Annual Stormwater Monitoring Report

Water Years 2014-2016

Developed by the
Tahoe Resource Conservation District
for the
Implementers' Monitoring Program &
Regional Stormwater Monitoring Program

Submitted to the
Lahontan Regional Water Quality Control Board and the
Nevada Division of Environmental Protection

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Implementers' Monitoring Program (IMP)

Component of the

Regional Stormwater Monitoring Program (RSWMP)

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State of California Department of Conservation

Water Boards

Submitted by the Tahoe Resource Conservation District
in cooperation with:

California

El Dorado County

Placer County

City of South Lake Tahoe

California Department of Transportation

Nevada

Douglas County

Washoe County

Nevada Tahoe Conservation District

Nevada Department of Transportation

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List of Acronyms

AC	Autosampler Composite Sample
BMP	Best Management Practice
Caltrans	California Department of Transportation
CEC	Characteristic Effluent Concentration
cf	cubic feet
cfs	cubic feet per second
CI	Contech MFS Inflow
CICU	Commercial, Industrial, Communications, Utilities
CMP	Corrugated Metal Pipe
CPP	Corrugated Plastic Pipe
CO	Contech MFS Outflow
CPC	Characteristic Pollutant Concentration
EMC	Event Mean Concentration
FB	Field Blank
FF	First Flush Sample
FSP	Fine Sediment Particles
GS	Grab Sample
IMP	Implementers' Monitoring Program
IV	Incline Village
JI	Jellyfish Inflow
JO	Jellyfish Outflow
Lahontan	Lahontan Regional Water Quality Control Board
MS	Manual Sample
NDEP	Nevada Division of Environmental Protection
NDOT	Nevada Department of Transportation
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resource Conservation Service
NTU	Nephlometric Turbidity Units
PD	Pasadena
PI	Pasadena Inflow
PO	Pasadena Outflow
PLRM	Pollutant Load Reduction Model
PSD	Particle Size Distribution
QAPP	Quality Assurance Project Plan
QAQC	Quality Assurance, Quality Control
RI	Rubicon Inflow
RO	Rubicon Outflow
ROW	Right-of-Way
RSWMP	Regional Storm Water Monitoring Program
RCD	Resource Conservation District
RTD	Rapid Transfer Device
RU	Rubicon
SAP	Sampling and Analysis Protocol

SB	Speedboat
S5	SR431 Catchment Outfall
SR	State Route 431
TA	Tahoma
Tahoe RCD	Tahoe Resource Conservation District
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
TV	Tahoe Valley
USDA	United States Department of Agriculture
UT	Upper Truckee
WY	Water Year

1. Monitoring Purpose

The Implementers' Monitoring Program (IMP) was established by the California and Nevada implementing jurisdictions in 2013 to collectively fulfill California National Pollutant Discharge Elimination System (NPDES) Permit requirements and Nevada Interlocal Agreement commitments. Partnership development was inspired by permit language that encouraged jurisdictions to comply collaboratively with regulatory requirements to promote cost savings through economies of scale. IMP is a partnership between the Tahoe Resource Conservation District (Tahoe RCD), El Dorado County, Placer County, the City of South Lake Tahoe, the California Department of Transportation (Caltrans), Douglas County, Washoe County, the Nevada Tahoe Conservation District, and the Nevada Department of Transportation (NDOT). Regulations require that California and Nevada jurisdictions in the Lake Tahoe Basin take measures to decrease pollutant loading from stormwater runoff in urbanized areas by implementing pollutant controls to decrease fine sediment particles (FSP, particles less than 16 microns) and nutrient inputs to Lake Tahoe. In the first permit term, which encompasses water years 2014-2016, jurisdictions were collectively required to monitor urban catchment outfalls at a minimum of four sites and Best Management Practices (BMPs) at a minimum of two sites for flow volumes and pollutant loads. Samples must be taken during a minimum of one event per season. Monitoring provides empirical data that will be used to (1) assess nutrient and sediment loading at chosen catchments (2) evaluate BMP effectiveness at chosen BMPs, and (3) refine characteristic effluent concentrations (CECs) used by the Pollutant Load Reduction Model (PLRM) to calculate load reductions from chosen treatment BMPs. PLRM is the standard tool developed specifically for the Tahoe Basin to calculate pollutant loads and load reductions from water quality improvement projects.

Though this report is intended to fulfill regulatory requirements, the IMP represents a historic first step toward implementing a comprehensive Regional Stormwater Monitoring Program (RSWMP) for the Tahoe Basin. All data has been collected in a manner consistent with RSWMP monitoring protocols designed to provide consistent data collection, management, analysis, and reporting approaches so that results can easily align with RSWMP objectives (Tahoe RCD et al 2015). Data collected for permit and agreement compliance initiate efforts to satisfy RSWMP's primary objective of establishing sites around the Lake Tahoe Basin for long-term stormwater monitoring and the secondary objective of refining CECs for the PLRM. Long-term data will be useful in identifying status and trends in the watershed and verifying PLRM estimates.

2. Study Design

During Water Year 2014 (WY14), five catchments (monitoring sites) were monitored for continuous flow and sampled for water quality at eleven monitoring stations. The monitoring stations were the outfalls of the five selected catchments and the inflows to, and outflows from, four BMPs located within three of those catchments (two BMPs are located within the same catchment). Three additional catchment outfalls were monitored in Water Year 2015 (WY15). Three monitoring stations were retired in Water Year 2016 (WY16): one outfall monitoring station and one BMP site with two monitoring stations. This monitoring program exceeds the minimum regulatory requirement of four monitored catchments and two monitored BMPs. The catchments were chosen because of their direct hydrologic connectivity to Lake Tahoe, diversity of urban land uses, range of sizes, and a reasonably equitable distribution among the participating jurisdictions. BMP effectiveness sites were selected because of their potential efficacy in treating storm water runoff characteristic of the Lake Tahoe Basin, the broad interest in, and lack of conclusive data regarding the efficiency of the selected BMPs in reducing runoff volumes and pollutant loads, especially FSP, and the importance of determining maintenance intervals required to retain effectiveness. See Figure 1 for stormwater monitoring site and meteorological station locations.

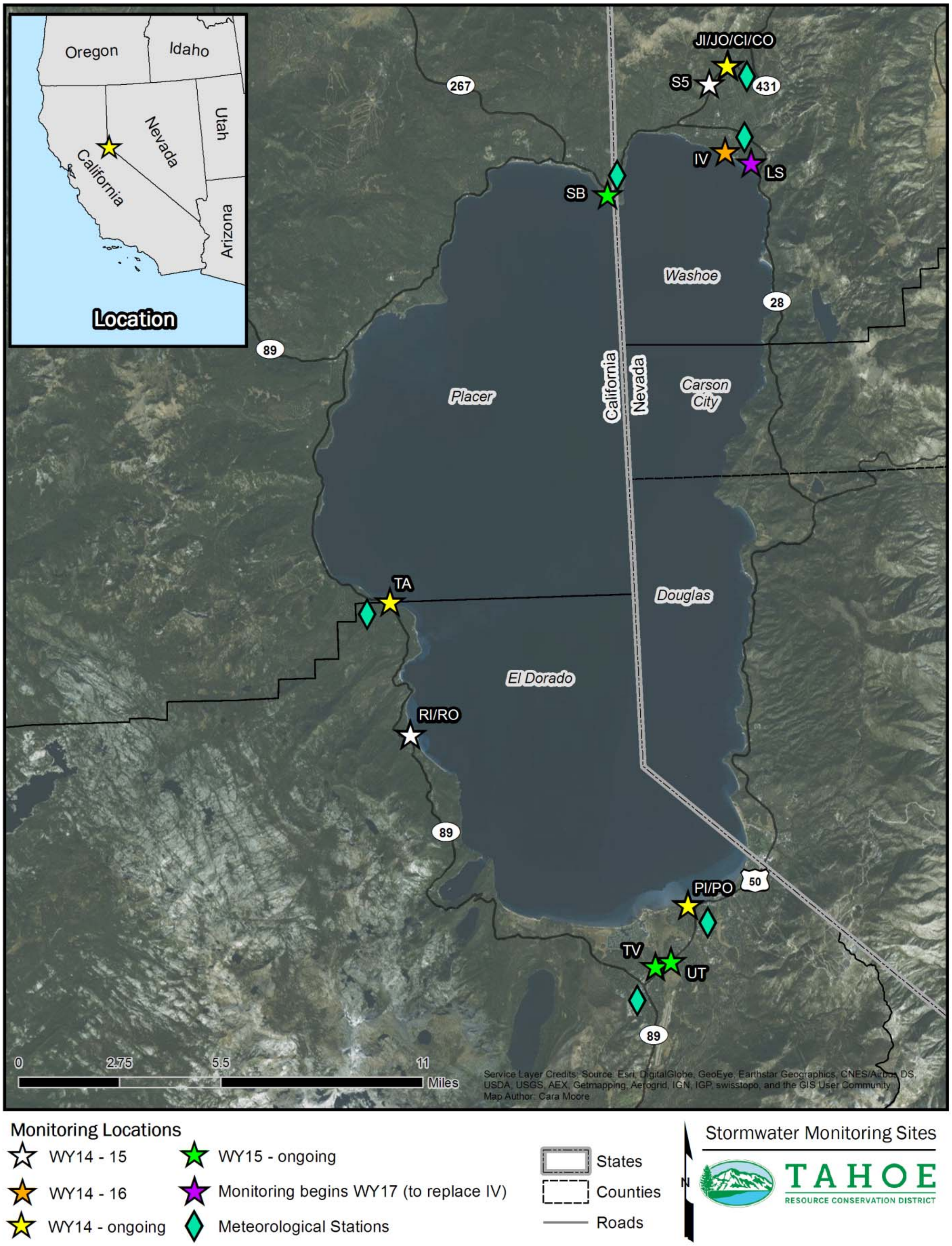


Figure 1: Stormwater monitoring sites and meteorological stations. Incline Village (IV), Pasadena Inflow (PI), Pasadena Outflow (PO), Jellyfish Inflow (JI), Jellyfish Outflow (JO), Contech MFS Inflow (CI), Contech MFS Outflow (CO), and Tahoma (TA) were monitored WY14, WY15, and WY16. Speedboat (SB), Tahoe Valley (TV), and Upper Truckee (UT) were monitored WY15 and WY16. Rubicon Inflow (RI), Rubicon Outflow (RO), and the SR431 outfall (S5) were monitored WY14 and WY15 (See sections 2.3 and 2.4). Lakeshore (LS) will be monitored in WY17.

Table 1 summarizes the selected catchments and their corresponding designation as a catchment outfall monitoring site and/or BMP effectiveness monitoring site. Also included are the number of monitoring stations in the catchment, jurisdiction, total catchment area, percent impervious area, and dominant land uses in each catchment.

Table 1: Monitoring site specifics. Dominant urban land use is highlighted in dark pink, second most dominant in medium pink, and third most dominant in light pink. The vegetated class was not considered in this ranking. SR431 has two checkmarks under BMP because there are two different cartridge filters at this site.

Site Name	Outfall	BMP	# Monitoring Stations	Jurisdiction	Total Acres	Impervious Area	Single Family Residential	Multi-Family Residential	CICU*	Primary Roads	Secondary Roads	Vegetated
Incline Village	√		1	Washoe	83.6	46%	3%	38%	33%	2%	12%	12%
Lakeshore	√		1	Washoe	97.8	41%	2%	43%	31%	1%	10%	13%
Pasadena	√	√	2	CSLT	78.8	39%	52%	13%	5%	0%	16%	14%
Rubicon	√	√	2	El Dorado	13.8	24%	76%	0%	0%	0%	13%	11%
Speedboat	√		1	Placer	29.0	30%	49%	3%	9%	4%	10%	25%
SR 431	√	√√	5	NDOT	1.4	89%	0%	0%	0%	89%	0%	11%
Tahoe Valley	√		1	CSLT, Caltrans	338.4	39%	19%	12%	20%	2%	13%	34%
Tahoma	√		1	Placer, El Dorado, Caltrans	49.5	30%	41%	4%	12%	3%	15%	25%
Upper Truckee	√		1	CSLT, Caltrans	10.5	72%	14%	7%	39%	14%	18%	8%

*Commercial, Industrial, Communications, Utilities

2.1 Incline Village Site Description

The Incline Village monitoring site is located on the western edge of the parking lot of Incline Beach Park near the end of Village Blvd on the south side of Lakeshore Blvd in Incline Village, Nevada. It is monitored as a catchment outfall at one monitoring station (IV). At 83.6 acres, this is the second largest catchment monitored and it includes runoff from Washoe County and NDOT jurisdictions. The catchment drains a relatively steep, highly urbanized area of Incline Village with dominant urban land-uses consisting of moderate to high density residential, commercial, and secondary roads. Forty-six percent of the catchment area is impervious and there is a lack of any intervening natural dispersion and infiltration areas due to steep slopes and high density development. Runoff discharges directly to Lake Tahoe via a 30-inch corrugated metal pipe (CMP) that daylights into a rock-lined ditch before entering the lake. The monitoring station was originally located within the rock-lined ditch.

On June 11, 2015 the monitoring station was removed from the rock-lined ditch because the flume installed in the ditch constricted very large flows and caused considerable channel erosion during a large thunderstorm in the summer of 2014. The channel was repaired and on July 7, 2015 and monitoring equipment was reinstalled at the end of the 30" CMP. Flow and turbidity sensors and the sample intake tube were mounted directly to the bottom of the CMP without a flume to ensure that large flows could pass unimpeded.

As part of the Central Incline Village Phase II Water Quality Improvement Project, constructed during the summer of 2015, substantial improvements were made in the catchment upstream of the monitoring site. New infiltration features that reduce roadway runoff in the existing 30" CMP prior to reaching the monitoring site include: (1) a series of three upstream infiltration basins that receives 1.8 cfs of low flow from the pipe network, (2) two small roadside infiltration pools, and (3) 450 linear feet of roadside infiltration channels. A Jellyfish cartridge filter similar to the one installed at State Route 431 (SR431) (see section 2.4) was also installed downstream of the new infiltration features and immediately upstream of the monitoring site. Drainage calculations by Washoe County engineers indicated the Jellyfish would receive low flows during average precipitation events even after the new upstream infiltration capacity was accounted for. However, the upstream improvements have been exceptionally successful and as of July 2015, this site has experienced only minimal flows that have been insufficient for sampling. As infiltration rates decrease over time, low flows are expected to exit the Jellyfish and pass through the 30" CMP. However, additional improvements made in the catchment during the summer of 2016 reduced the low flows even further, and this site was retired after WY16. It was replaced by a new site called "Lakeshore" that was installed in the road-side channel on the northern side of Lakeshore Blvd., near Third Creek. This site was installed prior to the commencement of WY17. The drainage area for this outfall is similar to Incline Village and receives flow not routed to the old Incline Village monitoring site in addition to flow from Lakeshore Blvd. east of Village Blvd. Data from Lakeshore Blvd. will be collected beginning October 1, 2016 and will be reported in the Annual Stormwater Monitoring Report WY14-17 to be submitted March 15, 2018.

2.2 Pasadena Site Description

The Pasadena monitoring site is located at the northernmost end of Pasadena Ave. in the City of South Lake Tahoe. It is monitored as a catchment outfall and BMP effectiveness site. A 36-inch outfall CMP emerging from the side of the steep slope at the end of Pasadena Avenue conveys runoff directly to Lake Tahoe. The pipe is the terminus of a 78.8 acre catchment designated the "G12" urban planning catchment by the City of South Lake Tahoe. The dominant land uses are moderate density single and multi-family residential and secondary roads. Thirty-nine percent of the catchment is impervious. In addition to the upstream permeable and porous road shoulders and perforated storm drain pipes, a pre-treatment Vortechnics storm vault and two Contech Stormfilter cartridge filter vaults were installed in parallel at the end of the catchment before discharge to the lake through the 36-inch CMP. Prior to WY14 monitoring, one of the Contech Stormfilters was not receiving any flow due to a missing orifice plate and the filter cartridges were therefore clean. The cartridges in the other Contech Stormfilter were replaced at the same time the missing orifice plate was installed (September 30, 2013). No further maintenance has been done on this system since September 2013. Thus, both Contech Stormfilters had clean cartridge filters prior to the start of this study. Pasadena Inflow (PI) is a monitoring station located at the inflow to the pre-treatment Vortechnics vault and two Stormfilter cartridge filter vaults (below the in-situ infiltration BMPs), and Pasadena Outflow (PO) is located in the 36-inch outfall CMP, the outflow from the pre-treatment vault and two Stormfilter cartridge filter vaults.

2.3 Rubicon Site Description

The Rubicon monitoring site is located on Rubicon Drive in the Rubicon Estates subdivision on the west shore of Lake Tahoe. At 13.8 acres, Rubicon is the third smallest monitored catchment and is characterized by low density single-family residential properties, secondary roads, and relatively gentle slope near lake level. Most of the roadways have unimproved shoulders, but a few steeper sections are bordered by asphalt dikes. Twenty-four percent of the catchment is impervious. The Rubicon V Erosion Control Project in 2010 (EIP#713.3) installed two sets of parallel Stormtech stormwater retention chambers at the lowest point in the catchment to control neighborhood flooding and reduce stormwater runoff volumes prior to discharge into Lake Tahoe. The Rubicon site is monitored as a catchment outfall and a BMP effectiveness project at two monitoring stations, Rubicon Inflow (RI) and Rubicon Outflow (RO). RI is located at the inflow to the Stormtech chambers and RO is located at the outflow from the Stormtech chambers and is also considered the catchment outfall. During WY14 and WY15 no flow was detected at the monitoring site outflow, demonstrating that this BMP was 100% effective in infiltrating flow at least during relatively dry years. Monitoring conducted by El Dorado County prior to WY14 had the same results. Therefore the IMP working group voted to remove this monitoring site after WY15.

2.4 Speedboat Site Description

The Speedboat monitoring site is located midway along the western side of Speedboat Avenue just south of Dip Street in Kings Beach, California. The 29.0 acre catchment is monitored as a catchment outfall at a single monitoring station (SB). It receives co-mingled runoff from Placer County and Caltrans jurisdictions delivered by a 12 inch CMP. The catchment is comprised of thirty percent impervious surfaces and drains a steep area that is characterized predominately by single family residences, vegetation, and secondary roads. After passing through an H-flume at the monitoring station, runoff from the catchment drains untreated through a series of CMPs along a pedestrian footpath at the intersection of Lake Street and Harbor Avenue directly to Lake Tahoe.

This site was monitored from 2003 to 2012 by the University of California, Davis, Tahoe Environmental Research Center (UCD TERC) and the Desert Research Institute (DRI). Data collected from this site was included in the initial Total Maximum Daily Load (TMDL) study that ultimately populated the PLRM used to estimate pollutant loading from urban catchments.

2.5 SR431 Site Description

The SR431 monitoring site is located on State Route 431 in Washoe County above Incline Village, Nevada. The 1.4 acre catchment encompasses NDOT right-of-way (ROW) of which approximately 89% is impervious. During winter months, when snow blocks stormwater infrastructure (like drop inlets) this catchment area may be larger, though this difficult to verify. This is the smallest catchment monitored and outfall discharges directly into a perennial stream called Deer Creek which connects with Incline Creek and discharges into Lake Tahoe, giving this site the distinction of being directly connected to the lake despite being 2.5 miles away. SR431 is monitored as a catchment outfall site and for evaluating and comparing the effectiveness of two adjacent stormwater cartridge filter vaults, the Contech MFS and the Jellyfish, containing different types of cartridge filters. There are five monitoring stations at SR431; the inflow and outflow to the Contech MFS vault (CI, CO), the inflow and outflow to the Jellyfish vault (JI, JO), and the outflow from the catchment (S5). S5 captures flow that bypasses the cartridge filter vaults. Though located in a rural area with moderate highway traffic density, SR431 is the only site that isolates runoff from primary roads and can therefore be used to characterize runoff from one land-use type. In addition, SR431 is the only site currently available where a true side-by-side comparison of stormwater cartridge filter types can be performed. During WY14 and WY15 very little runoff was received at the S5 outfall site, making monitoring difficult. Therefore the IMP working group voted to remove this monitoring location after WY15; monitoring continues at the Contech MFS and Jellyfish BMP sites.

2.6 Tahoe Valley Site Description

The Tahoe Valley monitoring site is located on the eastern side of Tahoe Keys Boulevard just south of the intersection with Sky Meadows Court in South Lake Tahoe, California near the entrance to the Sky Meadows Condominium Complex. With an area of 338.4 acres, this is the largest catchment monitored. It is a relatively flat, highly urbanized catchment consisting primarily of CICU, single family residences, secondary roads, and vegetation. Thirty-nine percent of the catchment is impervious. This site is monitored as a catchment outfall at a single monitoring site (TV). Runoff to the site is delivered by a 36 inch “squashed” CMP from the City of South Lake Tahoe jurisdiction. After passing by the TV monitoring station, runoff is conveyed through a vegetated swale along the northwest edge of the Sky Meadows Condominium Complex directly to the Upper Truckee River and eventually to Lake Tahoe.

Many water quality improvement projects have been implemented in this catchment in the last 25+ years. The existing Helen Basin and almost 3,200 linear feet of vegetated swales were built as part of the Tahoe Valley Erosion Control Project (ECP) in 1989 to increase stormwater infiltration upstream of the current monitoring site. This area was maintained under a contract with the California Conservation Corps in 2014 and included removing sediment that was blocking pipes, excess vegetation in the basin and swales, drug paraphernalia, empty liquor bottles, and human waste. Additionally, Caltrans completed the $12 Million US Highway 50 water quality improvement project in 2012 which included curb, gutter, rock-lined swales, infiltration chambers and basins along Highways 50 and 89 to address highway runoff in the catchment. Lastly, to ensure high infiltration rates, the City of South Lake Tahoe removed accumulated sediment, excess vegetation, and trash in the Caltrans swales upstream of Tahoe Keys Boulevard near Council Rock Road and behind the storage units on Eloise in May and June of 2015, also under a contract with the California Conservation Corps. Nearby homeless camps littered with trash, human waste, empty liquor bottles, and used needles were also removed.

2.7 Tahoma Site Description

Tahoma is monitored as a catchment outfall at one monitoring station (TA). The 49.5 acre catchment straddles the Placer County/El Dorado County border and comingles waters from both jurisdictions, plus waters from the Caltrans maintained Highway 89. The land-uses in this catchment are primarily moderate density residential and secondary roads in the Tahoe Cedars subdivision, but also include some commercial/industrial/communications/utilities (CICU) and primary roads. Thirty percent of the catchment area is impervious. The runoff from this catchment discharges directly into Lake Tahoe via a 36-inch oval "squashed" CMP at the bottom of the Water's Edge North condominium complex driveway without infiltration or treatment. Because of the high direct connectivity between the catchment and Lake Tahoe, this storm drain system has great potential to deliver high FSP loads to the lake.

A water quality improvement project completed in the fall of 2014 installed nine sediment traps to decrease flow rates and capture coarse sediment, one new drop inlet to more effectively capture and route flow, and more than 80 feet of perforated infiltration pipe to decrease runoff volumes to the catchment outflow.

2.8 Upper Truckee Site Description

The Upper Truckee monitoring site is located on the eastern bank of the Upper Truckee River at the intersection of Highway 50 and River Drive a short distance upstream of the bridge on Highway 50 that crosses the Upper Truckee River in the City of South Lake Tahoe, California. The 10.5 acre catchment drains a highly urbanized area which is primarily composed of CICU, primary and secondary roads, and single family residences. This is the second smallest catchment monitored, but with a high percentage of impervious coverage (72%) it receives relatively high volumes of co-mingled runoff from the City of South Lake Tahoe and Caltrans jurisdictions through an 18 inch Corrugated Plastic Pipe (CPP). After exiting the CPP, runoff is discharged to an 80 inch x 48 inch x 24 inch trash collection device lined with filter fabric and then to a 15 foot rock lined slope that leads directly into the Upper Truckee River and eventually to Lake Tahoe. The site is monitored as a catchment outfall site at a single location (UT). Improvements were made in this catchment by the City of South Lake Tahoe in the summer of 2015 that included an 8,100 cubic foot infiltration gallery, 394 linear feet of perforated pipe and infiltration trenches, seven sediment traps/dry wells, and 3,340 linear feet of stabilized road shoulders. However, since the majority of runoff in this catchment originates from Highway 50, under Caltrans' jurisdiction, volume and pollutant reductions at this monitoring site have been hard to detect. Caltrans has plans for further improvements in the summer of 2017. This site provides an opportunity to assess the effectiveness of these improvements with pre- and post-implementation data.

3. Data Collection Methods, Sampling Protocols, Analytic Methods

Continuous hydrology and stormwater samples are collected using ISCO brand automated samplers per RSWMP protocols (RSWMP FIG 2015 section 10.2.1, Tahoe RCD et al 2015) at all eleven monitoring stations in WY14, fourteen monitoring stations in WY15, and eleven monitoring stations in WY16 to support seasonal [fall/winter (October 1-February 28), spring (March 1-May 31), and summer (June 1-September 30)] volume and load reporting. Autosamplers were installed and sites maintained according to protocols outlined in the RSWMP FIG sections 10.1.2.2 and 10.2.1.3 respectively. Nine of the eleven WY14 monitoring stations, twelve of the fourteen WY15 monitoring stations, and all eleven WY16 monitoring stations collected continuous turbidity with an FTS DTS-12 turbidimeter. Turbidimeters were installed and maintained as outlined in the RSWMP FIG sections 10.2.2.1 and 10.2.2.2. Equations that relate turbidity to FSP concentration have been developed specifically for the Tahoe Basin and were applied to estimate FSP loads (2NDNATURE et al 2014).

Continuous data series logged at each monitoring station consist of parameters measured in the field at a constant time interval; continuous series consist of data for flow, turbidity, and meteorology. Flow and turbidity data are QAQC'd with frequent stage and turbidity field measurements to ensure that no drift has occurred in the readings and sensors are performing optimally (RSWMP FIG sections 10.2.1.7 and 10.2.2.5). Visual observations are used to confirm when a flume or pipe is dry and stage and turbidity should read zero. Visual observations are also used to determine if ice in the flume or pipe is causing stage errors that need to be adjusted to zero. Visual observations and field measurements are made every two weeks at a minimum but more often during precipitation events. Recalibration of stage measuring equipment is done by adjusting the level measurement on the autosampler. Turbidimeter accuracy was verified on all in-situ turbidimeters with a solution of known turbidity in late August 2015, June 2016, and again in late September/early October 2016. In-situ turbidimeter verification occurs regularly prior to the beginning of each water year as well as during the sampling season. Turbidimeters requiring servicing are sent back to the manufacturer for recalibration.

Weather is monitored closely and autosamplers are programmed to sample at the beginning of each runoff event in accordance with RSWMP FIG sections 10.2.1.4 and 10.2.1.5. Samples are selected as singles or made into flow-weighted composites (RSWMP FIG section 10.2.1.10) based on their occurrence on the hydrograph. First flush singles; rising limb composites, falling limb composites, or full event composites; and quality control samples are analyzed for total nitrogen (TN) concentration, total phosphorus (TP) concentration, total suspended solid (TSS) concentration, turbidity, and particle size distribution (PSD) to determine fine sediment particle (FSP) concentration at the UC Davis Tahoe Environmental Research Center Laboratory in Incline Village, NV, the UC Davis Laboratory in Davis, CA, or the High Sierra Water Laboratory, Inc. in Tahoe City, CA. Additional single samples at each station were analyzed for turbidity and PSD to aid in the refinement of a rating curves relating turbidity to FSP in WY14 and WY15. This task was suspended in WY16 due to high costs associated with PSD analysis and the unlikelihood of refining the rating curves. Beneficial rating curve refinement would require hundreds of data points in the upper range of turbidity values and substantial funding, both of which are, at this time, unavailable. Table 2 summarizes the sample type acronyms and their meaning. Table 3 summarizes the analytical methods and detection limits for all analyses. Raw analytical data for all samples is presented in Appendix A.

Table 2: Sample types and acronyms.

Sample Acronym	Sample Type
FF	**F**irst **F**lush single
AC	**A**uto-sampler **C**omposite, flow-weighted composite of whole or part of hydrograph
AS	**A**uto-sampler **S**ingle
FB	**F**ield **B**lank (QA/QC)
GS	**G**rab **S**ample single (QA/QC)
MS	**M**anually triggered auto-**S**ampler single (QA/QC)
PT	Single sample for **P**SD and **T**urbidity analysis only

Table 3: Analytical methods and detection limits.

Analyte	Methods	Description	Detection Limit	Target Reporting Limit
Total Phosphorus as P	TERC Low Level Method	Colorimetric, Total Phosphorus, Persulfate digestion, low level	2 ug/L	10 ug/L
Total Kjeldahl Nitrogen	EPA 351.1; or EPA 351.2	Colorimetric, block digestion, phenate	40 ug/L	100 ug/L
Nitrate + Nitrite	TERC Low Level Method	Colorimetric, NO3 + NO2 Hydrazine Method, low level	2 ug/L	10 ug/L
Total Nitrogen as N	N/A	Total Kjeldahl Nitrogen + Nitrate + Nitrite	40 ug/L	100 ug/L
Total Suspended Solids	EPA 160.2 or SM 2540-D	Gravimetric	0.4 mg/L	1 mg/L
Turbidity	EPA 180.1 or SM 2130-B	Nephelometric	0.05 NTU	0.1 NTU
Particle Size Distribution	SM 2560 or RSWMP addendum SOP	Laser backscattering	0.5 mg/L	1 mg/L

Meteorological data in each catchment is recorded using a Davis Instruments Vantage Pro weather station installed and maintained following recommendations in the RSWMP FIG sections 10.2.3.1 and 10.2.3.2. Meteorological data is used to calculate seasonal and annual precipitation totals (RSWMP FIG section 10.2.3.5) and to estimate the amount of flow that can be expected in a particular catchment for a particular amount of precipitation to aid with autosampler programming for event based sampling (RSWMP FIG section 10.2.1.4).

Sample handling and processing includes proper labeling of samples in the field, transporting samples to a laboratory immediately after collection in a cooler with ice, compositing single samples on a flow-weighted basis, taking turbidity measurements with a calibrated instrument, shipping to an analytical laboratory with proper chain-of-custody procedures, and filtering samples within a 24-hour period. A minimum of 10% of all samples analyzed were QAQC samples to identify problems related to field sampling and sample processing (RSWMP FIG section 10.2.1.6). Analytical data for all QAQC samples is presented in Appendix B.

4. Data Management Procedure

Continuous data series and sample dates and times are offloaded from the auto-samplers with rapid transfer devices (RTDs) (or through an online data management system at SR431) at the time samples are collected, maintenance is required, or every two weeks during dry periods. Any other field measurements and observations are recorded in a field notebook. Samples, RTDs, and notes are transported to a processing lab immediately after collection. Hydrology and turbidity data and sample dates and times are offloaded from the RTDs to the Tahoe RCD server using the software program Flowlink; all data are input into an Excel workbook for storing continuous parameters and sample dates and times. A separate Excel workbook is used for calculating flow-weighted compositing schedules for the rising limb, falling limb, or full event composites at each monitoring station. All samples are measured for turbidity and values are recorded on standard data sheets in the laboratory and entered into an Excel workbook for storing nutrient and sediment data. All samples are sent to proper laboratories within appropriate holding times for TN, TP, TSS, and PSD analysis. For a complete description of holding times for sampled parameters, see the RSWMP Quality Assurance Project Plan (QAPP) (DRI et al 2011a). Results from analytical laboratories are entered into the same Excel workbook for storing nutrient and sediment data. Data are offloaded from meteorological stations every two weeks using a laptop and the software program Weatherlink, and input into an Excel workbook for storing continuous meteorological data. A separate sheet in the meteorological station Excel workbook is used to extract discrete storm statistics such as event total precipitation, event duration, maximum and minimum temperatures, and peak precipitation rates. All Excel workbooks are housed on one central server (with backup device) and managed by Tahoe RCD staff. All data management procedures described above follow protocols outlined in the RSWMP FIG section 10.2.1.

5. Data Analysis

The raw hydrologic data set includes stage, velocity (at select sites), flow (determined by an equation relating stage in a weir, flume or pipe, or stage and velocity in a smooth walled pipe to flow), and turbidity recorded every 5 or 10 minutes (depending on the site) throughout the water year. Data gaps were short and rare. Erroneous readings are corrected and data gaps are filled following protocols outlined in the RSWMP FIG sections 10.2.1.7 for flow and 10.2.2.5 for turbidity.

Seasonal and annual volumes are calculated in accordance with RSWMP FIG sections 10.2.1.8 and 10.2.1.9. Results from lab analysis are used to calculate a flow-weighted event mean concentration (EMC) as outlined in section 10.2.1.10 of the RSWMP FIG. EMCs are grouped by season and a seasonal characteristic pollutant concentration is calculated for each site; these concentrations are then applied to each hydrologic measurement for that season. Loads are calculated by summing concentrations multiplied by runoff volumes over time as outlined in section 10.1.2.11 of the RSWMP FIG. Turbidity is converted to FSP concentration (in both mass per liter and number of particles per liter) using equations relating turbidity to FSP (2NDNATURE et al 2014) and integrated over time to calculate seasonal and annual load estimates in pounds and number of particles (RSWMP FIG sections 10.2.2.6 and 10.2.2.7).

Raw meteorological data include a precipitation and a temperature reading every 5 or 10 minutes (depending on the site) throughout the water year. Precipitation occurring as snow is converted to inches of water by a heated tipping bucket at the meteorological station that melts falling snow upon contact with the device. Data is QAQC'd by comparing event, seasonal and annual totals to the closest neighboring meteorological station. Data gaps were rare, but were filled with data from a neighboring station when they occurred (RSWMP FIG section 10.2.3.4). Individual storm events are extracted from the raw data and compiled on a summary page that includes beginning and end time of the event, event duration, total precipitation, peak precipitation, minimum and maximum temperature, storm event type, and whether the event produced sufficient runoff to sample or not. This summary page is used to sum seasonal and annual precipitation totals for reporting and to determine what size, intensity, and type of events are required for successful sampling.

6. Catchment Outfall Monitoring

6.1 Summary Data for All Monitoring Sites

The Natural Resources Conservation Service (NRCS) maintains a Snotel meteorological station called the Tahoe City Cross located north of Tahoe City at an elevation of 6800 feet (www.wcc.nrcs.usda.gov). Per RSWMP protocols, this station is to be used as a reference station to determine if a particular water year is wet, average, or dry (assuming that a wet, average, or dry season in Tahoe City will be the same around the lake). Using a 35-year precipitation record (water years 1981-2016) from this station, WY14 and WY15 fall into the lowest quartile at 24.6 and 22.9 total inches respectively and are therefore designated dry years (Table 4, Figure 2). According to the Association of California Water Agencies, WY14 and WY15 were some of the driest in the State's recorded history. WY16 was an average year, with a total of 30.4 inches falling very close to the 35-year median.

Table 4: Annual precipitation statistics from the Tahoe City Cross meteorological reference station, water years 1981-2016.

WY 1981-2016	Annual Precipitation (in)
minimum	17.5
1st quartile	26.2
median	30.7
3rd quartile	45.0
maximum	73.9

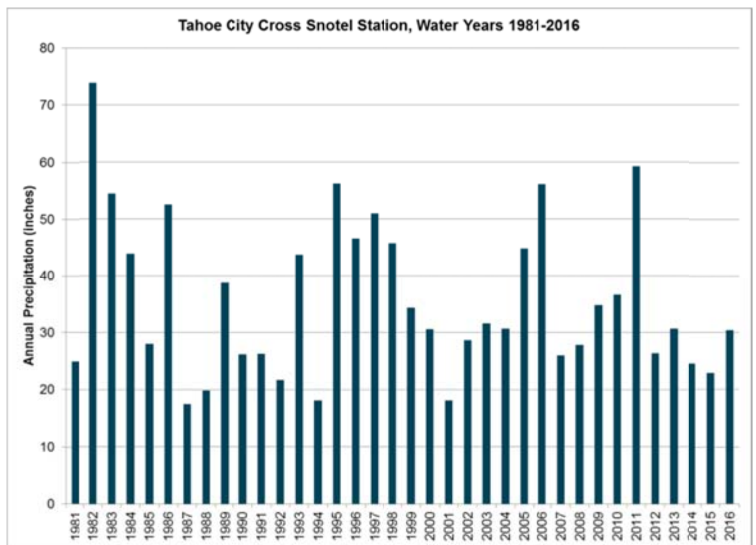


Figure 2: Long-term precipitation record at the Tahoe City Cross meteorological station, water years 1981-2016.

Three primary "seasons" are defined by the NPDES permit; fall/winter (October 1 - February 28), spring (March 1 - May 31), and summer (June 1 - September 30). The seasons are defined as such to better fit with precipitation patterns and storm event types that occur in the Tahoe Basin. The primary event types in the fall/winter are frontal rain storms, rain on snow, mixed rain/snow, or event snowmelt. An event snowmelt occurs during and shortly after a snow event when enough snow melts (generally on the roads from the heat generated by automobile traffic) to produce runoff at a given monitoring site. Spring event types include the fall/winter event types plus non-event snowmelts. A non-event snowmelt event generally occurs in the spring when temperatures are greater than 50 degrees Fahrenheit and accumulated snowpack melts. With the exception of Speedboat in WY16, Tahoma in WY14, WY15, and WY16, Tahoe Valley in WY16, and Upper Truckee in WY15, most monitoring sites did not receive sufficient spring non-event snowmelt to sample. Summer events are primarily thunderstorms and frontal rain storms.

Summary data for all sites are presented in Table 5a for WY14, 5b for WY15, and 5c for WY16. Figures 3 - 9 illustrate Tables 5a, 5b, and 5c in graphical form. Seasonal and annual precipitation values represent the total precipitation that fell in the catchment for that period, not just the sum of the storm totals of the events sampled. Seasonal and annual runoff volumes represent the cumulative runoff volume measured at the sampling stations during the respective period, not just the sum of the volumes of the events sampled. FSP loads are calculated from continuous turbidity, and TN and TP loads are calculated from event sampling. As not every runoff event was sampled during the year, the seasonal and annual TN and TP loads represent an average (volume weighted) load estimation for the respective period based on the events that were sampled in that period. (Average seasonal and annual FSP loads at Rubicon Inflow (RI) are calculated in this manner as well as there is no continuous turbidimeter installed at this site.)

The two west shore monitoring sites, Tahoma and Rubicon, received the most precipitation in both WY14 and WY15; Rubicon was retired in WY16, but Tahoma received the most precipitation in WY16 as well. Incline Village site received the least in WY14, Speedboat received the least in WY15; both these sites are located in the northeastern quadrant of the Tahoe Basin. Two sites on the south shore (Pasadena and Upper Truckee) that use the same meteorological station received the least in WY16, but Speedboat and Incline Village were close behind. The SR431 site on the north shore and Tahoe Valley on the south shore received comparable amounts in all three water years. In general the west shore of the lake gets more precipitation than the north, south, or east shores. Though located within the same region, SR431 likely received more precipitation than Incline Village all three water years as it lies about 900 feet higher in elevation. All regions of the lake received the greatest amount of precipitation during the fall/winter season, and most sites received the least amount of precipitation during the summer for all monitored years. However, both Pasadena and Tahoma received more precipitation during the summer than the spring in WY14. It is interesting to note that Tahoma received less precipitation in the spring of WY14 when compared to its neighbor Rubicon. The Rubicon meteorological station recorded greater precipitation during the March 5-6, March 29-30, April 25, and May 19-21, 2014 events than the Tahoma station did, plus an event on March 31, 2014 that did not occur in the Tahoma catchment. In contrast, during WY15, the Rubicon meteorological station recorded substantially less precipitation than the Tahoma station did during events occurring December 2 and December 10, 2014. This is evidence of how localized precipitation events can be in the Tahoe Basin. With few exceptions, sites received less precipitation across all seasons in WY15 than WY14. However, WY16 saw substantially less precipitation in the summer than WY14 or WY15, but annual totals were generally higher in WY16 because of greater fall/winter and spring precipitation.

Tahoma had the greatest seasonal and annual runoff volumes in WY14, likely due to its median catchment size, relatively large precipitation totals and high direct connectivity to the outfall despite being only 30% impervious. In WY15 two of the three new sites, Speedboat and Tahoe Valley, had higher seasonal and annual runoff volumes than Tahoma except during the summer when Tahoma had more runoff than any other site despite having slightly less precipitation than the south shore. In WY 16, Tahoe Valley again had the largest annual runoff volume, but Tahoma had runoff volumes more than twice that of Speedboat, likely due to the greater precipitation on the west shore than the north shore. Runoff volumes at Tahoe Valley in the fall/winter in WY15 and fall/winter and spring in WY16 far exceeded any other site, undoubtedly explained by its very large catchment size (338.4 acres), more than three times the size of the next largest catchment (Incline Village; 83.6 acres). Pasadena and Incline Village have similar catchment areas with similar impervious area and received similar amounts of precipitation in all three water years, but Pasadena had approximately twice the runoff that Incline Village did in the fall/winter and for the whole year in WY14. In WY15 Pasadena had approximately half the runoff that Incline Village did in the fall/winter though they had comparable runoff volumes for the year. In WY16, despite significant improvements in the Incline Village catchment that reduced total runoff by about two thirds, Pasadena only had about twice the annual runoff volume of Incline Village. This illustrates the great variability within a site and between sites, but with only three years of data it is difficult to pinpoint a reason for these differences. Pasadena inflow and outflow volumes are similar because the Stormfilter installed in this catchment is not designed to infiltrate flows. This is true for the Contech MFS and Jellyfish cartridge filters at SR431 as well. Slightly larger inflow volumes may be due either to a small amount of error inherent in the flow monitoring equipment or because some of the inflow remains trapped in the cartridge filter vault and a portion eventually evaporates and never outflows. In WY16 the Jellyfish vault received more flow than the Contech MFS vault likely due to sediment accumulation in the splitter vault that preferentially sent flow to the Jellyfish. With regular maintenance of the system, both vaults receive approximately equal flow volumes. The Rubicon catchment received the greatest amount of precipitation both WY14 and WY15 but produced little runoff at the inflow station either year, undoubtedly due to its small catchment area and the improvements (such as a series of microbasins designed to increase infiltration) that have been made upstream of the inflow. The outflow station recorded no outflow at all from the Stormtech chambers installed at the end of the catchment, indicating that all runoff was infiltrated and there was no discharge from this catchment outfall to Lake Tahoe. For this reason the Rubicon site was retired after WY15. The small SR431 catchment (only 1.4 acres) received a substantial amount of precipitation all three years, much of which fell as snow due to its elevation, and produced very little runoff despite being 96% impervious. The outfall site at SR431 got the least amount of runoff of any site in WY14 and WY15 because the cartridge filter vaults divert most of the runoff away from this site; hence this site was retired after WY15. Summer runoff volumes in this catchment in WY14 were larger than any other season because of a few high intensity thunderstorms. Due to very low precipitation in the summer of WY16, runoff volumes were much smaller during this season than in WY14 or WY15. The only exception to this is that one very intense thunderstorm localized to the west shore caused the greatest summer runoff volumes at Tahoma in all three years. Two south shore sites (Pasadena, and Tahoe Valley), measured no runoff at all during the summer of WY16. Upper Truckee, also on the south shore, measured 752 cubic feet of dry weather runoff during the summer, not runoff from precipitation events, and is therefore highlighted pink in Table 5c.

Average seasonal and annual FSP concentrations are within the same order of magnitude at all the sites, but overall in WY14 the inflows to the two vaults on SR431 were the dirtiest and Rubicon was the cleanest. The highest average concentration was seen in the fall/winter at the inflow to the Jellyfish vault and in the spring at the inflows to both vaults on SR431, likely due to the catchment's high imperviousness, classification as primary road, and the relatively large amount of road sand that runs off after snow events in that catchment. In WY15, Rubicon was again the cleanest and the SR431 sites were among the dirtiest, but Speedboat and Tahoma had the highest and second highest annual FSP concentrations respectively. Both these catchments receive primary road (highway) runoff. Speedboat is relatively steep, which may contribute to greater erosion in this catchment. In WY16, both the inflows and the outflows to the two vaults on SR431 had the highest average annual FSP concentrations. However, the FSP concentrations at the Jellyfish inflow during the fall/winter may be elevated due to sediment accumulation on the sensor. Jellyfish inflow and Contech MFS inflow concentrations should be roughly equal as designed. In the spring and summer, all four sensors (Contech MFS inflow and outflow and Jellyfish inflow and outflow) were covered in sediment and concentrations were elevated. The data and observation of sediment accumulation prompted a full clean-out of the SR431 system, but that did not occur until October 2016 as described in section 7.3. FSP concentrations and loads highlighted pink in Table 5c may have been affected by sediment accumulation on the sensors. Despite being elevated during the spring and summer at all four stations and elevated at Jellyfish Inflow during the fall/winter, the fall/winter concentrations at the other three stations at SR431 indicate that this is still indeed the dirtiest site. However, a summer thunderstorm at Speedboat in WY16 produced the highest FSP concentration (547 mg/L) ever seen at any site in any water year. The greatest FSP loading came from the Tahoma catchment during all seasons in WY14, primarily due to the large runoff volumes and relatively high FSP concentrations in this catchment, especially during the fall/winter season. While Tahoma had the second largest FSP loading in WY15, the Speedboat catchment had a load 1.6 times higher than Tahoma due to high volumes and very high FSP concentrations. Inflow to the Pasadena Stormfilter in WY14 and Tahoe Valley and Upper Truckee outfalls in WY15 also resulted in relatively high loads because of their large runoff volumes. Speedboat, Tahoma, Tahoe Valley and Upper Truckee FSP loads in all seasons far exceeded the other sites due to large runoff volumes.

Despite comparatively low annual FSP concentrations, Tahoe Valley had the third greatest FSP load in WY15 and the greatest FSP load in WY16 because of its very large flow volumes. The SR431 catchment outfall and Rubicon produced the smallest FSP loads in WY14 and WY15 as they have relatively small runoff volumes. Incline Village produced the smallest FSP load in WY16 due to relatively low FSP concentrations (except in the summer where it had the second highest FSP concentration but only 216 cubic feet of runoff) and a small runoff volume, a testament to the efficacy of the water quality improvements made in that catchment.

Generally, average seasonal TN and TP concentrations at all sites were highest in the summer. However, in WY16, south shore sites received no runoff in the summer (with the exception of Upper Truckee, which received 752 cubic feet of dry weather runoff) and the only two sites that were sampled were Speedboat and Tahoma. Therefore only Speedboat and Tahoma sites have nutrient data for the summer. Summer season TN and TP concentrations at both sites were high. All five SR431 and the Incline Village stations had the highest average annual TN concentrations in WY14. In WY15 Incline Village had an average annual TN concentration more than twice as high as the next highest average annual TN concentration (SR431 catchment outfall). In WY16 Upper Truckee had the highest average annual TN concentration, but TN concentrations across all sites in WY16 were similar. The SR431 catchment outfall and Incline Village had the highest average annual TP concentrations in WY14, Incline Village had the highest TP concentration in WY15 and the SR431 inflow sites had the highest TP concentrations in WY16.   In general, Rubicon and Tahoe Valley had lower TN and TP concentrations all three water years. However, the Pasadena and Rubicon inflows had high TP concentrations in the summer of 2014, and Pasadena had the highest in the summer of 2015. TN and TP loads were much smaller than FSP loads at all sites for all seasons during all water years. TN and TP loads were greatest at Tahoma and second greatest at the Pasadena inflow in all seasons due to the large runoff volumes in WY14. Despite typical TN and TP concentrations, TN and TP loads were the greatest at Tahoe Valley due to very large runoff volumes in WY15. Tahoe Valley had the largest TN load in the fall/winter, spring, and the largest annual load despite relatively TN low concentrations. Tahoma had a little more than a third of the runoff volume of Tahoe Valley, but only slightly smaller TN loads due to higher concentrations. Similarly, Tahoma and Tahoe Valley had the largest TP loads in general. TN and TP loads were the smallest at the SR431 catchment outfall and Rubicon in WY14 and WY15 and the smallest at all four SR431 BMP sites in WY16 due to small runoff volumes. Average seasonal and annual TP concentrations were lower than average TN concentrations at every site in every season, as were the loads. TN and TP concentrations and loads are not available for the spring season of WY14 at Pasadena due to equipment failure during the only spring event that produced sufficient runoff to sample in this catchment. TN and TP concentrations and loads are not available for the summer season of WY15 at Incline Village because improvements in this catchment increased infiltration above the monitoring site and resulted in little to no flow at the monitoring station. TN and TP concentrations and loads are not available for the summer season of WY15 at Upper Truckee due to numerous short duration flows that did not produce enough runoff to sample effectively. TN and TP concentrations and loads are not available for the summer season of WY16 at most sites due to a lack of sufficient runoff for sampling.

In summary, the greatest loads of all pollutants come from catchments with high pollutant concentrations and large runoff volumes. However, data indicate that runoff volume has more influence on loads than concentrations do. Therefore, even catchments with relatively low pollutant concentrations can discharge very large pollutant loads if they have large runoff volumes. The fall/winter season has the largest discharge volumes and therefore contributes the greatest pollutant load to the lake. In general, loads were greater in the wetter WY16 than in the dryer WY14 and WY15, but not always. FSP concentrations and loads are generally greatest in the fall/winter, but concentrations can spike in the summer with intense thunderstorms, likely due to increased erosion potential from high impact raindrops on dry, exposed soil. TN concentrations tend to be highest in the summer, especially at sites near primary roads. TN loads are generally larger in the fall/winter because of larger runoff volumes. TP concentrations and loads can be very high in the spring and summer, but loads tend to be greatest in the fall/winter due to large runoff volumes. From this data we can infer that implementing improvements that reduce stormwater runoff volumes is more effective in treating pollutant loading to the lake than installing treatment devices that aim to reduce pollutant concentrations.

Table 5a: Summary statistics for all catchments for WY14. Top table shows seasonal precipitation, seasonal volumes, and FSP data, bottom table shows seasonal volumes and nutrient data.

Water Year 2014 Oct. 1, 2013 - Sep. 30, 2014			Seasonal Precipitation (in)			Total Annual Precip (in)	Seasonal Volumes (cf)			Total Annual Runoff Volume (cf)	Average Seasonal FSP Concentrations (mg/L)			Average Annual FSP Concen-tration (mg/L)	Seasonal FSP Load (lbs)			Total Annual FSP Load (lbs)	Seasonal FSP Load (#particles)			Total Annual FSP Load (#particles)
Catchment (Site) Name	Station Name	Station Acronym	Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)	
Incline Village	Incline Village	IV	8.76	3.59	2.13	14.47	47,074	12,321	16,610	76,005	78	27	113	77	228	21	117	364	2.3E+16	1.7E+15	8.7E+15	3.4E+16
Pasadena	Pasadena In	PI	8.34	3.59	4.54	16.47	99,687	9,943	25,424	135,054	85	35	81	81	530	22	128	680	5.2E+16	1.7E+15	9.4E+15	6.3E+16
	Pasadena Out	PO					99,382	9,301	24,478	133,161	36	84	118	55	225	49	180	454	2.0E+16	4.2E+15	1.3E+16	3.8E+16
Rubicon	Rubicon In	RI	13.66	5.78	3.64	23.08	19,012	15,545	1,816	36,374	12	16	106	18	<1	<1	<1	<1	1.2E+15	1.2E+15	8.2E+14	3.3E+15
	Rubicon Out	RO					0	0	0	0	0	0	0	0	0	0	0	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00
SR431	Contech In	CI	8.91	4.36	3.83	17.10	4,024	6,372	7,561	17,957	269	431	116	262	68	171	55	293	7.8E+15	1.8E+16	3.9E+15	2.9E+16
	Contech Out	CO					3,003	4,007	6,575	13,584	182	236	92	155	34	59	38	131	3.8E+15	5.7E+15	2.7E+15	1.2E+16
	Jellyfish In	JI					3,022	4,837	8,377	16,236	442	433	103	264	83	131	54	268	1.0E+16	1.3E+16	3.8E+15	2.7E+16
	Jellyfish Out	JO					3,320	4,695	8,122	16,136	109	230	74	127	23	67	38	128	2.4E+15	6.4E+15	3.8E+01	8.8E+15
	SR431 Outfall	S5					245	329	3,249	3,823	65	195	69	80	1	4	14	19	1.2E+14	3.9E+14	9.4E+14	1.4E+15
Tahoma	Tahoma	TA	14.95	3.13	4.01	22.09	207,798	65,114	59,000	331,911	111	50	70	92	1,446	204	258	1,908	1.6E+17	2.0E+16	2.4E+16	2.1E+17

Water Year 2014 Oct. 1, 2013 - Sep. 30, 2014			Seasonal Volumes (cf)			Total Annual Runoff Volume (cf)	Average Seasonal TN Concentrations (ug/L)			Average Annual TN Concen-tration (ug/L)	Seasonal TN load (lbs)			Total Annual TN load (lbs)	Average Seasonal TP Concentrations (ug/L)			Average Annual TP Concen-tration (ug/L)	Seasonal TP load (lbs)			Total Annual TP load (lbs)
Catchment (Site) Name	Station Name	Station Acronym	Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)	
Incline Village	Incline Village	IV	47,074	12,321	16,610	76,005	1,141	915	4,938	1,935	3.4	0.7	5.1	9.2	758	343	1,698	896	2.2	0.3	1.8	4.3
Pasadena	Pasadena In	PI	99,687	9,943	25,424	135,054	1,034	na	3,355	1,395	6.4	na	5.3	11.8	484	na	2,197	771	3.0	na	3.5	6.5
	Pasadena Out	PO	99,382	9,301	24,478	133,161	748	na	2,036	932	4.6	na	3.1	7.7	462	na	1,558	631	2.9	na	2.4	5.2
Rubicon	Rubicon In	RI	19,012	15,545	1,816	36,374	272	417	5,078	574	0.3	0.4	0.6	1.3	112	157	2,188	235	0.1	0.2	0.2	0.5
	Rubicon Out	RO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR431	Contech In	CI	4,024	6,372	7,561	17,957	2,078	2,194	2,084	2,122	0.5	0.9	1.0	2.4	670	1,207	406	749	0.2	0.5	0.2	0.8
	Contech Out	CO	3,003	4,007	6,575	13,584	1,672	1,451	2,221	1,873	0.3	0.4	0.9	1.6	419	635	354	451	0.1	0.2	0.1	0.4
	Jellyfish In	JI	3,022	4,837	8,377	16,236	1,936	2,646	2,076	2,220	0.4	0.8	1.1	2.3	1,056	1,341	407	806	0.2	0.4	0.2	0.8
	Jellyfish Out	JO	3,320	4,695	8,122	16,136	1,109	1,372	1,816	1,542	0.2	0.4	0.9	1.6	300	627	299	394	0.1	0.2	0.2	0.4
	SR431 Outfall	S5	245	329	3,249	3,823	726	2,426	1,490	1,522	<0.1	<0.1	0.3	0.4	57	1,077	965	916	<0.1	<0.1	0.2	0.2
Tahoma	Tahoma	TA	207,798	65,114	59,000	331,911	538	1,193	2,383	994	7	5	9	21	345	857	1,643	676	4	3	6	14

Table 5b: Summary statistics for all catchments for WY15. Top table shows seasonal precipitation, seasonal volumes, and FSP data, bottom table shows seasonal volumes and nutrient data.

Water Year 2015 Oct. 1, 2014 - Sep. 30, 2015			Seasonal Precipitation (in)			Total Annual Precip (in)	Seasonal Volumes (cf)			Total Annual Runoff Volume (cf)	Average Seasonal FSP Concentrations (mg/L)			Average Annual FSP Concen-tration (mg/L)	Seasonal FSP Load (lbs)			Total Annual FSP Load (lbs)	Seasonal FSP Load (#particles)			Total Annual FSP Load (#particles)
Catchment (Site) Name	Station Name	Station Acronym	Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)	
Incline Village	Incline Village	IV	7.41	4.68	2.05	14.14	59,355	3,239	13	62,607	20	15	<1	19	73	3	<1	76	6.5E+15	2.8E+14	0.0E+00	6.8E+15
Pasadena	Pasadena In	PI	6.61	2.86	2.85	12.32	31,797	2,931	16,402	51,130	51	46	157	85	102	8	161	272	9.3E+15	6.6E+14	1.1E+16	2.1E+16
	Pasadena Out	PO					30,276	2,739	15,887	48,902	39	41	130	68	73	7	129	209	6.5E+15	4.7E+14	8.5E+15	1.6E+16
Rubicon	Rubicon In	RI	13.33	4.16	3.05	20.54	11,902	640	1,245	13,787	7	1	25	8	5	<1	2	7	3.7E+14	2.3E+12	1.3E+14	5.1E+14
	Rubicon Out	RO					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR431	Contech In	CI	9.78	5.58	3.53	18.88	11,877	9,804	3,831	25,512	128	142	17	117	95	87	4	186	1.0E+16	8.3E+15	2.0E+14	1.9E+16
	Contech Out	CO					9,379	7,976	3,295	20,650	118	94	19	93	69	47	4	120	7.1E+15	4.1E+15	3.0E+14	1.2E+16
	Jellyfish In	JI					11,014	11,281	4,359	26,654	125	119	18	105	86	84	5	175	9.5E+15	8.0E+15	3.0E+14	1.8E+16
	Jellyfish Out	JO					10,976	10,977	3,780	25,733	155	99	25	112	106	68	6	180	1.1E+16	6.1E+15	4.0E+14	1.8E+16
	SR431 Outfall	S5					460	635	758	1,853	21	15	6	13	<1	<1	<1	2	5.1E+13	4.9E+13	2.2E+13	1.2E+14
Speedboat	Speedboat	SB	6.60	3.23	2.02	11.85	154,783	53,349	22,481	230,613	150	354	195	201	1,446	1,178	274	2,898	1.5E+17	1.2E+17	2.5E+16	3.0E+17
Tahoma	Tahoma	TA	13.59	3.90	2.92	20.41	113,102	35,155	27,445	175,702	182	116	159	165	1,283	254	272	1,809	1.5E+17	2.5E+16	2.0E+16	1.9E+17
Tahoe Valley	Tahoe Valley	TV	11.06	3.63	3.06	17.75	517,596	45,322	22,580	585,498	21	34	58	23	669	95	82	846	5.6E+16	7.5E+15	5.4E+15	6.9E+16
Upper Truckee	Upper Truckee	UT	11.06	3.63	3.06	17.75	51,589	28,338	22,738	102,665	118	131	101	118	380	231	143	754	3.7E+16	2.1E+16	9.9E+15	6.8E+16

Water Year 2015 Oct. 1, 2014 - Sep. 30, 2015			Seasonal Volumes (cf)			Total Annual Runoff Volume (cf)	Average Seasonal TN Concentrations (ug/L)			Average Annual TN Concen-tration (ug/L)	Seasonal TN load (lbs)			Total Annual TN load (lbs)	Average Seasonal TP Concentrations (ug/L)			Average Annual TP Concen-tration (ug/L)	Seasonal TP load (lbs)			Total Annual TP load (lbs)
Catchment (Site) Name	Station Name	Station Acronym	Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)	
Incline Village	Incline Village	IV	59,355	3,239	13	62,607	4,269	8,811	na	4,503	15.8	1.8	na	17.6	647	599	na	645	2.4	0.1	na	2.5
Pasadena	Pasadena In	PI	31,797	2,931	16,402	51,130	804	939	5,174	2,214	1.6	0.2	5.3	7.1	505	438	1,598	852	1.0	<0.1	1.6	2.7
	Pasadena Out	PO	30,276	2,739	15,887	48,902	1,118	873	3,031	1,725	2.1	0.1	3.0	5.3	468	458	1,367	759	0.9	<0.1	1.4	2.3
Rubicon	Rubicon In	RI	11,902	640	1,245	13,787	1,522	671	1,224	1,455	1.1	<0.1	<0.1	1.3	218	150	262	219	0.2	<0.1	<0.1	0.2
	Rubicon Out	RO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR431	Contech In	CI	11,877	9,804	3,831	25,512	1,174	1,046	891	1,082	0.9	0.6	0.2	1.7	899	703	153	711	0.7	0.4	<0.1	1.1
	Contech Out	CO	9,379	7,976	3,295	20,650	1,107	942	1,437	1,096	0.6	0.5	0.3	1.4	728	565	212	583	0.4	0.3	<0.1	0.8
	Jellyfish In	JI	11,014	11,281	4,359	26,654	1,157	968	153	913	0.8	0.7	<0.1	1.5	948	736	153	728	0.7	0.5	<0.1	1.2
	Jellyfish Out	JO	10,976	10,977	3,780	25,733	898	976	1,153	969	0.6	0.7	0.3	1.6	740	532	214	574	0.5	0.4	<0.1	0.9
	SR431 Outfall	S5	460	635	758	1,853	1,061	1,591	4,204	2,528	<0.1	<0.1	0.2	0.3	593	1,365	1,152	1,086	<0.1	<0.1	<0.1	0.1
Speedboat	Speedboat	SB	154,783	53,349	22,481	230,613	1,024	1,387	3,356	1,335	9.9	4.6	4.7	19.2	406	397	467	410	3.9	1.3	0.7	5.9
Tahoma	Tahoma	TA	113,102	35,155	27,445	175,702	561	814	5,680	1,411	4.0	1.8	9.7	15.5	604	295	1,281	648	4.3	0.6	2.2	7.1
Tahoe Valley	Tahoe Valley	TV	517,596	45,322	22,580	585,498	874	1,331	2,976	990	28.2	3.8	4.2	36.2	239	233	664	255	7.7	0.7	0.9	9.3
Upper Truckee	Upper Truckee	UT	51,589	28,338	22,738	102,665	1,708	3,360	na	1,786	5.5	5.9	na	11.4	766	1,043	na	673	2.5	1.8	na	4.3

Table 5c: Summary statistics for all catchments for WY16. Top table shows seasonal precipitation, seasonal volumes, and FSP data, bottom table shows seasonal volumes and nutrient data. Pink cells indicate values that may be affected by sediment accumulation on the sensors.

Water Year 2016 Oct. 1, 2015 - Sep. 30, 2016			Seasonal Precipitation (in)			Total Annual Precip (in)	Seasonal Volumes (cf)			Total Annual Runoff Volume (cf)	Average Seasonal FSP Concentrations (mg/L)			Average Annual FSP Concen-tration (mg/L)	Seasonal FSP Load (lbs)			Total Annual FSP Load (lbs)	Seasonal FSP Load (#particles)			Total Annual FSP Load (#particles)
Catchment (Site) Name	Station Name	Station Acronym	Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)	
Incline Village	Incline Village	IV	13.04	7.28	0.32	20.64	23,367	5,234	216	28,817	56	31	371	54	82	10	5	97	9.5E+15	1.2E+15	4.1E+14	1.1E+16
Pasadena	Pasadena In	PI	10.15	8.40	0.08	18.63	33,847	23,853	0	57,700	53	62	0	57	113	93	0	206	1.1E+16	7.8E+15	0.0E+00	1.9E+16
	Pasadena Out	PO					27,038	18,063	0	45,101	44	66	0	53	74	74	0	148	6.7E+15	6.2E+15	0.0E+00	1.3E+16
SR431	Contech In	CI	14.46	7.91	0.30	22.67	16,104	9,367	325	25,796	288	272	49	279	290	159	1	450	3.4E+16	1.6E+16	5.4E+13	5.1E+16
	Contech Out	CO					12,994	8,255	324	21,573	275	202	99	244	223	104	2	329	2.6E+16	1.1E+16	7.6E+13	3.7E+16
	Jellyfish In	JI					23,182	12,585	718	36,485	415	298	45	367	600	234	2	836	7.5E+16	2.5E+16	1.8E+14	1.0E+17
	Jellyfish Out	JO					19,830	15,904	705	36,439	159	246	23	194	197	244	1	442	2.2E+16	2.5E+16	2.5E+13	4.7E+16
Speedboat	Speedboat	SB	12.97	6.69	0.28	19.94	216,777	82,478	322	299,577	139	203	547	157	1,879	1,047	11	2,937	2.0E+17	1.0E+17	8.0E+14	3.1E+17
Tahoma	Tahoma	TA	16.70	11.60	1.26	29.56	371,286	262,234	62,839	696,359	62	51	86	60	1,446	832	337	2,615	1.5E+17	8.5E+16	3.6E+16	2.7E+17
Tahoe Valley	Tahoe Valley	TV	15.86	9.14	0.09	25.09	922,144	850,345	0	1,772,489	43	41	0	42	2,497	2,166	0	4,663	2.4E+17	1.9E+17	0.0E+00	4.3E+17
Upper Truckee	Upper Truckee	UT	10.15	8.40	0.08	18.63	158,201	90,517	752	249,470	183	133	<1	164	1,812	749	<1	2,561	1.9E+17	7.2E+16	5.0E+12	2.6E+17

Water Year 2016 Oct. 1, 2015 - Sep. 30, 2016			Seasonal Volumes (cf)			Total Annual Runoff Volume (cf)	Average Seasonal TN Concentrations (ug/L)			Average Annual TN Concen-tration (ug/L)	Seasonal TN load (lbs)			Total Annual TN load (lbs)	Average Seasonal TP Concentrations (ug/L)			Average Annual TP Concen-tration (ug/L)	Seasonal TP load (lbs)			Total Annual TP load (lbs)
Catchment (Site) Name	Station Name	Station Acronym	Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)	
Incline Village	Incline Village	IV	23,367	5,234	216	28,817	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Pasadena	Pasadena In	PI	33,847	23,853	0	57,700	2,701	1,210	0	1,538	5.7	1.8	0	7.5	699	713	0	710	1.5	1.1	0	2.5
	Pasadena Out	PO	27,038	18,063	0	45,101	3,182	1,437	0	2,002	5.4	1.6	0	7.0	608	627	0	621	1.0	0.7	0	1.7
SR431	Contech In	CI	16,104	9,367	325	25,796	1,807	2,450	na	1,914	1.8	1.4	na	3.2	1,503	3,732	na	1,872	1.5	2.2	na	3.7
	Contech Out	CO	12,994	8,255	324	21,573	1,441	2,228	na	1,580	1.2	1.1	na	2.3	1,448	1,953	na	1,537	1.2	1.0	na	2.2
	Jellyfish In	JI	23,182	12,585	718	36,485	1,508	3,189	na	1,819	2.2	2.5	na	4.7	1,578	2,688	na	1,783	2.3	2.1	na	4.4
	Jellyfish Out	JO	19,830	15,904	705	36,439	1,222	2,519	na	1,467	1.5	2.5	na	4.0	1,158	3,123	na	1,530	1.4	3.1	na	4.5
Speedboat	Speedboat	SB	216,777	82,478	322	299,577	1,155	1,409	26,200	1,279	15.6	7.3	0.5	23.4	530	784	4,957	605	7.2	4.0	0.1	11.3
Tahoma	Tahoma	TA	371,286	262,234	62,839	696,359	1,295	546	10,030	1,945	30.0	9.0	39.6	78.6	997	342	2,868	942	23.1	5.6	11.3	40.0
Tahoe Valley	Tahoe Valley	TV	922,144	850,345	0	1,772,489	786	852	0	812	45.2	45.3	0	90.5	307	315	0	310	17.7	16.7	0	34.4
Upper Truckee	Upper Truckee	UT	158,201	90,517	752	249,470	2,694	2,318	na	2,590	26.6	13.1	na	39.7	15	1,463	na	1,265	11.7	8.3	na	20.0

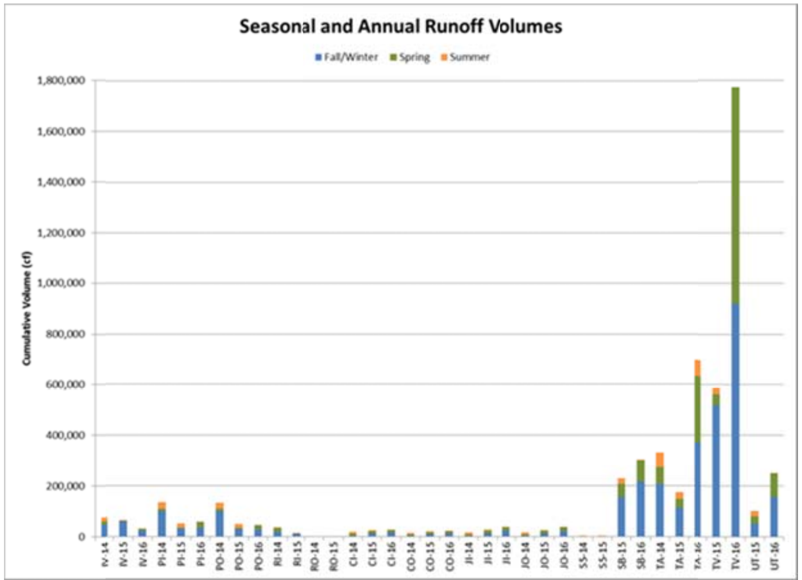


Figure 3: Runoff volumes at each monitoring station, WY14, WY15, and WY16.

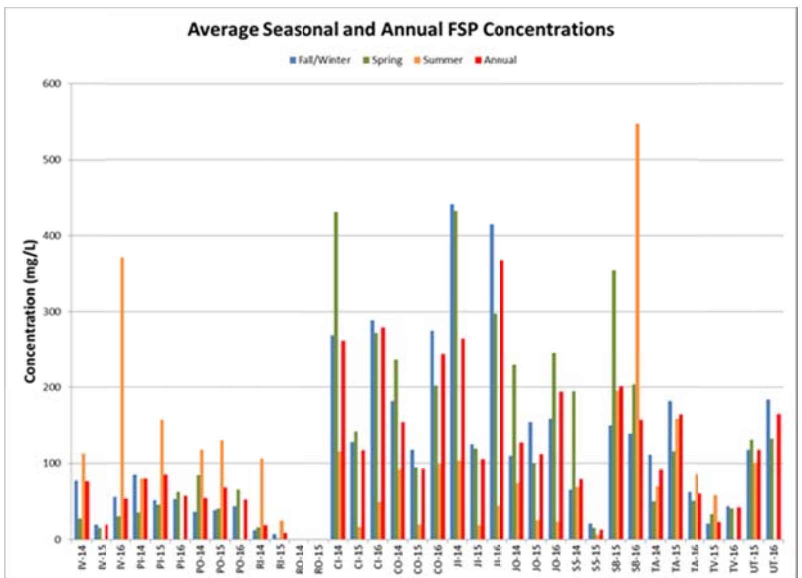


Figure 4: FSP concentrations at each monitoring station, WY14, WY15, and WY16.

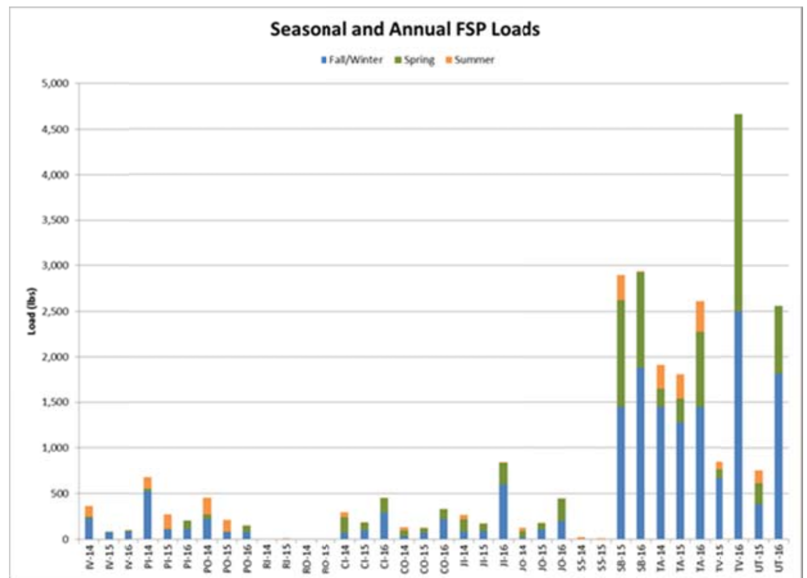


Figure 5: FSP loads at each monitoring station, WY14, WY15, and WY16.

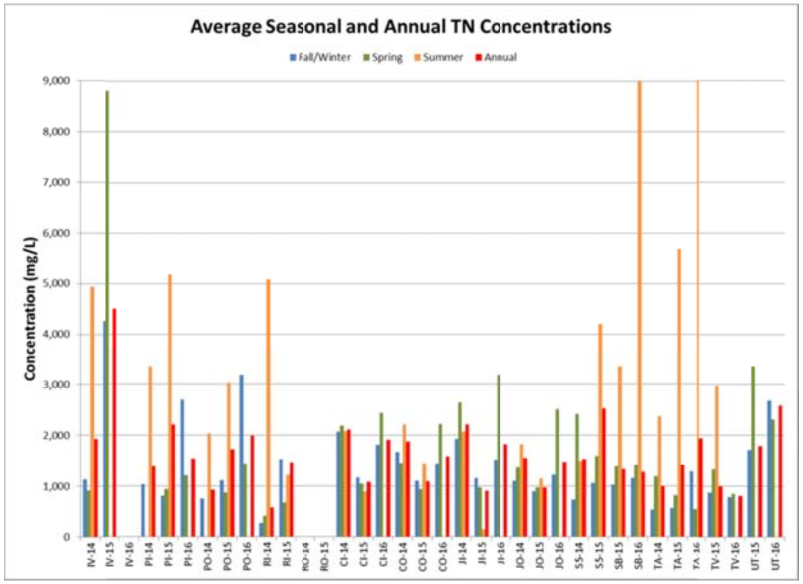


Figure 6: TN concentrations at each monitoring station, WY14, WY15, and WY16.

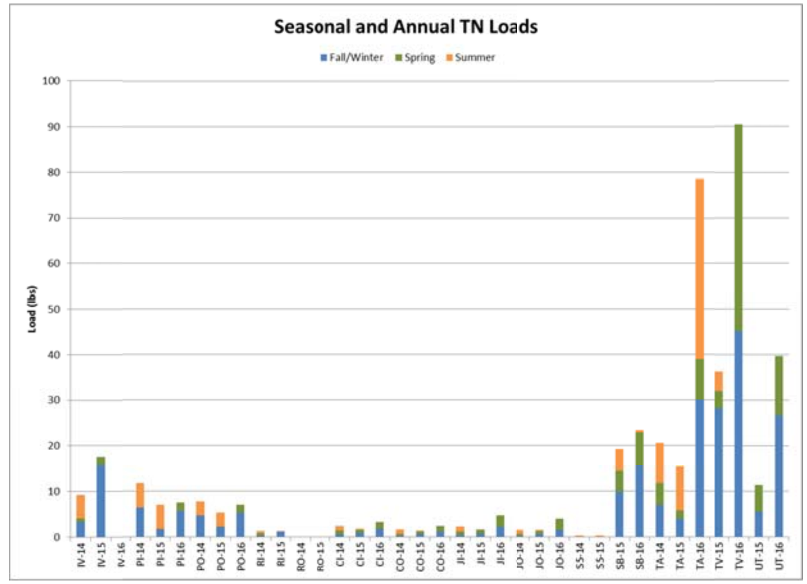


Figure 7: TN loads at each monitoring station, WY14, WY15, and WY16.

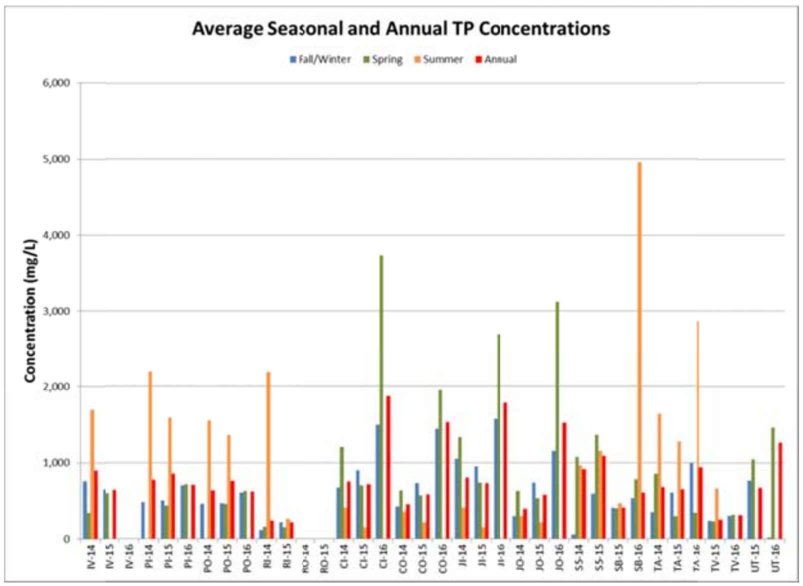


Figure 8: TP concentrations at each monitoring station, WY14, WY15, and WY16.

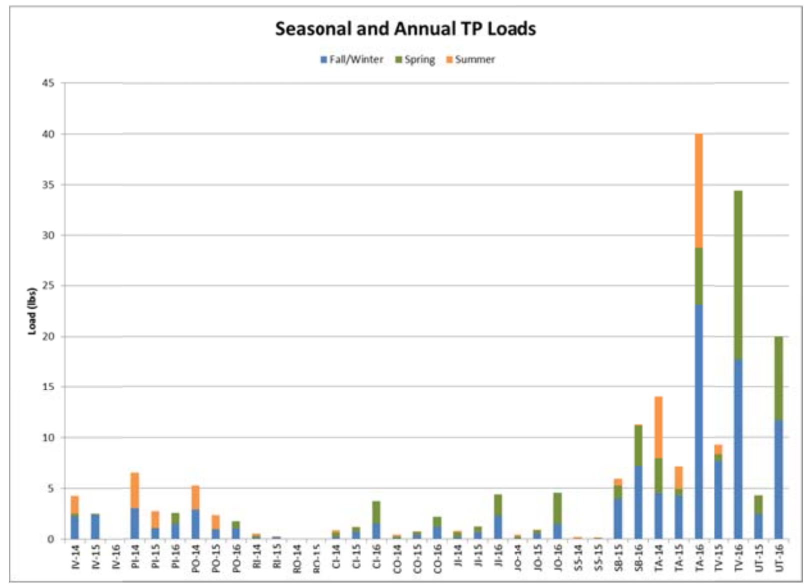


Figure 9: TP loads at each monitoring station, WY14, WY15, and WY16.

6.2 Summary Data for Individual Catchments

6.2.1 Incline Village

The total precipitation for WY14 in the Incline Village catchment was 14.47 inches, more than three inches less than the minimum annual precipitation recorded at the Tahoe City Cross reference station since 1981 (Table 4). Figure 10a shows the average daily flow and cumulative precipitation for WY14. The majority of the precipitation fell in the fall/winter season (8.76 inches). The spring season received 3.59 inches and the summer season received 2.13 inches. A total of 31 discrete precipitation events were measured at the Incline Village meteorological station, 13 in the fall/winter, 12 in the spring, and 6 in the summer. Approximately one third of the events during WY14 produced less than a tenth of an inch of precipitation, and just under three quarters of the events produced less than half an inch. The largest storm occurred between February 6, 2014 and February 10, 2014, falling as mixed rain and snow and producing 4.80 inches of precipitation in Incline Village. Though not sampled, the highest instantaneous peak flows (about 1.44 cubic feet per second (cfs)) were experienced during a high intensity thunderstorm on July 20, 2014.

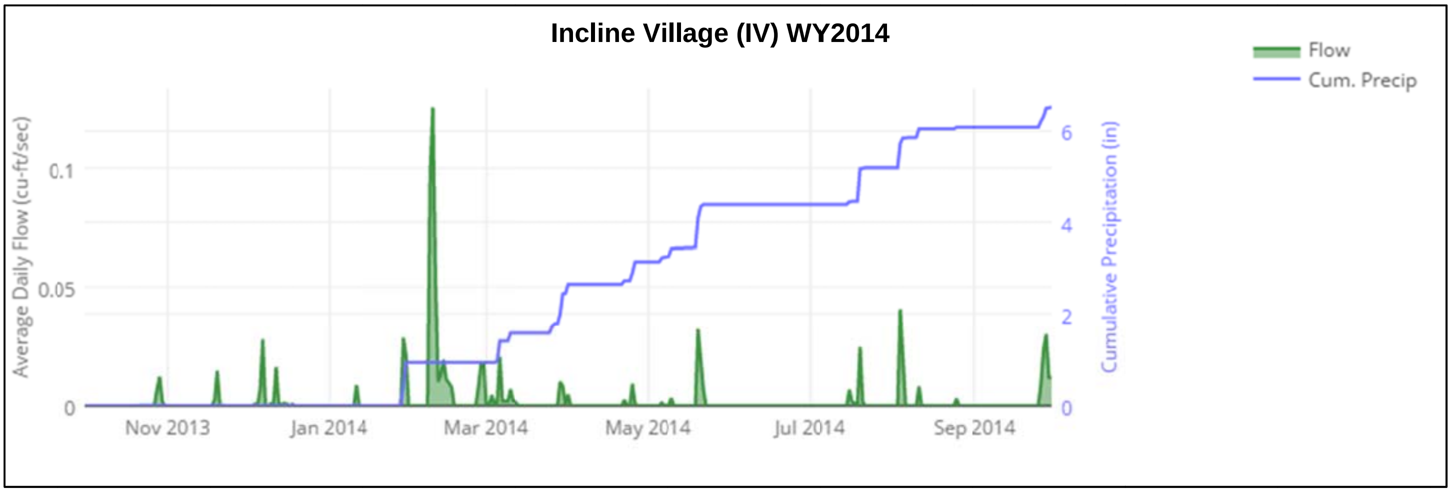


Figure 10a: Average daily flow and cumulative precipitation at the Incline Village catchment outfall, WY14.

The total precipitation for WY15 in the Incline Village catchment was 14.14 inches, more than three inches less than the minimum annual precipitation recorded at the Tahoe City Cross reference station since 1981. Figure 10b shows the average daily flow and cumulative precipitation for WY15. The majority of the precipitation fell in the fall/winter season (7.41 inches). The spring season received 4.68 inches and the summer season received 2.05 inches. A total of 36 discrete precipitation events were measured at the Incline Village meteorological station, 15 in the fall/winter, 12 in the spring, and 9 in the summer. Approximately 33% of the events during WY15 produced less than a tenth of an inch of precipitation, and approximately 75% of the events produced less than half an inch. The largest storm occurred between February 6, 2015 and February 11, 2015, falling as mixed rain and snow and resulting in 3.34 inches of precipitation in the Incline Village catchment. The highest instantaneous peak flows (about 0.95 cfs) occurred during this precipitation event.

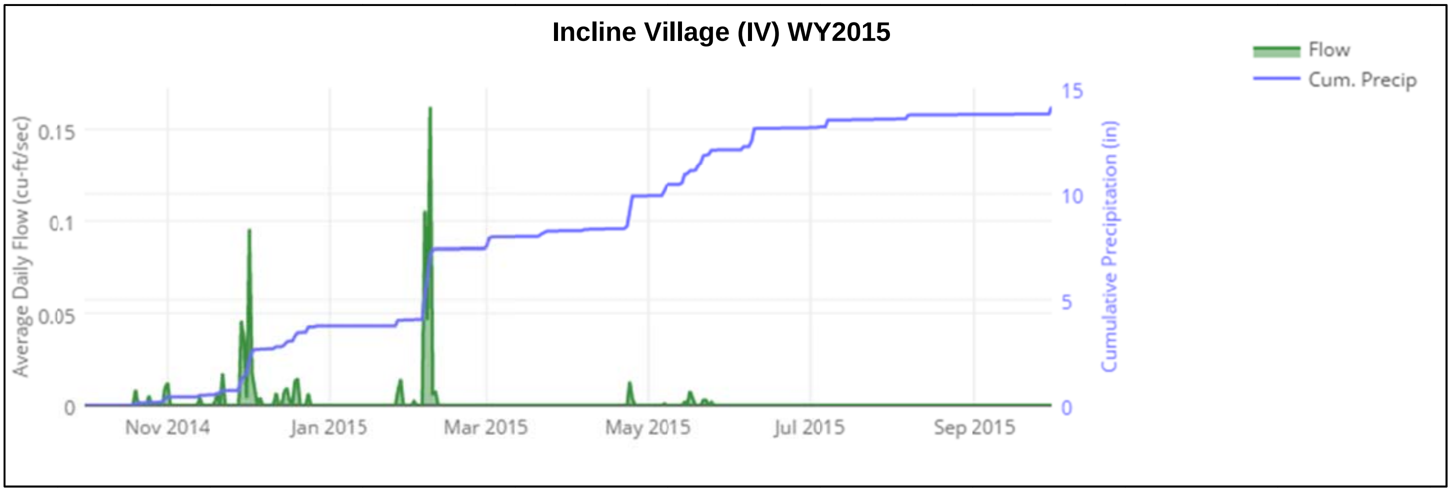


Figure 10b: Average daily flow and cumulative precipitation at the Incline Village catchment outfall, WY15.

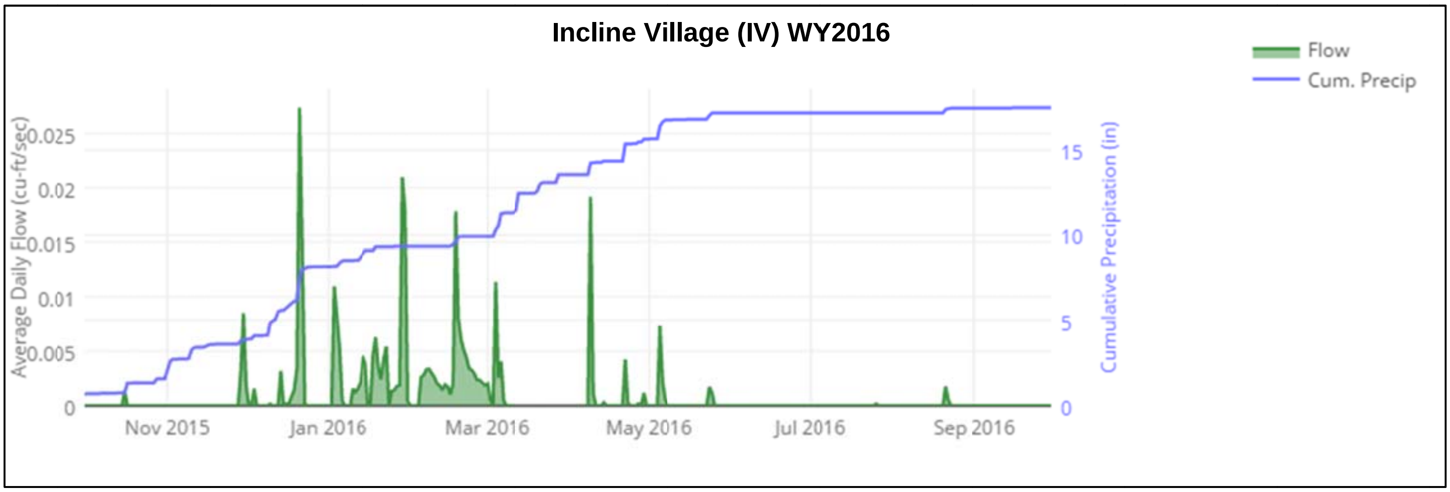


Figure 10c: Average daily flow and cumulative precipitation at the Incline Village catchment outfall, WY16.

The total precipitation for WY16 in the Incline Village catchment was 20.64 inches, within the first quartile of the annual precipitation recorded at the Tahoe City Cross reference station since 1981 (Table 4). Figure 10c shows the average daily flow and cumulative precipitation for WY16. The majority of the precipitation fell in the fall/winter season (13.04 inches). The spring season received 7.28 inches and the summer season received 0.32 inches. A total of 44 discrete precipitation events were measured at the Incline Village meteorological station, 25 in the fall/winter, 16 in the spring, and 3 in the summer. Approximately 34% of the events during WY16 produced less than a tenth of an inch of precipitation, and 52% of the events produced less than half an inch. The largest storm occurred between December 16, 2015 and December 22, 2015. This mixed precipitation event produced 2.47 inches of precipitation in Incline Village. The highest instantaneous peak flow (0.22 cfs) was experienced during a rain-on-snow event on April 9, 2016.

In WY14, nine precipitation events in the Incline Village catchment produced sufficient runoff to sample and water quality samples were taken across the hydrograph during six of these runoff events. As this was the first year of monitoring, two extra events were sampled at Incline Village in an effort to learn the nuances of the site and to guarantee successful capture of the requisite four runoff events. Continuous hydrology, continuous turbidity and events sampled during WY14 are presented in Figure 11a. The highest instantaneous peak flows occurred during the July 20, 2014 storm, but these storms were not sampled as the required one summer event had already been sampled on July 16,

2014. Turbidimeter readings exceeded the maximum range of the sensor (1600 NTU) on one occasion in WY15 (September 26, 2014). Additionally, the high instantaneous peak flows on July 20, 2014 produced by a peak precipitation of 0.29 inches in 10 minutes overwhelmed the flume and severely eroded the channel below the sampling station. Washoe County has since repaired the channel, but the eroded channel did not affect sampling at this location.

In WY15, ten precipitation events in the Incline Village catchment produced sufficient runoff to sample during the fall/winter and spring seasons and water quality samples were taken across the hydrograph during three of these runoff events, thereby fulfilling the requisite number of sample events for fall/winter and spring. The requisite summer runoff event was not captured primarily due to lack of runoff, but also due to equipment failure during an event that could have been large enough to sample. As a result of improvements in the upper watershed (section 2.1), the CMP where the monitoring equipment is now located is designed to discharge flow only during 10-year (or larger) storm events. Unfortunately, the equipment that was installed in the CMP was later found to be faulty, so not only is it uncertain whether any of the summer thunderstorms would have generated enough runoff to sample, but no summer thunderstorms were captured. Continuous hydrology, continuous turbidity, and events sampled during WY15 are presented in Figure 11b. Turbidimeter readings exceeded the maximum range of the sensor (1600 NTU) on one occasion in WY15 (November 19, 2014). The highest instantaneous peak flows occurred during the large February 2015 storm event which produced 1.52 total inches of precipitation.

As a result of the water quality improvement projects installed in the Incline Village catchment (section 2.1) in WY15, no precipitation events in the Incline Village catchment produced sufficient runoff to sample across the hydrograph. Low flow was occasionally observed at the outfall, and grab samples were collected and analyzed during two separate events; one in the fall/winter and one in the summer. Continuous hydrology, continuous turbidity, and events sampled during WY16 are presented in Figure 11c. Turbidimeter readings exceeded the maximum range of the sensor (1600 NTU) on three occasions in WY16. The highest instantaneous peak flow (0.22 cfs) was experienced during a rain-on-snow event on April 9, 2016, a much lower maximum flow rate than was observed in other monitoring years.

Continuous hydrology, continuous turbidity, and water quality samples for the individual events sampled at Incline Village are presented in Appendix C (Not included for WY16 because only grab samples were analyzed).

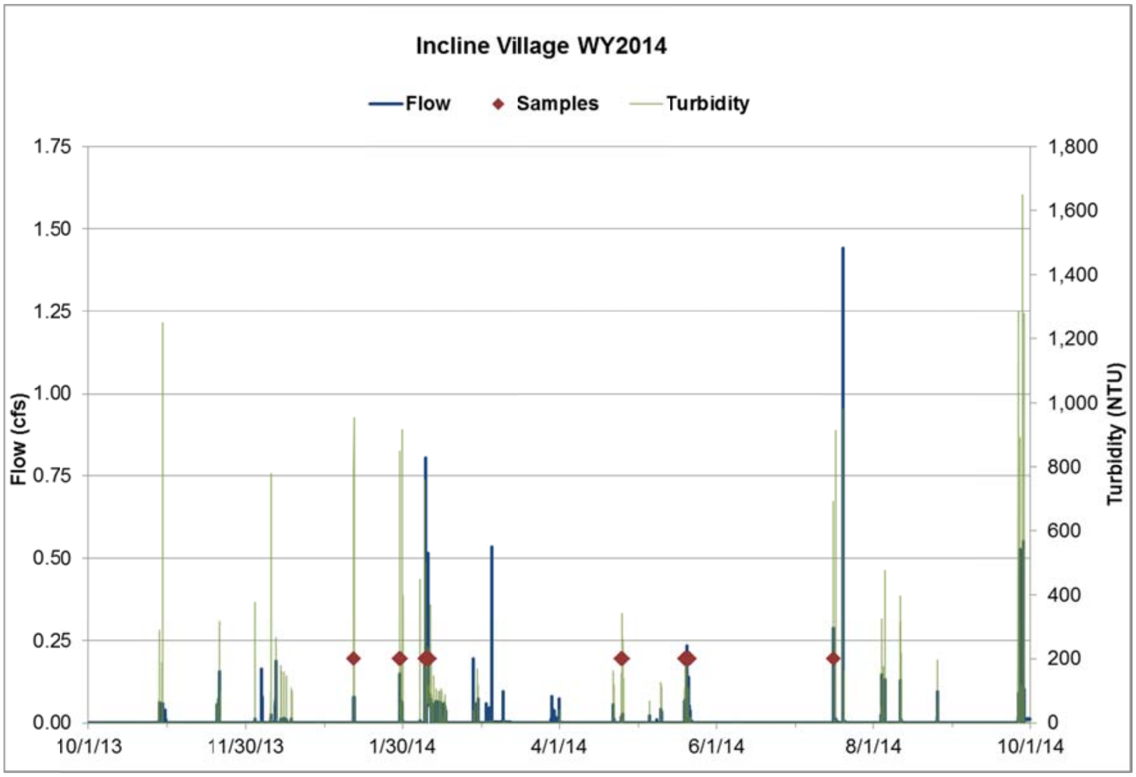


Figure 11a: Continuous hydrology, turbidity and sampled events at the Incline Village catchment outfall, WY14.

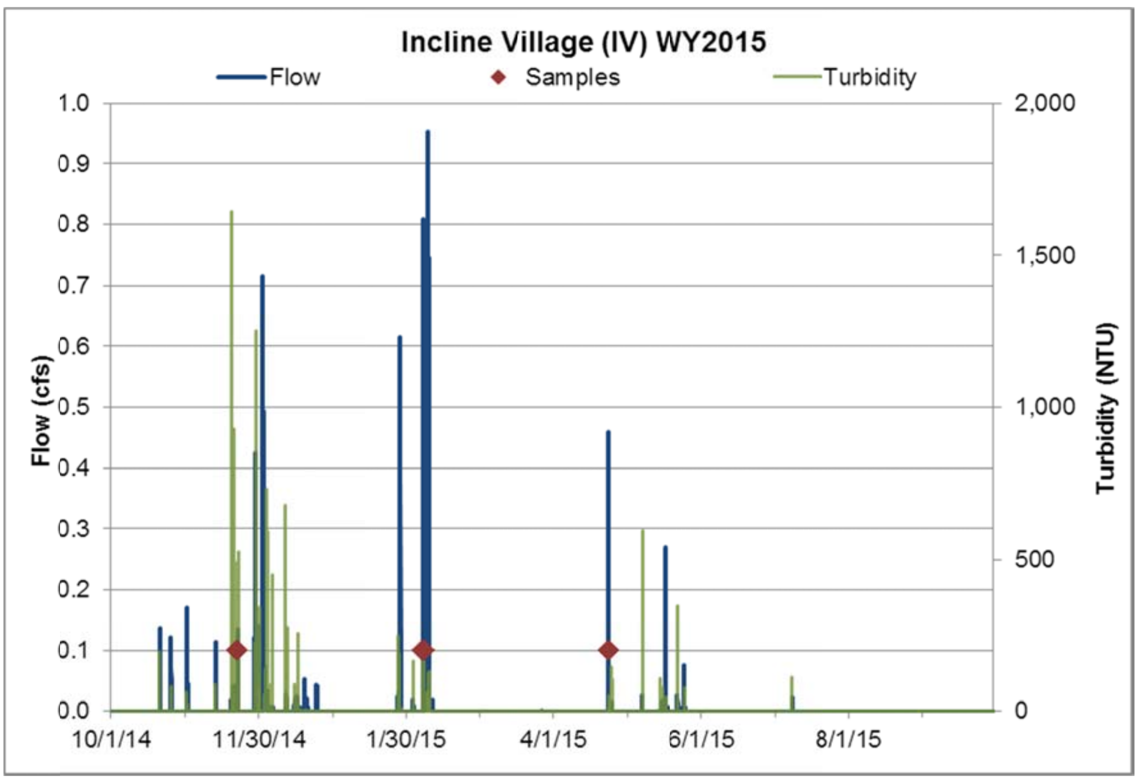


Figure 11b: Continuous hydrology, turbidity and sampled events at the Incline Village catchment outfall, WY15.

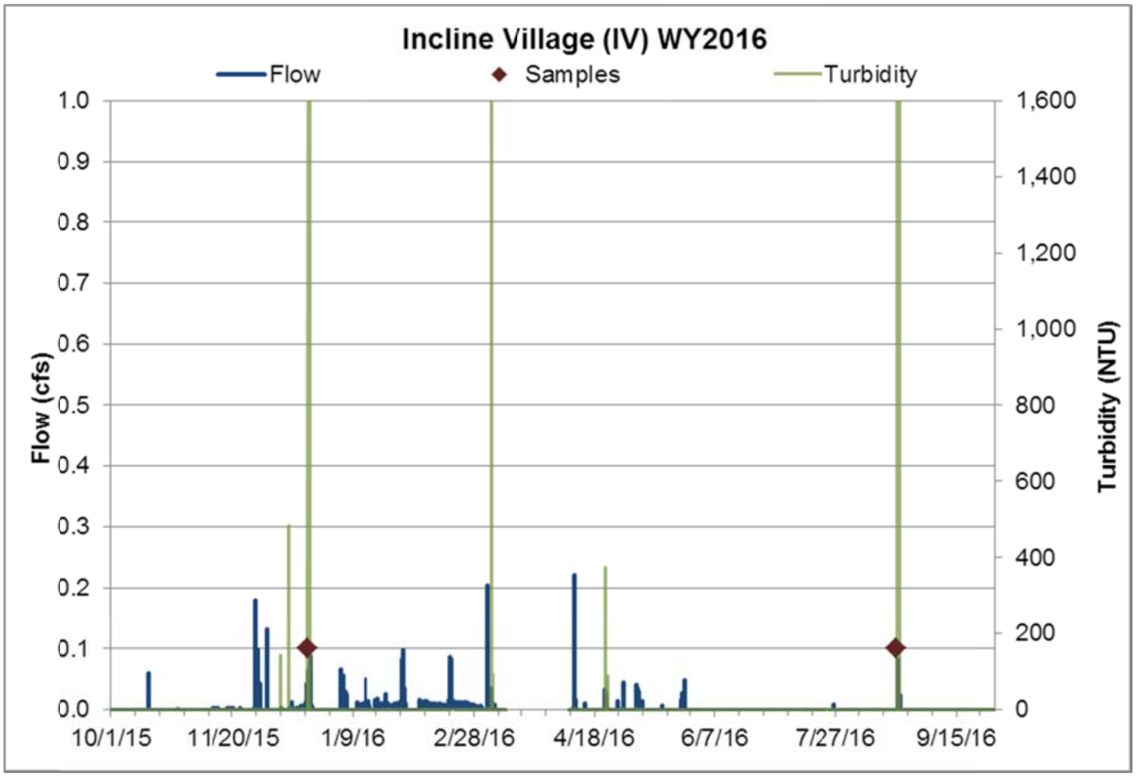


Figure 11c: Continuous hydrology, turbidity and sampled events (grab samples only) at the Incline Village catchment outfall, WY16. The maximum range of the turbidity sensor is 1,600NTU, thus this is the maximum range on the graph axis.

