12	3464.84	3468.70	3468.94	3468.58	3467.86
Grade or Surface Elevation (ft, MSL)	3462.2	3461.9	3465.7	3465.9	3465.6	3465.4
Well Depth (ft,)	246	146.5	234	248	119	233.5
Screen Interval, From(ft) To(ft)	230 245	135.5 145.5	218 233	232 247	108 118	218 233
Facility Coordinates (e.g., lat/long or company coordinates)						
32°26'	26.12"	26.19"	25.68"	25.64"	25.72"	25.21"
130°03'	45.74"	45.95"	44.15"	44.04"	44.26"	42.73"

TABLE 6.6-4 UNIT GROUNDWATER DETECTION MONITORING SYSTEM - continued

Waste Management Unit/Area Name						
Well Number(s)	DW-35B	SW-35	DW-36A	DW-36B	SW-36	
Hydrogeologic Unit Monitored	225	125	22	225	125	
Type- point of compliance (POC), background (BG), observation (Observ)	POC	Observ	POC	POC	Observ	
Up or Down Gradient (UG, DG)	DG	DG	DG	DG	DG	
Casing Diameter and Material	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	
Screen Diameter and Material	4" PVC	4" PVC	4" PVC	4" PVC	4" PVC	
Screen Slot Size (in.)	0.010"	0.010"	0.010"	0.010"	0.010"	
Top of Casing Elevation (ft, MSL)	3467.95	3467.95	3467.59	3467.93	3467.22	
Grade or Surface Elevation (ft, MSL)	3465.4	3465.5	3465.0	3465.4	3464.7	
Well Depth (ft,)	249	123.5	238.5	253.5	118.5	
Screen Interval, From(ft) To(ft)	233 248	113 123	223 238	238 253	108 118	
Facility Coordinates (e.g., lat/long or company coordinates)						
32º26'	25.18"	25.24"	24.83"	24.80"	24.86"	
130º03'	42.62"	42.85"	41.25"	41.14"	41.37"	

TABLE 6.6-5
WASTE CONTROL SPECIALISTS LLC
GROUNDWATER SAMPLE ANALYSIS

For each well or group of wells, specify the suite of parameters for which groundwater samples will be analyzed.
Well No(s). 32A, 32B, 33A, 33B, 34A, 34B, 35A, 35B, 36A, 36B

Parameter	*Sampling Frequency*	*Analytical Method*	*Detection Limits*	*Concentration Limits*[1]
Volatile Organic Priority Pollutant Monitoring Parameters				
Acetone	Staggered Semi-Annual	SW-846 8260/EPA Method 624	100 µg/L	100 µg/L
Benzene	Staggered Semi-Annual	SW-846 8260/EPA Method 624	5 µg/L	5 µg/L
Bromoform	Staggered Semi-Annual	SW-846 8260/EPA Method 624	5 µg/L	5 µg/L
Carbon Disulfide	Staggered Semi-Annual	SW-846 8260/EPA Method 624	5 µg/L	5 µg/L
Carbon Tetrachloride	Staggered Semi-Annual	SW-846 8260/EPA Method 624	5 µg/L	5 µg/L
Chlorobenzene	Staggered Semi-Annual	SW-846 8260/EPA Method 624	5 µg/L	5 µg/L
Chlorodibromomethane	Staggered Semi-Annual	SW-846 8260/EPA Method 624	5 µg/L	5 µg/L
Chloroethane	Staggered Semi-Annual	SW-846 8260/EPA Method 624	10 µg/L	10 µg/L
Chloroform	Staggered Semi-Annual	SW-846 8260/EPA Method 624	5 µg/L	5 µg/L
Dichlorobromomethane	Staggered Semi-Annual	SW-846 8260/EPA Method 624	5 µg/L	5 µg/L
1,1-Dichloroethane	Staggered Semi-Annual	SW-846 8260/EPA Method 624	5 µg/L	5 µg/L
1,2-Dichloroethane	Staggered Semi-Annual	SW-846 8260/EPA Method 624	5 µg/L	5 µg/L
1,1-Dichloroethylene	Staggered Semi-Annual	SW-846 8260/EPA Method 624	5 µg/L	5 µg/L

[1] The concentration limit is the basis for determining whether a release has occurred from the waste management unit/area.

TABLE 6.6-5
WASTE CONTROL SPECIALISTS LLC
GROUNDWATER SAMPLE ANALYSIS

For each well or group of wells, specify the suite of parameters for which groundwater samples will be analyzed.
Well No(s). 32A, 32B, 33A, 33B, 34A, 34B, 35A, 35B, 36A, 36B

Parameter	*Sampling Frequency*	*Analytical Method*	*Detection Limits*	*Concentration Limits*[1]
Volatile Organic Priority Pollutant Monitoring Parameters (concluded)				
1,2-Dichloropropane	Staggered Semi-Annual	SW-846 8260/EPA Method 624	5 µg/L	5 µg/L
cis-1,3_Dichloropropylene	Staggered Semi-Annual	SW-846 8260/EPA Method 624	5 µg/L	5 µg/L
trans-1,3_Dichloropropylene	Staggered Semi-Annual	SW-846 8260/EPA Method 624	5 µg/L	5 µg/L
Ethylbenzene	Staggered Semi-Annual	SW-846 8260/EPA Method 624	5 µg/L	5 µg/L
Methyl Bromide	Staggered Semi-Annual	SW-846 8260/EPA Method 624	10 µg/L	10 µg/L
Methyl Chloride	Staggered Semi-Annual	SW-846 8260/EPA Method 624	10 µg/L	10 µg/L
1,1,2,2-Tetrachloroethane	Staggered Semi-Annual	SW-846 8260/EPA Method 624	5 µg/L	5 µg/L
Tetrachloroethylene	Staggered Semi-Annual	SW-846 8260/EPA Method 624	5 µg/L	5 µg/L
Toluene	Staggered Semi-Annual	SW-846 8260/EPA Method 624	5 µg/L	5 µg/L
1,2-trans-Dichloroethylene	Staggered Semi-Annual	SW-846 8260/EPA Method 624	10 µg/L	5 µg/L
1,1,1-Trichloroethane	Staggered Semi-Annual	SW-846 8260/EPA Method 624	5 µg/L	5 µg/L
1,1,2-Trichloroethane	Staggered Semi-Annual	SW-846 8260/EPA Method 624	5 µg/L	5 µg/L
Trichloroethylene	Staggered Semi-Annual	SW-846 8260/EPA Method 624	5 µg/L	5 µg/L
Vinyl Chloride	Staggered Semi-Annual	SW-846 8260/EPA Method 624	10 µg/L	10 µg/L

[1] The concentration limit is the basis for determining whether a release has occurred from the waste management unit/area.

TABLE 6.6-5
WASTE CONTROL SPECIALISTS LLC
GROUNDWATER SAMPLE ANALYSIS

For each well or group of wells, specify the suite of parameters for which groundwater samples will be analyzed.

Well No(s). 32A, 32B, 33A, 33B, 34A, 34B, 35A, 35B, 36A, 36B

Parameter	*Sampling Frequency*	*Analytical Method*	*Detection Limits*	*Concentration Limits*
Semi-Volatile Monitoring Parameter				
Phenol	Staggered Semi-Annual	SW-846 8270/EPA Method 625	10 µg/L	10 µg/L
1, 4 Dioxane	Staggered Semi-Annual	SW-846 8270/EPA Method 625	10 µg/L	10 µg/L
Metal Monitoring Parameters				
Arsenic	Staggered Semi-Annual	SW-846 6010/EPA Method 200.7	0.01 mg/L	NA
Nickel	Staggered Semi-Annual	SW-846 6010/EPA Method 200.7	0.005 mg/L	NA
Cadmium	Staggered Semi-Annual	SW-846 6010/EPA Method 200.7	0.005 mg/L	NA
Selenium	Staggered Semi-Annual	SW-846 6010/EPA Method 200.7	0.005 mg/L	NA

[1] The concentration limit is the basis for determining whether a release has occurred from the waste management unit/area.

TABLE 6.6-6
SUMMARY OF METALS CONCENTRATIONS
IN INDIVIDUAL LEACHATE SAMPLES AT THE WCS FACILITY

METAL	LEACHATE CONCENTRATIONS (PPB)				MAXIMUM LEACHATE CONCENTRATION (PPB)	AVERAGE LEACHATE CONCENTRATION (PPB) [1]
	CELL A	CELL B	CELL C	CELL D		
Antimony	NA	NA	NA	NA	ND	ND
Arsenic	50.3	128	141	231	231	137.6
Barium	34.5	33	35.6	32.8	35.6	34.0
Beryllium	NA	NA	NA	NA	ND	ND
Cadmium	113	<5	<5	<5	113	30.1
Chromium	<10	<10	<10	<10	ND	ND
Cobalt	28.7	47	<10	27.3	47	27.0
Copper	224	56.6	26	15.5	224	80.5
Lead	40.2	36.9	16.1	15.7	40.2	27.2
Mercury	0.27	0.21	<0.20	<0.20	0.27	0.17
Nickel	201	216	68.3	<40	216	126.3
Selenium	<15	<15	17.1	<15	17.1	9.9
Silver	<10	<10	<10	<10	ND	ND
Vanadium	18.7	15.9	<10	<10	18.7	11.2

NA - Not Analyzed

[1] Where a parameter was detected in one or more cells and also not detected in one or more cells, the average concentration was calculated using one-half the reporting limit.

TABLE 6.6-7
CALCULATIONS FOR SOIL-LEACHATE PARTITION FACTOR
FOR METALS AT THE WCS FACILITY

INPUT PARAMETERS

Parameter	Description	Value	Source
Kd	Soil-water partition coefficient (cm3-water/g-soil)	Chemical-Specific	See footnotes below calculations table
H'	Dimensionless Henry's Law Constant	Chemical-Specific	TCEQ Physical/Chemical Properties Table, updated 31 March 2003
ρb	Soil bulk density (g/cm3)	1.67	Default Value, TRRP Tier 2 Soil-to-GW PCL Equation
θws	Volumetric water content of vadose zone soils (cm3-water / cm3-soil)	0.31	Site-specific; clay, sandy, low plasticity; Soil Attenuation Model, Table 2, Groundwater Services, Inc. July, 1997.
θas	Volumetric air content of vadose zone soils (cm3-air / cm3-soil)	0.07	Site-specific; clay, sandy, low plasticity; Soil Attenuation Model, Table 2, Groundwater Services, Inc. July, 1997.
K_{sw}	Soil-leachate partitian factor for COC (mg/L-water / mg/kg-soil)	Calculated	TRRP Tier 2 Soil-to-Groundwater PCL Equation; Also see Soil Attenuation Model, Groundwater Services, Inc., July 1997

EQUATION FOR SOIL-LEACHATE PARTITION FACTOR

$$K_{sw} = \frac{\rho_b}{\theta_{ws} + K_d\rho_b + H'\theta_{as}}$$

CALCULATIONS TABLE

METAL	H'	Kd - Values				Calculated Ksw (mg/L-water / mg/kg-soil)			
		pH 5.0	pH 6.0	pH 7.0	pH 8.0	pH 5.0	pH 6.0	pH 7.0	pH 8.0
Antimony (1)	0	45	45	45	45	2.21E-02	2.21E-02	2.21E-02	2.21E-02
Arsenic (2)	0	25	27	29	31	3.97E-02	3.68E-02	3.43E-02	3.21E-02
Barium (2)	0	12	30	42	52	8.21E-02	3.31E-02	2.37E-02	1.92E-02
Beryllium (2)	0	26	82	1700	100000	3.82E-02	1.22E-02	5.88E-04	1.00E-05
Cadmium (2)	0	17	37	110	4300	5.82E-02	2.69E-02	9.08E-03	2.33E-04
Chromium (2)	0	1900	200000	2500000	4300000	5.26E-04	5.00E-06	4.00E-07	2.33E-07
Cobalt (5)	0	45	45	45	45	2.21E-02	2.21E-02	2.21E-02	2.21E-02
Copper (4)	0	50.1	794	15849	25119	1.99E-02	1.26E-03	6.31E-05	3.98E-05
Lead (3)	0	597	597	597	597	1.67E-03	1.67E-03	1.67E-03	1.67E-03
Mercury (2)	0.474	0.06	4	82	200	3.77E+00	2.38E-01	1.22E-02	4.99E-03
Nickel (2)	0	18	38	88	1900	5.50E-02	2.62E-02	1.13E-02	5.26E-04
Silver (2)	0	0.13	1	13	110	3.17E+00	8.43E-01	7.58E-02	9.08E-03
Selenium (2)	0	17	9	4	2	5.82E-02	1.09E-01	2.39E-01	4.58E-01
Vanadium (1)	0	1000	1000	1000	1000	1.00E-03	1.00E-03	1.00E-03	1.00E-03

(1) Kd value obtained from 30 TAC 350.73(e)(1)(C); non-pH dependent inorganic.
(2) Kd value obtained from 30 TAC 350.73(e)(1)(C); pH dependent inorganics.
(3) Kd value obtained from 30 TAC 350.73(e)(1)(A). Loamy soils with pH ranging between 5 and 9.
(4) Kd value obtained from Table B-2, Overview of CSST Procedures fro the Derivation of Soil Quality Matrix Standards for Contaminated Sites, Risk Assessment Unit, Environmental Protection Department, Government of British Columbia, dated 31 January 1996
(5) Kd value obtained from TCEQ Chemical/Physical Table updated March 31, 2003. No pH specific values are known to be available for this constituent.

TABLE 6.6-8
WASTE CONTROL SPECIALISTS LLC
CONCENTRATION-WEIGHTED MOBILITY FACTORS

Maximum Leachate Concentration Factors

METAL	Calculated Ksw (mg/L-water / mg/kg-soil)			Maximum Leachate	Concentration * Ksw	Concentration * Ksw	Concentration * Ksw
	pH 6.0	pH 7.0	pH 8.0	Concentration	pH 6.0	pH 7.0	pH 8.0
Arsenic (2)	3.68E-02	3.43E-02	3.21E-02	231	8.50E+00	7.914854329	7.407258065
Barium (2)	3.31E-02	2.37E-02	1.92E-02	35.6	1.18E+00	0.843889283	0.682180149
Cadmium (2)	2.69E-02	9.08E-03	2.33E-04	113	3.04E+00	1.02554209	0.026277935
Cobalt (5)	2.21E-02	2.21E-02	2.21E-02	47	1.04E+00	1.040153724	1.040153724
Copper (4)	1.26E-03	6.31E-05	3.98E-05	228	2.87E-01	0.014385597	0.009076727
Lead (3)	1.67E-03	1.67E-03	1.67E-03	40.2	6.73E-02	0.067315753	0.067315753
Mercury (2)	2.38E-01	1.22E-02	4.99E-03	0.27	6.42E-02	0.003284452	0.001348614
Nickel (2)	2.62E-02	1.13E-02	5.26E-04	216	5.66E+00	2.449378692	0.113673105
Selenium (2)	1.09E-01	2.39E-01	4.58E-01	17.1	1.86E+00	4.085407725	7.823835616
Vanadium (1)	1.00E-03	1.00E-03	1.00E-03	18.7	1.87E-02	0.018696529	0.018696529

(1) Kd value obtained from 30 TAC 350.73(e)(1)(C); non-pH dependent inorganic.
(2) Kd value obtained from 30 TAC 350.73(e)(1)(C); pH dependent inorganics.
(3) Kd value obtained from 30 TAC 350.73(e)(1)(A). Loamy soils with pH ranging between 5 and 9.
(4) Kd value obtained from Table B-2, Overview of CSST Procedures fro the Derivation of Soil Quality Matrix Standards for Contaminated Sites, Risk Assessment Unit, Environmental Protection Department, Government of British Columbia, dated 31
(5) Kd value obtained from TCEQ Chemical/Physical Table updated March 31, 2003. No pH specific values are known to be available for this constituent.

Average Leachate Concentration Factors

METAL	Calculated Ksw (mg/L-water / mg/kg-soil)			Average Leachate	Concentration * Ksw	Concentration * Ksw	Concentration * Ksw
	pH 6.0	pH 7.0	pH 8.0	Concentration	pH 6.0	pH 7.0	pH 8.0
Arsenic (2)	3.68E-02	3.43E-02	3.21E-02	137.575	5.06E+00	4.713792573	4.411487135
Barium (2)	3.31E-02	2.37E-02	1.92E-02	33.975	1.13E+00	0.805369056	0.651041308
Cadmium (2)	2.69E-02	9.08E-03	2.33E-04	30.125	8.10E-01	0.273402261	0.007005512
Cobalt (5)	2.21E-02	2.21E-02	2.21E-02	27	5.98E-01	0.597535118	0.597535118
Copper (4)	1.26E-03	6.31E-05	3.98E-05	80.525	1.01E-01	0.005080703	0.003205717
Lead (3)	1.67E-03	1.67E-03	1.67E-03	27.225	4.56E-02	0.04558884	0.04558884
Mercury (2)	2.38E-01	1.22E-02	4.99E-03	0.17	4.04E-02	0.002067988	0.000849128
Nickel (2)	2.62E-02	1.13E-02	5.26E-04	126.325	3.31E+00	1.432489645	0.066480347
Selenium (2)	1.09E-01	2.39E-01	4.58E-01	9.9	1.08E+00	2.365236052	4.529589041
Vanadium (1)	1.00E-03	1.00E-03	1.00E-03	11.15	1.11E-02	0.011147931	0.011147931

(1) Kd value obtained from 30 TAC 350.73(e)(1)(C); non-pH dependent inorganic.
(2) Kd value obtained from 30 TAC 350.73(e)(1)(C); pH dependent inorganics.
(3) Kd value obtained from 30 TAC 350.73(e)(1)(A). Loamy soils with pH ranging between 5 and 9.
(4) Kd value obtained from Table B-2, Overview of CSST Procedures fro the Derivation of Soil Quality Matrix Standards for Contaminated Sites, Risk Assessment Unit, Environmental Protection Department, Government of British Columbia, dated 31
(5) Kd value obtained from TCEQ Chemical/Physical Table updated March 31, 2003. No pH specific values are known to be available for this constituent.

TABLE 6.6-9
WASTE CONTROL SPECIALISTS LLC
CONCENTRATION/MOBILITY RANKING BASED ON MAXIMUM LEACHATE CONCENTRATIONS

Ranking - Soil pH 6.0

METAL	Calculated Ksw (mg/L-water / mg/kg-soil) Soil pH 6.0	Maximum Leachate Concentration	Concentration * Ksw
Arsenic	3.68E-02	231	8.50E+00
Nickel	2.62E-02	216	5.66E+00
Cadmium	2.69E-02	113	3.04E+00
Selenium	1.09E-01	17.1	1.86E+00
Barium	3.31E-02	35.6	1.18E+00
Cobalt	2.21E-02	47	1.04E+00
Copper	1.26E-03	228	2.87E-01
Lead	1.67E-03	40.2	6.73E-02
Mercury	2.38E-01	0.27	6.42E-02
Vanadium	1.00E-03	18.7	1.87E-02

Ranking - Soil pH 7.0

METAL	Calculated Ksw (mg/L-water / mg/kg-soil) Soil pH 7.0	Maximum Leachate Concentration	Concentration * Ksw
Arsenic	3.43E-02	231	7.914854329
Selenium	2.39E-01	17.1	4.085407725
Nickel	1.13E-02	216	2.449378692
Cobalt	2.21E-02	47	1.040153724
Cadmium	9.08E-03	113	1.02554209
Barium	2.37E-02	35.6	0.843889283
Lead	1.67E-03	40.2	0.067315753
Vanadium	1.00E-03	18.7	0.018696529
Copper	6.31E-05	228	0.014385597
Mercury	1.22E-02	0.27	0.003284452

Ranking - Soil pH 8.0

METAL	Calculated Ksw (mg/L-water / mg/kg-soil) Soil pH 8.0	Maximum Leachate Concentration	Concentration * Ksw
Selenium	4.58E-01	17.1	7.823835616
Arsenic	3.21E-02	231	7.407258065
Cobalt	2.21E-02	47	1.040153724
Barium	1.92E-02	35.6	0.682180149
Nickel	5.26E-04	216	0.113673105
Lead	1.67E-03	40.2	0.067315753
Cadmium	2.33E-04	113	0.026277935
Vanadium	1.00E-03	18.7	0.018696529
Copper	3.98E-05	228	0.009076727
Mercury	4.99E-03	0.27	0.001348614

TABLE 6.6-10
WASTE CONTROL SPECIALISTS LLC
CONCENTRATION/MOBILITY RANKING BASED ON AVERAGE LEACHATE CONCENTRATIONS

Ranking - Soil pH 6.0

METAL	Calculated Ksw (mg/L-water / mg/kg-soil) Soil pH 6.0	Average Leachate Concentration	Concentration * Ksw
Arsenic	3.68E-02	137.575	5.06E+00
Nickel	2.62E-02	126.325	3.31E+00
Barium	3.31E-02	33.975	1.13E+00
Selenium	1.09E-01	9.9	1.08E+00
Cadmium	2.69E-02	30.125	8.10E-01
Cobalt	2.21E-02	27	5.98E-01
Copper	1.26E-03	80.525	1.01E-01
Lead	1.67E-03	27.225	4.56E-02
Mercury	2.38E-01	0.17	4.04E-02
Vanadium	1.00E-03	11.15	1.11E-02

Ranking - Soil pH 7.0

METAL	Calculated Ksw (mg/L-water / mg/kg-soil) Soil pH 7.0	Average Leachate Concentration	Concentration * Ksw
Arsenic	3.43E-02	137.575	4.713792573
Selenium	2.39E-01	9.9	2.365236052
Nickel	1.13E-02	126.325	1.432489645
Barium	2.37E-02	33.975	0.805369056
Cobalt	2.21E-02	27	0.597535118
Cadmium	9.08E-03	30.125	0.273402261
Lead	1.67E-03	27.225	0.04558884
Vanadium	1.00E-03	11.15	0.011147931
Copper	6.31E-05	80.525	0.005080703
Mercury	1.22E-02	0.17	0.002067988

Ranking - Soil pH 8.0

METAL	Calculated Ksw (mg/L-water / mg/kg-soil) Soil pH 8.0	Average Leachate Concentration	Concentration * Ksw
Selenium	4.58E-01	9.9	4.529589041
Arsenic	3.21E-02	137.575	4.411487135
Barium	1.92E-02	33.975	0.651041308
Cobalt	2.21E-02	27	0.597535118
Nickel	5.26E-04	126.325	0.066480347
Lead	1.67E-03	27.225	0.04558884
Vanadium	1.00E-03	11.15	0.011147931
Cadmium	2.33E-04	30.125	0.007005512
Copper	3.98E-05	80.525	0.003205717
Mercury	4.99E-03	0.17	0.000849128

