2.3.2.2 Land Use

At present, land within 16 km (10 mi) of the site is used for potash mining operations, active oil and gas wells***,*** activities associated with hydrocarbon production, and grazing.

The WIPP Land Withdrawal Act (LWA) (U.S. Congress 1992) withdrew certain public lands from the jurisdiction of the Bureau of Land Management (BLM). The law provides for the transfer of the WIPP site lands from the ~~U.S. Department of the Interior (~~DOI~~)~~ to the DOE and effectively withdraws the lands, subject to existing rights, from entry, sale, or disposition; appropriation under mining laws; ***or*** operation of the mineral and geothermal leasing laws. The LWA directed the Secretary of Energy to produce a management plan to provide for grazing, hunting and trapping, wildlife habitat, mining, and the disposal of salt and tailings.

Between 1978 and 1988, DOE acquired all active potash and hydrocarbon leases within the WIPP site boundary. These were acquired either through outright purchase or through condemnation. In one condemnation proceeding, the court awarded DOE the surface and top 1.82 km (6,000 ft) of Section 31 and allowed the leaseholder to retain the subsurface below 1.82 km (6,000 ft). This was allowed because analysis showed that wells developed within this lease below the 1.82-km (6,000-ft) limit would be too far away from the waste panels to be of consequence to the WIPP (see, for example, Brausch et al. 1982). This is corroborated by the results of ***PA*** discussed in Section 6.2.5.1***;*** and Appendix ***PA, Attachment SCR, FEP 56*** ~~SCR (Section SCR.3.3.1)~~. Consequently, as the result of the DOE's acquisition activities, there are no producing hydrocarbon wells within the volumetric boundary defined by the land withdrawal (T22S, R31E, S15-22, 27-34). Two active wells were drilled to tap the oil and gas resources on the leases beneath Section 31. The James Ranch #13, drilled in 1982, is a gas well, and the James Ranch #27, drilled in 2000, is an oil well. Both wells are located on surface leases outside the WIPP ***s***ite boundary. Both wells enter Section 31 below a depth of 1.82 km (6,000 ft) beneath ground level. Except for the leases in Section 31, the LWA prohibits all drilling into the controlled area unless such drilling is in support of the WIPP.

Grazing leases have been issued for all land sections immediately surrounding the WIPP facility. Grazing within the WIPP site lands occurs within the authorization of the Taylor Grazing Act of 1934, the Federal Land Policy and Management Act (FLPMA), the Public Rangelands Improvement Act of 1978, and the Bankhead-Jones Farm Tenant Act of 1973.

The responsibilities of DOE include supervision of ancillary activities associated with grazing (for example, wildlife access to livestock water development)***,*** tracking of water developments inside WIPP lands to ensure that they are configured according to the regulatory requirements***,*** and ongoing coordination with respective allottees. Administration of grazing rights is in cooperation with the BLM according to the memorandum of understanding (MOU) and the coinciding Statement of Work through guidance established in the East Roswell Grazing Environmental Impact Statement. The WIPP site is composed of two grazing allotments administered by the BLM: the Livingston Ridge (No. 77027)***,*** and the Antelope Ridge (No. 77032) ***(see Figure 7-2)***.

2.3.2.3 History and Archaeology

From about 10,000 B.C. to the late 1800s, the WIPP site and surrounding region were inhabited by nomadic aboriginal hunters and gatherers who subsisted on various wild plants and animals. From about A.D. 600 onward, as trade networks were established with Puebloan peoples to the west, domesticated plant foods and materials were acquired in exchange for dried meat, hides, and other products from the Pecos Valley and Plains. In the late 1500s, the Spanish Conquistadors encountered Jumano and Apachean peoples in the region who practiced hunting and gathering and engaged in trade with Puebloans. After the Jumanos abandoned the southern Plains region, the Comanches became the major population of the area. Neighboring populations with whom the Comanches maintained relationships ranging from mutual trade to open warfare included the Lipan, or Southern Plains Apache, several Puebloan Groups, Spaniards, and the Mescalero Apaches.

The best documented indigenous culture in the WIPP region is that of the Mescalero Apaches, who lived west of the Pecos. The lifestyle of the Mescalero Apaches represents a transition between the full sedentism of the Pueblos and the nomadic hunting and gathering of the Jumanos. In 1763, the San Saba expedition encountered and camped with a group of Mescaleros in Los Medaños. Expedition records indicate the presence of both Lipan and Mescalero Apaches in the region.

A peace accord reached between the Comanches and the Spaniards in 1786 resulted in two historically important economic developments: (1) organized buffalo hunting by Hispanic and Puebloan ciboleros, and (2) renewal and expansion of the earlier extensive trade networks by Comancheros. These events placed eastern New Mexico in a position to receive a wide array of both physical and ideological input from the Plains culture area to the east and north and from Spanish-dominated regions to the west and south. Comanchero trade began to mesh with the Southwest American trade influence in the early nineteenth century. However, by the late 1860s, the importance of Comanchero trade was cut short by Texan influence.

The first cattle trail in the area was established along the Pecos River in 1866 by Charles Goodnight and Oliver Loving. By 1868, Texan John Chisum dominated much of the area by controlling key springs along the river. Overgrazing, drought, and dropping beef prices led to the demise of open-range cattle ranching by the late 1880s.

Following the demise of open-range livestock production, ranching developed using fenced grazing areas and production of hay crops for winter use. Herd grazing patterns were influenced by the availability of water supplies as well as by the storage of summer grasses for winter feeding.

The town of Carlsbad was founded as Eddy in 1889 as a health spa. In addition to ranching, the twentieth century brought the development of the potash, oil, and gas industries that have increased the population eightfold in the last 50 years.

Although technological change has altered some of the aspects, ranching remains an important economic activity in the WIPP region. This relationship between people and the land is still an important issue in the area. Ranch-related sites dating to the 1940s and 1950s are common in parts of the WIPP area. These will be considered historical properties within the next several years, and thus will be treated as such under current law.

The National Historic Preservation Act (NHPA***) (***16 USC Part 470 et seq.) was enacted to protect the nation's cultural resources in conjunction with the states, local governments, Indian tribes, and private organizations and individuals. The policy of the federal government includes***:*** (1) providing leadership in preserving the prehistoric and historic resources of the nation***,*** (2) administering federally owned, administered, or controlled prehistoric resources for the benefit of present and future generations***,*** (3) contributing to the preservation of nonfederally owned prehistoric and historic resources***,*** and (4) assisting state and local governments and the national trust for historic preservation in expanding and accelerating their historic preservation programs and activities. The act also established the National Register of Historic Places (National Register). At the state level, the State Historic Preservation Officer (SHPO) coordinates the state's participation in implementing the NHPA. The NHPA has been amended by two acts: the Archeological and Historic Preservation Act (16 USC Part 469 et seq.), and the Archeological Resource Protection Act (16 USC Part 470aa et seq.).

