SPATIAL VARIABILITY IN SUBSURFACE FLOW THROUGH THE UNSATURATED ZONE IN THE VICINITY OF THE PANTEX PLANT, SOUTHERN HIGH PLAINS, TEXAS

Final Report

by

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ABSTRACT

Many of the previous studies of the High Plains have assumed that recharge to the underlying Ogallala aquifer is uniformly distributed. Use of areally averaged recharge rates greatly underestimates contaminant transport velocities in areas of focused flow. The objective of this study was to evaluate spatial variability in subsurface water movement at a variety of scales that ranged from playa/interplaya scale to desiccation crack/root tubule scale. The study was conducted in the vicinity of the Department of Energy's Pantex Plant, near Amarillo, Texas.

Hydraulic and chemical approaches were used to evaluate subsurface flow in natural playa and interplaya settings. A maximum of 35 boreholes from 7 playa/interplaya settings were sampled. Hydraulic methods included laboratory measurement of water content and water potential. Chemical tracers included meteoric chloride, chlorine-36, and tritium. To evaluate preferential flow in surficial sediments, applied tracers such as bromide and organic dyes were used.

Water fluxes were high beneath playas, as indicated by high water contents, high water potentials, and low chloride concentrations. High tritium levels (4.4 ± 0.4 to 77 ± 5 TU) throughout the 29-m profile beneath a playa indicated movement of post-1952 water to at least that depth. In contrast to water fluxes in the playas, water fluxes in interplaya settings were negligible. Sediment samples collected in interplaya areas had lower water contents, lower minimum water potentials, and higher maximum chloride concentrations than samples from adjacent playas. The maximum depth of penetration of the wetting front after rainfall was 0.3 m. Low minimum water potentials in surficial sediments indicate that the soils were dry near the surface and water potentials increased with depth, which suggest an upward driving force for liquid and isothermal vapor movement. High peak chloride concentrations are attributed to concentration of chloride by evapotranspiration. Estimated water fluxes in annular zones surrounding the playas were similar to

those in adjacent playas in some areas. In other areas, annular profiles had moderately high chloride concentrations, which indicate that fluxes are not uniformly high in annular zones.

In addition to focused recharge beneath the playas, applied tracer experiments showed preferential flow of water and solutes, primarily along root tubules and between soil peds in interplaya settings and along desiccation cracks and interped spaces in playas. Ponding conditions used in these tracer experiments are appropriate for the playas and also serve as analogs for man-made ditches at the Pantex Plant that were used for wastewater discharge. The vertical extent and continuity of preferred pathways are difficult to assess; however, the multipeaked tritium profile is consistent with preferential flow to ~ 27 m.

The primary control on subsurface flow is surface ponding of water, which occurs in playas and in ditches. The ponding focuses recharge to the underlying aquifer. Subsurface layering of sediments affects flow and results in natural capillary barriers and perching layers. Structureless sand layers may also affect the vertical extent of preferred pathways and may provide a reservoir for volatile contaminants.

INTRODUCTION

Much of the previous work conducted on the High Plains concentrated on ground water resource evaluation and used areally averaged recharge values for numerical simulations of ground water flow (Knowles et al., 1984; Luckey et al., 1986). Although spatial variability in subsurface water movement may not be very important for groundwater-resource evaluation, it is critical for estimation of the rate of contaminant transport. Focusing of recharge through playas and ditches allows contaminants to migrate rapidly to the groundwater and to bypass the buffering capacity of much of the unsaturated zone (Gee and Hillel, 1988).

Previous Work

Much of the previous work in the Southern High Plains concentrated on water resource evaluation because of the importance of the Ogallala aquifer in the region. The majority of areally averaged recharge values were within 1 to 25 mm yr^{-1} (table 1). Studies dating back to the early 1900's, however, suggested that recharge is not uniformly distributed and that playas focus recharge (Johnson, 1901; Gould, 1906). Evidence of higher recharge is provided by much greater water-level responses in wells in the vicinity of playas than in upland areas (Broadhurst, 1942; White et al., 1946). In addition, mounding of the water table beneath a playa after precipitation events provides further evidence of focused flow (Havens, 1966). Numerical simulations of groundwater flow showed that the groundwater levels were similar for areally uniform recharge and focused recharge through playas, demonstrating that water resource evaluation is insensitive to spatial variability in recharge (Mullican et al., 1994).

Because of the depletion of groundwater resources caused by irrigation pumping, artificial recharge to the Ogallala aquifer was investigated in the 1960's to early 1980's. Basins were excavated in an interplaya setting, and water was ponded on a 0.3-m-thick caliche layer (Schneider and Jones, 1984). Neutron probe monitoring of water content documented the migration of the wetting front at a rate of ~0.15 m hr^{-1}. The long-term average water flux was ~0.4 m d^{-1}. Groundwater mounds formed on top of an indurated calcium carbonate layer ("caprock"). Similar experiments were also conducted by Aronovici et al. (1970) in an interplaya setting, and the results were comparable to those described by Schneider and Jones (1984).

Several studies in the 1970's and 1980's suggested that playas act as evaporation pans, which is consistent with the use of playas for wastewater discharge (Lehman, 1972). Claborn et al. (1985) suggested that clays in the playas act as a liner and that natural recharge only occurred when water levels in playas rose above the level of the clay to the silty loam in the annular region around the playa. Osterkamp and Wood (1987) and Wood and Osterkamp (1987) indicated that recharge occurred primarily in the annular regions surrounding playas. More recent studies by Wood and

Table 1. Published recharge values, Southern High Plains.

Author	Areal or focused recharge	Recharge (mm yr^{-1})
Johnson (1901)	Regional	76–102
Gould (1906)	Regional	152
Theis (1937)	Regional	3.2–17.0
Cronin (1961)	Regional	13
Havens (1966)	Regional	20.6
Brown and Signor (1973)	Regional	0.6–2.0
Bell and Morrison (1979)	Regional	13
Klemt (1981)	Regional	4.8
U.S. Bureau of Reclamation (1982)	Regional	24
Wood and Osterkamp (1984)	Regional	2.5
Wood and Osterkamp (1984)	Playa	40
Wood and Petraitis (1984)	Regional	2.5
Wood and Petraitis (1984)	Playa	40–50
Knowles (1984)	Regional	5.1
Knowles et al. (1984)	Regional	1.5–6.3
Gutentag et al. (1984)	Regional	1.4–2.8
Stone (1984)	Playa	2.8
Stone (1984)	Sand hills	1.25
Stone (1984)	Nonirrig. cover sand	0.24
Stone and McGurk (1985)	Playa	12.2
Stone and McGurk (1985)	Interplaya	0.75
Nativ (1988)	Playa	13–80
Stone (1990)	Interplaya	0.75
Mullican et al. (1994)	Playa	219
Mullican et al. (1994)	Regional	6
Wood and Sanford (1995)	Regional	11±2
Wood and Sanford (1995)	Playa	77±8

Sanford (1995) showed that recharge (77 ± 8 mm yr^{-1}) occurs as piston flow through playas, as evidenced by high levels of tritium throughout the unsaturated zone (Wood and Sanford, 1995). Low chloride concentrations in pore water beneath the playas provide evidence of recharge. Chloride concentrations in pore water were used to calculate a recharge rate of 12 mm yr^{-1} in playas in New Mexico (Stone and McGurk, 1985). Additional evidence for recharge in playas was provided by tritium in groundwater beneath and downgradient from playas (Nativ, 1988; Wood and Sanford, 1995). The absence of evaporite minerals in playa sediments also indicates recharge.

Objectives

The objectives of this study were to determine spatial and temporal variability in subsurface water fluxes. Spatial variability was examined at both large scales (such as playa/interplaya) and small scales (such as desiccation crack/root). The scales for temporal variability ranged from seasonal to geologic time scales (thousands of years). Data from hydraulic and chemical approaches were used to evaluate subsurface flow processes. These data were used to develop a conceptual model of unsaturated flow processes in this system. Evaluation of subsurface flow is important in determining the distribution of contaminants in the unsaturated zone and is critical for development of an effective remediation strategy for the Pantex Plant.

This study differs from previous studies in that both physical and tracer data were integrated, whereas previous studies generally relied on physical or tracer data alone. Detailed studies of physical parameters, such as water potential, in the unsaturated zone had not been previously conducted. The variety of tracers including environmental (Cl, ^{36}Cl, and ^{3}H) and applied ($CaBr_2$, FD&C blue dye) tracers and integration with physical measurements provide multiple independent lines of evidence to evaluate subsurface flow processes. The number of playas studied (seven) and the density of data is far greater than those in previous studies.

This study is part of a comprehensive geologic, hydrologic, and hydrochemical characterization that was conducted in the vicinity of the Department of Energy's Pantex Plant near

Amarillo, Texas, to understand the subsurface movement of contaminants and to guide remediation of this site. The Pantex Plant, established in 1952, was originally the site for assembly of nuclear weapons. Today it is used for disassembly of weapons and for high-explosive research. Wastewater transported along ditches to playas has resulted in contamination of underlying perched aquifers (64 to 94 m depth) with chromium, trichloroethylene, high explosives, and other compounds.

Piston versus Preferential Flow

Preferential flow refers to nonuniform downward water movement in which some of the water in the profile is bypassed by the infiltrating water. Nonuniform movement of water can occur at a variety of scales. Increased water fluxes beneath playas and ephemeral streams in arid and semiarid regions have been referred to as macroscopic scale preferential flow by Gee and Hillel (1988). Most researchers, however, restrict the use of the term preferential flow to much smaller scale features such as cracks and fractures and do not include such topographic features as playas and ephemeral streams. Macropore and unstable flow are generally included in preferential flow (Steenhuis et al., 1994). Macropore flow refers to flow along noncapillary-size openings such as fractures, cracks, and root tubules. Unstable flow results from wetting front instability and requires the system to be within the gravity flow regime (Hendrickx and Yao, in press). Many studies that emphasize preferential flow were conducted in more humid environments (Gish and Shirmohammadi, 1991) where water tables are shallow and flow is concentrated along preferred pathways.

Important factors in evaluation of preferential flow include local input conditions in generating preferential flow, soil type, and the continuity of preferred pathways (Beven, 1991). Previously it was thought that ponded conditions were required for the development of preferential flow; however, although ponding greatly enhances the potential for flow along preferred pathways, preferential flow can occur under natural rainfall and sprinkler conditions. Because water flow in noncapillary size pores only occurs when saturation is approached, preferential flow has been found mostly in humid sites with higher rainfall (Gish and Shirmohammadi, 1991). Preferential flow has been documented in fractured rock in arid settings and is shown by deep penetration of bomb pulse tracers such as chlorine-36 and tritium (Fabryka-Martin et al., 1993; Nativ et al., 1995). Soil texture affects preferential flow; structured clay soils are much more susceptible to preferential flow than structureless sandy soils (Steenhuis and Parlange, 1991). The continuity of preferred pathways depends on the type of pathways. Desiccation cracks and root tubules are generally fairly shallow, whereas rock fractures can extend to great depths.

The type of contaminants is also important in determining the importance of preferential flow. Preferential flow is much more important for contaminants that exceed health standards in the part per billion or part per trillion range, such as pesticides, than for contaminants that exceed health standards in the part per million range, such as nitrate (Steenhuis and Parlange, 1991). Nitrate contamination requires movement of the bulk of the pore water, which is much greater than the generally small water volumes transported along preferred pathways. The arrival of the first 1% of a chemical at the groundwater is more readily accommodated by preferential flow rather than the transport of the bulk of the mass.

Hydrodynamics

The hydrodynamic approach to evaluating flow in the unsaturated zone involves measurement of physical parameters such as water content, water potential, and temperature. Temporal variations in water content monitored with a neutron probe are often used to evaluate the movement of water pulses through the unsaturated zone. Monitoring water content may not be sufficiently accurate to detect small fluxes in some arid settings. Under constant flux conditions, water content will not vary; therefore, the lack of temporal variations in water content does not preclude water movement. Water content is discontinuous across different sediment types;

therefore, variations in water content with depth cannot be used to determine the direction of water movement.

In contrast to water content, energy potential is continuous across different sediment types and is typically used to infer the flow direction. In the unsaturated zone many gradients may be important, as indicated by the generalized flux law (modified from de Marsily, 1986):

$$q = -L_1 \Delta H - L_2 \Delta T - L_3 \Delta C \qquad (1)$$

where q is the flux, L_1, L_2 and L_3 are proportionality constants, Δ is the gradient operator, H is the hydraulic head (sum of matric and gravitational potential heads), T is temperature, and C is the solute concentration. Solute or osmotic potentials (ψ_π, MPa) can be estimated from chloride concentrations in the pore water according to the Vant Hoff equation (Campbell, 1985):

$$\psi_\pi = -(\nu C \chi R T) / 1000 \qquad (2)$$

where ν is the number of osmotically active particles (2 for NaCl), C is chemical concentration (mol/kg), χ is osmotic coefficient (Robinson and Stokes, 1959), R is the gas constant (8.3142 J mol^{-1} K^{-1}), and T is temperature (K). Osmotic potential is generally much less than matric potential in arid settings. The generalized flux law holds for systems in which water flow occurs in liquid and vapor phases. In semiarid and arid regions, the direction of liquid flux is controlled primarily by gradients in hydraulic head, whereas the direction of isothermal and thermal vapor flux is controlled by hydraulic head and temperature gradients, respectively.

In areas of moderate to high subsurface water flux, hydraulic head is the dominant driving force. Under equilibrium or no-flow conditions, matric potential and gravitational potential heads are balanced. If z (the vertical space coordinate) is taken as positive upward and zero at the water table, then the equilibrium matric potential is zero at the water table and equal to the negative of the gravitational potential head or height above the water table. Under steady flow conditions, matric potentials that plot to the right of the equilibrium line indicate downward flow, whereas those that plot to the left of the equilibrium line indicate upward flow. Matric potentials can be measured with tensiometers; however, these instruments are restricted to the wet range (0 to –0.08 MPa).

Thermocouple psychrometers are used to measure water potential (sum of matric and osmotic potential) in dry sediments typical of those in arid settings. Because osmotic potentials are generally low (Scanlon, 1994), the terms matric and water potential are often used interchangeably.

In addition to estimation of the direction of water movement, temporal variations in water potential recorded at various depths also provide data on the depth of water penetration after rainfall events.

Environmental and Applied Tracers

Environmental tracers generally provide information on cumulative water flux over longer time periods than represented by the hydrodynamic approach. Chloride concentrations in soil water have been widely used to evaluate water fluxes in semiarid systems (Allison and Hughes, 1978; Edmunds and Walton, 1980). Chloride is an ideal tracer because it is chemically conservative. According to the chloride mass balance approach, the source of chloride is assumed to be in precipitation and dry fallout. Because chloride is nonvolatile its concentration increases through the root zone as a result of evapotranspiration. The water flux (q_w) can be estimated by dividing the chloride deposition rate (D_{Cl}) by the chloride concentration in pore water (C_{Cl}).

$$q_w = D_{Cl} / C_{Cl} \qquad (3)$$

If the chloride deposition rate is assumed uniform at a site, then the chloride concentration in the pore water is inversely proportional to the water flux; low chloride concentrations indicate high water flux, and high chloride concentrations indicate low water flux.

There are many assumptions associated with the chloride mass balance approach:

- one-dimensional, vertical, downward, piston flow
- steady-state subsurface flow
- precipitation and dry fallout only sources of chloride
- chloride deposition constant with time
- no run on or runoff

The piston-flow assumption is being questioned at many sites. Piston flow is not valid in fractured rock, particularly where such rocks are exposed at the surface (Fabryka-Martin et al., 1993; Nativ et al., 1995). Bulge-shaped chloride profiles at many sites in nonfractured sediments could result from preferential flow (Peck et al., 1981) or from transient flow (Scanlon, 1991; Stone, 1992; Phillips, 1994). Preferential flow is generally evaluated by analyzing pore-water samples for bomb pulse tracers such as ^{36}Cl or ^{3}H because they provide pulse input rather than the continuous input provided by meteoric chloride. Bulge-shaped chloride profiles typical of many sites in the southwestern United States are attributed to higher water fluxes during the Pleistocene, when the climate was cooler and wetter (Scanlon, 1991; Phillips, 1994; Tyler et al., in press). In these areas, the steady-state subsurface flow assumption is not valid, and the chloride mass balance approach has been applied to different segments of the profiles that are considered to represent steady state (Phillips, 1994). The residence time represented by chloride at depth z can also be evaluated by dividing the cumulative total mass of chloride from the surface to that depth by the annual chloride deposition

$$t = \frac{\int_0^z \theta C_{Cl} dz}{D_{Cl}} \quad . \tag{4}$$

Equation 4 does not require the steady-state flow assumption and only assumes that the chloride deposition rate is constant. The chloride deposition rate for the study area was calculated from the chloride concentration in precipitation and dry fallout (0.6 g m^{-3}, Lodge, 1968; Wood and Sanford, 1995) and the long-term mean annual precipitation (500 mm).

Meteoric chloride data provide information on net water fluxes over long time periods and are not sensitive to preferential flow along roots or fractures (Nativ et al., 1995). In contrast, pulse type tracers such as bomb pulse chlorine-36 (half-life 301,000) and tritium (12.45 yr) are generally used to evaluate preferential flow in arid and semiarid regions (Tyler et al., in press). Nuclear weapons tests conducted in the Pacific from 1952 to 1958 resulted in ^{36}Cl concentrations in rainfall that were as much as 10,000 times greater than natural fallout levels (Bentley et al., 1986). Tritium concentrations increased from 10 to ≥ 2000 TU during atmospheric nuclear testing (IAEA, 1983) from 1952 and peaked in 1963. Chlorine-36 is restricted to liquid phase flow whereas tritiated water exists in liquid and vapor phases. These tracers have been used in many arid regions to estimate water flux; however, in areas of low water flux these tracers are generally found within the root zone and the estimated water fluxes overpredict water fluxes below the root zone because evapotranspiration removes much of the water in the root zone (Tyler and Walker, 1994). Deep penetration of chlorine-36 and tritium (down to ~ 440 m) at Yucca Mountain and of tritium (down to ~13 m) (Liu et al., 1995; Yang, pers. comm., 1995) in the Negev desert in Israel (Nativ et al., 1995) has been attributed to preferential flow along fractured rock.

In addition to environmental tracers, applied tracers can also be used to evaluate flow processes. Although applied tracers generally reflect flow over a short time (≤1 yr), contaminants at a site may also be considered as applied tracers, e.g., bromide in an industrial complex in the Negev desert (Nativ et al., 1995). Applied tracers have been widely used in humid regions where subsurface water fluxes are high and water tables are shallow (≥1 m). In arid regions applied tracers are generally used with irrigation or ponding because subsurface water fluxes associated with natural rainfall are generally too low. Inorganic tracers such as bromide or chloride are used because they are conservative. Colored organic dyes such as FD&C blue organic dye and Rhodamine WT have been used extensively to delineate preferential flow paths such as cracks and roots (Kung, 1990; Steenhuis et al., 1994). Most of these studies involve digging trenches to visually inspect the distribution of the dyes, and these studies are therefore restricted to the shallow subsurface. In some experiments, samplers such as gravity pan and wick samplers are installed beneath the experimental plots to monitor temporal variations in tracer movement. Some of these organic dyes have adsorption characteristics similar to pesticides and can be used as analogs of pesticide movement. FD&C blue organic dye has a sorption coefficient similar to atrazine; however, the dye is not adsorbed along the preferred pathways. Although the dye tracing experiments provide qualitative evidence of preferential flow, it is difficult to quantify the relative magnitude of piston and preferential flow.

Site Description

The study area (35°20'N, 102°22'W), ~25 km northeast of Amarillo, lies within the Southern High Plains (fig. 1). The topography is relatively flat, and the elevation ranges from 1052 to 1082 m. There is no integrated drainage system, and water drains into approximately 25,000 playas throughout the Southern High Plains of Texas and New Mexico. Playa basins are generally less than 1.5 km^2 in area. The natural vegetation is grass, and much of the region is used for agriculture. The area north of the Pantex Plant has been irrigated since 1957, and playas in this region have received irrigation return flow. Perched aquifers, which are found beneath some areas of the study region, range in depth from 76 to 107 m. The main aquifer in the region is the Ogallala; the Ogallala water table ranges from 46 to 137 m below the surface in the study area.

The Blackwater Draw Formation is host to the playa sediments and is an eolian deposit (Holliday, 1989). The formation ranges from a thick deposit of clay loam in the northeast, with a typical thickness of approximately 25 m in the Pantex area, to a thin deposit of sandy loam in the southwest (Sabin and Holliday, 1995). The Blackwater Draw Formation is underlain by the Ogallala Formation. Randall clay soils are mapped on the playa floors in the northern part of the High Plains and are generally ≤ 2 m thick. These soils are Vertisols. Because of seasonal wetting and drying of the playas, desiccation cracks develop in these smectite-rich clays.

The study concentrated on seven playa basins in the Pantex area (figs. 1–8, table 2). Boreholes were drilled in playa, annular, and interplaya settings over a period of 3 yr (table 3). The playa setting is the flat floor of the playa basin, and the playa generally contains Randall clay soils. The annular setting is considered to be the break in slope at the playa margin, near the annual high water line. The interplaya setting is characterized by the Pullman and Estacado soil series developed on the Blackwater Draw Formation, generally a silty clay loam with a well-developed calcic horizon. Organic matter and fine-grained material generally increase toward the playa (Warren, 1992).

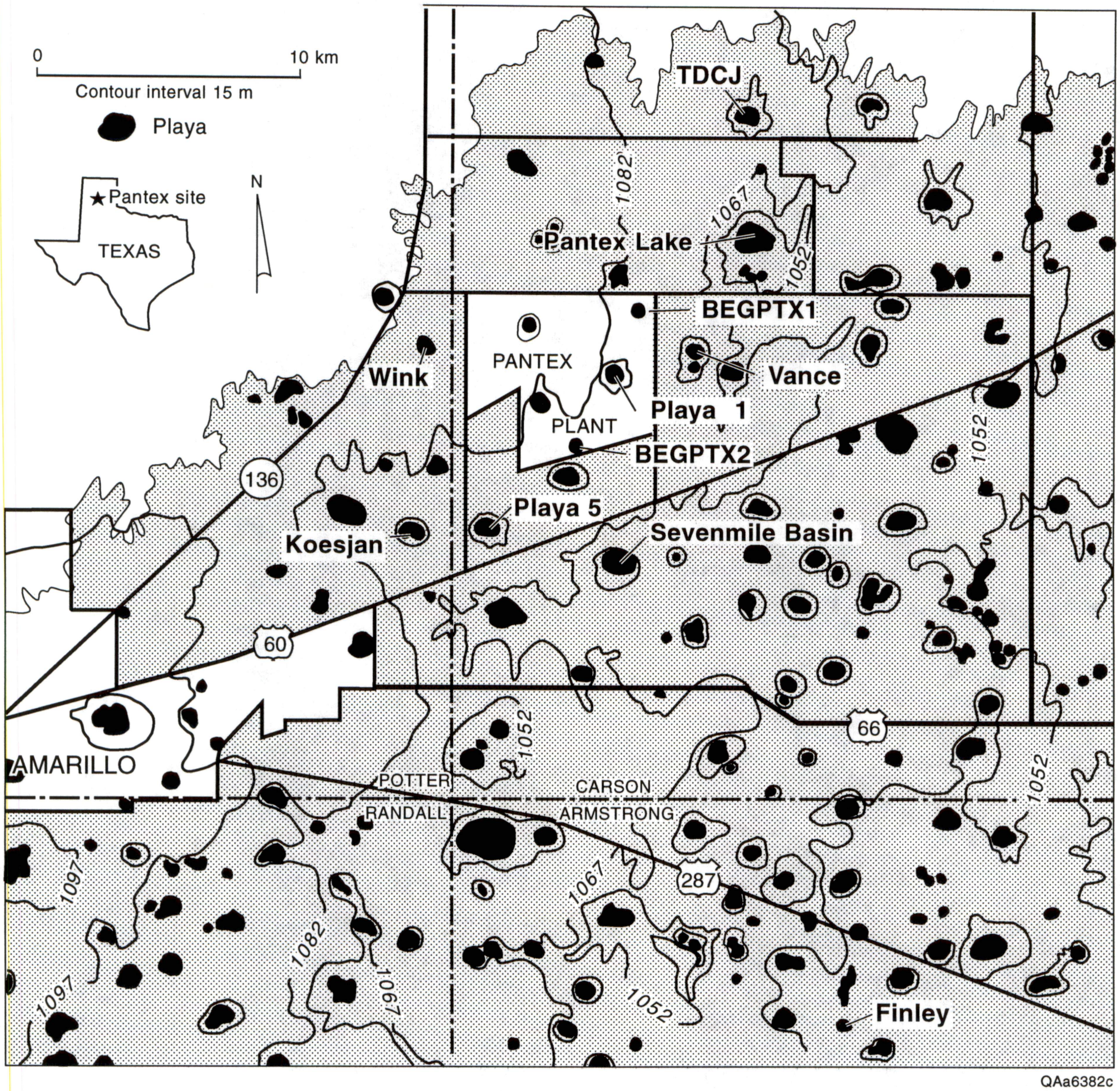

Figure 1. Location of the study area.

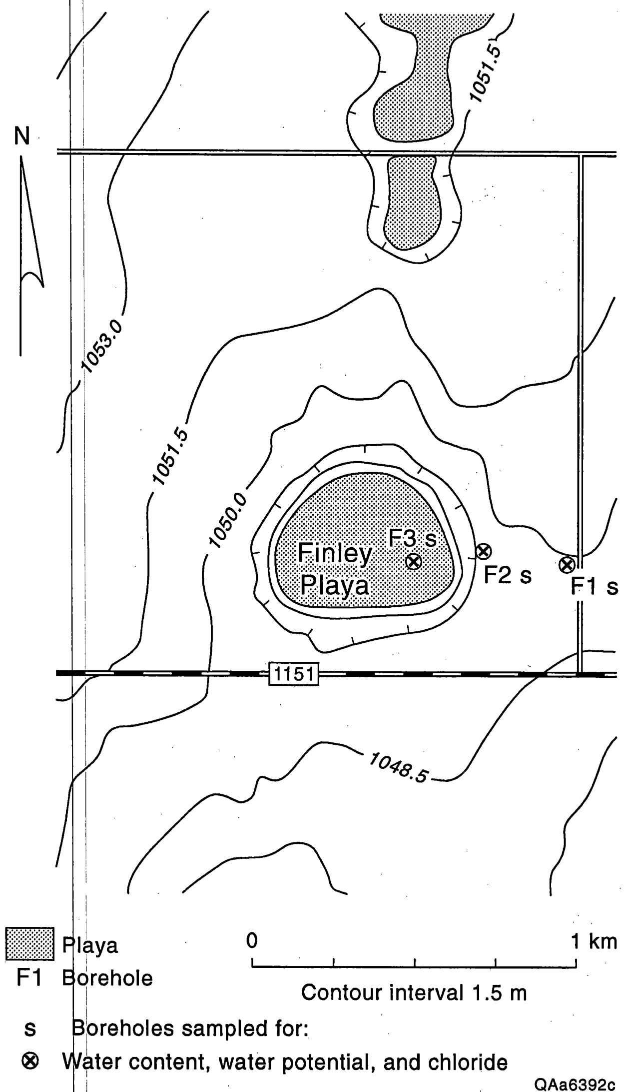

Figure 2. Location of sampled boreholes at Finley playa basin.

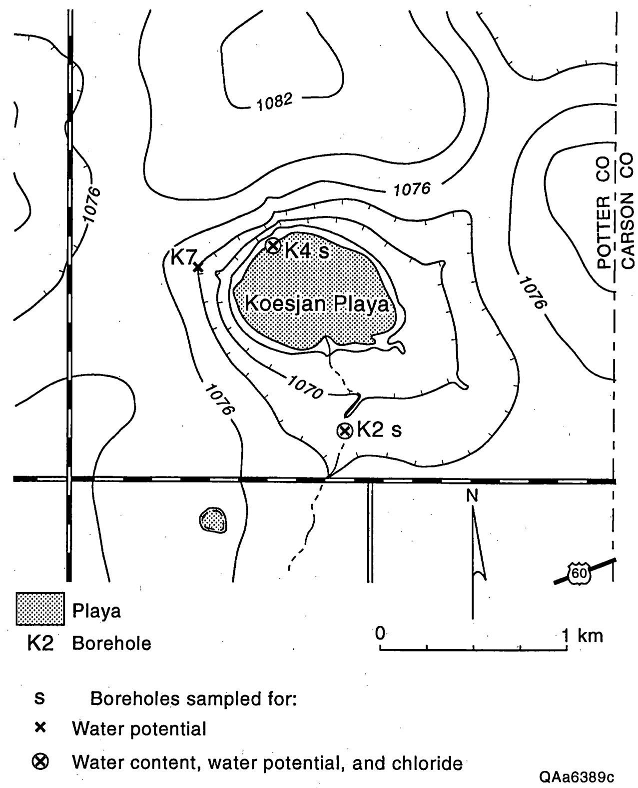

Figure 3. Location of sampled boreholes at Koesjan playa basin.

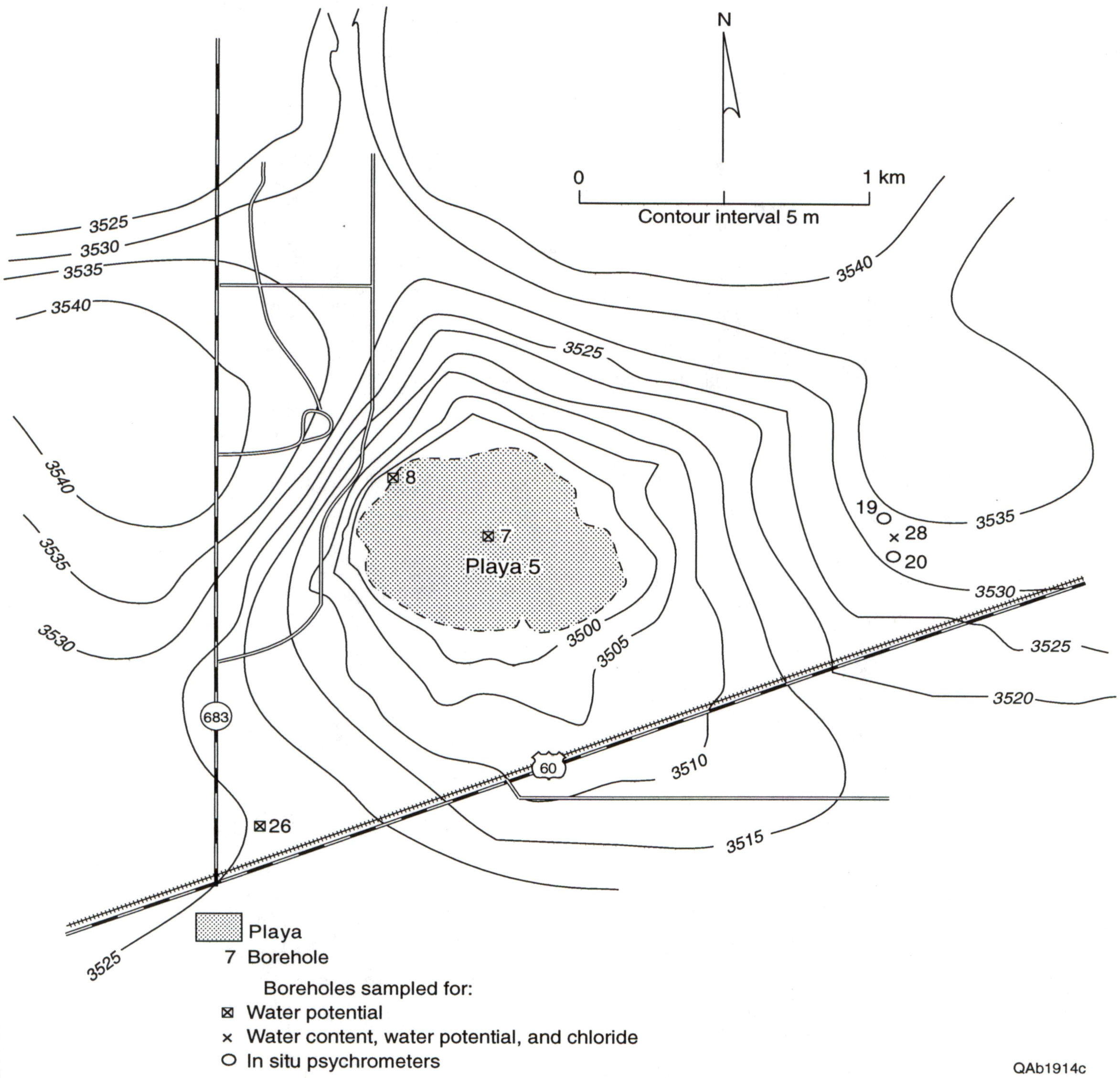

Figure 4. Location of sampled boreholes and unsaturated zone monitoring equipment at Playa 5 basin.

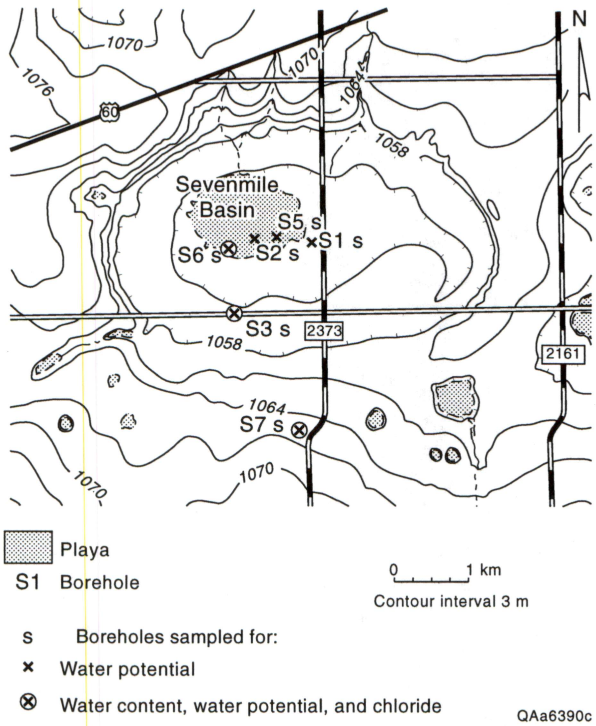

Figure 5. Location of sampled boreholes at Sevenmile Basin playa basin.

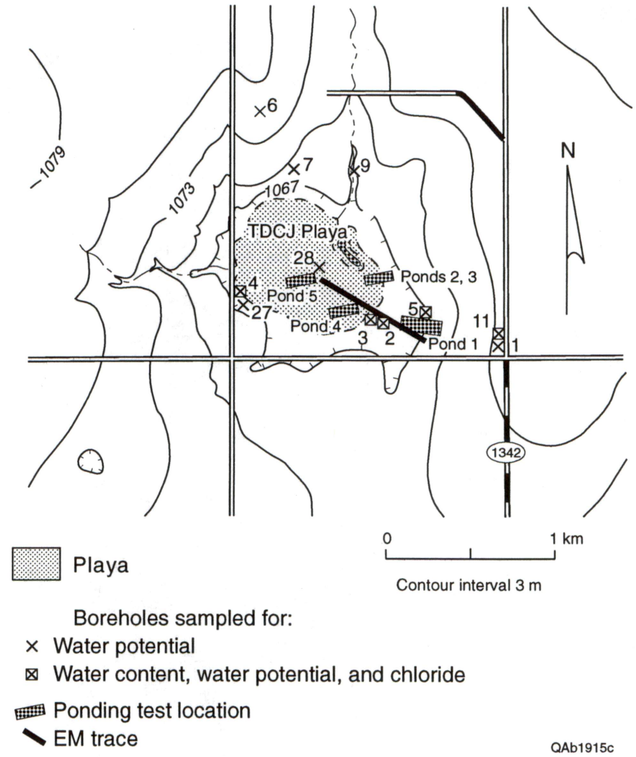

Figure 6. Location of sampled boreholes, trenches, and EM transect at TDCJ playa basin.

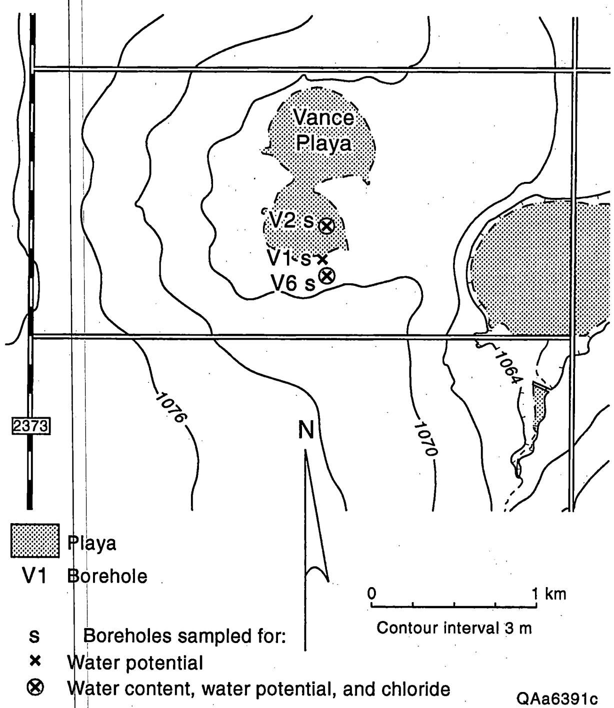

Figure 7. Location of sampled boreholes at Vance playa basin.

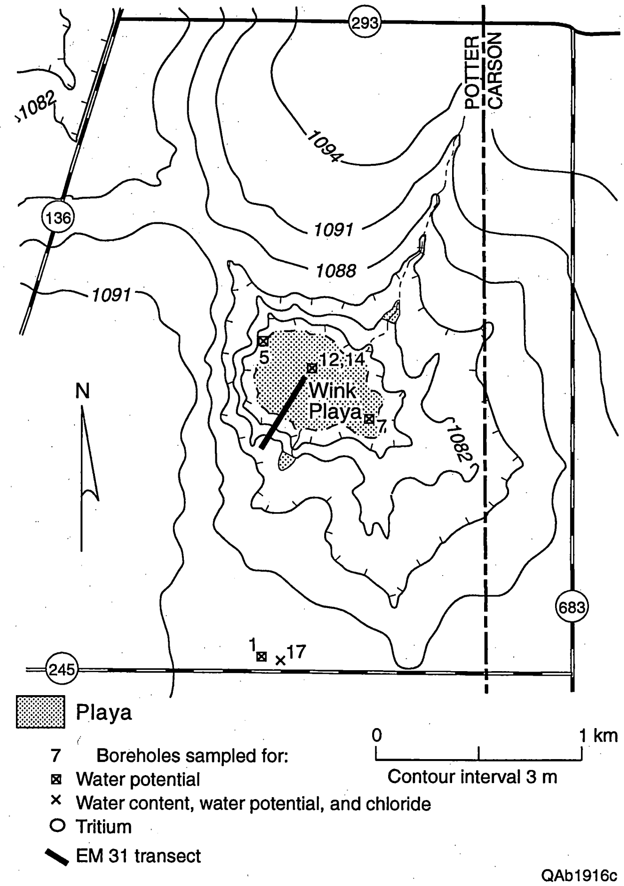

Figure 8. Location of sampled boreholes and EM transect at Wink playa basin.