TABLE 6.6-11
WASTE CONTROL SPECIALISTS LLC
ORGANIC CONSTITUENTS DETECTED IN LANDFILL LEACHATE

	Concentration, ppb							Log Kow	Solubility (mg/L)
	Composite Samples			Individual Cell Samples (March 2002)					
	Q1 02	Q2 02	Q3 02	A	B	C	D		
Volatile Organic Analytes									
Acetone	14 B	22	13	14	<10	<10	<10	-0.235	600,000
Benzene	<1.0	<1.0	0.64 J	<1.0	<1.0	<1.0	<1.0	1.99	1,770
Carbon Disulfide	0.73 J	3.3	0.71 J	<1.0	2	2.6	<1.0	1.94	2,300
1,4 Dioxane (1)	NA	NA	NA	<200	780	<200	<200	-0.32	900,000
Toluene	1.7	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.54	530
Chloroform	<1.0	0.29 J	0.82 J	<1.0	<1.0	<1.0	<1.0	1.52	7,920
Napthalene	NA	NA	NA	<1.0	1.3	<1.0	<1.0	3.17	31.4
Vinyl Chloride	<1.0	<1.0	0.86 J	<1.0	<1.0	<1.0	<1.0	1.62	2,760
Semi-volatile Organic Analytes									
Bis(2-ethlyhexyl)phthlate	7.3 J	100	<10	<10	46	<10	<10	2.65	1,080
Phenol	<10	68	3.6 J	<10	<10	<10	<10	1.51	87,000
4-Chloro-3-Methlyphenol	<10	<10	5.5 J	<10	<10	<10	<10	2.99	5,430
1,4 Dioxane (1)	<10	120	<10	NA	NA	NA	NA	-0.32	900,000
Ethylene glycol (2)	<25	7.4 J	<25	NA	NA	NA	NA	-1.2	1,000,000
Herbicides/Pesticides									
Methyl parathion	<0.5	0.12 J	<0.5	NA	NA	NA	NA	2.75	50
2,4-D	<4.0	<4.0	1.1 J	NA	NA	NA	NA	2.62	890
4,4-DDE	0.011 J, COL	<0.050	<0.050	NA	NA	NA	NA	6	0.065
2,4,5-TP (Silvex)	0.035 J, COL	<1.0	<1.0	NA	NA	NA	NA	3.68	140
PCBs									
Arochlor 1248	NA	NA	NA	<1.0	<1.0	2.9	<1.0	6.3	0.0555
Arochlor 1254	NA	NA	NA	<1.0	<1.0	1.3	<1.0	6.3	0.0555

NA = Not Analyzed

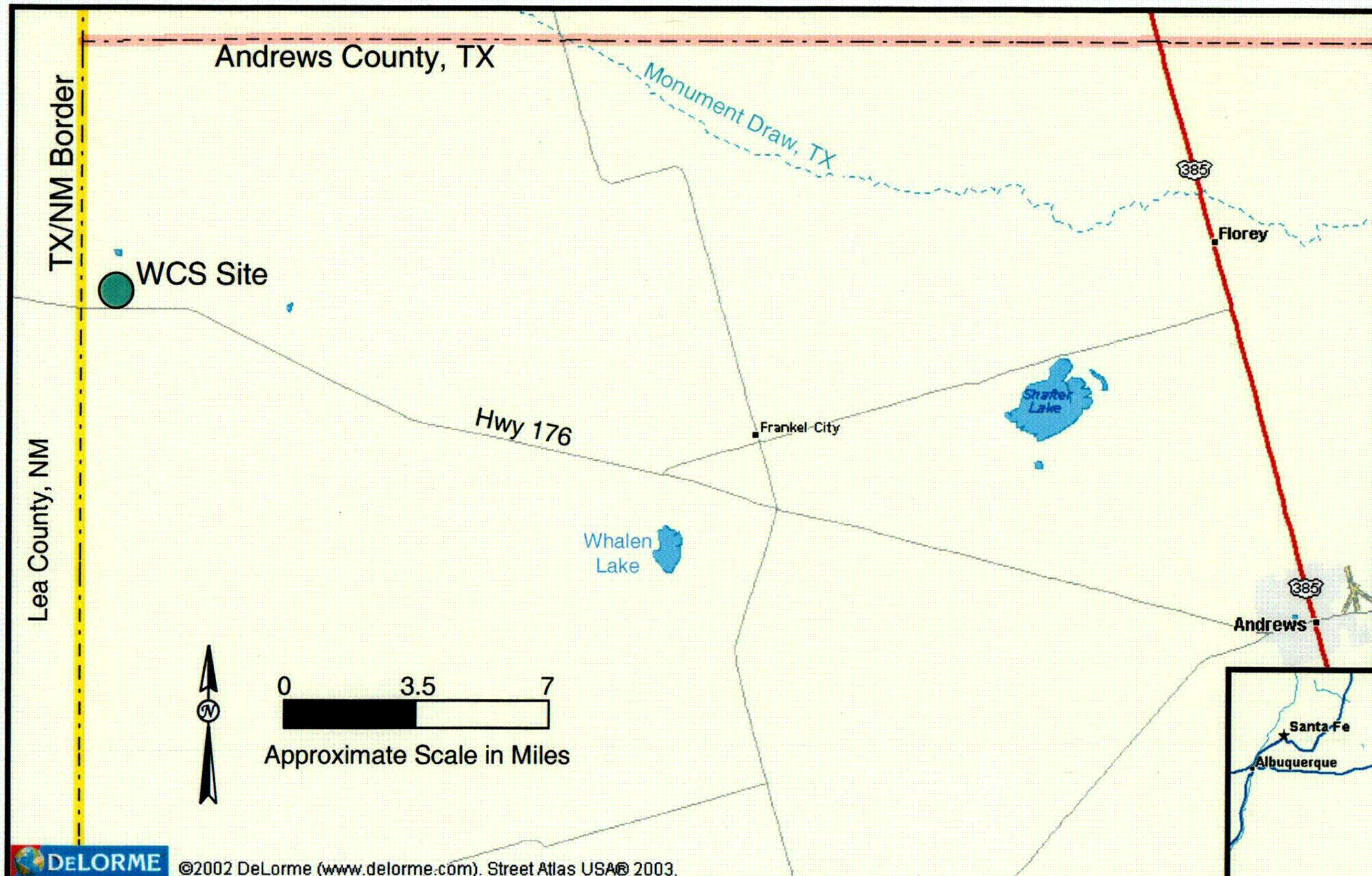
(1) 1,4-Dioxane was reported using Method 8260 (for volatile organics) for the special leachate sampling event conducted in March 2002. For the routine leachate monitoring, the analytical laboratory reported 1,4-Dioxane using Method 8270 (for semi-volatile organics).

(2) Ethylene glycol is analyzed for the routine leachate monitoring using Method 8015. All other detected semi-volatile organics are analyzed using Method 8270.

TABLE 6.6-12
WASTE CONTROL SPECIALISTS LLC
PROPOSED DETECTION MONITORING PARAMETERS

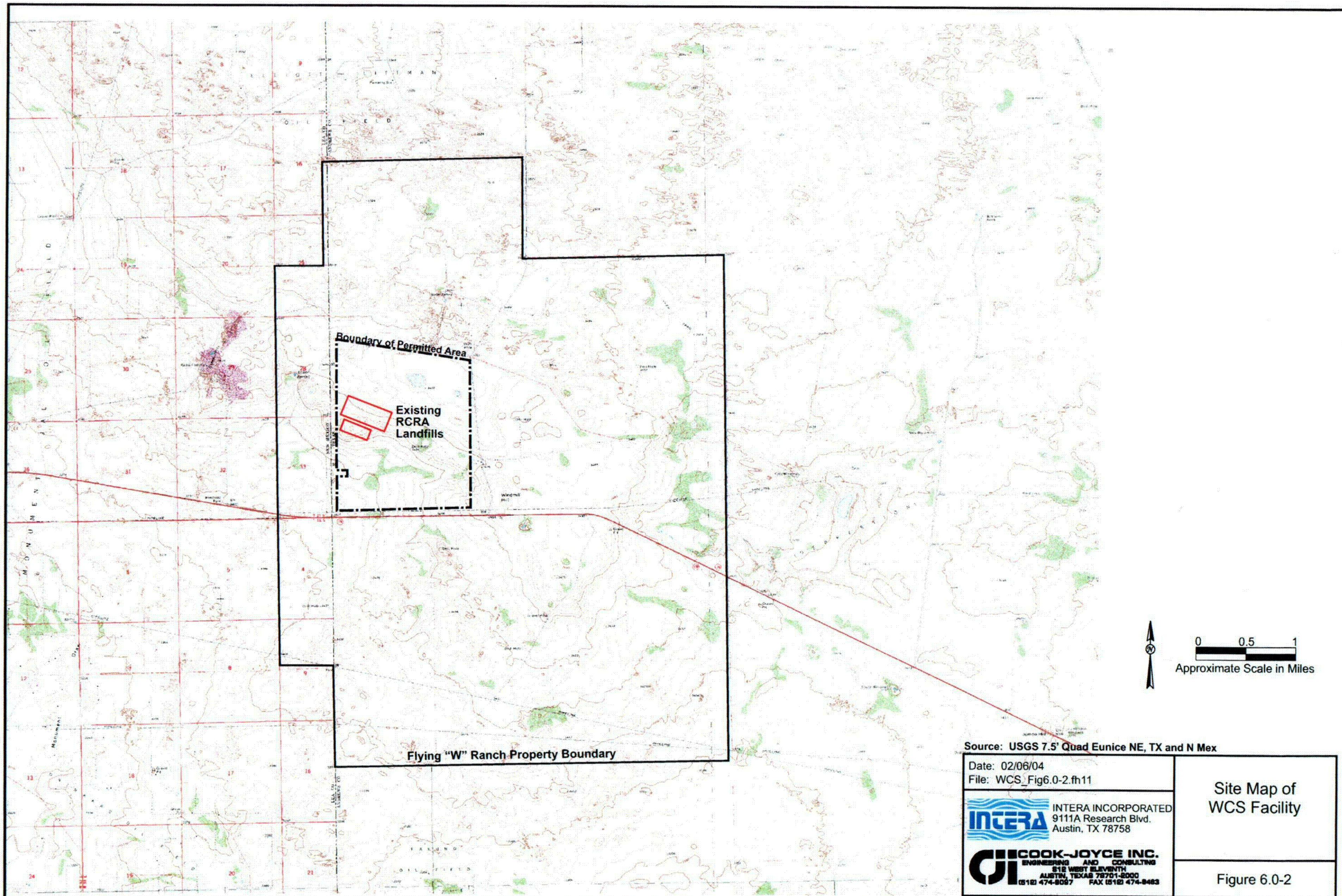
Proposed Monitoring Parameter	Analytical Method
Arsenic	SW-846 6010/EPA Method 200.7
Cadmium	SW-846 6010/EPA Method 200.7
Nickel	SW-846 6010/EPA Method 200.7
Selenium	SW-846 6010/EPA Method 200.7
Volatile Organic Constituents:	
acetone	SW-846 8260/EPA Method 624
benzene	(for all volatile organic parameters)
bromoform	
carbon disulfide	
carbon tetrachloride	
chlorobenzene	
chlorodibromomethane	
chloroethane	
chloroform	
dichlorobromomethane	
1,1-dichloroethane	
1,2-dichloroethane	
1,1-dichloroethylene	
1,2-dichloropropane	
cis-1,3-dichloropropylene	
trans-1,3-dichloropropylene	
ethylbenzene	
methyl bromide	
methyl chloride	
1,1,2,2-tetrachloroethane	
tetrachloroethylene	
toluene	
1,2-trans-dichloroethylene	
1,1,1-trichloroethane	
1,1,2-trichloroethane	
trichloroethylene	
vinyl chloride	
Semi-volatile Organic Constituents:	
phenol	SW-846 8270/EPA Method 625
1,4-dioxane	(for all semi-volatile parameters)

FIGURES



Date: 01/20/04 File: WCS-Location-map.ppt	WCS Site Location Map
INTERA INCORPORATED 9111A Research Blvd. Austin, Texas 78758 COOK-JOYCE INC. ENGINEERING AND CONSULTING 812 WEST ELEVENTH AUSTIN, TEXAS 78701-2000 (512) 474-9097 FAX (512) 474-8463	Figure 6.0-1

C12


Boundary of Permitted Area
Existing RCRA Landfills
Flying "W" Ranch Property Boundary
0 0.5 1
Approximate Scale in Miles
Source: USGS 7.5' Quad Eunice NE, TX and N Mex
Date: 02/06/04
File: WCS_Fig6.0-2.fh11
INTERA INCORPORATED
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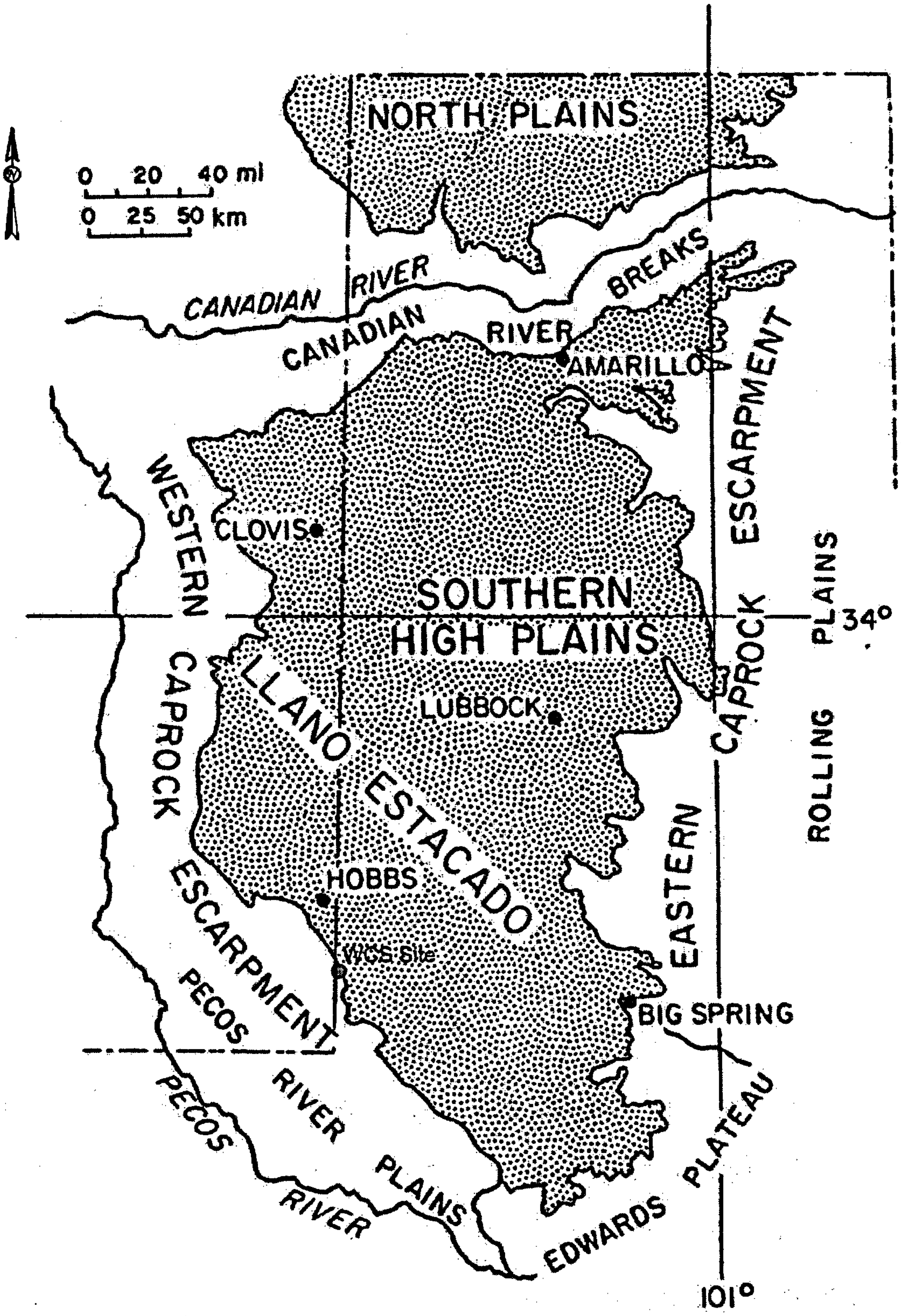
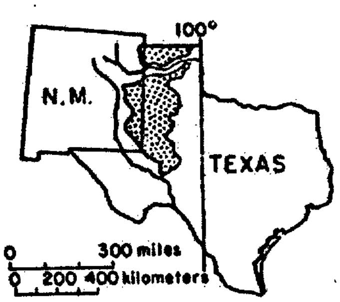
COOK-JOYCE INC.
ENGINEERING AND CONSULTING
Site Map of WCS Facility
Figure 6.0-2

C13





Source: Finley and Gustavson, 1981

Date: 02/05/04
File: WCS_Fig6.1-1.fh11

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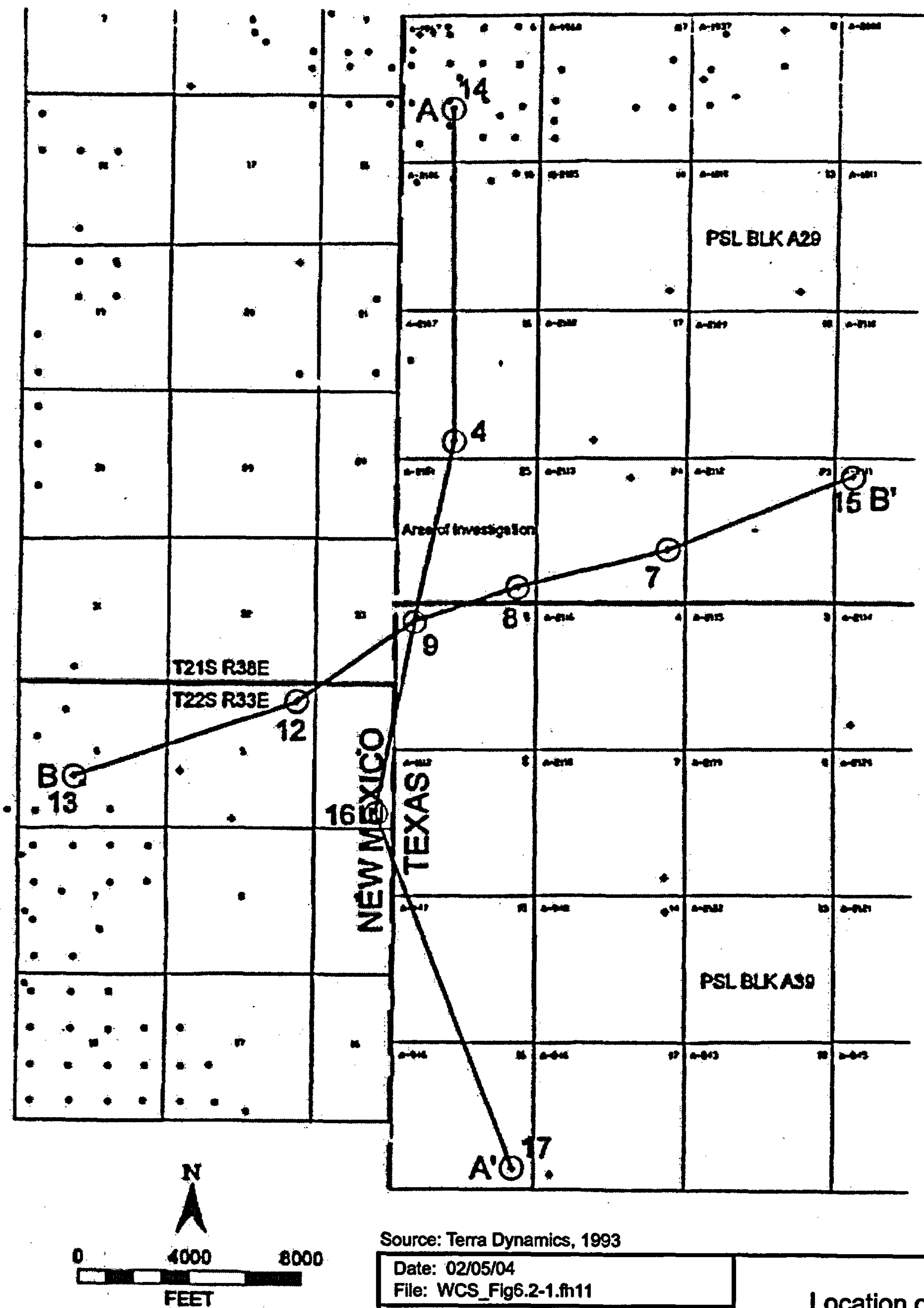
Physiographic Regions of the Texas Panhandle and Adjacent Areas of Texas and New Mexico

Figure 6.1-1



Source: Terra Dynamics, 1993

Date: 02/05/04
File: WCS_Fig6.2-1.fh11

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Location of Stratigraphic Cross Sections

Figure 6.2-1

Years BP (millions)	SYSTEM/SERIES		GROUP	FORMATION
0.01	QUATERNARY		RECENT/HOLOCENE	Windblown Sand; Playa Deposits
	QUATERNARY		PLEISTOCENE	Blackwater Draw or Tahoka; Playa Deposits
1.6	TERTIARY			Ogallala; Gatuna
66	CRETACEOUS		COMMANCHEAN	Duck Creek
	CRETACEOUS		COMMANCHEAN	Kiamichi
	CRETACEOUS		COMMANCHEAN	Edwards
	CRETACEOUS		COMMANCHEAN	Comanche Peak
	CRETACEOUS		COMMANCHEAN	Walnut
	CRETACEOUS		COMMANCHEAN	Antlers
144	JURASSIC			
208	TRIASSIC		DOCKUM	Redonda
	TRIASSIC		DOCKUM	Cooper Canyon
	TRIASSIC		DOCKUM	Trujillo
	TRIASSIC		DOCKUM	Tecovas
	TRIASSIC		DOCKUM	Santa Rosa
245	PERMIAN	OCHOA		Dewey Lake
	PERMIAN	OCHOA		Rustler
	PERMIAN	OCHOA		Salado
	PERMIAN	GUADALUPE	WHITEHORSE	Tansill
	PERMIAN	GUADALUPE	WHITEHORSE	Yates
	PERMIAN	GUADALUPE	WHITEHORSE	Seven Rivers
	PERMIAN	GUADALUPE	WHITEHORSE	Queen
	PERMIAN	GUADALUPE	WHITEHORSE	Grayburg
	PERMIAN	GUADALUPE	SAN ANDRES	Glorieta
	PERMIAN	LEONARD	CLEAR FORK	U. Clear Fork
	PERMIAN	LEONARD	CLEAR FORK	Tubb Sd.
	PERMIAN	LEONARD	CLEAR FORK	L. Clear Fork
	PERMIAN	LEONARD	WICHITA	Wichita-Abo
	PERMIAN	WOLFCAMP	WOLFCAMP	
286	PENNSYLVANIAN	CISCO	CISCO	
	PENNSYLVANIAN	CANYON	CANYON	
	PENNSYLVANIAN	STRAWN	STRAWN	
	PENNSYLVANIAN	ATOKA	ATOKA	
320	MISSISSIPPIAN	MERAMEC		Mississippian Lime
	MISSISSIPPIAN	KINDERHOOK	KINDERHOOK	
360	DEVONIAN	UPPER	WOODFORD	Woodford Shale
	DEVONIAN	LOWER	DEVONIAN	
408	SILURIAN	U. NIAGARAN		Upper Silurian Shale
	SILURIAN	L. NIAGARAN	FUSSELMAN	
	SILURIAN	ALEXANDRIAN	FUSSELMAN	
438	ORDOVICIAN	UPPER	MONTOYA	
	ORDOVICIAN	MIDDLE	SIMPSON	
	ORDOVICIAN	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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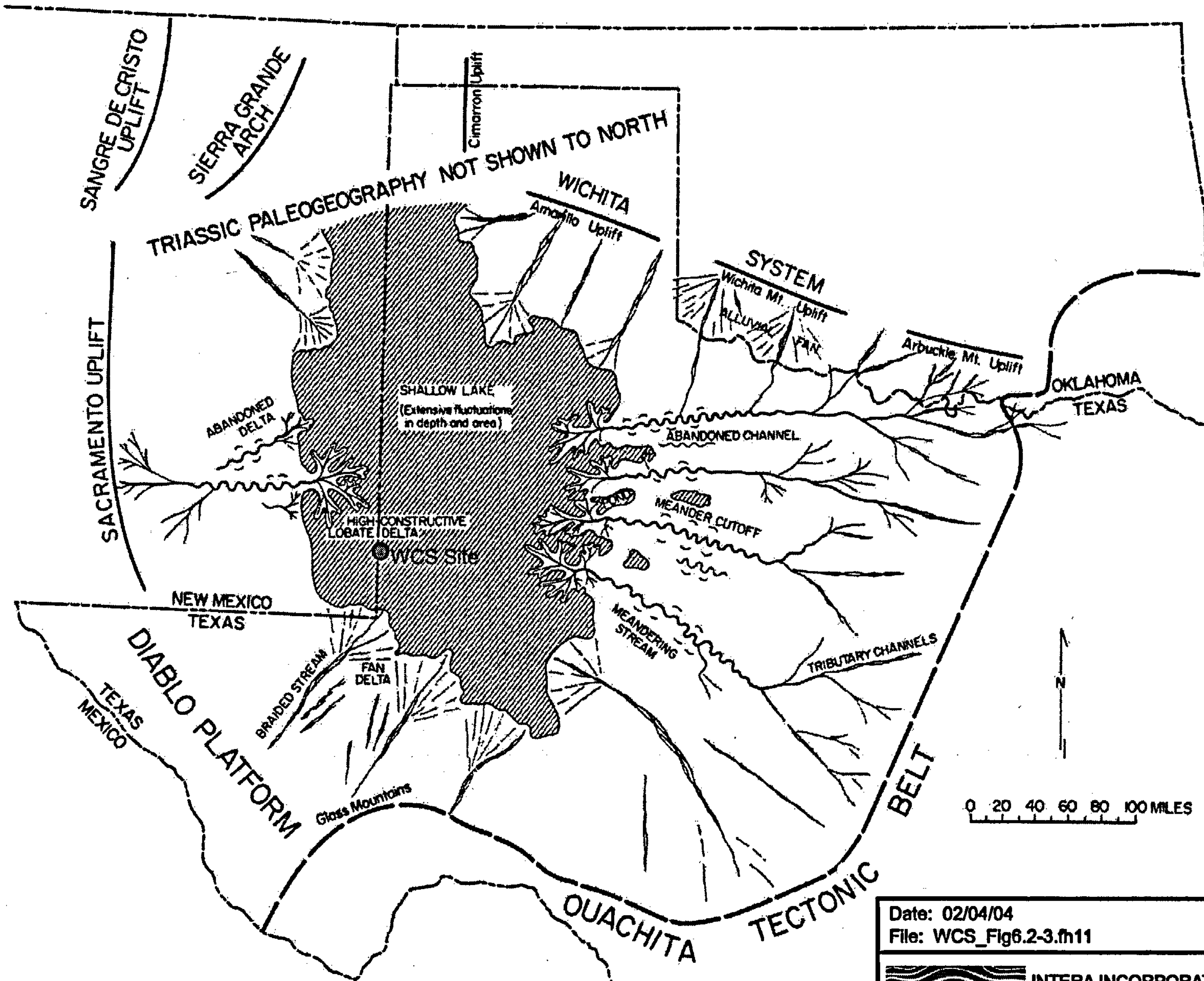
Stratigraphic Column Central Basin Platform

