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Prepared in cooperation with the U.S. Department of Energy's Office of Environmental Management and National Nuclear Security Administration, Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, Nye County, Nevada, and Inyo County, California

Hydrologic Monitoring Networks in the Death Valley Regional Flow System, Nye County, Nevada and Inyo County, California

Introduction

Water is an important resource in the arid southwest region of the United States where there is a limited supply of surface water and groundwater. In the Death Valley regional groundwater flow system (DVRFS) in southern Nevada and eastern California, groundwater is the main source of supply for agricultural, commercial, and domestic water needs.

For over four decades, the U.S. Geological Survey (USGS) Nevada Water Science Center (NVWSC) has assisted environmental programs with the collection of hydrologic information within the DVRFS. Three hydrologic networks, managed in cooperation with local (Nye County, Nev. and Inyo County, Calif.) and federal (Bureau of Land Management, U.S. Fish and Wildlife Service, National Park Service, U.S. Department of Energy's Office of Environmental Management and National Nuclear Security Administration) agencies, are used to actively monitor wells and springs in the region.

Location

The DVRFS has an area of about 80,000 square kilometers and includes the Amargosa Desert area, Nevada National Security Site (NNSS), and Yucca Mountain (fig. 1). The Amargosa Desert area is bounded by Death Valley National Park (DEVA) to the southwest, the NNSS to the northeast, and south of Yucca Mountain and includes the community of Amargosa Valley, Nev., Ash Meadows National Wildlife Refuge, and Devils Hole, a detached unit of DEVA. The Nevada National Security Site is a federal facility where the United States tested over 900 nuclear devices (atmospheric and underground) between the 1950s and early 1990s. Yucca Mountain is the proposed national repository for high-level nuclear waste and spent nuclear fuel. The three hydrologic monitoring networks within the approximate area of the DVRFS extend north to south from Big Sand Springs Valley to Pahrump Valley and west to east from DEVA to the Sheep Range north of Las Vegas.

Purpose

Data collected through the hydrologic monitoring networks are necessary for evaluating potential impacts to water-dependent natural and economic resources and to assist resource managers in making informed decisions.

U.S. Geological Survey monitoring data for the DVRFS include:

- depth to water
- groundwater withdrawal rate and volume
- spring discharge
- water temperature

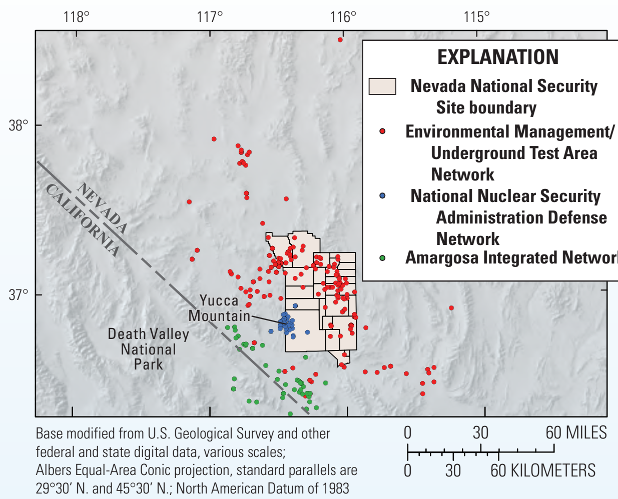

Figure 1. Map showing the location of the monitoring networks and sites.

These data are needed to effectively quantify specific changes in groundwater levels and spring discharge to better understand and manage water resources in the DVRFS. For example, data from the hydrologic monitoring networks have been used to evaluate and assess:

- predevelopment depth-to-water and spring discharge
- groundwater level variability and trends
- the direction of regional groundwater flow and the influence of geologic structures on regional groundwater flow paths
- the horizontal and vertical rate of change in groundwater levels (hydraulic gradient)
- effects of widespread groundwater withdrawals on managed resources within the DVRFS
- the hydraulic connection between observation wells and areas of recharge or groundwater withdrawals
- the accuracy of regional groundwater numerical models

