



Status of Climate and Water Resources at Organ Pipe Cactus National Monument

Water Year 2018

Natural Resource Report NPS/SODN/NRR—2019/2029



ON THE COVER

Spring monitoring at Dripping Springs, Organ Pipe Cactus National Monument. NPS photo.

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Contents

Figures v

Tables vii

Executive Summary ix

Acknowledgements xi

1 Introduction 1

2 Climate..... 3

 2.1 Background and methods 3

 2.2 Results and discussion 4

3 Groundwater..... 7

 3.1 Background 7

 3.2 Methods..... 9

 3.3 Results..... 9

4 Springs 13

 4.1 Background 13

 4.2 Methods..... 13

 4.3 Results and discussion 14

5 Literature Cited 23

Figures

Figure 2-1. Aridity index vs. elevation of selected southwestern national parks, including Organ Pipe Cactus National Monument..... 3

Figure 2-2. Departures from 30-year (1981–2010) normal minimum and maximum air temperature and precipitation, Organ Pipe Cactus National Monument, water year 2018..... 5

Figure 2-3. Climogram for Organ Pipe Cactus National Monument, water year 2018 5

Figure 2-4. Reconnaissance drought index (RDI), Organ Pipe Cactus National Monument, water years 1981–2018..... 6

Figure 2-5. Five-year moving mean of annual precipitation, Organ Pipe Cactus National Monument, water years 1981–2018..... 6

Figure 3-1. Location of monitored wells, Organ Pipe Cactus National Monument, water year 2018. 8

Figure 3-2. Park employee conducting monitoring at the Bates #2 well..... 9

Figure 3-3. Depth-to-water measurements at ten wells in Organ Pipe Cactus National Monument, 1976–2018 10

Figure 3-4. Water-elevation measurements at ten wells in Organ Pipe Cactus National Monument, 1976–2018 10

Figure 4-1. Dripping Springs Orifice A and adjacent, non-channelized, wet area resulting from overflow from pool. Organ Pipe Cactus National Monument, March 2018. 14

Figure 4-2. Estimated wet/dry days at Dripping Springs, WY2018. 15

Figure 4-3. East Arroyo Tinaja orifice, Organ Pipe Cactus National Monument, March 2018..... 16

Figure 4-4. Estimated wet/dry days at East Arroyo Tinaja, WY2018..... 17

Figure 4-5. Quitobaquito Spring orifice, Organ Pipe Cactus National Monument, March 2018..... 18

Figure 4-6. Estimated wet/dry days at Quitobaquito Spring, WY2018..... 19

Figure 4-7. Snake Pit Tinaja orifice, Organ Pipe Cactus National Monument, March 2018..... 20

Figure 4-8. Estimated wet/dry days at Snake Pit Tinaja, WY2018..... 21

Tables

Table 3-1. Summary of groundwater monitoring summary at Organ Pipe Cactus National Monument, WY2018.	8
Table 3-2. Groundwater monitoring summary at Organ Pipe Cactus National Monument, water year 2018.	9
Table 4-1. Water-quality data for Dripping Springs, Organ Pipe Cactus National Monument, WY2018.	15
Table 4-2. Water-chemistry data (mg/L) for Dripping Springs, Organ Pipe Cactus National Monument, WY2018.	15
Table 4-3. Water-quality data for East Arroyo Tinaja, Organ Pipe Cactus National Monument, WY2018.	17
Table 4-4. Water-chemistry data (mg/L) for East Arroyo Tinaja, Organ Pipe Cactus National Monument, WY2018.	17
Table 4-5. Water-quality data for Quitobaquito Spring, Organ Pipe Cactus National Monument, WY2018.	19
Table 4-6. Water-chemistry data (mg/L) for Quitobaquito Spring, Organ Pipe Cactus National Monument, WY2018.	19
Table 4-7. Water-quality data for Snake Pit Tinaja, Organ Pipe Cactus National Monument, WY2018.	21
Table 4-8. Water-chemistry data (mg/L) for Snake Pit Tinaja, Organ Pipe Cactus National Monument, WY2018.	21

Executive Summary

Climate and hydrology are major drivers of ecosystems. They dramatically shape ecosystem structure and function, particularly in arid and semi-arid ecosystems. Understanding changes in climate, groundwater, and surface water is central to assessing the condition of park biota and key cultural resources. This report combines data collected on climate, groundwater, and surface water at Organ Pipe Cactus National Monument (NM) to provide an integrated look at climate and water conditions during water year 2018 (October 2017–September 2018).

Overall annual precipitation was 44% of normal. The cool season (October–March) was particularly dry, receiving just 18% (-4.07") of normal precipitation. A majority of the rainfall occurred in July. All other months, with the exception of June, had 0–45% of normal precipitation. Temperatures tended to be warmer than normal, and there were fewer extremely cold days. The reconnaissance drought index indicated that the regional drought that began in 2000 continued through WY2018.

Water levels declined (-0.18 to -1.70 feet) at all nine monitored wells compared to WY2017. Over the data record, six wells, including the four wells around Lukeville, showed a general downward trend. The Bates #2, Bonita, and USGS #3 wells have been more variable, with periods of recovery occurring outside seasonal cycles.

Disturbance surveys resulted in a median value of 1 = undisturbed for both anthropogenic and natural disturbance at all of the monument's monitored springs except Quitobaquito Spring, given a rating of 2 for slight anthropogenic disturbance. Quitobaquito was also the only spring where invasive plants were observed. Sensor displacement prevented collection of reliable data on water quantity at two springs. Dripping Springs and Quitobaquito Spring were wetted throughout the water year. Water-quality measurements fell within the expected range for all springs.

Acknowledgements

We thank superintendent Scott Stonum, Chief of Resource Management Rijk Morawe, and the staff of Organ Pipe Cactus National Monument for their on-site support of the monitoring effort. Charles Conner measured groundwater wells quarterly. Gregory Goodrum and Kate McNicholas assisted with springs data collection and processing. Kristen Bonebrake led the management and posting of all data products. Mike Tercek developed the www.climateanalyzer.org tool that was used for all climate data analysis. Andy Hubbard and Colleen Filippone contributed to this report.

1 Introduction

Climate and hydrology are major drivers of ecosystems. They dramatically shape ecosystem structure and function, particularly in arid and semi-arid ecosystems. Understanding changes in climate, groundwater, and water quality is central to assessing the condition of park biota and key cultural resources. This document summarizes climate and water resource conditions for water year

(WY) 2018 (October 2017–September 2018) at Organ Pipe Cactus National Monument (NM), a large (517-mi²) National Park Service unit in southwestern Arizona. Detailed analyses of trends will follow in subsequent reports as the period of record warrants such assessments. For details on the monitoring protocols, park setting and resources, and information on other resources of management focus, please see the Sonoran Desert Network [website](#).

2 Climate

2.1 Background and methods

Climate is the suite of characteristic meteorological conditions of the near-surface atmosphere at a given place (Strahler 2013), and is the primary driver of ecological processes on earth. A broader temporal scale (seasons to years) is what distinguishes climate from the instantaneous conditions reflected by the term, “weather.”

Climate mediates the fundamental properties of ecological systems, such as soil–water relationships, plant–soil interactions, net primary productivity, the cycling of nutrients and water, and the occurrence, extent, and intensity of disturbances—in short, the underpinnings of the natural resources that the National Park Service manages and protects.

Organ Pipe Cactus National Monument has operated a National Oceanic and Atmospheric Administration (NOAA) Coopera-

tive Observer Program (COOP) weather station since 1944 (ORGAN PIPE CACTUS NM #26132). This station provides a reliable long-term climate dataset. We used this excellent data source for all subsequent analyses. The monument has also hosted a Remote Automated Weather Station (RAWS) since 2011. Data from both stations are accessible through [The Climate Analyzer](#). See the SODN climate monitoring protocol (Hubbard et al. in prep) for details on methods and data handling.

An Aridity Index (UNEP 1992), based on the long-term average annual precipitation relative to the average annual potential evapotranspiration, can be a useful tool for contrasting the local climate of national parks. Used globally to classify climate zones, aridity index seeks to answer the question “How dry is dry?” (Tsakiris and Vangelis 2005). Using the period of record (1944–present), the climate of Organ Pipe Cactus NM is classified as arid (Figure 2-1).

