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DEPARTMENT OF WATER RESOURCES
Division of Integrated Regional Water Management
North Central Region Office
Water Quality Evaluation Section

Truckee River
Water Quality Monitoring Report
for
Truckee River Operating Agreement
Water Year 2017

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Acronyms and Abbreviations

^{0}C	degrees Celsius
af	acre-feet
Bridge 8	Truckee River at Bridge 8
CDEC	California Data Exchange Center
DO	dissolved oxygen
DWR	California Department of Water Resources
EC	Electrical Conductivity
EIS/EIR	environmental impact statement/environmental impact report
Farad	Truckee River at Farad
HOBO	Honest OBserver by Onset temperature logger
DOI	U.S. Department of the Interior
LRWQCB	Lahontan Regional Water Quality Control Board
LSWA	local water supply alternative
LTAB	Littlie Truckee River above Boca
mg/L	milligrams per liter
NCRO	North Central Region Office
NTU	nephelometric turbidity unit
PL	public law
QA/QC	quality assurance/quality control
SWE	Snow Water Equivalency
TMDL	total maximum daily load
TROA	Truckee River Operating Agreement
TTSA	Truckee River above Tahoe Truckee Sanitation Agency
µS/cm	microsiemens per centimeter
USGS	U. S. Geological Survey
WDL	Water Data Library
WQES	Water Quality Evaluation Section
WY	water year
YSI	Yellow Springs Instruments

Introduction

This report provides a summary and discussion of the completed and ongoing tasks conducted by the California Department of Water Resources (DWR), North Central Regional Office (NCRO), and Water Quality Evaluation Section (WQES) during Water Year (WY) 2017, covering the period from October 1, 2016, through September 30, 2017. The described tasks are related to Lake Tahoe and Truckee River Basin reservoir operations, now governed by the Truckee River Operating Agreement (TROA). This report includes background information on the project and study area, along with data analysis, results, and discussion on work completed by WQES staff through September 2017. Recommendations are also provided for ongoing and supplemental tasks.

Background

The runoff into the Truckee River Basin originates in the Lake Tahoe and Truckee River watershed basins in the Sierra Nevada of California. A portion of that runoff is diverted and stored in reservoirs, including Lake Tahoe, Donner Lake, Independence Lake, Prosser Creek Reservoir, Stampede Reservoir, Boca Reservoir, and Martis Creek Reservoir (California Department of Water Resources 1991). Operation of these reservoirs regulates much of the flow in the Truckee River in most years. Together, these reservoirs can store approximately a million acre-feet of water, in an average year, for beneficial use at later times during the year (California Department of Water Resources 1991). Several court decrees, agreements, and regulations govern day-to-day operations of these reservoirs, which are generally administered by the TROA Administrator, currently the federal watermaster for the Orr Ditch court (U.S. Department of the Interior 2008; California Department of Water Resources 2008). The reservoirs are generally operated to capture runoff that becomes available when flow in the river is greater than needed to serve downstream water rights in Nevada, and to maintain prescribed streamflows in the Truckee River, known as *Floriston rates*, which are measured at the Farad gauge near the California-Nevada state line (U.S. Department of the Interior 2008; California Department of Water Resources 2008). Floriston rates define the prescribed flow in the Truckee River that serves downstream water rights in Nevada, including hydropower generation, municipal and industrial use in Truckee Meadows, and agricultural water rights. In general, the water stored in each reservoir has been authorized to serve specific uses. Releases are made from the reservoirs, as necessary, to meet dam safety and flood control requirements, and to serve water rights when adequate unregulated flow cannot be provided to serve those rights. Minimum reservoir releases are also maintained as specified in TROA and in applicable prior agreements (U.S. Department of the Interior 2008; California Department of Water Resources 2008) or as agreed upon by the TROA signatory parties.

The environmental impact statement/environmental impact report (EIS/EIR) for TROA was jointly prepared in January of 2008 by the U.S. Department of the Interior and DWR to evaluate methods of reservoir operations along the Truckee River. The EIS/EIR evaluated the existing conditions and four alternatives, including the proposed TROA, an alternate to TROA, the Local Water Supply Alternative (LWSA), and a No Action Alternative (U.S. Department of the Interior 2008; California Department of Water Resources 2008). The EIS/EIR concluded that implementation of TROA would have no adverse environmental effects and that its implementation was the preferred alternative.

TROA is the result of section 205(a) of Public Law 101-618, which directed the U.S. Department of the Interior to negotiate an agreement with California and Nevada to increase the operational flexibility and efficiency of Lake Tahoe and the reservoirs in the Truckee River Basin.

In September of 2008, TROA was conditionally signed into agreement by the U.S. Department of the Interior, U.S. Department of Justice, states of California and Nevada, Pyramid Lake Paiute Tribe, Truckee Meadows Water Authority, and other entities in California and Nevada. In December 2015, TROA was implemented by the TROA Administrator and the Orr Ditch Court, District of Nevada, after completing the remaining requirements of Public Law 101-618 for TROA implementation.

The EIS/EIR did not identify any significant negative impacts or mandate any mitigations for any effects of TROA. Nevertheless, California DWR and California Department of Fish and Wildlife chose to implement this project, designed and carried out by the WQES, to provide and evaluate data for certain water quality parameters and identify possible effects or trends of TROA implementation and related reservoir operations on water quality (both positive and negative) in the Truckee River and its tributaries for a period of approximately five years. Data obtained during this study will be compared with available pre-implementation data to identify possible effects and also provide a baseline for relevant future studies.

NCRO WQES Tasks

To monitor certain streamflow characteristics and provide a continuing record, NCRO WQES staff, in coordination with the NCRO California-Nevada & Watershed Assessment Section, continued the monitoring effort implemented in 2016 and performed several tasks for the Truckee River Water Quality Monitoring Program during 2017, as outlined in the following points:

- Maintained four continuous (15-minute data) multi-parameter water-quality monitoring stations that had been operated prior to the implementation of TROA and re-installed in 2016. Each station was equipped with YSI probes (described below). These stations are located at: (1) Truckee River at Bridge 8, (2) Truckee River above the Tahoe-Truckee Sanitation Agency (TTSA), (3) Little Truckee River above Boca Reservoir, and (4) Truckee River at Farad. These stations collect data for the following parameters: water temperature in degrees Celcius (°C), specific conductance in micro-Siemens per centimeter (µS/cm), dissolved oxygen (DO) concentration in milligrams per liter (mg/L), percentage of dissolved oxygen saturation, turbididty in nephelometric turbidity units (NTU), and acidity (hydrogen ion concentration [or pH]).
- Maintained temperature gauges along the Truckee River and upstream of its confluences with Donner Creek, Prosser Creek, and the Little Truckee River to monitor temperature influences of reservoir inflow to the mainstem of the Truckee River.
- Analyzed water quality trends observed during Water Year 2017.
- Compared the water quality conditions observed in post-TROA water years with conditions observed in water years with similar hydrologic conditions prior to TROA implementation.
- Investigated the observed temperature conditions along the Truckee River for WY 2017, identifying and examining any observed effects of reservoir releases on the temperature of the Truckee River.

Materials and Methods

Instrumentation

NCRO WQES staff deployed Yellow Springs Instruments (YSI) multi-parameter sondes (Figure 1) along the Truckee River, approximately 15 centimeters (cm) to 1 meter below the water surface, to record water quality parameters at 15-minute intervals. For this study, the parameters of primary concern measured by the sondes are water temperature (°C), specific conductance (µS/cm, which is the measure of electrical conductance (EC) at a constant temperature of 25 °C), dissolved oxygen concentration (mg/L), percentage of dissolved oxygen saturation, turbididty (NTU), and acidity (pH). Sondes were deployed within a polyvinyl chloride (PVC) pipe housing with several 2.25-inch diameter holes drilled through the side of the pipe, nine-inches apart, to allow adequate water flow to the water quality sensors. Note that in this report the terms “probe” and “sensor” are used interchangeably.

Figure 1 YSI 6600 Multi-Parameter Water Quality Sonde with Temperature, EC, Dissolved Oxygen, Turbidity, and pH Probes

For the temperature study, WQES staff deployed Honest OBserver by Onset Water Temperature Pro v2 loggers (HOBOs) (Figure 2) to record the temperature at 15-minute intervals. The loggers were weighted, attached to a cable, and placed into a pool along the river. The cable was anchored to the bank with a spiral ground anchor approximately 20 to 40 cm long. The probes, which were not contained within a PVC housing (unlike the sondes), were then placed into the river.

Figure 2 Onset HOBO Water Temperature Pro v2 Loggers, P/N U22-001

In addition to continuous water-quality monitoring using YSI multi-parameter sondes, NCRO staff used field instruments to take measurements during field runs to check the validity of the sonde data. These instruments are listed below:

- YSI Pro 1030 handheld unit to measure water temperature, pH, specific conductance, and salinity.
- YSI Pro-ODO luminescent dissolved oxygen handheld unit to measure water temperature and dissolved oxygen concentrations.
- HACH 2100P turbidimeter to measure turbidity.

The YSI Pro 1030 and YSI Pro-ODO handheld units are calibrated before each field run. The Hach 2100P turbidimeter is calibrated every three months and is also checked for accuracy, using deionized water (which has a turbidity of 0 NTU), before each field run.

Data Collection

NCRO WQES staff clean and calibrate each sonde before deployment to ensure each probe is operating correctly. Calibration methods for each constituent are based on the “Principles of Operation” section of each YSI product’s operation manual (Yellow Springs Instruments 2009). Sondes are deployed for one month before they are exchanged with newly calibrated sondes. Increased biological activity (typically in warmer months) can foul probes and cause instrument malfunctions that decrease the deployment time of a sonde. During a field visit, water quality parameters are measured with the field instruments at each site. Field instrument readings are compared to sonde data at sampling time to verify sonde data quality.

Data Quality Assurance / Quality Control (QA/QC)

NCRO WQES staff performs three procedures to verify that sondes retrieved from the field have recorded data with acceptable accuracy during their deployment period. First, a post-deployment accuracy check is performed on the day the sondes are removed from the field. Second, field water-quality measurements are compared to sonde data recorded at the closest 15-minute interval. Third, the data are visually inspected by WQES staff to identify questionable and unreliable data (California Department of Water Resources 2015).

The accuracy of sonde water quality data can be compromised by probe malfunction, drift from initial calibration, and fouling caused by biological growth or sediment on the probe reading surface while deployed. After removal from the site, accuracy of sonde data is verified by testing the water quality probes by using the calibration standards at NCRO's water quality lab prior to cleaning them. The quality of the data is then rated as “Excellent,” “Good,” “Fair,” or “Poor” based on probe deviation from the calibration standard. Data rated as “Poor” are flagged in the database and are not used in this report.

During site visits, field data are collected within five minutes before or after the closest 15-minute interval as a secondary check on data accuracy. Large differences between field and sonde data can indicate poor quality data and may also result in a rating of “Poor” and a decision to exclude said data from analysis.

Sonde water quality data are visually inspected by WQES in NCRO’s Hydstra database as a final quality assurance/quality control (QA/QC) check before the data uploads to DWR’s Water Data Library (WDL). The WDL can be found at http://wdl.water.ca.gov/. Outliers and other questionable data are flagged in Hydstra as “Unreliable” by the reviewer following established protocols (California Department of Water Resources 2015). Data deemed unreliable do not transfer from Hydstra to WDL and are not used for further data analysis.

Data gaps can occur in these datasets because of these outliers, equipment malfunction, freezing water temperatures, environmental fouling of the sensors, and environmental conditions that may cause damage to the sonde. Such conditions, including the water in the housing freezing around the sonde, may result in removal of the sonde from the testing area.

WY 2017 Results and Discussion

Water Quality Station

Multi-parameter water quality sondes were maintained at four stations along the Truckee River during WY 2017 (Figure 3 and Table 1). All four sites monitor for temperature (°C), dissolved oxygen (mg/L), specific conductance (µS/cm), turbidity (NTU), and acidity (pH).

Figure 3 **Water Quality Monitoring Sites Along the Truckee River and its Tributaries**

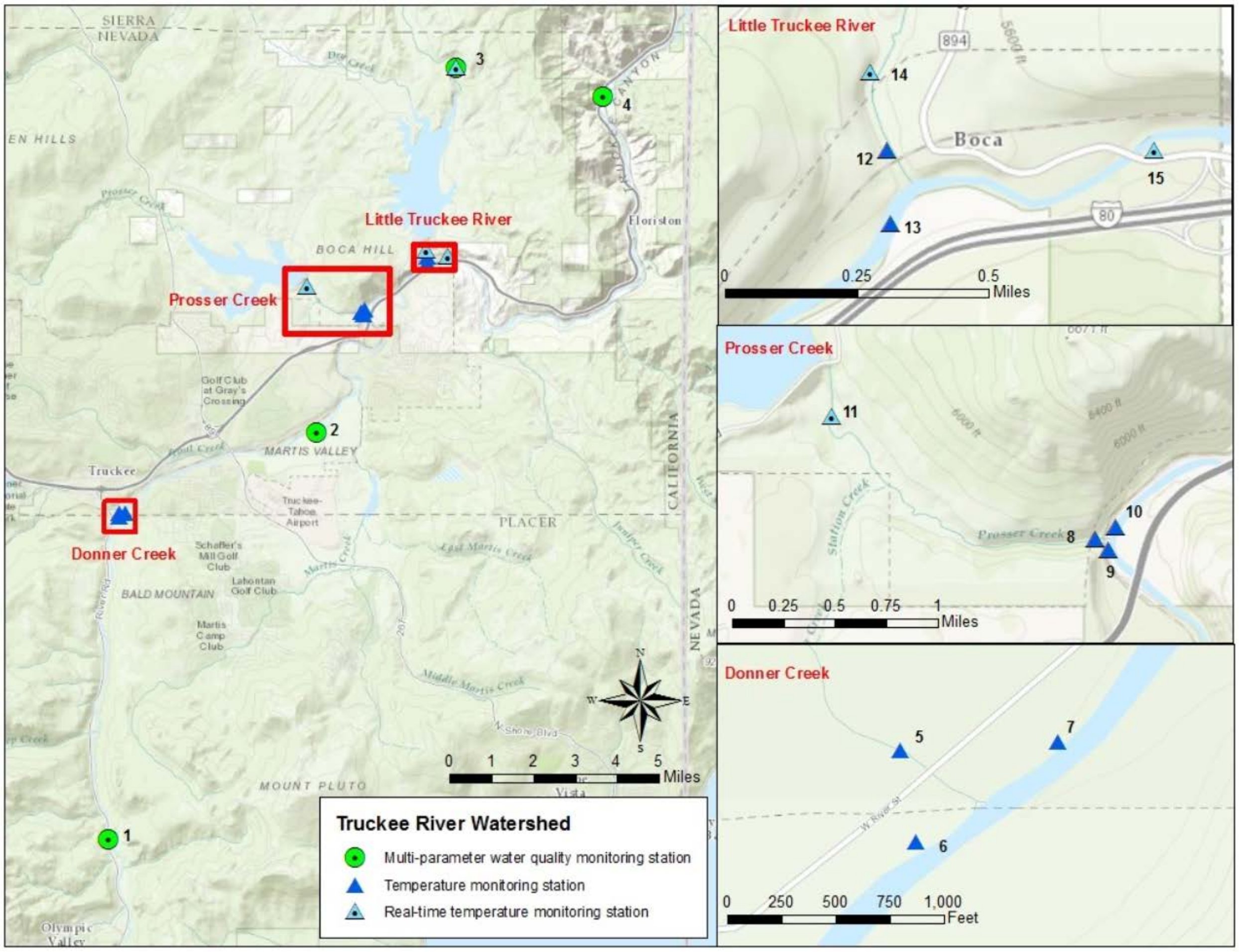


Table 1 **Multi-Parameter Water Quality Monitoring Stations Along the Truckee River and Tributaries, WY 2017**

Station Number	Station Name	Station Abbreviation	Latitude	Longitude	Installation Date
1	Truckee River at Bridge 8	Bridge 8	39.22933	-120.20522	September 11, 2015
2	Truckee River above Tahoe Truckee Sanitation Agency	TTSA	39.33820	-120.13326	March 16, 2016
3	Little Truckee River above Boca Reservoir	LTAB	39.43577	-120.08493	March 16, 2016
4	Truckee River at Farad	Farad	39.42790	-120.03406	September 11, 2015

In addition to the multi-parameter water quality stations, a network of temperature monitoring stations is used to check temperature influences of Donner Creek, Prosser Creek, and Little Truckee River along the Truckee River (Figure 3). Eight of these temperature monitoring stations are HOBO loggers maintained by WQES staff. Two HOBO loggers are deployed at each site to check data for accuracy and provide redundancy.

