



Hydrologic Monitoring in Walnut Canyon National Monument

2010–2011 Summary Report

Natural Resource Data Series NPS/SCPN/NRDS—2012/359



ON THE COVER

Stage gage mounted above stream channel in Walnut Canyon National Monument
Photograph courtesy of SCPN

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The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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1 Introduction and background

The National Park Service Inventory and Monitoring Program was designed to determine the current status and monitor long-term trends in the condition of park natural resources, providing park managers with a scientific foundation for making decisions and working with other agencies and the public to protect park ecosystems. Hydrologic vital signs are the fundamental components defining overall riparian and aquatic ecosystem integrity. The Southern Colorado Plateau Network (SCPN) has identified 7 vital signs pertaining to riparian and spring ecosystems, and we focus on the first one in this report: 1) stream flow and depth to groundwater, 2) channel morphology, 3) stream water quality, 4) spring water quality, 5) spring, seep and tinaja ecosystems, 6) riparian vegetation, composition, and structure, and 7) aquatic macroinvertebrates. These vital signs are closely related and are all included in the *Vital Signs Monitoring Plan for the Southern Colorado Plateau Network* (Thomas et al. 2006). The context and ecological significance of these vital signs are further explained in Scott et al. (2005).

Walnut Canyon National Monument (WACA) is located 6.4 km southeast of Flagstaff, Arizona, encompassing approximately 14.5 km² (3,600 acres). Approximately 13 linear km of Walnut Creek trend from west to east within the monument. The canyon is eroded into the Kaibab Limestone and Coconino Sandstone in sinuous, entrenched meanders. It is typically ½ kilometer wide from north rim to south rim, and is 120 m (400 feet) from rim to floor at its deepest point. The canyon bottom is narrowly-incised within sandstone bedrock, where the Walnut Creek drainage meanders through shallow, coarse stream terrace deposits and talus blocks from the canyon walls. Upstream of the monument, the Walnut Creek watershed encompasses approximately 340 km² (83,200 acres) to the south and west, which is mostly dominated by ponderosa pine (*Pinus ponderosa*) forest within the Coconino National Forest.

Near the downstream end of the canyon, the Santa Fe Dam was built around 1885 to supply water to the Santa Fe Railway. In the 1930s local ranchers reportedly dynamited the dam, and in recent years streamflows readily leak through fractures in the dam or pass over the spillway. During rare flood flows, for short periods of time the canyon bottom is totally inundated for about 1.6 kilometers upstream of the dam, and this reach of the canyon is now filled with fine sediment deposits.

The first of 2 dams on Walnut Creek, upstream from the monument, was completed in 1904 to create Lower Lake Mary for the purpose of providing water to early historic sawmills in Flagstaff. This dam disrupted water flow through Walnut Canyon, but additionally, it is along a local fault zone and most water infiltrates the highly porous and fractured bedrock rather than flowing downstream. A second dam was built further upstream, in 1941, to create Upper Lake Mary, an important public water supply for Flagstaff. Prior to construction of the first upstream dam, Walnut Creek most likely had a reliable seasonal flow regime (Brian 1992). As with similar nearby intermittent drainages, reliable flows likely occurred during spring snowmelt, and less predictable flows occasionally occurred during the summer and fall thunderstorm season. Since the second upstream dam was completed in 1941, streamflow has been documented in the canyon only 3 times, each of these after extreme storm events completely filled both Upper and Lower Lake Mary (Rowlands et al. 1995). Other flow events, particularly localized flows within segments of the canyon bottom, may have occurred.

The absence of seasonal stream flows during the last 65–105 years has affected the drainage channel morphology, canyon bottom vegetation, and wildlife habitat. In historic photographs dating as early as 1897, some reaches of the canyon had a well-defined, open drainage channel (Brian 1992). By 1989, the channel was obscured by a dense vegetation community dominated by red osier dogwood (*Cornus sericea*), New Mexico locust (*Robinia neomexicana*), wild rose (*Rosa woodsii*), and Arizona wild grape (*Vitis arizonica*) (Phillips 1990). The stream channel and terraces may be increasingly buried with coarse sand, gravel, and rock deposits derived from the canyon walls, and fan deposits derived from small tributary canyons. SCPN will provide support for NPS management of this canyon bottom riparian ecosystem by monitoring seasonal stream flows in Walnut Creek to supply basic hydrologic information.

In 1995, the United States Geological Survey (USGS) established a network of 4 crest-stage gages designed to monitor flood-flows through WACA (McCormack et al. 2003). These gages were maintained by the USGS through 2002, but became inactive after that year. The SCPN began streamflow monitoring at 3 of these sites in 2010 by installing data loggers to record stage and temperature in the existing gages. Because we installed a recording pressure transducer in the gages, they are referred to in this report as recording stage gages, or RSGs

(Waltemeyer 2005). The objective of SCPN hydrologic monitoring at WACA is to document timing, duration, and magnitude of surface water flows in Walnut Creek and Cherry Creek, in and near the monument. We monitored the following sites (fig. 1) and list their locations, codes and common names in Appendix A:

- *Walnut Creek below Lower Lake Mary*, (WACALLM01), is identified in this report as LLM01, and is the same as USGS station 09400890.
- *Walnut Creek near upstream (old) boundary*, (WACANUB01), is identified in this report as NUB01, and is the same as USGS station 09400930. The “old” boundary was that prior to park boundary expansion in 1996.
- *Cherry Creek near downstream*, (WACACHC01), is identified in this report as CHC01, and is the same as USGS station 09400940. The gage is located on Cherry Creek about 0.4 kilometers upstream of its confluence with Walnut Creek.