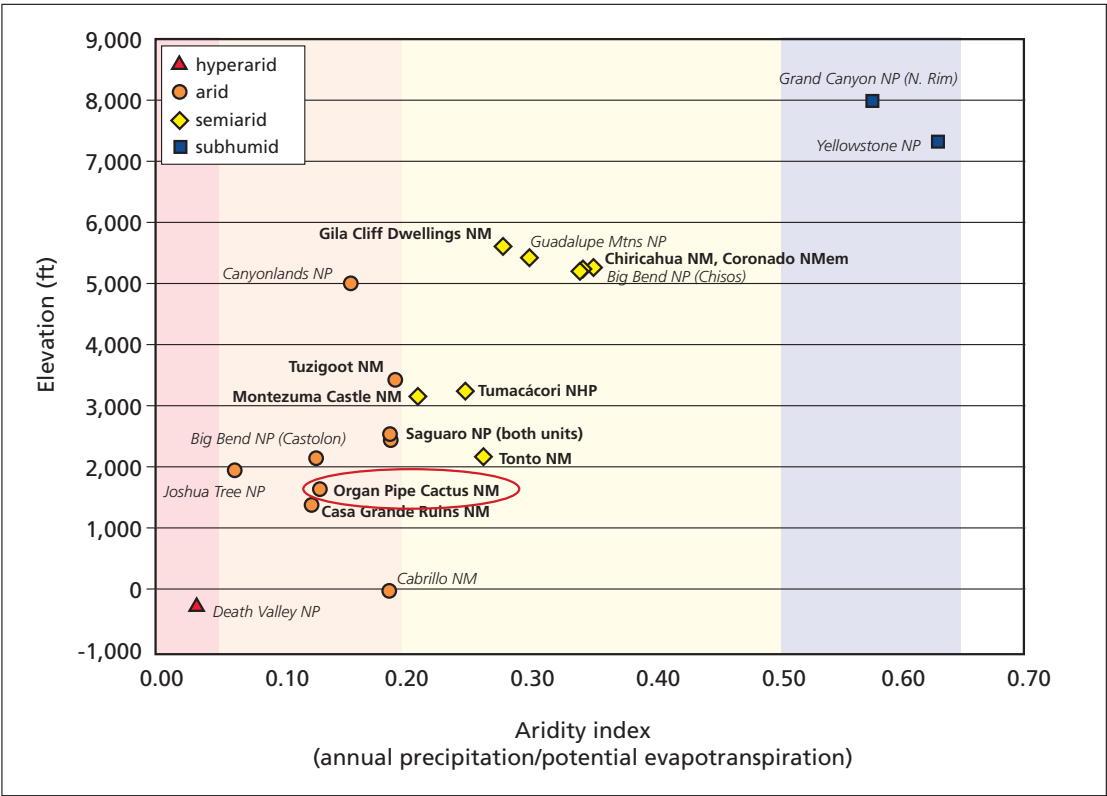


Figure 2-1. Aridity index vs. elevation of selected southwestern national parks, including Organ Pipe Cactus National Monument. Figure from Hubbard and others (in prep).

2.2 Results and discussion

2.2.1 Departures from 30-year normals (1981–2010)

Data quality during WY2018 was good, with missing values on 10 days. Overall annual precipitation was 44% of normal for Organ Pipe Cactus NM (4.43" vs 10.08").

2.2.1.1 Cool season (October–March)

Precipitation was only 18% (-4.07") of normal for fall and winter WY2018 (Figure 2-2). October was completely dry, and only 0.01 inch was recorded in both November and March (Figure 2-3). The COOP station was missing precipitation data for four days in January. However, the nearby RAWS station recorded no rainfall on those days, indicating that January precipitation was only 0.04 inches. Mean monthly maximum and minimum air temperatures for fall and winter were generally warmer than normal (1.9–9.0°F), except in January, when temperatures were within 0.5°F of normal.

2.2.1.2 Warm season (April–September)

Precipitation was also below normal (67%, -1.75") for the spring and summer months in WY2018. Residual moisture from a Pacific hurricane resulted in a single, unseasonable, 0.4-inch storm event in June, constituting 400% of June's normal rainfall (see Figure 2-2). The monsoon started strong in July, with nearly twice the normal rainfall, accounting for over half the total precipitation for WY2018 (see Figure 2-3). The monsoon tapered off quickly in August, and September was dry. Mean monthly maximum and minimum air temperatures in the warm season were generally warmer than normal (0.9–5.4°F), except the mean monthly maximum temperature in May, which was near normal (-0.3°F) (see Figure 2-2).

2.2.2 Reconnaissance Drought Index

Reconnaissance drought index (Tsakiris and Vangelis 2005) provides a measure of drought severity and extent relative to the

long-term climate based on the ratio of average precipitation to average potential evapotranspiration over shorter periods of time (seasons to years). The reconnaissance drought index for Organ Pipe Cactus NM (Figure 2-4) reflects the extended regional drought since 2000, which has continued through WY2018. The five-year moving mean of total annual precipitation (Figure 2-5) indicated that the park has experienced a multi-year precipitation deficit since WY2000. However, the annual precipitation total could not be calculated for three of the last five years due to missing data.

2.2.3 Extreme weather events

Stochastic events, such as air-temperature extremes and unusually intense precipitation events, may be as important to understanding ecological patterns as long-term climate averages are. Although high air temperatures are a defining feature of warm deserts, extreme frost events also have important consequences for Sonoran Desert ecosystems. For example, sustained low air temperatures can damage or even kill long-lived keystone plants, such as columnar cacti (e.g., saguaro and organ pipe cacti) and native trees (e.g., velvet mesquite; Turner et al. 2003). Extreme precipitation events can also cause localized flooding and erosion events that spur or inhibit plant productivity and reproduction, and modify animal behavior.

Extremely cold days (<35°F, 5th percentile of 1981–2010 data) occurred 61% as often as normal in WY2018 (10 vs. 16.4 ± 1.1 days), and were of a similar duration (2 consecutive days vs. 1.8 ± 0.1 days).

No extreme precipitation events (>1") occurred in WY2018 compared to the mean of 2.0 days for 1981–2010. The largest event occurred on July 11 (0.88").

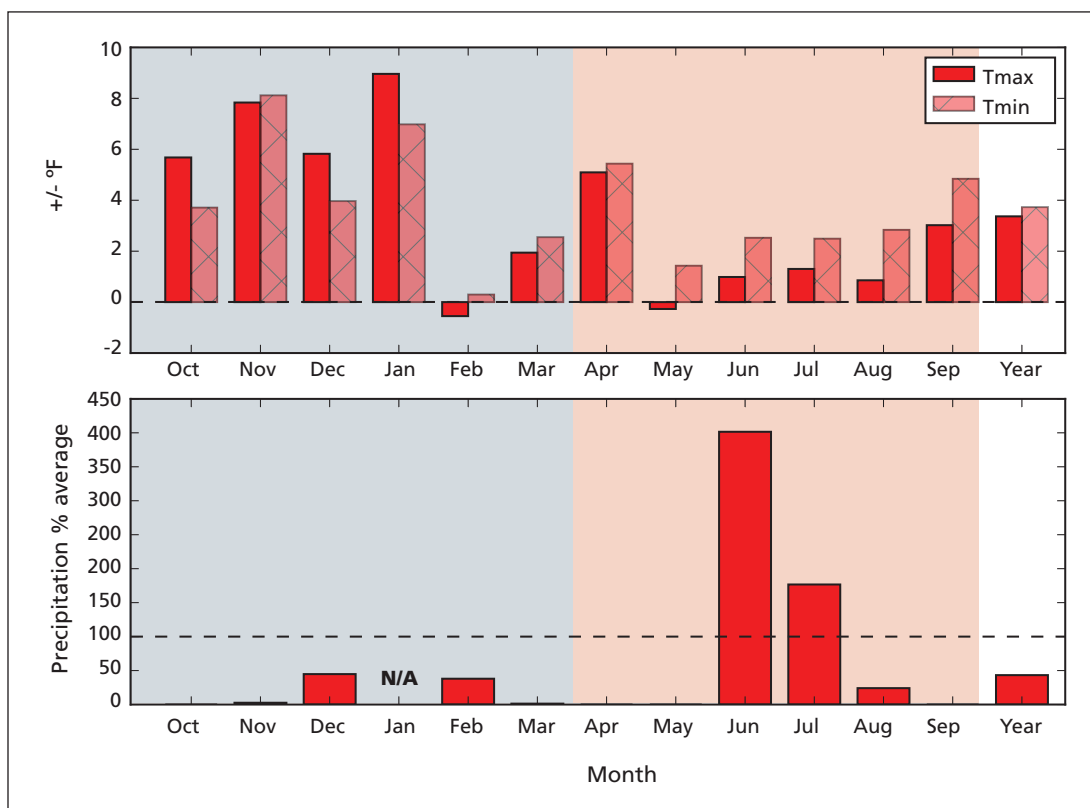


Figure 2-2. Departures from 30-year (1981–2010) normal minimum and maximum air temperature and precipitation, Organ Pipe Cactus National Monument, water year 2018. "N/A" = insufficient data to generate reliable data. Graphics generated by climateanalyzer.org.