In 2016, WQES staff coordinated with the U.S. Geological Survey (USGS) to install and connect temperature probes to certain existing USGS stations already outfitted with telemetry systems in order to provide real-time temperature data through the California Data Exchange Center (CDEC) website. CDEC provides a centralized location to store and process real-time hydrologic information gathered by various operators throughout the state. Data for these telemetered stations can be found at http://cdec.water.ca.gov/queryQuick.html by searching for a station's 3-letter CDEC code, as provided in Table 2.

Note that there are two temperature sensors at the Little Truckee above Boca (LTAB) station, one that is telemetered and the other is included on the sonde. A separate temperature sensor was installed to enable data telemetry to provide for more real-time regional context of temperature variations. In this report, only the temperature data from the sonde was used.

The USGS station Prosser Creek below Prosser Creek Dam is located immediately downstream of the release valve on the dam. This means that the temperature sensor will only record temperatures from controlled releases and not from overflows from the spillway, as those releases flow through a separate channel below the dam.

Table 2 Temperature Monitoring Stations Along the Truckee River and its Tributaries, WY 2017

Station Number	Station name	CDEC Code	Latitude	Longitude	Installation Date
5	Donner Creek above Truckee River	--	39.31672	-120.20146	June 15, 2016
6	Truckee River above Donner Creek	--	39.31582	-120.20126	June 15, 2016
7	Truckee River Below Donner Creek	--	39.3168	-120.19946	June 15, 2016
8	Prosser Creek above Truckee River	--	39.37037	-120.11786	June 15, 2016
9	Truckee River above Prosser Creek	--	39.36974	-120.1169	June 15, 2016
10	Truckee River below Prosser Creek	--	39.37101	-120.11644	June 15, 2016
11	USGS10340500, Prosser Creek below Prosser Creek Dam	PTK	39.377	-120.1363	August 13, 2016
12	Little Truckee River above Truckee River	--	39.38517	-120.09502	June 15, 2016
13	Truckee River above Little Truckee River	--	39.38362	-120.09491	June 15, 2016
3	USGS 10344400, Little Truckee River Above Boca Reservoir	LAB	39.43577	-120.08493	July 26, 2016
14	USGS10344500, Little Truckee River below Boca Dam	LTK	39.38685	-120.09547	July 26, 2016
15	USGS 10344505, Truckee River at Boca Bridge	TBB	39.38519	-120.08768	July 26, 2016

Hydrology

Hydrologic conditions are typically discussed using "water years," which begin on October 1 of one calendar year and end on September 30 of the named year. The analysis conducted in this report covers WY 2017, which is October 1, 2016, to September 30, 2017.

Additionally, seasons were reorganized into water years to fully capture each season and improve correlations between water quality and hydrologic conditions in the study area. In this report, the seasons were shifted from conventional seasons by approximately 9 to 12 days, and are defined as fall (October 1 to December 31), winter (January 1 to March 31), spring (April 1 to June 30), and summer (July 1 to September 30).

Several different methods of classifying the water year in the Truckee River Basin exist, including:

- Comparing the total annual precipitation to the average precipitation for the area.
- Comparing the annual April 1 snowpack survey to historical data, which helps forecast the runoff the watershed will have in the spring and summer.
- Comparing the total runoff for the watershed.

These three qualifiers provide insight into classifying the water year, yet each have trade-offs. Total annual precipitation is a good qualifier, to the extent that it is not impacted by recharge, storage, or reservoir regulation, although total precipitation and precipitation type (rain versus snow) vary significantly throughout the watershed.

There is an extensive historical database of April 1 snowpack data, which makes it a good qualifier, but it does not fully capture liquid precipitation totals. With climate change, the snowpack may be melting earlier (California Department of Water Resources 2013), so the April 1 snowpack would be less representative of the predicted runoff as climate change progresses.

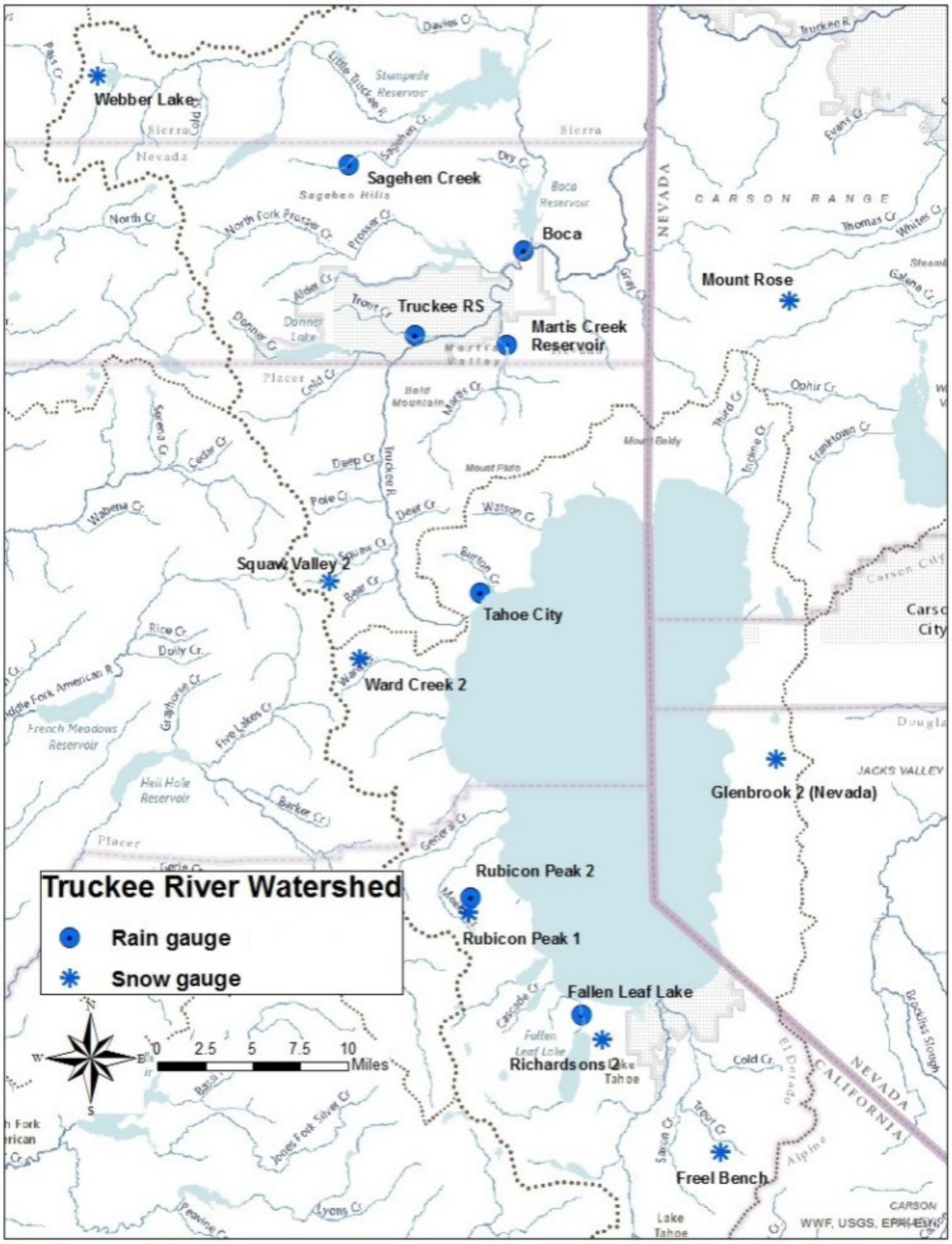
Total runoff, measured as streamflow, represents how much of the water collected in a watershed eventually drains into the river but does not account for water storage in reservoirs. Regulated reservoirs are typically operated to store winter stormwater until they are full, and then release that water later in the year. Large reservoirs can store water for multiple years. Filling a reservoir with water will reduce the downstream flow, and releasing stored water from a reservoir will increase the downstream flow. Therefore, the measured streamflow will not represent the natural runoff. To use streamflow to classify water year type, reservoir operations need to be considered as well.

This report will analyze at all three methods and compare WY 2017's data to historical averages to determine the classification for WY 2017.

Precipitation

To examine the precipitation of the Truckee River Watershed for WY 2017, WQES looked at the precipitation totals for gauges within the watershed (Figure 4).

Figure 4 Selected Rain and Snow Gauges Within the Truckee River Watershed



Note: The dotted lines outline the individual watersheds.

These rain gauges were selected to show the spatial and topographical variance of precipitation within the watershed. Table 3 displays the annual total precipitation for each station and the percentage of average precipitation, based on the historical record.

Table 3 **Annual Precipitation Totals Within the Truckee River Basin for WY 2017**

Station	CDEC Code	Elevation *(feet)*	Years Measured	Average Annual Precipitation *(inches)*	WY17 Precipitation Total *(inches)*	Percent of Average
Boca	BCA	5575	93	22.62	53.77	238%
Tahoe City	TAC	6230	108	31.58	68.73	218%
Truckee RS	TKE	6020	101	29.59	58.86	199%
Martis Creek Reservoir	MRT	5745	29	16.01	25.82	161%
Fallen Leaf Lake	FLL	6250	32	32.33	76.90	238%
Rubicon Peak 2	RP2	7500	31	41.52	81.5	196%

WY 2017 had the highest amount of precipitation on record for the state of California. Many areas within the Truckee River watershed experienced over twice the average amount of rainfall.

Table 4 **Comparison of Annual Percentage of Average Precipitation for Water Years 2000 to 2017**

Water Year	Boca	Tahoe City	Truckee RS	Sagehen Creek	Martis Creek Reservoir	Fallen Leaf Lake	Rubicon Peak 2
2000	86%	98%	98%	43%	102%	27%	26%
2001	33%	55%	53%	10%	44%	45%	58%
2002	77%	87%	72%	61%	--	85%	88%
2003	92%	89%	99%	48%	53%	94%	97%
2004	61%	76%	64%	70%	--	83%	76%
2005	108%	120%	113%	80%	141%	111%	118%
2006	142%	153%	156%	170%	219%	153%	137%
2007	58%	62%	78%	73%	84%	62%	65%
2008	69%	61%	82%	84%	72%	71%	68%
2009	67%	87%	85%	94%	71%	86%	87%
2010	89%	93%	79%	98%	111%	95%	100%
2011	162%	164%	149%	170%	504%	160%	147%
2012	69%	68%	50%	86%	128%	72%	66%
2013	74%	80%	70%	76%	106%	94%	179%
2014	65%	62%	59%	70%	74%	87%	119%
2015	83%	48%	65%	61%	53%	59%	57%
2016	122%	102%	104%	130%	107%	108%	115%
2017	238%	218%	199%	-	161%	238%	196%

Table 4 looks at the average annual precipitation for water years 2000 to 2017, the period of record for water quality monitoring along the Truckee River. Within this period, WY 2011 is the next highest in average precipitation and the closest in comparison to WY 2017. The main difference between WY 2011 and WY 2017 is the difference in precipitation distribution, most notably at Martis Creek. In WY 2011, Martis Creek had about five times its average rainfall, which is a greater amount of precipitation than in

WY 2017. Sagehen Creek is no longer being maintained by the USGS, therefore the annual precipitation data for Sagehen Creek is not included for WY 2017.

Snow Water Equivalency

The Sierra Nevada snowpack is a critical surface water resource for the State of California. The snow water equivalency (SWE) is a key index used not only for forecasting the timing and amount of streamflow, but for a wide variety of water management decisions based on the predicted flow days and months in the future (California Department of Water Resources 2014). SWE is a common snowpack measurement that describes the amount of water contained within the snowpack. Simply, it is depth of water that would theoretically result if the entire snowpack melted instantaneously (Natural Resources Conservation Service 2008). Snow surveys are collected manually and electronically throughout the Sierra Nevada by a wide variety of agencies at predetermined locations known as *snow courses* (California Department of Water Resources 2014). Measurements are made monthly throughout the winter at snow courses, with the April 1 measurements having the most importance. This measurement is key for water managers in forecasting the timing and amount of streamflow for the spring and summer.

To help classify the water year type in the Truckee River Basin, this report looks at the April 1 measurements for eight different snow courses (Figure 4 and Table 5), spread throughout the watershed at varying elevations, to show the spatial and topographic variations in snowpack.

Table 5 SWE for Snow Courses in the Truckee River Basin, WY 2017

Station Name	CDEC Code	Elevation *(feet)*	Years Measured	Average SWE *(inches)*	WY17 SWE *(inches)*	Percent of Average
Squaw Valley 2	SQ2	9000	59	47.2	80.5	171%
Webber Lake	WBB	7000	92	31.2	54.5	175%
Freel Bench	FBN	7300	86	10.4	18	173%
Ward Creek 2	WR2	7000	100	40.4	61	151%
Rubicon Peak 1	RP1	8100	81	47.5	93	196%
Glenbrook 2 (Nevada)	GL2	6900	75	11.3	19	168%
Mount Rose	MRO	9000	101	34.5	82	237%
Richardsons 2	RCH	6500	73	15.2	23	151%

Table 6 Percentage of Average April 1 SWE for Snow Courses in the Truckee River Basin for Water Years 2000 to 2017

Water Year	Site and elevation (*feet*)							
	Squaw Valley 2	Webber Lake	Freel bench	Ward Creek 2	Rubicon Peak 1	Glenbrook 2 (Nevada)	Mount Rose	Richardsons 2
	9000	7000	7300	7000	8100	6900	9000	6500
2000	93%	113%	51%	83%	--	64%	85%	73%
2001	52%	66%	28%	42%	58%	25%	53%	42%
2002	96%	115%	113%	89%	--	70%	117%	88%
2003	73%	81%	41%	54%	83%	48%	99%	61%
2004	85%	108%	63%	79%	88%	46%	94%	90%
2005	112%	119%	179%	118%	--	144%	126%	162%
2006	118%	56%	105%	98%	137%	92%	187%	93%
2007	56%	59%	12%	43%	62%	23%	49%	47%
2008	83%	105%	106%	84%	84%	111%	--	125%
2009	86%	103%	74%	80%	93%	41%	93%	80%
2010	83%	92%	129%	72%	89%	78%	100%	105%
2011	144%	197%	229%	155%	163%	181%	153%	194%
2012	63%	78%	42%	51%	71%	28%	59%	58%
2013	63%	61%	11%	40%	--	26%	81%	31%
2014	50%	35%	0%	36%	--	18%	48%	7%
2015	24%	2%	0%	0%	37%	0%	39%	0%
2016	99%	109%	82%	78%	103%	40%	122%	23%
2017	171%	175%	173%	151%	196%	168%	237%	151%

In WY 2017, all eight snow courses received an above average amount of snow (Table 5).

WY 2011 is the most comparable to WY 2017. The average of April 1 SWE for all stations in WY 2011 and 2017 are 177 percent and 178 percent, respectively. Differences in snowfall distribution do exist, but based on overall SWE for the watershed, WY 2011 is the most comparable to WY 2017.

Storage and Runoff

The total runoff for a watershed serves as another qualifier for classifying the water year type. In the Truckee River Basin, the number of reservoirs within the basin and the regulations on their releases provides some difficulty quantifying the total runoff.

For the Truckee River Basin, WQES staff looked at the total runoff measured at the USGS 10337500 Truckee River at Tahoe City and the USGS 10346000 Truckee River at Farad stations. These sites represent a total drainage area of 952 square miles (U.S. Geological Survey 2016) contained within the Lake Tahoe and Truckee River watersheds.