Table 2. Characteristics of playas examined during this study (modified from Hovorka, 1995).

Playa name	Playa area (km²)	Basin area (km²)	Playa relief (m)	Basin relief (m)	Length of defined drainages (km)
Finley	0.19	4	2	5	0.9
Koesjan	0.43	7	6	12	2.3
Playa 5	0.42	8	2	11	3
Sevenmile Basin	1.3	47	6	20	8.2
TDCJ	0.53	11	3	11	4.9
Vance	0.45	5	2	11	10
Wink	0.29	8	8	11	4.6

Table 3. Summary of boreholes drilled, samples collected, and monitoring equipment installed.

Borehole	Geomorphic setting	Drilling date	Analyses	Total depth (m)
BEGPTX 1	Interplaya	1/92	wc, wp, Cl	24.35
BEGPTX 2	Interplaya	1/92	wc, wp, Cl	22.06
Finley 1	Interplaya	9/9/91	wc, wp, Cl	4.24
Finley 2	Annulus	9/10/91	wc, wp, Cl	12.18
Finley 3	Playa	9/13/91	wc, wp, Cl	14.22
Koesjan 2	Interplaya	8/28/92	wc, wp, Cl	13.35
Koesjan 4	Annulus	8/27/92	wc, wp, Cl	31.49
Koesjan 7	Interplaya	8/26/93	wp	19.17
Playa 5 #19	Interplaya	4/4/94	psychrometers	22.49
Playa 5 #20	Interplaya	4/4/94	psychrometers	23.1
Playa 5 #7	Playa	10/12/94	wc, wp, Cl	26.97
Playa 5 #8	Sewage outfall	10/20/94	wc, wp, Cl	25.42
Playa 5 #26	Interplaya	10/24/94	wc, wp, Cl	17.65
Playa 5 #28	Interplaya	10/23/94	wp	25.44
Sevenmile Basin 1	Annulus	9/9/92	wp	22.71
Sevenmile Basin 2	Playa	8/30/92	wc, wp, Cl	27.04
Sevenmile Basin 3	Interplaya	9/13/92	wc, wp, Cl	21.98
Sevenmile Basin 5	Playa	9/12/92	wp	10.42
Sevenmile Basin 6	Playa	9/11/92	wp	10.7
Sevenmile Basin 7	Interplaya	9/15/92	wc, wp, Cl	20.6
TDCJ 1	Interplaya	9/16/91	wc, wp, Cl	9.22
TDCJ 1B	Interplaya	9/23/91	wc, wp, Cl	4.5
TDCJ 2	Annulus	9/24/91	wc, wp, Cl	9.04
TDCJ 3	Annulus	9/27/91	wc, wp, Cl	24.38
TDCJ 4	Annulus	12/3/91	wc, wp, Cl	26.21
TDCJ 5	Interplaya	12/4/91	wc, wp, Cl	18.56
TDCJ 6	Interplaya	8/4/92	wp	24.38
TDCJ 7	Annulus	8/5/92	wp	22.34
TDCJ 9	Drainage	8/7/92	wc, wp, Cl	29.87
TDCJ 11	Interplaya	8/25/92	wp	23.25
TDCJ 27	Annulus	4/1/93	wp	35.36
TDCJ 28	Playa	4/2/93	wc, wp, Cl	21.4
Vance 1	Interplaya	3/16/93	wp	6.92
Vance 2	Playa	10/11/93	wc, wp, Cl	25.48
Vance 6	Interplaya	10/13/93	wc, wp, Cl	12.16
Wink 1	Interplaya	9/1/92	wc, wp, Cl, ^{36}Cl	26.27
Wink 5	Annulus	8/26/92	wc, wp, Cl	32.03
Wink 7	Playa	2/23/93	wc, wp, Cl	33.8
Wink 13	Playa	9/22/93	wc, Cl	30.69
Wink 14	Playa	9/26/93	tritium	29.78
Wink 17	Interplaya	10/7/93	wp	17.95

wc = water content, wp = water potential, Cl = chloride.

TDCJ, Wink, and Finley playa basins (figs. 2, 6, and 8) had boreholes most clearly set in distinct interplaya and playa settings. Boreholes TDCJ 1, Wink 1, and Finley 1 contain the best examples of interplaya sediments. Samples from the interplaya regions at Koesjan (Koesjan 2) (fig. 3), and Sevenmile Basin (SMB 3, 7, fig. 5) were collected from boreholes in locations that appear to be drainage areas. The borehole Vance 6 (fig. 7) is within 200 m of the playa and may be more representative of an annular setting.

Detailed geologic and geophysical studies indicate that the playas in the study area existed during sediment deposition (Gustavson, 1995). The existence of paleotopography on subsurface stratigraphic horizons was shown by analysis of geologic logs and by geophysical data. Shallow seismic reflection profiles across four playas in the study area indicate that dissolution of Permian salt was important in their development (Paine, 1995). The distributions of lake clays and delta sediments also indicate that playa size has varied with time, presumably in response to paleoclimatic variations (Hovorka, 1995). These ideas about playa origin contrast with those of Osterkamp and Wood (1987) and Wood and Osterkamp (1987), who suggested that playa lake basins are recent and result from focused flow that dissolves carbonate in the subsurface and results in piping and illuviation.

Climate

The regional climate is semiarid, with long-term mean annual precipitation of 500 mm based on precipitation recorded in Amarillo from 1948 to 1992 (fig. 9). Precipitation in the region, which is characterized by large interannual variations, ranged from 243 mm (1970) to 931 mm (1960). Analysis of precipitation data from 1948 to 1992 indicates that approximately 70% falls from May through September. Some precipitation falls as snow during the winter but generally melts after a short time. During the study period (1991 through 1994), average annual precipitation was 440 mm, which is slightly lower than the long-term average precipitation (fig. 9). Wind speeds generally range from 16 to 24 km hr^{-1} (NOAA, 1974).

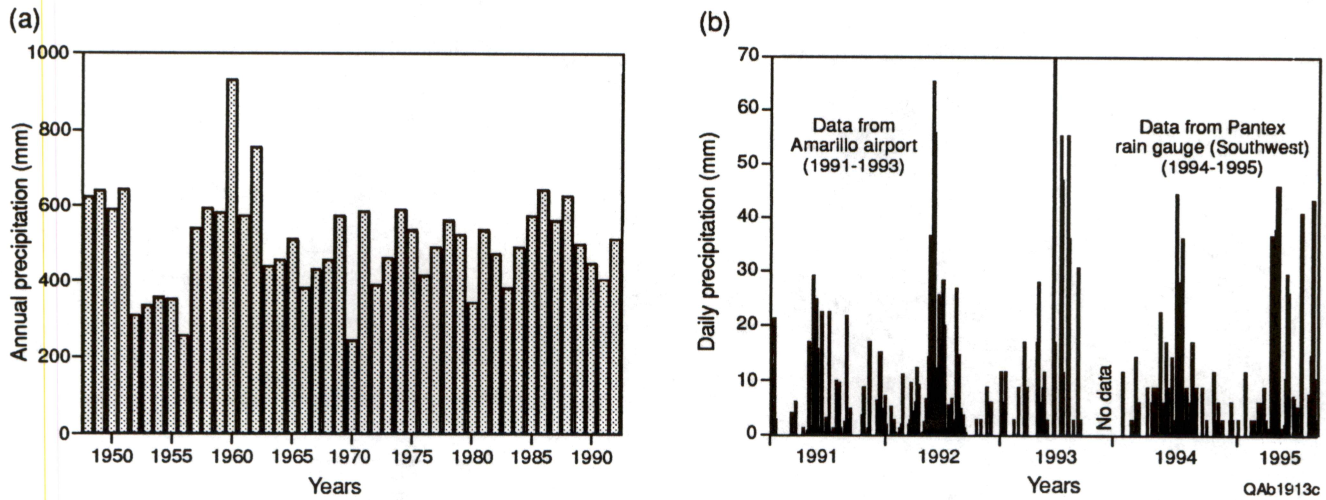

Figure 9. (a) Annual precipitation (1948–1992) from Amarillo airport and (b) daily precipitation at Amarillo airport (1991–1993) and at Playa 5 (1994–1995).

METHODS

Laboratory Methods

Texture and water content

Particle size analyses were conducted on sediment samples from 18 boreholes. Carbonate was dissolved in 10% HCl with constant stirring until the pH of the sample was ≤5. The gravel fraction (≥2 mm) was determined by sieve analysis, and the percent sand, silt, and clay was determined by hydrometer analysis (Gee and Bauder, 1986). Sediment samples generally contained less than 2% gravel and were classified according to the U.S. Department of Agriculture (1975) system.

Samples were collected from 26 boreholes for laboratory measurement of gravimetric water content (figs. 2–8). These samples were placed in pre-weighed containers and sealed in the field with paraffin tape. The samples were weighed the same day they were collected. Gravimetric water content was measured by oven drying the soil samples at 105°C for 24-hr intervals until the weight change was less than 5%.

Water potential

Sediment samples were collected from 38 boreholes (figs. 2–8) for water potential measurements in the laboratory. Many of the samples were collected from the same boreholes as those sampled for water content. The samples were transferred from the core barrel to mason jars, which were sealed with paraffin wax or beeswax. Water potential was measured in the laboratory using two different instruments, a water activity meter (model CX-2), and a thermocouple psychrometer with a sample changer (model SC-10), both manufactured by Decagon Devices, Inc., Pullman, WA. The water activity meter measures the water activity (A_W) of soil samples from 0.100 to 1.000. This corresponds to water potentials of –316 to 0 MPa with a resolution of ± 0.003 water activity units across the range (Gee et al., 1992). The water activity is converted to water potential (ψ, in MPa) using the Kelvin equation (Rawlins and Campbell, 1986):

$$\psi = RT/M \ln(A_W) \tag{5}$$

where R is the ideal gas constant (8.31 J K^{-1} mol^{-1}, T is temperature (K), and M is the molecular mass of water (0.018 kg mol^{-1}). The accuracy of the water activity meter was checked using saturated salt solutions before and after each set of samples. The Decagon SC-10 was calibrated using NaCl solutions that ranged in concentration from 0.05 M to saturated and corresponded to water potentials of –0.2 to –38 MPa at 20°C (Lang, 1967). The standard error of estimate for the SC-10 thermocouple psychrometer based on analysis of 20 calibration solutions was 0.06 MPa. To evaluate uncertainties in water potentials measured with the SC-10 and CX-2 in the wet range (≥ –0.2 MPa), matric potential was measured with tensiometers in six samples from Playa 5 # 7. Core samples collected for matric potential were sealed in plastic wrap and encased in wax and cheesecloth. Pressure transducer tensiometers (Model #136PC15G1 pressure transducers, Microswitch, Dallas, TX; Model # 652X03B1M3 ceramic cups, Soil Moisture Equipment Corp., Santa Barbara, CA) were saturated under vacuum with deaired water. A small hole, slightly smaller than the tensiometer was drilled in each sample, and the tensiometer was installed and sealed with silicone. The tensiometers were monitored with a datalogger (Model CR10, Campbell Scientific Inc., Logan, UT). Matric potentials were read when readings stablized after 24 hr.

Environmental tracers

Meteoric Chloride

A total of 26 boreholes were sampled for chloride concentrations (figs. 2–8). Chloride was extracted from the pore water by adding double-deionized water to the dried sediment sample in a 3:1 ratio. Samples were agitated on a reciprocal shaker table for 4 hr. Chloride in the supernatant was then analyzed by potentiometric titration using a 672 Titroprocessor and a 655 Dosimat (Metrohm Inc., Switzerland) or by ion chromatography (Model 2010i chromatograph, Dionex Corp., Sunnyvale, CA) on samples filtered through 0.45 μm filters.

Chlorine-36

Three chlorine-36 samples were collected from borehole Wink 1 (fig. 8) at depths of 2.8, 4.4, and 10.9 m. Chloride concentrations at these depths were 117, 59, and 25 mg Cl kg^{-1} soil, respectively. Approximately 1 kg of soil was collected for the two shallowest samples, and 1.5 kg of soil for the deepest sample. Samples were then prepared by extracting the chloride in double deionized water. The supernatant was purified by repeatedly precipitating chloride with $AgNO_3$ and dissolving the precipitate with NH_4OH. Sulfates were removed by precipitation with $Ba(NO_3)_2$. Blanks were prepared from reagent grade chloride that has a very low $^{36}Cl/Cl$ ratio. These blanks were processed along with the samples in order to detect any contamination during processing. The resultant AgCl was shipped in vials wrapped in aluminum foil to Lawrence Livermore National Laboratory for quantitative determination of chlorine-36 by tandem accelerator mass spectrometry according to procedures outlined in Elmore et al. (1984). Uncertainties were calculated following Elmore et al. (1984) and are reported as one standard deviation.

Tritium

Samples for tritium analysis were collected from borehole Wink 14 in November 1993 (fig. 8). The samples were collected with a split spoon sampler and were immediately transferred to mason jars, which were sealed with paraffin wax and placed in thermally sealed plastic core bags. The water was extracted from the core samples in the laboratory by toluene azeotropic distillation. The pore water samples were purified with paraffin wax and analyzed enriched and unenriched by standard direct scintillation methods. Originally 25 samples were analyzed unenriched. Each sample was distilled, and 10 g were counted for 500 min. The detection limit was 9 TU, and the standard error was ± 5 TU. Eight additional samples were measured enriched by combining adjacent samples to obtain sufficient water for analysis. Samples with 150 to 170 g of water had a standard error of 1.0 TU. Five samples with 100 to 150 g of water had a standard error of 1.3 TU. The detection limit for these samples was 0.7 TU.

Field Methods

Water Potential

Thermocouple psychrometers were installed in the interplaya setting adjacent to Playa 5 to monitor temporal variations in water potential and temperature (boreholes 19, 20; fig. 4). The psychrometers consisted of screen-caged, thermocouple psychrometers (Model 74, PST 66; J.R.D. Merrill Specialty Equipment, Logan, UT). At shallow depths, the psychrometers were installed with a Bosch rotary hammer drill (Model 11209) and auger bit in pilot holes drilled horizontally into the wall of a 1.8-m-deep pit. Psychrometers were installed in duplicate at staggered depths of 0.1, 0.2, 0.3, 0.5, 0.8, 1.1, and 1.4 m. The holes were sealed with backfill from the pit, and the pit was backfilled with the original sediments. At greater depths, duplicate psychrometers were installed in two adjacent boreholes, drilled with a 76-mm-diameter solid-stem auger to depths of 22.5 and 23.0 m. The psychrometers were emplaced in PVC screens (25.4 mm diameter, 0.010 slot size, 152 mm long) filled with commercial 20-40 sand. The psychrometers were installed at depths of 1.7, 4.6, 6.1, 12.2, 18.3, and 21.3 m. The boreholes were backfilled with commercial 20-40 sand. Epoxy (DER324/DEH24, Dow Chemical Company) was used to prevent preferential water or air flow between psychrometer stations within the borehole and to form a seal at the surface, precluding surface drainage into the borehole. Epoxy properties such as curing time, viscosity, and exothermic curing temperature were tested in the laboratory prior to field use. The sand and epoxy were poured down separate tremie pipes, and the sand was poured down the tremie pipe immediately after the epoxy to form a sand/epoxy column, minimizing the exothermic reaction temperature. The psychrometers were connected to a datalogger (Model CR7; Campbell Scientific, Inc., Logan, UT) that is powered by a solar panel, rechargeable internal battery, backed up by a 12V deep-cycle marine battery. Water potentials and temperatures were logged daily at 0900 hr local time.

Electromagnetic Induction

Measurements of apparent electrical conductivity were made with an EM-31 instrument (Geonics, Mississauga, Ontario, Canada) from the interplaya to the playa in Wink and TDCJ playa basins (figs. 6, 8). The theoretical basis for these measurements is described in McNeill (1992). The EM-31 instrument operates at a frequency of 9800 Hz and consists of a transmitter coil placed on the ground that is energized with an alternating current at an audio frequency. This current generates a primary magnetic field, which in turn induces small currents that generate their own secondary magnetic field. The receiver coil responds to both the primary and secondary magnetic field components. Under low values of induction number, the secondary magnetic field is a linear function of conductivity. The intercoil spacing on the EM31 is 3.7 m and results in an exploration depth of 3.0 m when the instrument is operated in the horizontal dipole mode (both coils lying vertically on the ground) and 6 m when the instrument is operated in the vertical dipole mode (both coils lying horizontally on the ground). The instrument was operated in the horizontal and vertical dipole modes in this study to evaluate changes in conductivity with depth.

Ponding Tests

A total of five ponding tests were conducted at TDCJ playa basin (fig. 6, table 4). Three ponding tests were conducted in May and June 1993, and two were conducted in December 1994. Ponding tests were conducted in interplaya, annulus, and playa areas. The general procedure for all the ponding tests was similar and included application of dyed water until a head of 100 to 180 mm was attained in various ponds (table 4). The ponded water was allowed to drain. After drainage

Table 4. Ponding tests conducted at TDCJ playa basin.

Pond no.	Date	Initial ponding depth (m)	Location	Area ponded	Vegetation	Tracer concentration (M Br^-)	Tracer concentration FD&C Blue dye (wt. %)	Amount of H_2O applied (L)	Time to drainage (hr)
1	5/93	100	Interplaya	2 m^2	Cleared	2.24×10^{-3}	est. 1.5	240	6
2	6/93	180	Annulus above high water line	2 m^2	Cleared	none	est. 1.5	240	>16
3	6/93	150	Annulus below high water line	2 m^2	Cleared	none	est. 1.5	200	>18
4	12/94	100	Playa 30 m from annulus	2.6 m^2	None	9.58×10^{-2}	0.26	600	25
5	12/94	100	Playa 320 m from annulus	2.6 m	None	9.61×10^{-2}	0.32	300	72

was complete, a trench was excavated through the ponded area to visually inspect the distribution of the dye in the subsurface and to collect soil samples for water content and bromide. The dye patterns on the vertical face were photographed and traced. Gravimetric water content was determined in the laboratory. The bromide was extracted in the same manner as the chloride, and was analyzed with a ion specific bromide electrode (Model 94-35, Orion Research Inc., Boston, MA) and a pH meter (Model PHM64, Radiometer Copenhagen, NV).

The following describes differences in the techniques used in the various ponding tests. Water was ponded in tests 1, 2, and 3 with a wooden frame 1 m by 1 m, whereas a ring infiltrometer (radius 0.9 m) was used for ponding tests 4 and 5. Ponds 2 and 3 were excavated before all the water had infiltrated. Approximately 100 mm of water had drained in 16 hr in Pond 2 and 120 mm in Pond 3 when the trench was excavated. Wick samplers were installed beneath Ponds 4 and 5 to evaluate temporal variations in preferential flow. An access trench was dug with a backhoe, adjacent to each ring. Tunnels were dug by hand to install the wick samplers. The wick samplers were installed at a depth of 1.1 m directly beneath the ponds. The wick samplers consisted of 25 wicks, each sampling an area of 50 mm by 50 mm. The samplers exert a nominal suction of 0.005 MPa on the soil. Water collected in the samplers was analyzed for dye concentration on a filtered subsample with a spectrophotometer (Model DB, Beckman Instruments Inc., Fullerton, CA) using a wavelength of 410 nm.

RESULTS

Sediment Texture

Textural analyses conducted in this study provide point measurements of texture and were compared with lithologic core descriptions and geologic cross sections described in Hovorka (1995). Surficial sediments in many playas were clay rich (app. A). The amount of clay generally ranged from 40 to 60%. The thickness of this clay rich zone varied widely among playas and was fairly shallow in some playas (1.5 m, Finley 3; 1.4 m Wink 7) and was much deeper in other playas (13.9 m SMB 2; 14.4 m TDCJ 28). Many playas have a more sand rich zone (40 to 91% sand) at depth (~7 m Finley 3; ~11 m SMB 3; ~16 m TDCJ 28; ~11 m Vance 2). Some of the playas have alternating sand and clay rich zones every few m beneath the playa (Finley 3), whereas others have clay lenses at depth. Surficial sediments in the annular region were coarser grained than corresponding zones beneath the playa. The annular profiles generally consist of alternating sand and clay rich zones that mark fluctuations in the playas with time (Hovorka, 1995), particularly in TDCJ 3. Interplaya sediments are coarser grained than the playa sediments in the shallow subsurface and generally contain a lower percent clay and higher percent silt (TDCJ 1, 2, and 3; Wink 1). Geologic cross sections indicate that the deeper sand-rich zones extend from the playas to the interplayas and maintain the topography of the playas. Texture profiles in the interplayas and playas are generally more uniform than those in the annular regions.

The carbonate content in playa sediments is generally ≤10% (TDCJ 28 and Wink 13) (app. A). Finley playa, which is smaller than TDCJ or Wink playas, has more variable carbonate content (2 to 45%) throughout the profile. In contrast, carbonate content is much higher in the interplaya profiles (5 to 54%), particularly in the upper 1 to 2 m zones (Finley 1, TDCJ 1, and TDCJ 5). Pits dug adjacent to TDCJ 1 showed massive carbonate in the top 1 to 2 m section (Stage III; Hovorka, 1995). In contrast, cores from the Finley 1 profile showed stringers of carbonate that resembled roots. The carbonate content decreases in the profiles toward the playas, and profiles in the annular regions have only local zones of high carbonate (TDCJ 2, 3, and 4). The reduction in carbonate content from interplaya to playa profiles is seen in the decrease in mean carbonate content in the profiles (app. A).

Water Content

Water content was generally much higher in profiles beneath the playas than in profiles in interplaya settings (figs. 10–16, apps. A and B). Water content in the profiles in the annular settings of the playa basin generally was intermediate between those of the playa and interplaya settings. The water content variations among the different settings cannot be explained solely by

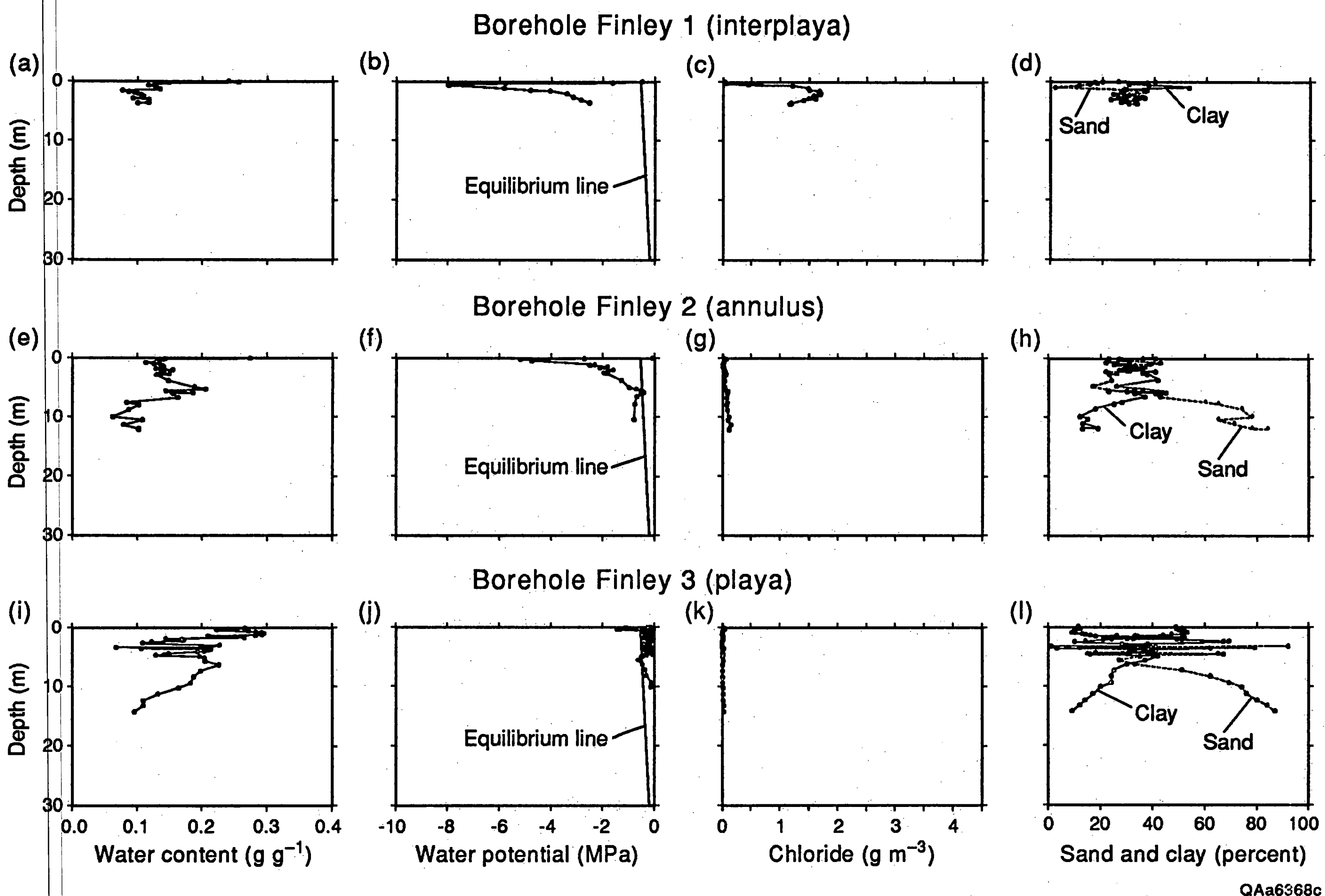

Figure 10. Profiles of gravimetric water content, water potential, chloride, and texture for boreholes in Finley playa basin.

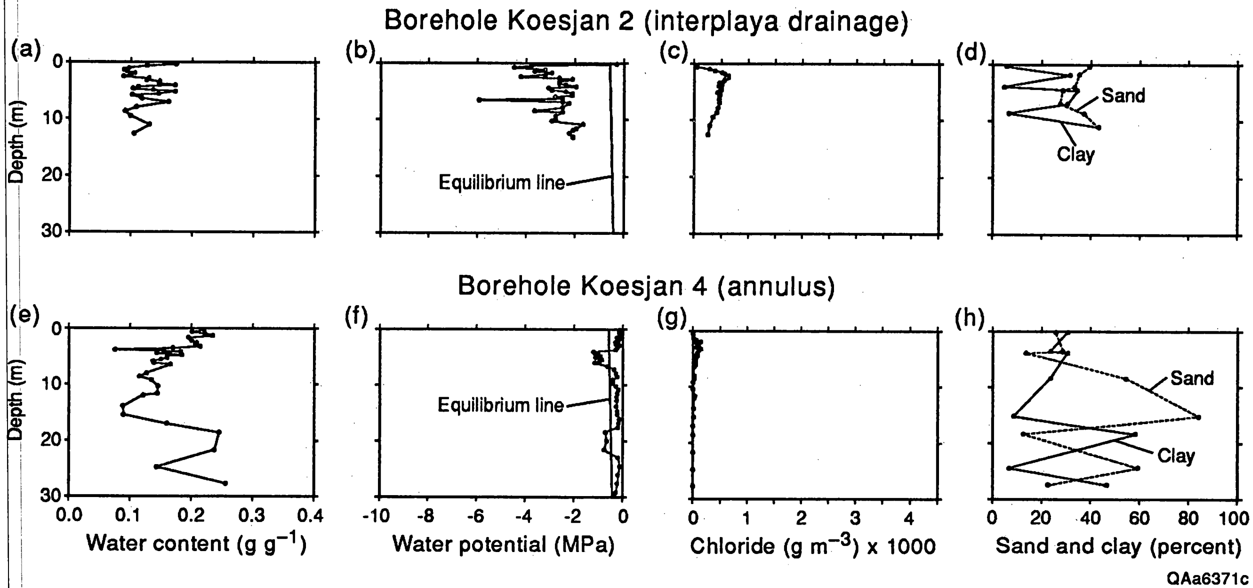

Figure 11. Profiles of gravimetric water content, water potential, chloride, and texture profiles for boreholes in Koesjan playa basin.

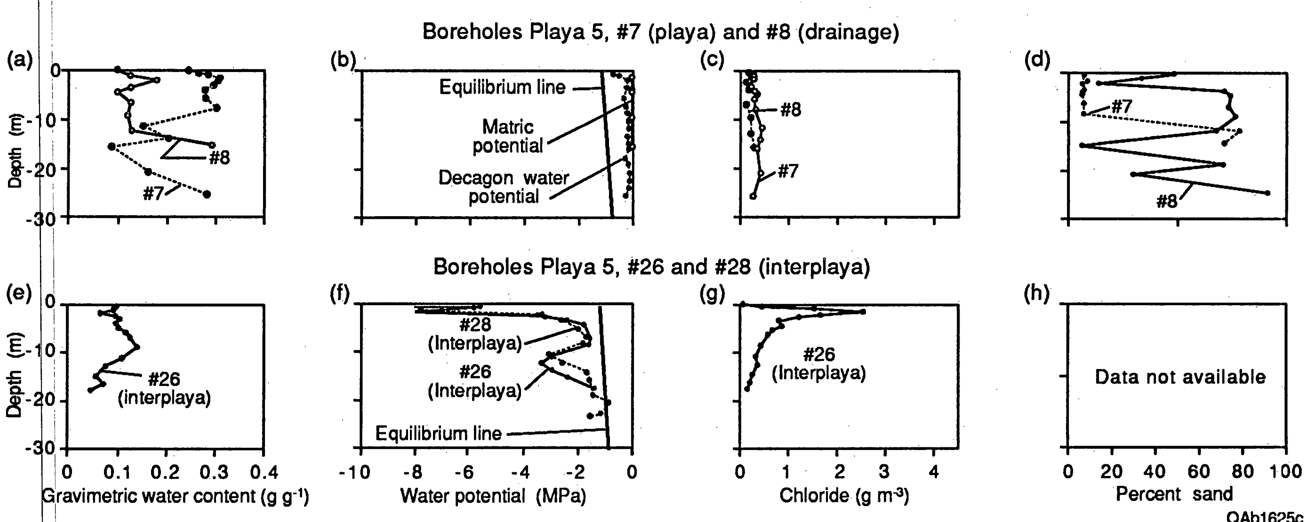

Figure 12. Profiles of gravimetric water content, water potential, chloride, and texture for boreholes in Playa 5 playa basin.

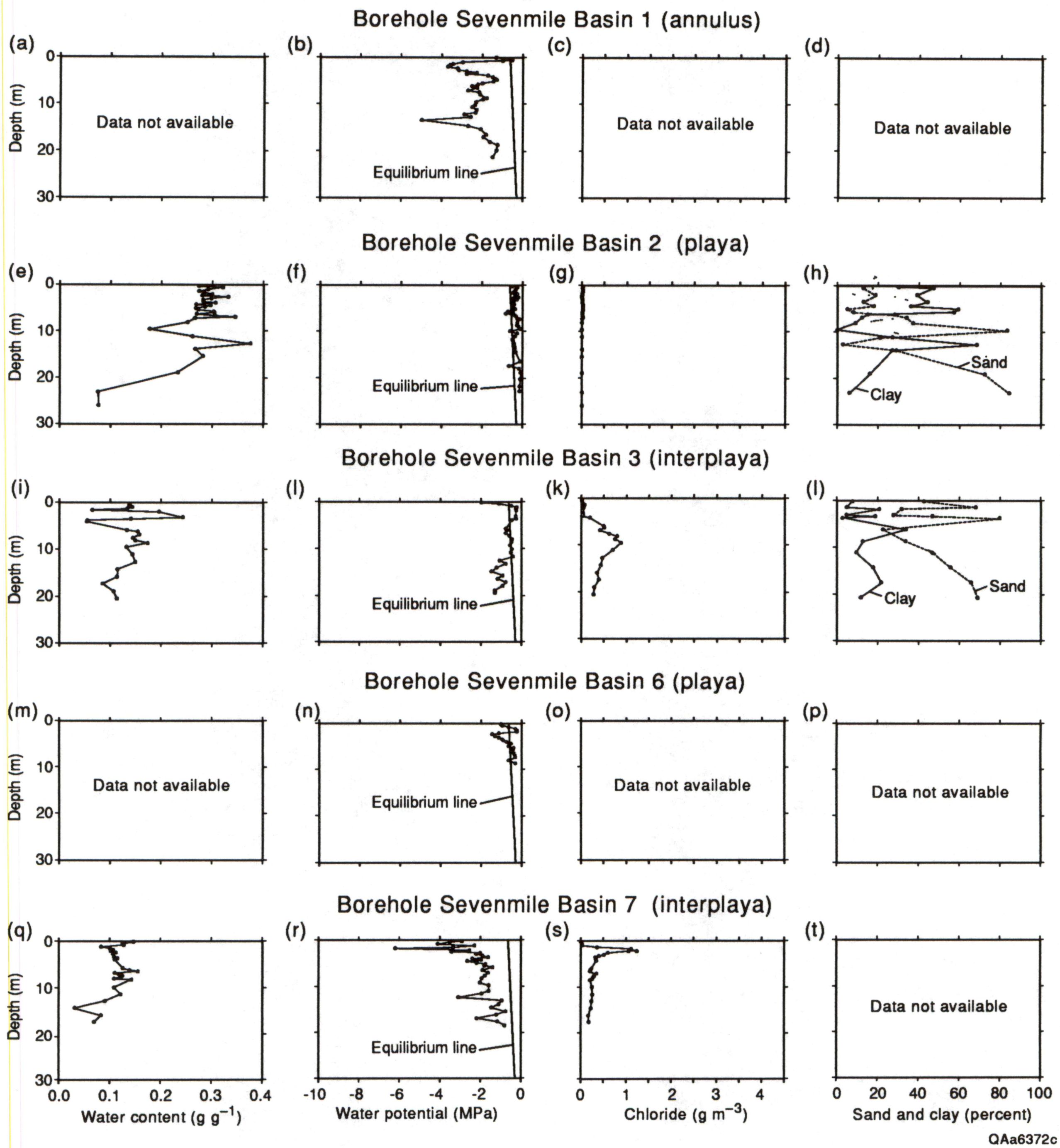

Figure 13. Profiles of gravimetric water content, water potential, chloride, and texture for boreholes in Sevenmile Basin playa basin.

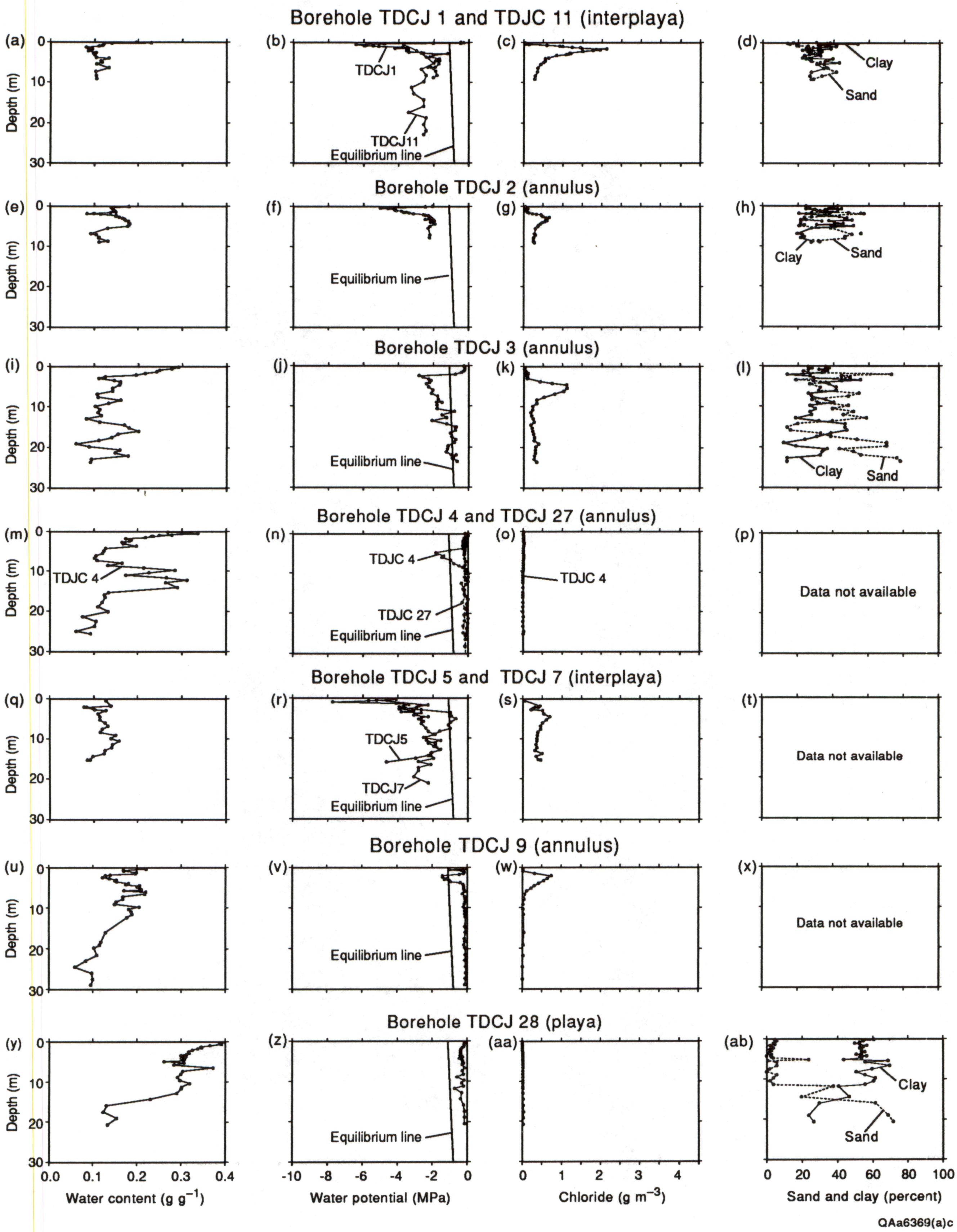

Figure 14. Profiles of gravimetric water content, water potential, chloride, and texture for boreholes in TDCJ playa basin.