Summary data for all six events sampled at Incline Village in WY14 are presented in Table 6a. Three runoff events were sampled during the fall/winter, two during the spring, and one during the summer. In general, only precipitation events greater than 0.2 inches produced sufficient runoff for water quality sampling, though the summer thunderstorm on July 16, 2014 of only 0.06 inches produced sufficient runoff to sample as peak precipitation reached 0.03 inches in 10 minutes. The largest runoff event, with a runoff volume of 23,950 cubic feet, occurred February 8 – 10, 2014 and resulted in the largest FSP, TN, and TP loads of the year despite mid-range concentrations for all three pollutants. The highest concentrations for all three pollutants occurred during the summer thunderstorm on July 16, 2014, however loading was low because the total runoff volume was low. Fall/winter and summer events had peak turbidities of 700-1,000 NTU occurring at the beginning of each runoff event. Spring events had peak turbidities of only 200-350 NTU occurring in the middle of the storm when the flows were the highest (Appendix C).

Table 6a: Event summary data for six sampled events at Incline Village in WY14.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
IV	Fall/Winter	1/11/14 12:40	1/11/14 18:50	6:10	3,856	0.28	rain/snow	90%	193	46	1,555	0.4	1,114	0.3
IV	Fall/Winter	1/29/14 13:30	1/30/14 5:00	15:30	7,577	0.94	rain/snow	100%	191	90	1,556	0.7	1,117	0.5
IV	Fall/Winter	2/8/14 7:00	2/10/14 21:30	62:30	23,950	4.80	rain on snow	85%	103	154	944	1.4	587	0.9
IV	Spring	4/25/14 4:40	4/26/14 2:30	21:50	856	0.41	event snowmelt	95%	88	5	1,869	0.1	225	<0.1
IV	Spring	5/20/14 5:20	5/21/14 11:20	30:00	3,897	0.96	thunderstorm	100%	62	15	706	0.2	369	0.1
IV	Summer	7/16/14 20:10	7/16/14 22:50	2:40	578	0.06	thunderstorm	80%	391	14	4,938	0.2	1,698	0.1

Summary data for all three events sampled at Incline Village in WY15 are presented in Table 6b. Two runoff events were sampled during the fall/winter, one during the spring, and none during the summer due to insufficient runoff volumes for sampling and equipment failure (described above). Similar to WY14, only precipitation events greater than 0.2 inches produced sufficient runoff for water quality sampling. The largest runoff event, with a runoff volume of 11,284 cubic feet, occurred February 6 - 7, 2015 (only about half of the runoff of the February event in 2014) and resulted in the highest FSP, TN, and TP concentrations and loads of the year. In WY14, the highest concentrations for all three pollutants occurred during a summer thunderstorm, but WY15 thunderstorms likely produced no runoff in this catchment due to upstream improvements to infiltration (though this is uncertain due to equipment failure after reinstallation of monitoring equipment). Peak turbidities in WY15 were much lower than in WY14 across all seasons, likely due to catchment improvements. Peak turbidities occurred at the beginning of each event (Appendix C).

Table 6b: Event summary data for three sampled events at Incline Village in WY15.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
IV	Fall/Winter	11/22/14 5:50	11/22/14 12:20	6:30	1,434	0.13	489	0.23	rain	100%	74	7	2,513	0.2	493	<0.1
IV	Fall/Winter	2/6/15 15:30	2/7/15 12:00	114:00	11,284	0.81	195	1.52	snow, rain	100%	141	99	4,492	3.2	667	0.5
IV	Spring	4/24/15 0:10	4/24/15 6:30	6:20	1,081	0.46	50	0.56	rain	80%	123	8	1,146	0.6	599	<0.1

No events were sampled at Incline Village in WY16 due to very low flows. This site was retired after WY16.

6.2.2 Pasadena

The total precipitation for WY14 in the Pasadena catchment was 16.47 inches, approximately one inch less than the minimum annual precipitation recorded at the Tahoe City Cross reference station since 1981 (Table 4). Figure 12a shows the average daily flow and cumulative precipitation for WY14. The majority of the precipitation fell in the fall/winter season (8.34 inches). The spring season received 3.59 inches and the summer season received 4.54 inches. A total of 30 discrete precipitation events were measured at the South Lake Tahoe meteorological station, 10 in the fall/winter, 13 in the spring, and 7 in the summer. Almost 40% of the events during WY14 produced less than a tenth of an inch of precipitation, and three quarters of the events produced less than half an inch. The largest storm occurred between February 7, 2014 and February 10, 2014, falling as mixed rain and snow and producing 3.93 inches of precipitation in South Lake Tahoe. The highest instantaneous peak flows (about 1.4 cfs at Pasadena Inflow and about 1.5 cfs at Pasadena Outflow) were experienced during this same precipitation event.

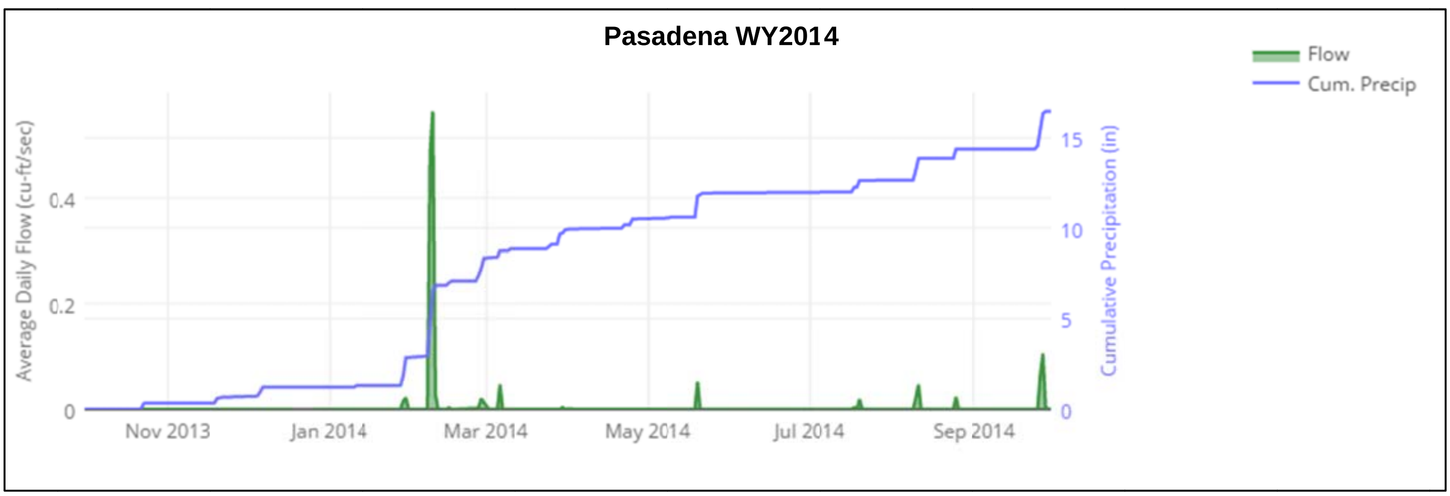


Figure 12a: Average daily flow and cumulative precipitation at the Pasadena monitoring site, WY14.

The total precipitation for WY15 in the Pasadena catchment was 12.32 inches, more than five inches less than the minimum annual precipitation recorded at the Tahoe City Cross reference station since 1981 (Table 4). Figure 12b shows the average daily flow and cumulative precipitation for WY15. The majority of the precipitation fell in the fall/winter season (6.61 inches). The spring season received 2.86 inches and the summer season received 2.85 inches. A total of 37 discrete precipitation events were measured at the South Lake Tahoe meteorological station, 17 in the fall/winter, 9 in the spring, and 11 in the summer. Approximately 57% of the events during WY15 produced less than a tenth of an inch of precipitation, and approximately 92% of the events produced less than half an inch. The largest storm occurred between February 6, 2015 and February 9, 2015, falling as mixed rain and snow and resulting in 3.09 inches of precipitation in the Pasadena catchment. The highest instantaneous peak flows (about 1.81 cfs at Pasadena Inflow and about 2.2 cfs at Pasadena Outflow) occurred during this precipitation event.

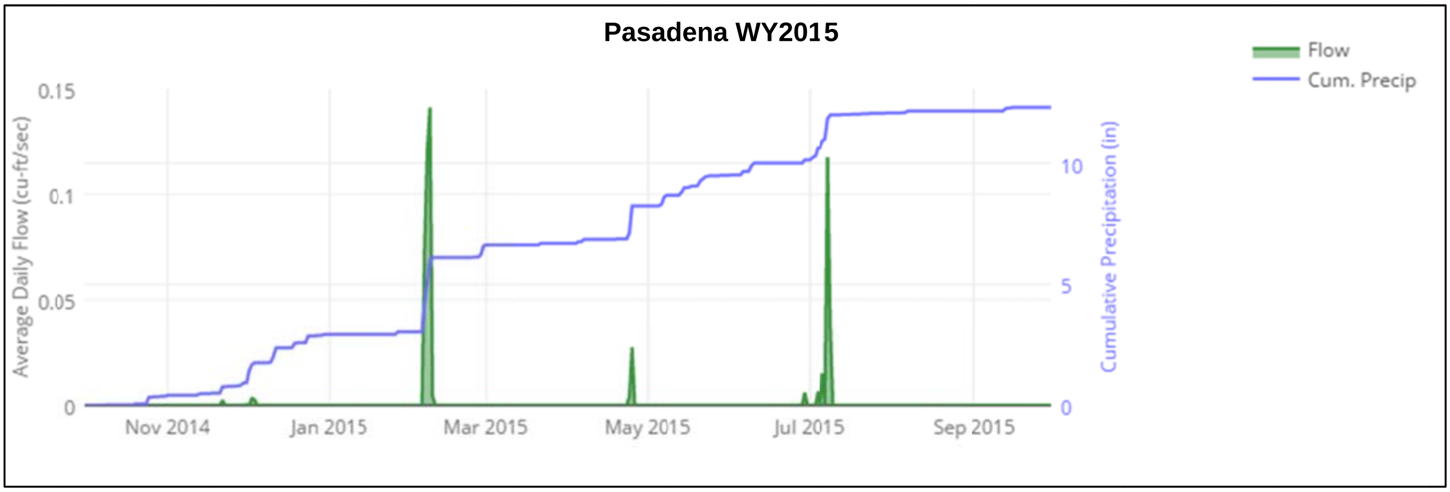


Figure 12b: Average daily flow and cumulative precipitation at the Pasadena monitoring site, WY15.

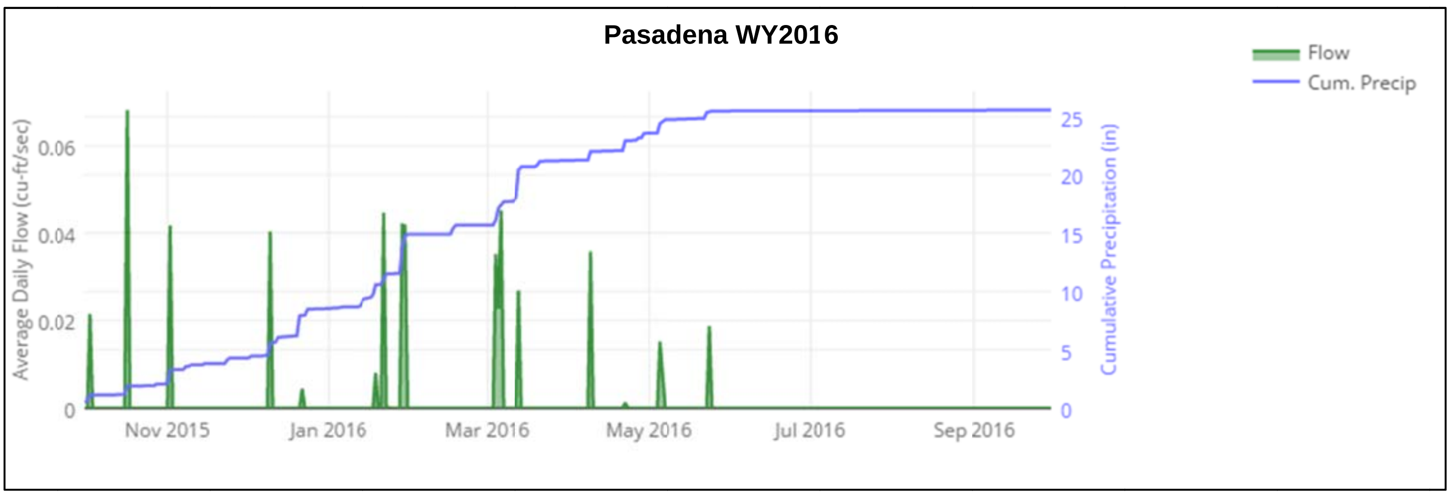


Figure 12c: Average daily flow and cumulative precipitation at the Pasadena monitoring site, WY16.

The total precipitation for WY16 in the Pasadena catchment was 18.63 inches, within the first quartile of the annual precipitation recorded at the Tahoe City Cross reference station since 1981 (Table 4). Figure 12c shows the average daily flow and cumulative precipitation for WY16. The majority of the precipitation fell in the fall/winter season (10.15 inches). The spring season received 8.40 inches and the summer season received 0.08 inches. A total of 41 discrete precipitation events were measured at the South Lake Tahoe meteorological station, 22 in the fall/winter, 17 in the spring, and 2 in the summer. Approximately one-third of the events during WY16 produced less than a tenth of an inch of precipitation, and slightly more than half of the events produced less than half an inch. The largest storm occurred between March 3, 2016 and March 7, 2016, falling as snow and rain and producing 2.02 inches of precipitation in South Lake Tahoe. The highest instantaneous peak flow at Pasadena Inflow was observed during a rain-on-snow event on April 9, 2016 (1.04 cfs). The highest instantaneous peak flow at Pasadena Outflow was observed on October 17, 2015 during a rain event (1.36 cfs).

Though nine precipitation events in the Pasadena catchment produced sufficient runoff to sample during WY14, water quality samples were taken across the hydrograph during four runoff events as required for regulatory compliance. Continuous hydrology, continuous turbidity, and events sampled during WY14 are presented in Figure 13a (Pasadena Inflow) and Figure 14a (Pasadena Outflow). The highest inflow turbidities to the storm filter occurred during the first storm of the year, January 29-30, 2014. The greatest inflow volumes occurred during the largest storm of the year (February 8-10, 2014) and the thunderstorm that occurred on August 10, 2014 as the peak precipitation reached 0.28 inches in ten minutes. However, this event was not sampled as the requisite one summer event was already sampled on July 17, 2014. Peak outflow turbidities for WY14 occurred during the intense August 10, 2014 thunderstorm, and highest instantaneous peak outflows occurred during the large February 2014 event.

In WY15, only four precipitation events in the Pasadena catchment produced sufficient runoff to sample and water quality samples were taken across the hydrograph during all four runoff events as required for regulatory compliance. Continuous hydrology, continuous turbidity, and events sampled during WY15 are presented in Figure 13b (Pasadena Inflow) and Figure 14b (Pasadena Outflow). The highest inflow and outflow turbidities to the Stormfilter occurred on June 29, 2015, but the storm did not produce enough flow to sample. The highest instantaneous peak flows for both the inflow and outflow occurred during a high intensity summer thunderstorm on July 8, 2015 which produced a peak precipitation rate of 0.32 inches in 10 minutes.

Ten precipitation events in the Pasadena catchment produced sufficient runoff to sample during WY16 and water quality samples were taken across the hydrograph during five of these runoff events, thereby fulfilling the requisite number of sample events for fall/winter and spring. The requisite summer runoff event was not captured due to lack of precipitation; no storms produced sufficient runoff to sample (the summer total was only 0.08 inches). Continuous hydrology, continuous turbidity, and events sampled during WY16 are presented in Figure 13c (Pasadena Inflow) and Figure 14c (Pasadena Outflow). The highest inflow turbidities to the storm filter occurred during the December 21, 2015 event. The greatest inflow and outflow volumes occurred during the largest storm of the year (March 3, 2016 to March 7, 2016). Peak precipitation of 0.14 inches in ten minutes occurred during the October 3, 2015 to October 4, 2015 rain storm event. Peak outflow turbidities for WY16 were observed during the January 29, 2016 storm event.

Continuous hydrology, continuous turbidity, and water quality samples for the individual events at Pasadena Inflow and Outflow are presented in Appendix D.

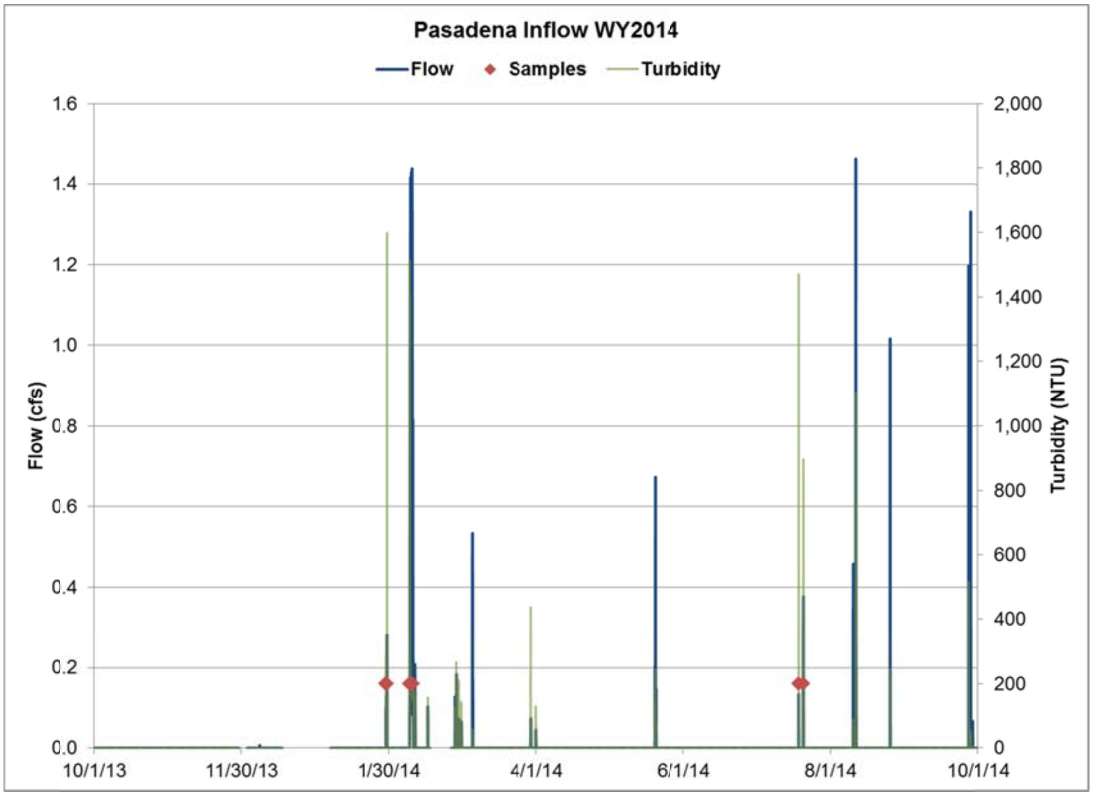


Figure 13a: Continuous hydrology, turbidity and sampled events at the inflow to the Pasadena Stormfilter, WY14. Two events were sampled mid-July (July 18 and July 20, 2014).

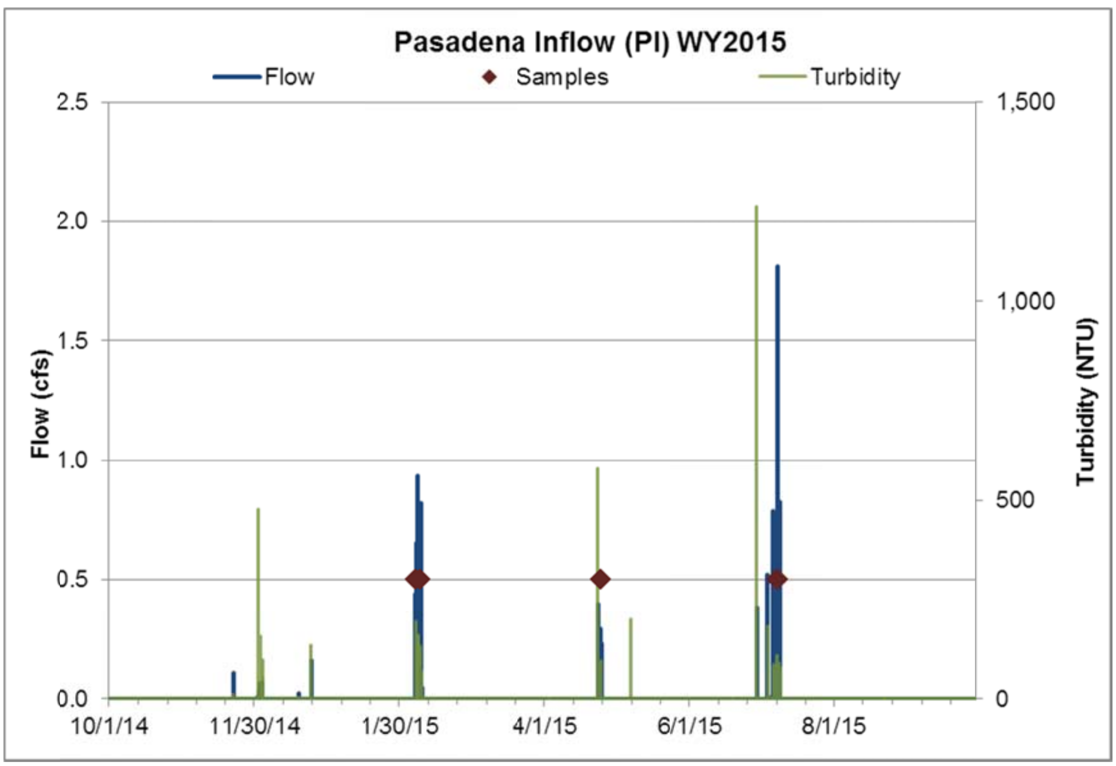


Figure 13b: Continuous hydrology, turbidity and sampled events at the inflow to the Pasadena Stormfilter, WY15. Two discrete events were sampled during the large February 6-8, 2015 storm.

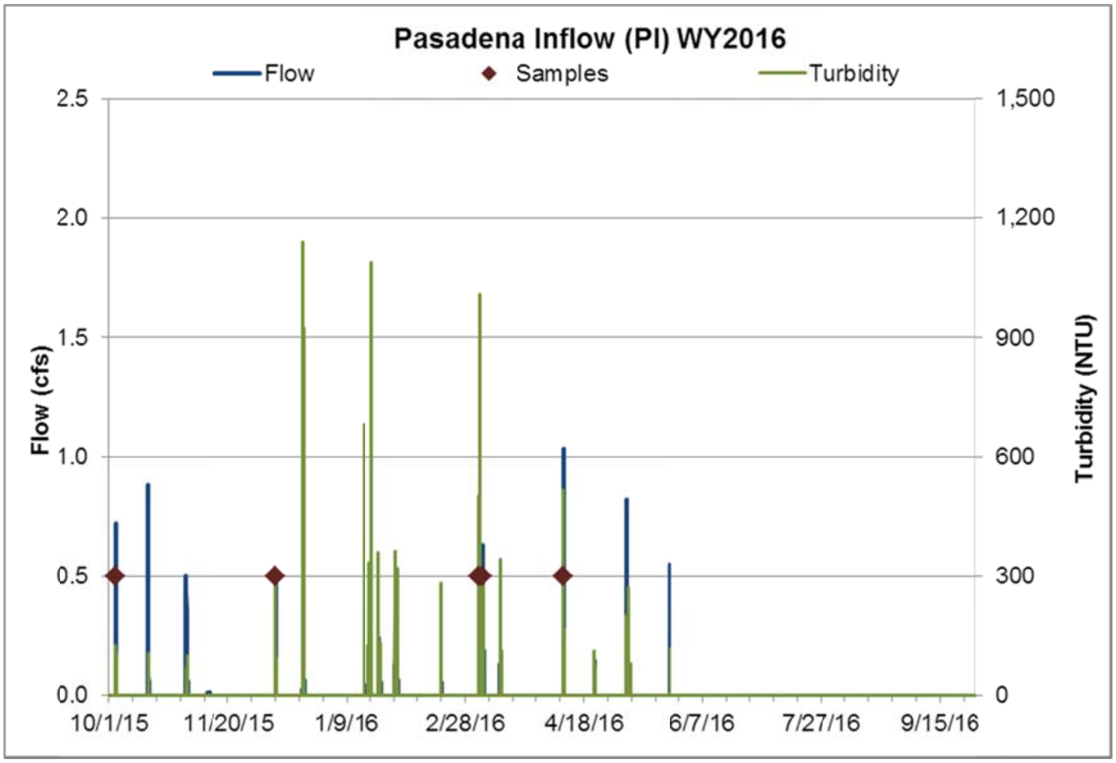


Figure 13c: Continuous hydrology, turbidity and sampled events at the inflow to the Pasadena Stormfilter, WY16. Two discrete events were sampled during the large March 3-7, 2016 storm.

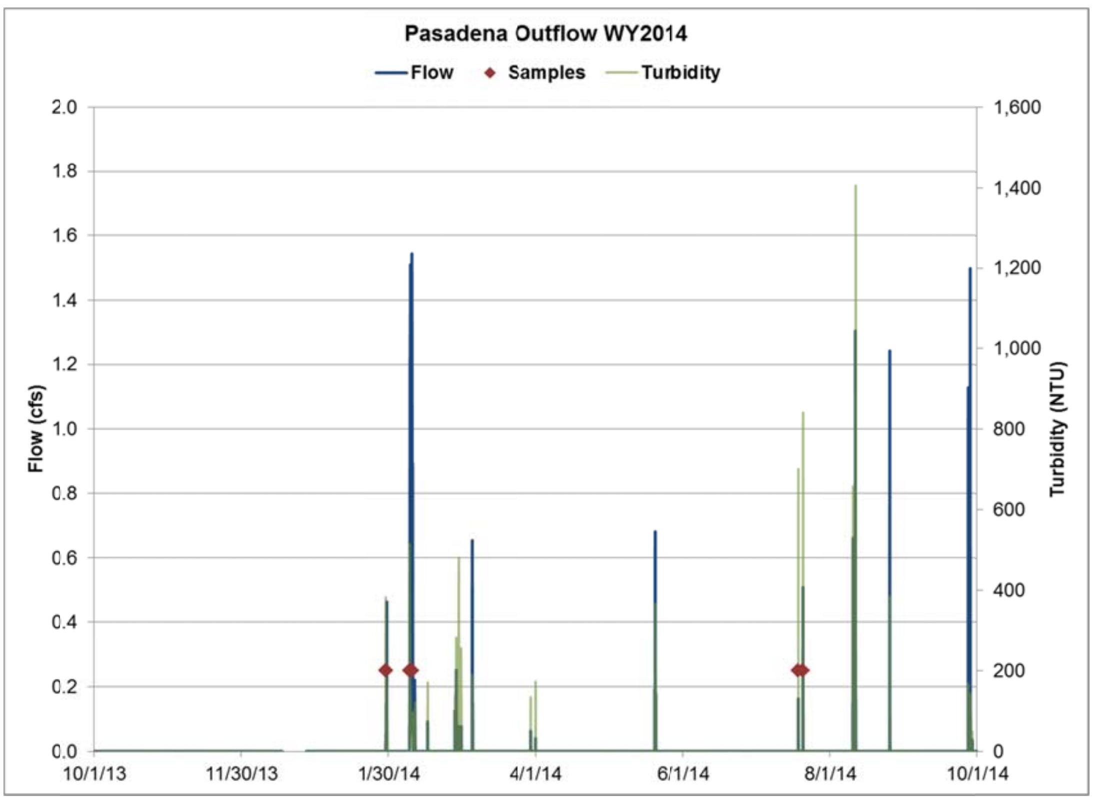


Figure 14a: Continuous hydrology, turbidity and sampled events at the outflow from the Pasadena Stormfilter, WY14. Two events were sampled mid-July (July 18 and July 20, 2014).

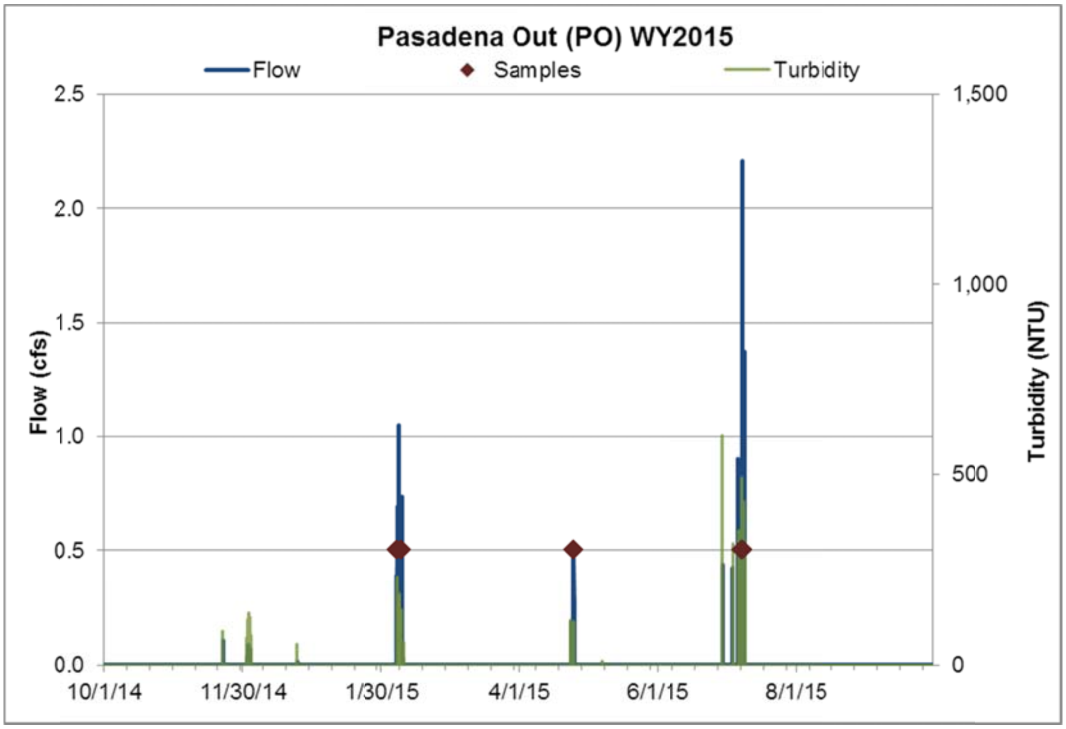


Figure 14b: Continuous hydrology, turbidity and sampled events at the outflow from the Pasadena Stormfilter, WY15. Two discrete events were sampled during the large February 6-8, 2015 storm.

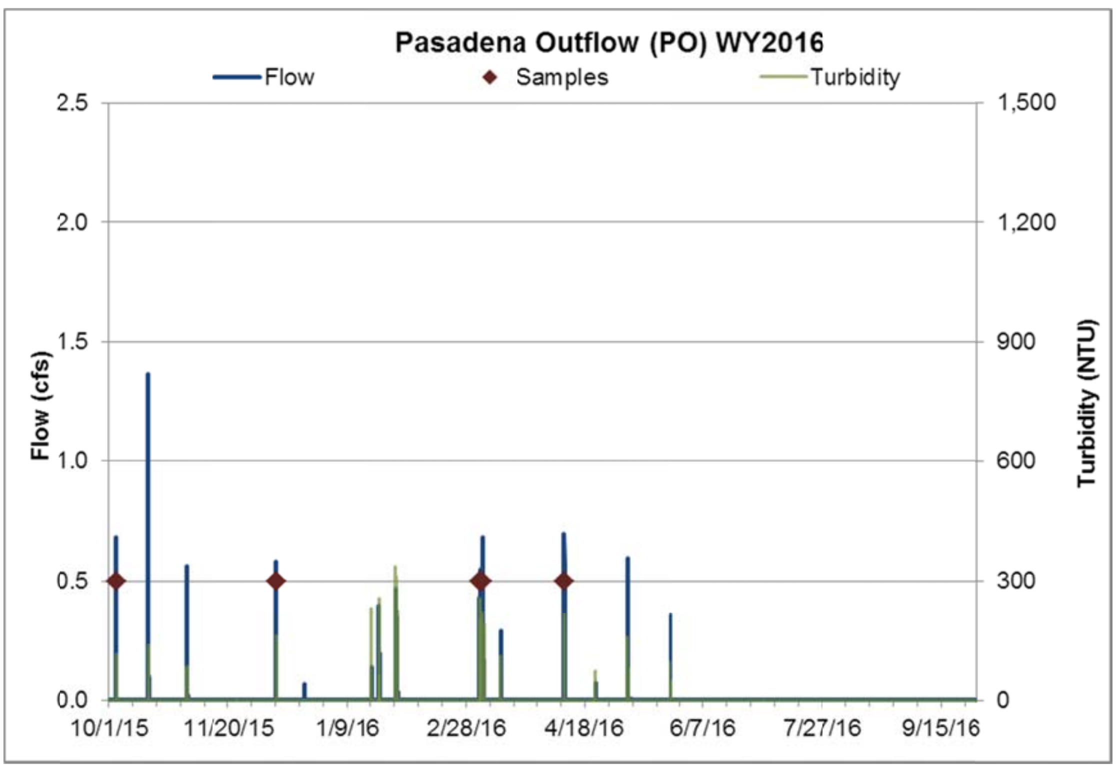


Figure 14c: Continuous hydrology, turbidity and sampled events at the outflow from the Pasadena Stormfilter, WY16. Two discrete events were sampled during the large March 3-7, 2016 storm.

Summary data for the four events sampled at Pasadena in WY14 are presented in Table 7a. Two runoff events were sampled during the fall/winter and two during the summer. Only one runoff event during the spring produced sufficient runoff to sample (May 20, 2014) but unfortunately equipment failure at the outflow did not allow for successful sampling. Due to the effectiveness of the upstream in-situ infiltration BMPs, this site requires a relatively large amount of precipitation before it begins to flow and therefore only precipitation events greater than 1.5 inches and high intensity thunderstorms greater than 0.3 inches produced sufficient runoff for water quality sampling. With greater than 90,000 cubic feet of runoff between February 8th and 10th, this rain on snow event resulted in the greatest FSP, TN, and TP loading at the outflow, despite having the lowest concentrations of all three pollutants. The highest inflow concentrations of all three pollutants occurred during the July 18th thunderstorm despite the low runoff volumes, likely due to the high intensity of the storm (0.14 inches in 10 minutes) that is easily able to mobilize sediments and nutrients and deliver them to the monitoring site. The highest outflow concentrations of FSP and TP occurred during the July 20, 2014 event, and the highest outflow TN concentration occurred two days prior during the July 18th event. Since the requisite number of summer events had already been sampled, the larger summer events occurring August 10th (1.20 inches of precipitation, runoff volume 1,947 cubic feet), August 25th (0.52 inches of precipitation, runoff volume 2,020 cubic feet) and September 26th (2.09 inches of precipitation, runoff volume 8,066 cubic feet) were not sampled. Because of large runoff volumes, it is likely that loading from these events, the September event in particular, were large. Stormfilter efficiency will be discussed in section 7.1. Fall/winter events and the first summer event had peak inflow turbidities of close to 1,600 NTU. The second summer event had peak inflow turbidities of about 900 NTU and peak outflow turbidities of about 850 NTU (Appendix D).

Table 7a: Event summary data for four sampled events at Pasadena in WY14.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
PI	Fall/Winter	1/29/14 15:10	1/30/14 3:40	12:30	10,109	1.54	rain/snow	70%	64	40	1,884	1.2	873	0.6
PO		1/29/14 15:50	1/30/14 2:40	10:50	10,072			100%	110	69	2,583	1.6	980	0.6
PI	Fall/Winter	2/8/14 9:10	2/10/14 5:20	44:10	90,399	3.93	rain/snow	100%	46	257	939	5.3	440	2.5
PO		2/8/14 9:20	2/10/14 6:30	45:10	90,934			100%	46	260	544	3.1	404	2.3
PI	Summer	7/18/14 17:00	7/18/14 18:20	1:20	280	0.32	thunderstorm	90%	534	9	9,837	0.2	3,615	0.1
PO		7/18/14 17:20	7/18/14 18:10	0:50	245			70%	207	3	3,627	0.1	1,497	<0.1
PI	Summer	7/20/14 14:10	7/20/14 16:40	2:30	1,671	0.37	thunderstorm	95%	262	27	2,269	0.2	1,960	0.2
PO		7/20/14 14:30	7/20/14 17:30	3:00	1,646			100%	250	26	1,799	0.2	1,567	0.2

Summary data for the four events sampled at Pasadena in WY15 are presented in Table 7b. Two runoff events were sampled during the fall/winter, one in the spring, and one in the summer. Similar to WY14, this site required greater than one inch of precipitation in order to flow in WY15. The events beginning February 6, 2015 and February 8, 2015 were actually one four day rain event split in two because of a cessation in flow between the morning of February 7 and the afternoon of February 8. Similar to Upper Truckee, the EMCs of all three pollutants remained relatively high during the latter part of the storm at this site. This is unlike results at Speedboat, Tahoma, and Tahoe Valley where the second portion of the runoff was cleaner than the first part. The highest EMCs of all three pollutants occurred during the very large summer thunderstorm, and consequently resulted in the greatest loads of all three pollutants as well. Stormfilter efficiency will be discussed in section 7.1. Interestingly, peak turbidities were higher at the outflow (PO) for all events, generally occurring at the beginning of each event, perhaps due to flushing of sediments from previous events retained in the vault. Peak turbidities in WY15 ranged from about 100 to 400 NTU, lower than in WY14 and low compared to most other sites (Appendix D).

Table 7b: Event summary data for four sampled events at Pasadena in WY15.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
PI	Fall/Winter	2/6/15 19:10	2/7/15 5:10	10:00	10,347	0.82	195	1.24	snow, rain	90%	62	40	889	0.6	611	0.4
PO		2/6/15 19:20	2/7/15 6:00	24:00	10,033	0.69	231			100%	57	36	1,690	1.1	589	0.4
PI	Fall/Winter	2/8/15 13:10	2/9/15 7:20	18:10	12,855	2.38	131	1.85	rain	100%	43	35	736	0.6	419	0.3
PO		2/8/15 13:20	2/9/15 0:10	10:50	12,258	3.13	143			100%	35	27	649	0.5	369	0.3
PI	Spring	4/25/15 9:40	4/25/15 14:30	4:50	3,406	0.49	96	1.38	rain	100%	46	10	939	0.2	438	0.1
PO		4/25/15 10:10	4/25/15 15:20	5:10	2,369	0.50	114			100%	51	8	873	0.1	458	0.1
PI	Summer	7/8/15 11:30	7/8/15 19:50	8:20	10,021	1.81	108	1.36	thunderstorm	90%	157	98	5,174	3.2	1,598	1.0
PO		7/8/15 12:00	7/8/15 21:40	9:40	10,173	2.21	428			100%	112	71	3,031	1.9	1,367	0.9

Summary data for the five events sampled at Pasadena in WY16 are presented in Table 7c. Two runoff events were sampled during the fall/winter, and three in the spring. No events were sampled in the summer due to a lack of sufficient precipitation to result in any recorded flow at this site. In general, this site requires about one inch of precipitation in order to flow, however, intense thunderstorms and rain on snow events can cause flow even when under one inch as seen during the October 3, 2015 and March 4, 2016 events. The events beginning March 4, 2016 and March 5, 2016 were actually one three day rain on snow event split in two because of a cessation in flow between the morning of March 5 and the afternoon of March 5. The highest FSP concentrations occurred during these two rain on snow events, with the largest loads occurring with the second of the two events because of the large runoff volume. The lowest FSP concentrations occurred at the inflow during the October 3, 2015 thunderstorm; however outflow concentrations were about 6 times higher than inflow concentrations. This indicates that some of the sediment that had accumulated in the vaults over the past two years was flushed out. Loads were relatively small for this event because of small runoff volumes. Similarly, TN and TP concentrations were higher at the outflow than the inflow for this event. Additionally, TN and TP concentrations were the highest for the whole year during this October event. TN and TP concentrations remained relatively constant during the spring, although TN was curiously low at the inflow site during the March 4, 2016 event while TP concentrations were curiously high for that event. Again, the system flushed TN out of the vaults on March 4 as outflow concentrations were about 6 times higher than inflow concentrations. Stormfilter efficiency will be discussed in section 7.1. Peak turbidities were generally higher at the inflow and occurred at the beginning of each event. Peak turbidities in WY16 ranged from about 100 to 1000 NTU, higher than in WY15 and low compared to most other sites (Appendix D).

Table 7c: Event summary data for five sampled events at Pasadena in WY16.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Peak Precip (in/10 min)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
PI	Fall/Winter	10/3/15 22:10	10/4/15 0:50	2:40	3,040	0.96	126	0.28	0.09	thunderstorm	100%	9	2	2,990	0.6	1,344	0.3
PO		10/3/15 22:20	10/4/15 0:00	1:40	2,102	0.73	116				100%	58	8	3,800	0.5	1,478	0.2
PI	Fall/Winter	12/10/15 5:10	12/10/15 10:10	5:00	3,646	0.51	279	1.73	0.11	rain, snow	90%	69	16	2,460	0.6	161	<0.1
PO		12/10/15 6:50	12/10/15 10:00	3:10	3,499	0.58	162				90%	67	15	2,850	0.6	141	<0.1
PI	Spring	3/4/16 16:20	3/4/16 23:40	7:20	3,232	0.68	1,009	0.43	0.04	rain	60%	150	30	228	<0.1	1,011	0.2
PO		3/4/16 17:00	3/5/16 0:10	7:10	3,053	0.55	257				100%	104	20	1,293	0.2	692	0.1
PI	Spring	3/5/16 19:10	3/6/16 3:00	7:50	14,910	1.83	242	1.99	0.18	rain	100%	124	115	1,303	1.2	648	0.6
PO		3/5/16 20:00	3/6/16 3:20	7:20	14,733	1.45	412				65%	109	100	1,395	1.3	573	0.5
PI	Spring	4/9/16 11:20	4/9/16 19:30	8:10	5,540	1.04	516	0.93	0.17	rain	85%	102	35	1,530	0.5	715	0.2
PO		4/9/16 12:10	4/9/16 19:30	7:20	3,089	0.70	216				100%	97	19	1,658	0.3	650	0.1

6.2.3 Rubicon

The total precipitation for WY14 at the Rubicon meteorological station was 23.08 inches, within the first quartile of the annual precipitation recorded at the Tahoe City Cross reference station since 1981 (Table 4). Figure 15a shows the average daily flow and cumulative precipitation for WY14. The majority of the precipitation fell in the fall/winter season (13.66 inches). The spring season received 5.78 inches and the summer season received 3.64 inches. A total of 33 discrete precipitation events were measured at the Rubicon meteorological station, 13 in the fall/winter, 13 in the spring, and 7 in the summer. About a fifth of the events during WY14 produced less than a tenth of an inch of precipitation, and two thirds of the events produced less than half an inch. The largest storm occurred between February 8, 2014 and February 10, 2014, falling as mixed rain and snow and producing 5.60 inches of precipitation in Rubicon. The highest instantaneous peak flows (about 0.5 cfs) were experienced during a high intensity thunderstorm on July 17, 2014.

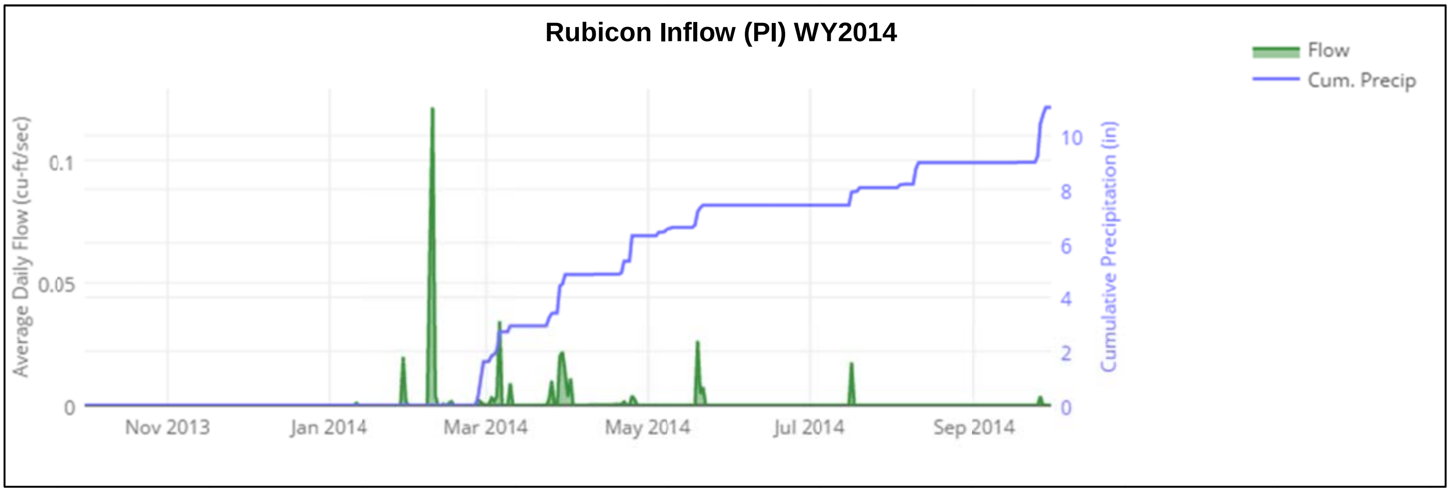


Figure 15a: Average daily flow and cumulative precipitation at the Rubicon Inflow station, WY14.

The total precipitation for WY15 at the Rubicon meteorological station was 20.54 inches, which falls within the first quartile of the annual precipitation recorded at the Tahoe City Cross reference station since 1981 (Table 4). Figure 15b shows the average daily flow and cumulative precipitation for WY15. The majority of the precipitation fell in the fall/winter season (13.33 inches). The spring season received 4.16 inches and the summer season received 3.05 inches. A total of 37 discrete precipitation events were measured at the Rubicon meteorological station, 15 in the fall/winter, 12 in the spring, and 10 in the summer. Approximately 32% of the events during WY15 produced less than a tenth of an inch of precipitation, and approximately 70% of the events produced less than half an inch. The largest storm occurred between February 6, 2015 and February 9, 2015, falling as rain and resulted in 6.40 inches of precipitation in the Rubicon catchment. The highest instantaneous peak flows (about 0.3 cfs) occurred during this precipitation event.

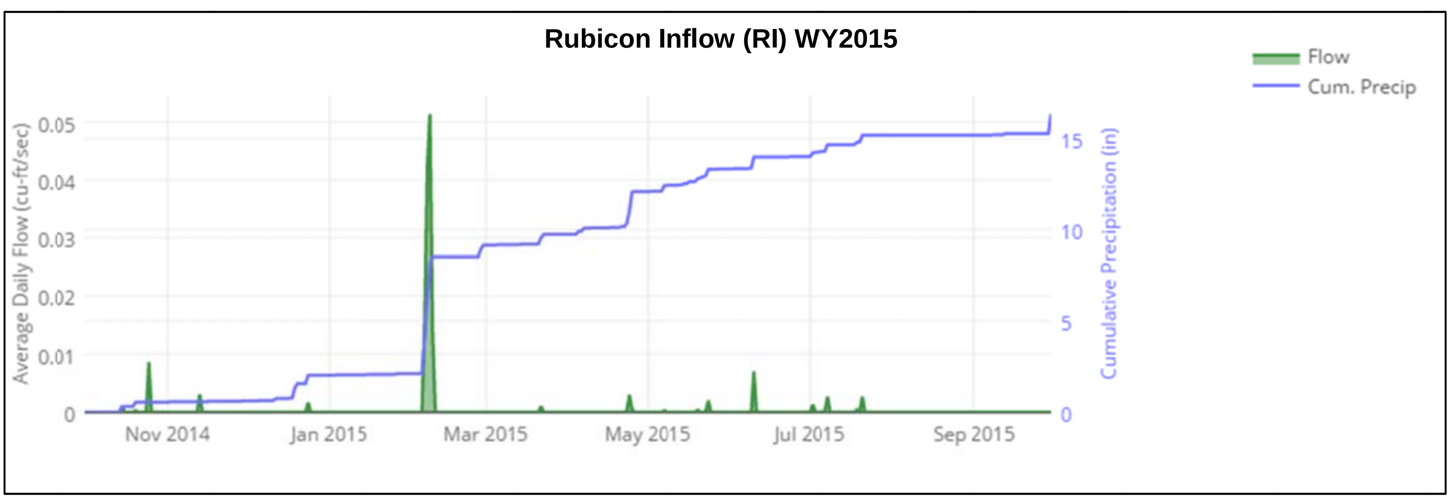


Figure 15b: Average daily flow and cumulative precipitation at the Rubicon Inflow station, WY15.

During both WY14 and WY15, the monitoring station at the outflow from the Stormtech chambers at Rubicon never measured any flow, indicating that 100% of runoff volumes were successfully infiltrated and no pollutant loads were delivered to the lake. Monitoring was therefore discontinued in WY16 (see section 2.3 for full discussion).

Though six runoff events in the Rubicon catchment in WY14 produced sufficient runoff to sample at the inflow, water quality samples were taken across the hydrograph during four runoff events as required for regulatory compliance. Continuous hydrology at the inflow to the Stormtech chambers and events sampled during WY14 are presented in Figure 16a. (There is no continuous turbidimeter at this station). The greatest inflows for WY14 occurred during the July 17, 2014 thunderstorm even though peak precipitation only reached 0.03 inches in ten minutes.

In WY15, though four runoff events in the Rubicon catchment produced sufficient runoff to sample at the inflow, water quality samples were taken across the hydrograph during three runoff events; the large February storm event was missed due to equipment failure. Continuous hydrology at the inflow and events sampled during WY15 are presented in Figure 16b. For WY15, the greatest inflows occurred during the large February 6-8, 2015 event, however, as previously mentioned, this storm was not sampled due to equipment failure.

Continuous hydrology, continuous turbidity, and water quality samples for the four individual events in WY14 and three individual events in WY15 are presented in Appendix E.

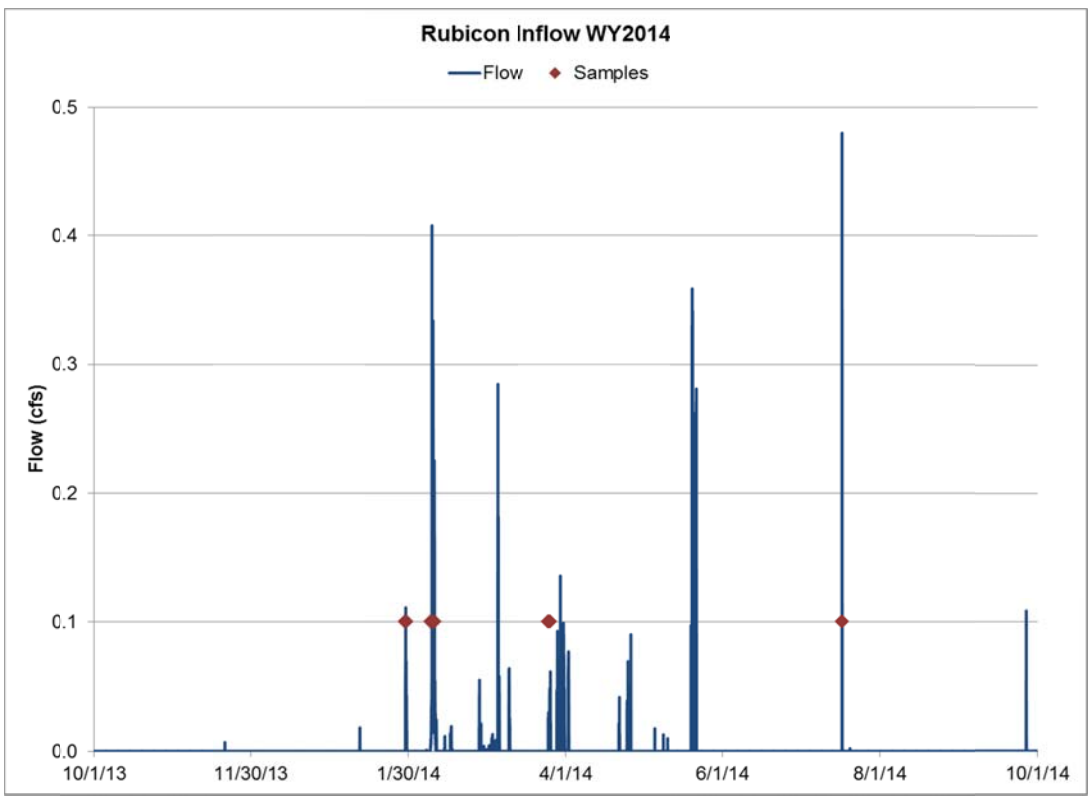


Figure 16a: Continuous hydrology and sampled events at the inflow to the Rubicon Stormtech chambers, WY14.

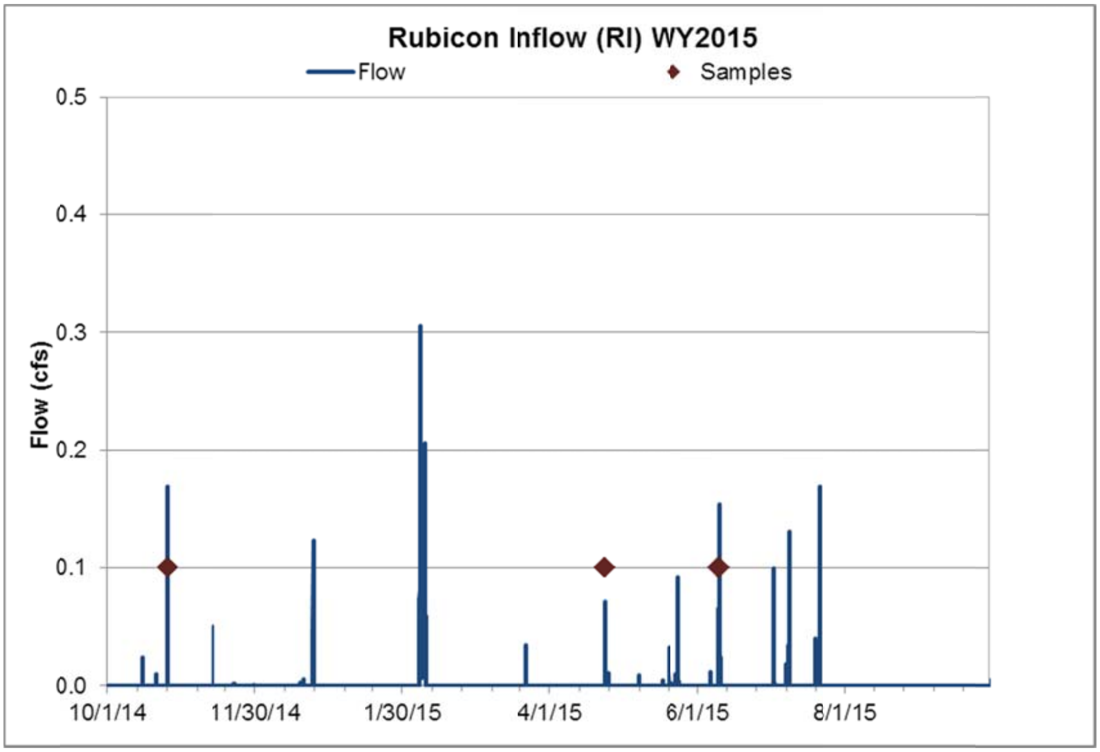


Figure 16b: Continuous hydrology and sampled events at the inflow to the Rubicon Stormtech chambers, WY15. The large February 6, 2015 storm was not sampled due to equipment failure.

Summary data for the four events sampled at Rubicon in WY14 are presented in Table 8a. Two runoff events were sampled during the fall/winter, one during the spring, and one during the summer. Due to the very large runoff volumes, FSP, TN, and TP loads were the greatest for the event occurring February 8-10, 2014 despite having the lowest pollutant concentrations. As with Pasadena, concentrations of all three pollutants were the highest during the large thunderstorm on July 17, 2014 that produced the highest instantaneous peak flows of the year in this catchment. The relatively high flows that occurred on May 20, 2014 were not sampled because the requisite one spring event had already been successfully sampled on March 25, 2014.

Table 8a: Event summary data for four sampled events at Rubicon in WY14.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
RI	Fall/Winter	1/29/14 12:30	1/30/14 2:30	14:00	1,829	3.29	rain/snow	100%	28	3	378	<0.1	259	<0.1
RO		na	na	na	0			-	-	-	-	-	-	-
RI	Fall/Winter	2/8/14 2:50	2/10/14 4:50	50:00	16,441	5.60	rain/snow	100%	11	11	261	0.3	95	0.1
RO		na	na	na	0			-	-	-	-	-	-	-
RI	Spring	3/25/14 20:20	3/26/14 20:50	24:30	1,073	0.47	event snowmelt	100%	16	1	417	<0.1	157	<0.1
RO		na	na	na	0			-	-	-	-	-	-	-
RI	Summer	7/17/14 14:40	7/17/14 17:20	2:40	1,501	0.50	thunderstorm	75%	106	10	5,078	0.5	2,188	0.2
RO		na	na	na	0			-	-	-	-	-	-	-

Summary data for the three events sampled at Rubicon in WY15 are presented in Table 8b. One runoff event was sampled in each season. FSP and TP concentrations were the highest in the summer, and TN concentration was highest in the fall/winter. FSP concentration and event load were very small in the spring; in fact, the sample was too clean for PSD analysis. FSP concentration and event load were greatest in the summer after a relatively high intensity thunderstorm on June 10, 2015. TN and TP loads were very small for all events because of minimal runoff volumes.

Table 8b: Event summary data for three sampled events at Rubicon in WY15.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
RI	Fall/Winter	10/25/14 11:50	10/25/14 15:00	3:10	742	0.17	na	0.51	rain	95%	7	0.3	1,522	<0.1	218	<0.1
RO		na	na	na	0	na	na			-	-	-	-	-	-	-
RI	Spring	4/23/15 21:20	4/24/15 2:50	5:30	274	0.07	na	0.72	rain	100%	na	na	671	<0.1	150	<0.1
RO		na	na	na	0	na	na			-	-	-	-	-	-	-
RI	Summer	6/10/15 1:10	6/10/15 21:40	20:30	603	0.15	na	0.62	thunderstorm	85%	25	0.9	1,224	<0.1	262	<0.1
RO		na	na	na	0	na	na			-	-	-	-	-	-	-

Efficiency of the Rubicon Stormtech chamber will be discussed in section 7.2.

6.2.4 SR431

The total precipitation for WY14 at the SR431 meteorological station was 17.10 inches, 0.4 inches lower than the minimum annual precipitation value at the Tahoe City Cross reference station since 1981 (Table 4). Figure 17a shows the average daily flow at the catchment outfall station (S5) and the inflow to the cartridge filter vaults as well as cumulative precipitation for WY14. Incoming flow to the cartridge filter vaults is split roughly in half, as water is diverted equally into the Jellyfish and Contech MFS cartridge filter vaults. The majority of the precipitation fell in the fall/winter season (8.91 inches). The spring season received 4.36 inches and the summer season received 3.83 inches. A total of 39 discrete precipitation events were measured at the SR431 meteorological station, 14 in the fall/winter, 13 in the spring, and 12 in the summer. Fall/winter and spring precipitation events were either snow, rain, or mixed rain and snow. Summer events were either thunderstorms or frontal rain storms. Close to 40% of the events during WY14 produced less than a tenth of an inch of precipitation, and three quarters of the events produced less than half an inch. The largest storm occurred between February 6, 2014 and February 10, 2014, falling as mixed rain and snow and producing 4.80 inches of precipitation at SR431, but failed to produce sufficient runoff to sample. Almost 60% of the precipitation events resulted in no runoff at the outfall station. The highest instantaneous peak flows (about 1.4 cfs) occurred during a high intensity thunderstorm on July 20, 2014.

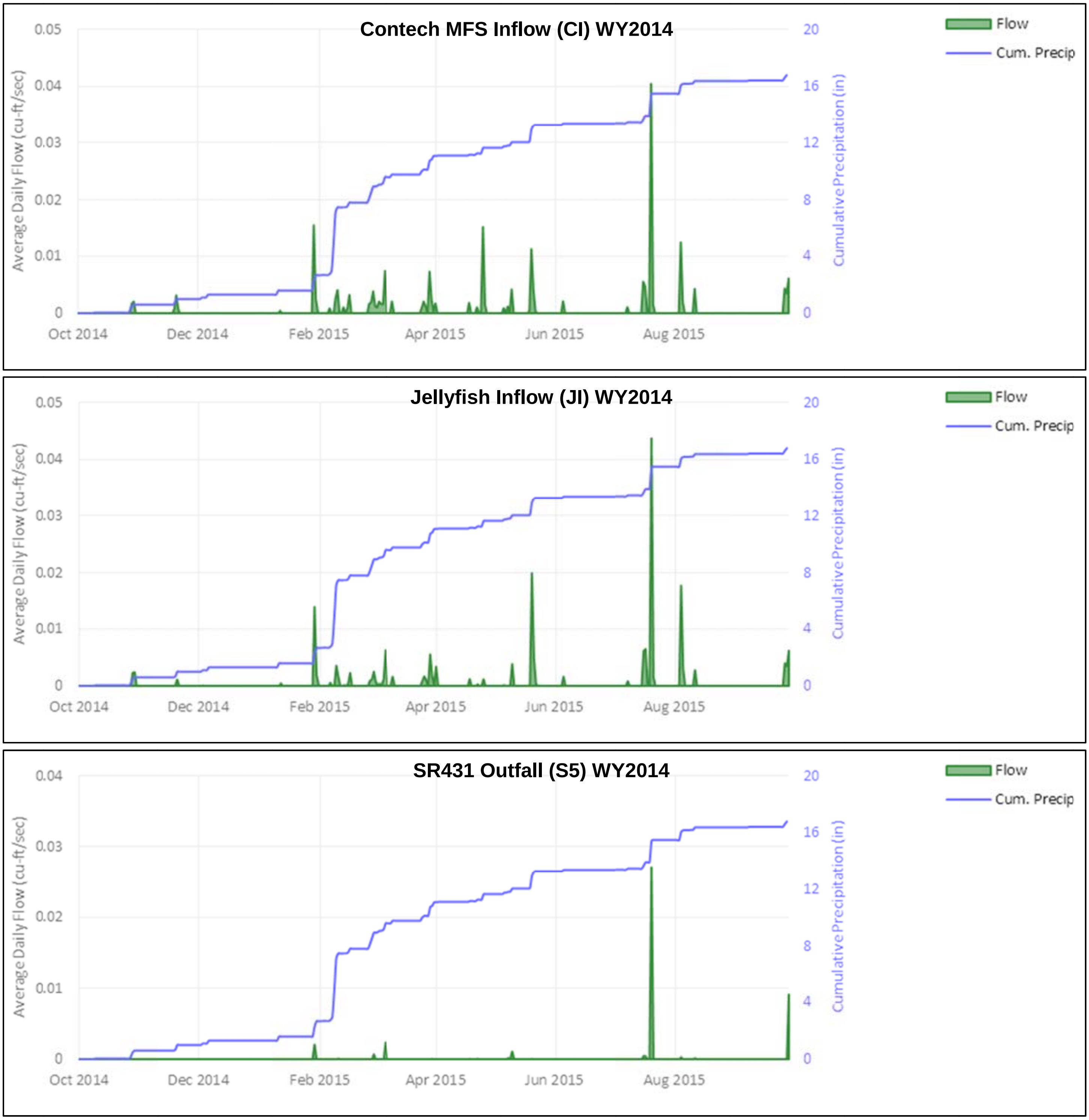


Figure 17a: Average daily flow at the inflows to the SR431 cartridge filter vaults (CI, JI) and the catchment outfall (S5), and cumulative precipitation, WY14.

The total precipitation for WY15 at the SR431 meteorological station was 18.88 inches, which falls within the first quartile of the annual precipitation recorded at the Tahoe City Cross reference since 1981 (Table 4). Figure 17b shows the average daily flow at the catchment outfall station (S5) and the inflow to the cartridge filter vaults. The majority of the precipitation fell in the fall/winter season (9.78 inches). The spring season received 5.58 inches and the summer season received 3.53 inches. A total of 41 discrete precipitation events were measured at the SR431 meteorological station, 17 in the fall/winter, 12 in the spring, and 12 in the summer. Approximately 40% of the events during WY15 produced less than a tenth of an inch of precipitation, and approximately 78% of the events produced less than half an inch. The largest storm occurred between February 6, 2015 and February 9, 2015, falling as mixed rain and snow and resulting in 3.77 inches of precipitation at in the SR431 catchment. Just over 60% of the precipitation events resulted in no runoff at the outfall station. The highest instantaneous peak flow at the catchment outfall station (about 0.2 cfs) occurred during a thunderstorm on July 4, 2015, while the instantaneous peak flow at the cartridge filter vault inlets occurred during a mixed rain and snow event on May 5, 2015.

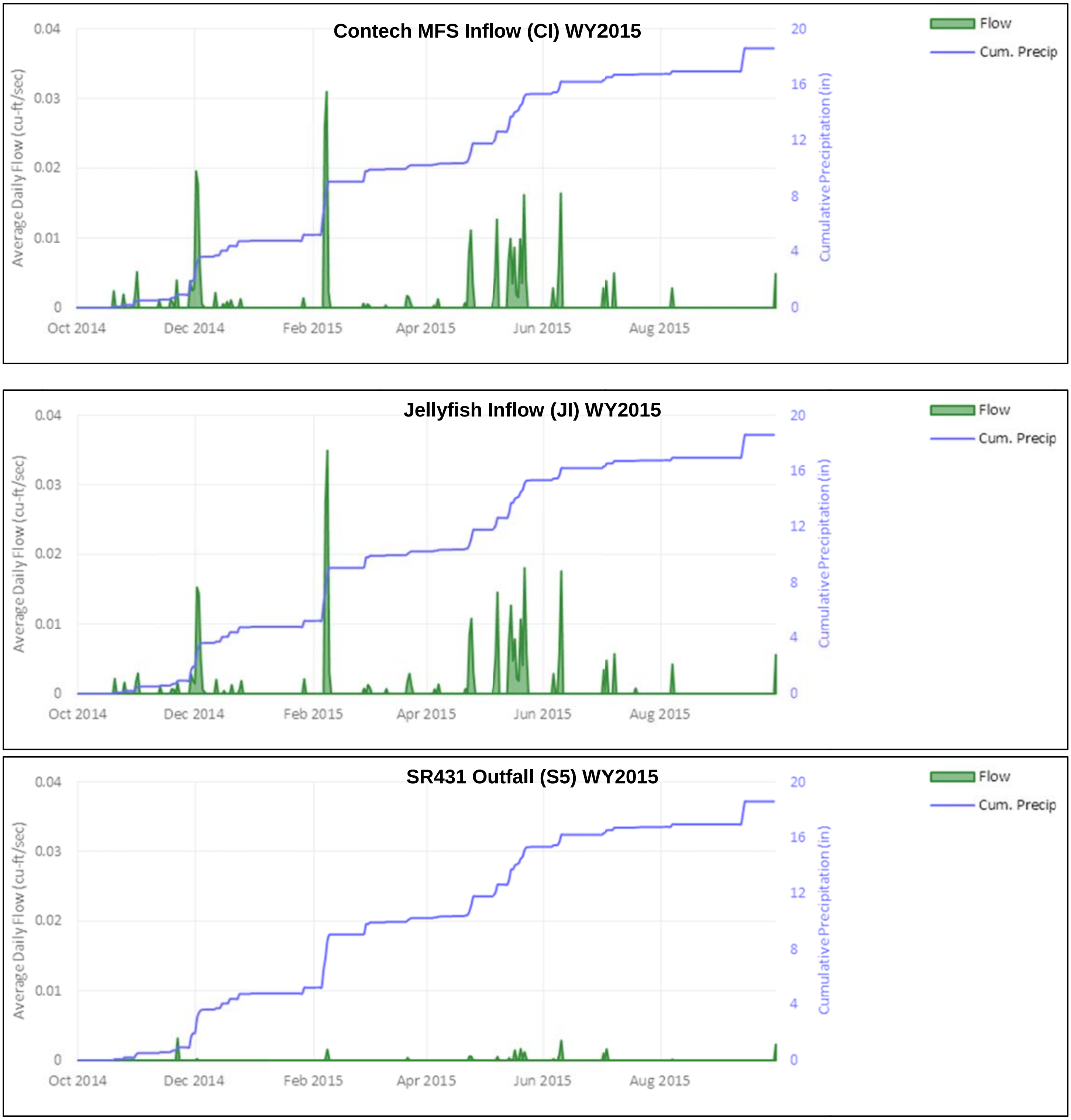
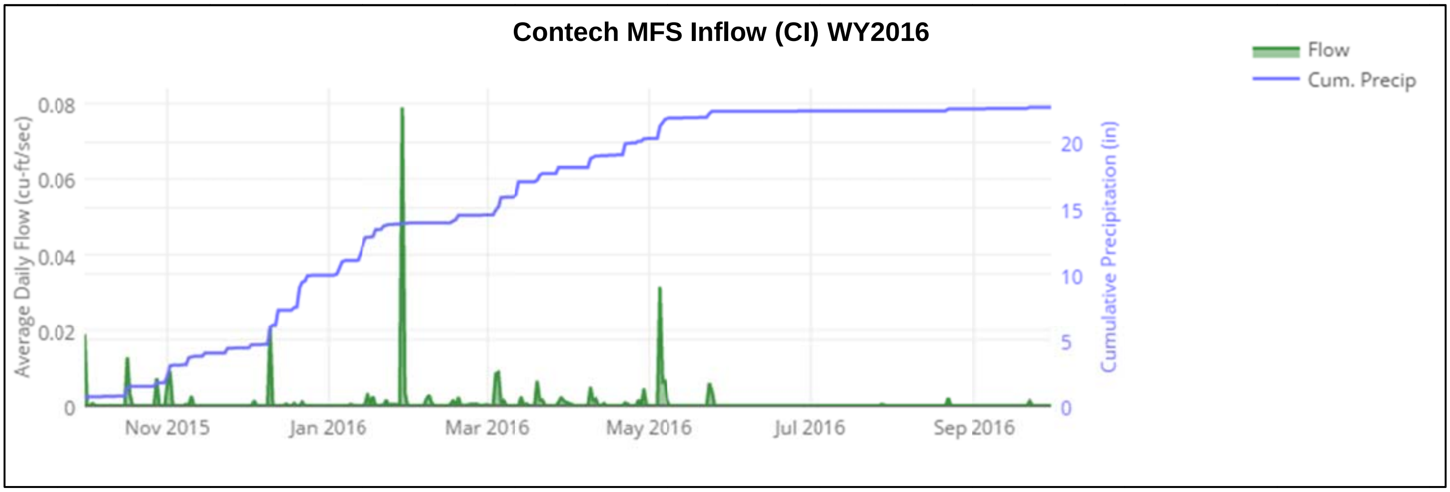


Figure 17b: Average daily flow at the inflows to the SR431 cartridge filter vaults (CI, JI) and the catchment outfall (S5), and cumulative precipitation, WY15.

The total precipitation for WY16 in the SR431 catchment was 22.68 inches, within the first quartile of the annual precipitation recorded at the Tahoe City Cross reference station since 1981 (Table 4). Figure 17c shows the average daily flow and cumulative precipitation for WY16 for the inflow to the cartridge filter vaults. The majority of the precipitation fell in the fall/winter season (14.46 inches). The spring season received 7.91 inches and the summer season received 0.30

inches. A total of 54 discrete precipitation events were measured at the SR431 meteorological station, 24 in the fall/winter, 25 in the spring, and 5 in the summer. A little less than half of the events during WY16 produced less than a tenth of an inch of precipitation, and nearly sixty percent of the events produced less than half an inch. The largest storm occurred between December 20, 2015 and December 25, 2015, falling as mixed rain and snow and producing 2.44 inches of precipitation. The highest instantaneous peak flows at the cartridge filter vaults were experienced during a thunderstorm on October 1, 2015.



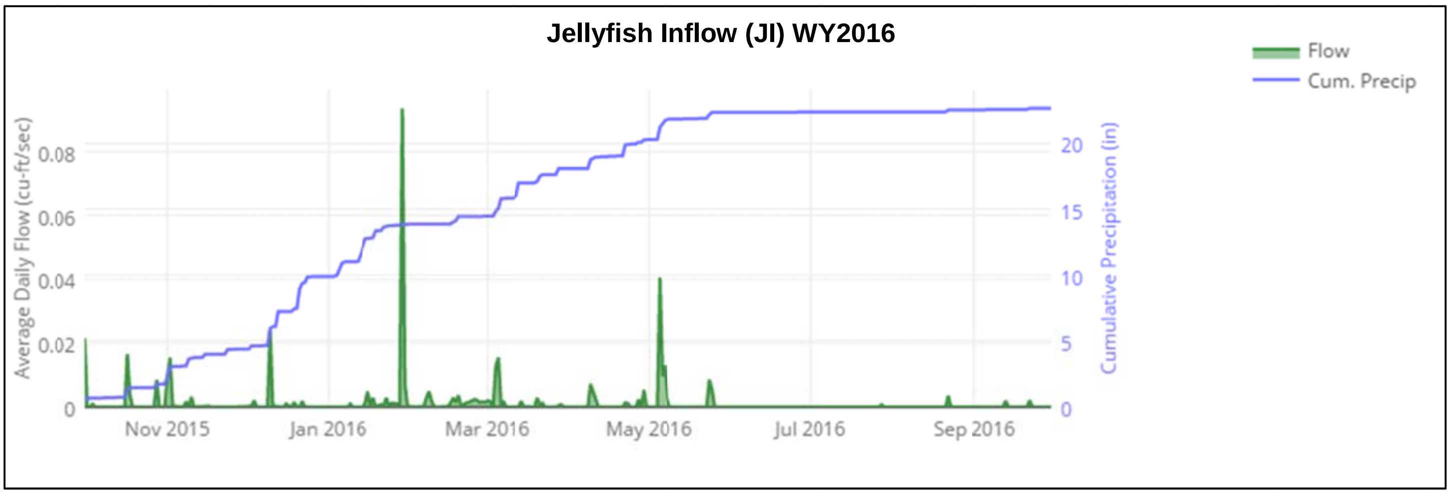


Figure 17c: Average daily flow at the inflows to the SR431 cartridge filter vaults (CI, JI) and cumulative precipitation, WY16.

6.2.4.1 SR431 Cartridge Filter Vaults

There were eight runoff events successfully monitored at both the Contech MFS vault and the Jellyfish vault during WY14, representing almost 50% of total runoff through these vaults during the year. Continuous hydrology, continuous turbidity, and events sampled during WY14 are presented in Figures 18a – 21a. Higher inflow turbidities were observed earlier in the year, in part due to sediment accumulation in the system from highway runoff, as discussed further in section 7.3. The highest instantaneous peak inflows occurred during thunderstorms that occurred in July and August 2014. The first of these large events produced a peak precipitation of 0.074 inches per five minutes and was successfully sampled (July 16, 2014). Lower turbidities were measured after the spring runoff, in part due to retrofits upstream of the flumes to remove coarse sediments that were fouling sensors and conveyance lines. Turbidimeter readings exceeded the maximum range of the sensor (1600NTU) on several occasions at the inflows to the vault in WY14 (outflow readings did not exceed the maximum range).

In WY15, ten events produced sufficient runoff to sample and water quality samples were taken across the hydrograph during nine of these events. Four events were sampled in the fall/winter season, four in the spring season, and only one thunderstorm in the summer produced enough runoff to sample. Continuous hydrology, continuous turbidity, and events sampled during WY15 are presented in Figures 18b - 21b. Similar to WY14, higher inflow turbidities were observed earlier in the year, and lower turbidities were measured after the spring runoff. The highest instantaneous peak inflows occurred during thunderstorms that occurred in May 2015. The first of these events produced a peak precipitation of only 0.05 inches per five minutes and was successfully sampled (May 6, 2015). Turbidimeter readings exceeded the maximum range of the sensor (1600NTU) on several occasions at the inflows to the vault in WY15 (outflow readings did not exceed the maximum range).

In WY16, eight events produced sufficient runoff to sample and water quality samples were taken across the hydrograph during six of these events. Four events were sampled in the fall/winter season and two were sampled in the spring season, thereby fulfilling the requisite number of sample events for fall/winter and spring. The requisite summer runoff event was not captured due to lack of precipitation; no storms produced sufficient runoff to sample (the summer precipitation total was only 0.30 inches over five events). Continuous hydrology, continuous turbidity, and events sampled during WY16 are presented in Figures 18c - 21c. Similar to WY14 and WY15, higher inflow turbidities were observed earlier in the year, and lower turbidities were measured after the spring runoff. Turbidimeter readings exceeded the maximum range of the sensor (1600NTU) on several occasions in WY16 for both the inflows and the outflows. The highest instantaneous peak inflows were observed during a thunderstorm that occurred on October 1, 2015. This thunderstorm also produced a peak precipitation of 0.09 inches per five minutes and was successfully sampled. The largest flow volumes occurred on the mixed precipitation event from January 29, 2016 to February 1, 2016.

Annual inflow and outflow hydrographs and cumulative volumes for vaults are presented in Appendix F. See DRI et al 2015 for additional information on individual WY 14 and WY15 events.

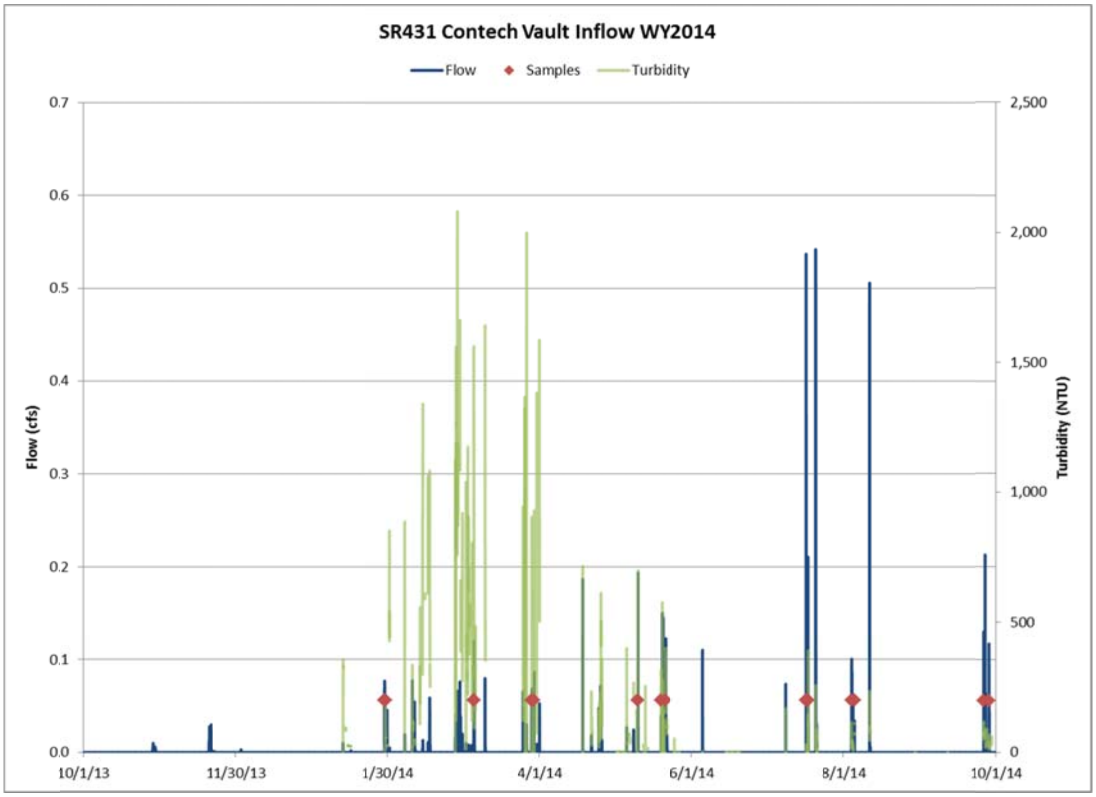


Figure 18a: Continuous hydrology, turbidity and sampled events at the inflow to the Contech MFS vault at SR431, WY14.

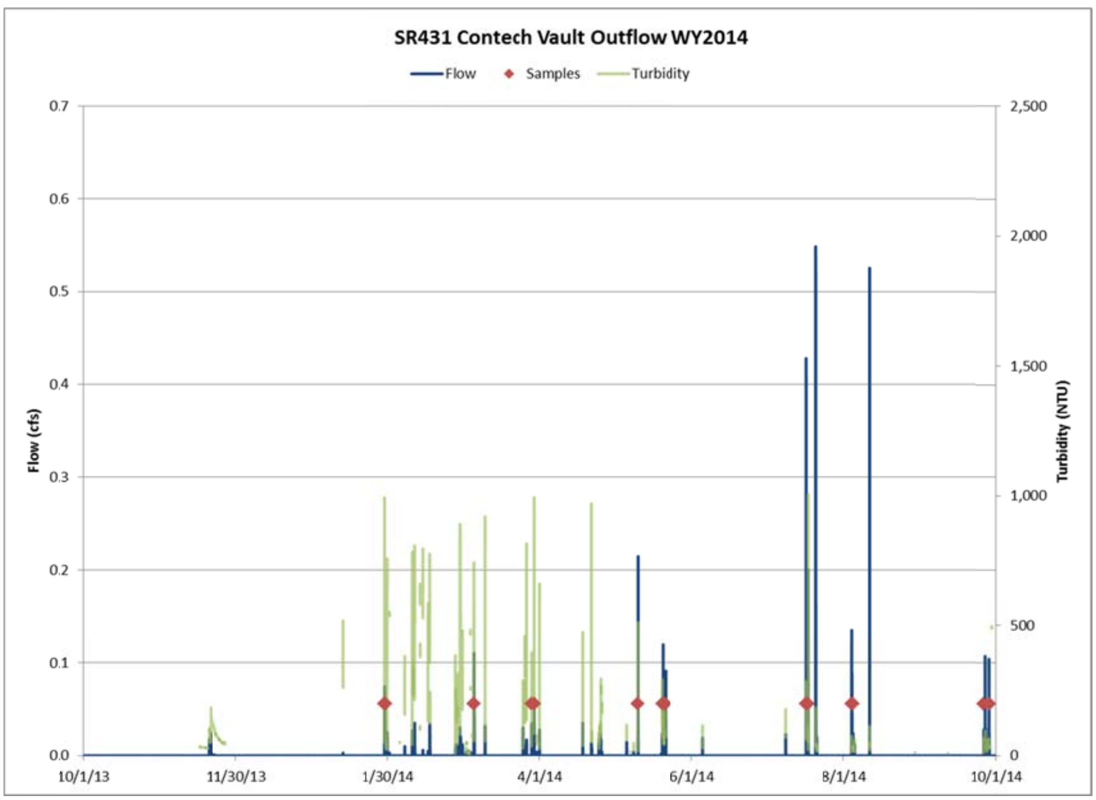


Figure 19a: Continuous hydrology, turbidity and sampled events at the outflow from the Contech MFS vault at SR431, WY14.

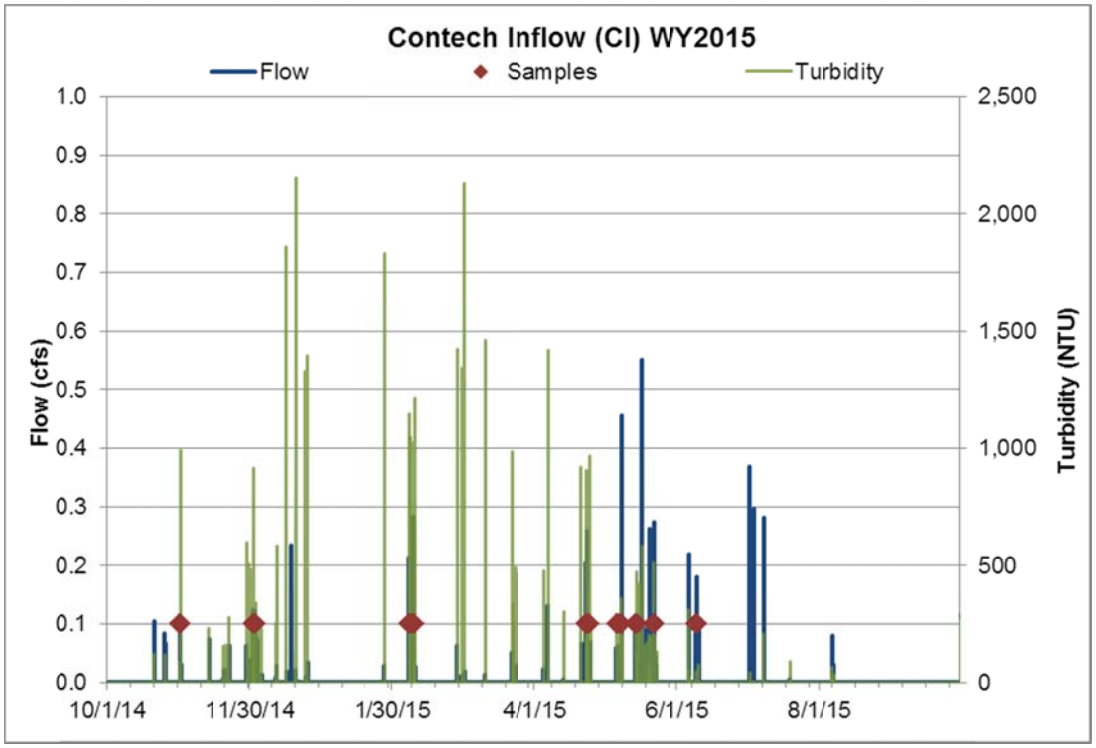


Figure 18b: Continuous hydrology, turbidity and sampled events at the inflow to the Contech MFS vault at SR431, WY15. Two events were sampled during the large February 6, 2015 storm.

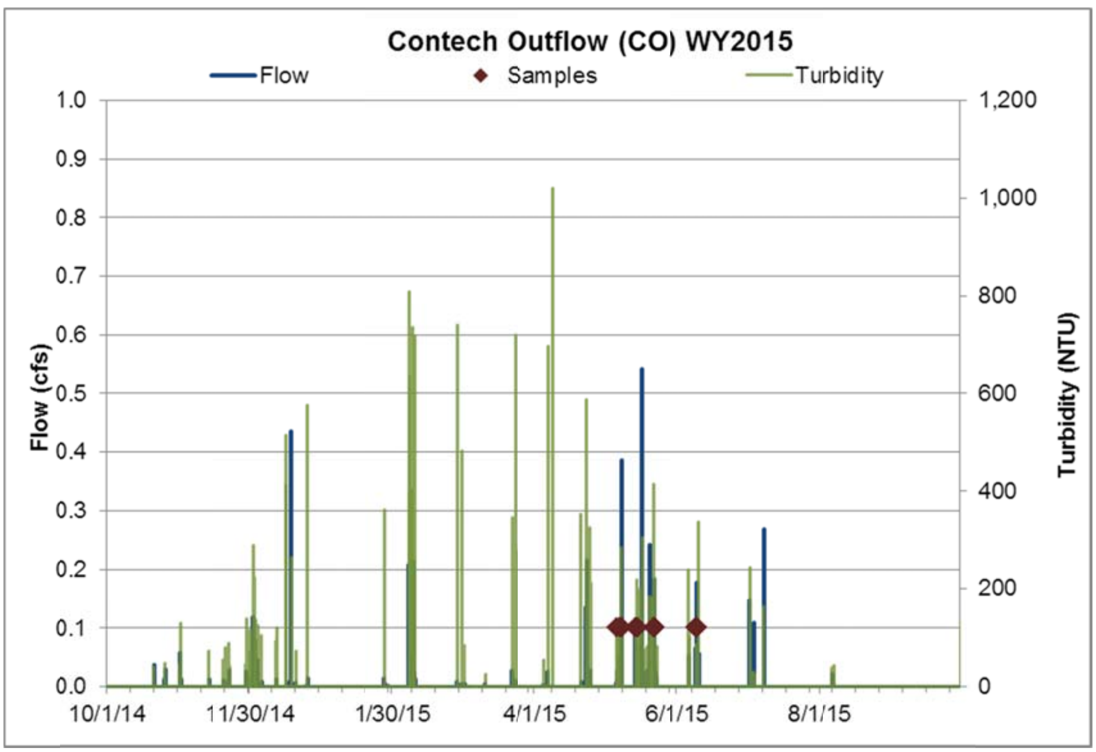


Figure 19b: Continuous hydrology, turbidity and sampled events at the outflow from the Contech MFS vault at SR431, WY15. Two events were sampled during the large February 6, 2015 storm.

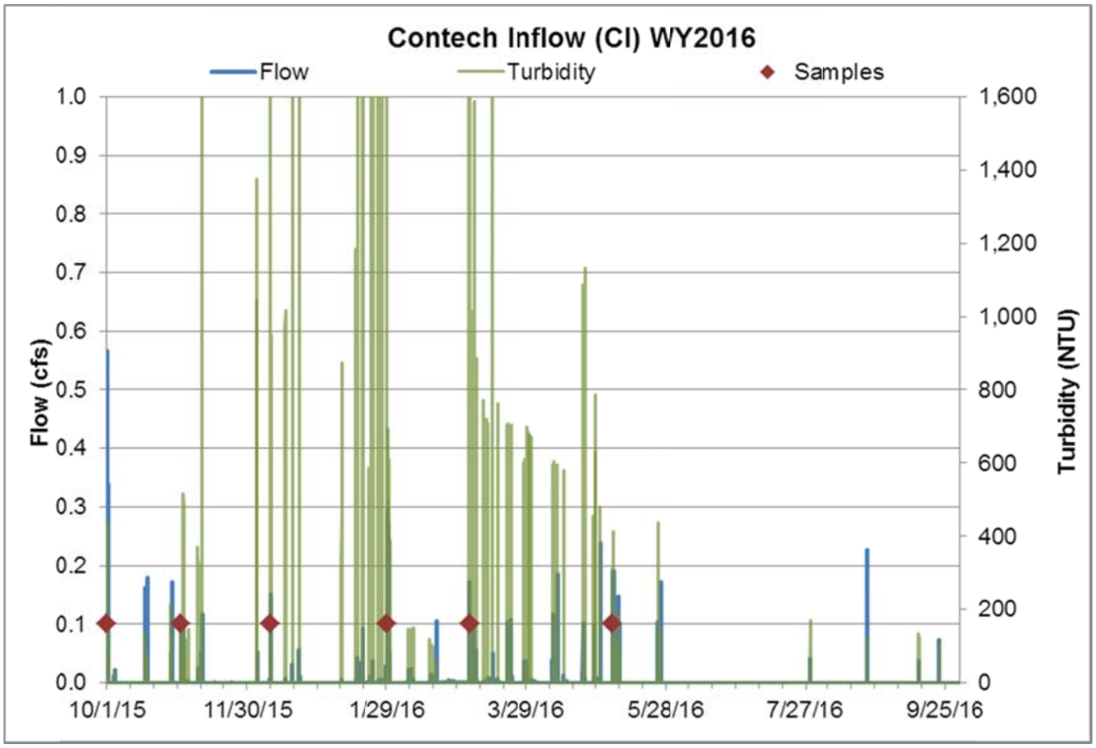


Figure 18c: Continuous hydrology, turbidity and sampled events at the inflow to the Contech MFS vault at SR431, WY16. The maximum range of the turbidity sensor is 1,600NTU, thus this is the maximum range on the graph axis.

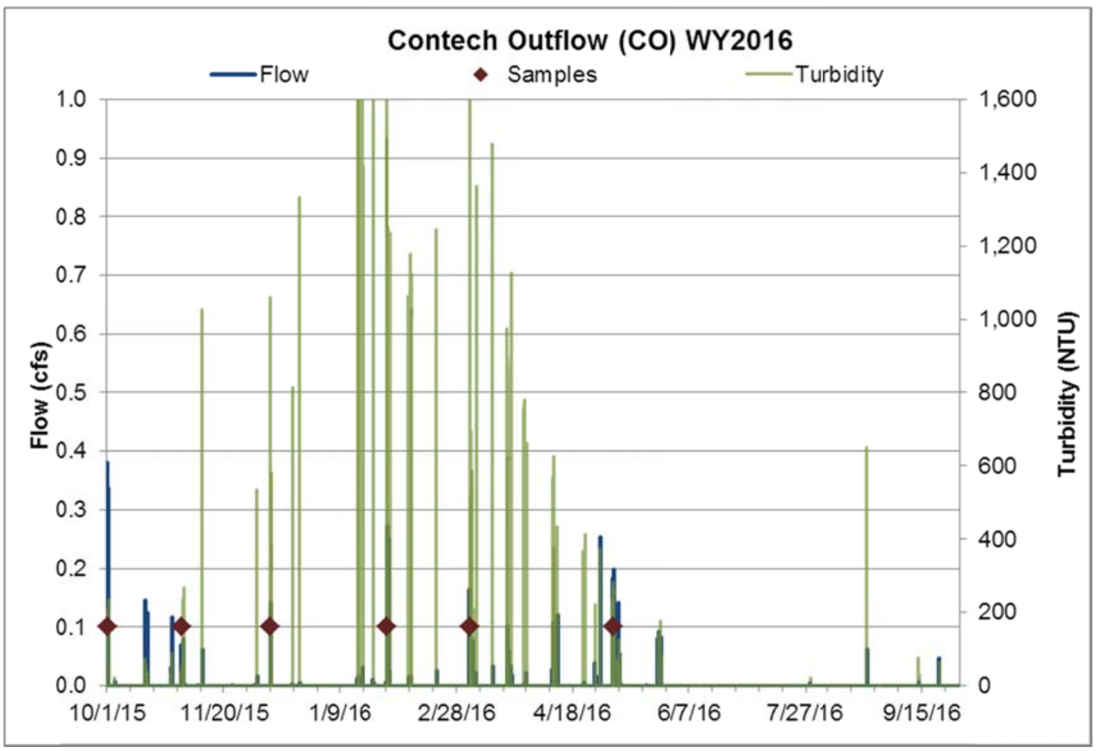


Figure 19c: Continuous hydrology, turbidity and sampled events at the outflow from the Contech MFS vault at SR431, WY16. The maximum range of the turbidity sensor is 1,600NTU, thus this is the maximum range on the graph axis.

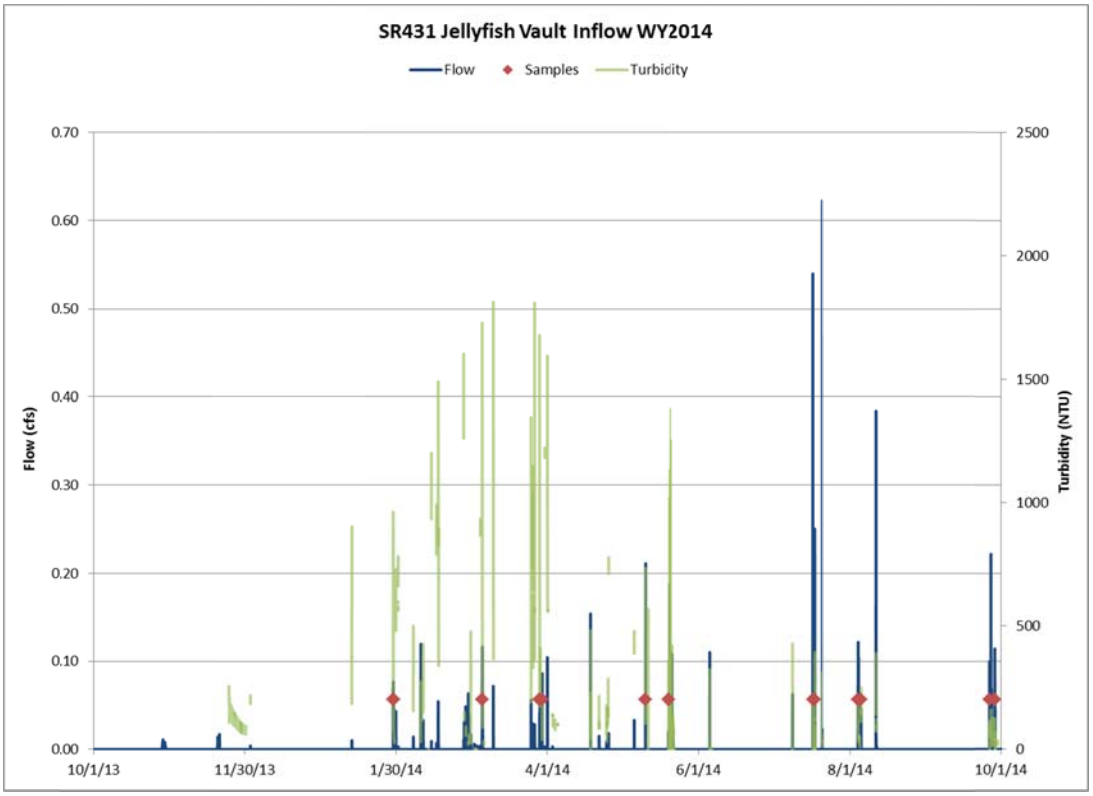


Figure 20a: Continuous hydrology, turbidity and sampled events at the inflow to the Jellyfish vault at SR431, WY14.