Network Description

The three USGS hydrologic monitoring networks in the DVRFS (fig. 1) include:

- Environmental Management (EM)–Underground Test Area (UGTA; 233 wells)
- National Nuclear Security Administration (NNSA) Defense Network (34 wells)
- Amargosa Integrated Network (54 wells and springs)

Water levels, water use (groundwater withdrawals from pumping), spring discharge, and water temperatures are measured by the USGS at selected monitoring sites within these networks. Water temperatures include groundwater temperature profiles in selected observation wells and spring discharge temperature at selected springs. The frequency of measurement for all networks ranges from monthly to annually, with some overlap in spatial extent and purpose between the networks. The cooperating agency, monitoring site type, and number of monitoring sites are presented in table 1 and illustrated in figure 1. Apparent differences in the number of monitoring sites presented in table 1 and figure 1 are the result of the scale of the map and/or sites existing in the same borehole at different depths.

Data Collection and Quality Assurance

All USGS field data collection follow established protocols and data are quality-assured and approved prior to being archived in an appropriate, publicly accessible database. For water-level measurements, steel tapes and electric tapes are used; however, steel tapes are used to measure water levels less than 100 feet (ft) deep, whereas electric tapes are used to measure water levels ranging from 100 ft to more than 4,000 ft below land surface (fig. 2*A*, *B*). The methods used to measure water levels are outlined in groundwater technical procedures of the USGS (Cunningham and Schalk, 2011).

Water-level measurement tapes are calibrated annually to ensure that they are accurately measuring the depth to water in a well or borehole. This is especially important for areas of the DVRFS where depths-to-water are great (more than 1,000 ft) and tapes can stretch and deform under their own weight. The NVWSC has been performing annual steel and electric tape calibrations in-house since 1999. At designated wells or boreholes, a multi-point vertical calibration of the measurement tape is performed against a NIST-certified steel reference tape using the well-measurement-comparison calibration method (Fulford and Clayton, 2015).

Spring discharge is determined using velocity, flume, or volumetric measurements (fig. 2*C*). The method selected to measure individual spring discharge is dependent upon the spring's discharge rate and site condition. Discrete discharge measurements are generally collected with a Son Tek Flow Tracker (velocity meter), Parshall flume, or container of known capacity (volumetric) using standard USGS methods (Buchanan and Somers, 1969; Kilpatrick and Schneider, 1983; U.S. Geological Survey Office of Surface Water, 2004).

Table 1. Hydrologic monitoring networks in the Death Valley regional groundwater flow system.

[EM, Environmental Management; UGTA, Underground Testing Area; CAU, Corrective Action Unit; NNSA, National Nuclear Security Administration; FWS, U.S. Fish and Wildlife Service; NPS, National Park Service; USGS, U.S. Geological Survey; —, no data]

Network	Sub-network	Site type	Number
EM/UGTA	Pahute Mesa CAU	Wells	107
	Yucca Flat CAU	Wells	57
	Post Closure	Wells	69
NNSA Defense	—	Wells	34
Amargosa Integrated	FWS	Wells	5
		Springs	4
	NPS	Wells	10
		Open fracture	1
	USGS	Wells	24
		Springs	1
	Nye County	Wells	9

Figure 2. Photographs showing staff measuring *A*, water level in well ER-OV-05, Oasis Valley, Nevada, using a steel tape; *B*, water level in well USW VH-1 (CF-2), Crater Flat, Nevada, using an electric tape; and *C*, discharge in an unknown spring using a velocity meter (photographs courtesy of the U.S. Geological Survey).