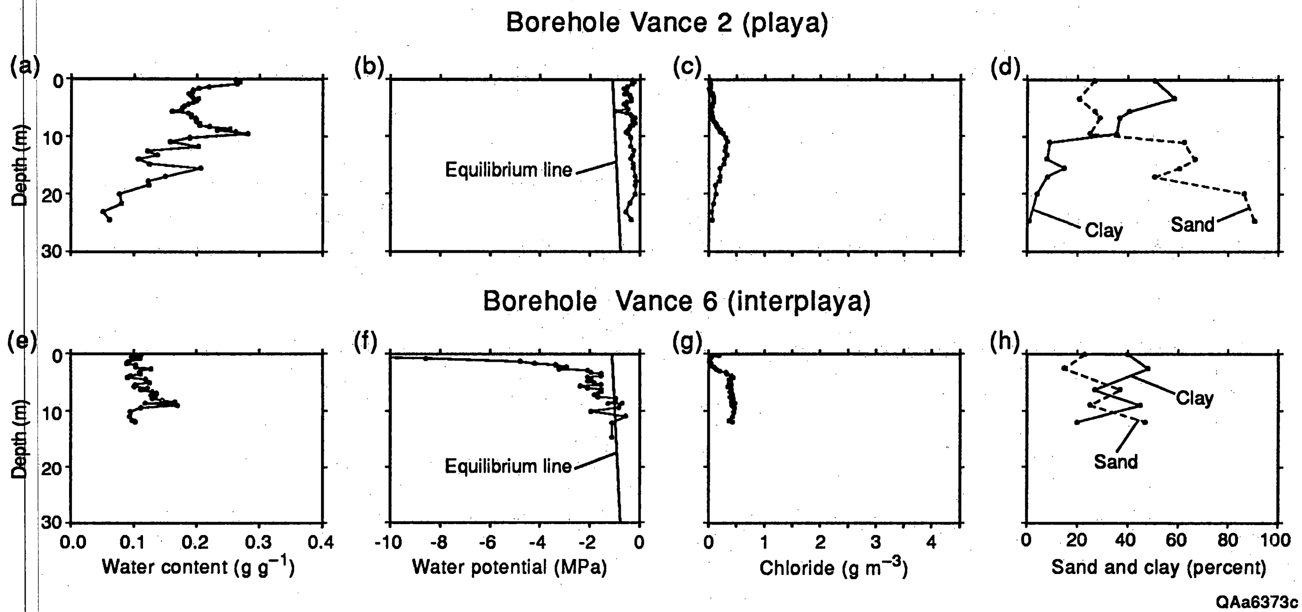

Figure 15. Profiles of gravimetric water content, water potential, chloride, and texture for boreholes in Vance playa basin.

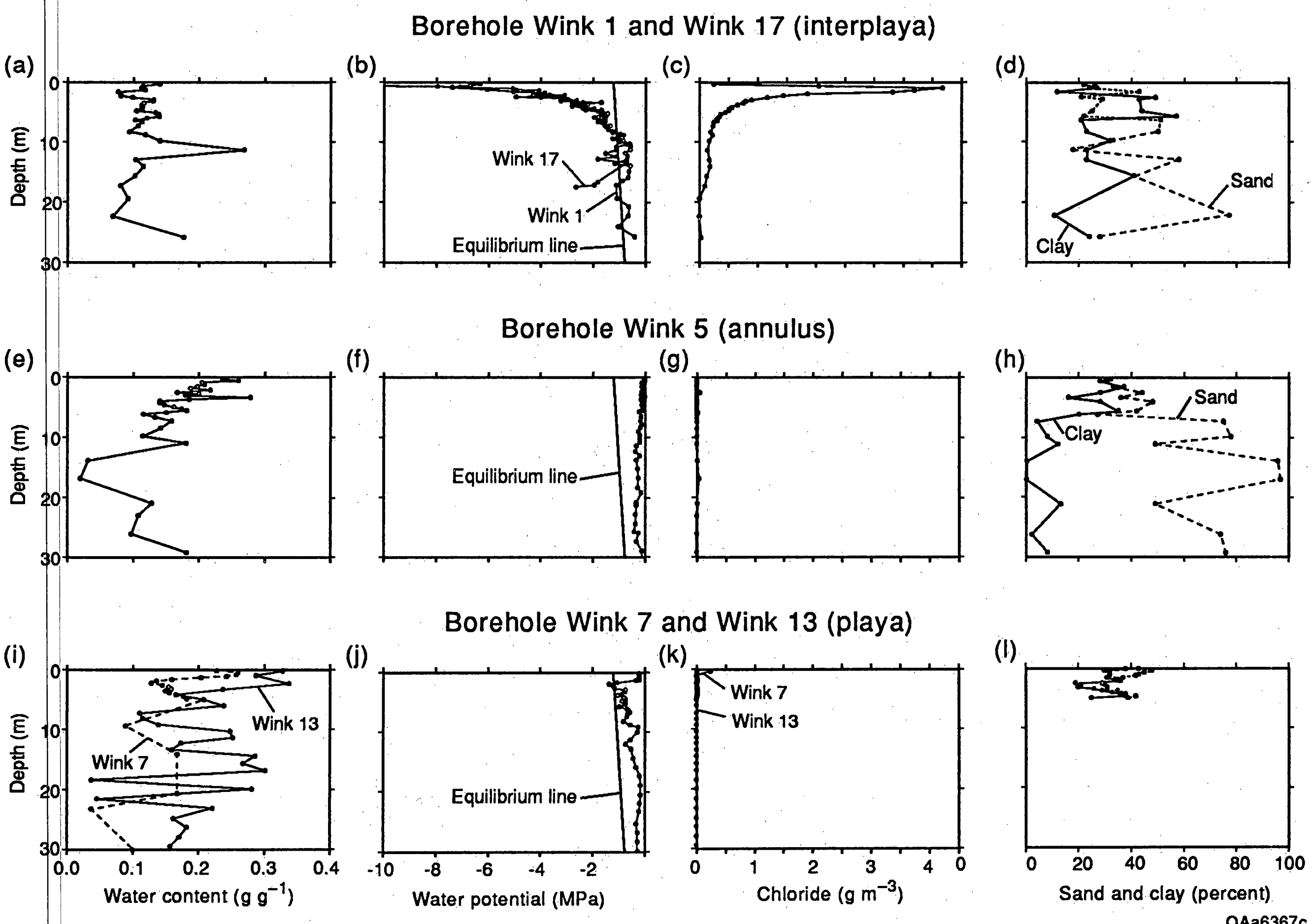

Figure 16. Profiles of gravimetric water content, water potential, chloride, and texture for boreholes in Wink playa basin.

differences in texture. In Finley playa basin, for example, similar textures (clay loam) had average water contents of 0.10 g g^{-1} in the interplaya borehole (Finley 1), 0.14 g g^{-1} in the annular borehole (Finley 2), and 0.21 g g^{-1} in the playa borehole (Finley 3). These differences are attributed to higher subsurface water fluxes beneath playas than in the annular and interplaya settings.

Water content and texture were highly correlated. Correlations between water content and clay and silt content were generally positive and between water content and sand content were generally negative (app. A). With the exception of profiles in Wink Playa, correlations between water content and texture were highest for profiles in the playa settings (r sand, –0.89 to –0.65; r clay, 0.62 to 0.85) and were lower for profiles in interplaya settings (r sand, –0.88 to 0.25; r clay, –0.13 to 0.85; table 5). This may be attributed to the higher carbonate content in the interplaya settings, which is not reflected in the grain size distribution.

Some profiles sampled after rainfall had highest water content in near-surface sediments. This is most obvious in profiles in interplaya areas and showed that the wetting front generally penetrated to depths of 0.2 to 0.3 m where water contents decreased by ~ 0.1 g g^{-1} (Finley 1 and 2, and TDCJ 1; figs. 10a, 10e, and 14a).

Water Potential

In playa sediments, laboratory-measured water potentials were much higher than those in the interplaya sediments, particularly in the upper 5 to 10 m (figs. 10–16, app. C). The high water potentials are consistent with the high water contents in profiles beneath playas. The osmotic potentials estimated from the chloride concentrations in the pore water were ≥ –0.01 MPa except in two playas (Vance 2, ψ_π –0.003 to –0.045; and Playa 5 #7, ψ_π –0.02 to –0.06 MPa; app. C). Vance playa is much smaller than many of the other playas, and the chloride is not completely flushed out. Playa 5 received discharge from sewage, and the high chloride content from the sewage accounts for the more negative values of osmotic potentials. In the remainder of the playas, however, the matric potential was approximately equivalent to the water (sum of matric and osmotic) potential because the magnitude of the osmotic potential was low. The matric potential gradient in the playa profiles was close to zero, and the calculated hydraulic head (sum of matric and gravitational potential) gradient was close to unity and suggests that water was draining. Water potentials in the playa profiles plot to the right of the equilibrium matric potential, which also indicates that under steady flow conditions water is draining in these sediments.

In the interplaya setting, boreholes sampled after a long dry period had low water potentials in near-surface sediments (as low as –30 MPa, Wink 17, at 0.05 m depth; app. C). These low water potentials indicate that the surficial sediments were extremely dry. Some profiles were sampled after rainfall and had high water potentials (–1.6 MPa, Finley 1, –0.46 MPa, TDCJ 1) near the surface that decreased markedly at the base of the wetting front (~ –4 MPa reduction in the 0.1 m depth interval at ~ 0.3 m depth, Finley 1 and TDCJ 1 and 11; figs. 10b and 14b). Except in the shallow subsurface after rainfall, water potentials generally increased with depth. Gradients were very steep in the shallow zone (~1.0 to 1.5 MPa m^{-1} in the upper 4 m TDCJ 1 and Wink 1 profiles). In contrast, gravitational potential gradients were negligible in this zone. The upward decrease in water potentials in the top 5 to 20 m indicates that there is an upward driving force for liquid and isothermal vapor movement. The osmotic potential was higher in the interplaya profiles (≥ –0.5 MPa) than in the playa profiles; however, when expressed as a percentage of the water potential the osmotic component was low (≤ 10%). In addition to the water potential gradients in the interplaya profiles, which indicate upward flow particularly in the upper 5 to 10 m, the water potentials plot to the left of the equilibrium line (figs. 10–16). Water potential gradients decreased with depth and indicate that water may be draining in the deeper subsurface in some profiles (figs. 12f, 15f, and 16b). Water potentials in these profiles also plot close to the equilibrium line, which further suggests drainage of water at depth.

The above analysis of water potential data was based on laboratory measurements with the Decagon SC-10 thermocouple psychrometer. The trends in water potentials with depth measured with the water activity meter were similar to those measured with the SC-10 psychrometer;

however, water potentials measured in the same samples with the water activity meter were slightly lower than those measured with the SC-10 psychrometer (fig. 17). Water potential measurements are not very accurate in the wet range (≥ –0.2 MPa). In the wet range typical of playa profiles, it would be more accurate to measure matric potentials with a tensiometer. Matric potentials measured with tensiometers on sediments from the Playa 5 #7 profile were higher than the water potentials measured with either the Decagon SC-10 or CX-2 (fig. 12b, table 5). This difference can only be partly accounted for by the osmotic component of the water potential not measured by the tensiometer and indicates the degree of uncertainty in the water potential measurements with thermocouple psychrometers at high water potentials.

Water potentials were monitored with in situ thermocouple psychrometers installed adjacent to Playa 5 (boreholes 19 and 20; fig. 4) in early April 1994 (fig. 18a). There is generally good agreement between duplicate psychrometers in the upper 1.3 m; however, one or both psychrometers installed at greater depths drifted toward zero, indicating failure of the psychrometer. It is difficult to assess psychrometer equilibration because the psychrometers were installed in early April, and monitoring did not begin until mid May because of problems with the data acquisition system. The field monitoring data showed that water potentials in the upper 0.3 m were close to zero, which indicates the maximum penetration depth of the wetting front during the monitoring period (fig. 18a). High rainfall was recorded in Playa 5 between April 25 and May 11 (38 mm) and also on May 23 (20 mm) that resulted in this wetting front. Water potentials decreased sharply, particularly at 0.3 and 0.5 m depth, in June 1994, which indicates rapid drying of the sediments as a result of evapotranspiration. Water potentials in the upper 0.8 m remained fairly low (~ –4 to –9 MPa) throughout the remainder of the monitoring period. Seasonal fluctuations in water potential (~ 0.5 MPa) were recorded at depths of 1.1 and 1.7 m. These seasonal water potential fluctuations have been recorded at many sites (Fischer, 1992; Scanlon, 1994) and are attributed to seasonal temperature fluctuations and to changes in water content as a result of thermal vapor flux. Below these depths water potentials remained fairly uniform after the initial equilibration period. The vertical distribution of water potentials show an upward decrease in

Table 5. Matric potentials measured with pressure transducer tensiometers from Playa 5 #7 core samples.

Depth (m)	Matric potential (MPa)
1.11	−0.056
1.28	−0.036
2.93	−0.037
4.33	−0.057
9.51	−0.047
15.36	−0.025

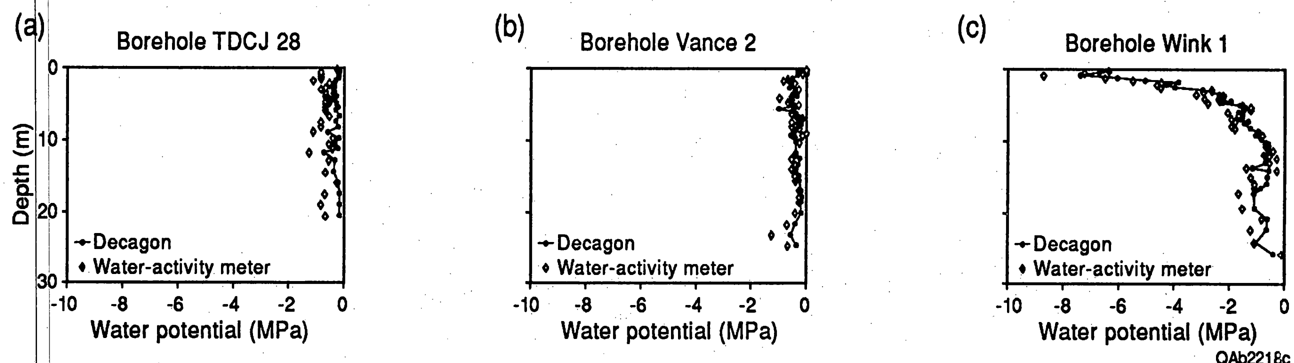

Figure 17. Comparisons of water potential measured with a Decagon SC10 sample chamber and CX-2 water activity meter in soil samples from TDCJ 28, Vance 2, Wink 1,.

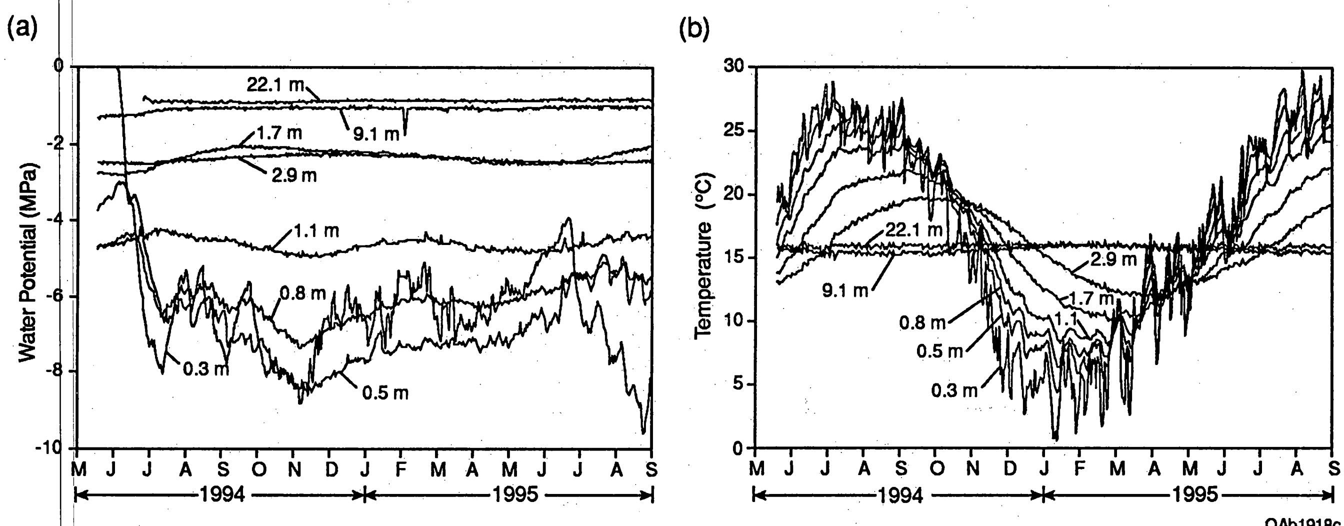

Figure 18. Variations with depth and time of water potential monitored daily by in situ psychrometers at Playa 5 (interplaya setting).

water potentials, which indicates an upward driving force for liquid and isothermal vapor movement (fig. 19). At depths ≥ ~18 m, field-monitored water potentials plot to the right of the equilibrium line, which suggests drainage of water in this zone. Field-monitored water potentials were similar to laboratory-measured water potentials based on soil samples collected in interplaya settings (fig. 19).

Temperature

Temperatures monitored with the thermocouple psychrometers displayed large seasonal fluctuations, particularly in the upper 5 m (figs. 18b and 20). The amplitude of the seasonal fluctuations decreased with depth, and the fluctuations were essentially damped out by the 12-m depth. The phase of the wave also shifted with depth. Temperature gradients were steepest in the upper 5 m and decreased to near zero below this depth. Temperature gradients were steepest in mid summer and midwinter (fig. 20). In the summer, temperature gradients were downward and ranged from 29°C at 0.3 m depth (~day 185 of the year) to 14.5°C at 4.6 m depth. These downward temperature gradients in the summer provide a downward driving force for thermal vapor movement and oppose the upward water potential gradients. In contrast, temperature gradients were upward in the winter, similar to water potential gradients, and ranged from 16.7°C at 4.6 m depth to 0.7°C at 0.3 m depth (~ day 5 of the year).

Electromagnetic Induction

Apparent conductivities measured with the EM-31 instrument were uniformly low in the interplaya settings (TDCJ, mean VD 34 mS m^{-1}; Wink, mean VD 27 mS m^{-1}; fig. 21, table 6). The low apparent conductivities are similar in both Wink and TDCJ interplayas. Apparent conductivities increased markedly from the interplaya to the playa. Conductivities increased from 40 to 90 ms m^{-1} (VD) and from 36 to 69 mS m^{-1} (HD) across a 30-m section that delineated the annulus of TDCJ playa (fig. 21a). The annular region in Wink playa was much shorter (15 m), and

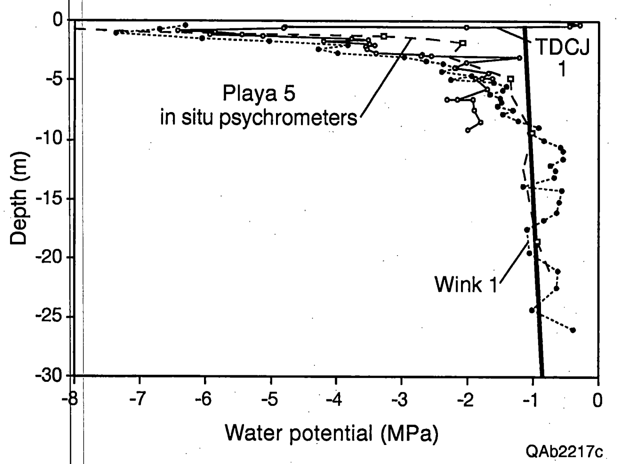

Figure 19. Vertical distribution of water potential measured by in situ psychrometers at Playa 5 and by the Decagon psychrometer in the laboratory on samples collected from interplaya settings.

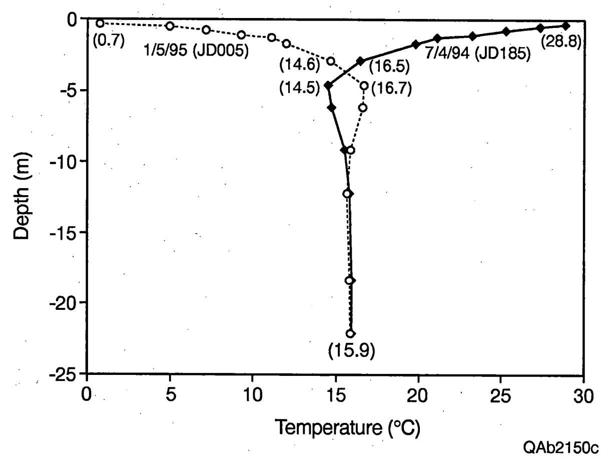

Figure 20. Vertical distribution of temperature measured by in situ psychrometers at Playa 5 (interplaya setting).

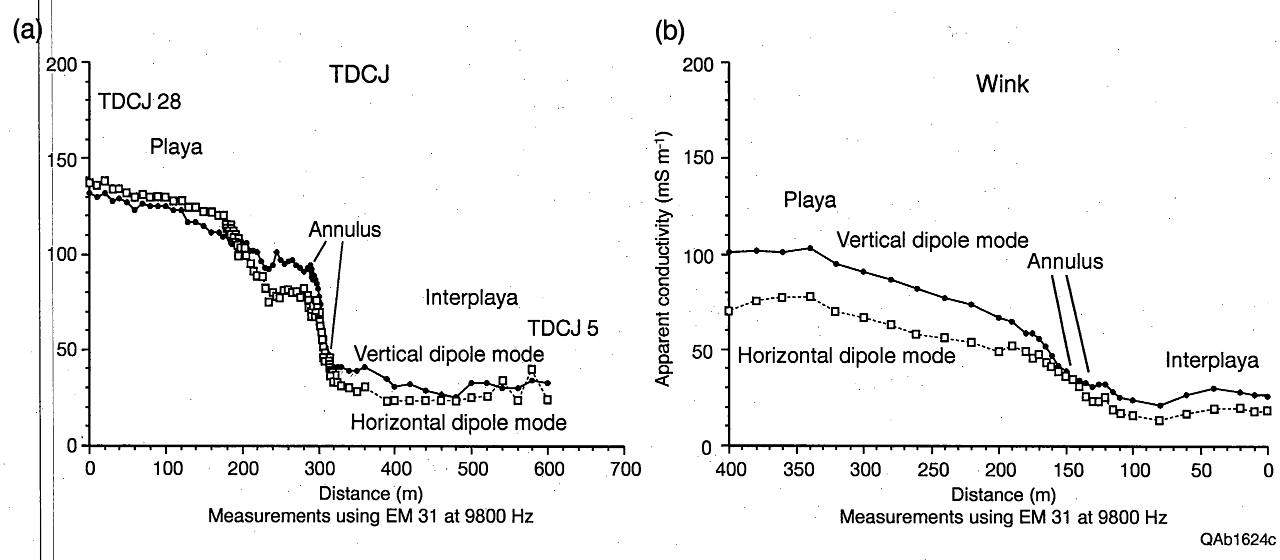

Figure 21. Profiles of apparent conductivity (mS m^{-1})measured with an EM 31 ground conductivity meter along transects at TDCJ and Wink playa basins.

Table 6. Apparent conductivity measurements using the EM 31 along transects at TDCJ and Wink playa basins.

TDCJ			Wink		
Distance (m)	Vertical dipole mode ($mS\ m^{-1}$)	Horizontal dipole mode ($mS\ m^{-1}$)	Distance (m)	Vertical dipole mode ($mS\ m^{-1}$)	Horizontal dipole mode ($mS\ m^{-1}$)
0	132	137	0	26	19
10	130	136	10	27	18
20	132	138	20	28	20
30	128	134	40	30	20
40	129	134	60	27	17
50	127	132	80	21	14
60	123	130	100	24	16
70	126	131	110	25	17
80	125	130	115	28	19
90	125	130	120	32	25
100	125	130	125	32	23
110	123	128	130	31	23
120	123	128	135	33	25
130	117	124	140	34	31
140	117	124	145	34	35
150	115	122	150	39	37
160	111	122	155	42	39
170	111	120	160	47	41
175	109	120	165	52	44
180	110	115	170	56	47
181	112	115	175	59	46
182	109	114	180	59	49
183	108	115	190	65	52
184	108	112	200	67	49
185	107	113	220	74	54
186	106	110	240	77	57
187	105	111	260	82	58
188	109	111	280	87	63
189	109	109	300	91	67
190	108	109	320	95	70
190	107	109	340	103	78
191	108	108	360	101	77
192	108	106	380	102	76
193	103	107	400	101	70
194	102	105			
195	104	104			
196	105	99			
197	102	103			
198	100	103			
199	102	104			
200	106	103			
200	106	103			

Table 6 (cont.)

Distance (m)	TDCJ Vertical dipole mode (mS m^{-1})	Horizontal dipole mode (mS m^{-1})
205	106	99
210	102	95
215	102	91
220	101	88
225	96	88
230	93	82
235	92	75
240	94	80
245	101	78
250	97	77
255	95	81
260	96	81
265	97	80
270	94	80
275	93	77
280	91	82
285	92	78
286	93	75
287	92	77
288	92	76
289	94	72
290	90	69
290	92	69
291	88	71
292	87	72
293	89	67
294	89	67
295	87	67
295	87	71
296	87	71
297	85	73
298	85	76
299	82	67
300	78	69
301	75	65
302	74	62
303	68	63
304	62	59
305	61	55
306	60	51
307	57	47
308	55	45
309	51	45

Table 6 (cont.)

Distance (m)	TDCJ Vertical dipole mode (mS m^{-1})	Horizontal dipole mode (mS m^{-1})	
310	50	44	
311	48	45	
312	47	44	
313	48	45	
314	44	42	
315	44	40	
316	43	38	
317	41	36	
318	39	37	
319	40	36	
320	41	33	
325	41	33	
330	41	31	
340	39	30	
350	39	28	
360	41	31	
370	46	32	
375	99	30	
380	160	179	
390	35	23	
400	31	24	
420	32	24	
440	29	24	
460	27	24	
480	25	24	
500	33	25	
520	33	26	
540	30	34	
560	30	24	
580	34	40	
600	33	24	

conductivities did not change in this zone (fig. 22b). A gradual increase in apparent conductivities was measured from the playa margin to the playa center in both TDCJ (VD; 90 to 132 mS m^{-1}, HD; 69 to 137 mS m^{-1}) playas and Wink (VD; 33 to 103 mS m^{-1}; HD; 31 to 78 mS m^{-1}). TDCJ playa had higher apparent conductivities than those in Wink playa. Vertical (playa center; VD 132 mS m^{-1}) and horizontal (playa center; HD 137 mS m^{-1}) dipole mode measurements were similar in TDCJ playa, whereas vertical dipole mode measurements (playa center; 103 mS m^{-1}) were much higher than horizontal dipole mode measurements (playa center; 78 mS m^{-1}) in Wink playa. These data indicate that apparent conductivities increase with depth in Wink playa.

Apparent conductivity varies with water content, salt content, sediment texture, structure, and mineralogy. A linear model can be used to describe variations in apparent conductivity of the subsurface:

$$EC_a = EC_w \theta \tau + EC_s \quad (6)$$

where EC_w is pore water conductivity, θ is volumetric water content, τ is tortuosity, and EC_s is surface conductance of the sediment. The increase in EC_a along the transect from the interplaya to the playa and within the playa can be attributed to the increase in water content and the increase in EC_s associated with the higher clay content in the playa relative to the interplaya setting. EC_w in pore water in the playa is less than that in the interplaya sediments because of lower chloride in playa pore water; however, the effect of EC_w is overridden by the synergistic effects of increased water and clay content on EC_a in the playa.

Environmental Tracers

Meteoric Chloride

Chloride concentrations in profiles sampled beneath the playas were uniformly low, generally less than 100 g m^{-3} with the exception of Playa 5 (#7, 170 to 451 g m^{-3}; # 8, 141 to 343 g m^{-3}; figs. 12c and g) and Vance 2 (19 to 338 g m^{-3}; figs. 15c and g). The generally low chloride concentrations in playa profiles provide evidence for high subsurface water fluxes and indicate that either chloride never accumulated or it has been flushed out. This is consistent with the low carbonate contents in sediments beneath playas. Higher chloride concentrations beneath Vance playa reflect incomplete flushing beneath this playa and are consistent with carbonate nodules in these sediments (Hovorka, 1995). Vance playa is also densely vegetated with grasses, which suggests infrequent flooding. High chloride concentrations in Playa 5 profiles are attributed to discharge of sewage and waste into the playa from 1968 through 1992. The chloride mass balance approach (equation 3) is not valid for flow beneath the playas because the contribution of chloride from run-on into the playa cannot be calculated and the piston flow assumption is not valid.

In contrast to the low chloride concentrations in playa settings, maximum chloride concentrations in interplaya settings were high and ranged from 1,166 (1-m depth, BEG PTX #2; fig. 1) to 4,171 g m^{-3} (1-m depth, Wink 1; fig. 16c). Chloride profiles in interplaya settings had generally low concentrations in the upper 0.1 to 0.5 m depth. Chloride concentrations increased sharply to maximum concentrations generally at depths of 1 to 2 m and decreased gradually below the peak to low values at depth (down to 39 g m^{-3} at 26 m depth Wink 1; fig. 16c). High maximum chloride concentrations in interplaya settings are attributed to evapotranspiration, which concentrates chloride. Maximum chloride concentrations in profiles in and adjacent to drainages in interplaya settings ranged from 641 (2 m depth, Koesjan 2; fig. 11c) to 893 g m^{-3} (9.5 m depth, SMB 3; fig. 13k). Chloride profiles in annular regions were generally low relative to those in the adjacent playa setting (figs. 10g, 14o, 16g); however, some profiles in annular regions had chloride concentrations intermediate between those in adjacent playa and interplaya settings (figs. 14g, k, w).

It is difficult to estimate water fluxes from chloride data in interplaya profiles because the chloride concentrations do not remain constant below the peak. The reduction in chloride concentration below the peak could result from preferential flow diluting chloride at depth or higher water fluxes during the past. Chlorine-36 data from three samples in Wink 1 profile (fig. 8) were used to evaluate the preferential flow hypothesis. The $^{36}Cl/Cl$ ratios were 4.42×10^{-13} (2.8 m), 4.16×10^{-13} (4.4 m), and 4.3×10^{-13} (10.9 m) and are typical of background $^{36}Cl/Cl$ ratios found at many sites (4.47×10^{-13}, Scanlon, 1992a; 4.9×10^{-13}; Fabryka-Martin et al., 1993). Although these data are limited, they suggest that the reduction in chloride concentrations is more likely the result of transient conditions resulting in increased flux in the past than from preferential flow.

The time period represented by the chloride profiles was calculated based on equation (4). The total amount of chloride stored in the interplaya profiles results in water ages that range from 2,750 yr (TDCJ 1, 8.4-m depth) to 5,000 yr (Wink 1, 26-m depth; app. B). Plots of cumulative chloride versus cumulative water content can be used to assess the transient conditions in these profiles (fig. 22). Straight-line segments in these plots indicate periods of uniform environmental conditions. Slopes of the lines were used to calculate average fluxes, and the time period represented by the lines was estimated using equation (4). The profile from Wink 1 borehole represents the longest record in an interplaya setting (fig. 22c). Although the plot of cumulative chloride versus water is curvilinear rather than linear, the profile can be subdivided into four segments. The uppermost segment spans the last 3,000 yr and the estimated flux is 0.12 mm yr^{-1}. Prior to that time, the estimated fluxes were much higher and increased below this zone. TDCJ 1 profile shows an increase in flux from 0.27 mm yr^{-1} to 0.63 mm yr^{-1} ~ 1,700 yr ago (fig. 22b). The Finley 1 interplaya profile shows uniform flux during the past 2,500 yr of 0.2 mm yr^{-1} (fig. 22a).

Tritium

Tritium levels in the soil water beneath Wink 14 playa (table 7) ranged from 4.4 ± 0.4 to 77 ± 5 TU (fig. 23b). These values indicate post-1952 water flux to a depth of at least 29 m. The tritium profile had multiple peaks. The highest tritium concentration of 77 TU was found at 21 m depth. The zone of fairly high tritium concentrations (39 to 77 TU) from 18 to 21 m depth corresponds to a zone of low water contents (2.7 to 4.6 g g–1) and to a laterally extensive sand

Table 7. Tritium measurements in soil water samples collected from borehole Wink 14 (playa).

Depth (m)	Tritium units	Standard error (±)
0.25	<5	
1.23	15	5
2.04	28	5
2.21	14.9	0.6
3.19	23.3	1.3
3.48	20	5
3.63	27	5
3.78	24.3	0.8
4.74	32	5
6.07	47	6
6.21	28.8	0.9
6.56	19.3	0.9
7.58	<9	N/A
8.18	44	7
8.71	24	5
9.56	26	5
10.63	40	6
11.54	21	5
12.61	24	6
13.67	21	5
14.89	32	5
15.35	29.8	1
16.72	14.7	0.7
17.24	21	5
18.25	42	7
18.61	57	5
19.77	39	6
21.00	77	5
22.67	17	5
24.80	17	5
26.05	<7	N/A
27.24	<5	N/A
28.01	4.4	0.4

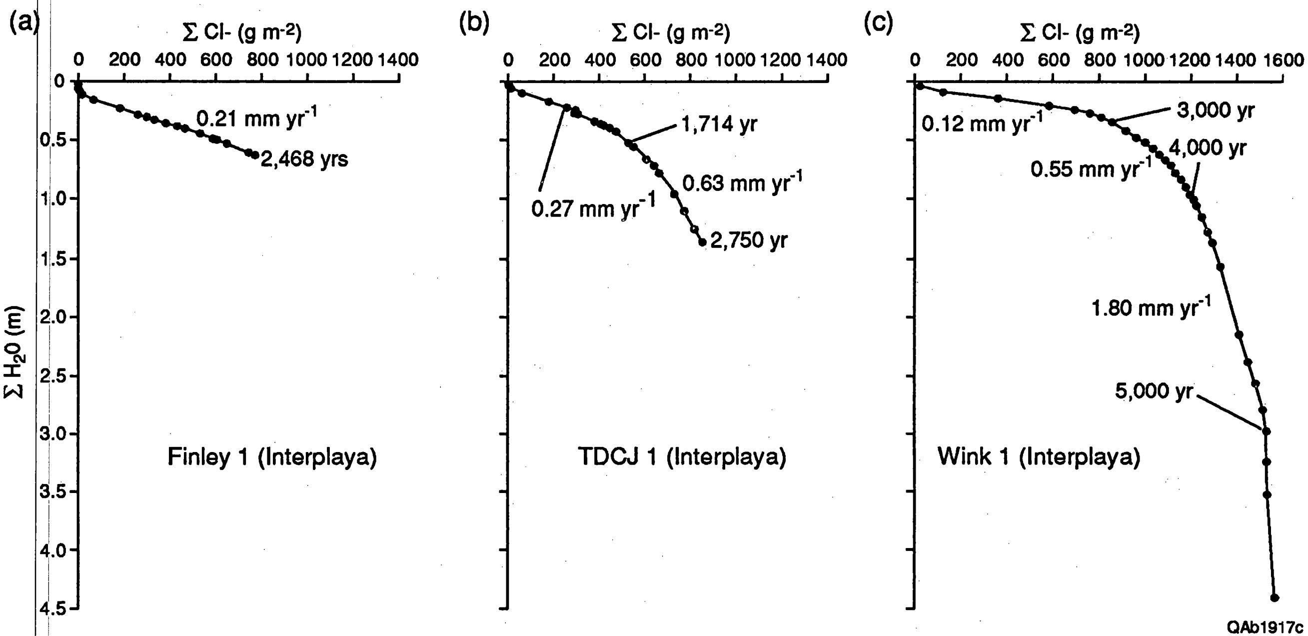

Figure 22. Calculated water fluxes, chloride mass balance ages and cumulative chloride plotted against cumulative water for Finley 1, TDCJ 1, and Wink 1.

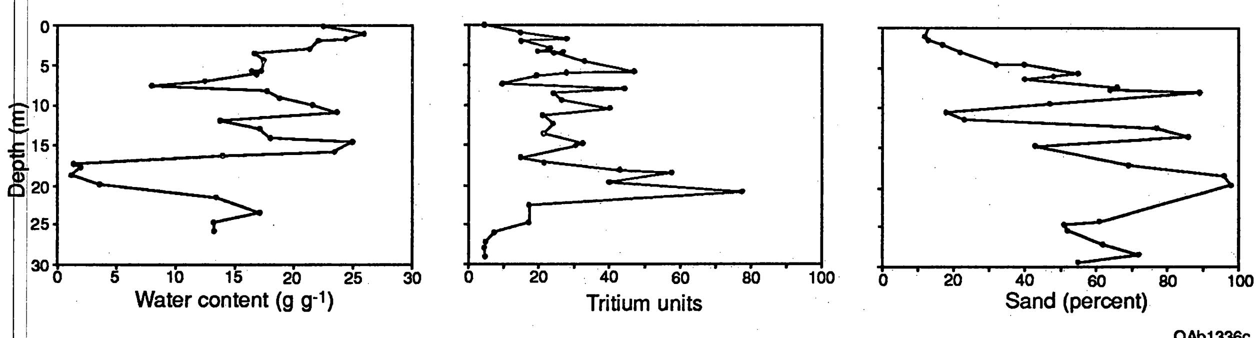

Figure 23. Vertical profile of gravimetric water content, ^3H, and sand content in soil samples collected from Wink 14 (playa setting).

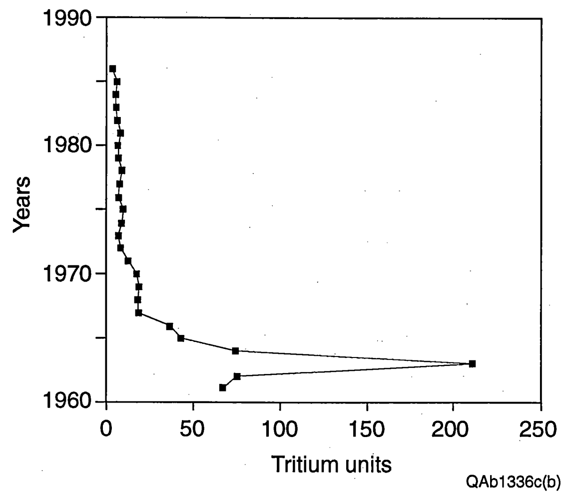

Figure 24. Decay corrected (to 1993) ^3H measured in precipitation at Waco, Texas.

layer (sand 96 to 98%; app. A). This sand layer is found in borehole Wink 12 from 18.5 to 22.1 m depth (sand 92 to 99%; app. A), which is approximately 300 m from Wink 14, where tritium samples were collected (table 7). This zone of high tritium levels probably corresponds to the 1963 tritium peak based on comparison with fallout data from Waco, Texas (fig. 24). Tritium concentrations were low in the base of the profile (<13 TU in an unenriched sample from 27 to 29 m depth and 4.4 ± 0.4 TU in an enriched combined sample from two depths [28 and 29.1 m]). Tritium concentration in perched groundwater adjacent to Wink playa was 1.8 TU (Mullican et al., 1994).