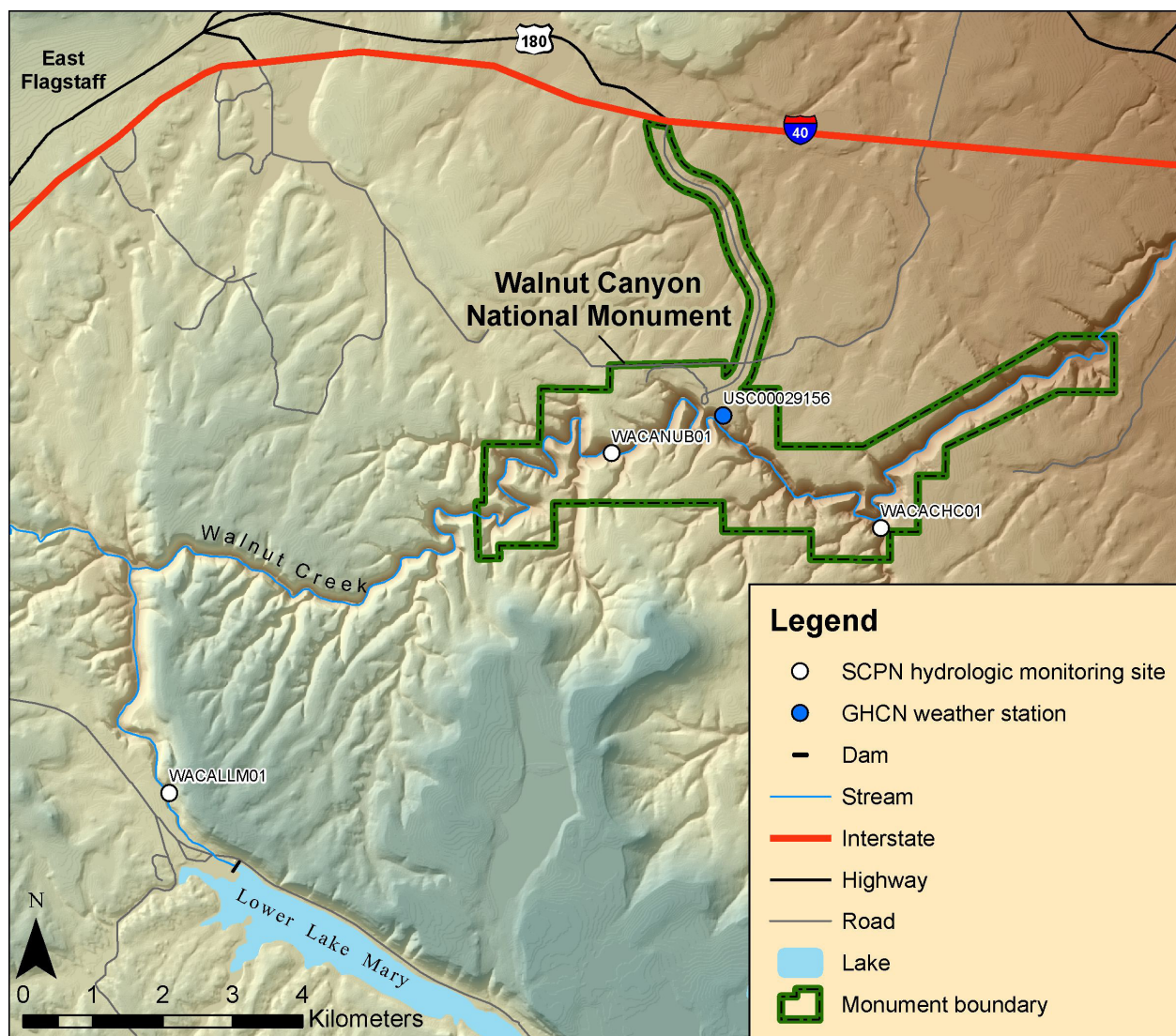


Figure 1. Location of sites associated with SCPN hydrologic monitoring in Walnut Canyon N.M., Arizona, 2010–2011

At each of the 3 sites, SCPN water resources staff also surveyed the stream channel and established survey control points on existing features to relate each gage to a local datum. The survey data enable estimations of flood magnitude and, with repeat surveys, a means of monitoring geomorphic change at each site if that becomes a future objective.

The purpose of this report is to (a) document SCPN hydrologic monitoring activities that have occurred at WACA, (b) summarize the data collected, and (c) where appropriate, place the data in the context of current environmental conditions.

2 Methods

Methods are described for a 2009 reconnaissance visit, equipment installation in 2010, and data collection and analysis from January 10, 2010 through September 30, 2011. SCPN water resources staff visits each site once or twice per year to download the instrumentation, document site conditions, and obtain manual measurements of any surface water present at the gages. Site conditions are documented and photographed during repeat visits. For further details on methods used please refer to the hydrologic standard operating procedures (SOPs) of the network's draft integrated riparian monitoring protocol (Monroe et al. in preparation).

2.1 Field methods

2.1.1 Site reconnaissance

Each of the 3 monitoring sites was visited by SCPN water resources staff in 2009 to check the status of the gages and to assess site conditions. The existing crest-stage gages were inspected and all were found to be in working condition. The gages at LLM01 and CHC01 consist of an upper and a lower riser, constructed of 2-inch galvanized pipe securely anchored to bedrock or a large boulder. Each riser pipe is capped on the top and bottom, with holes drilled near the bottom of the pipe to allow water to enter the pipe during flow events, and then to drain as the water level recedes. The gage at NUB01 is a single 10 ft (3.05 m) 2-inch galvanized pipe riser attached to the sandstone canyon wall on stream right (facing downstream). The channel at the base of the gage had scoured, and we lowered the gage closer to the channel bottom in order to capture data during low flows. There was evidence of flow at NUB01 and CHC01 since the last time they had been visited, in 2002.

2.1.2 Hydrologic monitoring equipment installation

2.1.2.1 Walnut Creek below Lower Lake Mary

At LLM01, SCPN water resources staff installed a recording water pressure and temperature transducer (Solinst Levellogger Junior) in the lower gage riser on January 18, 2010. The transducer was set to record at 15-minute intervals. A locking well plug was used to secure the transducer inside the riser pipe. We returned to the site on October 14, 2010, to download the instrumentation and to survey the stream channel, the gage, and selected survey control points.

2.1.2.2 Walnut Creek near upstream (old) boundary

In December 2009, SCPN staff adjusted the existing crest-stage gage at NUB01, lowering the riser nearer to the channel bottom. The change consisted of modifications to the support brackets; no holes were drilled in the canyon walls. During the same visit, a recording water pressure and temperature transducer (Solinst Levellogger Junior) was installed in the gage, and a recording barometric pressure sensor (Solinst Barologger Gold) was suspended from a tree in an unobtrusive location across the channel from the gage. The Barologger data are used to compensate for barometric pressure effects on data recorded by the water pressure transducers at all 3 sites. The transducer and Barologger were each set to a 15-minute recording interval. A locking well plug was used to secure the transducer inside the riser pipe. We returned on October 11, 2010, to download the transducer and Barologger and to survey the stream channel, the gage, and selected control points. For unknown reasons, the transducer data collected since installation were found to be corrupted and the transducer was replaced on October 23, 2010.

2.1.2.3 Cherry Creek near downstream

On October 13, 2010, at CHC01, a recording water pressure and temperature transducer (Solinst Levellogger Junior) was installed in the lower gage riser and set to record at 15-minute intervals. A locking well plug was used to secure the transducer inside the riser pipe. The stream channel, the gage, and selected survey control points were also surveyed on this date.

2.1.3 Survey

We used a total station survey instrument (Topcon GTS-229W) to survey the stream channel, the gage, and several selected survey control points at each site. The control points were established on natural, stable features and enable repeatability of comparative future surveys. Each channel survey included 3 transects perpendicular to the stream channel and the longitudinal stream channel bottom (thalweg) profile. All surveyed point coordinates were reported relative to the arbitrary survey origin and datum, and the survey datum was always set to 1000.00 m. We documented and photographed the gages, survey control points, and the stream channel at each site.

2.1.4 Hydrologic data collection

SCPN water resources staff visited each site at least once after the equipment installations and surveys. The LLM01 instrumentation was downloaded on October 14, 2010, and on November 12, 2011. Data were downloaded at NUB01 on November 12, 2011, and at CHC01 on November 11, 2011.

Local daily precipitation data were downloaded from Global Historical Climatology Network (GHCN) station USC00029156, located in WACA about 300 m southeast of the Visitor Center. This station is operated by the National Climatic Data Center (NCDC) (National Climatic Data Center, Climate Data Online n.d.).

2.2 Data analysis

2.2.1 Hydrologic data processing

Hydrologic data collected by SCPN consist of water and barometric pressure data logged by the Solinst transducers and Barologger, respectively, in metric units, and water and air temperature data collected by the same instruments in °C (not reported here). The Barologger pressure data are used to correct (compensate) for barometric pressure effects on the raw transducer water level data.

We used points surveyed on the top of each gage riser to transform water levels recorded by the transducers (compensated for barometric pressure) into elevation format. Data were archived in the SCPN hydrology database. The transformed data document any surface flow events that occur at the monitoring sites, and can be evaluated relative to measurements of daily precipitation collected at nearby climate stations.

2.2.2 Survey data processing

Survey data collected at each monitoring site consist of coordinates (x, y) and elevations (z) for each point mapped during the total station survey, reported in metric units relative to the arbitrary survey origin and datum. Terramodel terrain modeling software (v. 10.4, 2005) was used to construct a plan view diagram of the surveyed points. We constructed diagrams of the surveyed thalweg profile and transects in SigmaPlot (v. 8.0, 2007).