Table 7 **Historical Annual Streamflow of the Truckee River for Water Years 2000 to 2017**

Water Year	Truckee River at Tahoe City		Truckee River at Farad		
	Streamflow (acre feet)	Percentage of Average	Streamflow (acre feet)	Percentage of Average	Difference (acre feet)
2000	121,000	76%	459,000	84%	338,000
2001	188,000	118%	384,000	71%	196,000
2002	107,000	67%	394,000	72%	287,000
2003	77,000	48%	384,000	71%	307,000
2004	48,000	30%	370,000	68%	322,000
2005	52,000	33%	381,000	70%	329,000
2006	103,000	65%	856,000	157%	753,000
2007	125,000	79%	406,000	75%	281,000
2008	143,000	90%	361,000	66%	218,000
2009	58,000	36%	352,000	65%	294,000
2010	48,000	30%	357,000	66%	309,000
2011	60,000	38%	703,000	129%	643,000
2012	129,000	81%	395,000	73%	266,000
2013	124,000	78%	403,000	74%	279,000
2014	80,000	50%	299,000	55%	219,000
2015	208	0%	162,000	30%	161,792
2016	19,700	12%	346,000	64%	326,300
2017	314,000	197%	1,332,000	246%	1,018,000
Historical Average:*	159,000		542,000		
Historical Maximum:	833,000		1,770,000		
Historical Minimum:	--		133,000		

* Historical data for both flow sites date back to Water Year 1909.

The winter of WY 2017 was the wettest year on record in terms of precipitation and had the greatest annual streamflow of the past 17 years. For historical context, the Truckee River at Tahoe City annual streamflow was 38 percent of the historical maximum, and annual streamflow at the Truckee River at Farad station was 75 percent of the historical maximum. During WY 2017, Lake Tahoe nearly reached its maximum level of 6229.1 feet after beginning the year at 6222.6 feet, and by the end of the water year the lake was at 6228.1 feet. 5.5 feet of reservoir storage was captured during WY2017. Otherwise, the average Lake Tahoe outflow for this very wet year would have been considerably higher.

Determining a comparable water year for annual streamflow during the past 17 years is difficult. The addition of reservoirs in a watershed allows for flood protection and water storage; in other words, reservoirs allow a regulated disconnect between precipitation in a watershed and the resulting streamflow. This is important to consider when comparing water years. For example, WY 2011, which has the next highest amount of total precipitation of the past 17 years, was followed by WY 2012, a below average year. But WY 2012 had almost twice the annual streamflow of WY 2011 measured at Truckee River at Tahoe City. The difference in streamflow between Truckee River at Tahoe City and Truckee River at Farad is also important to consider, as it can show either differences in precipitation distribution or differences in reservoir releases.

Table 8 Historical October 1 Lake Tahoe Lake Levels for Water Years 2000 to 2017

Water Year	Reservoir Head on October 1 (feet above or below the rim)	Percent of Average October 1 Reservoir Head	Reservoir Minimum Head (feet above or below the rim)	Date of Lowest Recorded Lake Level
2000	4.94	171%	3.97	January 14, 2000
2001	4.51	156%	1.52	September 30, 2001
2002	1.52	53%	0.52	September 30, 2002
2003	0.51	18%	-0.03	November 6, 2002
2004	0.63	22%	-0.16	September 30, 2004
2005	-0.18	-6%	-0.52	December 5, 2004
2006	1.32	46%	0.79	November 24, 2005
2007	4.62	160%	2.7	September 29, 2007
2008	2.67	92%	0.69	September 30, 2008
2009	0.69	24%	0.07	December 19, 2008
2010	0.15	5%	-0.38	December 6, 2009
2011	0.46	16%	0.46	October 1, 2010
2012	4.67	161%	3.03	September 30, 2012
2013	3.04	105%	1.53	September 30, 2013
2014	1.53	53%	0.15	September 25, 2014
2015	0.13	4%	-1.11	September 30, 2015
2016	-1.06	-37%	-1.67	December 9, 2015
2017	-0.33	-11%	-0.6	October 14, 2016

Note: as recorded by USGS.

Lake levels for WY 2017 started 0.33 feet below the natural rim of the lake, while the historical average is 2.89 feet above the natural rim for October 1st. The average lake level is not a true representation of hydrologic conditions, as the reservoir is regulated, but it does provide historical context. WY 2017 had the second lowest level out of the previous 17 years of October 1 lake levels. With winter and spring storms beginning in January, lake levels rose quickly and steadily until reaching a maximum of 6 feet above the natural rim in July 2017. WY 2017 ended with a lake level of 5.17 feet above the natural rim on September 30, 2017.

Water Year Classification

The results presented in this report use the three hydrologic qualifiers described above (precipitation, SWE, and storage plus runoff) to determine water year classification, some with differing results.

WY 2017 was an extremely wet year. Compared to data from the previous 17 years, WY 2017 had the most precipitation, SWE, and total runoff for the Truckee River. In fact, WY 2017 is widely considered the wettest year in modern recorded history (100+ year) for the region. Moreover, WY 2018 will start with the highest water level in Lake Tahoe for the October 1 level in the previous 18 years.

WQES staff determined that WY 2011 was most similar to WY 2017 in overall hydrology. Of the water years considered for comparison, WY 2011 had the most precipitation and SWE. Nevertheless, of the water years considered, WY 2011 did not have the most total runoff. In WY 2011, the USGS streamflow gauge station, Truckee River at Tahoe City, had below average total runoff. This was because, in part, the previous year's precipitation was low and consequently there were low levels in Lake Tahoe. Further downstream, more of the watershed contributes to the streamflow. The total streamflow at USGS gauge station Truckee River at Farad was above average in WY 2011.

While WY 2006 may be more comparable than WY 2011 to WY 2017 in terms of total runoff, other hydrologic factors in WY 2011 are more comparable. In addition, the water quality data are not as comprehensive for WY 2006 as WY 2011. Therefore, WQ staff decided to use WY 2011 for the pre-TROA comparison.

Streamflow

The United States Geological Survey has established a network of streamflow gauging stations along the Truckee River and its tributaries (Figure 5). Using a stage-to-flow rating curve, continuous flow data are computed from the 15-minute stage readings recorded by pressure sensors. For this report, the 15-minute flow data were computed into daily maximums, minimums, and averages, as well as computed into total streamflow.

Figure 5 USGS Streamflow Gauging Stations Along the Truckee River and its Tributaries

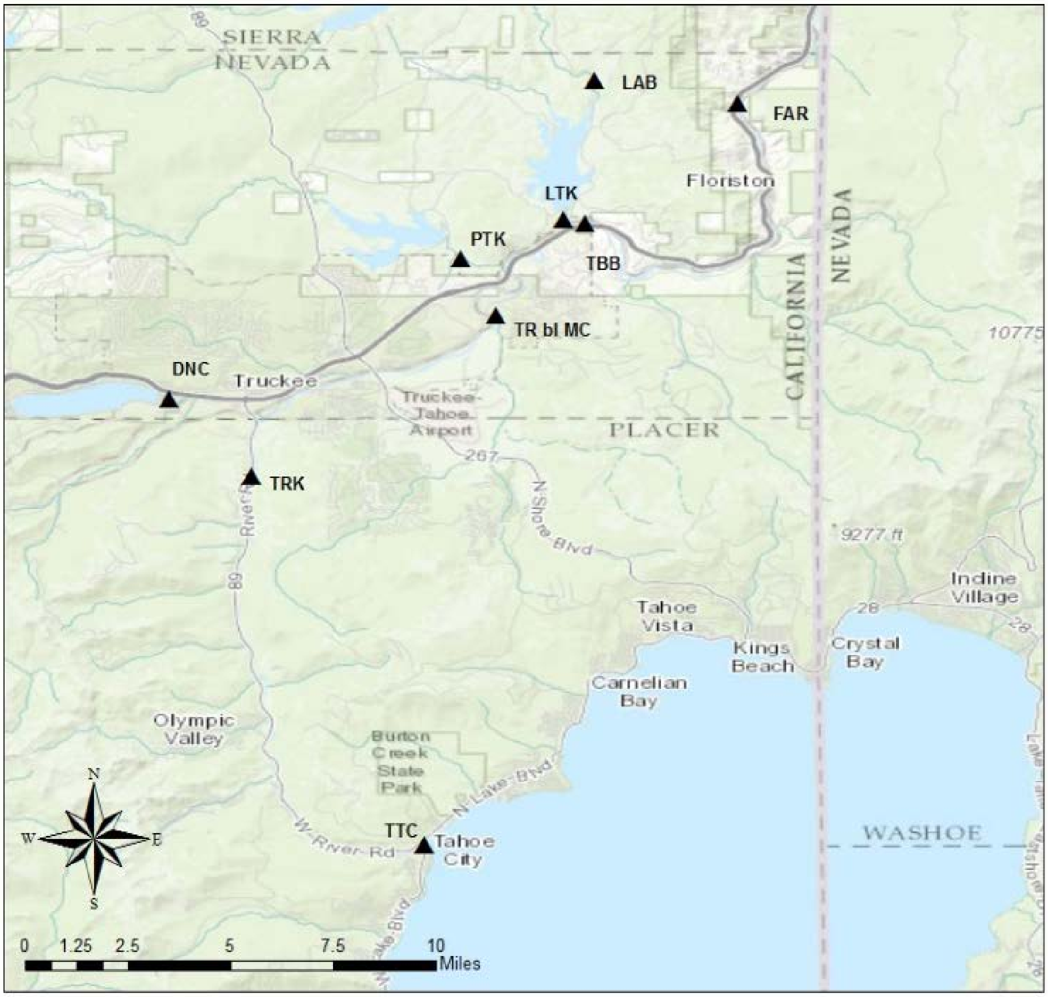


Table 9 **USGS Streamflow Gauging Stations Along the Truckee River and its Tributaries**

Station ID	Station Name	CDEC Code	Latitude	Longitude
10337500	Truckee River at Tahoe City	TTC	39.166296	-120.144359
10338000	Truckee River near Truckee	TRK	39.296295	-120.205475
10338500	Donner Creek at Donner Lake	DNC	39.323517	-120.234365
10339410	Truckee River below Martis Creek	TR bl MC*	39.353056	-120.119444
10340500	Prosser Creek below Prosser Creek Dam	PTK	39.37324	-120.131587
10344400	Little Truckee River above Boca Reservoir	LAB	39.435741	-120.084366
10344500	Little Truckee River below Boca Dam	LTK	39.386852	-120.095476
10344505	Truckee River at Boca Bridge	TBB	39.385185	-120.087698
10346000	Truckee River at Farad	FAR	39.427964	-120.034087

* USGS 10339410 Truckee River below Martis Creek does not transmit to CDEC.

Flow releases from reservoirs along the Truckee River and its tributaries are now regulated under TROA, but the hydrograph still responds during storm events. In WY 2017, several large storms dominated the hydrographs. At the Truckee River at Farad station, the maximum peak flow of 9,160 cubic feet per second was recorded on 1/8/2017 at 23:30. Other stations had peak flows at similar times. The main exception being Truckee River at Tahoe City, which did not reach its peak flow for WY 2017 until 4/26/2017 (figures 6 and 7).

Figure 6 **Daily Average Flows Along the Truckee River and Donner Creek, WY 2017**

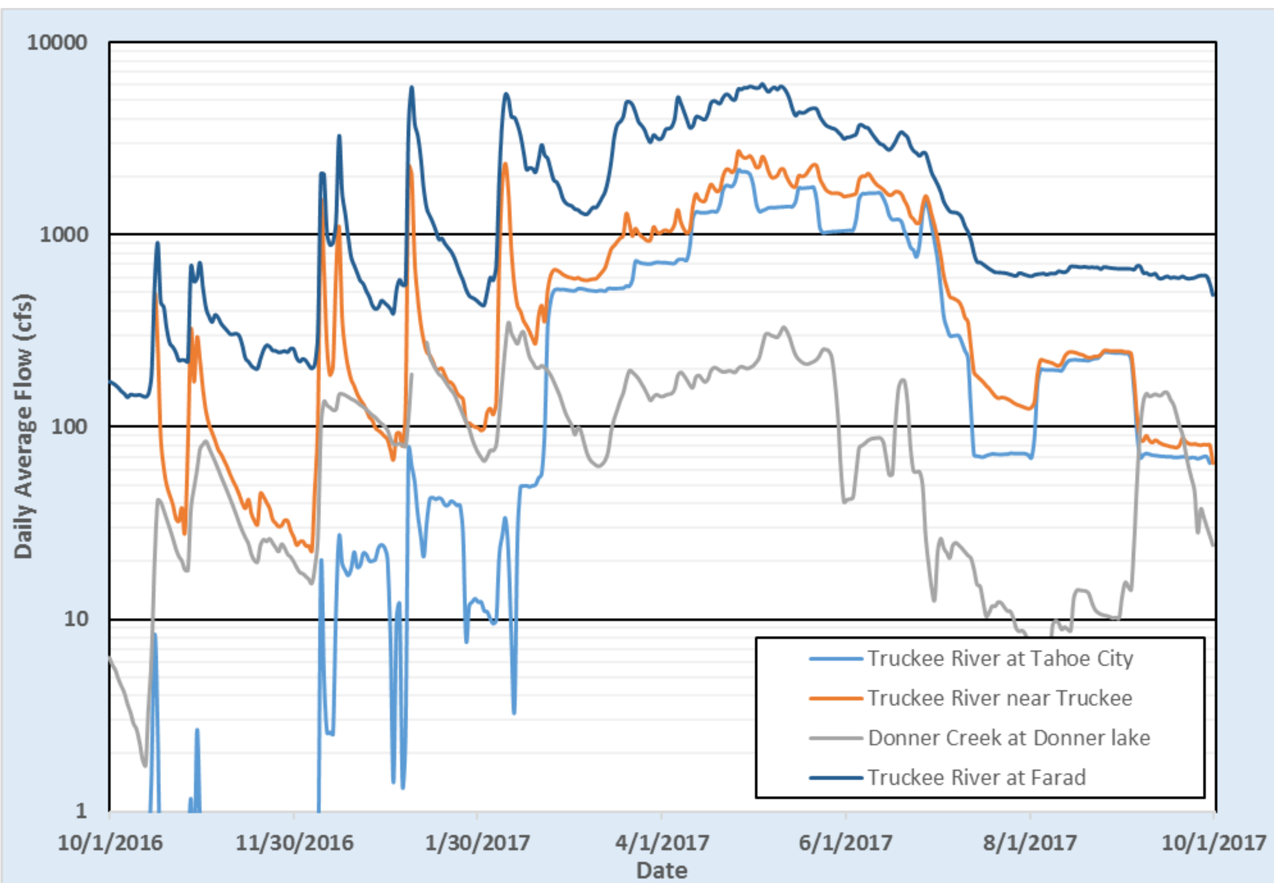
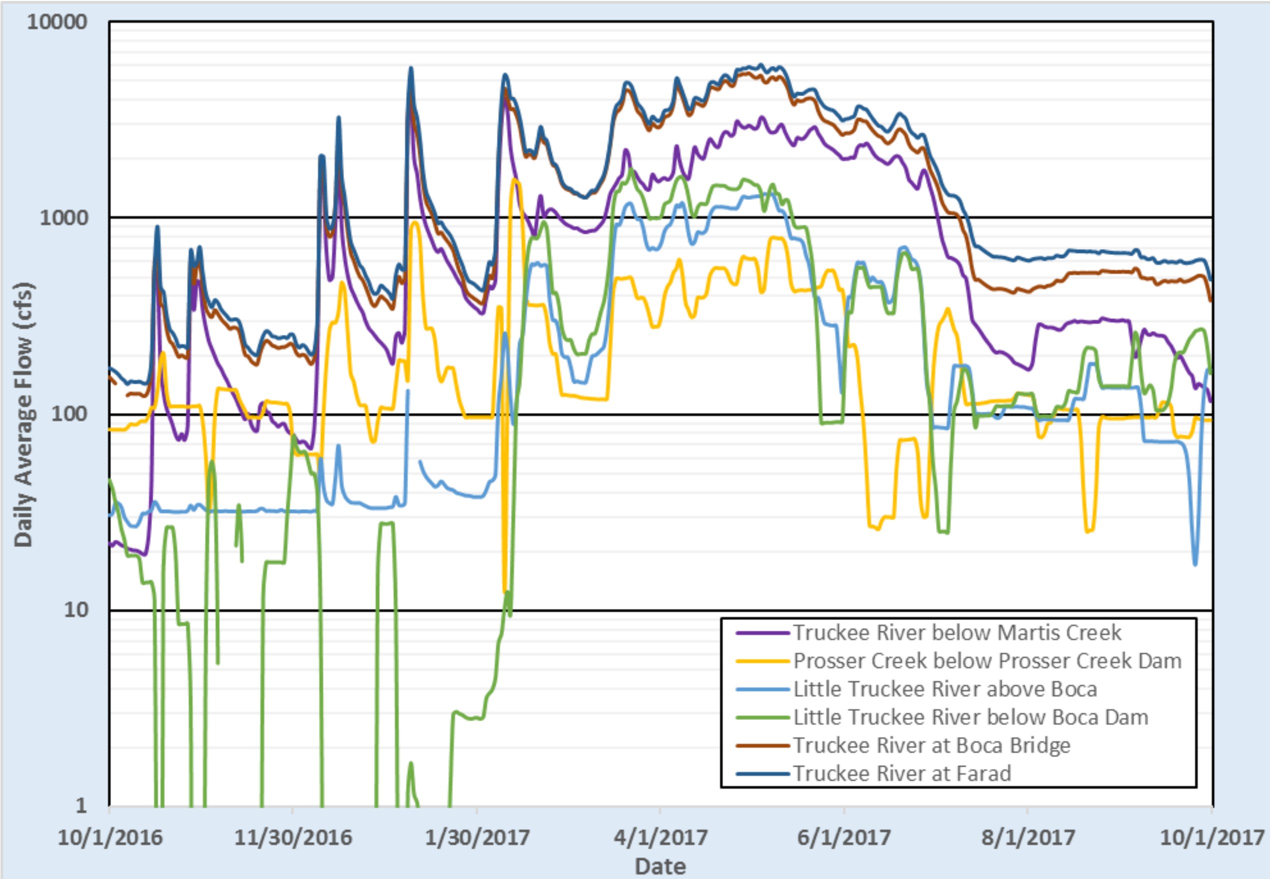


Figure 7 **Daily Average Flows Along the Truckee River, Prosser Creek, and the Little Truckee River, WY 2017**



Figures 6 and 7 show the daily average flows along the Truckee River and its tributaries, from Lake Tahoe to the state line at Farad. Farad flows were put on both figures for regional context.