The multiple tritium peaks could result from variations in tritium input to the system over time or from preferential flow. The Waco tritium fallout data are smooth, and a smooth, single-peaked tritium profile beneath a playa to the south of the study area (Wood and Sanford, 1995) suggests that the multiple peaks are more likely the result of preferential flow. In areas of preferential flow, Cook et al. (1994) suggest that the center of mass rather than the peak concentration should be used to estimate water fluxes because the latter does not conserve mass. The center of mass of the tritium profile is at 14.2 m depth, and the center of mass of the fallout occurred in 1964 (based on data from Ottawa, Canada, from 1953 to 1987). This results in a water velocity of 0.5 m yr^{-1}. The average volumetric water content from the surface to the center of mass is 0.24 m^3 m^{-3} (gravimetric water content, 0.17 g g^{-1}; bulk density 1.4 kg m^{-3}), which results in a water flux of 0.12 m yr^{-1}. This flux can be used to estimate the average recharge rate but cannot be used to estimate preferential flow or first arrival time for contaminants.

Applied Tracers

All the field ponding experiments conducted at the TDCJ playa basin showed varying degrees of preferential flow. The first ponding test was conducted in an interplaya setting after a 6-mm rain had fallen several days prior to the test and no cracks were visible at the surface. FD&C blue dye was uniformly distributed in the upper 70 mm beneath Pond 1; however, below this depth the dye was restricted to preferred pathways such as roots, root tubules, and interped spaces (fig. 25). The maximum penetration depth of the dye was 0.6 m. The density of the preferred pathways decreased with depth. Bromide concentrations were above the background value of 2.5 g m^{-3} throughout the upper 0.6 m of the sampled section (fig. 26). The wetting front was found at a depth of ~ 0.6 m, and water content ranged from 0.20 to 0.31 g g^{-1} above the wetting front and from 0.08 to 0.13 g g^{-1} below the wetting front.

Pond 2 was located above and Pond 3 below the 1993 high-water line. Open cracks were found at the surface at both of these sites prior to ponding. The upper 10 to 20 mm of the soil zone was uniformly dyed beneath Ponds 2 and 3. FD&C blue dye penetrated to a maximum depth of 1 m beneath Pond 2 and to 0.65 m beneath Pond 3. The pathways under both ponds included roots and root tubules and near-vertical planar fractures. Many of the dyed areas had a two-dimensional geometry and probably originated as desiccation cracks caused by shrink/swell of the clay.

The two ponding tests conducted in TDCJ playa in December 1994 were intended to evaluate temporal variability in tracer movement with the use of wick samplers; however, no water was collected in the wick sampler installed beneath Pond 4, and only a small amount of water was collected in the wick sampler beneath Pond 5. Although every precaution was taken to minimize smearing of the clay prior to installation, it is likely that some smearing occluded the preferred pathways. Surface cracks were up to 10 mm wide at Pond 4 and up to 7 mm wide at Pond 5 prior to ponding. In Pond 4, 15 min elapsed after water application began and before ponding commenced, whereas ponding occurred immediately after water application began in Pond 5. Seepage occurred at the face of the access trench near Pond 4, particularly at depths shallower than 0.15 m. This is attributed to large cracks in the soil and to the fact that the ponded surface did not extend far enough away from the trench face (0.4 m). In contrast, only a small amount of dyed water seeped out the wall of the access trench adjacent to Pond 5, which was located 0.6 m from the trench face.

Dyed water dripped from roots in the ceiling of the access tunnel beneath Pond 5 as early as 7 hr after the ponding test started and provided visual evidence of preferential flow. A total of

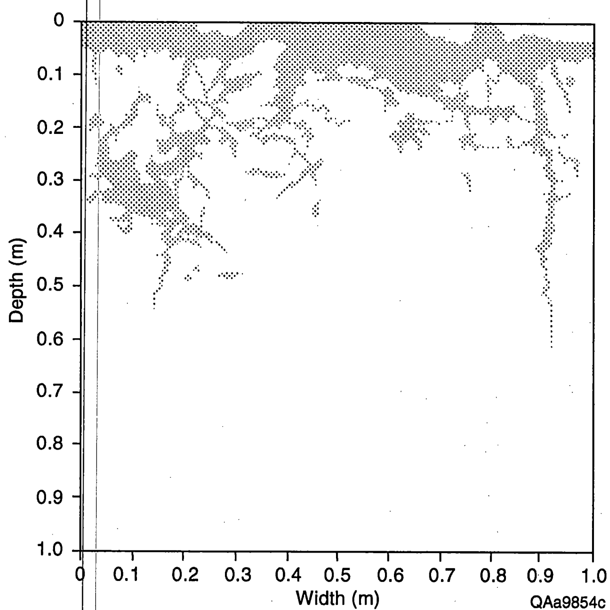

Figure 25. Profile of blue dye under Pond 1 infiltration test at TDCJ playa basin (interplaya setting).

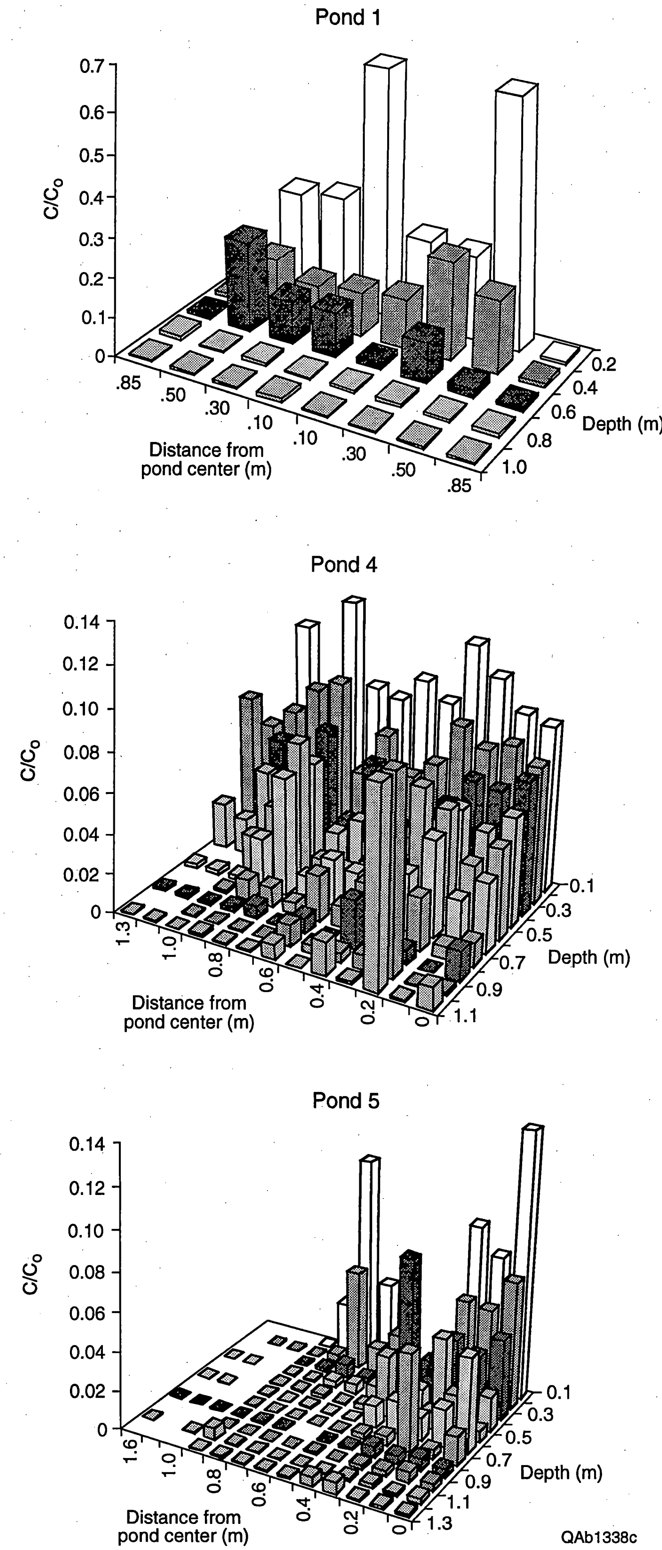

Figure 26. Profiles of bromide concentration in soil samples collected under Ponds 1, 4, and 5 at TDCJ playa basin.

700 mL of water was recovered from the root, which represented 0.6% of the ponded water. Concentrations of bromide and dye decreased with time (Br: 0.06 M [7 hr] to 0.04 M [129 hr]; dye 1,045 g m^{-3} [7 hr] to 517 g m^{-3}[129 hr]) in water from these roots and is attributed to dilution of the preferential flow with water from the matrix. Water had collected in the wick samplers beneath Pond 5 72 hr after the test began, and presumably water started to collect some time prior to 72 hr but not earlier than 54 hr, when it had been previously checked. A total of 350 mL of water was recovered in the wick samplers, and concentration in these water samples ranged from < 0.1 g m^{-3} (1.25×10^{-6} M) to 500 g m^{-3} (5.6×10^{-3} M). This only represented 0.3% of the ponded water.

Trenches were excavated beneath these ponds to provide visual evidence of the stained pathways and to sample for water content, bromide, and dye (fig. 26). In both Ponds 4 and 5, the dye was uniformly distributed within the uppermost 10 to 20 mm of soil. Stained fractures and roots were found beneath Pond 4, particularly in the upper 0.2 m. Some of the dyed roots extended to 0.5 m. Stained pathways beneath Pond 5 were restricted to short segments of roots.

There was no visible wetting front beneath Ponds 4 and 5. Initial water contents were lower beneath Pond 4 (0.25 to 0.30 g g^{-1}) than beneath Pond 5 (0.28 to 0.33 g g^{-1}). Water contents after ponding were also lower beneath Pond 4 (0.25 to 0.46 g g^{-1}) than beneath Pond 5 (0.28 to 0.53 g g^{-1}). Highest water contents were measured in surficial sediments. Bromide concentrations were also highest at the surface and ranged from 611 to 943 mg kg^{-1} at the surface to 2 to 749 mg/kg at 1.0 m depth beneath Pond 4. More bromide was found in the surficial sediments beneath Pond 5 (660 to 5871 mg kg^{-1}) than beneath Pond 4, and bromide concentrations at depth beneath Pond 5 were uniformly low (2 to 44 mg kg^{-1}). Mass balance on the bromide indicated that 45% of the applied bromide could be accounted for in the sampled domain beneath Pond 4 and 69% beneath Pond 5. The low recovery of bromide in Pond 4 is attributed to lateral movement and seepage on the face of the access trench. All the data suggest that preferential flow was greater beneath Pond 4 (300 m from playa center), where the sediments were initially drier and cracks were more evident than beneath Pond 5 (playa center), which was more frequently flooded.

DISCUSSION

Spatial Variability in Subsurface Water Movement

Spatial variability in subsurface water flux occurs at two different scales; large-scale variability between playa, annular, and interplaya settings and small-scale variability along preferred pathways such as roots and cracks. Conceptual models of subsurface flow in the Southern High Plains have suggested that clays in the floors of playas have low permeability or are impermeable. Some researchers assumed that playas act as evaporation pans (Claborn et al., 1985), whereas others assumed that recharge occurs primarily in the annular regions surrounding the playas (Wood and Osterkamp, 1987). The soil physics and soil water chemistry data collected in this study both indicate that playas focus recharge. High water contents, high water potentials, low chloride and high tritium concentrations in pore water and low carbonate content in the sediment all indicate high water fluxes beneath playas. These data are consistent with findings of Wood and Sanford (1995), which showed low chloride and high tritium concentrations beneath playas. The concept of playas as evaporation pans is inconsistent with the lack of chloride buildup in the ponded water (Wood and Osterkamp, 1987), the soil physics and chemistry data in this study, and information on perched aquifer water table response to rainfall events (White and others, 1946). The restriction of flow to the annular regions is also not supported by data in this study. Some of the profiles in the annular regions were similar to those in the adjacent playas; however, others had chloride and water potential profiles intermediate between those in the playas and adjacent interplaya settings, which suggests lower water fluxes in these annular regions relative to the adjacent playa setting.

In contrast to the playa settings, subsurface water fluxes in undisturbed interplaya settings under current climatic conditions are much lower. This is supported by low water contents, low minimum water potentials, and high maximum chloride concentrations in pore water and high carbonate content in the sediment. The upward decrease in water potentials in the top 5 to 20 m indicates net upward water movement in this zone.

At the Pantex Plant, interplaya settings have been altered and ditches have been excavated to transport liquid wastes and storm water to playas. Chloride is flushed out beneath these ditches because of infiltration of ponded water in the ditches (Bennett, pers. comm., 1995). In these altered systems, ditches, like playas, focus subsurface flow and allow rapid transport of contaminants. Calcic soils in interplaya settings do not provide a barrier to flow, as evidenced by the artificial recharge experiments conducted in interplaya settings on calcic soils that showed rapid downward water movement (Aronovici et al., 1970; Schneider and Jones, 1984).

Evidence of Spatial Variability Based on Saturated Zone Studies

Hydraulic and hydrochemical studies conducted by Mullican et al. (1994) and Fryar and Mullican (1995) in perched aquifers provide abundant evidence of spatial variability in recharge that corroborates the results of the unsaturated zone studies discussed above. Mounding of perched water tables beneath Playa 1 on the Pantex Plant indicates that recharge is focused beneath this playa. Extension of this mound to the south beneath a ditch indicates that water fluxes were high beneath the manmade ditches constructed on site to transport wastewater to the playas. Evaluation of historic discharges along these unlined ditches suggest that soils in some of the ditches probably remained saturated from 1952 to 1990 (Ramsey et al., 1995). Elevated levels of ^{3}H and ^{14}C in perched groundwater adjacent to playas further substantiate focused recharge beneath playas. The highest ^{3}H concentrations were measured in groundwater adjacent to and south of Playa 1 ($\geq$ 9 TU to maximum of 44.4 TU). Highest ^{14}C abundances were also recorded adjacent to Playa 1 ($\geq$ 85 percent modern carbon, pmc). In contrast, ^{3}H concentrations in perched aquifers between playas and distant from ditches were $\leq$ 1.2 TU (Fryar and Mullican, 1995).

Preferential Flow

The conditions in the playas are ideal for preferential flow. Many researchers have shown that preferential flow is greater under ponding than under natural rainfall. The ponding boundary is appropriate for the playas because water floods the playas; however, ponding in interplaya settings is generally restricted to natural drainage systems and to manmade ditches. Shrink-swell clays and the seasonal cycles in wetting and drying in playas greatly enhance the susceptibility of the playas to preferential flow. Many playas have dense vegetation that grows during the summer season, and roots associated with these plants also provide pathways, as demonstrated in ponding experiments in this study. While ponding may greatly increase the occurrence of preferential flow initially after a dry season, continued ponding may reduce preferential flow as the clays swell. Shrink-swell structures and root tubules allow water to move rapidly below the zone of evapotranspiration and thus become recharge. Desiccation cracks and interped spaces provide pathways through the low-permeability clays in the playa floors.

Ponding tests conducted in this study provided qualitative evidence of preferential flow in and adjacent to the playas. Preferred pathways exist in both the playa and interplaya settings; however, the ponding boundary condition may not be appropriate in the natural interplaya setting. The interplaya ponding tests may be considered analogs of the ditches on the Pantex Plant where wastewater was discharged.

The importance of piston flow in transporting the bulk of the water in structured clay soils is questionable because recent studies of flow in near-surface clay soils in an area of shallow groundwater indicated that only a few percent of the flow occurred in large macropores such as shrink-swell cracks, and most of the transport occurred through mesopores, which consisted of interped spaces (Bronswijk et al., 1995). Intra-aggregate flow or flow within the peds was thought to be negligible, and these aggregates basically served to retard contaminants (Bronswijk et al., 1995). Detailed analysis of this type is not possible in this study because the water table is much deeper and there are no tile drains that integrate flow. However, there is abundant geologic and diagenetic evidence of preferential flow in planar structures and also along interped spaces beneath the playas at this site that is described by Hovorka (1995). Geologic evidence of long-term transport along these preferred pathways includes organic matter and iron and manganese oxide staining, gleying, and clay illuviation. Slickensided fractures are also found at depth. The diagenetic alterations along these pathways are attributed to high water fluxes during previous high lake levels; however, the pathways may also allow preferential flow of surface water to great depths (Hovorka, 1995).

The vertical continuity of preferred pathways is difficult to assess. Most of the pathways such as desiccation cracks and root tubules are found mainly in the shallow subsurface (few meters depth). It is possible that these pathways extend to great depths. The subsurface stratigraphy beneath the playas indicates that there are as many as five paleosols beneath the present playas (Hovorka, 1995). These mark periods of surface stability when soil development occurred. Plant roots are highly opportunistic and generally grow in areas where there is least mechanical resistance, as evidenced by large roots in subsurface fractures at a site in West Texas (Scanlon, 1992a). Gustavson (1995) has suggested that plant roots may grow into existing root tubules and serve to connect pathways from different depths. A live root (radius 0.1 mm) was found in a larger root tubule (radius 1.5 mm) at a depth of 14 m (Gustavson, 1995). Root growth may have occurred at different times in the past when soil development occurred and may provide an interconnected network of preferred pathways. The occurrence of high tritium in the sand layer beneath Wink playa suggests that the pathways may terminate in these structureless units.

Most studies of preferential flow are restricted to the shallow subsurface (upper few meters). Preferential flow in thick unsaturated sections is not readily evaluated. Because preferred pathways are generally vertical, it is difficult to intercept such pathways with vertical profiles. The tritium profile beneath Wink playa provides qualitative evidence of preferential flow, as indicated by the multiple peaks in the profile. The tritium samples were extracted from large soil samples and more likely represent a mixture of water from preferred pathways and from the matrix. Preferential flow through thick unsaturated sections may be more readily evaluated by frequent sampling of the perched groundwater. Saturated sections integrate all preferential flow and, like tile drains and shallow water tables, may provide information on the relative importance of piston and preferential flow.

Although preferential flow was found in the playas in the vicinity of the Pantex Plant, this does not mean that subsurface flow in all playas is characterized by preferential flow. The gradual increase in tritium from 16 TU (0.5 m depth) to 157 TU (7.5 m depth) above the water table (8.5 m depth) beneath a playa in the central part of the Southern High Plains indicates piston flow beneath this playa (Wood and Sanford, 1995). Textural analyses were not conducted on the sediments in this profile; therefore, it is not possible to determine if the sediments are coarser grained, which could account for piston flow.

Preferential Flow of Volatile Organics

This discussion of preferential flow has been restricted to water flow; however, the pathways discussed above also serve as preferred pathways for air and vapor. Permeability studies in TDCJ playa indicated that vertical air permeability was extremely high (29×10^{-8} m^2 in top 0.9 m, 16×10^{-8} m^2 from 0.9 to 2.4 m, and 6.5×10^{-8} m^2 from 2.4 to 4.1 m), corresponding to the zone of desiccation cracks and roots (Nicot, 1995). Barometric-pressure fluctuations at the surface result in breathing and facilitate volatilization of organics (Nicot, 1995). Preferred pathways such as desiccation cracks increase the surface area available for volatilization and enhance upward movement of these contaminants. Desiccation cracks and root tubules also result in rapid downward movement of volatile organics. Evidence for rapid downward movement of volatiles is provided by TCE and other volatile contaminants in the part per billion range in the perched aquifer. These volatile contaminants may accumulate in the structureless sand layers because of their low water content and possible lack of preferred pathways. The high tritium levels in the sand horizon beneath Wink playa suggest that the sand layers may act as reservoirs for volatile contaminants. Sampling of these layers for volatile contaminants should be conducted to test this hypothesis. If the volatiles concentrate in the sand layers, remediation efforts to remove volatile contaminants should focus on these sand layers.

Temporal Variability in Subsurface Water Flux

The playas represent an extremely dynamic system that responds to seasonal variations in precipitation. The shrink-swell nature of the surface clays greatly increases the dynamic response of the playas to flooding. Water movement is likely to be most rapid after the playas have dried out and desiccation cracks have developed. Therefore, ponding of the playas after long dry periods will result in large subsurface water fluxes. During ponding for long times, the clays expand and decrease the size of the cracks and thus reduce the downward flux. Ponding tests in TDCJ playa in December 1995 showed that water infiltrated much more readily in the drier sediments near the margin of the playa than in the wetter sediments in the center. The reduction in air permeabilities by a factor of 3 to 6 in May 1995 relative to those in December 1994 can be attributed to swelling of the clay soils after rainfall in May (Nicot, 1995).

Water fluxes in the interplaya setting are much lower than those in the playa and do not demonstrate the short-term response shown by the playas. Laboratory-measured water potentials and water potential monitoring for 1 yr showed that the maximum penetration depths of the wetting fronts ranged from 0.2 to 0.3 m. The bulge-shaped chloride profiles in the interplaya setting could result from preferential flow diluting chloride at depth; however, limited $^{36}Cl/Cl$ data beneath the chloride peak indicate that there is no bomb pulse tracer at the sampled depths. Bulge-shaped chloride profiles in fractured chalk were attributed to preferential flow as evidenced by bomb pulse tritium at depth below the chloride peak (Nativ et al., 1995). If piston flow is assumed for the interplaya setting, then the chloride profiles indicate that water fluxes were low (0.1 to 0.3 mm yr^{-1}) in the past 2,000 to 3,000 yr and increased prior to this time (0.6 to 1.8 mm yr^{-1}). Water potentials measured at depth are consistent with the chloride data and suggest that older water may be draining in the profile.

The periods of higher water flux estimated from the chloride data in some of these interplaya profiles are at a much shorter time scale than the Pleistocene/Holocene variations in climate that resulted in higher subsurface water fluxes at many sites in the southwestern U.S. (Scanlon, 1991;

Phillips, 1994). The interplaya chloride profiles may suggest shorter term climatic variations. Chloride can be readily flushed out of the profiles after short-term ponding. The time scales represented by the chloride profiles may be much shorter than those preserved in the paleoclimatic record. Alternatively, the chloride profiles may reflect changes in other factors that control subsurface water flux, such as vegetation. The importance of vegetation in removing water from the subsurface has been demonstrated in many areas. Replacement of shrub vegetation with grasses at the Hanford site as a result of wildfires resulted in marked increases in subsurface water flux (Prych, 1995). Therefore, vegetation changes may account for the variations in subsurface water flux with time.

Contaminants as Long-Term Applied Tracers

Subsurface contaminants at the Pantex Plant may be considered long-term applied tracers. Wastewater, including sewage, was discharged to Playa 5 between 1968 and 1992 and resulted in high chloride concentrations in pore water throughout the sampled section (25.4 m, #7 borehole; 15.4 m #8 borehole; fig. 12c). Chloride profiles adjacent to the sewage outfall and further toward the center of the playa were similar. High chloride concentrations (324 g m^{-3}) were also detected in the Ogallala groundwater (well FPOP-MW-06; Fryar and Mullican, 1995) and suggest that water has migrated 71 m in at most 24 yr. These data provide a minimum water velocity of ~3 m/yr, which assumes that the annual velocity was constant over time. Other contaminants found in the groundwater include chromium, trichloroethylene (TCE) 1,2 dichloroethylene, and high explosives such as RDX and HMX. Chromium has been found in all samples from well PM-20 since 1990, and concentrations in 1994 ranged from 0.53 to 1.95 g m^{-3} (Battelle Pantex, 1995) which exceeds the drinking water MCL of 0.1 g m^{-3}. The mean TCE concentration in well PM20 (0.094 g m^{-3}) was greater than the drinking water MCL of 0.005 g m^{-3}. These contaminants can be considered tracers and indicate that solutes in water such as chromium that sorb and also volatiles have migrated to the underlying perched aquifer since the Pantex Plant began to operate (1952).

Controls on Subsurface Flow and Transport

Integration of the results of this study with results from other investigations conducted in the vicinity of the Pantex Plant provide information on controls of subsurface flow and transport. The primary control on subsurface flow is the upper boundary condition. Ponding of water at the surface results in high subsurface water fluxes and also in high solute transport velocities. Ponding occurs naturally in playas and artificially in manmade ditches at the Pantex Plant. Whereas historic data from the Pantex Plant suggest that the surficial sediments in the ditches may have been saturated since 1952, the seasonal wetting and drying of the playas is important in controlling flow as it allows the clays in the playas to shrink and swell, thereby creating pathways for flow. Subsurface layering of sediments is also important as the different layers may act as natural capillary barriers or as perching horizons. In addition, structureless sand layers may limit the connectivity of preferred pathways and may promote lateral spreading of water and volatile contaminants. The geologic history is important in understanding not only the development of the current system but also the distribution of sediments and diagenetic alteration of preferred pathways.

Implications for Contaminant Transport and Site Remediation

Results of the unsaturated flow studies have important implications for site remediation. In the natural system, playas act as focal points of recharge because water ponds ephemerally in playas. The area covered by playas was estimated to be 3% on the basis of GIS analysis of a 5×10^9 m^2 area surrounding the study region (Mullican et al., 1994); therefore, the spatial focusing exerted by the playas is extreme. If recharge is assumed to be uniformly distributed rather than focused, calculated contaminant transport velocities would be greatly underestimated.

At the Pantex Plant, water was ponded in ditches, and therefore the ditches would also focus subsurface water movement. Contaminants should therefore be concentrated beneath playas and ditches in the unsaturated zone. There are several landfills on the Pantex Plant, and surficial sediments were markedly disturbed in these settings. Studies should be conducted to evaluate subsurface flow beneath these features. The low rates of water movement in interplaya settings indicate that if surface contamination occurred in interplaya settings that were not subjected to ponding or disturbance, these contaminants should be restricted to the shallow subsurface.

The two main options for remediation of the unsaturated zone are soil vapor extraction and bioremediation. These options will address remediation of contaminants such as volatile organics. These two options are not mutually exclusive as oxygen added during soil vapor extraction could enhance biodegradation. Volatile organic contaminants can be at least partially removed from the unsaturated zone by soil vapor extraction (venting). Key factors that may affect the suitability and efficiency of soil vapor extraction include: the vapor pressure of the chemical contaminant; grain size of the sediments, because preferential pathways may play an important role in migration of contaminants in fine-grained sediments; water content of the sediments, because volatile organic chemicals move as much as 10,000 times faster in the gas phase than in the liquid phase; and the distribution of contaminants in the subsurface relative to air permeability of the sediments, because restriction of volatile contaminants to zones of low air permeability would reduce the efficiency of the soil vapor extraction method.

Our studies indicate that water content of sediments beneath playas is quite high, which may be a limitation of the efficiency of the soil vapor extraction method. In addition, soils are relatively fine grained, which may also result in air from the venting operation being restricted to preferential pathways. Interplaya settings where leaking underground storage tanks are located or in landfills may be more readily remediated with soil vapor extraction. Numerical modeling would be required to predict the efficiency of soil vapor extraction and design of the remedial approach at these locations.

Our studies indicate that preferential flow is important, particularly with respect to contaminants that sorb onto sediments. These contaminants will likely be concentrated along and adjacent to preferred pathways. If these pathways are air filled, then soil vapor extraction may be successful in volatilizing contaminants and removing them from the subsurface.

Unanswered Questions

Although the data described in our studies indicate negligible water fluxes in undisturbed interplaya settings, low chloride concentrations beneath the chloride peak could result from preferential flow diluting chloride beneath the peak or from higher recharge in the past. The occurrence or significance of preferential flow in interplaya settings is important because it will help determine whether contaminants may be located in these areas. To evaluate the possibility of preferential flow beneath known or suspected contaminant sources, soil samples should be analyzed for bomb pulse tracers such as chlorine-36 and tritium. The presence of such tracers below the chloride peak would indicate whether preferential flow is important for moving water and contaminants in selected areas in interplaya settings.

Our unsaturated zone studies concentrated on playa settings and on interplaya settings that were not subjected to ponding. A major source of potential contamination at the Pantex Plant is ditches that were ponded for long times. Our studies did not specifically address subsurface water flow beneath ditches. It is reasonable to assume that subsurface flow beneath ditches is similar to that beneath playas with the exception that flow rates may be even higher beneath ditches because of the lack of Randall clay soils. Detailed studies of water flow beneath ditches are an essential prerequisite for optimal remediation of the Pantex facility. Information is required on texture, water content, water potential, chloride concentration, bomb pulse tracer distribution, and contaminant distribution. In addition, monitoring of water content and water potential would be required to understand the dynamics of subsurface water movement. These hydraulic and chemical parameters beneath ditches should be compared with similar data from areas adjacent to ditches to predict rates and locations of contaminant transport.

If soil venting is pursued as a remediation option, additional air permeability tests should be conducted in the areas where the procedure will be used. Numerical simulations of vapor flow should be conducted to test the feasibility of venting and to optimize borehole spacing.

No information has been collected on unsaturated zone processes beneath the perched aquifer. This is a critical area of study because hydraulic and hydrochemical processes in this zone will greatly affect how rapidly contaminants are migrating from the perched aquifer to the underlying Ogallala aquifer. Important data include matric potential heads, water contents, water chemistry, tritium and chlorine-36 concentrations, and contaminant concentrations in water and soil samples.

CONCLUSIONS

Evaluation of subsurface flow and solute transport is important in determining the distribution of contaminants in the unsaturated zone and is critical for development of an effective remediation strategy. Understanding flow and contaminant transport processes allows the subsurface distribution of contaminants to be estimated and also helps in evaluating the rate of contaminant transport through the unsaturated zone.

Subsurface water movement is focused beneath playas, as evidenced by high water content, high water potentials, low carbonate content in the sediments, and low chloride concentrations. Water potentials were close to zero and suggest drainage of water under unit gradient conditions. Low carbonate content is attributed to dissolution or nonprecipitation of carbonate as a result of high water fluxes. Low chloride concentrations indicate high water fluxes, which prevent chloride accumulation or flush out previously accumulated chloride. In contrast, subsurface water movement in interplaya regions not subject to ponding is negligible, as shown by low water contents, low minimum water potentials, high carbonate content, and high maximum chloride concentrations. Water potentials increase with depth except in the shallow subsurface after rainfall, which results in an upward driving force for liquid and isothermal vapor movement. Calcic soils are abundant in interplaya settings. Maximum chloride concentrations at depths of 1 to 2 m in different profiles reflect concentration of chloride as a result of evapotranspiration. The low $^{36}Cl/Cl$ ratios found in interplaya sediments are consistent with low water flux. Hydraulic and hydrochemical data from playa and interplaya settings suggest that subsurface water movement is focused beneath playas and is negligible in interplaya settings. However, results from ponding tests and profiles from drainage systems in the interplaya setting suggest that ponded conditions in the interplaya may also result in higher water flux.

Applied tracer experiments conducted in playa and interplaya settings indicate that preferential flow is important. Preferred pathways occur in both playa and interplaya settings; however, ponded conditions in playa settings result in much more preferential flow than in natural interplaya settings.

The unsaturated zone studies conducted in this program provide the basic information required to evaluate different remediation approaches. Application and optimal design of a specific remediation approach will also rely heavily on the information on estimated distribution and rate of transport of contaminants provided by the unsaturated zone studies.

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Appendix A. Texture, water content, and carbonate content of sampled boreholes.

Borehole number	Depth (m)	Gravel %	Sand %	Silt %	Clay %	Texture	Water content (g g-1)	Carbonate wt. %
BEGPTX2 interplaya	0.11	0	19	41	40	silty clay	0.27	
	0.57	0	21	37	41	clay	0.14	
	1.01	1	24	33	42	clay	0.08	
	4.23	13	24	25	38	gravelly mud	0.14	
	6.06	1	29	37	33	clay loam	0.11	
	9.41	0	31	54	15	silt loam	0.15	
	12.15	1	32	47	20	loam	0.13	
	13.68	40	33	8	19	muddy sandy gravel	0.08	
	15.20	2	30	43	25	loam	0.16	
	16.73	63	20	4	14	muddy sandy gravel	0.06	
	18.20	0	68	14	18	sandy loam	0.10	
	20.48	0	80	7	14	sandy loam	0.08	
	r	-0.55	-0.21	0.80	0.16			
	r^2	0.30	0.04	0.64	0.03			
Finley 1 interplaya	0.02	0	20	54	26	silt loam	0.24	16
	0.17	0	17	43	40	silty clay	0.25	11
	0.32	0	18	45	37	silty clay loam	0.15	13
	0.47	0	15	55	30	silty clay loam	0.13	16
	0.72	0	11	51	38	silty clay loam	0.12	12
	1.16	0	2	45	53	silty clay	0.13	42
	1.43	0	29	44	28	clay loam	0.14	13
	1.63	0	37	35	28	clay loam	0.08	54
	1.81	0	36	37	27	clay loam	0.09	41
	2.03	0	33	39	28	clay loam	0.10	33
	2.23	0	33	42	24	loam	0.10	34
	2.38	0	30	39	30	clay loam	0.11	21
	2.65	0	35	39	26	loam	0.11	31
	2.90	0	34	39	27	clay loam	0.11	23
	2.97	0	36	36	29	clay loam	0.09	24
	3.15	0	32	44	23	loam	0.12	23
	3.64	0	27	40	33	clay loam	0.12	30
	3.79	0	33	37	30	clay loam	0.10	40
	r		-0.61	0.86	0.38			mean
	r^2		0.37	0.74	0.14			27
Finley 2 annulus	0.09	0	23	36	41	clay	0.27	8
	0.20	0	27	37	36	clay loam	0.14	14
	0.29	0	28	36	36	clay loam	0.14	14
	0.56	0	31	38	31	clay loam	0.13	13
	0.84	0	43	35	22	loam	0.11	9
	1.01	0	39	35	26	loam	0.13	12
	1.16	0	25	45	31	clay loam	0.14	15
	1.36	0	33	35	33	clay loam	0.14	11
	1.57	0	37	33	30	clay loam	0.14	11
	1.81	0	29	36	35	clay loam	0.13	17
	2.06	0	27	37	36	clay loam	0.16	25
	2.27	0	31	39	30	clay loam	0.14	23
	2.42	0	22	38	41	clay	0.14	21
	2.73	0	26	38	36	clay loam	0.15	24
	2.88	0	23	39	38	clay loam	0.13	31
	3.87	0	24	34	42	clay	0.15	38
	4.91	0	17	56	26	silt loam	0.19	13
	5.30	0	21	46	33	clay loam	0.21	10
	5.59	0	30	34	36	clay loam	0.14	26
	5.68	0	30	47	23	loam	0.15	26
	5.96	0	43	13	45	clay	0.19	44
	6.05	0	41	26	33	clay loam	0.16	15
	6.72	0	43	20	37	clay loam	0.16	21
	7.61	0	60	12	28	sandy clay loam	0.08	42
	7.94	0	65	9	25	sandy clay loam	0.10	25

Appendix A. Texture, water content, and carbonate content of sampled boreholes.

Borehole number	Depth (m)	Gravel %	Sand %	Silt %	Clay %	Texture	Water content (g g-1)	Carbonate wt. %
	8.76	0	74	9	18	sandy loam	0.09	9
	10.06	0	78	11	12	sandy loam	0.06	15
	10.53	0	65	20	15	sandy loam	0.11	5
	11.32	0	71	16	13	sandy loam	0.08	18
	12.10	0	78	3	19	sandy loam	0.10	3
	12.19	0	84	2	13	loamy sand	0.10	11
	r		-0.79	0.67	0.69			mean
	r^2		0.62	0.45	0.48			18
Finley 3 playa	0.14	0	11	40	49	clay	0.27	20
	0.29	0	12	40	49	clay	0.22	14
	0.44	0	11	38	51	clay	0.22	18
	0.58	0	10	40	50	clay	0.27	10
	0.72	0	10	39	51	clay	0.28	18
	0.85	0	10	38	52	clay	0.29	12
	1.05	0	9	38	53	clay	0.29	15
	1.20	0	13	37	51	clay	0.29	13
	1.36	0	14	39	47	clay	0.28	13
	1.46	0	16	40	44	clay	0.21	43
	1.57	0	26	41	33	clay loam	0.25	
	1.69	0	18	48	34	silty clay loam	0.26	15
	1.91	0	52	27	21	sandy clay loam	0.14	11
	2.07	0	33	38	30	clay loam	0.17	20
	2.16	0	49	26	24	sandy clay loam	0.17	5
	2.27	0	51	28	21	sandy clay loam	0.17	4
	2.47	0	69	16	14	sandy loam	0.12	3
	2.64	0	67	23	10	sandy loam	0.11	
	2.96	0	28	35	38	clay loam	0.23	2
	3.34	0	41	29	29	clay loam	0.21	8
	3.37	0	92	7	1	sand	0.07	10
	3.44	0	39	24	38	clay loam	0.21	12
	3.57	0	79	9	12	sandy loam	0.11	2
	3.66	0	3	35	62	clay	0.21	34
	3.79	0	38	26	37	clay loam	0.21	10
	3.95	0	41	26	33	clay loam	0.20	7
	4.07	0	41	29	31	clay loam	0.19	2
	4.40	0	18	42	40	silty clay	0.15	45
	4.59	0	65	21	15	sandy loam	0.14	
	4.67	0	67	17	16	sandy loam	0.13	
	4.88	0	38	22	40	clay	0.20	
	5.06	0	35	23	42	clay	0.20	
	5.68	0	27	35	37	clay loam	0.20	
	6.36	0	33	37	30	clay loam	0.23	17
	7.38	0	51	24	25	sandy clay loam	0.20	
	8.35	0	62	14	24	sandy clay loam	0.19	1
	9.43	0	69	7	24	sandy clay loam	0.18	28
	10.22	0	74	7	20	sandy clay loam	0.16	8
	11.28	0	76	7	17	sandy loam	0.13	
	12.40	0	80	6	14	sandy loam	0.11	0
	13.23	0	84	4	12	loamy sand	0.11	19
	14.20	0	87	4	9	loamy sand	0.10	32
	r		-0.86	0.75	0.85			mean
	r^2		0.74	0.56	0.72			14
Koesjan 2 interplaya	0.29	0	40	54	6	silt loam	0.17	
	1.91	4	36	28	32	gravelly sandy mud	0.11	
	4.07	0	34	61	5	clay loam	0.17	
	4.65	0	29	36	35	clay loam	0.10	
	7.09	9	28	32	31	gravelly mud	0.16	
	8.70	0	38	56	7	silt loam	0.09	
	11.05	12	44	0	44	gravelly mud	0.13	

Appendix A. Texture, water content, and carbonate content of sampled boreholes.

