Letter Report

Review of Data on Hydrogeology and Related Issues in Andrews County, Texas

by

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Summary

Technical issues for siting a low-level radioactive waste repository in Andrews County, Texas, include ensuring that a considered site satisfies the licensing requirements spelled out in State regulations (TRCR Part 45). Most of Andrews County is underlain by the High Plains aquifer, which includes the Ogallala Formation as well as older Cretaceous formations. The presence of this aquifer should be expected to pose a great deal of questions from regulators and the public for licensing a low-level radioactive waste repository. Available maps do not unambiguously identify any area of Andrews County where the High Plains aquifer is absent. Possible areas that merit further evaluation include the WCS Site near the State line with New Mexico and the south-central part of the county near the border with Ector and Winkler Counties.

The High Plains aquifer material is thin at the WCS Site. Documents submitted as part of a RCRA permit application in 1993 and comments by WCS consultants indicate that saturated ground-water conditions do not occur at the WCS Site. Additional scientific data would be needed to confirm or refute this conclusion and address site-suitability requirements for licensing. An additional WCS document presents a revised interpretation that the High Plains aquifer material at the WCS Site does not include the Ogallala Formation. The data forming the basis for this interpretation remains to be presented and scientifically evaluated. The presence or absence

of the Ogallala Formation within the High Plains aquifer material, however, appears to be more of a public perception issue than a technical issue related to site performance.

Andrews County lies at the southern limit of the High Plains aquifer in Texas, and the aquifer material tends to be thinner in Andrews County than in areas to the north. At least one map suggests that both the Ogallala Formation and Cretaceous rocks making up the High Plains aquifer are absent along part of the border with Ector and Winkler Counties. If this is correct, siting a repository there might avoid ground-water issues related to the High Plains aquifer, although other siting or performance issues may be important.

Introduction

The Bureau of Economic Geology was asked in January 1999 to review data on hydrogeology and issues related to ground water for siting a low-level radioactive waste repository in Andrews County, Texas. Specific tasks included consideration of the following:

(1) the extent of the Ogallala Formation, which makes up part of the High Plains aquifer,

(2) the depth to ground water and the saturated thickness of ground water in the High Plains aquifer,

(3) the features affecting recharge and discharge of ground water.

To carry out this review, Bureau scientists reviewed maps showing the extent of the Ogallala Formation and technical reports relevant to hydrogeology of Andrews County, and discussed information regarding the WCS and Envirocare Sites with their technical consultants.

Site-Suitability Requirements

State licensing requirements related to ground water can be summarized in six site-suitability criteria. These criteria and an overview of how they are generally met in Andrews County are presented in Table 1.

Extent of the Ogallala Formation

Various maps show the extent of the Ogallala aquifer in Andrews County (Eifler and others, 1976; Weeks and Gutentag, 1981; Knowles and others, 1984; Ashworth and Hopkins, 1995). The maps vary considerably in scale and accordingly in the accuracy with which local geology can be shown. The maps indicate the presence of the Ogallala Formation or High Plains aquifer across most of Andrews County with the exception of the southwestern corner and part of the border with Ector and Winkler Counties. The delineation of the Ogallala Formation or High Plains aquifer is inconsistent between the maps. Quaternary windblown sand covers bedrock in most of the county and obscures where the Ogallala Formation is present or absent. In the southern half of the county the amount of data from shallow borings and logged sections of oil wells is too sparse to increase the accuracy of surface geologic mapping.

The Hobbs 1:250,000 sheet of the Geological Atlas of Texas (Eifler and others, 1976) shows the Tertiary-age Ogallala Formation as cropping out at ground surface along Monument Draw across northern Andrews County, around Shafter and Whaten Lakes, at the headward reaches of Mustang Greek in eastern Andrews County, and along parts of the Texas–New Mexico state line including the WCS Site. The map shows that the uppermost geologic unit in most of Andrews County is windblown sand.

The small-scale map by Weeks and Gutentag (1981) undoubtedly generalizes the distribution of the High Plains aquifer in Andrews County. It shows the High Plains aquifer occurring in all but the southwestern corner of Andrews County.

Maps from the Texas Water Development Board (Knowles and others, 1984; Ashworth and others, 1991; Ashworth and Hopkins, 1995) show a small strip along the border with Ector and Winkler Counties where the High Plains aquifer is absent.