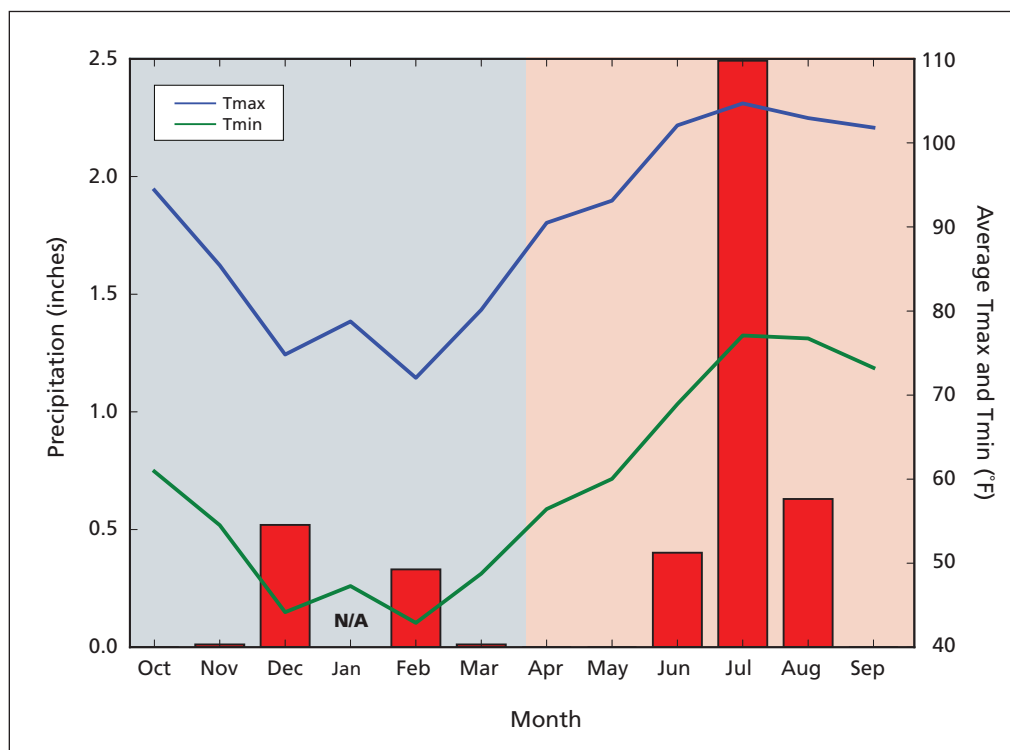


Figure 2-3. Climogram for Organ Pipe Cactus National Monument, water year 2018. "N/A" = insufficient data to generate reliable data. Graphics generated by climateanalyzer.org.

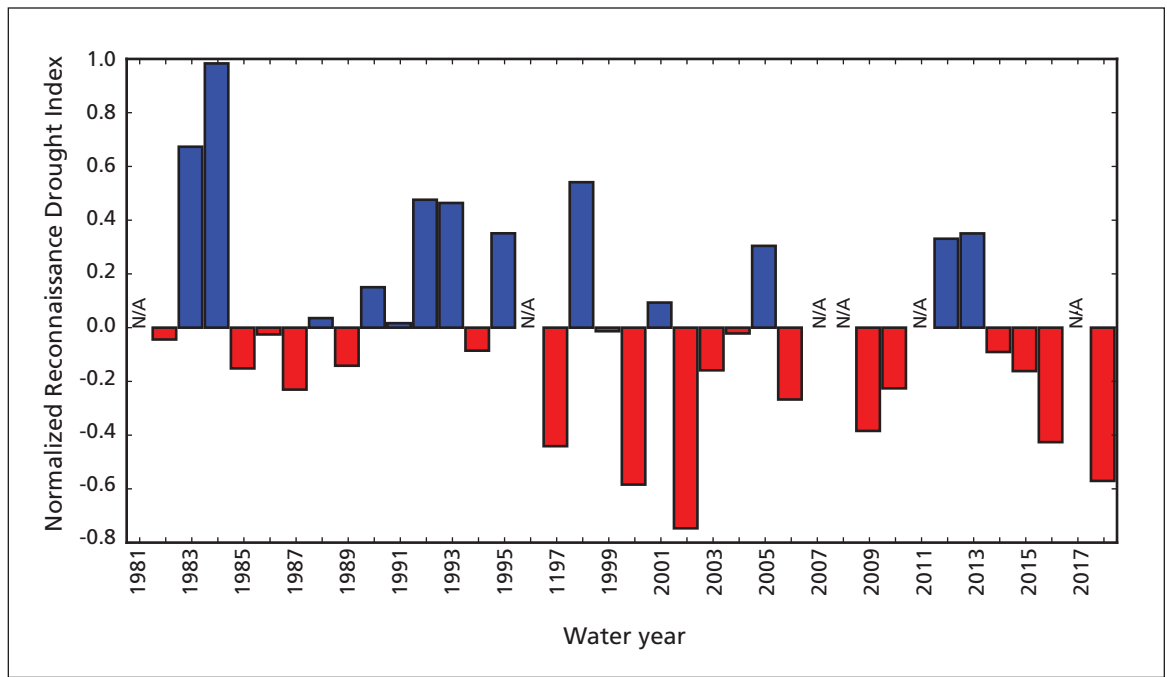


Figure 2-4. Reconnaissance drought index (RDI), Organ Pipe Cactus National Monument, water years 1981–2018. “N/A” = insufficient data to generate reliable RDI estimates. Graphics generated by climateanalyzer.org.

