

Groundwater Monitoring Wells

Source: Porter et al. (2009)

Introduction and Background

The Chihuahuan Desert Inventory and Monitoring Network (CHDN) encompasses six national park units in western Texas and southeastern New Mexico and one wild and scenic river stretch in western Texas (Figure 1). The CHDN has identified 21 vital signs for long-term monitoring, including groundwater quantity. In fact, groundwater dynamics ranked highest throughout the vital signs selection process. Surface water resources, which are sparsely distributed in the semi-arid and arid terrestrial ecosystems of the CHDN, are essential in the support of native biota. Although groundwater quantity monitoring has been conducted at some of the park units, uniform network-wide monitoring has not been conducted. In 2011, CHDN will initiate an effort that integrates surface and groundwater monitoring. An integrated approach is important for three reasons. First, the majority of CHDN surface water sources are closely tied to groundwater discharge. Second, the regional use of groundwater resources is increasing. Third, surface and groundwater quantity are expected to be

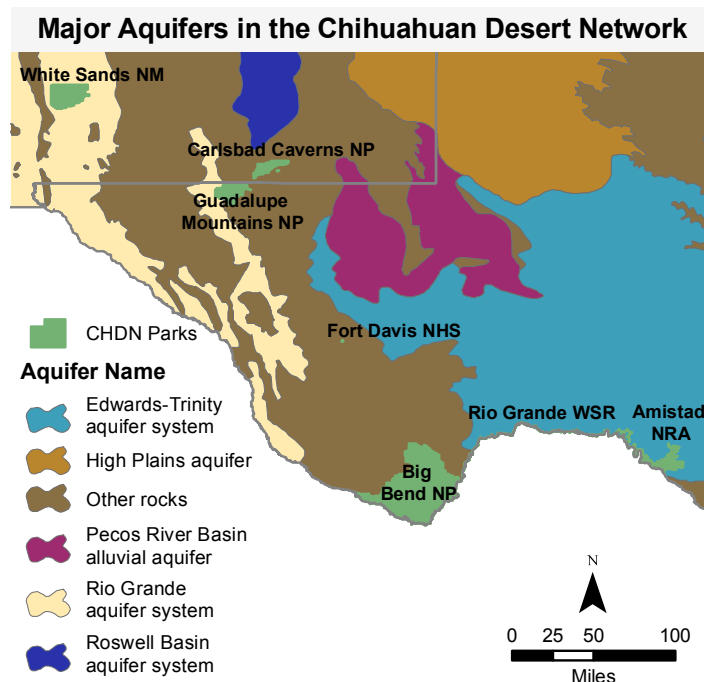


Figure 1. Parks and major aquifers in the CHDN.

OVERVIEW



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Checking a monitoring well at Big Bend NP

altered by climate change. Additionally, each of the parks in the CHDN depends on groundwater to supply potable (drinkable) water. The network-wide monitoring that will begin in 2011 will measure the depth to groundwater in wells to determine seasonal, annual, and long-term trends in groundwater resources in or adjacent to the CHDN park units.

The focus of this overview is the current status of groundwater resources in the CHDN, including information on the monitoring wells located in the parks. A recent project by the Edwards Aquifer Research and Data Center (EARDC) of Texas State University, in cooperation with the National Park Service (NPS), collected and examined existing data to address groundwater quantity/hydrology issues within the network (i.e., Porter et al. 2009). The report provides tables of water well and groundwater level information for each CHDN park, except for the Rio Grande Wild and Scenic River (for which no data were available). No systematically collected water level data are available for wells within CHDN parks, except for work done at White Sands National Monument (NM) and Big Bend National Park (NP). At White Sands NM, there were 10 years of data (1997-2008) from the park's groundwater monitoring network, and at Big Bend NP there were data from recent (2004-2008) water level monitoring. When available data were adequate for doing so, Porter et al. (2009) identified relationships among annual precipitation, likely recharge, nearby pumping, and observed water level trends for a given park.