To protect and preserve cultural resources found within the WIPP site boundary, the WIPP submitted a mitigation plan to the New Mexico SHPO describing the steps to either avoid or excavate archaeological sites. A site was defined as a place used and occupied by prehistoric people. In May 1980, the SHPO made a determination of "no adverse effect from WIPP facility activities" on cultural resources. The Advisory Council on Historic Preservation concurred that the WIPP Mitigation Plan is appropriate to protect cultural resources.

Known historical sites (more than 50 years old) in southeastern New Mexico consist primarily of early twentieth century homesteads that failed***,*** or isolated features from late nineteenth century and early twentieth century cattle or sheep ranching***, or*** military activities. To date, no Spanish or Mexican sites have been identified. Historic components are rare but are occasionally noted in the WIPP area. These include features and debris related to ranching.

Since 1976, cultural resource investigations have recorded 98 archaeological sites and numerous isolated artifacts within the 41-km^2 (16-mi^2) area enclosed by the WIPP site. In the central 10.4-km^2 (4-mi^2) area, 33 sites were determined to be eligible for inclusion on the National Register as archaeological districts. Investigations since 1980 have recorded an additional 14 individual sites outside the central 10.4-km^2 (4-mi^2) area that are considered eligible for inclusion on the National Register. The following major cultural resource investigations to date are broken out in the list that follows. Additional information can be found in the bibliography ***of CCA Chapter 2***.

1977. The first survey of the area was conducted for SNL by Nielson of the Agency for Conservation Archaeology (ACA). This survey resulted in the location of 33 sites and 64 isolated artifacts.

1979. MacLennan and Schermer of ACA conducted another survey to determine access roads and a railroad right-of-way for Bechtel, Inc. The survey encountered two sites and 12 isolated artifacts.

1980. Schermer conducted another survey to relocate the sites originally recorded by Nielson. This survey redescribed 28 of the original 33 sites.

1981. Hicks (1981a, 1981b) directed the excavation of nine sites in the WIPP core area.

1982. Bradley (Lord and Reynolds 1985) recorded one site and four isolated artifacts in an archaeological survey for a proposed water pipeline.

1985. Lord and Reynolds ***(1985)*** examined three sites within the WIPP core area that consisted of two plant-collecting and processing sites and one base camp used between 1000 B.C. and A.D. 1400. The artifacts recovered from the excavations are in the Laboratory of Anthropology at the Museum of New Mexico in Santa Fe.

1987. Mariah Associates, Inc.~~,~~ identified 40 sites and 75 isolates in an inventory of 2,460 ac in 15 quarter-section units surrounding the WIPP site. In this investigation, 19 of the sites were located within the WIPP site's boundary. Sites encountered in this investigation tended to lack evident or intact features. Of the 40 new sites defined, 14 were considered eligible for inclusion in the National Register, 24 were identified as having insufficient data to determine eligibility, and 2 were determined to be ineligible for inclusion. The eligible and potentially eligible sites have been mapped and are avoided by DOE in its current activities at the WIPP site.

1988–1992. Several archaeological clearance reports have been prepared for seismic testing lines on public lands in Eddy County, New Mexico.

All archaeological sites are surface or near-surface sites, and no reasons exist (either geological or archeological) to suspect that deep drilling would uncover or investigate archaeological sites.

No artifacts were encountered during cultural resource surveys performed from 1992 until present. The following list provides examples of WIPP projects that required cultural resource surveys. All investigations were performed and reported in accordance with requirements established by the New Mexico Office of Cultural Affairs (OCA) and administered by the SHPO.

- ***SPDV site investigation into status of a previously recorded site (#LA 33175) to determine potential impacts from nearby reclamation activity. Assessment included minor surface excavation.***
- ***WIPP well bore C-2737. Cultural resource investigation for well pad and access road.***
- ***WIPP well bores WQSP 1-6 and 6a. Individual cultural resource investigations conducted for construction of each respective well pad and access road.***
- ***WIPP well bores SNL 1, 2, 3, 9 and 12. Cultural resource investigations conducted for construction of each respective well pad and access road.***
- ***WIPP well bore WTS 4. Cultural resource investigation conducted in support of siting and constructing reserve pits for well drilling and development.***

- ***North Salt Pile Expansion. Cultural resource investigation conducted in support of the expansion of the North Salt Pile, a project designed to mitigate surface water infiltration.***

All of the aforementioned archeological investigations received determinations of "No Adverse Affect" from the OCA and the SHPO. This determination serves as a clearance to proceed with work.

The Delaware Basin has been used in the past for an isolated nuclear test. This test, Project Gnome, took place in 1961 at a location approximately 13 km (8 mi) southwest of the WIPP. The primary objective of Project Gnome was to study the effects of an underground nuclear explosion in salt. The Gnome experiment involved the detonation of a 3.1-kiloton nuclear device at a depth of 361 m (1,200 ft) in the bedded salt of the Salado (Rawson et al. 1965). The explosion created a cavity of approximately 28,000 m^3 (1,000,000 ft^3) and caused surface displacements over an area of about a 360-m (1,200-ft) radius. Fracturing and faulting caused measurable changes in rock permeability and porosity at distances up to approximately 100 m (330 ft) from the cavity. No earth tremors were reported at distances over 40 km (25 mi) from the explosion. Project Gnome was decommissioned in 1979.

2.4 Background Environmental Conditions

Background environmental conditions at and near the WIPP site were characterized prior to the initiation of the operation of the facility and are described in CCA Section 2.4. Because background characterization focuses on environmental conditions existing prior to operations, it is not meaningful to redefine background environmental conditions after operations began. Accordingly, information presented in CCA Section 2.4 is not repeated and updated in this recertification application.

~~One of the criteria established for the selection of a repository site was that the impacts on the ecology from constructions and operations be minimal. Consequently, as the DOE assessed the geological and hydrological characteristics of the site, they also assessed the ecological characteristics. The result was a demonstration, documented in the FEIS, that the ecological impacts are minimal and within acceptable bounds. The FEIS concluded that adverse impacts on the ecology were expected to be slight for the following reasons:~~

1. ~~No natural areas proposed for protection are present on or near the site,~~
2. ~~No endangered species of plants or animals are known to inhabit the site or the vicinity of the site; nor are any critical habitats known to exist on or near the site,~~
3. ~~Water requirements for the site are low,~~
4. ~~The land contains soil types and vegetation associations that are common throughout the region, and~~
5. ~~Access in the form of dirt roads is already available throughout the area; therefore, recreational use of the area is not likely to increase significantly.~~

~~The results of the DOE's assessment of background environmental conditions are provided in this application as part of the complete description of the WIPP and its vicinity. Background environmental conditions form the baseline for determining if releases to the environment have occurred during the operational period or during any postoperational monitoring period (Wolfe et al. 1977). For this reason, the EPA considers these are important criteria for certification as stated in 40 CFR § 194.14(g). The DOE routinely collects environmental information at and around the WIPP site in accordance with the WIPP Environmental Monitoring Plan (see Appendix EMP). The EMP satisfies the criteria of 40 CFR § 194.14(g) in that it provides programmatic specifications for implementing and operating the WIPP environmental monitoring program. Appendix EMP includes a description of sampling locations, sampling frequencies, sample management practices, and where appropriate, analytical procedures. Specific field procedures are maintained at the WIPP site in a separate Environmental Monitoring Procedures Manual. Emphasis is placed on ecological conditions, water quality, and air quality and includes the following.~~