3 Results

Results from the data collected during the period from January 2010 through September 2011 are summarized below.

3.1 Hydrologic conditions

3.1.1 Water levels

At LLM01, no flow events were recorded by the RSG between January 2010 and the end of September 2011, although snowmelt at the site probably left standing pools of water during spring months, and isolated pools were observed in October 2010. No flows were detected at NUB01 between October 2010 and September 2011.

Scattered, brief surface flows were recorded at CHC01 in late December 2010, and in March, April, May, and August of 2011. These events were short in duration, with all flows except early March lasting less than 30 minutes. Streamflow at CHC01 in early March occurred over an 8-hour period, coinciding with a slight warming trend in temperatures reported by the transducer at the site. The highest flow recorded reached a depth of about 0.3 m above the stream channel bottom. Figure 2 shows water level data from December 2010 through September 2011 in relation to daily precipitation recorded at GHCN station USC00029156, near the WACA Visitor Center. The GHCN station is about 2.5 km northwest of CHC01. Zero precipitation was recorded on 66 of 304 days during the period (21.7%). The largest amounts of precipitation during any consecutive 10 days occurred in late February 2011 (snowfall, equivalent to 65 mm of water) and in August 2011 (64 mm). Eighty percent of the 10-day August precipitation was received on a single day—August 15—however, the only surface flow recorded at CHC01 that month occurred on August 2. The GHCN station reported approximately 15 mm of rainfall for August 1–2.

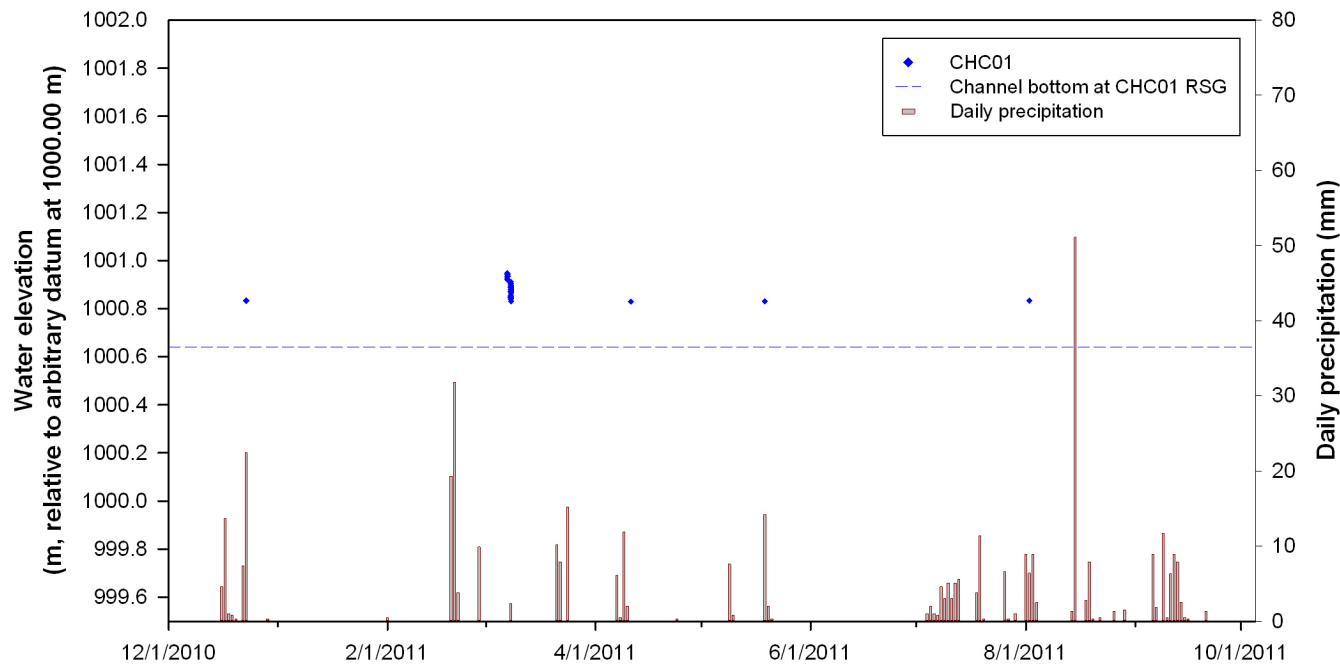


Figure 2. Recorded water levels at CHC01 from December 13, 2010 through September 30, 2011, in Walnut Canyon N.M. Daily precipitation recorded at the GHCN weather station near the WACA Visitor Center from December 1, 2010 through September 30, 2011 is plotted relative to the right axis.

3.2 Topographic and hydrologic instrumentation mapping

Table 1 lists the elevation of the top lip of the RSG, channel bottom at the RSG, and transducer port elevation (minimum water detection elevation) for each of the 3 sites, based on the survey data collected in October 2010. Plan views of the surveyed channel thalweg, transects, and hydrologic monitoring installations at each site were created in Terramodel (v. 10.4, 2005) from the survey data. The internal survey precision was ± 0.01 m, both horizontal and vertical.

Table 1. Elevations from the initial survey data collected at LLM01, NUB01, and CHC01 in Walnut Canyon N.M., October 2010, relative to the arbitrary survey datum of 1000.00 m at each site

Location	Elevation (m)		
	LLM01	NUB01	CHC01
Top lip, lower gage —RSG measuring point	1001.56	1003.22 ^a	1002.28
Transducer port—minimum water sensing elevation	1000.12	1000.30	1000.78
Channel bottom at RSG	999.99	999.88	1000.61

^aThere is a single gage riser pipe at the NUB01 site.

3.2.1 Walnut Creek below Lower Lake Mary

Figure 3 is the plan view of points mapped at LLM01 in October 2010. The 3 cross-channel transects (T1–T3) mapped at the site are numbered in downstream to upstream order. The surveyed profile reach is approximately 120 m long, ending where a series of remnant concrete bridge abutments cross the channel.

Figure 3. Plan view from the LLM01 survey near Walnut Canyon N.M., October 2010. The small red dots are points surveyed along the 3 cross-channel transects (T1–T3); the RSG is located on transect T2. Large blue diamonds are points surveyed in the main channel thalweg. Brown polygons indicate the survey control points (RM1–RM3, OP1), and the upper and lower stage gages.

