

ARTICLE

Climate and Water Monitoring at Gila Cliff Dwellings National Monument

Gila Cliff Dwellings National Monument



Climate and surface water are closely related. At Gila Cliff Dwellings National Monument, the Sonoran Desert Network monitors both to track broad-scale change and provide early warning of potential problems.

Overview

Together, climate and hydrology shape ecosystem structure and function, particularly in arid and semi-arid ecosystems. Understanding changes in climate, groundwater, and surface water is key to assessing the condition of park biota—and often, cultural resources.

At Gila Cliff Dwellings National Monument, scientists from the [**Sonoran Desert Network**](#) help park managers know what kind of change is happening by taking the same measurements of key resources year after year, much as a doctor keeps track of a patient's vital signs. This long-term ecological monitoring provides early warning of potential problems, giving managers time to figure out how to mitigate them before they become worse. At Gila Cliff Dwellings, that monitoring includes climate, weather, springs, and streams, among other "vital signs."

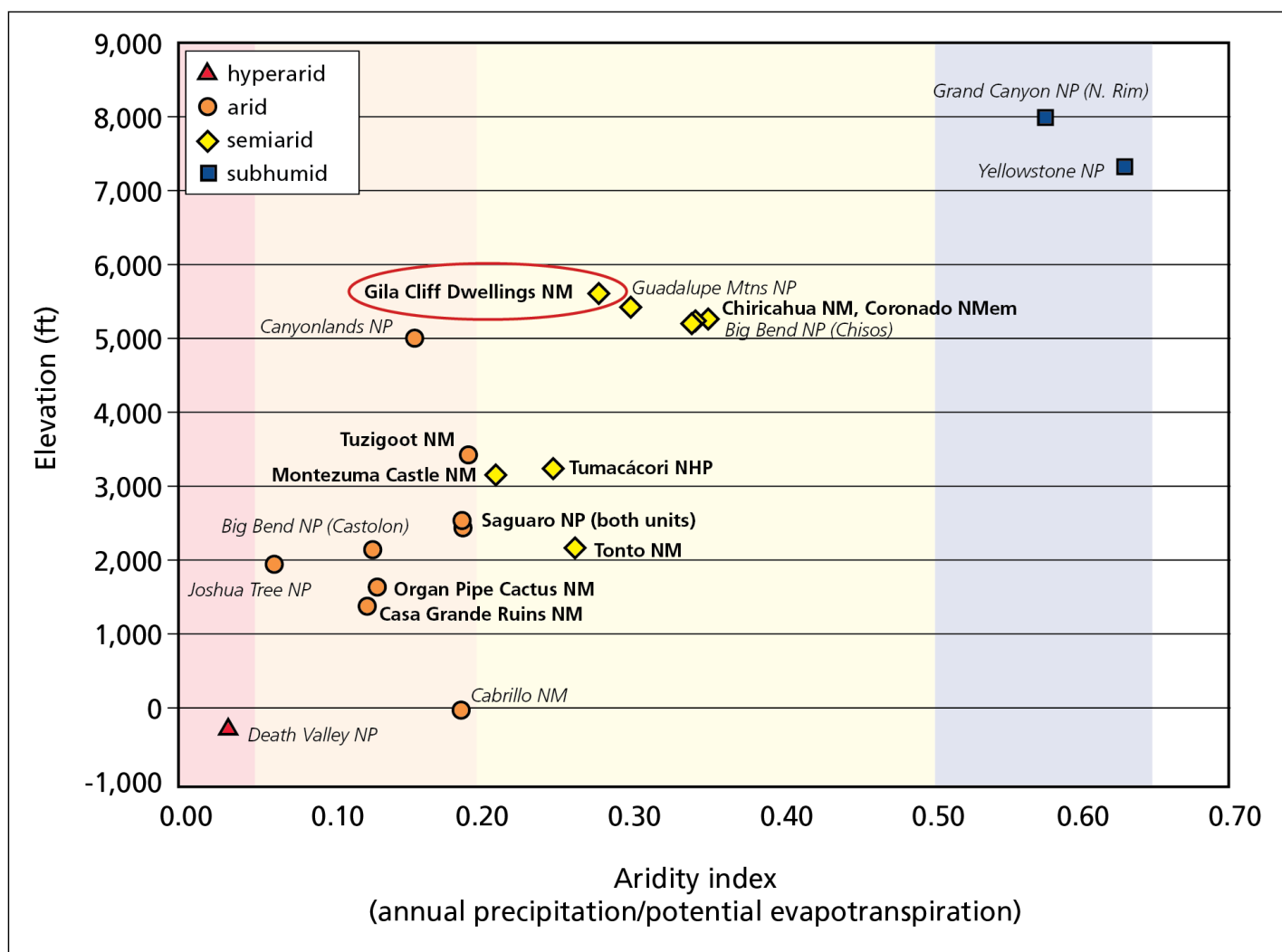
Water conditions are closely related to climate conditions. Because the two are better understood together, the Sonoran Desert Network reports on climate in conjunction with water resources. Reporting is done by water year (WY), which begins in October and ends the following September. Information is added to this page as it becomes available throughout the year.