Figure 6.2-2



Source: McGowen et al., 1979

Date: 02/04/04
File: WCS_Fig6.2-3.fh11

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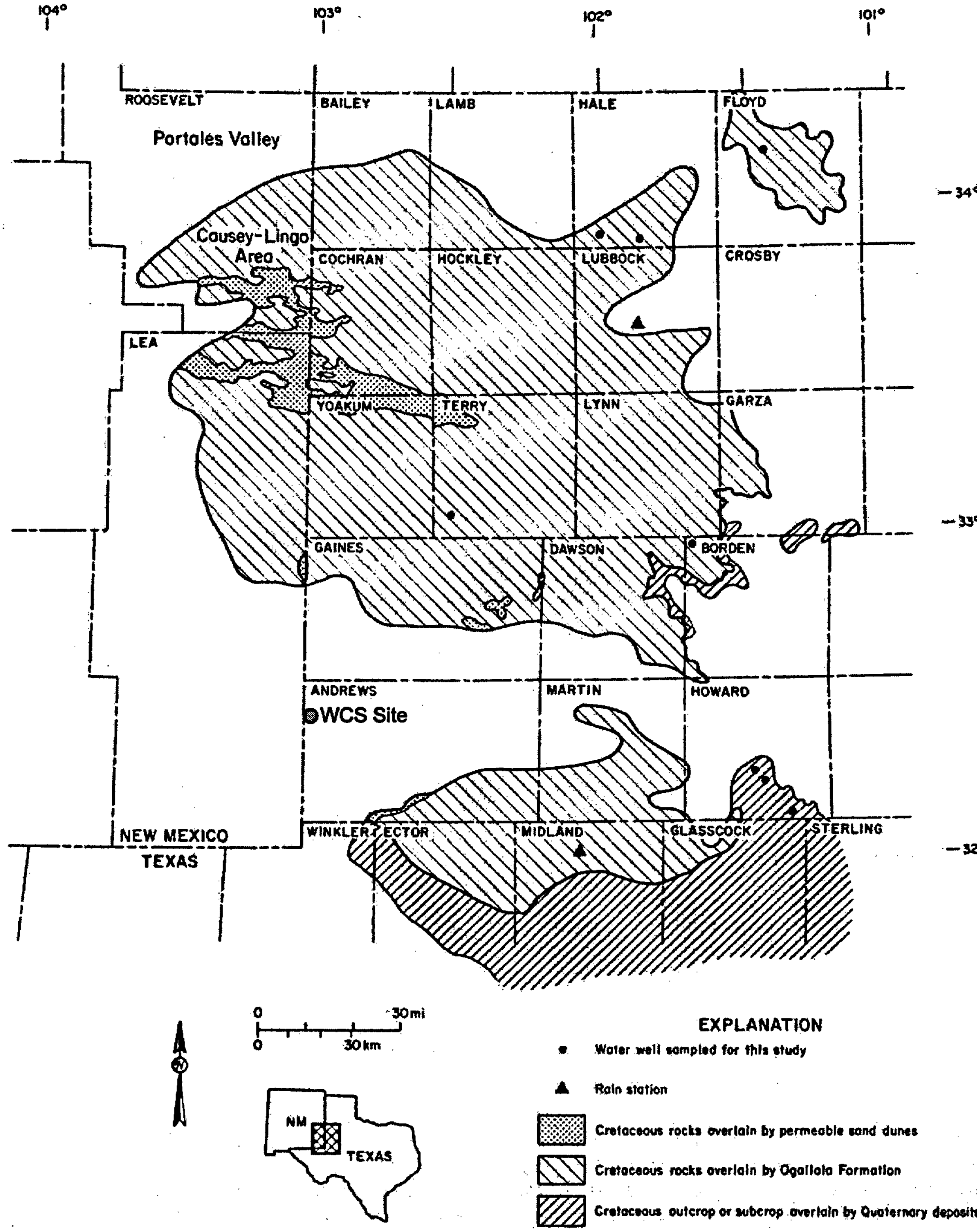
Inferred Paleogeography of Dockum Sedimentation

Figure 6.2-3



Source: Nativ and Gutierrez, 1988

Date: 02/04/04 File: WCS_Fig6.2-4.fh11	Map of Cretaceous Subcrops
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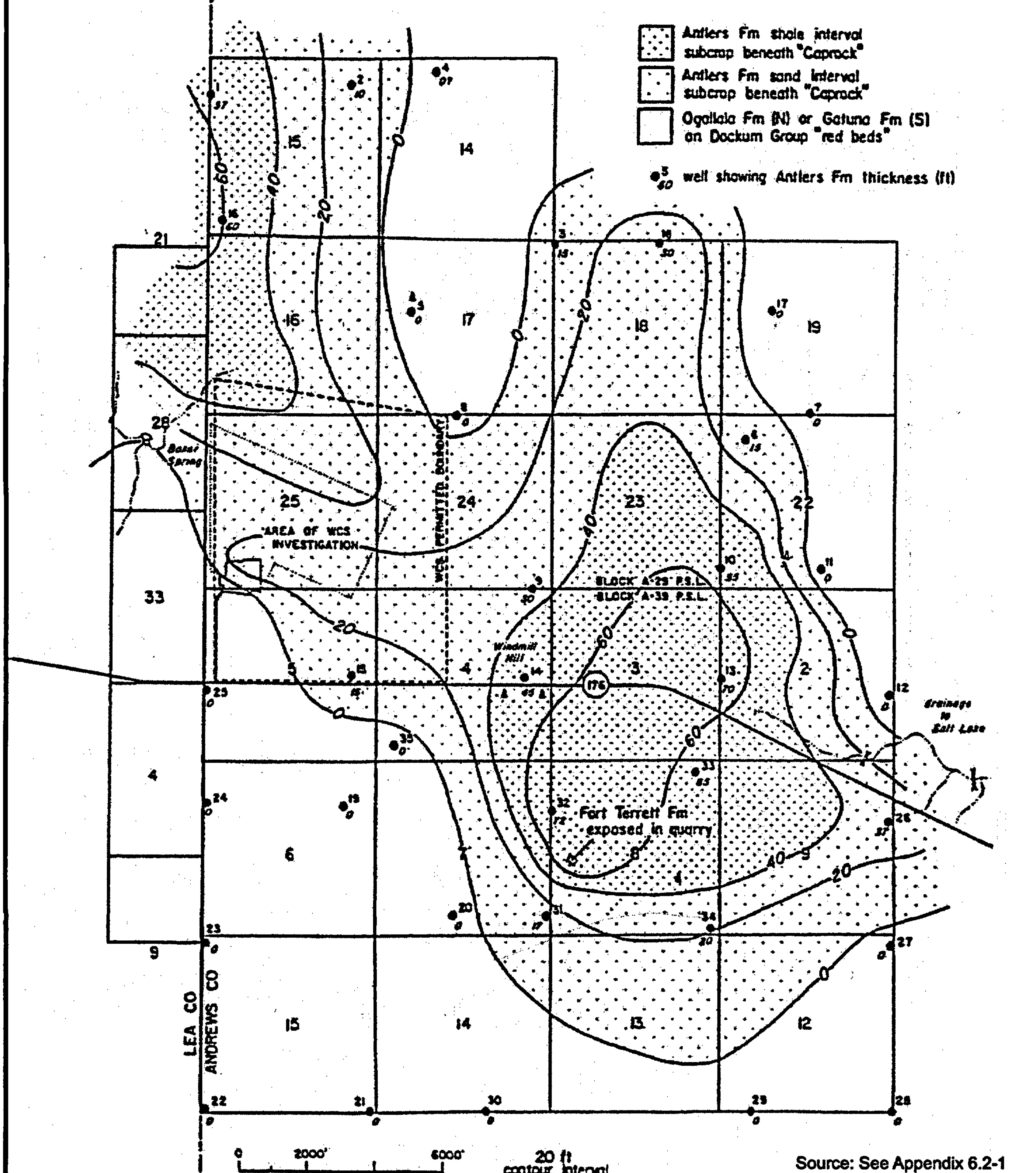
COOK-JOYCE INC. ENGINEERING AND CONSULTING 812 WEST ELEVENTH AUSTIN, TEXAS 78701-2000 (512) 474-9097 FAX (512) 474-8483	Figure 6.2-4



Source: See Appendix 6.2-1

Date: 02/04/04
File: WCS_Fig6.2-5.fh11

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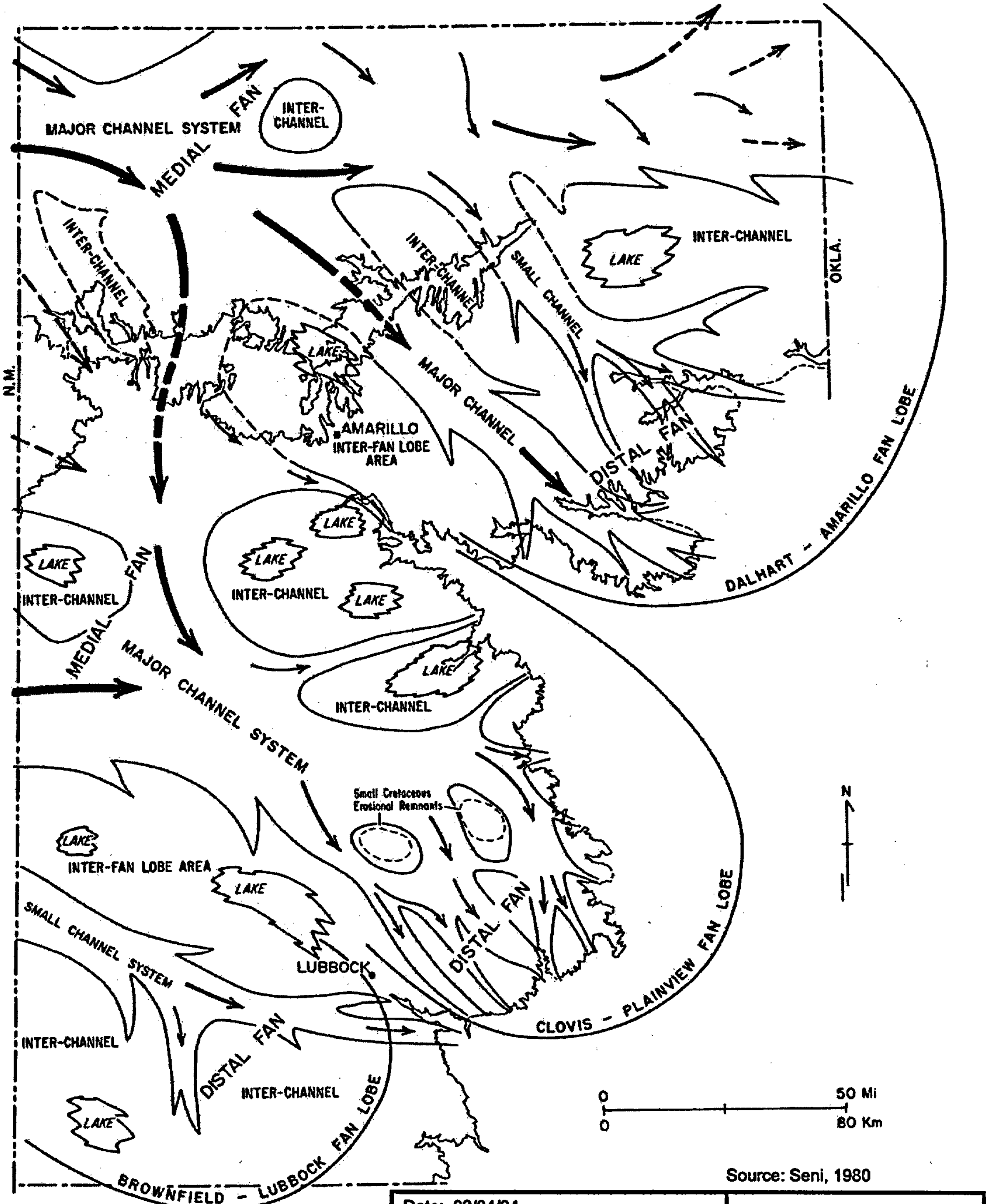
Thickness of Antlers Formation

Figure 6.2-5



Source: Seni, 1980

Date: 02/04/04
File: WCS_Fig6.2-6.fh11

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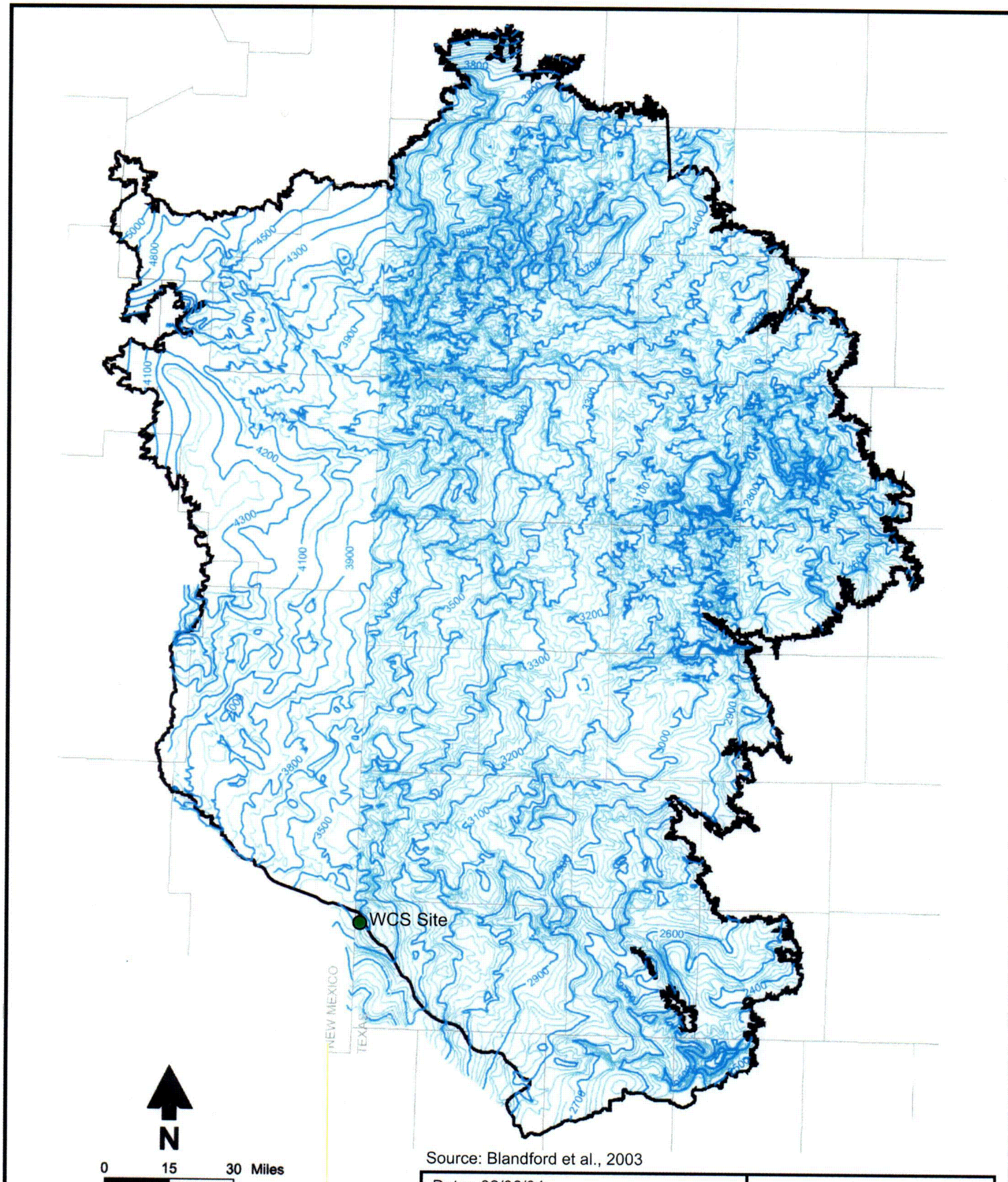
Ogallala Depositional Facies Map

Figure 6.2-6



Source: Blandford et al., 2003

Explanation

- Aquifer bottom elevation (ft-MSL)
- Study area
- County

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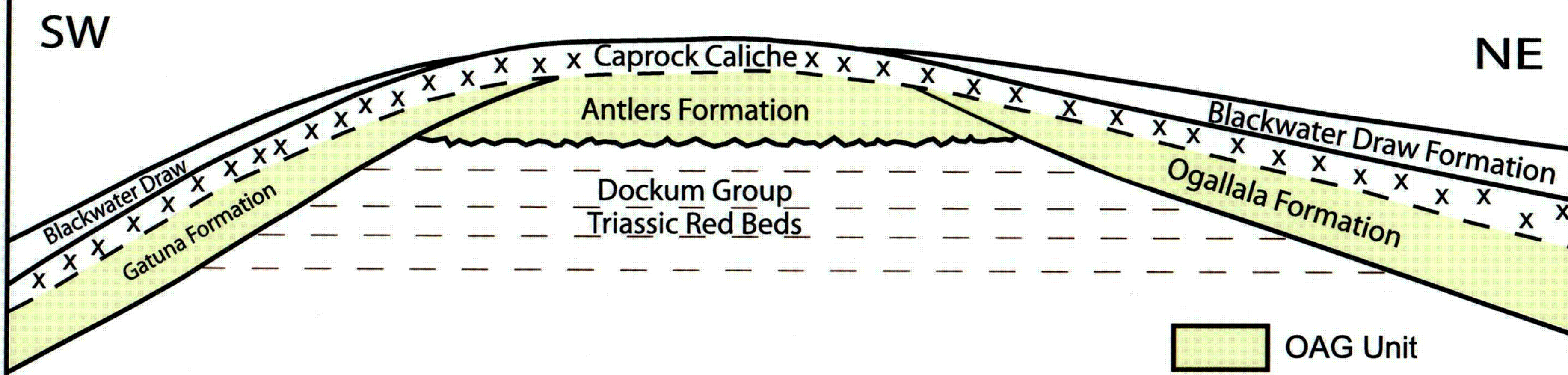
Structure Contour Map of the Base of the Ogallala Formation

Figure 6.2-7

C14



Date: 02/06/04
File: WCS_Fig.fh11

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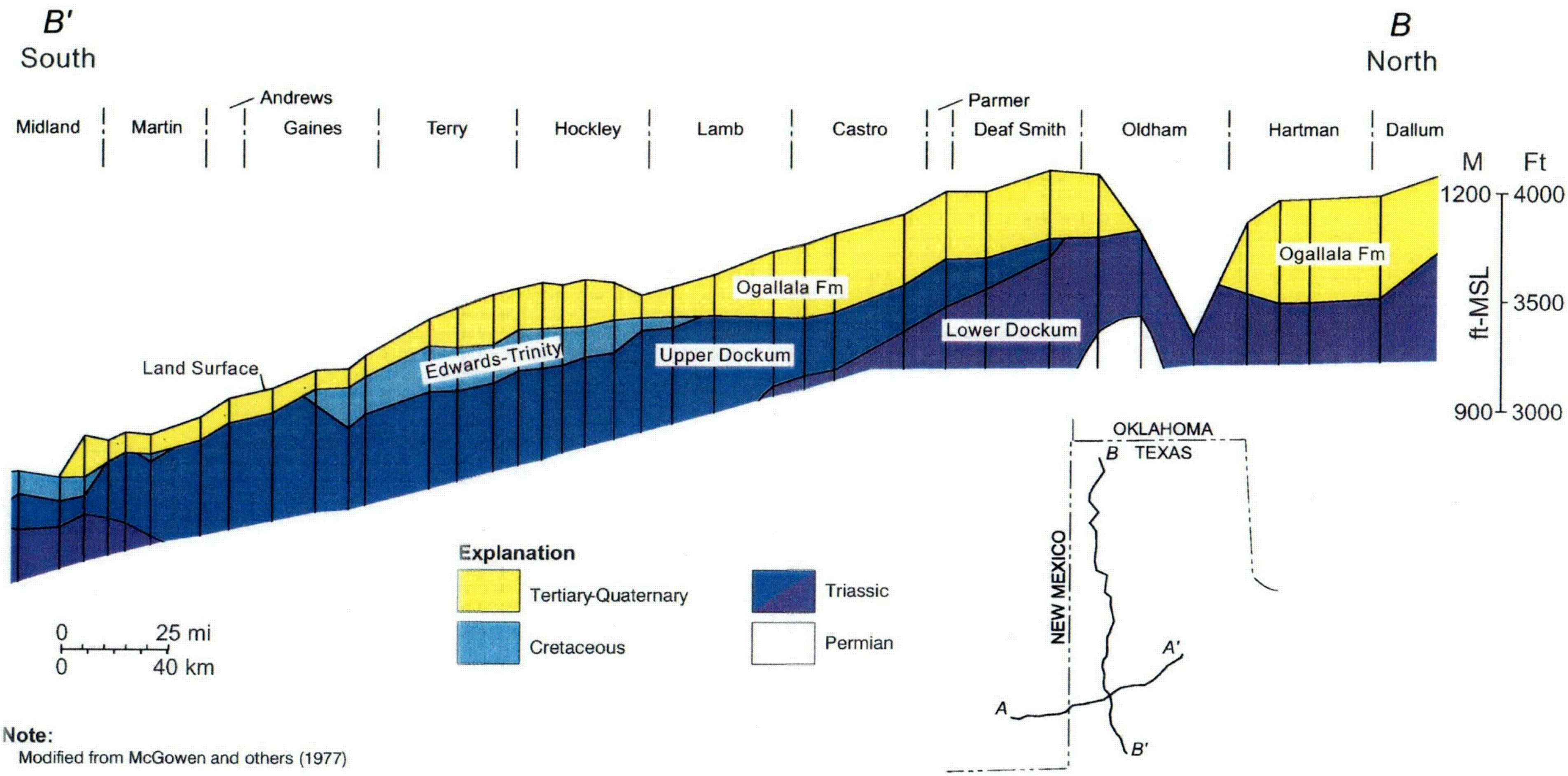
Schematic Cross Section of the OAG (Ogallala, Antlers, Gatuna) Unit at the WCS Facility