For WY 2017, the streamflows in the Truckee River and its tributaries appear to have a strong correlation. This is most likely because of the large amount of water in the system; the entire watershed was saturated and the reservoirs were full. When reservoirs are not full, there can be delays in storm runoff as the reservoir refills.

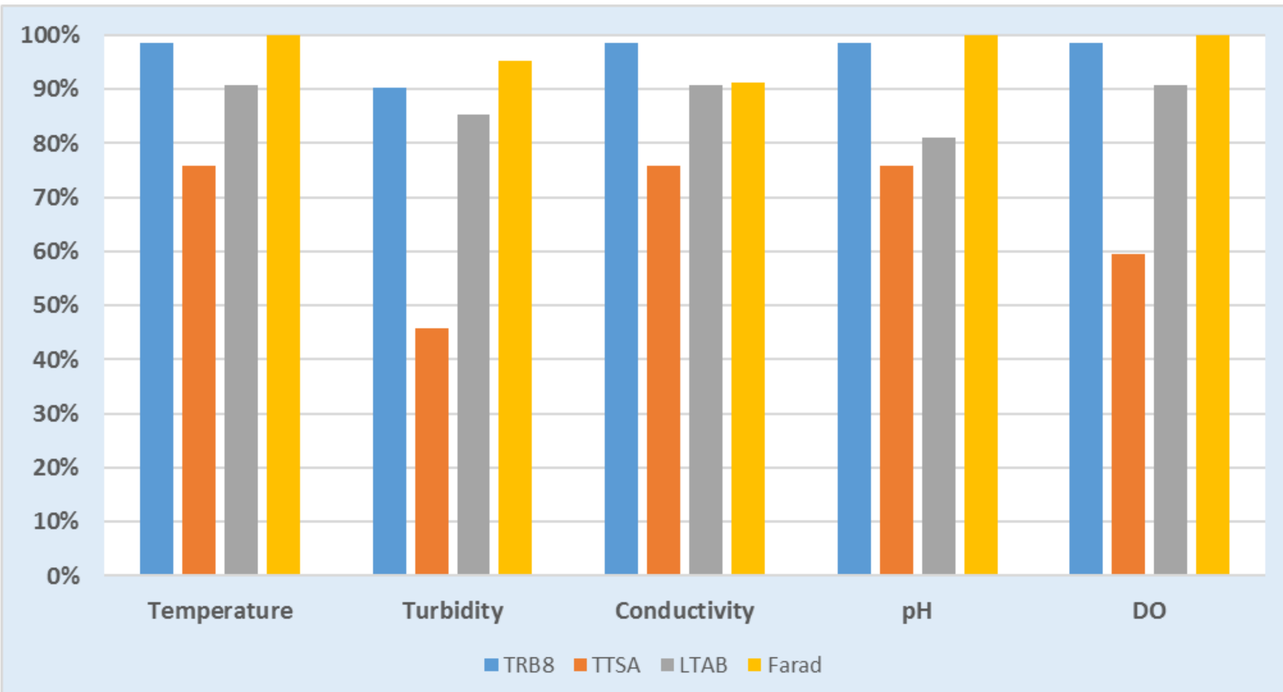
Water Quality Results

Water Year 2017

Sondes were installed for the entirety of WY 2017. But there were some data losses resulting from equipment failures and station problems, which meant that some data failed to meet QA/QC standards (see page 4). The most common equipment failure is batteries going dead. Sondes are always deployed with full batteries, but stations can become inaccessible for months because of weather. The most common cause of data failing QA/QC standards is environmental fouling of the sonde or station. The severity of the fouling may result in a few data points up to long periods of data being marked as unreliable. The optical turbidity probe is most likely to be affected by fouling. Figure 8 shows the percentage of data collected for the sonde stations. Data are counted as missing whenever a 15-minute interval is not included in the record, either because of equipment failure or data marked as unreliable.

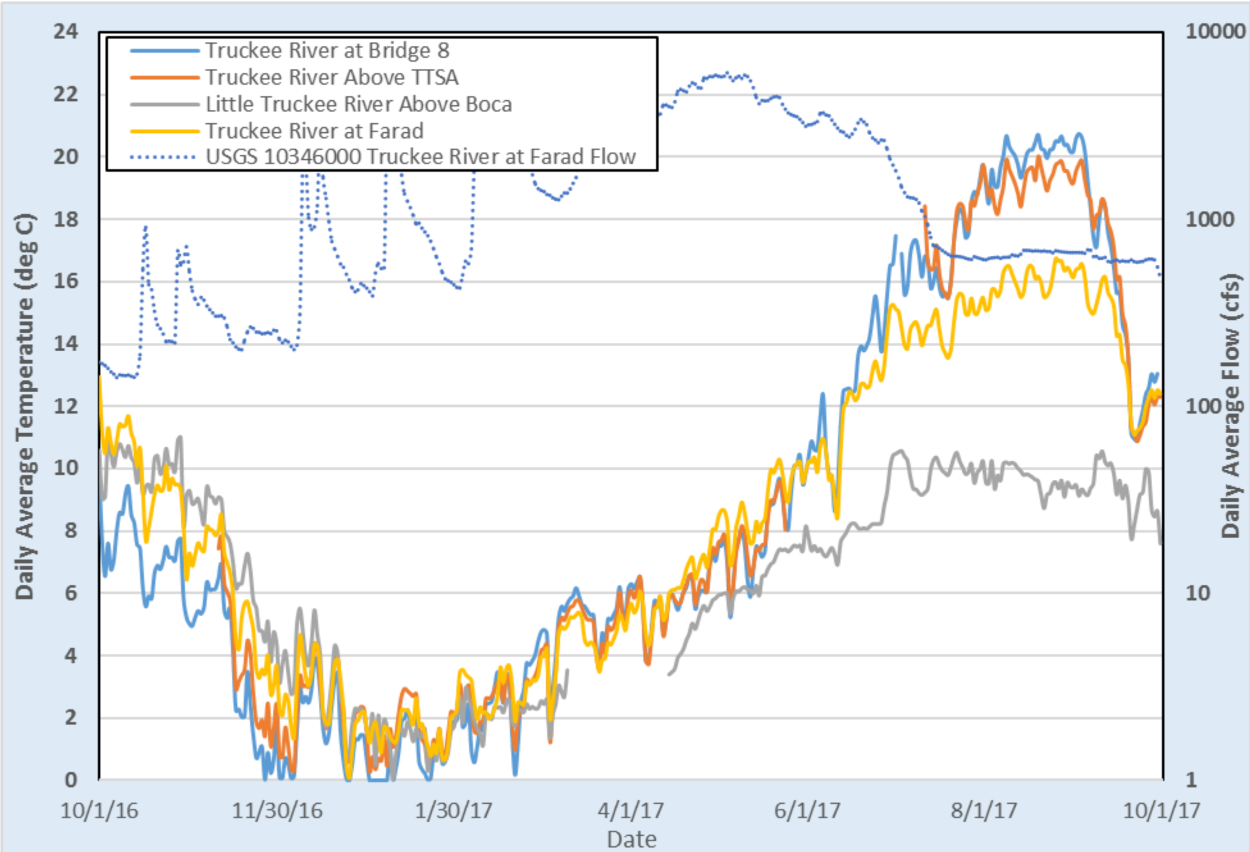
The Bridge 8 station had sporadic missing values resulting from a sonde failure in July. The TTSA station had no data in October and June, and there were numerous periods when data quality was suspect, possibly because of fouling from localized sedimentation at the station site. During station visits, WQES staff clear the area immediately around the station, but the high flow dynamics often cause sediment to deposit near the sonde's sensors. The LTAB site is missing data in March and April because the station was inaccessible in the winter and the batteries eventually died. The Farad station had a four-week deployment, after which the conductivity sensor failed the QA/QC post-deployment accuracy check.

Figure 8 Percentage of Total Data Collected for Each Water Quality Sonde Station



Temperature

Figure 9 Daily Average Temperatures Along the Truckee River for WY 2017



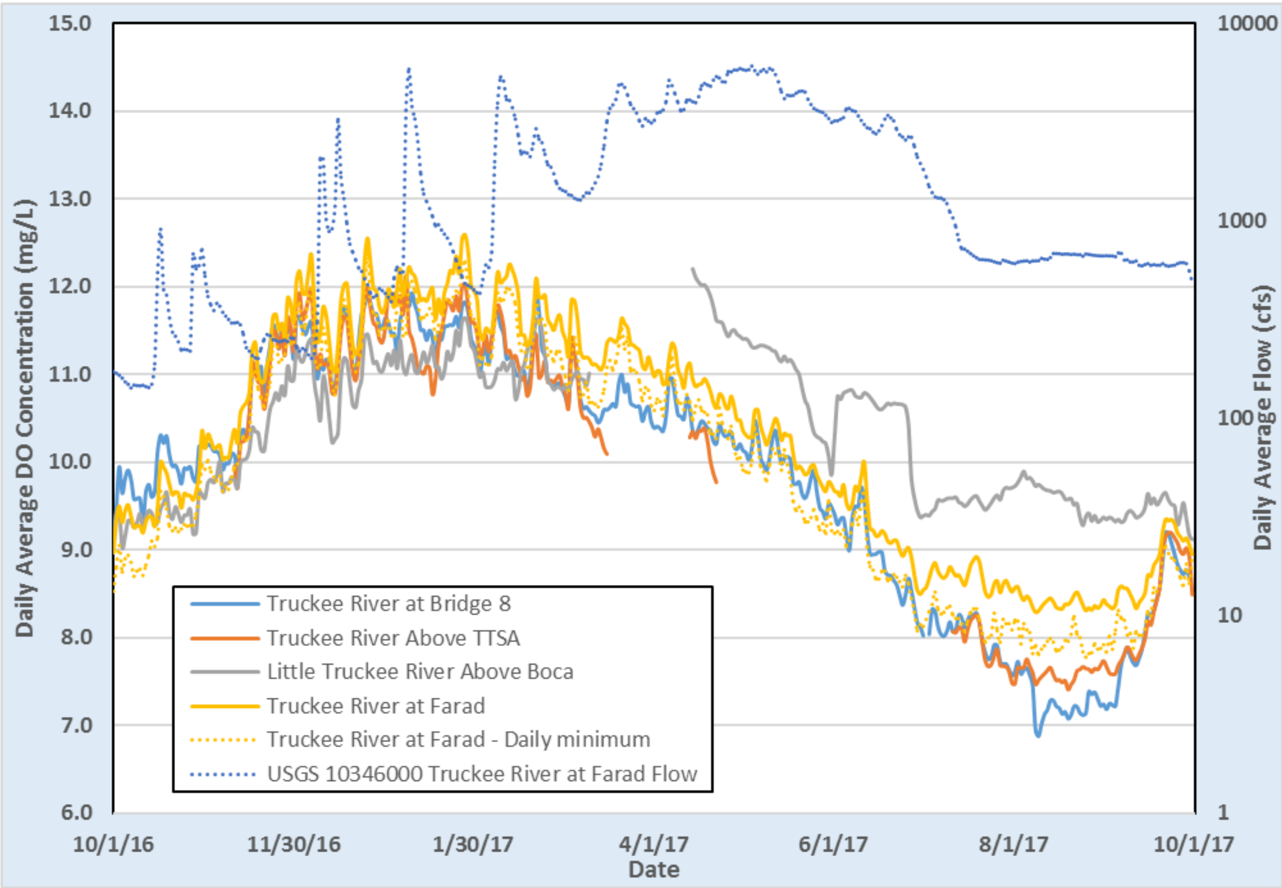
Daily average temperatures are strongly influenced by seasonal temperature differences. All stations show the same general seasonal trend. Temperatures are low in the winter and rise through the spring and summer. Temperatures are highest at Bridge 8 and above the TTSA stations. These stations are most influenced by water from Lake Tahoe, specifically the dam at Tahoe City releasing warmer water from the top of the lake. The warmest temperatures recorded in WY 2017 were just under 21 degrees Celsius (ºC) at Bridge 8.

LTAB water is cold, as it is released from the bottom of Stampede Reservoir. Even in the summer, water temperatures from LTAB remain low. Truckee River at Farad is also influenced by reservoirs releasing cold water, and because of this, the summer temperatures are lower than at Bridge 8 and TTSA, which are more directly affected by releases from Lake Tahoe. The maximum difference in temperature between the upstream stations (Bridge 8 and TTSA) and the downstream station (Farad) occurs in late summer.

Temperature is not directly affected by flow rate, but flow rate can give an indication as to the source of the water. Large spikes in the hydrograph are caused by winter storms. While these winter storms will affect temperature, the effect is minimal compared with the larger seasonal trend. In the summer, the flowrate is stable, indicating that the river flow is being regulated by reservoir releases. At the same time, the largest difference in upstream and downstream temperatures is recorded, indicating that reservoir operation is likely a contributing factor to lower temperatures downstream.