Climate and Weather

Background

There is often confusion over the terms "weather" and "climate." In short, "weather" describes instantaneous meteorological conditions, such as whether it's currently raining or snowing, or a hot or frigid day. "Climate" reflects patterns of weather at a given place over long periods of time (seasons to years). Climate is the primary driver of ecological processes on earth. Climate and weather information provide a basis for understanding what we see happening in other park vital signs.

An aridity index can be useful for contrasting the climate of national parks and help answer the question, "How dry is dry?" Used globally to classify climate zones, aridity indices are used to compare long-term average annual precipitation relative to the average annual potential evapotranspiration. The climate of Gila Cliff Dwellings National Monument is classified as semi-arid.



Aridity index vs. elevation of selected national parks, including Gila Cliff Dwellings National Monument.

Methods

Since 1957, a National Oceanic and Atmospheric Administration Cooperative Observer Program weather station (GILA HOT SPRINGS #0293530) has operated near Gila Cliff Dwellings National Monument. This station provides a reliable, long-term climate dataset used for all analyses. The monument has also hosted a Remote Automated Weather Station (RAWS) since 1998. Data from both stations are accessible through the [Climate Analyzer](#).

Recent Findings

Total precipitation at the Gila Hot Springs station in WY2019 was 16.6 inches (42.2 cm) (Fig. A), 0.37 inches (0.94 cm) greater than the 1981–2010 normal. Extreme rainfall events (>1 in/2.54 cm) occurred on 2 days, which is the normal annual frequency. Large events occurred on July 7 (1.12 in/2.84 cm) and August 4 (1.53 in/3.89 cm).

Mean annual air temperature in WY2019 was within 1°F (0.56°C) of normal (Fig. B). However, maximum temperatures were generally greater than normal in June–September. The August mean maximum temperature of 91.6°F (33.1°C), was 7.1°F (4.5°C) above normal. Extremely hot temperatures (>92.0°F/33.3°C) occurred on 37

days, which was 2.5 times the normal frequency.

Reconnaissance drought index 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 Gila Hot Springs in WY2019 (Fig. C) indicated an average year from the perspective of both precipitation and evaporative demand.