Figure 6.2-8

C15



Note:
Modified from McGowen and others (1977)

Source: Blandford et al., 2003

Date: 02/04/04
File: WCS_Fig6.3.1.fh11

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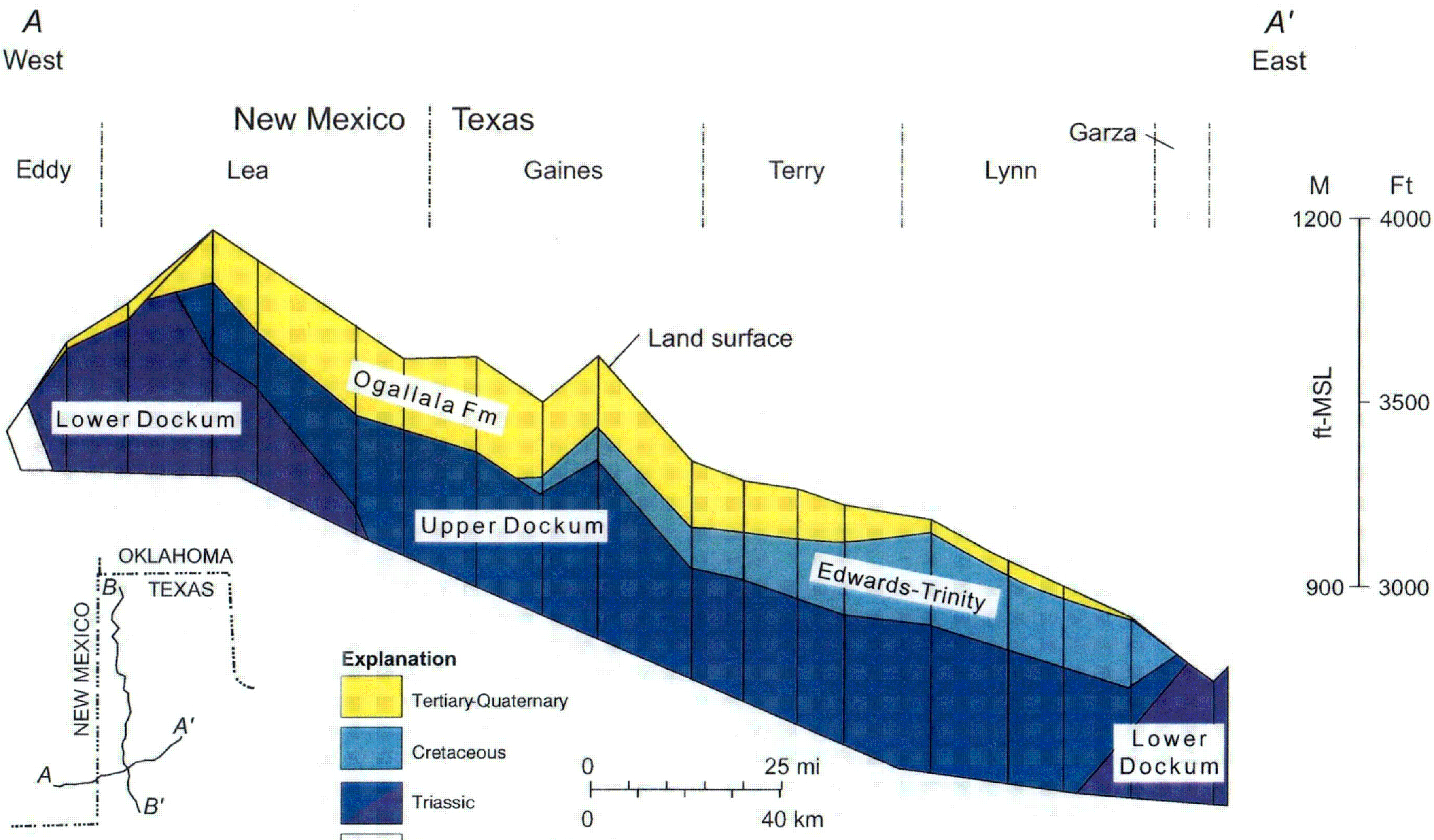
North to South Geologic Cross Section Showing Relationship of Ogallala Formation to Underlying Strata

Figure 6.3-1



Note:
Modified from McGowen and others (1977)

Source: Blandford et al., 2003

Date: 02/04/04
File: WCS_Fig6.3.2.fh11

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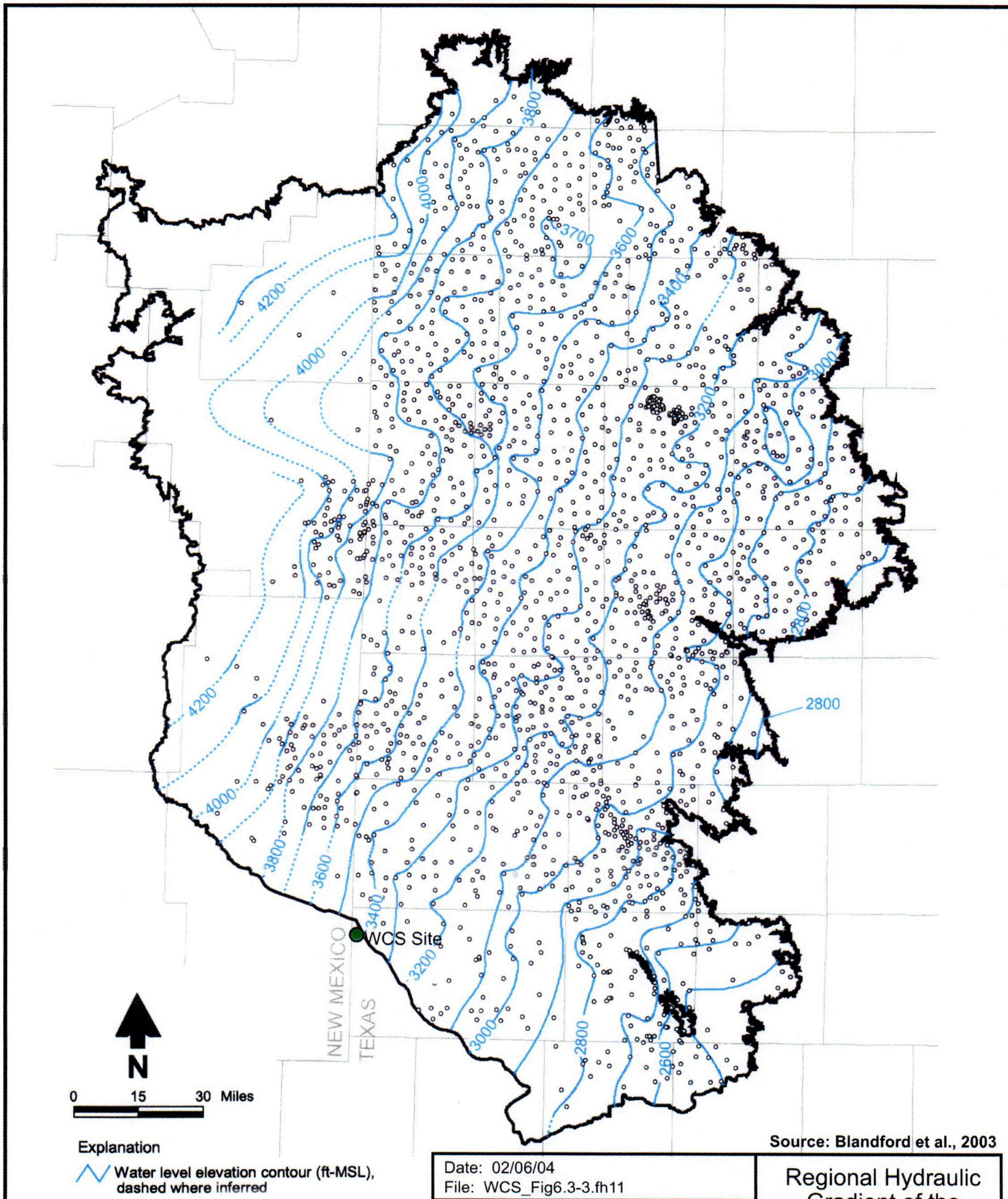
West to East Geologic Cross Section Showing Relationship of Ogallala Formation to Underlying Strata

Figure 6.3-2

C17



Source: Blandford et al., 2003

Date: 02/06/04
File: WCS_Fig6.3-3.fh11

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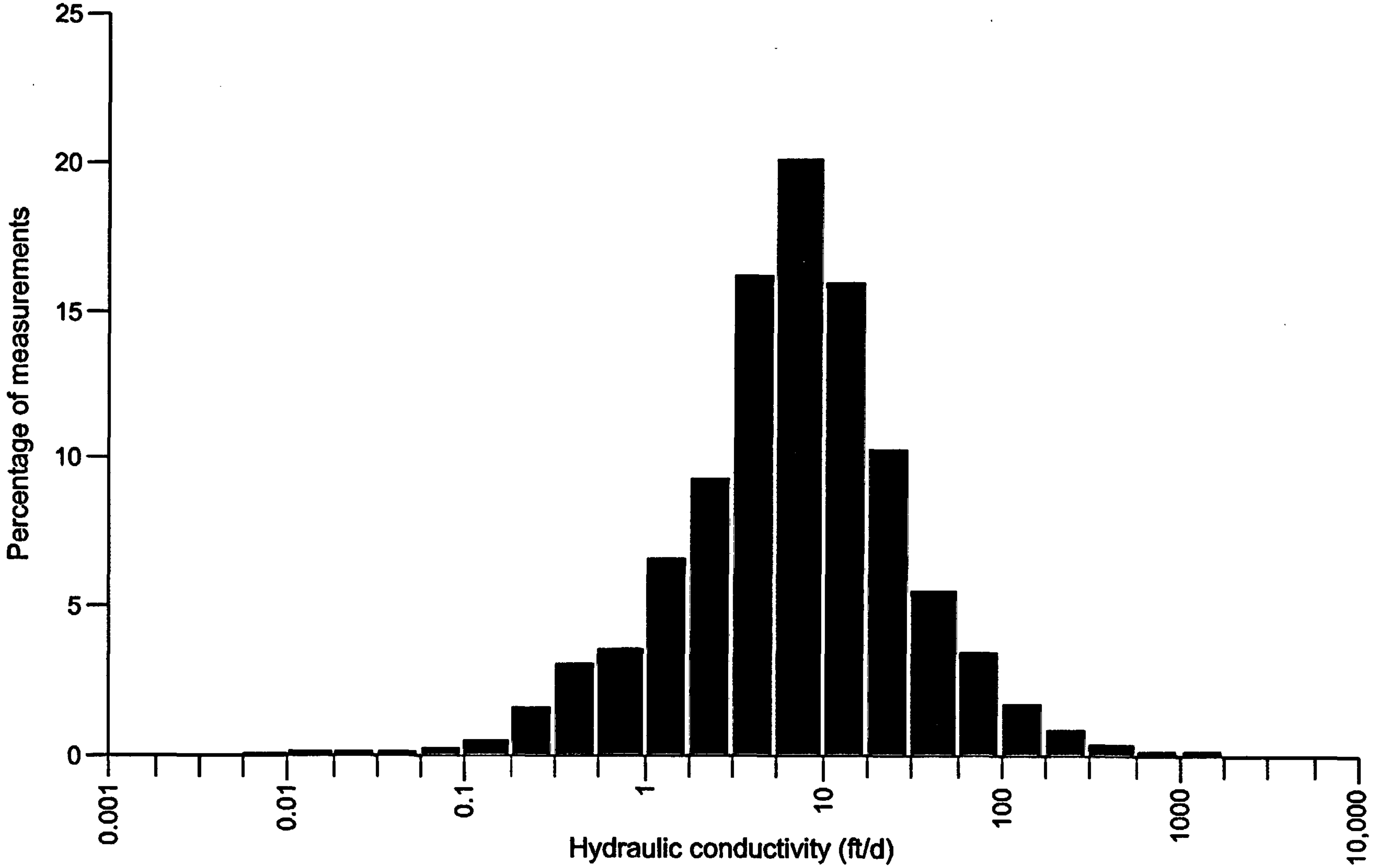
Regional Hydraulic Gradient of the Ogallala Aquifer, November 1999 - April 2000

Figure 6.3-3



Source: Blandford et al., 2003

Date: 02/04/04 File: WCS_Fig6.3-4.fh11	Histogram of Hydraulic Conductivity of the Ogallala Aquifer
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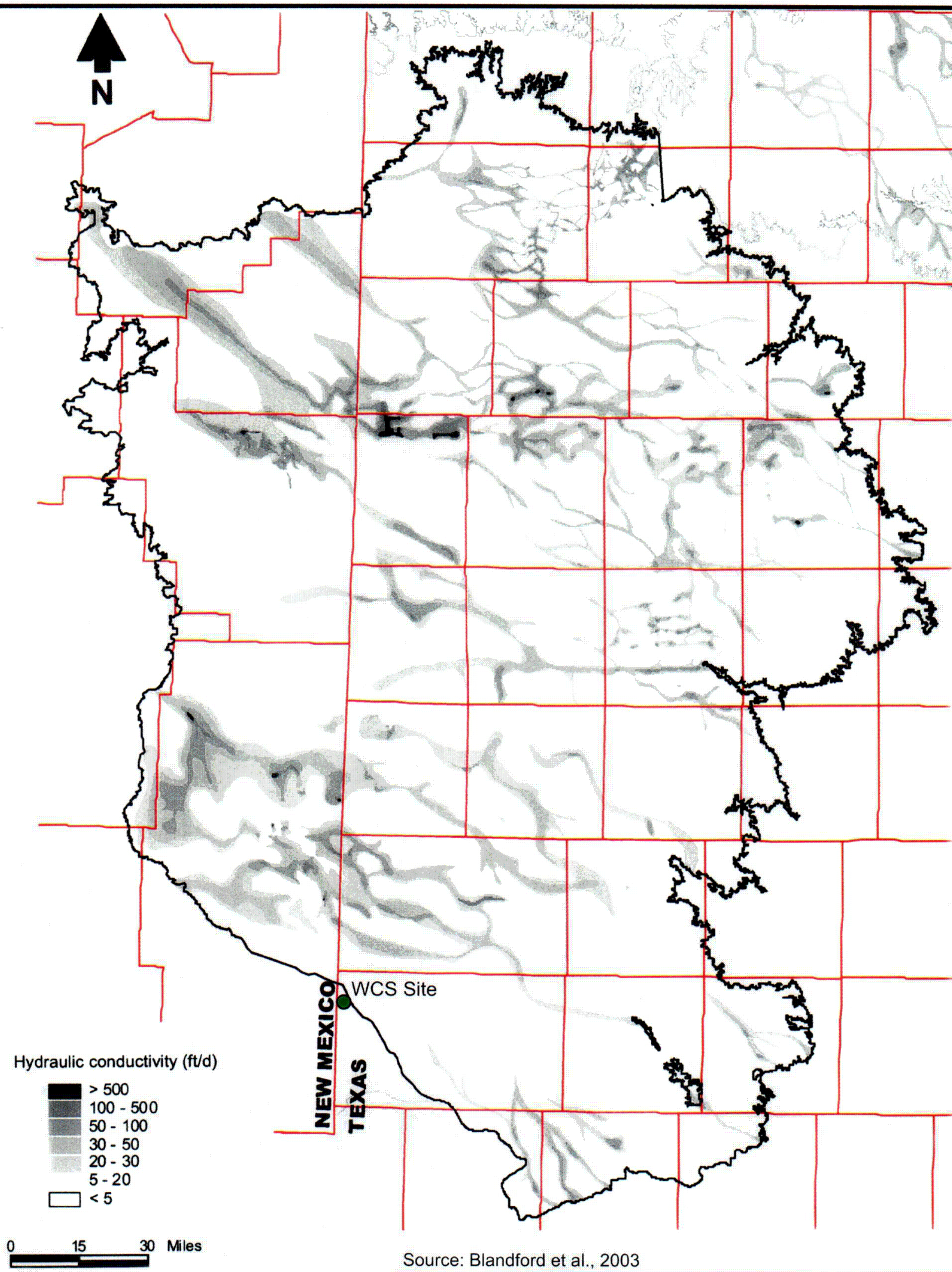
COOK-JOYCE INC. ENGINEERING AND CONSULTING 812 WEST ELEVENTH AUSTIN, TEXAS 78701-2000 (512) 474-9097 FAX (512) 474-8463	Figure 6.3-4



Source: Blandford et al., 2003

Date: 02/05/04
File: WCS_Fig6.3-5.fh11

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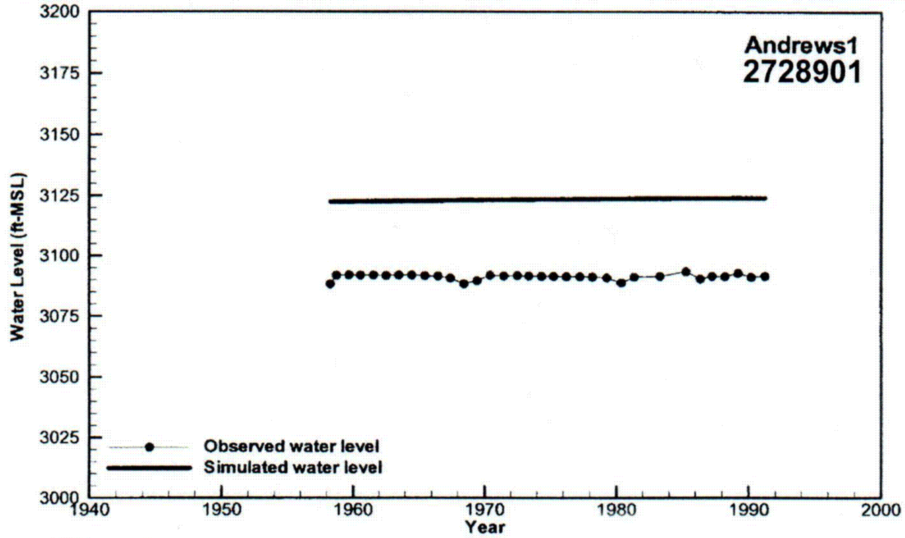
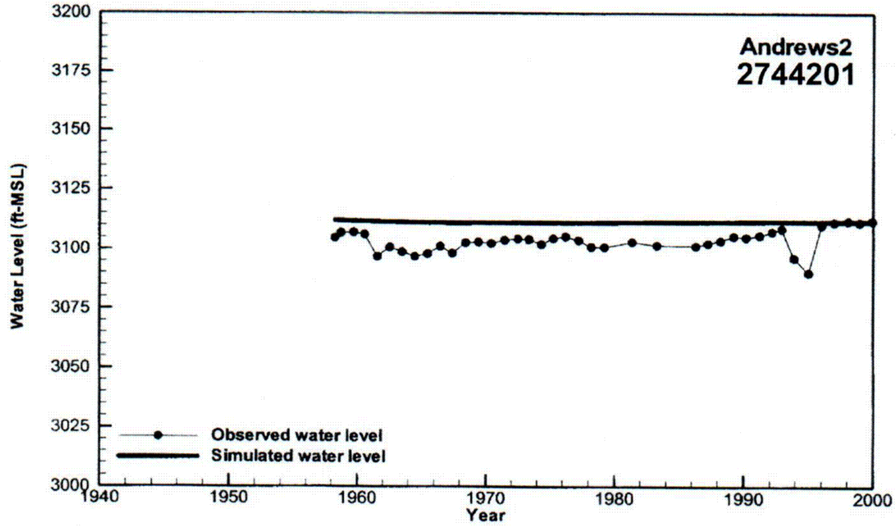
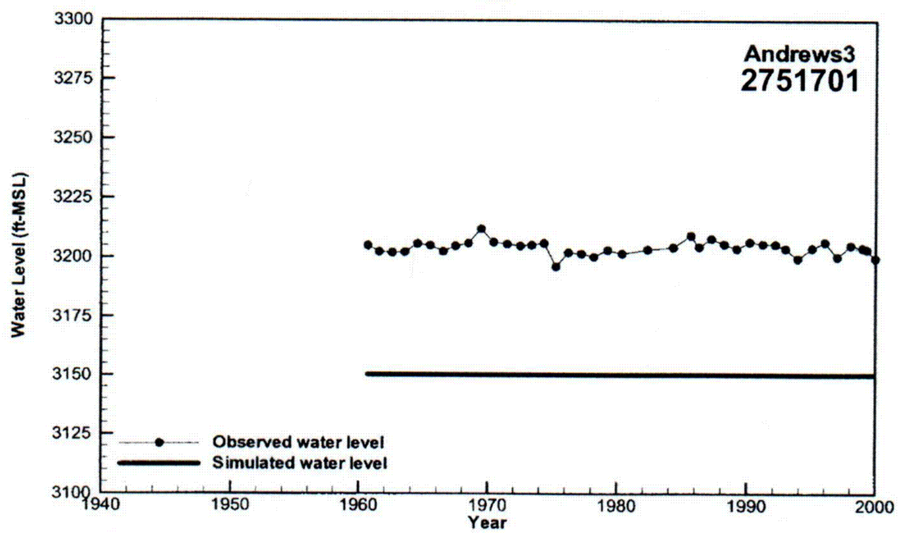
Distribution of Hydraulic Conductivity in the Ogallala Aquifer