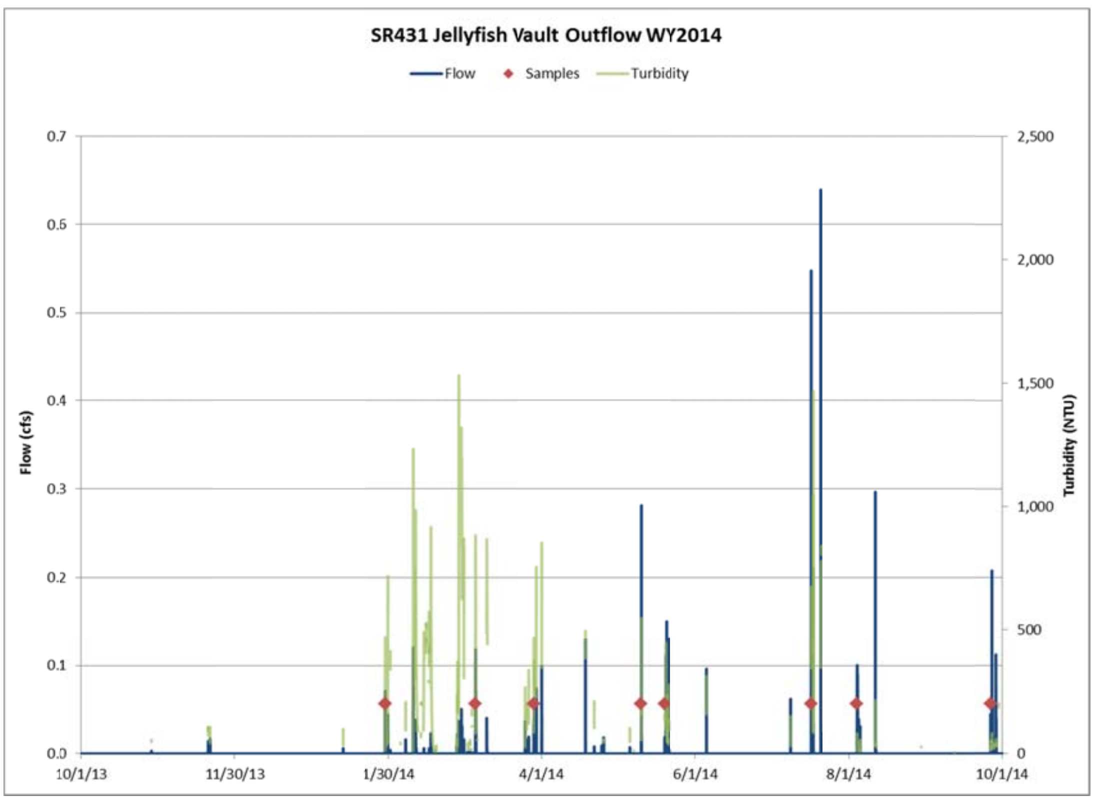


Figure 21a: Continuous hydrology, turbidity and sampled events at the outflow from the Jellyfish vault at SR431, WY14.

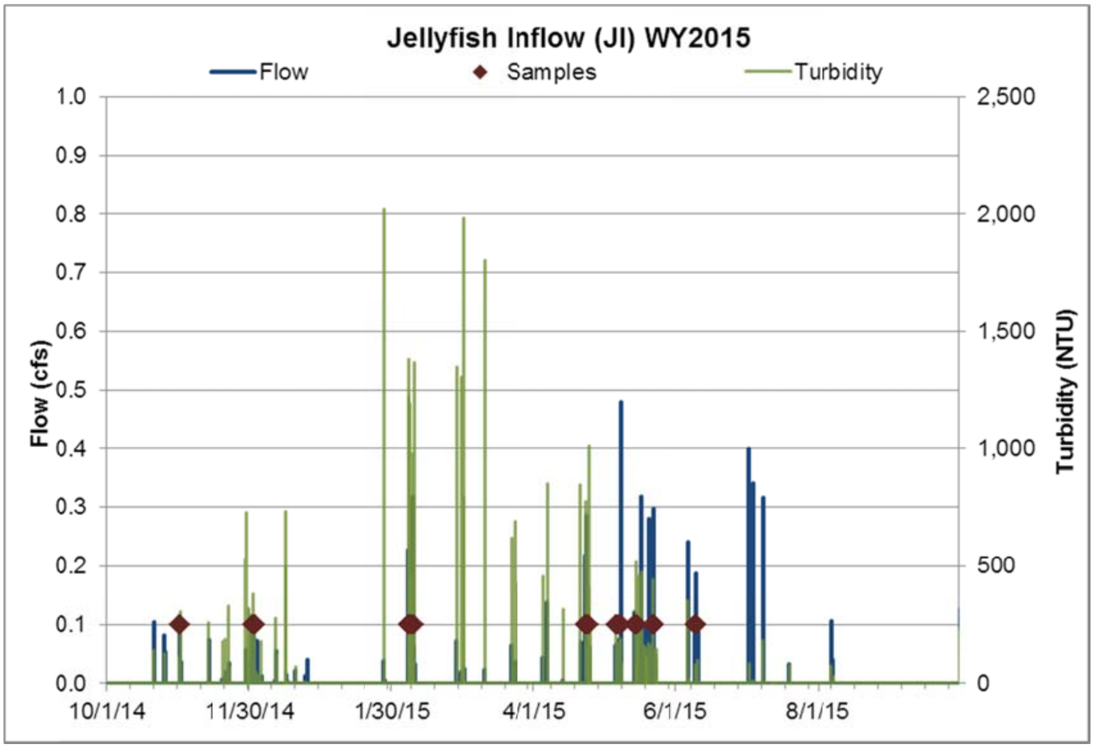


Figure 20b: Continuous hydrology, turbidity and sampled events at the inflow to the Jellyfish vault at SR431, WY15. Two events were sampled during the large February 6, 2015 storm.

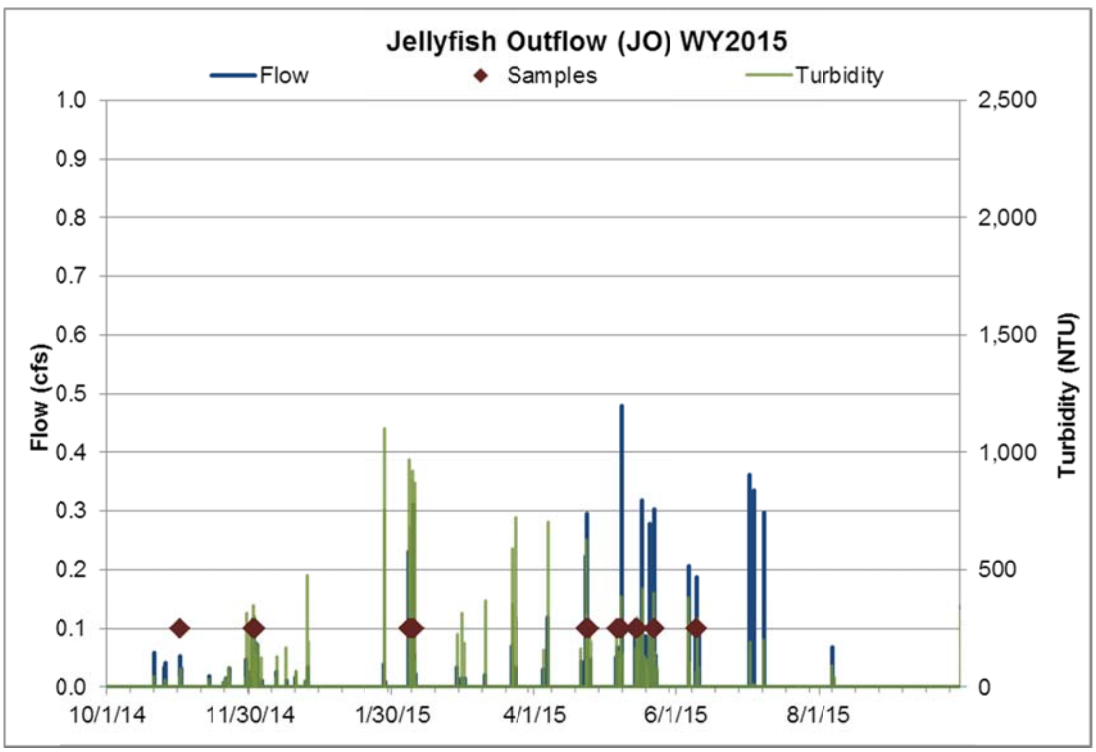


Figure 21b: Continuous hydrology, turbidity and sampled events at the outflow from the Jellyfish vault at SR431, WY15. Two events were sampled during the large February 6, 2015 storm.

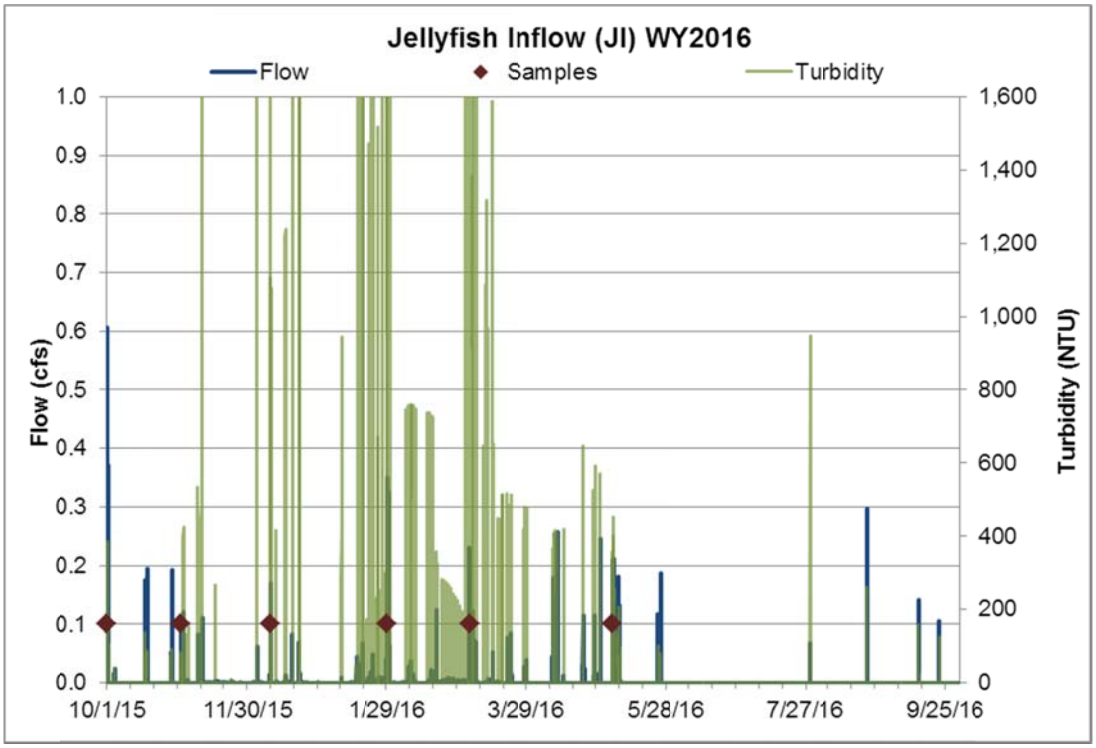


Figure 20c: Continuous hydrology, turbidity and sampled events at the inflow to the Jellyfish vault at SR431, WY16. The maximum range of the turbidity sensor is 1,600NTU, thus this is the maximum range on the graph axis.

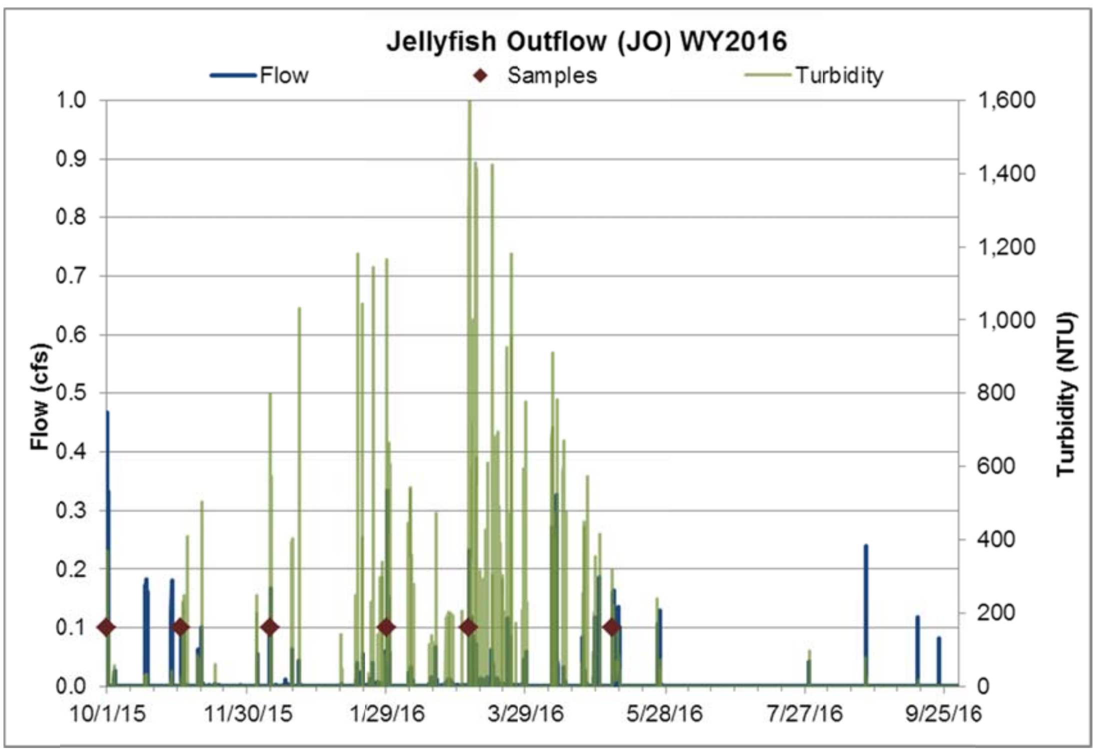


Figure 21c: Continuous hydrology, turbidity and sampled events at the outflow from the Jellyfish vault at SR431, WY16. The maximum range of the turbidity sensor is 1,600NTU, thus this is the maximum range on the graph axis.

Summary data for the eight sampled events at the SR431 cartridge filter vaults in WY14 are presented in Table 9a (Contech MFS vault) and Table 10a (Jellyfish vault). One runoff event was sampled during the fall/winter period, four events were sampled during the spring period and three events were sampled during summer. Although runoff at this site responds relatively quickly to precipitation, it takes a large volume to fill vaults before matched sampling can occur at both the inflow and outflow stations. After a year of many attempts, it is evident that the precipitation events must be greater than about 0.5 inches to produce sufficient runoff for successful water quality sampling. In WY14 the largest runoff events sampled occurred in January, May and August, however, these did not always produce the highest pollutant concentrations or loads. The highest outflow concentrations for FSP and TP occurred during the May 10th event, along with relatively high runoff, but inflow loading was lower than during previous sampled runoff events that year. The highest outflow concentration for TN occurred during the July 16th event, which was the first large summer thunderstorm. Relative efficiency of pollutant removal for each of these two vaults will be discussed in section 7.3. See DRI et al 2015 for more information on individual events.

Table 9a: Event summary data for eight sampled events at the Contech MFS vault at SR431 in WY14.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Storm Total (in)	Event Type	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
CI	Fall/Winter	1/29/14 12:05	1/30/14 1:30	13:25	1,395	1.09	rain on snow	269	23	2,078	0.18	670	0.06
CO		1/29/14 12:20	1/30/14 1:30	13:10	1,142			182	13	1,672	0.12	419	0.03
CI	Spring	3/5/14 6:15	3/6/14 15:35	33:20	821	0.52	rain on snow	744	38	3,420	0.18	2,180	0.11
CO		3/5/14 6:25	3/6/14 5:50	23:25	633			286	11	1,394	0.06	740	0.03
CI	Spring	3/29/14 8:40	3/30/14 12:55	28:15	829	0.97	rain on snow	514	27	2,882	0.15	1,383	0.07
CO		3/29/14 9:20	3/30/14 11:55	26:35	677			322	14	1,924	0.08	844	0.04
CI	Spring	5/10/14 13:40	5/10/14 17:05	3:25	514	0.22	event snowmelt	458	15	1,702	0.05	1,210	0.04
CO		5/10/14 13:55	5/10/14 16:55	3:00	285			332	6	1,554	0.03	970	0.02
CI	Spring	5/19/14 18:55	5/22/14 4:55	58:00	1,389	1.23	rain/snow	186	16	1,242	0.11	525	0.05
CO		5/19/14 18:55	5/22/14 4:55	58:00	957			115	7	1,124	0.07	319	0.02
CI	Summer	7/16/14 19:55	7/17/14 16:55	21:00	878	0.45	thunderstorm	311	17	2,791	0.15	940	0.05
CO		7/16/14 19:55	7/17/14 17:00	21:05	823			208	11	2,645	0.14	765	0.04
CI	Summer	8/4/14 7:25	8/5/14 14:10	30:45	1,240	0.69	rain	40	3	1,176	0.09	160	0.01
CO		8/4/15 8:15	8/5/15 14:20	30:05	1,013			31	2	1,520	0.10	125	0.01
CI	Summer	9/26/14 8:00	9/28/14 14:40	54:40	1,194	0.67	rain	51	4	2,506	0.19	270	0.02
CO		9/26/14 8:05	9/28/14 14:40	54:35	791			49	2	2,679	0.13	220	0.01

Table 10a: Event summary data for eight sampled events at the Jellyfish vault at SR431 in WY14.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Storm Total (in)	Event Type	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
JI	Fall/Winter	1/29/14 12:05	1/30/14 1:40	13:35	1,237	1.09	rain on snow	442	34	1,936	0.15	1,056	0.08
JO		1/29/14 12:15	1/30/14 2:15	14:00	1,318			109	9	1,109	0.09	300	0.02
JI	Spring	3/5/14 6:15	3/6/14 5:20	23:05	641	0.52	rain on snow	681	27	3,598	0.14	2,180	0.09
JO		3/5/14 6:55	3/6/14 18:05	35:10	801			345	17	1,511	0.08	970	0.05
JI	Spring	3/29/14 8:45	3/30/14 11:30	26:45	615	0.97	rain on snow	511	20	2,891	0.11	1,598	0.06
JO		3/29/14 9:10	3/30/14 11:45	26:35	588			196	7	1,315	0.05	465	0.02
JI	Spring	5/10/14 13:40	5/10/14 17:05	3:25	462	0.22	event snowmelt	605	17	2,404	0.07	1,790	0.05
JO		5/10/14 14:00	5/10/14 16:50	2:50	325			442	9	1,753	0.04	1,220	0.02
JI	Spring	5/19/14 18:55	5/22/14 4:55	58:00	2,315	1.23	rain/snow	309	45	2,366	0.34	950	0.14
JO		5/19/14 18:55	5/22/14 4:55	58:00	2,536			174	28	1,293	0.20	480	0.08
JI	Summer	7/16/14 19:55	7/17/14 16:50	20:55	1,119	0.45	thunderstorm	244	17	2,988	0.21	910	0.06
JO		7/16/14 19:55	7/17/14 17:00	21:05	1,052			210	14	2,920	0.19	802	0.05
JI	Summer	8/4/14 7:25	8/5/14 15:25	32:00	1,405	0.69	rain	37	3	1,336	0.12	145	0.01
JO		8/4/14 7:50	8/5/14 23:25	39:35	1,165			25	3	1,143	0.15	109	0.01
JI	Summer	9/26/14 8:00	9/28/14 14:45	54:45	1,158	0.67	rain	48	3	2,094	0.15	240	0.02
JO		9/26/14 8:10	9/28/14 14:50	54:40	1,001			39	2	2,111	0.13	180	0.01

Summary data for the eight sampled events at the SR431 cartridge filter vaults in WY15 are presented in Table 9b (Contech MFS vault) and Table 10b (Jellyfish vault). Three runoff events were sampled in the fall/winter, four events in the spring, and one in the summer. Runoff volumes are very small at this site when compared to other sites; even the very large precipitation event in February 2015 of 3.77 inches produced only approximately 5,000 cubic feet of runoff.

Differences between the two cartridge filter vaults are generally negligible. Flow gets split at the inflows relatively evenly (though the Jellyfish tends to get a slightly larger portion of the flow), and since the vaults are not designed to reduce volumes, outflow volumes are consequently similar. Inflow concentrations of all three pollutants should be very similar; differences are likely due to small variations in concentrations at the slightly different times samples are taken. Relative efficiency of pollutant removal for these two vaults will be discussed in section 7.3, but concentrations of pollutants at the outflows are typically similar as well. Though runoff volumes, and consequently loads, are very small at this site, the largest runoff volumes and loads occurred with the large February event. The highest inflow concentrations of TN occurred with the event beginning October 31, 2014. The highest TP concentration occurred with the large February event and the April 23, 2015 event. Relative efficiency of pollutant removal for each of these two vaults will be discussed in section 7.3. Turbidities ranged from about 50 NTU in the summer to about 1,300 NTU during the February event and generally occurred with peak flows (Appendix F). See DRI et al 2015 for more information on individual events.

Table 9b: Event summary data for eight sampled events at the Contech MFS vault at SR431 in WY15.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
CI	Fall/Winter	10/31/14 21:00	11/1/14 11:05	14:05	595	0.10	991	0.31	rain	100%	76	3	3,150	0.1	293	<0.1
CO		10/31/14 21:10	11/1/14 10:00	12:50	370	0.06	131			100%	59	1	2,200	<0.1	233	<0.1
CI	Fall/Winter	12/2/14 11:05	12/4/14 13:35	50:30	3,709	0.12	914	2.73	snow, rain	100%	141	33	730	0.2	424	<0.1
CO		12/2/14 11:25	12/4/14 12:05	48:40	2,738	0.12	289			100%	121	21	820	0.1	328	<0.1
CI	Fall/Winter	2/7/15 0:20	2/8/15 22:00	45:40	4,920	0.28	1,214	3.77	rain, snow	100%	402	123	1,270	0.4	1,330	0.4
CO		2/7/15 0:35	2/8/15 22:55	46:20	4,595	0.21	808			100%	342	98	1,190	0.3	1,006	0.3
CI	Spring	4/23/15 15:55	4/25/15 15:25	47:30	1,930	0.26	968	1.44	rain, snow	100%	332	40	1,260	0.2	1,101	0.1
CO		4/23/15 22:40	4/25/15 14:05	39:25	1,612	0.22	588			100%	275	28	1,170	0.1	812	<0.1
CI	Spring	5/6/15 16:10	5/8/15 23:25	55:15	1,600	0.46	360	0.84	rain	100%	316	32	1,006	0.1	126	<0.1
CO		5/6/15 16:25	5/9/15 0:10	55:45	1,310	0.39	285			100%	239	20	494	<0.1	92	<0.1
CI	Spring	5/14/15 15:50	5/15/15 19:40	27:50	1,436	0.11	472	1.11	snow	100%	168	15	829	<0.1	662	<0.1
CO		5/14/15 16:05	5/15/15 20:35	28:30	1,116	0.10	218			100%	149	10	1,378	<0.1	648	<0.1
CI	Spring	5/22/15 8:40	5/22/15 23:00	14:20	1,391	0.27	375	0.46	snow, rain	100%	211	18	1,020	<0.1	856	<0.1
CO		5/22/15 11:25	5/23/15 0:35	13:10	1,289	0.18	414			100%	160	13	734	<0.1	665	<0.1
CI	Summer	6/9/15 19:30	6/10/15 7:50	12:20	1,641	0.18	47	0.75	thunderstorm	100%	78	8	891	<0.1	153	<0.1
CO		6/9/15 19:40	6/10/15 8:10	12:30	1,536	0.18	87			100%	49	5	1,437	0.1	212	<0.1

Table 10b: Event summary data for eight sampled events at the Jellyfish vault at SR431 in WY15.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
JI	Fall/Winter	10/31/14 21:00	11/1/2014 11:05	14:05	401	0.08	307	0.31	rain	100%	76	2	4,080	0.1	299	<0.1
JO		10/31/14 21:15	11/1/2014 10:35	13:20	320	0.05	80			100%	27	1	1,220	<0.1	172	<0.1
JI	Fall/Winter	12/2/2014 11:10	12/4/2014 11:55	48:45	3,000	0.11	381	2.73	snow, rain	100%	149	28	850	0.2	445	<0.1
JO		12/2/2014 11:25	12/4/2014 11:55	48:30	2,904	0.12	347			100%	114	21	860	0.2	312	<0.1
JI	Fall/Winter	2/7/2015 0:20	2/9/2015 3:15	50:55	5,406	0.32	1,382	3.77	rain, snow	100%	405	137	1,110	0.4	1,275	0.4
JO		2/7/2015 0:30	2/9/2015 1:40	49:10	5,166	0.31	970			100%	342	110	900	0.3	1,015	0.3
JI	Spring	4/23/2015 15:55	4/25/2015 16:00	48:05	1,922	0.29	1,014	1.44	rain, snow	100%	394	47	1,350	0.2	1,322	0.2
JO		4/23/2015 16:00	4/25/2015 15:25	47:25	1,812	0.30	627			100%	264	30	1,170	0.1	792	<0.1
JI	Spring	5/6/15 16:10	5/8/15 23:50	55:40	1,847	0.48	265	0.84	rain	100%	256	30	760	<0.1	56	<0.1
JO		5/6/15 16:20	5/8/15 23:50	55:30	1,800	0.48	385			95%	243	27	889	<0.1	48	<0.1
JI	Spring	5/14/15 15:50	5/15/15 19:50	28:00	1,783	0.12	517	1.11	snow	100%	167	19	1,144	0.1	664	<0.1
JO		5/14/15 15:55	5/15/15 19:55	28:00	1,674	0.11	286			100%	113	12	1,294	0.1	519	<0.1
JI	Spring	5/22/15 11:25	5/22/15 23:40	12:15	1,526	0.30	335	0.46	snow, rain	100%	196	19	531	<0.1	906	<0.1
JO		5/22/15 11:25	5/22/15 23:30	12:05	1,534	0.30	201			100%	202	19	502	<0.1	806	<0.1
JI	Summer	6/9/15 19:30	6/10/15 7:55	12:25	1,658	0.19	76	0.75	thunderstorm	95%	73	8	988	0.1	153	<0.1
JO		6/9/15 19:35	6/10/15 8:05	12:30	1,658	0.19	59			90%	52	5	1,153	0.1	214	<0.1

Summary data for the six sampled events at the SR431 cartridge filter vaults in WY16 are presented in Table 9c (Contech MFS vault) and Table 10c (Jellyfish vault). Four runoff events were sampled in the fall/winter and two events in the spring. Sediment accumulation on the sensors after May did not allow for further events to be sampled. Partial maintenance occurred in August, but the system was not fully cleaned out until October 2016. Monitoring did not resume until after the system was maintained in October. There was very little precipitation all summer so no major events were missed due to the needed maintenance. Again, runoff volumes at this site were very small when compared to other sites due to the small catchment area and the flow restriction to the system that occurs at the drop inlet upstream of the inflow chamber where the flow gets split to the two different vaults. Though runoff volumes, and consequently loads, are very small at this site, the highest concentrations of all three pollutants occurred during the March 4, 2016 rain on snow event. The lowest concentrations of FSP and TP occurred during the November 1, 2015 event. TN concentrations during this event were relatively low. Relative efficiency of pollutant removal for each of these two vaults will be discussed in section 7.3. Peak turbidities ranged from about 150 NTU during the relatively "clean" November 1, 2015 event to about 2,000 NTU during the relatively "dirty" March 4, 2016 event and generally occurred with peak flows. In general turbidities mirror the hydrograph (Appendix F).

Table 9c: Event summary data for six sampled events at the Contech MFS vault at SR431 in WY16.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Peak Precip (in/5 min)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
CI	Fall/Winter	10/1/15 0:10	10/1/15 12:55	12:45	1,214	0.57	439	0.28	0.09	thunderstorm	90%	199	15	893	0.1	1,417	0.1
CO		10/1/15 0:30	10/1/15 13:30	13:00	1,042	0.38	206				75%	154	10	1,139	0.1	1,222	0.1
CI	Fall/Winter	11/1/15 11:45	11/2/15 10:05	22:20	915	0.08	156	1.33	0.03	rain, snow	90%	45	3	1,088	0.1	219	<0.1
CO		11/1/15 12:15	11/2/15 9:25	21:10	730	0.07	52				90%	20	1	839	<0.1	130	<0.1
CI	Fall/Winter	12/10/15 1:20	12/10/15 13:45	12:25	1,760	0.15	1,733	1.44	0.02	snow	100%	728	80	3,124	0.3	1,651	0.2
CO		12/10/15 4:25	12/10/15 14:30	10:05	1,509	0.14	1,058				100%	12	1	1,681	0.2	1,507	0.1
CI	Fall/Winter	1/29/16 5:20	1/30/16 4:30	23:10	6,903	0.29	1,712	0.12	0.004	rain/snow	100%	1,110	478	1,728	0.7	1,651	0.7
CO		1/29/16 6:10	1/30/16 2:20	20:10	6,285	0.27	1,621				100%	951	373	1,504	0.6	1,624	0.6
CI	Spring	3/4/16 10:50	3/5/16 7:15	20:25	999	0.17	2,021	0.42	0.04	rain	100%	3,244	202	2,830	0.2	6,424	0.4
CO		3/4/16 15:50	3/5/16 8:05	16:15	916	0.16	1,602				90%	1,397	80	2,655	0.2	2,867	0.2
CI	Spring	5/5/16 4:45	5/5/16 9:20	4:35	1,143	0.19	413	0.37	0.02	thunderstorm	80%	379	27	2,118	0.2	1,379	0.1
CO		5/5/16 4:50	5/5/16 10:55	6:05	1,141	0.18	284				90%	308	22	1,886	0.1	1,219	0.1

Table 10c: Event summary data for six sampled events at the Jellyfish vault at SR431 in WY16.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Peak Precip (in/5 min)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
JI	Fall/Winter	10/1/15 0:10	10/1/15 13:05	12:55	1,389	0.61	385	0.28	0.09	thunderstorm	90%	173	15	722	0.1	1,433	0.1
JO		10/1/15 0:15	10/1/15 14:15	14:00	1,496	0.55	368				80%	127	12	1,049	0.1	1,048	0.1
JI	Fall/Winter	11/1/15 11:45	11/2/15 10:25	22:40	1,699	0.11	84	1.33	0.03	rain, snow	100%	44	5	1,259	0.1	198	<0.1
JO		11/1/15 12:15	11/2/15 10:55	22:40	1,685	0.11	28				100%	<1	<1	584	0.1	80	<0.1
JI	Fall/Winter	12/10/15 1:10	12/10/15 14:05	12:55	2,076	0.17	1,895	1.44	0.02	snow	90%	717	93	2,886	0.4	1,663	0.2
JO		12/10/15 1:20	12/10/15 14:05	12:45	2,033	0.17	799				70%	419	53	1,173	0.1	969	0.1
JI	Fall/Winter	1/29/16 5:15	1/30/16 7:40	26:25	8,327	0.35	1,959	0.12	0.004	rain/snow	100%	1,126	585	1,346	0.7	1,862	1.0
JO		1/29/16 5:30	1/30/16 7:35	26:05	7,811	0.34	1,165				100%	825	402	1,405	0.7	1,461	0.7
JI	Spring	3/4/16 10:50	3/5/16 8:05	22:55	1,609	0.23	2,106	0.42	0.04	rain	70%	2,666	268	4,467	0.4	3,873	0.4
JO		3/4/16 11:05	3/5/16 9:05	22:00	1,610	0.23	1,757				90%	1,341	135	3,233	0.3	4,913	0.5
JI	Spring	5/5/16 4:45	5/5/16 10:05	5:20	1,457	0.21	452	0.37	0.02	thunderstorm	80%	396	36	1,776	0.2	1,379	0.1
JO		5/5/16 4:50	5/5/16 10:15	5:25	1,429	0.19	317				100%	297	26	1,715	0.2	1,105	0.1

6.2.4.2 SR431 Catchment Outfall

In WY14 there were seven events at the SR431 catchment outfall that produced sufficient runoff to sample and water quality samples were taken across the hydrograph during all of them. It should be noted that this site produces very little runoff, and "sufficient runoff" at this site is a paltry 30cf. Continuous hydrology, continuous turbidity, and events sampled during WY14 are presented in Figure 22a. The highest turbidities were seen during the largest storm of the year (February 6-10, 2014), but the event resulted in only 7 cubic feet of flow on the morning of February 10. Despite the 4.65 inches of precipitation, temperatures remained below freezing for the duration of the storm at this site and therefore the precipitation fell as snow and did not produce sufficient runoff. The highest instantaneous peak flow occurred during the July 20, 2014 thunderstorm, as peak precipitation reached 0.13 inches in five minutes. .

In WY15 twelve precipitation events produced sufficient runoff to sample at the SR431 catchment outfall, and water quality samples were taken across the hydrograph at seven of these events. Continuous hydrology, continuous turbidity, and events sampled during WY15 are presented in Figure 22b. The highest instantaneous peak flow occurred during the

July 4, 2014 thunderstorm, as peak precipitation reached only 0.05 inches in five minutes. The highest turbidity was observed on March 2, 2015, but the event did not produced sufficient runoff to sample.

Monitoring was discontinued at the SR431 outfall (S5) location in WY16 due to lack of runoff, but monitoring continues at the Contech MFS and Jellyfish BMP sites. See Section 2.5 for further discussion.

Annual inflow and outflow hydrographs and cumulative volumes for the outfall for WY14 and WY15 are presented in Appendix G.

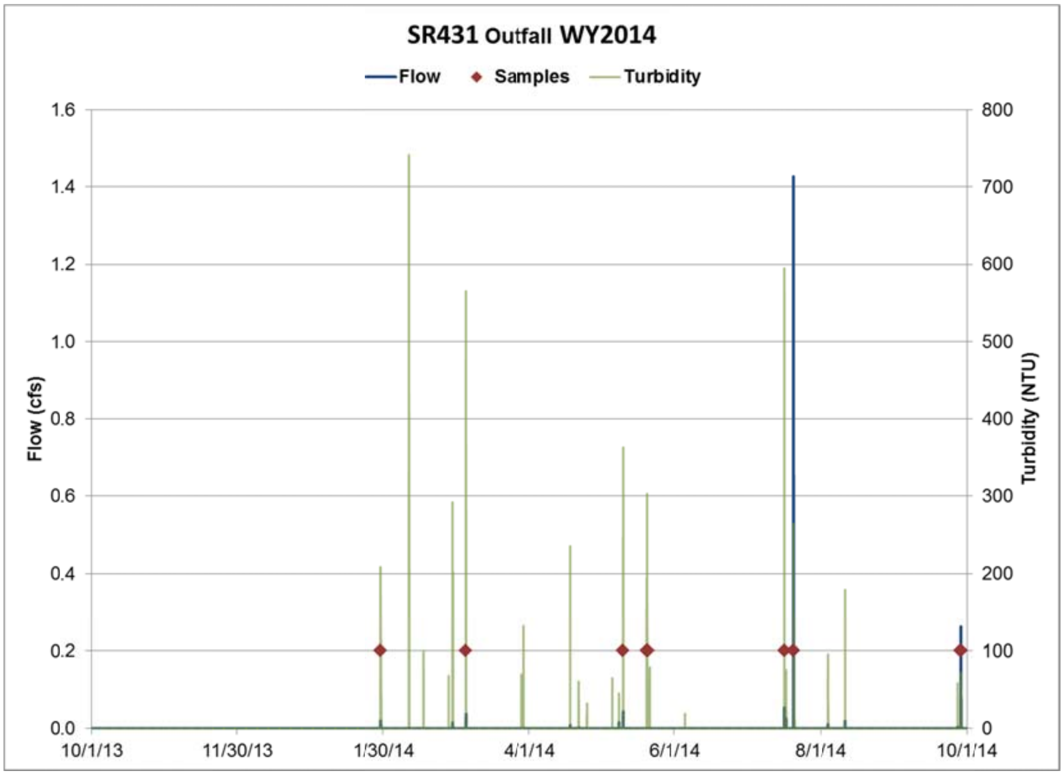


Figure 22a: Continuous hydrology, turbidity and sampled events at the SR431 catchment outfall, WY14.

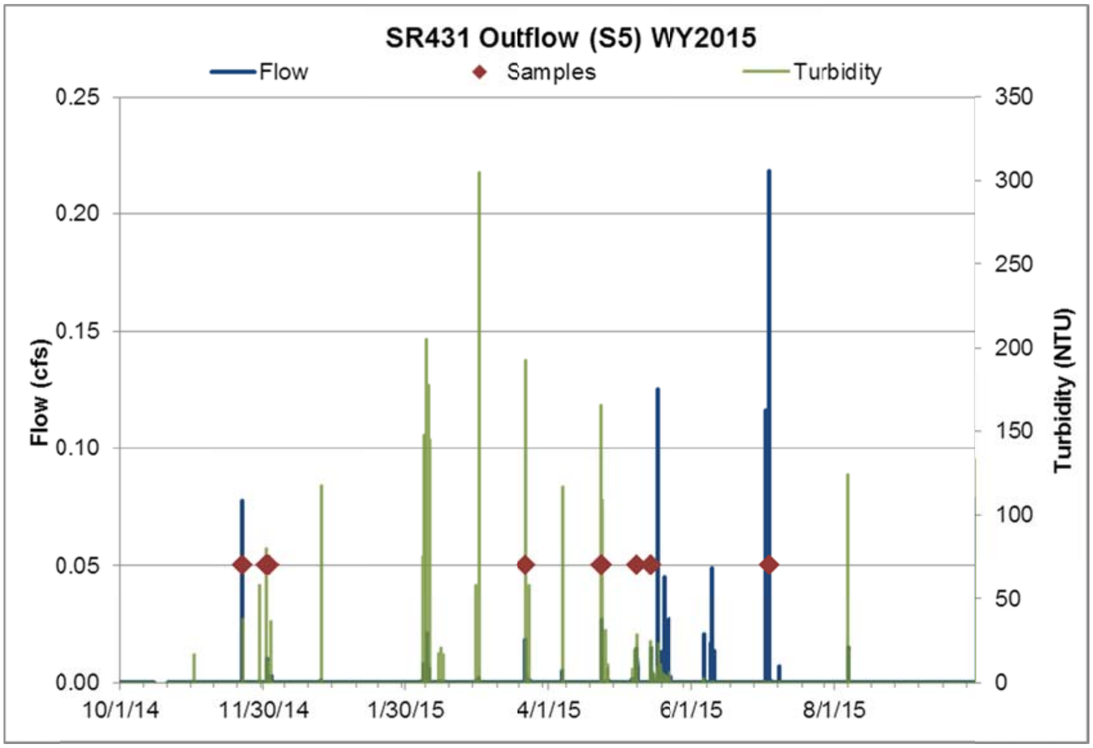


Figure 22b: Continuous hydrology, turbidity and sampled events at the SR431 catchment outfall, WY15.

Summary data for all seven events sampled at the SR431 Outfall in WY14 are presented in Table 11a. One runoff event was sampled during the fall/winter, three during the spring, and three during the summer. In general, only precipitation events greater than 0.5 inches produced sufficient runoff for water quality sampling, though one spring snow event of only 0.22 inches produced sufficient snowmelt to sample. However, the total runoff volume was only 88 cubic feet, and sample density was low. It was unusually difficult to capture runoff events at this site as runoff volumes were consistently lower than would be assumed for a catchment that is 96% impervious, but much of the runoff is diverted to the cartridge filter vaults and only flow bypassing the cartridge filter vaults is captured at the catchment outfall station (S5). This caused staff to set the sample pacing too high, and resulted in poor sampling density for the first two storms sampled. Consequently, staff began to set a lower pacing, which caused the sampler to run out of bottles too quickly during the July 20, 2014 thunderstorm. Only the beginning of this storm was sampled successfully. There is no nutrient data available for the May 10, 2014 storm as samples were not delivered to the lab within the proper holding time. All events at SR431 had peak turbidities in the range of 250-600 NTU usually concurrent with peak flow (Appendix G).

Table 11a: Event summary data for seven sampled events at the SR431 catchment outfall in WY14.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
S5	Fall/Winter	1/29/14 15:20	1/30/14 1:20	10:00	180	1.09	rain on snow	10%	63	1	726	<0.1	57	<0.1
S5	Spring	3/5/14 23:50	3/6/14 3:00	3:10	200	0.52	rain on snow	10%	319	4	1,714	<0.1	922	<0.1
S5	Spring	5/10/14 13:50	5/10/14 16:30	2:40	88	0.22	event snowmelt	65%	246	1	na	na	na	na
S5	Spring	5/20/14 6:50	5/21/14 1:00	18:10	103	1.23	rain/snow	95%	88	1	1,149	<0.1	198	<0.1
S5	Summer	7/16/14 19:50	7/16/14 20:30	0:40	37	0.45	thunderstorm	100%	441	1	2,142	<0.1	2,450	<0.1
S5	Summer	7/20/14 14:30	7/20/14 16:50	2:20	2,319	1.57	thunderstorm	45%	271	39	1,780	0.3	1,179	0.2
S5	Summer	9/28/14 9:50	9/28/14 12:10	2:20	699	0.67	rain	100%	48	2	414	<0.1	125	<0.1

Summary data for all seven events sampled at the SR431 Outfall in WY15 are presented in Table 11b. Two runoff events were sampled during the fall/winter, four during the spring, and one during the summer. With the exception of a high intensity thunderstorm on July 4, 2015 and a rain on snow event on March 22, 2015 relatively large precipitation events are required for sufficient runoff to sample at this site. Sampling was more successful in WY15 than WY14, but due to consistently small runoff volumes this site was retired at the end of WY15. The highest concentrations of all three pollutants occurred during the March 22, 2015 rain event, but loads were very low due to the low runoff volume. As with other sites, TN concentrations were highest in the summer. Peak turbidities are low compared to the inflows to the cartridge filter vaults but much of the sediment that could potentially reach this monitoring station has likely settled out in the three sediment traps directly upstream of this station (Appendix G).

Table 11b: Event summary data for seven sampled events at the SR431 catchment outfall in WY15.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
S5	Fall/Winter	11/22/14 5:55	11/22/14 8:20	2:25	270	0.08	38	0.35	rain	100%	128	2.2	1,016	<0.1	608	<0.1
S5	Fall/Winter	12/2/14 11:25	12/3/14 16:20	28:55	32	0.01	212	1.44	rain/snow	100%	101	0.2	1,443	<0.1	461	<0.1
S5	Spring	3/22/15 19:45	3/22/15 21:45	2:00	30	0.02	192	0.21	rain	85%	791	1.5	3,090	<0.1	3,383	<0.1
S5	Spring	4/23/15 15:50	4/24/15 0:55	9:05	88	0.03	166	0.68	snow	100%	351	1.9	1,670	<0.1	1,202	<0.1
S5	Spring	5/8/15 18:05	5/8/15 21:15	3:10	41	0.01	28	0.84	rain	80%	106	0.3	845	<0.1	774	<0.1
S5	Spring	5/14/15 16:00	5/15/15 9:45	17:45	28	0.01	24	1.11	snow	85%	126	0.2	802	<0.1	556	<0.1
S5	Summer	7/4/15 10:00	7/4/15 11:55	1:55	136	0.22	1	0.19	thunderstorm	90%	320	2.7	4,204	<0.1	1,152	<0.1

6.2.5 Tahoma

The total precipitation for WY14 at the Tahoma meteorological station was 22.09 inches, within the first quartile of the annual precipitation recorded at the Tahoe City Cross reference station since 1981 (Table 4). Figure 23a shows the average daily flow and cumulative precipitation for WY14. The majority of the precipitation fell in the fall/winter season (14.95 inches). The spring season received 3.13 inches and the summer season received 4.01 inches. A total of 36 discrete precipitation events were measured at the Tahoma meteorological station, 15 in the fall/winter, 13 in the spring, and 8 in the summer. Half of the events during WY14 produced less than a tenth of an inch of precipitation, and three quarters of the events produced less than half an inch. The largest storm occurred between February 7, 2014 and February 10, 2014, falling as mixed rain and snow and producing 9.32 inches of precipitation in Tahoma. However, the highest instantaneous peak flows (about 3.2 cfs) were experienced during a high intensity thunderstorm on August 10, 2014.

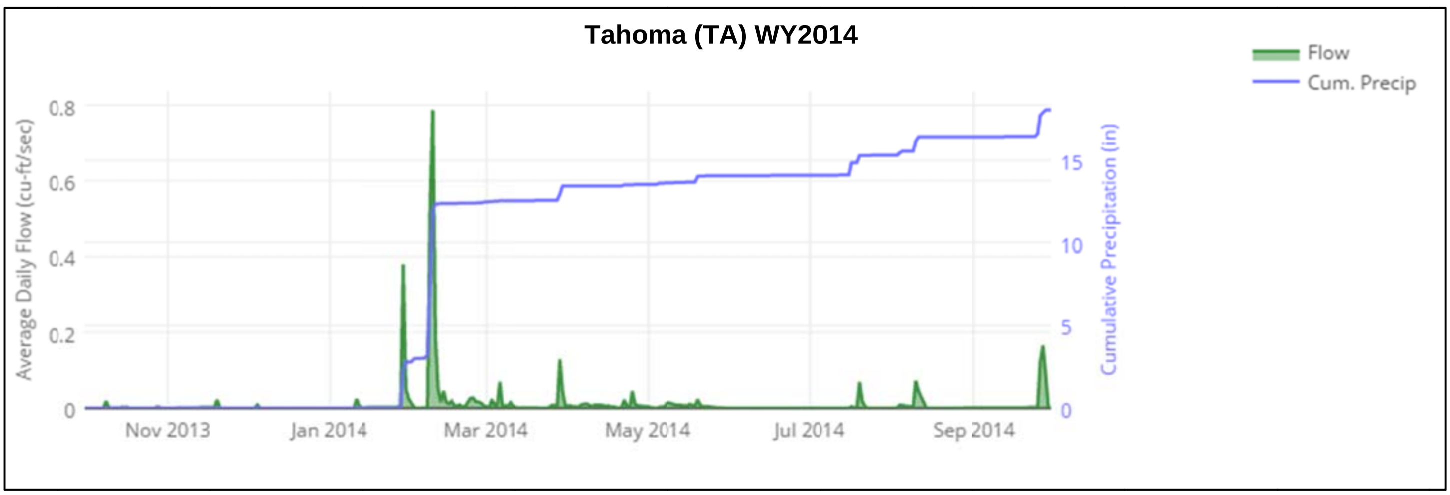


Figure 23a: Average daily flow and cumulative precipitation at the Tahoma catchment outfall, WY14.

The total precipitation for WY15 at the Tahoma meteorological station was 20.41 inches, which falls within the first quartile of the annual precipitation recorded at the Tahoe City Cross reference station since 1981 (Table 4). Figure 23b shows the average daily flow and cumulative precipitation for WY15. The majority of the precipitation fell in the fall/winter season (13.59 inches). The spring season received 3.9 inches and the summer season received 2.92 inches. A total of 35 discrete precipitation events were measured at the Tahoma meteorological station, 15 in the fall/winter, 11 in the spring, and 9 in the summer. 29% of the events during WY15 produced less than a tenth of an inch of precipitation and 63% of the events produced less than half an inch. The largest storm occurred between February 6, 2015 and February 9, 2015, falling as mixed rain and snow and resulted in 4.91 inches of precipitation in the Tahoma catchment. However, the highest instantaneous peak flows (about 4.7 cfs) occurred during a high intensity thunderstorm on July 19, 2015.

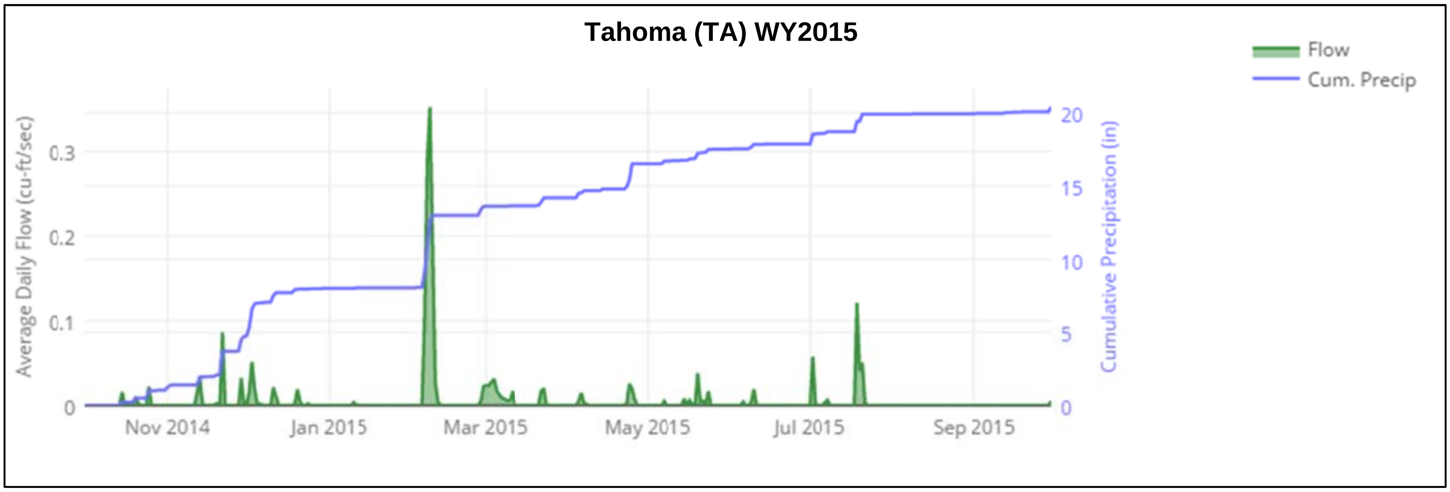


Figure 23b: Average daily flow and cumulative precipitation at the Tahoma catchment outfall, WY15

The total precipitation for WY16 in the Tahoma catchment was 29.56 inches, approximately one inch less than the median of the annual precipitation recorded at the Tahoe City Cross reference station since 1981 (Table 4). Figure 23c shows the average daily flow and cumulative precipitation for WY16. The majority of the precipitation fell in the fall/winter season (16.70 inches). The spring season received 11.60 inches and the summer season received 1.26 inches. A total of 51 discrete precipitation events were measured at the Tahoma meteorological station, 31 in the fall/winter, 17 in the spring, and 3 in the summer. Approximately forty percent of the events during WY16 produced less than a tenth of an inch of precipitation, and nearly half of the events produced less than half an inch. The largest storm occurred during January 28-31, 2016, falling initially as rain before turning into snow. The event produced 3.47 inches of precipitation in Tahoma. The highest instantaneous peak flows (7.04 cfs) were experienced during a snow and rain event on November 16, 2015.

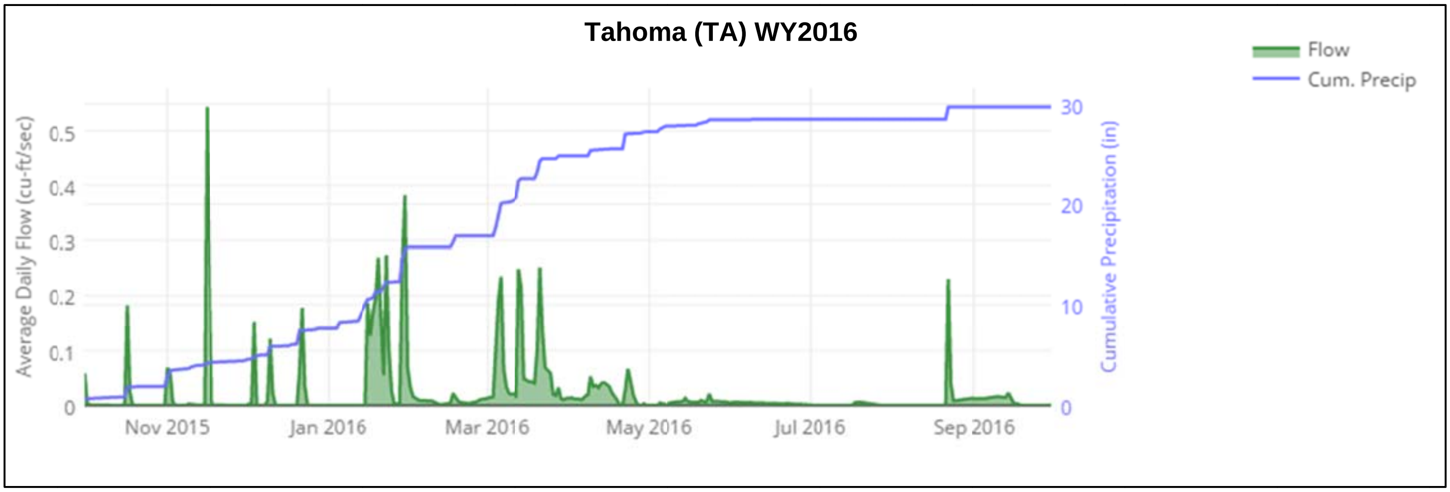


Figure 23c: Average daily flow and cumulative precipitation at the Tahoma catchment outfall, WY16

Water quality samples were taken across the hydrograph at every feasible opportunity at the Tahoma monitoring station and successful sampling occurred during eleven runoff events. (This site had additional funding through an EPA sponsored SNPLMA grant; hence the number of events sampled was greater than required for regulatory compliance.) Continuous hydrology, continuous turbidity and events sampled during WY14 are presented in Figure 24a. The greatest flows in WY14 were seen during the thunderstorm that occurred on August 10, 2014 as the peak precipitation reached 0.28 inches in ten minutes. Turbidimeter readings exceeded the maximum range of the sensor (1600NTU) on two occasions in WY15.

During WY15 there were twenty-four precipitation events in the Tahoma catchment that produced sufficient runoff to sample and water quality samples were taken across the hydrograph during fourteen runoff events. Continuous hydrology, continuous turbidity and events sampled during WY15 are presented in Figure 24b. (This site had additional funding through Proposition 84 during WY15; hence the number of events sampled was greater than required for regulatory compliance.) The greatest flows in WY15 were seen during the thunderstorm that occurred on August 19, 2015 as the peak precipitation reached 0.31 inches in ten minutes. Turbidimeter readings exceeded the maximum range of the sensor (1600NTU) on three occasions in WY15.

During WY16, twenty-four precipitation events in the Tahoma catchment produced sufficient runoff to sample during the year and water quality samples were taken across the hydrograph during twelve of these runoff events, thereby fulfilling the requisite number of sample events for the year. (This site had funding through Proposition 84; hence the number of events sampled was greater than required for regulatory compliance.) It should be noted that Tahoma was the only monitoring site to receive enough runoff to sample across the hydrograph during the summer of WY16, caused by an impressive hour and twenty minute thunderstorm that produced 1.22 inches of precipitation and a peak precipitation of 0.27 inches in ten minutes. Continuous hydrology, continuous turbidity, and events sampled during WY16 are presented in Figure 24c. The largest total volumes occurred during a snow and rain event January 28-31, 2016. Turbidimeter readings exceeded the maximum range of the sensor (1600NTU) on four occasions in WY16.

Continuous hydrology, continuous turbidity, and water quality samples for the individual events at Tahoma are presented in Appendix H.

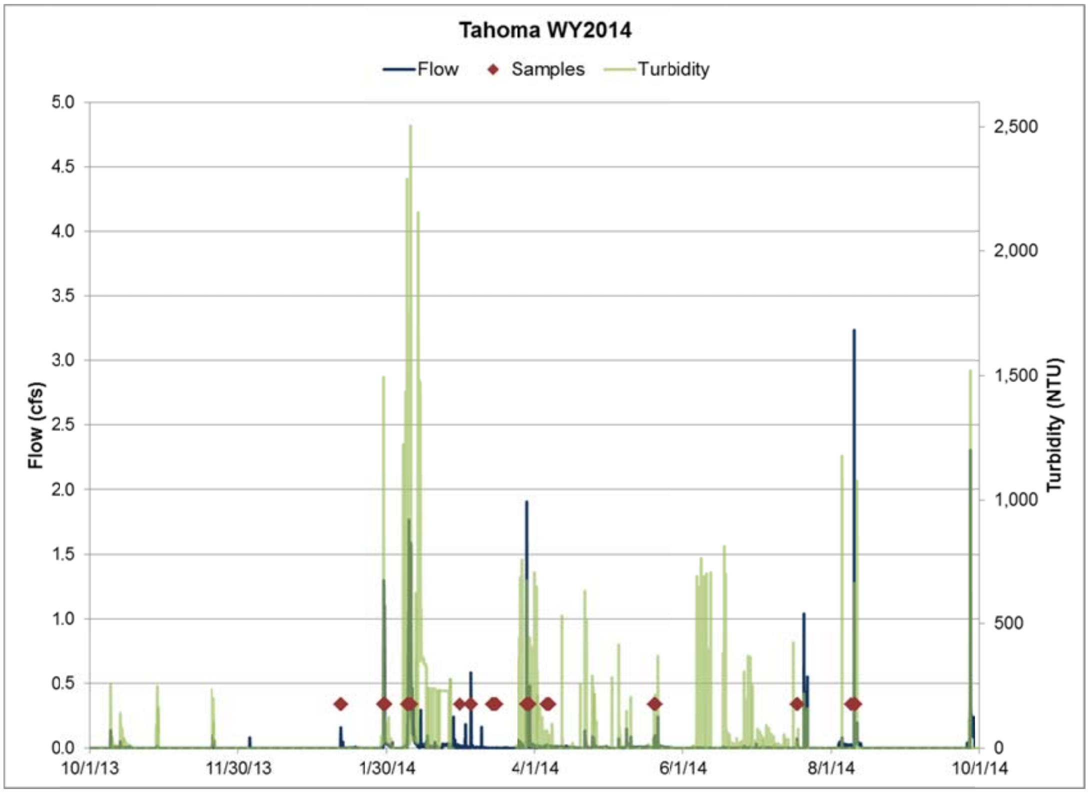


Figure 24a: Continuous hydrology, continuous turbidity, and sampled events at the Tahoma catchment outfall, WY14.

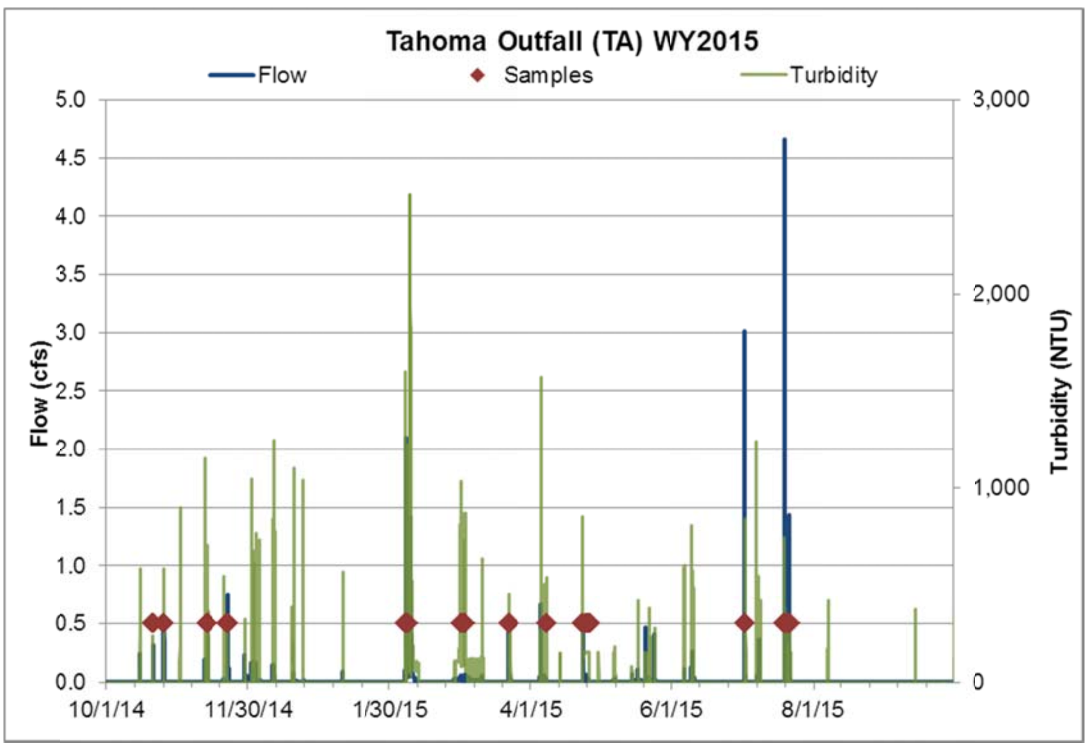


Figure 24b: Continuous hydrology, continuous turbidity, and sampled events at the Tahoma catchment outfall, WY15. Two events were sampled during the large February 6-8, 2015 storm, two events were sampled at the end of April (April 23, 2015 and April 25, 2015), and two events were sampled towards the end of July (July 19, 2015 and July 21, 2015).

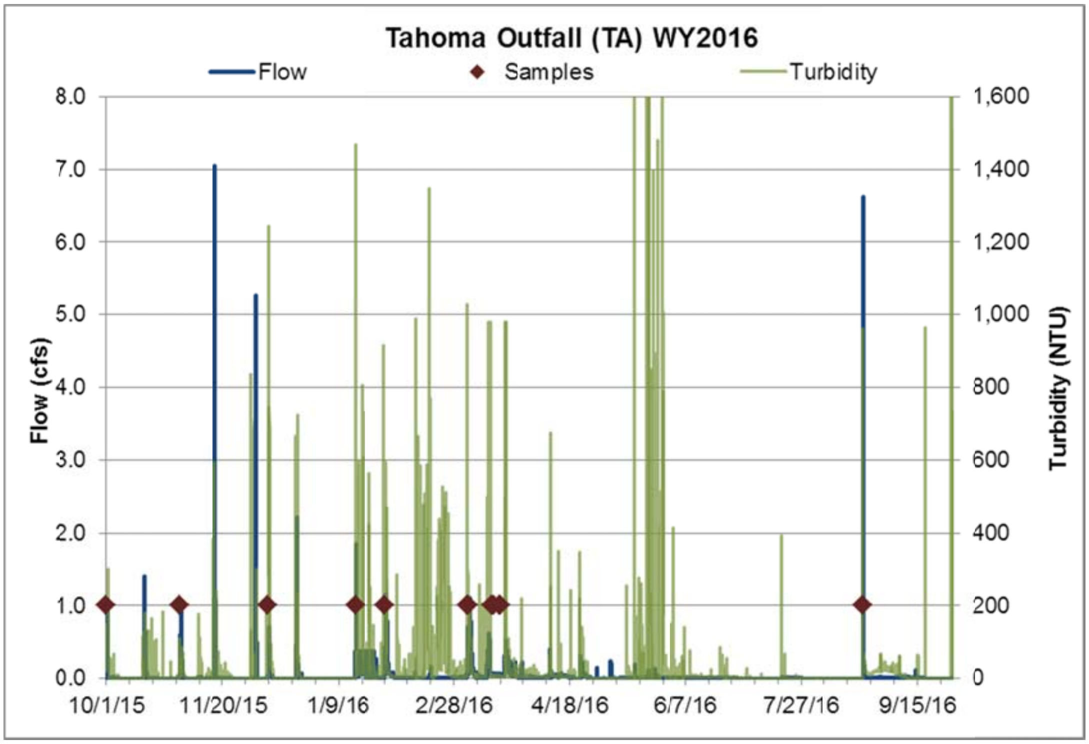


Figure 24c: Continuous hydrology, continuous turbidity, and sampled events at the Tahoma catchment outfall, WY16. Two events were sampled during the large March 3-7, 2016 storm and four events were sampled during the March 15-19, 2016 snowmelt. The maximum range of the turbidity sensor is 1,600NTU, thus this is the maximum range on the graph axis.

Summary data for the eleven events sampled in WY14 are presented in Table 12a. Three precipitation events were sampled during the fall/winter, six during the spring, and two during the summer. In general, only precipitation events greater than 0.3 inches produced sufficient runoff for water quality sampling, though one spring rain on snow event of only 0.05 inches produced sufficient runoff to sample as melting snow increased the total runoff volume. Two snowmelt events were sampled when temperatures rose to the mid-50's (°F) and snowmelt at the Tahoma catchment outfall was sufficient to sample. It is interesting to note that while FSP concentrations were not detectable for both snowmelt events, TN and TP concentrations were generally very high. However, loads for all three pollutants were low for these two events as total runoff volumes were relatively low. The high intensity thunderstorm that began on August 10, 2014 had very high concentrations of all three pollutants, as did the first significant storm of the fall/winter season beginning on January 11, 2014. Though FSP concentrations were about average, the largest FSP loads were produced during the two fall/winter mixed rain and snow events that occurred beginning January 29, 2014 and February 8, 2014 because of the large runoff volumes. These two events also produced the largest loads for TN and TP. The March 29, 2014 and August 10, 2014 events also produced relatively large FSP loads. It is also interesting to note that though summer received significantly more precipitation than the spring did, the runoff volumes were similar. This is likely due to the additional runoff produced by snowmelt in the spring.

Fall/winter events had peak turbidities in the range of 1,500-2,500 NTU usually occurring at the beginning of each runoff event. Spring events had peak turbidities in the range of 400-700 NTU usually occurring in the middle of the storm when the flows were the greatest. The April 6-8, 2014 non-event snowmelt had a very low peak turbidity of about 70 NTU (Appendix H).

Table 12a: Summary data for eleven sampled events at the Tahoma catchment outfall in WY14.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
TA	Fall/Winter	1/11/14 11:30	1/11/14 22:10	10:40	2,048	0.52	rain/snow	75%	383	49	3,762	0.5	1,015	0.1
TA	Fall/Winter	1/29/14 9:10	1/30/14 2:20	17:10	34,160	2.79	rain/snow	100%	120	255	1,408	3.0	318	0.7
TA	Fall/Winter	2/8/14 1:20	2/10/14 4:30	51:10	120,236	9.32	rain/snow	100%	51	381	235	1.8	341	2.6
TA	Spring	3/5/14 22:20	3/6/14 8:40	10:20	5,672	0.05	rain on snow	100%	179	63	793	0.3	984	0.3
TA	Spring	3/14/14 16:00	3/16/14 16:00	48:00	175	na	snowmelt	100%	<1	<0.1	346	<0.1	55	<0.1
TA	Spring	3/29/14 3:00	3/29/14 17:00	14:00	10,630	0.37	rain	100%	170	113	1,510	1.0	942	0.6
TA	Spring	3/30/14 2:40	3/30/14 23:50	21:10	3,735	0.50	snow	70%	188	44	1,554	0.4	1,116	0.3
TA	Spring	4/6/14 7:00	4/8/14 7:00	48:00	2,039	na	snowmelt	100%	<1	<0.1	388	<0.1	87	<0.1
TA	Spring	5/20/14 0:00	5/20/14 21:40	21:40	1,943	0.38	rain	100%	57	7	851	0.1	402	<0.1
TA	Summer	7/17/14 18:40	7/18/14 6:10	11:30	645	0.77	thunderstorm	100%	28	1	2,887	0.1	265	<0.1
TA	Summer	8/10/14 14:50	8/11/14 6:00	15:10	7,086	0.59	thunderstorm	100%	270	120	2,337	1.0	1,769	0.8

Summary data for the fourteen events sampled in WY15 are presented in Table 12b. Six precipitation events were sampled during the fall/winter, five events were sampled during the spring, three of which were snowmelt events and two of which were precipitation events, and three precipitation events were sampled during the summer. In general, only precipitation events greater than 0.5 inches produced sufficient runoff for water quality sampling, though one small fall/winter rain event of 0.27 inches was successfully sampled. The events beginning February 6, 2015 and February 7, 2015 were actually part of the same four day rain event split in two because of a cessation in precipitation the morning of February 7. Similar to Speedboat and Tahoe Valley, concentrations of all three pollutants dropped during the second part of the storm at this site. The first and largest of the three snowmelt events sampled occurred between March 2 and March 4, 2015 after a medium size snow event when temperatures rose to the high 30's and low 40's (°F). The smallest snowmelt event sampled, only 109 cubic feet, occurred on April 8, 2015 after another medium sized snow event when temperatures rose to the low 40's (°F). The third snowmelt event occurred April 25 through April 27, 2015 after a large mixed snow and rain event when temperatures reached the mid 50's (°F). All three snowmelt events produced very low FSP loads. Concentrations were the highest during the summer for all three pollutants, especially during the high intensity thunderstorms that occurred between July 2 and July 3, 2015. TN concentrations were notably higher in the summer than any other season, perhaps due to high summer traffic densities. The thunderstorms that occurred between July 19 and 20, 2015 produced the greatest summer runoff volume and resulted in the largest TN load of the entire year, more than twice the load of the next largest TN load two weeks earlier. The February 6-7, 2015 fall/winter event was the largest precipitation event of the year and had the largest FSP and TP loads due to the large runoff volumes and relatively high EMCs. However, event mean TN concentrations during that event were relatively low and resulted in an average TN load.

The highest peak turbidities occurred in the winter concurrent with peak flows. The force of the very high peak flows during the February 6-7, 2015 event blew the continuous turbidimeter out of position, thus there is no continuous turbidity data and no peak turbidity calculated for this event. The turbidimeter was restored to its permanent position on February 7 for the February 7-8, 2015 event. High peak turbidity also occurred during the first snowmelt event on March 2, 2015 but turbidity tended to come in short pulses and resulted in the lowest event mean FSP concentration and event load of the year. High turbidities generally occurred with peak flows and at the beginning of events (Appendix H).

Table 12b: Summary data for fourteen sampled events at the Tahoma catchment outfall in WY15.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
TA	Fall/Winter	10/20/14 19:50	10/21/14 6:00	10:10	1,005	0.40	236	0.27	rain	100%	40	2	4,390	0.3	495	<0.1
TA	Fall/Winter	10/25/14 12:00	10/25/14 16:10	4:10	1,910	0.55	585	0.51	rain	100%	21	3	1,427	0.2	486	<0.1
TA	Fall/Winter	11/13/14 2:50	11/13/14 13:40	10:50	2,705	0.39	706	0.54	rain	100%	19	3	794	0.1	329	<0.1
TA	Fall/Winter	11/22/14 2:40	11/22/14 18:00	15:20	7,464	0.76	1,728	1.76	rain	100%	43	20	462	0.2	437	0.2
TA	Fall/Winter	2/6/15 14:50	2/7/15 11:00	20:10	21,616	2.10	na	2.22	snow, rain	100%	164	222	309	0.4	970	1.3
TA	Fall/Winter	2/7/15 11:00	2/8/15 6:00	19:00	13,808	0.78	1,221	0.73	rain	90%	29	25	563	0.5	200	0.2
TA	Spring	3/2/15 12:00	3/4/15 12:00	48:00	5,404	0.11	1,033	na	snowmelt	100%	<1	<1	320	0.1	79	<0.1
TA	Spring	3/22/15 18:40	3/23/15 16:40	22:00	3,183	0.51	452	0.52	rain, snow	95%	94	19	1,828	0.4	428	<0.1
TA	Spring	4/8/15 8:20	4/8/15 16:50	8:30	109	0.03	537	na	snowmelt	60%	105	<1	1,731	<0.1	358	<0.1
TA	Spring	4/23/15 21:30	4/24/15 5:20	7:50	2,168	0.46	855	0.51	rain	90%	116	16	719	<0.1	690	<0.1
TA	Spring	4/25/15 7:30	4/27/15 7:30	58:40	2,155	0.06	154	na	snowmelt	100%	54	7	605	<0.1	243	<0.1
TA	Summer	7/2/15 15:20	7/3/15 2:20	11:00	5,131	3.01	839	0.69	thunderstorm	90%	186	60	6,783	2.2	2,029	0.6
TA	Summer	7/19/15 15:00	7/20/15 9:30	18:30	12,699	4.66	745	0.72	rain	100%	149	118	6,411	5.1	1,203	1.0
TA	Summer	7/21/15 13:10	7/22/15 7:20	18:10	4,570	1.44	347	0.48	rain	100%	146	42	2,409	0.7	657	0.2

Summary data for the twelve events sampled in WY16 are presented in Table 12c. Five precipitation events were sampled during the fall/winter, six events were sampled during the spring, four of which were snowmelt events and two of which were precipitation events, and only one event was sampled during the summer due to very little precipitation. Most precipitation events sampled WY16 were greater than one inch. The events beginning March 4, 2016 and March 5, 2016 were actually part of the same three day rain event split in two because of a cessation in precipitation the morning of March 5. Concentrations of all three nutrients were reduced in the second of these two events; loads were also lower despite a bit less than twice the runoff volume. FSP concentrations were the highest during two fall/winter rain on snow events beginning December 9, 2015 and January 29, 2016. FSP loads were the greatest during the second of these two events due to the large runoff volume. FSP concentrations, and therefore loads, were below the detection limit of 1 mg/L for all four snowmelt events. Similarly, TN and TP concentrations and loads were also low for all four snowmelt events. TN and TP concentrations and loads were consistently high during the four rain on snow events from December 9, 2015 through March 5. 2016. FSP concentrations were also below the detection limit for the event beginning November 1, 2015. This is similar to what occurred in the Speedboat catchment for this event. The highest TN and TP concentrations and loads occurred during the thunderstorm beginning August 22, 2016.

The highest peak turbidities occurred in December and January, often concurrent with peak flows. High peak turbidity also occurred during the first spring event on March 4, 2016. High turbidities generally occurred with peak flows and at the beginning of events (Appendix H).

Table 12c: Summary data for twelve sampled events at the Tahoma catchment outfall in WY16.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Peak Precip (in/10 min)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
TA	Fall/Winter	10/1/15 0:00	10/2/15 6:20	30:20	5,169	1.02	301	1.00	0.06	thunderstorm	100%	94	30	649	0.2	1,108	0.4
TA	Fall/Winter	11/1/15 12:10	11/3/15 4:00	39:50	11,434	0.92	110	1.64	0.06	rain, snow	100%	<1	<1	594	0.4	191	0.1
TA	Fall/Winter	12/9/15 13:30	12/11/15 13:00	47:30	12,428	0.71	1,245	0.85	0.04	rain	100%	328	254	1,431	1.1	1,310	1.0
TA	Fall/Winter	1/16/16 5:50	1/17/16 10:00	28:10	18,396	1.85	1,470	2.17	0.04	rain	90%	137	157	1,924	2.2	1,667	1.9
TA	Fall/Winter	1/29/16 0:10	1/30/16 3:50	27:40	32,965	1.16	593	3.47	0.07	rain	100%	295	608	1,238	2.5	768	1.6
TA	Spring	3/4/16 8:30	3/5/16 21:10	36:40	16,643	0.71	1,028	0.98	0.01	rain	100%	270	281	1,013	1.1	852	0.9
TA	Spring	3/5/16 21:30	3/7/16 9:10	35:40	28,483	1.10	199	2.32	0.05	rain/snow	100%	33	58	407	0.7	155	0.3
TA	Spring	3/15/16 0:00	3/16/16 0:00	24:00	4,157	0.08	6	na	na	snowmelt	100%	<1	<1	223	0.1	35	<0.1
TA	Spring	3/16/16 0:00	3/17/16 0:00	24:00	3,985	0.06	11	na	na	snowmelt	100%	<1	<1	209	0.1	37	<0.1
TA	Spring	3/18/16 10:00	3/19/16 10:00	24:00	3,703	0.06	11	na	na	snowmelt	100%	<1	<1	168	<0.1	49	<0.1
TA	Spring	3/19/16 10:00	3/20/16 10:00	24:00	3,417	0.06	7	na	na	snowmelt	100%	<1	<1	226	<0.1	38	<0.1
TA	Summer	8/22/16 15:30	8/22/16 18:00	2:30	17,576	6.63	960	1.22	0.27	thunderstorm	80%	153	167	10,027	11.0	2,868	3.1

6.2.6 Speedboat

The total precipitation for WY15 in the Speedboat catchment was 11.85 inches, more than five and a half inches less than the minimum annual precipitation recorded at the Tahoe City Cross reference station since 1981 (Table 4). Figure 25a shows the average daily flow and cumulative precipitation for WY15. The majority of the precipitation fell in the fall/winter season (6.6 inches). The spring season received 3.23 inches and the summer season received 2.02 inches. A total of 40 discrete precipitation events were measured at the Speedboat meteorological station, 17 in the fall/winter, 12 in the spring, and 11 in the summer. Approximately 48% of the events during WY15 produced less than a tenth of an inch of precipitation, and approximately 85% of the events produced less than half an inch. The largest storm occurred between February 6, 2015 and February 9, 2015, falling as mixed rain and snow and resulted in 3.06 inches of precipitation in the Speedboat catchment. The highest instantaneous peak flows (about 3.2 cfs) occurred during this precipitation event.

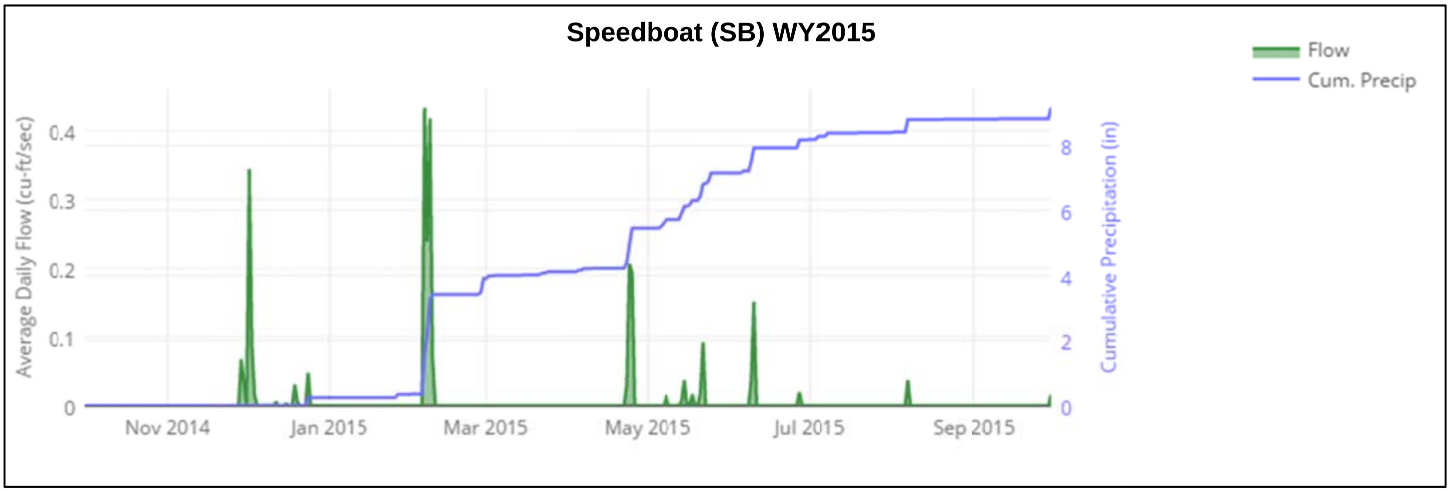


Figure 25a: Average daily flow and cumulative precipitation at the Speedboat catchment outfall, WY15.

The total precipitation for WY16 in the Speedboat catchment was 19.94 inches, within the first quartile of the annual precipitation recorded at the Tahoe City Cross reference station since 1981 (Table 4). Figure 25b shows the average daily flow and cumulative precipitation for WY16. The majority of the precipitation fell in the fall/winter season (12.97 inches). The spring season received 6.69 inches and the summer season received 0.28 inches. A total of 44 discrete precipitation events were measured at the Speedboat meteorological station, 23 in the fall/winter, 18 in the spring, and 3 in the summer. About one-third of the events during WY16 produced less than a tenth of an inch of precipitation, and half of the events produced less than half an inch. The largest storm occurred between December 20, 2015 and December 22, 2015, falling as mixed rain and snow and producing 1.71 inches of precipitation. The highest instantaneous peak flow (4.37 cfs) was experienced during thunderstorm on October 1, 2015.

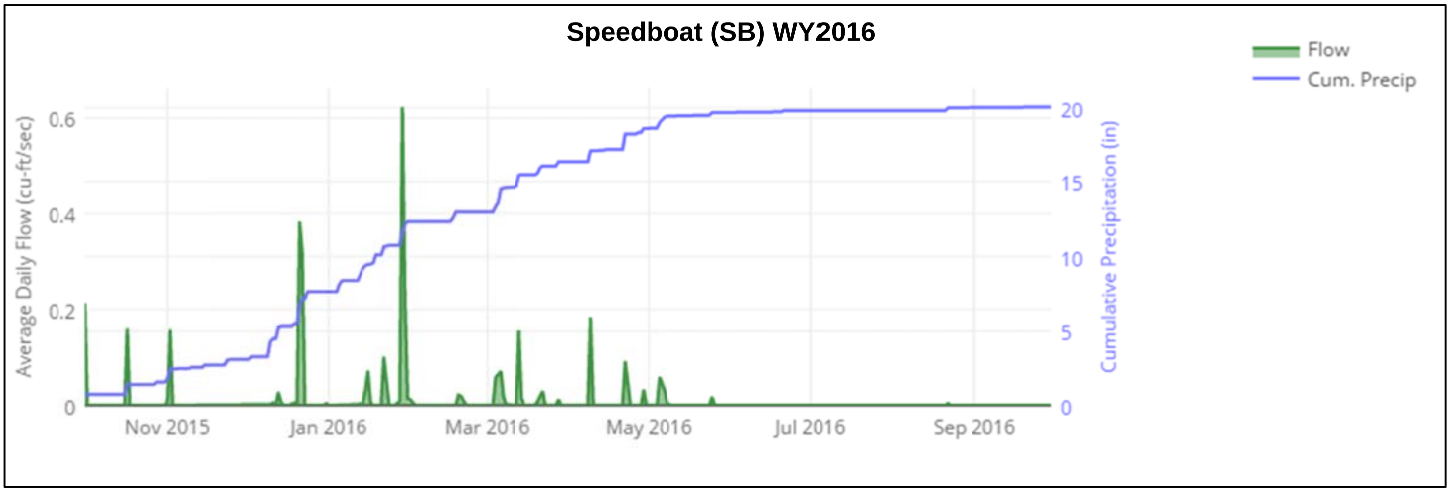


Figure 25b: Average daily flow and cumulative precipitation at the Speedboat catchment outfall, WY16.

Though there were fifteen precipitation events in the Speedboat catchment during WY15 that produced sufficient runoff to sample, water quality samples were taken across the hydrograph during eleven runoff events. Continuous hydrology, continuous turbidity and events sampled during WY15 are presented in Figure 26a. (This site had funding through Proposition 84; hence the number of events sampled was greater than required for regulatory compliance.) The greatest flows in WY15 occurred during the February 6-8, 2015 storm. Turbidimeter readings exceeded the maximum range of the sensor (1600NTU) on six occasions in WY15.

During WY16, fifteen precipitation events in the Speedboat catchment produced sufficient runoff to sample during the fall/winter and spring seasons and water quality samples were taken across the hydrograph during eleven of these runoff events, thereby fulfilling the requisite number of sample events for the fall/winter and spring. Speedboat received enough runoff during one event to capture two grab samples during the summer of WY16 but not enough to sample sufficiently across the hydrograph. This summer thunderstorm was a small event (0.18 inches) that produced only 322 cf of runoff (for reference, minimum flow volume for typical sampling at the Speedboat site is 3,000 cf and event totals greater than 10,000 cf are common). Continuous hydrology, continuous turbidity, and events sampled during WY16 are presented in Figure 26b. (This site had funding through Proposition 84; hence the number of events sampled was greater than required for regulatory compliance.) The largest total volumes occurred during the mixed rain and snow event from January 29, 2016 to January 31, 2016 that produced 1.62 inches of precipitation. Peak precipitation of 0.10 inches in ten minutes occurred during a thunderstorm on October 1, 2015. Turbidimeter readings exceeded the maximum range of the sensor (1600NTU) on eleven occasions in WY16.

Continuous hydrology, continuous turbidity, and water quality samples for the individual events at Speedboat are presented in Appendix I.

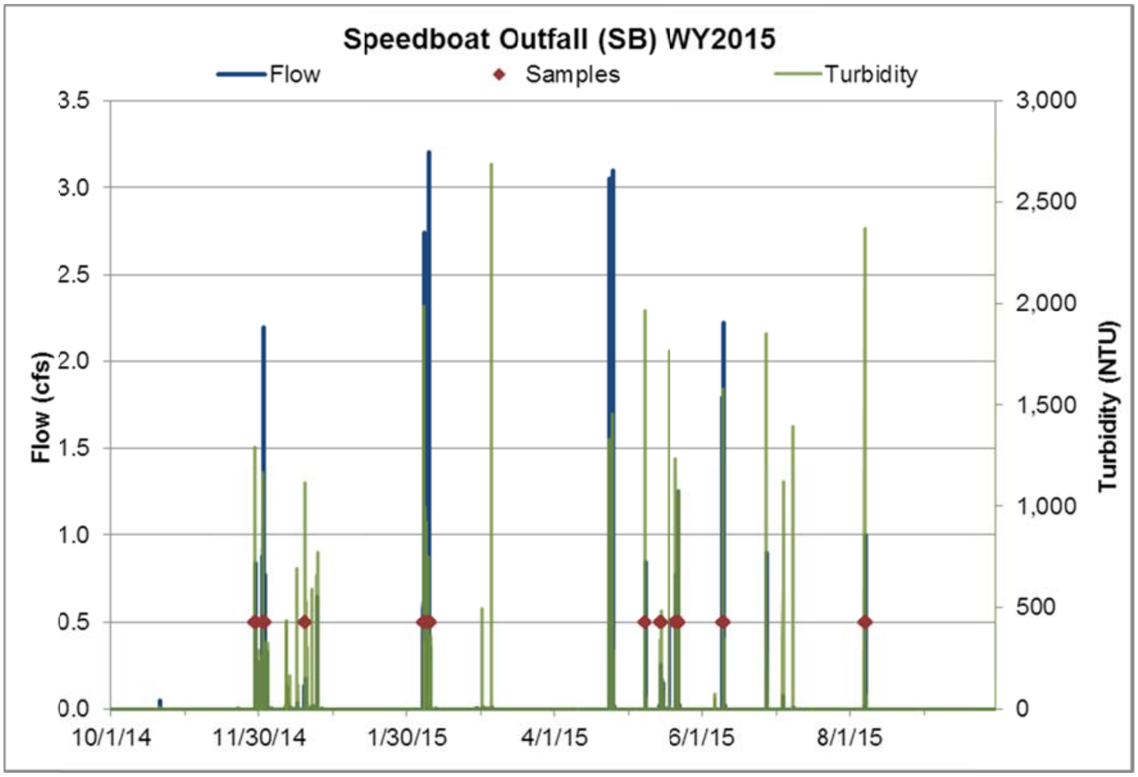


Figure 26a: Continuous hydrology, continuous turbidity, and sampled events at the Speedboat catchment outfall, WY15. Two events were sampled during the large February 6-8, 2015 storm and two events were sampled towards the end of (May 21 and May 22, 2015).

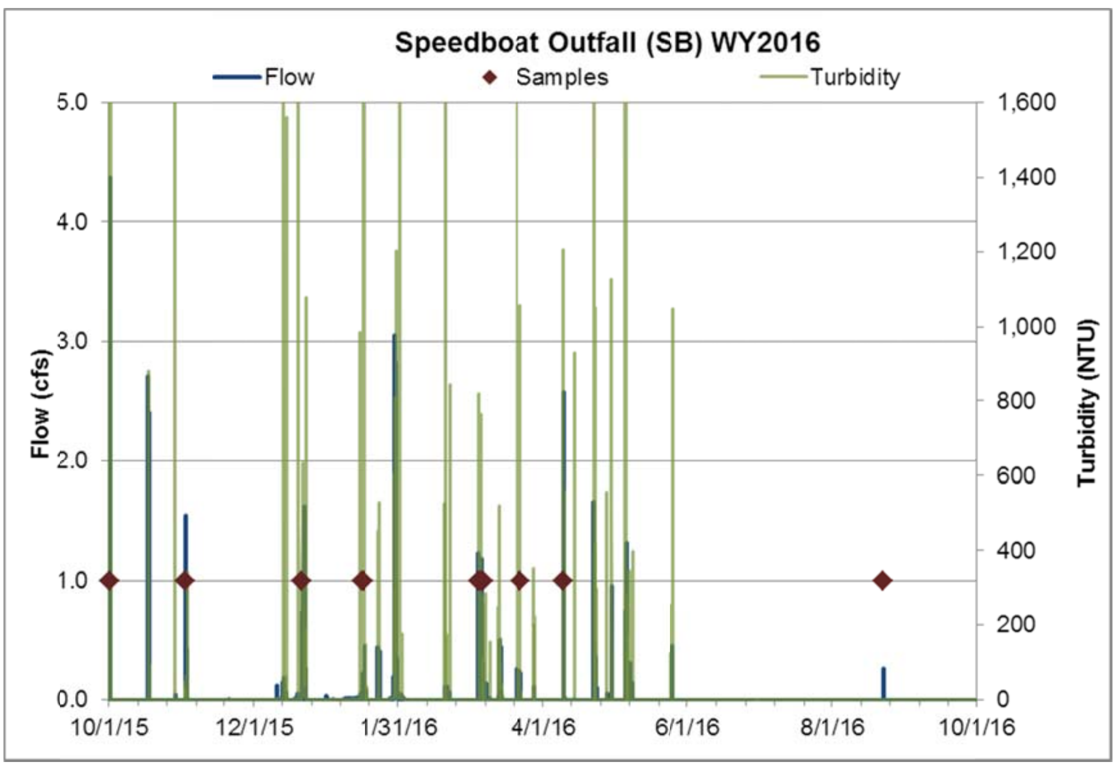


Figure 26b: Continuous hydrology, continuous turbidity, and sampled events at the Speedboat catchment outfall, WY16. Two events were sampled during the January 13-16, 2016 storm and three events were sampled during the large March 3-7, 2016 storm. The maximum range of the turbidity sensor is 1,600NTU, thus this is the maximum range on the graph axis.

Summary data for the eleven events sampled at Speedboat in WY15 are presented in Table 13a. Five precipitation events were sampled during the fall/winter, four events were sampled during the spring, and two precipitation events were sampled during the summer. In general, only precipitation events greater than 0.25 inches produced sufficient runoff for water quality sampling, though one small spring rain event of 0.13 inches was successfully sampled. The two largest events, beginning February 6, 2015 and February 8, 2015 could be interpreted as one combined event with 2.70 inches of rain and a total runoff volume of 89,141 cubic feet, but the event was split in two because of a cessation of flow between the morning of February 7 and the afternoon of February 8. It is interesting to note that the FSP concentration for the first part of this event was 136 mg/L and subsequently dropped to less than 1 mg/L for the second part of the event. The same pattern is evident with FSP load, as well as the concentrations and loads of TN and TP. The first part of this event delivered the greatest loads of all three pollutants the entire year. The thunderstorm of August 7, 2015 had relatively high concentrations of FSP and TP, but very high TN. (The turbidimeter malfunctioned during the August 7, 2015 event, but replaced with turbidity measurements taken on all single autosampler samples across the hydrograph.)

Speedboat has some of the highest peak turbidities of all sites, generally greater than 1,000 NTU. Peak turbidities generally occur at the beginning of each event as roads are being washed clean (Appendix I).

Table 13a: Summary data for eleven sampled events at the Speedboat catchment outfall in WY15.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
SB	Fall/Winter	11/29/14 10:40	11/29/14 15:50	5:10	3,351	0.84	1,294	0.52	rain/snow	85%	62	13	1,555	0.3	493	0.1
SB	Fall/Winter	12/2/14 12:20	12/3/14 17:50	29:30	37,175	2.19	1,167	1.10	rain/snow	90%	30	69	707	1.6	138	0.3
SB	Fall/Winter	12/19/14 12:10	12/20/14 15:30	27:20	2,987	0.18	1,116	0.29	snow	70%	147	27	1,214	0.2	774	0.1
SB	Fall/Winter	2/6/15 15:00	2/7/15 9:30	18:10	47,735	2.74	1,989	1.51	rain	100%	136	405	1,474	4.4	677	2.0
SB	Fall/Winter	2/8/15 12:30	2/9/15 13:50	26:30	41,406	3.20	751	1.19	rain	85%	<1	3	732	1.9	301	0.8
SB	Spring	5/8/15 18:00	5/8/15 20:50	2:50	1,284	0.85	1,966	0.27	rain	75%	236	19	2,825	0.2	1,110	<0.1
SB	Spring	5/14/15 15:00	5/15/15 12:10	0.88	2,660	0.26	481	0.40	rain	100%	29	5	1,097	0.2	231	<0.1
SB	Spring	5/21/15 12:00	5/21/15 14:40	2:40	1,599	0.77	1,238	0.13	rain	95%	137	14	1,759	0.2	542	<0.1
SB	Spring	5/22/15 14:20	5/22/15 22:50	8:30	7,905	1.25	620	0.37	rain	90%	61	30	1,175	0.6	307	0.2
SB	Summer	6/9/15 19:20	6/10/15 8:00	13:10	15,626	2.19	1,579	0.72	thunderstorm	100%	57	56	3,101	3.0	407	0.4
SB	Summer	8/7/15 14:30	8/7/15 18:40	4:10	3,163	1.00	373	0.38	thunderstorm	95%	88	17	4,614	0.9	764	0.2

Summary data for the eleven events sampled at Speedboat in WY16 are presented in Table 13b. Five precipitation events were sampled during the fall/winter, five events were sampled during the spring, and only one event was sampled during the summer due to very little precipitation. In general, only precipitation events greater than 0.35 inches were sampled, though one small fall/winter rain event of 0.09 inches was successfully sampled and the summer thunderstorm was only 0.18 inches. The events beginning March 4, 2016 and March 5, 2016 were actually part of the same three day rain event split in two because of a cessation in precipitation the morning of March 5. The concentrations and loads for all three pollutants were lower during the second of these two events. FSP concentrations were relatively consistent throughout the year, with the exception of the mixed rain and snow event that began November 1, 2015, where FSP concentrations were below the detection limit. This is similar to the Tahoma catchment for this event. FSP loads were the greatest during the December 21, 2015 mixed rain and snow event due to the very large runoff volume. Similar to Tahoma, the highest TN and TP concentrations were measured during the August 22, 2016 thunderstorm, however the runoff volume was low and therefore did not result in a large load. The greatest TN load occurred with the first event of the season on October 1, 2015. In general, TN and TP concentrations were elevated between December and March, similar to Tahoma.

Speedboat had some of the highest peak turbidities of all sites for the second year in a row, often greater than 2,000 NTU for WY16. Peak turbidities generally occur at the beginning of each event as roads are being washed clean (Appendix I).

Table 13b: Summary data for eleven sampled events at the Speedboat catchment outfall in WY16.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Peak Precip (in/10 min)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
SB	Fall/Winter	10/1/15 4:00	10/1/15 17:10	13:10	18,318	4.37	1,711	1.06	0.10	thunderstorm	100%	64	73	5,754	6.6	610	0.7
SB	Fall/Winter	11/1/15 21:10	11/2/15 16:10	19:00	14,100	1.55	64	0.86	0.04	rain, snow	100%	<1	<1	738	0.6	187	0.2
SB	Fall/Winter	12/21/15 6:20	12/23/15 5:40	47:20	60,669	1.61	633	1.71	0.03	rain/snow	100%	117	442	1,173	4.4	601	2.3
SB	Fall/Winter	1/15/16 10:50	1/15/16 21:10	10:20	2,632	0.22	2,121	1.01	0.03	rain	80%	153	25	1,274	0.2	861	0.1
SB	Fall/Winter	1/16/16 8:00	1/16/16 23:40	15:40	6,263	0.45	2,493	0.09	0.03	rain	80%	279	109	1,765	0.7	1,355	0.5
SB	Spring	3/4/16 16:20	3/5/16 2:20	10:00	5,162	1.23	821	0.37	0.04	rain	90%	381	123	2,395	0.8	1,321	0.4
SB	Spring	3/5/16 19:40	3/6/16 1:50	6:10	7,835	1.18	766	0.56	0.04	rain	100%	127	62	837	0.4	518	0.3
SB	Spring	3/6/16 9:40	3/6/16 18:10	8:30	3,583	0.32	258	na	na	snowmelt	90%	153	34	869	0.2	689	0.2
SB	Spring	3/22/16 8:30	3/22/16 17:50	9:20	2,464	0.24	1,058	0.61	0.02	rain/snow	100%	51	8	562	0.1	240	<0.1
SB	Spring	4/9/16 18:00	4/10/16 0:20	6:20	15,637	2.55	1,207	0.76	0.07	rain	75%	306	298	1,617	1.6	847	0.8
SB	Summer	8/22/16 13:10	8/22/16 14:20	1:10	322	0.26	na	0.18	0.09	thunderstorm	80%	234	5	26,200	0.5	4,957	0.1

6.2.7 Tahoe Valley

The total precipitation for WY15 at the Tahoe Valley meteorological station was 17.75 inches, which falls within the first quartile of the annual precipitation recorded at the Tahoe City Cross reference station since 1981 (Table 4). Figure 27a shows the average daily flow and cumulative precipitation for WY15. The majority of the precipitation fell in the fall/winter season (11.06 inches). The spring season received 3.63 inches and the summer season received 3.06 inches. A total of 36 discrete precipitation events were measured at the South Lake Tahoe meteorological station, 16 in the fall/winter, 10 in the spring, and 10 in the summer. Roughly 31% of the events during WY15 produced less than a tenth of an inch of precipitation, and 75% of the events produced less than half an inch. The largest storm occurred between February 6, 2015 and February 9, 2015, falling as mixed rain and snow and resulted in 5.49 inches of precipitation in the Tahoe Valley catchment. The highest instantaneous peak flows (about 5.3 cfs) occurred during this event.

