

Floods in the SW USA in August and September 2023

Poplave v JZ delu ZDA v avgustu in septembru 2023

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Povzetek

Zaradi orkana Hilary so v JZ delu ZDA razglasili prvo opozorilo v zgodovini. Od 19. do 20. avgusta 2023 je v južni Nevadi padlo 234 mm padavin, kar je nov rekord in predstavlja podvojitve starega rekorda iz leta 1906. Tudi v zveznih državah Montana, Idaho in Oregon so preseгли stare rekorde za okrog 25 mm. Dne 22. avgusta 2023 je bil zaprt tudi dostop do Grand Canyon South Rim, saj je v dveh do treh urah padlo 50 do 76 mm padavin, kar je povzročilo poplavo v kraju Tusayan (Arizona). Obilne padavine so se nadaljevale tudi 1. in 2. septembra, ko je tropska nevihta s 50 do 100 mm dežja na območju Las Vegasa povzročila poplave. Okrog 20 in 30 km JZ od Las Vegasa so v dveh urah zabeležili 81 mm padavin, v 45 minutah kar 60 mm. Zaradi obilnega dežja in naplavin so bili zaprti številni narodni parki kot tudi avtocesta med Las Vegasom in Los Angelesom. Monsunsko deževje v poznem poletju je v JZ delu ZDA sicer reden pojav, vendar se je v avgustu 2023 intenziteta padavin močno povečala, kar pripisujejo klimatskim spremembam in vplivu El Niño.

Ključne besede: poplave, puščava, JZ ZDA.

Abstract

Due to the Hurricane Hilary, the Southwestern United States received its first-ever official hurricane warning. From August 19-20, 2023, as much as 234 mm of precipitation fell in southern Nevada, which is a new record and represents a doubling of the old record from 1906. The states of Montana, Idaho and Oregon also exceeded the old records by about 25 mm. On August 22, 2023, access to the Grand Canyon South Rim was closed as 50-76 mm of rain fell in 2-3 hours, causing flooding in Tusayan (Arizona). Heavy rainfall continued on September 1-2, when a tropical storm with 50-100 mm of rain caused flooding in the Las Vegas area. About 20-30 km SW of Las Vegas, 81 mm of rain was recorded in two hours, 60 mm in just 45 minutes. Due to heavy rain and debris, many national parks were closed as well as the main highway between Las Vegas and Los Angeles. Monsoon rains in late summer in the SW part of the USA are a regular phenomenon, but in August and September 2023 the intensity of precipitation increased significantly, which is attributed to climate change and the influence of El Niño.

Keywords: floods, desert, SW USA.

Introduction

In the framework of the bilateral project ARIS BI-US/22-24-074 "Micro-climatic monitoring in tourist caves, comparison of Grand Canyon Caverns with Slovenian caves" in the period from 17-29 August 2023 we visited UNLV (University of Nevada, Las Vegas). As Hurricane Hilary was approaching the SW part of the USA, we were forced to change the planned field trips and adapt to the extraordinary weather conditions. We witnessed heavy rain and flooding in the otherwise dry desert southwestern part of the USA.

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Hurricane Hilary, which developed from a weather disturbance south of Mexico, entered the Pacific Ocean on August 12, 2023 from Central America. It was named Tropical Storm Hilary on August 16, 2023, and a Category 4 hurricane on August 17, 2023, with winds of up to 236 km/h. The cyclone weakened to a tropical storm over the next few days and made landfall 345 km S-SE of San Diego on 20 August 2023 (Wikipedia, 2023a).

In the states of Arizona, California, Nevada and Utah, 26 million residents were exposed to bad weather. On August 18, 2023, the National Hurricane Center (NHC, 2023), which was established in 1965, issued its first-ever warning for the desert valleys of Southern California.

Between August 19-20, 2023, the following national parks were fully closed or at least partially closed: Joshua Tree National Park, Death Valley National Park, Mojave National Preserve, Lake Mead National Recreation Area, and Red Rock Canyon National Conservation Area. Portions of I-15, the major highway connecting Los Angeles and Las Vegas, were closed to traffic several times during this period due to flooding.