Dissolved Oxygen

Figure 10 Daily Average Dissolved Oxygen Concentration Along the Truckee River for WY 2017

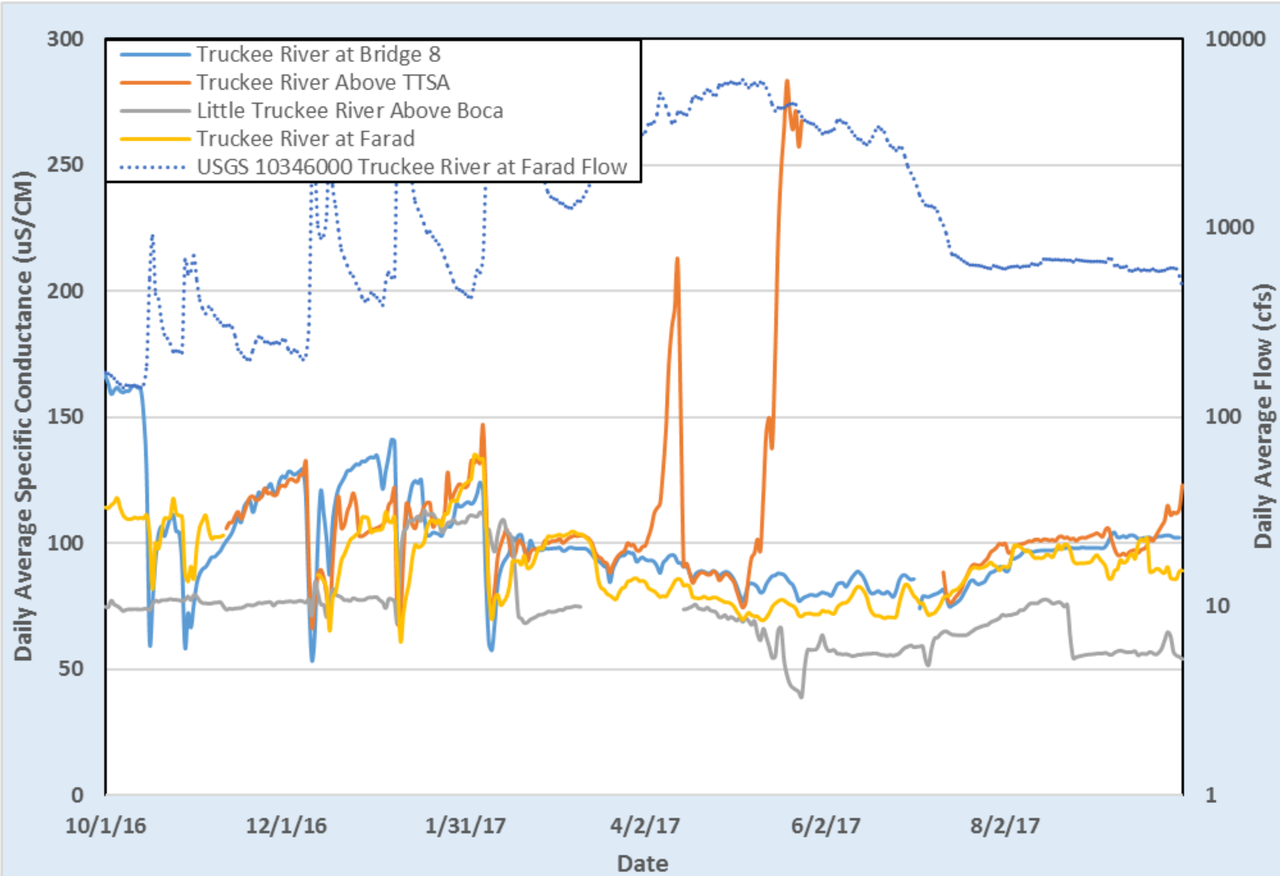


Colder water can hold more dissolved oxygen than warmer water. This is shown in Figure 10; the highest DO levels are seen in the winter when the temperature is the coldest, and the lowest DO levels are seen in the summer when the temperature is warmer. DO levels and trends are similar at all stations. The notable exception being the DO levels at LTAB, which are higher in the summer when compared with other stations. This is correlated with the colder water released from Stampede Reservoir, which is about 6 to 10 ºC colder than at the other stations (see Figure 8).

DO levels at all sites are adequate to sustain aquatic life. At no time in WY 2017 did DO levels fall below 5 mg/L, which is considered the lower limit for healthy fish habitat. The lowest recorded DO was 6.1 mg/L on 8/10/2017 at Bridge 8. The lowest DO levels measured at Farad occurred around the same time, but were all near 8.0 mg/L. The Farad station is the last point for water quality measurements before the Truckee River flows into Nevada.

Dissolved Salts

Figure 11 Daily Average Specific Conductance Along the Truckee River for WY 2017

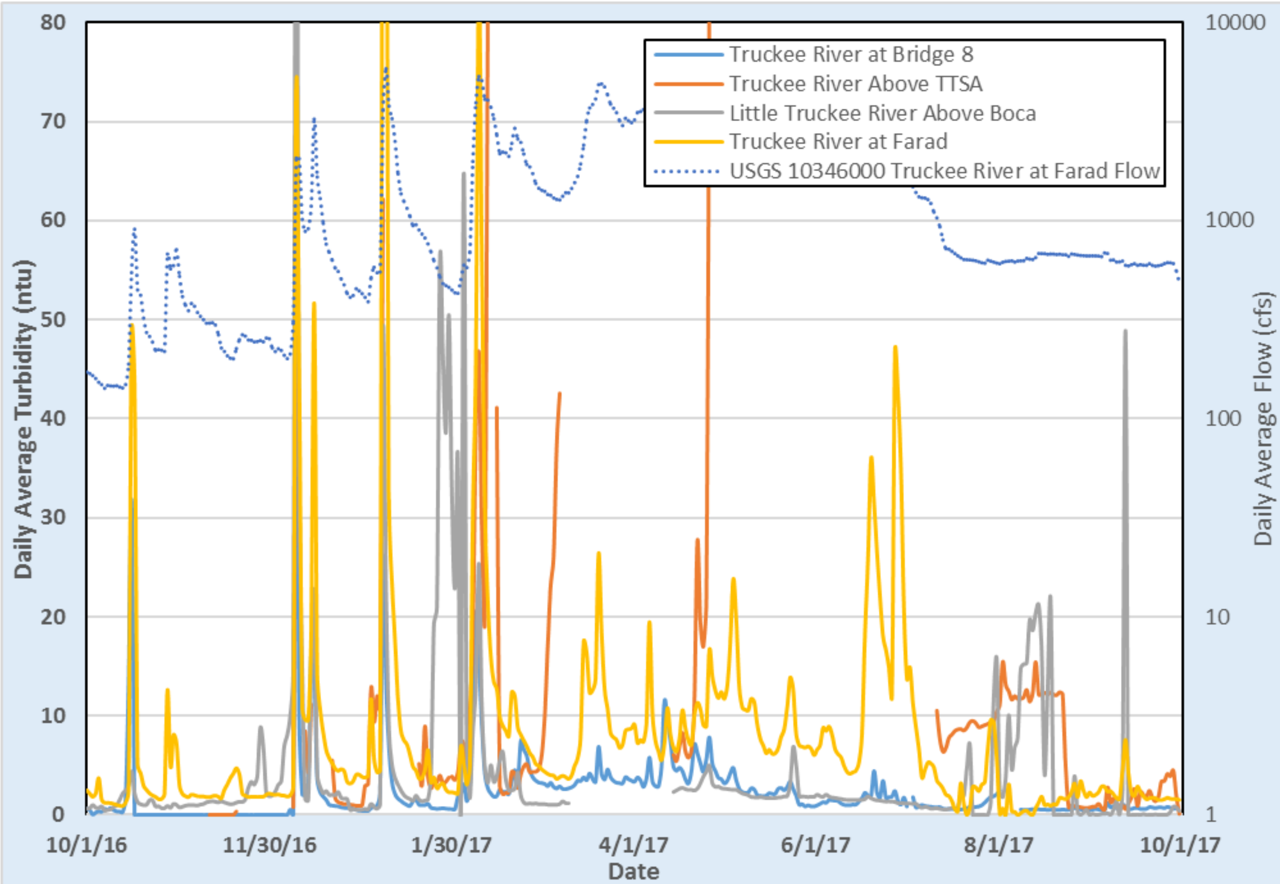


Daily specific conductance is used to measure dissolved salts in water. All values in WY 2017 are consistent with expected values for a freshwater mountain river. Precipitation, both rain and snow, tend to have a low conductance values, but minerals in the soil will slowly leach into the water. During high flows and storms, the conductance will drop as the increased volume of water tends to dilute any dissolved minerals. The conductance will then increase as flow rates drop (Figure 10).

Except for the TTSA station, readings never exceed 200 µS/cm and are usually about 100 µS/cm. The TTSA station is subject to sedimentation, where sediments deposit and build up around the sonde sensors and possibly affect readings. This occurred in June, and is likely the cause of the spikes in the data around the beginning of June. Other sites upstream or downstream did not record higher specific conductance values at the same times and because of this the spikes are not considered representative of the Truckee River.

Turbidity

Figure 12 Daily Average Turbidity Along the Truckee River for WY 2017

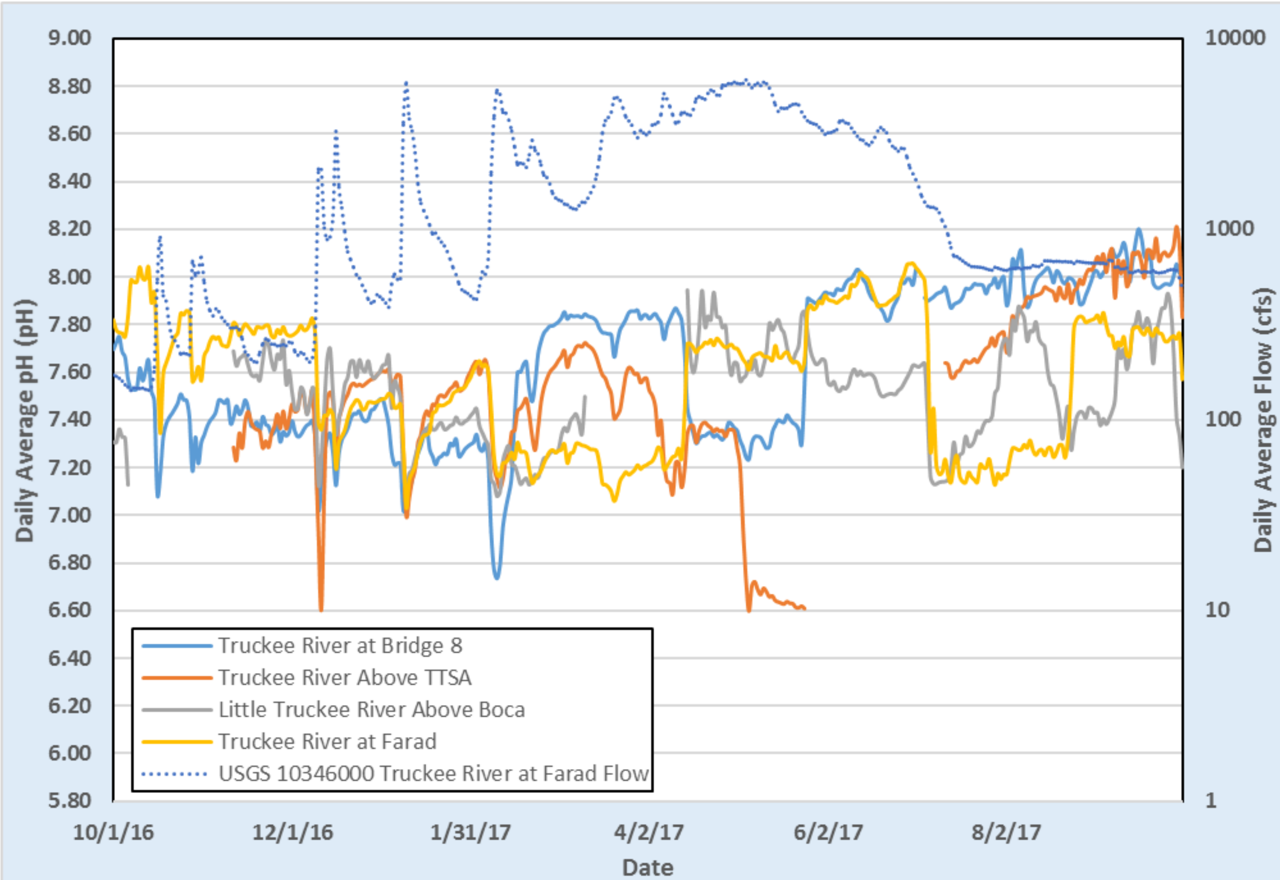


Turbidity is a measure of water clarity and reflects the number of suspended particles in the water. Turbidity is affected by storm events that cause erosion from runoff and high flow rates, which in turn cause river sediment to be re-suspended in the water column. WY 2017 had many storms as well as high flow rates that lasted into the summer. High turbidity is expected in these conditions.

As mentioned earlier, the TTSA station is subject to sedimentation. This sedimentation can disrupt sensor readings and may not accurately represent the rest of the river channel at these times. Data that does not meet QA/QC standards are not included in this report, but it can be subjective as to what data represents high turbidity in the River and what data represents localized conditions of high turbidity at a particular station. The turbidity data in March and April, as well as June and July, were largely unusable because the values were very sporadic and greater than realistic. Some data for the TTSA station in Figure 11 may be affected by sedimentation, but was left in the report because there was not enough evidence to disqualify it.

pH

Figure 13 Daily Average pH Along the Truckee River for WY 2017



Values of pH in WY 2017 are in a normal range for the Truckee River. Typical values are below 8.20 and above 7.00. Large storm systems tended to decrease the pH. The lowest recorded pH was 6.60, but the decrease in pH at the TTSA station in May also corresponds to periods of known sedimentation issues at that station.

Also note that on 4/14/2017, 5/25/2017, and 7/6/2017 water quality sondes were exchanged as part of routine station maintenance. These sondes were calibrated prior to installation and the calibration was checked according to WQES procedures after the deployment and met QA/QC standards. Nevertheless, by changing sondes and recalibrating probes, some discontinuities can be introduced into the data and manifest as “steps” in the data. This is most noticeable on 4/14/2017, when pH at the Bridge 8 site dropped by approximately 0.4 pH while the downstream station Farad rose very quickly by approximately 0.4 pH.

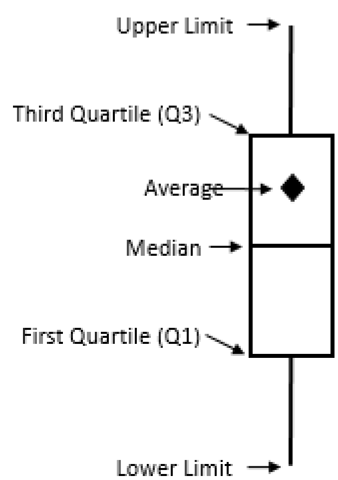
Comparison to Pre-TROA Conditions

Based on precipitation and SWE, WY 2011 was chosen to compare pre-TROA conditions to the implementation of TROA in WY 2017.

For WY 2017, data were collected at all sites during the year. Nevertheless, there were gaps in the data because of equipment failures (sensor fouling and electronic failures) and data recorder errors causing data to not meet QA/QC standards. WY 2011 does not have sonde data for the entire year, but the comparison will focus on spring and summer, when the operation of reservoirs under TROA is more likely to affect water quality.

To analyze the two water years, the data were split up into two seasons, spring (April 1 to June 30) and summer (July 1 to September 30), and displayed with box plots to compare the seasonal variability. A box plot is a standardized way of displaying the distribution of data based on the maximum, minimum, average, median, and first and third quartiles (Figure 14).

Figure 14 Box-Plot Analysis of the Components Presented in this Report



Note: Outliers are not displayed on boxplots in this report.

Temperature Comparison

Temperatures between WY 2011 and WY 2017 were very similar. Spring temperatures at Bridge 8 were 2 °C higher in WY 2017, and summer temperatures were also slightly higher at both Bridge 8 and TTSA. The low, narrow range at LTAB in the summer indicates that the water feeding the Little Truckee River from Stampede Reservoir is consistently cooler compared with other stations along the Truckee River.