Groundwater in CHDN parks either discharges from onsite springs or is pumped from local aquifers (Porter et al. 2009). These groundwater sources are affected by weather, area pumping, and land use. The infiltration of precipitation, sub-surface inflow of groundwater from adjacent aquifers, leakage from surface-water bodies, and return flow from irrigation are all ways in which aquifers are replenished. In the CHDN, however, aquifer recharge is limited by the amount and nature of the precipitation that occurs, as well as high rates of evaporation. By observing water levels in wells and discharge from local springs and seeps, the effects of groundwater recharge and discharge can be monitored. This type of monitoring over time is critical to understanding the long-term sustainability of an aquifer or spring.

Monitoring Wells in the Parks

Because of the limited data available for most of the parks, Porter et al. (2009) provided hydrographs only for water levels from wells at White Sands NM and Big Bend NP; these hydrographs are reproduced in this overview. To address the other parks, Porter et al. (2009) presented hydrographs of water levels in the closest state- or U.S. Geological Survey (USGS)-operated wells to each park; although not reproduced in this overview, these hydrographs are discussed below.

Amistad National Recreation Area (NRA)

The primary groundwater source in Amistad NRA and the surrounding area is the Edwards aquifer. There are five groundwater wells in the NRA (Table 1 on Page 6). Table 1 contains descriptive information for each well as well as the highest and lowest water levels recorded for each well, when they are available. There is a typical seasonal range of about 30 feet between the highest and lowest water levels, as indicated by the new Diablo East well. However, most of the apparent differences in water levels reflect adjustments in aquifer levels to changes in the stage of Lake Amistad.



Confluence of the Pecos River and Rio Grande at Amistad NRA



Monitoring well (on right) near Circle J at Big Bend NP

The information in Table 1 is the only data available on water levels at the NRA. Porter et al. (2009) constructed a hydrograph to examine long-term trends of other wells near the NRA that tap the Edwards aquifer. The water levels in most wells within about five miles of the reservoir (which began to fill during late 1968) fluctuated by less than 50 feet, while those farther to the north fluctuated by 50-75 feet during the same period. The more stable groundwater levels near the NRA are due to the buffering influence that Lake Amistad provides.

Big Bend NP

Aquifers that exist in the Big Bend NP region include the Tertiary Volcanics (Igneous) aquifer and the “Upper Cretaceous Series,” or what is known locally as the “Cretaceous Limestone” or “Santa Elena” aquifer. The Tertiary Volcanics aquifer is comprised primarily of congealed lava flows and characterized by fractures, crevices, and vesicular zones within the upper parts. The most permeable areas are generally in the tops and bottoms of the lava layers, because they are highly fractured rubble zones (caused by the rapid cooling of once molten lava). Water is transmitted relatively quickly between the aquifer and land surface. The “Upper Cretaceous Series” or “Cretaceous Limestone” aquifer is the southern extension of the regionally extensive Edwards-Trinity aquifer (Barker and Ardis 1996) and apparently underlies much of the Big Bend area. This carbonate-rock aquifer provides most of the park’s well water.

The most reliable water supply for Big Bend NP is provided by groundwater, including water emerging as spring or seep flow (MacNish et al. 1996). The temporal and spatial distribution of these springs and seeps supports the biological diversity and aesthetic beauty of the Rio Grande. Spring discharge is extremely variable with time and sensitive to variations in the hydrologic balance between recharge and discharge. If

aquifer water levels are lowered due to drought or excessive pumping, then reductions in springflow and streamflow would occur. Recent computer modeling suggests the possibility of significant water-level declines in the Edwards-Trinity aquifer of Brewster and Terrell Counties due to the pumping of groundwater (Porter et al. 2009).

Table 2 provides a summary of the information available on the 12 water level observation wells at Big Bend NP. Porter et al. (2009) also contains similar information on another 17 wells within the park. The park maintains a database that includes 71 additional wells dug or drilled in the park during the last 100 years. One of the wells listed in Table 2, Panther Junction #10 (near the Panther Junction visitor center), is unique among those currently within CHDN parks. Other than the set of eight wells at White Sands NM (described below), it is the only well designed to electronically monitor the status of groundwater quantity over time. The well has a continuous recorder and uses satellite telemetry. However, the well was installed in May 2007, so it has not yet produced enough information to examine long-term trends.