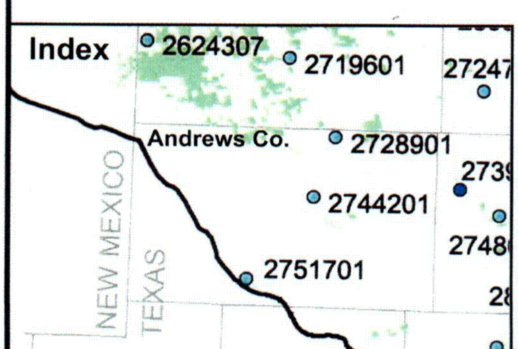
Figure 6.3-5

C19









Source: Blandford et al., 2003

Date: 02/05/04
File: WCS_Fig6.3-6.fh11

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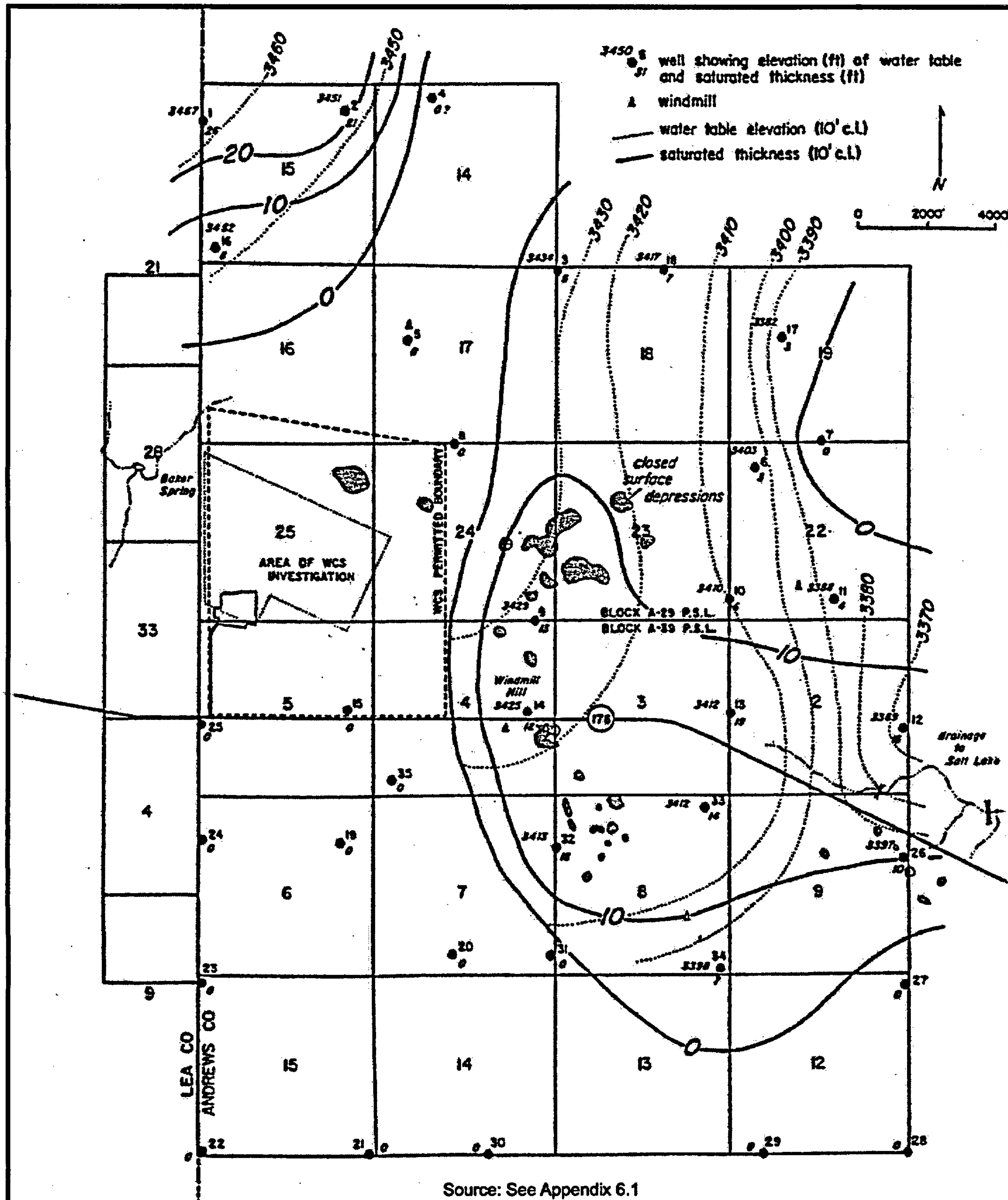
Water Levels in the Ogallala Aquifer in Andrews County, Approximately 1960 to Present

Figure 6.3-6

C20



Source: See Appendix 6.1

Date: 02/05/04
File: WCS_Fig6.3-7.fh11

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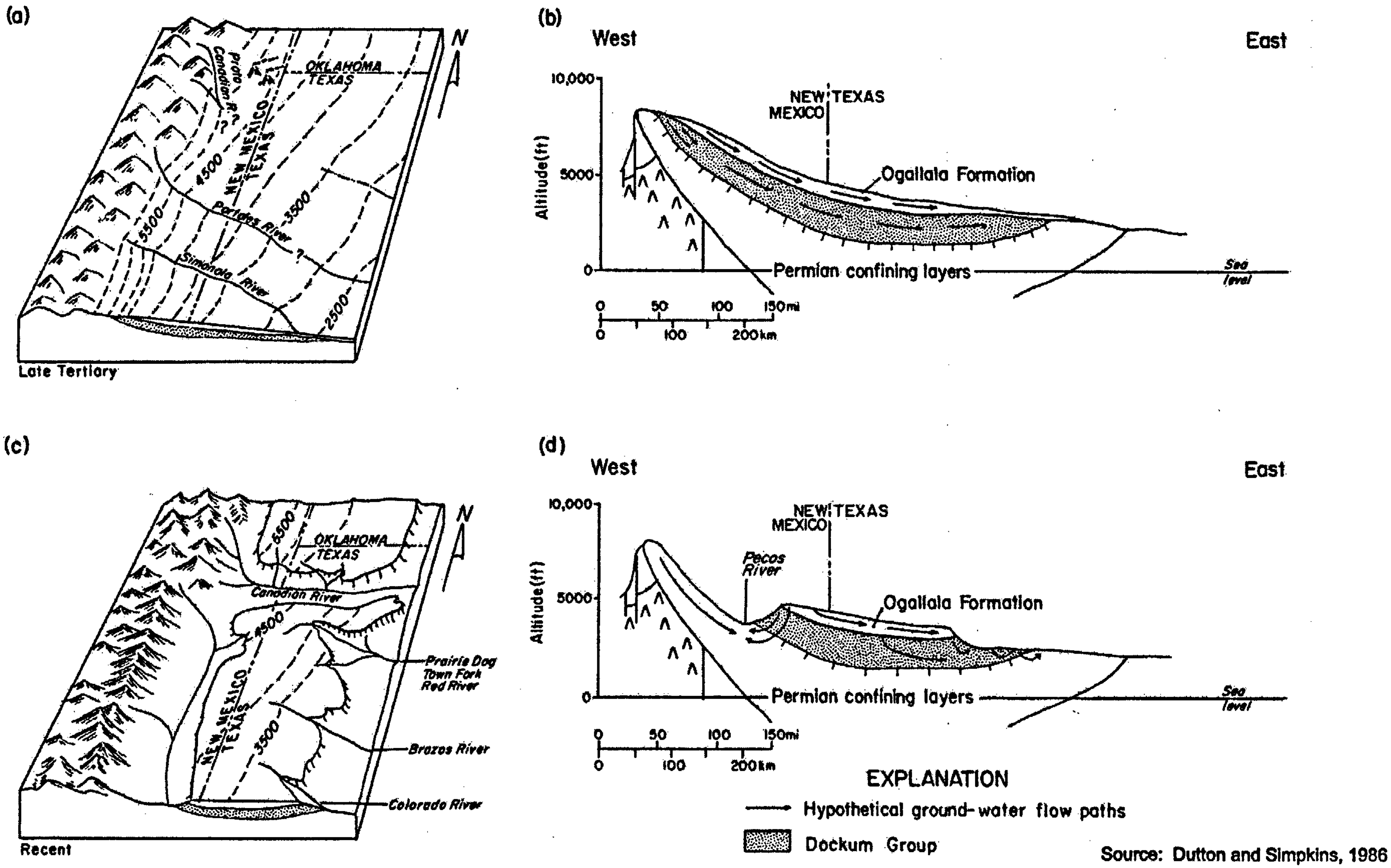
Groundwater Elevation and Saturated Thickness in the Vicinity of the WCS Facility

Figure 6.3-7



Source: Dutton and Simpkins, 1986

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File: WCS_Fig6.3-8.fh11

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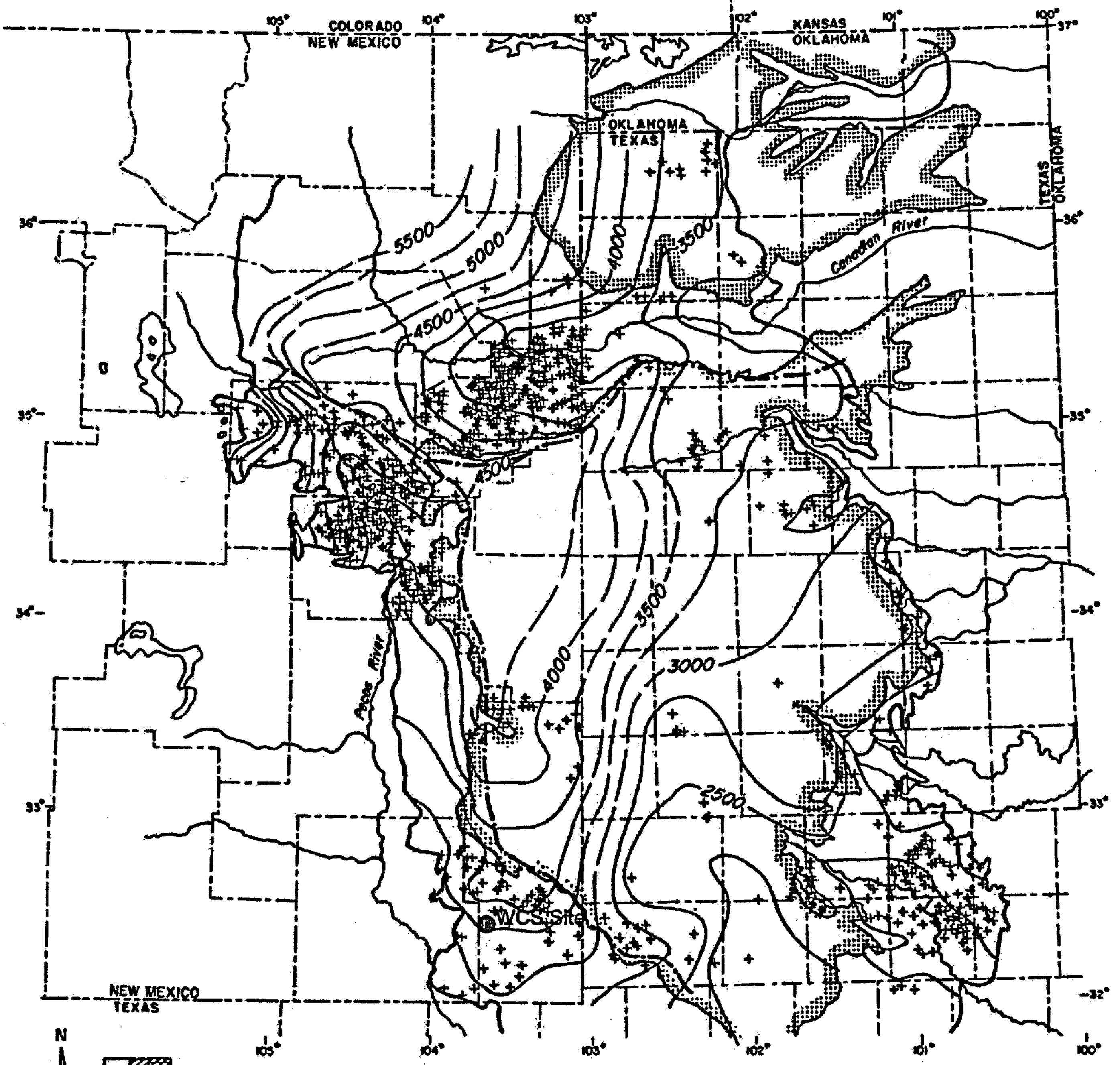
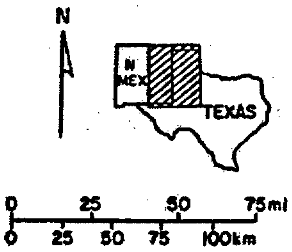
Schematic Showing Recharge to the Dockum Group Before and After Development of the Pecos River

Figure 6.3-8





EXPLANATION

High Plains surface – Caprock Escarpment

Inferred subcrop limit (from Granata, 1981)

3000 Approximate altitude of hydraulic head in the Lower Dockum aquifer. Sea level datum. Contour interval: 250 ft (76.2 m)

Regional ground-water-basin divide inferred from potentiometric surface

+ Data from water wells in Dockum Group

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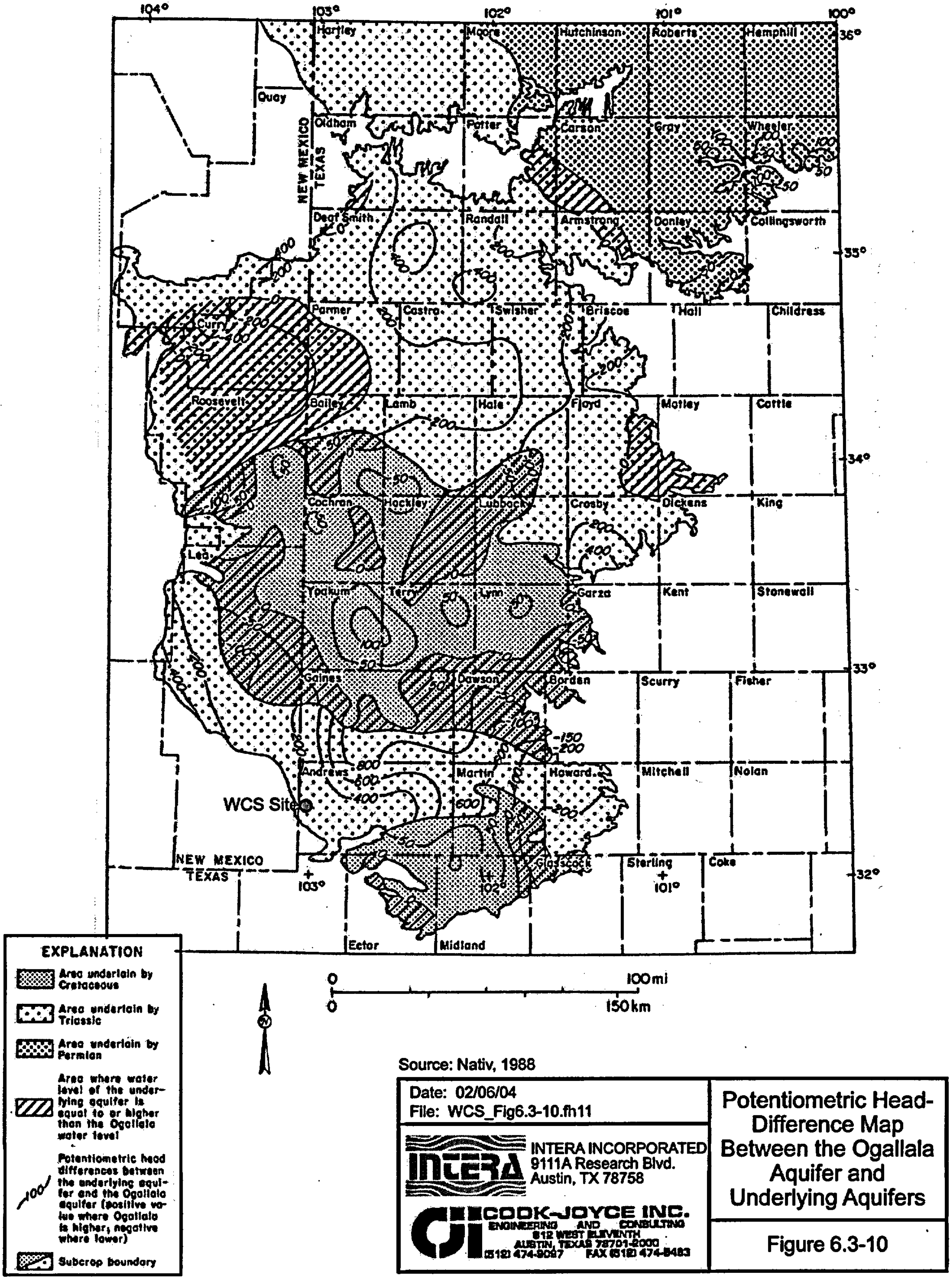
Potentiometric Surface Map of the Dockum Group Aquifer

Figure 6.3-9

Source: Dutton and Simpkins, 1986



Source: Nativ, 1988

Date: 02/06/04
File: WCS_Fig6.3-10.fh11

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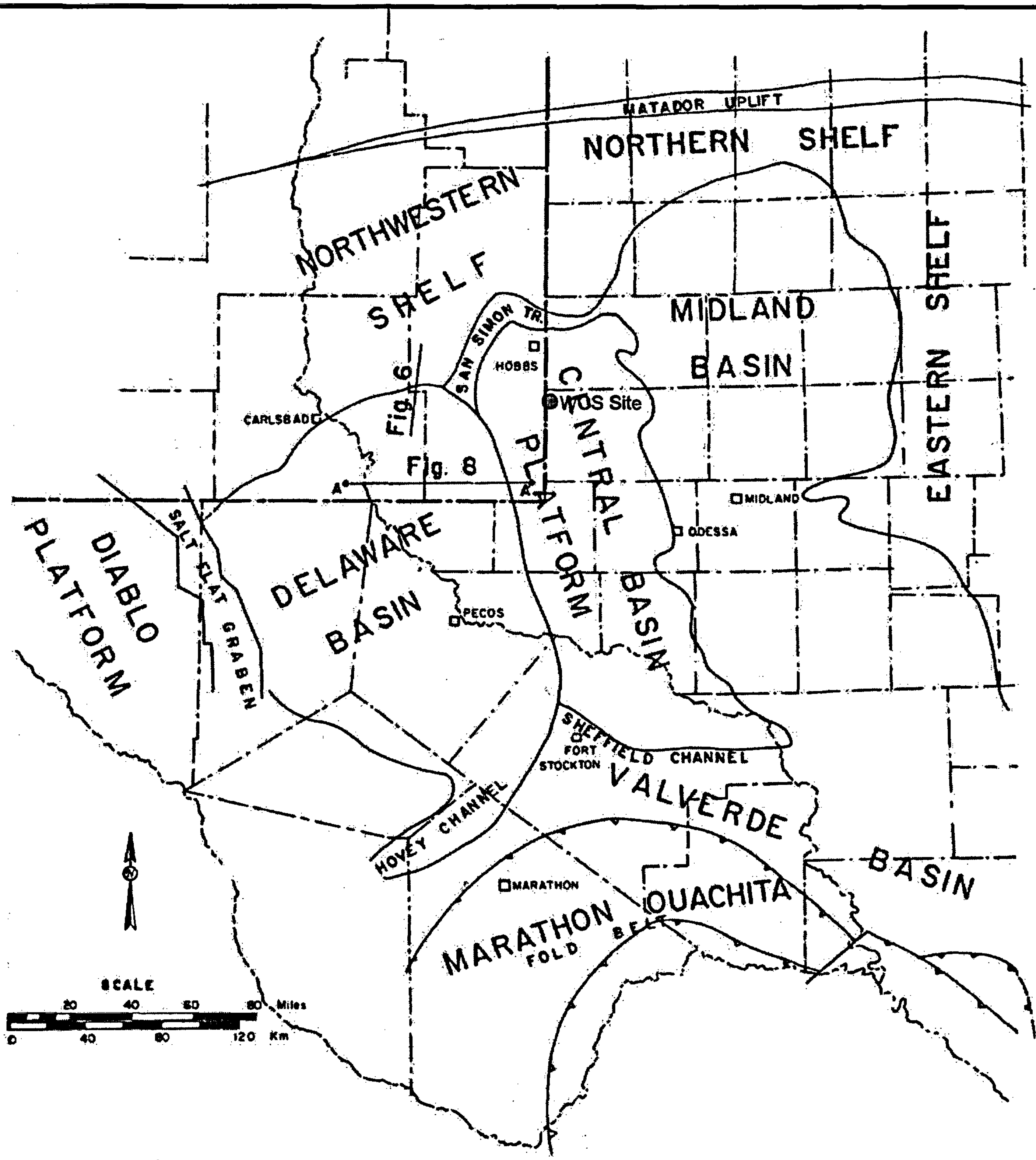
Potentiometric Head-Difference Map Between the Ogallala Aquifer and Underlying Aquifers

Figure 6.3-10



Source: Hills, 1985

Date: 02/04/04 File: WCS_Fig6.4-1.fh11	Major Structural Provinces of West Texas and Southeastern New Mexico
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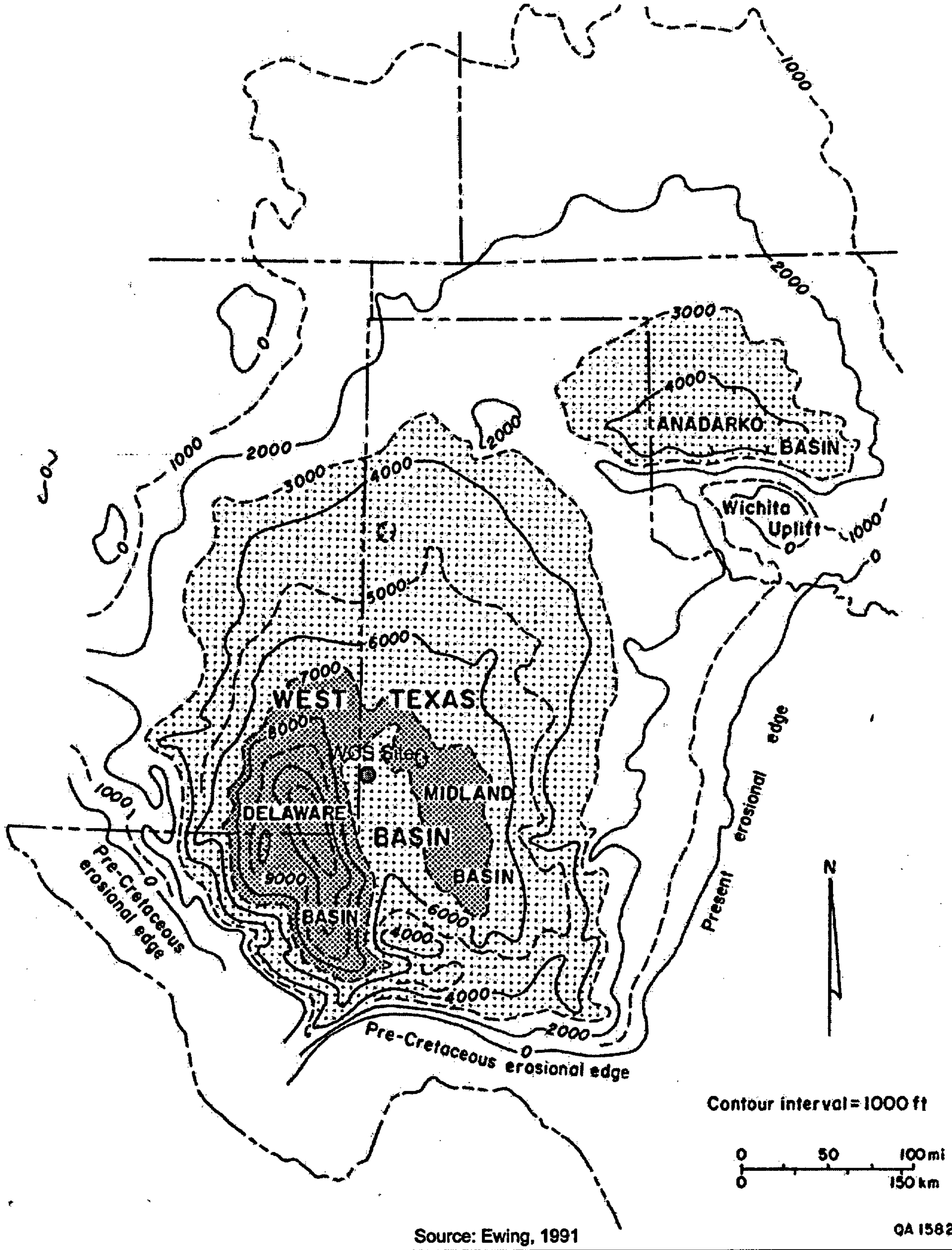