Figure 15 **Boxplot of Daily Average Temperatures Along the Truckee River During the Spring (April 1 to June 30) of Water Years 2011 and 2017**

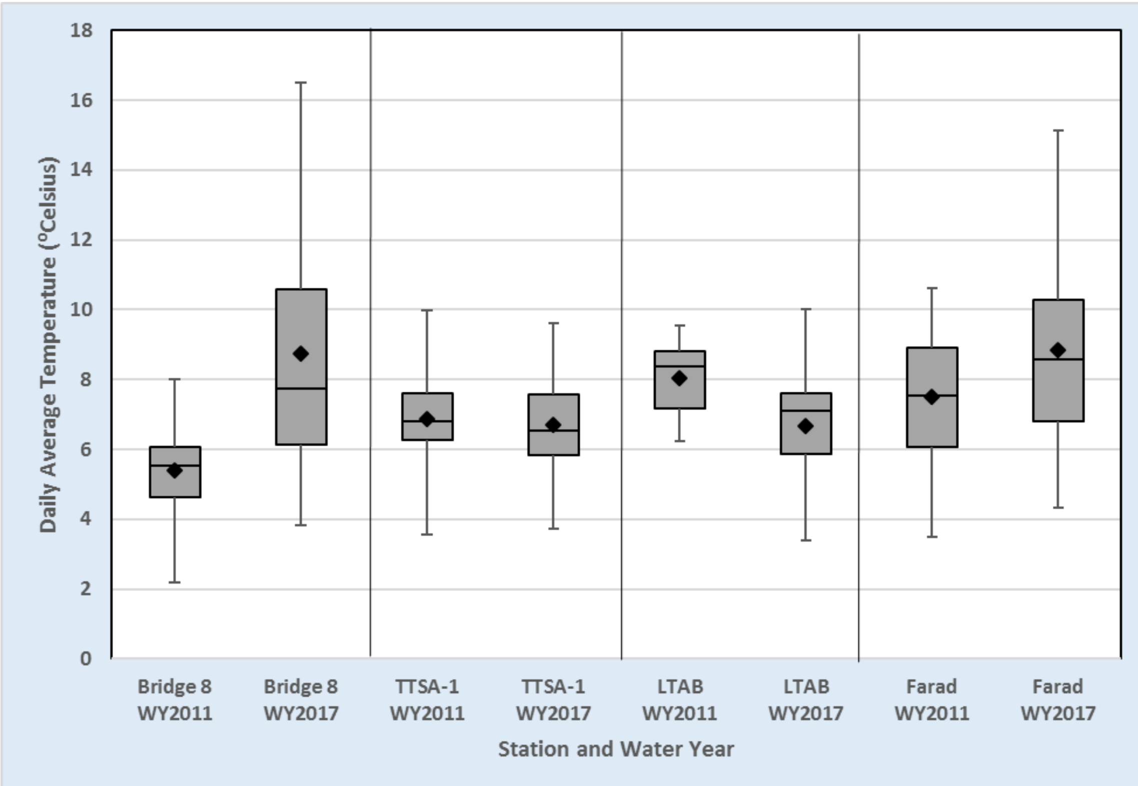
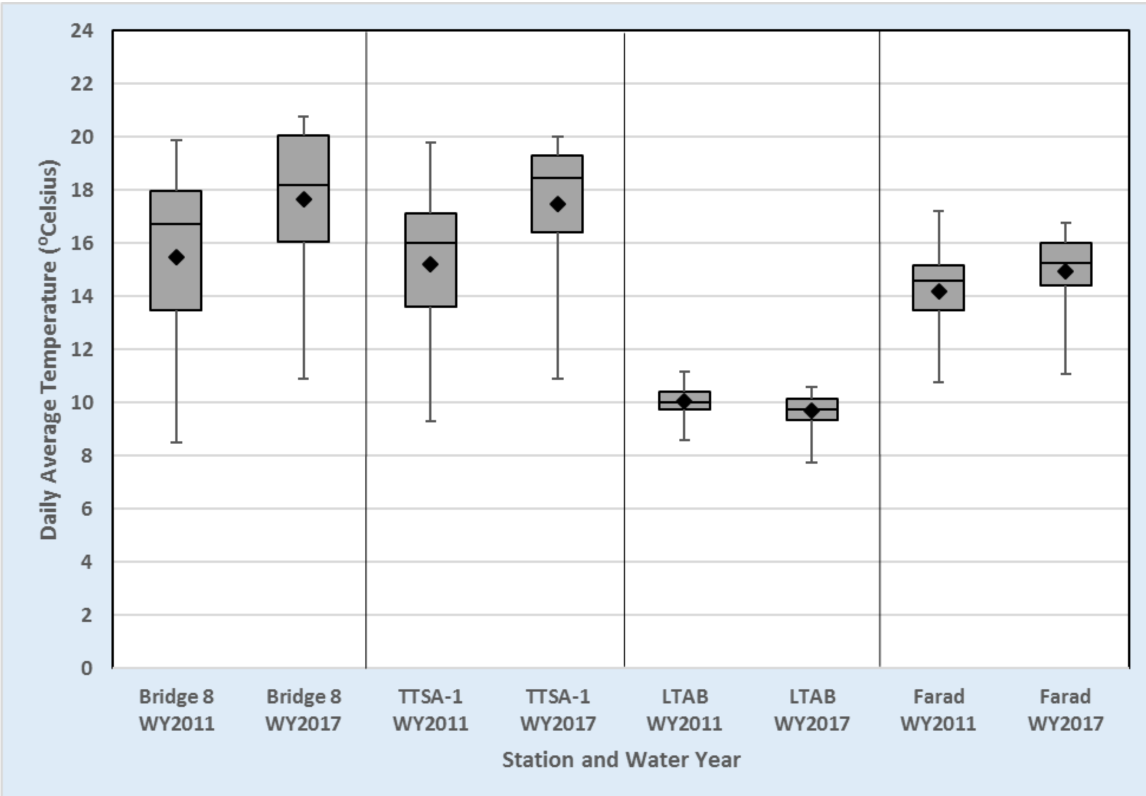


Figure 16 **Boxplot of Daily Average Temperatures Along the Truckee River During the Summer (July 1 to September 30) of Water Years 2011 and 2017**



Dissolved Oxygen Comparison

Comparing DO levels shows very little difference between WY 2011 and WY 2017 in either spring or summer. There is a slight decrease in DO in the summer, which is likely a result of the increase in temperature. LTAB has the lowest summer temperatures, and correspondingly has the highest summer DO levels.

Figure 17 Boxplot of Daily Average Dissolved Oxygen Concentration Along the Truckee River During the Spring (April 1 to June 30) of Water Years 2011 and 2017

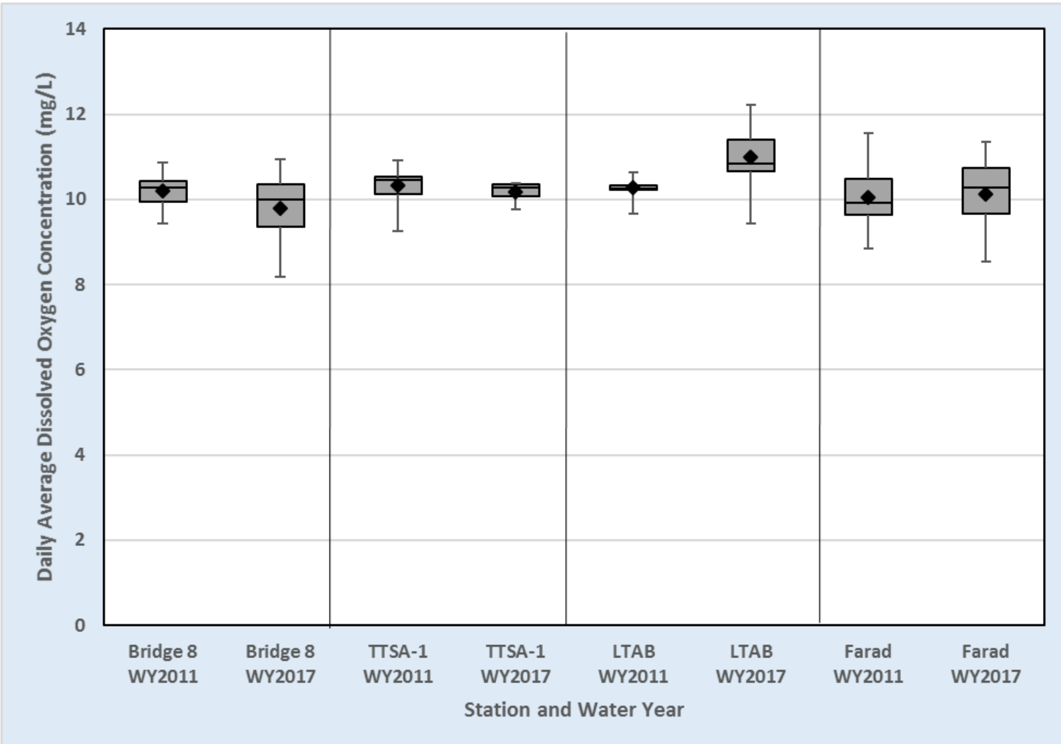
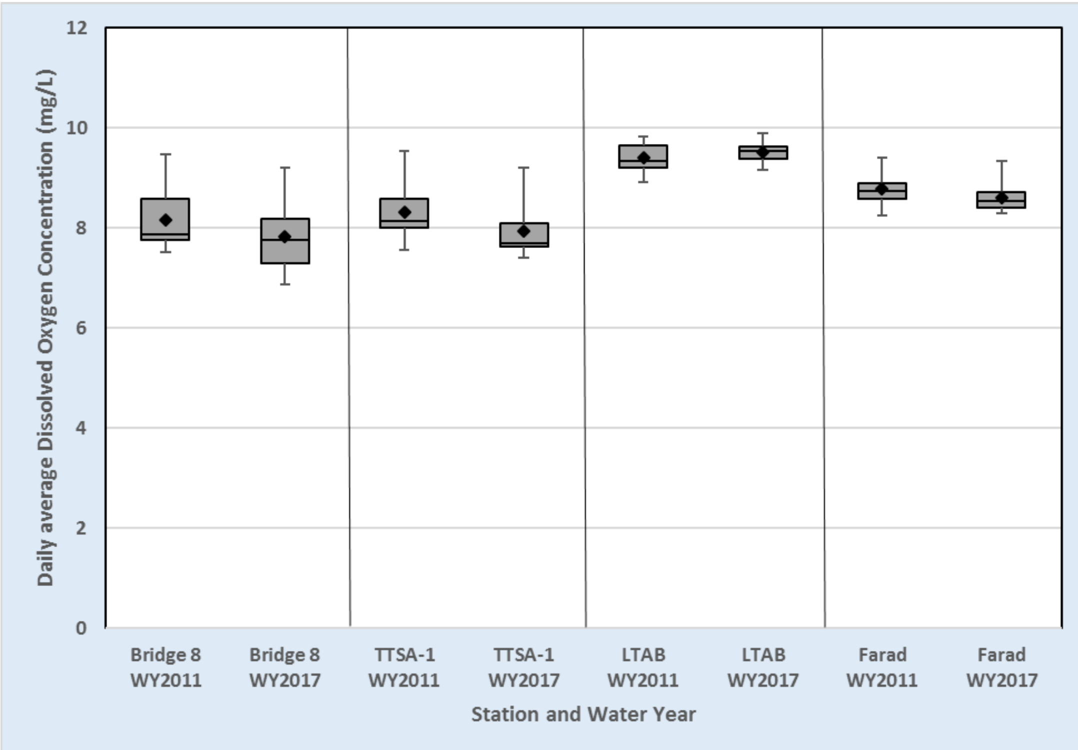


Figure 18 Boxplot of Daily Average Dissolved Oxygen Concentration Along the Truckee River During the Summer (July 1 to September 30) of Water Years 2011 and 2017



Specific Conductance Comparison

With the exception of the TTSA station, there is no significant difference in Specific Conductance between WY 2011 and WY 2017 for all sites. Comparing spring and summer, the specific conductance is very similar at all stations and ranges between 60–100 µS/c. In both WY 2011 and WY 2017, TTSA has the most variability of the stations; specifically, during summer of WY 2011 and spring of WY 2017. This is likely caused by the localized sedimentation observed at the station affecting the sonde sensors.

Figure 19 Boxplot of Daily Average Specific Conductance Along the Truckee River During the Spring (April 1 to June 30) of Water Years 2011 and 2017

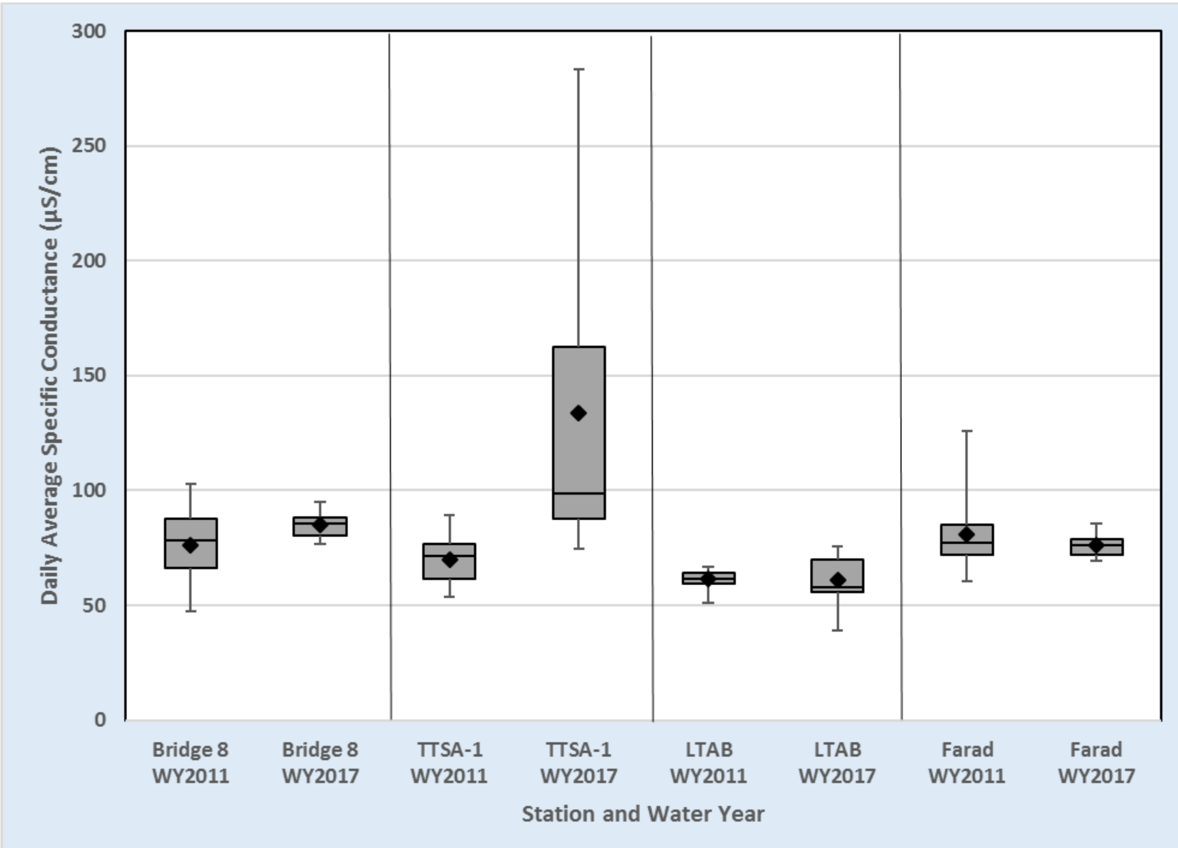
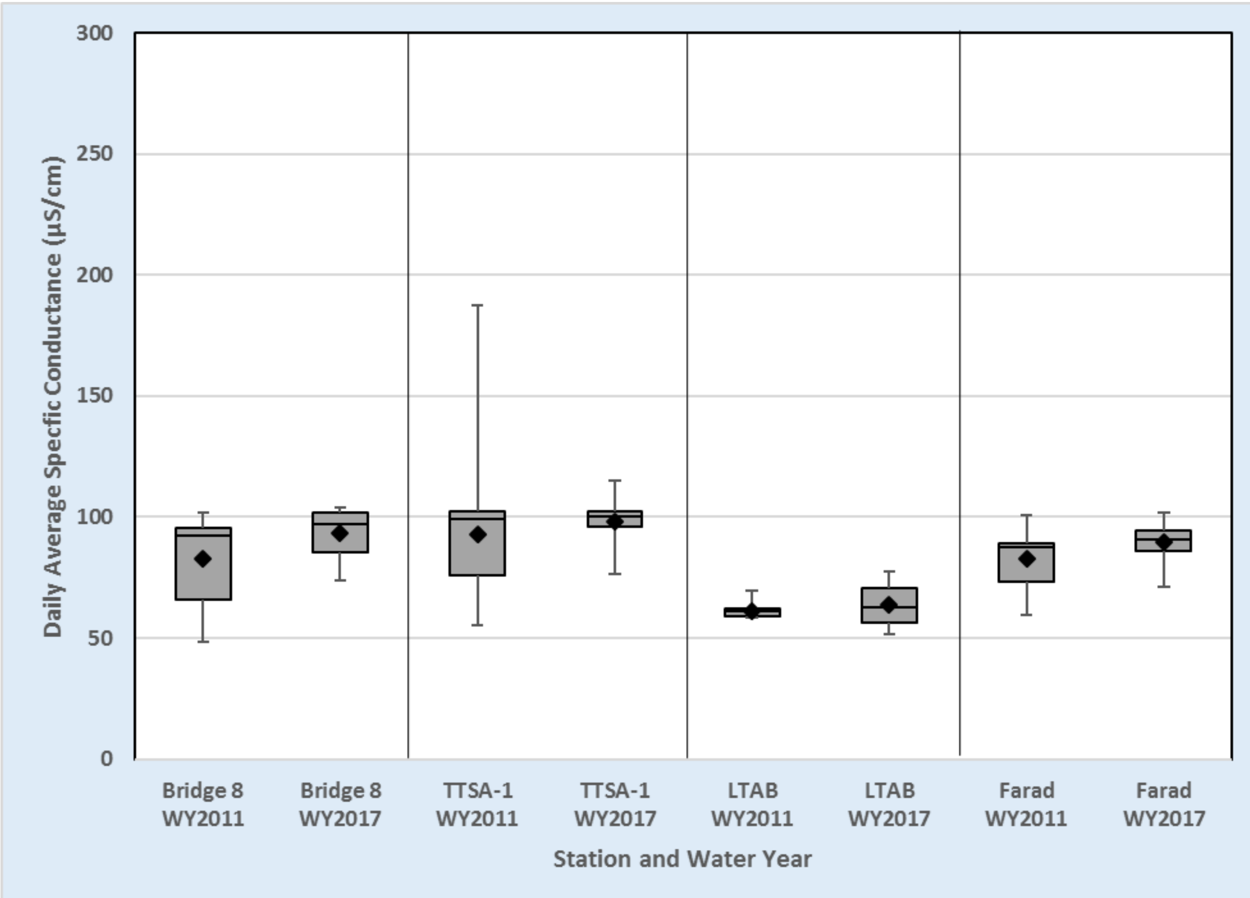


Figure 20 **Boxplot of Daily Average Specific Conductance Along the Truckee River During the Summer (July 1 to September 30) of Water Years 2011 and 2017**



Turbidity Comparison

The Truckee River is generally clear and has low turbidity. In both WY 2017 and WY 2011, spring turbidity values are generally less than 10 ntu. WY 2017 spring turbidity at Farad is slightly higher than in WY 2011 and is likely a result from higher flow rates in WY 2017. In the summer, turbidity values are generally less than 5 ntu for both years. The difference at TTSA is a result of sediment depositing around the sensor probes and interfering with the optical turbidity measurement.