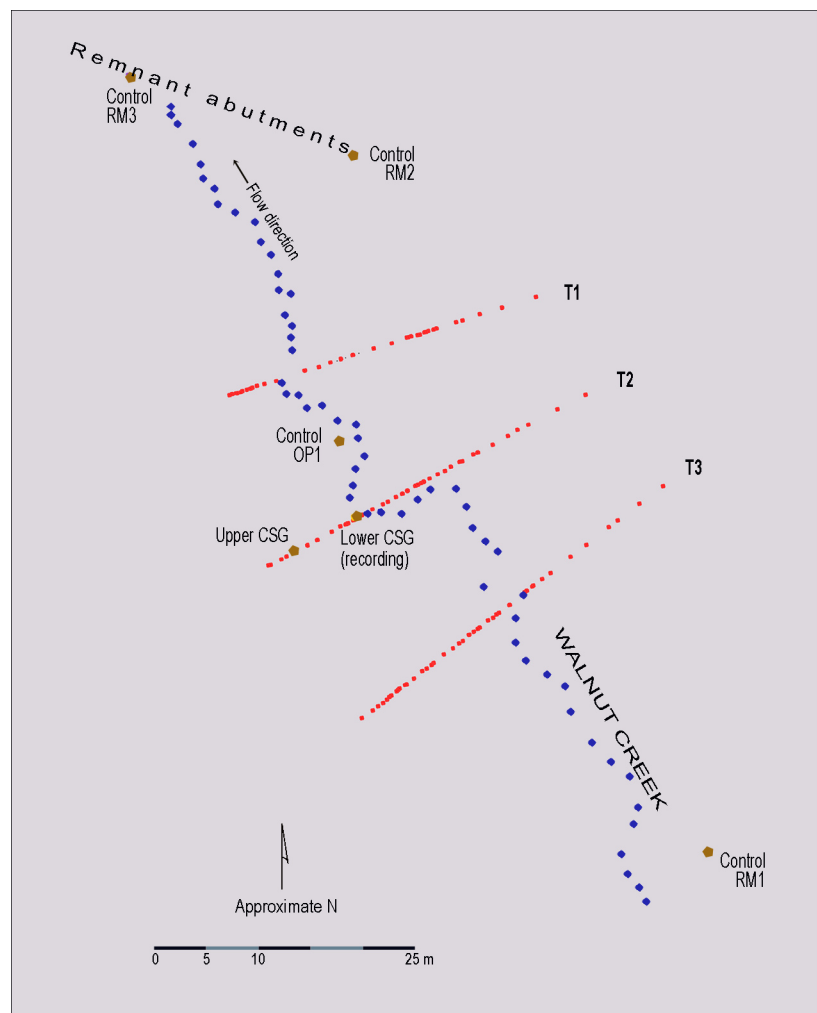


Figure 4 shows the surveyed channel profile and the positions of the lower and upper stage gages; the recording transducer is suspended in the lower gage. The overall slope through the surveyed reach shown on Figure 4 is 0.6%; however, from the highest-elevation point surveyed (near station 108) to the lowest (near station 183), the elevation difference is about 1.4 m and the resulting slope is steeper, nearly 1.9%. The channel bottom is rocky and crosses a number of exposed bedrock areas; dense growths of grass and sedge species cover much of the channel bottom through the surveyed reach. The bedrock substrate creates areas where isolated pools form following streamflow recession or substantial localized precipitation, as between stations 175 and 190 on Figure 4. No water was present at the base of the gage on the survey date.

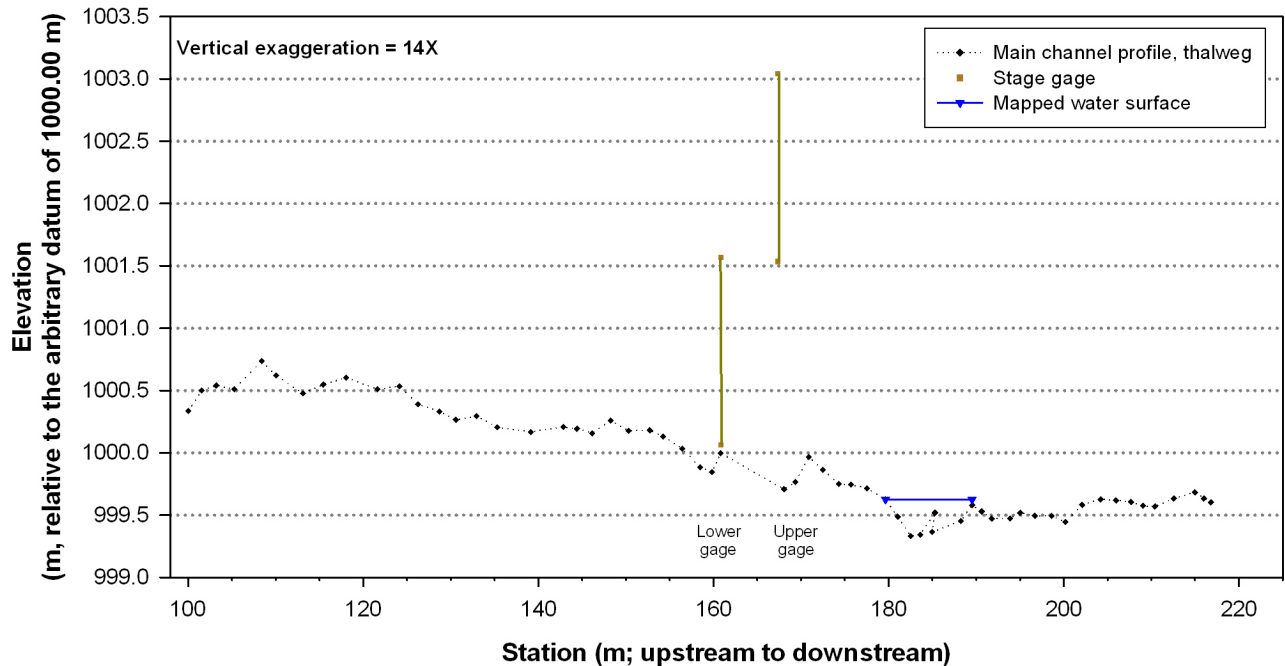


Figure 4. Profile view of the LLM01 site thalweg through the surveyed reach, including surface water present on the survey date, and the locations and relative elevations of the hydrologic monitoring equipment near Walnut Canyon N.M., October 2010. X axis stationing is distance from the profile origin (arbitrarily set to 100.00 m); Y axis scaling is exaggerated 14 times to show detail. Each monitoring installation is labeled just above the bottom axis. The elevations of both the top and bottom of each gage are graphed for reference.

Figures 5a–c show the surveyed transects at LLM01. T1, the downstream-most transect, was approximately 30 m wide (fig. 5a); 2 isolated pools were present along it on the survey date. The channel narrows slightly at T1, but is generally consistent through the reach. The T2 transect, covering the lower and upper gages, is approximately 35 m wide and was dry on the survey date (fig. 5b). T3, the upstream-most transect, is about 35 m wide, and was also dry on the survey date (fig. 5c). Abrupt elevation changes on all transects are boulders or bedrock outcrops.

3.2.2 Walnut Creek near upstream (old) boundary

Figure 6 is the plan view of points surveyed at NUB01 in October 2010. The 3 cross-channel transects (T1–T3) surveyed at the site are numbered in downstream to upstream order. The surveyed profile reach is approximately 90 m long.

Figure 7 shows the surveyed channel profile and the position of the crest-stage gage in which the recording transducer is suspended. Irregularities in the bedrock to which the gage is attached preclude positioning the bottom of the gage closer than 0.3 m above the channel bottom. No surface water was present in the surveyed reach on the survey date. The channel profile in this reach reflects areas of substantial flood-deposited debris comprised of lightweight vegetation, branches, and tree trunks; a series of depositional areas are created by the flood debris and dense brushy vegetation is present throughout the channel bottom. Channel aggradation at the downstream end of the mapped reach is caused by a large mass of flood debris blocking the channel bottom (approximately stations 175–185). The aggradation creates a negative overall slope in the surveyed reach of about -0.7%, so that any surface flows that do occur would tend to pool in the reach.