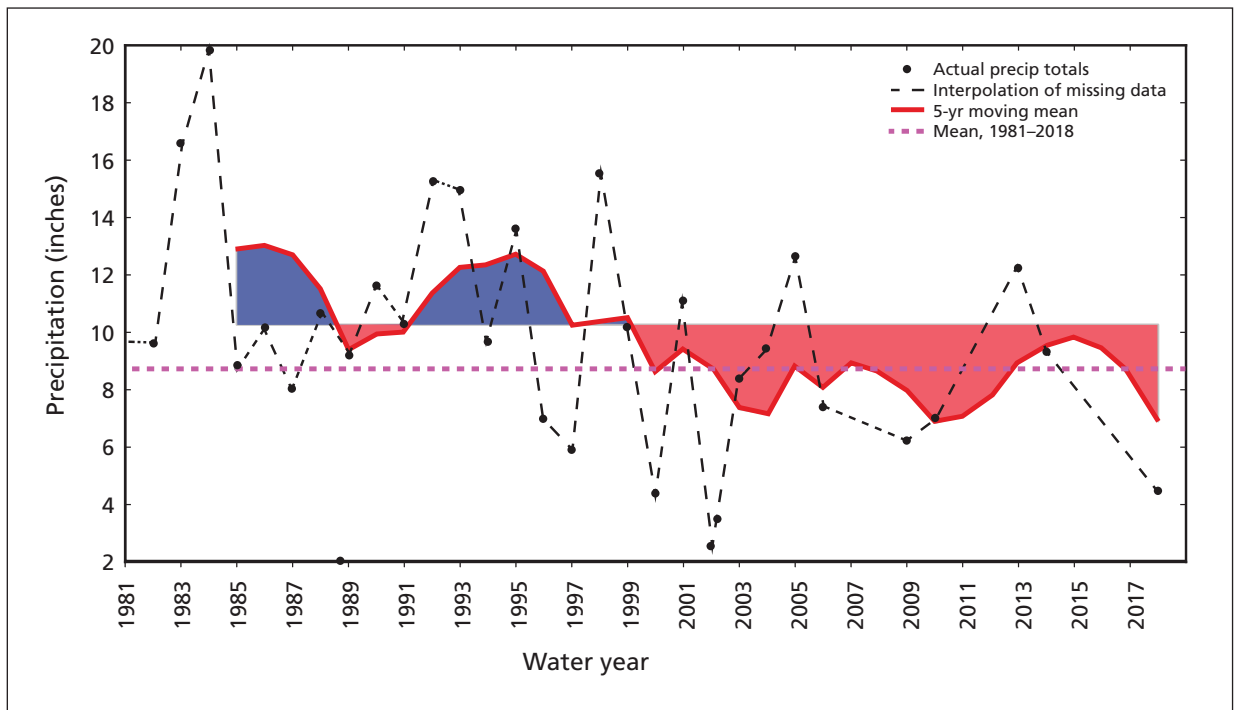


Figure 2-5. Five-year moving mean of annual precipitation, Organ Pipe Cactus National Monument, water years 1981–2018. The moving mean (solid red line) is based on a timeseries with 21.1% (8 of 38) missing values, and includes the current year and previous four years. Blue and red fields represent water surplus and deficit. Missing years are linearly interpolated (dashed black lines). Graphics generated by climateanalyzer.org.

3 Groundwater

3.1 Background

Groundwater is one of the most critical natural resources of the American Southwest, providing drinking water, irrigating crops, and sustaining rivers, streams, and springs throughout the region. Groundwater is closely linked to long-term precipitation and surface waters, as ephemeral flows sink below ground to reappear months, years, decades, or even centuries later as perennial and intermittent streams and springs. Groundwater also sustains vegetation throughout the region, and is the primary source of water for almost all humans in the southwestern U.S. Groundwater therefore interacts either directly or indirectly with all key ecosystem features of the arid Sonoran Desert ecoregion.

3.1.1 Study area

The monument is in the Basin and Range ecological province, which is characterized by highly permeable, alluvium-filled basins bounded by steep mountains composed of mostly low-porosity rock. Groundwater recharge in the basins occurs predominantly along mountain fronts and beneath ephemeral channels conveying runoff originating in the mountains (Filippone et al. 2006). Evapotranspiration, pumping, and spring-flow contribute to groundwater discharges.

The monument straddles two groundwater basins: the Western Mexican Drainage Basin in the southern half, and the Lower Gila Basin in the northern half. Groundwater flows north to south–southwest in the Western Mexican Drainage Basin, and south to north–northwest in the Lower Gila Basin (ADWR 2009).

Geology, climate, and anthropogenic factors create non-uniform groundwater conditions throughout Organ Pipe Cactus NM. The mountainous terrain and highly localized monsoon storms can result in an annual precipitation disparity across the park. Groundwater pumping south of the U.S.–Mexico border has resulted in a decreasing water table near Lukeville and Sonoyta. Climate change may exacerbate groundwa-

ter declines through reduced precipitation and increased evapotranspiration, diminishing recharge rates and increasing the need to pump groundwater. Roads within the park also have the potential to alter runoff infiltration patterns—and thus, recharge, by capturing water and diverting it into other areas (Filippone et al. 2006).

Monitoring groundwater throughout the park helps us better understand the impact of these factors and the implications for sustaining the ecology and surface waters of the monument, including the Quitobaquito Spring Complex.

3.1.2 Monitored wells

Nine wells are monitored at Organ Pipe Cactus NM (Figure 3-1 and Table 3-1). The Bates Ranch wells are located in the northwest part of the park, adjacent to Growler Wash. Bates #1 (ADWR 629121) was monitored from 1984 until it became obstructed in 2014. Bates #2 (Bates East), located 300 feet from Bates #1, has been monitored quarterly since 2010. Water levels in the two wells are historically similar. Recharge in this area primarily originates from the Growler Mountains, with likely contribution from subsurface flow of the Cherioni and Cuerda de Leña washes (Filippone et al. 2006).

Bonita Well is in the west-central part of the park, in the alluvium of Aguajita Wash. Located on the northwest edge of the La Abra Plain, this well is important for monitoring some of the source waters for the Quitobaquito springs and pond complex (Carruth 1996 and Filippone et al. 2006).

Headquarters #5 is a water-supply well, monitored annually by ADWR. A second water-supply well, Headquarters #4 (South), is located 300 feet away. However, it is not monitored by the park or ADWR. Headquarters #5 was decommissioned in 2016. Before that, the park's water supply was pumped alternately between the two wells.

Other monitored wells include Corner, Kalil, Stack, and USGS numbers 1, 2, and 3, which are all within 0.5 miles of the U.S.–Mexico border.

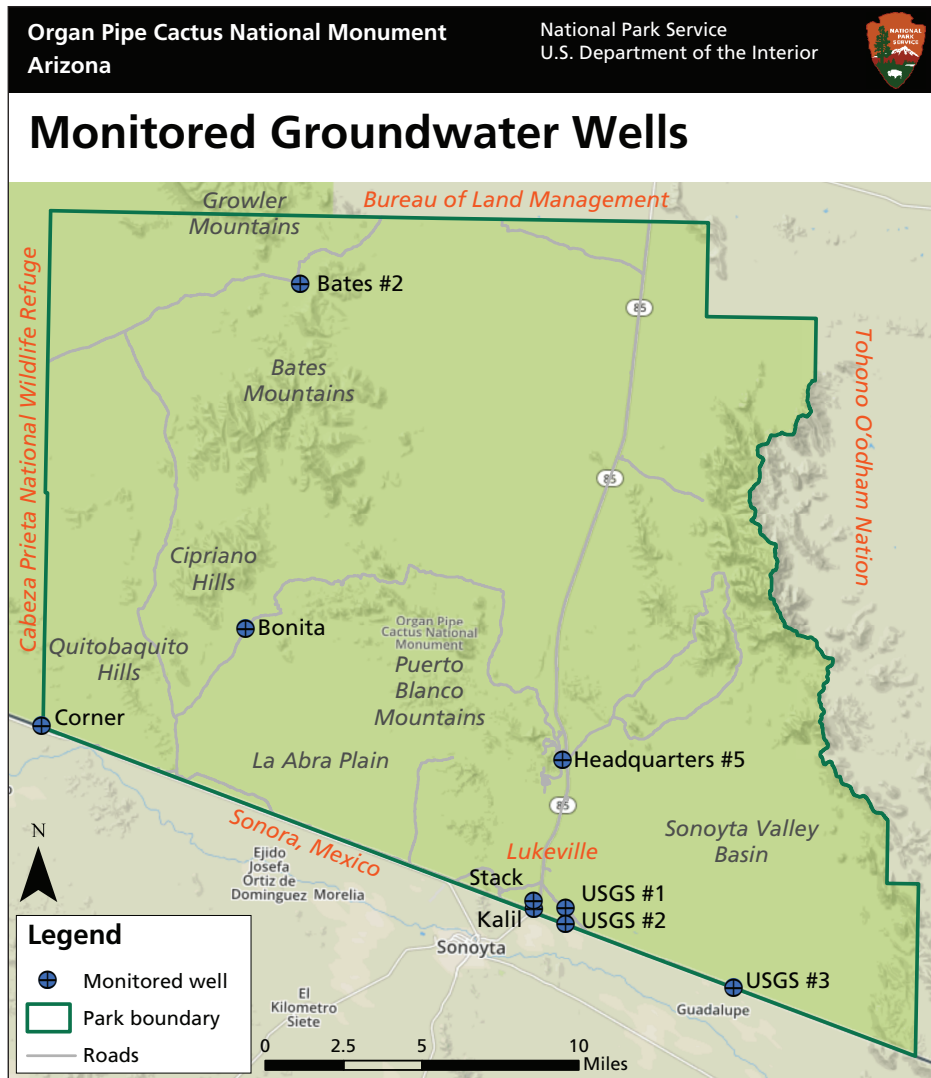


Figure 3-1. Location of monitored wells, Organ Pipe Cactus National Monument, water year 2018.