Figure 2 shows the depths to groundwater recorded since January 2004 in the 11 observation wells within the park (i.e., the remaining wells shown in Table 2). Nine of the 11 wells (those except for K-Bar #6 and #7) are thought to track water levels in the Tertiary Volcanics aquifer. Note that measurements at the wells are taken annually to semi-annually, so seasonal effects of aquifer recharge and discharge are not observed; the data allow only year-to-year comparisons of groundwater levels. Based on the information available, there is no significant trend in groundwater quantity since 2004. Future measurements at the wells will provide a longer-term perspective of trends.

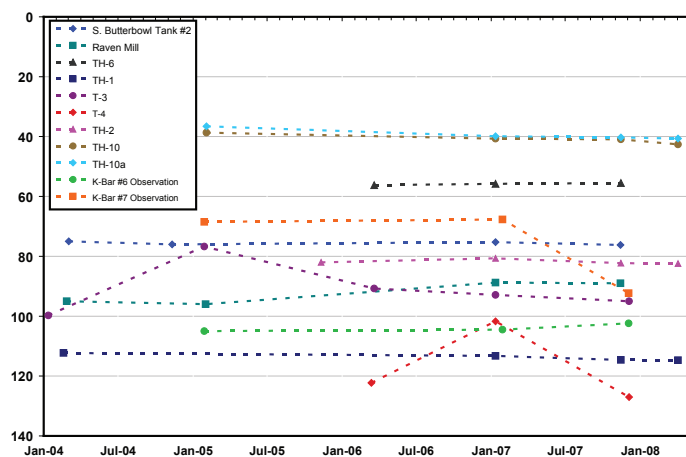


Figure 2. Hydrographs of water levels in Big Bend NP showing depths to groundwater (below measuring point, in feet) in wells tapping the Tertiary Volcanics & Upper Cretaceous Limestone Aquifers (2004-2008; Porter et al. 2009).



Oak Grove Well in Fort Davis NHS

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Carlsbad Caverns NP

There is one well at Carlsbad Caverns NP, at Rattlesnake Springs (Table 1). Irrigation water has been taken from Rattlesnake Springs for NPS property and nearby land for more than 50 years. Rattlesnake Springs has been the subject of several government or university studies (in the 1950's, 60's and 90's). The most recent study (Bowen 1998) indicated that variations in discharge from Rattlesnake Springs were due primarily to fluctuations in annual precipitation. The author reported that while the level of agricultural impact in 1998 was minimal, increased rates of well withdrawals could have a significant effect on Rattlesnake Springs.

An examination of springflow and groundwater levels in three wells operated by the USGS south of Rattlesnake Springs showed a downward trend in both measures since at least January 2001. Springflow data date from 2001-2006, but groundwater data indicate that recharge to the area's flow regime was probably dropping since about 1990. Annual precipitation totals for the area show a similar pattern. One of the previous reports (Cox 1963) provided a description of groundwater levels in the Rattlesnake Springs area as being, in general, highest over the winter (October-March), before pre-planting irrigation started, and lowest during the summer, when irrigation needs were the greatest.

Fort Davis National Historic Site (NHS)

The Tertiary Volcanics aquifer exists in the Fort Davis NHS area and is the only source of water for the residents of Fort Davis. The hydrogeologic framework and associated aquifer characteristics in the area can be extremely complex (Porter et al. 2009). Groundwater levels can differ by several hundreds of feet, even between closely spaced wells. The rugged topography in the area and/or the highly variable porosity and stor-

age capacity of the dominant volcanic-rock types can also lead to large water level differences. Most discharge in the area is a result of springflow and well withdrawals; there is not much evidence of prolonged groundwater discharge to perennial streams. There have been concerns at the NHS with regards to the long-term dependability of potable water sources.

There are four wells at Fort Davis NHS (Table 1). No historical water level data are available. The entries in the “highest water level” column were measured by EARDC personnel in April of 2008, and it is not known how these measurements compare to historical levels. Porter et al. (2009) constructed hydrographs for wells to the east and west of the park. Although none indicate a water level change greater than ± 5 feet, all three show a slight downward trend over their periods of record (~40 years, 40 years, and 7 years). Groundwater within the Tertiary Volcanics aquifer near the park is closely tied to deviations from the long-term average rate of precipitation in the area.