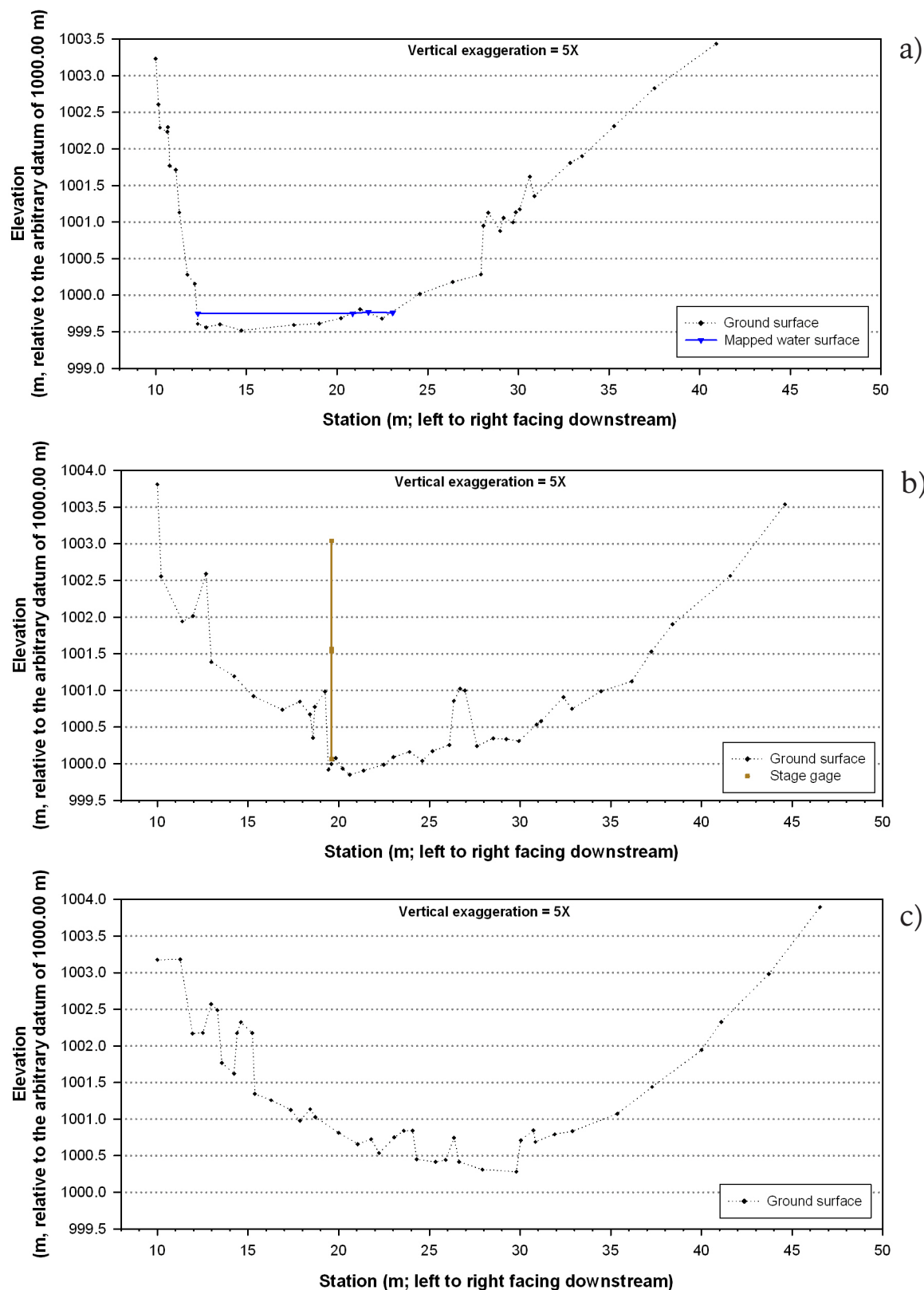


Figure 5. Cross-section views of the T1 (a), T2 (b), and T3 (c) transects at LLM01 near Walnut Canyon N.M., October 2010. X axis stationing is distance from the left endpoint (arbitrarily set to 10.00 m); Y axis scaling is exaggerated 5 times to show detail. Two isolated pools were mapped on the T1 transect, but no water was present on the survey date on the other transects. Figure 5b shows the elevations of the lower and upper gages (vertically stacked) on T2 for reference.

Figures 8a–c show the surveyed transects within the NUB01 reach. T1, the downstream-most transect, is approximately 15 m wide and is bounded by vertical bedrock (fig. 8a). The T2 transect on which the gage is located is approximately 20 m wide (fig. 8b). T3, the upstream-most transect, is also about 20 m wide (fig. 8c). The channel thalweg at both T2 and T3 is at the far right of the channel, against the base of a vertical bedrock wall.

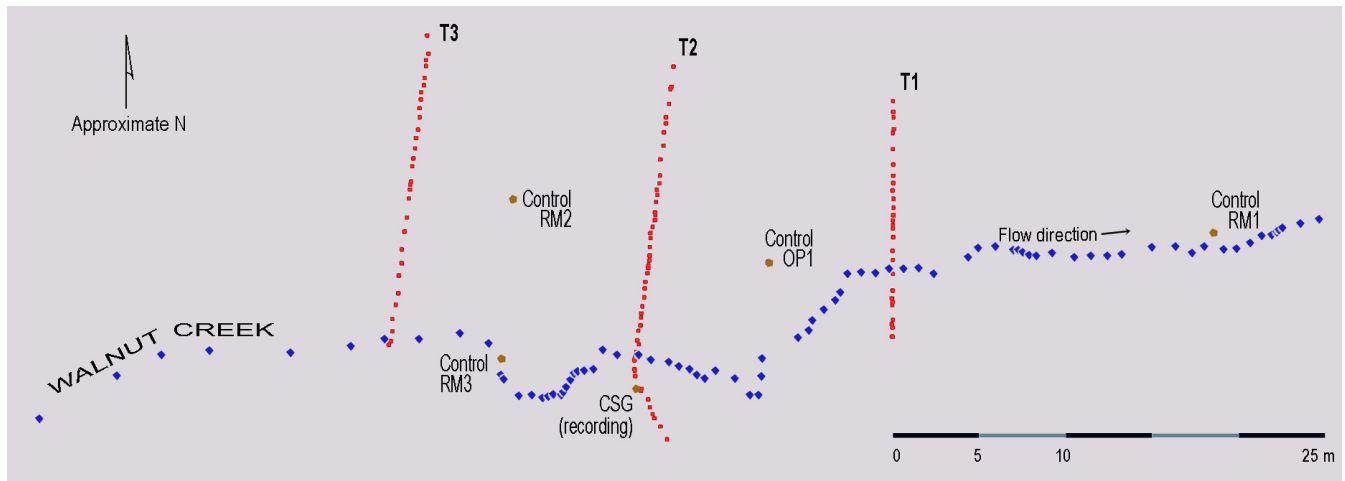


Figure 6. Plan view from the NUB01 survey in Walnut Canyon N.M., October 2010. The small red dots are points surveyed along the 3 cross-channel transects (T1–T3); the RSG is located on transect T2. Large blue diamonds are points surveyed in the main channel thalweg. Brown polygons indicate the survey control points (RM1–RM3, OP1), and the recording stage gage (RSG).