WCS Site

Detailed site information is available from the 1993 RCRA permit application for the WCS Site (AM Environmental, 1993). That document identifies substrate at the WCS Site as Ogallala Formation on the basis of geologic logs of borehole samples. Descriptions of core material resemble descriptions of other rock samples from the Ogallala and Blackwater Draw Formations.

Lehman (1996) presents a new interpretation that substrate at the WCS Site is not Ogallala Formation, but Cretaceous materials of the Antlers Formation or younger Cretaceous limestone beds or both. He states that Ogallala is absent at the WCS Site. This finding is apparently based on Lehman's observations from outcrop exposures in the area and in a WCS excavation. No scientific description or documentation (logged sections, drawings, or photographs of outcrops) were included with the text of Lehman (1996) to substantiate these interpretations.

Lehman (1996) also emphasizes a distinction between the location of Ogallala and Gatuña Formation materials. This distinction is not geologically

significant, but creates an impression that the Ogallala ends northeast of the WCS Site. The Ogallala was deposited contemporaneously with the development of subsidence basins forming west of the Central Basin Platform and along the present trend of the Pecos River in eastern New Mexico (Gustavson and Finley, 1985). The Gatuña deposits are equivalent to the Ogallala Formation.

Lehman (1996) implies that the Ogallala was not deposited at the WCS Site, rather than being eroded since its deposition. He states that the "Red Bed Ridge," a broad, northwest-oriented ridge on the buried, eroded surface of the Triassic Dockum Group, locally controlled deposition of the Ogallala Formation. Lehman (1996) considers the "Red Bed Ridge" to have been a persistent feature in the geomorphic history of the region. There is, however, little evidence for this interpretation. The "Red Bed Ridge" probably has been progressively developed during the Cenozoic with movement along the faults bounding the west side of the Central Basin Platform and dissolution of more deeply buried Permian salt beds. The "Red Bed Ridge" probably had less impact on Ogallala deposition than Lehman assumes.

Scientifically documenting that the Ogallala is absent at the WCS Site requires multiple independent and qualified geologists to examine the data and reach the same conclusion. This step has not yet been taken and the Lehman (1996) interpretation should be considered an alternate hypothesis until such consensus is made. Data to substantiate the interpretation would include but not be limited to:

- Drawings, logged sections, and photographs of regional and on-site exposures showing the basis for the interpretation, including

primary and secondary sedimentary structures, vertical trends in sediment texture, and characteristics of caliche beds.

- Petrographic examination of rock samples to determine the presence or absence of diagnostic framework grains (igneous and metamorphic rock fragments, fossil material, and detrital carbonate rock fragments.
- Regional map of thickness of sand and gravel in the High Plains aquifer around the vicinity of the WCS Site.
- Integration of data from an in-progress core study by WCS with data from outcrop exposures.
- Description of soil to evaluate whether site soils are the same vertisols typical of the Blackwater Draw Formation. If the Blackwater Draw Formation is present, its relation to the underlying material needs to be documented.

WCS has sponsored a geological investigation of the relationship between Cretaceous and Ogallala materials located northeast of the WCS Site. (Allen Messenger, personal communication, January 1999). One objective of this work is to document the extent of each stratigraphic unit and the location of their unconformable contact. The work is being done by drilling and logging a number of core holes.

Envirocare Site

Additional detailed site information has been collected for the Envirocare Site, which is located approximately 8 miles southeast of the WCS Site. The Envirocare Site also lies along the "Red Bed Ridge," a subsurface feature with a broad, northwest-oriented ridge on the buried eroded surface of

the Triassic Dockum Group. Based on geological description of core samples and outcrop exposures, the Envirocare Site is identified as being underlain by the Blackwater Draw and Ogallala Formations (Bruce Darling, personal communication, February 1999). The description of core materials from the Envirocare Site resembles the description of core from the WCS Site contained in the 1993 RCRA permit application.

Depth to Ground Water and Saturated Thickness

Regional maps (Knowles and others, 1984; Weeks and Gutentag, 1981) show that in most places the saturated thickness of the High Plains aquifer in Andrews County is less than 100 ft and there are large areas with less than 20 ft. The saturated thickness is the height between the water table and the base of the aquifer on the Dockum Group. The regional maps are limited in amount of abundant local data to define where the saturated thickness might be very small owing to a high elevation on the base of the aquifer or to a low elevation of the water table.