Guadalupe Mountains NP

Supplies of groundwater at Guadalupe Mountains NP may be affected by at least three widespread aquifers, as well as locally important permeable zones in the alluvial fan complex to the east of the Guadalupe Mountains (Porter et al. 2009). Of the three aquifers, the closest and most important is the Capitan Reef Complex (or Capitan), followed by the Bone Spring-Victorio Peak aquifer, and the Salt Bolson and Delaware Mountain Group aquifer. Recharge to these aquifers is minimal because of limited precipitation and high rates of evaporation in the region.

Permeability and well yields are generally high in the Capitan aquifer, but the water quality is usually inadequate for municipal or irrigation use (because of its sodium-chloride-sul-

fate levels). The aquifer is tapped by the park’s Pine Springs (Glover #13) well, the park’s main water supply. The Bone Spring-Victorio Peak aquifer underlies Guadalupe Mountains NP at depths greater than the Capitan Reef Complex. Water from this aquifer is generally acceptable for irrigation; the community of Dell City uses it as a potable water supply, but must use a demineralization process before distributing it. The Salt Bolson and Delaware Mountain Group has been considered as a potential water supply for the park, but the aquifer is probably susceptible to future declines in water levels due to the area’s growing demand for irrigation and potable drinking water.

There are seven groundwater wells in or near the park (Table 1). The limited information in Table 1 is the only data available on water levels at the NP, so Porter et al. (2009) constructed hydrographs to examine long-term trends of the three wells closest to the park (that have adequate data). The wells are located six or more miles from the park. The westernmost observation well in Hudspeth County monitors activity affecting the Bone Spring-Victorio Peak aquifer. The closest well (to the south) penetrates the Capitan Reef and Associated Limestones aquifer (the same aquifer supporting the Pine Springs [Glover #13] and other wells within the park). The third well is located 39 miles to the south of the second well. Although they tap three different aquifers, none of the water levels in these three wells indicates a difference between the lowest and highest water levels of more than 20 feet. The highest water levels in any of the three wells since the early 1970s occurred during the mid-1990s. These high water levels appear to correspond to sharp increases in precipitation in 1994-1996 in the area.

White Sands NM

The “basin-fill-aquifer,” within the Tularosa Basin, is formed by an assortment of basin-fill deposits (Huff 2005). The source of the basin fill is the re-deposition of material eroded from the surrounding mountains and fluvial (produced by stream action) sedimentation within the ancestral Rio Grande basin. Aquifer thickness ranges from less than 100 feet to 4,000 feet. There is evidence that a clay layer exists beneath the gypsum dunes about 25 feet below land surface (unpublished material from the park, cited in Porter et al. 2009). This layer may be impermeable, isolating the sand above from the general aquifer.

Information for eight wells at White Sands NM is shown in Table 2. The last two wells in the list, constructed in the early 1990s, are used for monitoring the depth to ground water (unpublished material from the park, cited in Porter et al. 2009). The other six wells were constructed in 1997 under a grant by the NPS Water Resources Division. Three wells are in the picnic loop and three are in the vicinity of the park’s headquar-



Guadalupe Mountains NP

PHOTO: © DUSTIN NELSON

ters. The wells have been used for obtaining water samples for chemical analyses and for measuring depth to ground water (which is ongoing). The park staff has been collecting data on depth to ground water since 1997; attempts are made to collect data at eight wells quarterly. The hydrograph below (Figure 3) shows the water level data from these wells for November 1997-January 2008.

There are no obvious trends in the data, except for a slight downward movement of water levels that seems to have rebounded after mid-2004 (Porter et al. 2009). For the most part, the water levels in the eight wells reflect the effects of similar phenomena within a common hydrologic framework. Except perhaps for the NL Lucero well, the wells are thought to tap a perched flow regime that is not subjected to pumping. Therefore, the observed fluctuations in water levels reflect the net effect of evapotranspiration and recharge from precipitation that vertically infiltrates the overlying sand or soil.