~~*Ecological Conditions*~~

- ~~Vegetation~~
- ~~Mammals~~
- ~~Reptiles and amphibians~~
- ~~Birds~~
- ~~Arthropods~~
- ~~Aquatic ecology~~
- ~~Endangered species.~~

~~*Quality of Environmental Media*~~

- ~~Surface water~~
- ~~Groundwater~~
- ~~Air.~~

~~*2.4.1 Terrestrial and Aquatic Ecology*~~

~~The vegetation, mammals, reptiles and amphibians, birds, arthropods, aquatic ecology, and endangered species of the WIPP site and its environs are characterized in the sections that follow. Much of the information in this section was reported in the FEIS (DOE 1980). Where this information has been updated with more recent data, this update is noted.~~

2.4.1.1 Vegetation

The WIPP site is in an area characterized by stabilized sand dunes. The vegetation is dominated by shinnery oak, mesquite, sand sage, dune yucca, smallhead snakeweed, three-awn, and numerous species of forbs and perennial grasses. The dominant shrubs are deep-rooted species with extensive root systems. The shrubs not only stabilize the dune sand but serve as food, shelter, and nesting sites for many species of wildlife inhabiting the area.

The vegetation in the vicinity of the WIPP site is not a climax vegetation, at least in part because of past grazing management. The composition of the plant life at the site is heterogeneous because of variations in terrain and in the type and depth of soil. Shrubs are conspicuous members of all plant communities. The site lies within a region of transition between the northern extension of the Chihuahuan Desert (desert grassland) and the southern Great Plains (short grass prairie); it shares the floral characteristics of both.

Grazing, primarily by domestic livestock, and fire control are largely responsible for the shrub-dominated seral communities of much of southeastern New Mexico. A gradual retrogression from the tall- and mid-grass-dominated vegetation of 100 years ago has occurred throughout the region. The cessation of grazing would presumably not alter the domination by shrubs, but it would result in an increase in grasses. Experimental exclosures have been established to study site-specific patterns of succession in the absence of grazing, but long-term results are not yet available.

The semiarid climate makes water a limiting factor in the entire region. The amount and timing of rainfall greatly influence plant productivity and, therefore, the food supply for wildlife and livestock. The seeds of desert plants are often opportunistic: they may lie dormant through long periods of drought to germinate in the occasional year of favorable rainfall. Significant fluctuations in the abundance and distribution of plants and wildlife are typical of this region. Several examples of such fluctuations have been documented in the area within 8.3 km (5 mi) of the center of the WIPP site, which has been intensively studied.

Two introduced species of significance in the region are the Russian thistle, or tumbleweed, a common invader in disturbed areas, and the Tamarisk, or salt cedar, which has proliferated along drainage ways.

Several distinct biological zones occur on or near the site: the mesa, the central dunes complex, the creosote-bush flats, the Livingston Ridge escarpment, and the Tobosa Flats in Nash Draw west of the ridge. A low, broad mesa named the Divide lies on the eastern edge of the study area and supports a typical desert-grassland vegetation. The dominant shrub and subshrub are mesquite and snakeweed, respectively. The most abundant grasses are black grama, bush muhly, ring muhly, and fluffgrass. Cacti, especially varieties of prickly pear, are present.

Where the ground slopes down from the Divide to the central dune plains, the soil becomes deep and sandy. Shrubs like shinnery oak, mesquite, sand sagebrush, snakeweed, and dune yucca are dominant. In some places, all of these species are present; in others, one or more are either missing or very low in density. These differences appear to be caused by localized variations in the type and depth of soil. Thus, a number of closely related but distinct plant associations form a patchwork complex, or mosaic, across the stabilized dunes in the central area. Hummocky, partially stabilized sand dunes occur, and large, active dunes are also present. The former consist of islands of vegetation, primarily mesquite, separated by expanses of bare sand. The mesquite-anchored soil is less susceptible to erosion, mainly by wind, than is the bare sand. The result is a series of valley-like depressions, or blowouts, between vegetated hummocks. Active dunes running east to west are found 16 km (10 mi) south and east of the site.

To the west and southwest, the soil changes again, becoming more dense and shallow (less than 2.5 cm [10 in.] to caliche) than in the dune area. The composition of the plant life is radically altered, and creosote bushes become dominant. Toward Livingston Ridge to the west and northwest, creosote bushes gradually give way to an acacia-dominated association at the top of the escarpment. The western face of the ridge drops sharply to a valley floor (flats) that is densely populated with tobosa grass, which is rare elsewhere in the study area.

2.4.1.2 Mammals

The most conspicuous wild mammals at the site are the black-tailed jack rabbit and the desert cottontail. Common small mammals found at the WIPP site include the Ord's kangaroo rat, the Plains pocket mouse, and the northern grasshopper mouse. Big-game species, such as the mule deer and the pronghorn antelope, and carnivores, such as the coyote, are present in small numbers.

2.4.1.3 Reptiles and Amphibians

Commonly observed reptiles in the study area are the side-blotched lizard, the western box turtle, the western whiptail lizard, and several species of snakes, including the bullsnake, the prairie rattlesnake, the western diamondback rattlesnake, the coachwhip, the western hognose, and the glossy snake. Of these, only the side-blotched lizard is found in all habitats. The others are mainly restricted to one or two associations within the central dunes area, although the western whiptail lizard and the western diamondback rattlesnake are found in areas dominated by creosote bush as well. The yellow mud turtle is found only in the limited number of aquatic habitats in the study area (that is, dirt stock ponds and metal stock tanks), but it is common in these locales.

Amphibians are similarly restricted by the availability of aquatic habitat. Stock-watering ponds and tanks may be frequented by tiger salamanders and occasional frogs and toads. Fish are sometimes stocked in the ponds and tanks.

2.4.1.4 Birds

Numerous birds inhabit the area either as transients or year-long residents. Loggerhead shrikes, pyrrhuloxias, and black-throated sparrows are examples of common residents. Migrating or breeding waterfowl species do not frequently occur in the area. Some raptors (for example, Harris hawks) are residents. The density of large avian predators' nests has been documented as among the highest recorded in the scientific literature.