Table 3-1. Summary of groundwater monitoring summary at Organ Pipe Cactus National Monument, WY2018.

Well name	State registration number/ GWSI number	Total depth (feet)	Year completed	Wellhead elevation (est. ft)
Bates #2 (Bates East)	632186/321005112565501	80	1950	1,360
Bonita	629153/320115112573001	40	1937	1,355
Corner	None/315743113050201	101	unknown	1,000
Kalil	None/315254112490201	187	unknown	1,390
Stack	None/315313112490701	unknown	unknown	1,405
USGS #1 (Camino Dos Republicas)	522034/315257112475301	250	1988	1,400
USGS #2 (Lukeville)	522035/315232112475501	250	1988	1,390
USGS #3 (Salsola)	522033/315056112424301	300	1988	1,467
Headquarters #5 (North)	629090/315702112480401	420	1974	1,660

3.2 Methods

Eight of the monument’s nine monitored wells are visited quarterly by park staff as part of the Organ Pipe Cactus NM Ecological Monitoring Program (Figure 3-2). Headquarters #5 is monitored annually by the Arizona Department of Water Resources (ADWR). ADWR data for Headquarters #5 are available at the ADWR [website](#). The park has several additional wells. Monitoring occurred at most of these in previous years but was discontinued due to decline of water levels below the bottom of the well, obstruction, or other damage. More detailed information on monitoring methods may be found in the SODN groundwater monitoring protocol (Filippone et al. 2014).

3.3 Results

Nine wells were monitored in WY2018. Water levels declined in all wells compared to WY2017 (Table 3-2). The lowest recorded water levels at six of the wells occurred in WY2018 (a seventh was dry). Six wells show a general downward trend over the monitoring record: Headquarters #5, Kalil, Stack, USGS #1, USGS #2, and Corner.

Headquarters #5 and the Lukeville-area wells, including Kalil, Stack, USGS #1, and USGS #2, are experiencing similar rates of decline (Figures 3-3 and 3-4). Over the period of record, all four wells near Lukeville have demonstrated cyclic decreases in



Figure 3-2. Park employee conducting monitoring at the Bates #2 well.

water levels, generally occurring in the warm seasons and followed by partial recovery at the start of the winter season. Seasonal groundwater pumping to support agriculture south of the U.S.–Mexico border is one factor leading to warm-season declines in

Table 3-2. Groundwater monitoring summary at Organ Pipe Cactus National Monument, water year 2018.

Well name	Mean depth to water WY2018 (feet bgs ¹)	Mean elevation (feet amsl ²)	Change from water year 2017 (+/- feet)	Change from earliest recorded water level (+/- feet)	Lowest recorded water level (feet bgs ¹)
Bates #2 (Bates East)	41.34	1,308.66	-2.54	-1.39 (2001)	42.73 (2011)
Bonita	>32.90	1,322.10	-0.81	-11.20 (1984)	>40.00 (dry)
Corner	63.65	936.35	-0.18	-5.20 (1984)	63.76 (2018)
Kalil	109.01	1,280.99	-1.45	-37.71 (1977)	110.51 (2018)
Stack	128.44	1,276.56	-1.40	-33.52 (1984)	129.25 (2018)
USGS #1 (Camino Dos Republicas)	116.07	1,283.93	-1.57	-30.35 (1993)	117.37 (2018)
USGS #2 (Lukeville)	104.88	1,285.12	-1.38	-32.68 (1993)	106.60 (2017)
USGS #3 (Salsola)	99.44	1,360.56	-0.53	-1.30 (1993)	99.78 (2018)
Headquarters #5 (North)	351.00	1,309.00	-1.60	-39.87 (1976)	351.14 (2018)

¹Below ground surface; ²Above mean sea level

Figure 3-3. Depth-to-water measurements at ten wells in Organ Pipe Cactus National Monument, 1976–2018. Measurements taken while groundwater pumping occurred are indicated in red. White indicates that the well was dry.

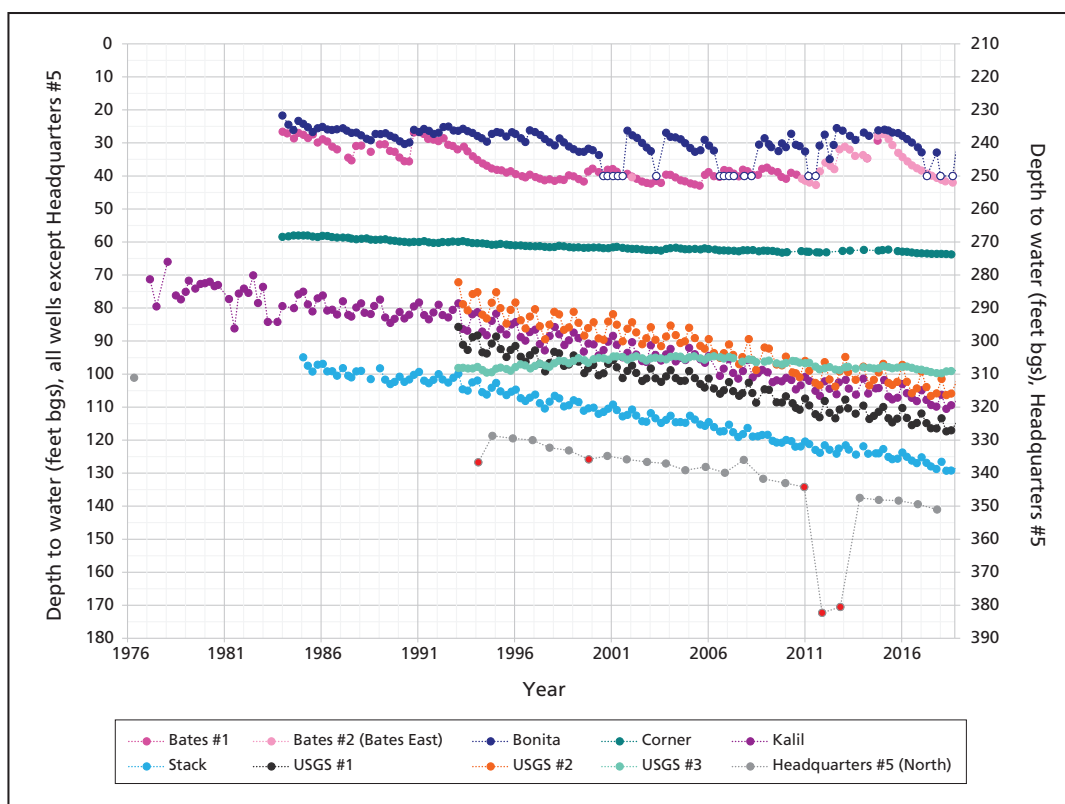
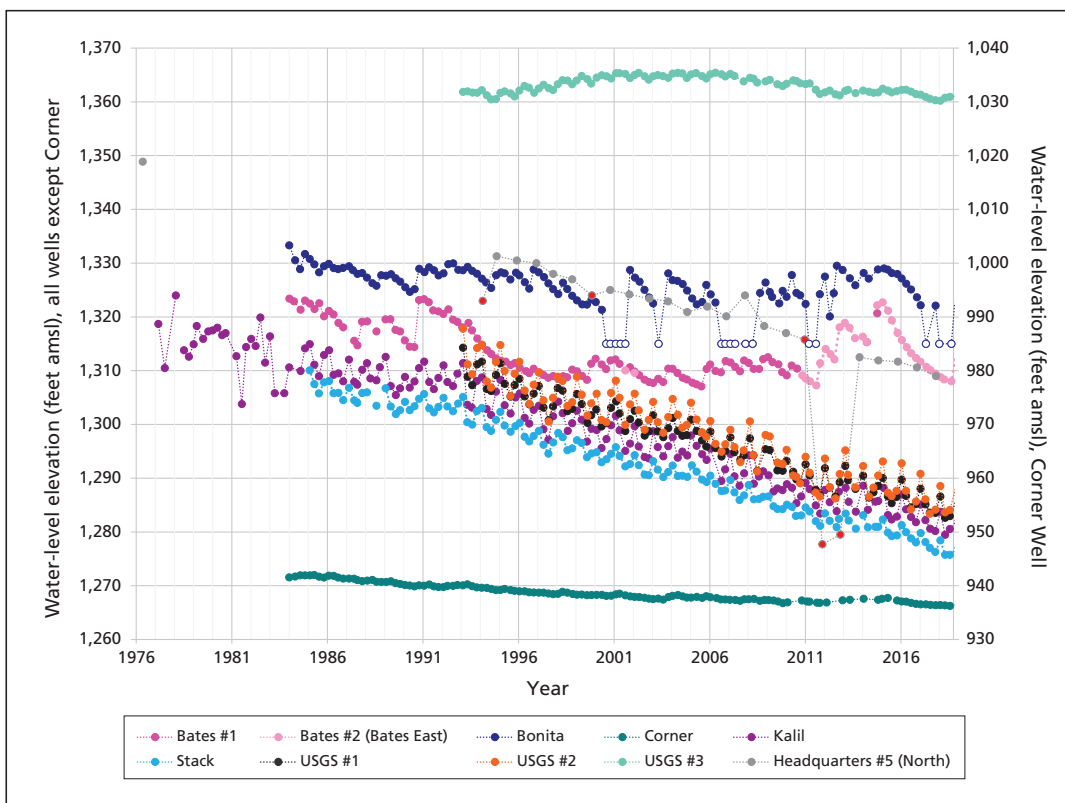