Source: Ewing, 1991

Date: 02/04/04 File: WCS_Fig6.4-2.fh11	Isopach Map of post-Wolfcampian Permian Strata in the West Texas and Andarko Basins
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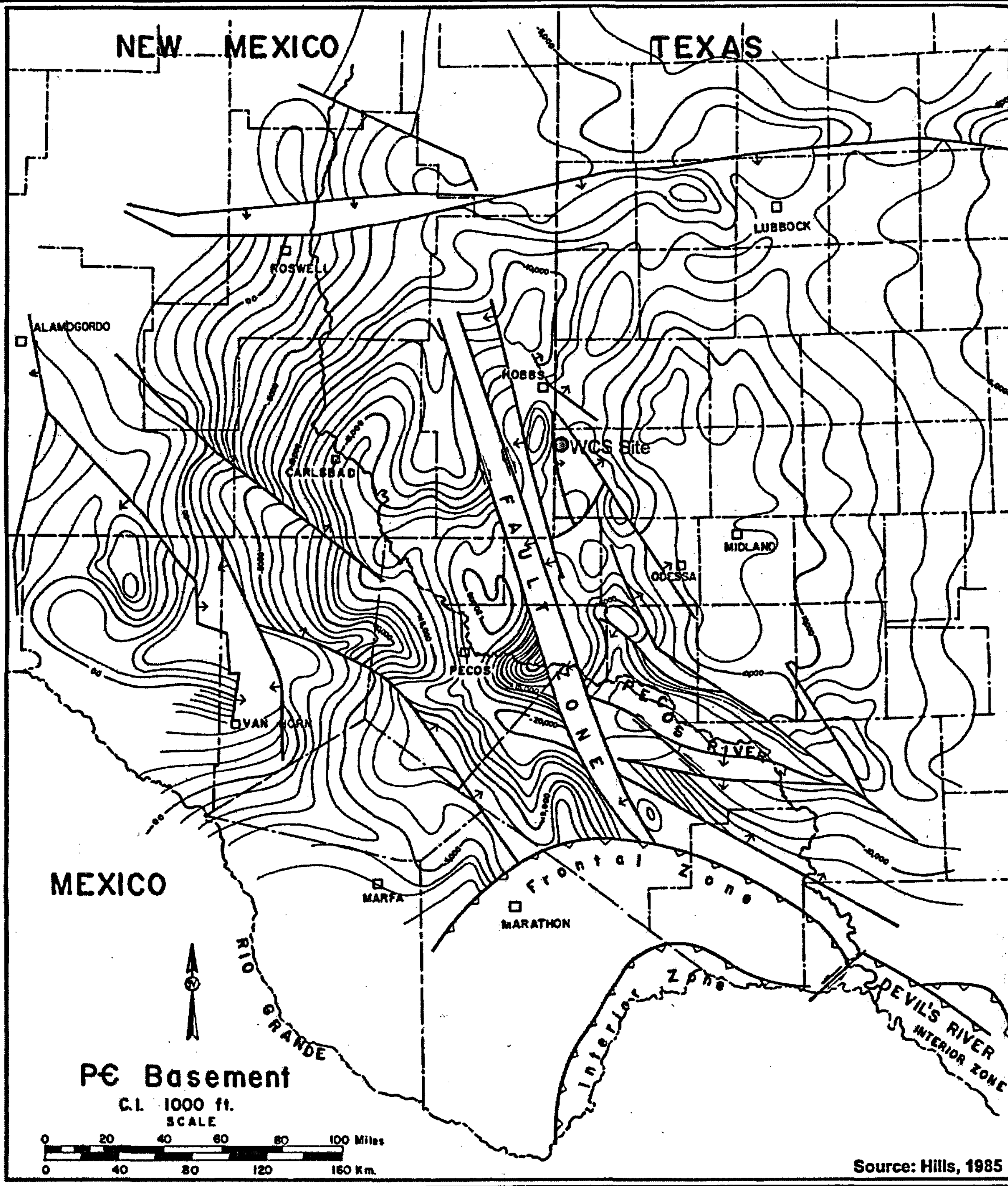
COOK-JOYCE INC. ENGINEERING AND CONSULTING 812 WEST ELEVENTH AUSTIN, TEXAS 78701-2000 (512) 474-9097 FAX (512) 474-8483	Figure 6.4-2



Date: 02/04/04
File: WCS_Fig6.4-1.fh11

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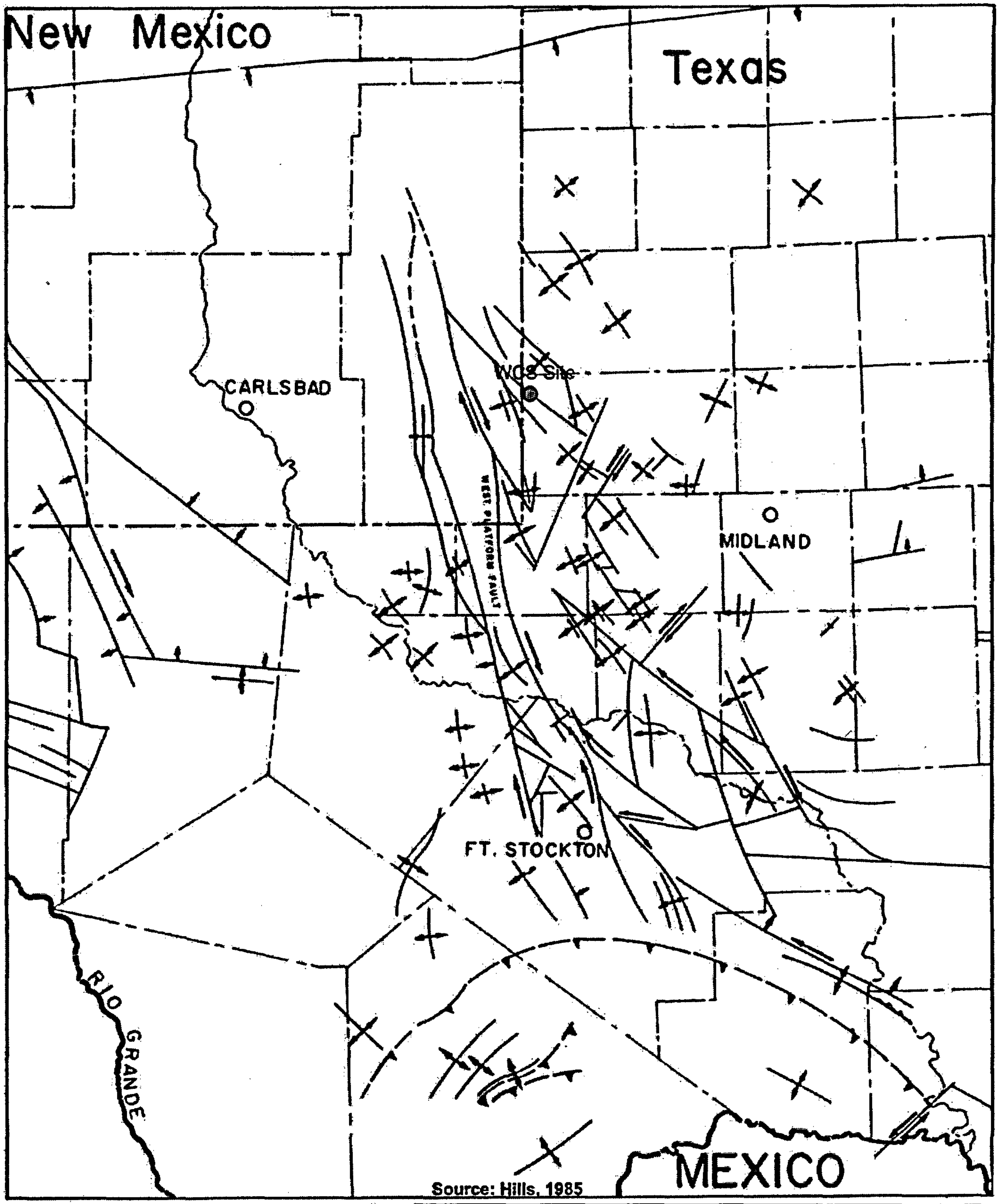
Regional Structure Contour Map of the Precambrian Basement

Figure 6.4-3



0 Miles 50

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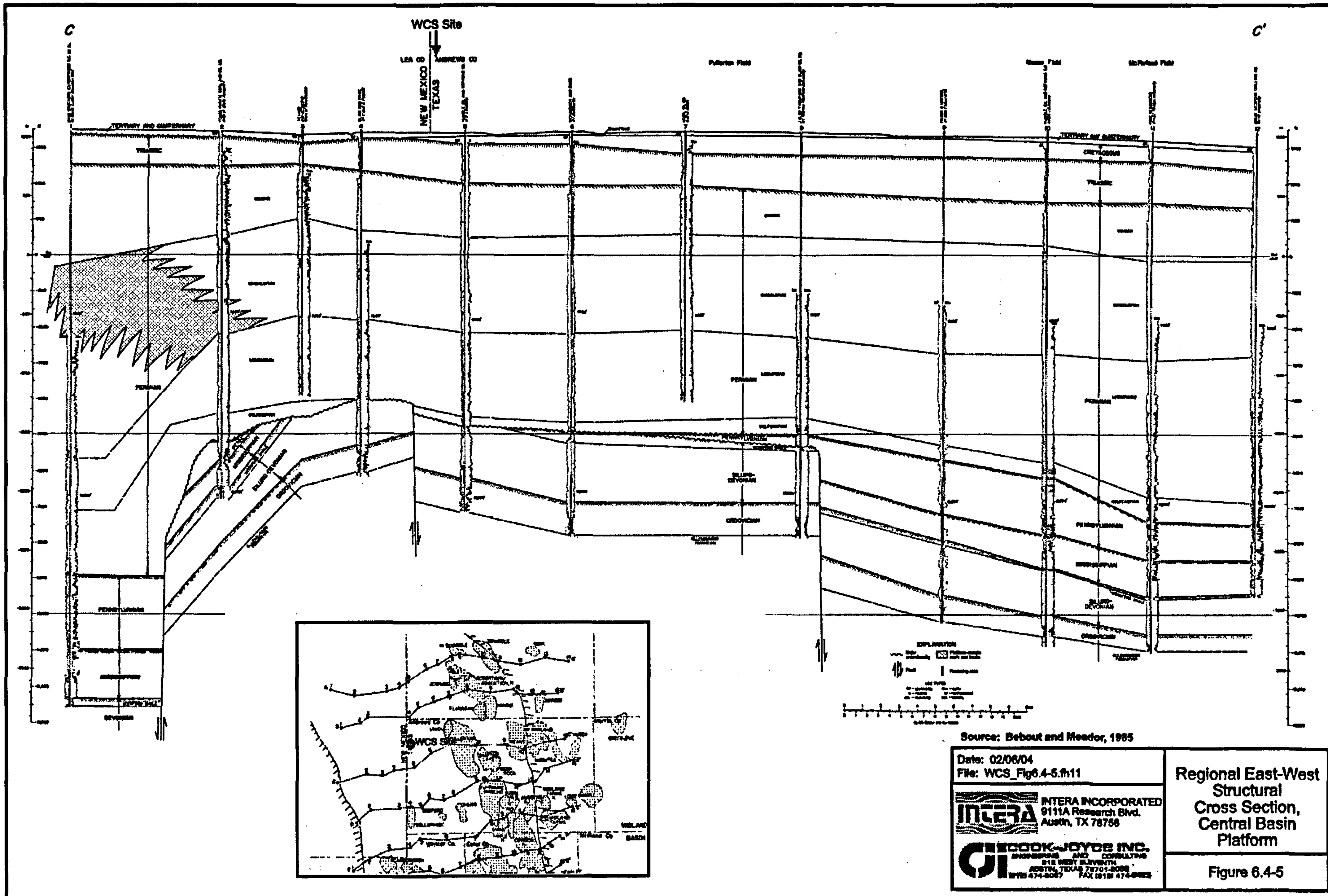
Major Tectonic Features of the Permian Basin - Late Mississippian to Early Permain

Figure 6.4-4



Source: Bebout and Meador, 1985

Date: 02/06/04
File: WCS_Fig6.4-5.fh11

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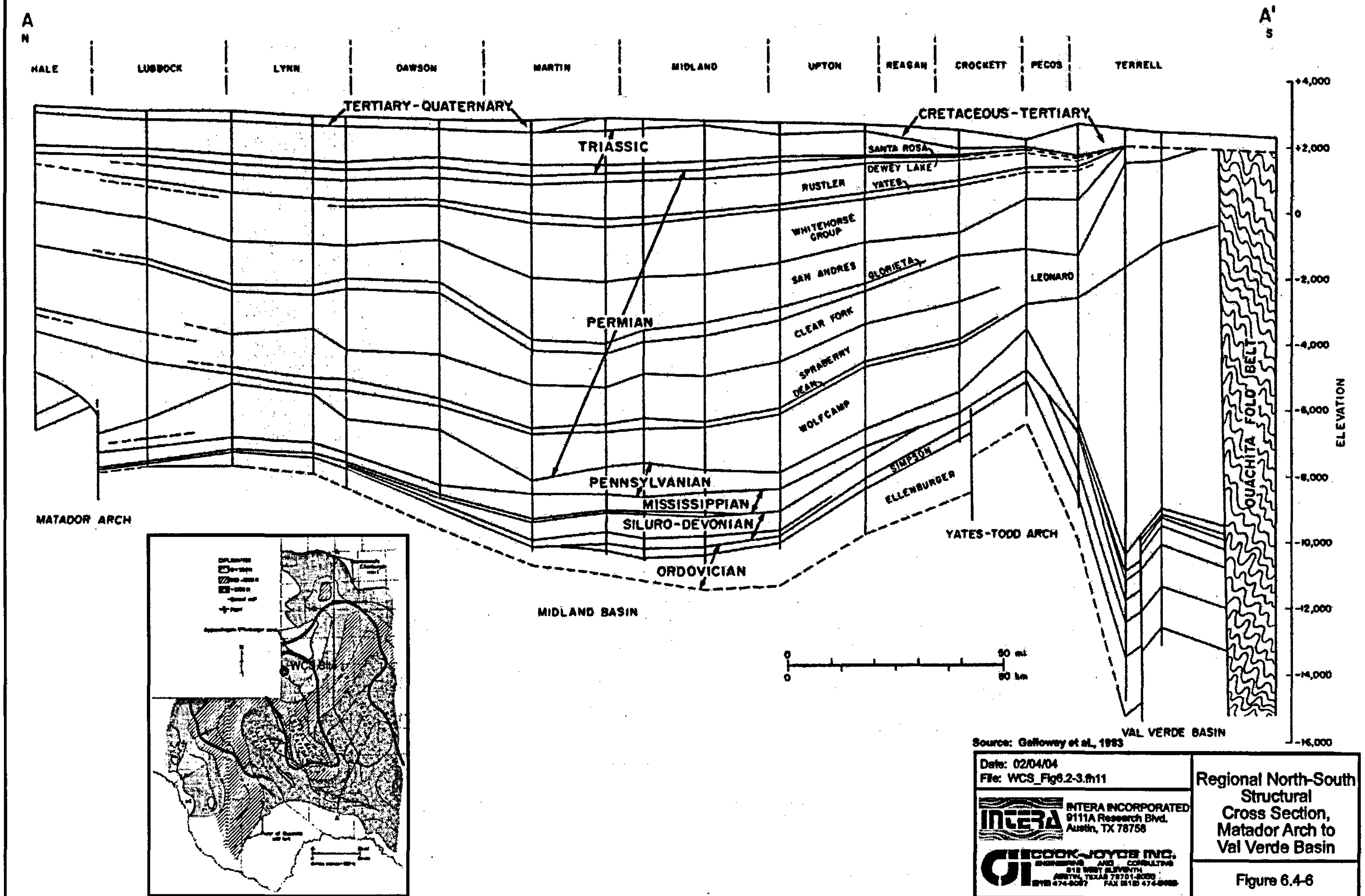
Regional East-West Structural Cross Section, Central Basin Platform

Figure 6.4-5



Source: Galloway et al., 1983

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File: WCS_Fig6.2-3.fh11

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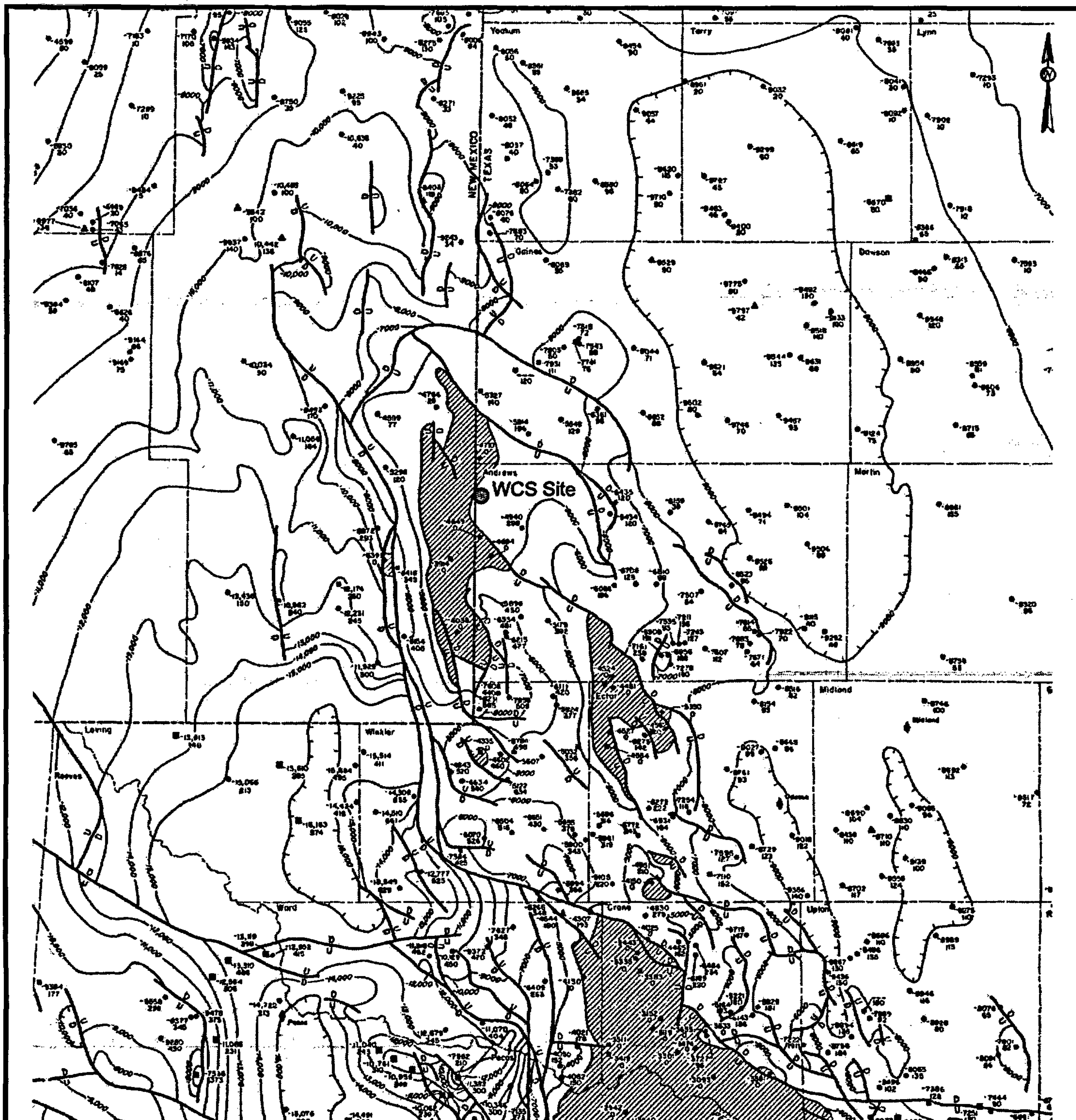
Regional North-South Structural Cross Section, Matador Arch to Val Verde Basin

Figure 6.4-6



EXPLANATION

•	Wireline log	-4307	Subsea elevation, top of Woodford (ft)
■	Scout ticket	193	Thickness of Woodford (ft)
▲	Core	—7000—	Structure contour in feet below sea level, drawn on top of Woodford Formation; extrapolated where control is sparse on the basis of elevation of top of Ellenburger (SE) or top of Devonian (NW)
////	Woodford absent		

Date: 02/04/04
File: WCS_Fig6.4-7.fh11

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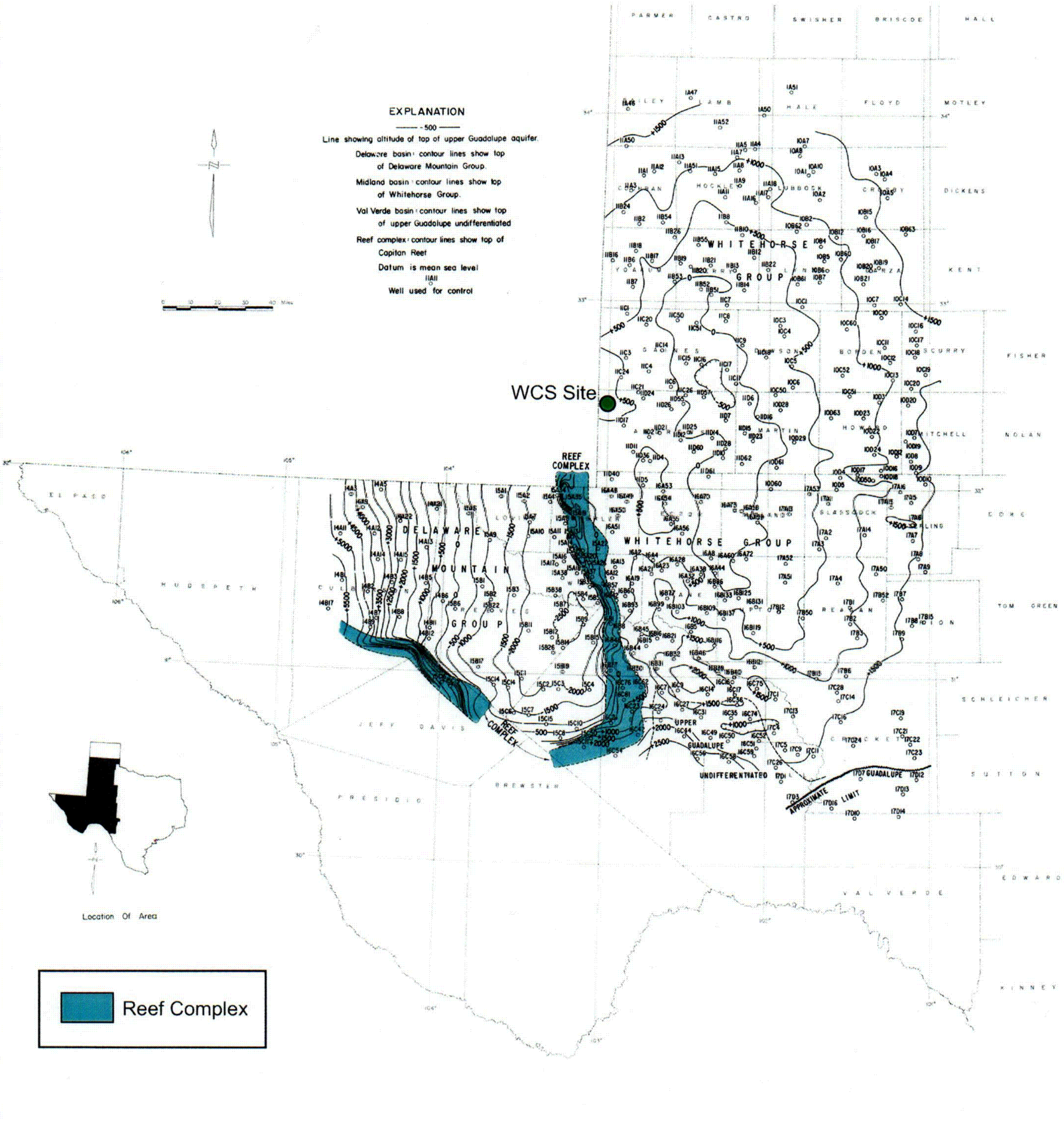
Regional Structure Contour Map of the Woodford Formation