~~2.4.1.5 Arthropods~~

~~About 1,000 species of insects have been collected in the study area. Of special interest are subterranean termites. Vast colonies of these organisms are located across the study area; they are detritivores and play an important part in the recycling of nutrients in the study area.~~

~~2.4.1.6 Aquatic Ecology~~

~~Aquatic habitats within a 8-km (5-mi) radius of the WIPP site are limited. Stock-watering ponds and tanks constitute the only permanent surface waters. Ephemeral surface-water puddles form after heavy thunderstorms. At greater distances, seasonally wet, shallow lakes (playas) and permanent salt lakes are found.~~

~~Laguna Grande de la Sal is a large, permanent salt lake at the south end of Nash Draw. Natural brine springs, effluent brine from nearby potash refineries, and surface and subsurface runoff discharge into the lake. One of the natural brine springs at the northern margin of the lake has been found to support a small population of the Pecos River pupfish. This species is among the species recognized as threatened by the state of New Mexico. The spring, now called Surprise Spring, is about 18 km (11 mi) west-southwest of the WIPP site.~~

~~Several marine organisms are present in the Lower Pecos River and in the Red Bluff Reservoir. They include small, shelled protozoans (Foraminifera), a Gulf Coast shrimp, an estuarine oligochaete and a dragonfly, and several species of marine algae. These species have presumably been introduced. Salt-tolerant species of insects, oligochaetes, and nematodes and unusual algal assemblages characterize this stretch of the river. The combination of high salinity, elevated concentrations of heavy metals, and salt-tolerant and marine fauna makes the Lower Pecos River a unique system (DOE 1980, Section 7.1.3.).~~

~~2.4.1.7 Endangered Species~~

~~The DOE consulted with the U.S. Fish and Wildlife Service (FWS) in 1979 to determine the presence of threatened and endangered species at the WIPP site. At that time the FWS listed the Lee pincushion cactus, the black-footed ferret, the American peregrine falcon, the bald eagle, and the Pecos gambusia as threatened or endangered and as occurring or having the potential to occur on lands within or outlying the WIPP site. In 1989, the FWS advised the DOE that the list of species provided in 1979 is still valid, with the exception of the black-footed ferret. The DOE believes that the actions described in the 1990 *Final Supplement Environmental Impact Statement* (SEIS, in the bibliography) will have no impact on any threatened or endangered species because these activities do not involve any ground disturbance that was not already evaluated in the FEIS. In addition, there is no critical habitat for terrestrial species identified as endangered by either the FWS or the New Mexico Department of Game and Fish (NMDG&F) at the site area.~~

~~Also in 1989, the DOE consulted with the NMDG&F regarding the endangered species listed by the state in the vicinity of the WIPP site. The NMDG&F currently lists (based on NMDG&F Regulation 657, dated January 9, 1988) seven birds and one reptile that are in one of two endangerment categories and that occur or are likely to occur at the site. The NMDG&F agreed in 1989 that the proposed WIPP activities would probably not have appreciable impacts on~~

endangered species listed by the state in the area. *A Handbook of Rare and Endemic Plants of New Mexico*, published by the University of New Mexico (UNM) (UNM 1984), lists the plants in New Mexico classified as threatened, endangered, or sensitive, and includes 20 species, representing 14 families, that are found in Eddy County and could occur at or near the WIPP site.

2.4.2 Water Quality

In this section, the DOE presents a discussion of the quality of groundwater and surface water in the WIPP area.

2.4.2.1 Groundwater Quality

Based on the major solute compositions described in Siegel et al. (1991, Section 2.3.2.1), four hydrochemical facies are delineated for the Culebra, as shown in Figure 2-40.

Zone A. A sodium chloride brine (approximately 3.0 molar) with a magnesium/calcium (Mg/Ca) mole ration between 1.2 and 2.0 exists here. This water is found in the eastern third of the WIPP site. The zone is roughly coincident with the region of low transmissivity described by LaVenue et al. (1988, 6-1). On the western side of the zone, halite in the Rustler has been found only in the unnamed lower member. In the eastern portion of the zone, halite has been observed throughout the Rustler.

Zone B. A dilute anhydrite-rich water (ionic strength < 0.1 molar) occurs in the southern part of the site. The Mg/Ca mole ratios are uniformly low (0.0 to 0.5). This zone is coincident with a high-transmissivity region, and halite is not found in the Rustler in this zone.

Zone C. Waters of variable composition with low to moderate ionic strength (0.3 to 1.6 molar) occur in the western part of the WIPP site and along the eastern side of Nash Draw. Mg/Ca mole ratios range from 0.3 to 1.2. This zone is coincident with a region of variable transmissivity. In the eastern part of this zone, halite is present in the lower member of the Rustler. Halite is not observed in the formation on the western side of the zone. The most halite-rich water is found in the eastern edge of the zone, close to core locations where halite is observed in the Tamarisk Member.

Zone D. A fourth zone can be defined based on inferred contamination related to potash refining operations in the area. Waters from these wells have anomalously high solute concentrations (3 to 7 molar) and potassium/sodium (K/Na) weight ratios (0.2) compared to waters from other zones (K/Na = 0.01 to 0.09). In the extreme southwestern part of this zone, the composition of the Culebra well water has changed over the course of a seven-year monitoring period. The Mg/Ca mole ratio at WIPP-29 is anomalously high, ranging from 10 to 30 during the monitoring period (Siegel et al. 1991, Figure 2-19).

This zonation is consistent with that described by Ramey in 1985, who defined three zones. The fourth zone (D) was added by Siegel et al. in 1991 to account for the local potash contamination.

Together, the variations in solutes and the distribution of halite in the Rustler exhibit a mutual interdependence. Concentrations of solutes are lowest where Rustler halite is less abundant,