The saturated thickness probably is small along the "Red Bed Ridge" in western Andrews County. The RCRA application for the WCS Site (AM Environmental, 1993; Allen Messenger, personal communication, January 1999) indicates that saturated thickness locally is zero and that the High Plains aquifer does not remain saturated across the "Red Bed Ridge" This situation is depicted in the conceptual model shown in figure 1a. Farther southeast along the "Red Bed Ridge" the High Plains aquifer is more continuously saturated (fig. 1b). For example, at the Envirocare Site, which is also near the crest of the "Red Bed Ridge" southeast of the WCS Site, ground water is reported to range in thickness from 0 to as much as 20 ft (Bruce Darling, personal communication, February 1999).

The ridge dips to the southeast at about 9 ft/mile whereas the overlying water table has an apparent dip in that direction of about 7.75 ft/mile (Knowles and others, 1984, v. 4). On average, therefore, the thickness of the High Plains aquifer increases by 1.25 ft/mile to the southeast along the ridge. Envirocare is reported to have at most about 20 ft of saturated section (Bruce Darling, personal communication, February 1999), so one might expect the High Plains aquifer above the ridge near the State line, for example, at the WCS Site, to have no more than 10 ft of saturated section. It also is likely that the elevation of the water table in the High Plains aquifer fluctuates through time with differences in weather and recharge rate. A saturated section can develop and build up across the "Red Bed Ridge" in a given area that presently is unsaturated. So conditions reflected in figure 1a might at a later time come to resemble those shown in figure 1b.

Additional data need to be collected and scientifically interpreted to address the site-suitability requirements for licensing a low-level radioactive waste repository (table 1). Questions that would have to be addressed include but are not limited to:

- where the water table in the High Plains aquifer ends (fig. 1a), for example, in the vicinity of the WCS Site or at other possible locations in Andrews County,
- what the fluctuation in the elevation of the water table is in the High Plains aquifer at and around the WCS Site, and
- what are the hydrologic processes and their rates that control the fluctuations in saturated thickness and elevation of the water table.

Questions remain about the data that formed the basis for concluding that there is no ground water at the WCS Site. Data collection deserves special

care in order to evaluate ground-water conditions where the saturated thickness of the High Plains aquifer might be less than 10 ft, and where well yield possibly is low.

- First, the 1993 RCRA application notes that core from most boreholes is moist or wet. At other locations at the southern end of the High Plains aquifer, including the Envirocare Site, presence of moist or wet core can reflect saturated ground water conditions (Bruce Darling, personal communication, February 1999).
- Second, the test boreholes at the WCS Site were reportedly left open overnight and no free water was found within the High Plains aquifer section (Allen Messenger, personal communication, January 1999). It is possible, however, that any shallow ground water drained down into the boreholes, which had been drilled deep into the Triassic section. At the Envirocare Site, it is reported to take many days for water levels to recover in a borehole under such conditions (Bruce Darling, personal communication, February 1999). Monitoring wells would have to be completed within the High Plains aquifer material to provide a test for the presence and fluctuation of saturated conditions.
- Third, no seepage into the surface excavation at the WCS Site was reported and this has been taken for evidence that there is no ground water at the site (Allen Messenger, personal communication, January 1999). Additional documentation would be necessary to use such observation as a basis of fact, including an accurate visual record from the first day of excavation onward, to document that water never was entering the excavation from seeps in the wall at the contact above the Triassic section. The High Plains aquifer material in western Andrews County has a hydraulic conductivity of less than 34 ft/day and only a

thin saturated section Knowles and others, 1984). It is possible for an excavation to quickly dewater the area around the cut, so that the free-water surface would retreat from the wall face and later discharge by evaporation.

Recharge and Discharge

The distribution of ground water is tied to the location and amount of recharge. Recharge to the High Plains aquifer in Andrews County probably occurs (a) across large upland areas where the land surface is underlain by porous wind-blown sand and (b) in small focused areas where surface-water runoff drains to playas, which are shallow closed depressions of the ground surface. Saturated zones can be discontinuous where recharge rates from playas are low (fig. 2a) or more continuous where recharge rates are greater (fig. 2b). For example, only a few wells or boreholes in the vicinity of the WCS Site have been reported to find ground water, and these have been located near a playa (Allen Messenger, personal communication, January 1999). This would be consistent with the conceptual model shown in figure 2a. Additional documentation on recharge processes and rates, and their relation to the continuity of the underlying saturated section, would be needed to address the site-suitability requirements for licensing a low-level radioactive waste repository (table 1).