Figure 6.4-7



Source: Texas Water Development Board, 1972

Date: 02/04/04
File: WCS_Fig6.4-8.fh11

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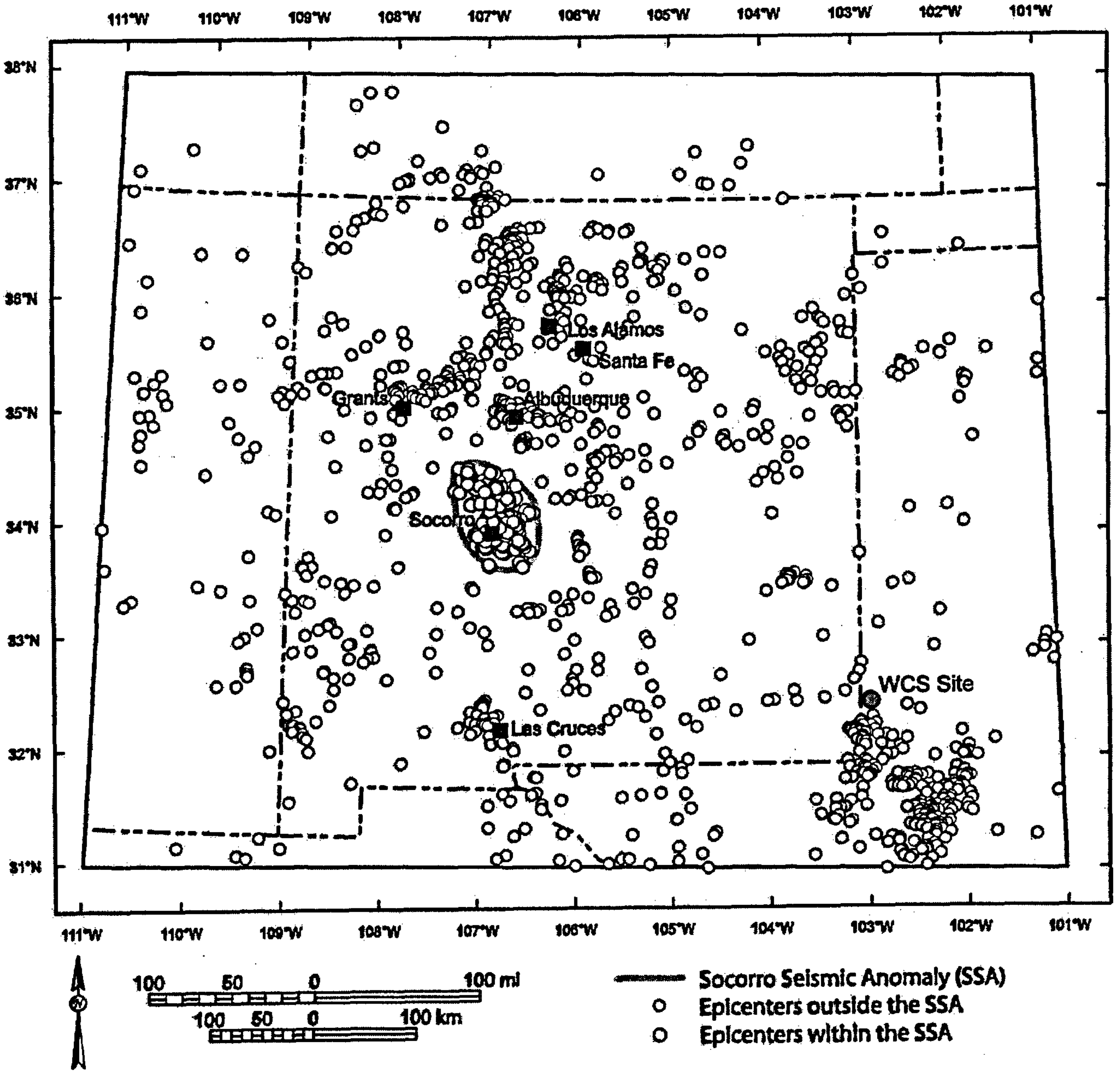
Regional Structure Contour Map of the Upper Guadalupe (Whitehorse Group)

Figure 6.4-8

C21



Source: Sanford et al., 2002

Date: 02/04/04 File: WCS_Fig6.4-9.fh11	Seismicity of New Mexico and Bordering Areas (1962 - 1995; Moment Magnitudes > 1.3)
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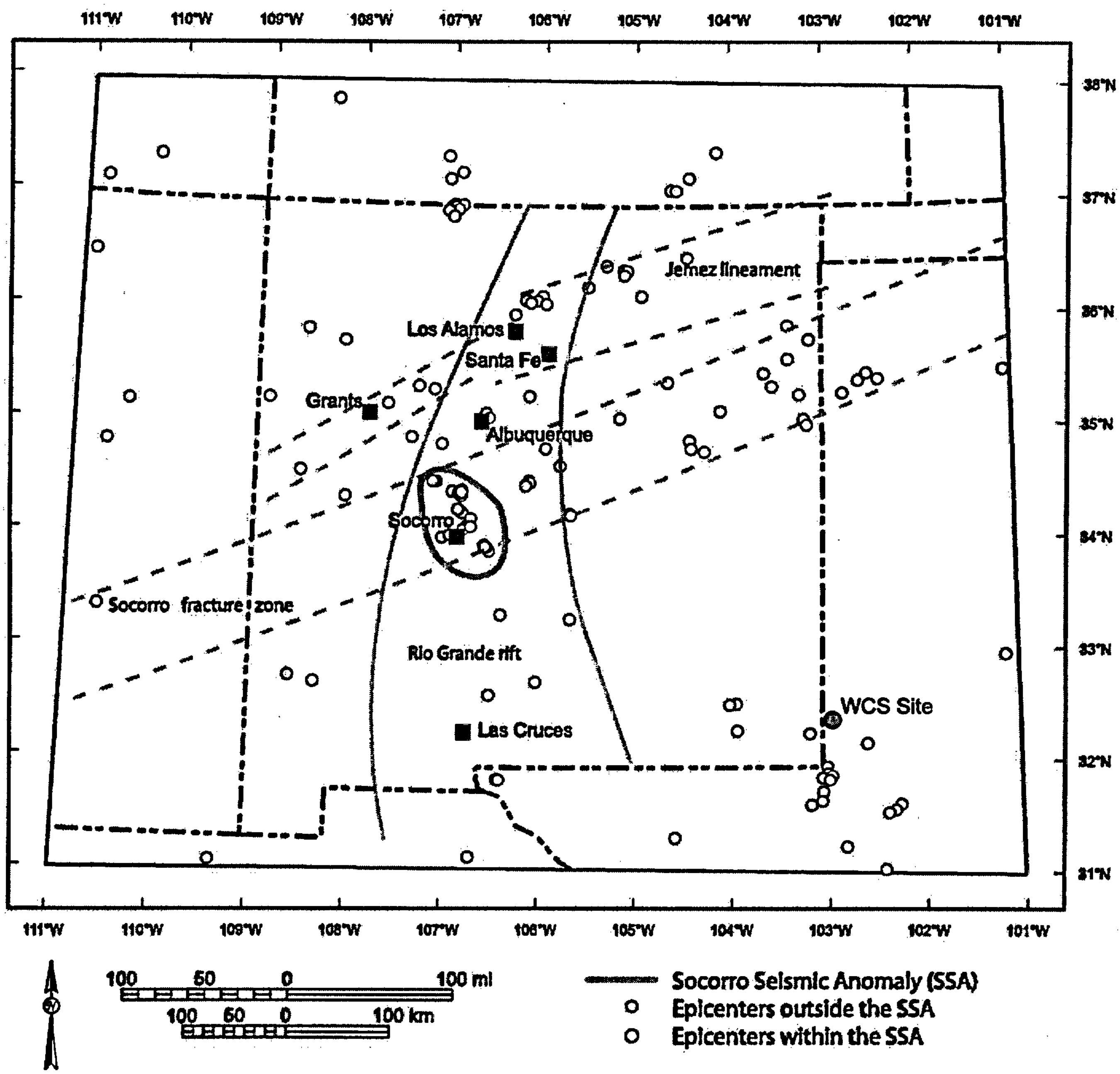

Source: Sanford et al., 2002

Date: 02/05/04
File: WCS_Fig6.4-10.fh11

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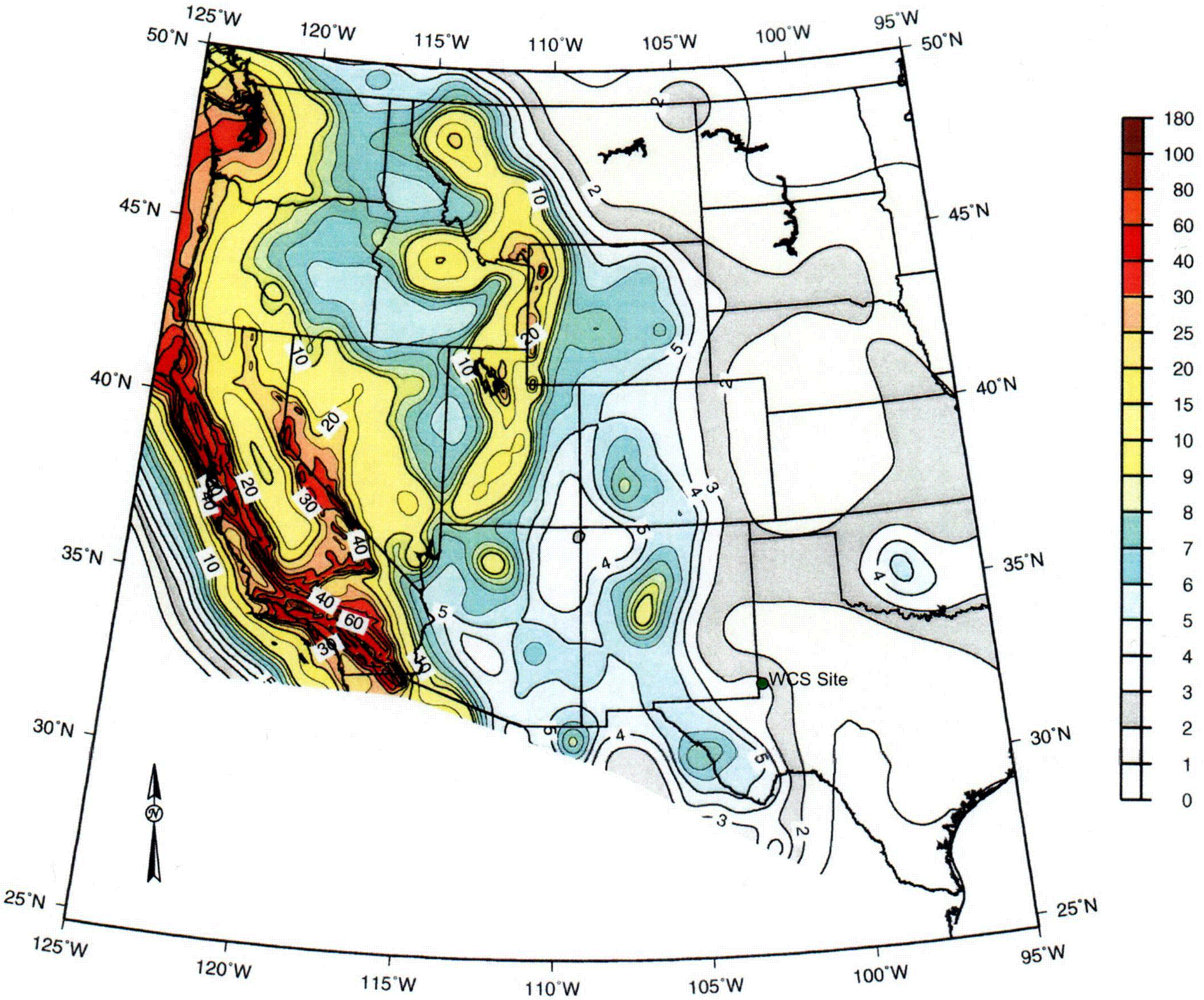
Seismicity of New Mexico and Bordering Areas (1962 - 1995; Moment Magnitudes > 3)

Figure 6.4-10



Source: http://geohazards.cr.usgs.gov/eg

Date: 02/06/04 File: WCS_Fig6.4-11.fh11	Peak Ground Acceleration (%g) with 10% Probability of Exceedance in 50 Years
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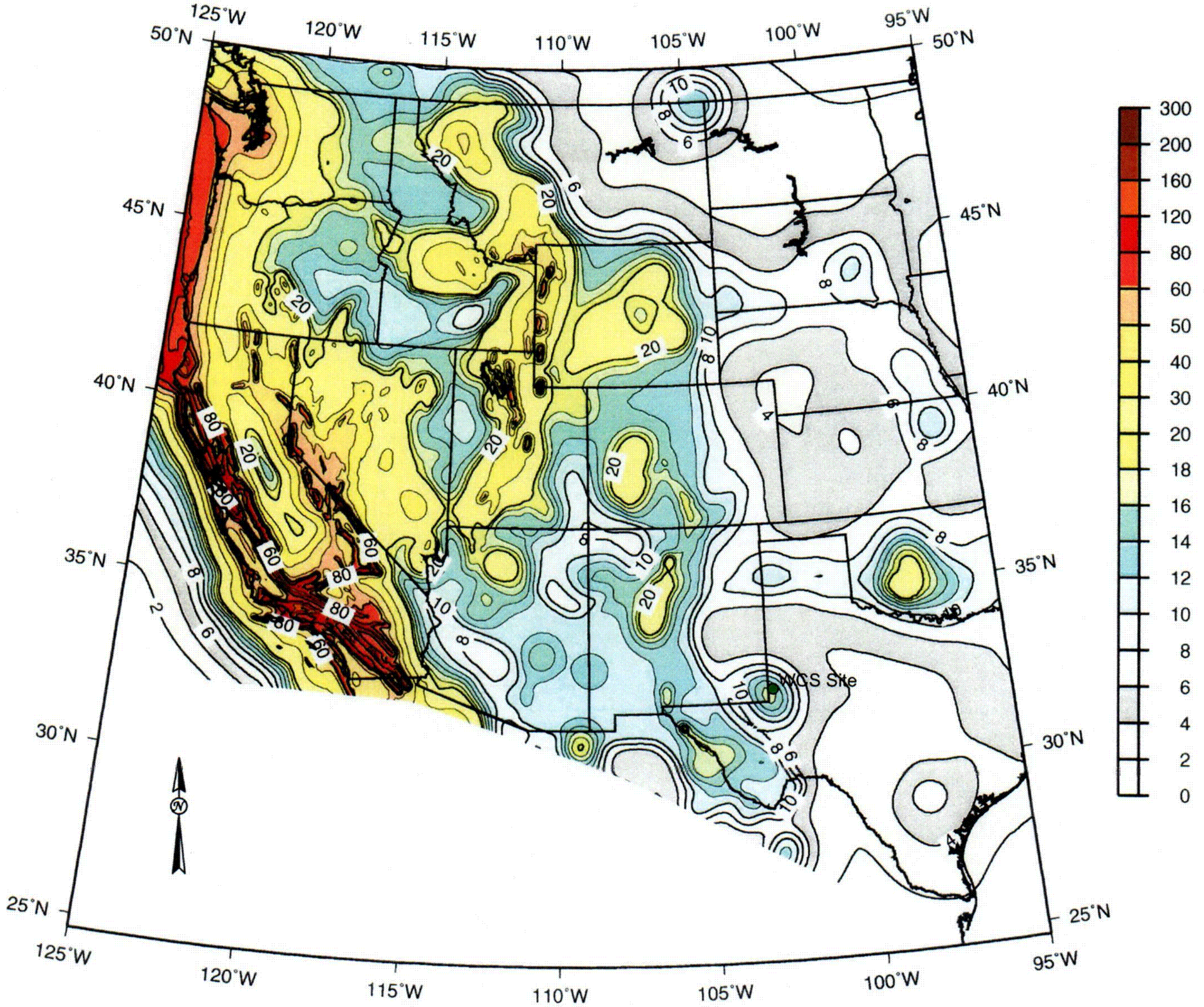
C22



Source: http://geohazards.cr.usgs.gov/eg

Date: 02/06/04 File: WCS_Fig6.4-12.fh11	Peak Ground Acceleration (%g) with 2% Probability of Exceedance in 50 Years
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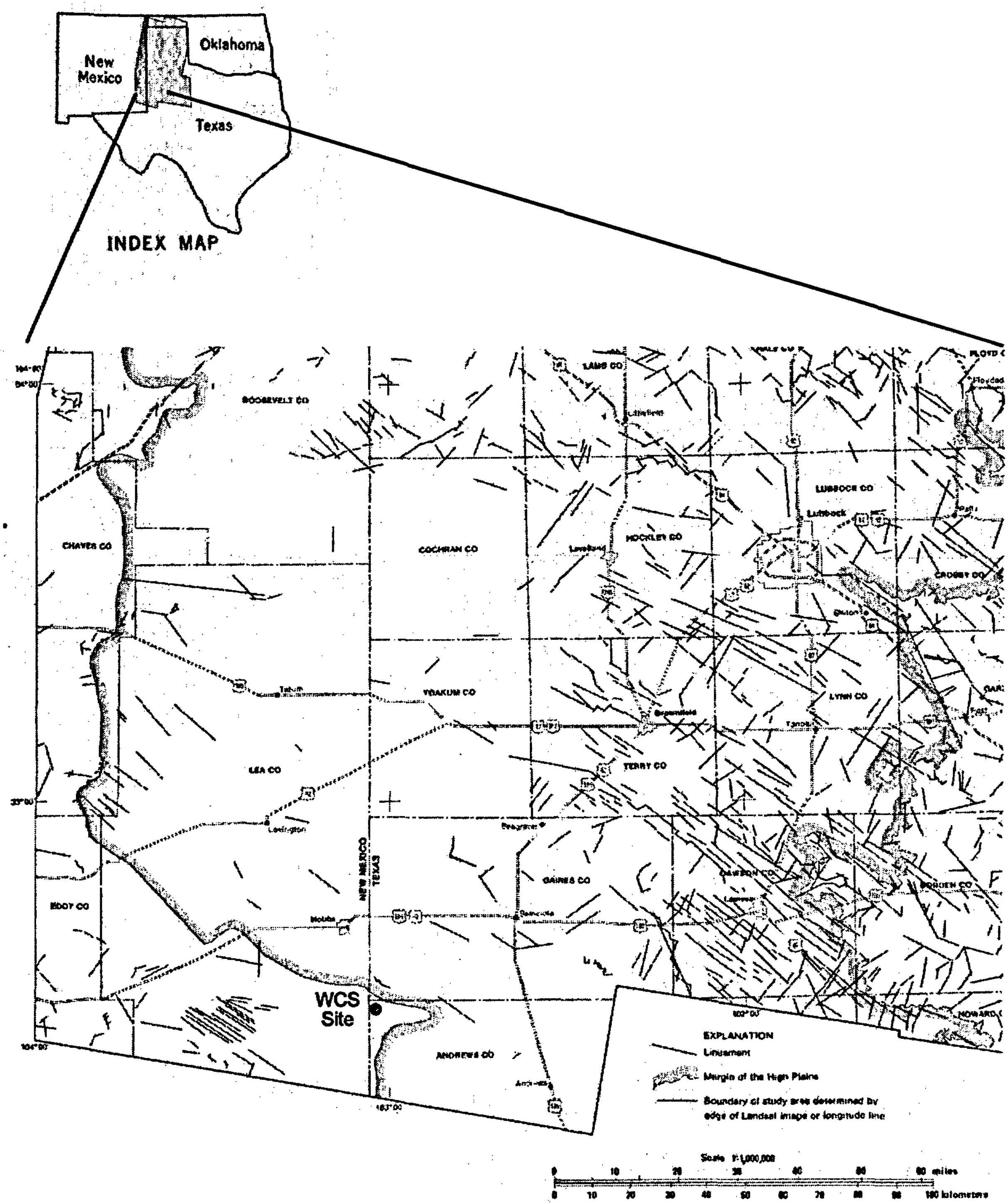
C23