Click graphics to enlarge

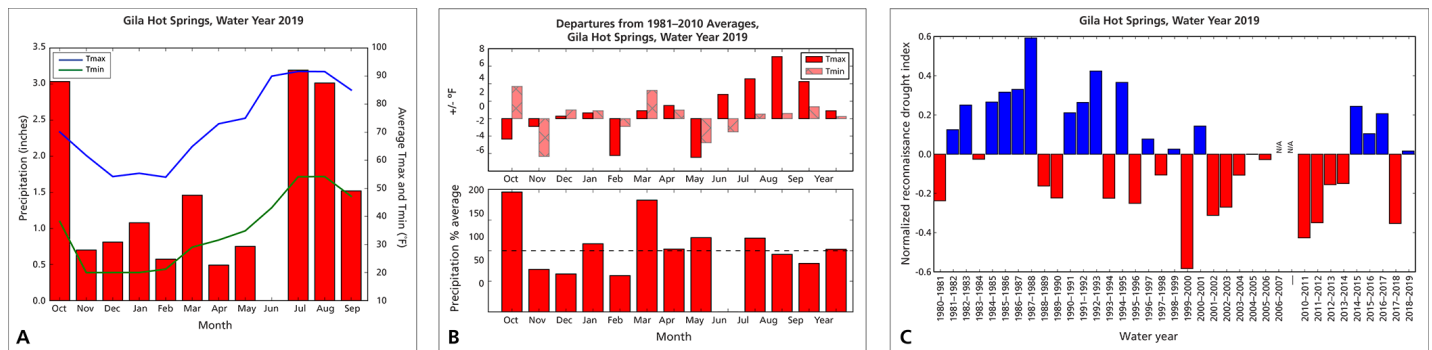


Figure A. Climogram showing amount of precipitation per month (red bars), and average maximum (blue line) and minimum (green line) temperature, WY2019.

Figure B. Departures from 30-year normal minimum and maximum air temperature and precipitation, WY2019.

Figure C. Reconnaissance drought index, WY1981–2019. "N/A" = insufficient data to generate reliable estimates. The station was abandoned from 2007 to 2010.

Graphics generated by climateanalyzer.org

Springs

Background

Springs, seeps, and tinajas are small, relatively rare biodiversity hotspots in arid lands. They are the primary connection between groundwater and surface water, and are important water sources for park plants and animals. For springs, the most important questions we ask are about persistence (How long was there water in the spring?), and water quantity (How much water was in the spring?).

Methods

[Read Methods section](#)

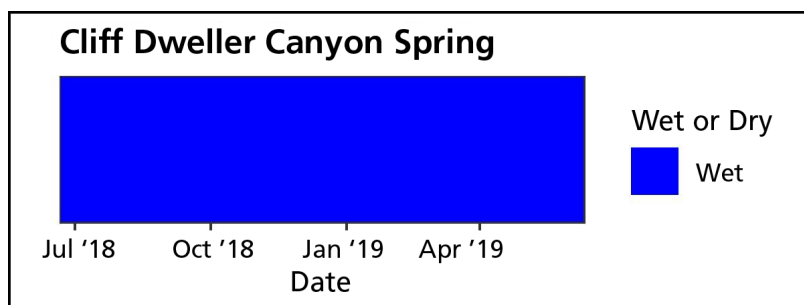
Recent Findings

Cliff Dweller Canyon Spring

Cliff Dweller Canyon Spring is a rheocrene spring (*a flowing spring that emerges into one or more stream channels*). When last characterized (in water year 2017), the spring emerged near a large bedrock wall as a pool below a boulder. The springflow immediately became a shallow, narrow brook, ending as it entered the ground downstream. The brook was interrupted by scattered pools and small, braided sections. The substrate was sand, gravel, and small cobble, with patches of bedrock. The water was uniformly cold and clear, even in pools where flow lost velocity. There did not appear to be surface flow upstream of where the spring emerged from the bed of the ephemeral stream.



Cliff Dweller Canyon Spring downstream of orifice, May 2019.



Water persisted at Cliff Dweller Canyon Spring for the entire sampling period.

Temperature sensors indicated that Cliff Dweller Canyon Spring was “wetted” (contained water) during all of WY2019 (October 2018–September 2019). Discharge was estimated at 17.3 (± 0.33) liters (4.6 ± 0.1 gal) per minute. The spring’s brook was >500 meters (>1,640 ft) long. Width and depth averaged 71.7 centimeters (28.2 in) and 2.5 centimeters (1 in), respectively, within the first 100 meters.

The site was classified as undisturbed, with minimal evidence of wildlife disruption in the form of trampling and tracks. No obligate/facultative wetland plants were observed, but two invasive plants were noted at low density (1–5 individuals): common mullein (*Verbascum thapsus*) and stinkgrass (*Eragrostis cilianensis*). No invasive crayfish or bullfrogs were observed.

Core water quality and water chemistry for water year 2019 were measured at the first pool downstream of the orifice (emergence point). Water-quality data were sampled at 8:15 am, in the shade.

Water-quality data for Cliff Dweller Canyon Spring, water year 2019.