Figure 3-4. Water-elevation measurements at ten wells in Organ Pipe Cactus National Monument, 1976–2018. Measurements taken while groundwater pumping occurred are indicated in red. White indicates that the well was dry.



the water table at these Lukeville-area wells (Filippone et al. 2006). Corner Well also demonstrated a downward trend, but the rate of decline has been more gradual. Corner Well is likely less impacted by groundwater withdrawals than Headquarters #5 and the Lukeville wells.

The monitoring records at the Bates #2, Bonita, and USGS #3 wells have been more variable, indicating localized factors impacting groundwater levels across the park. In the northwest part of the park, the entrenched North Boundary Road actively captures runoff from Kuakatch Wash and surrounding areas, altering patterns of surface flow and groundwater recharge in

that area. These processes may explain why water-level patterns in the Bates area differ from those elsewhere in the park. Bonita often experiences water-level peaks in the fall, indicating the importance of recharge from the summer monsoon (Filippone et al. 2006). This well was dry two of the three times it was monitored in WY2018. Bonita has recovered several times after previously going dry in 2000, 2001, 2003, 2006, 2007, 2011, and 2017. USGS #3 is located 6.5 miles southeast of Lukeville, on the international border in the Sonoyta Valley. The well's distance from Lukeville, and its location in the interior of the Sonoyta Valley Basin, likely explain the less-substantial seasonal variation and relatively stable water levels.

4 Springs

4.1 Background

Spring, tinaja, and seep (hereafter “springs”) ecosystems are small, relatively rare biodiversity hotspots in arid lands. Their associated aquatic organisms, riparian vegetation, and fauna can vary greatly by spring type (Sada et al. 2005).

Common stressors to springs biota include reduced water availability, water temperature extremes (freezing, high temperatures), reduced light penetration (due to turbidity), and biochemical conditions outside the usual environmental range for a given site (Sada 2013a; 2013b). Climate change is an emerging influence on springs in the American Southwest, with increased air temperatures, reduced precipitation, increased evaporation rates, increased drought frequency, and increased frequency and magnitude of extreme weather events all expected (Garfin et al. 2013). These changes may cause springs to go dry (Comer et al. 2012; Dekker and Hughson 2014) or experience reduced flow (Grimm et al. 1997; Weissinger et al. 2016), which may disrupt ecological functions and reduce species diversity (Garfin et al. 2013).

4.2 Methods

Sonoran Desert Network springs monitoring focuses on four sentinel sites (McIntyre et al. 2018): Dripping Springs, East Arroyo Tinaja, Quitobaquito Spring, and Snake Pit Tinaja. This sample design allows us to detect change and measure trend in selected parameters at a given spring site over time. It does not provide statistical inference across the monument.

The Sonoran Desert Network monitors a suite of vital signs and parameters organized into four modules: site characterization, site condition, water quantity, and water quality (McIntyre et al. 2018). A brief description of the data-collection methodologies followed at Organ Pipe Cactus NM during WY2018 is presented below. See McIntyre and others (2018) for additional details.

4.2.1 Site characterization

The site-characterization module is a modi-

fication of the inventory methods developed for the Mojave Desert Network (Sada and Pohlmann 2006). This module is completed once every five years, or after significant events, and provides context for interpreting change in the other modules. The module includes spring type and characterization, GPS locations, site diagram and site description, and vegetation community description. This module was completed at Organ Pipe Cactus NM in 2017 and 2018 (Snake Pit Tinaja) and will be recollected in 2022. This report presents a highly condensed version of the information collected in the site-characterization module.

4.2.2 Site condition

The site-condition module is based on inventory methods developed for the Mojave Desert Network (Sada and Pohlmann 2006). It contains four subsections: disturbance, photo points, obligate/facultative wetland plants, and invasive non-native plants and wildlife (McIntyre et al. 2018). The disturbance assessment is a categorical measure of natural and anthropogenic disturbance and the level of stress on vegetation and soils in springs ecosystems (Sada and Pohlmann 2006). The magnitude of each disturbance was classified on a scale of 1–4, where 1 = undisturbed, 2 = slightly disturbed, 3 = moderately disturbed, and 4 = highly disturbed (Sada and Pohlmann 2006). Photographs were taken from designated photo points to show the spring and its landscape context. The presence of a suite of obligate or facultative wetland plants was noted during each visit using a picklist that identifies plants to the family, genus, or species level. The presence and density of invasive non-native plants was also recorded during each visit, with a goal of identifying them to the species level. The presence of invasive non-native aquatic wildlife species (i.e., crayfish or bullfrogs) was also recorded.

4.2.3 Water quantity

The water-quantity module provides information on the persistence of springs, spring discharge, and wetted extent. The persistence of surface water at springs is estimated by analyzing the variance of temperature measurements taken by electronic data

recorders every one or two hours (Anderson et al. 2015). A sensor placed at or near the orifice (or in the deepest-possible part of a tinaja) is used to estimate the presence of water. A submerged sensor will mediate variation in diurnal temperatures; an exposed sensor will not (Anderson et al. 2015). The method can yield both false wet and false dry estimates, and quality control/quality assurance procedures are yet to be developed. A timed sample of water volume estimates the system's surface discharge. Wetted extent provides information about the length (up to 100 m), width, and depth of water present. It is assessed using a technique for either standing water (e.g., limnocrene and heleocrene springs, and some tinajas) or flowing water (e.g., rheocrene springs and some tinajas).

4.2.4 Water quality

Water-quality monitoring measures core wa-

ter-quality parameters and water chemistry. Core parameters sampled by SODN included water temperature, pH, specific conductivity, dissolved oxygen, and total dissolved solids. Discrete samples of these parameters were collected with a multiparameter meter (YSI Professional Plus) deployed on-site. Water chemistry was assessed by collecting a surface-water sample(s) and estimating the concentration of major ions with a photometer (YSI 9500).

4.3 Results and discussion

4.3.1 Dripping Springs

4.3.1.1 Site characterization and visit information

Dripping Springs (Figure 4-1) emerges as numerous seeps that flow down a wall recessed in a bedrock cliff to form a bathtub-sized tank. It is fed by numerous seeps



Figure 4-1. Dripping Springs Orifice A and adjacent, non-channelized, wet area resulting from overflow from pool. Organ Pipe Cactus National Monument, March 2018.

along the back wall of the tank. The spring was wetted during the WY2018 sample. The main orifice (Orifice A) is the largest pool, approximately 2 × 2 × 3 meters (6.6 × 6.6 × 9.8 ft). At time of sampling, it was filled with warm, non-flowing water. A short, damp, non-channelized section of wetted substrate extended from the mouth of the pool toward the hiking trail (Figure 4-1). A small seep (Orifice B) adjacent to the pool generated an amount of water too small to effectively sample.