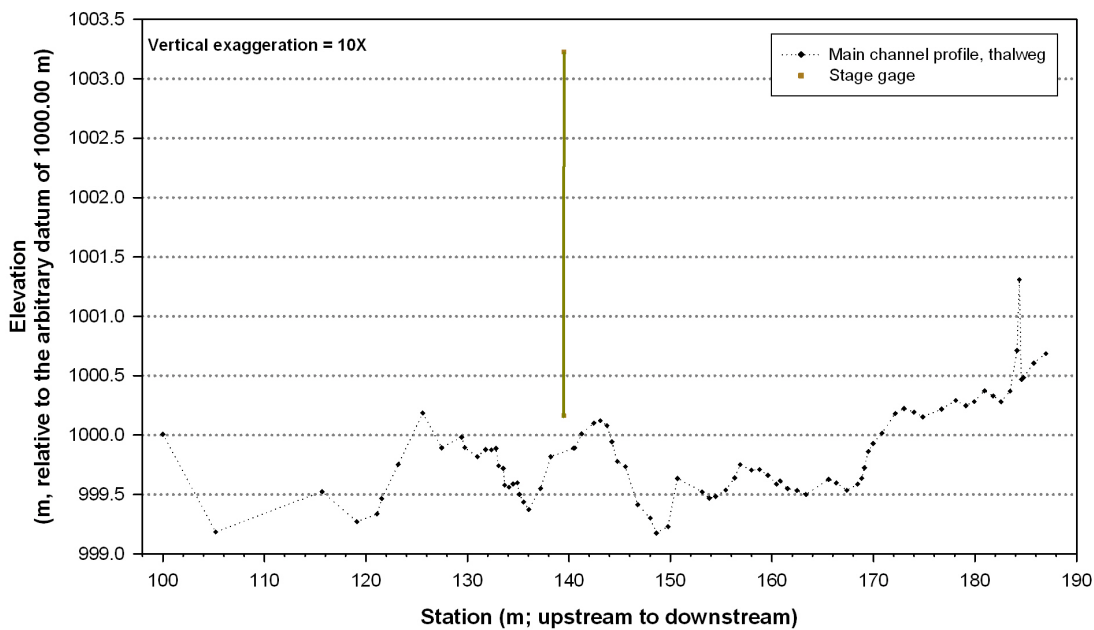


Figure 7. Profile view of the NUB01 thalweg through the surveyed reach, and the location and relative elevation of the hydrologic monitoring equipment, in Walnut Canyon N.M., October 2010. X axis stationing is distance from the profile origin (arbitrarily set to 100.00 m); Y axis scaling is exaggerated 10 times to show detail.

3.2.3 Cherry Creek near downstream

Figure 9 is the plan view of points mapped at CHC01 in October 2010. The 3 cross-channel transects (T1–T3) mapped at the site are numbered in downstream to upstream order. The surveyed profile reach is approximately 55 m long. No water was present on the day of the survey, although there was evidence of recent flows (light flood debris along the channel banks) about 0.5 m above the channel thalweg. The lower gage in which the recording transducer is suspended is on channel right, and the upper gage is on channel left.

Figure 10 shows the surveyed channel profile and the positions of the lower and upper stage gages; the recording transducer is suspended in the lower gage. The overall slope through the surveyed reach shown on Figure 10 is steep, about 2.6%; most of the drop occurs in 2 scour pools, approximately stations 112–120 and 128–143. Boulders and large cobbles occupy the channel bottom, which is bounded by outcrops of bedrock.

Figures 11a–c show the surveyed transects within the CHC01 reach. All 3 transects are approximately 22 m wide, and the channel form is generally consistent through the mapped reach. On Figure 11b, the positions of the upper and lower gages on T2 are shown; the upper gage is mounted at an angle on sloping bedrock.

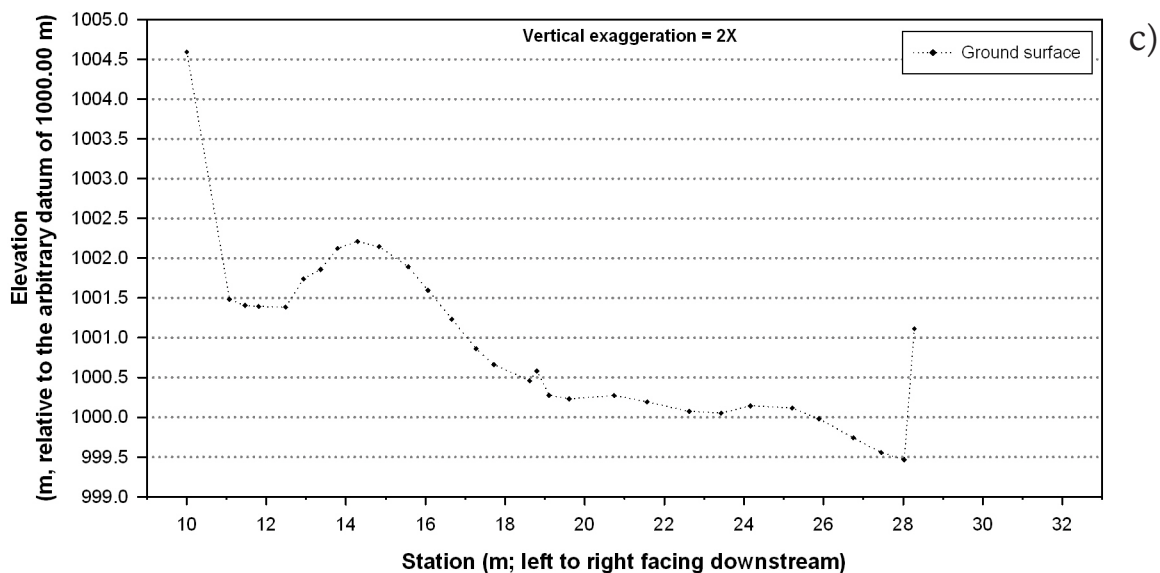
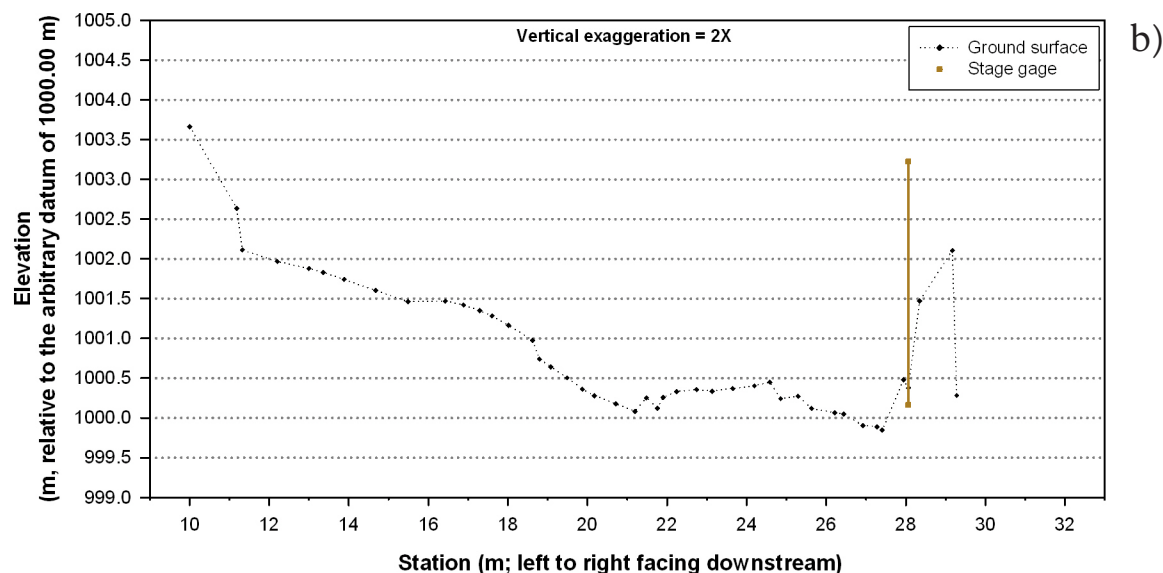
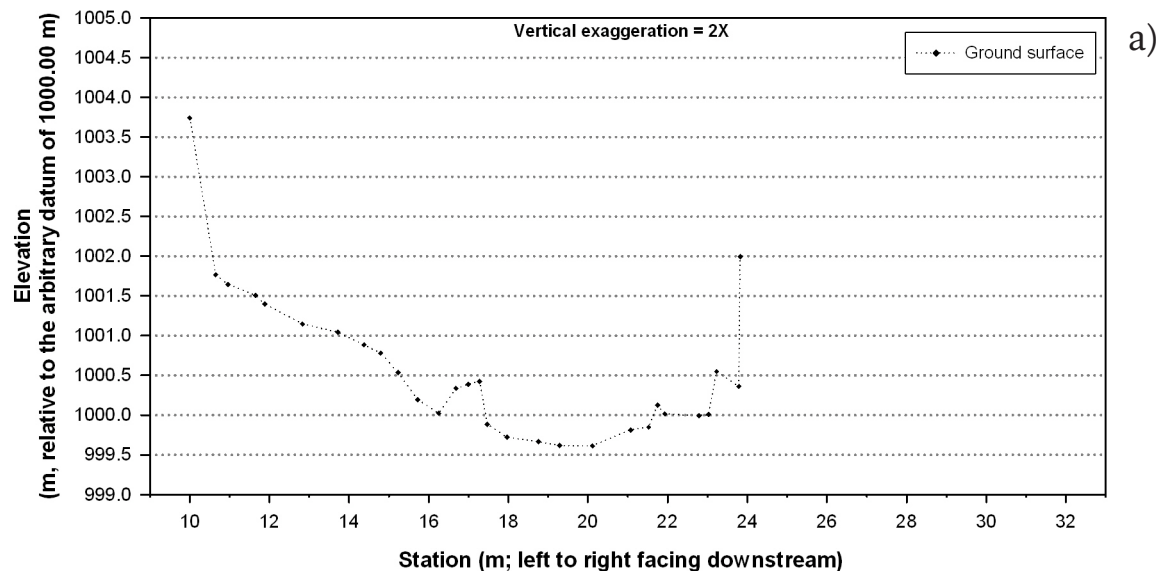