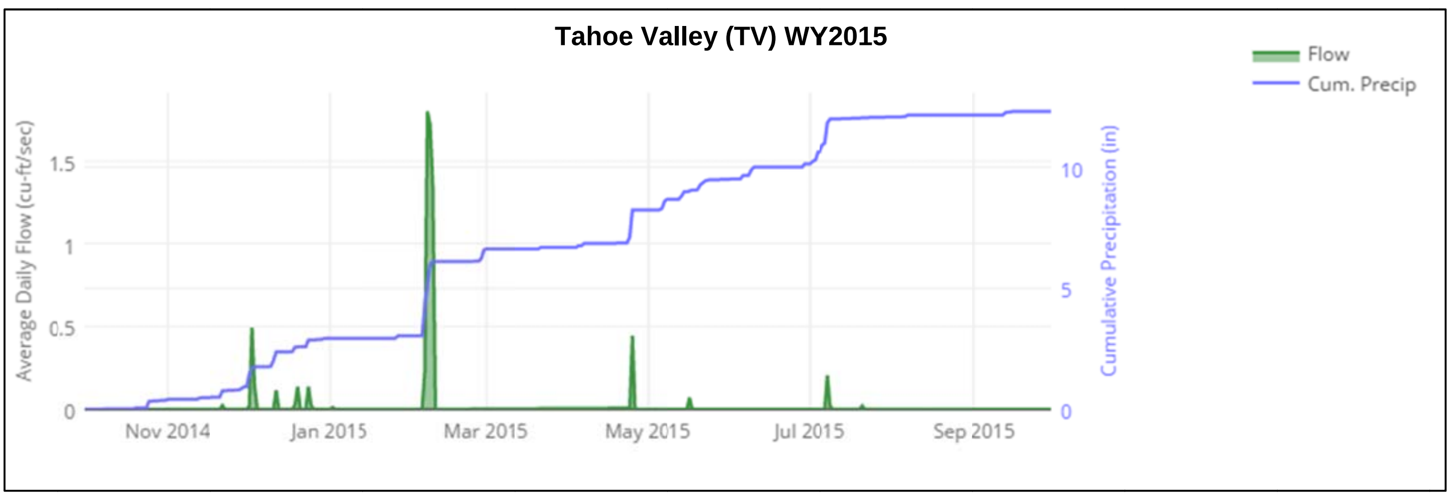


Figure 27a: Average daily flow and cumulative precipitation at the Tahoe Valley catchment outfall, WY15.

The total precipitation for WY16 in the Tahoe Valley catchment was 18.63 inches, within the first quartile of the annual precipitation recorded at the Tahoe City Cross reference station since 1981 (Table 4). Figure 27b shows the average daily flow and cumulative precipitation for WY16. The majority of the precipitation fell in the fall/winter season (10.15 inches). The spring season received 8.40 inches and the summer season received 0.08 inches. A total of 41 discrete precipitation events were measured at the South Lake Tahoe meteorological station, 22 in the fall/winter, 17 in the spring, and 2 in the summer. Approximately one-third of the events during WY16 produced less than a tenth of an inch of precipitation, and more than half of the events produced less than half an inch. The largest storm occurred between March 3, 2016 and March 7, 2016, falling as snow and rain and producing 2.02 inches of precipitation in South Lake Tahoe, which caused the highest observed instantaneous peak flow at Tahoe Valley (6.63 cfs).

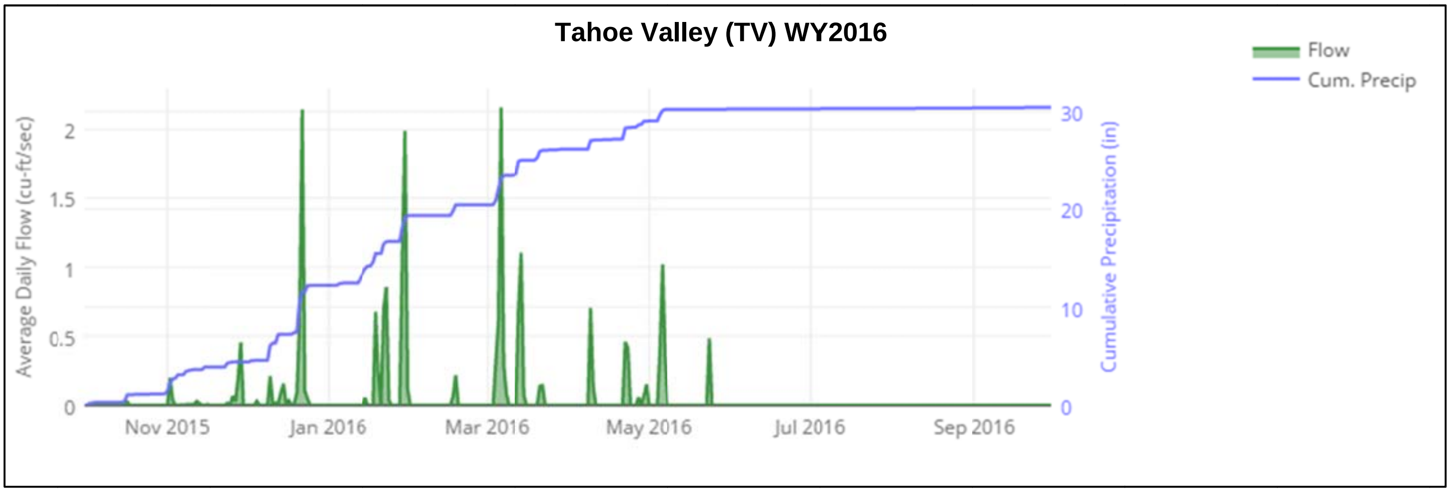


Figure 27b: Average daily flow and cumulative precipitation at the Tahoe Valley catchment outfall, WY16.

Though there were eleven precipitation events in the Tahoe Valley catchment during WY15 that produced sufficient runoff to sample, water quality samples were taken across the hydrograph during seven runoff events. Three of the unsampled events occurred in the fall/winter season after the requisite number of sample events had been met. One spring event was missed due to equipment failure, and the one event during the summer that produced enough runoff to sample was sampled. Continuous hydrology, continuous turbidity and events sampled during WY15 are presented in Figure 28a. (This site had funding through Proposition 84; hence the number of events sampled was greater than required for regulatory compliance.) The greatest flows in WY15 were seen during the largest storm of the year (February 6-8, 2015). Turbidimeter readings exceeded the maximum range of the sensor (1600NTU) during this event.

During WY16, nineteen precipitation events in the Tahoe Valley catchment produced sufficient runoff to sample during the fall/winter and spring seasons and water quality samples were taken across the hydrograph during eleven of these runoff events, thereby fulfilling the requisite number of sample events for fall/winter and spring. The requisite summer runoff event was not captured due to lack of precipitation; no storms produced sufficient runoff to sample (the summer total was only 0.08 inches), Continuous hydrology, continuous turbidity, and events sampled during WY16 are presented in Figure 28b. (This site had funding through Proposition 84; hence the number of events sampled was greater than required for regulatory compliance.) The largest total volumes occurred during the large rain event from October 3, 2015 to October 4, 2015 which produced 2.02 inches of precipitation and the annual peak precipitation of 0.14 inches in ten minutes. Turbidimeter readings exceeded the maximum range of the sensor (1600NTU) on two occasions in WY16.

Continuous hydrology, continuous turbidity, and water quality samples for the individual events at Tahoe Valley are presented in Appendix J.

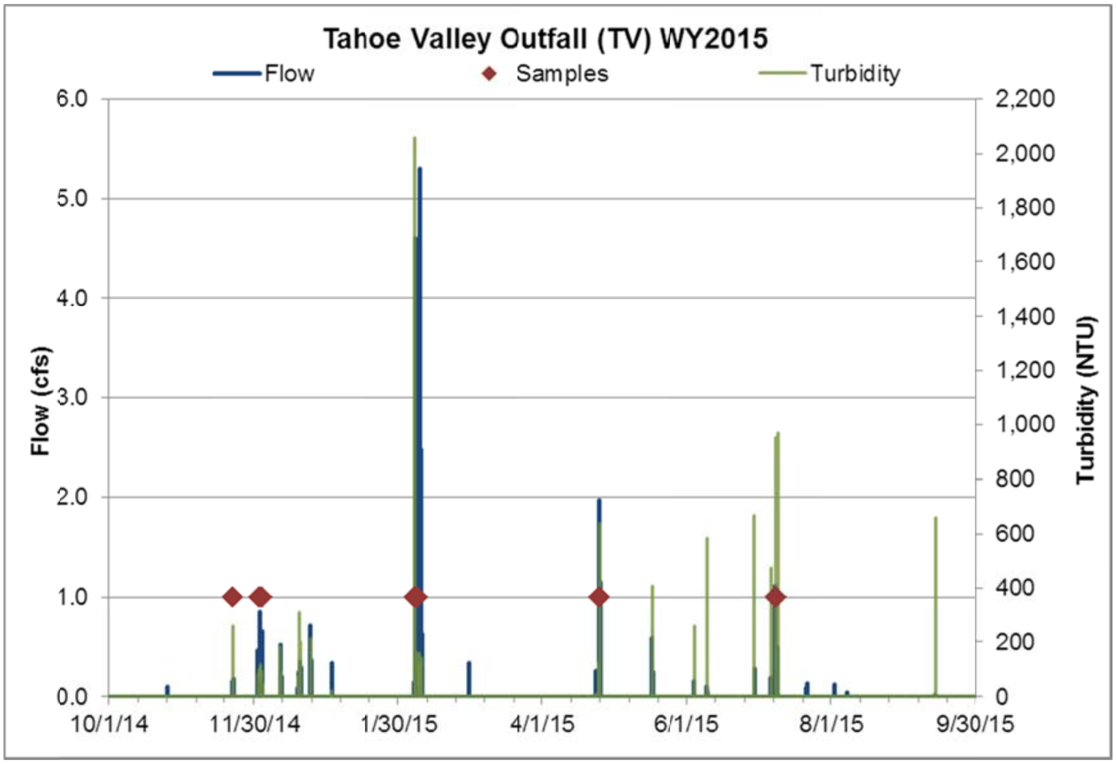


Figure 28a: Continuous hydrology, continuous turbidity, and sampled events at the Tahoe Valley catchment outfall, WY15. Two events were sampled during the large February 6-8, 2015 storm and two events were sampled at the beginning of December (December 3 and December 4, 2015).

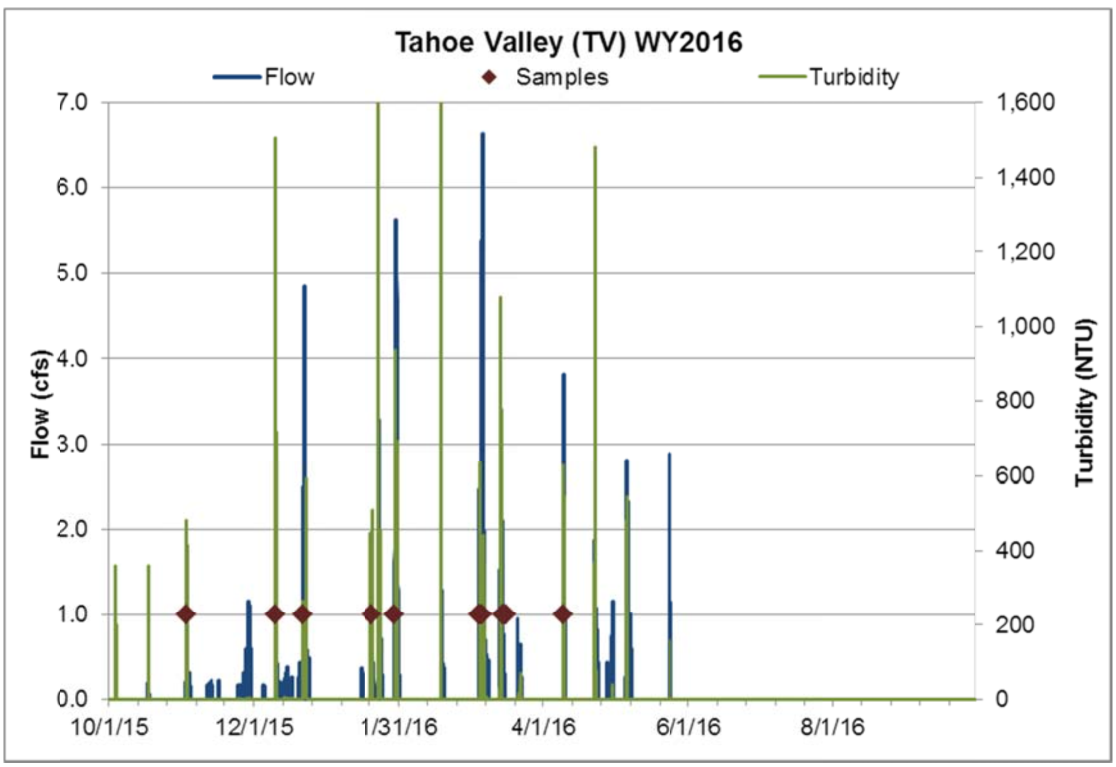


Figure 28b: Continuous hydrology, continuous turbidity, and sampled events at the Tahoe Valley catchment outfall, WY16. Two events were sampled during the large March 3-7, 2016 storm and three events were sampled during the March 14-16, 2016 snowmelt. The maximum range of the turbidity sensor is 1,600NTU, thus this is the maximum range on the graph axis.

Summary data for the seven events sampled at Tahoe Valley in WY15 are presented in Table 14a. Five precipitation events were sampled during the fall/winter, one event in the spring, and one event in the summer. This site only flows during very large precipitation events of at least 0.8 inches but generally greater than one inch. The 0.18 inch precipitation event that began on December 4, 2014 was actually a continuation of the event that began on December 3, 2014 but was split in two because of the significant decrease in flow between 2:40 and 6:00 on December 4. Similarly, the very large event that began on February 6, 2015 and ended on February 8, 2015 was split in two. With 3.71 inches of rain and a cumulative 203,753 cubic feet of runoff, the February event was nearly ten times greater than the next two largest events. The first half of this event resulted in average concentrations but largest loads of all three pollutants all year while the second half of the event had concentrations of less than 1 mg/L of FSP and the lowest TN and TP concentrations of the year. It is interesting to note that, with the exception of the first runoff event of the year (November 2014), the largest event of the year (February 2015), and a very large thunderstorm (July 2015), FSP concentrations at this site were consistently below 1 mg/L and loads were correspondingly low. Concentrations and loads of TN and TP are within the same range as the other sites. Though the Tahoe Valley catchment has relatively high density development with a significant amount of commercial and industrial areas, low pollutant concentrations may be the result of extensive water quality improvements implemented in this catchment in the last 25+ years (see section 2.7 for description). Data collected in future years may elucidate other reasons for the low concentrations. The greatest peak turbidity occurred at the beginning of the February 6, 2015 event. Peak turbidities are generally concurrent with peak flows at this site (Appendix J).

Table 14a: Summary data for seven sampled events at the Tahoe Valley catchment outfall in WY15.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
TV	Fall/Winter	11/22/14 6:30	11/22/14 12:40	6:10	1,975	0.18	259	0.85	rain	95%	84	10	1,235	0.2	545	<0.1
TV	Fall/Winter	12/3/14 9:50	12/4/14 2:40	16:50	23,891	0.86	119	1.19	rain	85%	<1	1	685	1.0	269	0.4
TV	Fall/Winter	12/4/14 6:00	12/4/14 14:00	8:00	9,691	0.66	93	0.18	rain	100%	<1	<1	885	0.5	199	0.1
TV	Fall/Winter	2/6/15 17:00	2/7/15 13:00	20:30	99,321	4.61	2,058	2.87	rain	100%	83	517	1,185	7.3	291	1.8
TV	Fall/Winter	2/7/15 13:00	2/8/15 9:50	20:50	104,432	3.80	124	0.84	rain	90%	<1	7	613	4.0	181	1.2
TV	Spring	4/25/15 9:10	4/25/15 21:20	12:10	36,010	1.97	636	1.13	rain	100%	<1	2	1,331	3.0	233	0.5
TV	Summer	7/8/15 11:20	7/9/15 6:10	18:50	18,058	1.11	956	1.36	thunderstorm	100%	143	161	2,976	3.4	664	0.7

Summary data for the eleven events sampled at Tahoe Valley in WY16 are presented in Table 14b. Five precipitation events were sampled during the fall/winter, and six events in the spring, three of which were snowmelt events and three of which were rain on snow events. No events were sampled in the summer due to very little precipitation. Similar to WY15 findings, this site only flows during very large precipitation events, generally greater than one inch. However, the 0.46 inch precipitation event that began March 4, 2016 was a rain on snow event and therefore melting snow augmented the runoff volume attributable to the rain. The event that began March 5, 2016 was actually a continuation of the event that began on March 4, but was split in two because of the significant decrease in flow between 13:50 and 18:50 on March 5. The largest runoff volumes occurred during two rain on snow events in the fall/winter beginning December 21, 2015 and January 29, 2015. Runoff volumes exceeded 200,000 cubic feet during both these events; this is greater than the total annual flow volume at all sites except Speedboat and Tahoma. Fortunately, much like WY15, FSP concentrations are relatively low, but flow volumes were very large in WY16 and therefore resulted in sizable FSP loads. Relatively low FSP concentrations in such a large, highly urbanized catchment are unexpected. The highest FSP concentrations occurred during the December 10, 2015 mixed rain and snow event. All three snowmelt events had very low FSP concentrations and loads, and relatively TN and TP concentrations and loads. The highest TN and TP concentrations occurred during the December 10, 2015 and March 4, 2016 events, but the largest TN and TP loads occurred during the December 21, 2015 and January 29, 2016 events when flow volumes were greatest. The highest peak turbidity occurred at the beginning of the December 10, 2015 event. Peak turbidities are generally concurrent with peak flows at this site (Appendix J).

Table 14b: Summary data for eleven sampled events at the Tahoe Valley catchment outfall in WY16.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Peak Precip (in/10 min)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
TV	Fall/Winter	11/2/15 7:00	11/2/15 23:00	16:00	17,124	1.13	481	1.13	0.09	rain, snow	90%	35	37	975	1.0	262	0.3
TV	Fall/Winter	12/10/15 5:40	12/10/15 15:00	9:20	18,235	1.66	1,506	1.73	0.11	rain, snow	100%	122	139	1,385	1.6	660	0.8
TV	Fall/Winter	12/21/15 14:30	12/23/15 6:50	40:20	280,487	4.86	266	4.19	0.21	snow, rain	100%	27	468	762	13.3	223	3.9
TV	Fall/Winter	1/19/16 9:40	1/20/16 8:30	22:50	70,389	1.94	508	1.28	0.26	snow, rain	85%	78	343	850	3.7	402	1.8
TV	Fall/Winter	1/29/16 9:10	1/31/16 9:50	48:40	276,229	5.62	938	2.66	0.10	rain, snow	100%	70	1,198	744	12.8	337	5.8
TV	Spring	3/4/16 16:20	3/5/16 13:50	21:30	50,191	2.47	635	0.46	0.04	rain	100%	88	276	1,145	3.6	461	1.4
TV	Spring	3/5/16 18:50	3/7/16 11:00	40:10	232,198	6.63	440	2.31	0.18	rain	100%	53	772	750	10.9	316	4.6
TV	Spring	3/14/16 9:10	3/15/16 9:10	24:00	45,076	1.01	4	na	na	snowmelt	100%	<1	<1	598	1.7	114	0.3
TV	Spring	3/15/16 9:10	3/16/16 9:10	24:00	5,527	0.12	1	na	na	snowmelt	100%	8	3	880	0.3	76	<0.1
TV	Spring	3/16/16 9:10	3/17/16 9:10	24:00	2,106	0.05	1	na	na	snowmelt	100%	3	<1	867	0.1	69	<0.1
TV	Spring	4/9/16 11:40	4/10/16 7:40	20:00	72,224	3.82	630	0.93	0.12	rain	100%	84	379	1,127	5.1	336	1.5

6.2.8 Upper Truckee

The total precipitation for WY15 at the Upper Truckee meteorological station was 17.75 inches, which falls within the first quartile of the annual precipitation recorded at the Tahoe City Cross reference station since 1981 (Table 4). Figure 29a shows the average daily flow and cumulative precipitation for WY15. The majority of the precipitation fell in the fall/winter season (11.06 inches). The spring season received 3.63 inches and the summer season received 3.06 inches. A total of 36 discrete precipitation events were measured at the South Lake Tahoe meteorological station, 16 in the fall/winter, 10 in the spring, and 10 in the summer. Roughly 31% of the events during WY15 produced less than a tenth of an inch of precipitation, and 75% of the events produced less than half an inch. The largest storm occurred between February 6, 2015 and February 9, 2015, falling as mixed rain and snow and resulted in 5.49 inches of precipitation in the Upper Truckee catchment. However, the highest instantaneous peak flows (about 3.3 cfs) occurred during a high intensity thunderstorm on July 8, 2015.

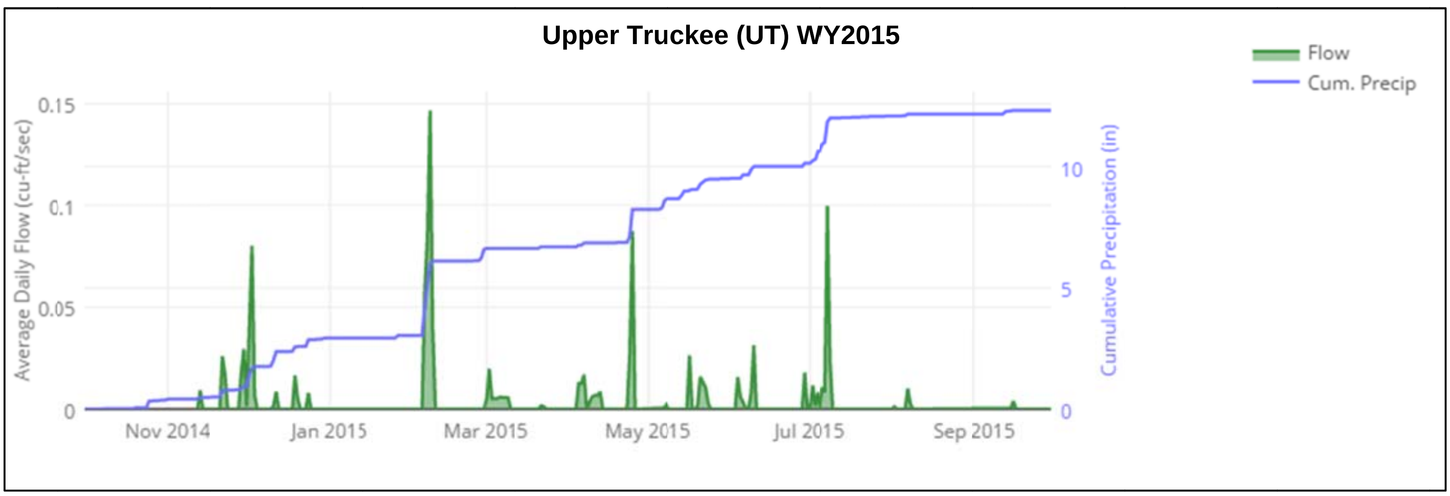


Figure 29a: Average daily flow and cumulative precipitation at the Upper Truckee catchment outfall, WY15.

The total precipitation for WY16 in the Upper Truckee catchment was 18.63 inches, approximately one inch more than the minimum annual precipitation recorded at the Tahoe City Cross reference station since 1981 (Table 4). Figure 29b shows the average daily flow and cumulative precipitation for WY16. The majority of the precipitation fell in the fall/winter season (10.15 inches). The spring season received 8.40 inches and the summer season received 0.08 inches. A total of 41 discrete precipitation events were measured at the South Lake Tahoe meteorological station, 22 in the fall/winter, 17 in the spring, and 2 in the summer. Approximately one-third of the events during WY16 produced less than a tenth of an inch of precipitation, and more than half of the events produced less than half an inch. The largest storm occurred between March 3, 2016 and March 7, 2016, falling as snow and rain and producing 2.02 inches of precipitation in South Lake Tahoe. The highest instantaneous peak flow (1.61 cfs) was experienced during a rain event on October 3, 2015.

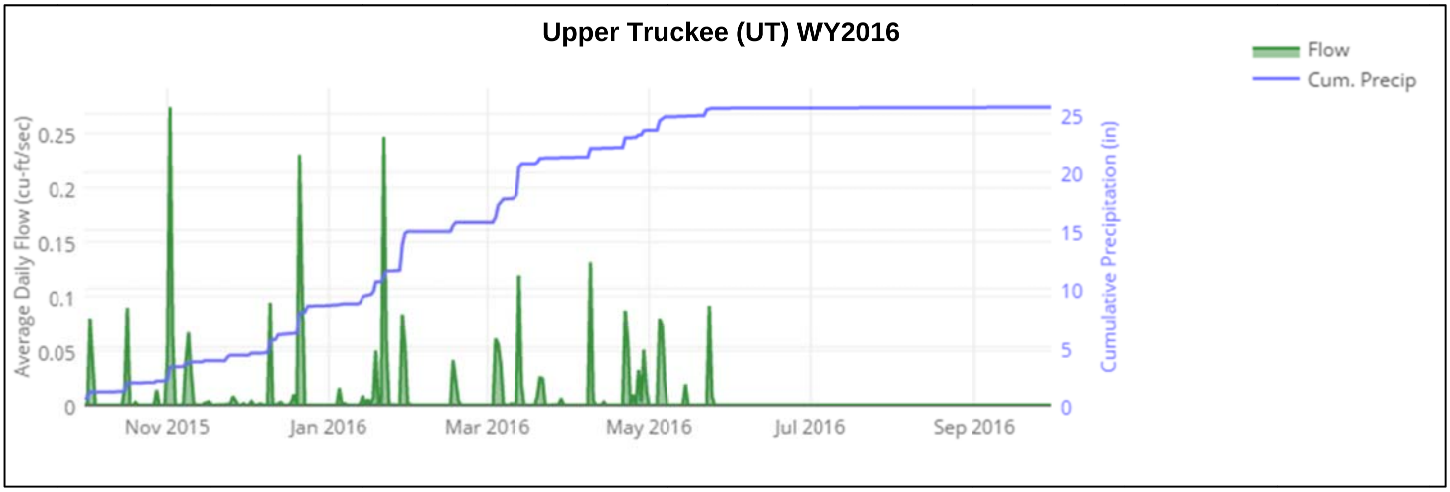


Figure 29b: Average daily flow and cumulative precipitation at the Upper Truckee catchment outfall, WY16.

During WY15, though there were fifteen precipitation events in the Upper Truckee catchment that produced sufficient runoff to sample; water quality samples were taken across the hydrograph during nine runoff events. However, despite the many thunderstorms that occurred during the summer season, only one thunderstorm on July 8, 2015 produced enough runoff to sample and unfortunately the station experienced a power failure during that time that prevented sampling. Fortunately, the requisite number of sampled events was reached during the fall/winter and spring seasons. Continuous hydrology, continuous turbidity and events sampled during WY15 are presented in Figure 30a. (This site had funding through Proposition 84; hence the number of events sampled was greater than required for regulatory compliance.) The highest turbidities in WY15 were seen on Dec 24, 2014, but the storm did not produce enough runoff to sample. The greatest flows in WY15 were seen during the thunderstorm that occurred on July 8, 2015 as the peak precipitation reached 0.32 inches in ten minutes. As previously mentioned, the July 8, 2015 thunderstorm event was not sampled due to equipment failure.

During WY16, nineteen precipitation events in the Upper Truckee catchment produced sufficient runoff to sample during the fall/winter and spring seasons and water quality samples were taken across the hydrograph during eight of these runoff events, thereby fulfilling the requisite number of sample events for fall/winter and spring. The requisite summer runoff event was not captured due to lack of precipitation; no storms produced sufficient runoff to sample (the summer total was only 0.08 inches), Continuous hydrology, continuous turbidity, and events sampled during WY16 are presented in Figure 30b. The largest total volumes occurred during the large rain and snow event from November 1, 2015 to November 3, 2015 which produced 1.25 inches of precipitation. Peak precipitation of 0.14 inches in ten minutes occurred during the October 3, 2015 to October 4, 2015 rain storm event. Runoff at this site often has high turbidities, and peak turbidities exceeded the turbidimeter range of 1600NTU on nine different occasions during WY16.

Continuous hydrology, continuous turbidity, and water quality samples for the individual events at Upper Truckee are presented in Appendix K.

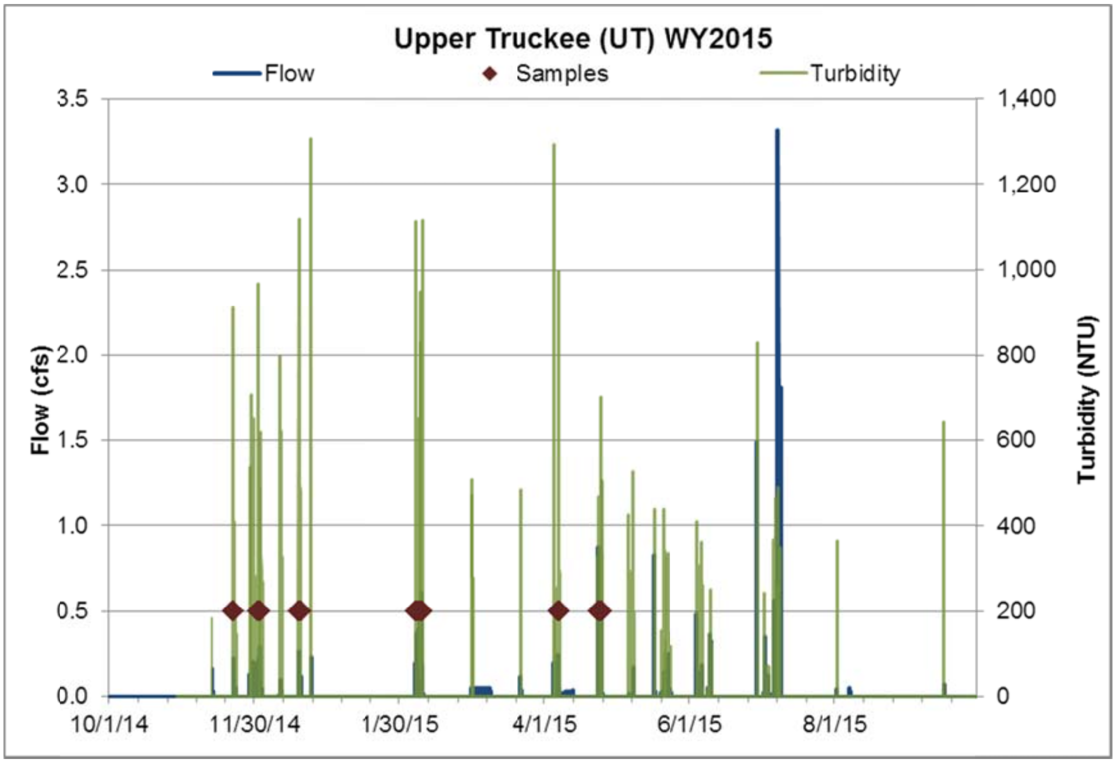


Figure 30a: Continuous hydrology, continuous turbidity, and sampled events at the Upper Truckee catchment outfall, WY15. Three events were sampled during the large February 6-8, 2015 storm and two events were sampled towards the end of April (April 23 and April 25, 2015).

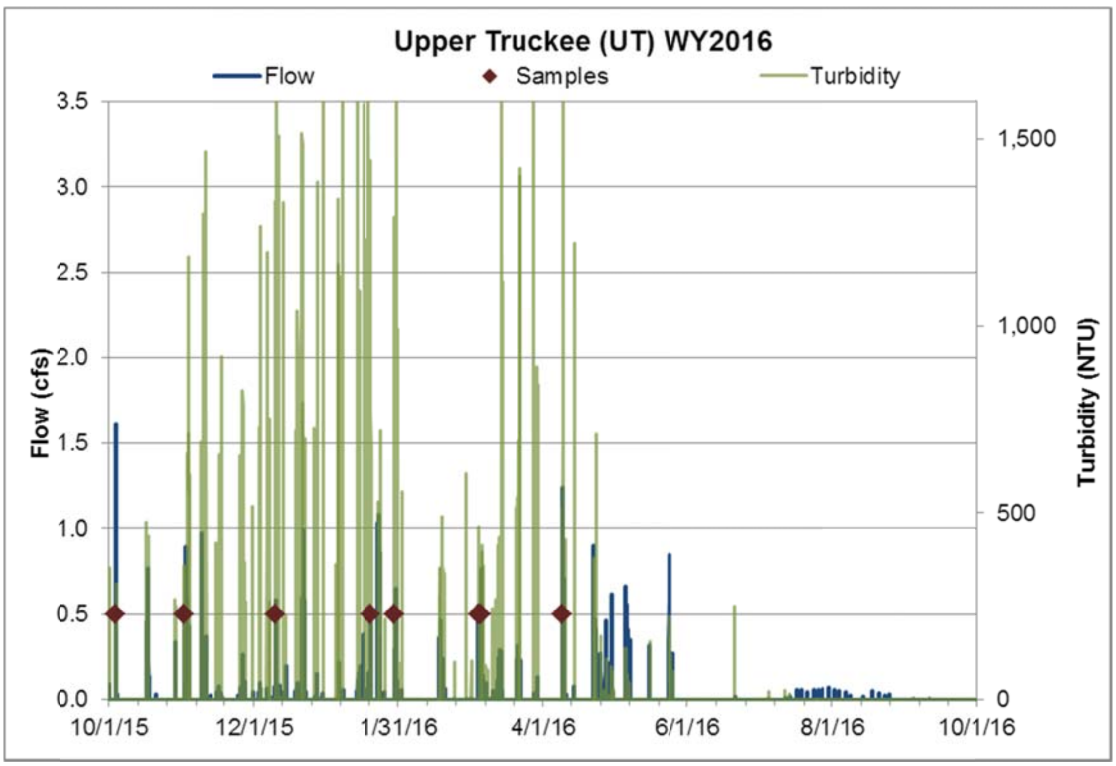


Figure 30b: Continuous hydrology, continuous turbidity, and sampled events at the Upper Truckee catchment outfall, WY16. Two events were sampled during the large March 3-7, 2016 storm. Summer runoff is dry weather discharge. The maximum range of the turbidity sensor is 1,600NTU, thus this is the maximum range on the graph axis.

Summary data for the nine events sampled at Upper Truckee in WY15 are presented in Table 15a. Six precipitation events were sampled during the fall/winter and three events were sampled in the spring. No events were sampled at this site during the summer due to numerous small events that of themselves did not produce sufficient runoff for successful sampling, and equipment failure during the one event that produced enough runoff to sample. Upper Truckee will produce low flows with small amounts of precipitation; however it generally produces sufficient runoff to sample only during moderately sized precipitation events of about 0.4 inches. A portion of the runoff that occurred in the first two events of April was likely due to melting of the accumulated snowpack and is not attributable exclusively to the precipitation that fell during that period. The December 19, 2015 event had higher FSP concentrations and relatively high nutrient concentrations but a small runoff volume resulted in average loads of all three pollutants. Like Speedboat, Tahoma, and Tahoe Valley, the large February event was split. At Upper Truckee it was split into three events due to significant drops in flow on the mornings of February 7 and 8. Unlike Speedboat, Tahoma, and Tahoe Valley, the latter portion of the event did not see greatly reduced concentrations of all three pollutants. In fact, the last sampling event in the series, beginning February 8, had concentrations of all three pollutants on par with the first sampling event in the series. Not surprisingly, since the last event in the series had the greatest flow, it delivered the largest loads of all pollutants. Concentrations of TN and TP were highest during the April 7-8 event but loading was small as the runoff volume was small. High peak turbidities were about 1,110 NTU during three fall/winter events and occurred at the beginning of each event (Appendix K).

Table 15a: Summary data for nine sampled events at the Upper Truckee catchment outfall in WY15.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
UT	Fall/Winter	11/22/14 5:20	11/22/14 13:50	8:30	2,594	0.22	259	0.85	rain	60%	354	57	1,349	0.2	1,001	0.2
UT	Fall/Winter	12/2/14 12:40	12/3/14 16:20	27:40	9,689	0.29	967	1.37	rain/snow	80%	195	116	1,749	1.0	858	0.5
UT	Fall/Winter	12/19/14 11:40	12/20/14 12:10	24:30	2,062	0.26	1,117	0.45	rain/snow	100%	709	91	3,449	0.4	1,999	0.3
UT	Fall/Winter	2/6/15 15:10	2/7/15 8:10	17:00	6,712	0.37	1,113	2.87	rain	85%	268	112	1,856	0.8	844	0.4
UT	Fall/Winter	2/7/15 11:40	2/8/15 3:00	15:20	5,749	0.40	651	0.84	rain	100%	137	49	1,772	0.6	538	0.2
UT	Fall/Winter	2/8/15 9:00	2/9/15 12:30	27:30	15,708	0.61	1,114	1.78	rain	100%	163	160	1,428	1.4	560	0.5
UT	Spring	4/7/15 11:30	4/8/15 6:40	19:10	1,697	0.24	997	0.09	snow	95%	470	50	5,877	0.6	2,067	0.2
UT	Spring	4/23/15 11:10	4/24/15 5:50	18:30	2,413	0.88	468	0.25	rain	80%	94	14	3,885	0.6	863	0.1
UT	Spring	4/25/15 2:30	4/25/15 17:50	15:20	7,106	0.45	701	1.13	rain	95%	270	120	2,580	1.1	860	0.4

Summary data for the eight events sampled at Upper Truckee in WY16 are presented in Table 15b. Five precipitation events were sampled during the fall/winter and three events were sampled in the spring. No events were sampled during the summer due very little precipitation. Though Upper Truckee produces low flows with small amounts of precipitation most events sampled in WY16 were events greater than one inch. Compared to Speedboat, Tahoma, and Tahoe Valley, flow volumes at this site are relatively low, but pollutant loads can be high due to high pollutant concentrations. The highest concentrations of FSP occurred during the January 19, 2016 event. However, the largest FSP loads occurred during the April 9, 2016 event when high peak turbidities and a relatively high flow volume combined to result in high loads. Much like Tahoma and Speedboat, the highest concentrations of TN occurred with the first rain event of the season on October 3, 2016. However, TP concentrations were highest during the December 10, 2015 and January 19, 2016 events; TN concentrations were high during these events as well. TN and TP loads were greatest during the November 1, 2015 event when flow volumes were the greatest. Upper Truckee measured some of the highest peak turbidities around the lake in WY16, often greater than 2000 NTU. Peak turbidities at Upper Truckee are generally concurrent with peak flows (Appendix K).

Table 15b: Summary data for eight sampled events at the Upper Truckee catchment outfall in WY16.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Peak Precip (in/10 min)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
UT	Fall/Winter	10/3/15 21:40	10/4/15 2:10	4:30	9,248	1.61	308	0.28	0.09	rain	80%	127	73	4,716	2.7	639	0.4
UT	Fall/Winter	11/1/15 13:30	11/3/15 6:10	40:40	28,736	0.89	659	1.13	0.09	rain, snow	100%	169	303	2,474	4.4	783	1.4
UT	Fall/Winter	12/10/15 4:20	12/10/15 10:00	5:40	7,750	0.58	1,332	1.73	0.11	rain, snow	100%	609	295	2,528	1.2	2,423	1.2
UT	Fall/Winter	1/19/16 9:10	1/19/16 13:50	4:40	4,341	0.53	1,442	1.28	0.26	rain	100%	1,011	274	3,046	0.8	2,874	0.8
UT	Fall/Winter	1/29/16 12:20	1/30/16 4:10	15:50	11,785	0.65	2,124	2.66	0.10	rain	100%	386	284	1,613	1.2	1,179	0.9
UT	Spring	3/4/16 15:10	3/4/16 23:00	7:50	5,288	0.55	463	0.43	0.04	rain	100%	588	194	2,564	0.8	1,960	0.6
UT	Spring	3/5/16 18:40	3/6/16 1:30	6:50	7,231	0.77	393	1.81	0.18	rain	90%	336	152	1,323	0.6	999	0.5
UT	Spring	4/9/16 4:50	4/9/16 19:20	14:30	11,357	1.24	2,296	0.93	0.17	rain	100%	584	414	2,839	2.0	1,528	1.1

7. BMP Effectiveness Monitoring

7.1 Pasadena

The cartridge filters currently installed in the Contech Stormfilter vaults at Pasadena had treated no flow at the beginning of WY14 monitoring (see Section 2.1 for details), so the filters were functioning at optimal levels at the beginning of this study. To date, maintenance of the system includes only vactoring of the pre-treatment chambers in the spring and fall of WY14 and WY15.

WY14 data suggests that the Stormfilter at Pasadena had a variable ability to reduce FSP, TN, and TP during runoff events. Though Table 16a suggests that the Stormfilter was about 58% effective in reducing FSP in the winter and 33% efficient overall for the year, data shows increases in loads in the spring (123%) and summer (41%). Load increases of over 100% in the spring may be due to sediment accumulation in the Stormfilter chamber from fall/winter events that was flushed out during a spring event. Therefore, it may be beneficial to perform annual maintenance in the early spring to ensure that accumulated fall/winter pollutants are not released to the lake. The Stormfilter is not designed to reduce runoff volumes.

WY15 data suggests that the Stormfilter at Pasadena has a somewhat less variable but diminished ability to reduce FSP, TN, and TP when compared with WY14. Table 16b shows that the Stormfilter was relatively consistent in annual and seasonal FSP load reductions (reductions of 23%, 16%, 20%, and 21% for fall/winter, spring, summer, and annual respectively). Additionally, unlike WY14, sediments were not flushed from the vaults in the spring and summer. The pre-treatment chambers upstream of the cartridge filters were vactored out at the end of WY14 and in the spring of WY15 and the WY15 fall/winter volume was about one third the WY14 fall/winter volume; therefore, it is possible that there was less accumulated sediment available to flush out in the spring and summer of WY15. Additionally, Table 16b shows that on an average annual basis the Stormfilter was more effective at reducing TN than TP, but in general annual reductions of all three pollutants were similar in WY15. The increase in TN load during the fall/winter may have been the result of flushing accumulated pollutants stored in the vault from previous events. The reduced pollutant removal efficiency in WY15 compared to WY14 may indicate a need to replace the cartridge filters in this vault.

WY16 data suggests that, in general, the Stormfilter at Pasadena had an increased ability to reduce FSP and TP, but a diminished ability to reduce TN compared to WY15. Table 16c shows that the Stormfilter was relatively consistent in annual and seasonal FSP load reductions (reductions of 35%, 20%, and 28% for fall/winter, spring, and annual respectively; no flow occurred in the summer). Similar to WY15, sediments were not flushed from the vaults in the spring as they were in the spring and summer of WY14. Table 16c also shows that the Stormfilter was relatively consistent in annual and seasonal TN load reductions (reductions of 6%, 10%, and 7% for fall/winter, spring, and annual respectively; no flow occurred in the summer) and in annual and seasonal TP load reductions (reductions of 31%, 33%, and 32% for fall/winter, spring, and annual respectively; no flow occurred in the summer). Unlike WY14 and WY15, the Stormfilter was more effective at reducing TP loads than TN loads in WY16. In general, the Stormfilter at Pasadena will reduce sediments and nutrients by approximately one third. The WY16 data seem to indicate that the vaults reduced runoff volumes more significantly than in previous years. Since the vaults are not designed to reduce volume, this either means that one of the flow sensors was a bit off (the inflow reading too high or the outflow reading too low) or that, because there were more events in WY16, more flow remained trapped in the vaults after events and evaporated, or leaked out through cracks in the system.

Table 16a: Summary statistics for volume and load reductions at the Pasadena Stormfilter in WY14.

Water Year 2014 Oct. 1, 2013 - Sep. 30, 2014			Seasonal Volumes (cf)			Total Annual Runoff Volume (cf)	Seasonal FSP Load (lbs)			Total Annual FSP Load (lbs)	Seasonal TN load (lbs)			Total Annual TN load (lbs)	Seasonal TP load (lbs)			Total Annual TP load (lbs)
Catchment (Site) Name	Station Name	Station Acronym	Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Seasonal TN load (lbs)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)	
Pasadena	Pasadena In	PI	99,687	9,943	25,424	135,054	530	22	128	680	6.4	na	5.3	11.8	3.0	na	3.5	6.5
	Pasadena Out	PO	99,382	9,301	24,478	133,161	225	49	180	454	4.6	na	3.1	7.7	2.9	na	2.4	5.2
Volume or Load Reduction			305	642	946	1,893	305	-27	-52	226	1.8	na	2.2	4.1	0.1	na	1.1	1.3
% Change			na	na	na	na	-58%	123%	41%	-33%	-28%	na	-42%	-34%	-5%	na	-32%	-19%

Table 16b: Summary statistics for volume and load reductions at the Pasadena Stormfilter in WY15.

Water Year 2015 Oct. 1, 2014 - Sep. 30, 2015			Seasonal Volumes (cf)			Total Annual Runoff Volume (cf)	Seasonal FSP Load (lbs)			Total Annual FSP Load (lbs)	Seasonal TN load (lbs)			Total Annual TN load (lbs)	Seasonal TP load (lbs)			Total Annual TP load (lbs)
Catchment (Site) Name	Station Name	Station Acronym	Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)	
Pasadena	Pasadena In	PI	31,797	2,931	16,402	51,130	95	8	161	265	1.6	0.2	5.3	7.1	1.0	<0.1	1.6	2.7
	Pasadena Out	PO	30,276	2,739	15,887	48,902	73	7	129	209	2.1	0.1	3.0	5.3	0.9	<0.1	1.4	2.3
Volume or Load Reduction			1,521	192	515	2,228	22	1	32	56	-0.5	<0.1	2.3	1.8	0.1	<0.1	0.3	0.4
% Change			na	na	na	na	-23%	-16%	-20%	-21%	32%	-13%	-43%	-25%	-12%	-2%	-17%	-15%

Table 16c: Summary statistics for volume and load reductions at the Pasadena Stormfilter in WY16.

Water Year 2016 Oct. 1, 2015 - Sep. 30, 2016			Seasonal Volumes (cf)			Total Annual Runoff Volume (cf)	Seasonal FSP Load (lbs)			Total Annual FSP Load (lbs)	Seasonal TN load (lbs)			Total Annual TN load (lbs)	Seasonal TP load (lbs)			Total Annual TP load (lbs)
Catchment (Site) Name	Station Name	Station Acronym	Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)	
Pasadena	Pasadena In	PI	33,847	23,853	0	57,700	113	93	0	206	5.7	1.8	0	7.5	1.5	1.1	0	2.5
	Pasadena Out	PO	27,038	18,063	0	45,101	74	74	0	148	5.4	1.6	0	7.0	1.0	0.7	0	1.7
Volume or Load Reduction			6,809	5,790	0	12,599	39	19	0	58	0.3	0.2	0	0.5	0.5	0.4	0	0.8
% Change			na	na	na	na	-35%	-20%	0%	-28%	-6%	-10%	0%	-7%	-31%	-33%	0%	-32%

Table 17a compares the efficiency of the Stormfilter at reducing concentrations and loads of all three pollutants for the individual events sampled in WY14. The event that began January 29, 2014 constituted 8% of the total flow, but showed increases greater than 70% in both FSP EMCs and event loads. The January 29th storm also saw about a one third increase in TN, and a small increase in TP. Since this was the first large event of the season, smaller previous events may have filled the Stormfilter chamber with turbid water that got flushed out during this event. This is supported by FSP concentrations that were higher at the outflow for all samples that were used to calculate the EMC (i.e. first flush sample, and rising and falling limb composites, see Table A2a, Appendix A). The City of South Lake Tahoe believes that the increase in turbidity could also be the result of filter replacement that occurred September 30, 2013. Since this time, the filters have not been cleaned or replaced, and maintenance activities have been limited to vactoring the pre-treatment chambers upstream of the cartridge filters in the spring and fall. Further investigation of filter effectiveness is warranted to validate this assumption and will be determined with continued water quality data collection. The event that began February 8, 2014 accounted for 68% of the total runoff volume but showed no improvement in FSP. This event showed reasonable reductions in TN, but only nominal reductions in TP. The event that began July 18, 2014 had reasonable reductions for all pollutants, but only comprised 0.2% of the total annual flow. The July 20, 2014 event showed nominal reductions for all pollutants and only accounted for 1% of the total annual flow.

Table 17b compares the efficiency of the Stormfilter at reducing concentrations and loads of all three pollutants for the individual events sampled in WY15. The event that began February 6, 2015 showed nominal reductions in FSP and TP concentrations and loads, and a very large increase in TN concentration and load. The event that began February 8, 2015 is a continuation of the February 6 event and showed less than 20% reductions in concentrations and loads of all three pollutants (with the exception of a 22% reduction in FSP load). This is noteworthy as the combined event constituted 45% of the annual flow measured at Pasadena and could indicate a need to change the filters prior to the beginning of each water year. The April 25, 2015 event showed variable removal efficiency of all three pollutants. Increases in concentrations of FSP and TP during this event may have been due to allowable margins of error in laboratory analysis. Calculated load reductions in these two pollutants, despite concentration increases, are due to smaller effluent volumes than influent volumes (as a result of some volume retention in the Stormfilter). The greatest removal efficiency for FSP and TN occurred with the summer thunderstorm on July 8, 2015 when concentrations of all three pollutants were at their highest.

Table 17c compares the efficiency of the Stormfilter at reducing concentrations and loads of all three pollutants for the individual events sampled in WY16. The October 3, 2015 event shows increases in concentrations of all three pollutants at the outflow, particularly FSP. This may be due to flushing of accumulated sediment in the unmaintained vault after a summer of very little precipitation. Though TN and TP loads showed nominal reductions during this event (due to a smaller effluent than influent volume; up to about 2,000 cubic feet of runoff tends to remain in the large chambers) the FSP load increased by 336%. The December 10, 2015 event showed nominal reductions in FSP and TP concentrations and loads, and a slight increase in TN concentrations and loads possibly due to flushing or system bypass. The March 4, 2016 event shows decent reductions of about 30% for FSP and TP concentrations and loads but an increase in TN concentrations and loads, again possibly due to flushing of previously accumulated nitrogen or system bypass. The March 5, 2016 and April 9, 2016 events both showed nominal FSP and TP reductions and a slight increase in TN concentrations. TN load also increased slightly during the March 5 event, but decreased during the April 9 event due to volume retention in the vault. In general, the pollutant removal efficiency of the Stormfilter vault at Pasadena was impaired in WY16 indicating a need for maintenance. Average annual changes for FSP concentrations and loads were 96% and 47% respectively, indicating a large contribution of sediment from the vault. Average annual changes for TN concentrations and loads were 105% and 80% respectively, also indicating a large contribution of nitrogen from the vault. Average annual changes for TP concentrations and loads were -11% and -27%, indicating that phosphorus was the only pollutant successfully reduced by the Stormfilter in WY16.

Table 17a: Efficiency summary for the Pasadena Stormfilter in WY14. Increases in concentrations and loads for all pollutants during the January 29, 2014 storm may have been due to flushing from previous events or filter maintenance prior to the event.

Event Start Date	Event Volume as a % of Total Annual Volume (cf)	FSP Concentration (mg/L)			FSP Load (lbs)			TN Concentration (ug/L)			TN Load (lbs)			TP Concentration (ug/L)			TP Load (lbs)		
		in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change
1/29/14	8%	64	110	72%	40.4	69.2	72%	1884	2583	37%	1.189	1.624	37%	873	980	12%	0.551	0.616	12%
2/8/14	68%	46	46	1%	257.0	259.8	1%	939	544	-42%	5.302	3.090	-42%	440	404	-8%	2.483	2.294	-8%
7/18/14	0.2%	534	207	-61%	9.3	3.2	-66%	9837	3627	-63%	0.172	0.055	-68%	3615	1497	-59%	0.063	0.023	-64%
7/20/14	1%	262	250	-5%	27.3	25.7	-6%	2269	1799	-21%	0.237	0.185	-22%	1960	1567	-20%	0.204	0.161	-21%

Table 17b: Efficiency summary for the Pasadena Stormfilter in WY15. Increases in concentrations for FSP and TP during the April 25, 2015 event may have been due to allowable margins of error in laboratory analysis. The large increase in TN concentrations and loads during the February 6, 2015 event may have been due to flushing from previous events.

Event Start Date	Event Volume as a % of Total Annual Volume (cf)	FSP Concentration (mg/L)			FSP Load (lbs)			TN Concentration (ug/L)			TN Load (lbs)			TP Concentration (ug/L)			TP Load (lbs)		
		in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change
2/6/15	20%	62	57	-7%	39.9	35.9	-10%	889	1,690	90%	0.574	1.058	84%	611	589	-4%	0.395	0.369	-7%
2/8/15	25%	43	35	-18%	34.6	27.2	-22%	736	649	-12%	0.591	0.497	-16%	419	369	-12%	0.336	0.282	-16%
4/25/15	7%	46	51	12%	9.7	7.5	-22%	939	873	-7%	0.200	0.129	-35%	438	458	5%	0.093	0.068	-27%
7/8/15	20%	157	112	-29%	98.4	71.2	-28%	5,174	3,031	-41%	3.237	1.924	-41%	1598	1367	-14%	1.000	0.868	-13%

Table 17c: Efficiency summary for the Pasadena Stormfilter in WY16.

Event Start Date	Event Volume as a % of Total Annual Volume (cf)	FSP Concentration (mg/L)			FSP Load (lbs)			TN Concentration (ug/L)			TN Load (lbs)			TP Concentration (ug/L)			TP Load (lbs)		
		in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change
10/3/15	14%	9	58	530%	1.7	7.6	336%	2,990	3,800	27%	0.567	0.499	-12%	1,344	1,478	10%	0.255	0.194	-24%
12/10/15	17%	69	67	-2%	15.6	14.6	-6%	2,460	2,850	16%	0.560	0.623	11%	161	141	-12%	0.037	0.031	-16%
3/4/16	15%	150	104	-31%	30.3	19.9	-34%	228	1,293	467%	0.046	0.246	436%	1,011	692	-32%	0.204	0.132	-35%
3/5/16	69%	124	109	-12%	115.4	100.3	-13%	1,303	1,395	7%	1.213	1.283	6%	648	573	-12%	0.604	0.527	-13%
4/9/16	26%	102	97	-5%	35.4	18.7	-47%	1,530	1,658	8%	0.529	0.320	-40%	715	650	-9%	0.247	0.125	-49%

The discrepancy between Tables 16a/b/c and 17a/b/c with respect to FSP are due to how the average seasonal and annual concentrations and loads are calculated. Since continuous turbidimeter data is available from both the inflow and outflow stations at Pasadena, seasonal and annual loads and average concentrations in Tables 16a/b/c were calculated using equations relating turbidity to FSP. Values in Tables 17a/b/c show event mean FSP concentrations calculated using results from water quality samples submitted to the analytical laboratory for PSD analysis and loads calculated from those concentrations. Both of these methods have limitations. Despite numerous comparisons to lab analyzed turbidity at the same date and time, the turbidimeter is not always accurate and could over or underestimate loads. In addition, though converting turbidity to FSP using universal equations has been shown to yield reasonable results, this method will likely introduce some error as turbidity to FSP relationships tend to show some site specificity. Calculating average seasonal and annual concentrations and loads from just a few events sampled can also introduce error as events can vary significantly in pollutant concentrations and loads and therefore average concentrations and loads will depend on which events were successfully sampled. (Average seasonal and annual concentrations and loads for TN and TP in Tables 16a/b/c are necessarily calculated from events sampled, so the alignment between the numbers in Tables 16a/b/c and the numbers from individual sampled events in Tables 17a/b/c is good.)

7.2 Rubicon

There has been no outflow from the Stormtech chambers at Rubicon recorded at RO in either WY14 or WY15. All runoff volumes measured at RI have been infiltrated by the Stormtech chambers thus far. This indicates 100% efficiency of the Stormtech chambers in reducing FSP, TN, and TP. This site was retired after WY15.

7.3 SR431

Data collected from matched inflow and outflow sampling at the Contech MFS stormwater cartridge filter vault and at the Jellyfish stormwater cartridge filter vault at SR431 during WY14 show relatively effective but variable removal of sediment and nutrients. Table 18a presents the summary data on removal efficiency for each vault in WY14. These data suggest that both vaults removed similar amounts of FSP (52-55%), TN (33-31%) and TP (51-54%) on an annual basis, with less variability observed in seasonal load reductions during summer storms. Table 18b presents the summary data on removal efficiency for WY15. The data suggest that the vaults were not equally as efficient at removing pollutants as they were in WY14. The pollutant removal efficiency of Contech MFS dropped a bit on an average annual basis; from 55% to 35% for FSP, from 33% to 18% for TN, and from 54% to 34% of TP in WY14 and WY15 respectively. However, the removal efficiency of the Jellyfish diminished more drastically. In fact, on an average annual basis it released FSP and TN (from a 52% reduction to 3% increase in FSP and from a 31% reduction to a 3% increase in TN for WY14 and WY15 respectively). Its ability to remove TP dropped from 51% to 24% on an average annual basis. The Jellyfish was cleaned September 23, 2015, shortly before the beginning of WY16. Table 18c presents the summary data on removal efficiency for each vault in WY16. The data suggest that, similar to WY15, the vaults did not remove equivalent amounts of pollutants as observed in WY14. While the Contech MFS remained relatively consistent with WY15 in its removal efficiency of all three pollutants, the Jellyfish becomes clogged with sediment more easily and therefore shows variable removal efficiencies across seasons and water years. Limited maintenance in WY16 created conditions in which the Jellyfish was not performing optimally. Sediment accumulation observed on the flow and turbidity sensors of the Jellyfish may have affected data recorded for this site during WY16.

Note that the both vaults show volume reductions in outflow relative to inflow during each season, especially during the fall/winter and spring seasons. In the absence of bypass flows, which were not observed, the inflow and outflow volumes should match. However, due to the size of the vaults, especially the Contech MFS, some runoff gets trapped in the vault following a runoff event and slowly evaporates or potentially leaks out through cracks in the system rather than flowing out.

In WY14 there were problems with maintaining stage transducers and turbidity sensors during fall/winter and spring runoff seasons due to extensive sediment accumulation in the conveyance lines and flume units. To help solve this problem, riser pipes were installed in the diverter vault in late summer of 2014 to retain coarse sediments prior to discharge into conveyance lines that lead into the monitoring flumes and cartridge filter vaults. This has resulted in much less sensor fouling and improved data collection.

Event efficiency results for both vaults are shown in Tables 19a/b/c and 20a/b/c. Though Table 18b shows an increase in FSP loads during the fall/winter and summer seasons from the Jellyfish, Table 20b indicates FSP load reductions for every fall/winter and all but one summer event. This is because values in Table 18b are calculated from continuous turbidity and account for all flow that passed through the monitoring station the whole year. Values in Table 20b are calculated from samples taken during events and analyzed for PSD. Even though each event sampled may have shown a decrease in FSP load from the Jellyfish, it does not mean there was a decrease in load from the Jellyfish during all flow not sampled.

The Desert Research Institute (DRI) submitted a summary report of the efficiency study they conducted on these vaults during WY14 and WY15 to the Nevada Department of Transportation and the Nevada Division of Environmental Protection (NDEP) in December 2015. A full analysis of cartridge filter vault efficiencies and comparison of the two different types can be found in DRI et al 2015.

Up until sediment accumulation in both vaults in mid-May 2016 lead to a cessation in monitoring because sensors were buried, the Contech MFS and Jellyfish vaults were fairly efficient at reducing concentrations and loads of all three pollutants in WY16. This system has been maintained intermittently throughout the three year monitoring period, generally once in the fall and once in the spring. In October 2016 the whole system was cleaned, right in time for WY17 monitoring to begin. The two cartridge filters show very little difference in their ability to reduce concentrations (and therefore loads) of all three pollutants. Tables 19c and 20c indicate that though reductions are variable for different events, there were very few instances where concentrations or loads increased. Like the Pasadena Stormfilter, TN appears to flush out of this system more readily than FSP or TP, as evidenced by the October 1, 2016 event. Average annual percent change for FSP concentrations and loads were -50% and -56% respectively for the Contech MFS and -48% and -48% respectively for the Jellyfish, indicating that both vaults reduced FSP by about half. Average annual percent change for TN concentrations and loads were -12% and -24% respectively for the Contech MFS and -18% and -17% respectively for the Jellyfish. Average annual percent change for TP concentrations and loads were -24% and -34% respectively for the Contech MFS and -25% and -25% respectively for the Jellyfish, indicating that both vaults were more effective at reducing TP than TN.

Table 18a: Summary statistics for volume and load reductions at the SR431 Contech MFS and Jellyfish vaults in WY14.

Water Year 2014 Oct. 1, 2013 - Sep. 30, 2014			Seasonal Volumes (cf)			Total Annual Runoff Volume (cf)	Seasonal FSP Load (lbs)			Total Annual FSP Load (lbs)	Seasonal TN load (lbs)			Total Annual TN load (lbs)	Seasonal TP load (lbs)			Total Annual TP load (lbs)
Catchment (Site) Name	Station Name	Station Acronym	Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)	
SR431	Contech In	CI	4,024	6,372	7,561	17,957	68	171	55	293	0.5	0.9	1.0	2.4	0.2	0.5	0.2	0.8
	Contech Out	CO	3,003	4,007	6,575	13,584	34	59	38	131	0.3	0.4	0.9	1.6	0.1	0.2	0.1	0.4
Volume or Load Reduction			1,021	2,365	986	4,373	34	112	17	162	0.2	0.5	0.1	0.8	0.1	0.3	<0.1	0.5
% Change			-25%	-37%	-13%	-24%	-50%	-65%	-31%	-55%	-40%	58%	7%	-33%	-53%	-67%	-24%	-54%
SR431	Jellyfish In	JI	3,022	4,837	8,377	16,236	83	131	54	268	0.4	0.8	1.1	2.3	0.2	0.4	0.2	0.8
	Jellyfish Out	JO	3,320	4,695	8,122	16,136	23	67	38	128	0.2	0.4	0.9	1.6	0.1	0.2	0.2	0.4
Volume or Load Reduction			-298	142	255	100	61	63	16	140	0.1	0.4	0.2	0.7	0.1	0.2	<0.1	0.4
% Change			na	na	na	na	-73%	-48%	-30%	-52%	37%	-50%	15%	-31%	-69%	-55%	-29%	-51%

Table 18b: Summary statistics for volume and load reductions at the SR431 Contech MFS and Jellyfish vaults in WY15.

Water Year 2015 Oct. 1, 2014 - Sep. 30, 2015			Seasonal Volumes (cf)			Total Annual Runoff Volume (cf)	Seasonal FSP Load (lbs)			Total Annual FSP Load (lbs)	Seasonal TN load (lbs)			Total Annual TN load (lbs)	Seasonal TP load (lbs)			Total Annual TP load (lbs)
Catchment (Site) Name	Station Name	Station Acronym	Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)	
SR431	Contech In	CI	11,877	9,804	3,831	25,512	95	87	4	186	0.9	0.6	0.2	1.7	0.7	0.4	<0.1	1.1
	Contech Out	CO	9,379	7,976	3,295	20,650	69	47	4	120	0.6	0.5	0.3	1.4	0.4	0.3	<0.1	0.8
Volume or Load Reduction			2,498	1,828	536	4,862	26	40	<0.1	66	0.2	0.2	<0.1	0.3	0.2	0.1	<0.1	0.4
% Change			-21%	-19%	-14%	-19%	-27%	-46%	0%	-35%	-26%	-27%	39%	-18%	-36%	-35%	19%	-34%
SR431	Jellyfish In	JI	11,014	11,281	4,359	26,654	86	84	5	175	0.8	0.7	<0.1	1.5	0.7	0.5	<0.1	1.2
	Jellyfish Out	JO	10,976	10,977	3,780	25,733	106	68	6	180	0.6	0.7	0.3	1.6	0.5	0.4	<0.1	0.9
Volume or Load Reduction			38	304	579	921	-20	16	-1	-5	0.2	<0.1	<0.1	<0.1	0.1	0.2	<0.1	0.3
% Change			na	na	na	na	23%	-19%	20%	3%	-23%	-2%	555%	3%	-22%	-30%	21%	-24%

Table 18c: Summary statistics for volume and load reductions at the SR431 Contech MFS and Jellyfish vaults in WY16. Cells highlighted in pink indicate values that may have been affected by sediment accumulation on the sensors.

Water Year 2016 Oct. 1, 2015 - Sep. 30, 2016			Seasonal Volumes (cf)			Total Annual Runoff Volume (cf)	Seasonal FSP Load (lbs)			Total Annual FSP Load (lbs)	Seasonal TN load (lbs)			Total Annual TN load (lbs)	Seasonal TP load (lbs)			Total Annual TP load (lbs)
Catchment (Site) Name	Station Name	Station Acronym	Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)	
SR431	Contech In	CI	16,104	9,367	325	25,796	290	159	1	450	1.8	1.4	na	3.2	1.5	2.2	na	3.7
	Contech Out	CO	12,994	8,255	324	21,573	223	104	2	329	1.2	1.1	na	2.3	1.2	1.0	na	2.2
Volume or Load Reduction			3,110	1,112	1	4,223	67	55	-1	121	0.6	0.3	na	0.9	0.3	1.2	na	1.5
% Change			-19%	-12%	0%	-16%	-23%	-35%	100%	-27%	-36%	-20%	na	-29%	-22%	-54%	na	-41%
SR431	Jellyfish In	JI	23,182	12,585	718	36,485	600	234	2	836	2.2	2.5	na	4.7	2.3	2.1	na	4.4
	Jellyfish Out	JO	19,830	15,904	705	36,439	197	244	1	442	1.5	2.5	na	4.0	1.4	3.1	na	4.5
Volume or Load Reduction			3,352	-3,319	13	46	403	-10	1	394	0.7	0.0	na	0.7	0.9	-1.0	na	-0.1
% Change			na	na	na	na	-67%	4%	-50%	-47%	-31%	0%	na	-14%	-37%	47%	na	3%

Table 19a: Efficiency summary for the Contech MFS vault at SR431 in WY14.

Event Start Date	Event Volume as a % of Total Annual Volume (cf)	FSP Concentration (mg/L)			FSP Load (lbs)			TN Concentration (ug/L)			TN Load (lbs)			TP Concentration (ug/L)			TP Load (lbs)		
		in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change
1/29/2014	8%	269	182	-32%	23.4	13.0	-45%	2,078	1,672	-20%	0.181	0.119	-34%	670	419	-37%	0.058	0.030	-49%
3/5/2014	5%	744	286	-62%	38.1	11.3	-70%	3,420	1,394	-59%	0.175	0.055	-69%	2,180	740	-66%	0.112	0.029	-74%
3/29/2014	5%	514	322	-37%	26.6	13.6	-49%	2,882	1,924	-33%	0.149	0.081	-45%	1,383	844	-39%	0.072	0.036	-50%
5/10/2014	3%	458	332	-28%	14.7	5.9	-60%	1,702	1,554	-9%	0.055	0.028	-49%	1,210	970	-20%	0.039	0.017	-56%
5/19/2014	8%	186	115	-38%	16.1	6.9	-57%	1,242	1,124	-10%	0.108	0.067	-38%	525	319	-39%	0.046	0.019	-58%
7/16/2014	5%	311	208	-33%	17.0	10.7	-37%	2,791	2,645	-5%	0.153	0.136	-11%	940	765	-19%	0.052	0.039	-24%
8/4/2014	7%	40	31	-21%	3.1	2.0	-35%	1,176	1,520	29%	0.091	0.096	6%	160	125	-22%	0.012	0.008	-36%
9/26/2014	7%	51	49	-3%	3.8	2.4	-36%	2,506	2,679	7%	0.187	0.132	-29%	270	220	-19%	0.020	0.011	-46%

Table 19b: Efficiency summary for the Contech MFS vault at SR431 in WY15.

Event Start Date	Event Volume as a % of Total Annual Volume (cf)	FSP Concentration (mg/L)			FSP Load (lbs)			TN Concentration (ug/L)			TN Load (lbs)			TP Concentration (ug/L)			TP Load (lbs)		
		in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change
10/31/14	2%	76	59	-23%	2.8	1.4	-52%	3,150	2,200	-30%	0.117	0.051	-57%	293	233	-20%	0.011	0.005	-51%
12/2/14	15%	141	121	-14%	32.6	20.7	-36%	730	820	12%	0.169	0.140	-17%	424	328	-23%	0.098	0.056	-43%
2/7/15	19%	402	342	-15%	123.4	98.0	-21%	1,270	1,190	-6%	0.390	0.341	-12%	1330	1006	-24%	0.409	0.289	-29%
4/23/15	8%	332	275	-17%	40.0	27.7	-31%	1,260	1,170	-7%	0.152	0.118	-22%	1101	812	-26%	0.133	0.082	-38%
5/6/15	6%	316	239	-25%	31.6	19.5	-38%	1,006	494	-51%	0.101	0.040	-60%	126	92	-27%	0.013	0.008	-40%
5/14/15	6%	168	149	-11%	15.1	10.4	-31%	829	1,378	66%	0.074	0.096	29%	662	648	-2%	0.059	0.045	-24%
5/22/15	5%	211	160	-24%	18.3	12.9	-30%	1,020	734	-28%	0.089	0.059	-33%	856	665	-22%	0.074	0.054	-28%
6/9/15	6%	78	49	-37%	7.9	4.7	-41%	891	1,437	61%	0.091	0.138	51%	153	212	38%	0.016	0.020	30%

Table 19c: Efficiency summary for the Contech MFS vault at SR431 in WY16.

Event Start Date	Event Volume as a % of Total Annual Volume (cf)	FSP Concentration (mg/L)			FSP Load (lbs)			TN Concentration (ug/L)			TN Load (lbs)			TP Concentration (ug/L)			TP Load (lbs)		
		in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change
10/1/15	3%	199	154	-23%	15.1	10.0	-34%	893	1,139	28%	0.068	0.074	9%	1,417	1,222	-14%	0.107	0.079	-26%
11/1/15	3%	45	20	-55%	2.6	0.9	-64%	1,088	839	-23%	0.062	0.038	-38%	219	130	-41%	0.012	0.006	-53%
12/10/15	5%	728	12	-98%	79.9	1.1	-99%	3,124	1,681	-46%	0.343	0.158	-54%	1,651	1,507	-9%	0.181	0.142	-22%
1/29/16	19%	1,110	951	-14%	478.4	373.0	-22%	1,728	1,504	-13%	0.745	0.590	-21%	1,651	1,624	-2%	0.712	0.637	-10%
3/4/16	3%	3,244	1,397	-57%	202.2	79.9	-60%	2,830	2,655	-6%	0.176	0.152	-14%	6,424	2,867	-55%	0.401	0.164	-59%
5/5/16	3%	379	308	-19%	27.0	21.9	-19%	2,118	1,886	-11%	0.151	0.134	-11%	1,379	1,219	-12%	0.098	0.087	-12%

Table 20a: Efficiency summary for the Jellyfish vault at SR431 in WY14.

Event Start Date	Event Volume as a % of Total Annual Volume (cf)	FSP Concentration (mg/L)			FSP Load (lbs)			TN Concentration (ug/L)			TN Load (lbs)			TP Concentration (ug/L)			TP Load (lbs)		
		in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change
1/29/2014	8%	442	109	-75%	34	9	-74%	1,936	1,109	-43%	0.150	0.091	-39%	1,056	300	-72%	0.082	0.025	-70%
3/5/2014	4%	681	345	-49%	27	17	-37%	3,598	1,511	-58%	0.144	0.076	-48%	2,180	970	-56%	0.087	0.049	-44%
3/29/2014	4%	511	196	-62%	20	7	-63%	2,891	1,315	-55%	0.111	0.048	-57%	1,598	465	-71%	0.061	0.017	-72%
5/10/2014	3%	605	442	-27%	17	9	-49%	2,404	1,753	-27%	0.069	0.036	-49%	1,790	1,220	-32%	0.052	0.025	-52%
5/19/2014	14%	309	174	-44%	45	28	-38%	2,366	1,293	-45%	0.342	0.205	-40%	950	480	-49%	0.137	0.076	-45%
7/16/2014	7%	244	210	-14%	17	14	-19%	2,988	2,920	-2%	0.209	0.192	-8%	910	802	-12%	0.064	0.053	-17%
8/4/2014	9%	37	25	-32%	3	3	5%	1,336	1,143	-14%	0.117	0.154	32%	145	109	-25%	0.013	0.015	16%
9/26/2014	7%	48	39	-19%	3	2	-30%	2,094	2,111	1%	0.151	0.132	-13%	240	180	-25%	0.017	0.011	-35%

Table 20b: Efficiency summary for the Jellyfish vault at SR431 in WY15.

Event Start Date	Event Volume as a % of Total Annual Volume (cf)	FSP Concentration (mg/L)			FSP Load (lbs)			TN Concentration (ug/L)			TN Load (lbs)			TP Concentration (ug/L)			TP Load (lbs)		
		in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change
10/31/14	2%	76	27	-64%	1.9	0.5	-71%	4,080	1,220	-70%	0.102	0.024	-76%	299	172	-42%	0.007	0.003	-54%
12/2/14	11%	149	114	-24%	28.0	20.7	-26%	850	860	1%	0.159	0.156	-2%	445	312	-30%	0.083	0.057	-32%
2/7/15	20%	405	342	-16%	136.8	110.2	-19%	1,110	900	-19%	0.375	0.290	-23%	1275	1015	-20%	0.430	0.327	-24%
4/23/15	7%	394	264	-33%	47.3	29.9	-37%	1,350	1,170	-13%	0.162	0.132	-18%	1322	792	-40%	0.159	0.090	-44%
5/6/15	7%	256	243	-5%	29.6	27.3	-8%	760	889	17%	0.088	0.100	14%	56	48	-15%	0.006	0.005	-17%
5/14/15	7%	167	113	-32%	18.6	11.9	-36%	1,144	1,294	13%	0.127	0.135	6%	664	519	-22%	0.074	0.054	-27%
5/22/15	6%	196	202	3%	18.7	19.3	4%	531	502	-5%	0.051	0.048	-5%	906	806	-11%	0.086	0.077	-11%
6/9/15	6%	73	52	-30%	7.6	5.3	-30%	988	1,153	17%	0.102	0.119	17%	153	214	40%	0.016	0.022	40%

Table 20c: Efficiency summary for the Jellyfish vault at SR431 in WY16.

Event Start Date	Event Volume as a % of Total Annual Volume (cf)	FSP Concentration (mg/L)			FSP Load (lbs)			TN Concentration (ug/L)			TN Load (lbs)			TP Concentration (ug/L)			TP Load (lbs)		
		in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change
10/1/15	3%	173	127	-26%	15.0	11.9	-21%	722	1,049	45%	0.063	0.098	57%	1,433	1,048	-27%	0.124	0.098	-21%
11/1/15	4%	44	1	-98%	4.6	0.1	-98%	1,259	584	-54%	0.134	0.061	-54%	198	80	-60%	0.021	0.008	-60%
12/10/15	5%	717	419	-42%	92.9	53.2	-43%	2,886	1,173	-59%	0.374	0.149	-60%	1,663	969	-42%	0.216	0.123	-43%
1/29/16	18%	1,126	825	-27%	585.3	402.1	-31%	1,346	1,405	4%	0.700	0.685	-2%	1,862	1,461	-22%	0.968	0.712	-26%
3/4/16	4%	2,666	1,341	-50%	267.8	134.8	-50%	4,467	3,233	-28%	0.449	0.325	-28%	3,873	4,913	27%	0.389	0.494	27%
5/5/16	3%	396	297	-25%	36.0	26.5	-26%	1,776	1,715	-3%	0.161	0.153	-5%	1,379	1,105	-20%	0.125	0.099	-21%

8. PLRM Modeling Results

The Tahoe RCD compared average annual runoff volumes and pollutant loads predicted by PLRMv2.1 to annual volumes and pollutant loads measured in WY14, WY15, and WY16 at all sites; results are presented in Table 21a-c. The models being used for this analysis were developed by TRCD and do not necessarily reflect the PLRM models that are used by the jurisdictions for registration. In reviewing model performance, **it is important to highlight that PLRM represents average annual conditions based on an 18-year meteorological average, and each water year is unique. Therefore, differences between PLRM estimates and measured values are expected.**

WY14 and WY15 were both exceptionally dry years. Therefore it is expected that PLRM-modeled results for average annual runoff volumes would be higher than measured for WY14 and WY15; however, there were two exceptions. First, modeled volume at the Incline Village site was lower than the measured values for these years. Secondly, PLRM predicted that there would never be flow that bypassed the two cartridge filter vaults at SR431 and thus all pollutant loads for the SR431 catchment outfall (S5) were also predicted to be zero. For this reason the SR431 catchment outfall (S5; not the Jellyfish and Contech MFS filters) is excluded from further discussion. As expected for these exceptionally dry years, PLRM model results for average annual FSP loads were greater than measured at all sites for WY14 and WY15. Also as expected, TN loads estimated by PLRM were higher than measured at all sites for WY14 and WY15 with the exception of Incline Village, which was lower than measured in WY15. Similarly, TP loads estimated by PLRM were also higher than measured at all sites for WY14 and WY15, with the exceptions of Pasadena Inflow and Outflow, which were lower than measured in WY14; Incline Village, which was lower than measured in WY and WY15; and Rubicon Outflow, which was accurately predicted to be zero.

WY16 was an average year, with measured precipitation falling near the median of the annual precipitation recorded at the Tahoe City Cross reference station since 1981. In WY16, measured volumes and pollutant loads fell around the PLRM 18-year estimated averages, with some sites estimated to be lower than measured, and some sites estimated to be higher than measured. PLRM volume estimates were higher than measured at the SR431 vaults, Speedboat, Tahoe Valley, and the Pasadena vaults, and lower than measured at Incline Village, Upper Truckee, and Tahoma. PLRM estimated FSP loads were higher than measured at all sites except for Incline Village. PLRM estimated TN values were higher than measured for all sites except Jellyfish Outflow, which was accurately predicted to be 4.0lbs/year; Upper Truckee, which was lower than measured; and Incline Village, which did not receive enough flow to calculate the annual TN load. At the inflow and outflow sites at SR431 (which are calibrated using site specific effluent concentrations), and Tahoma the model estimated slightly lower TP values than measured. For Pasadena, Speedboat, Tahoe Valley, and Upper Truckee, modeled TP was greater than the measured values in WY16. There was not enough flow at Incline Village to calculate the annual TP load.

There are many reasons why the modeled estimates differ from measured values. WY14 and WY15 received less than average precipitation and WY16 received close to average precipitation, therefore, PLRM average annual results, which are calculated based on precipitation from WY 1998 to WY 2006, should model larger runoff volumes and pollutant loads compared to the dry years, and similar runoff volumes and pollutant loads for the average year. All models are simplified versions of reality, and PLRM is no exception. Urban hydrology is complex, and the model makes many simplifying assumptions when routing runoff to the outfall of a catchment. Urban runoff pollutant load is based on land use characteristic runoff concentrations (CRCs), which are modeled as a static number for each land use, yet in reality these CRCs will vary throughout time and space. As modeling parameters are refined to better represent actual conditions, the accuracy of modeled volume and pollutant loads should improve.

PLRM does a reasonable job estimating relative conditions. For example, Tahoe Valley has the greatest annual runoff volume of all sites, which was predicted by PLRM. It is also important to highlight that models calibrated using refined CEC values (Pasadena Outflow, Jellyfish Outflow, and Contech MFS Outflow) tended to perform better than uncalibrated models. The improved model performance when predicting FSP, TN, and TP load at the three cartridge filter vault outfalls emphasizes the utility of model calibration with empirical data (see section 9 for full discussion of refined CECs and model performance). Finally, PLRM is the standard basin-wide model for pollutant load reduction estimates for the Lake Tahoe TMDL. PLRM assumes that roads and commercial properties tend to be the highest polluting land uses, while multi-family residential and single family residential are less so, which conforms with our basic understanding of Tahoe stormwater pollutant sources. All seven jurisdictions across two states are using the same modeling tool and are thus speaking the same language with regards to pollutant load estimates, making it easier to compare pollutant load reductions across jurisdictions. It is unrealistic to expect the model to perform perfectly; however, comparing monitoring results to modeled estimates and continuing to improve modeling assumptions will help narrow the gap between modeled estimates and reality.

Table 21a: PLRM predicted and WY14 measured values for all monitored catchments. WY14 was an exceptionally dry year; therefore modeled results are expected to be higher than measured values.

Water Year 2014 Oct. 1, 2013 - Sept. 30, 2014		Annual Runoff Volumes (cf)		Annual FSP Loads (lbs)		Annual TN Loads (lbs)		Annual TP Loads (lbs)	
Catchment (Site) Name	Station Name	PLRM	Measured	PLRM	Measured	PLRM	Measured	PLRM	Measured
Incline Village	Incline Village	56,628	76,005	391	364	10.0	9.2	2.0	4.3
Pasadena	Pasadena Inflow	143,748	135,054	1,184	680	20.0	11.8	5.0	6.5
	Pasadena Outflow	143,748	133,161	528	454	14.0	7.7	5.0	5.2
Rubicon	Rubicon Inflow	130,680	36,374	2,057	<1	24.0	1.3	7.0	0.5
	Rubicon Outflow	4,356	0	87	0	1.0	0.0	0.0	0.0
SR431	Contech Inflow	43,560	17,957	1,095	293	11.0	2.4	3.0	0.8
	Contech Outflow	43,560	13,584	402	131	4.0	1.6	2.0	0.4
	Jellyfish Inflow	43,560	16,236	1,095	268	11.0	2.3	3.0	0.8
	Jellyfish Outflow	43,560	16,136	458	128	4.0	1.6	2.0	0.4
	Catchment Outfall	0	3,823	0	19	0.0	0.4	0.0	0.2
Tahoma	Tahoma	666,468	331,911	10,801	1,908	127.0	20.6	37.0	14.0

Table 21b: PLRM predicted and WY15 measured values for all monitored catchments. WY15 was an exceptionally dry year; therefore modeled results are expected to be higher than measured values

Water Year 2015 Oct. 1, 2014 - Sept. 30, 2015		Annual Runoff Volumes (cf)		Annual FSP Loads (lbs)		Annual TN Loads (lbs)		Annual TP Loads (lbs)	
Catchment (Site) Name	Station Name	PLRM	Measured	PLRM	Measured	PLRM	Measured	PLRM	Measured
Incline Village	Incline Village	56,628	62,607	391	76	10.0	17.6	2.0	2.5
Pasadena	Pasadena Inflow	143,748	51,130	1,184	272	20.0	7.1	5.0	2.7
	Pasadena Outflow	143,748	48,902	528	209	14.0	5.3	5.0	2.3
Rubicon	Rubicon Inflow	130,680	13,787	2,057	6.9	24.0	1.3	7.0	0.2
	Rubicon Outflow	4,356	0	87	0	1.0	0.0	0.0	0
SR431	Contech Inflow	43,560	25,512	1,095	186	11.0	1.7	3.0	1.1
	Contech Outflow	43,560	20,650	402	120	4.0	1.4	2.0	0.8
	Jellyfish Inflow	43,560	26,654	1,095	175	11.0	1.5	3.0	1.2
	Jellyfish Outflow	43,560	25,733	458	180	4.0	1.6	2.0	0.9
	Catchment Outfall	0	1,853	0	1.5	0.0	0.3	0.0	0.1
Speedboat	Speedboat	317,988	230,613	4,911	2,898	58.4	19.2	17.0	5.9
Tahoma	Tahoma	666,468	175,702	10,801	1,809	127.0	16.0	37.0	7.1
Tahoe Valley	Tahoe Valley	5,449,356	585,498	53,305	846	764.0	36.2	196.0	9.3
Upper Truckee	Upper Truckee	283,140	102,665	5,476	754	57.0	11.4	17.0	4.3

Table 21c: PLRM predicted and WY16 measured values for all monitored catchments. WY16 was an average year; therefore modeled results are expected to be closer to measured values.

Water Year 2016 Oct. 1, 2015 - Sept. 30, 2016		Annual Runoff Volumes (cf)		Annual FSP Loads (lbs)		Annual TN Loads (lbs)		Annual TP Loads (lbs)	
Catchment (Site) Name	Station Name	PLRM	Measured	PLRM	Measured	PLRM	Measured	PLRM	Measured
Incline Village	Incline Village	13,068	28,817	69	97	2.0	na	0.0	na
Pasadena	Pasadena Inflow	143,748	57,700	1,184	206	20.0	7.5	5.0	2.5
	Pasadena Outflow	143,748	45,101	528	148	14.0	7.0	5.0	1.7
SR431	Contech Inflow	43,560	25,796	1,095	450	11.0	3.2	3.0	3.7
	Contech Outflow	43,560	21,573	402	329	4.0	2.3	2.0	2.2
	Jellyfish Inflow	43,560	36,485	1,095	836	11.0	4.7	3.0	4.4
	Jellyfish Outflow	43,560	36,439	458	442	4.0	4.0	2.0	4.5
Speedboat	Speedboat	317,988	299,577	4,911	2,937	58.4	23.4	17.0	11.3
Tahoma	Tahoma	666,468	696,359	10,801	2,615	127.0	78.6	37.0	40.0
Tahoe Valley	Tahoe Valley	5,449,356	1,772,489	53,305	4,663	764.0	90.5	196.0	34.4
Upper Truckee	Upper Truckee	213,444	249,470	4,658	2,561	14.0	39.7	47.0	20.0

9. Characteristic Effluent Concentrations

PLRMv2.1 uses a CEC to estimate pollutant loading from a particular BMP. Site specific FSP, TN, and TP CECs for the outflows from the Pasadena Stormfilter, SR431 Contech MFS, and SR431 Jellyfish cartridge filters were estimated as the average of the annual pollutant concentrations from WY14, WY15, and WY16 (see Table 5 for average annual concentrations of each pollutant at each site and Table 22a-c for site specific CECs). The current default FSP, TN, and TP CEC values used in PLRMv2.1 are 13 mg/L, 1500 µg/L, and 140 µg/L respectively. (NOTE: PLRM uses TN and TP concentrations in mg/L. However, this document reports all TN and TP concentrations in µg /L.) As the default FSP CEC of 13 mg/L is much lower than any of the estimated FSP CECs in Table 22a-c (59 to 164 mg/L) and the default TP CEC of 140 µg/L is lower than any of the estimated TP CECs in Table 22a-c (670 to 857 µg /L), using the default CECs when modeling these catchments will result in an overestimation of vault pollutant removal efficiency based on the measured data to date. Accordingly, FSP and TP loads discharged from these catchments will be underestimated if the default CEC is used. The current default PLRM TN CEC value for cartridge filters of 1,500 µg/L is very similar to the estimated values in Table 22a-c (1,329 to 1,553 µg /L) so modeled pollutant loads from these three cartridge filter vaults should be similar to measured values if runoff volume is accurately predicted.

The PLRM was run on two catchments (Pasadena and SR431) using the refined site specific CECs for each BMP as shown in Table 22a-c. PLRM estimated runoff volumes, FSP, TN, and TP loads (Table 22a-c) were higher than measured in all model simulations, with the exception of TP load at the Pasadena Outflow in WY14 and at Jellyfish/Contech MFS Outflow in WY16, which were lower than measured; and TN load at Jellyfish Outflow in WY16, which matched modeled results. **It is important to keep in mind that PLRM results represent average annual conditions based on an 18-year meteorological record, and WY14/WY15 were particularly dry years, while WY16 was an average year.** Since loads are dependent on runoff volume, it is not surprising that PLRM estimated loads were higher than measured in WY14 and WY15 even when using the refined CECs. Overall PLRM provided very reasonable results for both runoff volumes and pollutant loads when the refined CECs were used.

Table 22a: CECs for FSP, TN, and TP, PLRM estimated and measured (WY14) annual runoff volumes and pollutant loads for outflows at three monitored cartridge filter vaults. WY14 was an exceptionally dry year; therefore modeled results are expected to be higher than measured values. NOTE: PLRM uses TN and TP concentrations in mg/L, but this report reports all TN and TP concentrations in µg /L.

Water Year 2014 Oct. 1, 2013 - Sept. 30, 2014		Average CEC (2014 - 2016)			Annual Runoff Volumes (cf)		Annual FSP Loads (lbs)		Annual TN Loads (lbs)		Annual TP Loads (lbs)	
Station Name	Station Acronym	FSP (mg/L)	TN (µg/L)	TP (µg/L)	PLRM	Measured	PLRM	Measured	PLRM	Measured	PLRM	Measured
Pasadena Out	PO	59	1,553	670	143,748	133,161	528	454	14.0	7.7	5.0	5.2
Contech Out	CO	164	1,516	857	43,560	13,584	402	131	4.0	1.6	2.0	0.4
Jellyfish Out	JO	144	1,326	833	43,560	16,136	458	128	4.0	1.6	2.0	0.4

Table 22b: CECs for FSP, TN, and TP, PLRM estimated and measured (WY15) annual runoff volumes and pollutant loads for outflows at three monitored cartridge filter vaults. WY15 was an exceptionally dry year; therefore modeled results are expected to be higher than measured values. NOTE: PLRM uses TN and TP concentrations in mg/L, but this report reports all TN and TP concentrations in µg /L.

Water Year 2015 Oct. 1, 2014 - Sept. 30, 2015		Average CEC (2014 - 2016)			Annual Runoff Volumes (cf)		Annual FSP Loads (lbs)		Annual TN Loads (lbs)		Annual TP Loads (lbs)	
Station Name	Station Acronym	FSP (mg/L)	TN (µg/L)	TP (µg/L)	PLRM	Measured	PLRM	Measured	PLRM	Measured	PLRM	Measured
Pasadena Out	PO	59	1,553	670	143,748	48,902	528	209	14.0	5.3	5.0	2.3
Contech Out	CO	164	1,516	857	43,560	20,650	402	120	4.0	1.4	2.0	0.8
Jellyfish Out	JO	144	1,326	833	43,560	25,733	458	180	4.0	1.6	2.0	0.9

Table 22c: CECs for FSP, TN, and TP, PLRM estimated and measured (WY16) annual runoff volumes and pollutant loads for outflows at three monitored cartridge filter vaults. WY16 was an average year; therefore modeled results are expected to be closer to measured values. NOTE: PLRM uses TN and TP concentrations in mg/L, but this report reports all TN and TP concentrations in µg /L.

Water Year 2016 Oct. 1, 2014 - Sept. 30, 2015		Average CEC (2014 - 2016)			Annual Runoff Volumes (cf)		Annual FSP Loads (lbs)		Annual TN Loads (lbs)		Annual TP Loads (lbs)	
Station Name	Station Acronym	FSP (mg/L)	TN (µg/L)	TP (µg/L)	PLRM	Measured	PLRM	Measured	PLRM	Measured	PLRM	Measured
Pasadena Out	PO	59	1,553	670	143,748	45,101	528	148	14.0	7.0	5.0	1.7
Contech Out	CO	164	1,516	857	43,560	21,573	402	329	4.0	2.3	2.0	2.2
Jellyfish Out	JO	144	1,326	833	43,560	36,439	458	442	4.0	4.0	2.0	4.5

For the SR431 Contech MFS and Jellyfish cartridge filter vaults, the model results for percent FSP removed by the filters using the site specific CEC values from Table 22a-c is shown in Figure 31, depicted as a square and a triangle, respectively. Though obviously not as effective as the default CEC of 13mg/L (which provides a 97% FSP removal rate), the model with refined site-specific CEC values still shows very high FSP removal rates (58% for the Contech MFS and 63% for the Jellyfish). The PLRM models were also run with theoretical CECs for reference purposes (Figure 31). At this site, the relationship between FSP removed and FSP CEC is a negative linear relationship, and the filters continue to provide FSP removal up to a CEC of 393 mg/L. This means these filters should provide some FSP removal most of the time.

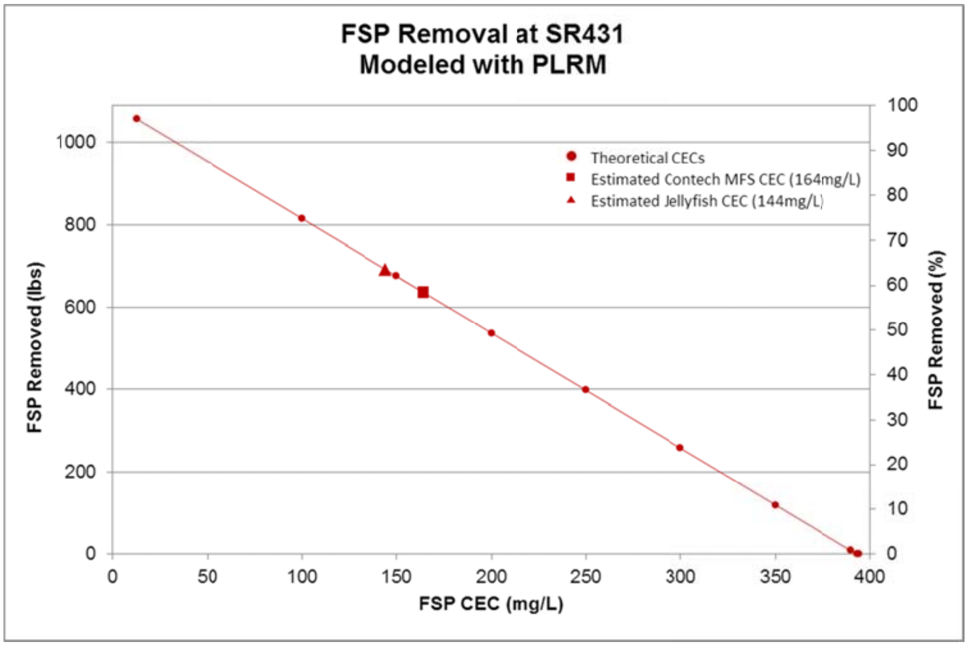


Figure 31: FSP removal at SR431 for the Contech MFS and Jellyfish cartridge filter vaults, as modeled by PLRM. Dots represent model runs with theoretical CECs, the square represents the model run with the refined CEC value for the Contech MFS filter (164mg/L), and the triangle represents the model run with the refined CEC for the Jellyfish filter (144 mg/L).

For the Pasadena cartridge filter vaults, filter vault #1 is modeled to treat up to 0.6 cfs; flows greater than this are routed to filter vault #2, which treats up to 1.6 cfs, and any flows greater than this bypass the filter vaults and is routed directly to the outlet. The FSP removal using the refined site specific CEC as shown in Table 22a-c (Figures 32 and 33, represented as a diamond), as well as theoretical CECs for reference purposes (represented as dots) were modeled with PLRM. The refined site-specific CEC of 59 mg/L provides 55% FSP removal for this catchment as modeled by PLRM. For both filter vaults, the amount of FSP removed increases rapidly with decreasing CEC. With a CEC greater than 392 mg/L, filter vault #1 provides no water quality treatment, while filter vault #2 provides cartridge filter up to a CEC of 200 mg/L.

It is unlikely that stormfilters in the Tahoe basin are treating runoff to a CEC of 13 mg/L for FSP, and these BMP effectiveness studies provide data to better understand cartridge filter treatment efficiency and to refine CECs. Treatment efficiency of the filters depends on multiple factors, including catchment characteristics and storm event type that dictate the input pollutant concentration, and the extent (vactoring pre-treatment chamber versus cleaning and replacing filters) and schedule of maintenance which determines filter performance. Because of this, treatment efficiency varies widely between catchments and storms. Continued monitoring of these and other filters in the Tahoe basin is suggested to better understand storm filter function and cost-effectiveness, and to further refine static CECs to use in PLRM.

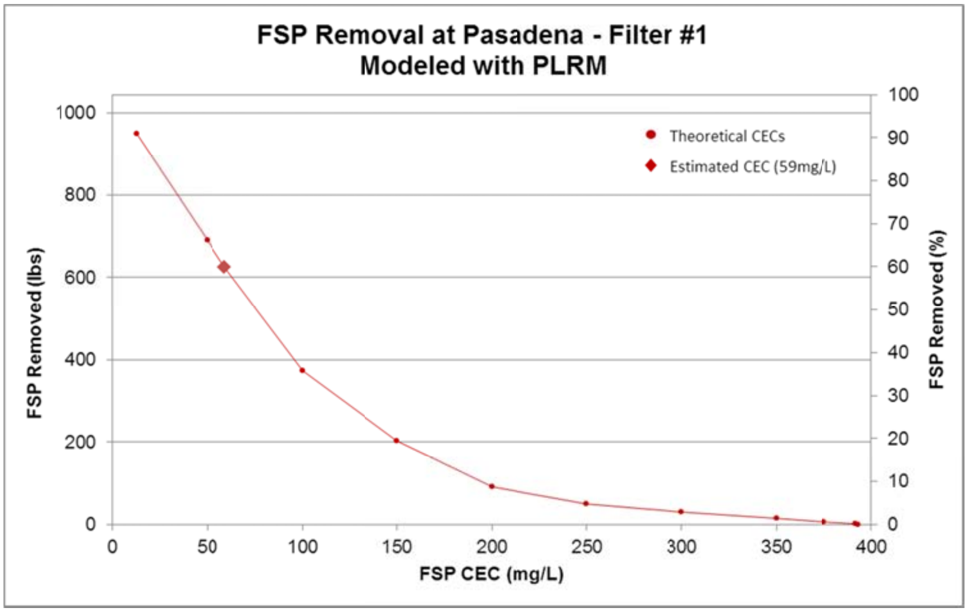


Figure 32: FSP removal at Pasadena filter vault #1, as modeled by PLRM. Dots represent model runs with theoretical CECs and the diamond represents the model run with the estimated CEC (59 mg/L).