Temporal Data

For several decades, USGS hydrologic monitoring in the DVRFS has provided baseline information to support a variety of water-resource studies and agency data needs. Long-term monitoring records (more than 20 years) of water levels and spring discharge have proven to be particularly useful for understanding factors (hydrologic stresses) that cause seasonal, annual, or decadal change and trends. For example, a hydrograph for well AM-4 (fig. 3*A*) shows changes in water levels at Devils Hole, which is a dissolution enlarged fracture that is home to the endangered Devils Hole pupfish (*Cyprinodon diabolis*; Fenelon and Moreo, 2002). Long-term monitoring at Devils Hole captured a critical period of declining water levels in the 1960s and early 1970s that was caused by nearby groundwater pumping, and the subsequent recovery of water levels over time after pumping was discontinued. Moreover, this long-term hydrograph has provided needed baseline information for federal and state of Nevada policy decisions on the management and protection of the Devils Hole pupfish. In addition to hydrologic stresses caused by groundwater pumping, water-level fluctuations in response to episodic recharge from greater-than-average precipitation also has been observed in long-term records for the DVRFS. For example, water levels in multiple wells near Yucca Mountain responded to recharge from the winters of 1995, 1998, 2000, 2001, 2005, and 2010, with a rising trend for most wells from 2000 to 2015 (fig. 3*A*; Jackson and Fenelon, 2018). In some areas of the DVRFS, water-level hydrographs exhibit short-term (seasonal) and longer-term (decadal) responses caused by multiple hydrologic stresses. The Beatty Wash Terrace Well (fig. 3*B*), for example, shows the influence of seasonal water-level fluctuations caused by changes in evapotranspiration and episodic recharge events, such as occurred in 1998 (Jackson and Fenelon, 2018). Superimposed on the shorter-term water-level record for this well is a longer-term trend of declining water levels likely caused by nearby pumping. The hydrograph for ER-20-4 deep (fig. 3*C*) shows the relatively static water levels at depth below Pahute Mesa. The large water-level decline shown in 2015 reflects pumping from this well for nearby construction activities (Elliott and Fenelon, 2010).

The DVRFS contains several springs that are maintained by recharge at distant source areas and groundwater flow through a regionally extensive carbonate aquifer (Faunt and others, 2010). Long-term records showing relatively consistent spring discharge over several decades is suggestive of regional groundwater flow and limited long-term influence from local hydrologic stresses such as from nearby groundwater pumping. For example, discharge at Crystal Pool, a spring at the Ash Meadows National Wildlife Refuge (fig. 3*D*), has been monitored for more than 20 years. Crystal Pool discharge over this period of record has remained within a relatively consistent range of 5 to 7 cubic feet per second (12,000–17,000 cubic meters per day), suggesting that the water is sourced from the regional carbonate-rock aquifer (San Juan and others, 2010).