Figure 8. Cross-section views of the T1 (a), T2 (b), and T3 (c) transects at NUB01 in Walnut Canyon N.M., October 2010. X axis stationing is distance from the left endpoint (arbitrarily set to 10.00 m); Y axis scaling is exaggerated 2 times to show detail. Figure 8b shows the elevation of the gage on T2 for reference. No water was present at the site during mapping in October 2010.

Figure 9. Plan view from the CHC01 survey in Walnut Canyon N.M., October 2010. The small red dots are points surveyed along the 3 cross-channel transects (T1–T3); the lower (recording) and upper gages are located on transect T2. Large blue diamonds are points surveyed in the main channel thalweg. Brown polygons indicate the survey control points (RM1–RM4, OP1), and the stage gages.

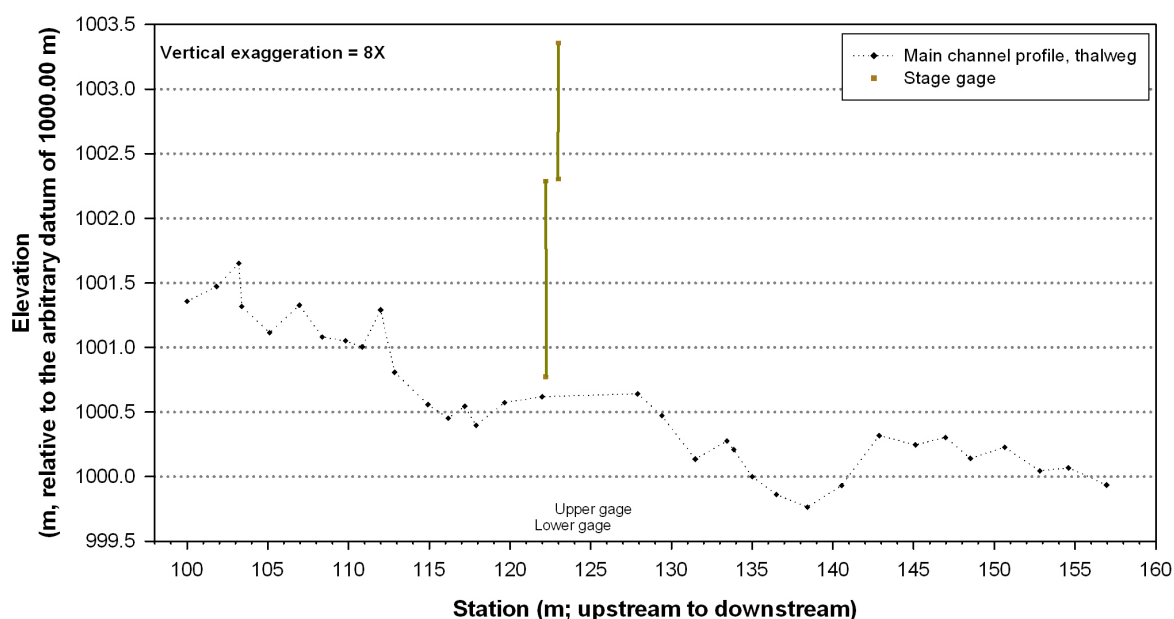
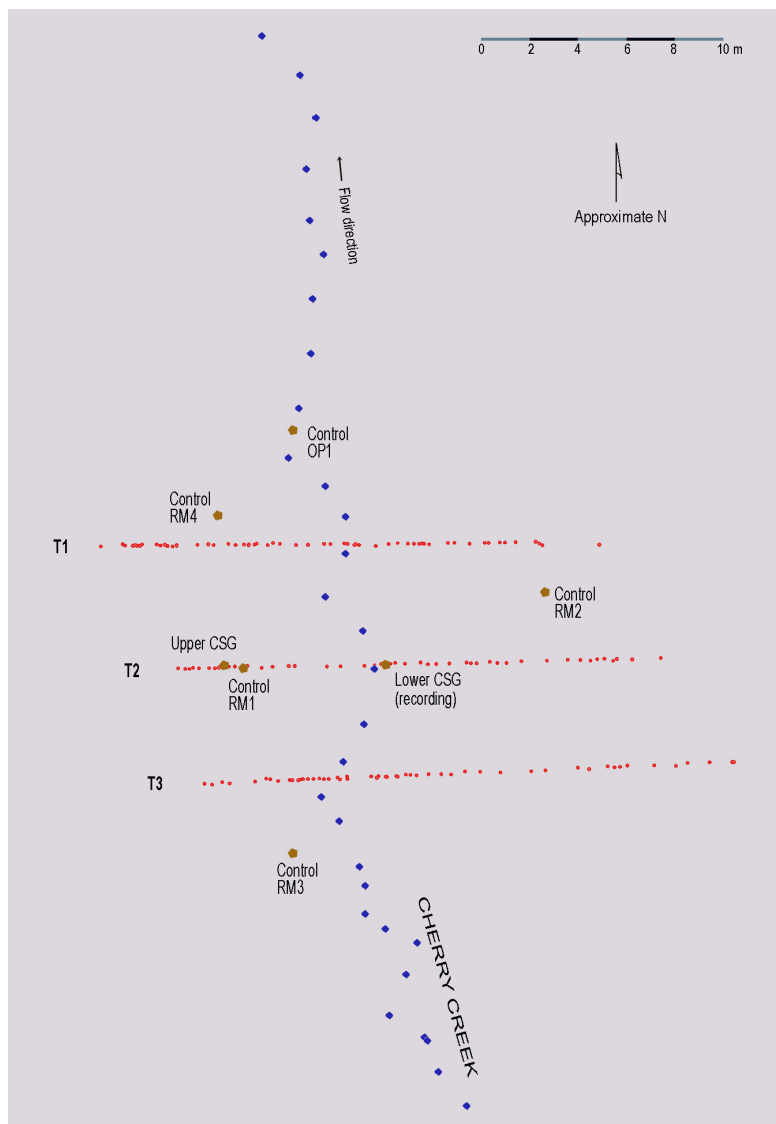


Figure 10. Profile view of the CHC01 site thalweg through the surveyed reach, including the locations and relative elevations of the stage gages in Walnut Canyon N.M., October 2010. X axis stationing is distance from the profile origin (arbitrarily set to 100.00 m); Y axis scaling is exaggerated 8 times to show detail. Each stage gage is labeled just above the bottom axis. The elevations of both the top and bottom of each gage are graphed for reference.