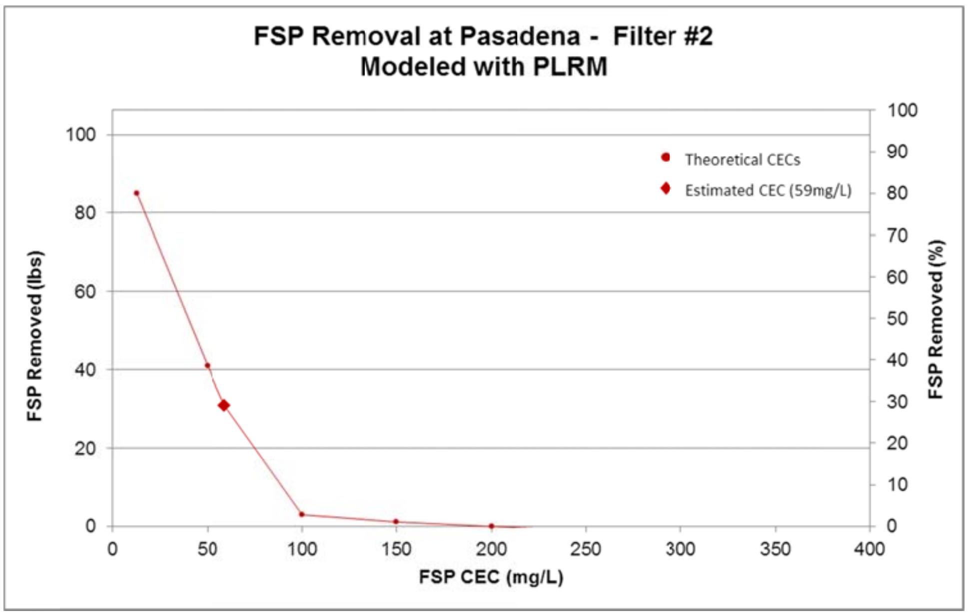


Figure 33: FSP removal at Pasadena filter vault #2, as modeled by PLRM. Dots represent model runs with theoretical CECs and the diamond represents the model run with the estimated CEC (59 mg/L).

10. Lessons Learned

One of the most valuable lessons learned is the importance of checking monitoring stations regularly, especially during runoff events, to identify any potential equipment malfunctions that may result in data gaps. There are a multitude of technical difficulties that can be encountered with stormwater monitoring, including equipment failure, freezing conditions, power failure, vandalism, and obstruction by sediment, snow, trash or other debris. Identifying and correcting these problems early results in a more accurate data set with fewer and shorter data gaps. The biggest cause of data gaps at monitoring stations was power failure. Although all stations are equipped with solar panels to recharge batteries, some stations do not have enough sun exposure to keep batteries continuously charged, and during periods of extended cloud cover and subsequent decrease in solar recharge, all stations are subject to power failure. Regularly checking battery voltage is recommended to avoid this.

Field verifying data as a QAQC procedure is essential to ensure an accurate and reliable dataset. Tahoe RCD staff members regularly check stage and make note of precipitation type and totals during storms to ensure equipment is functioning properly. The greater the level of QAQC during precipitation events, the higher the level of certainty the dataset is representative. The importance of detailed field notes and photographs cannot be understated. With passing time, the human memory lapses, while field notes and photographs can be referred to years and even decades after a monitoring event to explain what happened throughout the monitoring period.

Standing water can accumulate in the cartridge filter vaults at Pasadena and SR431 after runoff events and be flushed out with the following runoff event. Investigations into the cost-effectiveness of maintaining these vaults by pumping them out after each storm may be valuable. It may also be valuable to analyze inflow and outflow data shortly after each storm to determine if filter maintenance or replacement is required before the next event.

Real-time data from the SR431 vault monitoring site can be accessed through on online interface, which has proven exceptionally useful and efficient for site and staff management. For all other sites, it is necessary to physically visit the sites to learn the current status of sampling and thus the amount of extra effort to manage these sites is tremendous. In order to improve program efficiency, Tahoe RCD intends to get all sites on the West and North Shores online by the end of WY16. We also hope to get South Shore sites online by March 2017. Although this will greatly reduce the burden on the amount of staff time needed to check on sites during storms, it is still essential for staff to regularly check sites both during and between storms to QAQC data and ensure equipment is functioning properly.

Short duration, high intensity thunderstorms can be particularly difficult to sample, as the sometimes unpredictably large flow volumes can quickly fill all 24 sample bottles in the autosampler if the flow pacing is set too low. The result is that a portion of the end of the runoff hydrograph is not sampled. Due to the short nature of these events, it is incredibly difficult for staff to reach sites before runoff has ended to replace the full bottles with empty ones. Summer thunderstorms also tend to be very episodic in nature, and not all sites receive runoff over the summer period. As a result, several of the requisite summer events were missed or did not produce enough runoff to sample. In the future, it may be advisable to amend permit and agreement language to relax the summer thunderstorm sampling requirement.

Storm events not captured in a particular season due to insufficient runoff can be substituted by a different storm in the next season to meet permit and agreement requirements of one storm event per season as approved by the Lahontan Regional Water Quality Control Board (Lahontan). However, all efforts should be made to successfully sample an event within each season so that average seasonal pollutant concentrations and loads can be calculated. Fortunately, FSP concentrations and loads can be calculated from the continuous turbidity data, so these values should never be missing from any season.

Infiltration improvements implemented in the Incline Village catchment have been exceptionally effective at reducing flows, and therefore pollutant loads, to the lake (see section 2.1 for full description). The success of the Central Incline Village Phase II project has prompted the need to move the location of the Incline Village (IV) monitoring site to a nearby channel that receives sufficient flow to allow long-term status and trends monitoring to continue in a catchment in Nevada. The move was approved by the IMP partners, Lahontan, and NDEP, and occurred prior to the commencement of WY17 monitoring. Although abandoning monitoring in a successful catchment in order to monitor at an untreated catchment outfall will skew long-term status and trends data and may encourage a false perception that erosion control projects do not have a measureable benefit, it is documented here that the Central Incline Village Phase II Project effectively eliminated flows and pollutant loads to Lake Tahoe and thus the ability to continue monitoring at the original location.

11. Changes: Proposed and Accepted

Following WY15, the Tahoe RCD suggested to IMP that the two Rubicon monitoring stations (RI and RO) and the catchment outfall station at SR431 (S5) be removed from the monitoring network in WY16 due to extremely low flow volumes. Since three new sites had been added for WY15, the requisite number of monitoring sites was already met and exceeded (see Section 1 for description of requisite number of sites). The very small pollutant loads from these catchments and the relative difficulty of monitoring sites with low flow did not warrant the effort and cost required to continue monitoring these stations. The IMP agreed with this assessment and the request was brought to Lahontan and NDEP who approved the change for WY16. It is important to document that the reason that these monitoring sites receive such limited flow. In the case of Rubicon, the improvements to infiltration in this catchment (small infiltration basins, the well sized infiltration gallery) have been very successful and reduced flows significantly. In the case of SR431, the upstream cartridge filter vaults divert the majority of the runoff in this catchment away from the outfall site. The outfall site does not receive the treated runoff from the outflows of the cartridge filter vaults. Improvements made in this catchment have been successful in attempting to treat the majority of the runoff before discharge to the creek.

In the spring of WY16 the Tahoe RCD proposed a new location for the Incline Village monitoring site. As stated several times in this document, the Incline Village site received minimal flows following a successful environmental improvement project in the catchment making monitoring difficult. The new location was approved by IMP, Lahontan, NDEP and monitoring equipment was installed at a nearby site called Lakeshore as described in section 2.1.

In addition, the Tahoe RCD urged IMP to propose removing the first flush sample requirement to the regulators for the next permit term (beginning WY17) for three reasons:

1. The first flush sample is limited to the first sample collected in the series of samples taken across an event hydrograph with the autosampler. It is a single sample (i.e. not part of a composite) that does not represent a consistent percentage of the total runoff volume for an event and therefore it is difficult to compare the results across events or sites or to infer anything about loading during different parts of an event. This is due to the fact that the pacing of samples taken with an autosampler is determined by a flow volume and triggered when a certain level is reached. Generally the level trigger is consistent at each site, but the pacing is changed regularly depending on the predicted size of the incoming storm. The larger the storm, the greater the amount of flow

expected, and the higher the pacing is set. Due to the unpredictability of precipitation patterns in the Tahoe Basin, the first sample (first flush) rarely represents a consistent volume, and never represents a consistent percentage of the total runoff volume for the whole event. For example, an autosampler can be programmed to take a sample every 1,000 cubic feet and triggered to begin when the level reaches half an inch. If the pacing was set too low for a large storm, the first flush sample could represent a mere 1% or less of the total flow volume, or if the pacing was set too high for a small storm, that first sample could represent up to 100% of the total flow volume (if that was the only sample taken) or any combination in between. Though first flush samples do tend to be dirtier than composite samples representing the rest of the hydrograph, it is impossible to infer anything about what portion of the pollutant load is delivered during the first period of runoff because of what the first flush samples actually represent. In other words, it would be impossible to calculate that 75% of the pollutant load is delivered in the first 25% of the runoff volume, which would be valuable to the jurisdictions when trying to size an infiltration basin for example.

2. Since the first flush sample generally represents a very small portion of the total runoff volume, its contribution to the calculation of the flow-weighted EMC is often negligible. The concentrations of the pollutants in the bulk of the runoff volume dominate the calculation and make the first flush sample insignificant. The contribution of the first flush sample is even more insignificant when calculating seasonal and annual loads as the volume represented by the first flush sample is far out-weighed by the seasonal or annual volume. First flush when defined as the first bottle is insignificant, but sample processing methods could be changed to reflect that most academic studies define the first 30% of the storm as the first flush. Two composites could be made for each event, one that covers the first 30% of the runoff and one that covers the last 70% of the runoff.

3. Since continuous turbidimeters are installed at all monitoring sites, the calculation most valuable to implementers described in reason #1 above can be calculated easily and effectively, at least for FSP (which many argue is the pollutant of greatest concern). Continuous turbidimeters provide turbidity data every 10 minutes. Turbidity can be converted to FSP concentration using equations from 2NDNATURE et al 2014. Continuous FSP concentrations can then be converted to loads if multiplied by flow over the 10 minute interval. The result is that the cumulative FSP load can be calculated for any time period that corresponds to any percentage of the total runoff volume during the runoff event. For example, if a jurisdiction knows that a certain basin can only hold 10,000 cf before it is bypassed (based solely on basin size), it would be easy to calculate the portion of the total FSP load that was delivered in the first 10,000 cf of runoff for each event and then estimate an annual average pollutant load retention capacity. Conversely, this data could also be used to estimate basin sizes required to retain given percentages of FSP.

Recommendation: Since cost is a concern and questions pertinent to the jurisdictions can be answered much more effectively with continuous turbidity data as described in reason #3 above, the preferred solution to this issue is that the first flush requirement is dropped in the next permit term to reduce staff and analytical costs associated with collecting, processing, and analyzing these samples. Instead, continuous turbidity data will be analyzed to quantify pollutant loads associated with the first flush. Alternatively, the first flush could be redefined to include the first 30% of each runoff event and composites will be made accordingly as described in reason #2 above.

Result: The first flush sample requirement was removed for the second permit term.

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Appendix A: Raw Analytical Data

Tables A1a and A1b, A2a, A2b, and A2c, A3a and A3b, A4b and A4c, A5b and A5c, A6a and A6b, A7a, A7b,and A7c, A8a and A8b, A9a and A9b, and A10a and A10b present all available raw analytical data for first flush (FF) and autosampler composite (AC) samples. The Sample ID is comprised of a two letter monitoring site acronym and a two letter sample type acronym (see table 5 for station acronyms and Table 2 for sample type acronyms). Tables A4a and A5a present available EMC data for events sampled at the inflow and outflow of the Contech MFS and Jellyfish vaults at SR431 in WY14. Please see DRI et al 2015 for additional SR431 vault data.

Table A1a: Raw analytical data for samples taken at the Incline Village catchment outfall in WY14.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
IV-FF	1/11/14 12:43	121	218	79	3,378	756	0.48	4.19	10.6	20.5	41.1	65.6	75.5	100	100	100	100	100	100
IV-AC	1/11/14 13:06	514	1,236	413	5,963	1,727	0.59	5.89	15.4	29.8	55.9	80.4	86.9	100	100	100	100	100	100
IV-AC	1/11/14 14:15	335	865	266	3,802	1,835	0.63	6.55	18.1	33.8	58.3	79.3	84.9	100	100	100	100	100	100
IV-FF	1/29/14 13:33	559	1,178	484	8,204	2,849	0.90	9.45	26.0	45.2	70.1	86.6	90.5	100	100	100	100	100	100
IV-AC	1/29/14 13:59	293	536	230	4,084	1,427	0.57	5.96	17.0	33.2	58.0	78.6	84.3	100	100	100	100	100	100
IV-AC	1/29/14 21:15	45	69	33	1,341	315	0.68	6.90	18.3	33.1	54.5	73.1	78.3	96.1	100	100	100	100	100
IV-FF	2/8/14 8:08	385	915	325	2,998	1,874	0.78	8.07	22.0	39.8	65.8	84.3	88.5	100	100	100	100	100	100
IV-AC	2/8/14 9:29	223	279	152	1,352	913	0.48	4.78	12.6	24.2	44.1	68.0	75.9	100	100	100	100	100	100
IV-AC	2/9/14 1:41	111	108	75	714	404	0.63	5.66	14.2	25.7	46.0	68.0	75.2	100	100	100	100	100	100
IV-FF	4/25/14 4:33	46	38	31	1,426	531	0.83	6.43	14.4	24.2	47.1	67.0	77.5	100	100	100	100	100	100
IV-AC	4/25/14 10:13	101	164	88	1,874	222	0.97	9.76	25.0	43.9	70.6	87.3	92.7	100	100	100	100	100	100
IV-FF	5/20/14 5:25	59	52	42	5,732	359	0.71	6.34	15.6	28.7	51.4	70.7	78.5	99.8	100	100	100	100	100
IV-AC	5/20/14 6:34	80	94	67	686	393	0.79	7.90	20.7	39.7	66.2	84.1	90.0	100	100	100	100	100	100
IV-AC	5/20/14 23:12	73	60	50	700	309	0.50	5.01	13.2	26.0	47.4	68.5	76.1	99.4	100	100	100	100	100
IV-FF	7/16/14 20:13	2,039	>1000	844	6,460	2,664	0.25	2.39	6.04	12.2	24.5	41.4	48.2	83.1	92.9	100	100	100	100
IV-AC	7/16/14 20:20	499	329	292	4,608	1,489	0.33	3.26	8.51	18.3	36.7	58.6	67.0	97.2	100	100	100	100	100

Table A1b: Raw analytical data for samples taken at the Incline Village catchment outfall in WY15.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
IV-FF	11/22/14 6:07	58	70	42	3,493	335	2.77	19.3	36.3	54.2	82.1	87.4	90.4	100	100	100	100	100	100
IV-AC	11/22/14 6:40	101	124	75	2,488	496	0.97	7.71	18.7	32.2	58.4	80.8	89.1	100	100	100	100	100	100
IV-FF	2/6/15 15:32	309	419	233	4,272	1,126	0.82	7.00	16.9	29.2	53.2	77.2	86.2	100	100	100	100	100	100
IV-AC	2/6/15 17:07	194	178	141	4,493	666	0.69	5.92	16.7	31.0	57.8	76.8	86.5	100	100	100	100	100	100
IV-FF	4/24/15 0:11	97	78	93	1,659	561	1.92	13.5	30.8	53.0	88.0	97.9	100	100	100	100	100	100	100
IV-AC	4/24/15 0:27	145	107	125	1,112	601	0.63	5.78	17.3	31.8	59.6	86.3	94.6	100	100	100	100	100	100

Table A2a: Raw analytical data for samples taken at the inflow and outflow of the Pasadena Stormfilter in WY14 (the outflow is also the catchment outfall).

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
PI-FF	1/29/14 15:15	273	525	190	3,712	1,737	0.45	4.49	11.9	23.8	45.5	69.7	77.8	100	100	100	100	100	100
PI-AC	1/29/14 15:28	143	69	91	2,338	1,106	0.42	4.26	11.4	22.8	42.3	63.9	71.4	100	100	100	100	100	100
PI-AC	1/29/14 22:42	79	94	38	1,459	654	0.34	3.41	8.97	17.3	31.8	48.5	54.7	89.3	95.6	100	100	100	100
PO-FF	1/29/14 15:52	505	508	258	5,791	1,750	0.26	2.70	7.54	15.9	31.3	51.0	58.5	90.0	95.7	100	100	100	100
PO-AC	1/29/14 16:02	171	312	108	3,072	983	0.39	3.89	10.4	20.7	39.4	63.2	71.7	100	100	100	100	100	100
PO-AC	1/30/14 1:17	193	165	100	718	885	0.30	3.03	8.44	17.2	32.4	51.6	58.9	94.6	97.4	100	100	100	100
PI-FF	2/8/14 9:15	196	463	165	2,044	1,132	0.81	8.18	21.7	40.1	66.7	84.1	88.8	100	100	100	100	100	100
PI-AC	2/8/14 11:20	92	107	54	1,135	532	0.48	4.53	12.0	22.8	41.3	59.2	66.5	95.8	99.3	100	100	100	100
PI-AC	2/9/14 5:41	53	47	31	632	296	0.42	4.23	11.4	22.3	40.8	59.6	66.1	92.4	94.7	100	100	100	100
PO-FF	2/8/14 9:28	32	22	15	1,488	344	0.27	2.68	6.88	13.6	27.7	44.8	51.1	85.1	91.4	100	100	100	100
PO-AC	2/8/14 12:04	79	106	57	572	516	0.57	5.86	16.0	30.7	53.0	72.7	79.3	100	100	100	100	100	100
PO-AC	2/9/14 7:56	40	46	27	499	226	0.69	5.40	14.0	26.3	48.9	67.3	74.0	98.2	99.3	100	100	100	100
PI-FF	7/18/14 17:04	914	600	348	5,406	2,262	0.21	1.99	4.97	10.3	21.5	38.1	44.9	78.2	90.0	99.0	100	100	100
PI-AC	7/18/14 17:15	1,243	1,400	663	14,193	4,341	0.29	2.87	7.47	15.8	31.8	53.3	61.3	92.9	100	100	100	100	100
PI-AC	7/18/14 17:33	543	927	376	4,211	2,763	0.42	4.14	10.9	23.2	45.7	69.2	77.4	99.0	100	100	100	100	100
PO-FF	7/18/14 17:21	222	177	132	4,060	988	0.34	3.32	8.64	17.5	35.5	59.4	68.9	99.3	100	100	100	100	100
PO-AC	7/18/14 17:29	304	328	174	1,967	1,440	0.32	3.05	7.79	16.5	33.8	57.3	66.2	98.1	100	100	100	100	100
PO-AC	7/18/14 17:40	540	732	324	4,564	2,151	0.30	3.12	8.82	18.2	37.2	60.0	68.7	95.3	98.5	100	100	100	100
PI-FF	7/20/14 14:16	463	343	200	3,044	1,477	0.25	2.39	6.01	12.5	25.3	43.3	50.6	85.4	94.0	100	100	100	100
PI-AC	7/20/14 14:35	403	735	260	2,108	1,941	0.57	5.47	13.5	25.5	45.1	64.6	71.8	97.4	100	100	100	100	100
PI-AC	7/20/14 15:39	373	829	273	2,417	2,064	0.83	8.00	19.4	34.3	56.0	73.2	79.8	99.6	100	100	100	100	100
PO-FF	7/20/14 14:36	314	293	166	2,249	1,365	0.35	3.37	8.41	16.8	32.5	53.0	61.3	94.7	99.5	100	100	100	100
PO-AC	7/20/14 14:41	314	536	228	2,182	1,390	0.71	5.97	14.9	27.9	52.8	72.6	82.3	99.6	100	100	100	100	100
PO-AC	7/20/14 15:42	394	784	291	1,112	1,885	0.86	7.95	19.2	33.5	56.2	73.9	81.9	99.4	100	100	100	100	100

Table A2b: Raw analytical data for samples taken at the inflow and outflow of the Pasadena Stormfilter in WY15 (the outflow is also the catchment outfall).

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
PI-FF	2/6/15 19:16	218	315	135	888	1,078	0.50	4.68	12.3	23.9	43.8	63.8	71.6	96.8	100	100	100	100	100
PI-AC	2/6/15 19:36	89	105	61	889	610	0.52	5.22	14.1	28.9	51.0	72.3	79.7	100	100	100	100	100	100
PO-FF	2/6/15 19:29	128	97	56	1,497	662	0.28	2.73	6.97	14.0	26.8	44.5	51.6	85.9	98.7	100	100	100	100
PO-AC	2/6/15 19:49	82	135	57	1,692	588	0.74	5.80	15.1	28.8	55.7	75.4	85.8	100	100	100	100	100	100
PI-FF	2/8/15 13:11	103	163	61	1,432	511	0.59	4.91	12.3	21.7	41.6	61.9	70.9	97.6	100	100	100	100	100
PI-AC	2/8/15 13:49	62	96	43	728	418	0.52	5.18	13.9	28.4	50.1	71.6	78.9	100	100	100	100	100	100
PO-FF	2/8/15 13:23	213	144	87	961	901	0.31	2.81	7.38	13.8	26.4	41.2	48.3	81.5	93.8	100	100	100	100
PO-AC	2/8/15 14:03	48	72	35	649	368	0.58	5.46	14.8	29.2	53.0	75.4	83.7	100	100	100	100	100	100
PI-FF	4/25/15 9:45	51	41	34	1,233	302	0.54	4.82	13.3	24.1	45.6	67.2	75.0	94.2	100	100	100	100	100
PI-AC	4/25/15 10:30	65	66	46	923	445	0.51	5.14	13.9	28.0	48.8	72.1	79.8	100	100	100	100	100	100
PO-FF	4/25/15 10:12	76	54	38	1,443	564	0.39	3.38	8.99	16.5	32.1	49.5	56.9	88.5	99.8	100	100	100	100
PO-AC	4/25/15 10:47	61	65	52	841	452	0.71	6.17	17.1	32.1	59.3	84.7	91.9	100	100	100	100	100	100
PI-FF	7/8/15 11:36	478	205	131	2,184	982	0.18	1.68	4.27	8.82	16.8	27.5	32.0	60.4	81.2	92.9	98.8	100	100
PI-AC	7/8/15 11:46	421	366	157	5,186	1,601	0.25	2.39	6.03	12.2	23.2	37.4	43.0	73.9	96.1	100	100	100	100
PO-FF	7/8/15 11:49	243	162	88	2,620	1,122	0.24	2.31	5.73	11.2	21.3	36.4	42.2	74.1	96.9	100	100	100	100
PO-AC	7/8/15 11:56	262	330	113	3,053	1,380	0.30	2.82	7.28	14.3	27.7	43.3	49.0	80.0	100	100	100	100	100

Table A2c: Raw analytical data for samples taken at the inflow and outflow of the Pasadena Stormfilter in WY16 (the outflow is also the catchment outfall).

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
PI-FF	10/3/15 22:12	213	59	64	2,896	1,442	0.13	1.3	3.93	8.18	21	31	35.3	57.2	69	80	89	100	100
PI-AC	10/3/15 22:26	87	56	4	2,999	1,335	0.38	2.9	8.08	16.8	48.9	69.2	77.3	99.9	100	100	100	100	100
PO-FF	10/3/15 22:21	172	71	67	12,784	2,217	0.31	2.93	7.12	13.6	25.3	41	47.6	80.7	100	100	100	100	100
PO-AC	10/3/15 22:32	81	55	57	2,938	1,407	0.50	3.81	10.4	20.8	51.1	73.7	80.4	100	100	100	100	100	100
PI-FF	12/10/15 5:15	73	116	64	649	102	3.03	19.9	40.2	65.8	100	100	100	100	100	100	100	100	100
PI-AC	12/10/15 6:32	87	140	69	2,471	161	0.81	6.64	17.5	32	59.7	83.8	91.2	100	100	100	100	100	100
PO-FF	12/10/15 7:11	100	160	95	2,915	127	0.74	7.61	21.1	41.8	74.1	97.1	99.7	100	100	100	100	100	100
PO-AC	12/10/15 7:20	88	160	64	2,843	143	0.59	5.73	15.1	29.5	52.4	76.2	83.8	96.3	100	100	100	100	100
PI-AC	3/4/16 16:21	189	274	150	228	1,011	0.60	5.92	15.4	30.5	53.8	80.8	89.7	100	100	100	100	100	100
PO-AC	3/4/16 17:09	123	141	104	1,293	692	0.73	7.15	18.4	35.3	61	87	93.7	100	100	100	100	100	100
PI-AC	3/5/16 19:16	133	142	124	1,303	648	0.78	7.93	21.3	41.2	75.1	94.6	98.6	100	100	100	100	100	100
PO-AC	3/5/16 20:26	109	122	109	1,395	573	2.05	13.6	29.9	54	99	100	100	100	100	100	100	100	100
PI-AC	4/9/16 12:47	144	202	102	1,530	715	0.48	4.52	12.6	23.7	46.4	72	82.3	100	100	100	100	100	100
PO-AC	4/9/16 13:13	124	178	97	1,658	650	0.55	5.14	14.9	28.7	54.9	80.6	89.5	100	100	100	100	100	100

Table A3a: Raw analytical data for samples taken at inflow to the Rubicon Stormtech chambers in WY14. Composite sample on 1/29/14 at 19:10 was too clear for PSD analysis. The outflow from the Rubicon Stormtech chambers (also the catchment outfall) never flowed, thus no samples were possible.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
RI-FF	1/29/14 12:33	338	351	148	1,545	1,654	0.29	2.94	7.83	14.6	26.5	43.7	51.0	87.8	95.2	100	100	100	100
RI-AC	1/29/14 13:03	53	33	35	433	324	0.65	5.42	12.9	24.9	43.3	66.1	72.2	99.7	100	100	100	100	100
RI-AC	1/29/14 19:10	4	4	na	168	9	na	na	na	na	na	na	na	na	na	na	na	na	na
RI-FF	2/8/14 2:59	6	14	2	309	91	0.90	6.20	9.60	17.6	26.3	40.9	42.1	65.4	97.5	100	100	100	100
RI-AC	2/8/14 9:04	29	14	10	323	93	0.53	3.51	6.57	12.3	22.2	34.0	40.0	72.5	84.4	100	100	100	100
RI-AC	2/9/14 14:06	31	15	14	25	105	0.66	4.24	7.50	14.4	26.8	44.5	52.9	92.6	97.9	100	100	100	100
RI-FF	3/25/14 20:21	139	107	81	1,097	538	0.41	4.20	11.5	22.5	41.5	58.5	64.1	86.4	91.8	98.7	100	100	100
RI-AC	3/25/14 22:16	15	14	12	429	142	1.08	7.44	18.2	34.0	62.5	78.2	81.1	100	100	100	100	100	100
RI-AC	3/26/14 10:02	18	26	17	396	159	1.78	12.0	28.2	51.2	82.8	93.9	98.1	100	100	100	100	100	100
RI-FF	7/17/14 14:42	1,684	707	564	15,995	2,751	0.20	1.95	5.36	11.9	22.5	33.5	38.0	67.1	83.3	93.5	98.4	100	100
RI-AC	7/17/14 14:50	666	287	188	5,375	1,823	0.16	1.56	4.14	8.82	16.9	28.3	33.4	70.4	92.6	100	100	100	100
RI-AC	7/17/14 15:12	181	85	50	4,499	2,330	0.19	1.86	4.74	9.89	18.6	27.7	31.6	59.9	73.7	86.0	93.4	100	100

Table A3b: Raw analytical data for samples taken at inflow to the Rubicon Stormtech chambers in WY15. Composite sample on 4/24/15 at 1:07 was too clear for PSD analysis. The outflow from the Rubicon Stormtech chambers (also the catchment outfall) never flowed, thus no samples were possible.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
RI-FF	10/25/14 11:52	90	52	33	2,594	469	0.28	2.52	6.78	13.7	27.1	39.2	45.9	73.9	86.9	98.2	100	100	100
RI-AC	10/25/14 12:15	37	13	6	1,510	215	0.15	1.31	2.98	6.06	12.5	19.5	23.5	43.2	60.5	79.1	96.8	100	100
RI-FF	4/23/15 21:28	455	186	150	1,562	1,149	0.23	2.29	5.83	11.2	20.3	33.0	38.4	68.4	87.6	99.3	100	100	100
RI-AC	4/24/15 1:07	25	10	na	661	139	na	na	na	na	na	na	na	na	na	na	na	na	na
RI-FF	6/10/15 1:14	156	120	38	2,706	209	0.19	1.86	4.92	9.81	16.9	24.5	27.2	53.9	82.7	93.3	98.9	100	100
RI-AC	6/10/15 1:57	73	42	24	1,199	263	0.28	2.8	7.24	13.6	22.9	34.1	39.0	60.7	83.5	97.9	100	100	100

Table A4a: EMCs for samples taken at the inflow and outflow of the SR431 Contech MFS vault in WY14.

Event ID	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
CI-14-01	1/29/14 12:05	396	283	269	2,078	670	0.45	5.08	13.8	25.7	45.3	65.5	83.5	92.8	98.5	100	100	100	100
CO-14-01	1/29/14 12:20	209	236	182	1,672	419	0.58	6.62	18.4	34.2	58.4	79.4	95.0	100	100	100	100	100	100
CI-14-02	3/5/14 6:15	1,330	638	744	3,420	2,180	0.36	4.03	11.1	21.4	38.5	55.3	72.5	88.4	94.5	100	100	100	100
CO-14-02	3/5/14 6:25	356	249	286	1,394	740	0.71	6.52	18.4	34.2	61.3	77.3	92.1	100	100	100	100	100	100
CI-14-03	3/29/14 8:40	771	539	514	2,882	1,383	0.45	5.34	15.5	29.2	48.5	62.3	75.9	89.5	96.3	100	100	100	100
CO-14-03	3/29/14 9:20	366	359	322	1,924	844	0.80	7.60	20.7	38.5	65.1	80.9	94.4	100	100	100	100	100	100
CI-14-04	5/10/14 13:40	641	240	458	1,702	1,210	0.48	5.11	14.7	29.1	52.5	69.8	86.3	99.0	100	100	100	100	100
CO-14-04	5/10/14 13:55	439	224	332	1,554	970	0.46	4.98	14.0	27.7	51.7	72.6	90.3	100	100	100	100	100	100
CI-14-05	5/19/14 18:55	241	148	186	1,242	525	0.63	5.94	16.7	31.0	56.7	71.4	87.7	99.7	100	100	100	100	100
CO-14-05	5/19/14 18:55	126	104	115	1,124	319	0.62	6.99	19.4	36.7	61.9	79.6	93.3	100	100	100	100	100	100
CI-14-06	7/16/14 19:55	595	182	311	2,791	940	0.32	3.44	9.0	17.8	33.3	51.3	70.2	88.4	95.3	100	100	100	100
CO-14-06	7/16/14 19:55	323	146	208	2,645	765	0.40	4.33	11.7	23.4	43.8	63.1	81.1	94.9	98.0	100	100	100	100
CI-14-07	8/4/14 7:25	69	44	40	1,176	160	0.11	3.82	10.2	20.4	34.7	50.8	62.6	73.6	83.1	96.5	100	100	100
CO-14-07	7/16/14 19:55	39	33	31	1,520	125	0.52	6.00	14.9	29.3	47.8	65.8	76.1	82.6	89.6	98.4	100	100	100
CI-14-08	9/26/14 8:00	88	53	51	2,506	270	0.00	3.18	8.8	18.4	33.5	52.9	68.9	83.0	92.7	98.9	100	100	100
CO-14-08	9/26/14 8:05	69	46	49	2,679	220	0.10	4.32	11.6	24.1	44.3	69.8	86.3	95.5	99.2	100	100	100	100

Table A4b: Raw analytical data for samples taken at the inflow and outflow of the SR431 Contech MFS vault in WY15.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
CI-AC	10/31/14 21:11	93	75	76	3,150	293	0.33	5.72	14.9	29.1	49.5	72.1	79.5	93.6	97.9	99.9	100	100	100
CO-AC	10/31/14 21:25	72	55	59	2,200	233	0.35	5.68	14.8	29.2	49.8	72.3	79.4	92.5	97.9	100	100	100	100
CI-AC	12/2/14 11:34	174	128	141	730	424	1.64	8.38	19.0	34.4	55.4	76.4	82.8	95.2	98.8	99.9	100	100	100
CO-AC	12/2/14 11:51	131	118	121	820	328	2.33	10.0	22.6	40.7	64.1	84.9	90.4	98.3	100	100	100	100	100
CI-AC	2/7/15 0:42	562	383	402	1,270	1,330	1.90	8.11	17.7	31.0	49.5	69.6	76.3	93.0	98.7	100	100	100	100
CO-AC	2/7/15 0:57	409	324	342	1,190	1,006	2.82	10.1	21.5	37.4	58.7	79.7	86.1	97.7	99.9	100	100	100	100
CI-AC	4/23/15 16:08	435	279	332	1,260	1,101	1.52	7.88	17.9	32.0	52.0	73.2	79.8	94.5	99.0	100	100	100	100
CO-AC	4/23/15 16:14	302	221	275	1,170	812	2.60	10.5	23.5	41.7	65.4	86.4	91.4	98.4	99.6	100	100	100	100
CI-FF	5/6/15 16:22	875	445	338	4,887	305	0.33	3.27	8.83	17.4	28.3	39.0	42.6	71.2	83.7	97.7	100	100	100
CI-AC	5/7/15 7:12	367	320	316	950	123	0.66	6.75	18.6	36.6	62.4	88.8	96.8	100	100	100	100	100	100
CO-FF	5/6/15 16:48	173	161	157	1,395	80	0.86	9.33	28.0	54.9	91.6	100	100	100	100	100	100	100	100
CO-AC	5/7/15 21:59	258	188	240	481	92	0.80	8.09	21.9	42.9	72.0	97.5	99.9	100	100	100	100	100	100
CI-FF	5/14/15 16:01	212	193	196	3,538	852	1.29	11.5	29.5	53.5	89.6	100	100	100	100	100	100	100	100
CI-AC	5/14/15 16:31	179	201	168	792	659	1.94	13.5	31.6	52.9	88.3	100	100	100	100	100	100	100	100
CO-FF	5/14/15 16:33	143	88	130	1,266	584	1.13	8.81	22.8	39.8	71.8	94.4	98.9	100	100	100	100	100	100
CO-AC	5/14/15 17:12	161	192	150	1,382	650	2.13	14.7	34.1	56.7	92.2	100	100	100	100	100	100	100	100
CI-AC	5/22/15 11:29	275	217	211	1,020	856	0.66	6.39	18.9	32.9	59.0	81.8	91.4	100	100	100	100	100	100
CO-AC	5/22/15 11:43	177	168	160	734	665	1.83	12.5	28.7	49.3	87.5	100	100	100	100	100	100	100	100
CI-AC	6/9/15 19:37	80	59	78	891	153	4.51	25.8	47.7	69.1	95.3	100	100	100	100	100	100	100	100
CO-AC	6/9/15 20:01	54	38	49	1,437	212	1.83	12.7	30.1	53.2	88.1	96.9	99.6	100	100	100	100	100	100

Table A4c: Raw analytical data for samples taken at the inflow and outflow of the SR431 Contech MFS vault in WY16.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
CI-AC	10/1/15 0:29	361	130	199	893	1,417	0.41	4.07	10.4	20	35.3	55.7	63.7	95.3	100	100	100	100	100
CO-AC	10/1/15 6:12	217	100	154	1,139	1,222	0.55	5.47	14.3	27.7	48.7	72.8	82.6	100	100	100	100	100	100
CI-FF	11/1/15 12:43	76	61	72	4,303	610	2.31	15.5	33.6	57.1	99.4	100	100	100	100	100	100	100	100
CI-AC	11/1/15 18:45	45	25	42	801	184	7.08	41.3	83.7	100	100	100	100	100	100	100	100	100	100
CO-AC	11/1/15 18:59	24	22	20	839	130	7.16	42.7	84.6	100	100	100	100	100	100	100	100	100	100
CI-AC	12/10/15 4:24	775	983	728	3,124	1,651	0.91	9.18	24.3	45	72.7	95.6	99.6	100	100	100	100	100	100
CO-AC	12/10/15 4:41	613	892	12	1,681	1,507	0.91	9.79	27.9	51.7	86	99.9	100	100	100	100	100	100	100
CI-AC	1/29/16 6:25	1,140	1,006	1,110	1,728	1,651	1.05	10.9	29.1	50.8	86.9	100	100	100	100	100	100	100	100
CO-AC	1/29/16 9:11	980	948	951	1,504	1,624	1.03	10.4	27.1	47.9	80.5	99.9	100	100	100	100	100	100	100
CI-AC	3/4/16 15:47	3,254	2,980	3,244	2,830	6,424	0.91	9.79	27.6	50.6	87.6	100	100	100	100	100	100	100	100
CO-AC	3/4/16 16:12	1,719	1,983	1,397	2,655	2,867	0.69	6.97	18.4	34.1	58.1	81.9	88.2	100	100	100	100	100	100
CI-AC	5/5/16 4:55	389	394	379	2118	1,379	0.82	8.722	24.8	47.8	85.7	100	100	100	100	100	100	100	100
CO-AC	5/5/16 5:33	317	330	308	1886	1219	0.80	8.7	25.3	49.1	86.5	100	100	100	100	100	100	100	100

Table A5a: EMCs for samples taken at the inflow and outflow of the SR431 Jellyfish vault in WY14.

Event ID	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
JI-14-01	1/29/14 12:05	711	519	442	1,936	1,056	0.38	4.47	12.7	24.1	42.5	60.6	77.8	89.2	97	100	100	100	100
JO-14-01	1/29/14 12:15	135	104	109	1,109	300	0.52	6.01	16.8	31.7	54.6	75.3	92.8	100.0	100	100	100	100	100
JI-14-02	3/5/14 6:15	1,191	604	681	3,598	2,180	0.37	4.13	11.2	21.6	38.9	56.6	74.7	90.3	95	100	100	100	100
JO-14-02	3/5/14 6:55	462	311	345	1,511	970	0.61	5.80	16.5	30.6	55.8	72.1	88.9	100.0	100	100	100	100	100
JI-14-03	3/29/14 8:45	883	592	511	2,891	1,598	0.41	4.74	13.3	25.1	42.6	56.2	70.5	84.5	93	100	100	100	100
JO-14-03	3/29/14 9:10	206	213	196	1,315	465	0.78	8.54	24.2	44.3	71.1	84.8	95.7	100.0	100	100	100	100	100
JI-14-04	5/10/14 13:40	873	341	605	2,404	1,790	0.42	4.50	12.9	26.0	48.5	67.9	84.6	98.7	100	100	100	100	100
JO-14-04	5/10/14 14:00	593	248	442	1,753	1,220	0.42	4.69	13.6	27.6	51.4	72.8	91.7	100.0	100	100	100	100	100
JI-14-05	5/19/14 18:55	355	243	309	2,366	950	0.57	6.60	18.6	35.9	61.2	80.1	93.2	100	100	100	100	100	100
JO-14-05	5/19/14 18:55	177	131	174	1,293	480	0.63	7.24	20.2	38.1	63.0	79.9	93.1	100.0	100	100	100	100	100
JI-14-06	7/16/14 19:55	446	154	244	2,988	910	0.33	3.53	9.4	18.6	35.4	53.4	72.9	91.7	97	100	100	100	100
JO-14-06	7/16/14 19:55	363	121	210	2,920	802	0.34	3.53	9.7	19.0	37.1	56.0	76.3	93.0	97	100	100	100	100
JI-14-07	8/4/14 7:25	61	42	37	1,336	145	0.24	4.14	10.6	21.3	36.3	53.3	65.7	76.7	86	98	100	100	100
JO-14-07	8/4/14 7:50	29	29	25	1,143	109	0.73	6.17	14.4	26.9	45.8	67.1	81.9	92.0	98	100	100	100	100
JI-14-08	9/26/14 8:00	88	47	48	2,094	240	0.00	3.01	8.3	17.5	32.4	51.7	67.8	81.8	91	98	100	100	100
JO-14-08	9/26/14 8:10	54	35	39	2,111	180	0.05	3.96	10.8	23.1	41.3	65.1	82.7	93.7	99	100	100	100	100

Table A5b: Raw analytical data for samples taken at the inflow and outflow of the SR431 Jellyfish vault in WY15.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
JI-AC	10/31/14 21:11	106	74	76	4,080	299	0.26	5.22	13.4	25.8	44.1	65.2	72.9	90.2	96.6	99.7	100	100	100
JO-AC	10/31/14 21:22	33	35	27	1,220	172	0.13	4.62	12.5	27.1	47.8	70.5	78.7	94.3	98.8	100	100	100	100
JI-AC	12/2/14 11:34	192	130	149	850	445	1.60	8.10	18.2	32.8	52.9	73.7	80.3	94.4	98.6	99.9	100	100	100
JO-AC	12/2/14 11:40	129	102	114	860	312	1.48	8.37	19.7	36.8	60.2	82.1	88.2	97.4	99.8	100	100	100	100
JI-AC	2/7/15 0:41	579	352	405	1,110	1,275	1.90	8.03	17.4	30.3	48.3	67.9	74.5	92.2	98.4	100	100	100	100
JO-AC	2/7/15 0:49	424	290	342	900	1,015	2.70	9.66	20.5	35.4	55.7	76.6	83.3	96.8	99.7	100	100	100	100
JI-AC	4/23/15 16:08	516	328	394	1,350	1,322	1.35	7.42	17.1	31.4	52.3	74.1	80.6	94.6	98.2	99.9	100	100	100
JO-AC	4/23/15 16:11	317	203	264	1,170	792	1.61	8.35	19.3	35.4	57.9	79.8	85.9	97.2	99.6	100	100	100	100
JI-FF	5/6/15 16:22	684	398	541	5,479	121	0.56	5.76	16.1	33.1	56.8	80.3	90.8	100	100	100	100	100	100
JI-AC	5/6/15 16:54	343	245	253	706	56	1.05	8.03	17.5	33.5	61.2	76.7	82.7	100	100	100	100	100	100
JO-FF	5/6/15 16:28	209	283	131	794	29	4.97	37.9	73.9	100	100	100	100	100	100	100	100	100	100
JO-AC	5/7/15 7:18	301	214	244	891	48	0.63	6.54	18.3	36.3	60.9	84.2	91.7	100	100	100	100	100	100
JI-FF	5/14/15 16:01	205	185	190	2,815	1,009	2.02	13.5	30.4	52.1	92.6	100	100	100	100	100	100	100	100
JI-AC	5/14/15 16:29	176	179	167	1,123	659	2.15	14.5	33.0	55.1	91.7	100	100	100	100	100	100	100	100
JO-FF	5/14/15 16:07	100	125	65	1,303	342	4.32	29.9	55.5	80.9	100	100	100	100	100	100	100	100	100
JO-AC	5/14/15 16:36	126	142	114	1,294	521	2.18	15.0	33.7	56.2	94.6	100	100	100	100	100	100	100	100
JI-AC	5/22/15 11:29	272	209	196	531	906	0.63	6.32	16.8	31.9	53.1	76.3	84.5	100	100	100	100	100	100
JO-AC	5/22/15 11:32	220	189	202	502	806	1.54	10.9	26.4	46.5	82.7	100	100	100	100	100	100	100	100
JI-AC	6/9/15 19:37	77	49	73	988	153	2.14	14.5	32.9	58.7	99.9	100	100	100	100	100	100	100	100
JO-AC	6/9/15 19:45	56	42	52	1,153	214	2.23	14.8	33.8	59.3	99.9	100	100	100	100	100	100	100	100

Table A5c: Raw analytical data for samples taken at the inflow and outflow of the SR431 Jellyfish vault in WY16. In all cases where FSP is not available, samples were too clear for PSD analysis.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
JI-AC	10/1/15 0:27	303	129	173	722	1,433	0.43	4.24	10.9	20.8	37	58	65.6	95.6	100	100	100	100	100
JO-AC	10/1/15 0:30	177	61	127	1,049	1,048	0.59	5.8	14.9	27.9	48.2	73.5	82.4	95.6	100	100	100	100	100
JI-FF	11/1/15 12:45	76	68	72	3,357	351	1.19	11.8	34.3	63.4	99.9	100	100	100	100	100	100	100	100
JI-AC	11/1/15 18:45	44	28	42	1,170	191	6.80	39.9	83.6	100	100	100	100	100	100	100	100	100	100
JO-FF	11/1/15 12:46	17	15	na	1,815	311	na	na	na	na	na	na	na	na	na	na	na	na	na
JO-AC	11/1/15 18:48	13	10	na	541	72	na	na	na	na	na	na	na	na	na	na	na	na	na
JI-AC	12/10/15 4:22	731	988	717	2,886	1,663	0.95	10.1	28.7	53.3	89.1	100	100	100	100	100	100	100	100
JO-AC	12/10/15 4:38	431	645	419	1,173	969	0.94	10.3	30.1	55.9	90.4	100	100	100	100	100	100	100	100
JI-AC	1/29/16 5:52	1,153	1,036	1,126	1,346	1,862	2.00	13.9	31.3	50.7	89.7	100	100	100	100	100	100	100	100
JO-AC	1/29/16 5:59	845	846	825	1,405	1,461	1.03	10.4	26.4	47	77.9	99.9	100	100	100	100	100	100	100
JI-AC	3/4/16 15:47	2,677	2,343	2,666	4,467	3,873	0.98	10.5	29.7	55.4	95.5	100	100	100	100	100	100	100	100
JO-AC	3/4/16 15:50	1,354	1,478	1,341	3,233	4,913	1.94	13.5	31.8	54.8	96.8	100	100	100	100	100	100	100	100
JI-AC	5/5/16 4:55	413	373	396	1776	1,379	0.83	8.59	23.6	45.7	80.1	99.9	100	100	100	100	100	100	100
JO-AC	5/5/16 5:01	306	35	297	1715	1,105	1.28	10.1	26.3	48.3	87.4	100	100	100	100	100	100	100	100

Table A6a: Raw analytical data for samples taken at the SR431 catchment outfall in WY14. Nutrient analysis was not completed for 5/10/14 samples (samples not delivered to the analytical lab within adequate holding times).

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
S5-FF	1/29/14 15:22	200	239	140	1,221	850	0.50	5.18	14.4	27.6	49.0	69.9	76.2	97.0	99.7	100	100	100	100
S5-AS	1/29/14 16:27	93	139	62	718	44	0.50	5.21	14.5	27.7	48.1	66.8	72.5	93.2	99.6	100	100	100	100
S5-AS	3/6/14 0:52	440	538	352	2,159	886	0.31	3.70	12.9	30.0	56.3	80.1	86.8	100	100	100	100	100	100
S5-AS	3/6/14 1:14	405	504	303	1,500	940	0.52	5.37	14.9	30.1	53.8	74.8	81.4	100	100	100	100	100	100
S5-FF	5/10/14 13:57	257	198	179	na	na	0.66	5.46	15.5	29.4	53.9	69.8	78.6	99.5	100	100	100	100	100
S5-AC	5/10/14 14:15	281	243	205	na	na	0.53	5.18	14.8	29.6	53.9	72.8	80.6	99.4	100	100	100	100	100
S5-FF	5/20/14 6:54	166	180	132	932	678	0.83	7.09	20.4	36.6	63.7	79.5	87.3	100	100	100	100	100	100
S5-AC	5/20/14 8:59	97	108	87	1,369	105	0.98	8.70	24.7	45.4	77.3	90.2	96.9	100	100	100	100	100	100
S5-AC	5/20/14 14:15	110	106	87	575	433	0.78	6.63	19.1	34.9	64.1	79.0	88.3	100	100	100	100	100	100
S5-FF	7/16/14 19:57	1,369	568	661	3,527	2,763	0.30	2.91	7.13	14.1	28.2	48.3	56.4	91.8	97.4	100	100	100	100
S5-AC	7/16/14 19:59	800	499	435	2,103	2,442	0.34	3.31	8.21	16.3	32.3	54.4	62.9	96.6	100	100	100	100	100
S5-FF	7/20/14 14:31	363	152	182	2,070	1,075	0.35	3.35	8.36	16.1	30.6	50.2	58.2	94.9	98.2	100	100	100	100
S5-AC	7/20/14 14:36	594	195	277	1,761	1,186	0.32	3.12	7.68	14.6	27.6	46.7	54.8	92.8	97.2	100	100	100	100
S5-FF	9/28/14 9:56	146	88	67	1,240	510	0.34	3.30	8.38	16.7	30.5	46.0	52.3	85.2	91.8	100	100	100	100
S5-AC	9/28/14 10:02	73	52	48	413	125	0.62	4.93	13.5	26.0	50.2	66.2	75.8	93.3	100	100	100	100	100

Table A6b: Raw analytical data for samples taken at the SR431 catchment outfall in WY15. No value is available for TP on 4/23/15 at 15:54 because the sample was contaminated.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
S5-FF	11/22/14 5:56	245	146	158	1,435	714	0.59	5.81	14.7	26.7	45.9	67.8	76.0	100	100	100	100	100	100
S5-AC	11/22/14 6:06	176	148	125	982	600	0.63	6.05	16.6	31.4	54.4	75.9	83.4	100	100	100	100	100	100
S5-FF	12/2/14 11:23	103	125	84	3,255	421	1.11	9.65	23.8	39.5	66.4	88.7	95.5	100	100	100	100	100	100
S5-AC	12/2/14 12:23	120	119	102	1,385	463	1.05	8.10	20.5	36.9	67.8	89.3	96.7	100	100	100	100	100	100
S5-FF	3/22/15 19:48	627	466	418	2,760	1,986	0.50	5.02	13.1	25.0	44.1	67.4	76.1	99.9	100	100	100	100	100
S5-AC	3/22/15 20:00	1,131	876	833	3,127	3,538	0.54	5.49	14.9	29.1	50.9	74.0	81.2	100	100	100	100	100	100
S5-FF	4/23/15 15:54	948	830	713	1,313	na	0.65	5.96	16.3	29.3	53.4	75.9	83.6	100	100	100	100	100	100
S5-AC	4/23/15 16:01	328	358	314	1,705	1,202	0.81	7.95	22.8	43.6	75.5	97.9	99.9	100	100	100	100	100	100
S5-FF	5/8/15 18:20	82	66	73	792	3,272	0.86	8.90	25.0	47.9	75.1	95.6	99.6	100	100	100	100	100	100
S5-AC	5/8/15 18:26	122	92	115	860	49	0.67	7.18	21.0	42.2	72.7	97.1	99.7	100	100	100	100	100	100
S5-AC	5/14/15 16:01	131	92	126	802	556	1.63	11.6	28.1	49.7	87.7	100	100	100	100	100	100	100	100
S5-FF	7/4/15 10:02	1,069	373	409	2,796	2,623	0.30	2.86	6.83	11.7	21.5	38.3	45.6	81.0	100	100	100	100	100
S5-AC	7/4/15 10:03	375	200	319	4,214	1,141	4.11	23.3	42.7	60.3	78.1	85.7	89.2	100	100	100	100	100	100

Table A7a: Raw analytical data for samples taken at the Tahoma catchment outfall in WY14. In all cases where FSP is not available, samples were too clear for PSD analysis.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
TA-AC	1/11/14 13:55	274	944	213	4,504	1	0.96	9.69	24.8	40.6	61.3	77.7	83.2	100	100	100	100	100	100
TA-AC	1/11/14 15:18	655	835	519	3,167	1,829	0.85	8.64	22.8	39.3	62.0	79.3	84.2	100	100	100	100	100	100
TA-FF	1/29/14 9:17	195	336	68	2,536	1,013	0.26	2.50	5.98	10.6	19.6	35.1	42.6	89.3	96.3	100	100	100	100
TA-AC	1/29/14 10:56	356	456	175	1,324	170	0.37	3.69	9.31	17.1	30.7	49.1	56.9	94.8	99.1	100	100	100	100
TA-AC	1/29/14 19:17	117	85	35	1,536	545	0.21	2.12	5.50	10.1	18.5	30.2	34.8	69.9	82.5	92.3	97.1	100	100
TA-FF	2/8/14 1:52	422	886	373	1,950	1,935	1.35	13.4	33.1	51.8	75.6	88.4	93.1	100	100	100	100	100	100
TA-AC	2/8/14 7:12	153	137	96	405	611	0.59	5.43	13.9	24.8	43.6	62.8	70.5	99.4	100	100	100	100	100
TA-AC	2/8/14 23:49	53	38	26	188	210	0.36	3.73	10.1	18.0	32.2	49.0	54.7	88.4	95.9	100	100	100	100
TA-AC	2/9/14 13:10	36	30	20	58	136	0.82	5.49	11.0	20.9	37.1	54.9	58.6	89.7	94.5	100	100	100	100
TA-FF	3/5/14 23:29	358	573	251	2,110	720	0.64	6.42	16.4	29.4	50.2	70.2	77.6	100	100	100	100	100	100
TA-AC	3/6/14 0:43	625	595	376	1,196	1,957	0.46	4.55	11.8	22.1	39.7	60.2	68.0	98.4	99.4	100	100	100	100
TA-AC	3/6/14 2:11	74	82	53	439	410	0.65	6.54	17.2	31.3	52.6	71.0	77.0	99.6	100	100	100	100	100
TA-AC	3/14/14 16:33	8	12	na	350	65	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-AC	3/15/14 16:33	2	5	na	341	42	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-FF	3/29/14 3:02	226	323	162	1,299	914	0.80	6.94	17.8	31.3	55.2	71.8	80.5	100	100	100	100	100	100
TA-AC	3/29/14 6:37	202	314	150	1,720	870	0.78	7.06	18.3	33.2	57.7	74.2	81.6	100	100	100	100	100	100
TA-AC	3/29/14 9:29	296	341	204	1,159	1,064	0.61	5.45	14.7	26.8	49.7	69.0	78.0	99.9	100	100	100	100	100
TA-FF	3/30/14 2:48	9	10	na	628	55	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-AC	3/30/14 5:03	191	239	142	1,140	888	0.67	6.60	16.6	30.6	53	74.1	81.1	99.9	100	100	100	100	100
TA-AC	3/30/14 13:50	307	379	217	1,801	1,256	0.64	5.96	15.4	28.5	51.1	70.6	78.8	99.9	100	100	100	100	100
TA-AC	4/6/14 8:11	12	21	na	462	103	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-AC	4/7/14 10:10	6	13	na	315	72	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-FF	5/20/14 3:38	163	113	76	1,914	625	0.27	2.59	6.55	13.6	27.3	46.6	54.6	93.0	97.9	100	100	100	100
TA-AC	5/20/14 5:38	67	72	52	874	371	0.78	7.18	18.5	34.4	59.9	77.3	84.2	99.9	100	100	100	100	100
TA-AC	5/20/14 12:18	89	83	60	771	412	0.62	6.09	15.2	28.2	48.5	67.1	73.8	98.0	100	100	100	100	100
TA-AC	7/17/14 18:47	72	37	28	2,887	265	0.23	2.01	5.44	10.3	23.7	38.9	47.4	88.8	94.0	100	100	100	100
TA-FF	8/10/14 14:55	2,678	749	1,125	4,136	4,632	0.28	2.69	6.37	11.9	23.2	42.0	50.3	89.7	97.4	100	100	100	100
TA-AC	8/10/14 14:56	1,615	755	585	3,324	3,636	0.24	2.31	5.51	10.4	20.2	36.2	43.5	80.4	91.4	99.9	100	100	100
TA-AC	8/10/14 15:18	169	95	69	1,732	639	0.28	2.62	6.34	12.4	24.2	40.6	47.3	83.9	91.5	99.5	100	100	100

Table A7b: Raw analytical data for samples taken at the Tahoma catchment outfall in WY15. In all cases where FSP is not available, samples were too clear for PSD analysis.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
TA-FF	10/20/14 19:54	59	46	40	4,390	495	0.69	5.55	14.6	25.8	49.7	67.5	78.3	99.6	100	100	100	100	100
TA-AC	10/20/14 20:19	49	29	na	1,642	673	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-FF	10/25/14 12:21	88	53	19	2,050	523	0.15	1.52	3.90	7.49	14.1	21.6	24.5	42.1	49.0	66.1	85.4	99.9	100
TA-AC	10/25/14 12:32	80	35	21	1,424	486	0.20	1.81	4.21	8.42	16.7	26.8	31.3	61.2	71.0	89.1	99.0	100	100
TA-FF	11/13/14 3:00	74	57	42	552	240	0.45	3.14	7.77	16.4	39.5	57.3	68.8	96.8	100	100	100	100	100
TA-AC	11/13/14 4:04	48	37	18	796	330	0.51	3.38	7.51	13.3	27.8	38.0	47.1	75.6	93.5	99.3	100	100	100
TA-FF	11/22/14 4:28	76	144	61	1,228	418	2.29	15.9	30.6	47.7	82.3	90.4	94.0	100	100	100	100	100	100
TA-AC	11/22/14 5:27	87	57	43	457	437	0.44	4.22	10.5	20.0	35.5	53.7	61.2	94.4	99.8	100	100	100	100
TA-FF	2/6/15 14:54	4,074	6,664	2,302	14,721	7,893	0.49	4.79	11.9	21.7	37.6	56.5	63.9	91.6	98.4	100	100	100	100
TA-AC	2/6/15 18:43	275	270	163	301	966	0.58	5.08	13.3	23.3	42.2	60.6	68.7	96.3	100	100	100	100	100
TA-AC	2/7/15 12:02	54	57	29	563	200	0.96	6.21	11.8	18.8	38.3	53.2	62.0	91.9	95.4	100	100	100	100
TA-AC	3/2/15 12:30	16	19	na	338	91	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-AC	3/3/15 12:29	7	10	na	303	67	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-AC	3/22/15 18:44	112	119	94	1,828	428	0.79	7.97	21.1	39	64.5	88.6	94.0	100	100	100	100	100	100
TA-AC	4/8/15 9:25	117	122	105	1,731	358	1.25	10.1	26.0	45.1	78.2	94.8	98.5	100	100	100	100	100	100
TA-FF	4/23/15 21:34	239	252	224	2,368	1,022	1.52	11	25.6	44.6	80.0	98.2	100	100	100	100	100	100	100
TA-AC	4/24/15 0:06	152	109	116	714	689	0.63	5.65	15.6	28.0	52.1	76.6	85.2	100	100	100	100	100	100
TA-AC	4/25/15 9:05	81	90	75	681	296	7.03	41.5	83.2	100	100	100	100	100	100	100	100	100	100
TA-AC	4/26/15 9:05	22	20	na	402	102	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-FF	7/2/15 15:21	2,428	840	603	13,565	7,946	0.19	1.83	4.39	7.82	14.4	24.9	29.1	56.2	78.1	85.7	93.0	100	100
TA-AC	7/2/15 15:25	788	365	160	6,363	1,663	0.15	1.47	3.67	6.75	12.2	20.5	23.7	45.1	63.6	73.4	84.0	100	100
TA-AC	7/19/15 14:59	484	226	149	6,411	1,203	0.24	2.29	5.70	10.7	19.1	31.0	36.0	67.1	87.1	97.3	100	100	100
TA-AC	7/21/15 13:12	233	132	146	2,409	657	0.57	4.90	12.7	22.6	41.9	63.9	73.1	94.6	100	100	100	100	100

Table A7c: Raw analytical data for samples taken at the Tahoma catchment outfall in WY16. In all cases where FSP is not available, samples were too clear for PSD analysis.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
TA-AC	10/1/15 0:46	153	126	94	649	1,108	0.53	5.13	12.8	24.5	43.1	65.7	74.6	95.9	100	100	100	100	100
TA-AC	11/1/15 12:11	31	24	na	594	191	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-FF	12/9/15 18:32	36	55	na	1,392	150	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-AC	12/10/15 2:53	371	543	328	1,433	1,381	1.34	14	38	64.6	97.7	100	100	100	100	100	100	100	100
TA-AC	1/16/16 8:57	151	751	137	1,924	1,667	1.77	15	35.5	57.3	91.2	100	100	100	100	100	100	100	100
TA-AC	1/29/16 3:31	302	261	295	1,238	768	1.04	11	30.6	55.5	95.5	100	100	100	100	100	100	100	100
TA-AC	3/4/16 8:58	360	295	353	1,251	1,081	2.18	14.8	33	56.2	98.2	100	100	100	100	100	100	100	100
TA-AC	3/5/16 12:09	66	63	58	406	269	3.04	20.2	41.8	67.1	100	100	100	100	100	100	100	100	100
TA-AC	3/5/16 21:52	37	29	33	407	155	8.72	45.5	83.7	100	100	100	100	100	100	100	100	100	100
TA-AC	3/15/16 14:45	5	5	na	223	35	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-AC	3/16/16 14:45	4	4	na	209	37	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-AC	3/18/16 11:04	19	17	na	168	49	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-AC	3/19/16 11:04	16	14	na	226	38	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-AC	8/22/16 15:39	753	814	153	10027	2,868	0.13	1.33	3.44	6.35	11.6	20.5	24.2	48.6	65	79	87	97	100

Table A8a: Raw analytical data for samples taken at the Speedboat catchment outfall in WY15. Composite sample on 2/8/15 at 15:01 was too clear for PSD analysis

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
SB-FF	11/29/14 7:32	194	116	81	8,106	1,120	0.25	2.29	6.93	13.1	26.6	42.0	48.8	84.5	100	100	100	100	100
SB-AC	11/29/14 7:47	125	102	88	1,877	669	0.71	5.77	15.1	27.8	52.1	70.0	80.2	99.7	100	100	100	100	100
SB-FF	11/29/14 11:25	74	50	24	1,619	446	0.29	2.56	6.56	12.1	22.8	32.5	38.2	64.6	73.7	100	100	100	100
SB-AC	11/29/14 11:45	84	72	62	1,555	493	0.89	7.62	18.7	33.5	57.9	74.4	83.2	100	100	100	100	100	100
SB-FF	12/2/14 12:25	62	35	18	1,101	335	0.22	1.84	4.71	8.96	18.4	29.6	35.4	64.0	85.5	100	100	100	100
SB-AC	12/2/14 12:57	51	41	30	826	325	0.48	4.56	11.1	21.3	38.5	58.3	65.9	95.7	100	100	100	100	100
SB-FF	12/19/14 16:05	301	633	300	1,800	1477	1.21	13.1	37.0	63.5	91.9	100	100	100	100	100	100	100	100
SB-AC	12/19/14 17:23	125	222	125	1,129	671	1.29	13.8	38.5	65.4	95.1	100	100	100	100	100	100	100	100
SB-AC	2/6/15 15:11	198	158	136	1,474	677	0.77	5.77	14.1	26.1	48.5	68.8	79.4	100	100	100	100	100	100
SB-AC	2/8/15 15:01	63	49	na	732	301	na	na	na	na	na	na	na	na	na	na	na	na	na
SB-AC	5/8/15 17:57	375	245	236	2,825	1,110	0.42	4.16	10.8	21.3	39.4	63.4	71.8	96.9	100	100	100	100	100
SB-AC	5/14/15 15:05	36	28	29	1,097	231	8.14	46.0	87.9	100	100	100	100	100	100	100	100	100	100
SB-AC	5/21/15 12:06	154	127	137	1,759	542	0.75	6.91	19.9	35.7	64.9	92.6	98.9	100	100	100	100	100	100
SB-AC	5/22/15 14:22	76	59	61	1,175	307	2.9	17.9	40.2	56.1	74.2	88.5	94.8	100	100	100	100	100	100
SB-AC	6/9/15 19:38	84	61	57	3,101	407	3.77	20.1	34.8	45.3	56.3	72.0	78.1	99.9	100	100	100	100	100
SB-AC	8/7/15 14:54	207	113	88	4,614	764	0.32	3.04	7.96	14.9	27.7	43.7	49.8	83.2	99.6	100	100	100	100

Table A8b: Raw analytical data for samples taken at the Speedboat catchment outfall in WY16. Composite sample on 11/1/2015 at 21:38 was too clear for PSD analysis.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
SB-AC	10/1/15 14:12	103	52	46	2,388	459	0.32	2.81	7.08	13.8	27.8	46.8	54.7	87.5	98	100	100	100	100
SB-AC	11/1/15 21:38	33	23	na	738	187	na	na	na	na	na	na	na	na	na	na	na	na	na
SB-AC	12/21/15 8:15	132	184	117	1,173	601	1.05	11.2	32.3	58.9	94.3	100	100	100	100	100	100	100	100
SB-AC	1/15/16 14:18	171	322	153	1,274	861	1.66	17.4	47.9	73.8	99.98	100	100	100	100	100	100	100	100
SB-AC	1/16/16 12:11	307	610	279	1,765	1,355	1.35	14	37.1	63.9	97.4	100	100	100	100	100	100	100	100
SB-AC	3/4/16 16:19	403	410	381	2,395	1,321	1.16	8.84	22	38.3	70.7	96.6	99.7	100	100	100	100	100	100
SB-AC	3/5/16 19:43	137	123	127	837	518	2.12	14.3	32	56	99.1	100	100	100	100	100	100	100	100
SB-AC	3/6/16 10:52	174	253	153	869	689	2.64	17.6	37.5	61.4	99.5	100	100	100	100	100	100	100	100
SB-AC	3/22/16 8:38	61	69	51	562	240	3.26	21.2	44.6	73.1	100	100	100	100	100	100	100	100	100
SB-AC	4/9/16 18:01	327	233	306	1,617	847	0.98	7.93	20.4	36.6	68.4	94.6	98.9	100	100	100	100	100	100
SB-AC	8/22/16 13:13	996	425	234	26200	4,957	0.15	1.56	4.25	8.26	15	23.6	26.7	52.8	85	93	96	100	100

Table A9a: Raw analytical data for samples taken at the Tahoe Valley catchment outfall in WY15. In all cases where FSP is not available, samples were too clear for PSD analysis.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
TV-FF	11/22/14 6:35	297	189	139	1,913	666	0.34	3.35	8.47	16.4	29.8	47.5	54.7	88.4	99.3	100	100	100	100
TV-AC	11/22/14 7:22	106	146	83	1,220	542	1.61	11.9	26.9	44.6	74.7	88.7	93.8	100	100	100	100	100	100
TV-AC	12/3/14 11:25	40	80	na	685	269	na	na	na	na	na	na	na	na	na	na	na	na	na
TV-AC	12/4/14 6:06	27	62	na	885	199	na	na	na	na	na	na	na	na	na	na	na	na	na
TV-AC	2/6/15 18:32	116	119	83	1,185	291	0.96	6.46	14.1	25.8	50.7	71.9	82.8	100	100	100	100	100	100
TV-AC	2/7/15 14:36	37	71	na	613	181	na	na	na	na	na	na	na	na	na	na	na	na	na
TV-AC	4/25/15 9:49	51	65	na	1,331	233	na	na	na	na	na	na	na	na	na	na	na	na	na
TV-AC	7/8/15 11:22	546	180	143	2,976	664	0.24	2.27	5.60	10.3	17.7	26.4	29.6	45.0	59.8	74.4	89.7	100	100

Table A9b: Raw analytical data for samples taken at the Tahoe Valley catchment outfall in WY16. Composite sample on 3/14/16 at 9:38 was too clear for PSD analysis.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
TV-AC	11/2/15 7:06	47	53	35	975	262	4.38	29.6	61.1	74.9	82	90.2	94.1	100	100	100	100	100	100
TV-AC	12/10/15 5:47	133	214	122	1,385	660	1.20	13	37.8	66.2	98.3	100	100	100	100	100	100	100	100
TV-AC	12/21/15 15:18	38	66	27	762	223	7.36	46.6	85.5	100	100	100	100	100	100	100	100	100	100
TV-AC	1/19/16 11:05	97	151	78	850	402	2.11	20.5	52.2	88.9	100	100	100	100	100	100	100	100	100
TV-AC	1/29/16 9:11	78	108	70	744	337	2.66	17.5	36.9	60.2	99.7	100	100	100	100	100	100	100	100
TV-AC	3/4/16 16:24	97	123	88	1,145	461	2.78	18.3	37.6	64.2	100	100	100	100	100	100	100	100	100
TV-AC	3/5/16 20:34	62	71	53	750	316	1.58	12.9	33.1	55.4	92.6	99.6	100	100	100	100	100	100	100
TV-AC	3/14/16 9:38	24	29	na	598	114	na	na	na	na	na	na	na	na	na	na	na	na	na
TV-AC	3/15/16 11:22	13	10	8	880	76	11.80	57.3	87	100	100	100	100	100	100	100	100	100	100
TV-AC	3/16/16 11:22	10	7	3	867	69	4.18	20.8	35.3	43.8	54.8	72.3	79.9	99.99	100	100	100	100	100
TV-AC	4/9/16 11:42	88	186	84	1,127	336	2.58	16.9	36.3	64.2	100	100	100	100	100	100	100	100	100

Table A10a: Raw analytical data for samples taken at the Upper Truckee catchment outfall in WY15.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
UT-AC	11/22/14 6:34	417	341	354	1,349	1,001	1.18	9.35	22.8	40.1	68.9	87.7	95.4	100	100	100	100	100	100
UT-FF	12/2/14 12:41	349	430	259	2,016	1174	0.54	5.49	14.9	30.1	52.9	74.5	81.6	99.9	100	100	100	100	100
UT-AC	12/2/14 12:48	251	355	195	1,746	855	0.65	6.49	17.0	32.1	55.3	77.6	84.4	100	100	100	100	100	100
UT-FF	12/19/14 11:47	679	887	673	5,483	1305	1.13	10.9	30.0	53.5	86.3	99.2	100	100	100	100	100	100	100
UT-AC	12/19/14 12:03	959	1,244	908	4,098	2433	0.93	9.59	26.0	48.1	76.2	94.7	99.1	100	100	100	100	100	100
UT-AC	12/20/14 4:43	179	343	178	1,692	849	1.32	13.1	32.7	54.2	83.8	99.4	100	100	100	100	100	100	100
UT-AC	2/6/15 17:06	344	330	268	1,856	844	0.65	6.20	16.7	31.6	55.7	78.0	85.9	100	100	100	100	100	100
UT-AC	2/7/15 13:21	185	242	137	1,772	538	0.68	5.81	16.2	29.0	54.5	73.8	83.8	100	100	100	100	100	100
UT-AC	2/8/15 10:47	182	282	163	1,428	560	1.02	8.58	20.8	37.2	65.7	89.8	94.3	100	100	100	100	100	100
UT-AC	4/7/15 11:29	495	910	470	5,877	2,067	1.06	12.0	36.0	63.7	95.0	100	100	100	100	100	100	100	100
UT-AC	4/23/15 22:55	117	257	94	3,885	863	0.67	6.68	17.6	34.7	60.5	85.2	93.4	100	100	100	100	100	100
UT-AC	4/25/15 8:15	281	359	270	2,580	860	2.27	15.4	35.2	57.7	95.4	100	100	100	100	100	100	100	100

Table A10b: Raw analytical data for samples taken at the Upper Truckee catchment outfall in WY16.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
UT-AC	10/3/15 21:47	160	98	127	4,716	639	0.61	5.97	15.5	30.8	54.4	80.9	89.7	100	100	100	100	100	100
UT-AC	11/1/15 14:03	183	270	169	2,474	783	1.07	11.5	32.5	59	97.1	100	100	100	100	100	100	100	100
UT-AC	12/10/15 4:55	627	916	609	2,528	2,423	0.89	9.54	27.6	52.5	88.2	100	100	100	100	100	100	100	100
UT-AC	1/19/16 9:36	1,065	1,054	1,011	3,046	2,874	0.82	8.26	21.5	40.3	70.6	96.5	99.5	100	100	100	100	100	100
UT-AC	1/29/16 12:24	395	490	386	1,613	1,179	1.94	13.2	29.5	49.6	89.4	100	100	100	100	100	100	100	100
UT-AC	3/4/16 15:12	608	772	588	2,564	1,960	2.04	13.6	30.9	52.1	92.2	100	100	100	100	100	100	100	100
UT-AC	3/5/16 18:43	362	336	336	1,323	999	2.04	13.9	31.8	54.7	96.9	100	100	100	100	100	100	100	100
UT-AC	4/9/16 4:49	592	573	584	2,839	1,528	1.96	13.3	30.4	54.6	99	100	100	100	100	100	100	100	100

Appendix B: Quality Assurance/Quality Control Summary

Field duplicates are samples collected at the same time and treated identically and are used to assess the reproducibility of collected data. This provides a measure of analytical precision and can be used for detecting problems in sample collection, handling, transport processing, and analysis. The actual procedures for collecting field duplicate samples depend on the sampling methods and protocols used. When automated sampling equipment is used, duplicates need to be collected manually either by: (a) triggering the sampler manually twice in quick succession (two MS samples) or (b) manually triggering a sample and then collecting a grab sample at the same time (one MS sample and one GS sample), (RSWMP SAP, 2011). Field blanks (FB) are collected to identify sample contamination occurring during field collection, handling, transport, storage, and during laboratory handling and analysis. Field blanks are collected throughout the sampling season by pouring reagent-grade "blank" water into the autosampler bottles in the field and then exposing them to equivalent conditions as the standard sample bottles.

Tables B1a and B2a summarize the QAQC samples that were taken during WY14. Pink cells indicate differences in values of greater than 20% in Table B1a, and in Table B2a, indicate values that are above the detection limit. Most analytical results between field duplicate pairs (either MS/MS or GS/MS) are very similar. With regards to sediment (TSS, turbidity, and FSP), only two sample pairs show a difference greater than 20%, the MS/MS pair on January 29, 2014 for turbidity and the GS/MS pair on May 20, 2014 for TSS and FSP. The pair from Rubicon Inflow may have experienced a quick pulse in turbidity between when the two manual samples were triggered by the autosampler. Since FSP is calculated by multiplying TSS by the percent fraction less than 16 microns it is not surprising that they are both off by greater than 20% in the Tahoma pair. The difference in TSS may come from the fact that the autosampler intake tube may have been partially covered by sediment and therefore sucked up more sediment than was representative of the runoff. Only two sample pairs showed TP concentrations that differed by more than 20%, both of which were MS/MS pairs and may attest to the fact that concentrations can fluctuate in the short time period between the triggering of each sample. The same could be true of the difference in the smallest sediment fraction in the Pasadena Inflow pair on July 20, 2014. The difference in the smallest sediment fraction in the GS/MS pair from Tahoma on February 9, 2014 may be due to the difference in where the suction tube for the autosampler is mounted compared to where the grab sample was taken, though every effort is made to sample as close to the same location as possible. There are seven pairs of samples that have a greater than 20% difference in TN values. These values are the sum of Total Kjeldahl Nitrogen (TKN) from a raw sample and Nitrate-Nitrite (NO3+NO2) from a filtered sample. Summing the results from two different analyses introduces much more error along the whole sequence of analytical steps and therefore it is not surprising that TN has more error than the other analyses.

All field blanks with the exception of TN at S5 on September 28, 2014 were below detection limit for TSS, FSP, TN, and TP. Smoke from the large King Fire that occurred in late September 2014 may have caused the elevated TN value at S5. Turbidity values are not below their detection limit of 0.1 NTU, but are extremely low and within the range of what would be expected in a field blank.

Tables B1b and B2b summarize the QAQC samples that were taken during WY15 Pink cells indicate differences in values of greater than 20% in Table B1b, and in Table B2b, indicate values that are above the detection limit. Like in WY14, most analytical results between the field duplicate pairs (either MS/MS or GS/MS) are very similar. However, five sample pairs had differences greater than 20% in several analyses, especially with regard to sediment. The paired MS/MS samples at Pasadena Inflow (PI) on April 25, 2015 and Rubicon Inflow (RI) on October 25, 2014 both show differences greater than 20% for FSP and TSS. The paired samples at PI also show unusually large differences in all particle size classes that comprise FSP (<16μm). Because MS sample pairs require that both samples in the pair are taken with the autosampler, it is possible that a pulse of more turbid water with a greater proportion of FSP passed the sample intake tube just as the second sample in each case was taken. The paired MS/GS samples are more likely to be different than the MS/MS pairs as the collection method is different. This could account for most or all of the differences, though every attempt is made to collect the GS sample as close to the intake tube where the MS sample is collected as possible. The MS/GS pairs from Speedboat (SB) on December 4, 2014, and Tahoe Valley and Upper Truckee on November 22, 2014 all show differences greater than 20% for TSS, FSP, and TN. The Speedboat pair also shows a difference in TP and particle size classes less than 20μm. It is unusually difficult to collect a GS sample at Speedboat, and the collection location may not have been as representative of the flow sampled by the autosampler in the MS sample as at other sites. The Tahoe Valley pair also shows a difference in particle size classes less than 4μm and the Upper Truckee pair shows a difference in turbidity. The intent of the MS/GS pairs is to indicate whether or not the auto-sampler is collecting a representative sample. In most cases the auto-sampler does collect a representative sample, but as indicated by the data there are times when errors occur, especially with regards to sediment collection.

All field blanks in WY15 were below detection limits for all analytes.

Tables B1c and B2c summarize the QAQC samples that were taken during WY16. Pink cells indicate differences in values of greater than 20% in Table B1c. In Table B2c pink cells indicate values that are above the detection limit. Like in WY14 and WY15, most analytical results between the field duplicate pairs (MS/MS, GS/MS, GS/GS) are very similar. However, three sample pairs had differences greater than 20% in several analyses. The GS duplicate pair taken on November 1, 2015 at the Contech MFS Outflow (CO) show differences greater than 20% for TN and TP. Differences in TP results for these samples may be due to differences in sample collection or analysis, while differences in TN may be due to the use of contaminated sample bottles. It is possible that one sample bottle used in this duplicate pair was exposed to the open atmosphere for an extended since July 2016. If this was the case, high levels of atmospheric nitrogen originating from vehicular exhaust over a course of roughly four months may be the reason for elevated levels of nitrogen. In the future, sample bottles will be replaced if more than one month passes without sample bottles being used. The paired MS/GS samples taken at Tahoma (TA) on January 16, 2016 had a difference greater than 20% for particle size class less than 0.5 μm, with the GS containing a higher value. This difference may be attributed to the position within the water column that the GS was taken. It is possible the grab sample may have been taken higher in the water column where there are more suspended fine sediment particles. Though every attempt is made to collect the GS sample as close to the intake tube where the MS sample is collected as possible, this is not always possible. The MS/GS duplicate pair taken at Tahoe Valley (TV) on January 19, 2016 has a difference of greater than 20% for particle all size classes less than 4μm, with the GS containing higher values in all size classes. This difference may again be attributed to taking the GS sample higher in the water column than the position of the intake tube used to collect the MS. It is also may be possible that a pulse of more turbid water with a greater percentage of sediment particles classes less than 4μm passed the sample intake tube just as the GS was taken.

Field blanks, with the exception of TN on December 10, 2015 and December 11, 2015 at PI, PO, and JI, are below detection limits for TSS, FSP, TN, and TP in WY16. Turbidity values are above their detection limit of 0.1 NTU for all samples except for December 11, 2015, but are extremely low and within the range of what would be expected in a field blank. FB samples taken on December 10, 2015 and December 11, 2015 were all above detection limit for TN. As described above with the GS/GS duplicate samples taken on November 1, 2015, it may be possible that contaminated sample bottles were used for these samples; the FB sample bottles may have been exposed to the open atmosphere for an extended amount of time, based upon an investigation of the most recent sampling history at the site. If FB values are ever above the detection limit after data is received, a QAQC process will be undertaken to ensure sample bottles are clean and provide accurate data.

Table B1a: MS and GS sample data from all sites in WY14. Pink cells indicate paired samples that have a difference between them of greater than 20%.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
IV-MS	1/11/14 15:06	361	865	295	2,818	873	0.62	6.39	17.6	33.8	59.4	81.6	87.3	100	100	100	100	100	100
IV-MS	1/11/14 15:07	367	887	309	4,281	895	0.61	6.39	17.8	34.6	61.5	84.3	90.9	100	100	100	100	100	100
IV-MS	1/29/14 14:13	562	528	446	3,704	2,436	0.58	6.13	17.4	33.4	58.9	79.4	84.7	100	100	100	100	100	100
IV-MS	1/29/14 14:14	495	639	385	3,344	1,832	0.56	5.75	15.8	30.9	55.7	77.7	83.5	100	100	100	100	100	100
PI-MS	2/8/14 11:03	253	479	191	1,491	1,275	0.64	6.42	16.9	31.8	55.2	75.4	82.4	100	100	100	100	100	100
PI-MS	2/8/14 11:04	253	477	189	870	1,320	0.62	6.28	16.7	31.4	54.3	74.8	82.0	100	100	100	100	100	100
PI-MS	7/18/14 17:15	1,510	1,468	657	9,379	2,095	0.25	2.41	6.04	12.0	24.9	43.5	50.9	83.3	92.7	100	100	100	100
PI-MS	7/18/14 17:17	1,515	1,474	670	9,650	2,337	0.25	2.42	6.10	12.6	25.6	44.2	51.4	83.3	93.6	100	100	100	100
PI-MS	7/20/14 15:24	456	817	291	2,076	2,231	0.80	6.59	15.7	27.3	47.8	63.9	72.1	95.2	99.7	100	100	100	100
PI-MS	7/20/14 15:26	444	803	292	2,836	2,002	0.63	6.05	14.8	27.2	46.8	65.7	73.0	97.7	100	100	100	100	100
PO-MS	2/8/14 11:16	226	445	185	1,242	1,256	0.85	7.90	21.3	39.4	65.9	81.8	88.3	100	100	100	100	100	100
PO-MS	2/8/14 11:17	230	448	181	1,153	1,190	0.75	6.92	18.1	33.8	59.4	78.5	85.8	100	100	100	100	100	100
PO-MS	7/18/14 17:30	292	325	156	2,060	1,291	0.30	2.83	7.44	14.8	32.0	53.5	63.5	95.0	99.5	100	100	100	100
PO-MS	7/18/14 17:32	325	377	177	2,314	1,440	0.31	3.02	7.68	16.0	32.6	54.6	63.1	95.5	99.7	100	100	100	100
PO-MS	7/20/14 15:15	288	540	219	1,584	1,452	0.68	6.40	16.2	31.0	56.0	75.9	83.8	99.6	100	100	100	100	100
PO-MS	7/20/14 15:16	292	542	216	1,844	1,483	0.76	6.40	16.3	29.9	55.8	73.9	83.5	99.3	100	100	100	100	100
PO-GS	7/20/14 15:17	286	564	211	1,362	1,495	0.64	6.08	15.4	29.4	53.4	73.7	81.8	99.3	100	100	100	100	100
RI-MS	1/29/14 15:35	81	57	26	555	369	0.22	2.32	6.75	13.2	22.9	31.6	34.6	54.4	66.0	81.3	89.1	99.9	100
RI-MS	1/29/14 15:36	77	42	27	389	353	0.23	2.48	7.03	13.7	24.5	34.8	37.9	56.4	67.3	81.0	95.0	100	100
S5-MS	9/28/14 9:59	118	90	61	1,250	152	0.43	4.18	10.4	20.1	35.9	51.8	58.6	92.2	97.0	100	100	100	100
S5-MS	9/28/14 10:00	118	83	61	1,581	213	0.42	3.81	9.82	19.0	35.5	51.6	59.5	91.0	97.3	100	100	100	100
TA-MS	1/11/14 16:45	429	662	349	2,537	1,562	0.84	8.63	23.1	40.0	63.0	81.4	85.9	100	100	100	100	100	100
TA-MS	1/11/14 16:46	380	605	284	1,802	1,549	0.72	7.18	19.4	33.5	54.2	74.8	80.5	100	100	100	100	100	100
TA-MS	1/29/14 12:44	2,184	2,268	1,520	3,369	3,639	0.56	5.64	14.7	27.2	49.0	69.6	76.4	100	100	100	100	100	100
TA-GS	1/29/14 12:45	2,130	2,133	1,399	2,341	3,715	0.53	5.25	13.2	24.1	44.1	65.7	73.0	99.4	99.7	100	100	100	100
TA-GS	2/9/14 11:25	62	52	37	69	237	0.64	5.37	13.3	23.4	41.9	59.7	65.8	93.4	96.1	100	100	100	100
TA-MS	2/9/14 11:26	80	57	44	37	259	0.44	4.35	11.0	20.5	37.0	55.6	61.9	89.6	95.4	100	100	100	100
TA-MS	3/29/14 9:34	424	566	300	2,274	1,635	0.55	5.51	14.3	26.9	48.4	70.8	78.4	99.9	100	100	100	100	100
TA-MS	3/29/14 9:35	409	497	287	1,743	1,508	0.56	5.49	13.9	26.2	47.7	70.1	78.1	100	100	100	100	100	100
TA-GS	3/29/14 9:36	435	521	304	2,618	1,613	0.58	5.48	14.2	26.3	48.7	69.8	78.6	100	100	100	100	100	100
TA-GS	5/20/14 11:23	36	59	27	946	313	1.08	8.90	21.0	34.8	58.7	74.3	82.7	99.0	100	100	100	100	100
TA-MS	5/20/14 11:24	67	60	50	863	398	0.86	8.32	20.3	35.3	56.0	73.9	79.6	99.5	100	100	100	100	100
TA-MS	8/10/14 16:52	42	42	24	1,837	397	0.42	3.99	11.2	21.3	43.1	58.1	67.2	96.4	99.3	100	100	100	100
TA-GS	8/10/14 16:53	47	41	26	1,738	368	0.46	3.95	10.3	19.4	39.7	55.2	64.6	93.4	97.9	100	100	100	100

Table B1b: MS and GS sample data from all sites in WY15. Pink cells indicate paired samples that have a difference between them of greater than 20%.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
PI-MS	4/25/15 13:06	40	46	32	733	390	0.73	6.23	17.5	33.2	60.7	82.6	89.7	100	100	100	100	100	100
PI-MS	4/25/15 13:07	69	45	69	585	386	6.85	41.2	82.1	100	100	100	100	100	100	100	100	100	100
RI-MS	10/25/14 13:31	14	14	3	1,867	296	0.46	3.11	7.16	12.5	27.0	42.5	48.8	72.1	82.1	94.9	100	100	100
RI-MS	10/25/14 13:32	18	15	6	1,469	256	0.37	2.90	7.08	13.2	27.8	43.2	49.4	74.4	84.0	94.9	100	100	100
SB-MS	12/4/14 10:56	74	78	47	1,605	9,932	0.60	5.10	13.4	24.5	45.3	63.6	72.0	97.7	100	100	100	100	100
SB-GS	12/4/14 10:57	33	63	33	1,215	7,270	2.46	16.7	33.0	59.8	91.5	100	100	100	100	100	100	100	100
SB-GS	2/9/15 10:28	21	33	na	612	203	na	na	na	na	na	na	na	na	na	na	na	na	na
SB-MS	2/9/15 10:29	20	40	na	532	187	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-MS	10/25/14 14:12	26	21	na	1,210	418	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-GS	10/25/14 14:13	22	19	na	1,190	437	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-GS	2/7/15 13:21	196	212	73	1,287	595	0.31	3.04	7.79	14.3	24.6	37.5	42.8	68.8	79.9	92.3	96.1	99.9	100
TA-MS	2/7/15 13:22	182	216	71	1,229	547	0.32	3.18	8.12	15.1	26.0	39.1	44.8	73.3	87.1	98.4	100	100	100
TA-MS	3/23/15 8:12	50	72	42	971	264	5.22	37.9	81.6	100	100	100	100	100	100	100	100	100	100
TA-GS	3/23/15 8:13	53	75	45	897	280	4.81	36.8	81.2	100	100	100	100	100	100	100	100	100	100
TV-MS	11/22/14 11:45	41	92	30	956	329	3.69	26.1	50.0	78.3	100	100	100	100	100	100	100	100	100
TV-GS	11/22/14 11:46	67	87	53	1,468	291	2.04	16.7	38.3	59.1	89.2	95.4	99.1	100	100	100	100	100	100
TV-GS	2/7/15 16:52	35	81	30	824	206	3.51	19.6	39.5	54.4	72.3	84.8	92.7	100	100	100	100	100	100
TV-MS	2/7/15 16:53	39	76	34	885	212	4.37	20.7	39.8	54.3	71.3	85.9	92.0	100	100	100	100	100	100
TV-MS	4/25/15 12:24	98	119	91	1,516	330	5.64	36.0	75.5	100	100	100	100	100	100	100	100	100	100
TV-GS	4/25/15 12:25	92	117	86	1,460	349	2.75	17.8	39.0	66.4	100	100	100	100	100	100	100	100	100
UT-MS	11/22/14 8:00	132	92	106	1,175	685	0.88	8.23	20.8	37.8	63.4	85.8	92.6	100	100	100	100	100	100
UT-GS	11/22/14 8:01	278	203	222	1,650	797	0.88	7.80	20.2	36.4	63.0	82.9	90.1	100	100	100	100	100	100
UT-MS	12/2/14 12:34	349	488	299	2,403	1,234	0.72	6.74	18.5	36.2	63.5	85.5	93.2	100	100	100	100	100	100
UT-GS	12/2/14 12:35	383	522	293	2,118	1,177	0.65	5.83	15.9	30.8	55.8	76.4	85	100	100	100	100	100	100
UT-GS	2/7/15 17:01	281	371	203	1,366	787	0.58	5.56	15.0	28.7	51.2	72.4	80.9	100	100	100	100	100	100
UT-MS	2/7/15 17:02	329	351	232	1,587	715	0.66	5.46	14.7	26.9	51.0	70.5	80.3	100	100	100	100	100	100
UT-MS	4/25/15 12:49	241	270	228	2,387	669	1.81	13.8	32.7	55.3	92.9	100	100	100	100	100	100	100	100
UT-GS	4/25/15 12:50	230	263	216	2,540	685	1.62	12.6	29.8	49.8	82.3	100	100	100	100	100	100	100	100

Table B1c: MS and GS sample data from all sites in WY16. Pink cells indicate paired samples that have a difference between them of greater than 20%.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
CO-GS	11/1/2015 9:04	35	43	na	434	274	na	na	na	na	na	na	na	na	na	na	na	na	na
CO-GS	11/1/2015 9:05	35	42	na	1,208	198	na	na	na	na	na	na	na	na	na	na	na	na	na
TV-MS	12/21/2015 15:52	144	296	129	1504	755	1.43	15.2	42.4	69.1	99.6	100	100	100	100	100	100	100	100
TV-GS	12/21/2015 15:53	145	294	131	1472	755	1.46	15.4	42.5	68.7	99.6	100	100	100	100	100	100	100	100
TA-MS	1/16/2016 10:12	796	1,106	773	2794	2797	1.20	12.0	30.3	52.1	81.2	99.9	100	100	100	100	100	100	100
TA-GS	1/16/2016 10:13	761	1,052	732	2711	2778	1.83	14.1	33.1	53.1	84.0	100	100	100	100	100	100	100	100
SB-MS	1/16/2016 15:36	201	345	187	1344	893	1.27	13.3	36.3	63.3	98.1	100	100	100	100	100	100	100	100
SB-MS	1/16/2016 15:37	201	345	187	1364	893	1.27	13.2	35.4	62.0	96.9	100	100	100	100	100	100	100	100
TV-GS	1/19/2016 16:22	79	146	60	822	402	3.31	29.0	70.7	100	100	100	100	100	100	100	100	100	100
TV-MS	1/19/2016 16:23	82	150	63	835	402	1.91	19.7	51.3	74.8	100	100	100	100	100	100	100	100	100
TA-GS	3/5/2016 7:59	16	17	na	256	104	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-MS	3/5/2016 8:00	16	17	na	243	104	na	na	na	na	na	na	na	na	na	na	na	na	na

Table B2a: Field blank sample data from all sites in WY14. Pink cell highlights value greater than the method detection limit indicating possible contamination, likely from King Fire smoke. All samples were too clear for PSD analysis.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
TA-FB	1/11/14 15:44	<1	0.18	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
IV-FB	1/11/14 21:38	<1	0.16	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
IV-FB	1/29/14 14:35	<1	0.11	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
S5-FB	1/29/14 15:21	<1	0.16	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
RI-FB	1/29/14 15:37	<1	0.46	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-FB	1/29/14 16:15	<1	0.17	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
PO-FB	2/8/14 11:10	<1	0.22	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
PI-FB	2/8/14 11:15	<1	0.10	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
RI-FB	3/27/14 10:32	<1	0.15	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-FB	5/20/14 11:15	<1	0.29	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-FB	7/18/14 8:00	<1	0.12	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
S5-FB	9/28/14 10:46	<1	0.09	na	70	<10	na	na	na	na	na	na	na	na	na	na	na	na	na

Table B2b: Field blank sample data from all sites in WY15. All samples were too clear for PSD analysis.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
CO-FB	5/22/15 12:01	<1	<0.10	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
JO-FB	5/22/15 12:02	<1	<0.10	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
S5-FB	4/24/15 6:00	<1	<0.10	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
TV-FB	7/8/15 14:03	<1	<0.10	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
UT-FB	4/24/15 8:00	<1	<0.10	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na

Table B2c: Field blank sample data from all sites in WY16. Pink cell highlights value greater than the method detection limit indicating possible contamination, likely originating from atmospheric contamination from vehicular exhaust. All samples were too clear for PSD analysis.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
TV-FB	3/4/2015 18:05	<1	0.22	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
SB-FB	10/1/2015 13:00	<1	na	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
PI-FB	12/10/2015 9:00	<1	1.09	na	1,565	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
PO-FB	12/10/2015 9:30	<1	0.51	na	1,276	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
TV-FB	12/10/2015 17:03	<1	0.19	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-FB	12/11/2015 13:15	<1	0.08	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
JI-FB	12/11/2015 15:50	<1	0.16	na	1,485	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
SB-FB	1/16/2016 15:38	<1	0.37	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
TV-FB	1/19/2016 16:17	<1	0.10	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
UT-FB	1/19/2016 16:17	<1	0.11	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
UT-FB	1/29/2016 13:31	<1	0.28	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na
UT-FB	3/4/2016 16:15	<1	0.30	na	<50	<10	na	na	na	na	na	na	na	na	na	na	na	na	na

Appendix C: Incline Village Event Hydrographs

All event hydrographs in Appendices C-K show continuous hydrology, continuous turbidity, and water quality samples taken for each event sampled. Sample points on the same horizontal line represent samples that were composited into one bottle and sent to the lab for analysis. Single sample points on a horizontal line represent single samples that were sent to the lab for analysis.

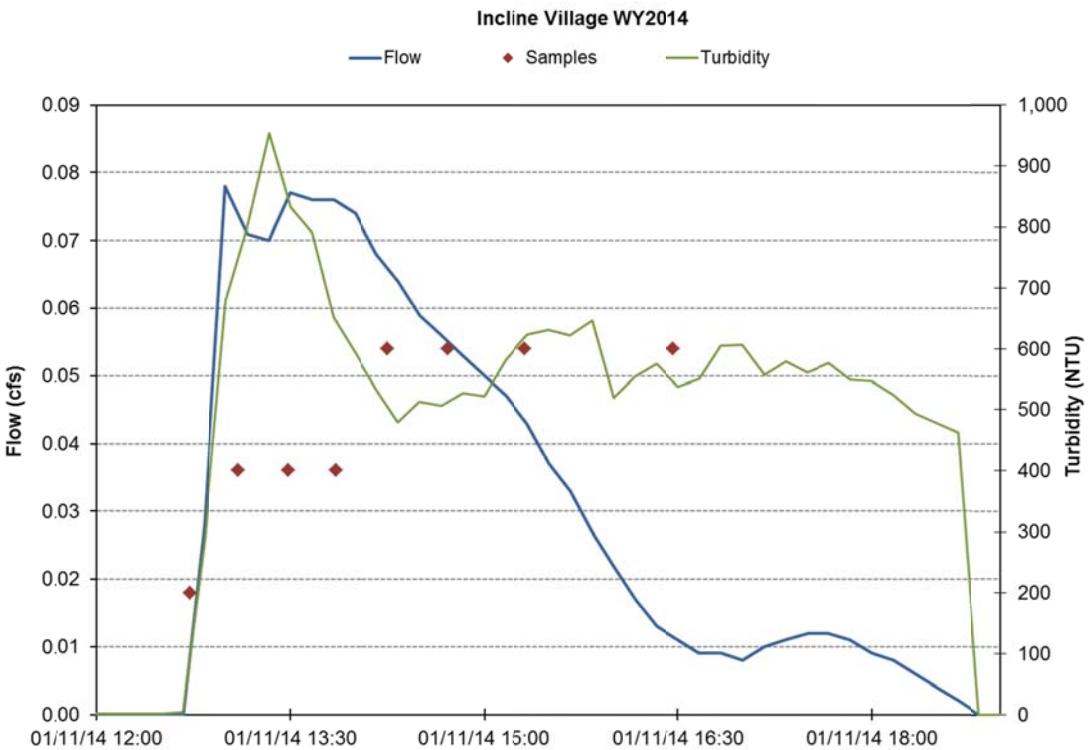

Figure C1: Continuous hydrology, continuous turbidity, and water quality samples for the 1/11/2014 event. Total volume sampled: 757 cf.