Ground water in the High Plains aquifer mainly flows laterally under the local gradient of the water table toward discharge locations. A regional hydrologic divide lies along the western side of the "Red Bed Ridge." Ground water west of the divide flows toward discharge sites in the Pecos River valley. Ground water east of the divide flows generally eastward across Andrews County. Average rate of ground-water flow in the High Plains

aquifer in Andrews County (<0.3 ft/day [<130 ft/yr]) is probably less than average flow in the aquifer (~0.58 ft/day [~210 ft/yr]) because hydraulic conductivity is less than the average (Knowles and others, 1984). Some ground water is discharged to water wells and some ground water within 10 to 20 ft of ground surface probably is discharged by evapotranspiration. A small amount of ground water also leaks downward from the High Plains aquifer and is the source of old ground water at depth in the Dockum Group (Dutton, 1995).

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Table 1. Site-suitability criteria related to ground water for siting a low-level radioactive waste repository

	Criteria	Information
(a)	The site must be capable of being characterized, modeled, analyzed, and monitored. TRCR 45.50(a)	An Andrews County site almost certainly can be characterized, modeled, analyzed, and monitored.
(b)	The site must be unlikely to be impacted by future growth and development (water availability is an important factor). TRCR 45.50(b)	Water availability is a regional issue and is being addressed under the context of Texas S.B. 1 and Andrews County is included in Planning Region F.
(c)	The site location must be unlikely to be impacted by resource exploitation. TRCR 45.50(c)	There are more than 30 major oil reservoirs in Andrews County.
(d)	Depth to ground water must be sufficient to preclude intrusion into waste. TRCR 45.50(f)	Most of Andrews County is underlain by the High Plains aquifer. Depth to water may be shallow enough that a facility may have to rely on engineered barriers to prevent intrusion of ground water over the life of the project and after site closure.
(e)	The site and facility must pose no risk to sole source aquifers. TRCR 45.50(g)	The Ogallala has not been designated a sole source aquifer. Regionally, the Ogallala is considered a major aquifer by the Texas Water Development Board. Distribution, amount, processes, and other factors regarding recharge in Andrews County are important judgment issues.
(f)	The hydrogeologic disposal unit must not discharge ground water to the surface at the site. TRCR 45.50(h)	Ground water in the disposal unit may discharge to the surface or to hydrogeologic units in contact with surface water where there is sufficient topographic relief and where the saturated part of the unit is underlain by claystone beds of the Dockum Group.