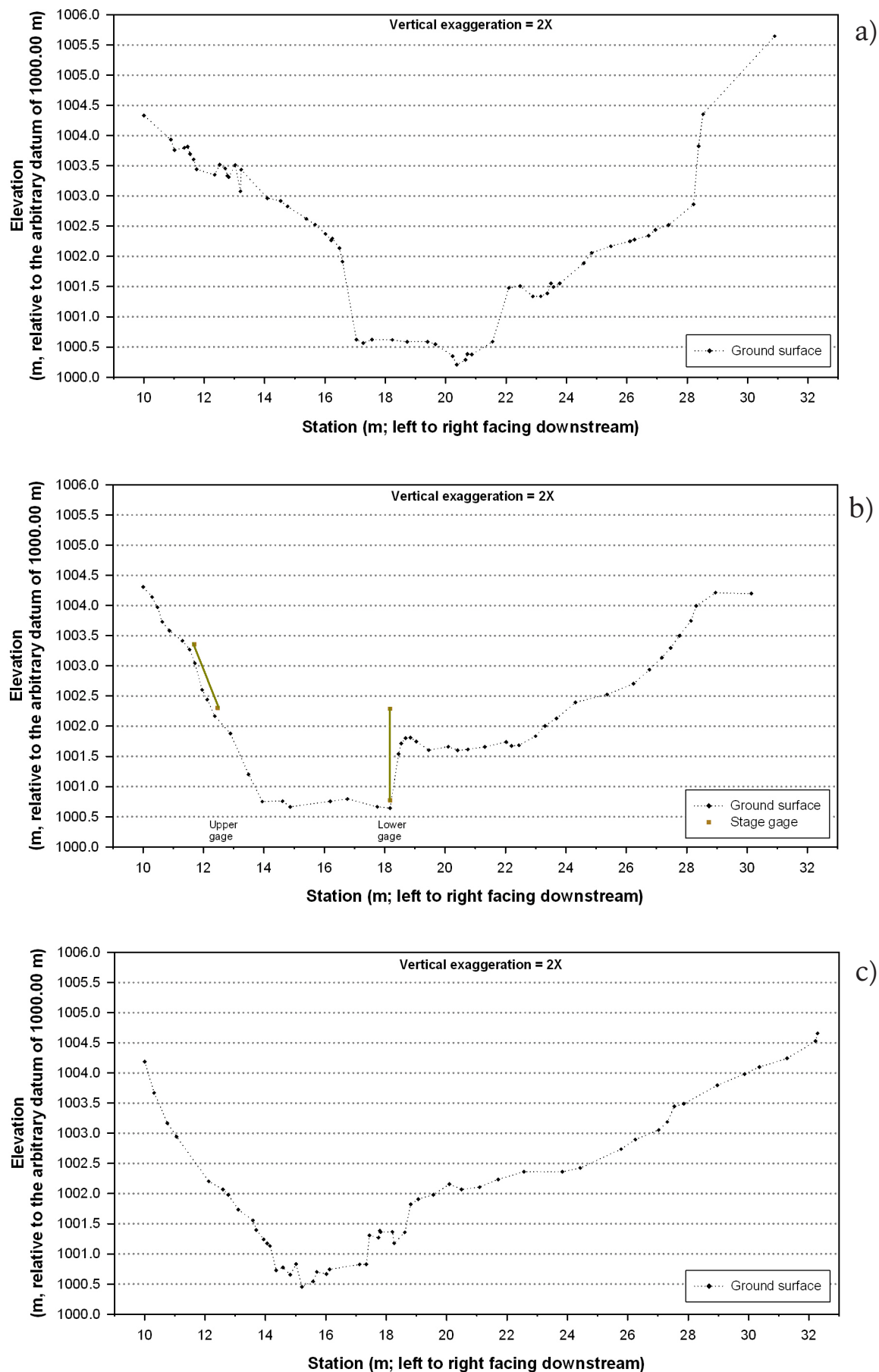


Figure 11. Cross-section views of the T1 (a), T2 (b), and T3 (c) transects at CHC01 in Walnut Canyon N.M., October 2010. X axis stationing is distance from the left endpoint (arbitrarily set to 10.00 m); Y axis scaling is exaggerated 2 times to show detail. Figure 11b shows the elevations and positions of the lower and upper gages on T2 for reference.

4 Summary

We report data collected during the first period of SCPN hydrologic monitoring for 3 sites in or near Walnut Canyon National Monument. Instrumentation installed by SCPN monitors water levels and water temperatures during ephemeral flows at 2 locations on Walnut Creek (one within and one upstream of the monument), and at Cherry Creek, a tributary to Walnut Canyon, within the monument. Air temperatures and barometric pressure levels are also recorded at one site (NUB01). The data are summarized here and are available on request.

Evaluations of hydrologic trends at any site in this region depend on long-term monitoring because of the region's high climatic variability. SCPN water resources staff will continue annual or semi-annual site visits to download the instrumentation placed at the sites and to collect manual measurements. Repeat surveys of the stream channel may be added in the future as an additional monitoring component in order to document geomorphic changes after major flood events.

4.1 Water levels

Through the period for which data have been collected, surface flows were recorded at only 1 of the 3 monitoring sites: CHC01. Five surface flows were recorded at this site. All were generally brief, lasting 30 minutes or less, except for an 8-hour flow event recorded in March 2011, during a period of warming temperatures. Substantial snowfall was recorded at the GHCN station (USC00029156) near the WACA Visitor Center during 10 days prior to the March flow event. More than 50 mm of rainfall were also recorded at the climate station on August 15, 2011, but no surface flows registered at CHC01 that day. The only surface flow recorded at CHC01 in August 2011 was on August 2, when the GHCN station reported about 15 mm of rainfall over a 2-day period.

4.2 Channel surveys

The initial total station survey of the thalweg profile and 3 transects at each site establishes a baseline condition against which results from repeat surveys can be compared. Changes over time in channel form or thalweg elevation may be evaluated for additional evidence of surface flow magnitudes.

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Appendix A: Monitoring site locations, metrics, collection methods and time-frames for hydrologic data collected at Walnut Canyon National Monument, January 2010–September 2011

Site code	Site common name	Coordinates UTM NAD 83 (m)	Elevation (m)	Data type(s)	Data period	Collection method, interval
WACALLM01	Walnut Creek below Lower Lake Mary	445927 E, 3886665 N	2060 (est)	water levels	1/18/2010– 9/30/2011	recording, quarter-hourly
				water levels	1/18/2010– 9/30/2011	manual, annually
				topographic	10/14/2010	total station, once
WACANUB01	Walnut Creek near upstream (old) boundary	452264 E, 3891534 N	1944 (est)	water levels	10/11/2010– 9/30/2011	recording, quarter-hourly
				water levels	10/11/2010– 9/30/2011	manual, annually
				topographic	10/11/2010	total station, once
WACACHC01	Cherry Creek near down- stream boundary	456125 E, 3890463 N	1920 (est)	water levels	10/13/2010– 9/30/2011	recording, quarter-hourly
				water levels	10/13/2010– 9/30/2011	manual, annually
				topographic	10/13/2010	total station, once
USC00029156	WACA GHCN climate station	453858.7 E, 3892079.7 N	2037.6	precipitation	1/1/2010 – 9/30/2011	unknown, daily