In the Lee Canyon area (Spring Mountains, Clark County, Nevada, including Mount Charleston (3633 m)), 234 mm of precipitation fell during this period, which is a new record for Nevada and doubles the old record from 1906 (Prociv, 2023). Also, in the Western US states of Montana (old record from 1976), Idaho (old record from 1982) and Oregon (old record from 1976) the rainfall exceeded the old records by around 25 mm in August 2023 (Prociv, 2023).

A tropical storm like Hilary, which brought torrential rain across four states, is unusual and only two similar cases have been recorded in the past. Hurricane Carla produced record rainfall in Iowa, Wisconsin, and Michigan in 1961, and Kathleen produced record rainfall in California, Oregon, and Idaho in 1976. Hurricane Hilary did not exceed the 1976 rainfall record for California, which remains 451 mm (Prociv, 2023).

Heavy rainfall continued in September as a tropical storm dropped 50-100 mm of rain in the Las Vegas area on September 1-2, 2023 (Table 1), flooding many roads especially in the E and S parts of the city. At the hydrological station located 8 km SW of Jean (Figure 1), which is about 20-30 km SW of Las Vegas, 81 mm of precipitation was recorded in two hours, and 60 mm in just 45 minutes (Table 1) (Clemons, 2023).

Table 1. Precipitation in southern Nevada for the period August 19-20, 2023 (after Clemons, 2023).
 Preglednica 1. Količina padavin v južni Nevadi za obdobje 19-20 avgust 2023 (po Clemons, 2023).

	mm (48 h)
Flamingo Wash near Nellis Boulevard, Las Vegas	96
Grapevine Springs 2, 100 km NW of Las Vegas	85
Jean, 20-30 km SW of Las Vegas	84
Las Vegas Wash in Las Vegas	80
Red Rock Canyon, 30 km W of Las Vegas	66
Center of Las Vegas	55

Floods in the metropolitan area of Las Vegas (610 m above sea level, Figure 1), which has more than 2 million inhabitants, threatened its unhoused people, who are said to number at least 1,500 (Signer, 2023). The number of unhoused people is said to have increased in recent years due to the opioid crisis and the corona virus pandemic (Signer, 2023). At least 500 live in more than 100 km of labyrinths and tunnels built under the city to reduce surface

flooding and drain floodwater to the eastern part of the city and into the 19-km long Las Vegas Wash. The Wash carries the majority of stormwater along with treated wastewater from the Las Vegas Valley through wetlands and finally into Lake Mead, a major reservoir on the Colorado River (Torres-Cortez, 2023). The Las Vegas Wash is an urban river, existing at its current extent because of the urban population. The drainage works in a systemic connection with the wetland in Clark County Wetlands Park, which covers 11.7 km² in the eastern part of the Las Vegas Valley (Clark County Wetlands Park, 2023).