Monitoring well at White Sands NM

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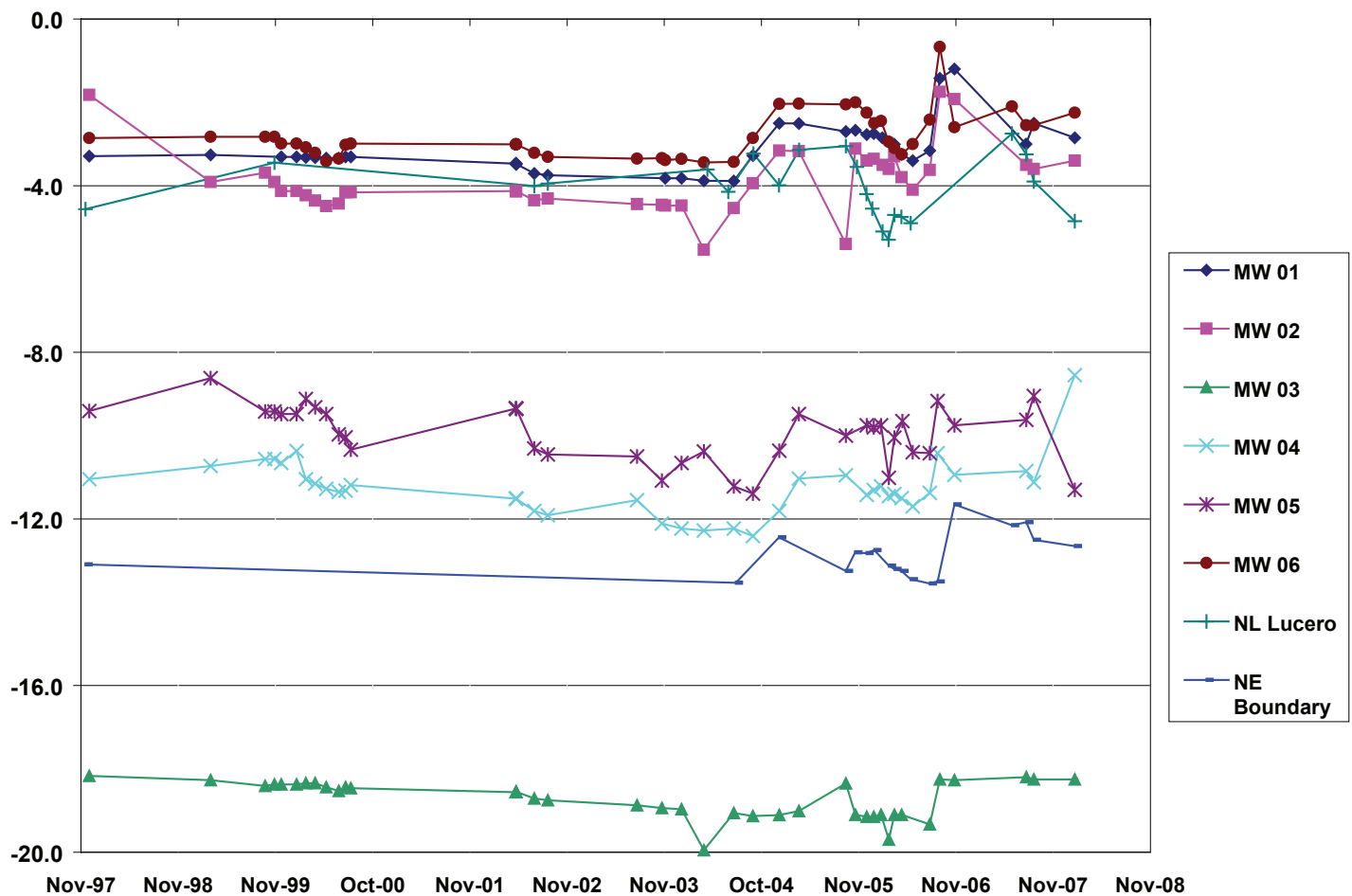


Figure 3. Hydrographs of groundwater levels (in feet) in White Sands NM monitoring wells, 1997-2008 (from Porter et al. 2009).

Table 1. Information for selected wells in Amistad NRA, Carlsbad Caverns NP, Fort Davis NHS, and Guadalupe Mountains NP (from Porter et al. 2009).