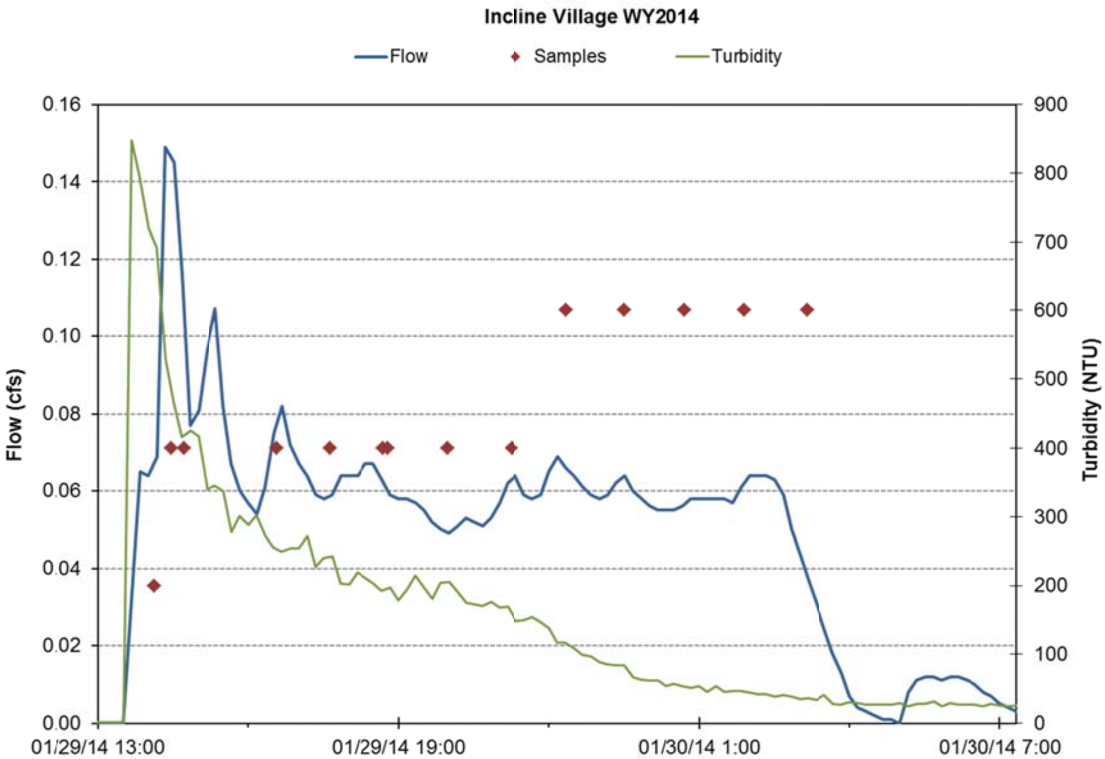

Figure C2: Continuous hydrology, continuous turbidity, and water quality samples for the 1/29/2014 event. Total volume sampled: 3,207 cf.

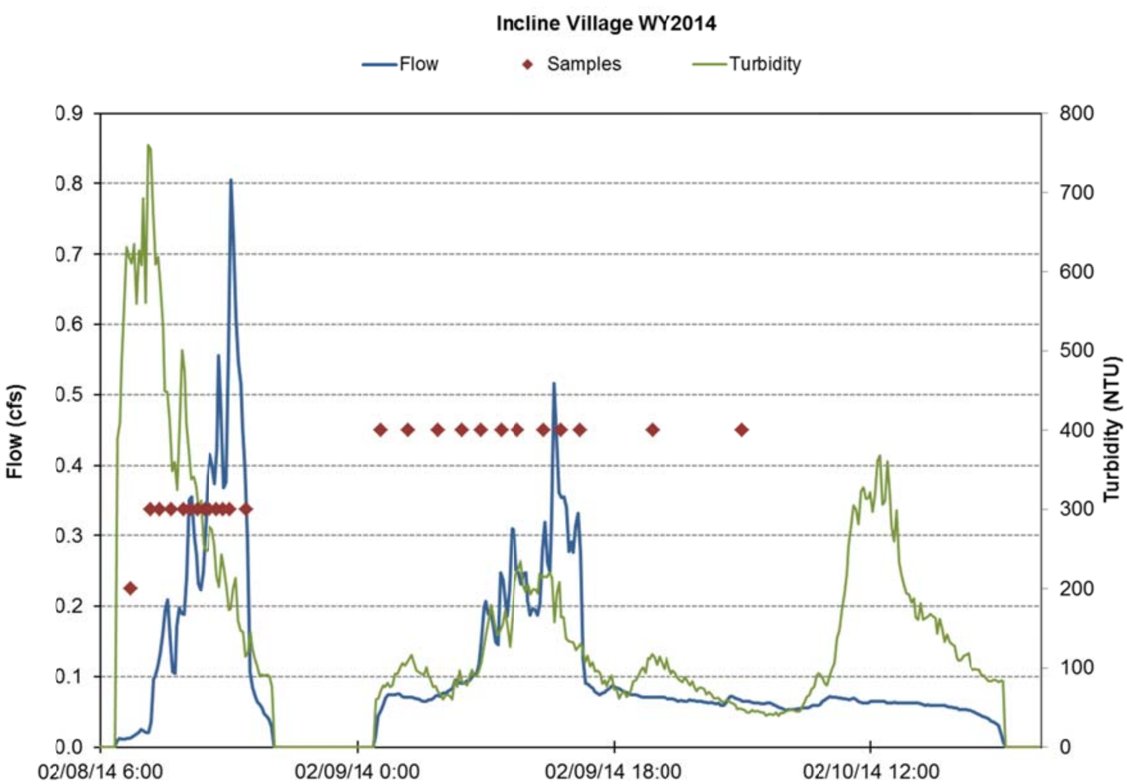

Figure C3: Continuous hydrology, continuous turbidity, and water quality samples for the 2/8/2014 event. Total volume sampled: 23,950 cf.

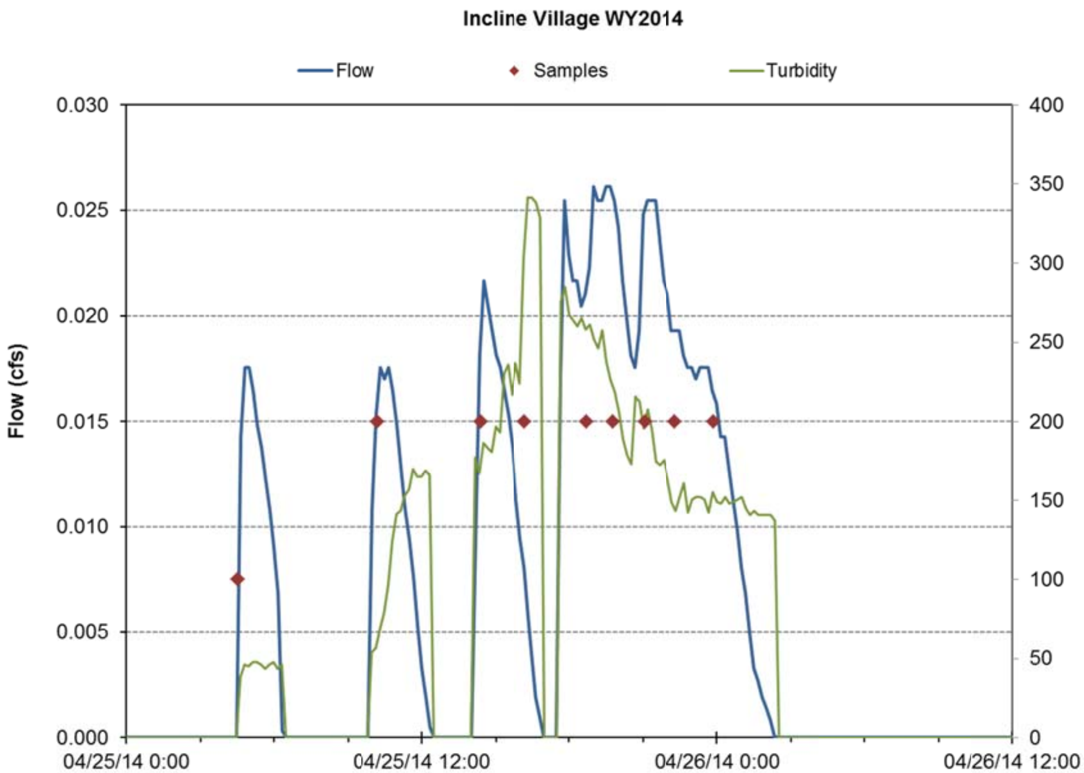

Figure C4: Continuous hydrology, continuous turbidity, and water quality samples for the 4/25/2014 event. Total volume sampled: 856 cf.

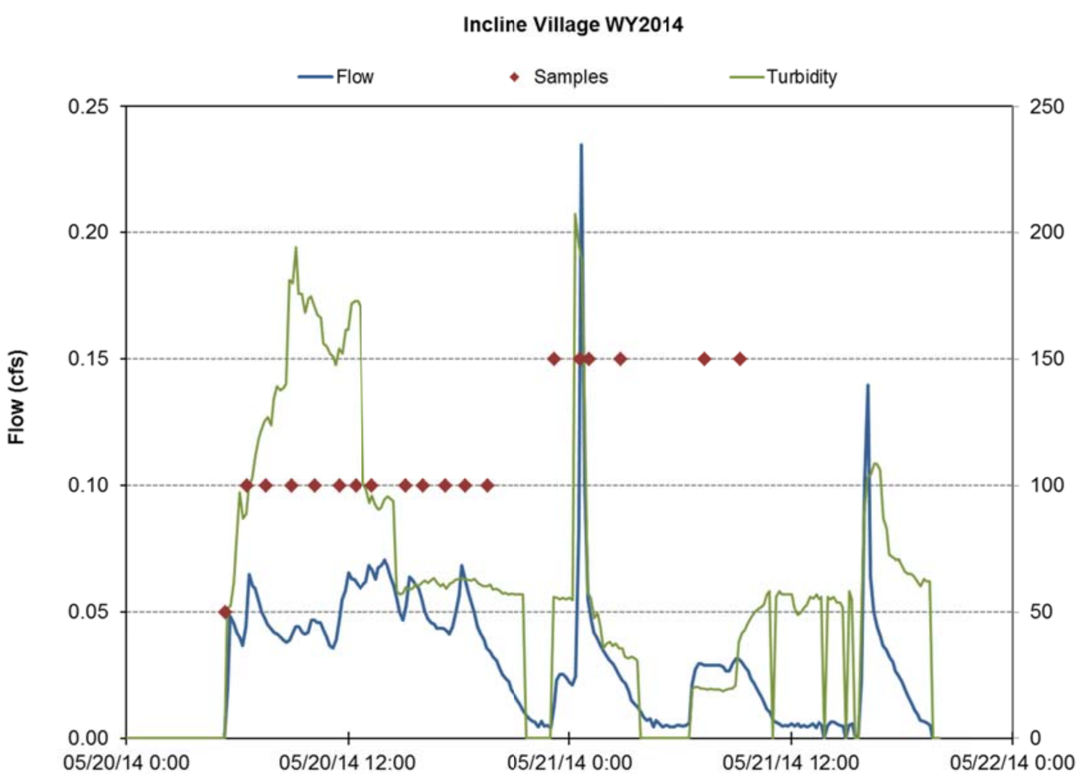

Figure C5: Continuous hydrology, continuous turbidity, and water quality samples for the 5/20/2014 event. Total volume sampled: 3,897 cf.

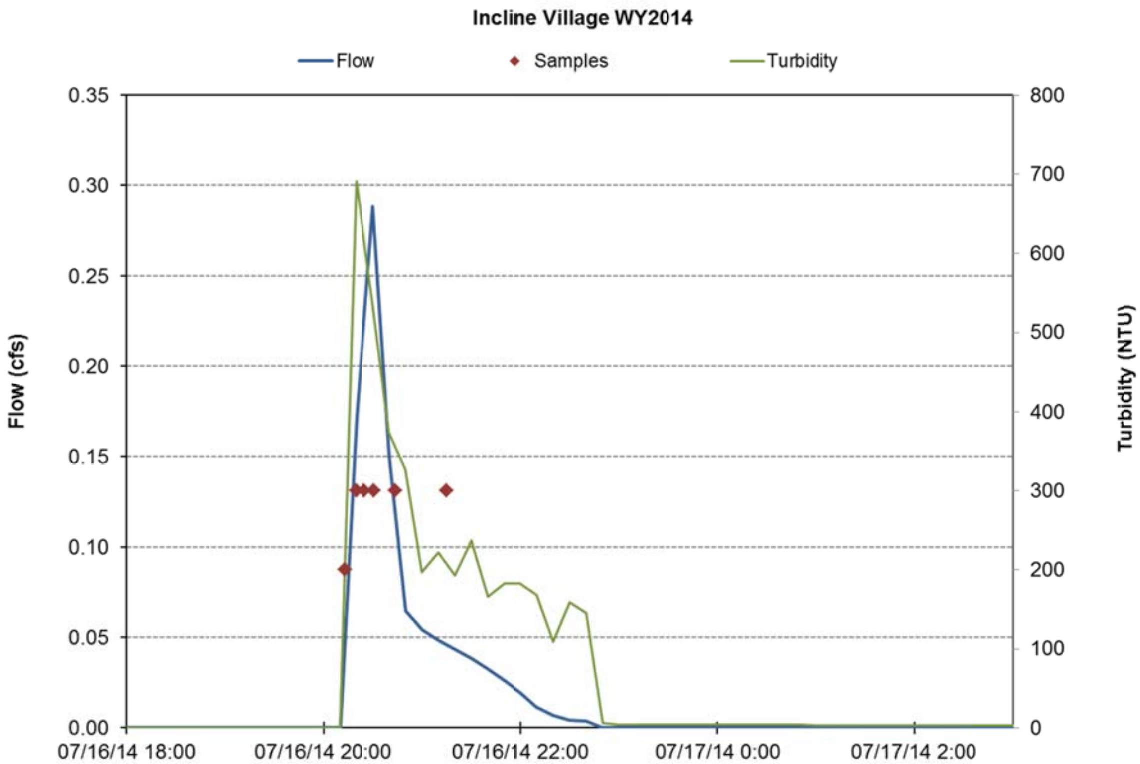

Figure C6: Continuous hydrology, continuous turbidity, and water quality samples for the 7/16/2014 event. Total volume sampled: 578 cf.

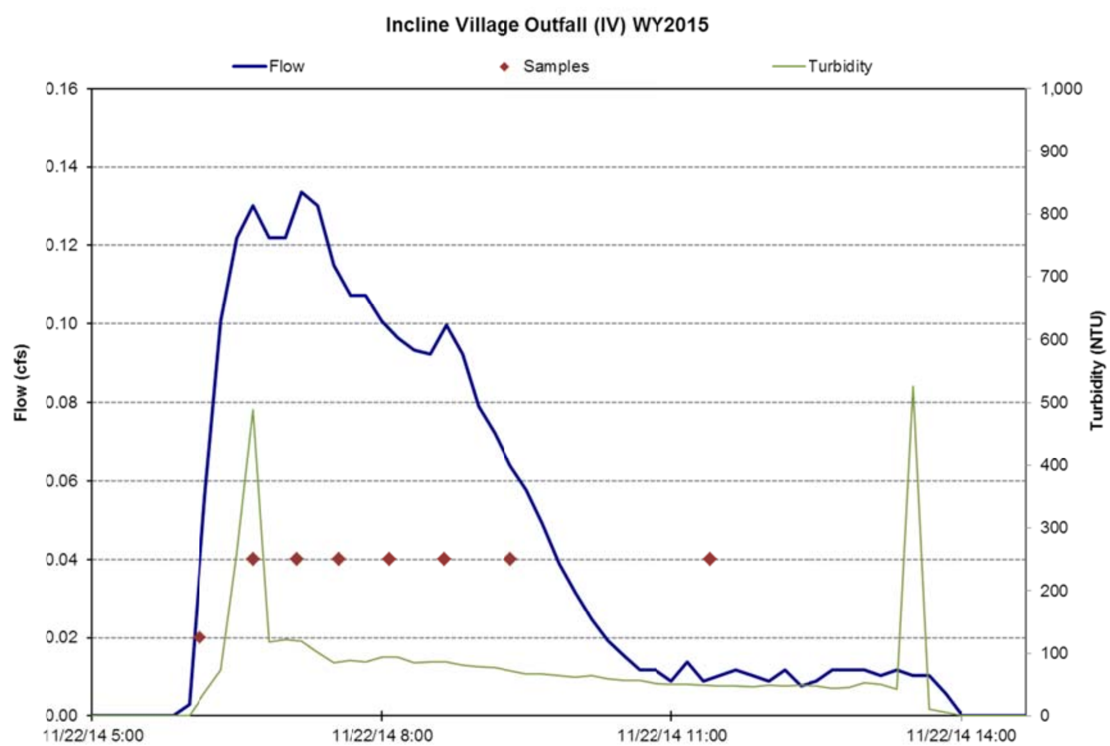

Figure C7: Continuous hydrology, continuous turbidity, and water quality samples for the 11/22/2014 event. Total volume sampled: 1,434 cf.

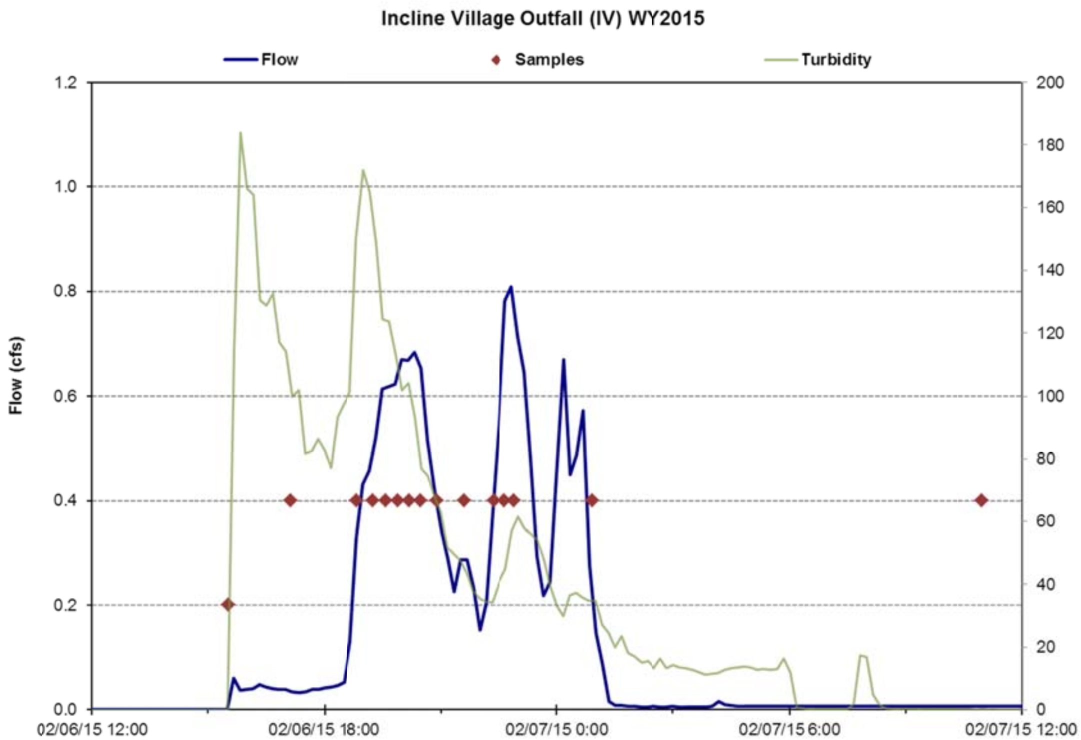

Figure C8: Continuous hydrology, continuous turbidity, and water quality samples for the 2/6/2015 event. Total volume sampled: 11,285 cf.

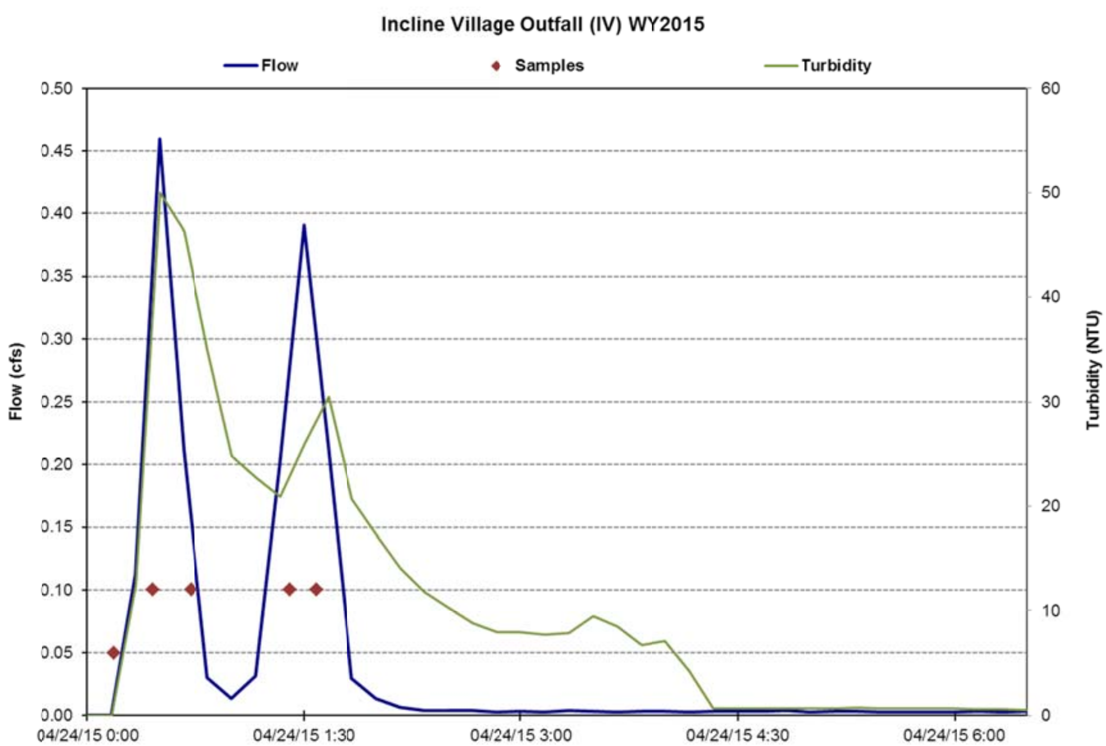

Figure C9: Continuous hydrology, continuous turbidity, and water quality samples for the 4/24/2015 event. Total volume sampled: 1,081 cf.

Appendix D: Pasadena Event Hydrographs

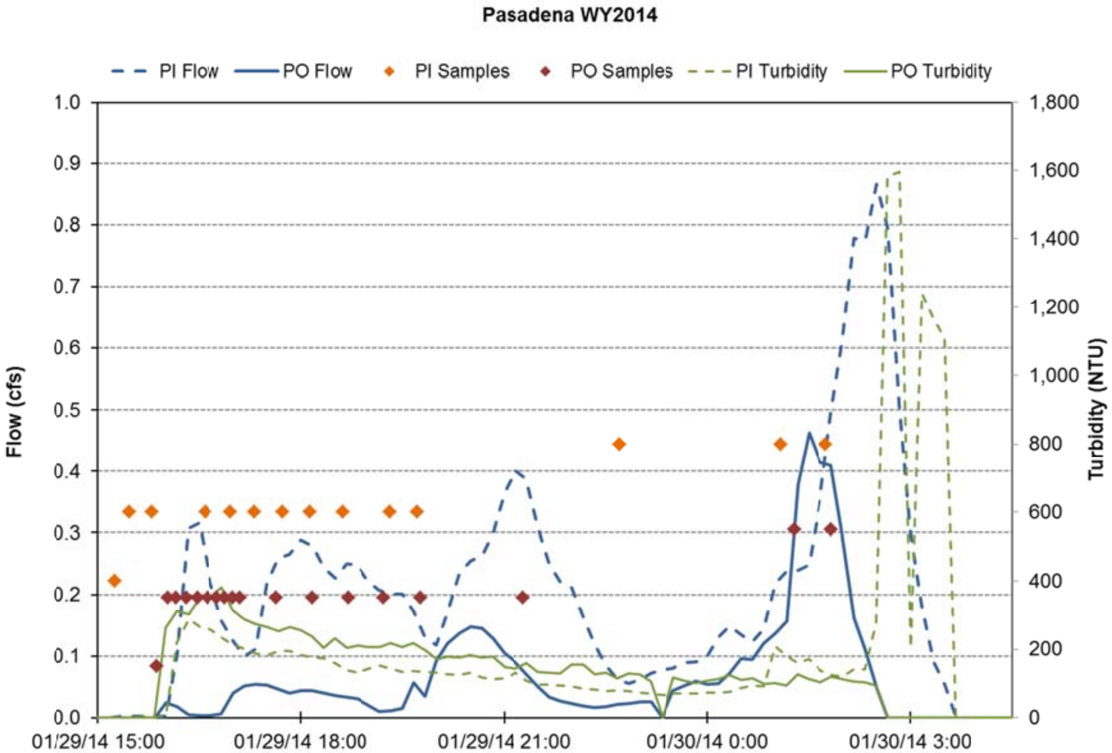

Figure D1: Continuous hydrology, continuous turbidity, and water quality samples for the 1/29/2014 event. Total volume sampled: 10,109 cf.

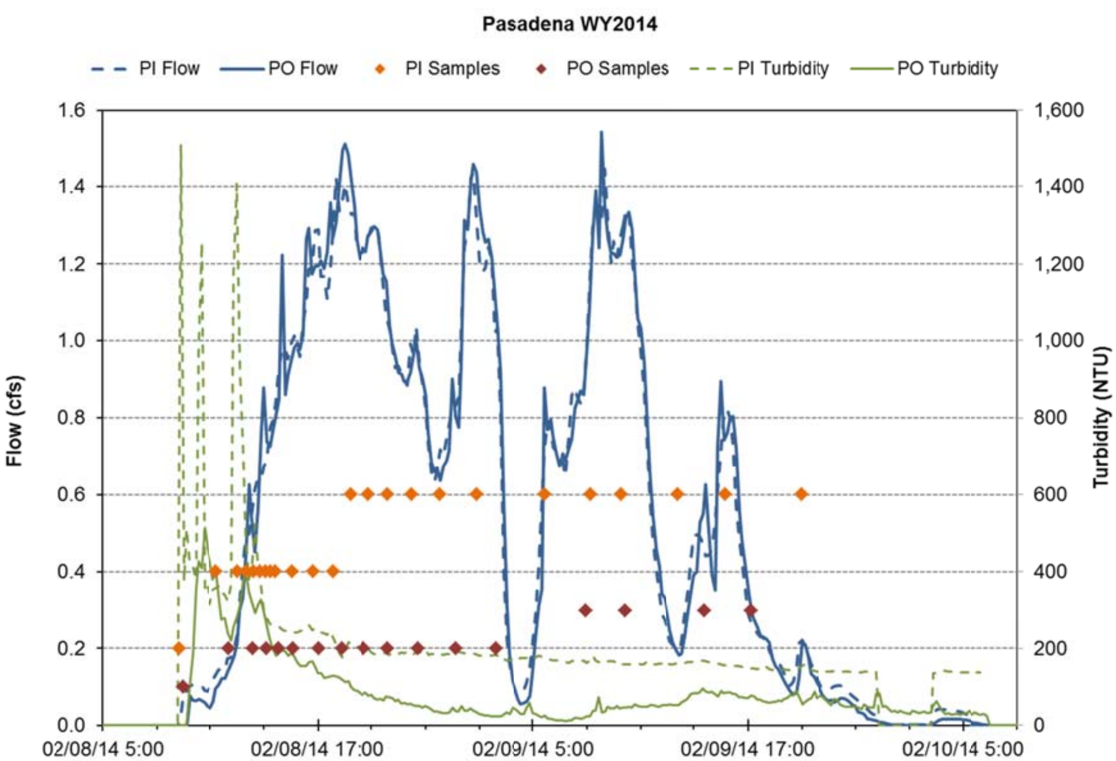

Figure D2: Continuous hydrology, continuous turbidity, and water quality samples for the 2/8/2014 event. Total volume sampled: 90,918 cf.

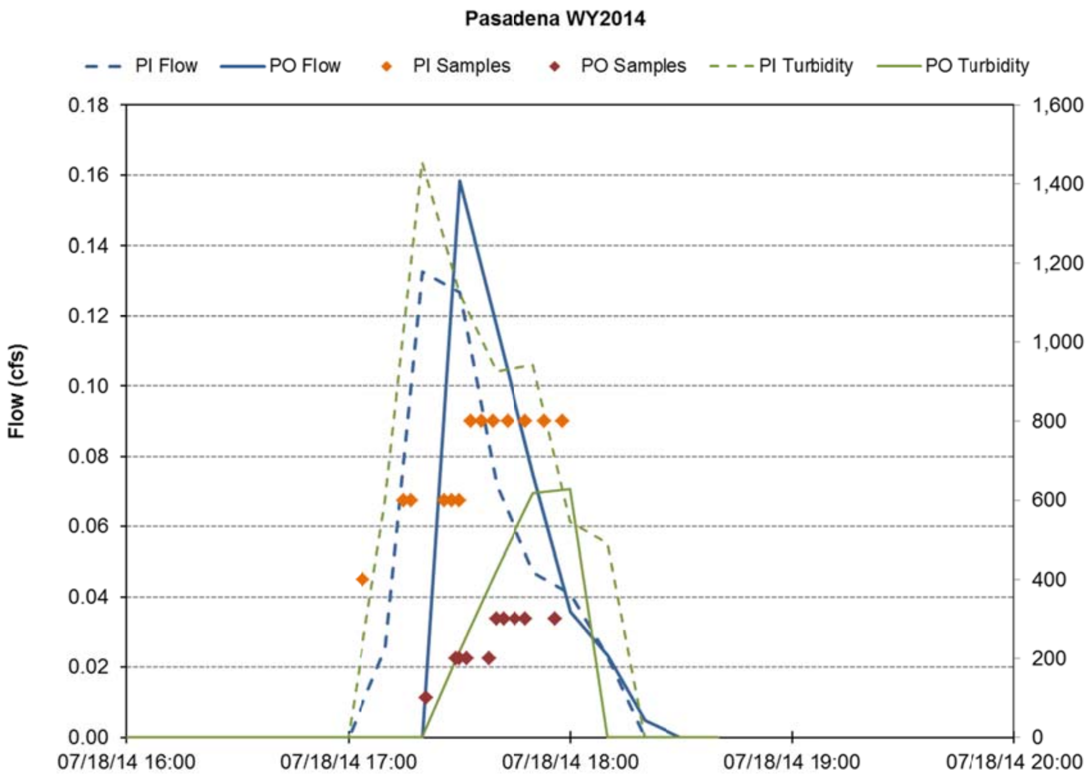

Figure D3: Continuous hydrology, continuous turbidity, and water quality samples for the 7/18/2014 event. Total volume sampled: 280 cf.

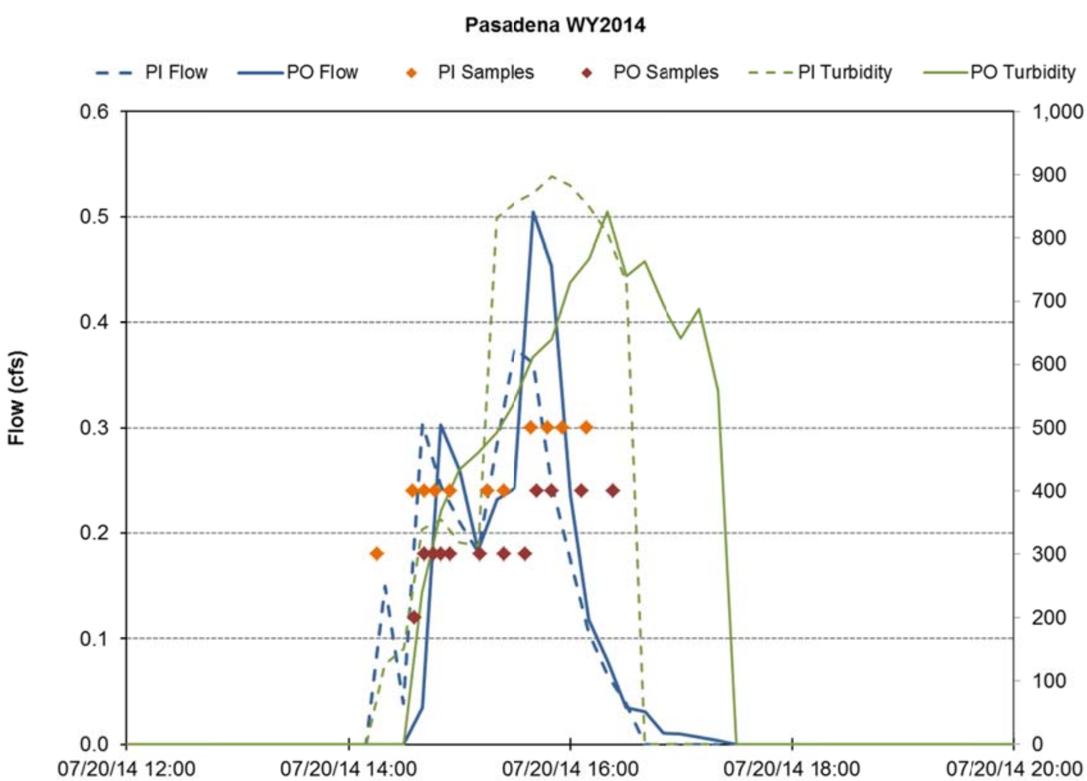

Figure D4: Continuous hydrology, continuous turbidity, and water quality samples for the 7/20/2014 event. Total volume sampled: 1,670 cf.

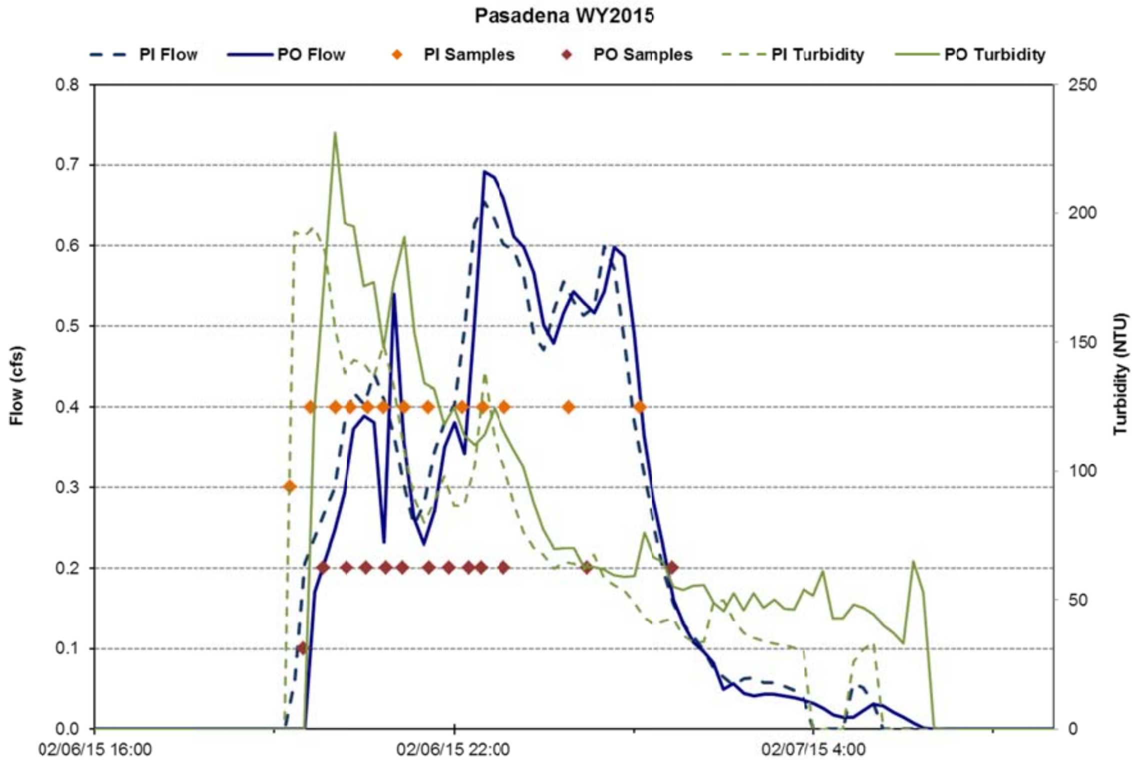

Figure D5: Continuous hydrology, continuous turbidity, and water quality samples for the 2/6/2015 event. Total volume sampled: 10,347 cf.

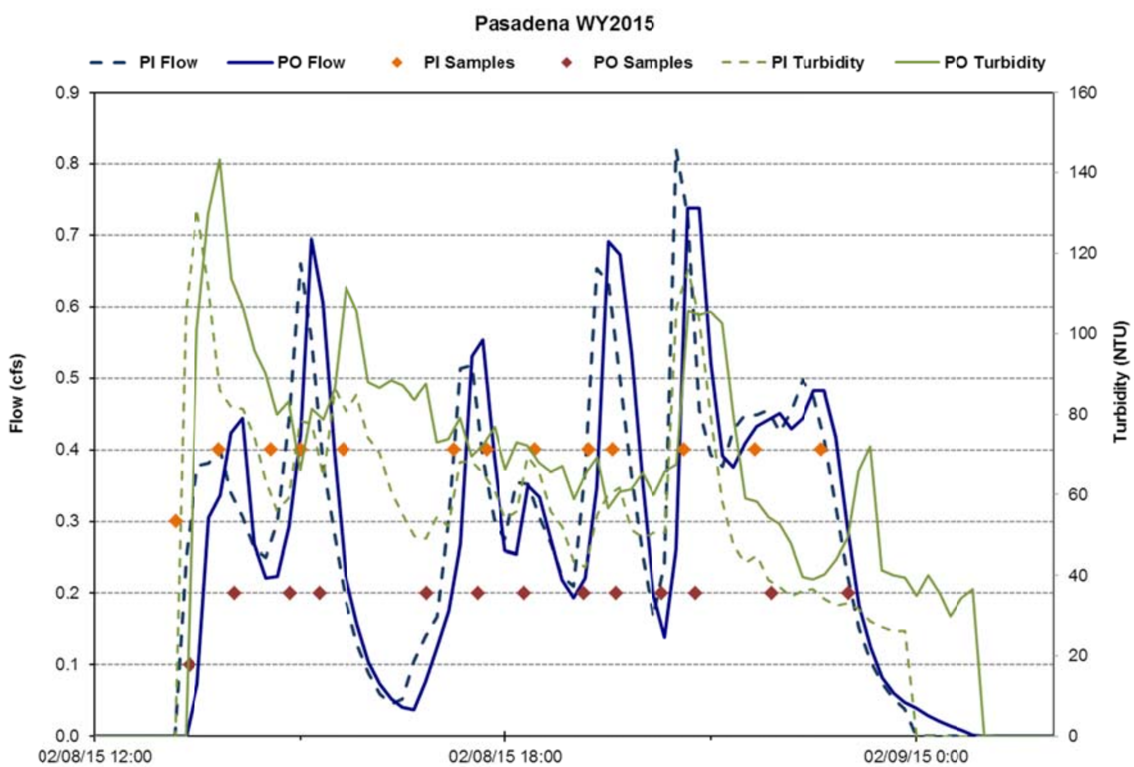

Figure D6: Continuous hydrology, continuous turbidity, and water quality samples for the 2/8/2015 event. Total volume sampled: 12,855 cf.

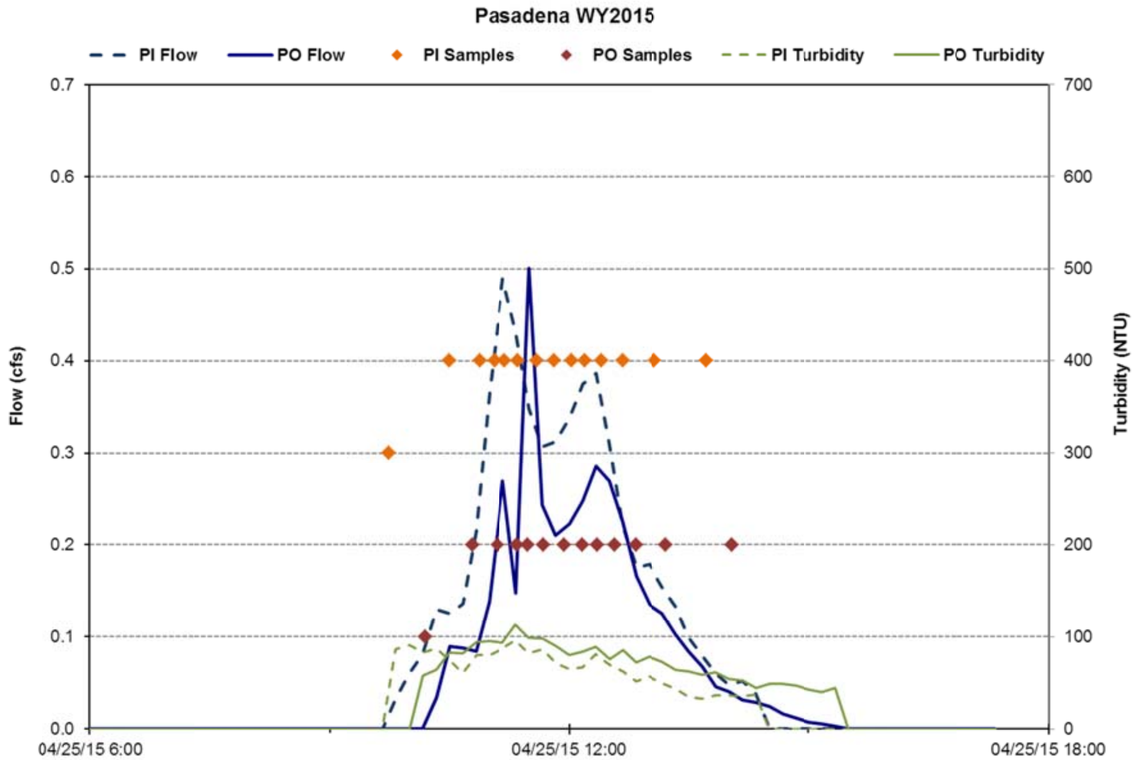

Figure D7: Continuous hydrology, continuous turbidity, and water quality samples for the 4/25/2015 event. Total volume sampled: 3,405 cf.

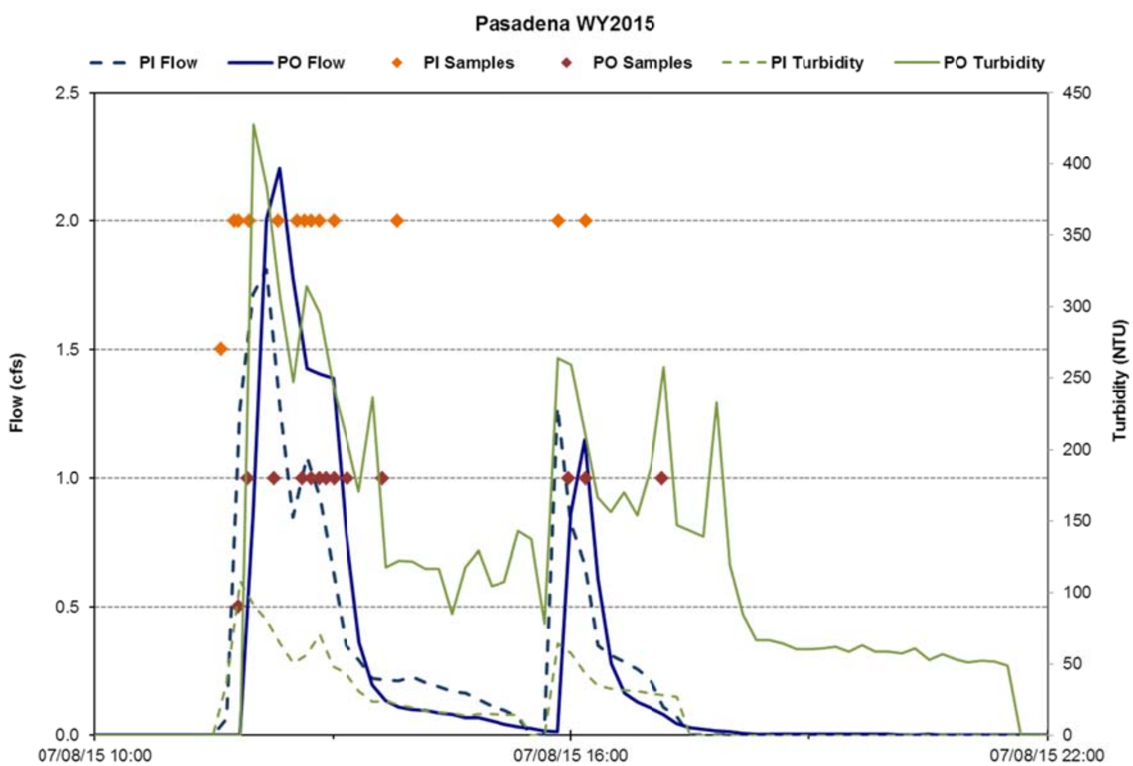

Figure D8: Continuous hydrology, continuous turbidity, and water quality samples for the 7/8/2015 event. Total volume sampled: 10,022 cf.

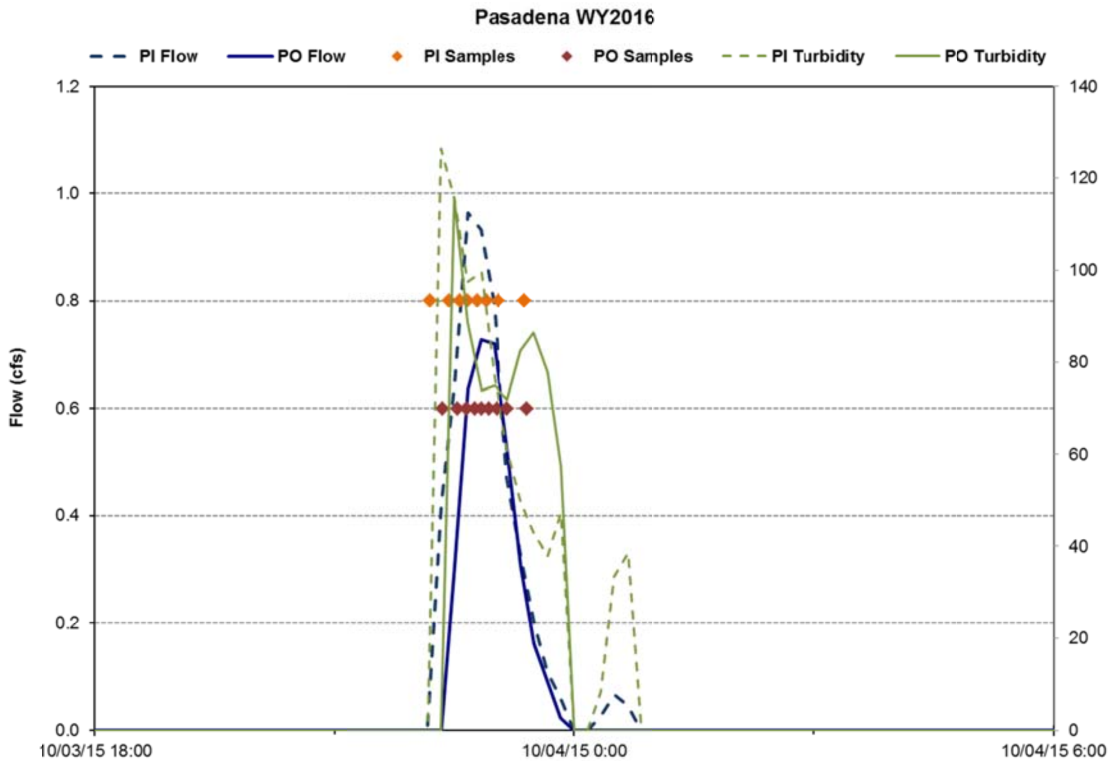

Figure D9: Continuous hydrology, continuous turbidity, and water quality samples for the 10/3/2015 event. Total volume sampled: 3,040 cf.

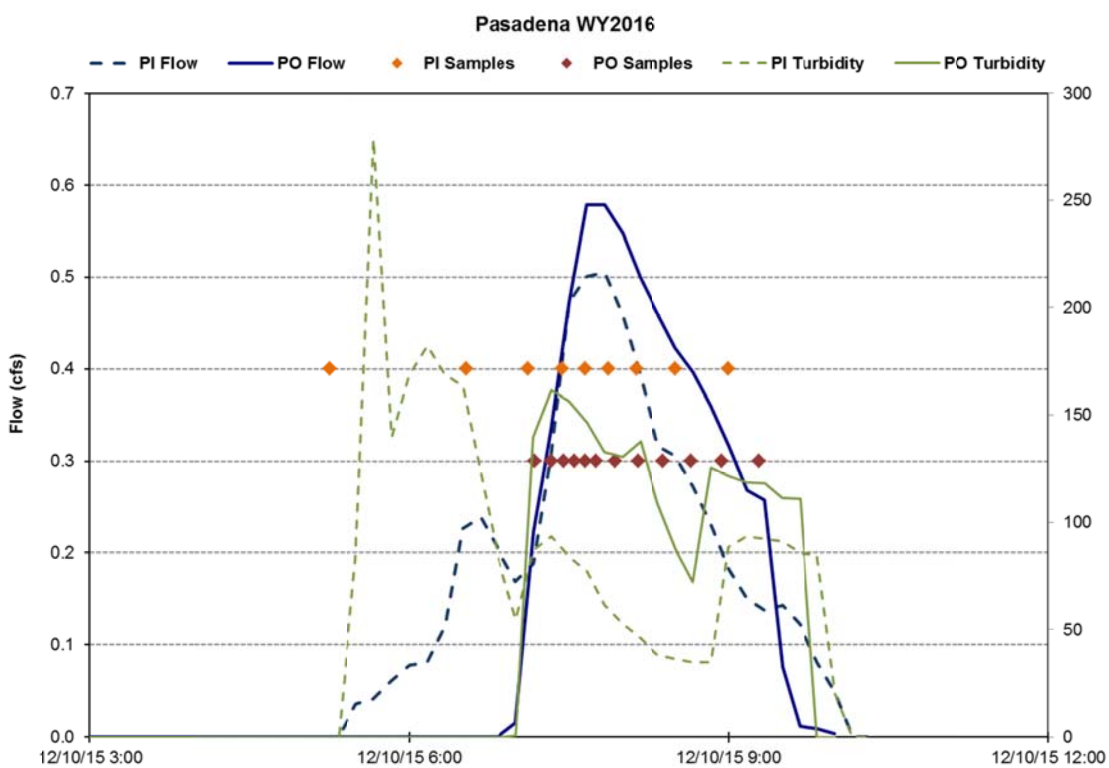

Figure D10: Continuous hydrology, continuous turbidity, and water quality samples for the 12/10/2015 event. Total volume sampled: 3,646 cf.

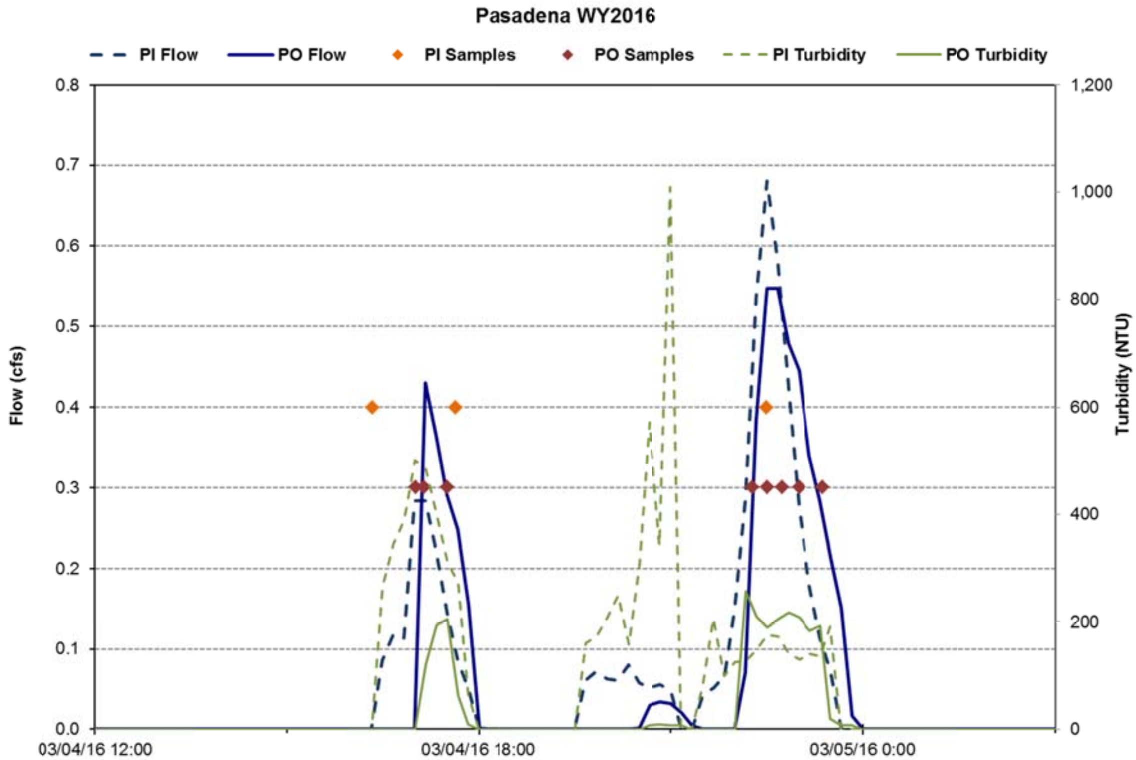

Figure D11: Continuous hydrology, continuous turbidity, and water quality samples for the 3/4/2016 event. Total volume sampled: 3,232 cf.

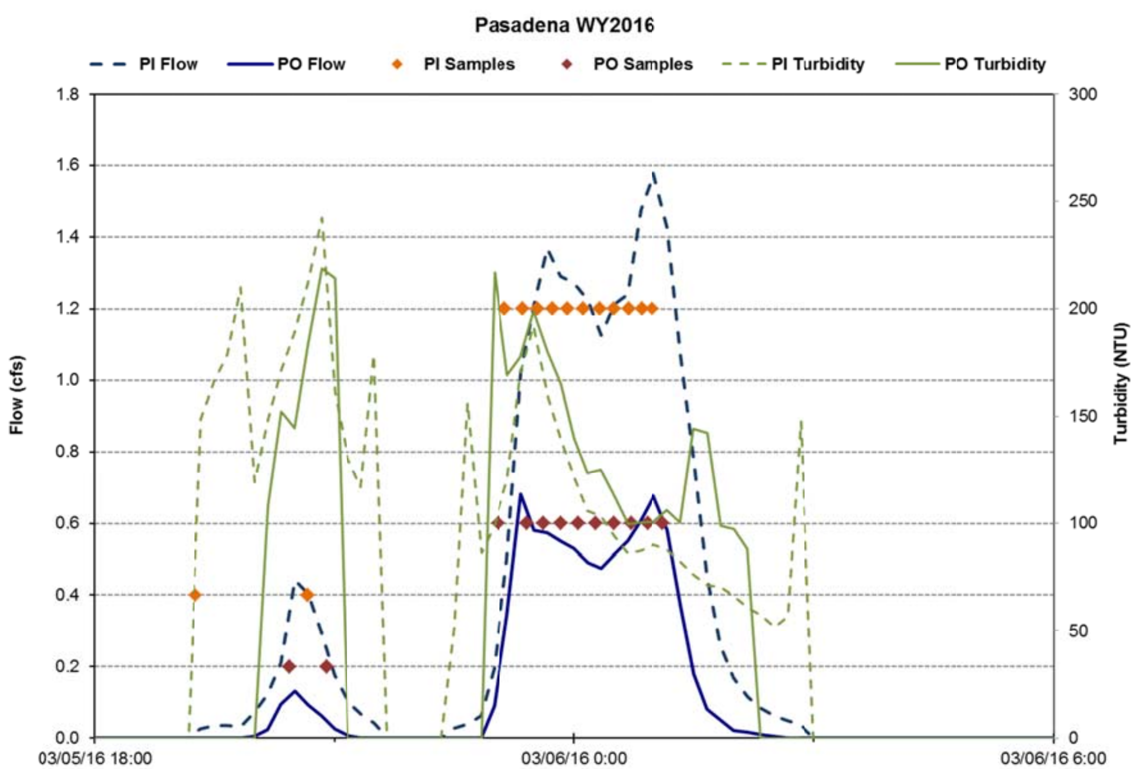

Figure D12: Continuous hydrology, continuous turbidity, and water quality samples for the 3/5/2016 event. Total volume sampled: 14,910 cf.

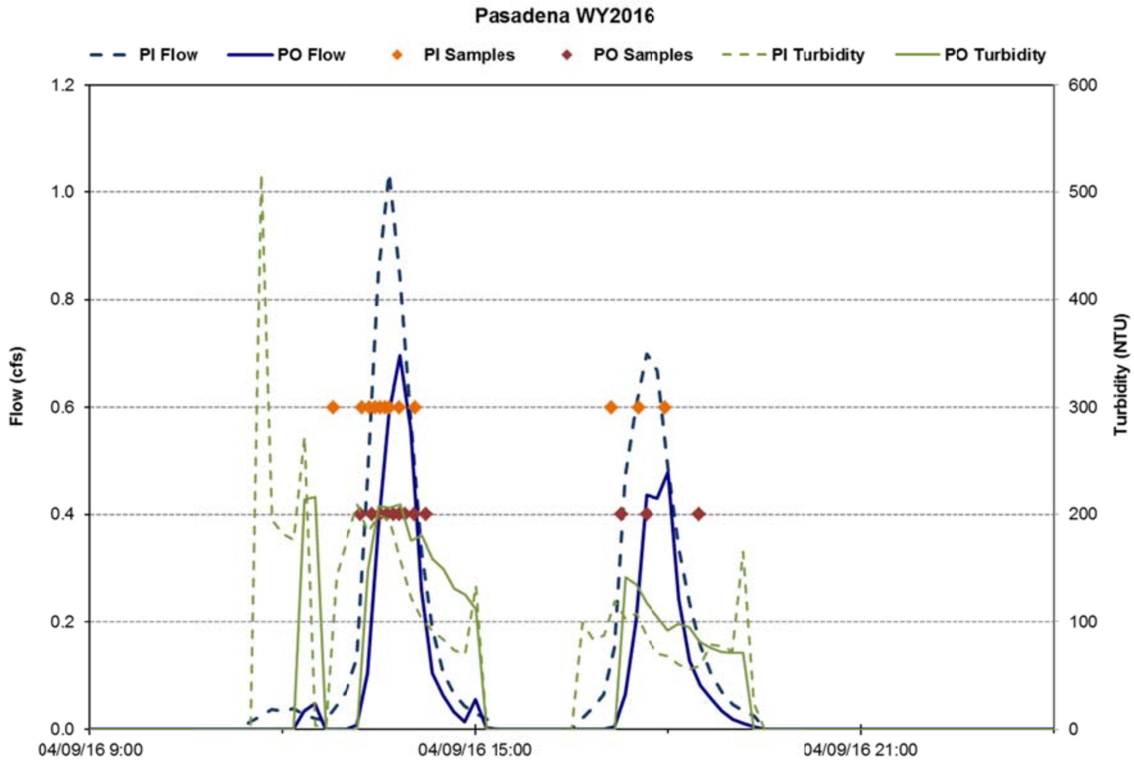

Figure D13: Continuous hydrology, continuous turbidity, and water quality samples for the 4/9/2016 event. Total volume sampled: 5,540 cf.

Appendix E: Rubicon Event Hydrographs

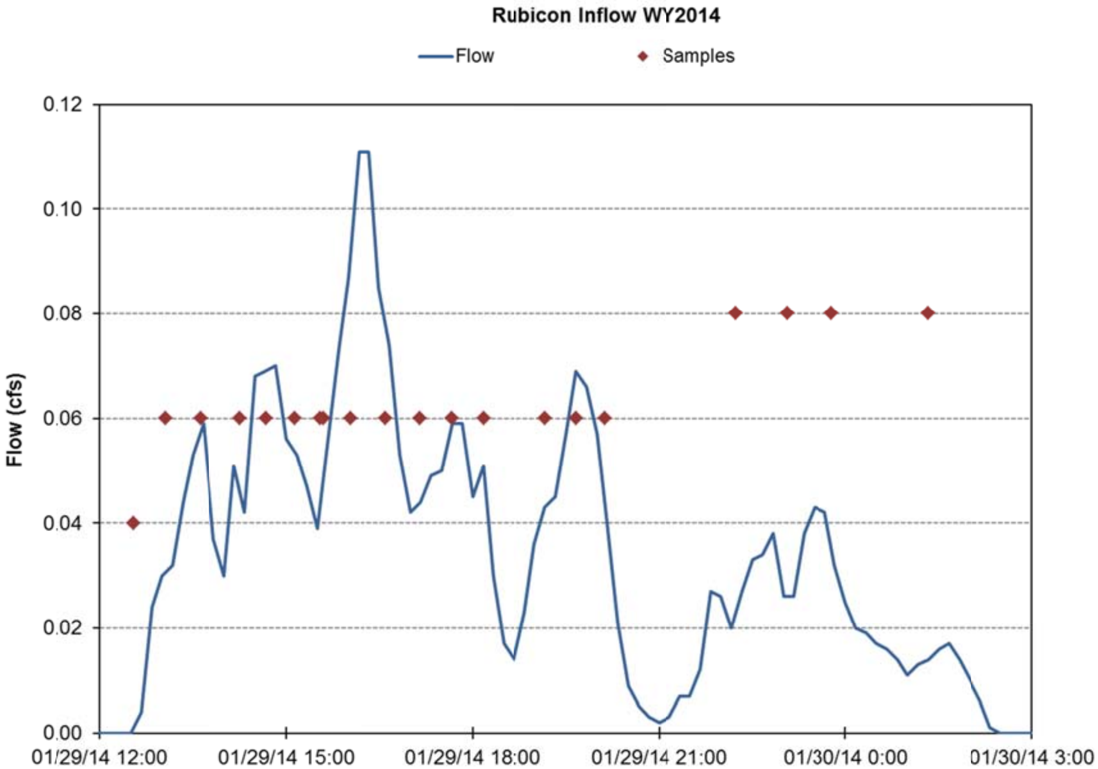

Figure E1: Continuous hydrology and water quality samples for the 1/29/2014 event. Total volume sampled: 392 cf.

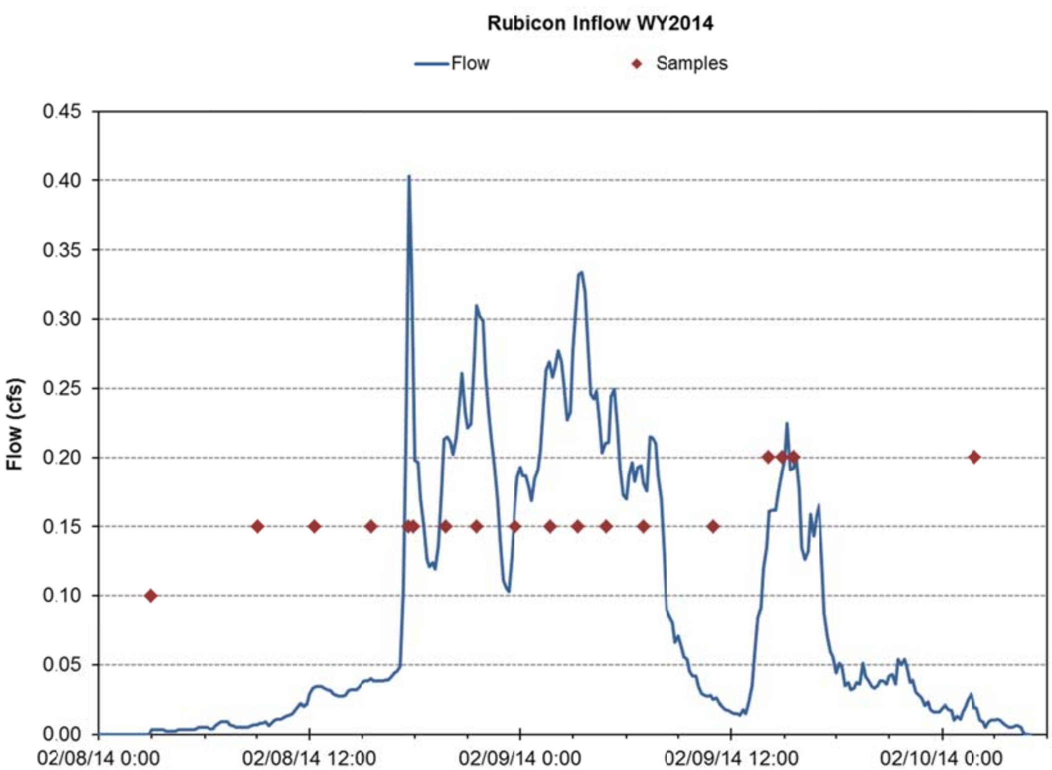

Figure E2: Continuous hydrology and water quality samples for the 2/8/2014 event. Total volume sampled: 16,441 cf.

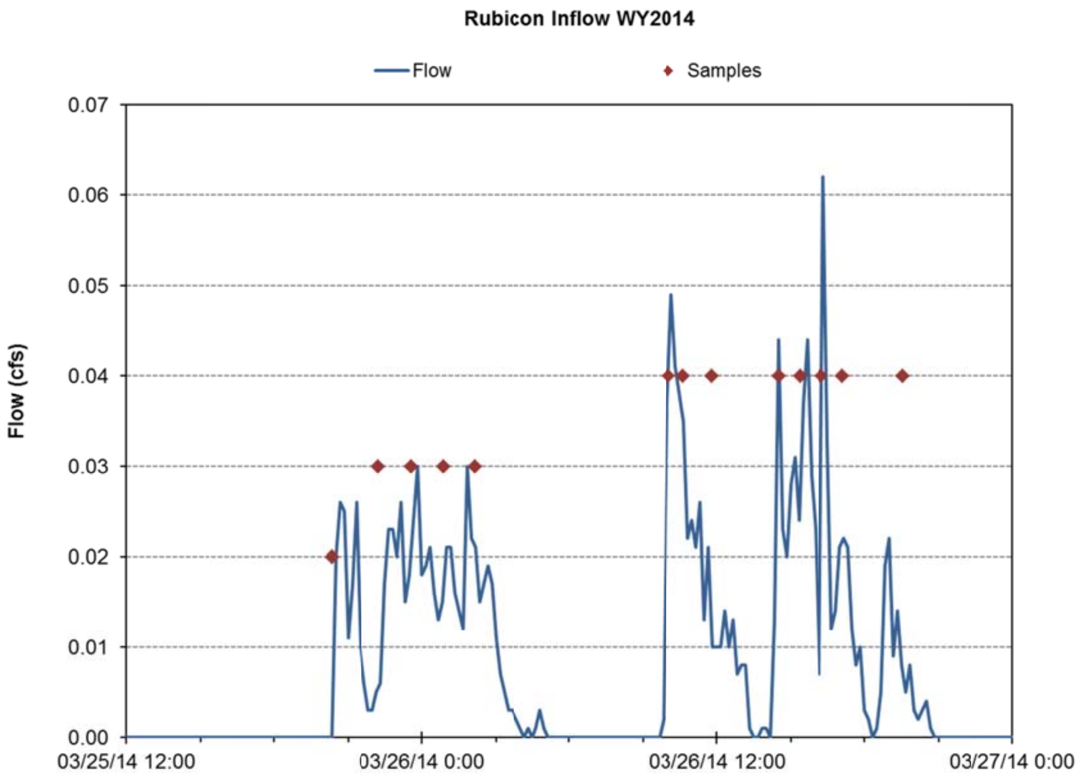

Figure E3: Continuous hydrology and water quality samples for the 3/25/2014 event. Total volume sampled: 1,073 cf.

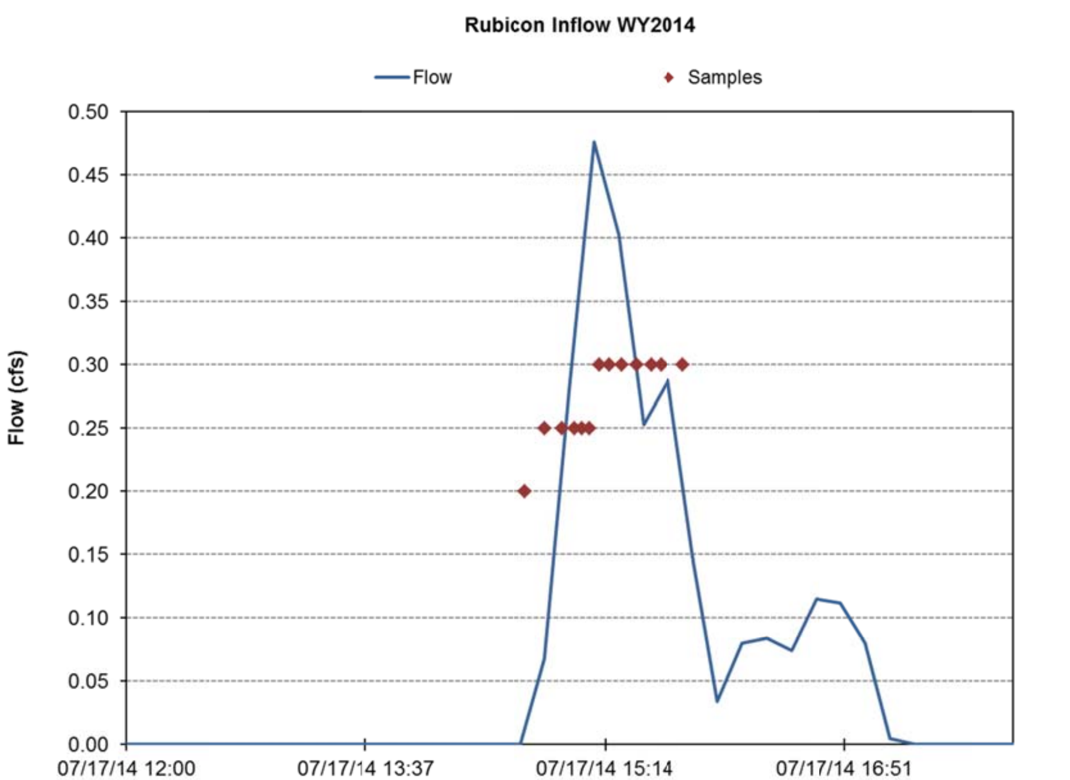

Figure E4: Continuous hydrology and water quality samples for the 7/17/2014 event. Total volume sampled: 1,501 cf.

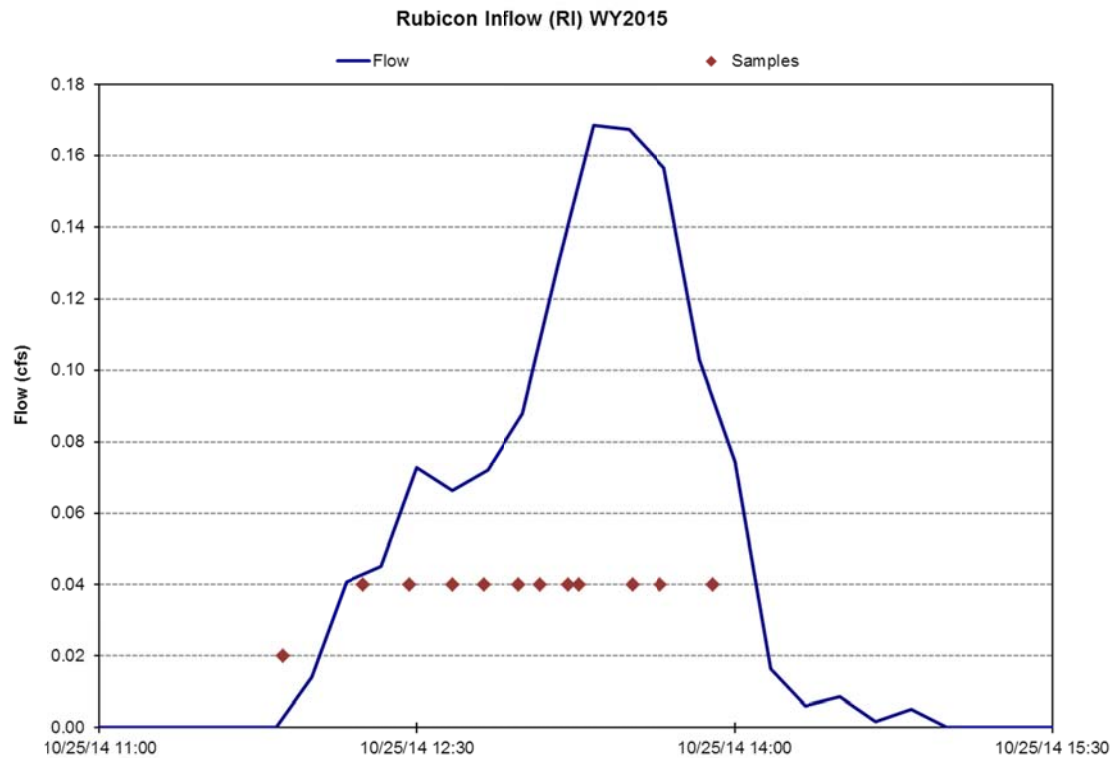

Figure E5: Continuous hydrology and water quality samples for the 10/25/2014 event. Total volume sampled: 741 cf.

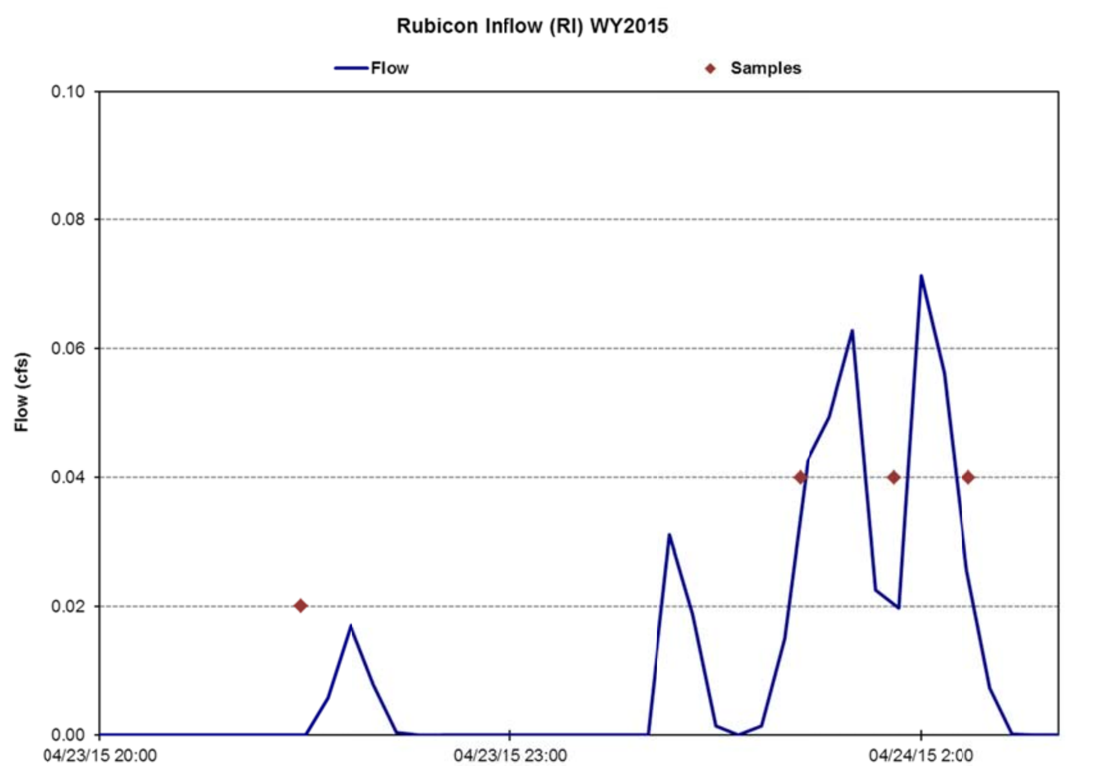

Figure E6: Continuous hydrology and water quality samples for the 4/23/2015 event. Total volume sampled: 273 cf.

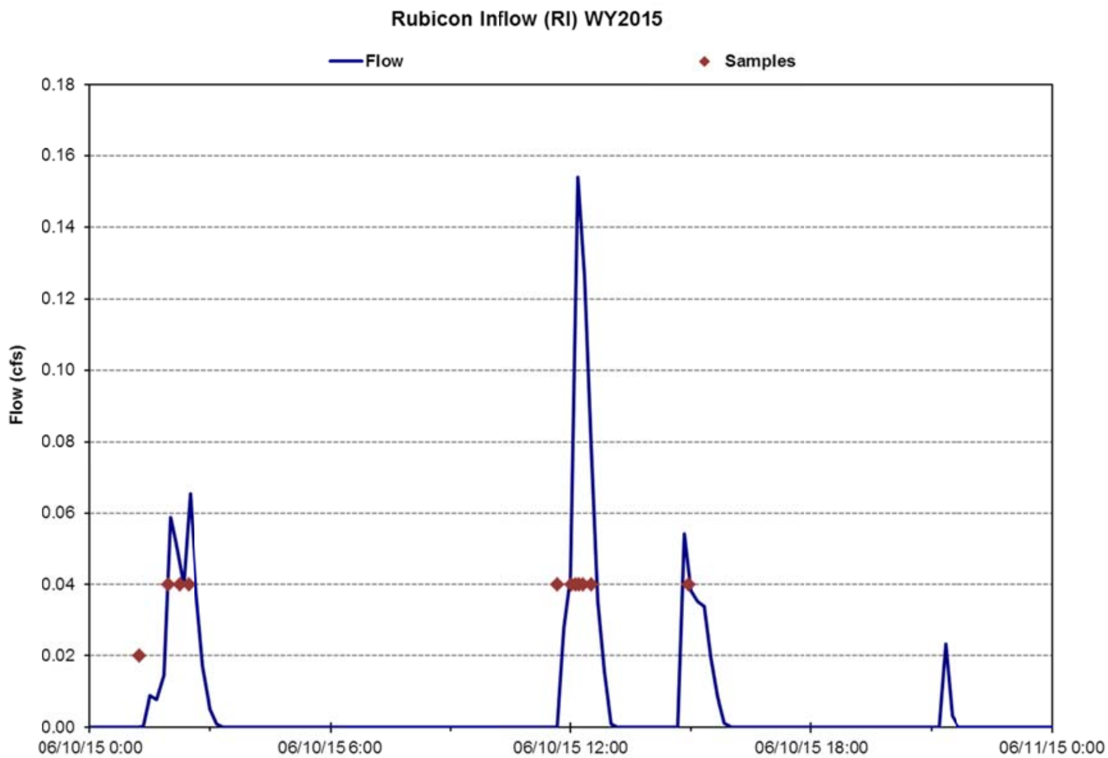

Figure E7: Continuous hydrology and water quality samples for the 6/10/2015 event. Total volume sampled: 603 cf.

Appendix F: SR431 Vaults, Annual Hydrographs

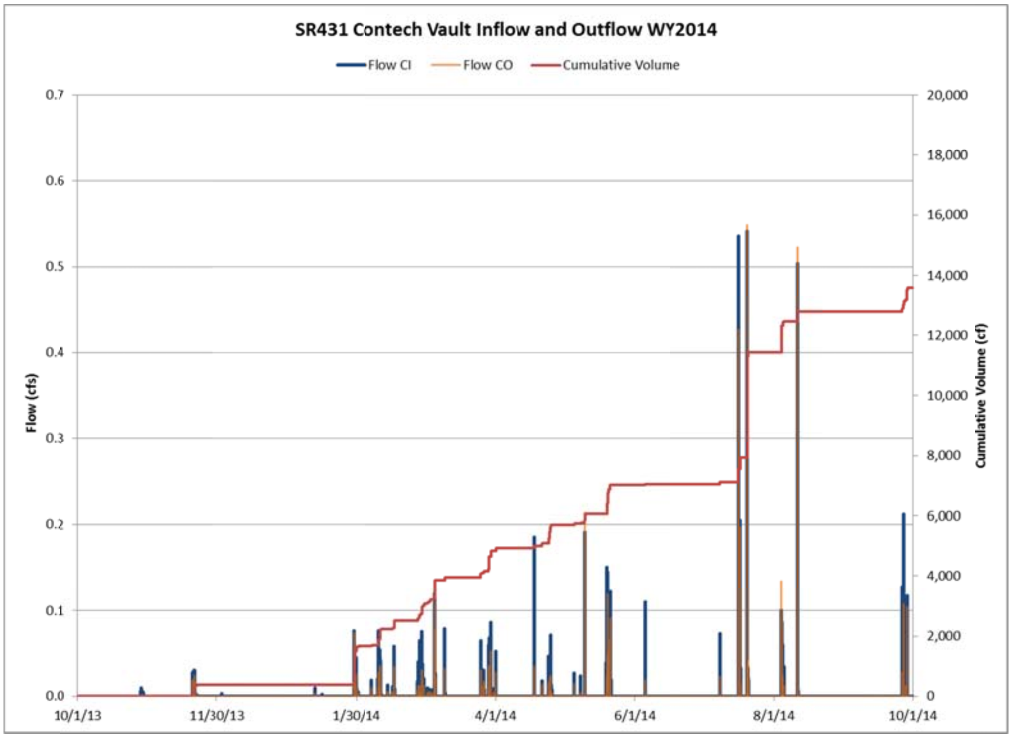

Figure F1a: Continuous hydrology and cumulative volume for the SR431 Contech MFS vault inflow (CI) and outflow (CO) in WY14. Data for individual sampled runoff events is presented in DRI et al 2015.

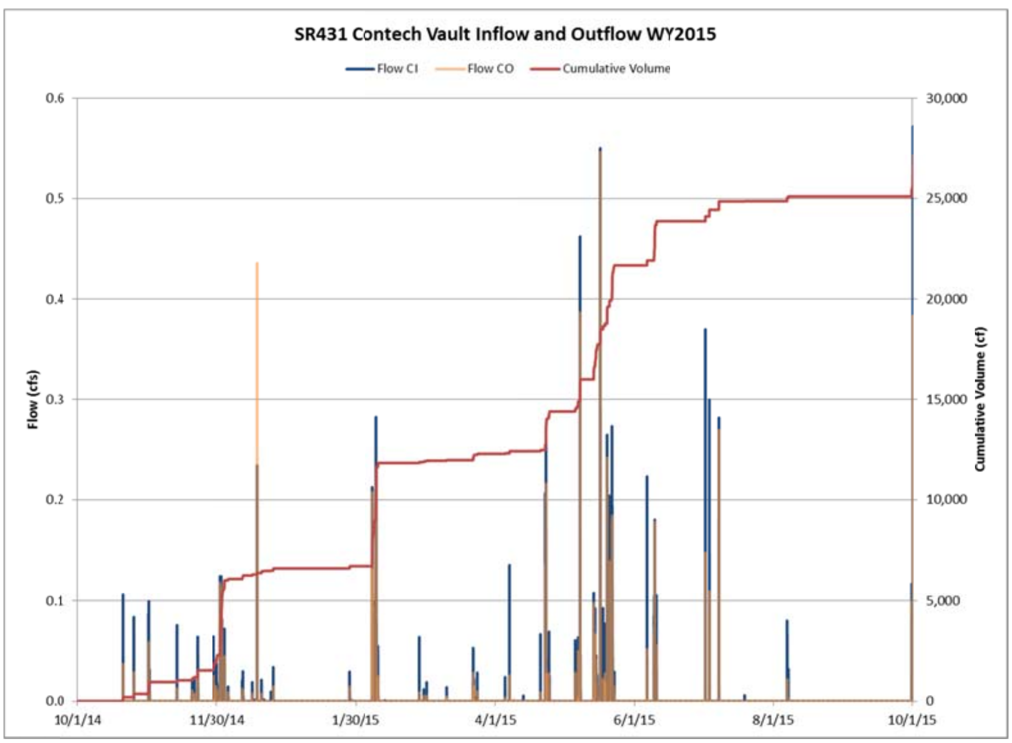

Figure F1b: Continuous hydrology and cumulative volume for the SR431 Contech MFS vault inflow (CI) and outflow (CO) in WY15. Data for individual sampled runoff events through April 2015 is presented in DRI et al 2015.

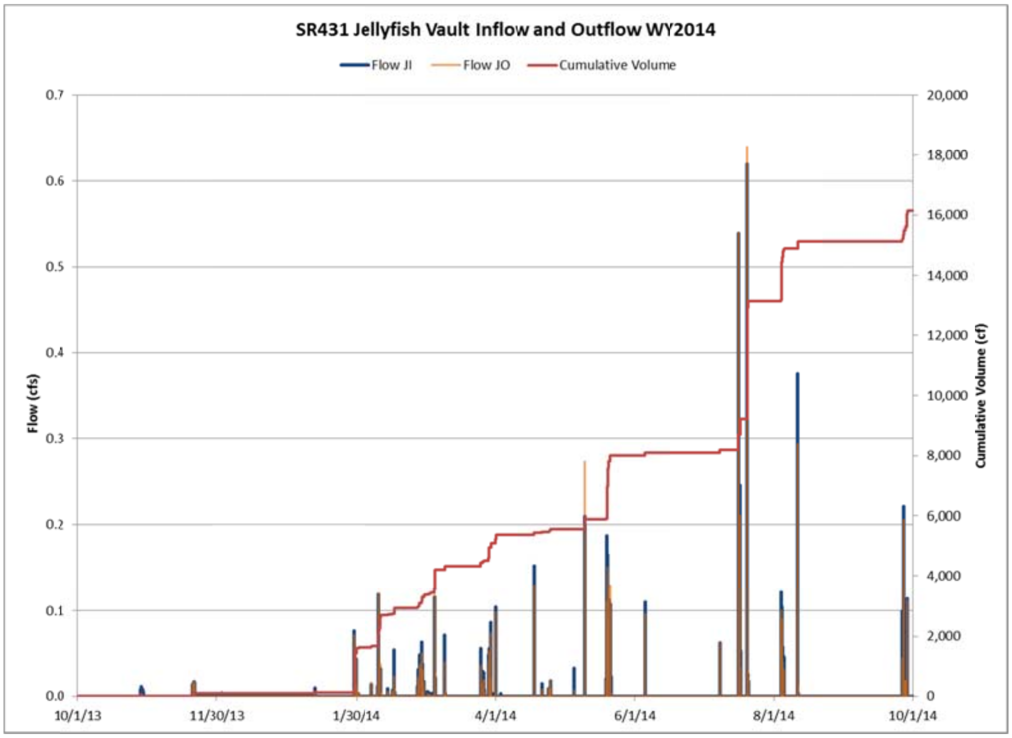

Figure F2a: Continuous hydrology and cumulative volume for the SR431 Jellyfish vaults in WY14. Data for individual sampled runoff events is presented in DRI et al 2015.

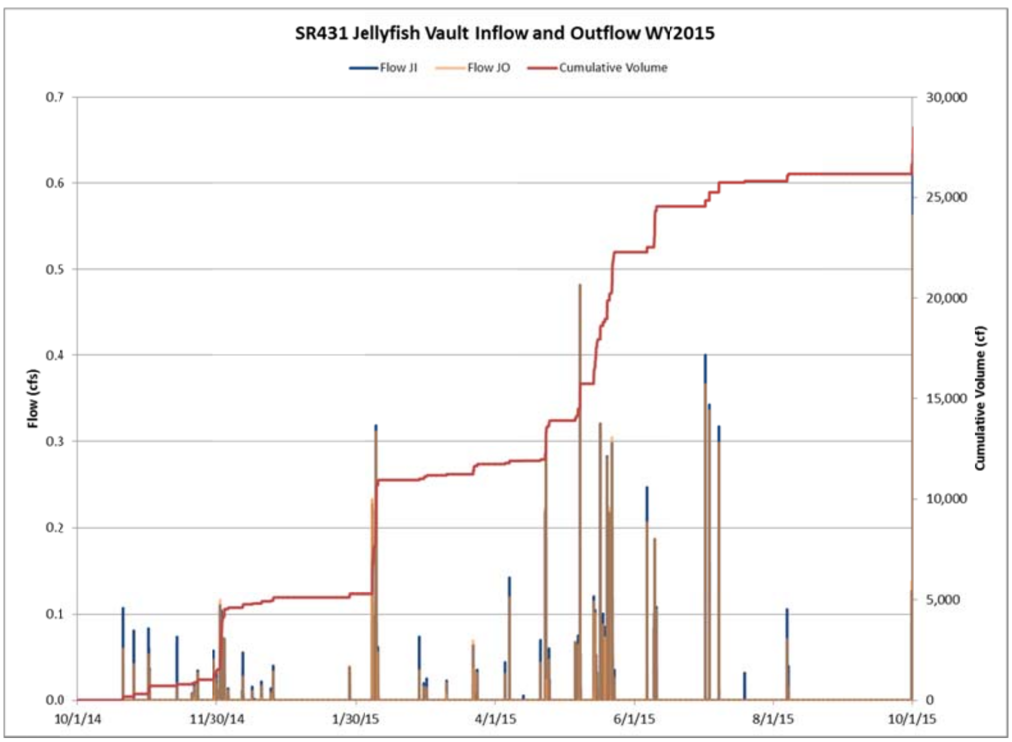

Figure F2b: Continuous hydrology and cumulative volume for the SR431 Jellyfish vaults in WY15. Data for individual sampled runoff events through April 2015 is presented in DRI et al 2015.

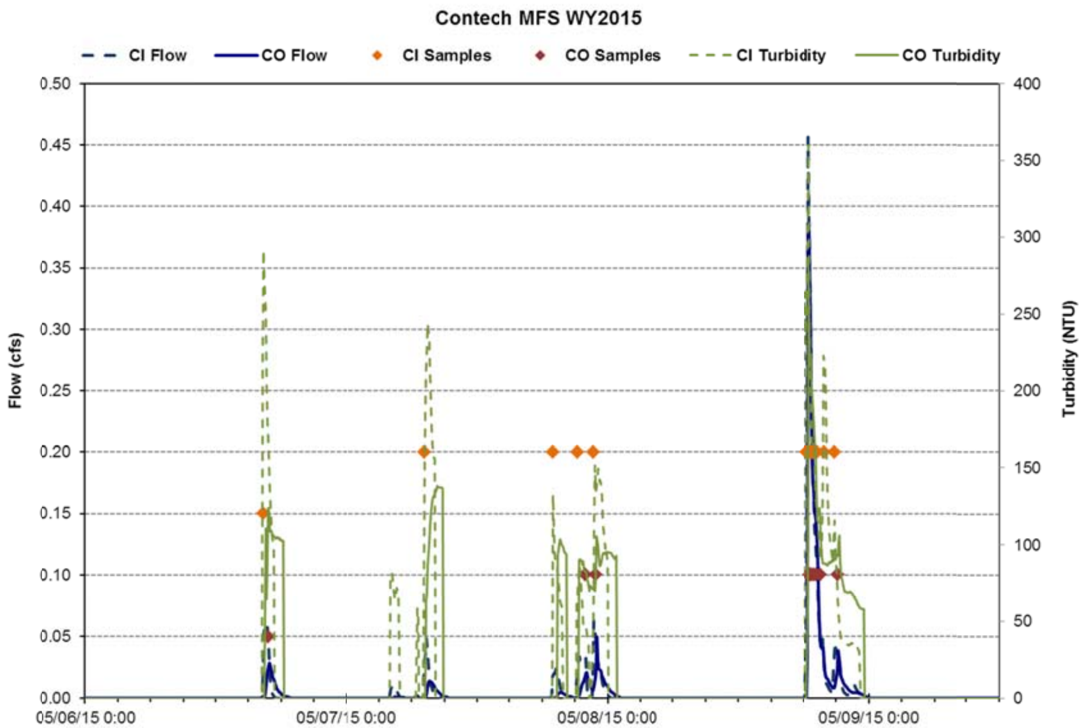

Figure F3: Continuous hydrology, continuous turbidity, and water quality samples for the 5/6/2015 event. Total volume sampled: 1,310 cf.

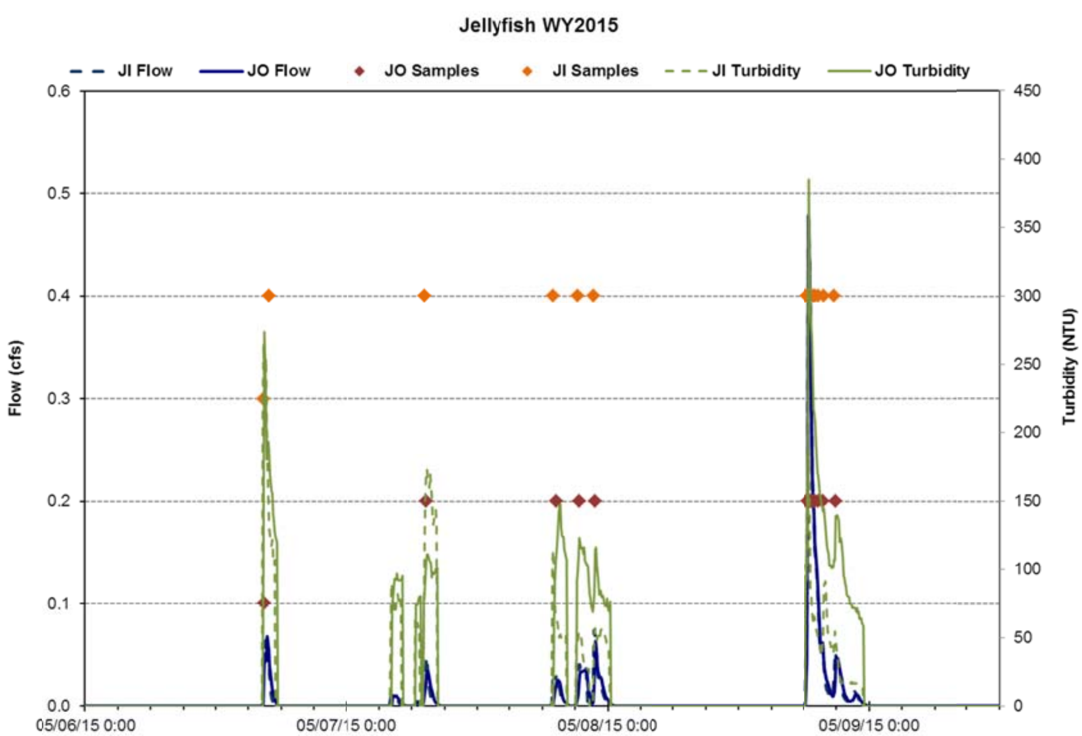

Figure F4: Continuous hydrology, continuous turbidity, and water quality samples for the 5/6/2015 event. Total volume sampled: 1,847 cf.

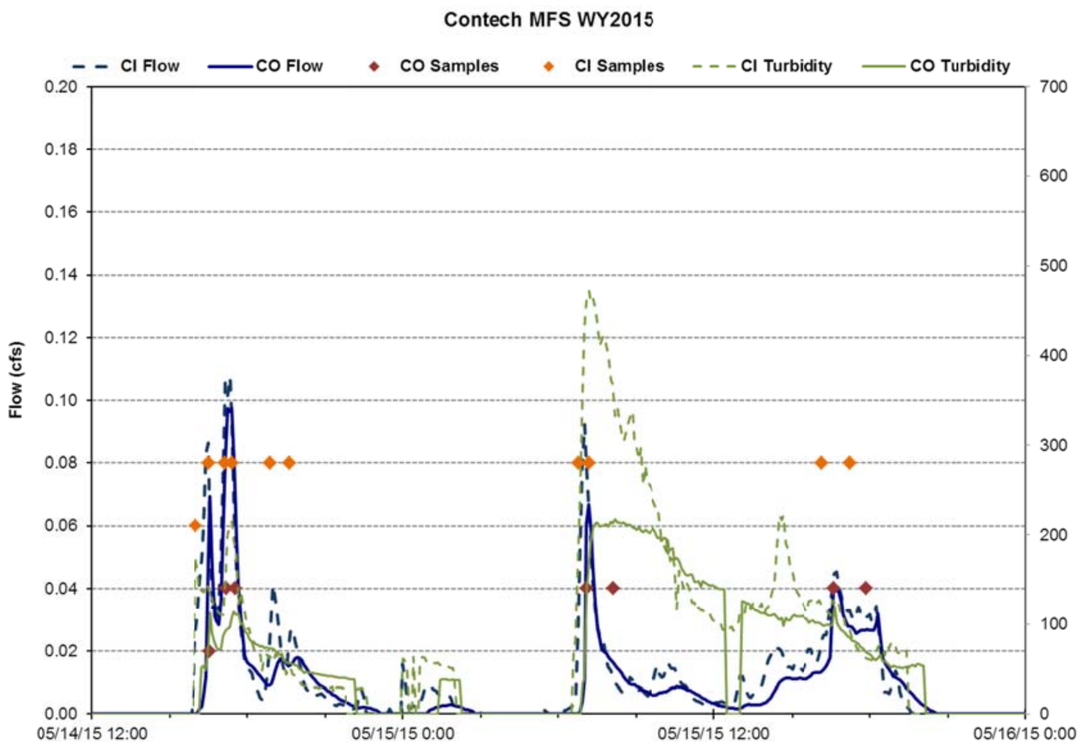

Figure F5: Continuous hydrology, continuous turbidity, and water quality samples for the 5/14/2015 event. Total volume sampled: 1,116 cf.

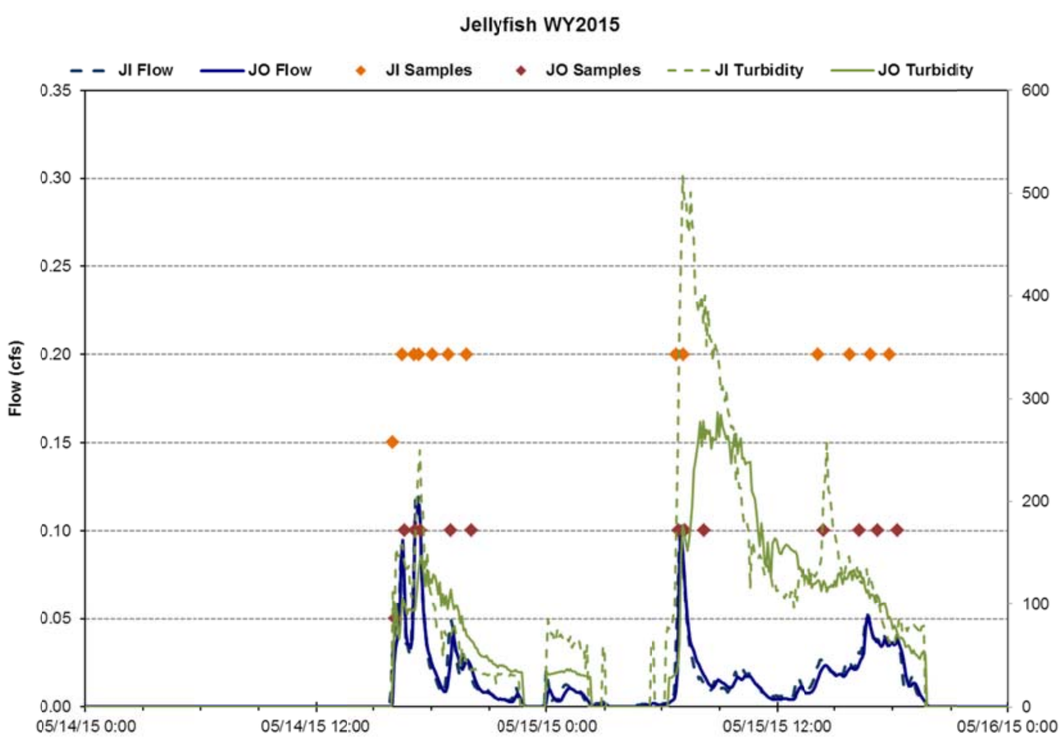

Figure F6: Continuous hydrology, continuous turbidity, and water quality samples for the 5/14/2015 event. Total volume sampled: 1,783 cf.