Borehole number	Depth (m)	Gravel %	Sand %	Silt %	Clay %	Texture	Water content (g g-1)	Carbonate wt. %
	r	0.32	-0.22	0.06	-0.13			
	r^2	0.10	0.05	0.00	0.02			
Koesjan 4 annulus	0.29	0	26	43	31	clay loam	0.22	
	3.73	0	29	47	24	loam	0.08	
	4.10	0	14	55	31	silty clay loam	0.18	
	8.61	10	55	10	24	gravelly muddy sand	0.12	
	15.47	3	85	3	9	gravelly muddy sand	0.09	
	18.61	13	13	15	59	gravelly mud	0.25	
	24.70	14	60	19	7	gravelly muddy sand	0.14	
	27.75	5	23	25	47	gravelly mud	0.26	
	r	0.30	-0.66	0.02	0.84			
	r^2	0.09	0.44	0.00	0.71			
Playa 5 #7 playa	0.12	0	5				0.24	
	0.58	0	5				0.26	
	1.04	0	7				0.28	
	1.68	0	4				0.31	
	2.29	0	5				0.31	
	3.20	0	4				0.30	
	4.15	0	4				0.28	
	5.73	0	5				0.28	
	7.89	0	5				0.30	
	11.49	0	77				0.15	
	13.99	0	70				0.20	
	r		-0.89					
	r^2		0.79					
Playa 5 #8 playa	0.12	0	48				0.10	
	1.19	0	33				0.12	
	2.23	0	13				0.18	
	3.75	0	70				0.13	
	4.66	0	73				0.10	
	7.00	0	72				0.12	
	9.00	0	75				0.12	
	12.00	0	66				0.13	
	15.00	0	6				0.29	
	19.00	0	70				0.13	
	21.00	0	29				0.19	
	25.00	0	89				0.06	
	r		-0.81					
	r^2		0.66					
SMB 2 playa	0.29	0	13	57	30	silty clay loam	0.27	
	0.59	0	13	40	47	clay	0.32	
	2.03	0	19	42	39	clay	0.30	
	3.55	0	13	43	44	clay	0.28	
	4.47	0	18	46	36	clay	0.30	
	5.07	0	5	35	59	clay	0.27	
	5.78	0	8	35	57	clay	0.30	
	6.29	0	28	57	15	silty clay	0.27	
	6.90	0	34	54	12	clay	0.34	
	8.12	0	37	54	9	silt loam	0.25	
	9.65	0	83	18	0	loamy sand	0.18	
	11.17	1	21	51	27	clay	0.26	
	12.69	0	3	29	68	clay	0.37	
	13.91	0	28	45	27	clay	0.27	
	18.91	0	72	13	16	sandy loam	0.23	
	23.06	0	84	10	6	loamy sand	0.08	
	r	-0.02	-0.82	0.58	0.62			
	r^2	0.00	0.67	0.34	0.38			
	0.29	0	43	49	8	loam	0.14	

Appendix A. Texture, water content, and carbonate content of sampled boreholes.

Borehole number	Depth (m)	Gravel %	Sand %	Silt %	Clay %	Texture	Water content (g g-1)	Carbonate wt. %
SMB 3 interplaya	1.60	0	68	27	5	sandy loam	0.06	
	2.00	0	32	47	21	clay loam	0.20	
	3.15	0	28	66	5	silt loam	0.24	
	3.46	0	47	34	19	loam	0.14	
	3.76	0	80	17	3	loamy sand	0.06	
	6.26	1	23	42	34	clay loam	0.15	
	8.73	2	34	51	13	clay loam	0.17	
	11.08	7	47	35	10	gravelly muddy sand	0.14	
	14.19	2	56	24	18	sandy loam	0.11	
	17.30	4	66	8	22	gravelly muddy sand	0.09	
	20.47	1	69	18	12	sandy loam	0.11	
	r	-0.09	-0.88	0.89	0.17			
	r^2	0.01	0.77	0.79	0.03			
TDCJ 1 & 1B interplaya	0.09	0	17	53	30	silty clay loam	0.19	17
	0.20	0	14	49	38	silty clay loam	0.23	20
	0.30	0	15	49	36	silty clay loam	0.14	16
	0.41	0	15	32	53	clay	0.12	13
	0.52	0	19	49	32	silty clay loam	0.12	16
	0.75	0	19	49	31	silty clay loam	0.12	17
	0.90	0	20	43	37	silty clay loam	0.12	7
	1.05	0	25	34	41	clay	0.11	24
	1.22	0	25	43	32	clay loam	0.08	40
	1.36	0	28	44	28	clay loam	0.08	43
	1.51	0	24	45	31	clay loam	0.09	42
	1.62	0	26	36	38	clay loam	0.09	42
	1.78	0	24	44	32	clay loam	0.10	28
	1.94	0	22	46	31	clay loam	0.09	33
	2.09	0	27	46	27	clay loam	0.09	19
	2.19	0	33	42	25	loam	0.09	21
	2.61	0	31	42	27	clay loam	0.10	14
	2.76	0	29	44	27	clay loam	0.10	21
	2.85	0	32	42	26	loam	0.10	23
	3.02	0	26	43	31	clay loam	0.10	19
	3.26	0	23	45	32	clay loam	0.10	29
	3.86	0	27	51	22	silt loam	0.10	27
	4.07	0	24	37	39	clay loam	0.13	17
	4.70	0	27	38	35	clay loam	0.11	19
	5.08	0	32	25	43	clay	0.12	40
	5.47	0	34	36	30	clay loam	0.11	17
	6.42	0	36	29	34	clay loam	0.13	25
	7.34	0	41	32	27	clay loam	0.10	14
	8.37	0	33	42	26	loam	0.10	18
	9.17	0	28	45	27	clay loam	0.11	22
	r		0.25	-0.61	0.47			mean
	r^2		0.06	0.37	0.22			23
	0.14	0	25	32	43	clay	0.18	7
	0.29	0	27	34	40	clay	0.14	14
	0.44	0	27	33	40	clay	0.14	15
	0.59	0	27	35	38	clay loam	0.14	16
	0.75	0	25	30	45	clay	0.14	3
	0.92	0	30	34	36	clay loam	0.14	14
	1.05	0	29	34	37	clay loam	0.15	14
	1.20	0	31	33	36	clay loam	0.15	15
	1.36	0	36	31	33	clay loam	0.14	13
	1.51	0	34	23	43	clay	0.15	4
	1.66	0	38	23	39	clay loam	0.14	2
	1.81	0	49	23	28	sandy clay loam	0.10	7
	1.94	0	56	22	21	sandy clay loam	0.08	2
	2.06	0	58	18	25	sandy clay loam	0.12	15
	2.39	0	38	26	36	clay loam	0.15	6

Appendix A. Texture, water content, and carbonate content of sampled boreholes.

Borehole number	Depth (m)	Gravel %	Sand %	Silt %	Clay %	Texture	Water content (g g-1)	Carbonate wt. %
TDCJ 2 annulus	2.55	0	35	33	32	clay loam	0.15	18
	2.77	0	28	28	44	clay	0.16	14
	3.09	0	24	28	48	clay	0.17	15
	3.26	0	24	29	47	clay	0.17	9
	3.41	0	25	28	47	clay	0.17	13
	3.58	0	22	27	51	clay	0.17	2
	3.75	0	34	27	38	clay loam	0.18	1
	4.09	0	22	37	41	clay	0.18	10
	4.42	0	22	32	46	clay	0.18	24
	4.73	0	24	45	31	clay loam	0.18	42
	4.98	0	21	27	52	clay	0.18	4
	5.51	0	39	33	28	clay loam	0.13	6
	6.88	0	56	24	20	sandy clay loam	0.09	4
	7.16	0	51	26	23	sandy clay loam	0.11	2
	7.73	0	47	29	24	loam	0.11	3
	7.95	0	47	31	22	loam	0.11	5
	8.70	0	32	39	29	clay loam	0.13	44
	9.02	0	33	39	28	clay loam	0.11	43
	r		-0.89	0.32	0.86			mean
	r^2		0.79	0.10	0.74			12
TDCJ 3 annulus	0.19	0	26	37	36	clay loam	0.29	9
	0.57	0	28	34	38	clay loam	0.28	7
	0.95	0	26	43	32	clay loam	0.25	18
	1.36	0	23	40	37	clay loam	0.24	8
	1.78	0	26	40	34	clay loam	0.22	10
	2.16	0	74	12	14	sandy loam	0.20	22
	2.54	0	45	28	27	clay loam	0.12	0
	2.95	0	50	21	29	sandy clay loam	0.11	
	3.47	0	19	25	56	clay	0.15	43
	3.77	0	29	25	45	clay	0.16	5
	4.15	0	36	31	33	clay loam	0.16	10
	4.61	0	27	35	38	clay loam	0.16	16
	5.45	0	33	25	42	clay	0.14	19
	6.13	0	32	26	42	clay	0.14	8
	6.90	0	55	19	26	sandy clay loam	0.11	5
	7.66	0	49	23	28	sandy clay loam	0.11	2
	8.42	0	28	36	36	clay loam	0.16	22
	9.18	0	31	28	41	clay	0.13	36
	9.94	0	49	25	27	sandy clay loam	0.10	
	10.71	0	40	31	30	clay loam	0.11	12
	11.47	0	52	21	27	sandy clay loam	0.11	10
	12.23	0	46	25	28	sandy clay loam	0.12	5
	12.99	0	59	22	19	sandy loam	0.08	4
	13.75	0	40	28	32	clay loam	0.11	12
	14.52	0	20	33	47	clay	0.17	17
	15.28	0	14	38	47	clay	0.18	22
	16.04	0	16	36	48	clay	0.20	2
	16.80	0	33	28	39	clay loam	0.15	3
	17.56	0	39	29	31	clay loam	0.14	
	18.33	0	54	22	24	sandy clay loam	0.11	8
	19.09	0	71	17	12	sandy loam	0.06	0
	19.85	0	71	10	19	sandy loam	0.09	1
	20.61	0	44	19	37	clay loam	0.16	0
	21.37	0	52	14	34	sandy clay loam	0.15	1
	22.14	0	56	10	33	sandy clay loam	0.18	4
	22.90	0	77	9	14	sandy loam	0.09	1
	23.66	0	79	6	14	sandy loam	0.09	3
	r		-0.62	0.54	0.58			mean
	r^2		0.38	0.29	0.34			10

Appendix A. Texture, water content, and carbonate content of sampled boreholes.

Borehole number	Depth (m)	Gravel %	Sand %	Silt %	Clay %	Texture	Water content (g g-1)	Carbonate wt. %
	0.11	0	21	37	41	clay	0.27	6
	0.46	0	20	48	33	silty clay loam	0.34	8
	0.88	0	15	42	43	silty clay	0.25	7
	0.88	0	1	48	51	silty clay	0.28	27
	1.18	0	15	41	44	silty clay	0.23	6
	1.18	0	15	43	42	silty clay	0.23	7
	1.49	0	14	45	41	silty clay	0.22	9
	1.79	0	33	41	26	loam	0.17	9
	2.10	0	30	44	27	loam	0.19	2
	2.40	0	25	46	29	clay loam	0.18	24
	2.71	0	26	50	24	loam	0.16	14
	3.01	0	20	43	37	silty clay loam	0.17	24
	3.11	0	23	51	26	silt loam	0.17	14
	3.72	0	17	55	28	silty clay loam	0.20	12
	4.33	0	20	47	33	clay loam	0.13	17
	4.94	0	31	38	30	clay loam	0.12	11
	5.55	0	28	41	31	clay loam	0.12	13
	6.16	0	41	35	24	loam	0.11	9
	6.77	0	51	30	19	loam	0.10	7
TDCJ 4	7.38	0	29	48	23	loam	0.11	17
annulus	7.99	0	6	58	35	silty clay loam	0.16	23
	8.60	0	37	42	22	loam	0.13	7
	9.20	0	19	38	43	clay	0.21	14
	9.81	0	3	43	53	silty clay	0.28	14
	10.42	0	28	46	26	loam	0.23	7
	11.03	0	46	42	12	loam	0.17	9
	11.64	0	14	60	25	silt loam	0.27	9
	12.25	0	11	54	35	silty clay loam	0.31	7
	12.86	0	13	51	36	silty clay loam	0.26	11
	14.08	0	9	44	47	silty clay	0.29	9
	15.30	0	74	6	19	sandy loam	0.13	2
	15.91	0	77	4	19	sandy loam	0.12	5
	16.52	0	79	5	16	sandy loam	0.13	4
	17.74	0	76	9	15	sandy loam	0.12	4
	18.96	0	80	6	14	sandy loam	0.11	4
	20.18	0	75	9	16	sandy loam	0.13	1
	22.62	0	90	10	<1	loamy sand	0.11	1
	23.84	0	86	14	<1	sandy loam	0.10	3
	25.05	0	95	5	<1	sand	0.06	19
	25.66	0	95	5	<1	loamy sand	0.09	39
	r		-0.74	0.63	0.70			mean
	r^2		0.55	0.40	0.49			11
	0.53	0	43	40	17	loam	0.13	11
	1.79	0	30	34	36	clay loam	0.14	26
	2.10	0	50	27	23	sandy clay loam	0.09	34
	2.10	0	29	49	22	loam	0.08	23
	2.40	0	29	49	22	loam	0.10	23
	2.71	0	28	45	28	clay loam	0.10	35
	3.01	0	39	38	24	loam	0.13	12
	3.77	0	43	40	17	loam	0.11	11
	4.53	0	35	47	18	loam	0.11	22
	5.30	0	29	44	27	clay loam	0.11	16
	6.06	0	38	34	28	clay loam	0.13	5
TDCJ 5	6.82	0	31	40	29	clay loam	0.13	13
interplaya	7.58	0	24	49	27	loam	0.12	21
	8.34	0	26	42	32	clay loam	0.12	34
	9.11	0	26	31	43	clay	0.15	7
	9.88	0	33	30	37	clay loam	0.14	11
	10.55	0	27	40	33	clay loam	0.16	7
	11.40	0	21	37	42	clay	0.14	22
	12.16	0	23	39	39	clay loam	0.14	12
	12.92	0	26	39	34	clay loam	0.13	39

Appendix A. Texture, water content, and carbonate content of sampled boreholes.

Borehole number	Depth (m)	Gravel %	Sand %	Silt %	Clay %	Texture	Water content (g g-1)	Carbonate wt. %
	13.69	0	34	30	36	clay loam	0.12	17
	14.45	0	49	28	23	sandy clay loam	0.10	6
	15.21	0	46	32	23	loam	0.09	8
	15.29	0	22	40	38	clay loam	0.09	40
	r		-0.35	-0.21	0.55			mean
	r^2		0.12	0.04	0.30			19
TDCJ 28 playa	0.22	0	5	34	61	clay	0.41	4
	0.53	0	6	39	55	clay	0.39	5
	0.83	0	5	41	53	silty clay	0.39	4
	1.14	0	4	46	50	silty clay	0.37	2
	1.41	0	5	42	53	silty clay	0.35	3
	1.71	0	2	41	57	silty clay	0.35	0
	2.02	0	3	42	55	silty clay	0.34	1
	2.32	0	4	43	53	silty clay	0.33	2
	2.66	0	2	44	54	silty clay	0.32	0
	2.96	0	3	43	54	silty clay	0.32	2
	3.27	0	2	42	56	silty clay	0.31	0
	3.57	0	2	44	54	silty clay	0.30	0
	3.88	0	3	46	51	silty clay	0.31	2
	4.24	0	0	43	57	silty clay	0.30	0
	4.52	0	3	44	53	silty clay	0.31	2
	4.82	0	4	42	54	silty clay	0.31	3
	5.13	0	24	32	44	clay	0.26	0
	5.43	0	1	30	69	clay	0.31	1
	5.84	0	6	38	56	clay	0.28	4
	6.59	0	6	23	70	clay	0.37	0
	7.40	0	2	37	60	clay	0.30	0
	8.15	0	0	50	51	silty clay	0.30	0
	8.88	0	6	38	56	clay	0.29	4
	9.70	0	4	34	62	clay	0.30	2
	10.49	0	2	37	61	clay	0.32	1
	11.25	0	4	40	56	clay	0.30	1
	11.71	0	38	22	41	clay	0.30	4
	14.36	0	20	33	47	clay	0.23	0
	15.92	0	62	8	30	sandy clay loam	0.13	0
	19.03	0	69	7	24	sandy clay loam	0.15	0
	20.58	0	72	2	27	sandy clay loam	0.13	0
	r		-0.83	0.72	0.78			mean
	r^2		0.69	0.52	0.61			2
Vance 2 interplaya	0.22	0	27	51	22	silty clay loam	0.26	
	3.45	0	21	59	19	silt loam	0.20	
	5.63	0	27	41	31	clay loam	0.16	
	6.80	0	29	37	34	clay loam	0.20	
	9.55	0	25	36	39	clay loam	0.28	
	10.98	5	63	9	23	gravelly muddy sand	0.16	
	13.94	4	67	8	21	gravelly muddy sand	0.11	
	15.49	0	61	15	25	sandy clay loam	0.21	
	16.95	19	51	8	22	gravelly muddy sand	0.15	
	20.00	0	87	4	9	loamy sand	0.08	
	24.57	0	91	1	8	sand	0.06	
	r	-0.12	-0.81	0.66	0.85			
	r^2	0.01	0.66	0.44	0.72			
Vance 6 playa	0.22	0	23	37	40	clay	0.11	
	2.57	2	15	35	48	clay	0.13	
	6.23	3	37	33	27	gravelly sandy mud	0.11	
	8.97	1	25	29	45	clay	0.17	
	11.89	0	47	33	20	loam	0.10	
	r	-0.04	-0.65	-0.71	0.80			
	r^2	0.00	0.42	0.50	0.64			

Appendix A. Texture, water content, and carbonate content of sampled boreholes.

Borehole number	Depth (m)	Gravel %	Sand %	Silt %	Clay %	Texture	Water content (g g-1)	Carbonate wt. %
Wink 1 interplaya	0.29	0	26	52	22	silty clay loam	0.14	2
	0.96	0	24	49	27	clay loam	0.11	4
	1.63	0	43	45	12	loam	0.08	44
	2.55	1	21	29	49	clay	0.10	46
	2.91	1	29	27	43	clay	0.13	9
	4.77	3	25	28	44	gravelly sandy mud	0.11	
	5.72	1	22	20	57	clay loam	0.14	15
	6.36	0	51	28	21	loam	0.10	
	8.24	0	50	27	23	sandy clay loam	0.09	
	9.83	1	33	34	32	clay loam	0.14	4
	11.35	0	18	59	23	silty clay loam	0.27	
	13.00	5	58	14	23	gravelly muddy sand	0.10	23
	15.68	2	41	16	41	clay	0.10	1
	22.36	0	77	12	11	sandy clay loam	0.07	
	25.86	0	28	48	24	loam	0.18	3
	r	-0.19	-0.59	0.65	0.08			
	r^2	0.04	0.35	0.42	0.01			
Wink 5 annulus	0.29	0	31	37	32	clay	0.24	
	0.59	0	30	42	28	clay loam	0.26	
	1.51	0	33	30	37	clay loam	0.20	
	2.51	5	44	23	28	gravelly mud	0.17	
	3.34	0	36	48	16	clay loam	0.28	
	4.01	6	48	18	28	gravelly mud	0.14	
	5.53	6	42	17	35	gravelly mud	0.18	
	6.08	44	27	10	20	muddy gravel	0.12	
	7.30	0	75	21	4	loamy sand	0.16	
	9.74	1	78	13	8	loamy sand	0.11	
	10.96	0	49	39	12	loam	0.18	
	13.82	0	96	4	0	sand	0.03	
	16.81	0	97	3	0	sand	0.02	
	20.99	0	49	38	13	loam	0.13	
	26.05	0	74	24	2	loamy sand	0.10	
	29.09	0	76	16	8	sandy loam	0.18	
	r	-0.07	-0.71	0.77	0.55			
	r^2	0.00	0.50	0.59	0.30			
Wink 7 playa	0.22	0	38	20	43	clay	0.23	1
	0.53	0	30	22	48	clay	0.26	0
	0.83	0	32	23	45	clay	0.26	2
	1.14	0	32	25	43	clay	0.24	3
	1.35	0	32	26	42	clay	0.20	5
	1.65	0	31	32	37	clay loam	0.16	9
	1.96	0	34	31	35	clay loam	0.14	7
	2.26	0	36	28	36	clay loam	0.13	4
	2.57	0	19	52	29	silty clay loam	0.15	0
	2.90	0	21	49	30	clay loam	0.15	2
	3.21	0	20	49	31	silty clay loam	0.16	3
	3.51	0	26	43	31	clay loam	0.15	3
	3.82	0	29	36	35	clay loam	0.16	4
	4.12	0	33	34	33	clay loam	0.17	5
	4.46	0	36	27	38	clay loam	0.18	2
	4.76	0	38	20	42	clay	0.18	3
	5.07	0	25	35	39	clay loam	0.21	2
	r		0.25	-0.61	0.86			mean
	r^2		0.06	0.37	0.74			3
	13.64	0	85					
	17.5	0	70					
	18.5	0	99					
	19.95	0	97					
	21.47	0	94					
	22.07	0	92					
	23.5	0	57					

Appendix A. Texture, water content, and carbonate content of sampled boreholes.

Borehole number	Depth (m)	Gravel %	Sand %	Silt %	Clay %	Texture	Water content (g g-1)	Carbonate wt. %
Wink 12 playa	24.61	0	59					
	25.31	0	55					
	26.22	0	57					
	26.69	0	58					
	27.8	0	67					
	28.38	0	56					
	29.34	0	63					
	29.99	0	59					
Wink 13 playa	1.20	0	36	58	6	silt loam	0.29	
	2.51	1	32	58	9	silty clay loam	0.34	
	3.47	0	43	51	6	clay loam	0.24	
	4.43	0	43	41	16	loam	0.17	
	6.20	0	35	45	20	loam	0.24	
	7.42	0	72	11	17	sandy loam	0.11	
	9.43	0	73	9	18	sandy loam	0.14	
	10.53	0	22	35	43	clay	0.25	
	13.64	0	78	4	18	sandy loam	0.16	
	14.65	3	8	41	48	gravelly mud	0.29	
	17.08	0	17	33	50	clay	0.30	
	20.16	0	48	26	26	loam	0.28	
	23.36	0	47	41	13	loam	0.22	
	26.44	0	47	41	12	loam	0.18	
	29.63	0	58	27	16	sandy loam	0.16	
	r	0.41	-0.80	0.70	0.30			
	r^2	0.17	0.64	0.49	0.09			
Wink 14 playa	0.25	0	13	34	52	clay		
	1.22	0	12	38	50	clay		
	1.66	0	13	39	48	clay		
	2.2	0	17	36	47	clay		
	3.18	0	22	38	41	clay		
	4.67	0	32	36	32	clay loam		
	4.73	0	40	38	23	loam		
	5.83	0	55	28	17	sandy loam		
	6.2	0	48	35	17	loam		
	6.56	0	40	34	26	loam		
	7.57	0	66	20	15	sandy loam		
	7.8	0	64	16	20	sandy loam		
	8.17	0	89	5	6	sand		
	9.55	0	47	33	20	loam		
	10.63	0	18	37	45	clay		
	11.53	0	23	31	46	clay		
	12.6	0	77	7	16	sandy loam		
	13.67	0	86	6	8	loamy sand		
	14.88	0	43	32	25	loam		
	17.23	0	69	13	20	sandy loam		
	18.6	0	96	3	1	sand		
	19.76	0	98	1	1	sand		
	24.33	0	61	28	12	sandy loam		
	24.79	0	51	40	9	loam		
	25.57	0	52	34	14	sandy loam		
	27.23	0	62	34	4	sandy loam		
	28.6	0	72	23	5	sandy loam		
	29.54	0	55	35	11	sandy loam		

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	0.11	0.11	0.170	5.6	32.7					
	0.34	0.23	0.175	5.7	32.8					
	0.57	0.23	0.086	4.5	51.9					
	0.79	0.22	0.117	40.8	349.6					
	1.03	0.24	0.119	56.9	478.2					
	1.26	0.23	0.118	88.8	753.5					
	1.49	0.23	0.115	92.9	**805.7**					
	1.64	0.15	0.117	80.5	690.6					
	1.87	0.23	0.094	41.8	447.5					
	2.10	0.23	0.095	16.8	177.9					
	2.34	0.24	0.113	9.1	80.6					
	2.55	0.21	0.128	6.2	48.2					
	2.78	0.23	0.165	5.8	35.0					
	3.01	0.23	0.163	4.1	25.2					
	3.31	0.30	0.136	4.8	35.0					
	3.62	0.30	0.152	3.5	22.9					
	3.89	0.27	0.140	3.2	22.9					
	4.23	0.34	0.150	1.9	12.9					
BEGPTX	4.53	0.30	0.194	1.2	6.3					
	4.84	0.30	0.183	1.4	7.6					
	5.14	0.30	0.122	1.1	9.4					
	5.51	0.37	0.148	0.9	6.2					
	5.75	0.24	0.144	1.1	8.0					
	6.06	0.30	0.138	1.0	7.3					
	6.36	0.30	0.132	0.7	5.6					
	6.67	0.30	0.157	0.9	5.4					
	7.03	0.37	0.157	0.0	0.0					
	7.28	0.24	0.145	0.7	5.1					
	7.58	0.30	0.154	1.8	11.7					
	8.34	0.76	0.194	1.6	8.5					
	9.11	0.76	0.175	1.1	6.2					
	9.87	0.76	0.177	0.7	4.0					
	10.63	0.76	0.201	0.9	4.5					
	11.39	0.76	0.178	1.4	7.8					
	12.13	0.74	0.186	1.3	7.1					

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	12.89	0.76	0.131	0.8	5.8					
	13.68	0.78	0.127	0.6	4.8					
	14.44	0.76	0.154	1.1	7.2					
	15.20	0.76	0.147	1.1	7.5					
	15.96	0.76	0.132	1.1	8.7					
	16.73	0.76	0.097	0.5	5.2					
	17.49	0.76	0.138	1.4	9.9					
	18.06	0.57	0.108	0.7	6.1					
	18.98	0.92	0.131	1.2	9.1					
	19.77	0.79	0.113	0.7	6.5					
	21.30	1.52	0.115	0.9	7.7					
	22.06	0.76	0.128	1.3	10.1					
	22.82	0.76	0.130	1.1	8.5					
	23.58	0.76	0.126	2.3	18.0					
	24.35	0.76	0.098	0.9	9.1					
	0.11	0.11	0.267	<.3	<1.1					0.04
	0.34	0.23	0.235	9.7	41.5	1.96	5.96	38.95	3.12	0.12
	0.57	0.23	0.138	57.7	418.1	0.19	1.00	269.90	21.59	0.16
	0.80	0.23	0.119	112.3	942.7	0.09	0.52	719.16	57.53	0.20
	1.01	0.21	0.080	93.2	**1165.5**	0.07	0.62	1067.08	85.37	0.22
	1.26	0.24	0.093	99.0	1064.3	0.08	0.59	1489.62	119.17	0.26
	1.49	0.47	0.100	94.9	948.2	0.09	0.61	1869.42	149.55	0.29
	1.64	0.15	0.091	91.9	1014.5	0.08	0.63	2114.56	169.16	0.31
	1.87	0.23	0.110	97.2	881.2	0.09	0.60	2503.35	200.27	0.34
	2.10	0.23	0.099	109.0	1103.6	0.07	0.53	2939.28	235.14	0.37
	2.32	0.23	0.110	102.2	925.9	0.09	0.57	3348.18	267.85	0.41
	2.55	1.30	0.135	117.5	869.3	0.09	0.49	6011.69	480.94	0.65
	2.78	0.23	0.141	109.5	778.3	0.10	0.53	6449.70	515.98	0.70
	3.01	0.23	0.110	78.9	714.7	0.11	0.73	6765.44	541.24	0.73
	4.23	1.22	0.139	59.9	431.3	0.19	0.97	8043.53	643.48	0.97
	4.53	0.30	0.121	46.5	384.1	0.21	1.25	8291.51	663.32	1.02
	4.84	0.30	0.123	44.7	364.7	0.22	1.30	8529.79	682.38	1.08
	5.75	0.91	0.132	41.8	316.8	0.26	1.39	9198.93	735.91	1.24
	6.06	0.30	0.109	32.9	301.0	0.27	1.76	9374.44	749.96	1.29

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	6.30	0.24	0.109	33.3	305.0	0.27	1.74	9516.68	761.33	1.33
	7.28	0.98	0.124	31.2	252.0	0.32	1.86	10049.66	803.97	1.50
	7.53	0.25	0.134	32.4	242.8	0.33	1.79	10192.33	815.39	1.55
	7.86	0.33	0.138	30.5	221.8	0.37	1.90	10367.22	829.38	1.61
	8.16	0.30	0.117	29.7	252.8	0.32	1.96	10525.47	842.04	1.66
	8.50	0.34	0.127	25.8	202.5	0.40	2.25	10676.70	854.14	1.72
	8.66	0.16	0.133	23.9	179.9	0.45	2.43	10743.59	859.49	1.75
BEGPTX	9.11	0.45	0.148	14.4	97.6	0.83	4.02	10857.00	868.56	1.84
	9.41	0.30	0.150	30.5	203.6	0.40	1.90	11019.65	881.57	1.90
	9.72	0.30	0.141	26.0	185.0	0.44	2.23	11158.52	892.68	1.96
	10.63	0.91	0.142	23.4	165.2	0.49	2.48	11532.76	922.62	2.15
	11.39	0.76	0.122	24.4	201.0	0.40	2.37	11858.45	948.68	2.28
	12.15	0.76	0.131	19.7	149.9	0.54	2.95	12120.69	969.66	2.42
	12.92	0.76	0.103	16.5	161.3	0.50	3.51	12341.27	987.30	2.52
	13.68	0.76	0.081	11.9	147.5	0.55	4.86	12500.39	1000.03	2.61
	14.44	0.76	0.108	13.2	122.5	0.66	4.40	12676.04	1014.08	2.73
	15.20	0.76	0.162	17.1	105.6	0.77	3.40	12903.65	1032.29	2.90
	15.96	0.76	0.117	13.2	113.2	0.72	4.39	13079.88	1046.39	3.02
	16.73	0.76	0.060	6.7	111.7	0.73	8.68	13168.95	1053.52	3.09
	18.20	1.47	0.103	7.6	73.4	1.11	7.64	13364.32	1069.15	3.30
	18.65	0.45	0.072	6.1	84.6	0.96	9.53	13412.23	1072.98	3.34
	19.65	1.01	0.070	3.6	51.9	1.56	15.89	13476.47	1078.12	3.44
	20.48	0.83	0.075	2.6	**34.7**	2.34	22.26	13514.34	1081.15	3.53
	21.30	0.82	0.057	3.8	65.8	1.23	15.40	13568.08	1085.45	3.60
	22.06	0.76	0.057	4.6	80.4	1.01	12.60	13629.44	1090.36	3.66
	0.22	0.22	0.262	5.8	22.2					
	0.53	0.30	0.269	7.1	26.5					
	0.83	0.30	0.264	8.7	33.1					
	1.32	0.49	0.219	7.8	35.7					
	1.62	0.30	0.203	3.9	19.3					
	1.93	0.30	0.194	4.1	21.3					
	2.23	0.30	0.193	7.8	40.6					
	2.57	0.34	0.188	13.3	70.7					
	2.84	0.27	0.191	15.0	78.7					

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	3.15	0.30	0.193	16.5	85.1					
	3.45	0.30	0.203	18.1	89.3					
	3.76	0.30	0.200	17.7	88.2					
	4.03	0.27	0.195	17.3	88.3					
	4.37	0.34	0.186	12.4	66.5					
	4.67	0.30	0.181	12.7	70.4					
	4.98	0.30	0.177	9.2	51.9					
	5.28	0.30	0.176	8.7	49.5					
	5.63	0.35	0.161	8.3	51.5					
	5.89	0.26	0.186	10.0	53.8					
	6.20	0.30	0.191	9.5	49.5					
	6.50	0.30	0.192	12.5	65.4					
	6.80	0.30	0.198	12.7	64.0					
	7.16	0.35	0.200	16.7	83.3					
	7.41	0.26	0.200	21.2	106.0					
	7.72	0.30	0.205	27.3	133.3					
Vance 2	8.02	0.30	0.205	27.3	133.6					
playa	8.33	0.30	0.221	33.7	152.7					
	8.69	0.37	0.254	47.2	185.9					
	8.94	0.24	0.233	50.5	216.9					
	9.24	0.30	0.262	55.4	211.6					
	9.55	0.30	0.282	76.0	269.6					
	10.23	0.69	0.189	57.5	303.5					
	10.98	0.75	0.159	53.7	**338.1**					
	11.76	0.78	0.203	61.5	303.7					
	12.47	0.72	0.123	36.6	297.6					
	13.24	0.76	0.138	45.7	331.8					
	13.94	0.70	0.108	30.8	284.3					
	14.78	0.84	0.125	35.2	281.1					
	15.49	0.72	0.207	44.5	214.9					
	16.95	1.46	0.151	31.2	206.9					
	17.79	0.84	0.124	23.9	192.7					
	18.48	0.69	0.124	15.8	126.9					
	20.00	1.52	0.078	10.3	132.6					
	21.65	1.65	0.081	6.9	85.2					

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	23.11	1.46	0.052	3.2	62.3					
	24.57	1.46	0.063	4.6	73.3					
	0.22	0.22	0.113	21.5	189.9					
	0.53	0.30	0.097	5.9	61.2					
	0.83	0.30	0.110	4.5	41.1					
	1.35	0.52	0.093	2.1	23.1					
	1.65	0.30	0.089	4.7	53.1					
	1.96	0.30	0.104	5.9	56.9					
	2.26	0.30	0.104	11.8	113.4					
	2.57	0.30	0.127	18.9	148.2					
	2.87	0.30	0.112	21.8	195.4					
	3.18	0.30	0.110	35.0	319.1					
	3.48	0.30	0.112	38.9	346.3					
Vance 6	3.79	0.30	0.095	39.6	415.8					
Annulus	4.08	0.29	0.091	40.6	**447.6**					
	4.40	0.32	0.120	44.8	374.4					
	4.79	0.40	0.122	47.7	391.6					
	5.01	0.21	0.125	48.1	383.9					
	5.31	0.30	0.103	42.7	413.5					
	5.59	0.27	0.102	36.1	355.0					
	5.92	0.34	0.122	50.3	411.0					
	6.23	0.30	0.112	46.1	412.8					
	6.53	0.30	0.131	52.4	400.8					
	6.84	0.30	0.137	58.9	429.7					
	7.11	0.27	0.128	56.1	436.4					
	7.44	0.34	0.135	52.7	391.3					
	7.75	0.30	0.130	58.0	446.8					
	8.05	0.30	0.146	61.8	423.8					
	8.36	0.30	0.166	69.3	417.2					
	8.62	0.26	0.118	57.8	**488.2**					
	8.97	0.35	0.170	72.4	426.0					
	9.36	0.40	0.112	52.4	469.5					
	10.11	0.75	0.095	44.3	464.1					
	10.92	0.81	0.094	41.6	441.4					

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	11.67	0.75	0.098	36.9	375.1					
	11.89	0.23	0.103	44.9	437.3					
	0.02	0.02	0.240	7.8	32.4	9.64	28.68	0.53	0.17	0.01
	0.17	0.15	0.255	8.4	33.0	9.47	26.53	6.28	1.96	0.06
	0.32	0.15	0.148	8.3	56.0	5.57	26.82	11.96	3.73	0.09
	0.47	0.15	0.126	57.6	455.9	0.68	3.87	51.33	16.01	0.12
	0.72	0.24	0.117	142.4	1217.8	0.26	1.56	207.18	64.64	0.16
	1.16	0.44	0.129	192.3	1489.9	0.21	1.16	588.52	183.62	0.24
	1.43	0.27	0.135	205.2	1514.8	0.21	1.09	841.12	262.43	0.29
	1.63	0.20	0.076	129.0	1687.9	0.18	1.73	955.81	298.21	0.31
	1.81	0.18	0.086	144.5	1671.7	0.19	1.54	1074.36	335.20	0.33
	2.03	0.21	0.096	164.1	**1706.1**	0.18	1.36	1231.48	384.22	0.36
Finley 1 interplaya	2.23	0.20	0.102	174.2	1699.5	0.18	1.28	1386.31	432.53	0.39
	2.38	0.15	0.106	168.5	1592.2	0.20	1.32	1501.52	468.47	0.41
	2.65	0.27	0.110	171.9	1565.8	0.20	1.30	1713.12	534.49	0.46
	2.90	0.24	0.109	163.9	1498.2	0.21	1.36	1892.50	590.46	0.49
	2.97	0.08	0.094	151.8	1619.7	0.19	1.47	1944.40	606.65	0.50
	3.15	0.18	0.117	166.1	1417.4	0.22	1.34	2080.68	649.17	0.53
	3.64	0.49	0.118	140.3	1191.8	0.26	1.59	2387.64	744.94	0.61
	3.79	0.15	0.100	117.2	1173.0	0.27	1.90	2467.76	769.94	0.63

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	0.09	0.09	0.274	9.6	35.0					
	0.20	0.11	0.143	9.5	66.9					
	0.29	0.09	0.139	4.4	31.6					
	0.56	0.27	0.130	4.0	30.6					
	0.84	0.27	0.113	3.2	27.8					
	1.01	0.17	0.126	2.4	19.0					
	1.16	0.15	0.136	3.8	28.0					
	1.36	0.20	0.140	2.9	20.6					
	1.57	0.21	0.142	2.7	19.3					
	1.81	0.24	0.129	4.2	32.3					
	2.06	0.24	0.155	5.5	35.6					
	2.27	0.21	0.137	6.1	44.8					
	2.42	0.15	0.142	7.7	54.1					
	2.73	0.30	0.150	7.9	52.5					
	2.88	0.15	0.130	8.6	66.0					
Finley 2	3.87	0.99	0.149	6.7	44.9					
Annulus	4.91	1.04	0.188	9.8	52.0					
	5.30	0.40	0.205	11.9	58.1					
	5.59	0.29	0.145	15.2	105.4					
	5.68	0.09	0.154	15.9	103.3					
	5.96	0.27	0.186	17.2	92.4					
	6.05	0.09	0.155	14.7	94.8					
	6.72	0.67	0.164	13.4	81.9					
	7.61	0.89	0.084	7.5	88.7					
	7.94	0.33	0.103	8.6	83.2					
	8.76	0.82	0.088	8.3	94.7					
	10.06	1.30	0.063	7.6	119.8					
	10.53	0.47	0.108	11.3	103.9					
	11.32	0.79	0.080	12.2	152.2					
	12.10	0.78	0.103	12.5	121.5					
	12.19	0.09	0.103	12.7	123.5					
	0.14	0.14	0.266	10.1	38.0					
	0.29	0.15	0.222	9.5	42.8					