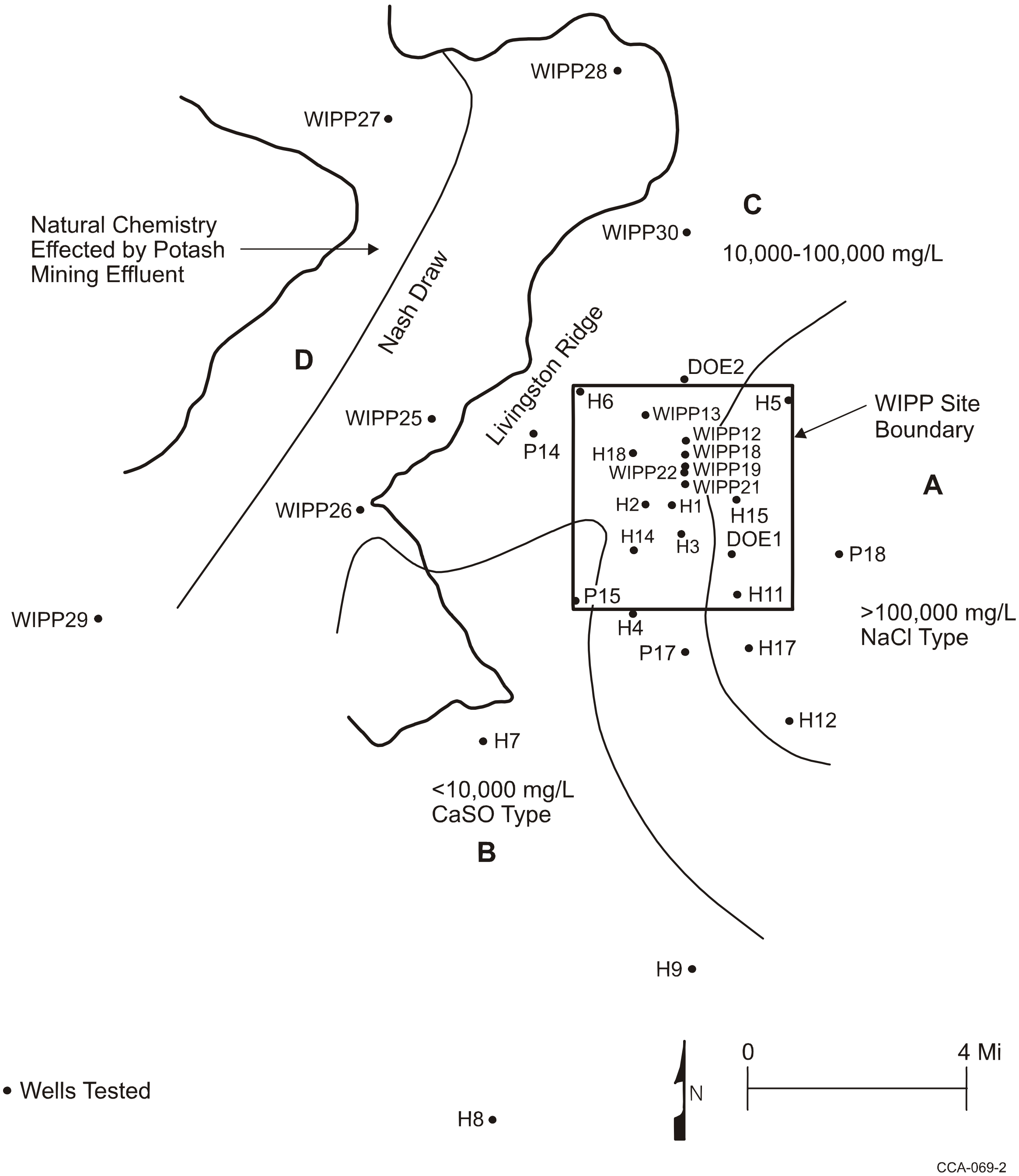

Figure 2-40. Hydrochemical Zones of the Culebra

consistent with the hypothesis that solutes in Rustler groundwaters are derived locally by dissolution of minerals (for example, halite, gypsum, and dolomite) in adjacent strata.

The TDS in the Magenta groundwater ranges in concentration from 3,240 to 222,000 milligrams per liter (Siegel et al. 1991, Table 4-6). This water is considered saline to briny. The transmissivity in areas of lower TDS concentrations is very low, thus greatly decreasing its usability, and the Magenta is not considered as a water supply. In general, the chemistry of

Magenta water is variable. Groundwater types range from a predominantly sodium chloride type to a calcium-magnesium-sodium-sulfate type chemistry. The water chemistry may indicate a general overall increase in TDS concentrations to the south and southwest, away from the WIPP site, and a potential change to a predominantly sodium chloride water in that area.

In the WIPP area, the water quality of the Magenta is better than that of the Culebra. However, water from the Magenta is not used anywhere in the vicinity of the WIPP. The DOE has performed an analysis to determine whether there are underground source of drinking water (USDWs) in the vicinity of the WIPP. This analysis has resulted in a conclusion that there could be three USDWs as defined by 40 CFR Part 191 exist in the area, as given in Appendix USDW. The impact of the WIPP on USDWs is discussed in Chapter 8.0.

2.4.2.2 Surface-Water Quality

The Pecos River is the nearest permanent surface water source to the WIPP site. Natural brine springs, representing outfalls of the brine aquifers in the Rustler, feed the Pecos River at Malaga Bend, southwest of the site. This natural saline inflow adds approximately 370 tons of chloride per day to the Pecos River (Appendix GCR, 6-7). Return flow from irrigated areas above Malaga Bend further contributes to the salinity. The concentrations of potassium, mercury, nickel, silver, selenium, zinc, lead, manganese, cadmium, and barium also show significant elevations at Malaga Bend but tend to decrease downstream. The metals presumably are rapidly adsorbed onto the river sediments. Natural levels of certain heavy metals in the Pecos River below Malaga Bend exceed the water quality standards of the World Health Organization, the EPA, and the state of New Mexico. For example, the maximum level for lead is 50 parts per billion, and levels of up to 400 parts per billion have been measured in the Pecos River.

As it flows into Texas south of Carlsbad, the Pecos River is a major source of dissolved salt in the west Texas portion of the Rio Grande Basin. Natural discharge of highly saline groundwater into the Pecos River in New Mexico keeps TDS levels in the water in and above the Red Bluff Reservoir very high. The TDS levels in this interval exceed 7,500 mg/L 50 percent of the time and, during low flows, can exceed 15,000 mg/L. Additional inflow from saline water-bearing aquifers below the Red Bluff Reservoir, irrigation return flows, and runoff from oil fields continues to degrade water quality between the reservoir and northern Pecos County in Texas. Annual discharge-weighted average TDS concentrations exceed 15,000 mg/L. Water use is varied in the southwest Texas portion of the Pecos River drainage basin. For the most part, water use is restricted to irrigation, mineral production and refining, and livestock. In many instances, surface-water supplies are supplemented by groundwaters that are being depleted and are increasing in salinity.

2.4.3 Air Quality

Measurements of selected air pollutants at the WIPP site began in 1976 and were reported by the DOE in the FEIS. Since the preparation of that document, a more extensive air quality monitoring program has been established. Seven classes of atmospheric gases regulated by the EPA have been monitored at the WIPP site between August 27, 1986, and October 30, 1994. These gases are carbon monoxide (CO), hydrogen sulfide (H_2S), ozone (O_3), nitrogen oxides (NO, NO_2, NO_x), and sulfur dioxide (SO_2). The total suspended particulates (TSPs) are

~~monitored in conjunction with the air-monitoring programs of the WIPP. The results of the monitoring program are detailed in the annual reports for the WIPP Environmental Monitoring Program (see Appendix SER; Westinghouse 1991b, 1992, 1993, 1994, 1995 in the Bibliography).~~

~~*2.4.4 Environmental Radioactivity*~~

~~The background radiation conditions in the vicinity of the WIPP site are influenced by natural sources of radiation, fallout from nuclear tests, and one local research project (Project Gnome). Prior to the WIPP project, long-term radiological monitoring programs were established in southeastern New Mexico to determine the widespread impacts of nuclear tests at the Nevada Test Site and to evaluate the effects of Project Gnome. As discussed in Section 2.3.2.3, Project Gnome resulted in the underground detonation of a nuclear device on December 10, 1961, at a site approximately 9 km (5.8 mi) southwest of the WIPP site.~~