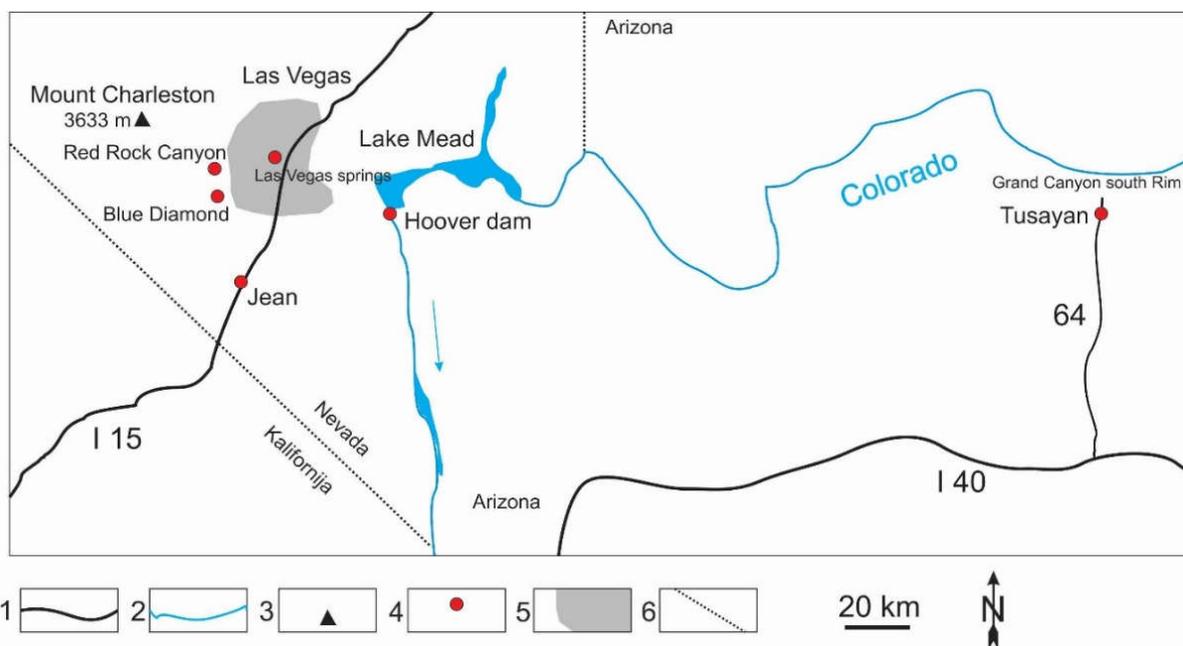


Figure 1 – The territory of Nevada and Arizona in the SW USA, which were visited in August 2023. 1-road, 2-river, 3-mountain top, 4-location described in the paper, 5-city of Las Vegas, 6-state border to the two US states (cartography: S. Šebela)

Slika 1 – Ozemlje Nevade in Arizone na JZ ZDA, ki smo ga obiskali v avgustu 2023. 1-cesta, 2-reka, 3-vrh gore, 4-lokacija opisana v prispevku, 5-mesto Las Vegas, 6-meja med zveznima državama (kartografija: S. Šebela)

Las Vegas Springs

The name Las Vegas comes from the Spanish meaning grassy meadows. Originally, natural springs flowed in what is today the heart of Las Vegas (Figure 1). The springs ensured the survival of the original inhabitants and became instrumental to exploration and trade routes across the desert landscape. But by 1962 the surface flow stopped due to the lowering of the groundwater level due to the pumping of water to supply the growing local population.

Today, the historic springs area is managed as a park which hosts museums, a botanical garden, hiking trails and historical interpretations (Springs Preserve, 2023), along with a working well field that contributes about 10% of the metropolitan water supply.

Red Spring – Calico Basin

One active spring area is the BLM's (National Conservation Lands, Bureau of Land Management) Calico Basin, located just a few miles north of the Red Rock Canyon Visitor

Center. There are three permanent springs in the Calico Basin area: Red Spring (Red Spring Picnic Area, 2023), Calico Spring, and Ash Spring. Next to the source of Red Spring, we find a grassy swamp (Figure 2A) with rich animal and plant life. This place was also favorable for the original inhabitants - the Indigenous People who are said to have lived here as early as 6000 years ago, as evidenced by petroglyphs, artifacts and other archaeological remains. Heavy rains during the period August 19-20, 2023 increased the flow of the Red Spring, which was seen as inundated grass (Figure 2B), and brought a lot of debris onto the roads.