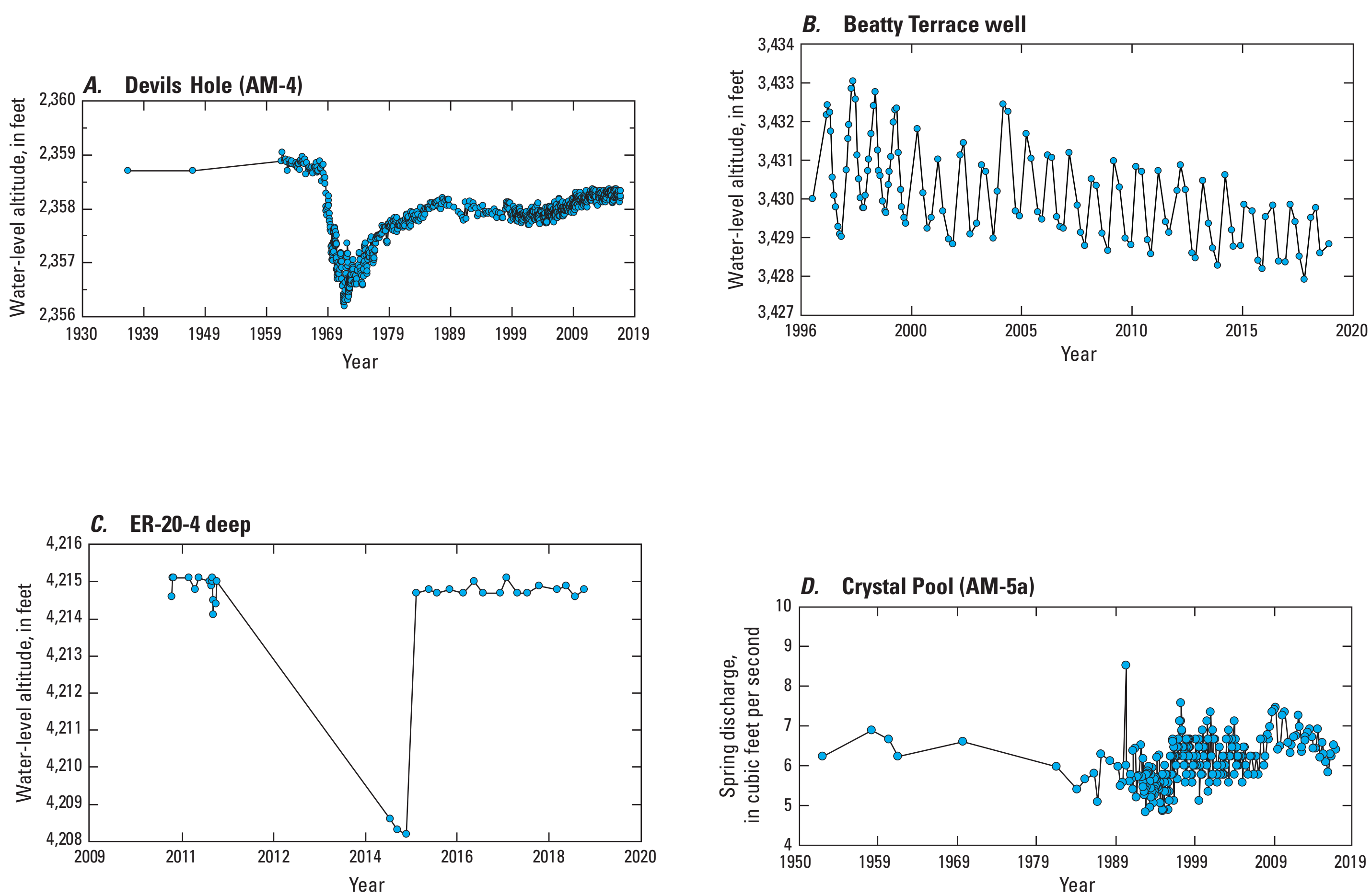

Figure 3. Hydrographs from *A*, Devils Hole well (AM-4); *B*, Beatty Wash Terrace Well; *C*, ER-20-4 deep well; and *D*, Crystal Pool (AM-5a).

Publication

The USGS stores all quality-assured monitoring data in the USGS National Water Information System (NWIS) database (U.S. Geological Survey, 2018a). All monitoring data collected for the DVRFS monitoring network are publicly accessible on the NWIS website (https://waterdata.usgs.gov/nv/nwis); for the NNSS networks, data are accessible on the U.S. Geological Survey—U.S. Department of Energy Cooperative Studies in Nevada project website (https://nevada.usgs.gov/doe_nv/; U.S. Geological Survey, 2018b).

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Photograph Credit:

Landscape view of Funeral Range banner, Wayne R. Belcher, U.S. Geological Survey

Photograph of Ash Meadows spring by Claudia C. Faunt, U.S. Geological Survey

From 1992 through March 2009, water-levels and spring-flow data in the Amargosa Desert area were measured monthly to support the Yucca Mountain Project (YMP) Environmental Monitoring Program (EMP). Yucca Mountain, Nevada, is the proposed national repository for high-level nuclear waste and spent nuclear fuel. The YMP-EMP network consisted of 35 wells, 6 springs, and Devils Hole. These data have been used to identify long-term trends and to assess impacts of construction and operation of the repository on groundwater users in the vicinity of the Amargosa Desert area and the Nevada National Security Site. In 2009, the YMP was defunded and the data-collection network was shut down. In 2010, a modified network was revived by agencies of the Department of the Interior (Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, and the U.S. Geological Survey) and counties in Nevada (Nye) and California (Inyo). This revived network became the Amargosa Integrated Network.

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