Source: Finley and Gustavson, 1981

Date: 02/06/04
File: WCS_Fig6.4-13.fh11

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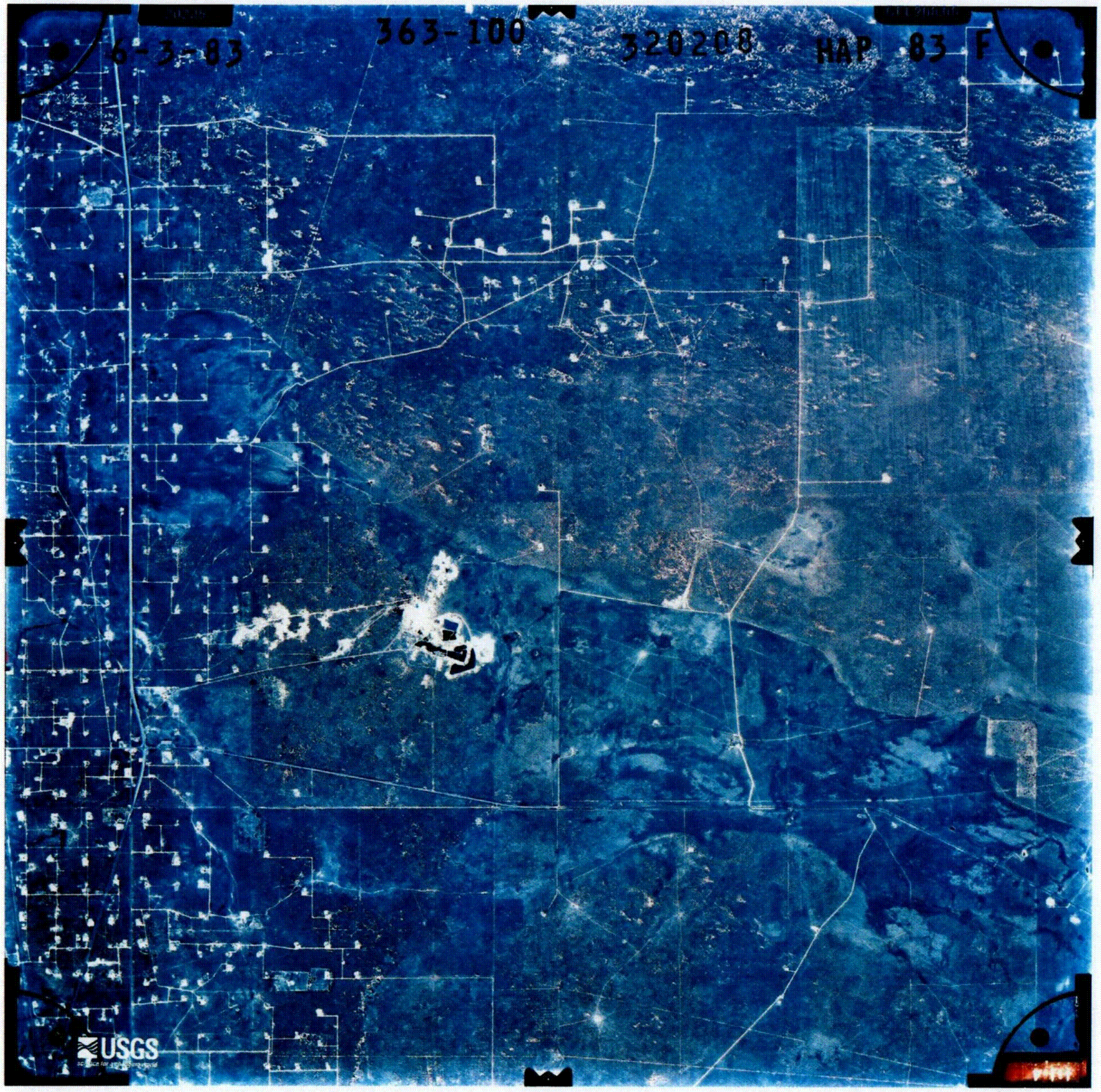
Lineament Map of the Texas Panhandle and Parts of Oklahoma and New Mexico

Figure 6.4-13



Date: 02/06/04
File: WCS_Fig6.4-14.fh11

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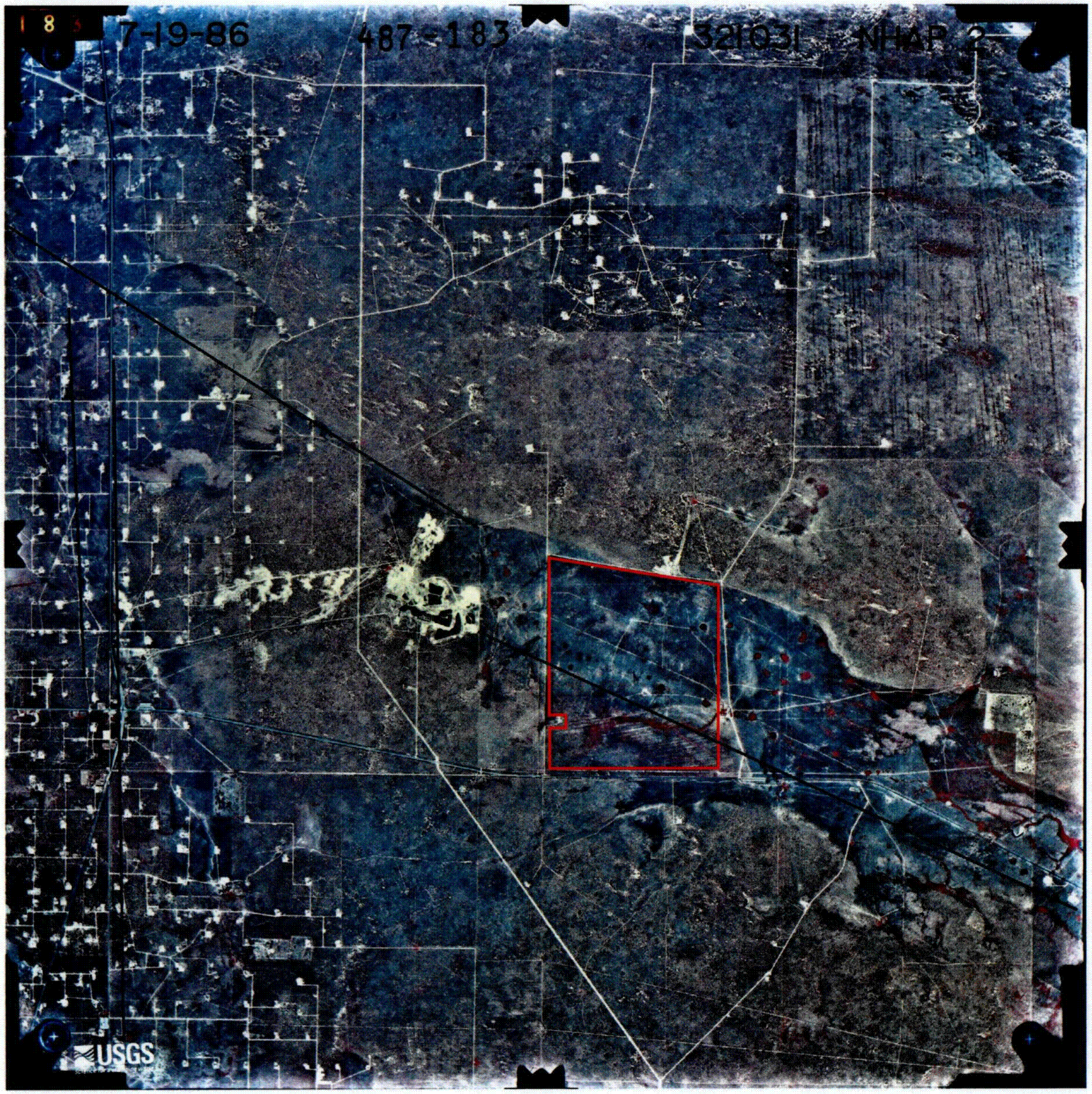
1983 Color Infrared Photograph - WCS Area

Figure 6.4-14

C24



0 1 2

Approximate Scale in Miles

Lineaments

RCRA Permitted Area

Date: 02/06/04
File: WCS_Fig6.4-15.fh11

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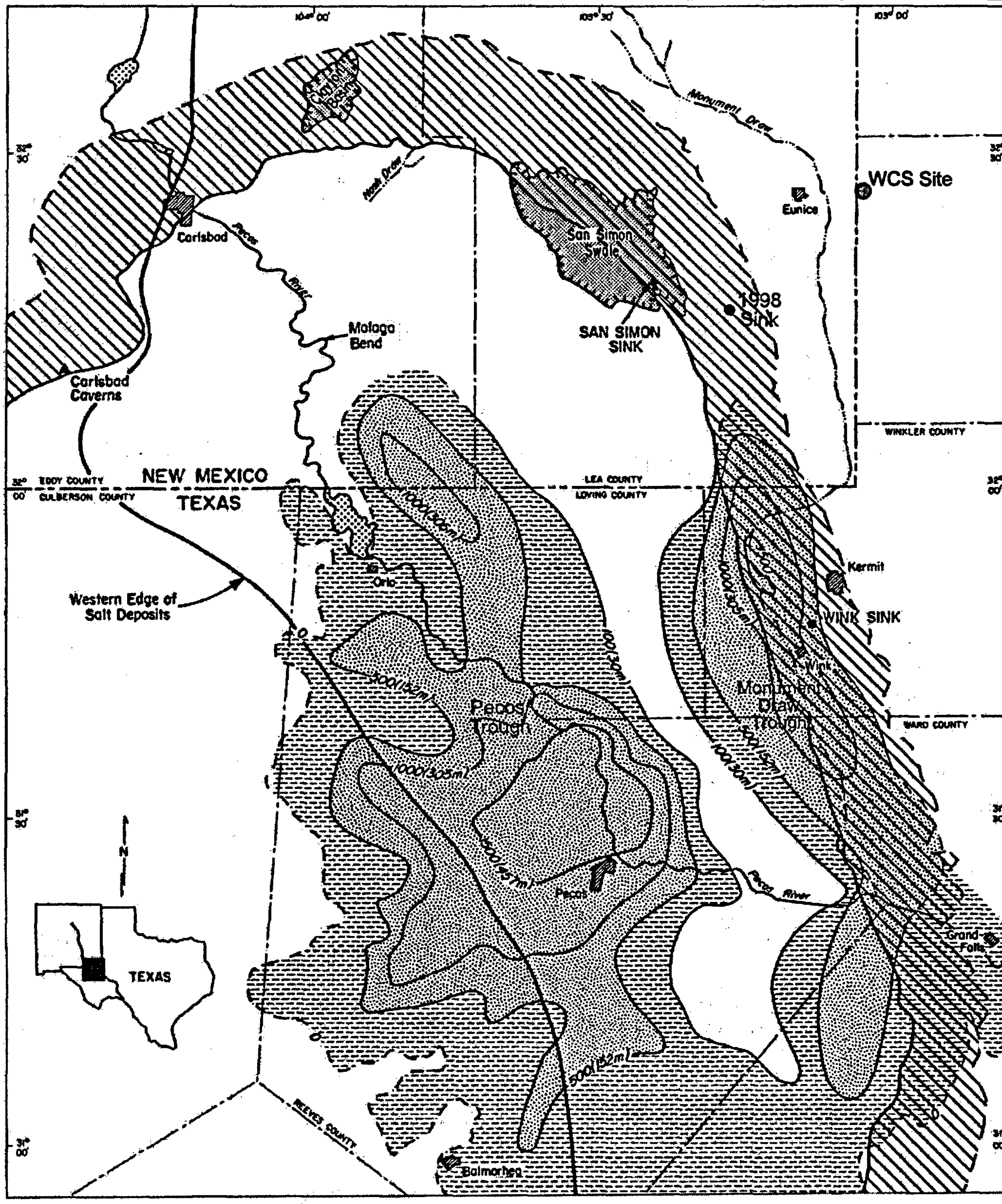
1986 Color Infrared Photograph - WCS Area

Figure 6.4-15

C25



Source: Baumgardner et al., 1982

0 10 20mi
0 10 20 30km
Contour Interval = 500ft

- Cenozoic fill. Limit dashed where inferred.
- Cenozoic fill over 500feet thick
- Capitan Reef. Margin dashed where inferred.

Date: 02/06/04
File: WCS_Fig6.4-16.fh11

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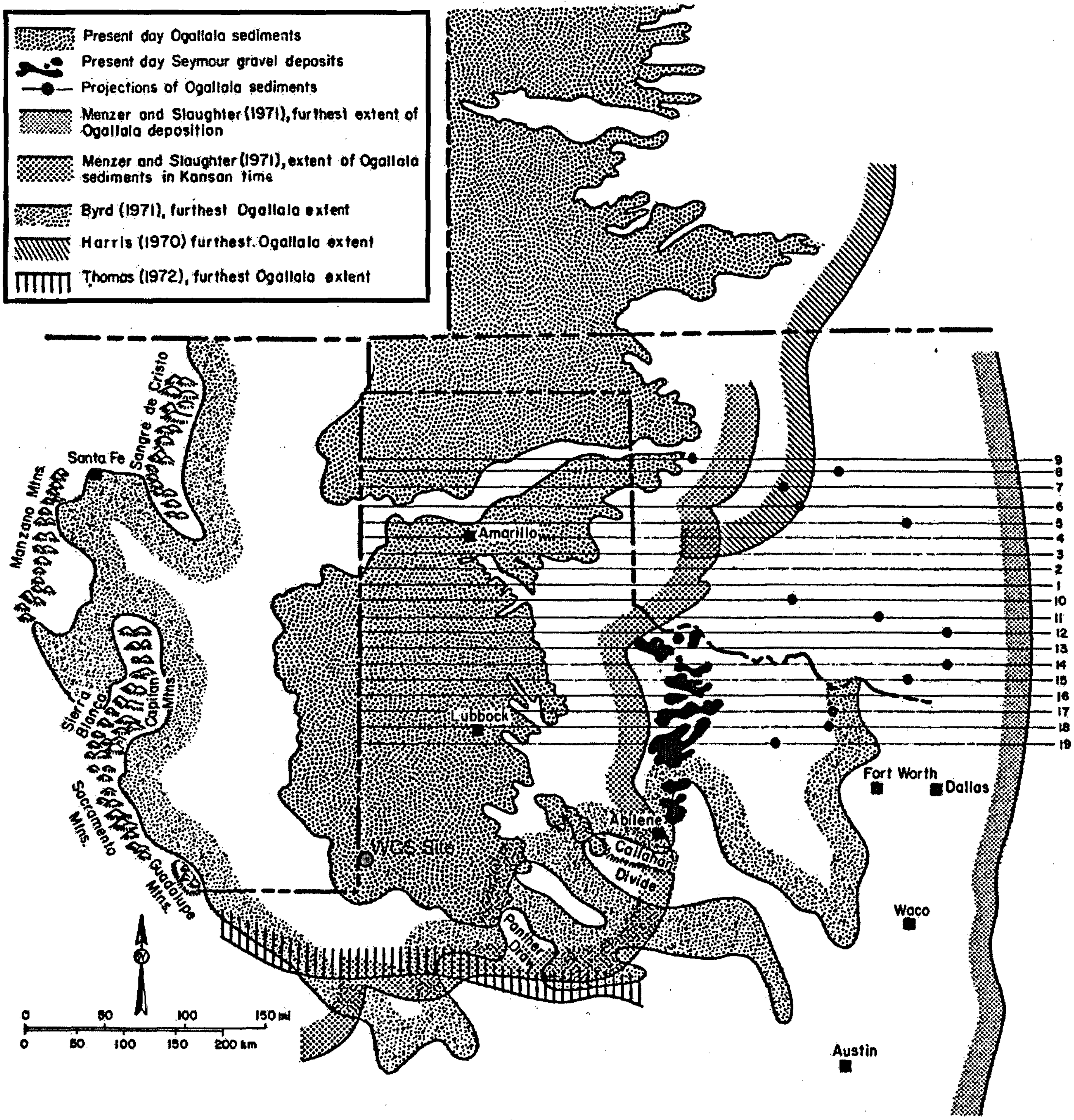
Location of Nearest Subsidence Features

Figure 6.4-16



Source: Gustavson et al., 1980

Date: 02/06/04
File: WCS_Fig6.4-17.fh11

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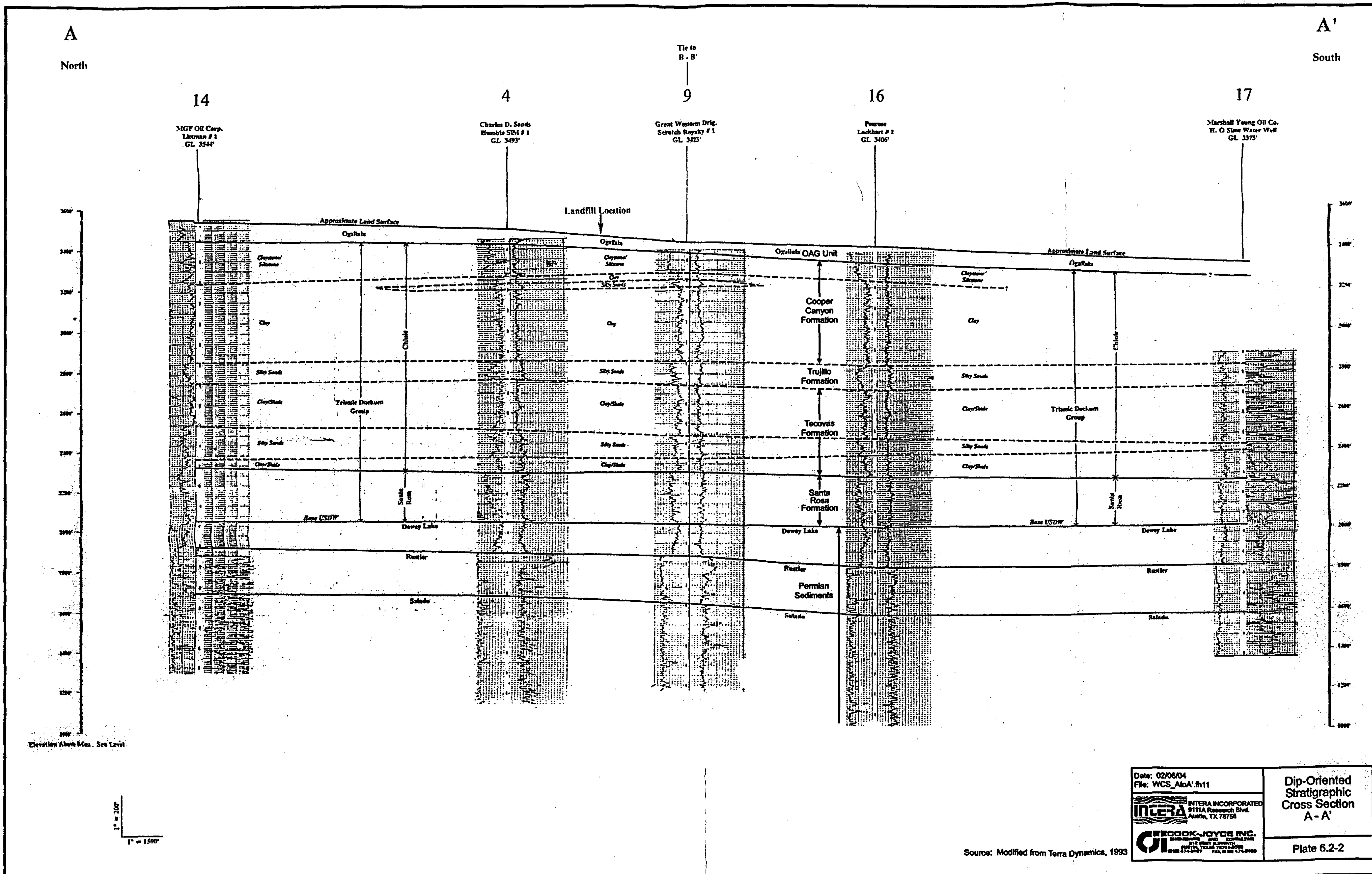
Original and Modern Location of the Ogallala Formation

Figure 6.4-17


A
North
A'
South
Tie to
B - B'
14
4
9
16
17
MGF Oil Corp.
Litman # 1
GL 3544'
Charles D. Sands
Humble SIM # 1
GL 3493'
Great Western Drlg.
Scratch Royalty # 1
GL 3423'
Penrose
Lockhart # 1
GL 3406'
Marshall Young Oil Co.
H. O Sims Water Well
GL 3373'
Landfill Location
Approximate Land Surface
Ogallala
OAG Unit
Claystone/
Siltstone
Clay
Silty Sands
Clay/Shale
Triassic Dockum
Group
Chinle
Santa
Rosa
Cooper
Canyon
Formation
Trujillo
Formation
Tecovas
Formation
Santa
Rosa
Formation
Base USDW
Dewey Lake
Rustler
Salado
Permian
Sediments
Elevation Above Mean Sea Level
1" = 200'
1" = 1500'
Source: Modified from Terra Dynamics, 1993
Date: 02/06/04
File: WCS_AtoA'.fh11
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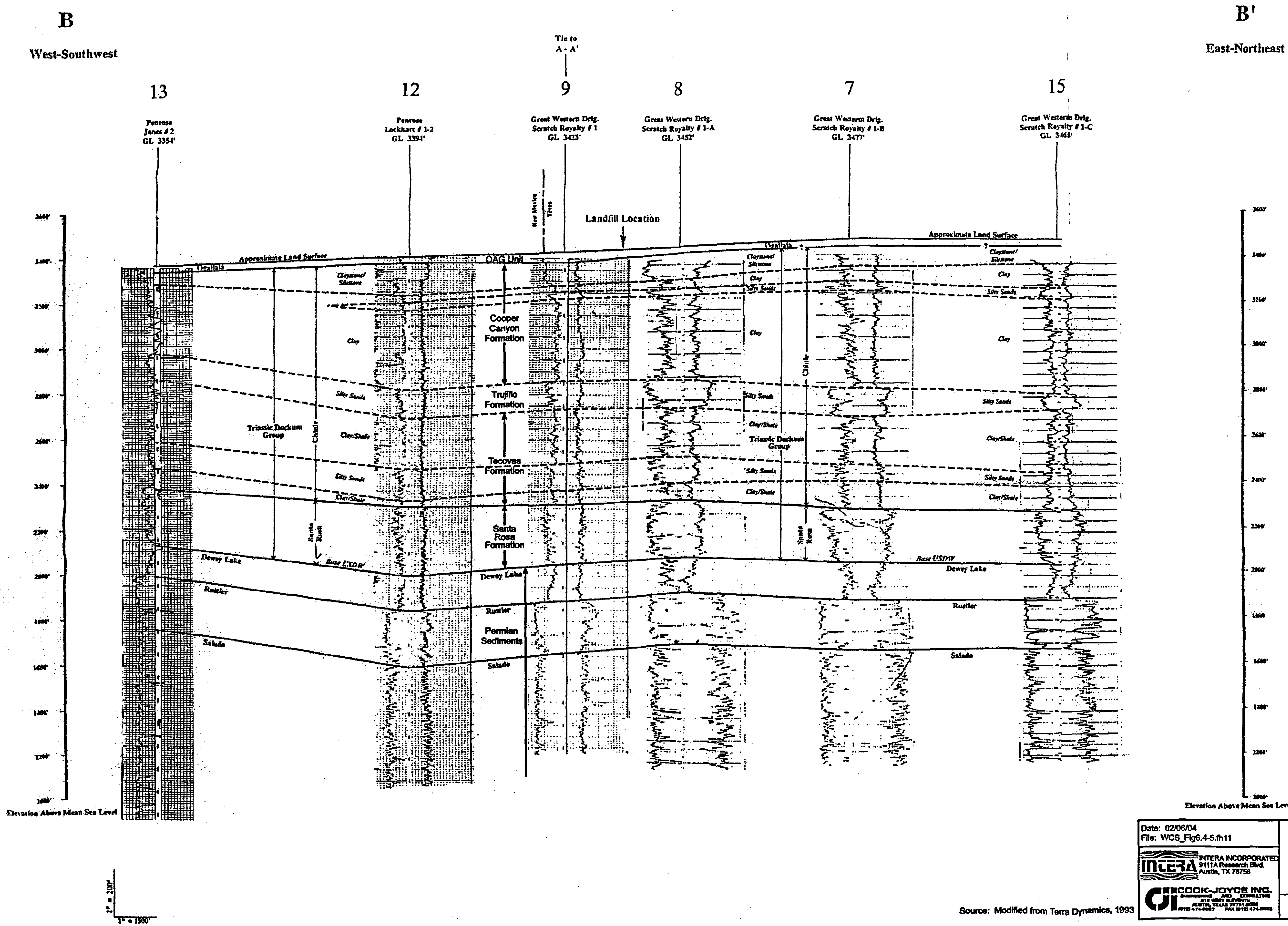
Dip-Oriented
Stratigraphic
Cross Section
A - A'
Plate 6.2-2



Source: Modified from Terra Dynamics, 1993

Date: 02/06/04
File: WCS_Fig6.4-5.fh11

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Strike-Oriented Stratigraphic Cross Section B - B'

Plate 6.2-3