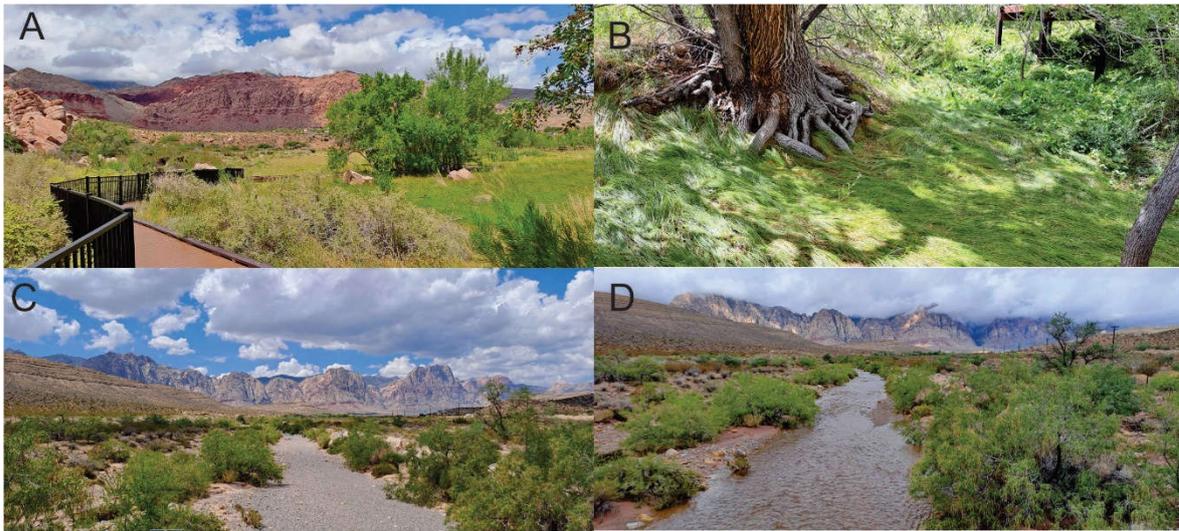


Figure 2 – A - Red Spring Calico Basin, August 21, 2023 (photo: S. Šebela), B - Red Spring Calico Basin after heavy rains, August 21, 2023 (photo: S. Bonzanni), C - Red Rocks, August 25, 2023 (photo: S. Šebela), D - Red Rocks, August 21, 2023 (photo: S. Šebela)

Slika 2 – A - Red Spring Calico Basin, 21. avgust 2023 (foto: S. Šebela), B - Red Spring Calico Basin po večjem deževju, 21. avgust 2023 (foto: S. Bonzanni), C - Red Rocks 25. avgust 2023 (foto: S. Šebela), D - Red Rocks, 21. avgust 2023 (foto: S. Šebela)

Blue Diamond

We spent quite a few days in Blue Diamond (Figure 1), which is a small independent settlement on the way from Las Vegas to the west. It is located in the Red Rock Canyon National Conservation Area, which sees more and more visitors every year. The settlement of around 280 inhabitants lies at an altitude of 1130 m and is located 41 km SW of Las Vegas. It developed in the 1940's as a settlement to support a nearby gypsum mine that has been in operation since 1924 (Blue Diamond Elementary School, 2023), next to Cottonwood Spring (also called Ojo de Cayetana or Pearl Spring), located between the springs in the Spring Mountains and the springs in Las Vegas.

Cottonwood Spring was a rest stop and stop along the Old Spanish Trail, which ran for about 1,100 km, connecting the area around Santa Fe, New Mexico, and southern California. Spanish conquistadors are said to have explored this area in the late 16th century, and merchants used this route intensively in the period 1830-1848 (Weimer Purkey, 1994). Later the route was called the Mormon Road.

Cottonwood Spring, as well as many other springs, was used by Native Americans as well as early settlers of the American West. Today, the spring is used to irrigate a verdant park and for drinking water. The water rights are privately owned.

During periods of heavy rain in Red Rock and the Spring Mountains, the customarily dry streambed that separates the village of Blue Diamond from State Road 159, which passes through the Red Rock Canyon, fill with water (Figure 2C and D and Figure 3A and B).



Figure 3 – A - Blue Diamond, Arroyo road - flood on July 1, 2016 (photo: S. Šebela), B - Blue Diamond, Arroyo road - flood on August 21, 2023 (photo: S. Bonzanni), C - Hoover Dam and Lake Mead on August 24, 2023. We can see the decreased water level in the lake. The Colorado River constitutes the border between Arizona on the E and Nevada on the W (photo: S. Šebela), D - Storm clouds at the Grand Canyon south Rim, August 22, 2023 (photo: S. Bonzanni)

Slika 3 – A - Blue Diamond, Arroyo road - poplava 1. julija 2016 (foto: S. Šebela), B - Blue Diamond, Arroyo road - poplava 21. avgusta 2023 (foto: S. Bonzanni), C - Hoover dam in jezero Mead 24. avgusta 2023, opazimo lahko nivo znižanja vode v jezeru, reka Kolorado je tudi mejna reka med Arizono na V in Nevado na Z (foto: S. Šebela), D - nevihtni oblaki na Grand Canyon south Rim, 22 avgust 2023 (foto: S. Bonzanni)

Lake Mead

At the beginning of the 20th century, due to the flooding of the Colorado River, the inhabitants of the SW part of the United States began to build a massive dam on the river in order to contain the floods, obtain electricity, and manage water for drinking and irrigation. At least 3,500 workers worked each month on the project, which was begun in 1931 and completed in 1935, and renamed from the original name Boulder Dam to Hoover Dam, in honor of the 31st US President (Weimer Purkey, 1994).