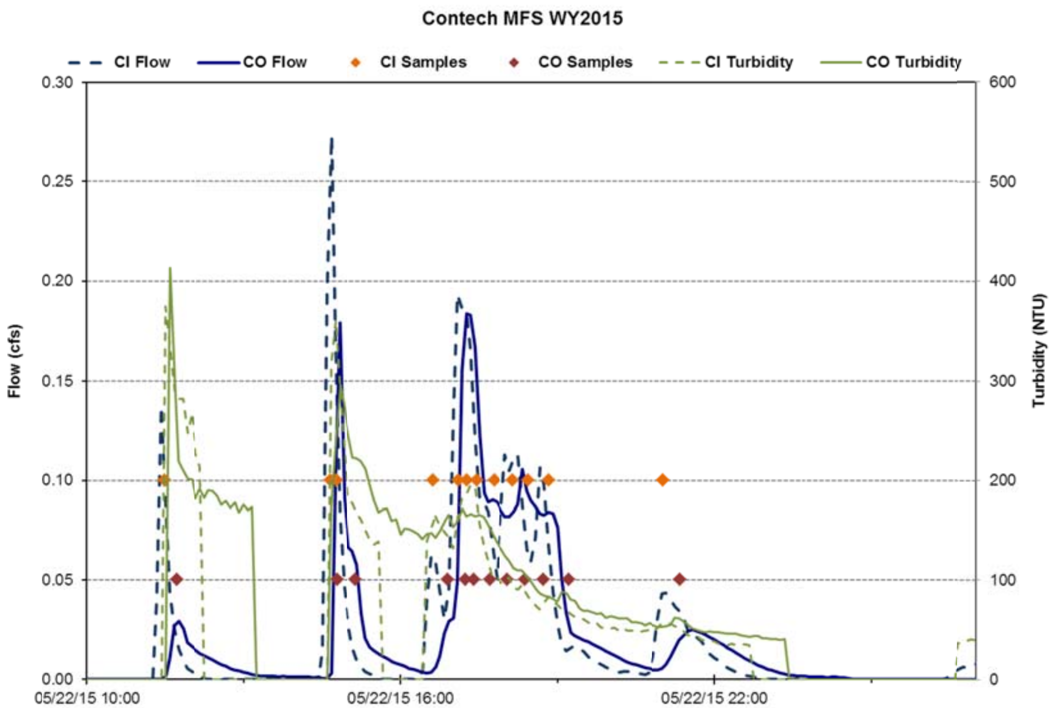

Figure F7: Continuous hydrology, continuous turbidity, and water quality samples for the 5/22/2015 event. Total volume sampled: 1,289 cf.

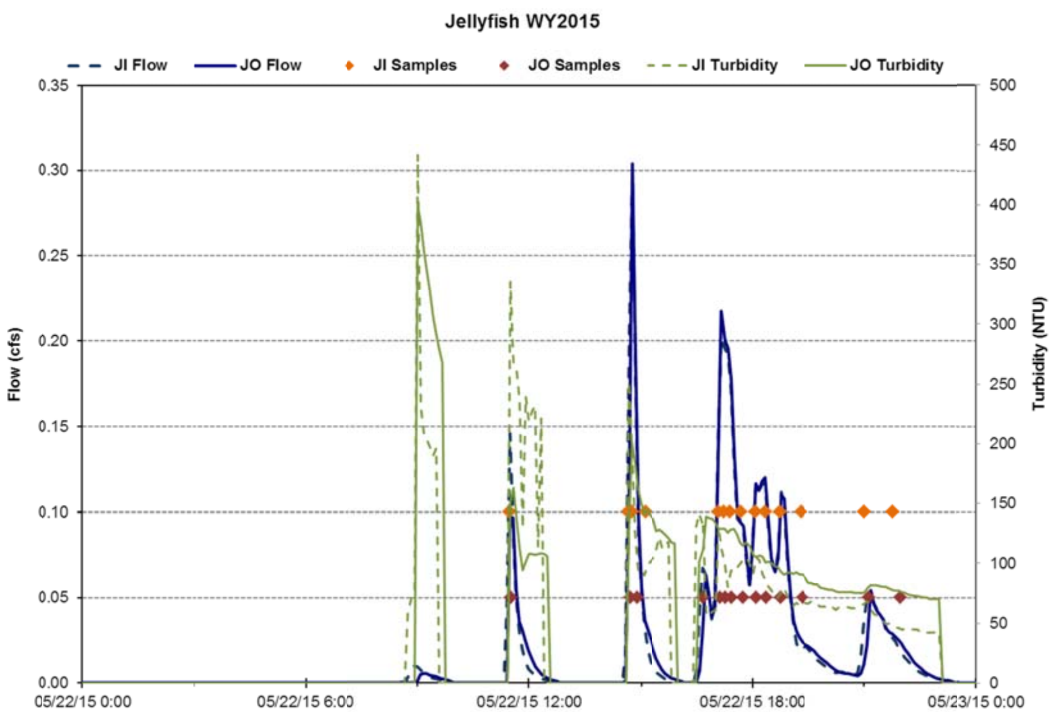

Figure F8: Continuous hydrology, continuous turbidity, and water quality samples for the 5/22/2015 event.
Total volume sampled: 1,526 cf.

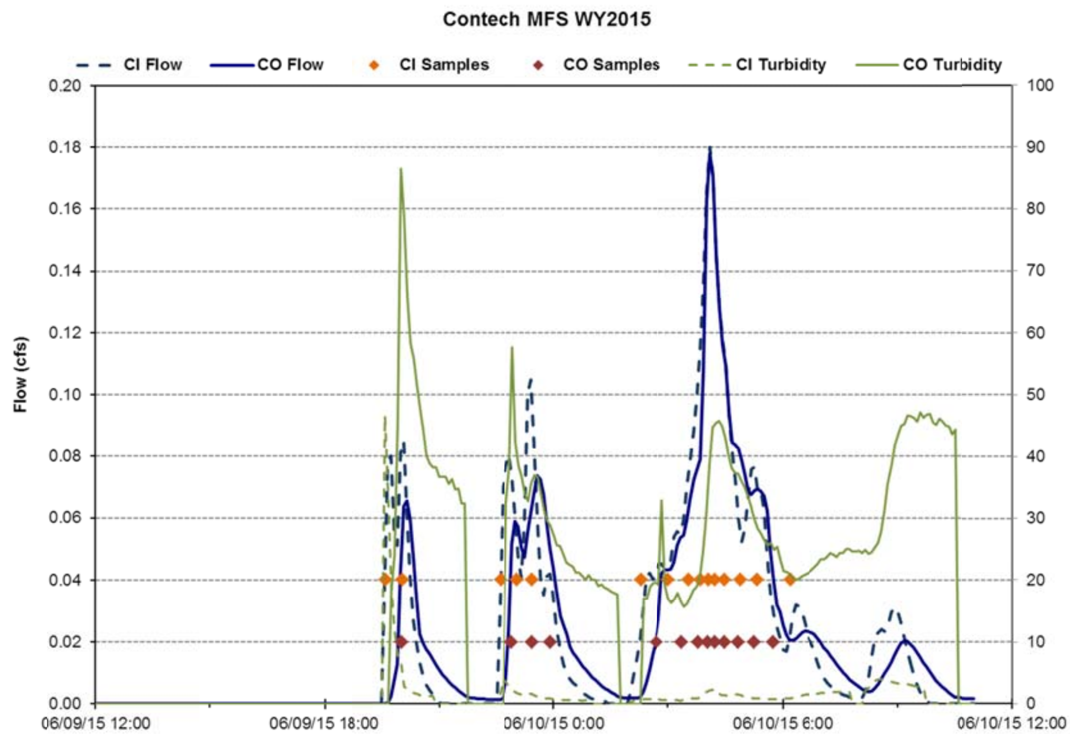

Figure F9: Continuous hydrology, continuous turbidity, and water quality samples for the 6/9/2015 event. Total volume sampled: 1,536 cf.

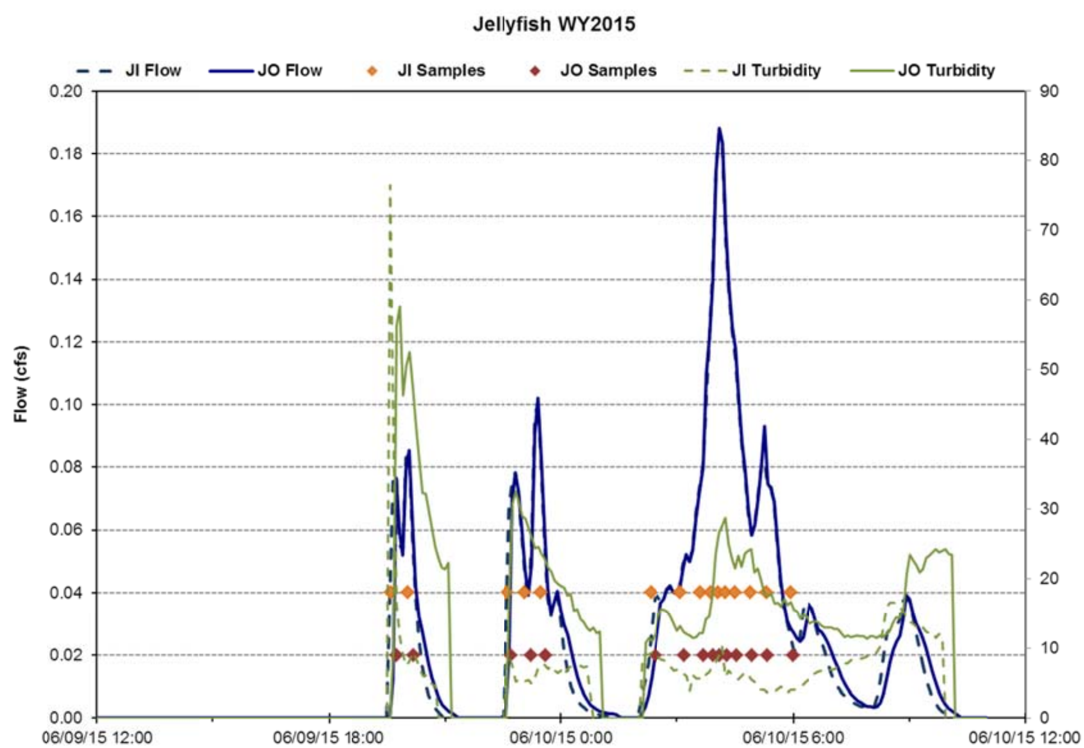

Figure F10: Continuous hydrology, continuous turbidity, and water quality samples for the 6/9/2015 event. Total volume sampled: 1,658 cf.

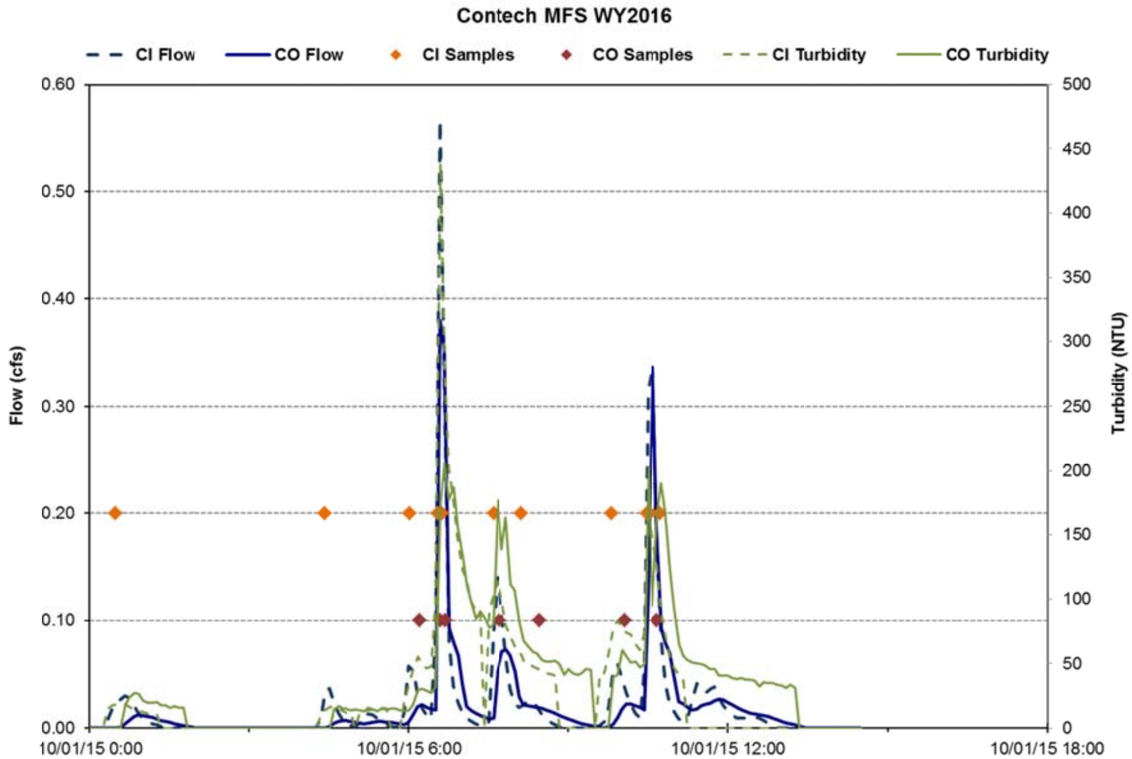

Figure F11: Continuous hydrology, continuous turbidity, and water quality samples for the 10/1/2015 event. Total volume sampled: 1,214 cf.

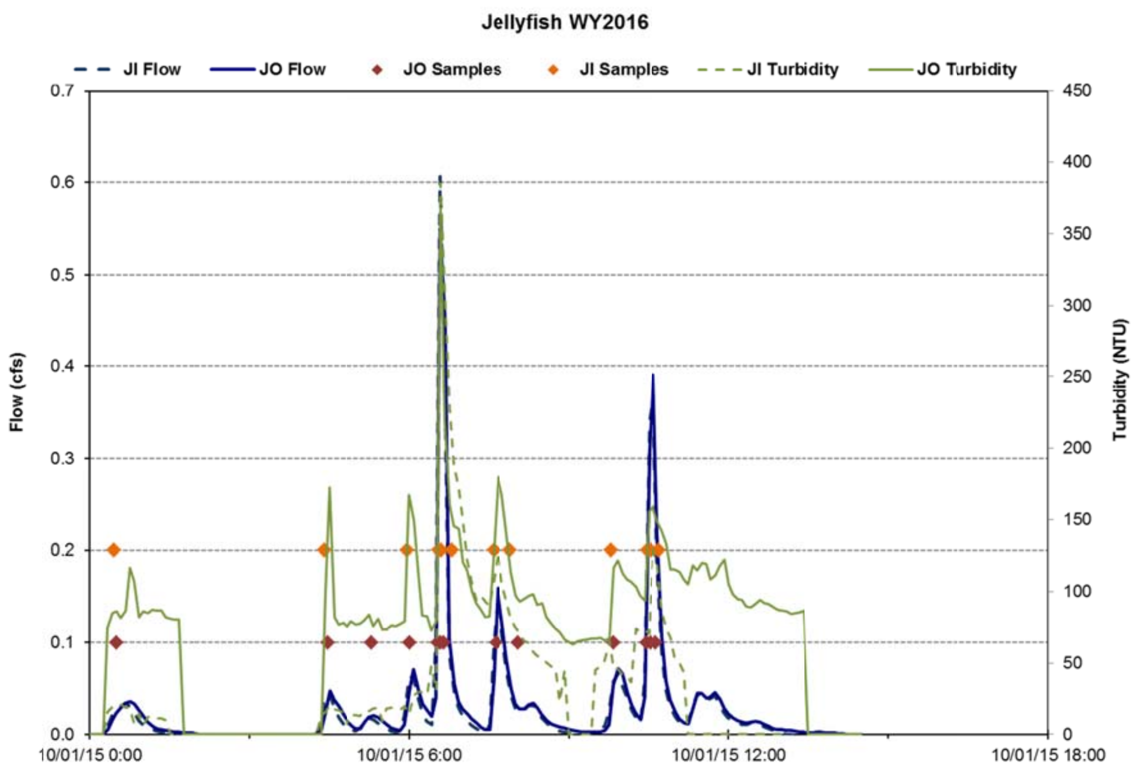

Figure F12: Continuous hydrology, continuous turbidity, and water quality samples for the 10/1/2015 event. Total volume sampled: 1,658 cf.

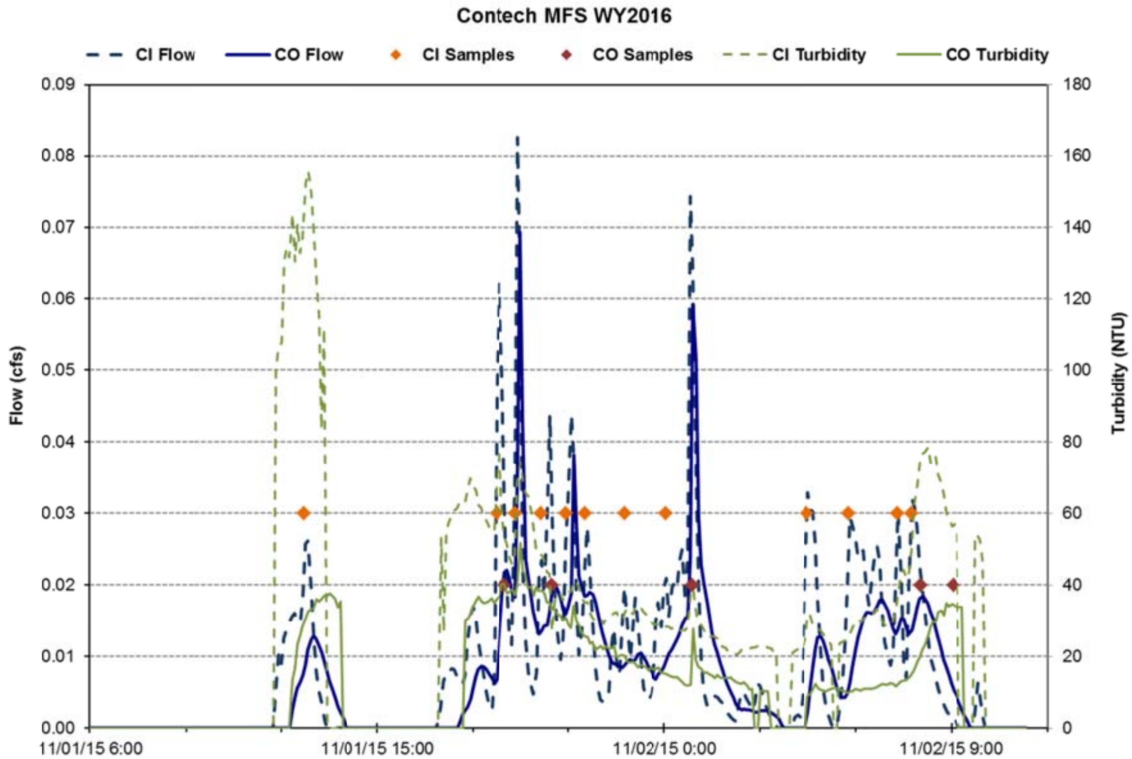

Figure F13: Continuous hydrology, continuous turbidity, and water quality samples for the 11/1/2015 event. Total volume sampled: 915 cf.

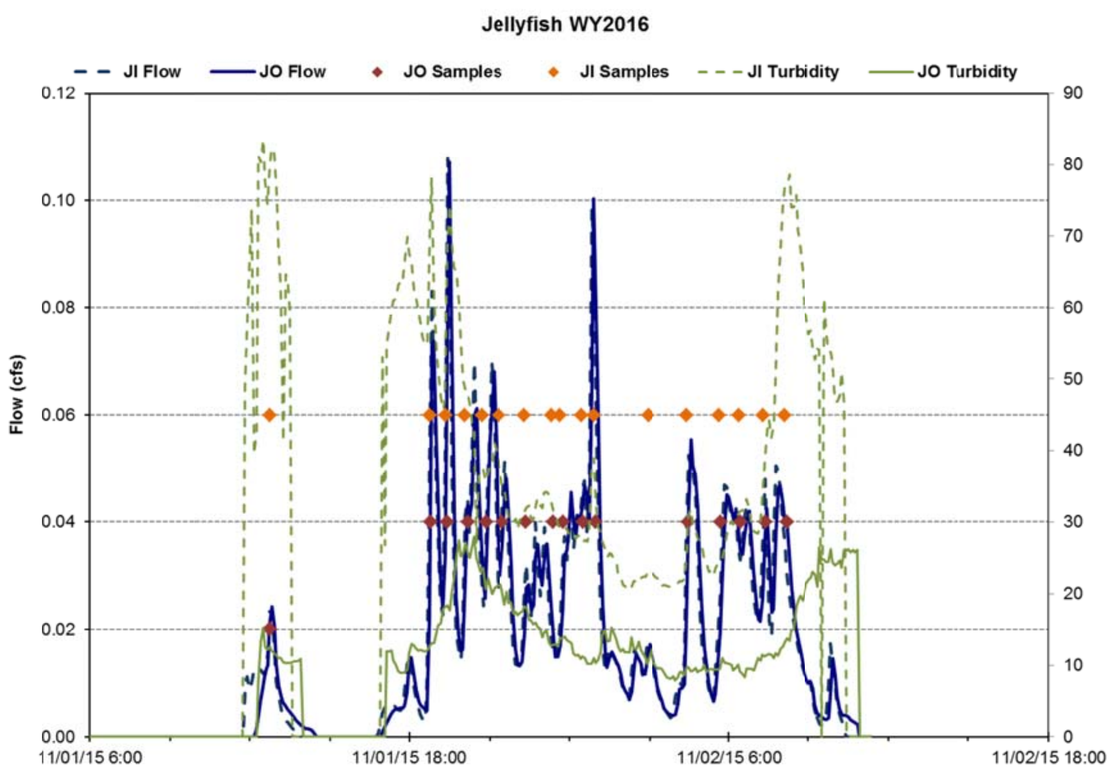

Figure F14: Continuous hydrology, continuous turbidity, and water quality samples for the 11/1/2015 event. Total volume sampled: 1,496 cf.

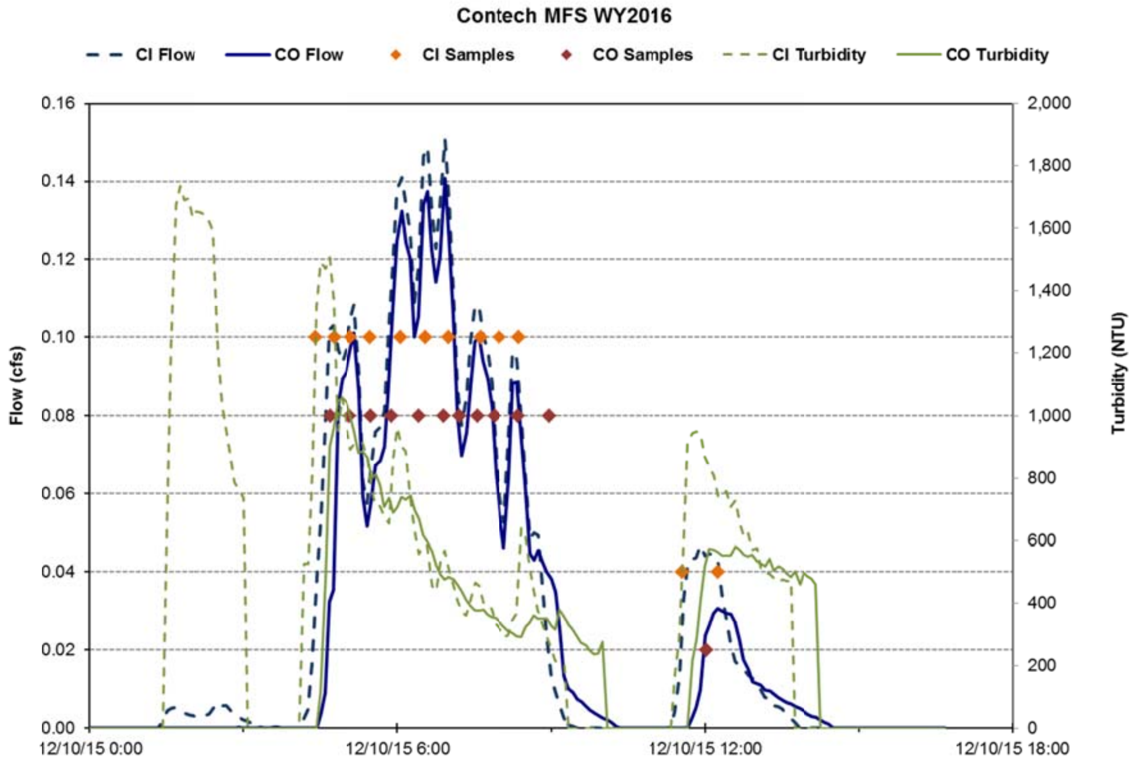

Figure F15: Continuous hydrology, continuous turbidity, and water quality samples for the 12/10/2015 event. Total volume sampled: 1,760 cf.

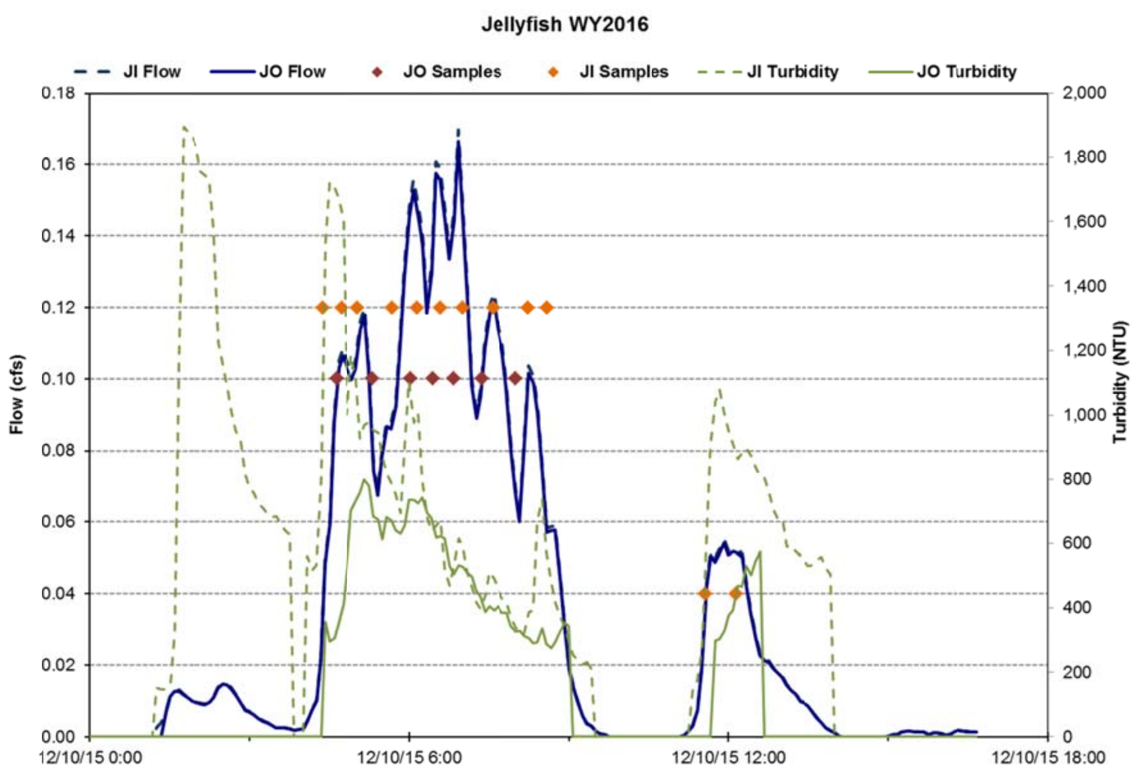

Figure F16: Continuous hydrology, continuous turbidity, and water quality samples for the 12/10/2015 event. Total volume sampled: 2,076 cf.

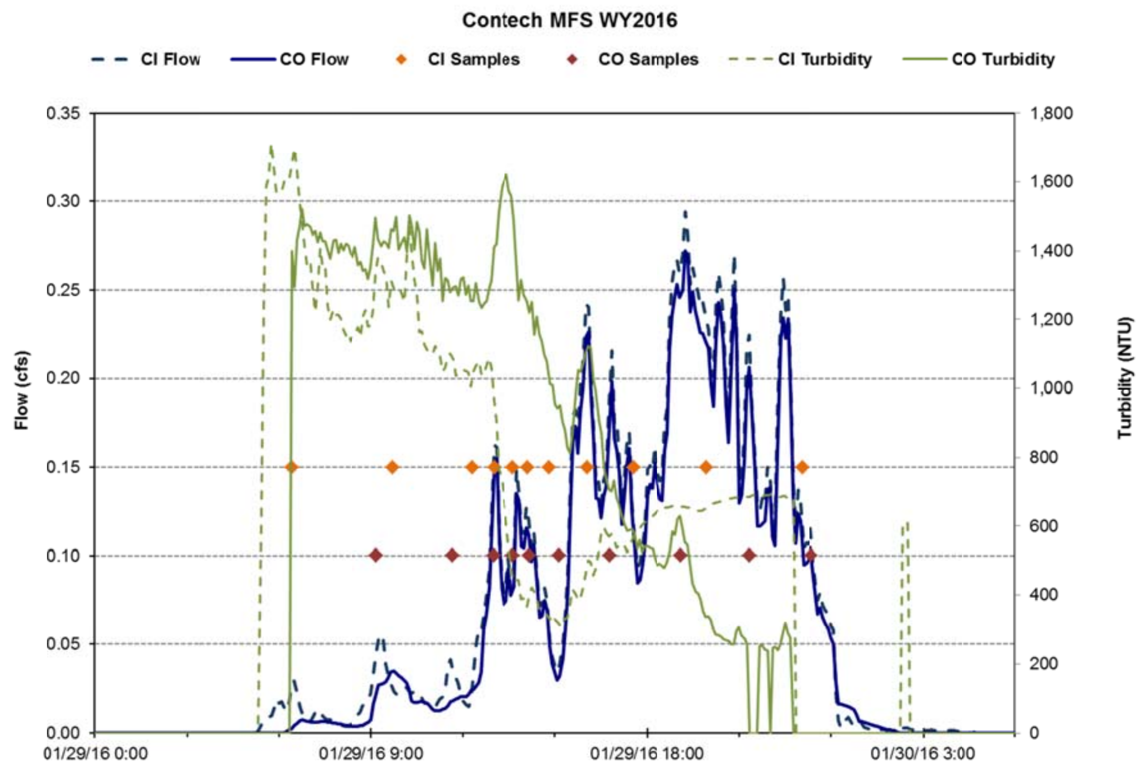

Figure F17: Continuous hydrology, continuous turbidity, and water quality samples for the 1/29/2016 event. Total volume sampled: 6,903 cf.

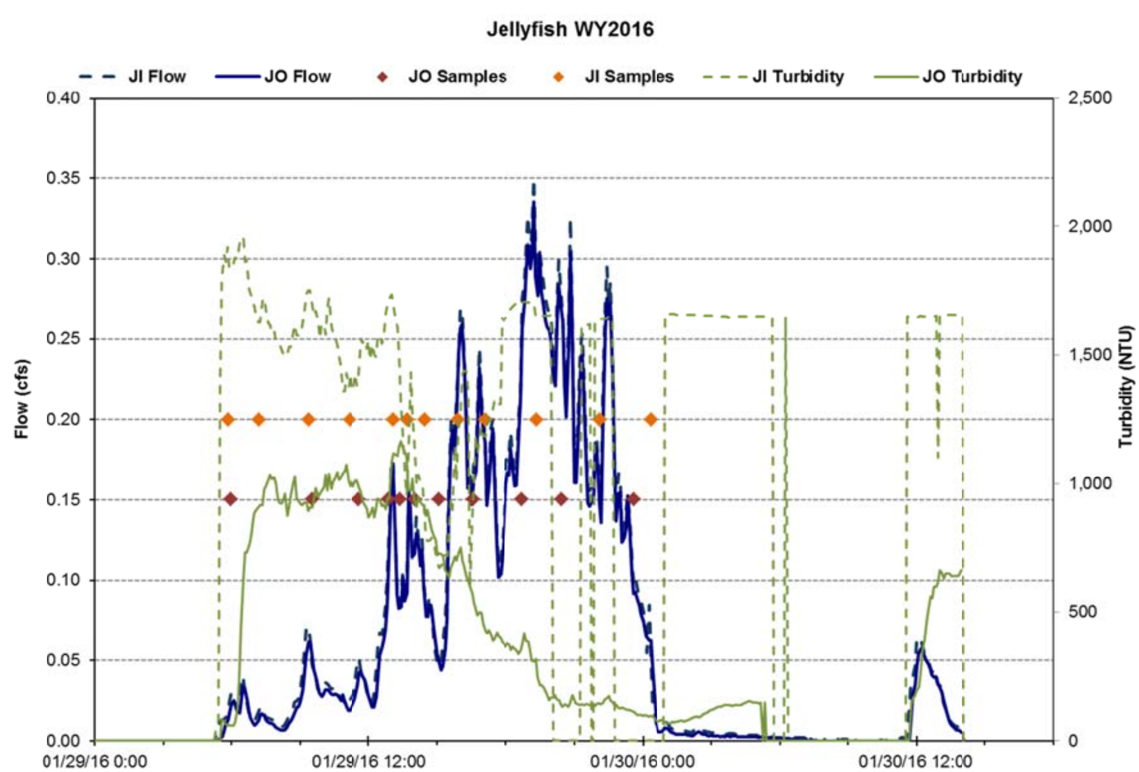

Figure F18: Continuous hydrology, continuous turbidity, and water quality samples for the 1/29/2016 event. Total volume sampled 8,327 cf.

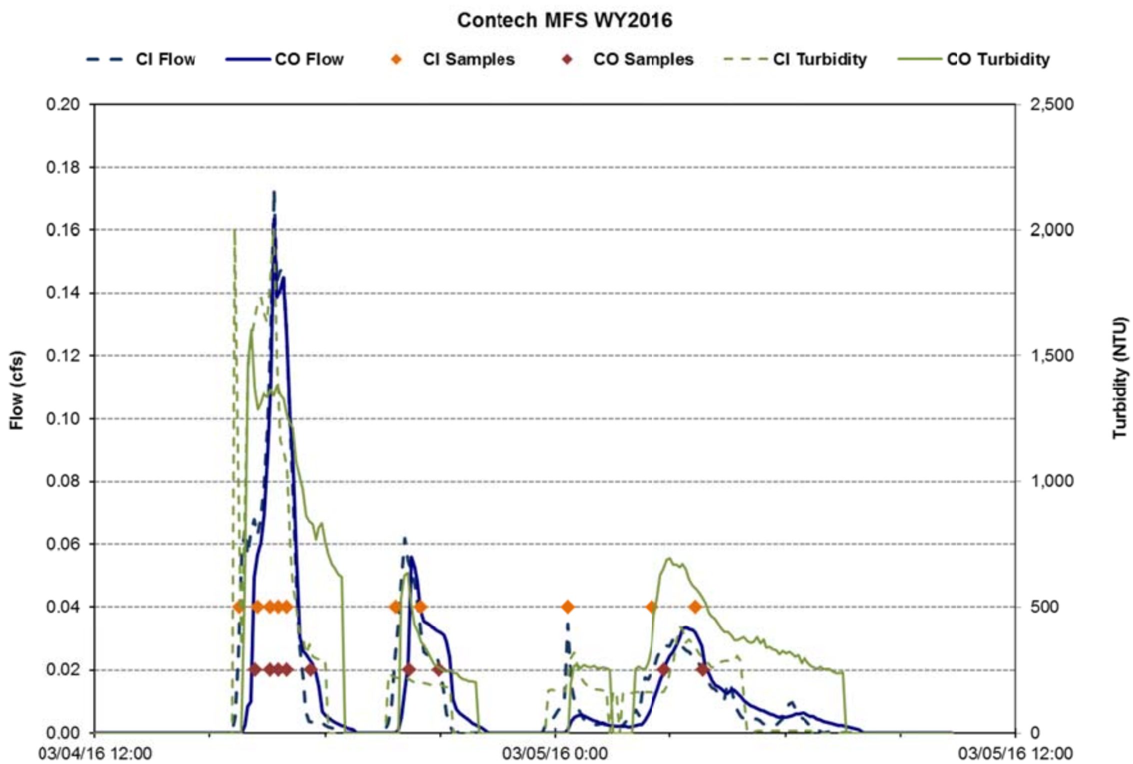

Figure F19: Continuous hydrology, continuous turbidity, and water quality samples for the 3/4/2016 event. Total volume sampled: 999 cf.

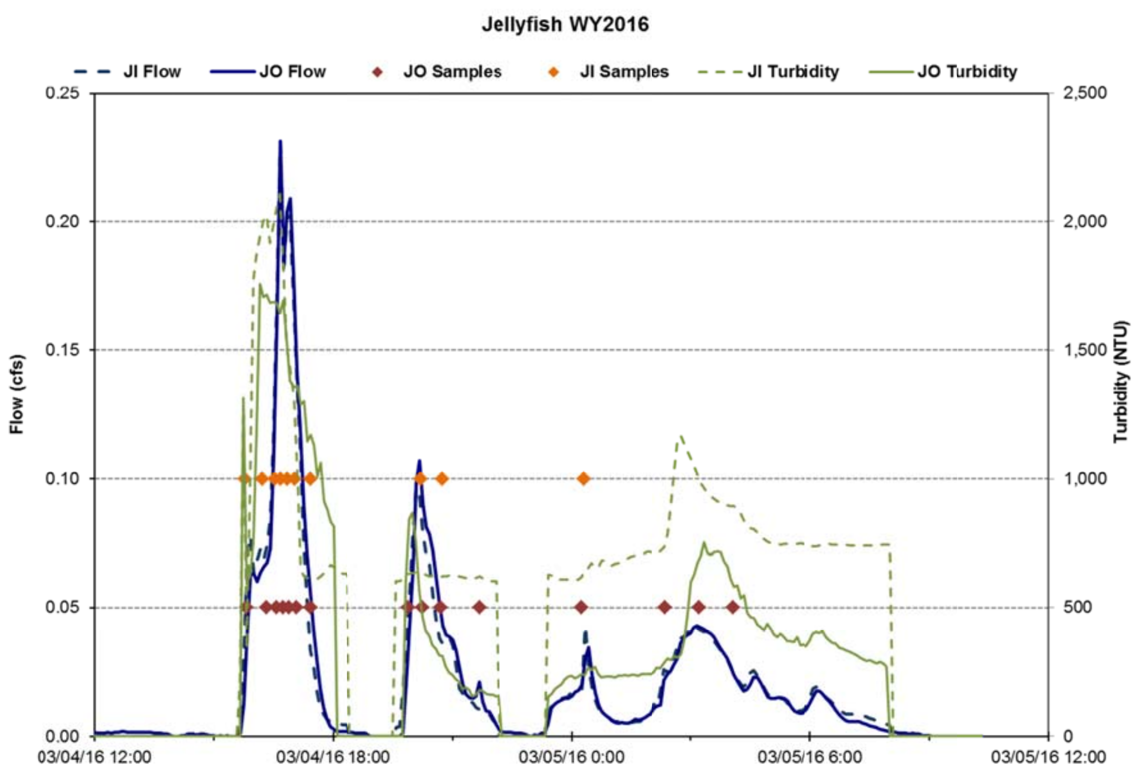

Figure F20: Continuous hydrology, continuous turbidity, and water quality samples for the 3/4/2016 event. Total volume sampled: 1,746 cf.

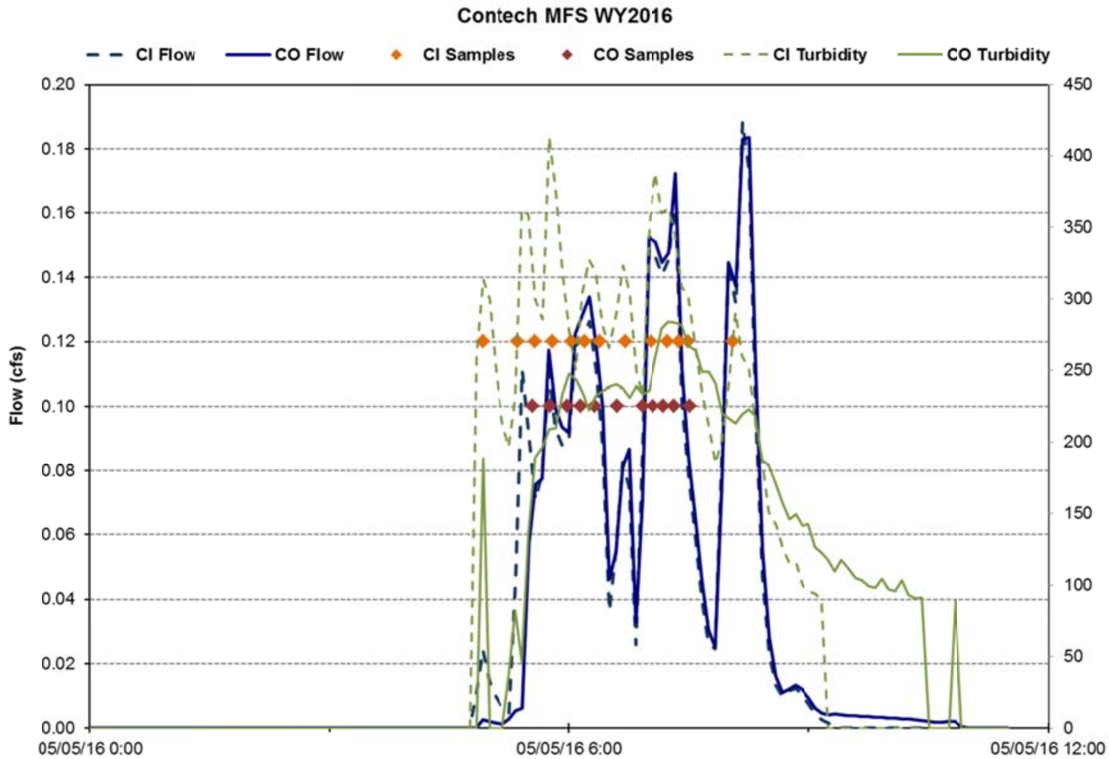

Figure F21: Continuous hydrology, continuous turbidity, and water quality samples for the 5/5/2016 event. Total volume sampled: 1,143 cf.

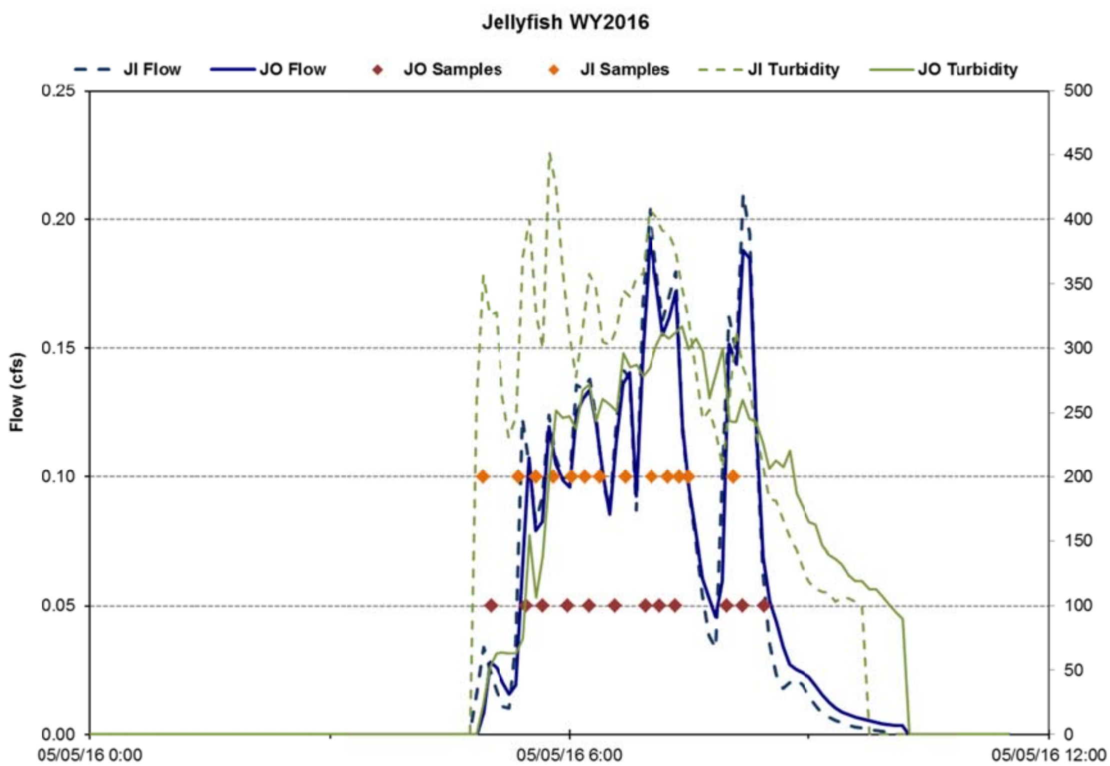

Figure F22: Continuous hydrology, continuous turbidity, and water quality samples for the 5/5/2016 event. Total volume sampled: 1,457 cf.

Appendix G: SR431 Outfall Event Hydrographs

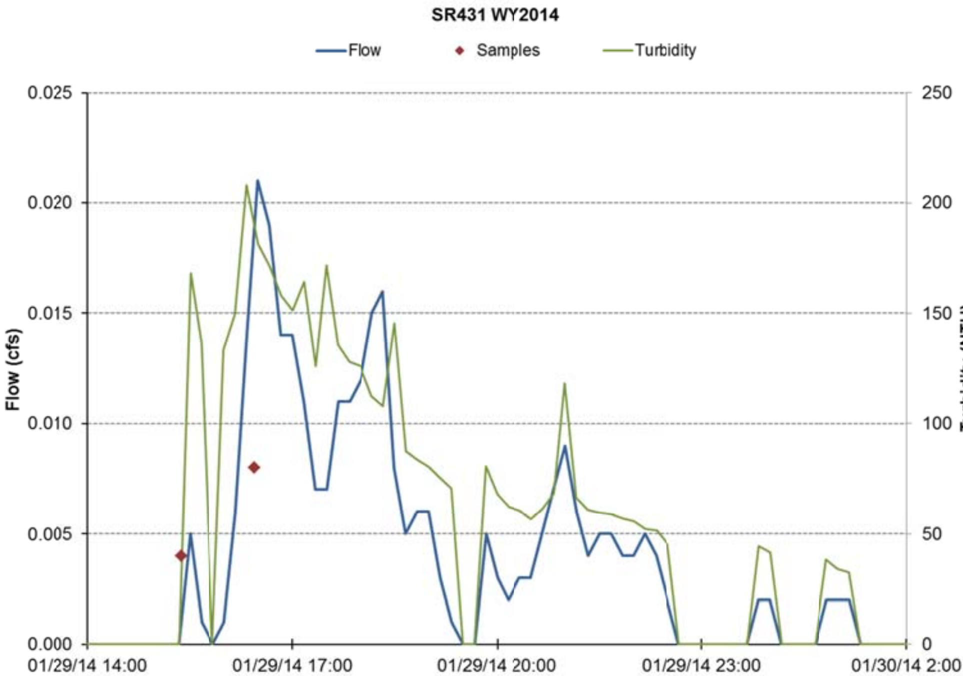

Figure G1: Continuous hydrology, continuous turbidity, and water quality samples for the 1/29/2014 event. End of event missed because of erratic flow and high sample pacing. Total volume sampled: 180 cf.

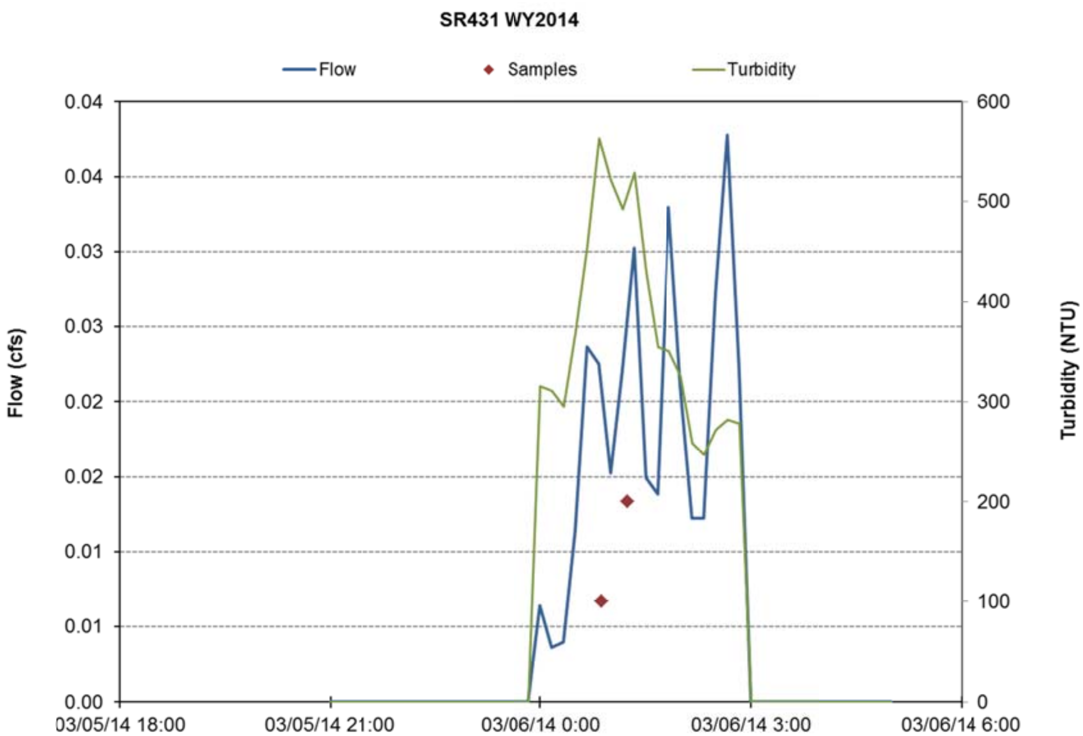

Figure G2: Continuous hydrology, continuous turbidity, and water quality samples for the 3/5/2014 event. End of event missed because of erratic flow and high sample pacing. Total volume sampled: 200 cf.

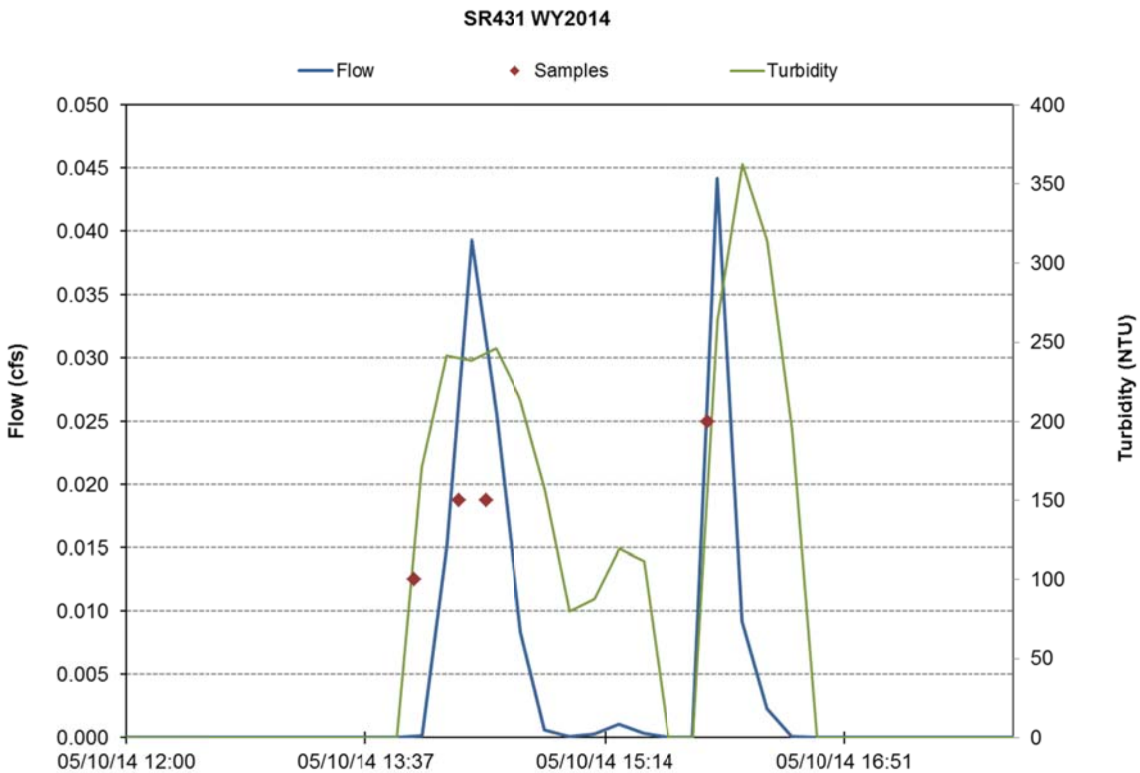

Figure G3: Continuous hydrology, continuous turbidity, and water quality samples for the 5/10/2014 event. Total volume sampled: 88 cf.

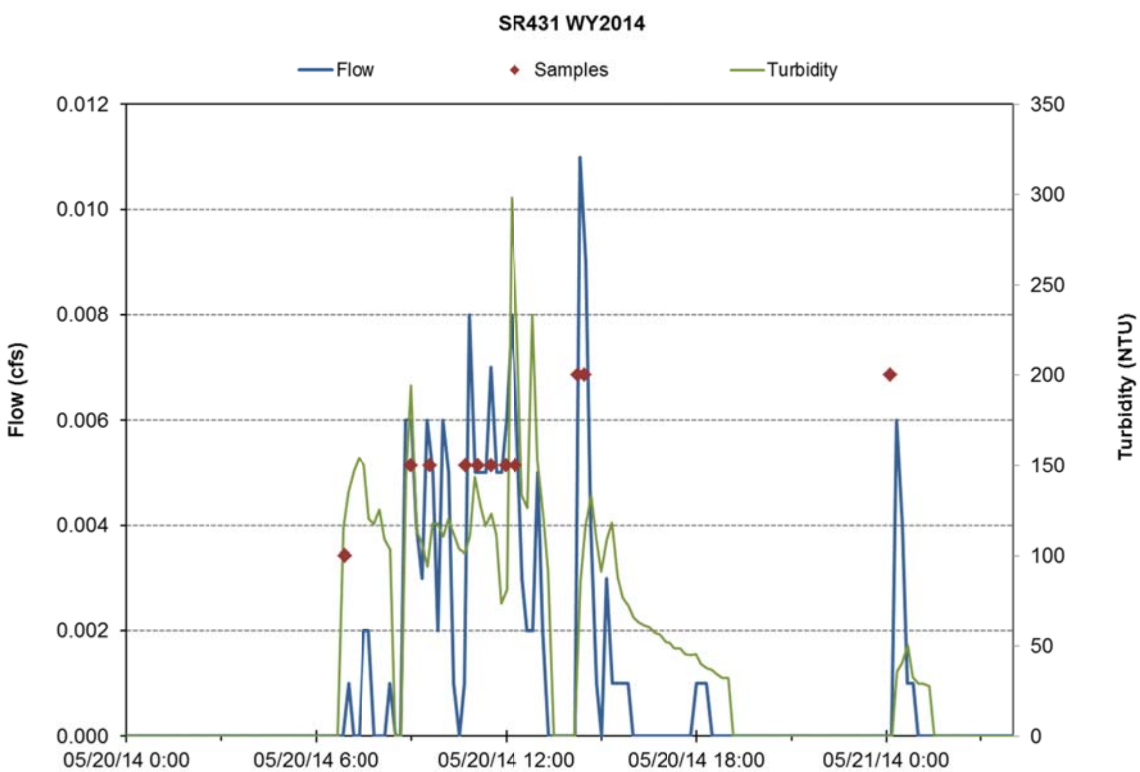

Figure G4: Continuous hydrology, continuous turbidity, and water quality samples for the 5/20/2014 event. Total volume sampled: 103 cf.

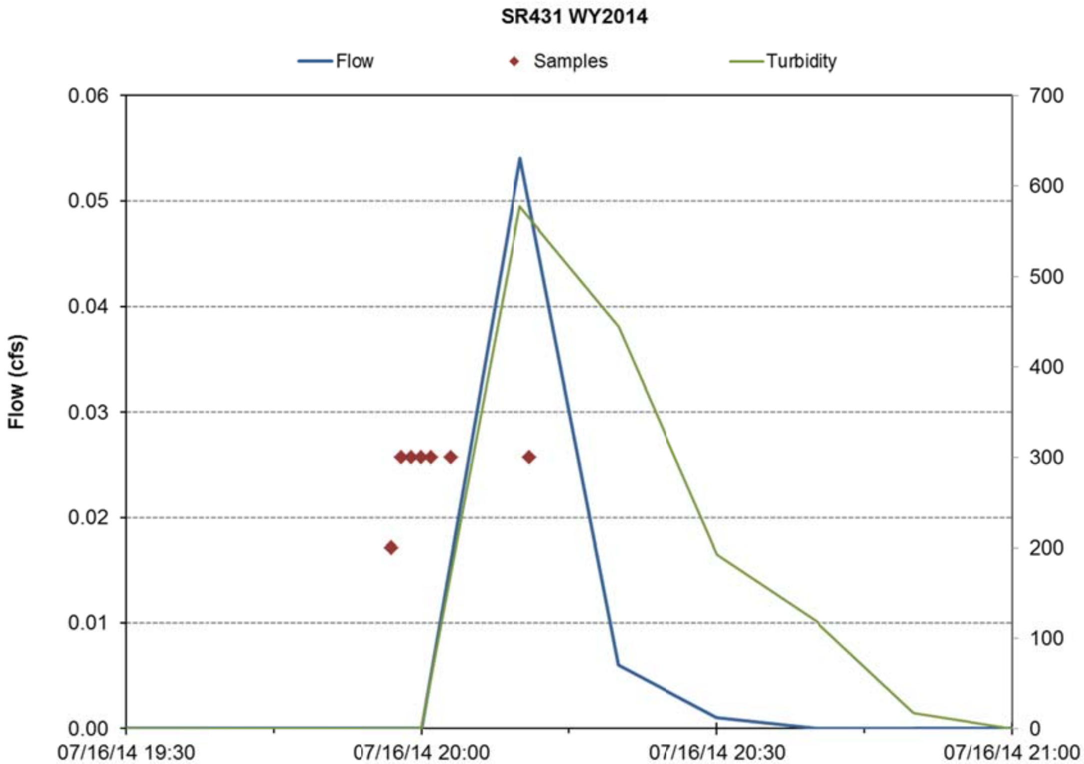

Figure G5: Continuous hydrology, continuous turbidity, and water quality samples for the 7/16/2014 event. Total volume sampled: 37 cf.

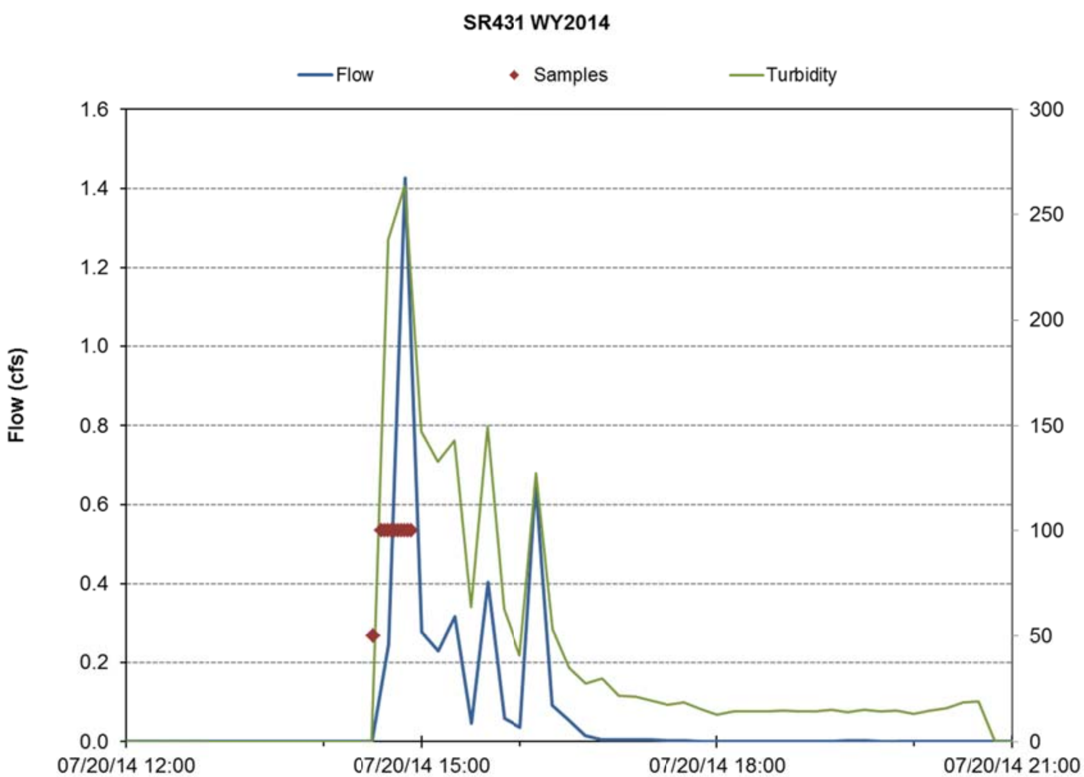

Figure G6: Continuous hydrology, continuous turbidity, and water quality samples for the 7/20/2014 event. End of event missed because sample pacing was too low. Total volume sampled: 2,319 cf.

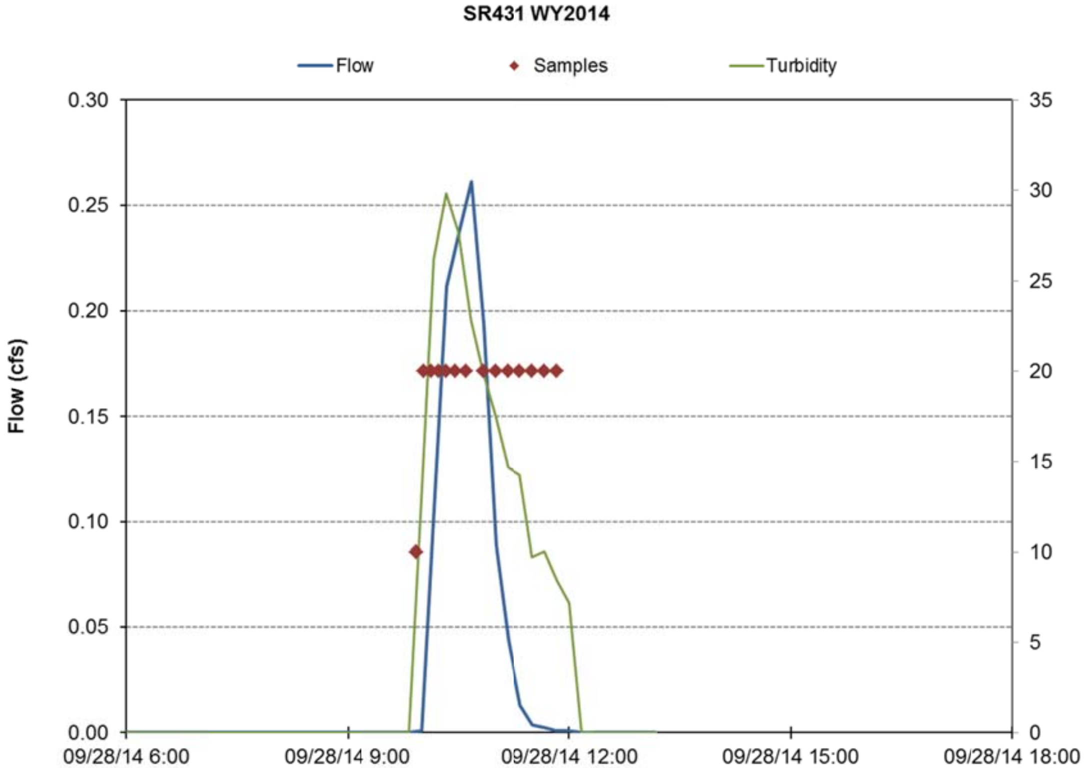

Figure G7: Continuous hydrology, continuous turbidity, and water quality samples for the 9/28/2014 event. Total volume sampled: 699 cf.

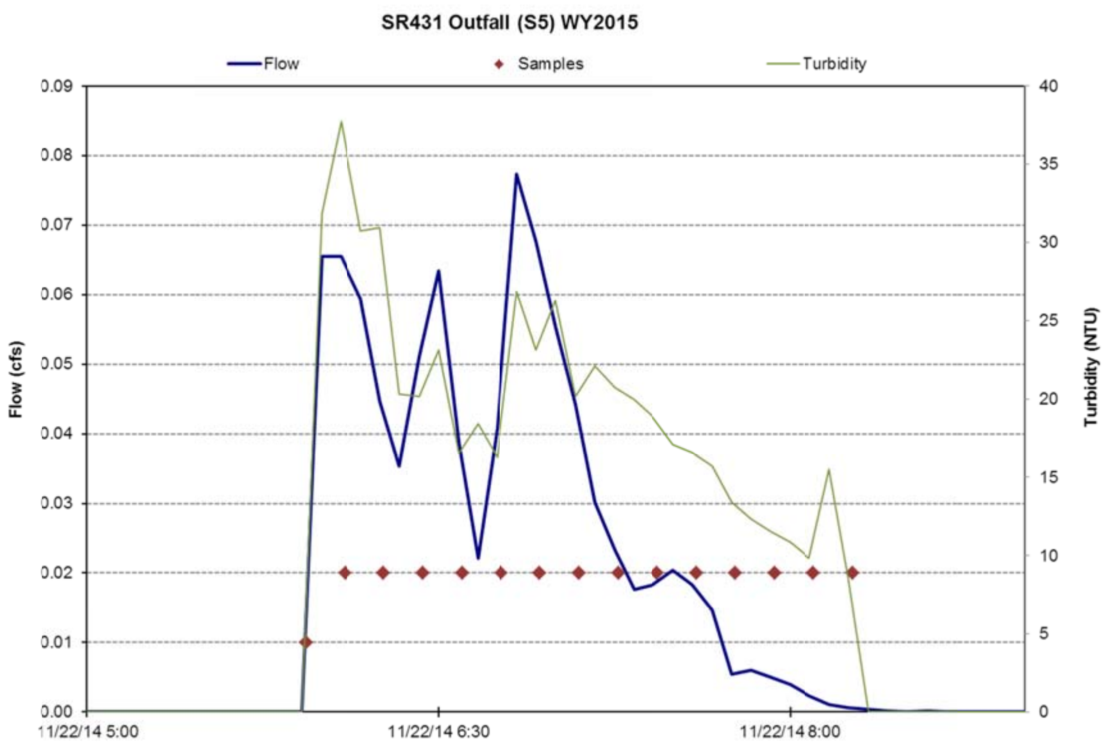

Figure G8: Continuous hydrology, continuous turbidity, and water quality samples for the 11/22/2014 event. Total volume sampled: 270 cf.

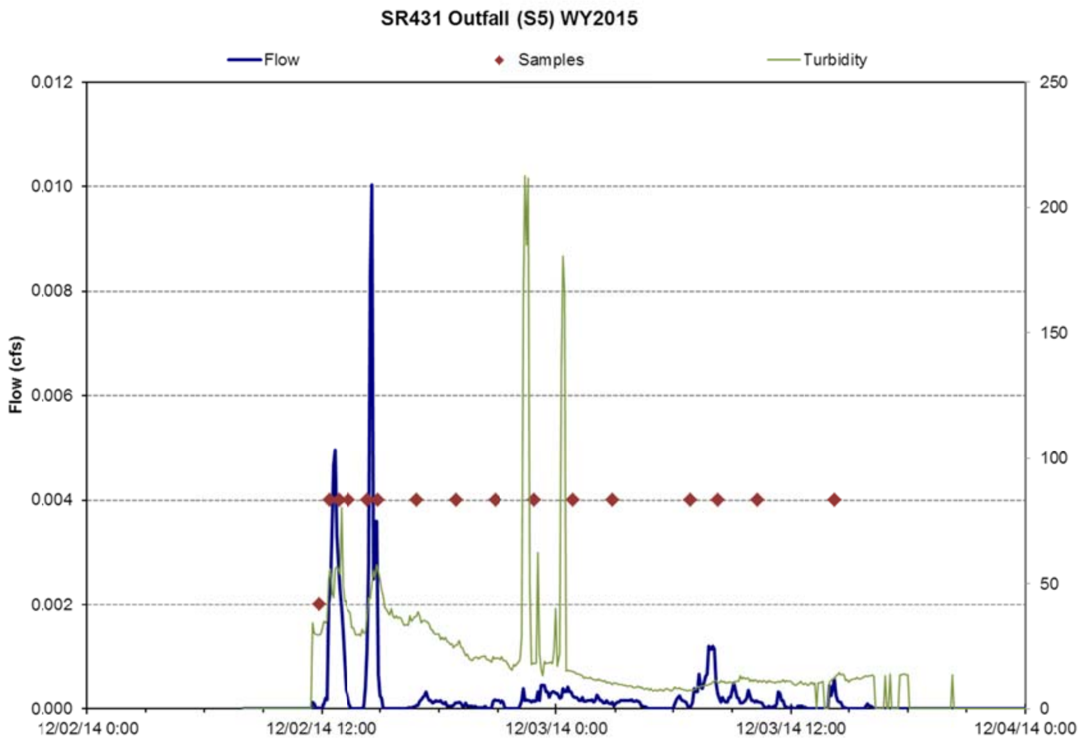

Figure G9: Continuous hydrology, continuous turbidity, and water quality samples for the 12/2/2014 event. Total volume sampled: 32 cf.

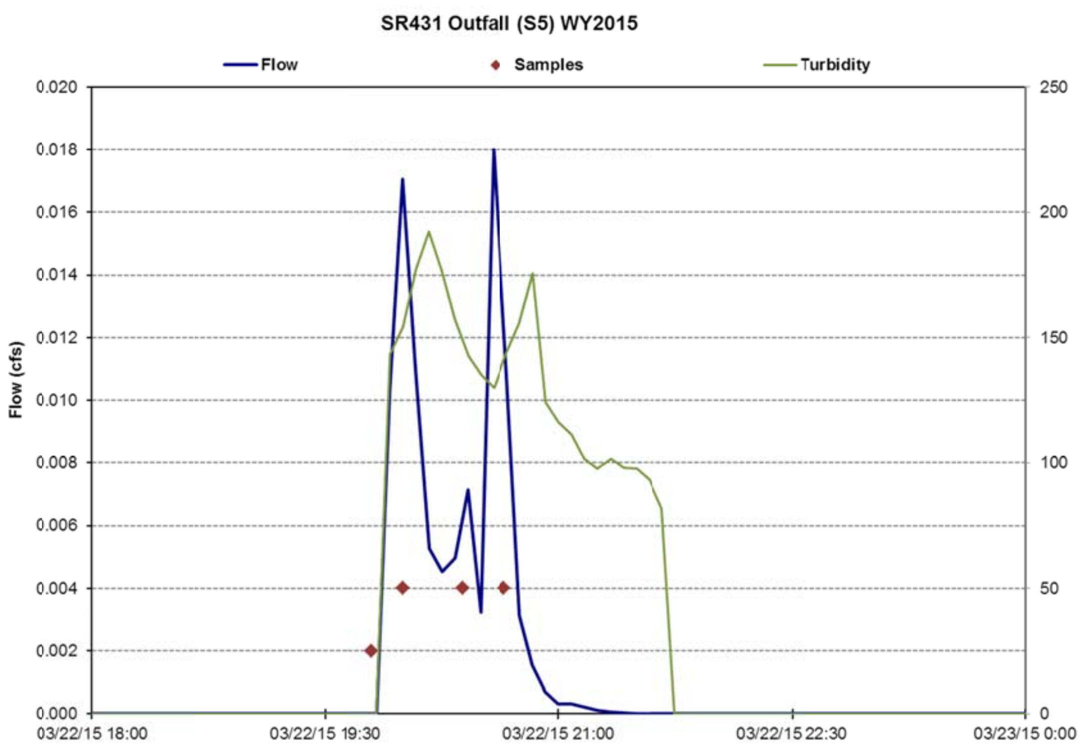

Figure G10: Continuous hydrology, continuous turbidity, and water quality samples for the 3/22/2015 event. Total volume sampled: 30 cf.

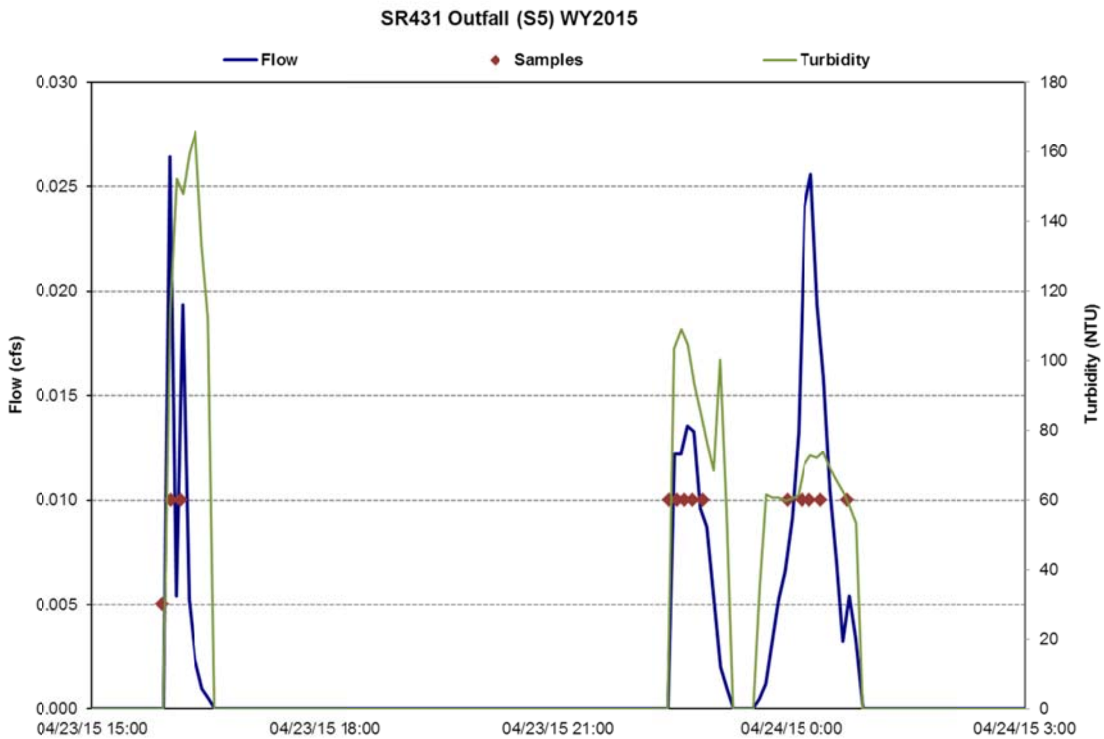

Figure G11: Continuous hydrology, continuous turbidity, and water quality samples for the 4/23/2015 event. Total volume sampled: 88 cf.

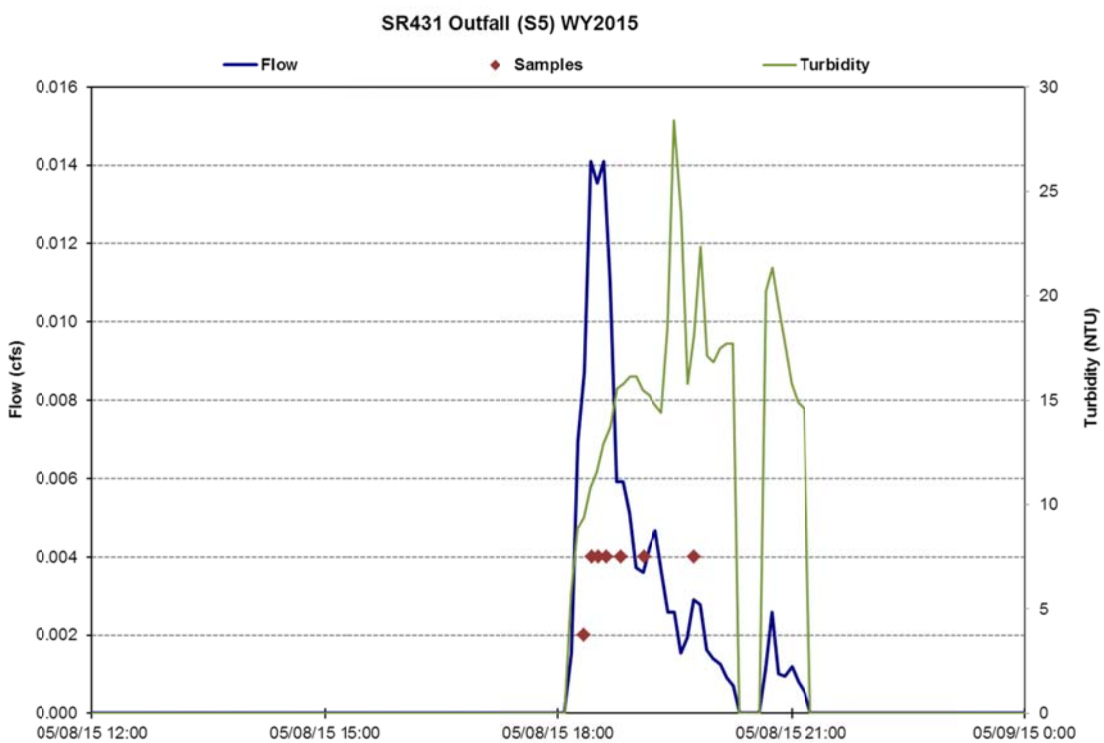

Figure G12: Continuous hydrology, continuous turbidity, and water quality samples for the 5/8/2015 event. Total volume sampled: 40 cf.

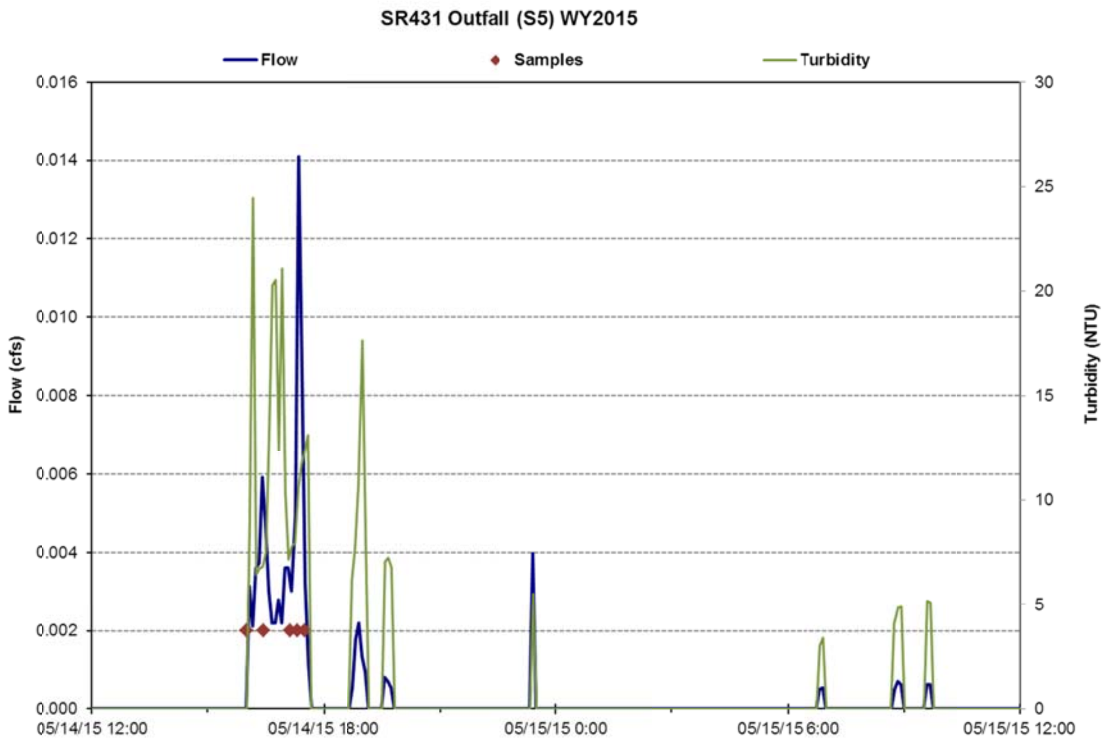

Figure G13: Continuous hydrology, continuous turbidity, and water quality samples for the 5/14/2015 event. Total volume sampled: 28 cf.

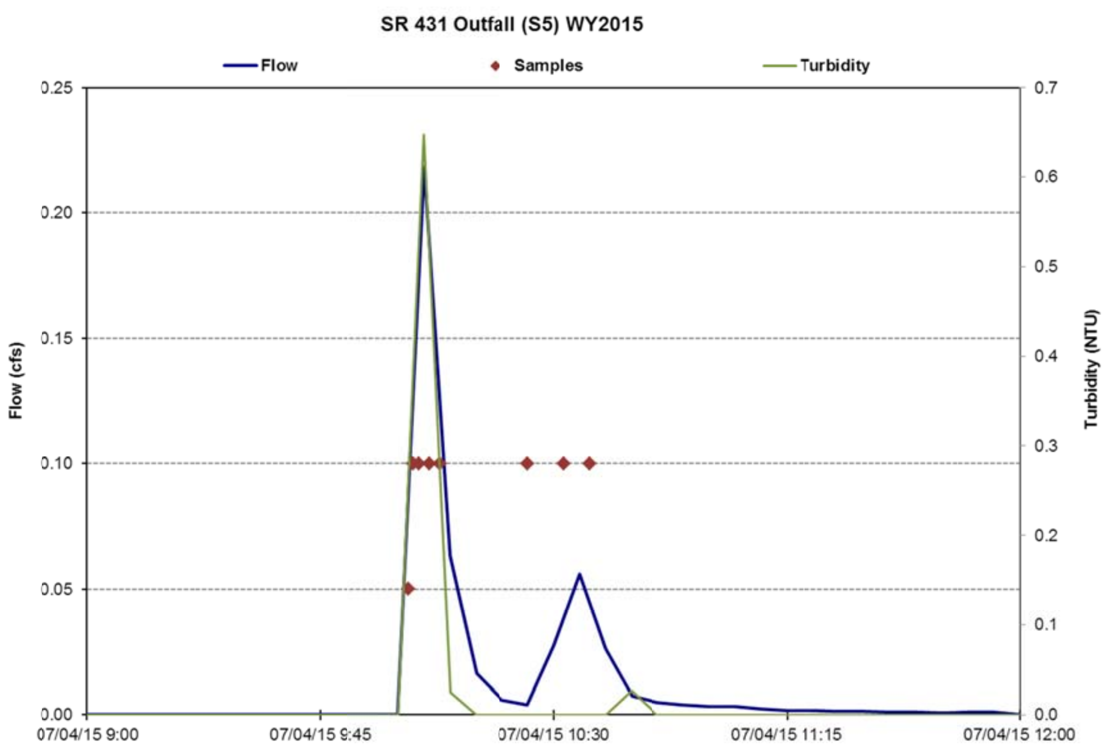

Figure G14: Continuous hydrology, continuous turbidity, and water quality samples for the 7/4/2015 event. Total volume sampled: 136

Appendix H: Tahoma Event Hydrographs

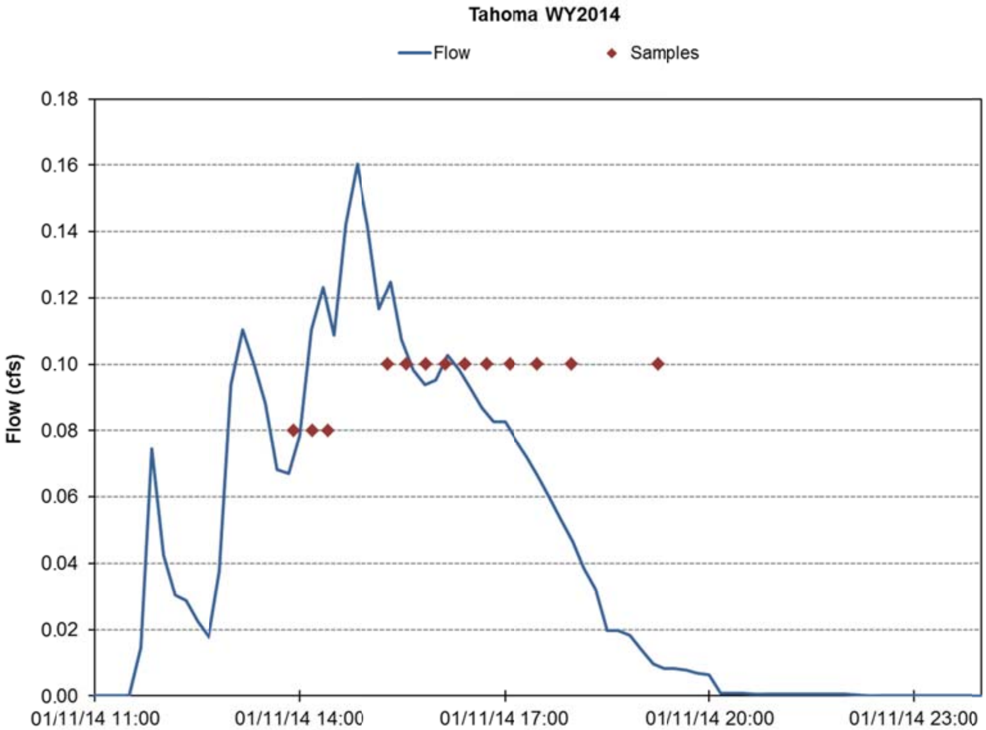

Figure H1: Continuous hydrology and water quality samples for the 1/11/2014 event. Turbidity data not available; sensor malfunctioned. Total volume sampled: 2,048 cf.

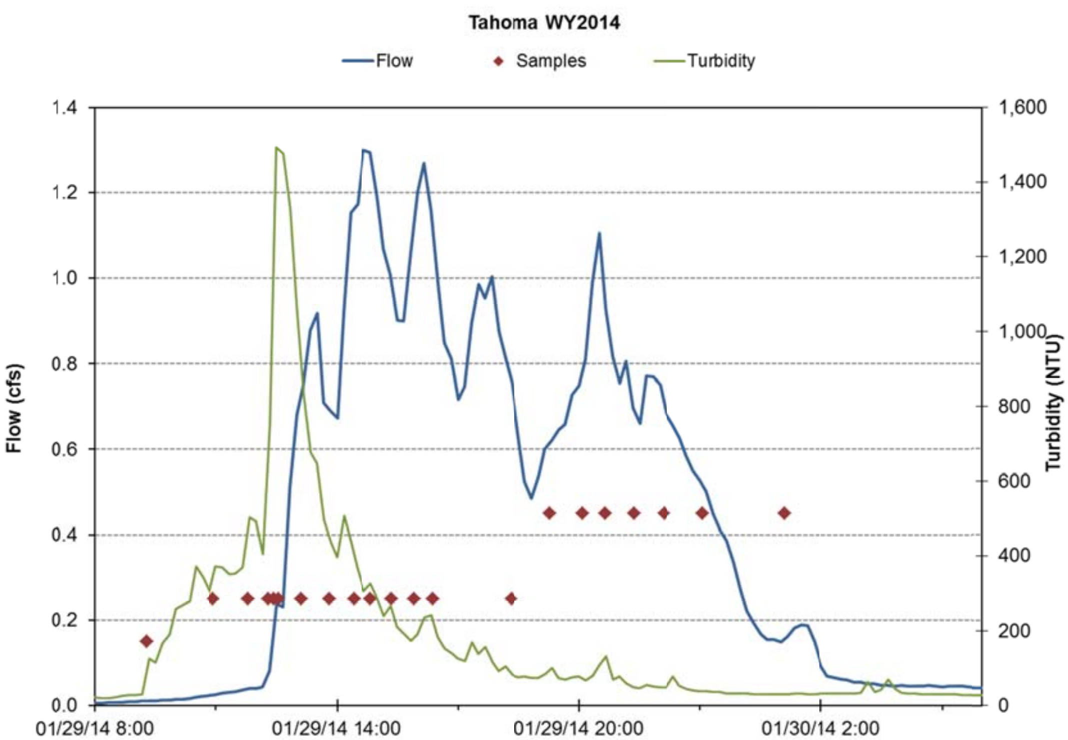

Figure H2: Continuous hydrology, continuous turbidity, and water quality samples for the 1/29/2014 event. Total volume sampled: 34,160 cf.

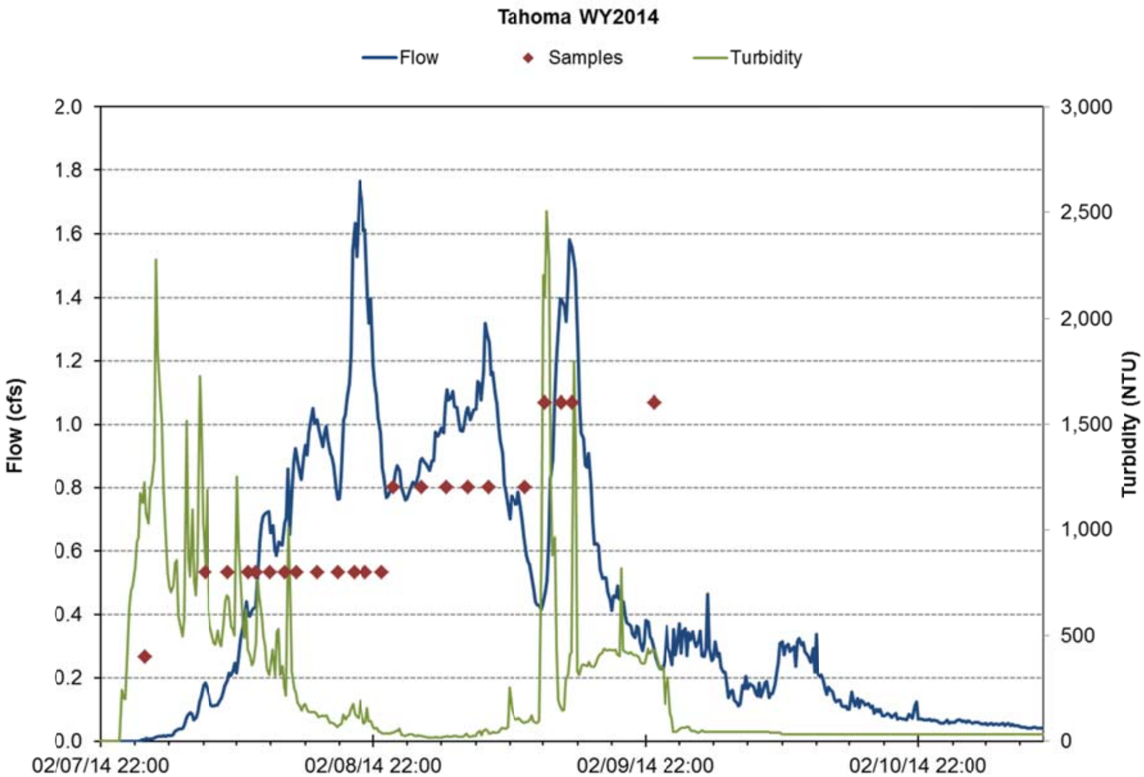

Figure H3: Continuous hydrology, continuous turbidity, and water quality samples for the 2/8/2014 event. Total volume sampled: 120,236 cf.

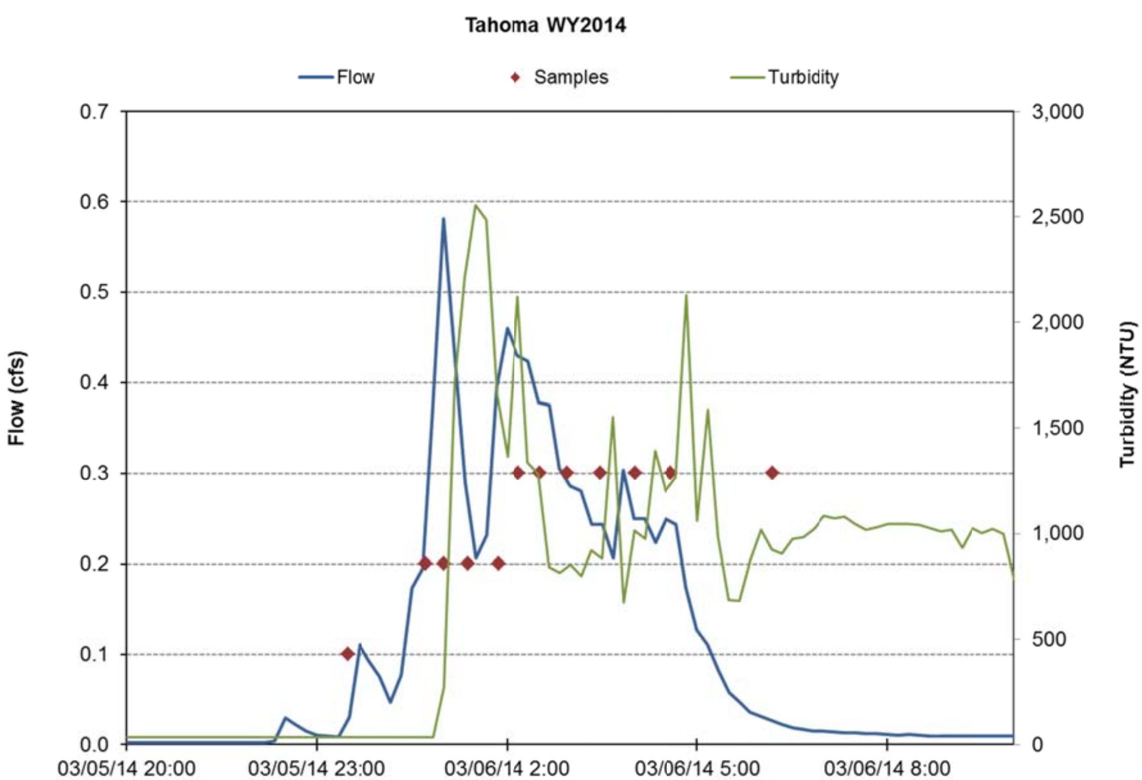

Figure H4: Continuous hydrology, continuous turbidity, and water quality samples for the 3/5/2014 event. Total volume sampled: 5,672 cf.

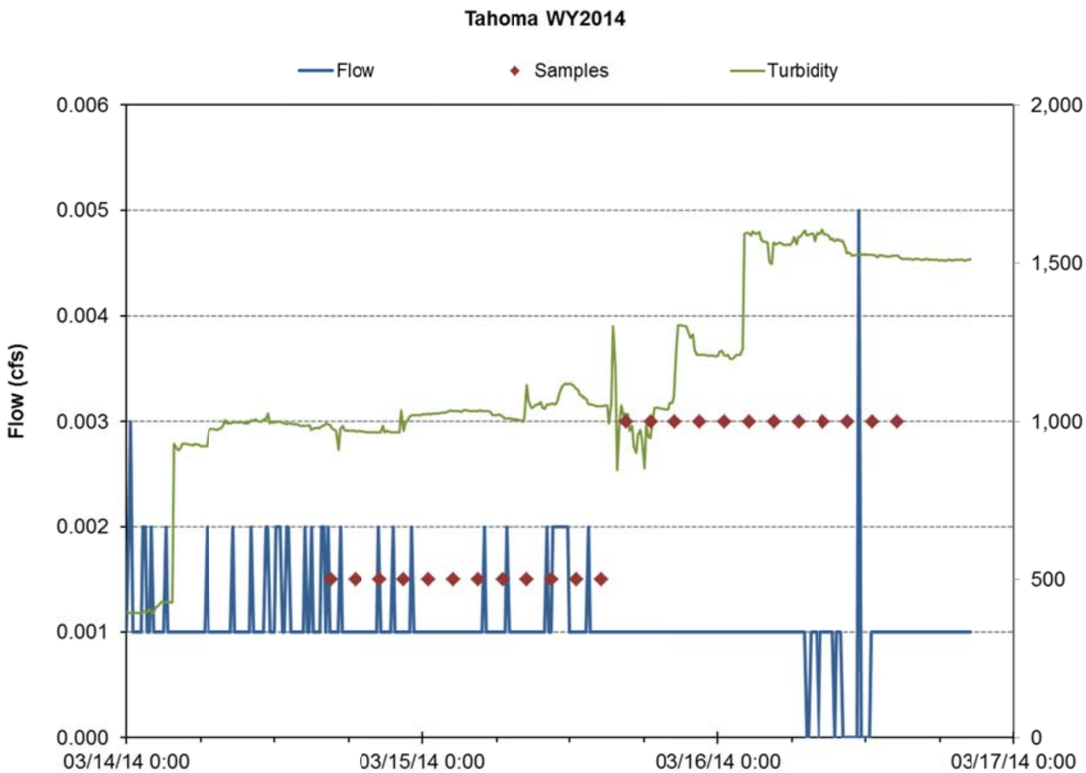

Figure H5: Continuous hydrology, continuous turbidity, and water quality samples for the 3/14/2014 event. Total volume sampled: 175 cf.