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	0.44	0.15	0.224	5.3	23.7					
	0.58	0.14	0.272	4.4	16.1					
	0.72	0.14	0.283	3.9	13.9					
	0.85	0.13	0.291	3.6	12.2					
	1.05	0.21	0.295	3.0	10.1					
	1.20	0.15	0.293							
	1.36	0.15	0.283	4.9	17.3					
	1.46	0.11	0.210	3.1	14.6					
	1.57	0.11	0.250	5.8	23.3					
	1.69	0.12	0.265	3.4	12.8					
	1.91	0.21	0.144	2.8	19.3					
Finley 3 playa	2.07	0.17	0.169	3.5	20.4					
	2.16	0.09	0.172	2.8	16.2					
	2.27	0.11	0.171	2.2	12.7					
	2.47	0.20	0.123							
	2.64	0.17	0.109							
	2.96	0.32	0.227							
	3.34	0.38	0.209							
	3.37	0.03	0.068							
	3.44	0.08	0.211	4.5	21.2					
	3.57	0.12	0.107	3.4	31.6					
	3.66	0.09	0.213	2.5	11.9					
	3.79	0.14	0.211	2.4	11.3					
	3.95	0.15	0.203	3.1	15.5					
	4.07	0.12	0.193	2.5	12.7					
	4.40	0.34	0.149	2.5	16.6					
	4.59	0.18	0.142	3.0	21.2					
	4.67	0.08	0.130	1.7	13.3					
	4.88	0.21	0.196	2.7	13.6					
	5.06	0.18	0.204	3.1	15.0					
	5.68	0.62	0.205	4.3	21.2					
	6.36	0.68	0.226	2.6	11.5					
	7.38	1.01	0.198	3.0	14.9					
	8.35	0.98	0.187	3.2	17.0					
	9.43	1.07	0.183	2.9	15.9					

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	10.22	0.79	0.164	3.5	21.4					
	11.28	1.06	0.132	3.2	24.4					
	12.40	1.12	0.110	2.4	21.7					
	13.23	0.83	0.110	4.1	37.6					
	14.20	0.98	0.097	3.5	36.1					
	0.29	0.29	0.174	9.1	52.5					
	0.59	0.30	0.126	7.4	58.2					
	0.99	0.40	0.096	27.1	282.5					
	1.30	0.30	0.089	34.4	388.5					
	1.60	0.30	0.093	48.3	517.3					
	1.91	0.30	0.106	59.8	565.8					
	2.21	0.30	0.099	63.4	**641.0**					
	2.58	0.37	0.087	55.7	639.5					
	2.82	0.24	0.130	74.7	575.9					
	3.12	0.30	0.125	68.5	548.5					
	3.43	0.30	0.146	69.6	475.7					
	3.73	0.30	0.145	75.5	519.6					
	4.07	0.34	0.172	77.0	447.0					
	4.34	0.27	0.112	56.4	505.4					
	4.65	0.30	0.103	51.4	500.5					
	4.95	0.30	0.136	64.0	470.8					
	5.26	0.30	0.172	74.2	432.3					
Koesjan 2	5.59	0.34	0.145	70.1	484.7					
interplaya	5.87	0.27	0.102	48.7	476.5					
	6.48	0.61	0.117	54.6	465.7					
	7.09	0.61	0.161	76.8	477.1					
	8.00	0.91	0.108	47.2	435.4					
	8.70	0.70	0.090	38.2	422.8					
	9.53	0.82	0.100	35.1	352.7					
	11.05	1.52	0.130	37.8	289.7					
	12.57	1.52	0.105	26.7	253.8					
	0.29	0.29	0.220	1.7	7.6					
	0.59	0.30	0.201	1.7	8.4					

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	0.90	0.30	0.222	2.3	10.4					
	1.30	0.40	0.235	3.5	14.8					
	1.60	0.30	0.195	12.0	61.5					
	1.91	0.30	0.199	28.3	142.4					
	2.21	0.30	0.201	16.3	81.2					
	2.58	0.37	0.209	22.3	107.2					
	2.82	0.24	0.207	14.8	71.8					
	3.12	0.30	0.215	30.3	141.1					
	3.43	0.30	0.170	19.1	112.8					
	3.73	0.30	0.076	6.8	89.4					
Koesjan 4	4.10	0.37	0.182	13.5	74.2					
Annulus	4.34	0.24	0.144	12.7	88.3					
	4.65	0.30	0.184	11.4	61.7					
	4.95	0.30	0.161	7.9	49.2					
	5.26	0.30	0.162	7.1	44.1					
	5.53	0.27	0.151	6.6	44.1					
	5.87	0.34	0.138	6.6	47.7					
	6.17	0.30	0.139	6.4	45.8					
	6.48	0.30	0.166	4.2	25.4					
	8.00	1.52	0.127	2.9	22.9					
	8.61	0.61	0.115	2.3	20.1					
	9.22	0.61	0.135	1.1	7.8					
	10.44	1.22	0.146	0.9	5.9					
	11.66	1.22	0.145	4.7	32.2					
	11.96	0.30	0.121	2.4	19.7					
	13.94	1.98	0.089	0.9	9.8					
	15.47	1.52	0.090	1.0	10.6					
	16.99	1.52	0.160	1.0	6.0					
	18.61	1.62	0.245	0.9	3.5					
	21.66	3.05	0.238	0.9	3.6					
	24.70	3.05	0.144	0.9	6.3					
	27.75	3.05	0.256	0.5	1.9					
	30.68	2.93	0.269							
	0.29	0.29	0.273	8.6	31.5					

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	0.59	0.30	0.321	7.6	23.8					
	1.05	0.46	0.291	11.1	38.0					
	1.42	0.37	0.274	9.5	34.6					
	1.72	0.30	0.284	8.0	28.1					
	2.03	0.30	0.300	8.1	27.0					
	2.33	0.30	0.280							
	2.70	0.37	0.331	6.3	19.0					
	2.94	0.24	0.298	8.7	29.1					
	3.25	0.30	0.282	8.0	28.3					
	3.55	0.30	0.281	8.1	28.9					
	3.86	0.30	0.306	6.3	20.6					
	4.25	0.40	0.268	8.5	31.6					
	4.47	0.21	0.296	11.7	39.4					
SMB 2	4.77	0.30	0.285	10.0	35.0					
playa	5.07	0.30	0.267	8.3	31.2					
	5.38	0.30	0.271	9.9	36.5					
	5.78	0.40	0.302	8.1	26.7					
	5.99	0.21	0.304	7.6	24.9					
	6.29	0.30	0.269	7.4	27.7					
	6.60	0.30	0.304	7.5	24.6					
	6.90	0.30	0.344	10.7	31.1					
	7.30	0.40	0.265	3.6	13.5					
	8.12	0.82	0.252	3.0	11.9					
	9.65	1.52	0.177	1.3	7.3					
	11.17	1.52	0.261	3.1	11.7					
	12.69	1.52	0.374	3.3	8.9					
	13.91	1.22	0.266	2.7	10.2					
	15.44	1.52	0.281	1.9	6.9					
	18.91	3.47	0.232	2.4	10.4					
	23.06	4.15	0.076	0.9	12.5					
	26.01	2.96	0.076	1.1	14.1					
	0.29	0.29	0.139	4.0	29.1					
	0.59	0.30	0.138	2.7	19.9					
	1.02	0.43	0.144	5.7	39.7					

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	1.30	0.27	0.133	10.7	80.0					
	1.60	0.30	0.065	4.7	72.5					
	2.00	0.40	0.196	10.6	53.9					
	3.15	1.16	0.243	11.6	47.8					
	3.46	0.30	0.141	6.4	45.2					
	3.76	0.30	0.055	1.5	27.7					
	4.07	0.30	0.055	10.7	196.0					
	5.96	1.89	0.133	66.9	501.1					
	6.26	0.30	0.154	79.0	512.2					
	6.87	0.61	0.158	65.8	417.7					
	7.51	0.64	0.145	91.5	630.9					
	8.12	0.61	0.150	119.3	797.2					
SMB 3	8.73	0.61	0.174	130.7	753.2					
interplaya	9.53	0.79	0.132	118.2	**893.0**					
	11.08	1.55	0.144	101.8	707.1					
	12.63	1.55	0.149	71.2	476.0					
	14.19	1.55	0.115	50.2	436.4					
	15.86	1.68	0.114	40.5	355.1					
	17.30	1.43	0.086	34.0	395.0					
	18.91	1.62	0.107	32.3	301.5					
	20.47	1.55	0.114	32.0	281.1					
	0.29	0.29	0.148	1.4	9.6					
	0.59	0.30	0.127	3.6	28.3					
	0.90	0.30	0.127	3.8	29.9					
	1.30	0.40	0.084	31.3	374.5					
SMB 7	1.60	0.30	0.101	115.5	1143.7					
interplaya	1.91	0.30	0.106	131.4	**1245.4**					
	2.21	0.30	0.103	111.8	1085.6					
	2.58	0.37	0.112	67.4	603.7					
	2.82	0.24	0.107	54.9	512.4					
	3.12	0.30	0.108	43.0	398.4					
	3.43	0.30	0.109	37.4	342.4					
	3.73	0.30	0.115	40.5	352.3					
	4.04	0.30	0.110	39.4	357.7					

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	5.87	1.83	0.126	31.7	251.5					
	6.17	0.30	0.139	31.5	227.2					
	6.48	0.30	0.155	34.9	224.6					
	6.81	0.34	0.110	36.1	328.8					
SMB 7	7.12	0.30	0.123	35.8	289.7					
interplaya	7.42	0.30	0.125	33.5	268.2					
	7.73	0.30	0.122	31.8	261.0					
	8.03	0.30	0.108	27.1	250.9					
	8.31	0.27	0.143	30.6	213.9					
	9.83	1.52	0.108	26.1	241.6					
	11.38	1.55	0.121	31.2	257.0					
	12.91	1.52	0.091	22.0	242.8					
	14.43	1.52	0.031	7.4	238.0					
	15.99	1.55	0.084	14.3	170.7					
	17.54	1.55	0.070	13.7	196.8					
	0.09	0.09	0.195	7.2	37.1	8.41	30.83	2.97	0.93	0.02
	0.20	0.11	0.229	5.7	24.8	12.58	39.24	5.69	1.77	0.06
	0.30	0.11	0.140	4.6	32.9	9.49	48.46	7.89	2.46	0.08
	0.41	0.11	0.122	7.3	59.5	5.24	30.65	11.37	3.55	0.10
	0.52	0.11	0.123	16.3	132.8	2.35	13.66	19.17	5.98	0.12
	0.75	0.23	0.120	71.1	592.0	0.53	3.13	92.11	28.74	0.16
	0.90	0.15	0.118	108.6	920.1	0.34	2.05	166.36	51.90	0.18
	1.05	0.15	0.111	110.9	999.1	0.31	2.01	242.20	75.57	0.20
	1.22	0.17	0.085	104.9	1239.7	0.25	2.13	321.08	100.18	0.22
	1.36	0.14	0.081	117.5	1443.3	0.22	1.90	393.40	122.74	0.24
	1.51	0.15	0.086	128.0	1485.4	0.21	1.74	480.93	150.05	0.26
	1.62	0.11	0.091	193.0	**2116.9**	0.15	1.15	573.32	178.88	0.27
	1.78	0.17	0.096	178.3	1851.7	0.17	1.25	707.43	220.72	0.29
	1.94	0.15	0.093	180.7	1950.6	0.16	1.23	831.01	259.28	0.31
TDCJ 1	2.09	0.15	0.090	159.0	1774.3	0.18	1.40	939.76	293.20	0.33
interplaya	2.19	0.11	0.086	130.2	1507.6	0.21	1.71	1002.07	312.65	0.35
	2.61	0.41	0.104	123.7	1185.1	0.26	1.80	1230.46	383.90	0.41
	2.76	0.15	0.103	124.1	1203.1	0.26	1.80	1315.32	410.38	0.43
	2.85	0.09	0.098	113.4	1152.5	0.27	1.97	1361.84	424.89	0.44

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	3.02	0.17	0.102	110.3	1086.1	0.29	2.02	1444.80	450.78	0.46
	3.26	0.24	0.101	84.9	843.0	0.37	2.62	1537.70	479.76	0.50
	3.86	0.59	0.105	66.4	635.9	0.49	3.35	1714.92	535.05	0.59
	4.07	0.21	0.133	72.5	544.2	0.57	3.07	1784.32	556.71	0.63
	4.70	0.63	0.114	62.6	548.0	0.57	3.56	1961.55	612.00	0.73
	5.08	0.38	0.117	58.8	501.7	0.62	3.79	2062.55	643.51	0.79
	5.47	0.39	0.105	46.5	442.7	0.70	4.79	2143.71	668.84	0.85
	6.42	0.94	0.133	48.7	367.0	0.85	4.58	2350.16	733.25	1.02
	7.34	0.92	0.103	36.1	350.4	0.89	6.18	2499.44	779.83	1.15
	8.37	1.03	0.104	30.8	295.5	1.06	7.24	2641.55	824.16	1.30
	9.17	0.80	0.105	30.3	288.5	1.08	7.35	2750.41	858.13	1.42
	0.14	0.14	0.180	8.4	46.5					
	0.29	0.15	0.144	11.8	81.9					
	0.44	0.15	0.140	10.0	71.2					
	0.59	0.15	0.143	15.5	109.1					
	0.75	0.15	0.144	12.7	88.0					
	0.92	0.18	0.143	10.5	73.1					
	1.05	0.13	0.146	10.2	69.9					
	1.20	0.15	0.147	11.2	75.9					
	1.36	0.15	0.145	13.2	91.3					
	1.51	0.15	0.151	16.9	112.4					
	1.66	0.15	0.138	19.4	139.8					
TDCJ 2	1.81	0.15	0.101	23.1	230.1					
Annulus	1.94	0.12	0.085	27.9	329.0					
	2.06	0.12	0.116	51.9	447.7					
	2.39	0.34	0.151	71.4	473.3					
	2.55	0.15	0.149	73.8	494.9					
	2.77	0.22	0.157	103.2	**656.9**					
	3.09	0.33	0.166	96.3	581.5					
	3.26	0.17	0.170	102.9	605.9					
	3.41	0.15	0.170	99.3	583.0					
	3.58	0.17	0.172	103.8	604.0					
	3.75	0.17	0.178	97.8	548.6					
	4.09	0.34	0.180	84.3	468.3					

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	4.42	0.33	0.182	77.4	426.1					
	4.73	0.31	0.180	69.6	387.5					
	4.98	0.24	0.177	63.9	361.6					
	5.51	0.53	0.131	40.5	308.3					
	6.88	1.37	0.094	26.6	283.8					
	7.16	0.27	0.106	32.7	309.4					
	7.73	0.58	0.112	29.5	263.9					
	7.95	0.21	0.110	28.6	259.3					
	8.70	0.75	0.132	33.9	256.4					
	9.02	0.32	0.111	31.5	282.7					
	0.19	0.19	0.292	9.7	33.4					
	0.57	0.38	0.276	8.0	29.0					
	0.95	0.38	0.249	9.0	36.2					
	1.36	0.41	0.242	16.0	66.1					
	1.78	0.41	0.216	26.5	122.7					
	2.16	0.38	0.196	11.5	58.8					
	2.54	0.38	0.125	13.5	108.0					
	2.95	0.41	0.111	11.5	103.6					
	3.47	0.52	0.146							
	3.77	0.30	0.160	68.5	428.8					
	4.15	0.38	0.159	117.0	736.1					
	4.61	0.46	0.157	175.0	1111.2					
	5.45	0.84	0.142	158.9	**1117.6**					
	6.13	0.69	0.142	145.7	1025.3					
	6.90	0.76	0.107	85.2	797.0					
	7.66	0.76	0.109	57.3	527.2					
TDCJ 3	8.42	0.76	0.160	54.1	337.3					
Annulus	9.18	0.76	0.133	45.7	343.4					
	9.94	0.76	0.103	24.7	240.0					
	10.71	0.76	0.112	26.3	234.2					
	11.47	0.76	0.109	20.2	186.0					
	12.23	0.76	0.117	24.2	207.1					
	12.99	0.76	0.083	20.6	249.1					
	13.75	0.76	0.113	30.9	273.3					

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	14.52	0.76	0.169	32.6	193.0					
	15.28	0.76	0.179	39.4	219.9					
	16.04	0.76	0.201	48.7	241.9					
	16.80	0.76	0.154	40.5	262.7					
	17.56	0.76	0.140	40.0	284.8					
	18.33	0.76	0.111	30.3	273.9					
	19.09	0.76	0.060	23.6	396.0					
	19.85	0.76	0.090	28.9	321.7					
	20.61	0.76	0.158	48.3	305.5					
	21.37	0.76	0.148	45.0	304.7					
	22.14	0.76	0.178	50.7	285.0					
	22.90	0.76	0.095	26.2	277.3					
		0.76	0.092	31.2	338.9					
	0.11	0.11	0.268	5.8	21.7					
	0.46	0.36	0.336	6.3	18.8					
	0.88	0.41	0.248	4.2	16.8					
	0.88	0.00	0.278	4.7	16.8					
	1.18	0.30	0.235	7.0	29.6					
	1.18	0.00	0.232	5.0	21.6					
	1.49	0.30	0.218	5.3	24.4					
	1.79	0.30	0.173	3.3	18.9					
	2.10	0.30	0.186	4.8	25.7					
	2.40	0.30	0.182	2.9	16.0					
	2.71	0.30	0.164	3.5	21.0					
	3.01	0.30	0.171	5.9	**34.6**					
	3.11	0.10	0.167	5.4	32.3					
	3.72	0.61	0.197	4.8	24.6					
	4.33	0.61	0.127	2.0	15.7					
	4.94	0.61	0.123	2.0	16.0					
	5.55	0.61	0.121	2.3	18.9					
	6.16	0.61	0.106	2.3	21.2					
	6.77	0.61	0.102	2.6	25.7					
	7.38	0.61	0.108	1.6	15.2					
TDCJ 4	7.99	0.61	0.164	1.7	10.2					

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
Annulus	8.60	0.61	0.132	1.4	10.4					
	9.20	0.61	0.214	2.2	10.4					
	9.81	0.61	0.284	3.8	13.5					
	10.42	0.61	0.225	1.6	7.3					
	11.03	0.61	0.173	1.2	6.8					
	11.64	0.61	0.265	1.0	3.8					
	12.25	0.61	0.311	0.9	3.0					
	12.86	0.61	0.263	1.7	6.4					
	14.08	1.22	0.291	1.4	4.7					
	15.30	1.22	0.134	0.9	6.9					
	15.91	0.61	0.125	0.7	5.4					
	16.52	0.61	0.126	0.9	7.3					
	17.74	1.22	0.119	0.8	6.5					
	18.96	1.22	0.110	0.5	4.7					
	20.18	1.22	0.133	0.7	5.6					
	21.40	1.22	0.075	0.8	10.2					
	22.62	1.22	0.106	0.6	5.6					
	23.84	1.22	0.103	0.7	6.9					
	25.05	1.22	0.060	1.7	27.6					
	25.66	0.61	0.094	0.8	8.7					
	0.53	0.53	0.129	5.9	45.9	6.79	37.69	55.20	4.42	0.10
	1.79	1.26	0.140	62.2	444.5	0.70	3.58	1424.21	113.94	0.34
	2.10	0.30	0.085	26.2	307.7	1.01	8.51	1563.89	125.11	0.38
	2.10	0.00	0.079	31.1	392.9	0.79	7.16	1563.89	125.11	0.38
	2.40	0.30	0.099	25.2	255.1	1.22	8.83	1698.47	135.88	0.42
	2.71	0.30	0.103	21.6	209.4	1.49	10.31	1813.79	145.10	0.47
	3.01	0.30	0.128	65.0	506.2	0.62	3.43	2160.40	172.83	0.52
	3.77	0.76	0.111	60.0	540.2	0.58	3.71	2961.06	236.89	0.64
	4.53	0.76	0.115	79.2	689.1	0.45	2.81	4017.74	321.42	0.76
	5.30	0.76	0.115	69.9	609.0	0.51	3.19	4949.42	395.95	0.88
	6.06	0.76	0.126	63.7	503.8	0.62	3.50	5799.02	463.92	1.02
	6.82	0.76	0.133	61.0	459.0	0.68	3.65	6612.20	528.98	1.16
TDCJ 5	7.58	0.76	0.121	56.2	465.9	0.67	3.97	7361.39	588.91	1.29
interplaya	8.34	0.76	0.116	44.6	383.9	0.81	5.00	7955.58	636.45	1.41

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	9.11	0.77	0.150	56.4	375.6	0.83	3.95	8715.71	697.26	1.57
	9.88	0.76	0.140	50.1	359.0	0.87	4.45	9384.13	750.73	1.72
	10.55	0.67	0.158	57.2	360.8	0.86	3.90	10055.21	804.42	1.87
	11.40	0.85	0.144	49.2	341.7	0.91	4.53	10790.10	863.21	2.04
	12.16	0.76	0.142	51.0	359.1	0.87	4.37	11470.41	917.63	2.20
	12.92	0.76	0.127	39.1	308.9	1.01	5.70	11991.66	959.33	2.33
	13.69	0.76	0.124	61.6	495.3	0.63	3.62	12813.69	1025.10	2.46
	14.45	0.76	0.100	34.0	341.3	0.91	6.56	13266.58	1061.33	2.57
	15.21	0.76	0.093	37.1	396.6	0.79	6.01	13760.97	1100.88	2.67
	15.29	0.08	0.087	40.2	463.0	0.67	5.54	13814.58	1105.17	2.68
	0.29	0.29		2.9	13.0					
	0.59	0.30	0.169							
	0.81	0.21	0.170	2.1	12.3					
	1.20	0.40	0.199							
	1.51	0.30	0.197	60.6	308.2					
	1.81	0.30	0.139							
	2.12	0.30	0.129	95.1	**736.6**					
	2.45	0.34	0.122							
	2.73	0.27	0.136	86.6	637.2					
	3.03	0.30	0.153							
	3.34	0.30	0.152	83.1	545.1					
	3.64	0.30	0.155							
	3.95	0.30	0.180	76.5	424.3					
TDCJ 9	4.25	0.30	0.174							
Annulus	4.56	0.30	0.205	60.9	297.2					
	4.86	0.30	0.200							
	5.17	0.30	0.205	46.7	227.8					
	5.47	0.30	0.211							
	5.78	0.30	0.171	20.2	118.1					
	6.08	0.30	0.221							
	6.69	0.61	0.219	14.5	66.5					
	7.30	0.61	0.167							
	7.91	0.61	0.168	6.4	38.0					
	8.52	0.61	0.154							

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	9.13	0.61	0.150	2.9	19.2					
	9.80	0.67	0.204							
	10.35	0.55	0.182	4.1	22.3					
	10.96	0.61	0.186							
	11.57	0.61	0.190	4.6	24.4					
	12.33	0.76	0.177							
	16.06	3.73	0.129	5.3	40.7					
	18.43	2.36	0.119							
	19.19	0.76	0.116	2.1	17.9					
	19.95	0.76	0.102							
	21.60	1.65	0.110	1.7	15.0					
	23.00	1.40	0.085							
	24.52	1.52	0.059	0.6	10.2					
	26.05	1.52	0.097							
	27.57	1.52	0.100	0.7	6.7					
	29.09	1.52	0.096							
	0.22	0.22	0.413	3.8	9.1					
	0.53	0.30	0.388	3.4	8.7					
	0.83	0.30	0.392	4.0	10.1					
	1.14	0.30	0.365	3.9	10.6					
	1.41	0.27	0.346	3.1	8.9					
	1.71	0.30	0.347	3.2	9.3					
	2.02	0.30	0.338	4.0	11.8					
	2.32	0.30	0.326	3.8	11.5					
	2.66	0.34	0.318	4.7	14.6					
	2.96	0.30	0.317	4.7	14.7					
TDCJ 28	3.27	0.30	0.312	4.7	15.2					
playa	3.57	0.30	0.300	4.1	13.7					
	3.88	0.30	0.310	3.7	12.0					
	4.24	0.37	0.300	4.2	14.0					
	4.52	0.27	0.308	3.9	12.7					
	4.82	0.30	0.306	3.8	12.5					
	5.13	0.30	0.262	4.0	15.2					
	5.43	0.30	0.307	3.8	12.4					

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	5.84	0.41	0.284	4.3	15.1					
	6.59	0.75	0.372	6.4	17.1					
	7.40	0.81	0.304	5.9	19.3					
	8.15	0.75	0.299	5.5	18.3					
	8.88	0.73	0.292	5.3	18.1					
	9.70	0.82	0.298	4.7	15.6					
	10.49	0.79	0.320	5.5	17.1					
	11.25	0.76	0.301	5.1	16.8					
	11.71	0.46	0.301	4.3	14.3					
	12.81	1.10	0.290	4.3	14.7					
	14.36	1.55	0.231	5.4	23.3					
	15.92	1.55	0.132	3.7	28.2					
	17.47	1.55	0.124	4.6	37.1					
	19.03	1.55	0.154	4.5	29.2					
	20.58	1.55	0.133	3.5	26.3					
	0.29	0.29	0.141	35.5	252.1	1.24	6.28	179.80	14.38	0.06
	0.59	0.30	0.115	235.9	2059.2	0.15	0.94	1438.04	115.04	0.11
	0.96	0.37	0.113	469.3	**4171.3**	0.07	0.47	4441.87	355.35	0.16
	1.33	0.37	0.119	439.7	3695.2	0.08	0.51	7255.99	580.48	0.22
	1.63	0.30	0.077	254.2	3319.2	0.09	0.88	8612.08	688.97	0.26
	1.94	0.30	0.081	150.4	1858.3	0.17	1.48	9414.53	753.16	0.29
	2.24	0.30	0.081	116.6	1443.3	0.22	1.91	10036.67	802.93	0.33
	2.55	0.30	0.099	115.4	1168.5	0.27	1.93	10651.95	852.16	0.37
	2.91	0.37	0.131	117.3	897.3	0.35	1.90	11402.68	912.21	0.44
	3.22	0.30	0.130	104.1	800.2	0.39	2.14	11957.93	956.63	0.49
	3.52	0.30	0.116	87.8	758.5	0.41	2.54	12426.27	994.10	0.54
	3.83	0.30	0.113	73.8	654.3	0.48	3.02	12819.75	1025.58	0.59
	4.16	0.34	0.114	63.7	557.4	0.56	3.50	13193.33	1055.47	0.64
Wink 1	4.47	0.30	0.113	58.9	519.4	0.60	3.78	13507.42	1080.59	0.69
interplaya	4.77	0.30	0.105	53.4	507.6	0.61	4.17	13792.35	1103.39	0.74
	5.07	0.30	0.135	59.6	443.2	0.70	3.74	14110.41	1128.83	0.79
	5.38	0.30	0.139	51.4	368.7	0.85	4.34	14384.55	1150.76	0.85
	5.72	0.34	0.140	48.1	343.7	0.91	4.64	14666.60	1173.33	0.92
	6.05	0.34	0.121	37.3	308.5	1.01	5.98	14885.23	1190.82	0.97

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	6.36	0.30	0.103	32.0	310.3	1.01	6.96	15056.03	1204.48	1.02
	6.66	0.30	0.114	28.3	249.1	1.25	7.87	15207.02	1216.56	1.07
	7.30	0.64	0.108	26.8	248.3	1.26	8.32	15507.19	1240.57	1.16
	8.24	0.94	0.095	18.9	199.2	1.57	11.80	15819.49	1265.56	1.29
	8.79	0.55	0.118	27.5	232.5	1.34	8.09	16083.91	1286.71	1.38
	9.83	1.04	0.140	24.6	174.8	1.78	9.08	16529.23	1322.34	1.58
	11.35	1.52	0.269	38.7	144.0	2.17	5.76	17561.58	1404.93	2.16
	13.00	1.65	0.104	18.3	176.2	1.77	12.18	18088.51	1447.08	2.40
	14.10	1.10	0.116	21.6	187.0	1.67	10.30	18503.88	1480.31	2.57
	15.68	1.58	0.103	13.3	128.9	2.42	16.77	18872.53	1509.80	2.80
	17.33	1.65	0.081	7.9	97.7	3.19	28.25	19099.77	1527.98	2.99
	19.40	2.07	0.092					19099.77	1527.98	3.26
	22.36	2.96	0.069					19099.77	1527.98	3.54
	25.86	3.51	0.177	7.0	**39.3**	7.93	32.03	19526.54	1562.12	4.41
	0.29	0.29	0.236	2.7	11.6					
	0.59	0.30	0.260	2.9	11.2					
	0.90	0.30	0.205	1.9	9.1					
	1.20	0.30	0.209	1.4	6.7					
	1.51	0.30	0.198	1.7	8.4					
	1.81	0.30	0.188	1.8	9.7					
	2.12	0.30	0.217	1.3	6.2					
	2.51	0.40	0.167	10.4	62.1					
	2.73	0.21	0.200	1.4	7.0					
	3.03	0.30	0.180	0.8	4.5					
	3.34	0.30	0.279	0.9	3.1					
	3.64	0.30	0.185	1.6	8.6					
	4.01	0.37	0.141	1.3	9.5					
	4.25	0.24	0.140	0.9	6.2					
	4.56	0.30	0.148	1.0	6.5					
	4.86	0.30	0.162	1.0	6.3					
Wink 5	5.17	0.30	0.174	1.1	6.3					
annulus	5.53	0.37	0.182	1.1	6.0					
	5.78	0.24	0.150	2.1	13.9					
	6.08	0.30	0.115	0.6	5.6					

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	6.69	0.61	0.133	0.7	4.9					
	7.30	0.61	0.159	0.7	4.4					
	8.46	1.16	0.142	0.5	3.8					
	9.74	1.28	0.115	0.5	4.3					
	10.96	1.22	0.181	0.6	3.5					
	13.82	2.87	0.031	0.5	16.7					
	16.81	2.99	0.020	1.0	49.1					
	20.99	4.18	0.128	1.1	8.6					
	23.00	2.01	0.108	0.4	4.0					
	26.05	3.05	0.098	0.7	6.9					
	29.09	3.05	0.182	0.5	2.5					
	32.08	2.99	0.082	1.6	19.4					
	0.22	0.22	0.228	3.1	13.4					
	0.53	0.30	0.260	3.4	12.9					
	0.83	0.30	0.260	4.5	17.4					
	1.14	0.30	0.242	3.7	15.3					
	1.35	0.21	0.204	3.7	18.1					
	1.65	0.30	0.159	2.7	17.0					
Wink 7	1.96	0.30	0.137	2.3	17.1					
playa	2.26	0.30	0.129	1.5	11.9					
	2.57	0.30	0.145	2.5	17.4					
	2.90	0.34	0.154	2.8	18.3					
	3.21	0.30	0.158	3.7	**23.1**					
	3.51	0.30	0.151	3.4	22.3					
	3.82	0.30	0.156	3.1	20.0					
	4.12	0.30	0.165	3.0	18.1					
	4.46	0.34	0.177	2.2	12.4					
	4.76	0.30	0.181	1.8	10.1					
	5.07	0.30	0.209	2.1	10.1					
	9.43	4.36	0.082	1.2	14.2					
	14.33	4.91	0.168	3.9	23.0					
	20.55	6.22	0.166	3.8	22.6					
	23.20	2.65	0.033	1.0	29.8					
	29.88	6.68	0.099	1.7	17.1					

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	0.50	0.50	0.328	80.4	244.8					
	1.20	0.70	0.287	3.0	10.3					
	2.51	1.31	0.337	3.0	8.9					
	3.47	0.96	0.237	3.6	15.2					
	4.43	0.96	0.167	3.0	17.7					
	5.23	0.79	0.208	2.3	10.9					
	6.20	0.98	0.239	2.3	9.6					
	7.42	1.22	0.110	0.8	7.3					
	8.43	1.01	0.116							
			0.116	0.4	3.8					
			0.116	1.4	12.1					
			0.116	1.5	12.9					
	9.43	1.01	0.138	1.6	11.4					
	10.53	1.10	0.249	1.6	6.5					
	11.54	1.01	0.253	0.6	2.5					
Wink 13	12.51	0.98	0.174	1.3	7.6					
playa	13.64	1.13	0.159	1.7	10.9					
	14.65	1.01	0.286	0.9	3.3					
	15.90	1.25	0.267	1.3	4.9					
	17.08	1.19	0.302	2.0	6.7					
	18.61	1.52	0.037							
			0.037	0.2	6.3					
			0.037	0.1	2.4					
			0.037	0.1	2.5					
	20.16	1.55	0.282	1.5	5.2					
	21.79	1.63	0.046							
			0.046	0.4	7.9					
			0.046	0.3	5.7					
			0.046	0.4	8.1					
	23.36	1.57	0.221	1.4	6.4					
	25.07	1.71	0.162	0.9	5.6					
	26.44	1.37	0.183	1.0	5.5					
	28.09	1.65	0.171	0.9	5.1					
	29.63	1.54	0.157	1.1	6.9					

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	0.12	0.12	0.242	41.1	170.3					
	0.58	0.46	0.263	70.2	267.2					
	1.04	0.46	0.283	72.7	256.5					
	1.68	0.64	0.308	85.2	276.3					
	2.29	0.61	0.305	65.2	213.4					
	3.20	0.91	0.296	67.5	228.2					
Playa 5 #7	4.15	0.94	0.276	81.8	296.8					
playa	5.73	1.58	0.278	83.5	300.3					
	7.89	2.16	0.301	94.5	314.4					
	11.49	3.60	0.152	68.8	**451.4**					
	13.99	2.50	0.202	85.7	424.4					
	15.74	1.75	0.086	31.3	365.5					
	20.76	5.01	0.161	67.4	419.5					
	25.42	4.66	0.281	80.6	286.9					
	0.12	0.12	0.097	17.6	181.4	0.45				
	1.19	0.15	0.124	29.0	234.1	0.35				
	2.23	0.30	0.178	25.0	140.6	0.58				
Playa 5 #8	3.75	0.30	0.125	22.0	175.9	0.46				
playa	4.66	0.30	0.097	33.2	343.0	0.24				
	6.78	0.59	0.125	16.0	127.9	0.63				
	9.30	0.87	0.119	26.2	220.7	0.37				
	12.47	0.87	0.127	29.9	236.1	0.34				
	15.42	0.94	0.292	84.6	289.2	0.28				
	0.12	0.12	0.099	3.7	37.0					
	0.58	0.46	0.098	40.6	414.1					
	1.02	0.44	0.096	144.5	1505.6					
	1.65	0.62	0.070	175.0	**2515.5**					
	2.26	0.61	0.100	162.4	1624.3					
	2.87	0.61	0.107	127.9	1192.4					
	3.78	0.91	0.101	77.9	774.7					
Playa 5 #26	4.69	0.91	0.104	86.0	825.6					
interplaya	5.65	0.96	0.120	76.8	640.2					

Appendix B. Water content and chloride content of sampled boreholes.