4.3.1.2 Site condition

Disturbance surveys resulted in a mean and median value of 1 = undisturbed for both anthropogenic and natural disturbance. A hiking trail leads directly to the site, causing slight contemporary disturbance from the walking path. No disturbance from border traffic was noted. The crew observed one obligate/facultative wetland plant: monkey-flower (*Mimulus* sp.). No invasive plants or animals were observed.

4.3.1.3 Water quantity

A temperature sensor deployed in the Orifice A pool indicated that the spring was wet throughout WY2018 (Figure 4-2). During the WY2018 site visit, water was observed flowing from the pool and onto the trail approaching the spring. The flow from the pool stretched 2.8 meters, nearly reaching the adjacent hiking trail. The field crew collected data on this overflow. Its mean wetted width and depth were 56.8 centimeters (1.8 ft) and 0.16 centimeters (0.06 in), respectively. Discharge was not measured because this laminar flow was inconsistent and of extremely low volume.

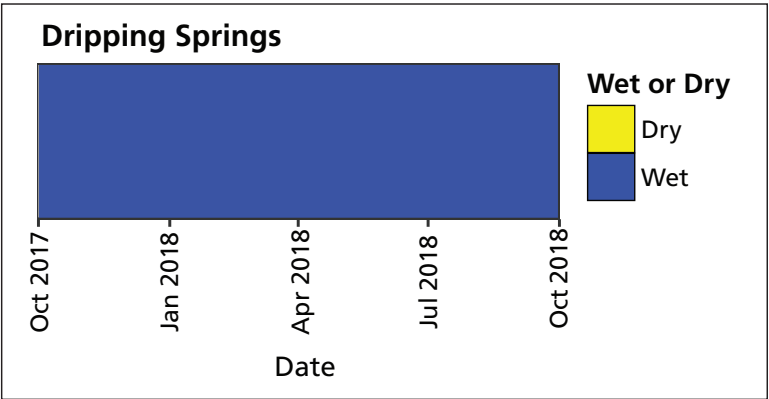


Figure 4-2. Estimated wet/dry days at Dripping Springs, WY2018.

4.3.1.4 Water quality

In 2018, core water-quality (Table 4-1) and water-chemistry (Table 4-2) samples were collected at the Orifice A pool. Measurements from this site fell within the expected range. It is not unusual for dissolved-oxygen (DO) concentrations in small, shallow, aridland spring pools to fall into hypoxic or anoxic ranges, as was the case at the Dripping Springs site.

Collecting water-quality data from shallow pools can be challenging. The operation of the DO sensor requires that water be moving across the surface of the sensor. When the sample site is composed of shallow, non-moving water (as is typical in many aridland springs), collecting a viable DO measurement requires the observer to constantly move the sensor to ensure water is moving across its surface. When this method is employed (as it was at this site in WY2018), SODN staff flags the DO data to indicate that this modified method was used, as it may decrease the accuracy of the data.

Table 4-1. Water-quality data for Dripping Springs, Organ Pipe Cactus National Monument, WY2018.

Sampling location	Orifice	Sample time	Temperature (°C)	Dissolved oxygen (mg/L)	pH	Specific conductivity (µS/cm)	Total dissolved solids (mg/L)	Exposure
1	A	09:20	12.9	1.5	7.15	407.8	265.20	shade

Table 4-2. Water-chemistry data (mg/L) for Dripping Springs, Organ Pipe Cactus National Monument, WY2018.

Sampling location	Orifice	Alkalinity	Calcium	Chloride	Magnesium	Potassium	Sulfate
1	A	125	2	5	4	no data	18

4.3.2 East Arroyo Tinaja

4.3.2.1 Site characterization and visit information

East Arroyo Tinaja (Figure 4-3) is a large, persistent tinaja. The spring was wetted during the WY2018 sample. The primary orifice pool (Orifice A) is a round, 10 × 10-meter (32.8 × 32.8-ft), bedrock tank that lies below a bedrock pouroff. The water is cool and murky, with no apparent movement. Two “bathtub rings” were visible above the pool during sampling, indicating historically higher water levels. The pool was approximately 70–100 centimeters (2.3–3.3 ft) deep, as estimated from the measurement location at the side of the pool. The pool is located in a large, distinct drainage that continues both up- and downstream. A distinct bathtub ring and staining indicate that a persistent channel can form on the two meters (6.6 ft) of bedrock immediately downstream of the pool, though it appears to be shallow, im-

mediately terminating into a rocky drainage bottom.

4.3.2.2 Site condition

Disturbance surveys resulted in a mean and median value of 1 = undisturbed for both anthropogenic and natural disturbance. Drying was considered a slight natural disturbance, as two bathtub rings around the pool indicated historically higher water levels. One ring was distinct and white, located 50 centimeters above the current waterline. The other was grey and faint, 10 centimeters above the current waterline. The crew observed one obligate/facultative wetland plant: monkeyflower (*Mimulus* sp.). No invasive plants or animals were observed.

4.3.2.3 Water quantity

Because temperature sensors were not deployed at this site during the first half of WY2018, no data are available from October 2017 to March 2018. Following deployment



Figure 4-3. East Arroyo Tinaja orifice, Organ Pipe Cactus National Monument, March 2018.

in April 2018, the sensor indicated that the site was wetted until July, then generally dry for the last half of the year (Figure 4-4). However, in December 2018 (WY2019), the sensor for East Arroyo Tinaja was found outside the pool, apparently dislodged by flooding. Hydroperiod data should be considered provisional due to the inability to determine when and how the probe was displaced. Sensors were redeployed for the WY2019 sampling period. Park staff indicate the spring generally remains perennially persistent. East Arroyo Tinaja could not be sampled for wetted extent or discharge due to safety concerns and the lack of any outflow from the pool.

4.3.2.4 Water quality

In WY2018, core parameters for water quality (Table 4-3) and water chemistry (Table 4-4) were measured at the orifice pool. Results were within the expected range. The DO data were flagged because, as described in Section 4.3.1.4, the observer had to constantly move the DO sensor to collect the best data possible.

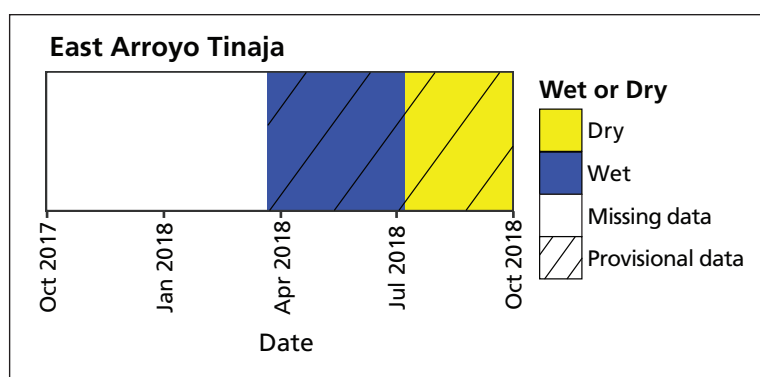


Figure 4-4. Estimated wet/dry days at East Arroyo Tinaja, WY2018. These data are considered provisional due to displacement of the sensor.

Table 4-3. Water-quality data for East Arroyo Tinaja, Organ Pipe Cactus National Monument, WY2018.

Sampling location	Orifice	Sample time	Temperature (°C)	Dissolved oxygen (mg/L)	pH	Specific conductivity (µS/cm)	Total dissolved solids (mg/L)	Exposure
1	A	11:00	12.8	10.28	8.43	283.5	184.6	NC*

*NC=not collected

Table 4-4. Water-chemistry data (mg/L) for East Arroyo Tinaja, Organ Pipe Cactus National Monument, WY2018.

Sampling location	Orifice	Alkalinity	Calcium	Chloride	Magnesium	Potassium	Sulfate
1	A	90	22	10	9	4.1	0

4.3.3 Quitobaquito Spring

4.3.3.1 Site characterization and visit information

Quitobaquito Spring is a rheocrene spring that emerges on the footslope of a low hill. The orifice (Orifice A, Figure 4-5) emerged as a muddy seep that formed a channel extending for 16 meters (52.5 ft). Beyond that, it flowed through a springbox into a human-made, concrete channel for the remainder of the reach included in our 100-meter sample. The water flowed quickly and clearly in the channelized segments, becoming slow and algae-choked while traversing occasional pools. The water was notably and consistently warm.