Sampling location	Temperature (°C)	Dissolved oxygen (mg/L)	pH	Specific conductivity (µs/cm)	Total dissolved solids (mg/L)	Exposure

Sampling location	Temperature (°C)	Dissolved oxygen (mg/L)	pH	Specific conductivity (µs/cm)	Total dissolved solids (mg/L)	Exposure
Cliff Dweller Canyon Spring	12.1	7.41	7.24	217.9	141.7	Shade

Water-chemistry data for Cliff Dweller Canyon Spring, water year 2019.

Sampling location	Alkalinity (mg/L)	Calcium (mg/L)	Chloride (mg/L)	Magnesium (mg/L)	Potassium (mg/L)	Sulfate (mg/L)
Cliff Dweller Canyon Spring	115	28	6	8	1.1	1

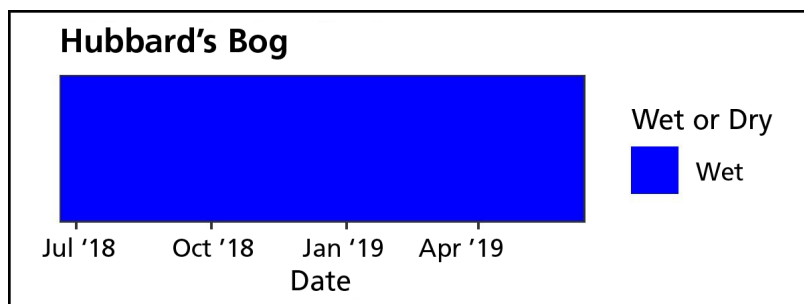
Hubbard's Bog

Hubbard's Bog is another rheocrene spring. When last characterized (in water year 2017), the spring emerged in the canyon bottom as a small brook with no obvious flow. It continued downstream as a low-flow brook with occasional small pools. Beyond the sampled extent, the brook continued intermittently downstream, never with the same volume of water or density of riparian vegetation found at the emergence site. Though rarely flowing, the water was cool and clear throughout. The drainage was characterized as primarily a low-angle silt and gravel streambed with occasional boulders and frequent snags. The brook's channel was



Hubbard's Bog.

very narrow. The drainage upstream of the orifice (emergence point) did not appear to contain flowing surface water. Steep canyon backslopes emerged immediately, with no obvious riparian character. Disturbance caused by the 2011 Miller Fire was notable in the form of sedimentation and downed trees.



Water persisted in Hubbard's Bog for the entire sampling period.

Temperature sensors indicated that Hubbard's Bog was "wetted" (contained water) for all of water year 2019 (October 2018–September 2019). Discharge was estimated at 0.69 (± 0.02) liters (0.18 ± 0.01 gal) per minute. However, the crew noted that subsurface flow may have caused inaccurate

measurements at this location. The spring's brook was 40 meters (131 ft) long. Width and depth averaged 55.7 centimeters (21.9 in) and 2.9 centimeters (1.1 in), respectively.

The site was classified as undisturbed, with minimal evidence of wildlife disruption in the form of trampling and tracks, and evidence of windthrow disturbance. The crew observed one family and two genera of obligate/facultative wetland plants: rushes (Juncaceae), monkeyflower (*Mimulus* sp.), and willow (*Salix* sp.). The invasive, common mullein (*Verbascum thapsus*), was noted at low density (1–5 individuals). No invasive crayfish or bullfrogs were observed.

Core water quality and water chemistry were measured at the first pool downstream of the orifice (emergence point). Water-quality data were sampled at 9:10 am, in the shade.

Water-quality data for Hubbard's Bog, water year 2019.

Sampling location	Sample time	Temperature (°C)	Dissolved oxygen (mg/L)	pH	Specific conductivity (µs/cm)	Total dissolved solids (mg/L)	Exposure
Hubbard's Bog	09:10	12.5	0.72	6.91	291.9	189.8	Shade

Water-chemistry data for Hubbard's Bog, water year 2019.

Sampling location	Alkalinity (mg/L)	Calcium (mg/L)	Chloride (mg/L)	Magnesium (mg/L)	Potassium (mg/L)	Sulfate (mg/L)
Hubbard's Bog	140	40	0	12	0.5	2

Streams

Background

Streams, and their associated riparian areas, are critical to ecological integrity. Riparian areas supply food, cover, and water, and serve as wildlife migration routes. They also help control water pollution, reduce erosion, mitigate floods, and increase groundwater recharge. Riparian systems perform numerous ecosystem functions important to humans, yet are one of the most endangered forest types in the United States. The West Fork Gila River, which crosses the

northeastern portion of Gila Cliff Dwellings National Monument, is a mountainous stream located in the Gila Wilderness. There is almost no upstream land use and little visitor impact in its small watershed.