Borehole #	Depth (m)	Interval thickness (m)	Gravimetric water content (g g-1)	Chloride (mg Cl kg-1 soil)	Chloride (mg Cl m-3 water)	Water flux (mm yr-1)	Water velocity (mm yr-1)	Age (yr)	Cumulative chloride (g m-2)	Cumulative H2O (m)
	6.52	0.87	0.128	69.6	544.4					
	8.69	2.16	0.144	59.2	410.5					
	10.94	2.26	0.112	33.0	294.4					
	12.62	1.68	0.078	25.3	325.8					
	14.75	2.13	0.060	13.7	227.6					
	16.34	1.58	0.074	12.4	167.2					
	17.62	1.28	0.048	5.7	118.1					

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	0.09	1.13	-0.05	1.07	0.11	-0.004
	0.34	1.12	-0.20	0.92	0.34	-0.004
	0.55	1.12	-0.15	0.97	0.57	-0.007
	0.79	1.12	**-5.50**	-4.38	0.79	-0.045
	1.01	1.12	-4.95	-3.83	1.30	-0.062
	1.25	1.12	-3.96	-2.85	1.26	-0.098
	1.46	1.11	-3.42	-2.31	1.49	-0.105
	1.62	1.11	-2.96	-1.85	1.64	-0.090
	1.86	1.11	-2.08	-0.97	1.87	-0.059
	2.07	1.11	-1.46	-0.36	2.10	-0.024
	2.32	1.10	-1.47	-0.37	2.34	-0.011
	2.53	1.10	-0.46	0.64	2.55	-0.006
	2.77	1.10	-0.43	0.67	2.78	-0.005
	2.99	1.10	-0.33	0.76	3.10	-0.003
	3.29	1.10	-0.10	1.00	3.31	-0.005
	3.60	1.09	-0.28	0.82	3.62	-0.003
	3.87	1.09	-0.26	0.83	3.89	-0.003
	4.21	1.09	-0.48	0.61	4.23	-0.002
	4.51	1.08	-0.53	0.56	4.53	-0.001
	4.82	1.08	-0.40	0.68	4.84	-0.001
	5.12	1.08	-0.48	0.60	5.14	-0.001
	5.73	1.07	-0.38	0.69	5.51	-0.001
	6.04	1.07	-0.47	0.60	5.75	-0.001
	6.10	1.07	-0.36	0.71	6.60	-0.001
BEGPTX 1	6.34	1.07	-0.25	0.81	6.36	-0.001
interplaya	6.64	1.06	-0.26	0.81	6.67	-0.001
	6.95	1.06	-0.30	0.76	7.30	0.000
	7.25	1.06	-0.24	0.82	7.28	-0.001
	7.56	1.05	-0.27	0.78	7.58	-0.002
	8.35	1.05	-0.21	0.83	8.34	-0.001
	9.08	1.04	-0.21	0.83	9.11	-0.001
	9.85	1.03	-0.10	0.93	9.87	-0.001
	10.61	1.02	-0.23	0.79	10.63	-0.001
	11.37	1.02	-0.12	0.89	11.39	-0.001
	12.13	1.01	-0.08	0.92	12.13	-0.001
	12.89	1.00	-0.08	0.92	12.89	-0.001
	13.66	0.99	-0.14	0.86	13.68	-0.001
	14.42	0.99	-0.12	0.87	14.44	-0.001
	15.18	0.98	-0.23	0.75	15.20	-0.001
	15.94	0.97	-0.10	0.87	15.96	-0.001
	16.70	0.96	-0.25	0.72	16.73	-0.001
	17.47	0.96	-0.38	0.58	17.49	-0.001
	18.07	0.95	-0.19	0.76	18.60	-0.001
	18.99	0.94	-0.09	0.86	18.98	-0.001
	19.75	0.93	-0.08	0.85	19.77	-0.001
	21.28	0.92	-0.07	0.85	21.30	-0.001
	22.04	0.91	-0.16	0.75	22.60	-0.001
	22.80	0.90	-0.15	0.75	22.82	-0.001
	23.56	0.90	-0.50	0.39	23.58	-0.002
	24.32	0.89	-0.24	0.65	24.35	-0.001

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	0.09	1.13	0.02	1.14	0.34	-0.005
	0.52	1.12	-0.23	0.89	0.57	-0.054
	0.55	1.12	-3.19	-2.07	0.80	-0.122
	0.79	1.12	**-3.40**	-2.28	1.10	-0.150
	1.01	1.12	-2.20	-1.08	1.26	-0.138
	1.28	1.11	-2.59	-1.47	1.49	-0.123
	1.46	1.11	-2.47	-1.36	1.64	-0.132
	1.62	1.11	-2.05	-0.94	1.87	-0.116
	1.89	1.11	-1.66	-0.55	2.10	-0.144
	2.07	1.11	-1.27	-0.16	2.32	-0.121
	2.32	1.10	-1.07	0.03	2.55	-0.114
	2.53	1.10	-1.61	-0.51	2.78	-0.102
	2.79	1.10	-1.67	-0.57	3.10	-0.094
	2.99	1.10	-1.45	-0.35	4.23	-0.057
	4.21	1.09	-1.75	-0.66	4.53	-0.051
	4.51	1.08	-1.84	-0.76	4.84	-0.048
	4.82	1.08	-1.71	-0.63	5.75	-0.042
	5.73	1.07	-1.99	-0.92	6.60	-0.040
	6.04	1.07	-1.89	-0.82	6.30	-0.040
	6.31	1.07	-2.21	-1.14	7.28	-0.033
	7.25	1.06	-1.97	-0.91	7.53	-0.032
BEGPTX 2	7.53	1.05	-2.07	-1.01	7.86	-0.029
interplaya	8.14	1.05	-1.64	-0.59	8.16	-0.033
	8.47	1.04	-1.91	-0.87	8.50	-0.027
	8.66	1.04	-2.12	-1.08	8.66	-0.024
	9.08	1.04	-1.74	-0.70	9.11	-0.013
	13.66	0.99	-1.66	-0.67	9.41	-0.027
	14.42	0.99	-2.21	-1.22	9.72	-0.025
	15.18	0.98	-1.95	-0.97	10.63	-0.022
	15.94	0.97	-1.76	-0.79	11.39	-0.027
	16.70	0.96	-1.92	-0.96	12.15	-0.020
	17.47	0.96	-1.83	-0.88	12.92	-0.021
	18.11	0.95	-1.91	-0.96	13.68	-0.020
	18.68	0.94	-1.45	-0.50	14.44	-0.016
	19.60	0.94	-1.42	-0.48	15.20	-0.014
	20.45	0.93	-1.64	-0.71	15.96	-0.015
	21.28	0.92	-1.23	-0.31	16.73	-0.015
	22.04	0.91	-0.97	-0.05	18.20	-0.010
					18.65	-0.011
					19.65	-0.007
					20.48	-0.005
					21.30	-0.009
					22.60	-0.011
	0.24	0.48	-1.60	-1.12	0.20	-0.004
	0.40	0.48	-5.78	-5.30	0.17	-0.004
	0.52	0.47	**-7.97**	-7.50	0.32	-0.007
	0.78	0.47	**-7.97**	-7.50	0.47	-0.059
	0.90	0.47	-0.49	-0.02	0.72	-0.157
	1.22	0.47	-5.82	-5.35	1.16	-0.192
	1.57	0.46	-4.78	-4.32	1.43	-0.195
	1.74	0.46	-4.04	-3.58	1.63	-0.217

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
Finley 1	2.15	0.46	-3.39	-2.93	1.81	-0.217
interplaya	2.77	0.45	-3.14	-2.69	2.30	-0.221
	3.23	0.45	-2.85	-2.40	2.23	-0.221
	3.70	0.44	-2.50	-2.06	2.38	-0.207
					2.65	-0.204
					2.90	-0.195
					2.97	-0.211
					3.15	-0.185
					3.64	-0.156
					3.79	-0.153
	0.14	0.48	-2.70	-2.22	0.90	-0.005
	0.24	0.48	**-5.16**	-4.68	0.20	-0.009
	0.30	0.48	-0.08	0.40	0.29	-0.004
	0.37	0.47	-4.70	-4.23	0.56	-0.004
	0.44	0.47	-4.12	-3.65	0.84	-0.004
	0.49	0.47	-4.74	-4.27	1.10	-0.003
	1.28	0.47	-2.48	-2.01	1.16	-0.004
	1.51	0.46	-1.80	-1.34	1.36	-0.003
	1.74	0.47	-2.09	-1.62	1.57	-0.003
	1.80	0.46	-2.28	-1.82	1.81	-0.004
	2.19	0.46	-1.79	-1.33	2.60	-0.005
	2.30	0.45	-1.58	-1.13	2.27	-0.006
	2.48	0.45	-1.93	-1.48	2.42	-0.007
	2.65	0.44	-1.84	-1.40	2.73	-0.007
	3.79	0.43	-1.27	-0.84	2.88	-0.009
Finley 2	5.10	0.46	-0.97	-0.51	3.87	-0.006
annulus	5.21	0.43	-0.69	-0.26	4.91	-0.007
	5.52	0.42	-0.49	-0.07	5.30	-0.008
	5.75	0.42	-0.41	0.01	5.59	-0.014
	5.88	0.42	-0.38	0.04	5.68	-0.014
	6.10	0.42	-0.51	-0.09	5.96	-0.012
	6.54	0.41	-0.68	-0.27	6.50	-0.013
	7.86	0.40	-0.74	-0.34	6.72	-0.011
	10.45	0.38	-0.78	-0.40	7.61	-0.012
					7.94	-0.011
					8.76	-0.013
					10.60	-0.016
					10.53	-0.014
					11.32	-0.020
					12.10	-0.016
					12.19	-0.016
	-0.06	0.48	-0.23	0.25	0.14	-0.005
	-0.06	0.48	-0.12	0.36	0.29	-0.006
	-0.21	0.48	-1.04	-0.56	0.44	-0.003
	-0.21	0.48	-1.12	-0.64	0.58	-0.002
	-0.37	0.47	**-1.43**	-0.96	0.72	-0.002
	-0.37	0.47	-0.68	-0.21	0.85	-0.002
	-0.37	0.47	**-1.43**	-0.96	1.50	-0.001
	-0.37	0.47	-1.32	-0.85	1.36	-0.002
	-0.53	0.47	-0.12	0.35	1.46	-0.002

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	-0.53	0.47	-0.35	0.12	1.57	-0.003
	-0.53	0.47	-0.30	0.17	1.69	-0.002
	-0.53	0.47	-0.33	0.14	1.91	-0.003
	-0.66	0.47	-0.31	0.16	2.70	-0.003
	-0.66	0.47	-0.39	0.08	2.16	-0.002
	-0.81	0.47	-0.42	0.05	2.27	-0.002
	-0.81	0.47	-0.40	0.07	3.44	-0.003
	-0.98	0.47	-0.26	0.21	3.57	-0.004
	-0.98	0.47	-0.30	0.17	3.66	-0.002
	-1.13	0.47	-0.07	0.40	3.79	-0.002
	-1.13	0.47	-0.17	0.30	3.95	-0.002
	-1.28	0.46	-0.20	0.26	4.70	-0.002
	-1.28	0.46	-0.13	0.33	4.40	-0.002
	-1.40	0.46	-0.24	0.22	4.59	-0.003
	-1.40	0.46	-0.33	0.13	4.67	-0.002
	-1.52	0.46	-0.04	0.42	4.88	-0.002
	-1.52	0.46	-0.06	0.40	5.60	-0.002
	-1.63	0.46	-0.26	0.20	5.68	-0.003
	-1.63	0.46	-0.28	0.18	6.36	-0.002
	-1.81	0.46	-0.40	0.06	7.38	-0.002
	-1.81	0.46	-0.28	0.18	8.35	-0.002
	-2.00	0.47	-0.26	0.21	9.43	-0.002
	-2.00	0.47	-0.10	0.37	10.22	-0.003
	-2.00	0.46	-0.17	0.29	11.28	-0.003
	-2.00	0.46	-0.11	0.35	12.40	-0.003
	-2.12	0.46	-0.12	0.34	13.23	-0.005
	-2.12	0.46	-0.03	0.43	14.20	-0.005
	-2.23	0.46	-0.20	0.26		
	-2.23	0.46	-0.22	0.24		
Finley 3	-2.44	0.45	-0.17	0.28		
playa	-2.44	0.45	-0.21	0.24		
	-2.56	0.45	-0.21	0.24		
	-2.56	0.45	-0.14	0.31		
	-2.90	0.45	-0.38	0.07		
	-2.90	0.45	-0.28	0.17		
	-3.25	0.45	-0.26	0.19		
	-3.25	0.45	-0.21	0.24		
	-3.38	0.44	-0.12	0.32		
	-3.38	0.44	-0.16	0.28		
	-3.51	0.44	-0.04	0.40		
	-3.51	0.44	-0.03	0.41		
	-3.60	0.44	-0.37	0.07		
	-3.60	0.44	-0.43	0.01		
	-3.72	0.44	-0.33	0.11		
	-3.72	0.44	-0.28	0.16		
	-3.89	0.44	-0.40	0.04		
	-3.89	0.44	-0.33	0.11		
	-4.01	0.44	-0.31	0.13		
	-4.01	0.44	-0.20	0.24		
	-4.01	0.44	-0.25	0.19		
	-4.01	0.44	-0.05	0.39		
	-4.33	0.44	-0.12	0.32		

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	-4.33	0.44	-0.03	0.41		
	-4.53	0.43	-0.03	0.40		
	-4.53	0.43	-0.02	0.41		
	-4.63	0.43	-0.03	0.40		
	-4.63	0.43	-0.04	0.39		
	-4.77	0.43	-0.36	0.07		
	-4.77	0.43	-0.30	0.13		
	-5.00	0.43	-0.48	-0.05		
	-5.00	0.43	-0.46	-0.03		
	-5.62	0.42	**-0.62**	-0.20		
	-6.31	0.42	-0.46	-0.04		
	-7.30	0.41	-0.35	0.06		
	-8.29	0.40	-0.30	0.10		
	-9.39	0.39	-0.10	0.29		
	-10.18	0.38	-0.13	0.25		
	0.23	0.72	-0.28	0.45	0.29	-0.007
	0.53	0.72	-3.79	-3.07	0.59	-0.008
	0.93	0.72	**-4.50**	-3.79	0.99	-0.037
	1.23	0.71	-3.22	-2.50	1.30	-0.050
	1.54	0.71	-3.64	-2.93	1.60	-0.067
	1.84	0.71	-2.94	-2.23	1.91	-0.074
	2.15	0.70	-3.22	-2.52	2.21	-0.084
	2.52	0.70	-4.22	-3.51	2.58	-0.083
	2.76	0.70	-2.65	-1.96	2.82	-0.076
	3.60	0.69	-2.09	-1.40	3.12	-0.072
	3.37	0.69	-2.66	-1.96	3.43	-0.063
	3.67	0.69	-2.66	-1.97	3.73	-0.069
	4.10	0.69	-2.37	-1.69	4.70	-0.059
	4.28	0.68	-1.95	-1.27	4.34	-0.067
	4.59	0.68	-3.08	-2.40	4.65	-0.066
	4.89	0.68	-2.94	-2.26	4.95	-0.062
	5.20	0.67	-2.38	-1.70	5.26	-0.057
Koesjan 2	5.53	0.67	-2.09	-1.42	5.59	-0.064
drainage	5.81	0.67	-2.09	-1.42	5.87	-0.063
	6.11	0.67	-2.80	-2.13	6.48	-0.061
	6.42	0.66	-2.52	-1.85	7.90	-0.063
	7.30	0.65	-2.51	-1.86	8.00	-0.058
	7.33	0.65	-2.23	-1.58	8.70	-0.056
	7.94	0.65	-2.51	-1.87	9.53	-0.047
	8.64	0.64	-3.65	-3.01	11.50	-0.038
	8.85	0.64	-2.52	-1.88	12.57	-0.034
	9.46	0.63	-2.80	-2.16		
	10.10	0.63	-2.80	-2.17		
	10.38	0.62	-2.94	-2.31		
	10.99	0.62	-1.67	-1.05		
	11.63	0.61	-1.95	-1.34		
	11.90	0.61	-2.09	-1.48		
	12.51	0.60	-2.23	-1.63		
	13.18	0.60	-2.09	-1.49		

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	0.23	0.72	-0.12	0.60	0.29	-0.001
	0.53	0.72	-0.14	0.58	0.59	-0.001
	0.87	0.72	-0.13	0.59	0.90	-0.001
	1.23	0.71	-0.06	0.65	1.30	-0.002
	1.54	0.71	-0.23	0.48	1.60	-0.008
	1.84	0.71	-0.13	0.58	1.91	-0.019
	2.15	0.70	-0.18	0.52	2.21	-0.011
	2.45	0.70	-0.30	0.40	2.58	-0.014
	2.76	0.70	-0.27	0.43	2.82	-0.010
	3.60	0.69	-0.11	0.58	3.12	-0.019
	3.37	0.69	-0.20	0.49	3.43	-0.015
	3.67	0.69	-0.28	0.41	3.73	-0.012
	4.40	0.68	**-1.19**	-0.51	4.10	-0.010
	4.28	0.68	-0.99	-0.31	4.34	-0.012
	4.59	0.68	-1.10	-0.42	4.65	-0.008
	4.89	0.68	-0.89	-0.21	4.95	-0.007
	5.20	0.67	-1.10	-0.43	5.26	-0.006
	5.47	0.67	-0.84	-0.17	5.53	-0.006
	5.81	0.67	-0.94	-0.27	5.87	-0.006
	6.72	0.66	-0.60	0.06	6.17	-0.006
	7.33	0.65	-0.33	0.32	6.48	-0.003
	7.94	0.65	-0.27	0.38	8.00	-0.003
	8.55	0.64	-0.21	0.43	8.61	-0.003
Koesjan 4	9.16	0.64	-0.39	0.25	9.22	-0.001
annulus	9.77	0.63	-0.41	0.22	10.44	-0.001
	10.38	0.62	-0.26	0.36	11.66	-0.004
	10.99	0.62	-0.14	0.48	11.96	-0.003
	11.60	0.61	-0.20	0.41	13.94	-0.001
	12.21	0.61	-0.22	0.39	15.47	-0.001
	12.82	0.60	-0.23	0.37	16.99	-0.001
	13.88	0.59	-0.26	0.33	18.61	0.000
	14.71	0.58	-0.22	0.36	21.66	0.000
	15.41	0.57	-0.19	0.38	24.70	-0.001
	16.17	0.57	-0.13	0.44	27.75	0.000
	16.93	0.56	-0.16	0.40		
	17.60	0.55	-0.18	0.37		
	18.55	0.54	-0.69	-0.15		
	20.70	0.52	-0.63	-0.11		
	21.60	0.51	-0.74	-0.23		
	23.12	0.50	-0.18	0.32		
	24.64	0.48	-0.10	0.38		
	26.17	0.47	-0.19	0.28		
	27.69	0.45	-0.20	0.25		
	29.22	0.44	-0.27	0.17		
	30.74	0.42	-0.32	0.10		
	0.11	0.72	**-4.79**	-4.06		
	0.21	0.72	-3.93	-3.21		
	0.42	0.72	-3.08	-2.36		
	0.51	0.72	-2.37	-1.65		
	0.72	0.72	-2.23	-1.51		

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	0.82	0.72	-2.23	-1.52		
	1.15	0.71	-1.81	-1.10		
	1.24	0.71	-1.53	-0.82		
	1.46	0.71	-1.67	-0.96		
	1.76	0.71	-1.95	-1.24		
	2.70	0.70	-2.23	-1.53		
	2.37	0.70	-2.37	-1.67		
	2.83	0.70	-2.23	-1.54		
	3.13	0.69	-2.09	-1.40		
	3.44	0.69	-1.81	-1.12		
	3.74	0.69	-2.37	-1.69		
	4.35	0.68	-2.37	-1.69		
Koesjan 7	4.66	0.68	-2.09	-1.41		
interplaya	4.96	0.68	-2.38	-1.70		
	5.27	0.67	-1.95	-1.28		
	5.57	0.67	-3.22	-2.55		
	5.88	0.67	-2.80	-2.13		
	6.18	0.66	-2.66	-1.99		
	6.42	0.66	-2.23	-1.57		
	7.86	0.65	-1.95	-1.30		
	8.62	0.64	-2.09	-1.45		
	9.38	0.63	-2.09	-1.46		
	10.10	0.63	-1.95	-1.33		
	10.90	0.62	-2.09	-1.47		
	11.70	0.61	-2.51	-1.90		
	12.73	0.60	-2.09	-1.49		
	14.68	0.58	-3.08	-2.50		
	15.57	0.57	-1.25	-0.68		
	17.12	0.56	-2.09	-1.53		
	18.46	0.54	-1.67	-1.13		
	0.66	1.17	**-0.75**	0.42	0.12	-0.023
	0.96	1.17	-0.52	0.65	0.58	-0.035
	1.89	1.16	-0.21	0.95	1.04	-0.033
	3.41	1.15	-0.23	0.92	1.68	-0.036
	5.64	1.13	-0.37	0.76	2.29	-0.028
	7.21	1.11	-0.28	0.83	3.20	-0.030
	8.55	1.10	-0.23	0.87	4.15	-0.039
	10.20	1.08	-0.18	0.90	5.73	-0.039
	11.60	1.07	-0.16	0.91	7.89	-0.042
Playa 5 7	13.30	1.05	-0.22	0.83	11.49	-0.060
playa	14.80	1.04	-0.18	0.86	13.99	-0.056
	15.80	1.03	-0.16	0.87	15.74	-0.048
	17.80	1.01	-0.29	0.72	20.76	-0.055
	19.00	0.99	-0.17	0.82	25.42	-0.038
	20.80	0.98	-0.12	0.86		
	21.90	0.97	-0.12	0.85		
	23.90	0.95	-0.15	0.80		
	25.50	0.93	-0.27	0.66		
	30.00	0.89				

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	0.05	1.09	**-13.60**	-12.51	0.12	-0.005
	0.20	1.09	-5.62	-4.53	0.58	-0.055
	0.35	1.08	-5.81	-4.73	1.02	-0.196
	0.96	1.08	-9.44	-8.36	1.65	-0.323
	1.88	1.07	-3.47	-2.40	2.26	-0.211
	2.18	1.07	-3.27	-2.20	2.87	-0.156
	3.09	1.06	-2.43	-1.37	3.78	-0.102
Playa 5 26	4.31	1.05	-1.85	-0.80	4.69	-0.108
annulus	6.60	1.02	-1.59	-0.57	5.65	-0.084
	7.82	1.01	-1.63	-0.62	6.52	-0.072
	10.20	0.99	-3.02	-2.03	8.69	-0.054
	11.70	0.97	-3.44	-2.47	10.94	-0.039
	13.20	0.96	-2.97	-2.01	12.62	-0.043
	14.70	0.94	-2.41	-1.47	14.75	-0.030
	17.00	0.92	-1.44	-0.52	16.34	-0.022
					17.62	-0.016
	0.50	1.08	**-19.30**	-18.22		
	0.50	1.08	-8.61	-7.53		
	0.81	1.08	-7.85	-6.77		
	1.84	1.07	-3.34	-2.27		
	3.37	1.06	-2.59	-1.53		
	4.59	1.04	-2.02	-0.98		
	6.26	1.03	-1.68	-0.65		
Playa 5 28	7.79	1.01	-1.85	-0.84		
interplaya	10.10	0.99	-3.05	-2.06		
	11.70	0.97	-2.61	-1.64		
	13.90	0.95	-1.69	-0.74		
	15.40	0.94	-1.61	-0.67		
	18.50	0.91	-1.49	-0.58		
	20.10	0.89	-0.93	-0.04		
	22.30	0.87	-1.20	-0.33		
	23.00	0.86	-1.56	-0.70		
	0.90	0.60	-1.29	-0.69		
	0.59	0.60	-0.51	0.09		
	0.81	0.60	-0.95	-0.35		
	1.14	0.60	-2.94	-2.34		
	1.45	0.59	-3.43	-2.84		
	1.75	0.59	-3.57	-2.98		
	2.60	0.58	-3.69	-3.11		
	2.39	0.58	-3.19	-2.61		
	2.73	0.58	-3.13	-2.55		
	3.30	0.58	-2.76	-2.18		
	3.34	0.58	-2.24	-1.66		
	3.64	0.57	-2.75	-2.18		
	3.95	0.57	-1.70	-1.13		
	4.31	0.57	-1.47	-0.90		
	4.62	0.56	-1.35	-0.79		
	4.92	0.56	-1.26	-0.70		
	5.23	0.56	-1.44	-0.88		

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	5.56	0.55	-1.98	-1.43		
	5.90	0.55	-2.18	-1.63		
	6.20	0.55	-2.49	-1.94		
SMB 1	6.60	0.54	-2.21	-1.67		
annulus	7.15	0.54	-2.68	-2.14		
	7.48	0.53	-2.13	-1.60		
	8.79	0.52	-1.76	-1.24		
	8.90	0.52	-2.08	-1.56		
	9.70	0.51	-1.93	-1.42		
	9.68	0.51	-2.27	-1.76		
	10.29	0.51	-2.32	-1.81		
	10.67	0.50	-2.45	-1.95		
	11.28	0.50	-2.25	-1.75		
	11.92	0.49	-2.30	-1.81		
	12.25	0.49	-2.87	-2.38		
	12.86	0.48	-2.54	-2.06		
	13.50	0.48	**-4.95**	-4.47		
	14.80	0.46	-2.67	-2.21		
	15.41	0.46	-2.05	-1.59		
	16.63	0.44	-1.78	-1.34		
	17.12	0.44	-1.91	-1.47		
	18.15	0.43	-1.60	-1.17		
	18.76	0.42	-1.22	-0.80		
	19.98	0.41	-1.25	-0.84		
	21.32	0.40	-1.45	-1.05		
	0.23	0.61	-0.51	0.10	0.29	-0.004
	0.53	0.60	-0.25	0.35	0.59	-0.003
	0.99	0.60	-0.32	0.28	1.50	-0.005
	1.36	0.59	-0.36	0.23	1.42	-0.004
	1.66	0.59	-0.44	0.15	1.72	-0.004
	1.97	0.59	-0.24	0.35	2.30	-0.004
	2.27	0.59	-0.33	0.26	2.70	-0.002
	2.67	0.58	-0.18	0.40	2.94	-0.004
	2.88	0.58	-0.42	0.16	3.25	-0.004
	3.19	0.58	-0.25	0.33	3.55	-0.004
	3.49	0.57	-0.45	0.12	3.86	-0.003
	3.80	0.57	-0.42	0.15	4.25	-0.004
	4.21	0.57	-0.40	0.17	4.47	-0.005
	4.40	0.56	-0.48	0.08	4.77	-0.005
	4.71	0.56	-0.46	0.10	5.70	-0.004
	5.10	0.56	-0.42	0.14	5.38	-0.005
	5.32	0.56	-0.34	0.22	5.78	-0.004
	5.72	0.55	-0.68	-0.13	5.99	-0.003
	5.93	0.55	-0.46	0.09	6.29	-0.004
	6.23	0.55	**-0.81**	-0.26	6.60	-0.003
	6.54	0.54	-0.36	0.18	6.90	-0.004
SMB 2	6.84	0.54	-0.30	0.24	7.30	-0.002
playa	7.24	0.54	-0.24	0.30	8.12	-0.002
	7.45	0.53	-0.13	0.40	9.65	-0.001
	8.60	0.52	-0.24	0.28	11.17	-0.002
	8.76	0.52	-0.27	0.25	12.69	-0.001

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	8.98	0.52	-0.18	0.34	13.91	-0.001
	9.59	0.51	-0.06	0.45	15.44	-0.001
	10.10	0.51	-0.58	-0.07	18.91	-0.001
	10.50	0.50	-0.23	0.27	23.60	-0.002
	11.11	0.50	-0.34	0.16	26.10	-0.002
	11.78	0.49	-0.48	0.01		
	12.20	0.49	-0.44	0.05		
	12.63	0.48	-0.39	0.09		
	13.34	0.48	-0.37	0.11		
	13.85	0.47	-0.37	0.10		
	14.46	0.47	-0.30	0.17		
	16.60	0.45	-0.09	0.36		
	17.51	0.44	-0.64	-0.20		
	18.12	0.43	-0.16	0.27		
	18.85	0.42	-0.08	0.34		
	2.38	0.58	-0.10	0.48		
	21.90	0.39	-0.12	0.27		
	23.00	0.38	-0.12	0.26		
SMB 3 interplaya	0.23	0.61	-1.94	-1.33	0.29	-0.004
	0.53	0.60	-1.06	-0.46	0.59	-0.003
	0.96	0.60	-0.47	0.13	1.20	-0.005
	1.23	0.60	-0.22	0.38	1.30	-0.010
	1.54	0.59	-0.26	0.33	1.60	-0.009
	1.94	0.59	-0.23	0.36	2.00	-0.007
	3.90	0.57	-0.27	0.30	3.15	-0.006
	3.40	0.57	-0.27	0.30	3.46	-0.006
	3.70	0.57	-0.24	0.33	3.76	-0.004
	4.10	0.57	-0.44	0.13	4.70	-0.026
	5.90	0.55	-0.74	-0.19	5.96	-0.066
	6.20	0.55	-0.69	-0.14	6.26	-0.068
	6.81	0.54	-0.75	-0.21	6.87	-0.055
	7.45	0.53	-0.55	-0.02	7.51	-0.083
	8.60	0.52	-0.46	0.06	8.12	-0.105
	8.70	0.52	-0.47	0.05	8.73	-0.099
	9.46	0.52	-0.52	0.00	9.53	-0.117
	10.23	0.51	-0.46	0.05	11.80	-0.093
	11.20	0.50	-0.50	0.00	12.63	-0.063
	11.81	0.49	-0.40	0.09	14.19	-0.058
	12.57	0.48	-1.05	-0.57	15.86	-0.047
	13.34	0.48	-0.74	-0.26	17.30	-0.052
	14.13	0.47	-1.22	-0.75	18.91	-0.040
	14.95	0.46	-1.46	-1.00	20.47	-0.037
	15.80	0.45	-0.91	-0.46		
	16.51	0.45	-1.16	-0.71		
	17.24	0.44	-0.74	-0.30		
	18.60	0.43	-0.91	-0.48		
	19.20	0.42	-1.28	-0.86		
	19.49	0.42	-1.30	-0.88		

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	0.23	0.61	-1.67	-1.06		
	0.53	0.60	-1.53	-0.93		
	1.20	0.60	-1.25	-0.65		
	1.36	0.59	-1.11	-0.52		
	1.66	0.59	-0.42	0.17		
	1.97	0.59	-0.69	-0.10		
	2.27	0.59	-1.39	-0.80		
	2.61	0.58	-1.67	-1.09		
	2.91	0.58	-2.37	-1.79		
	3.22	0.58	-1.53	-0.95		
	3.52	0.57	-1.25	-0.68		
SMB 5	3.83	0.57	-1.25	-0.68		
playa	4.19	0.57	-2.09	-1.52		
	4.43	0.56	-1.39	-0.83		
	4.74	0.56	-0.97	-0.41		
	5.40	0.55	-0.97	-0.42		
	5.35	0.56	-0.69	-0.13		
	5.65	0.55	-1.11	-0.56		
	6.20	0.55	-0.83	-0.28		
	6.60	0.54	-0.83	-0.29		
	7.24	0.54	-0.83	-0.29		
	7.85	0.53	-0.55	-0.02		
	8.52	0.52	-0.97	-0.45		
	9.10	0.52	-0.83	-0.31		
	0.23	0.61	-0.98	-0.37		
	0.53	0.60	-0.95	-0.35		
	0.90	0.60	-0.60	0.00		
	1.23	0.60	-0.28	0.32		
	1.54	0.59	-0.19	0.40		
	1.84	0.59	-0.21	0.38		
	2.15	0.59	-1.10	-0.51		
	2.45	0.58	-1.43	-0.85		
	2.85	0.58	-1.29	-0.71		
	3.16	0.58	-1.11	-0.53		
	3.76	0.57	-0.88	-0.31		
SMB 6	4.13	0.57	-0.71	-0.14		
playa	3.46	0.57	-0.94	-0.37		
	4.47	0.56	-0.49	0.07		
	4.77	0.56	-0.58	-0.02		
	5.80	0.55	-0.62	-0.07		
	5.38	0.56	-0.37	0.19		
	5.72	0.55	-0.40	0.15		
	6.80	0.54	-0.52	0.02		
	6.51	0.54	-0.36	0.18		
	6.93	0.54	-0.31	0.23		
	7.36	0.54	-0.27	0.27		
	8.12	0.53	-0.61	-0.08		
	8.76	0.52	-0.29	0.23		

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	0.23	0.61	-2.90	-2.29	0.29	-0.001
	0.53	0.60	-3.48	-2.88	0.59	-0.004
	0.84	0.60	-4.09	-3.49	0.90	-0.004
	1.54	0.59	-3.32	-2.73	1.30	-0.048
	1.84	0.59	**-6.19**	-5.60	1.60	-0.147
	2.15	0.59	-2.51	-1.92	1.91	-0.161
	2.52	0.58	-3.41	-2.83	2.21	-0.141
	3.60	0.57	-2.19	-1.62	2.58	-0.079
	3.67	0.57	-1.60	-1.03	2.82	-0.068
SMB 7	3.98	0.57	-2.38	-1.81	3.12	-0.053
interplaya	4.89	0.56	-2.15	-1.59	3.43	-0.045
	5.20	0.56	-1.74	-1.18	3.73	-0.047
	1.23	0.60	-2.27	-1.67	4.40	-0.047
	2.76	0.58	-1.99	-1.41	5.87	-0.033
	3.37	0.57	-1.85	-1.28	6.17	-0.030
	4.28	0.57	-1.95	-1.38	6.48	-0.030
	5.81	0.55	-1.38	-0.83	6.81	-0.043
	6.42	0.54	-1.87	-1.33	7.12	-0.038
	4.59	0.56	-2.63	-2.07	7.42	-0.036
	5.50	0.55	-1.79	-1.24	7.73	-0.035
	7.30	0.54	-1.58	-1.04	8.30	-0.033
	7.64	0.53	-1.74	-1.21	8.31	-0.028
	8.25	0.53	-1.90	-1.37	9.83	-0.032
	9.16	0.52	-1.99	-1.47	11.38	-0.034
	9.77	0.51	-1.56	-1.05	12.91	-0.032
	11.20	0.50	-1.57	-1.07	14.43	-0.032
	11.60	0.49	-1.92	-1.43	15.99	-0.023
	12.42	0.49	-3.04	-2.55	17.54	-0.026
	13.12	0.48	-0.92	-0.44		
	16.20	0.45	-1.19	-0.74		
	13.95	0.47	-1.07	-0.60		
	14.65	0.46	-1.44	-0.98		
	15.47	0.46	-0.72	-0.26		
	16.99	0.44	-2.17	-1.73		
	17.76	0.43	-1.12	-0.69		
	18.52	0.43	-0.78	-0.35		
	0.27	1.12	-7.10	-5.98		
	0.57	1.11	**-13.22**	-12.11		
	0.88	1.11	-9.01	-7.90		
	1.43	1.10	-6.97	-5.86		
	1.73	1.10	-4.78	-3.68		
	2.40	1.09	-4.50	-3.41		
	2.34	1.09	-3.22	-2.12		
	2.64	1.09	-4.51	-3.41		
	2.98	1.09	-3.22	-2.13		
Vance 1	3.28	1.09	-2.66	-1.57		
interplaya	3.59	1.08	-2.66	-1.57		
	3.89	1.08	-1.81	-0.73		
	4.20	1.08	-3.94	-2.86		
	4.53	1.07	-2.38	-1.30		

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	4.84	1.07	-2.24	-1.16		
	5.14	1.07	-2.37	-1.31		
	5.45	1.06	-1.67	-0.61		
	5.75	1.06	-2.52	-1.45		
	6.90	1.05	-1.81	-0.76		
	6.85	1.05	-1.95	-0.90		
	0.27	1.12	-0.32	0.80	0.22	-0.003
	0.57	1.11	-0.24	0.87	0.53	-0.003
	0.88	1.11	-0.31	0.80	0.83	-0.004
	1.36	1.10	-0.51	0.59	1.32	-0.005
	1.70	1.10	**-0.65**	0.45	1.62	-0.003
	1.97	1.10	-0.55	0.55	1.93	-0.003
	2.28	1.10	-0.52	0.58	2.23	-0.005
	2.61	1.09	-0.60	0.49	2.57	-0.009
	2.89	1.09	-0.40	0.69	2.84	-0.010
	3.19	1.09	-0.39	0.70	3.15	-0.011
	3.50	1.08	-0.34	0.74	3.45	-0.012
	3.80	1.08	-0.34	0.74	3.76	-0.012
	4.80	1.07	-0.53	0.54	4.30	-0.012
	4.41	1.07	-0.64	0.43	4.37	-0.009
	4.72	1.07	-0.57	0.50	4.67	-0.009
	5.20	1.07	-0.50	0.57	4.98	-0.007
	5.33	1.07	-0.49	0.58	5.28	-0.007
	5.94	1.06	-0.53	0.53	5.63	-0.007
	6.24	1.06	-0.37	0.69	5.89	-0.007
	6.55	1.05	-0.31	0.74	6.20	-0.007
	6.85	1.05	-0.18	0.87	6.50	-0.009
	7.19	1.05	-0.29	0.76	6.80	-0.008
Vance 2	7.46	1.04	-0.30	0.74	7.16	-0.011
playa	7.77	1.04	-0.19	0.85	7.41	-0.014
	8.70	1.03	-0.30	0.73	7.72	-0.018
	8.37	1.04	-0.40	0.64	8.20	-0.018
	8.74	1.03	-0.42	0.61	8.33	-0.020
	8.98	1.03	-0.49	0.54	8.69	-0.025
	9.29	1.03	-0.57	0.46	8.94	-0.029
	9.59	1.02	-0.49	0.53	9.24	-0.028
	10.28	1.02	-0.37	0.65	9.55	-0.036
	11.04	1.01	-0.29	0.72	10.23	-0.040
	11.80	1.00	-0.38	0.62	10.98	-0.045
	12.52	0.99	-0.24	0.75	11.76	-0.040
	13.28	0.99	-0.29	0.70	12.47	-0.039
	13.98	0.98	-0.38	0.60	13.24	-0.044
	14.82	0.97	-0.25	0.72	13.94	-0.038
	15.54	0.97	-0.26	0.71	14.78	-0.037
	17.00	0.95	-0.19	0.76	15.49	-0.028
	17.84	0.94	-0.14	0.80	16.95	-0.027
	18.52	0.94	-0.18	0.76	17.79	-0.026
	20.50	0.92	-0.17	0.75	18.48	-0.017

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	21.69	0.91	-0.39	0.52	20.00	-0.018
	23.16	0.89	-0.55	0.34	21.65	-0.011
	24.62	0.88	-0.35	0.53	23.11	-0.008
					24.57	-0.010
	0.27	1.12	**-13.16**	-12.05		
	0.57	1.11	-11.80	-10.69	0.22	-0.025
	0.88	1.11	-8.53	-7.42	0.53	-0.008
	1.39	1.10	-4.77	-3.67	0.83	-0.005
	1.70	1.10	-4.20	-3.10	1.35	-0.003
	2.00	1.10	-3.35	-2.25	1.65	-0.007
	2.31	1.10	-2.92	-1.83	1.96	-0.007
	2.61	1.09	-3.21	-2.12	2.26	-0.015
	2.92	1.09	-2.08	-0.99	2.57	-0.019
	3.22	1.09	-1.94	-0.85	2.87	-0.026
	3.53	1.08	-1.52	-0.44	3.18	-0.042
	3.83	1.08	-1.52	-0.44	3.48	-0.046
	4.12	1.08	-2.08	-1.00	3.79	-0.055
	4.44	1.07	-1.94	-0.87	4.80	-0.059
	4.84	1.07	-2.08	-1.01	4.40	-0.049
	5.50	1.06	-1.81	-0.75	4.79	-0.052
	5.36	1.07	-1.53	-0.46	5.10	-0.051
	5.63	1.06	-2.37	-1.31	5.31	-0.055
Vance 6	5.97	1.06	-2.09	-1.03	5.59	-0.047
interplaya	6.27	1.06	-1.53	-0.47	5.92	-0.054
	6.58	1.05	-1.53	-0.48	6.23	-0.055
	6.88	1.05	-1.67	-0.62	6.53	-0.053
	7.16	1.05	-1.81	-0.76	6.84	-0.057
	7.49	1.04	-1.67	-0.63	7.11	-0.058
	7.80	1.04	-0.97	0.07	7.44	-0.052
	8.10	1.04	-0.97	0.07	7.75	-0.059
	8.41	1.04	-0.97	0.07	8.50	-0.056
	8.66	1.03	-1.25	-0.22	8.36	-0.055
	8.71	1.03	-0.69	0.34	8.62	-0.064
	9.41	1.03	-0.83	0.20	8.97	-0.056
	10.97	1.01	-0.55	0.46	9.36	-0.062
	14.76	0.97	-1.11	-0.14	10.10	-0.061
	12.11	1.00	-1.11	-0.11	10.92	-0.058
					11.67	-0.050
					11.89	-0.058
	0.40	1.12	-0.46	0.66	0.90	-0.005
	0.14	1.12	-0.29	0.83	0.20	-0.003
	0.25	1.12	-0.46	0.66	0.30	-0.004
	0.30	1.12	-2.02	-0.90	0.41	-0.008
	0.36	1.12	-4.80	-3.68	0.52	-0.017
	0.46	1.12	-4.82	-3.70	0.75	-0.077
	0.67	1.11	**-6.42**	-5.31	0.90	-0.119
	0.82	1.11	-5.86	-4.75	1.50	-0.130
	0.98	1.11	-5.44	-4.33	1.22	-0.162
	0.98	1.11	-5.93	-4.82	1.36	-0.188
	1.13	1.11	-5.13	-4.02	1.51	-0.193
	1.28	1.11	-3.77	-2.66	1.62	-0.273

