Long-Term Climate Variability at the Waste Isolation Pilot Plant, Southeastern New Mexico, USA

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ABSTRACT / The United States Department of Energy is developing the Waste Isolation Pilot Plant (WIPP) in southeastern New Mexico for the disposal of transuranic wastes generated by defense programs. Because changes in climate during the next 10,000 years (10 ka) may affect performance of the repository, an understanding of long-term climate variability is essential for evaluating regulatory compliance.

Fluctuations in global climate corresponding to glaciation and deglaciation of the northern hemisphere have been regular in both frequency and amplitude for at least 780 ka. Coolest and wettest conditions in the past have occurred at the WIPP during glacial maxima, when the North American ice sheet reached its southern limit roughly 1200 km north of the WIPP and deflected the jet stream southward. Average precipitation in southeastern New Mexico during the last glacial maximum 22–18 ka before present (BP) was approximately twice that of the present. Driest conditions (precipitation approximately 90% of present) occurred 6.5–4.5 ka BP, after the ice sheet had retreated to its present location. Wet periods of unknown duration have occurred since the retreat of the ice sheet, but none have exceeded glacial conditions. Global climate models suggest that anthropogenic climate changes (i.e., warming caused by an increased greenhouse effect) will not result in an increase in precipitation at the WIPP. The climate of the last glacial maximum is therefore suitable for use as a cooler and wetter limit for variability during the next 10 ka.

The Waste Isolation Pilot Plant (WIPP), located 42 km east of Carlsbad, New Mexico (Figure 1), is being evaluated by the United States Department of Energy (DOE) for disposal of transuranic wastes generated since 1970 by defense programs. The repository is excavated approximately 655 m below the ground surface in bedded halite of the Late Permian Salado Formation, deposited approximately 255 million years before the present (255 Ma BP).

Before the WIPP can be used for long-term disposal of transuranic waste, the DOE must demonstrate compliance with the United States Environmental Protection Agency’s (EPA) Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Waste (40 CFR 191) (US EPA 1985), hereafter referred to as the standard. Although the standard was vacated by a Federal Court of Appeals in 1987 and is undergoing revision, by agreement with the State of New Mexico, the DOE is continuing to evaluate repository performance with respect to the regulation as first promulgated until a new version is available (US DOE and State of New Mexico 1981, as modified in 1984 and 1987).

The standard requires that the DOE consider “all significant processes and events that may affect the disposal system” during the 10,000 years (10 ka) following decommissioning. The performance assessment being conducted for the DOE by Sandia National Laboratories is therefore examining, among other things, the likelihood and consequences of long-term changes in climate. Climatic changes have the potential to affect repository performance directly, by altering groundwater recharge and flow in the region, and indirectly, by changing human land-use patterns in the region. Increases in precipitation are of primary concern because they may result in increased groundwater flow and, in the event of a breach of the repository, increased transport of radionuclides to the accessible environment.

Modern Climate at the WIPP

At present, the climate at the WIPP is arid to semi-arid. Mean annual precipitation at the WIPP has been estimated to be between 28 and 34 cm/yr (Hunter 1985). At Carlsbad, 100 m lower than the WIPP, 53-yr (1931–1983) annual means for precipitation and temperature are 32 cm/yr and 17.1°C (University of New Mexico 1989). Short-term variation about the annual means can be considerable, and historic weather data cannot be used to predict long-term

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climatic shifts. For example, the 105-yr (1878–1982) precipitation record from Roswell, 135 km northwest of the WIPP and 60 m higher, shows an annual mean of 27 cm/yr with a high of 84 cm/yr and a low of 11 cm/yr (Hunter 1985).

The climate of southeastern New Mexico is monsoonal: most of the precipitation falls in late summer, when solar warming of the continent creates an atmospheric pressure gradient that draws moist air inland from the Gulf of Mexico (Cole 1975). The coincidence of precipitation and temperature maxima is typical of a monsoonal climate (Figure 2). Much of the rain falls during localized and often intense summer thunderstorms, and winters are cool and generally dry. Both temperature and precipitation are dependent on elevation, and local climates vary with topography. At lower elevations throughout the region, including the vicinity of the WIPP, potential evaporation greatly exceeds precipitation. Freshwater pan evaporation in the region is estimated to exceed 274 cm/yr (Hunter 1985). Surface runoff and infiltration of rainwater

Figure 1. Location of the WIPP (after Bertram-Howery and Hunter 1989)

Figure 2. Climatograph showing 30-yr (1951–1980) monthly precipitation and temperature means recorded at the Carlsbad, New Mexico airport, approximately 45 km west of the WIPP and 50 m lower (data from NOAA 1989).