Natural stressors include drought, flooding, and fire. Since 2001, drought has decreased flow in the stream, which sometimes runs dry near the park's eastern boundary. This area is also prone to flooding. Inside the park, the floodplain is bounded by canyon walls that act as a bottleneck, increasing the destructive force of high flood waters. In 2008, a large rain-on-snow event carved a new stream channel and washed out camping facilities and a bridge, resulting in necessary repairs and reduced visitation.

Two major fires have burned in the watershed in recent years: the 2011 Miller Fire and the Whitewater–Baldy Fire, in 2012. Impacts from these fires have included degraded aquatic habitat, exotic-plant establishment, and potential future flooding and channel change.



West Fork Gila River.

Methods

[Read Methods section](#)

Recent Findings

Data Summary

[See Results to date](#)

Annual Summary

Supporting data can be found in the “Data Summary” section (see above).

WATER QUALITY

In WY2019, SODN staff made a total of four sampling visits to the West Fork Gila River index site. Discrete samples were collected in each quarter. Continuous sampling occurred during deployment periods in quarters 1, 3 and 4. Sampling did not occur in Q2 due to low winter temperatures beyond the measurement abilities of the logging multi-parameter sonde. Water-quality monitoring occurred at the index site near the park's eastern boundary (see map above).

A total of 243 discrete analyses were performed on water samples collected in WY2019. Of these, 89 were associated with state standards. There was **one exceedance** of New Mexico state water-quality standards noted in these samples, for Total Aluminum in quarter three. The compliance rate was 99%.

The state standard for dissolved oxygen "Beneficial Use" (NMAC 2013) indicates that oxygen levels cannot drop below 6 mg/L. During the Q4 sonde deployment (continuous sampling), 3% of the 1,818 measurements did not meet this standard. These events corresponded with short periods (<4 hours) of elevated water temperatures above 23°C.

CORE PARAMETERS

Discrete sampling—. Results for discrete measurements were all within the expected range for a mid-elevation stream in New Mexico.

Continuous sampling—. A logging multi-parameter sonde was deployed for 2–3 weeks during quarters 1, 3, and 4 of WY2019 to collect measurements of temperature, pH, specific conductivity, and dissolved oxygen at 15-minute intervals. A total of 5,308 measurements were collected. The sonde was not deployed during the second quarter of WY2019 due to concern over possible ice damage to the sonde. The sonde sampling location is currently at a secondary site, approximately 100 meters downstream from the footbridge. The primary site was located upstream from the footbridge but was abandoned after stream movement stranded the site out of the water away from the active channel.

NUTRIENTS

There were no exceedances of state water quality standards for nutrients in WY2019. Other results were within expected ranges.

BIOLOGICAL CONDITION

No exceedances were detected for this parameter group, which includes *E. coli*. The bacterium *E. coli* is a naturally occurring member of the biotic community. It is found in soil, decaying material, and the guts of mammals. It is used as an indicator of contamination of water by human fecal waste. SODN data for total coliforms and *E. coli* are expressed as a most probable number (MPN) per 100 mL of stream water, a statistical estimate of the number of bacteria. Although water-quality criteria are expressed as colony-forming units (cfu) per 100 mL (which, unlike MPN, does not assume estimation), the two units are comparable.

METALS AND METALLOIDS

There was one exceedance of state water quality standards for metals and metalloids in WY2019. In winter, Total Aluminum measured 3.4 mg/L, well above the calculated standard of 0.23 for chronic aquatic life. In spring, the anion/cation balance was outside of the expected range criteria of 5%. Anion/cation balance is a QA/QC metric assessing if all the anions and cations were considered in the analysis in total. A result such as the one from this sample period indicates that analytes were present but not tested, or there were inconsistencies with function or QC with the lab equipment. SODN staff is investigating the cause of this result. Other results were within expected ranges.