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	1.43	1.11	-3.52	-2.41	1.78	-0.240
	1.55	1.11	-4.20	-3.09	1.94	-0.252
	1.71	1.10	-3.49	-2.39	2.90	-0.230
	1.86	1.10	-3.42	-2.32	2.19	-0.196
	2.10	1.10	-3.56	-2.46	2.61	-0.155
TDCJ 1	2.18	1.10	-3.54	-2.44	2.76	-0.157
interplaya	2.48	1.10	-3.40	-2.30	2.85	-0.151
	2.65	1.09	-2.69	-1.60	3.20	-0.142
	2.74	1.09	-2.71	-1.62	3.26	-0.111
	2.74	1.09	-2.56	-1.47	3.86	-0.084
	2.87	1.09	-1.21	-0.12	4.70	-0.072
	3.31	1.09	-2.02	-0.93	4.70	-0.072
	3.78	1.08	-2.20	-1.12	5.80	-0.066
	4.15	1.08	-1.68	-0.60	5.47	-0.058
	4.66	1.07	-1.78	-0.71	6.42	-0.049
	5.46	1.07	-1.71	-0.64	7.34	-0.046
	6.36	1.06	-2.17	-1.11	8.37	-0.039
	6.36	1.06	-2.32	-1.26	9.17	-0.038
	6.36	1.06	-1.92	-0.86		
	7.30	1.05	-1.90	-0.85		
	8.31	1.04	-1.81	-0.77		
	8.93	1.03	-2.01	-0.98		
	30.00	0.83				
	0.60	1.11	-2.06	-0.95	0.14	-0.006
	0.21	1.12	-2.46	-1.34	0.29	-0.011
	0.37	1.11	-4.35	-3.24	0.44	-0.009
	0.52	1.11	**-5.01**	-3.90	0.59	-0.014
	0.67	1.11	-4.58	-3.47	0.75	-0.011
	0.82	1.11	-4.18	-3.07	0.92	-0.010
	0.98	1.11	-4.18	-3.07	1.50	-0.009
	1.13	1.11	-4.12	-3.01	1.20	-0.010
	1.28	1.11	-3.81	-2.70	1.36	-0.012
	1.43	1.10	-3.56	-2.46	1.51	-0.015
	1.58	1.10	-3.68	-2.58	1.66	-0.019
	1.74	1.10	-3.38	-2.28	1.81	-0.030
	1.92	1.10	-3.13	-2.03	1.94	-0.044
	2.16	1.10	-2.56	-1.46	2.60	-0.059
	2.33	1.09	-2.46	-1.37	2.39	-0.062
	2.47	1.09	-2.30	-1.21	2.55	-0.065
TDCJ 2	2.74	1.09	-2.18	-1.09	2.77	-0.086
annulus	3.20	1.09	-2.23	-1.14	3.90	-0.077
	3.17	1.09	-2.08	-0.99	3.26	-0.080
	3.34	1.08	-2.45	-1.37	3.41	-0.077
	3.51	1.08	-1.99	-0.91	3.58	-0.080
	3.69	1.08	-1.94	-0.86	3.75	-0.072
	4.20	1.08	-2.17	-1.09	4.90	-0.062
	4.42	1.07	-1.93	-0.86	4.42	-0.056
	5.00	1.07	-2.19	-1.12	4.73	-0.051
	5.49	1.06	-2.29	-1.23	4.98	-0.048
	7.13	1.05	-2.18	-1.13	5.51	-0.041
	7.92	1.04	-2.21	-1.17	6.88	-0.038

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
					7.16	-0.041
					7.73	-0.035
					7.95	-0.034
					8.70	-0.034
					9.20	-0.037
	0.18	1.12	-0.25	0.87	0.19	-0.004
	0.55	1.11	-0.21	0.90	0.57	-0.004
	0.94	1.11	-0.21	0.90	0.95	-0.005
	1.37	1.10	-0.25	0.85	1.36	-0.009
	1.77	1.10	-0.41	0.69	1.78	-0.016
	2.16	1.10	-0.75	0.35	2.16	-0.008
	2.53	1.09	**-2.81**	-1.72	2.54	-0.014
	2.90	1.09	-2.60	-1.51	2.95	-0.014
	3.38	1.08	-2.28	-1.20	3.47	0.000
	3.75	1.08	-2.12	-1.04	3.77	-0.057
	4.15	1.08	-2.22	-1.14	4.15	-0.097
	4.62	1.07	-2.41	-1.34	4.61	-0.145
	5.43	1.06	-2.27	-1.21	5.45	-0.146
	6.13	1.06	-2.03	-0.97	6.13	-0.134
	6.89	1.05	-2.09	-1.04	6.90	-0.105
	7.65	1.04	-1.77	-0.73	7.66	-0.070
	8.41	1.04	-1.73	-0.69	8.42	-0.045
TDCJ 3	9.17	1.03	-1.51	-0.48	9.18	-0.045
annulus	9.17	1.03	-1.82	-0.79	9.94	-0.032
	9.94	1.02	-1.77	-0.75	10.71	-0.031
	10.70	1.01	-1.78	-0.77	11.47	-0.025
	11.46	1.01	-0.81	0.20	12.23	-0.027
	12.22	1.00	-1.51	-0.51	12.99	-0.033
	12.98	0.99	-1.23	-0.24	13.75	-0.036
	13.75	0.98	-2.09	-1.11	14.52	-0.026
	14.58	0.97	-1.25	-0.28	15.28	-0.029
	15.27	0.97	-0.69	0.28	16.40	-0.032
	15.27	0.97	-0.75	0.22	16.80	-0.035
	16.32	0.96	-0.75	0.21	17.56	-0.038
	16.79	0.95	-1.02	-0.07	18.33	-0.036
	17.56	0.95	-0.95	0.00	19.90	-0.052
	18.32	0.94	-0.72	0.22	19.85	-0.043
	19.85	0.92	-0.81	0.11	20.61	-0.040
	19.85	0.92	-0.87	0.05	21.37	-0.040
	19.84	0.92	-1.15	-0.23	22.14	-0.038
	20.64	0.92	-1.18	-0.26	22.90	-0.037
	21.37	0.91	-1.28	-0.37	23.66	-0.045
	22.13	0.90	-0.96	-0.06		
	22.13	0.90	-0.69	0.21		
	22.89	0.89	-0.91	-0.02		
	22.89	0.89	-0.86	0.03		
	23.65	0.89	-0.65	0.24		
	0.37	1.11	0.13	1.24	0.11	-0.003
	0.37	1.11	0.10	1.21	0.46	-0.002
	0.40	1.11	0.05	1.16	0.88	-0.002

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	0.40	1.11	-0.06	1.05	0.88	-0.002
	0.65	1.11	0.21	1.32	1.18	-0.004
	0.65	1.11	0.16	1.27	1.18	-0.003
	0.87	1.11	0.07	1.18	1.49	-0.003
	0.87	1.11	-0.01	1.10	1.79	-0.002
	1.16	1.11	-0.05	1.06	2.10	-0.003
	1.16	1.11	-0.04	1.07	2.40	-0.002
	1.77	1.10	-0.21	0.89	2.71	-0.003
	2.73	1.09	-0.14	0.95	3.10	-0.005
	2.38	1.09	-0.18	0.91	3.11	-0.004
	2.68	1.09	-0.12	0.97	3.72	-0.003
	2.99	1.09	-0.26	0.83	4.33	-0.002
	3.19	1.09	-0.31	0.78	4.94	-0.002
	3.19	1.09	0.12	1.21	5.55	-0.003
	3.72	1.08	-0.17	0.91	6.16	-0.003
	4.33	1.08	-1.04	0.04	6.77	-0.003
	4.94	1.07	**-1.84**	-0.77	7.38	-0.002
	5.79	1.06	-1.43	-0.37	7.99	-0.001
	5.79	1.06	-1.32	-0.26	8.60	-0.001
	6.16	1.06	-1.49	-0.43	9.20	-0.001
	6.77	1.05	-0.99	0.06	9.81	-0.002
	7.62	1.04	-0.85	0.19	10.42	-0.001
	7.62	1.04	-0.74	0.30	11.30	-0.001
TDCJ 4	8.23	1.04	-0.60	0.44	11.64	0.000
annulus	8.23	1.04	-0.49	0.55	12.25	0.000
	8.60	1.03	-0.24	0.79	12.86	-0.001
	8.60	1.03	-0.40	0.63	14.80	-0.001
	9.25	1.03	-0.08	0.95	15.30	-0.001
	9.82	1.02	-0.01	1.01	15.91	-0.001
	10.36	1.02	0.09	1.11	16.52	-0.001
	11.34	1.01	0.09	1.10	17.74	-0.001
	11.64	1.00	-0.03	0.97	18.96	-0.001
	11.64	1.00	0.06	1.06	20.18	-0.001
	12.25	1.00	0.08	1.08	21.40	-0.001
	12.25	1.00	0.07	1.07	22.62	-0.001
	12.86	0.99	-0.14	0.85	23.84	-0.001
	12.86	0.99	-0.13	0.86	25.50	-0.004
	14.82	0.97	-0.29	0.68	25.66	-0.001
	15.31	0.97	-0.20	0.77		
	16.52	0.96	-0.01	0.95		
	16.52	0.96	0.00	0.96		
	17.74	0.94	-0.02	0.92		
	17.74	0.94	-0.10	0.84		
	18.96	0.93	-0.08	0.85		
	18.96	0.93	-0.04	0.89		
	20.18	0.92	-0.07	0.85		
	21.40	0.91	0.01	0.92		
	22.62	0.90	-0.02	0.88		
	23.84	0.88	-0.06	0.82		
	25.55	0.87	-0.06	0.81		
	25.66	0.87	-0.09	0.78		

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	0.52	1.11	**-5.19**	-4.08	0.53	-0.006
	1.78	1.10	-2.27	-1.17	1.79	-0.058
	2.90	1.09	-2.78	-1.69	2.10	-0.040
	2.39	1.09	-2.93	-1.84	2.10	-0.051
	2.70	1.09	-3.51	-2.42	2.40	-0.033
	3.00	1.09	-2.66	-1.57	2.71	-0.027
	3.76	1.08	-0.98	0.10	3.10	-0.066
	4.53	1.07	-0.93	0.14	3.77	-0.070
	5.29	1.07	-0.66	0.41	4.53	-0.091
	6.80	1.05	-0.96	0.09	5.30	-0.080
	6.83	1.05	-1.09	-0.04	6.60	-0.066
TDCJ 5	7.59	1.04	-0.98	0.06	6.82	-0.061
interplaya	8.35	1.04	-1.60	-0.56	7.58	-0.062
	9.11	1.03	-1.85	-0.82	8.34	-0.051
	9.88	1.02	-2.40	-1.38	9.11	-0.050
	10.55	1.01	-2.35	-1.34	9.88	-0.047
	11.40	1.01	-1.84	-0.83	10.55	-0.048
	12.16	1.00	-1.95	-0.95	11.40	-0.045
	12.92	0.99	-1.59	-0.60	12.16	-0.047
	13.69	0.98	-2.04	-1.06	12.92	-0.041
	14.45	0.98	-2.23	-1.25	13.69	-0.065
	15.13	0.97	-2.97	-2.00	14.45	-0.045
	16.60	0.95	-4.63	-3.68	15.21	-0.052
					15.29	-0.061
	0.40	1.11	**-3.08**	-1.97		
	0.19	1.12	-1.53	-0.41		
	0.34	1.11	-2.51	-1.40		
	0.50	1.11	-2.37	-1.26		
	0.86	1.11	-2.23	-1.12		
	1.20	1.11	-2.37	-1.26		
	1.78	1.10	-0.83	0.27		
	2.80	1.09	-0.83	0.26		
	2.39	1.09	-1.53	-0.44		
	2.69	1.09	-2.38	-1.29		
	2.93	1.09	-2.80	-1.71		
	3.30	1.09	-2.52	-1.43		
	3.60	1.08	-2.37	-1.29		
	3.91	1.08	-2.09	-1.01		
	4.21	1.08	-1.39	-0.31		
	4.52	1.07	-2.37	-1.30		
	4.82	1.07	-2.37	-1.30		
	5.13	1.07	-2.66	-1.59		
	5.43	1.06	-2.51	-1.45		
	5.74	1.06	-1.81	-0.75		
TDCJ 6	6.40	1.05	-2.37	-1.32		
interplaya	6.63	1.05	-2.37	-1.32		
	7.24	1.05	-3.08	-2.03		
	7.85	1.04	-2.51	-1.47		
	8.46	1.03	-2.79	-1.76		
	9.60	1.02	-2.23	-1.21		
	9.68	1.02	-2.37	-1.35		

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	10.29	1.02	-2.37	-1.35		
	10.90	1.01	-2.52	-1.51		
	11.51	1.00	-2.23	-1.23		
	12.15	1.00	-1.95	-0.95		
	13.94	0.98	-2.37	-1.39		
	14.86	0.97	-1.81	-0.84		
	15.77	0.96	-2.09	-1.13		
	16.99	0.95	-2.23	-1.28		
	17.91	0.94	-1.95	-1.01		
	18.82	0.93	-2.23	-1.30		
	20.40	0.92	-2.09	-1.17		
	20.96	0.91	-2.37	-1.46		
	21.87	0.90	-2.23	-1.33		
	22.84	0.89	-2.09	-1.20		
	0.23	1.12	-4.22	-3.10		
	0.53	1.11	-4.08	-2.97		
	0.88	1.11	-5.66	-4.55		
	1.23	1.11	**-7.70**	-6.59		
	1.54	1.10	-4.08	-2.98		
	1.84	1.10	-3.37	-2.27		
	2.15	1.10	-3.64	-2.54		
	2.45	1.09	-3.93	-2.84		
	2.76	1.09	-3.65	-2.56		
	3.06	1.09	-3.93	-2.84		
	3.37	1.08	-3.08	-2.00		
	3.67	1.08	-3.79	-2.71		
	3.98	1.08	-2.66	-1.58		
	4.28	1.08	-2.94	-1.86		
	4.59	1.07	-3.08	-2.01		
	4.89	1.07	-2.24	-1.17		
	5.20	1.07	-2.66	-1.59		
	5.50	1.06	-2.80	-1.74		
TDCJ 7	5.81	1.06	-2.65	-1.59		
annulus	6.11	1.06	-2.51	-1.45		
	6.72	1.05	-2.65	-1.60		
	7.79	1.04	-2.37	-1.33		
	8.58	1.03	-2.23	-1.20		
	9.31	1.03	-1.95	-0.92		
	10.10	1.02	-2.51	-1.49		
	10.84	1.01	-1.53	-0.52		
	11.60	1.00	-2.23	-1.23		
	12.36	1.00	-1.81	-0.81		
	13.12	0.99	-1.53	-0.54		
	13.88	0.98	-2.09	-1.11		
	14.65	0.97	-2.09	-1.12		
	15.41	0.97	-1.95	-0.98		
	16.17	0.96	-2.80	-1.84		
	16.93	0.95	-2.09	-1.14		

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	17.75	0.94	-2.80	-1.86		
	18.46	0.94	-2.80	-1.86		
	19.98	0.92	-3.08	-2.16		
	21.50	0.91	-2.23	-1.32		
	0.23	1.12	-0.18	0.94	0.29	-0.002
	0.53	1.11			0.81	-0.002
	0.75	1.11	-0.42	0.69	1.51	-0.040
	1.14	1.11	-0.22	0.89	2.12	-0.096
	1.45	1.10	-0.29	0.81	2.73	-0.084
	1.75	1.10	**-0.67**	0.43	3.34	-0.072
	2.60	1.09			3.95	-0.056
	2.39	1.09			4.56	-0.039
	2.67	1.09			5.17	-0.030
	2.97	1.09			5.78	-0.016
	3.28	1.09			6.69	-0.009
	3.58	1.08			7.91	-0.005
	3.89	1.08	-0.59	0.49	9.13	-0.003
	4.19	1.08	-0.36	0.72	10.35	-0.003
	4.50	1.07	-0.32	0.75	11.57	-0.003
TDCJ 9	4.80	1.07	-0.28	0.79	16.60	-0.005
drainage	5.11	1.07	-0.26	0.81	19.19	-0.002
	5.41	1.06	-0.26	0.80	21.60	-0.002
	5.72	1.06	-0.23	0.83	24.52	-0.001
	6.20	1.06	-0.19	0.87	27.57	-0.001
	6.63	1.05	-0.37	0.68		
	7.24	1.05	-0.20	0.85		
	7.85	1.04	-0.16	0.88		
	8.46	1.03	-0.17	0.86		
	9.70	1.02	-0.23	0.79		
	9.74	1.02	-0.29	0.73		
	10.29	1.02	-0.14	0.88		
	10.90	1.01	-0.17	0.84		
	11.51	1.00	-0.17	0.83		
	12.27	1.00	-0.16	0.84		
	14.60	0.97	-0.17	0.80		
	16.30	0.96	-0.16	0.80		
	17.62	0.94	-0.23	0.71		
	18.36	0.94	-0.20	0.74		
	19.13	0.93	-0.25	0.68		
	19.89	0.92	-0.19	0.73		
	21.53	0.91	-0.13	0.78		
	22.94	0.89	-0.17	0.72		
	24.46	0.88	-0.09	0.79		
	25.98	0.86	-0.12	0.74		
	27.51	0.85	-0.13	0.72		
	29.30	0.83	-0.17	0.66		
	0.91	1.11	**-3.64**	-2.53		
	2.44	1.09	-2.93	-1.84		
	3.93	1.08	-2.37	-1.29		
	5.52	1.06	-1.95	-0.89		

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
TDCJ 11 interplaya	7.40	1.05	-2.65	-1.60		
	8.56	1.03	-2.37	-1.34		
	10.90	1.01	-2.51	-1.50		
	11.61	1.00	-3.22	-2.22		
	13.14	0.99	-3.08	-2.09		
	14.66	0.97	-2.51	-1.54		
	16.18	0.96	-2.52	-1.56		
	17.71	0.94	-3.37	-2.43		
	19.50	0.93	-2.37	-1.44		
	20.73	0.91	-2.52	-1.61		
	22.25	0.90	-2.38	-1.48		
	23.23	0.89	-2.52	-1.63		
TDCJ 27 annulus	0.27	1.12	-0.15	0.97		
	0.57	1.11	-0.12	0.99		
	0.88	1.11	-0.11	1.00		
	1.18	1.11	-0.13	0.98		
	1.43	1.10	-0.21	0.89		
	1.73	1.10	-0.15	0.95		
	2.40	1.09	-0.26	0.83		
	2.34	1.09	-0.26	0.83		
	2.71	1.09	-0.26	0.83		
	2.98	1.09	-0.25	0.84		
	3.28	1.09	-0.21	0.88		
	3.59	1.08	-0.13	0.95		
	3.89	1.08	-0.24	0.84		
	4.26	1.08	-0.25	0.83		
	4.53	1.07	-0.16	0.91		
	4.84	1.07	-0.19	0.88		
	5.14	1.07	-0.19	0.88		
	5.45	1.06	-0.18	0.88		
	5.75	1.06	-0.19	0.87		
	6.70	1.05	-0.17	0.88		
	7.37	1.05	-0.12	0.93		
	8.25	1.04	-0.15	0.89		
	8.89	1.03	-0.21	0.82		
	9.81	1.02	-0.15	0.87		
	10.46	1.02	-0.13	0.89		
	11.36	1.01	-0.19	0.82		
	12.60	0.99	-0.14	0.85		
	12.92	0.99	-0.36	0.63		
	14.47	0.98	-0.18	0.80		
	16.30	0.96	-0.12	0.84		
	17.58	0.95	-0.32	0.63		
	19.13	0.93	-0.16	0.77		
	20.69	0.91	-0.22	0.69		
	22.24	0.90	-0.18	0.72		
	23.55	0.89	-0.26	0.63		
	25.20	0.87	-0.26	0.61		
	26.85	0.85	-0.14	0.71		
	28.46	0.84	-0.15	0.69		
	30.20	0.82	-0.12	0.70		

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	31.42	0.81	-0.10	0.71		
	33.00	0.79	-0.09	0.70		
	34.37	0.78	-0.13	0.65		
	0.27	1.12	-0.14	0.98	0.22	-0.001
	0.57	1.11	-0.15	0.96	0.53	-0.001
	0.88	1.11	-0.17	0.94	0.83	-0.001
	1.15	1.11	-0.18	0.93	1.14	-0.001
	1.46	1.10	-0.21	0.89	1.41	-0.001
	1.76	1.10	-0.29	0.81	1.71	-0.001
	2.70	1.09	-0.34	0.75	2.20	-0.002
	2.37	1.09	-0.36	0.73	2.32	-0.002
	2.71	1.09	-0.33	0.76	2.66	-0.002
	3.10	1.09	-0.38	0.71	2.96	-0.002
	3.32	1.09	-0.35	0.74	3.27	-0.002
	3.62	1.08	-0.40	0.68	3.57	-0.002
	3.92	1.08	-0.27	0.81	3.88	-0.002
	4.31	1.08	-0.44	0.64	4.24	-0.002
	4.56	1.07	-0.30	0.77	4.52	-0.002
	4.87	1.07	-0.25	0.82	4.82	-0.002
TDCJ 28 playa	5.17	1.07	-0.26	0.81	5.13	-0.002
	5.48	1.06	-0.21	0.85	5.43	-0.002
	5.89	1.06	-0.29	0.77	5.84	-0.002
	6.64	1.05	-0.16	0.89	6.59	-0.002
	7.45	1.04	-0.29	0.75	7.40	-0.003
	8.19	1.04	-0.20	0.84	8.15	-0.002
	8.92	1.03	-0.60	0.43	8.88	-0.002
	9.75	1.02	-0.19	0.83	9.70	-0.002
	10.54	1.01	-0.32	0.69	10.49	-0.002
	11.18	1.01	-0.21	0.80	11.25	-0.002
	11.76	1.00	**-0.71**	0.29	11.71	-0.002
	12.86	0.99	-0.32	0.67	12.81	-0.002
	14.41	0.98	-0.37	0.61	14.36	-0.003
	15.96	0.96	-0.22	0.74	15.92	-0.004
	17.52	0.95	-0.16	0.79	17.47	-0.005
	19.70	0.92	-0.15	0.77	19.30	-0.004
	20.63	0.92	-0.15	0.77	20.58	-0.003
	0.27	1.12	-7.10	-5.98		
	0.57	1.11	**-13.22**	-12.11		
	0.88	1.11	-9.01	-7.90		
	1.43	1.10	-6.97	-5.86		
	1.73	1.10	-4.78	-3.68		
	2.40	1.09	-4.50	-3.41		
	2.34	1.09	-3.22	-2.12		
	2.64	1.09	-4.51	-3.41		
	2.98	1.09	-3.22	-2.13		
Vance 1 interplaya	3.28	1.09	-2.66	-1.57		
	3.59	1.08	-2.66	-1.57		
	3.89	1.08	-1.81	-0.73		
	4.20	1.08	-3.94	-2.86		
	4.53	1.07	-2.38	-1.30		

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	4.84	1.07	-2.24	-1.16		
	5.14	1.07	-2.37	-1.31		
	5.45	1.06	-1.67	-0.61		
	5.75	1.06	-2.52	-1.45		
	6.90	1.05	-1.81	-0.76		
	6.85	1.05	-1.95	-0.90		
	0.27	1.12	-0.32	0.80	0.22	-0.003
	0.57	1.11	-0.24	0.87	0.53	-0.003
	0.88	1.11	-0.31	0.80	0.83	-0.004
	1.36	1.10	-0.51	0.59	1.32	-0.005
	1.70	1.10	**-0.65**	0.45	1.62	-0.003
	1.97	1.10	-0.55	0.55	1.93	-0.003
	2.28	1.10	-0.52	0.58	2.23	-0.005
	2.61	1.09	-0.60	0.49	2.57	-0.009
	2.89	1.09	-0.40	0.69	2.84	-0.010
	3.19	1.09	-0.39	0.70	3.15	-0.011
	3.50	1.08	-0.34	0.74	3.45	-0.012
	3.80	1.08	-0.34	0.74	3.76	-0.012
	4.80	1.07	-0.53	0.54	4.30	-0.012
	4.41	1.07	-0.64	0.43	4.37	-0.009
	4.72	1.07	-0.57	0.50	4.67	-0.009
	5.20	1.07	-0.50	0.57	4.98	-0.007
	5.33	1.07	-0.49	0.58	5.28	-0.007
	5.94	1.06	-0.53	0.53	5.63	-0.007
	6.24	1.06	-0.37	0.69	5.89	-0.007
	6.55	1.05	-0.31	0.74	6.20	-0.007
	6.85	1.05	-0.18	0.87	6.50	-0.009
	7.19	1.05	-0.29	0.76	6.80	-0.008
Vance 2	7.46	1.04	-0.30	0.74	7.16	-0.011
playa	7.77	1.04	-0.19	0.85	7.41	-0.014
	8.70	1.03	-0.30	0.73	7.72	-0.018
	8.37	1.04	-0.40	0.64	8.20	-0.018
	8.74	1.03	-0.42	0.61	8.33	-0.020
	8.98	1.03	-0.49	0.54	8.69	-0.025
	9.29	1.03	-0.57	0.46	8.94	-0.029
	9.59	1.02	-0.49	0.53	9.24	-0.028
	10.28	1.02	-0.37	0.65	9.55	-0.036
	11.04	1.01	-0.29	0.72	10.23	-0.040
	11.80	1.00	-0.38	0.62	10.98	-0.045
	12.52	0.99	-0.24	0.75	11.76	-0.040
	13.28	0.99	-0.29	0.70	12.47	-0.039
	13.98	0.98	-0.38	0.60	13.24	-0.044
	14.82	0.97	-0.25	0.72	13.94	-0.038
	15.54	0.97	-0.26	0.71	14.78	-0.037
	17.00	0.95	-0.19	0.76	15.49	-0.028
	17.84	0.94	-0.14	0.80	16.95	-0.027
	18.52	0.94	-0.18	0.76	17.79	-0.026
	20.50	0.92	-0.17	0.75	18.48	-0.017

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	21.69	0.91	-0.39	0.52	20.00	-0.018
	23.16	0.89	-0.55	0.34	21.65	-0.011
	24.62	0.88	-0.35	0.53	23.11	-0.008
					24.57	-0.010
Vance 6 interplaya	0.27	1.12	**-13.16**	-12.05		
	0.57	1.11	-11.80	-10.69	0.22	-0.025
	0.88	1.11	-8.53	-7.42	0.53	-0.008
	1.39	1.10	-4.77	-3.67	0.83	-0.005
	1.70	1.10	-4.20	-3.10	1.35	-0.003
	2.00	1.10	-3.35	-2.25	1.65	-0.007
	2.31	1.10	-2.92	-1.83	1.96	-0.007
	2.61	1.09	-3.21	-2.12	2.26	-0.015
	2.92	1.09	-2.08	-0.99	2.57	-0.019
	3.22	1.09	-1.94	-0.85	2.87	-0.026
	3.53	1.08	-1.52	-0.44	3.18	-0.042
	3.83	1.08	-1.52	-0.44	3.48	-0.046
	4.12	1.08	-2.08	-1.00	3.79	-0.055
	4.44	1.07	-1.94	-0.87	4.80	-0.059
	4.84	1.07	-2.08	-1.01	4.40	-0.049
	5.50	1.06	-1.81	-0.75	4.79	-0.052
	5.36	1.07	-1.53	-0.46	5.10	-0.051
	5.63	1.06	-2.37	-1.31	5.31	-0.055
	5.97	1.06	-2.09	-1.03	5.59	-0.047
	6.27	1.06	-1.53	-0.47	5.92	-0.054
	6.58	1.05	-1.53	-0.48	6.23	-0.055
	6.88	1.05	-1.67	-0.62	6.53	-0.053
	7.16	1.05	-1.81	-0.76	6.84	-0.057
	7.49	1.04	-1.67	-0.63	7.11	-0.058
	7.80	1.04	-0.97	0.07	7.44	-0.052
	8.10	1.04	-0.97	0.07	7.75	-0.059
	8.41	1.04	-0.97	0.07	8.50	-0.056
	8.66	1.03	-1.25	-0.22	8.36	-0.055
	8.71	1.03	-0.69	0.34	8.62	-0.064
	9.41	1.03	-0.83	0.20	8.97	-0.056
	10.97	1.01	-0.55	0.46	9.36	-0.062
	14.76	0.97	-1.11	-0.14	10.10	-0.061
	12.11	1.00	-1.11	-0.11	10.92	-0.058
					11.67	-0.050
					11.89	-0.058
	0.23	0.88	-6.31	-5.43	0.29	-0.033
	0.53	0.88	-6.71	-5.83	0.59	-0.264
	0.90	0.87	**-7.37**	-6.50	0.96	-0.527
	1.27	0.87	-6.05	-5.18	1.33	-0.468
	1.57	0.87	-5.03	-4.16	1.63	-0.422
	1.86	0.86	-3.84	-2.98	1.94	-0.239
	2.18	0.86	-4.28	-3.42	2.24	-0.186
	2.55	0.86	-3.98	-3.12	2.55	-0.151
	2.85	0.85	-2.97	-2.12	2.91	-0.118
	3.16	0.85	-2.63	-1.78	3.22	-0.105
	3.46	0.85	-2.38	-1.53	3.52	-0.100
	3.76	0.85	-2.18	-1.33	3.83	-0.086

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	4.10	0.84	-2.40	-1.56	4.16	-0.073
	4.40	0.84	-1.95	-1.11	4.47	-0.069
	4.71	0.84	-2.26	-1.42	4.77	-0.067
	5.01	0.83	-1.61	-0.78	5.07	-0.059
	5.32	0.83	-1.42	-0.59	5.38	-0.049
	5.65	0.83	-1.48	-0.65	5.72	-0.045
	5.99	0.82	-1.66	-0.84	6.05	-0.041
	6.29	0.82	-1.51	-0.69	6.36	-0.041
	6.60	0.82	-1.50	-0.68	6.66	-0.033
	6.90	0.81	-1.56	-0.75	7.30	-0.033
Wink 1	7.24	0.81	-1.31	-0.50	8.24	-0.026
interplaya	7.57	0.81	-1.47	-0.66	8.79	-0.031
	8.18	0.80	-1.23	-0.43	9.83	-0.023
	8.73	0.80	-0.93	-0.13	11.35	-0.019
	9.16	0.79	-1.06	-0.27	13.00	-0.023
	9.77	0.79	-0.84	-0.05	14.10	-0.025
	10.41	0.78	-0.58	0.20	15.68	-0.017
	10.74	0.78	-0.55	0.23	17.33	-0.013
	11.35	0.77	-0.55	0.22	25.86	-0.005
	11.96	0.77	-0.75	0.02		
	12.33	0.76	-0.66	0.10		
	12.94	0.76	-0.69	0.07		
	13.64	0.75	-1.16	-0.41		
	14.04	0.74	-0.57	0.17		
	14.95	0.74	-0.61	0.13		
	15.93	0.73	-0.64	0.09		
	16.54	0.72	-0.85	-0.13		
	17.27	0.71	-1.10	-0.39		
	19.34	0.69	-1.07	-0.38		
	20.80	0.68	-0.62	0.06		
	22.30	0.66	-0.65	0.01		
	24.13	0.65	-1.03	-0.38		
	25.80	0.63	-0.39	0.24		
	0.23	0.88	-0.03	0.85	0.29	-0.002
	0.53	0.88	-0.01	0.87	0.59	-0.001
	0.84	0.87	-0.09	0.78	0.90	-0.001
	1.14	0.87	-0.05	0.82	1.20	-0.001
	1.45	0.87	-0.10	0.77	1.51	-0.001
	1.75	0.87	-0.08	0.79	1.81	-0.001
	2.60	0.86	-0.07	0.79	2.12	-0.001
	2.45	0.86	-0.11	0.75	2.51	-0.008
	2.67	0.86	-0.08	0.78	2.73	-0.001
	2.97	0.85	-0.12	0.73	3.30	-0.001
	3.28	0.85	0.00	0.85	3.34	0.000
	3.58	0.85	-0.12	0.73	3.64	-0.001
	3.95	0.84	-0.10	0.74	4.10	-0.001
	4.19	0.84	-0.04	0.80	4.25	-0.001
	4.50	0.84	-0.09	0.75	4.56	-0.001
	4.80	0.84	-0.02	0.82	4.86	-0.001
	5.11	0.83	-0.06	0.77	5.17	-0.001
	5.47	0.83	-0.09	0.74	5.53	-0.001

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	5.72	0.83	-0.19	0.64	5.78	-0.002
	6.63	0.82	-0.13	0.69	6.80	-0.001
	7.24	0.81	-0.14	0.67	6.69	-0.001
Wink 5	7.85	0.81	-0.10	0.71	7.30	-0.001
annulus	8.40	0.80	-0.16	0.64	8.46	0.000
	9.70	0.79	-0.24	0.55	9.74	-0.001
	9.68	0.79	-0.19	0.60	10.96	0.000
	10.29	0.78	-0.18	0.60	13.82	-0.002
	10.90	0.78	-0.19	0.59	16.81	-0.007
	11.48	0.77	-0.32	0.45	2.99	-0.001
	12.42	0.76	-0.34	0.42	23.00	-0.001
	13.60	0.75	-0.17	0.58	26.50	-0.001
	13.76	0.75	-0.32	0.43	29.90	0.000
	15.19	0.73	-0.27	0.46	32.80	-0.003
	16.75	0.72	-0.23	0.49		
	18.49	0.70	-0.27	0.43		
	19.25	0.69	-0.12	0.57		
	20.93	0.68	-0.32	0.36		
	21.41	0.67	-0.31	0.36		
	22.94	0.66	-0.33	0.33		
	24.46	0.64	-0.35	0.29		
	25.80	0.63	**-0.39**	0.24		
	25.98	0.63	-0.24	0.39		
	27.51	0.61	-0.31	0.30		
	29.30	0.60	-0.10	0.50		
	30.56	0.58	-0.09	0.49		
	32.20	0.57	-0.11	0.46		
	0.27	0.88	-0.20	0.68	0.22	-0.002
	0.57	0.88	-0.17	0.71	0.53	-0.002
	0.88	0.87	-0.21	0.66	0.83	-0.002
	1.18	0.87	-0.19	0.68	1.14	-0.002
	1.39	0.87	-0.30	0.57	1.35	-0.002
	1.70	0.87	-1.04	-0.17	1.65	-0.002
	2.00	0.86	**-1.34**	-0.48	1.96	-0.002
	2.31	0.86	-1.19	-0.33	2.26	-0.002
	2.61	0.86	-1.12	-0.26	2.57	-0.002
	2.95	0.85	-0.73	0.12	2.90	-0.002
	3.25	0.85	-0.74	0.11	3.21	-0.003
	3.56	0.85	-0.84	0.01	3.51	-0.003
	3.86	0.84	-1.01	-0.17	3.82	-0.003
	4.19	0.84	-0.77	0.07	4.12	-0.002
	4.50	0.84	-0.72	0.12	4.46	-0.002
	4.81	0.84	-0.85	-0.01	4.76	-0.001
	5.11	0.83	-0.73	0.10	5.70	-0.001
	5.42	0.83	-0.74	0.09	9.43	-0.002
	5.78	0.83	-0.96	-0.13	14.33	-0.003
	6.60	0.82	-0.66	0.16	20.55	-0.003
Wink 7	6.36	0.82	-0.61	0.21	23.20	-0.004
playa	6.66	0.82	-0.57	0.25	29.88	-0.002
	6.97	0.81	-0.65	0.16		
	7.35	0.81	-0.67	0.14		

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	8.22	0.80	-0.79	0.01		
	8.88	0.80	-0.52	0.28		
	9.17	0.79	-0.22	0.57		
	9.98	0.78	-0.27	0.51		
	11.33	0.77	-0.52	0.25		
	12.30	0.76	-0.73	0.03		
	12.82	0.76	-0.51	0.25		
	14.38	0.74	-0.43	0.31		
	15.93	0.73	-0.32	0.41		
	17.34	0.71	-0.18	0.53		
	18.89	0.70	-0.16	0.54		
	20.60	0.68	-0.15	0.53		
	22.00	0.67	-0.18	0.49		
	23.25	0.65	-0.19	0.46		
	25.38	0.63	-0.31	0.32		
	26.82	0.62	-0.27	0.35		
	28.37	0.60	-0.26	0.34		
	29.92	0.59	-0.25	0.34		
Wink 13 playa					0.50	-0.032
					1.20	-0.001
					2.51	-0.001
					3.47	-0.002
					4.43	-0.002
					5.23	-0.001
					6.20	-0.001
					7.42	-0.001
					8.43	-0.001
					9.43	-0.002
					10.53	-0.001
					11.54	0.000
					12.51	-0.001
					13.64	-0.001
					14.65	0.000
					15.90	-0.001
					17.80	-0.001
					18.61	0.000
					20.16	-0.001
					21.79	-0.001
					23.36	-0.001
					25.70	-0.001
					26.44	-0.001
					28.90	-0.001
	0.50	0.88	**-30.10**	-29.22		
	0.15	0.88	-11.34	-10.46		
	0.25	0.88	-10.16	-9.28		
	0.35	0.88	-10.77	-9.89		
	0.45	0.88	-10.16	-9.28		
	0.55	0.88	-10.61	-9.73		
	0.65	0.88	-10.48	-9.60		
	0.75	0.88	-10.47	-9.60		

Appendix C. Calculated gravitational potential, measured water potential, calculated total potential (gravitational + water potential), and calculated osmotic potential.

Borehole number	Depth (m)	Gravitational potential (MPa)	Water potential (MPa)	Total potential (MPa)	Depth (m)	Osmotic potential (MPa)
	0.85	0.87	-7.95	-7.08		
	0.95	0.87	-7.08	-6.21		
	1.50	0.87	-7.37	-6.50		
	1.25	0.87	-5.06	-4.19		
	1.45	0.87	-4.93	-4.06		
	1.65	0.87	-4.07	-3.20		
	1.85	0.86	-4.07	-3.21		
	2.47	0.86	-4.07	-3.21		
	2.25	0.86	-3.64	-2.78		
	2.45	0.86	-3.08	-2.22		
	2.62	0.86	-4.93	-4.07		
	2.77	0.86	-3.22	-2.36		
	2.97	0.85	-3.22	-2.37		
	3.17	0.85	-2.94	-2.09		
	3.37	0.85	-3.22	-2.37		
	3.57	0.85	-1.67	-0.82		
	3.77	0.85	-2.79	-1.94		
Wink 17	3.97	0.84	-2.51	-1.67		
playa	4.20	0.84	-2.79	-1.95		
	4.40	0.84	-2.37	-1.53		
	4.59	0.84	-2.37	-1.53		
	4.80	0.84	-1.67	-0.83		
	4.99	0.83	-1.81	-0.98		
	5.52	0.83	-1.67	-0.84		
	6.43	0.82	-1.95	-1.13		
	6.55	0.82	-1.53	-0.71		
	6.82	0.82	-1.81	-0.99		
	7.57	0.81	-1.53	-0.72		
	8.77	0.80	-1.39	-0.59		
	8.60	0.80	-1.25	-0.45		
	9.98	0.78	-0.83	-0.05		
	9.61	0.79	-1.25	-0.46		
	10.89	0.78	-0.97	-0.19		
	10.62	0.78	-0.69	0.09		
	11.13	0.77	-1.11	-0.34		
	11.58	0.77	-1.11	-0.34		
	12.15	0.76	-1.52	-0.76		
	12.65	0.76	-1.11	-0.35		
	13.15	0.75	-1.80	-1.05		
	13.72	0.75	-0.69	0.06		
	16.84	0.72	-1.80	-1.08		
	17.33	0.71	-1.94	-1.23		
	17.67	0.71	-2.64	-1.93		