~~The WIPP Radiological Baseline Program (RBP), which included the Radiological Environmental Surveillance Program, was initiated in July 1985 to describe background levels of radiation and radionuclides in the WIPP environment prior to the underground emplacement of radioactive waste. The RBP consisted of five subprograms: (1) atmospheric baseline; (2) ambient radiation (measuring gamma radiation); (3) terrestrial baseline (sampling soils); (4) hydrologic baseline (sampling surface water and bottom sediments and groundwater); and (5) biotic baseline (analyzing radiological parameters in key organisms along potential radionuclide migration pathways). The RBP has been succeeded by the Environmental Monitoring Plan (EMP). The final report on the RBP is included as Appendix RBP. This report summarizes the statistical approach used to analyze the RBP data. In addition, Appendix RBP discusses how values below detection limits are handled. The sampling locations for the RBP are the same as those reported on Figures 5-2 through 5-7 in Appendix EMP. This appendix discusses the statistical analyses used to support data.~~

~~2.4.4.1 Atmospheric Radiation Baseline~~

~~Historically, most gross alpha activity in airborne particulates has shown little variation and is within the range of from 1×10^{-15} to 3×10^{-15} microcuries per milliliter, which is equivalent to 3.7×10^{-11} to 11×10^{-11} becquerels per milliliter. Mean gross beta activity in airborne particulates fluctuates but is typically within the range of from 1×10^{-14} to 4×10^{-14} microcuries per milliliter (3.7×10^{-10} to 15×10^{-10} becquerels per milliliter). A peak of 3.5×10^{-13} microcuries per milliliter (1.2×10^{-8} becquerels per milliliter) in mean gross beta activity occurred in May 1986 and has been attributed to atmospheric fallout from the Chernobyl incident in the former Soviet Union. The average level of gamma radiation in the environment is approximately 7.5 microroentgens per hour, or approximately 66 millirem per year.~~

~~For 1995, the mean gross alpha concentrations show limited fluctuation throughout the year and range from 2.0×10^{-15} to 2.6×10^{-14} microcuries per milliliter (7.5×10^{-11} to 9.6×10^{-10} becquerels per milliliter). These fluctuations appeared to be consistent among all sampling locations. The mean gross beta concentrations fluctuate throughout the year within the range of 2.4×10^{-14} to 4.0×10^{-14} microcuries per milliliter (8.9×10^{-10} to 1.5×10^{-9} becquerels per~~

milliliter). Individual gross alpha and beta concentrations reported for each location are documented in Appendix SER.

2.4.4.2 Ambient Radiation Baseline

Using the average rate of 7.5 microroentgens per hour, the estimated annual dose is approximately 66 millirem. The fluctuations noted are primarily due to calibration of the system and meteorological events such as the high-intensity thunderstorms that frequent this area in late summer. A seasonal rise in ambient radiation has been observed in the first and fourth quarters each year. It is speculated that this fluctuation may be due to variations in the emission and dispersion of radon-222 from the soil around the WIPP site. These variations can be caused by meteorological conditions, such as inversions, which would slow the dispersion of the radon and its progeny.

2.4.4.3 Terrestrial Baseline

Data were collected as part of the RBP at the WIPP in December 1985 and July 1987. Soil samples were collected and analyzed from a total of 37 locations within a 80-km (50-mi) radius of the WIPP (see Table 2-10). The soil samples were analyzed for 19 radionuclides: ^{40}K, ^{60}Co, ^{90}Sr, ^{137}Cs, two isotopes of radium, three isotopes of thorium, four isotopes of uranium, ^{237}Np, four isotopes of plutonium (^{239}Pu and ^{240}Pu were measured together), ^{241}Am, and ^{244}Cm. Four isotopes (^{40}K, ^{234}U, ^{235}U, and ^{238}U) exhibited significant differences among the three geographic groups, with samples from the outer sites having significantly higher levels of radioactivity than those from the 8-km (5-mi) ring sites (that is, 16 sampling sites in a ring around the WIPP with a 8-km [5-mi] radius). For ^{234}U, ^{235}U, and ^{238}U, the 8-km (5-mi) ring sites also showed higher levels than the WIPP sites. The isotopes ^{137}Cs, ^{226}Ra, ^{228}Th, and 230Th exhibited differences between the outer sites and the other two groups, which were indistinguishable. Again, the outer sites had significantly higher levels of radioactivity than the other two groups. Measured mean values for ^{40}K, ^{137}Cs, ^{226}Ra, the three thorium isotopes, and the three uranium isotopes were above detection limits, as shown in Table 2-10. The mean values for ^{60}Co, ^{90}Sr, ^{228}Ra, ^{233}U, ^{237}Np, the plutonium isotopes, ^{241}Am, and ^{244}Cm fell below detection limits.

2.4.4.4 Hydrologic Radioactivity

The hydrologic radioactivity monitoring program is designed to establish characteristic radioactivity levels in surface-water bodies, bottom sediments, and groundwater.

2.4.4.4.1 Surface Water and Sediment Background Radiation Levels

Samples of both surface water and groundwater were collected for the RBP. These samples were analyzed for 19 radionuclides (^{3}H, ^{40}K, ^{60}Co, ^{90}Sr, ^{137}Cs, two isotopes of radium, three isotopes of thorium, four isotopes of uranium, ^{237}Np, and four isotopes of plutonium [^{239}Pu and ^{240}Pu were measured together]). The resulting data from the sampling of surface water and groundwater were analyzed independently.

Table 2-10. Ranges of Mean Values Measured for Radioactive Isotopes In Soils at WIPP Site, 5 Miles from WIPP, and beyond 5 Miles from WIPP

	Range of Mean Values[a]	
Isotope	µCi/g	Bq/g
^{40}K	4.9 to 9.3 × 10^{-6}	1.8 to 3.4 × 10^{-1}
^{60}Co	-	0
^{90}Sr	-	0
^{137}Cs	1.3 to 2.2 × 10^{-7}	4.7 to 8.1 × 10^{-3}
^{226}Ra	2.6 to 5.4 × 10^{-7}	9.6 to 20 × 10^{-3}
^{228}Ra	-	b
^{228}Th	2.1 to 4.9 × 10^{-7}	7.8 to 18 × 10^{-3}
^{230}Th	2.5 to 52 × 10^{-7}	9.1 to 19 × 10^{-3}
^{232}Th	3.0 × 10^{-7}	1.1 × 10^{-2}
^{233}U	-	b
^{234}U	1.5 to 3.3 × 10^{-7}	5.4 to 12 × 10^{-3}
^{235}U	4.4 to 17 × 10^{-9}	1.6 to 6.3 × 10^{-4}
^{238}U	1.6 to 3.0 × 10^{-7}	5.7 to 11 × 10^{-3}
^{237}Np	-	b
^{238}Pu	-	b
$^{239/240}$Pu	-	b
^{241}Pu	-	b
^{241}Am	-	b
^{244}Cm	-	b

Source: Appendix RBP, Table 4-1.

[a] The ranges of mean values are expressed in terms of microcuries per gram of soil and becquerels per gram of soil.
[b] Below minimum detection limit of 3.7 × 10^{-3} becquerels per gram.

2.4.4.4.1.1 Surface Water

Samples of surface water were collected from 12 locations over the course of the RBP. Sampling locations were divided into three groups for an initial analysis of geographic variability. Stock tanks represented the largest group, with five locations; they are located closest to WIPP. Stock tanks in this area are typically man-made earthen catchment basins with no surface outflow. The Pecos River represents the next major surface-water group.