4.3.3.2 Site condition

Disturbance surveys resulted in a mean value of 1 = undisturbed for natural disturbance (no natural disturbance was noted). For anthropogenic disturbance, a mean value of 2 = slightly disturbed and median value of 1.5 = slightly disturbed were assigned. A hiking trail leads to the site and surrounds the spring, but there was no sign of impact to the spring itself. In WY2018, the crew found irrigation tubing adjacent to the channel, which contributed to the score for flow modification. The highest anthropogenic impacts came from the modification of flow by the springbox and concrete channel, and the removal of riparian herbaceous



Figure 4-5. Quitobaquito Spring orifice, Organ Pipe Cactus National Monument, March 2018.

vegetation by park staff to promote flow to Quitobaquito Pond. Water levels are a long-standing concern at the pond, which is designated critical habitat for the endangered Quitobaquito pupfish (*Cyprinodon eremus*). The pond also provides habitat and water for the endangered Sonoyta mud turtle (*Kinosternon sonoriense longifemorale*) and a wide array of other plant and animal species, as well as important ecosystem services for the larger terrestrial landscape (NPS 2013). For more information on the ecological importance of Quitobaquito Pond, download the monument’s [State of the Park](#) report.

The crew observed three obligate/facultative wetland species and one family: spikerush (*Eleocharis* sp.), bulrush (*Schoenoplectus* sp.), rabbitsfoot (*Polypogon* sp.), and cattail (*Typhaceae* sp.). Annual rabbitsfoot (*Polypogon monspeliensis*) is an invasive riparian grass. In WY2018, 1–5 individual rabbitsfoot plants were noted at the site. No invasive animals were observed.

4.3.3.3 Water quantity

The temperature sensor in a pool one meter upstream of the springbox (sampling location 2) indicated that the spring was wetted throughout WY2018 (Figure 4-6). Discharge from Orifice A was estimated at 33.0 ± 6.5

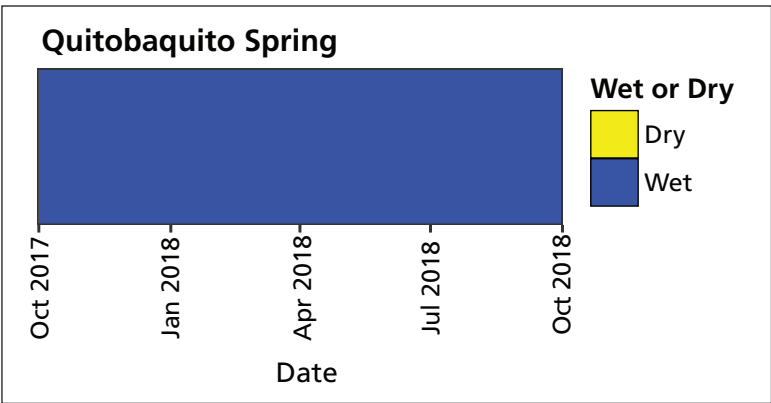


Figure 4-6. Estimated wet/dry days at Quitobaquito Spring, WY2018.

liters per minute. The channel length was in the 200–500 meter size class (656–1,640 ft). The first 100 meters downstream of Orifice A had a mean wetted width of 53.6 centimeters (1.76 ft) and mean depth of 14.2 centimeters (0.47 ft).

4.3.3.4 Water quality

In WY2018, core parameters for water quality (Table 4-5) and water chemistry (Table 4-6) were measured at two locations. Location 1 is the first measurable pool downstream (1.5 meters) of Orifice A. Location 2 is a large pool approximately one meter (3.3 ft) upstream of the springbox. Water quality and chemistry were within expected ranges.

Table 4-5. Water-quality data for Quitobaquito Spring, Organ Pipe Cactus National Monument, WY2018.								
Sampling location	Orifices	Sample time	Temperature (°C)	Dissolved oxygen (mg/L)	pH	Specific conductivity (µS/cm)	Total dissolved solids (mg/L)	Exposure
1	A	09:15	25.1	4.31	7.52	11.76	7.67	Partial
2	A	09:10	24.5	6.15	7.60	11.63	7.54	Partial

Table 4-6. Water-chemistry data (mg/L) for Quitobaquito Spring, Organ Pipe Cactus National Monument, WY2018.								
Sampling location	Orifices	Alkalinity	Calcium	Chloride	Magnesium	Potassium	Sulfate	
1	A	210	30	145	21	4.5	71	
2	A	215	28	150	20	4.5	96	

4.3.4 Snake Pit Tinaja

4.3.4.1 Site characterization and visit information

Snake Pit Tinaja (Figure 4-7) is a small, isolated tinaja in the middle of a large channel dominated by gravel and boulders. It contained water at the WY2018 visit. The cool water (15.2°C, 59.4°F) had no visible in- or outflow. While other tanks were noted on the hike in, no others were found in the immediate vicinity.

4.3.4.2 Site condition

Disturbance surveys resulted in a mean and median value of 1 = undisturbed for both anthropogenic and natural disturbance. Drying was considered a slight natural

disturbance, as there were multiple bathtub rings indicative of past water levels and of drying events. No wetland plants, invasive plants, or invasive animals were observed.

4.3.4.3 Water quantity

The temperature sensor indicated that the spring was wetted throughout the majority of WY2018 (Figure 4-8). On December 12, 2018, a crew member checking the site found the temperature logger approximately one meter up an embankment, under flood debris. Analysis of the sensor data indicated that the spring remained wetted, likely because the debris pile where the sensor was found was in a shaded crevice. Because the date of probe movement is unknown, data



Figure 4-7. Snake Pit Tinaja orifice, Organ Pipe Cactus National Monument, March 2018.

from March 22 (when the displaced sensor was originally installed) to September 30, 2018 are considered provisional. Park staff indicate that this spring remains perennially wetted.

The spring was assessed as a standing-water system with an average length, width, and depth of 65.0 × 41.2 × 14.5 centimeters (2.1 × 1.4 × 0.5 ft), respectively. No discharge was measured due to the lack of outflow.

4.3.4.4 Water quality

In WY2018, core parameters for water quality (Table 4-7) and water chemistry (Table 4-8) were sampled at the orifice pool. Workers collected DO data as described in Section 4.3.1.4. Results were in the expected range.

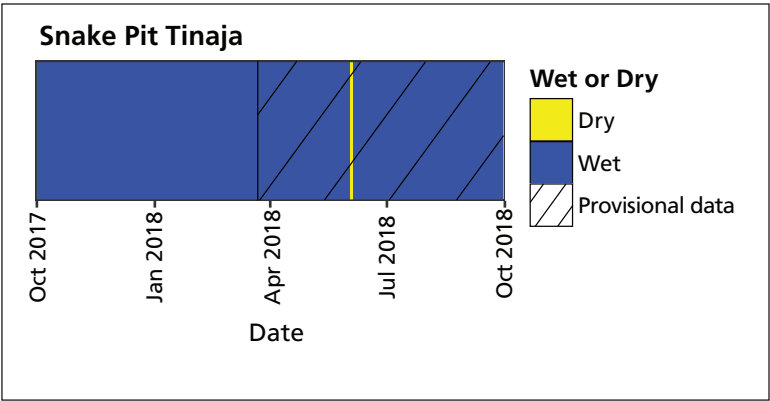


Figure 4-8. Estimated wet/dry days at Snake Pit Tinaja, WY2018. Some of these data are considered provisional due to displacement of the sensor.

Table 4-7. Water-quality data for Snake Pit Tinaja, Organ Pipe Cactus National Monument, WY2018.								
Sampling location	Orifice	Sample time	Temperature (°C)	Dissolved oxygen (mg/L)	pH	Specific conductivity (µS/cm)	Total dissolved solids (mg/L)	Exposure
1	A	10:15	14.0	11.9	8.56	1,045	676.0	Shade

Table 4-8. Water-chemistry data (mg/L) for Snake Pit Tinaja, Organ Pipe Cactus National Monument, WY2018.							
Sampling location	Orifice	Alkalinity	Calcium	Chloride	Magnesium	Potassium	Sulfate
1	A	470	74	Non-detect	Non-detect	9.5	0

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