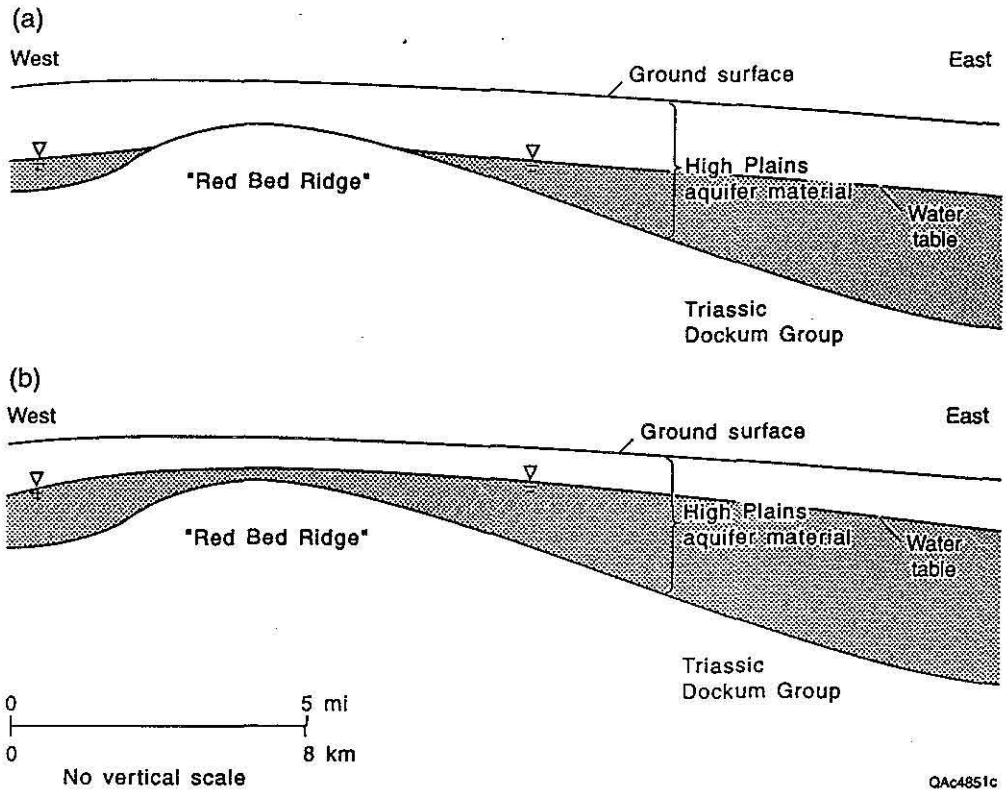

Figure 1. Conceptual model for ground water in High Plains aquifer in western Andrews County. An issue for siting a low-level radioactive waste repository in western Andrews County is the present and future position of the water table within the High Plains aquifer. The saturated zone is discontinuous across the "Red Bed Ridge" in (a) and continuous in (b). (a) represents the conditions as reported for the WCS Site (AM Environmental, 1993; Allen Messenger, personal communication, January 1999) and (b) represents reported conditions for the Envirocare Site (Bruce Darling, personal communication, February 1999). Additional scientific evaluation of data are needed to meet site suitability requirements related to ground water (TRCR 45.50).

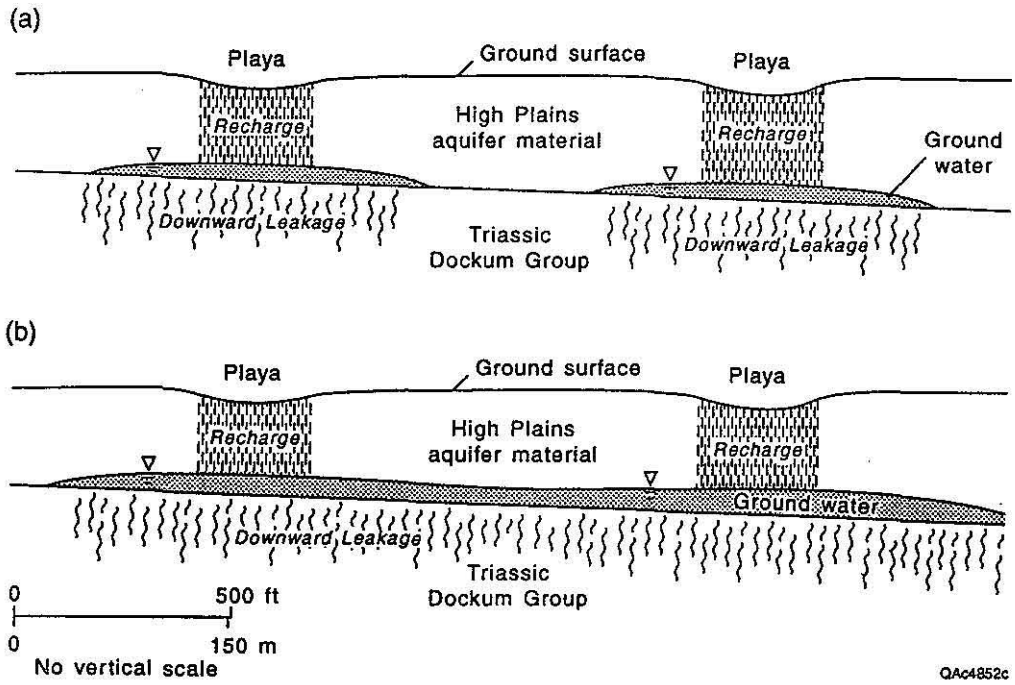

Figure 2. Conceptual model for recharge beneath playas. Thickness, lateral extent, and continuity of saturated zones varies with relative rates of recharge, downward leakage, evapotranspiration, and with hydraulic conductivity of High Plains aquifer material. Saturated zones are discontinuous (a) where recharge rates are low and more continuous where recharge rates are higher (b).