Four sampling locations were used along the Pecos River, from a northern (upriver) point near the town of Artesia to a southern (downriver) point near the town of Malaga, New Mexico. The third group, called Laguna Grande de la Sal, represents water from a series of playa lakes at the lower end of Nash Draw.

The sample mean radioactivity levels for most radionuclides were below their respective detection limits. Peak levels of ^{40}K from Laguna Grande de la Sal were 2.7×10^{-5} microcuries per gram (1.0 becquerels per gram), whereas the mean level at all other sampling locations was less than 2.7×10^{-7} microcuries per gram (0.01 becquerels per gram). All four isotopes of uranium exhibited significant differences among the three geographic groups. For all four isotopes, radionuclide levels in the tanks were at least one order of magnitude lower than levels found in the Pecos River and Laguna Grande de la Sal. Similar to ^{40}K, levels of uranium were highest in Laguna Grande de la Sal. Only ^{60}Co, ^{137}Cs, ^{228}Ra, ^{234}U, and ^{238}U were found to be above detection limits. (See Table 5-1 Appendix RBP for details.)

2.4.4.4.1.2 Sediments

Sediments were collected for the WIPP RBP from six locations: Hill Tank, Indian Tank, Noye Tank, Laguna Grande de la Sal, and two sites along the Pecos River. These samples were analyzed for 18 radionuclides (tritium was not analyzed in the sediments).

In all five cases where differences were found among location groups, the stock tanks had higher concentrations of radionuclides, possibly indicating an accumulation effect from the closed nature of the tanks. Laguna Grande de la Sal sediments contained significantly higher concentrations of ^{234}U than did the stock tanks and the Pecos River, which were indistinguishable.

2.4.4.4.2 Groundwater Radiological Characterization

Groundwater samples were collected from 37 wells: 23 completed by the DOE in the Culebra, four completed by the DOE in the Magenta, and 10 privately owned in various units. The samples were analyzed for the same 19 radionuclides as the surface-water samples. Elevated levels of ^{40}K were found in the Magenta and private wells, and in the Culebra (2.0×10^{-7} to 5.4×10^{-7} microcuries per gram, or 7.3×10^{-3} to 20×10^{-3} becquerels per gram, respectively). The increased levels of ^{40}K can be attributed to the generally high levels of dissolved solids in groundwater in these formations. Only ^{60}Co, ^{137}Cs, ^{234}U, ^{238}U, and ^{226}Ra, which were found to have a distinct geographic pattern in the Culebra, were found above detection limits, as shown in Table 2-11. Means from individual wells show that levels of ^{226}Ra increase in concentration from west to east. Means of radionuclide concentrations from wells around the WIPP site are shown in Table 2-11.

Groundwater samples were collected in accordance with the EMP (Appendix EMP) and the Groundwater Monitoring Plan (Appendix GWMP) (Westinghouse 1991a). The primary objective of the WQSP is to obtain representative and repeatable groundwater quality data from selected wells under rigorous field and laboratory procedures and protocols. At each well site, the well is pumped and the groundwater serially analyzed for specific field parameters. Once the field parameters have stabilized, denoting a chemical steady-state with respect to these parameters, a final groundwater sample is collected for analysis of radionuclides.

Table 2-11. Mean Values Measured for Radionuclides in Water Wells around the WIPP Site

Isotope	Mean Value (10^{-4} becquerels per gram)*
^{3}H	Below <MDL (56)
^{40}K	73 to 200
^{60}Co	12
^{90}Sr	<MDL (7.4)
^{137}Cs	7.2
^{226}Ra	6.9 to 52
^{228}Ra	9.6
^{228}Th	<MDL (3.7)
^{230}Th	<MDL (0.37)
^{232}Th	<MDL (0.37)
^{233}U	<MDL (0.37)
^{234}U	2.6
^{235}U	<MDL (N/S)
^{238}U	0.72
^{237}Np	<MDL (0.37)
^{238}Pu	<MDL (0.11)
$^{239/240}$Pu	<MDL (0.74)
^{241}Pu	<MDL (37)

Source: Appendix RBP, Table 5-4

* Units are becquerels per gram of sample.

Legend:

<MDL Less than the minimum detection level (MDL is shown in parentheses)
N/S MDL not specified

2.4.4.5 Biotic Baseline

This subprogram characterizes background radioactivity levels in key organisms along possible food-chain pathways to man. Vegetation, rabbits, quail, beef, and fish are sampled, and palatable tissues are analyzed for concentrations of transuranics and common naturally occurring radionuclides. Because of the small sample sizes in this program, no attempt has been made to interpret these data. The results are presented in Appendix RBP, Section 7.

2.5 Climate and Meteorological Conditions

The DOE did not consider climate directly in its site selection process, although criteria such as low population density and large tracts of federally owned land tend to favor arid and semi-arid areas in the western United States. The semi-arid climate around the WIPP is beneficial since it is a direct cause of the lack of a near surface water table and the minimization of radiation exposure pathways that involve surface or groundwater. Data used to interpret paleoclimates in the American ***s***outhwest come from a variety of sources and indicate alternating arid and subarid to subhumid climates throughout the Pleistocene. The information in this section was taken from Swift ***(***1992***)***, ***and*** included in ~~this application as~~ ***CCA*** Appendix CLI and references therein.

2.5.1 Historic Climatic Conditions

Prior to 18,000 years ago, radiometric dates are relatively scarce, and the record is incomplete. From 18,000 years ago to the present, however, the climatic record is relatively well constrained by floral, faunal, and lacustrine data. These data span the transition from the last full-glacial maximum to the present interglacial period; given the global consistency of glacial fluctuations described below, they can be taken to be broadly representative of extremes for the entire Pleistocene.

Early and middle Pleistocene paleoclimatic data for the southwestern United States are incomplete and permit neither continuous reconstructions of paleoclimates nor direct correlations between climate and glaciation prior to the last glacial maximum, which occurred 22,000 to 18,000 years ago. Stratigraphic and soil data from several locations, however, indicate that cyclical alternation of wetter and drier climates in the Southwest had begun by the Early Pleistocene. Fluvial gravels in the Gatuña exposed in the Pecos River Valley of eastern New Mexico suggest wetter conditions 1.4 million years ago and again 600,000 years ago. The Mescalero caliche, exposed locally over much of southeastern New Mexico, suggests drier conditions 510,000 years ago, and loosely dated spring deposits in Nash Draw west of the WIPP imply wetter conditions occurring again later in the Pleistocene. The Blackwater Draw Formation of the southern High Plains of eastern New Mexico and western Texas, correlating in time to both the Gatuña Formation and the Mescalero caliche, contains alternating soil and eolian sand horizons that show at least six climatic cycles beginning more than 1.4 million years ago and continuing to the present.