Figure 21 Boxplot of Daily Average Turbidity Along the Truckee River During the Spring (April 1 to June 30) of Water Years 2011 and 2017

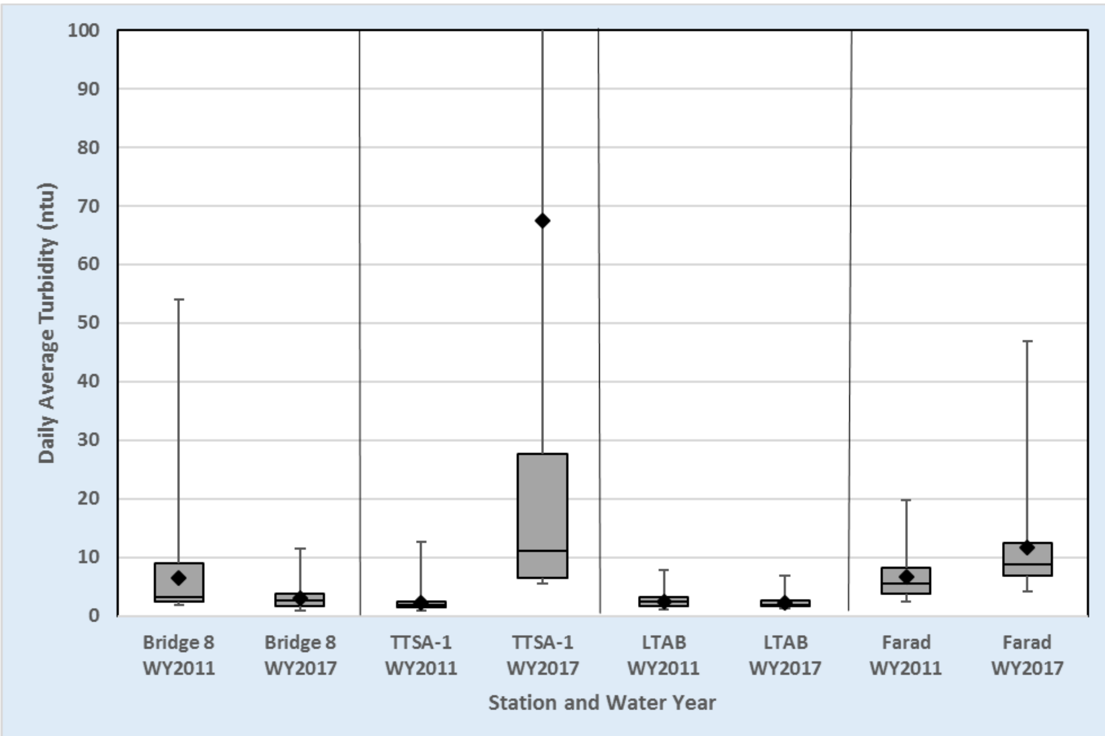
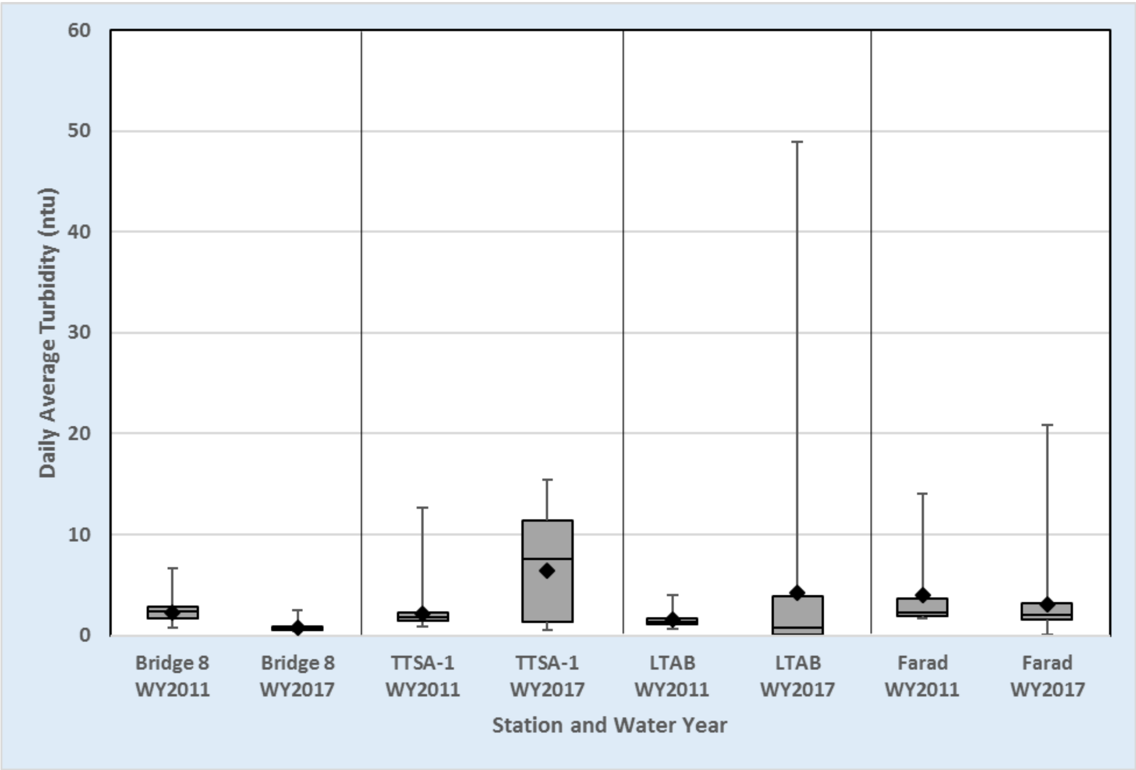


Figure 22 Boxplot of Daily Average Turbidity Along the Truckee River During the Summer (July 1 to September 30) of Water Years 2011 and 2017



pH Comparison

Excluding the TTSA station, there is little change in pH between seasons or between sites. There is a slight increase in pH at most stations in the summer compared with the spring (less than 0.5 pH). Higher summer temperatures and different contributions of source water will influence the pH values. In the summer, water in the Truckee River has been stored in the watershed longer. The water has been stored in a reservoir, as snowpack, or has been slowly draining from groundwater. Interactions with soil can influence the pH. The recorded values are consistent with expected values for a freshwater river system.

Figure 23 Boxplot of Daily Average pH Along the Truckee River During the Spring (April 1 to June 30) of Water Years 2011 and 2017

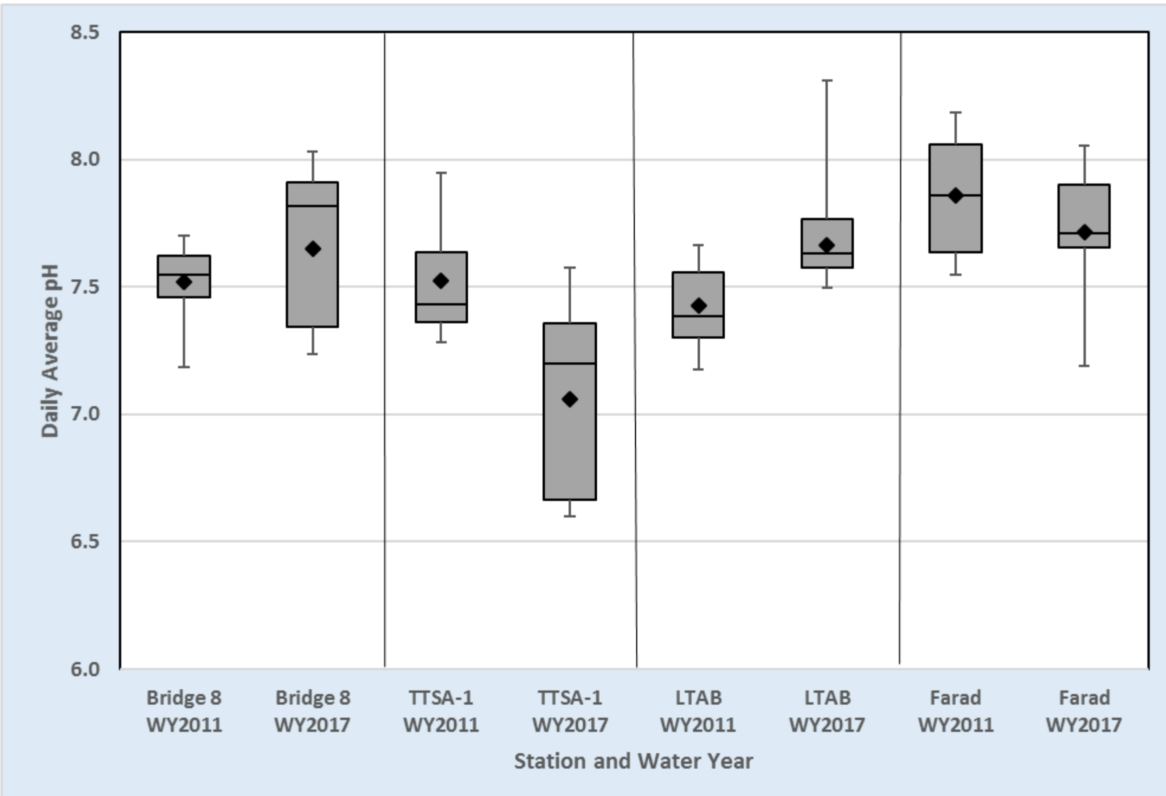
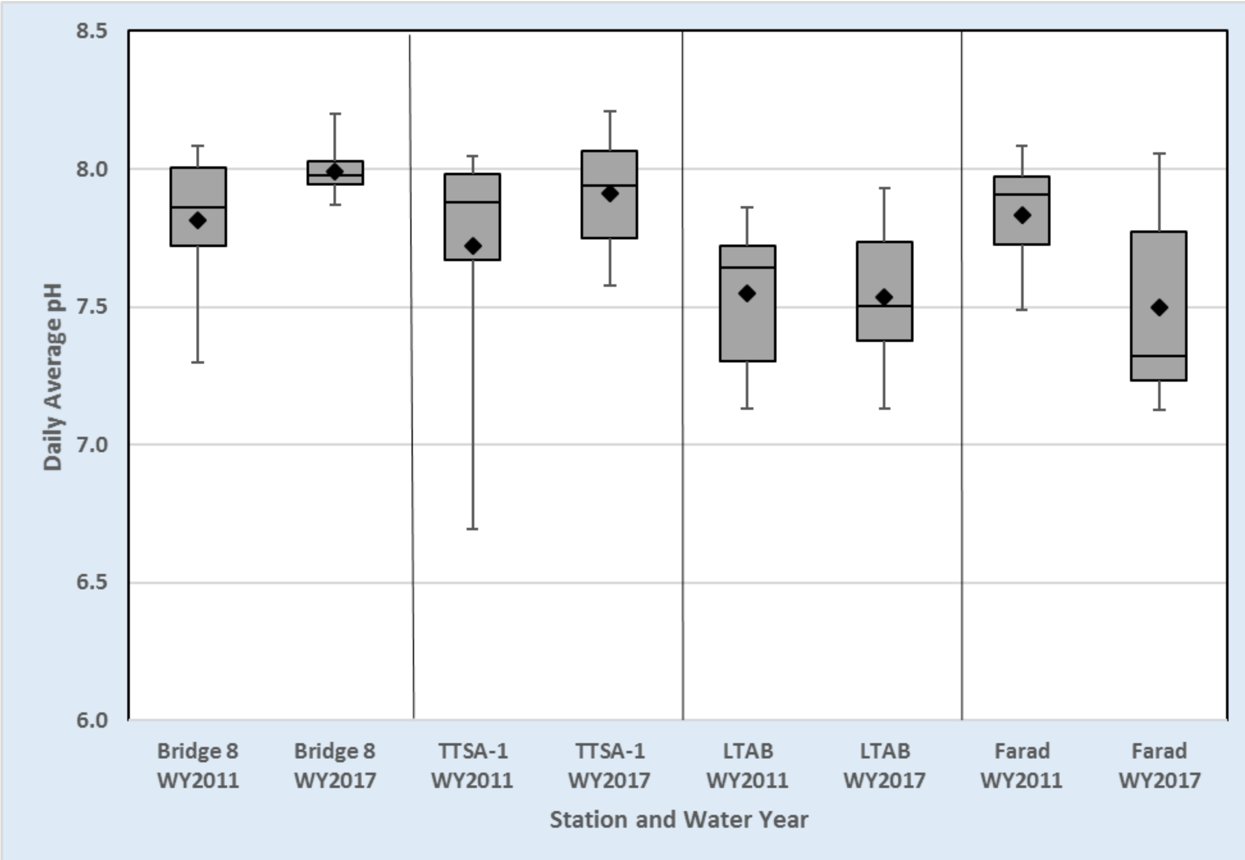


Figure 24 **Boxplot of Daily Average pH Along the Truckee River During the Summer (July 1 to September 30) of Water Years 2011 and 2017**



When comparing water quality data from the spring and summer seasons of WY 2017 and WY2011, no effects from implementing TROA have been found.

Temperature Study

In Water Year 2016, HOBO temperature loggers were installed along the Truckee River, Donner Creek, Prosser Creek, and the Little Truckee River (Figure 3) to measure the influences that those tributaries have on the temperature of the mainstem of the Truckee River. In WY 2017, WQES staff downloaded the temperature data from these probes to use in this report. In addition, there are four cabled water temperature probes, connected to real-time USGS stream gauging sites, that transmit data to CDEC at 15-minute intervals.