SUSPENDED AND TOTAL SEDIMENT

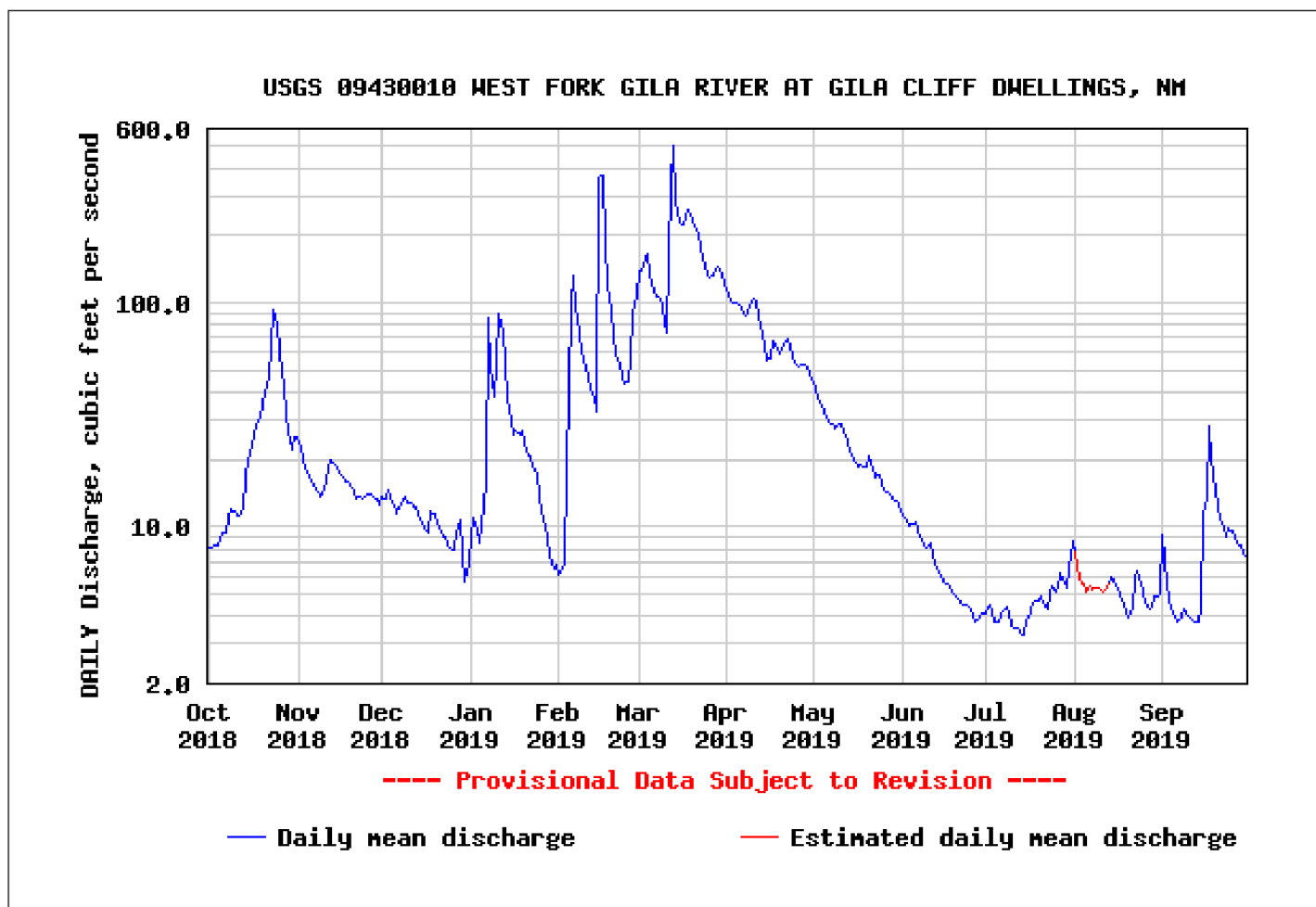
Results for suspended and total sediment fell within the expected range during WY2019.

GENERAL WATER QUALITY AND INORGANICS

Results for general water quality and inorganics were within the range of expected values during WY2019.