Data used to construct the more detailed climatic record for the latest Pleistocene and Holocene come from six independent lines of evidence dated using carbon-14 techniques: plant communities preserved in packrat middens throughout the ~~S~~***s***outhwest, including sites in Eddy and Otero counties, New Mexico; pollen assemblages from lacustrine deposits in western New Mexico and other locations in the ~~S~~***s***outhwest; gastropod assemblages from western Texas; ostracod assemblages from western New Mexico; paleolake levels throughout the ~~S~~***s***outhwest; and faunal remains from caves in southern New Mexico.

Prior to the last glacial maximum 22,000 to 18,000 years ago, evidence from faunal assemblages in caves in southern New Mexico, including the presence of species such as the desert tortoise that are now restricted to warmer climates, suggests hot summers and mild, dry winters. Lacustrine evidence confirms the interpretation of a relatively dry climate prior to and during the glacial advance. Permanent water did not appear in what was later to become a major lake in the Estancia Valley in central New Mexico until some time before 24,000 years ago, and water depths in lakes at higher elevations in the San Agustin Plains in western New Mexico did not reach a maximum until sometime between 22,000 and 19,000 years ago. Ample floral and lacustrine evidence documents cooler, wetter conditions in the ***s***outhwest during the glacial peak. These changes were not caused by the immediate proximity of glacial ice. None of the Pleistocene continental glaciations advanced farther southwest than northeastern Kansas, and the most recent, late-Wisconsinan ice sheet reached its limit in South Dakota, approximately 1,200 km (750 mi) from WIPP. Discontinuous alpine glaciers formed at the highest elevations throughout the Rocky Mountains, but these isolated ice masses were symptoms, rather than causes, of cooler and wetter conditions and had little influence on regional climate at lower elevations. The closest such glacier to WIPP was on the northeast face of Sierra Blanca Peak in the Sacramento Mountains, approximately 220 km (135 mi) to the northwest.

Global climate models indicate that the dominant glacial effect in the ~~S~~***s***outhwest was the disruption and southward displacement of the westerly jet stream by the physical mass of the ice sheet to the north. At the glacial peak, major Pacific storm systems followed the jet stream across New Mexico and the southern Rocky Mountains, and winters were wetter and longer than either at the present or during the previous interglacial period.

Gastropod assemblages at Lubbock Lake in western Texas suggest mean annual temperatures 5 ~~degrees~~ C~~elsius~~ ***(9° F)*** below present values. Both floral and faunal evidence indicate that annual precipitation throughout the region was 1.6 to 2.0 times greater than today's values. Floral evidence also suggests that winters may have continued to be relatively mild, perhaps because the glacial mass blocked the southward movement of arctic air. Summers at the glacial maximum were cooler and drier than at present, without a strongly developed monsoon.

The jet stream shifted northward following the gradual retreat of the ice sheet after 18,000 years ago, and the climate responded accordingly. By approximately 11,000 years ago, conditions were significantly warmer and drier than previously, although still dominated by winter storms and still wetter than today. Major decreases in total precipitation and the shift toward the modern monsoonal climate did not occur until the ice sheet had retreated into northeastern Canada in the early Holocene.

By middle Holocene time, the climate was similar to that of the present, with hot, monsoon-dominated summers and cold, dry winters. The pattern has persisted to the present, but not without significant local variations. Soil studies show that the southern High Plains were drier from 6,500 to 4,500 years ago than before or since. Gastropod data from Lubbock Lake indicate the driest conditions from 7,000 to 5,000 years ago (precipitation, 0.89 times present values; mean annual temperature, 2.5***°*** ~~degrees~~ C~~elsius~~ ***[4.5° F]*** higher than present values), with a cooler and wetter period 1,000 years ago (precipitation, 1.45 times present values; mean annual temperature, 2.5***°*** ~~degrees~~ C~~elsius~~ ***[4.5° F]*** lower than present). Plant assemblages from southwestern Arizona suggest steadily decreasing precipitation from the middle Holocene to the present, except for a brief wet period approximately 990 years ago. Stratigraphic work at Lake Cochise (the present Willcox playa in southeast Arizona) shows two mid-Holocene lake stands, one near or before 5,400 years ago and one between or before 3,000 to 4,000 years ago; however, both were relatively short-lived, and neither reached the maximum depths of the Late Pleistocene high stand that existed before 14,000 years ago.

Inferred historical precipitation indicates that during the Holocene, wet periods were relatively drier and shorter in duration than those of the late Pleistocene. Historical records over the last several hundred years indicate numerous lower-intensity climatic fluctuations, some too short in duration to affect floral and faunal circulation. Sunspot cycles and the related change in the amount of energy emitted by the sun have been linked to historical climatic changes elsewhere in the world, but the validity of the correlation is uncertain. Correlations have also been proposed between volcanic activity and climatic change. In general, however, causes for past short-term changes are unknown.

The climatic record presented here should be interpreted with caution because its resolution and accuracy are limited by the nature of the data used to construct it. Floral and faunal assemblages change gradually and show only a limited response to climatic fluctuations that occur at frequencies that are higher than the typical life span of the organisms in question. For long-lived species such as trees, resolution may be limited to hundreds or even thousands of years. Sedimentation in lakes and playas has the potential to record higher-frequency fluctuations, including single-storm events, but only under a limited range of circumstances. Once water levels reach a spill point, for example, lakes show only a limited response to further increases in precipitation.

With these observations in mind, three significant conclusions can be drawn from the climatic record of the American ***s***outhwest. First, maximum precipitation in the past coincided with the maximum advance of the North American ice sheet. Minimum precipitation occurred after the ice sheet had retreated to its present limits. Second, past maximum long-term average precipitation levels were roughly twice the present levels. Minimum levels may have been 90 percent of the present levels. Third, short-term fluctuations in precipitation have occurred during the present relatively dry, interglacial period, but they have not exceeded the upper limits of the glacial maximum.

Too little is known about the relatively short-term behavior of global circulation patterns to accurately predict precipitation levels over the next 10,000 years. The long-term stability of patterns of glaciation and deglaciation, however, do permit the conclusion that future climatic extremes are unlikely to exceed those of the late Pleistocene. Furthermore, the periodicity of glacial events suggests that a return to full-glacial conditions is highly unlikely within the next 10,000 years.

2.5.2 Recent Climatic Conditions

Recent climatic conditions are provided to allow for the assessment of impacts of these factors on the disposal unit and the site. Data are taken from the WIPP environmental monitoring reports (see ~~Westinghouse~~ ***WEC*** 1991a, ***1991***b, 1992, 1993, 1994, 1995***, 1996, 1997, 1998; WGESC 1999; ESRF 2000, 2001, 2002; and WRES 2003***~~in the Bibliography~~).

2.5.2.1 General Climatic Conditions

The climate of the region is semiarid, with generally mild temperatures, low precipitation and humidity, and a high evaporation rate. Winds are mostly from the southeast and moderate. In late winter and spring, there are strong west winds and dust storms. During the winter, the weather is often dominated by a high-pressure system situated in the central portion of the western United States and a low-pressure system located in north-central Mexico. During the summer, the region is affected by a low-pressure system normally situated over Arizona.