Figure 25 Truckee River and Donner Creek Temperature Comparisons for WY 2017

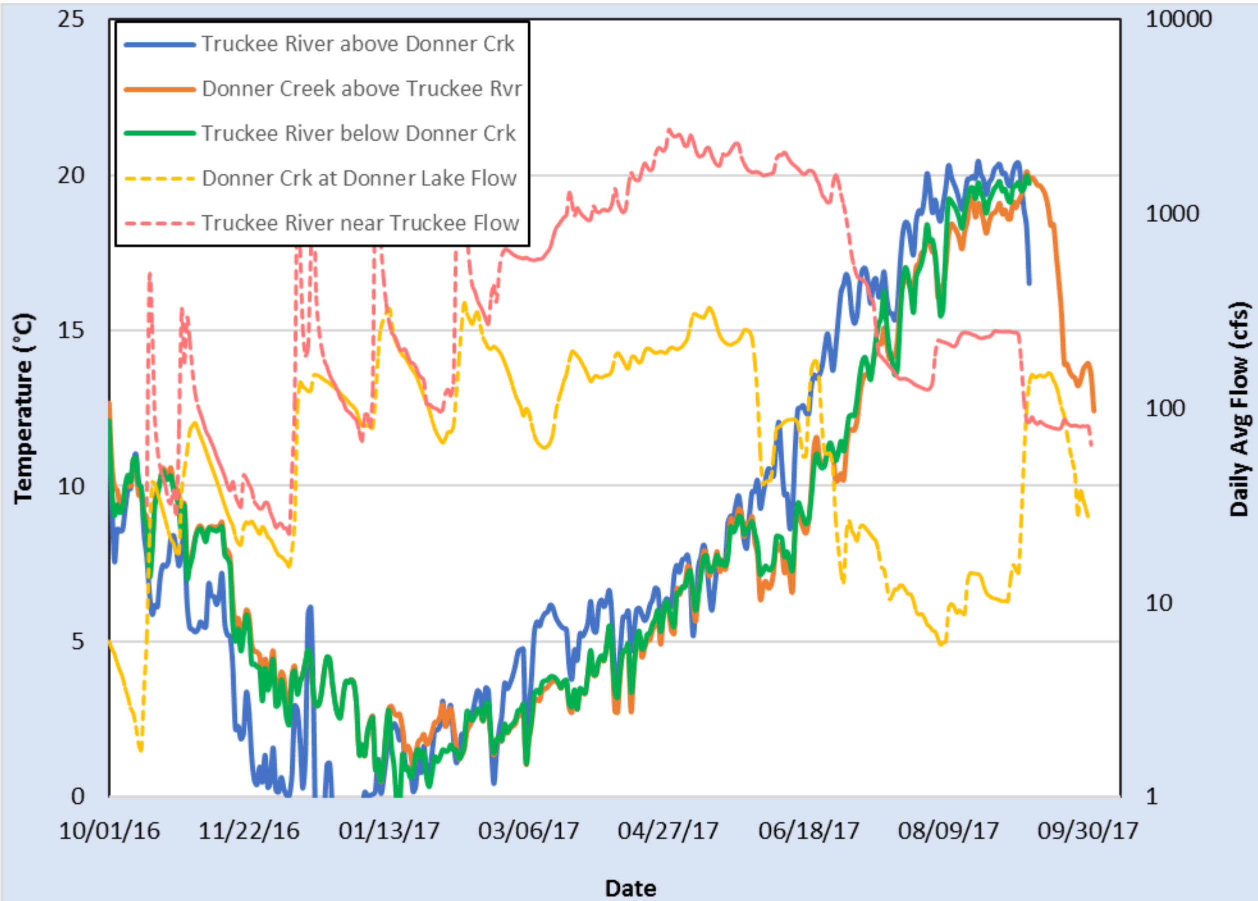


Figure 25 shows temperature data near the confluence of Truckee River and Donner Creek during WY 2017. For WY 2017, the measured temperatures at the confluence of Truckee River and Donner Creek were very similar and showed very little difference until late in the water year (Figure 24). The data shows that through the end of July, the water in Donner Creek is cooler than the water in Truckee River upstream of the confluence and is being cooled by releases from Donner Lake. The temperature difference is greatest in June.

It should be noted that since the temperature in Donner Creek is cooler than the Truckee River, it is expected that the Truckee River downstream of the confluence would be lower in temperature than the Truckee River upstream of the confluence. The temperature data during July in the Truckee River downstream of the confluence corresponds more closely with the water temperatures of Donner Creek than the Truckee River upstream of the confluence. Nevertheless, the streamflow in Donner Creek is significantly less than the streamflow in the Truckee River, and it is not physically possible for the water in Donner Creek to cool the entire Truckee River as drastically as the data suggests. The most likely explanation is the downstream HOBO logger is located too close to the confluence and is in the current of water entering from Donner Creek. These abnormalities may also be caused by changes in release volumes from Donner Lake or Lake Tahoe.

Figure 26 Truckee River and Prosser Creek Temperature Comparisons for WY 2017

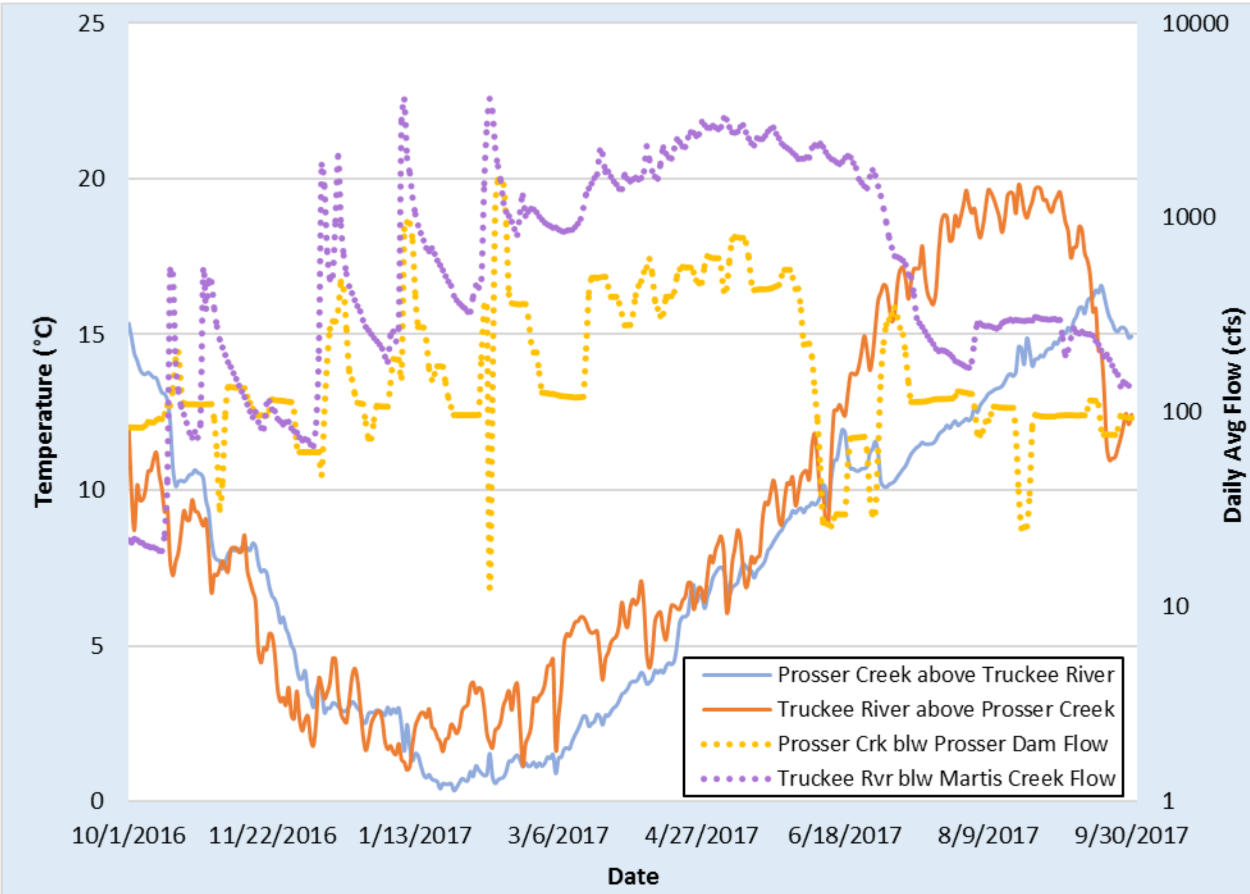


Figure 25 shows temperature data from near the confluence of Prosser Creek and the Truckee River during Water Year 2017. Prosser Creek is usually colder than the Truckee River by a few degrees. The largest temperature difference is in the summer months when Prosser Reservoir is releasing cold water into Prosser Creek. The cold water released from Prosser Creek acts to cool the Truckee River when temperatures in the Truckee River are highest.

Figure 27 **Truckee River and Little Truckee River Temperature Comparisons for WY 2017**

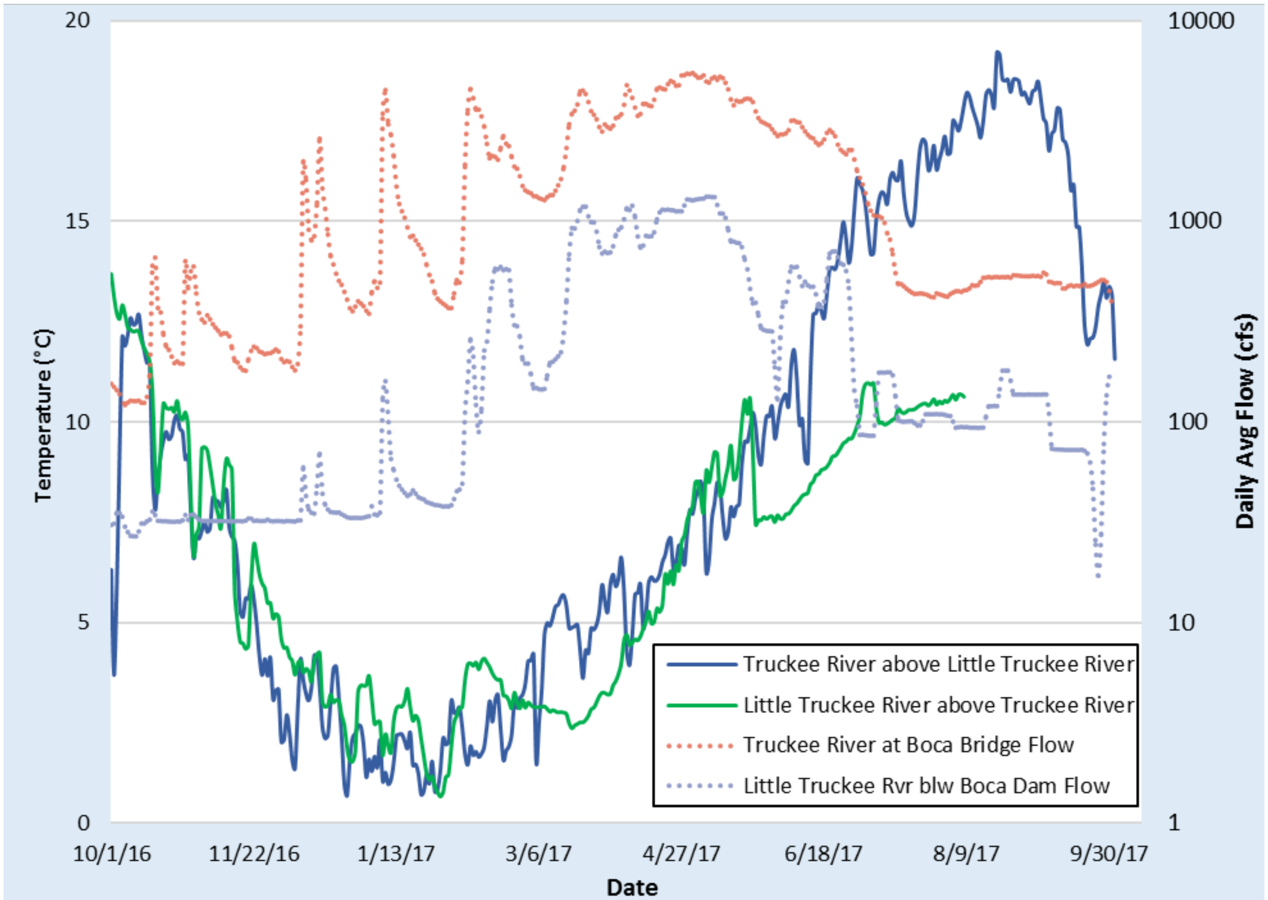


Figure 26 shows the temperature data near the confluence of the Little Truckee River and the Truckee River during WY 2017. The temperature for both the Little Truckee River and the Truckee River are similar through the fall and winter. In the spring and summer, when Boca Reservoir releases cold water, the temperature in the Little Truckee River drops. This influx of cold water acts to cool the Truckee River below the confluence, as expected and in relation to the magnitude of flow from the Little Truckee River.

Summary and Discussion

This report evaluated certain WY 2017 water quality data in the Truckee River and its tributaries and compared the difference in water quality conditions to a representative water year with similar hydrology from the pre-TROA implementation period. This work was accomplished by maintaining four multi-parameter water quality monitoring stations along the Truckee River and the Little Truckee River (Table 1) and 12 temperature monitoring stations, installed in 2016, along the Truckee River and three of its tributaries (Table 2).

To determine the water year type for 2017, WQES staff investigated three separate hydrologic qualifiers: (1) total precipitation, (2) snow water equivalency, and (3) total runoff measured at Farad. As the Truckee River watershed is made up of 760 square miles within the State of California (Nevada Division of Water Resources 1998), rain and snow stations were chosen throughout the watershed, at varying elevations and locations, to try and capture the hydrologic conditions of the entire watershed (Figure 3). Based on these qualifiers, WQES staff determined WY 2017 to be an extremely wet year, and after comparing WY 2017 with the previous 17 years, found Water Year 2011 to have the most similar hydrologic conditions, so WY 2011 was chosen as the comparable pre-TROA water year.

In WY 2017, there was very little change in water quality as water moved from the upstream monitoring location at Bridge 8 to the downstream station at Farad. Lower temperatures and increased dissolved oxygen were often found at Farad in comparison with TTSA, and this presumably was caused by the reservoir releases. Turbidity differences between Bridge 8 and Farad are likely a result of the higher flows measured at Farad.

The Lahontan Regional Water Quality Control Board (LRWQCB) adopted total maximum daily loads (TMDLs) and listed parts of the Truckee River Watershed under the Clean Water Act, Section 303(d), in 2009. The TMDLs address sedimentation/siltation concerns in three streams within the Truckee River watershed, including the Truckee River between the outlet of Lake Tahoe and the California/Nevada state line. While DWR may share information and coordinate as appropriate with the LRWQCB, this Truckee River Water Quality Monitoring Program is not intended to monitor any water quality standards for any purpose under the TMDL established by the LRWQCB (California Department of Water Resources 2016).

Comparing WY 2017 data to a similar pre-TROA implementation water-type year did not reveal any noticeable changes in water quality resulting from the implementation of TROA.

The temperature monitoring during WY 2017 showed positive benefits of reservoir releases on the temperature of the Truckee River. During summer, Donner Creek, Prosser Creek, and the Little Truckee River each had cooler water temperatures than the Truckee River upstream of the respective confluence. The net effect is that the water temperature measured at Farad in the summer when water temperatures are at their highest is approximately 4 degrees cooler than the water temperature measured upstream at TTSA and Bridge 8. Individual effects of the different tributaries are harder to quantify because temperature measurement sites must be located far enough downstream to allow the river and tributary to thoroughly mix so that the measurement site will represent the entire river.

Recommendations

This report summarizes the tasks completed in WY 2017 by WQES staff and analyzes available data to investigate the possible influences of TROA implementation. WQES staff have completed these tasks for WY 2017, but further data collection and analysis is recommended to better understand the influence of TROA on water quality in the Truckee River. Data collection and evaluation will continue for several more years to include varying water year types to better understand the effects of TROA and related reservoir operations under a variety of hydrologic conditions. Specific recommendations are outlined below.

- Analyze the water quality at the four continuous monitoring stations on the Truckee River during WY 2018.
- Continue to monitor the temperature of the Truckee River at the confluences with Donner Creek, Prosser Creek, and the Little Truckee River. Frequently check the temperature probes on routine monthly visits to minimize the loss of data.

- Re-locate HOBO temperature loggers to be further away from upstream tributaries to better estimate average river temperature.
- Compare the temperatures recorded on the cabled temperature data against the HOBO temperature loggers in an effort to switch to the cabled real-time temperature data. With real-time data, staff can monitor conditions remotely, reduce the risk of tampering, and reduce the risk of data loss.
- Address issues with the station location of TTSA. Either search for a better location for the TTSA station to avoid sedimentation issues or redesign the station to avoid fouling from sedimentation.

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