Well Name	North-ing	East-ing	Land Surface Altitude (ft amsl)	Well Depth (ft)	Aquifer	Highest Water Level (ft) ¹	Lowest Water Level (ft) ¹
AMISTAD NRA							
Diablo East	3261692	304369	1,178	480	Edwards	118.1	218.1
Diablo East, New	3261635	304634	1,160	600	“ “	40	71.35
Rough Canyon	_____	_____	_____	300	“ “	51.0	_____
Pecos River	_____	_____	_____	625	“ “	153.5	_____
Governors Landing	_____	_____	1,150	390	“ “	35.8	312.68
CARLSBAD CAVERNS NP							
Rattlesnake Springs	3552672	549830	3,640	118	_____	1	_____
FORT DAVIS NHS							
Church Camp, Original	_____	_____	_____	48	_____	38.4 ²	_____
Church Camp #2	3385305	605321	4,965	240 (?)	Tertiary Volcanics	93.06 ²	_____
Oak Grove	3385485	605979	4,915	_____	“ “	77.37 ²	_____
Maintenance Area	3385738	606696	4,870	_____	_____	30.65 ²	_____
GUADALUPE MOUNTAINS NP							
Pine Springs (Glover #13)	3528920	516304	5,840	2,577	Capitan Reef Complex	2,186	_____
McKittrick Canyon RS	3538148	523156	_____	76.5	_____	57.5	_____
Sara Ann (Dog Canyon)	3539709	515635	_____	2,970	_____	2,484	_____
Ship of the Desert	3536372	521690	5,550	155	Capitan Reef Complex	_____	_____
Pratt Cabin	3538608	520740	5,400	27	_____	_____	_____
Signal Peak	3523404	516029	4,565	1,240 (?) 1,500(?)	Capitan Reef Complex	357.6	_____
PX	3537298	504882	3,867	250-300	_____	234.4	_____

¹ Highest or lowest water levels on record (referred to as shallowest or deepest, respectively, by Porter et al. 2009).

² Listed water levels were measured by EARDC in April 2008; comparison to historical levels unknown.

Table 2. Information for selected wells in Big Bend NP and White Sands NP (from Porter et al. 2009).

Well Name	North- ing	East- ing	Land Surface Altitude (ft amsl)	Well Depth (ft)	Aquifer	Highest Water Level (ft) ¹	Lowest Water Level (ft) ¹
BIG BEND NP							
South Butterbowl Tank #2	3278638	667526	2,900	—	—	75	76.2
Raven Mill	3271804	671553	2,896	202	Tertiary Volcanics	95	96
T-3 (W. Lone Mtn #1)	3246756	673035	3,617	300	—	76.75	99.75
T-4 (W. Lone Mtn #2)	3246882	672591	3,653	260	—	101.7	127
TH-1 (I-41)	3246154	669649	4,008	387	—	112.3	114.6
TH-2 (Grapevine #1)	3247736	670296	3785	600	—	80.7	82.3
TH-6 (Grapevine #3)	3251172	672649	3,380	600	—	55.5	56.25
TH-10 (N. Lone Mtn #1)	3247872	674388	3,459	455	—	37	40.6
TH-10a (N. Lone Mtn #2)	3247888	674394	3,455	459	—	38.7	43
Panther Junction #10 (State Observation)	3244736	673606	3,880	620	Tertiary Volcanics	145.2	173.1
K-Bar #6 Observation	3243389	676544	3,498	165	Cretaceous Limestone	109	—
K-Bar #7 Observation	3242928	676984	3,470	130	“ “	75	—
WHITE SANDS NM							
WHSa MW-001	3632406	381332	3,994	25	Shallow, perched aquifer	1.20	3.89
WHSa MW-002	3631479	381382	3,996	30	“ “	1.75	5.54
WHSa MW-003	3628269	389221	4,003	40	“ “	18.17	19.95
WHSa MW-004	3627424	390014	3,992	37	“ “	8.55	12.41
WHSa MW-005	3626565	389404	3,991	29	“ “	8.62	11.39
WHSa MW-006	3631373	382087	3,998	29.5	“ “	0.67	3.44
N L. Lucero	3618672	363992	3,895	—	“ “	2.75	5.30
NE Boundary	3637808	392159	4,045	—	“ “	11.65	13.55

¹ Highest or lowest water levels on record (referred to as shallowest or deepest, respectively, by Porter et al. 2009).

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NPS PHOTO

Checking a monitoring well in the White Sands NM



NPS PHOTO

Groundwater monitoring well