Lake Mead (Figure 3C) with its peak surface area of 640 km² represents 90% of the surface water in southern Nevada (Lothead, 2023). Only two percent of the flow of the

Colorado River as it passes through Lake Mead is contractually allocated to southern Nevada (Lothead, 2023). This amounts to 12 m³/s which satisfies about 90% of demand for the Las Vegas Valley (Luke et al., 2022).

The Lake Mead reservoir provides water for 25 million people, as well as agricultural and natural ecosystem needs for Nevada, California, Arizona, and northern Mexico (Luke et al., 2022). If the lake was full of water, it would reach an altitude of 374 m and a maximum depth of 162 m. However, the level of the reservoir has been decreasing sharply and in June 2022 reached an altitude of 317 m above sea level, which means a decrease of 56 m from the highest water level, reduction in volume retained by about 70%, and the lowest level since 1936, when it was first filled (Luke et al., 2022).

Flooding in August and early September 2023 made only a minor contribution to the rise in Lake Mead, as 90-95% of the water for the Colorado River comes from snowmelt in mountains far to the north. A rise of the lake level by about 6 m in the period from March to September 2023 is attributed mainly to releases from the upstream Glen Canyon Dam which forms Lake Powell (Lothead, 2023).

Grand Canyon

On August 22, 2023, an interesting adventure awaited us in the Grand Canyon South Rim area, where we went after the main part of Tropical Storm Hilary passed through the Las Vegas area.

In the small town of Tusayan, which has about 600 inhabitants, lies at an altitude of 2,015 m, and is about 9 km from the Grand Canyon South Rim, we experienced a road closure due to flooding. On the afternoon of August 22, 2023, we visited the Grand Canyon National Park, where it rained from time to time, and it was heavily cloudy in the east, which allowed us to take beautiful photos (Figure 3D). When we wanted to return to the motel in Tusayan around 06:00 p.m., the main road through the place was already under water. Since there was not much rain in the area, some people thought it was a leaking water pipe.

In fact, 50-76 mm of rainfall fell within a few hours (2-3 h) in the Coconino Wash area about 10 km east of Tusayan (Sutton et al., 2023), causing flooding on the lowest part of Route 64 which passes through Tusayan. In Tusayan some motels and other infrastructure elements were also flooded, and there was no electricity. The Grand Canyon South Rim exit on Route 64 was closed until 9:30 p.m. on August 22, 2023, when the water receded. The inhabitants of this place did not recollect similar floods.

Concluding thoughts

The so-called monsoon rains in the SW part of the USA are a regular occurrence in the summer and early autumn, but in August 2023 the intensity of precipitation increased significantly, as for the first time since 1965, a tropical storm or hurricane warning was issued for the desert areas of Southern California.

The effect of El Niño on the warming of the Pacific Ocean is estimated to affect the climate of the entire planet. Extreme weather conditions are being recorded in many places around the world: At the beginning of August 2023, Slovenia was hit by its worst weather disaster (Wikipedia, 2023b), as 200 mm of precipitation (150-200 L/m²) fell over 12 hours in some places. At the beginning of September 2023, a record amount of precipitation fell in a few hours in parts of Greece. In the same month, the collapse of a dam in Libya caused a disaster of epic proportions after heavy rains. All this demonstrates to us that so-called

hundred-year floods are now occurring more frequently and, very intensively, affecting larger areas.

During our bilateral exchange in Nevada (as well as in the Grand Canyon, Arizona), we received multiple audio and text alerts on our cell phones that more rain and wind were approaching.

Simultaneously with Hurricane Hilary, on August 20, 2023, a magnitude 5.1 earthquake with numerous aftershocks was recorded in Southern California in the vicinity of Los Angeles. The term "hurriquake" appeared on social networks (Wikipedia, 2023a). Although the two events are not related, the earthquake caused a lot of speculation about the connection with the extreme weather.

The personal experience of floods and the adaptation of field work to weather conditions were an interesting experience that, from the point of view of study of natural phenomena on a dynamic planet, complemented the bilateral exchange oriented to karst geology.

Acknowledgements

The field work was made possible with the help of the bilateral project "Micro-climate monitoring in tourist caves, comparison of Grand Canyon Caverns with Slovenian caves" (ARIS BI-US/22-24-074), with the help of the infrastructure program "Co-financing of the implementation of the international infrastructure project EPOS" (ARIS I0-E017) and the research program "Karst Research" (ARIS P6-0119).

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