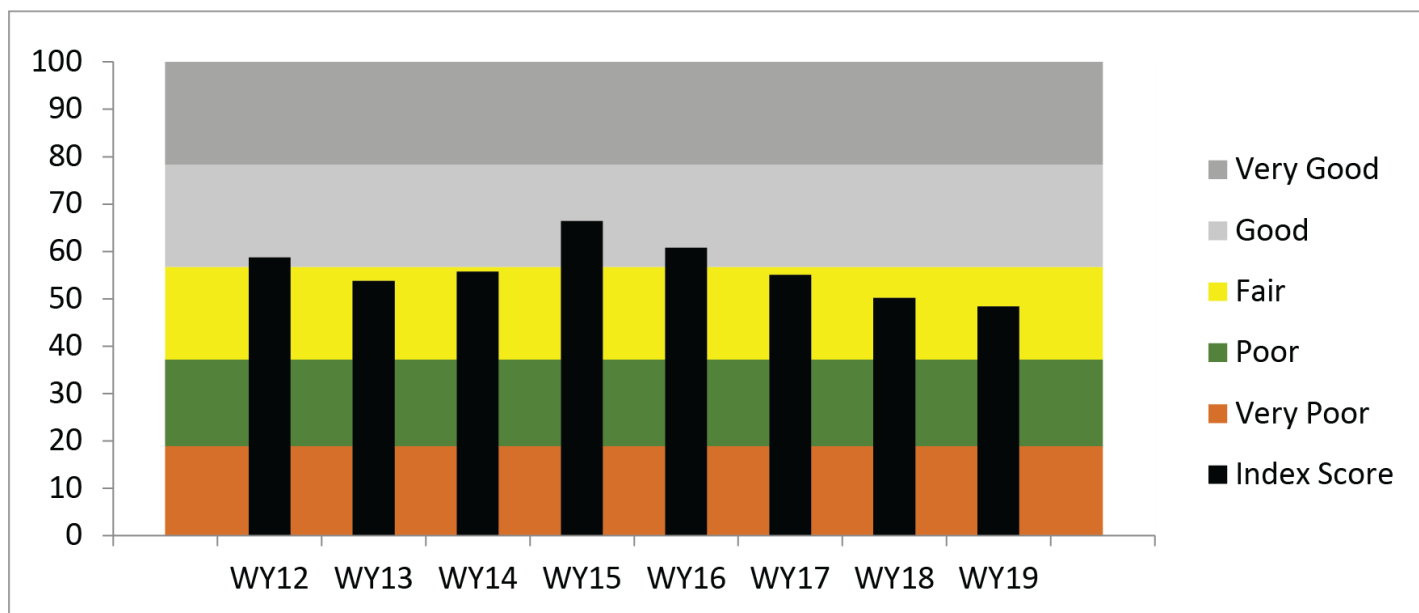
WATER QUANTITY

The hydrograph for WY2019 was typical of the Upper Gila Basin (NPS 1998). Peak streamflow occurred during late February to early April, corresponding to snowmelt in the watershed. The largest flow event, at 754 cfs (cubic feet per second) occurred on March 13, 2019. Mean annual discharge at the park's index station was 34.76 cfs (SD 58.75) in WY2019. The median was 11.0 cfs.



MACROINVERTEBRATES

Macroinvertebrate samples and associated habitat data were collected on October 17, 2018. A list of taxa collected from the index reach can be found in Appendix B. The State of New Mexico uses the New Mexico Stream Condition Indices (Jacobi et. al 2006) to meet mandates established by the U.S. Environmental Protection Agency. In WY2019, the index was measured at 48.37. This placed Gila Cliff Dwellings NM in the “fair” category, falling in the middle of New Mexico index sites quality in the “high-elevation small watershed” class.



New Mexico Stream Condition Index scores, West Fork Gila River, WY2012–2019.

[See Appendices](#)

[See Literature Cited](#)

Past Findings

[Climate and Water Monitoring at Gila Cliff Dwellings National Monument, Water Year 2018](#)

[Climate and Water Monitoring at Gila Cliff Dwellings National Monument, Water Year 2017](#)

[Climate and Water Monitoring at Gila Cliff Dwellings National Monument, Water Year 2016](#)

References

Information on background and methods was summarized from E. L. Gwilliam, L. Palacios, and K. Raymond, [Status of climate and water resources at Gila Cliff Dwellings National Monument: Water year 2018](#).