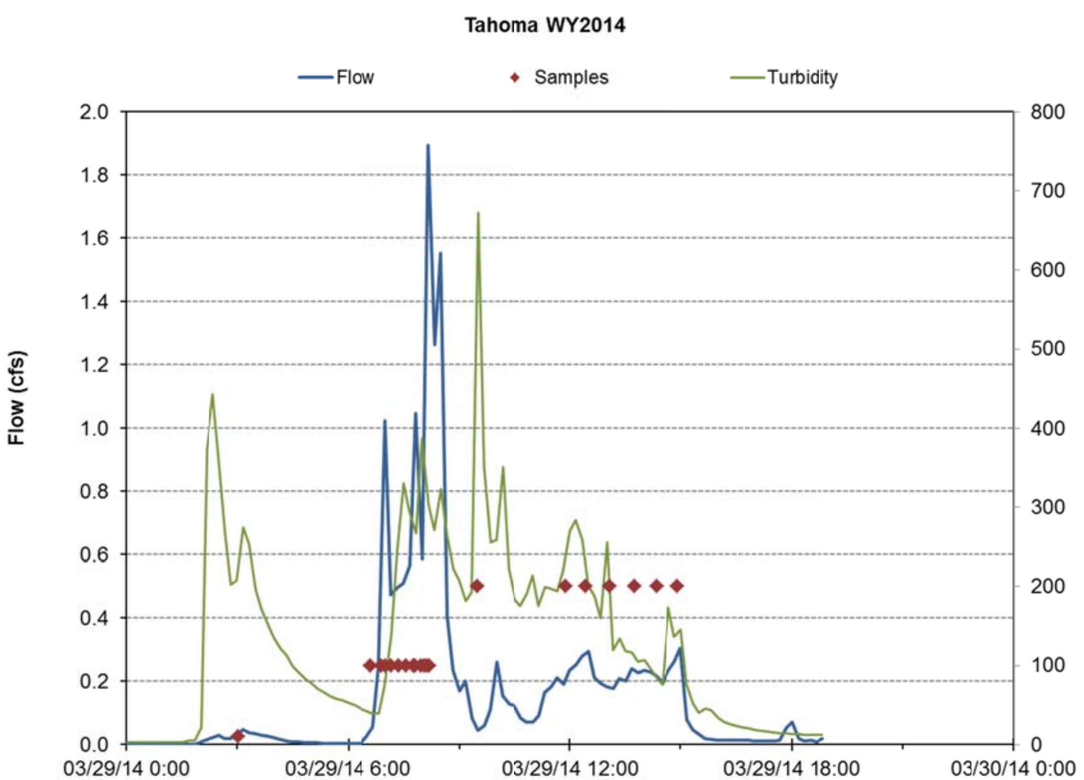

Figure H6: Continuous hydrology, continuous turbidity, and water quality samples for the 3/29/2014 event. Total volume sampled: 10,630 cf.

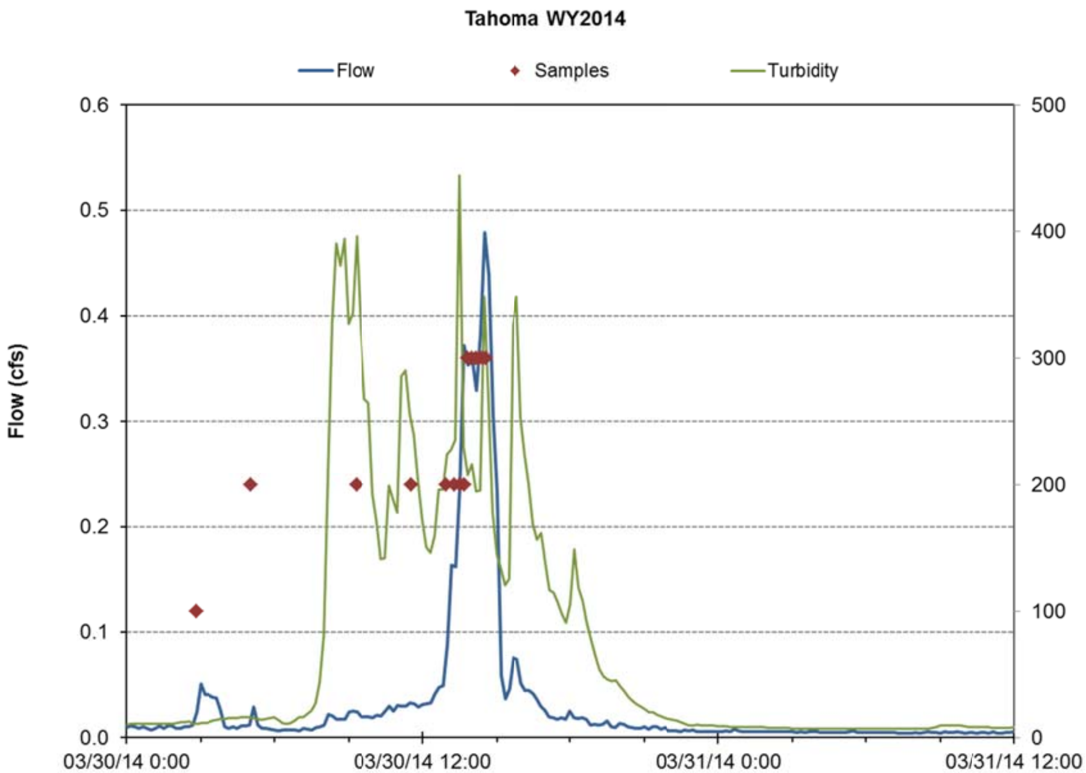

Figure H7: Continuous hydrology, continuous turbidity, and water quality samples for the 3/30/2014 event. Total volume sampled: 3,735 cf.

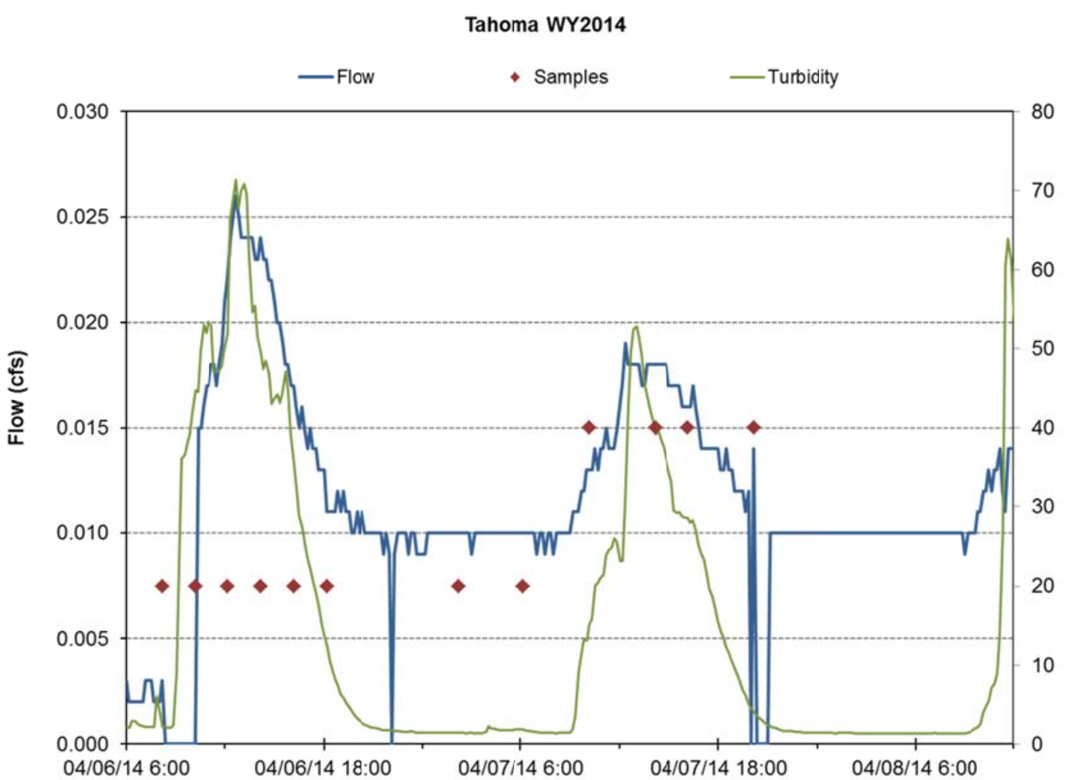

Figure H8: Continuous hydrology, continuous turbidity, and water quality samples for the 4/6/2014 event. Total volume sampled: 2,039 cf.

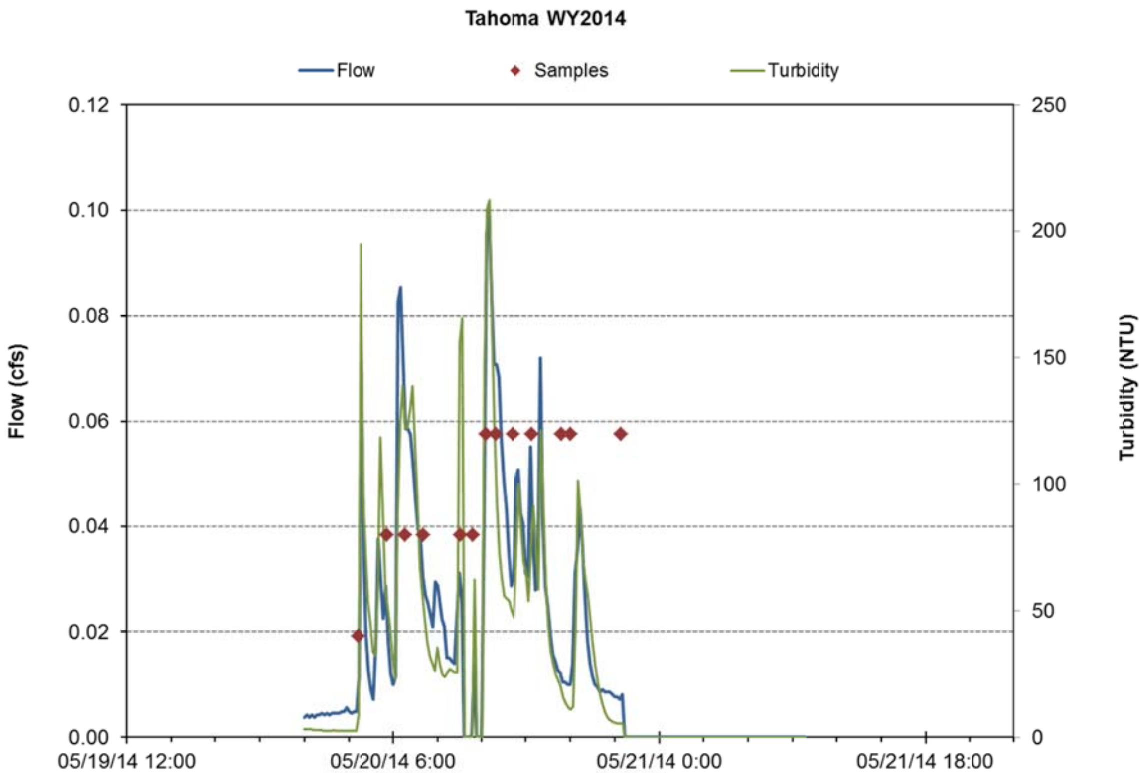

Figure H9: Continuous hydrology, continuous turbidity, and water quality samples for the 5/20/2014 event. Total volume sampled: 1,943 cf.

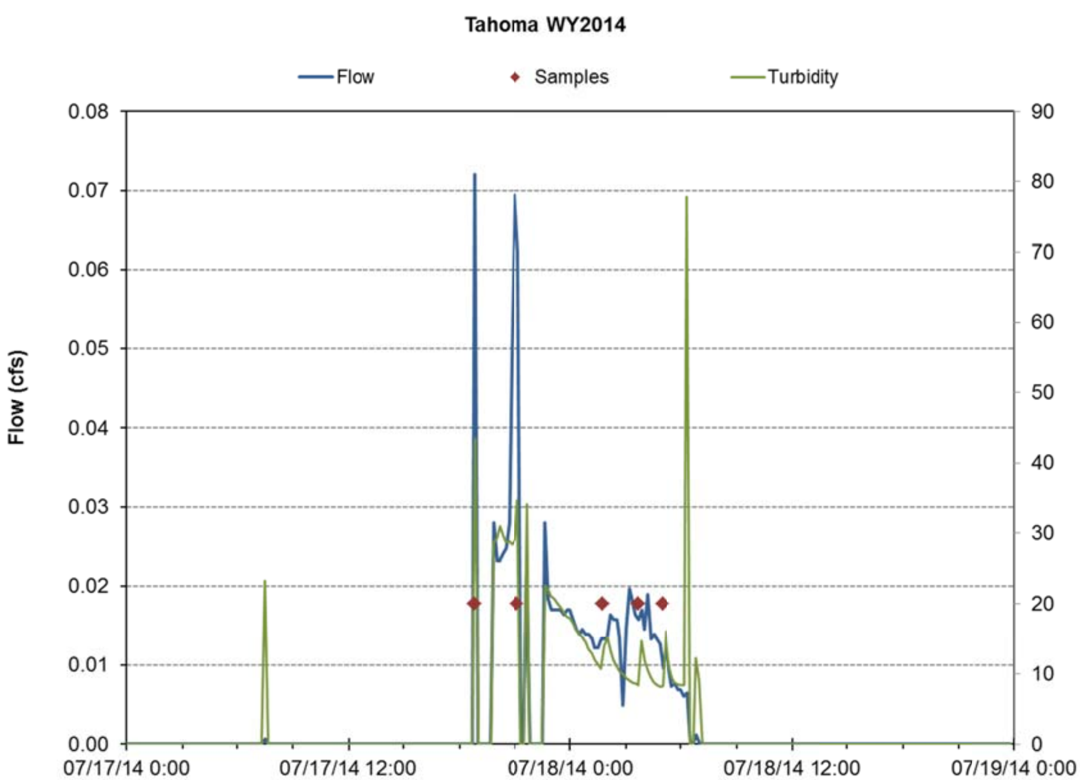

Figure H10: Continuous hydrology, continuous turbidity, and water quality samples for the 7/17/2014 event. Total volume sampled: 645 cf.

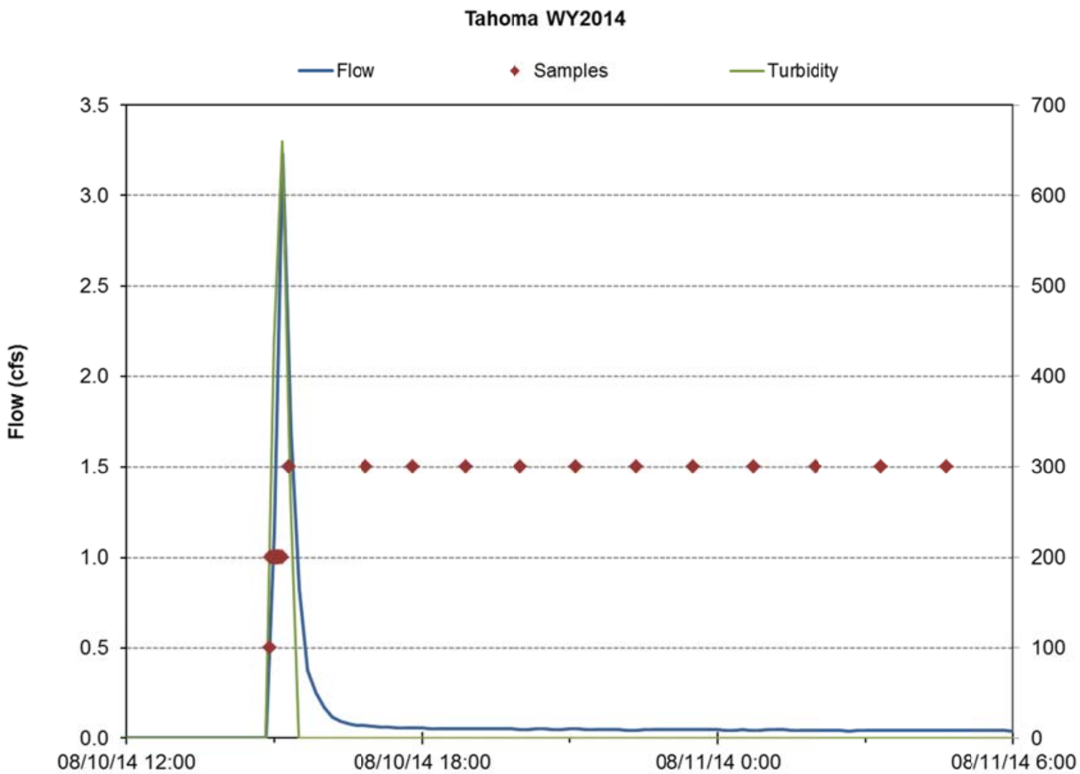

Figure H11: Continuous hydrology, continuous turbidity, and water quality samples for the 8/10/2014 event. Total volume sampled: 7,086 cf.

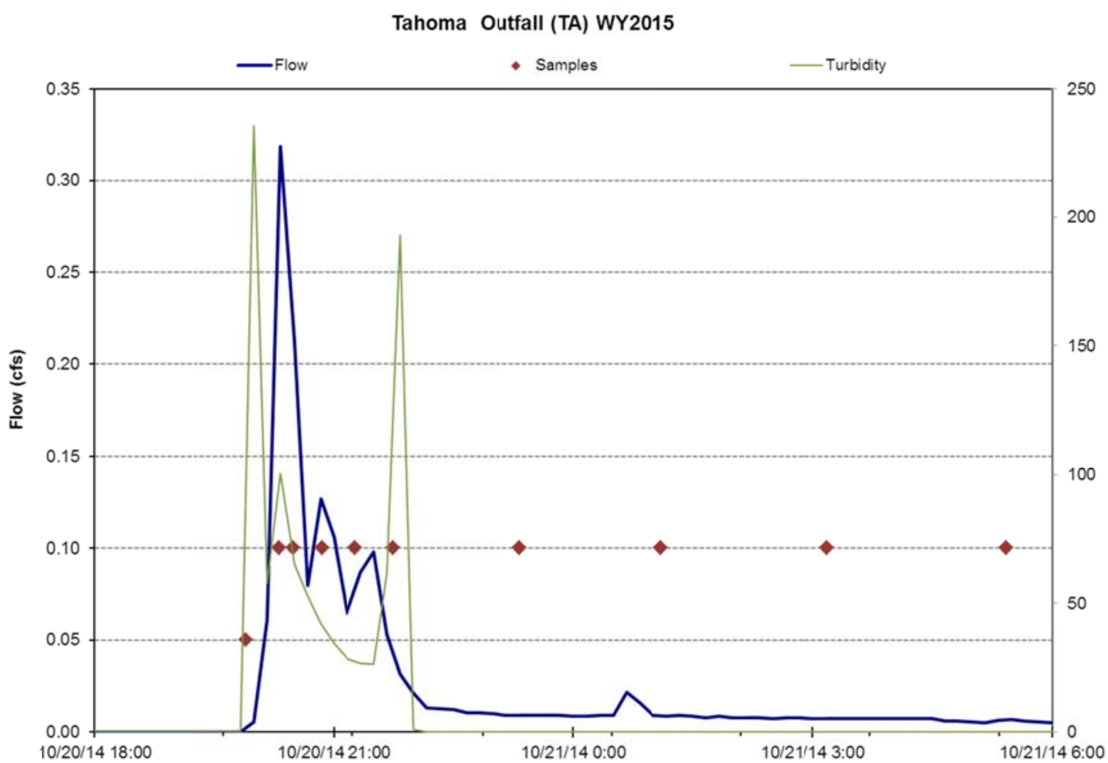

Figure H12: Continuous hydrology, continuous turbidity, and water quality samples for the 10/20/2014 event. Total volume sampled: 1,005 cf.

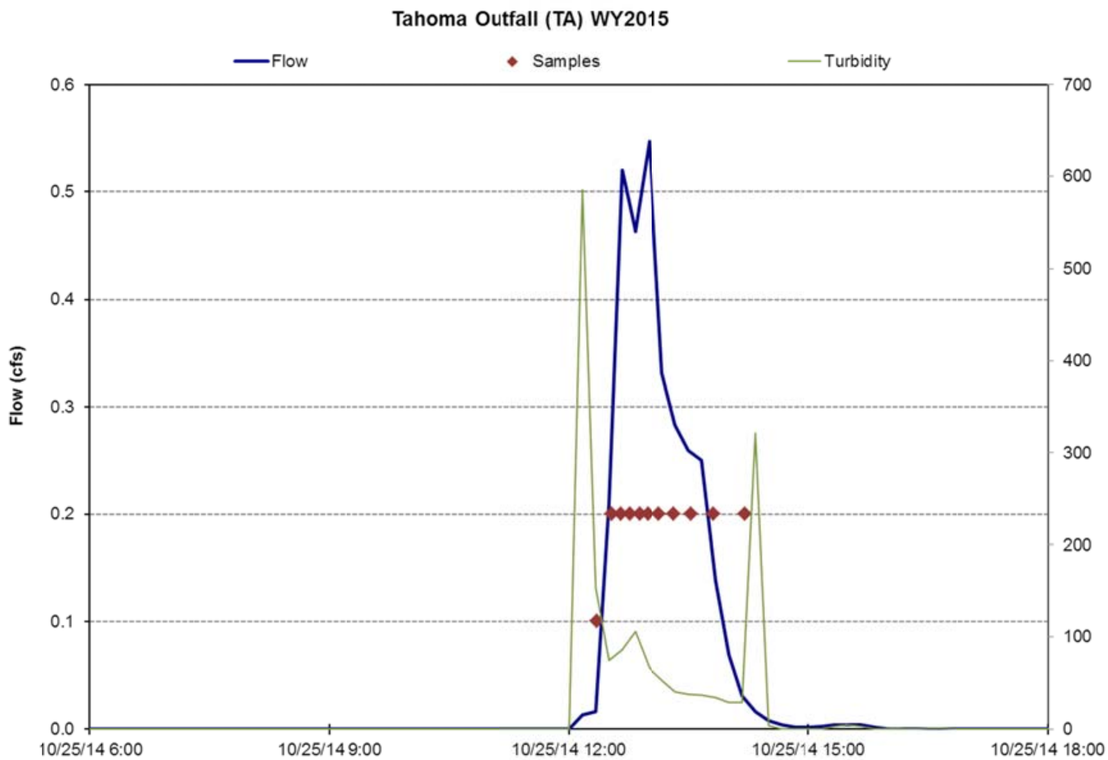

Figure H13: Continuous hydrology continuous turbidity, and water quality samples for the 10/25/2014 event. Total volume sampled: 1,910 cf.

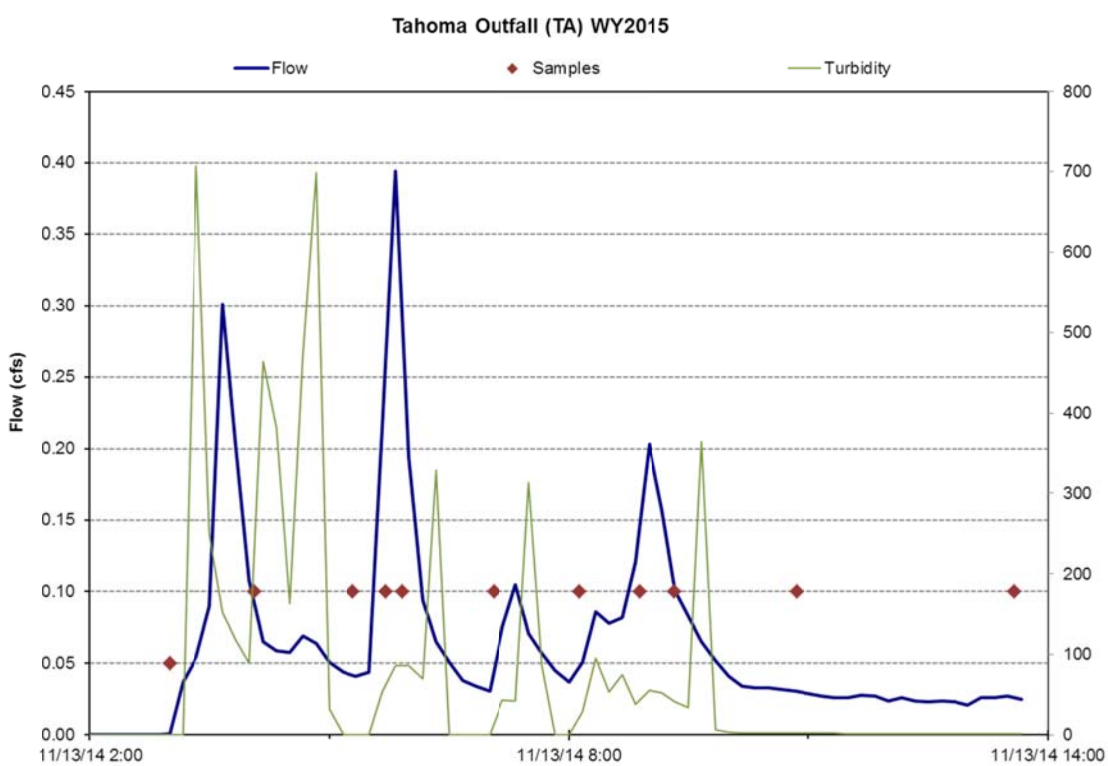

Figure H14: Continuous hydrology, continuous turbidity, and water quality samples for the 11/13/2014 event. Total volume sampled: 2,705 cf.

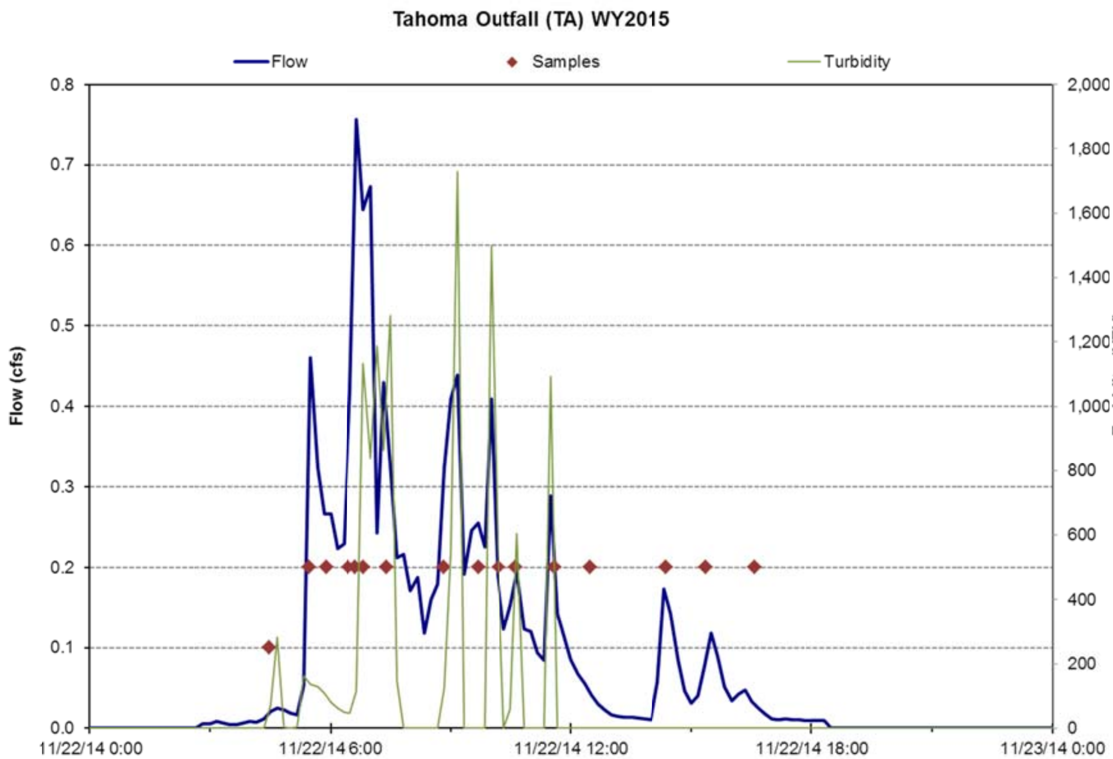

Figure H15: Continuous hydrology, continuous turbidity, and water quality samples for the 11/22/2014 event. Total volume sampled: 7,464 cf.

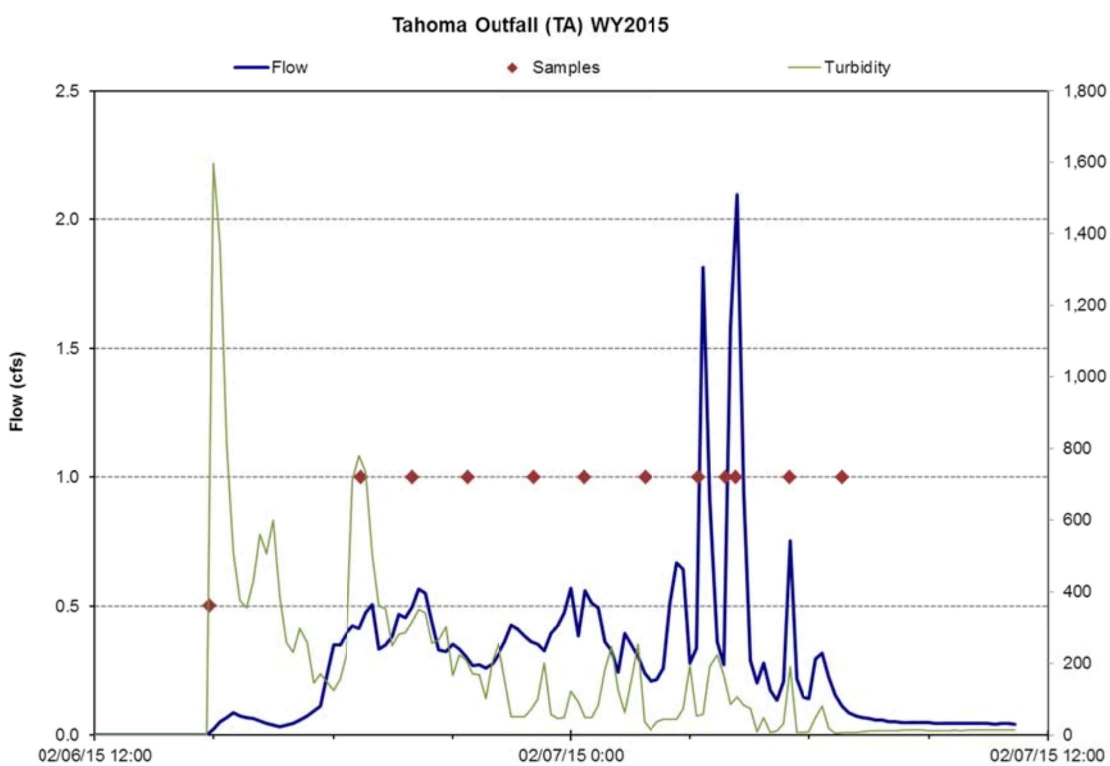

Figure H16: Continuous hydrology, continuous turbidity, and water quality samples for the 2/6/2015 event. Total volume sampled: 21,615 cf.

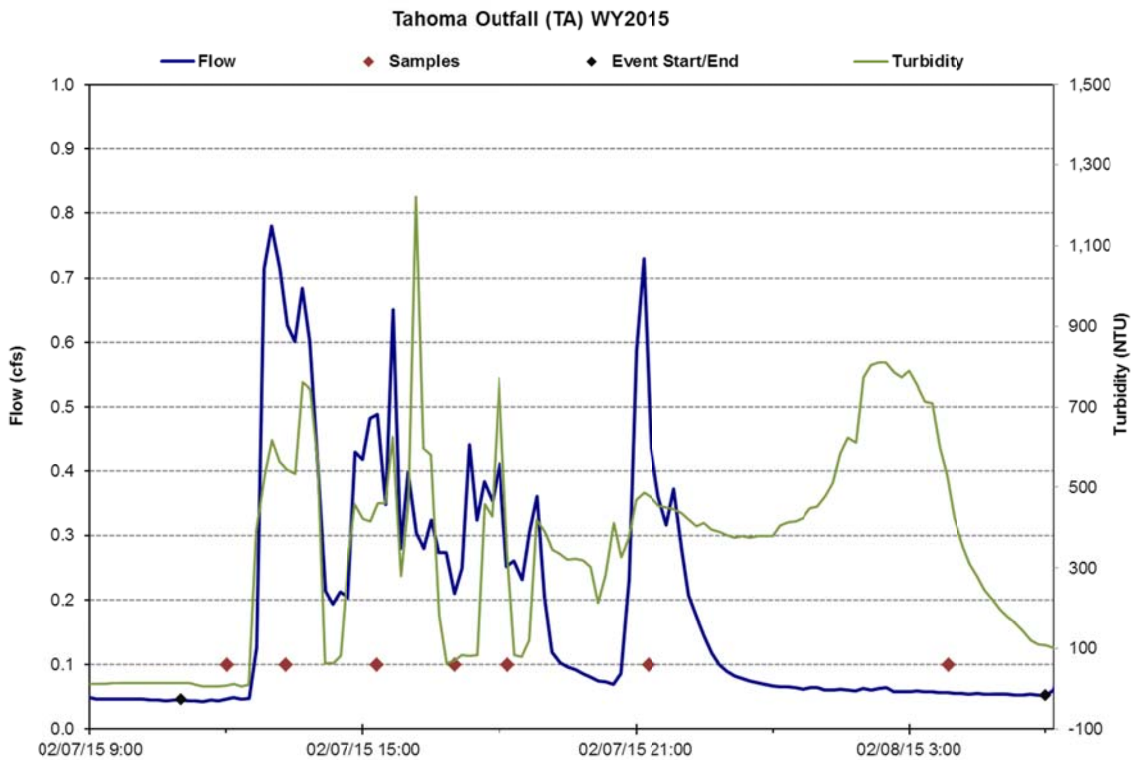

Figure H17: Continuous hydrology, continuous turbidity, and water quality samples for the 2/7/2015 event. Total volume sampled: 13,808 cf.

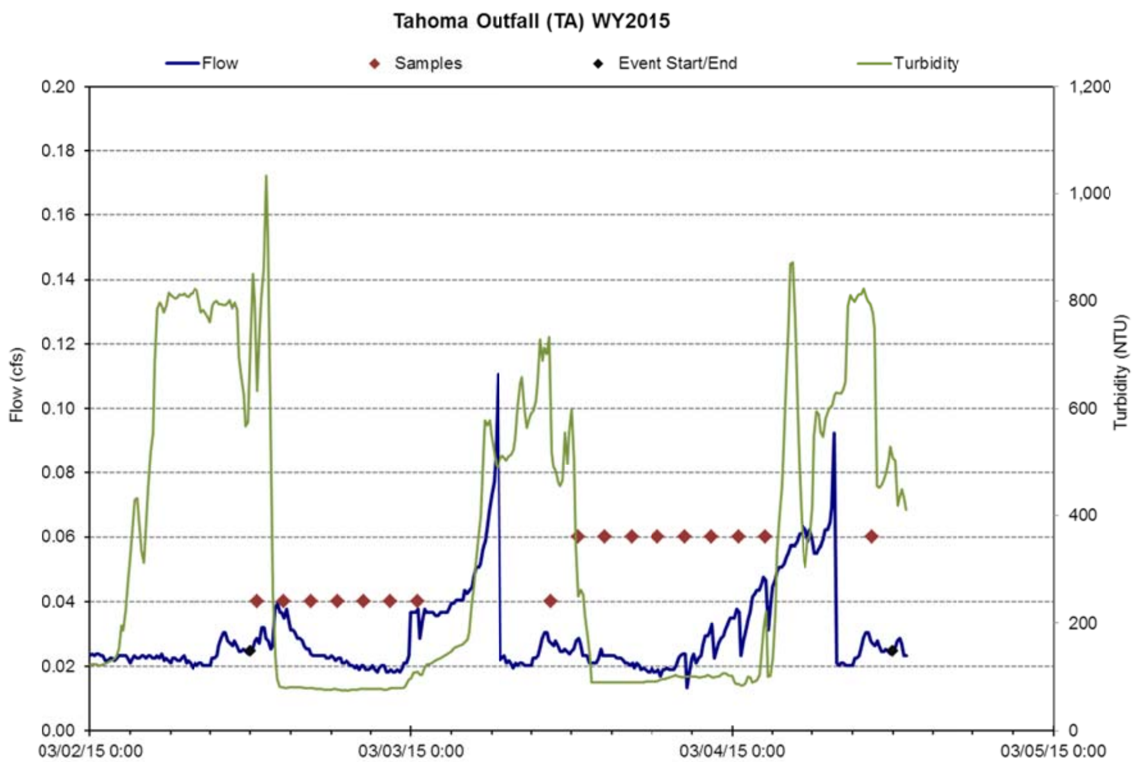

Figure H18: Continuous hydrology, continuous turbidity, and water quality samples for the 3/2/2015 event. Total volume sampled: 5,404 cf.

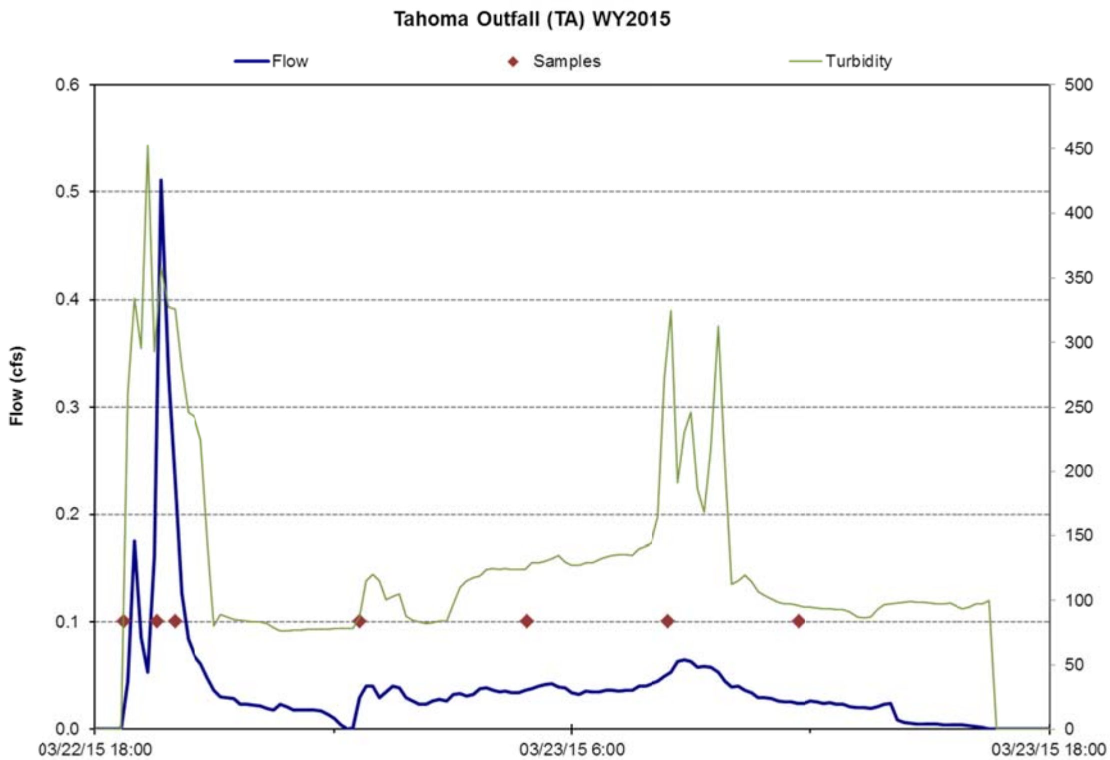

Figure H19: Continuous hydrology, continuous turbidity, and water quality samples for the 3/22/2015 event. Total volume sampled: 3,183 cf.

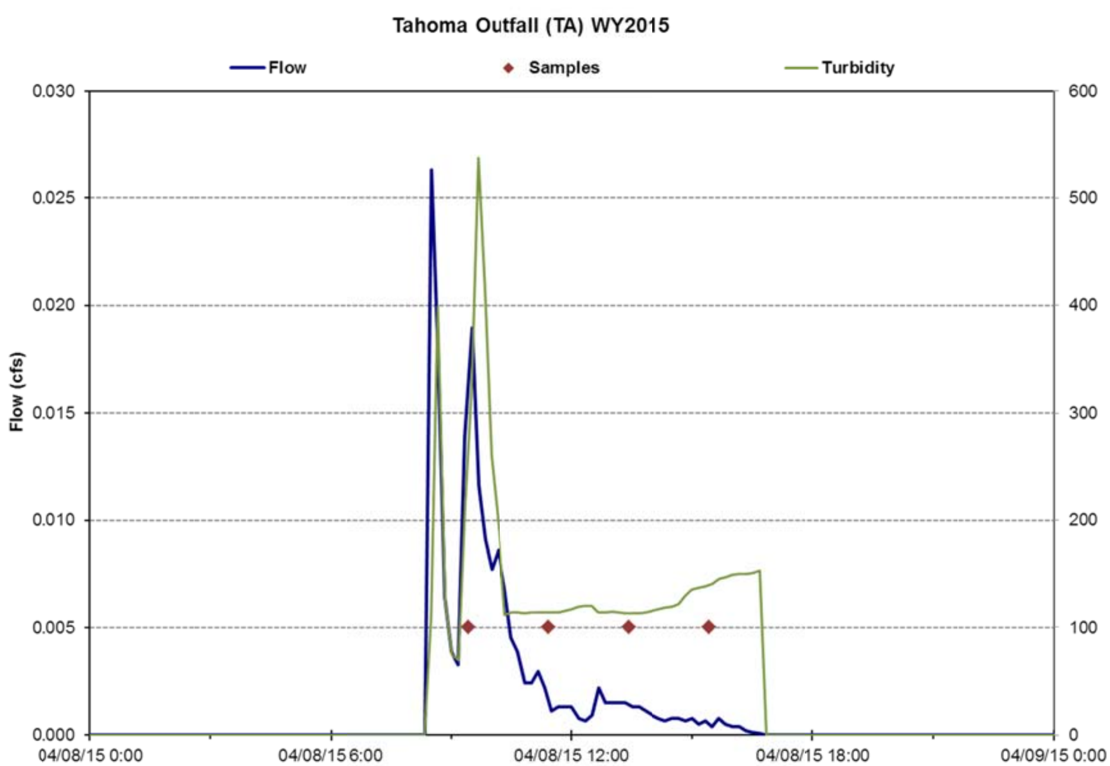

Figure H20: Continuous hydrology, continuous turbidity, and water quality samples for the 4/8/2015 event. Total volume sampled: 109 cf.

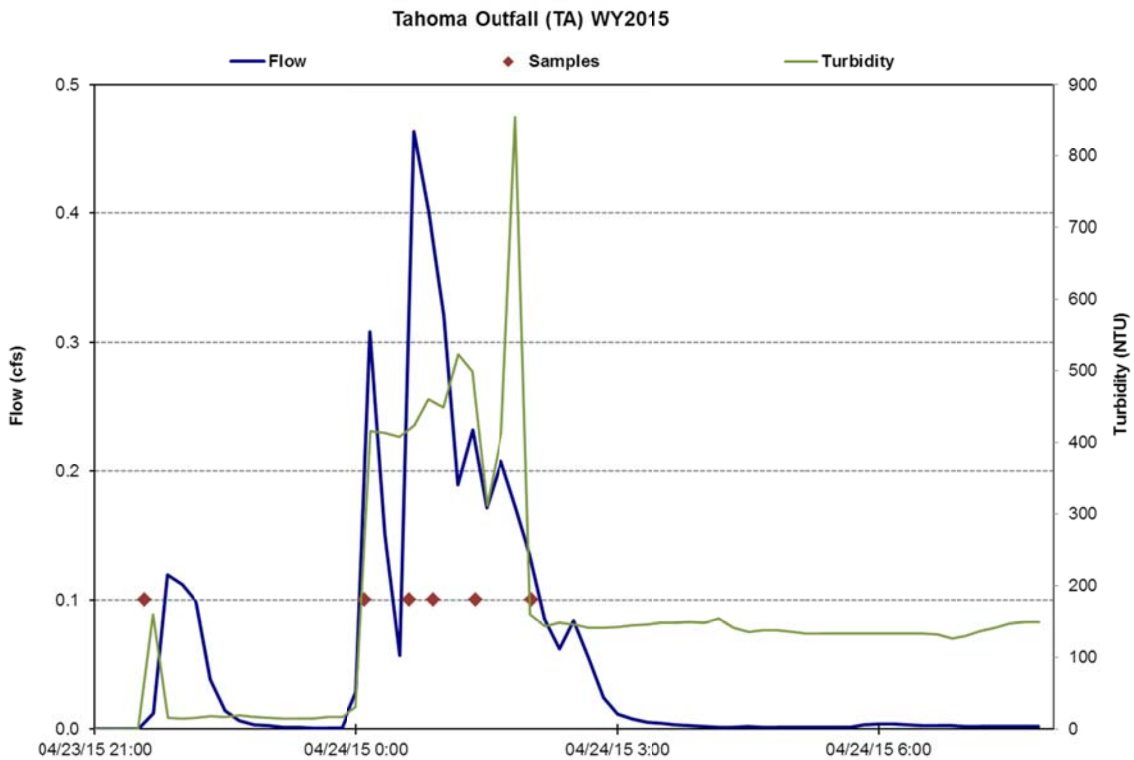

Figure H21: Continuous hydrology, continuous turbidity, and water quality samples for the 4/23/2015 event. Total volume sampled: 2,168 cf.

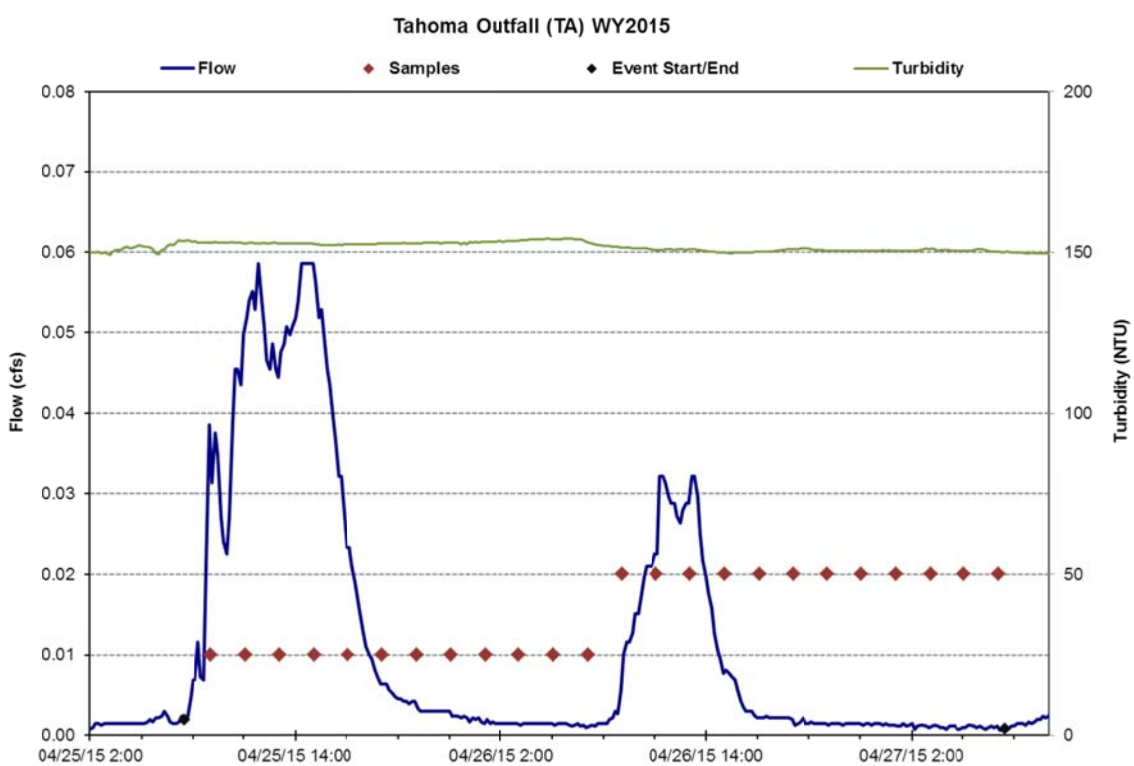

Figure H22: Continuous hydrology, continuous turbidity, and water quality samples for the 4/25/2015 event. Debris covering turbidity sensor likely causing steady reading. Total volume sampled: 2,155 cf.

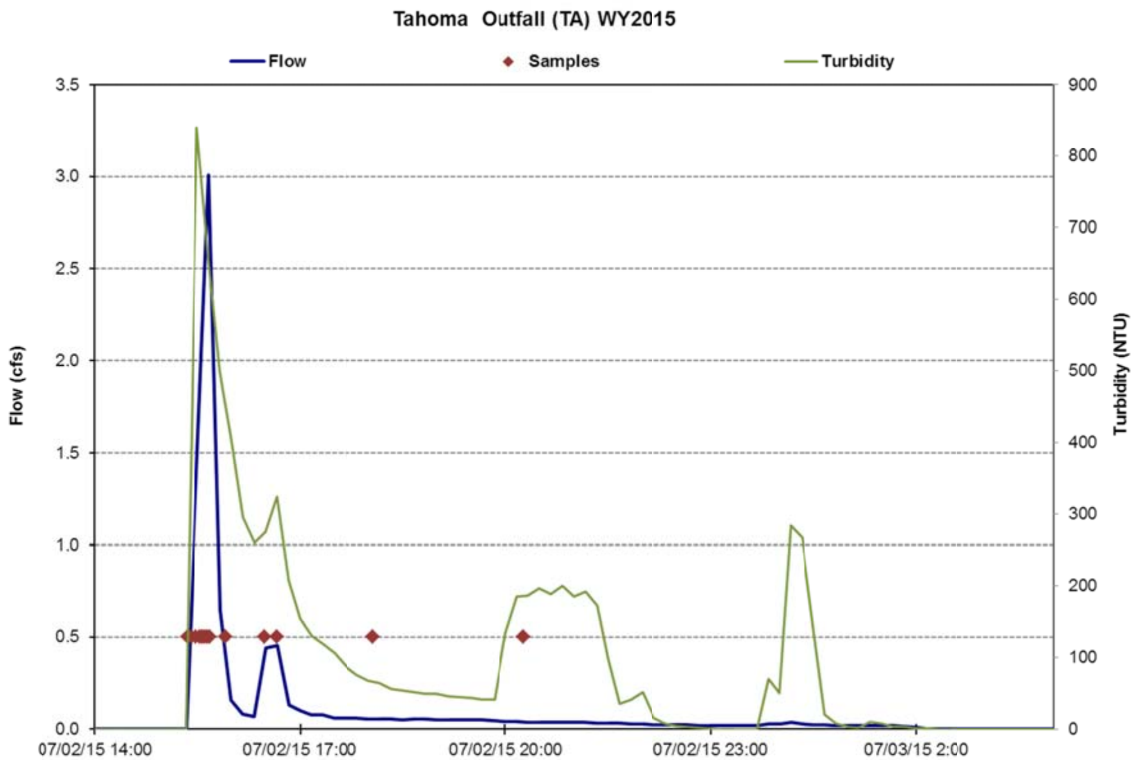

Figure H23: Continuous hydrology, continuous turbidity, and water quality samples for the 7/2/2015 event. Total volume sampled: 5,130 cf.

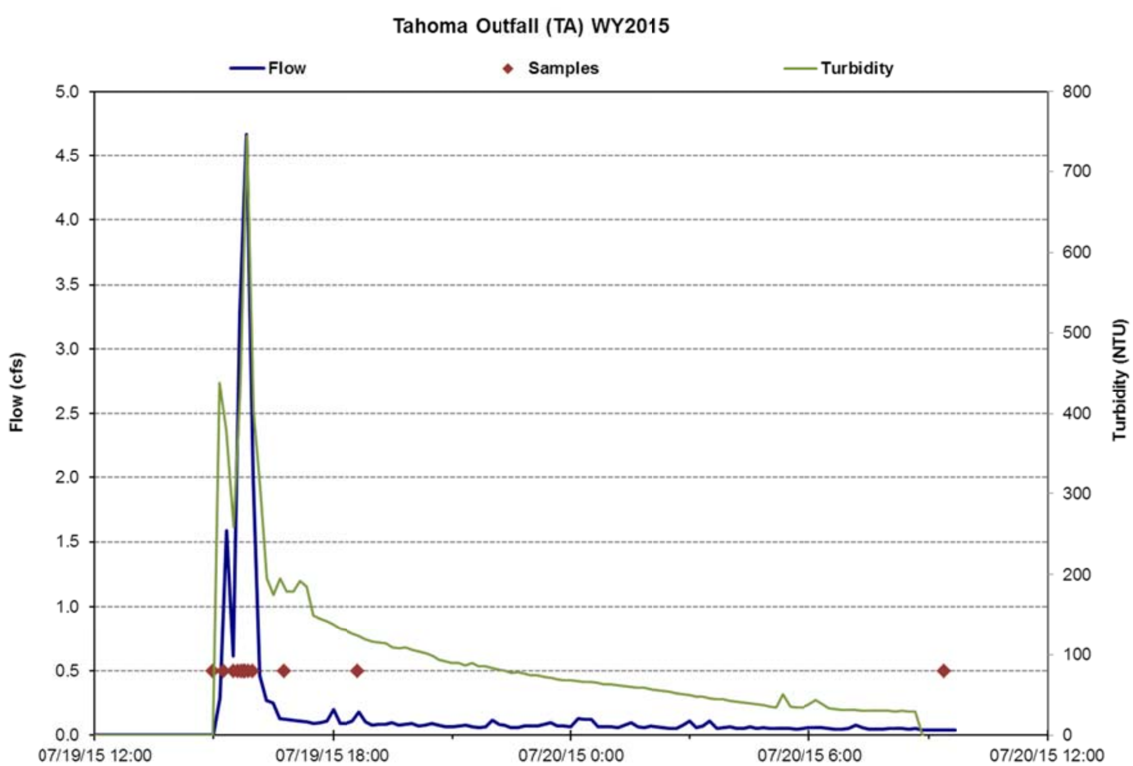

Figure H24: Continuous hydrology, continuous turbidity, and water quality samples for the 7/19/2015 event. Total volume sampled: 12,699 cf.

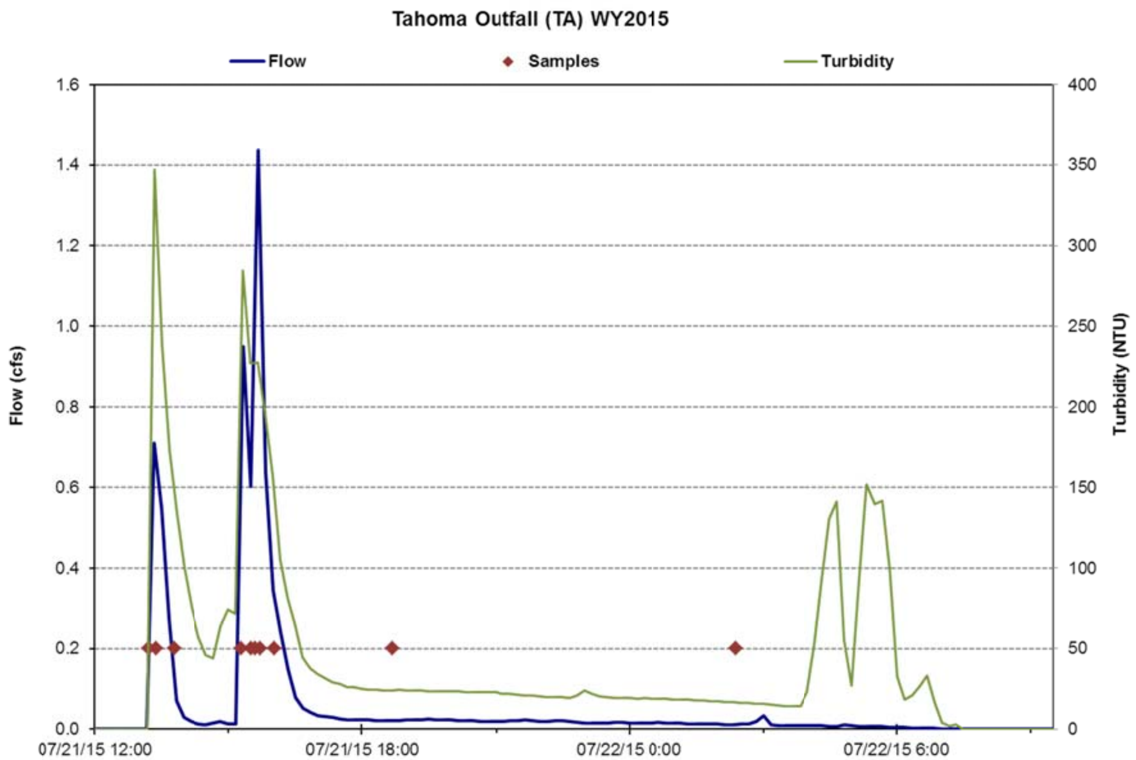

Figure H25: Continuous hydrology, continuous turbidity, and water quality samples for the 7/21/2015 event. Total volume sampled: 4,570 cf.

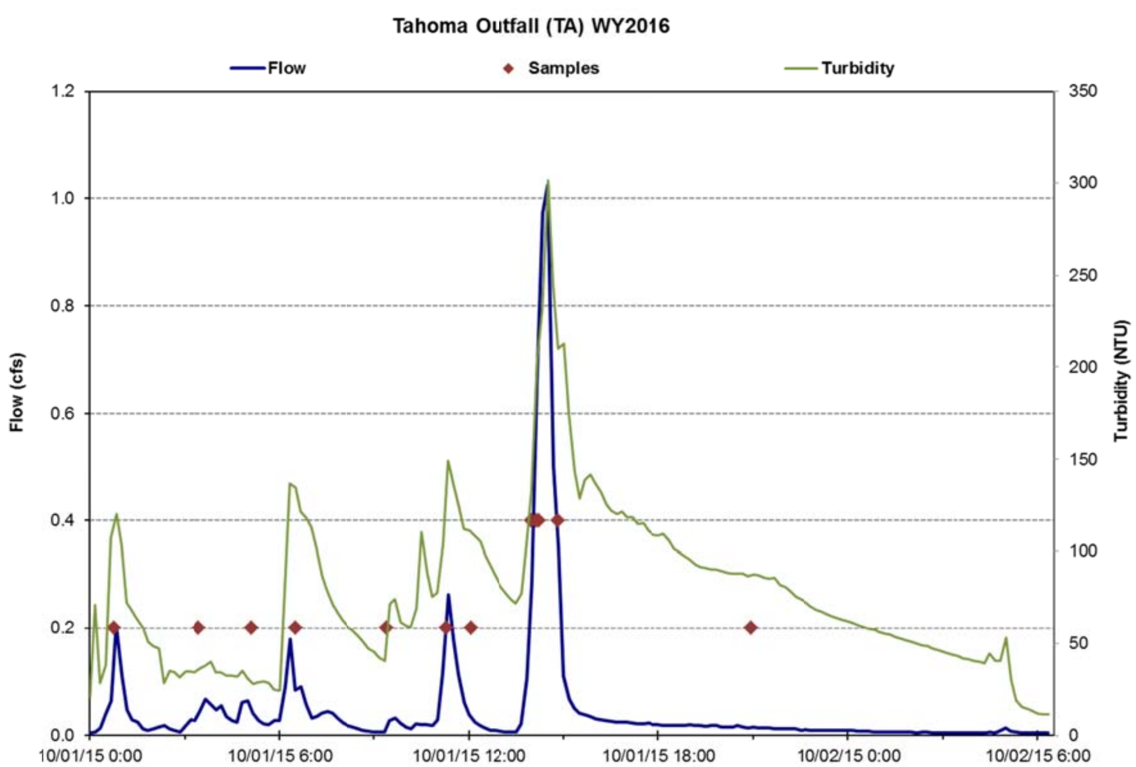

Figure H26: Continuous hydrology, continuous turbidity, and water quality samples for the 10/1/2015 event. Total volume sampled: 5,169 cf.

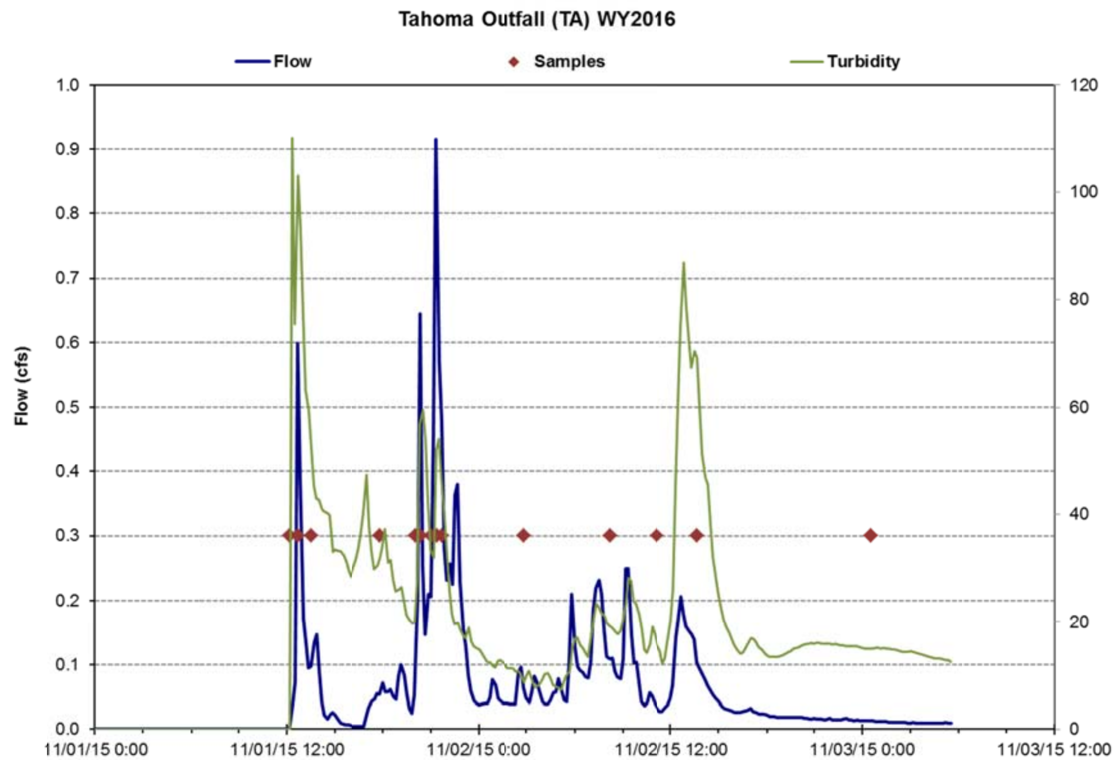

Figure H27: Continuous hydrology, continuous turbidity, and water quality samples for the 11/1/2015 event. Total volume sampled: 11,434 cf.

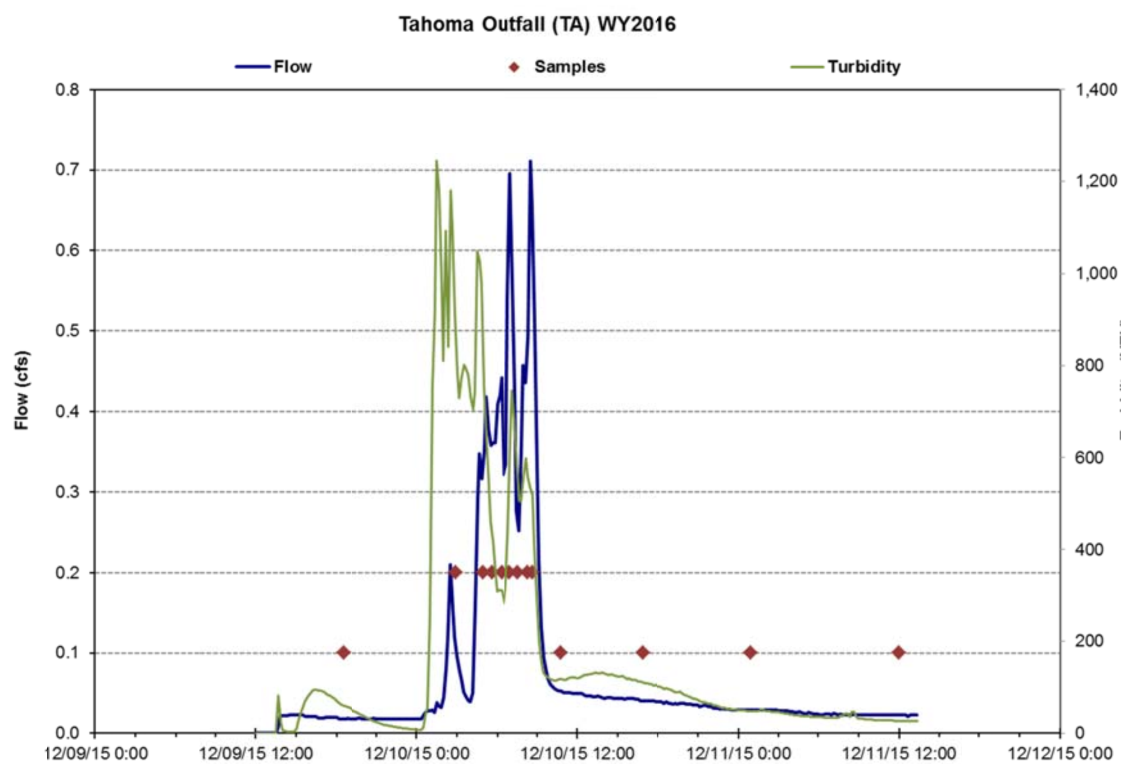

Figure H28: Continuous hydrology, continuous turbidity, and water quality samples for the 12/9/2015 event. Total volume sampled: 12,428 cf.

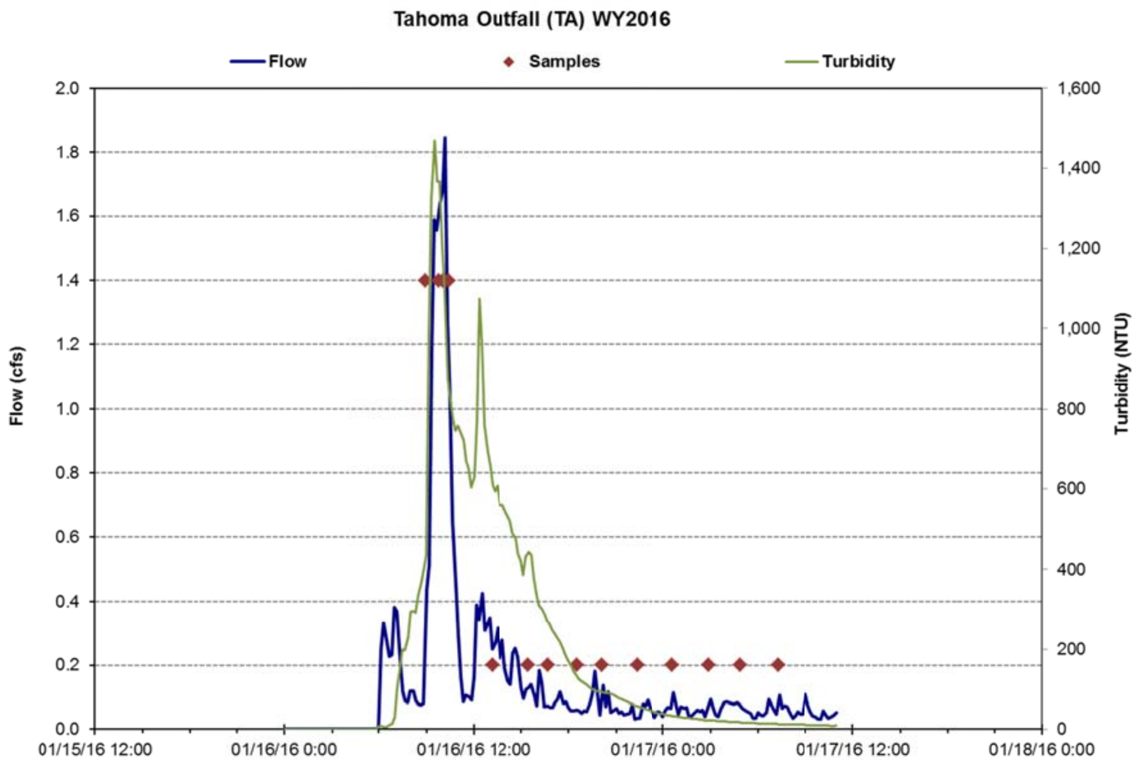

Figure H29: Continuous hydrology, continuous turbidity, and water quality samples for the 1/16/2016 event. Total volume sampled: 18,396 cf.

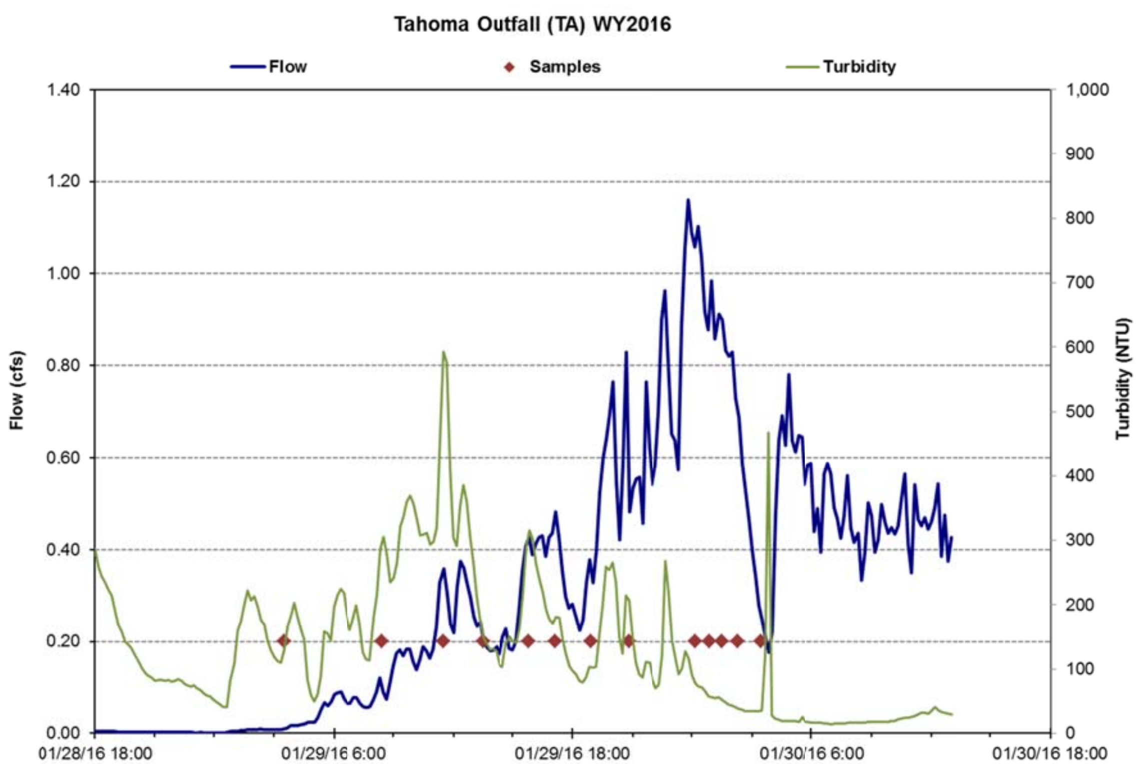

Figure H30: Continuous hydrology, continuous turbidity, and water quality samples for the 1/29/2016 event. Total volume sampled: 32,965 cf.

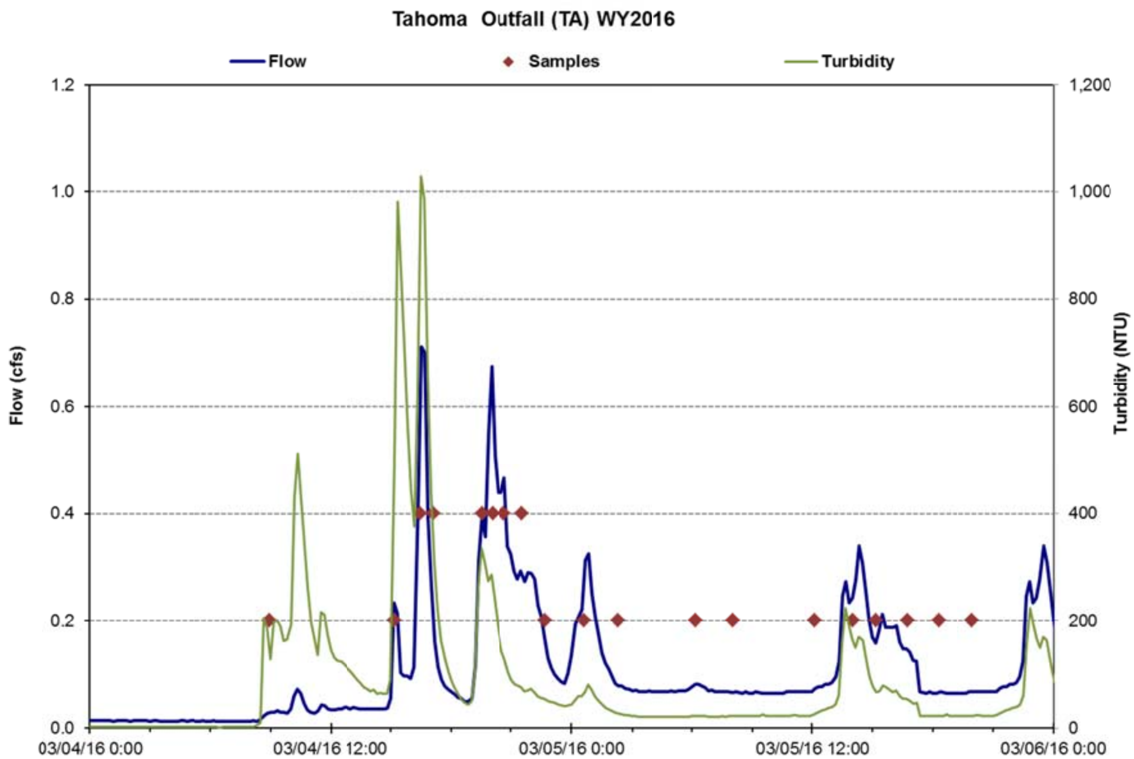

Figure H31: Continuous hydrology, continuous turbidity, and water quality samples for the 3/4/2016 event. Total volume sampled: 16,643 cf.

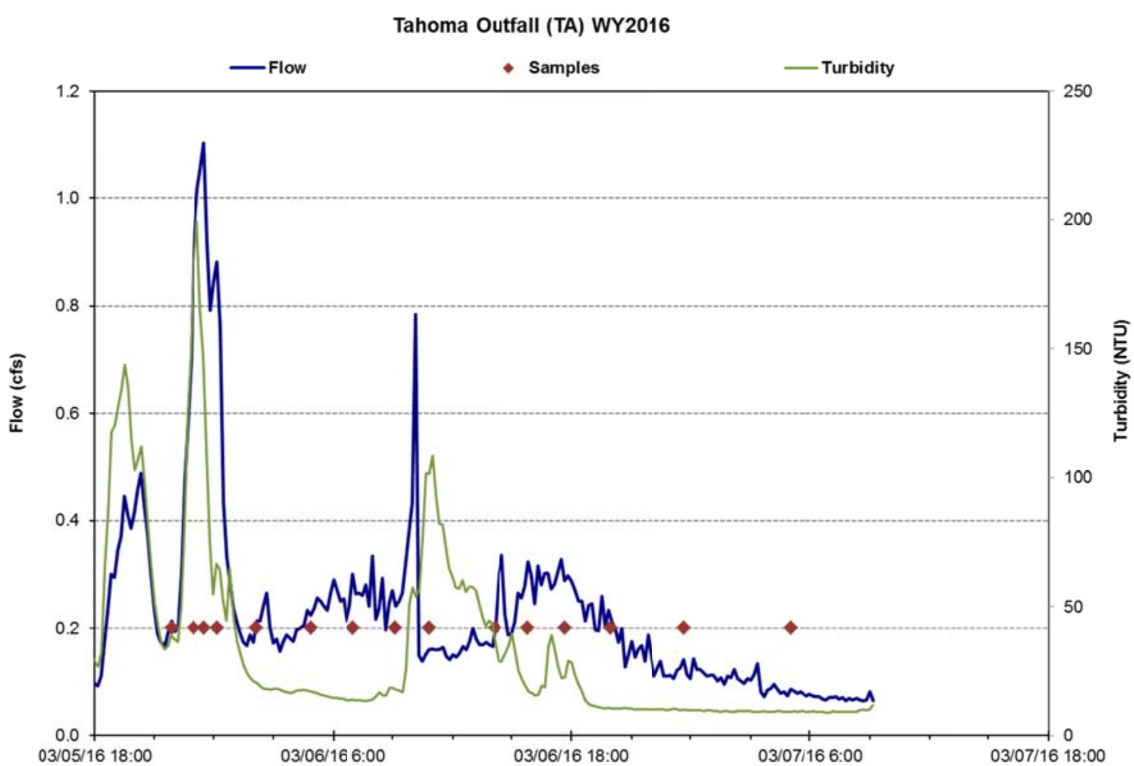

Figure H32: Continuous hydrology, continuous turbidity, and water quality samples for the 3/5/2016 event. Total volume sampled: 28,483 cf.

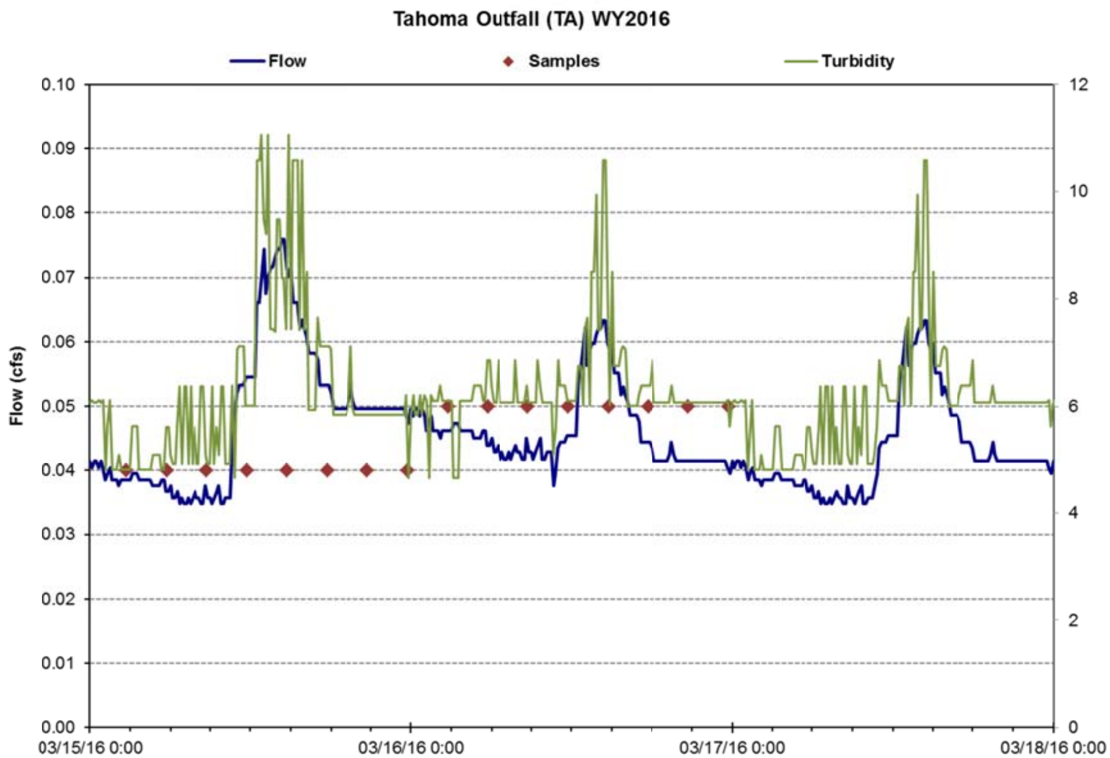

Figure H33: Continuous hydrology, continuous turbidity, and water quality samples for the 3/15/2016 event. Total volume sampled: 3,985 cf.

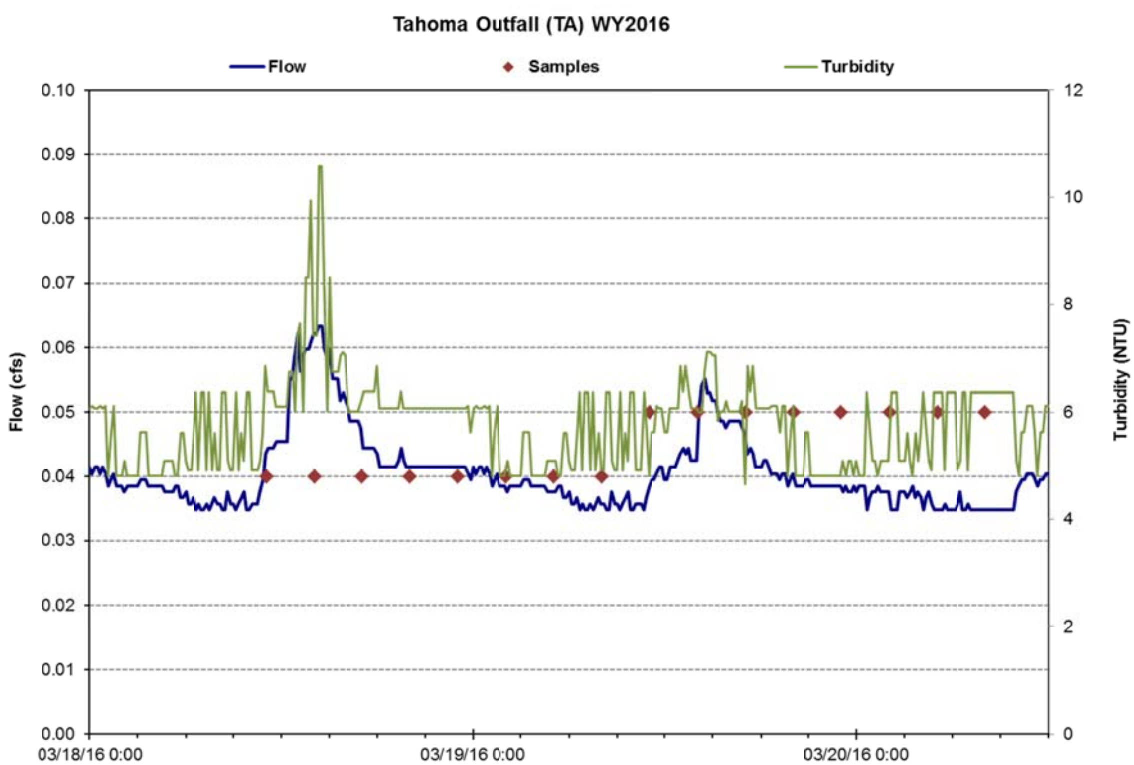

Figure H34: Continuous hydrology, continuous turbidity, and water quality samples for the 3/18/2016 event. Total volume sampled: 3,417 cf.

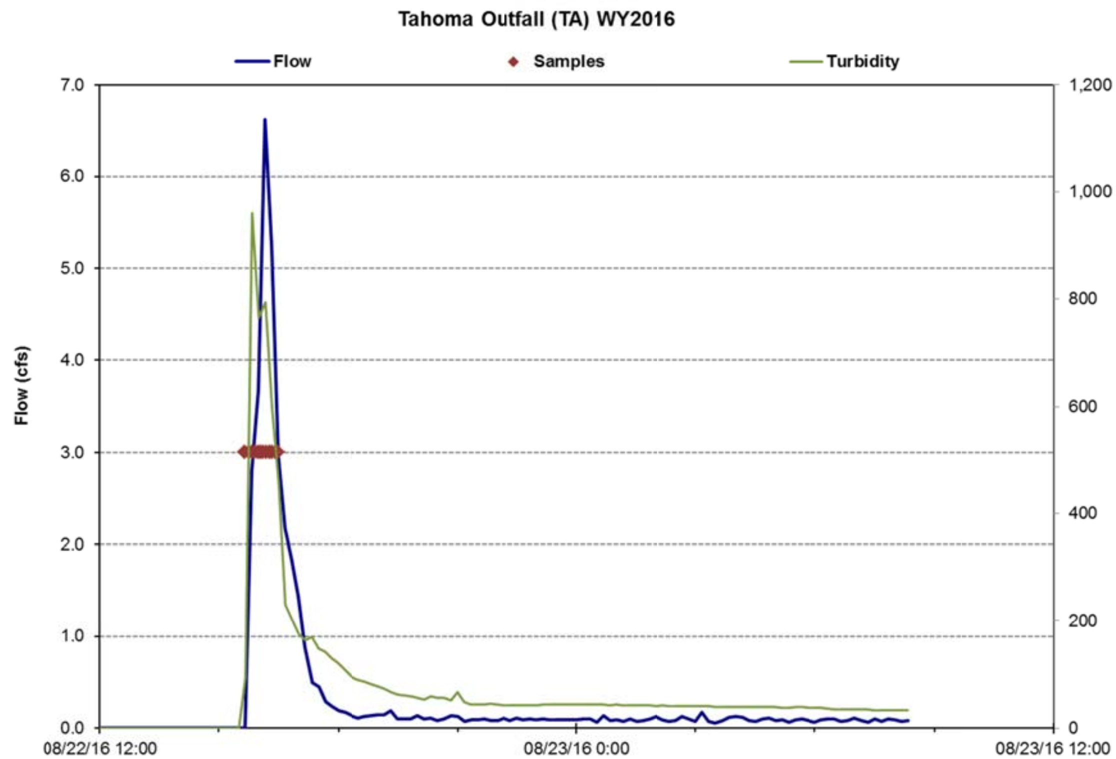

Figure H35: Continuous hydrology, continuous turbidity, and water quality samples for the 8/22/2016 event. Total volume sampled: 17,576 cf.

Appendix I: Speedboat Event Graphs

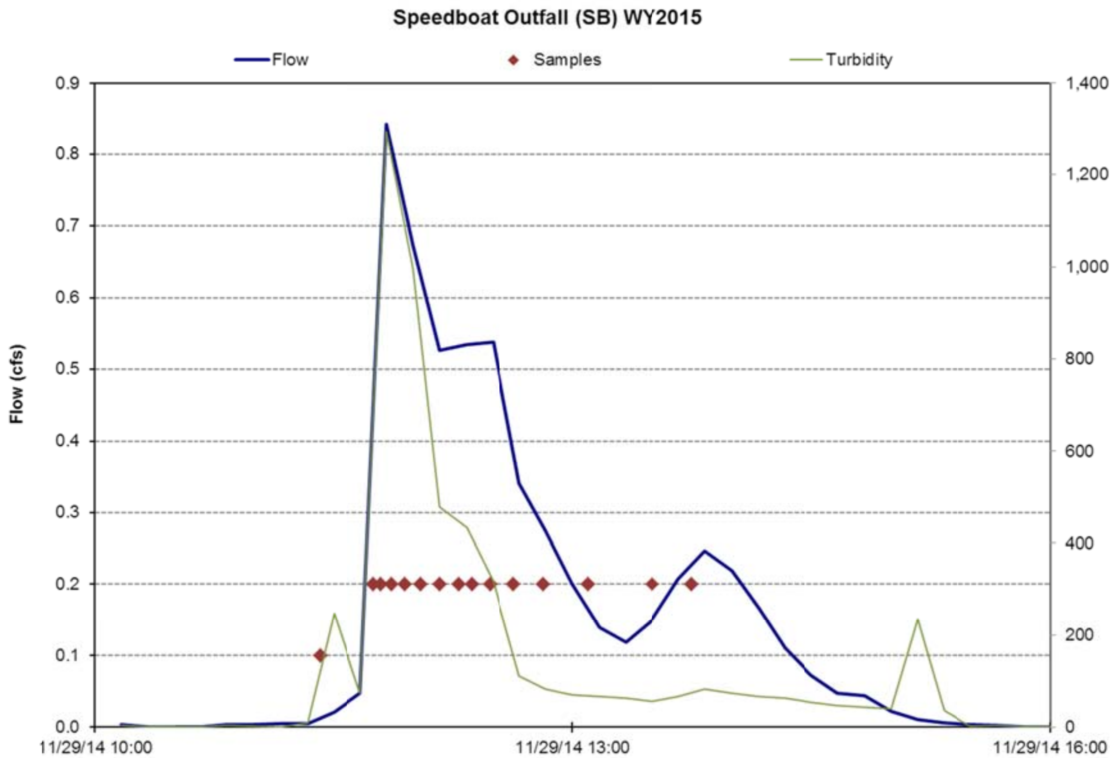

Figure I1: Continuous hydrology, continuous turbidity, and water quality samples for the 11/29/2014 event. Total volume sampled: 3,351 cf.

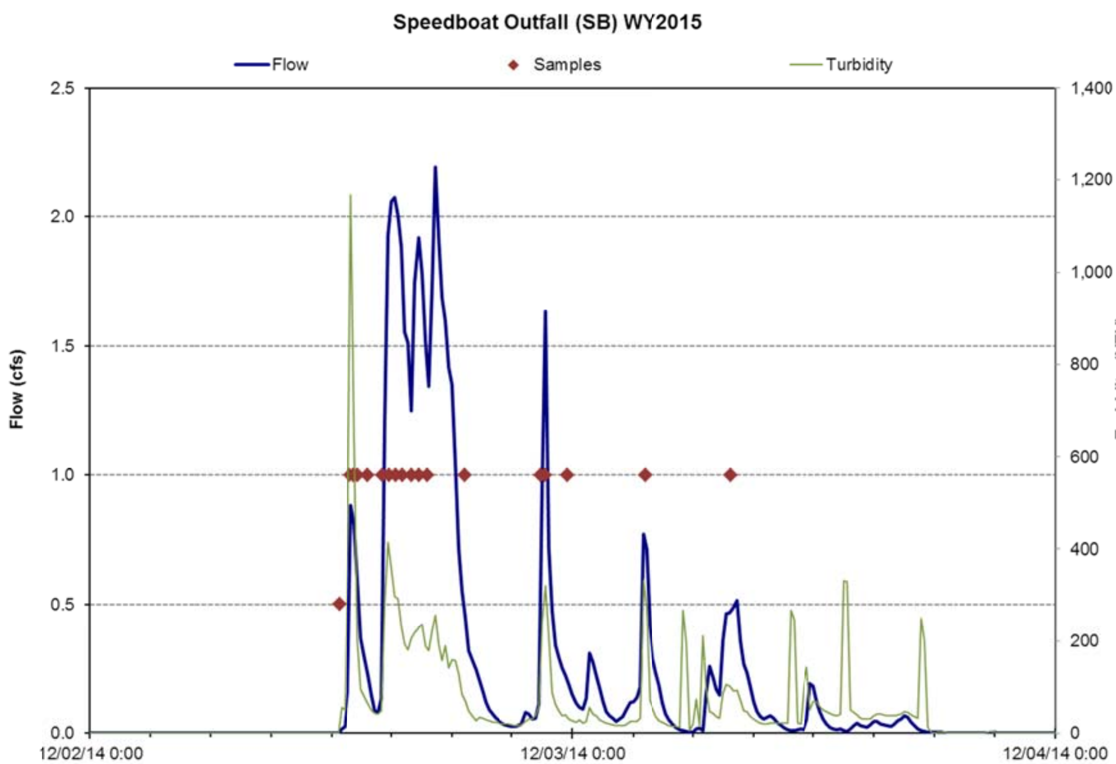

Figure I2: Continuous hydrology, continuous turbidity, and water quality samples for the 12/2/2014 event. Total volume sampled: 37,174 cf.

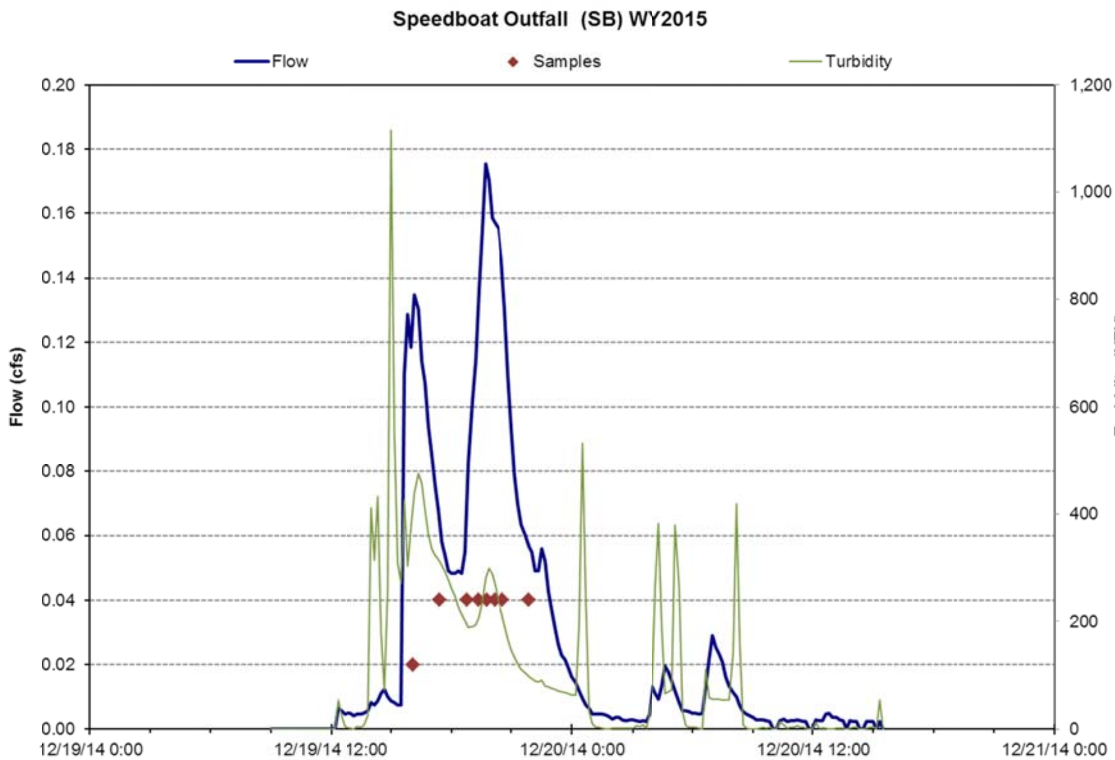

Figure I3: Continuous hydrology, continuous turbidity, and water quality samples for the 12/19/2014 event. Total volume sampled: 2,987 cf.

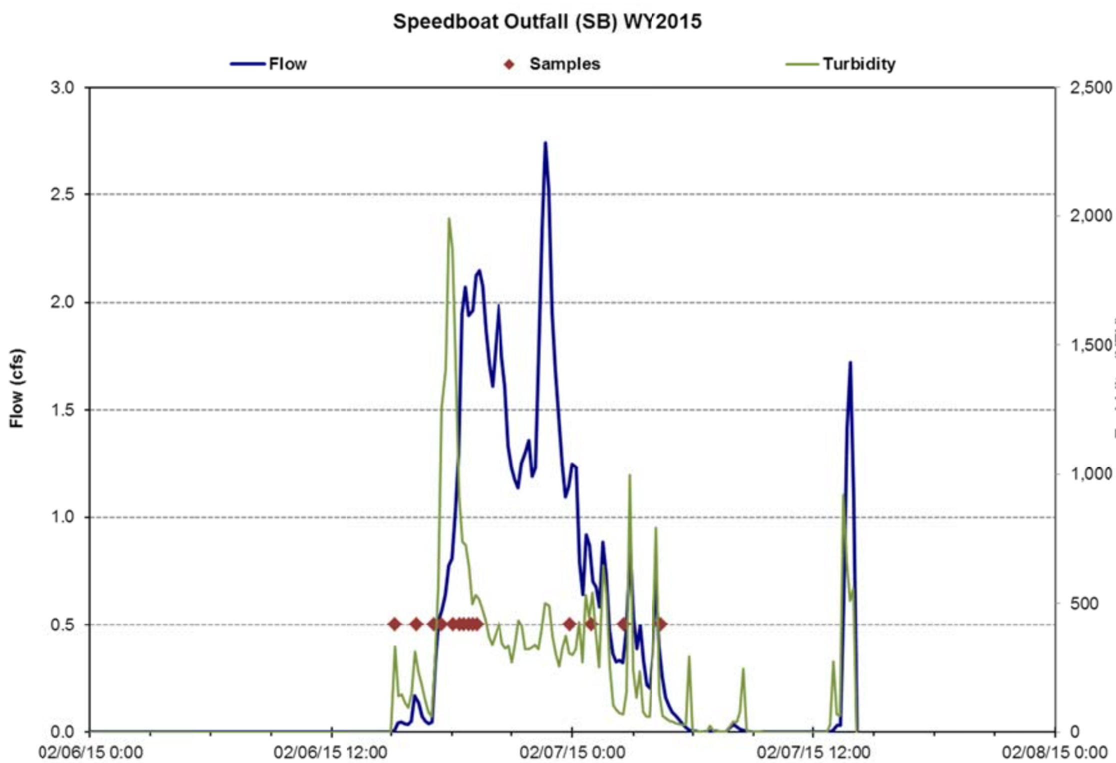

Figure I4: Continuous hydrology, continuous turbidity, and water quality samples for the 2/6/2015 event. Bottles ran out at peak of flow. Total volume sampled: 47,735 cf.

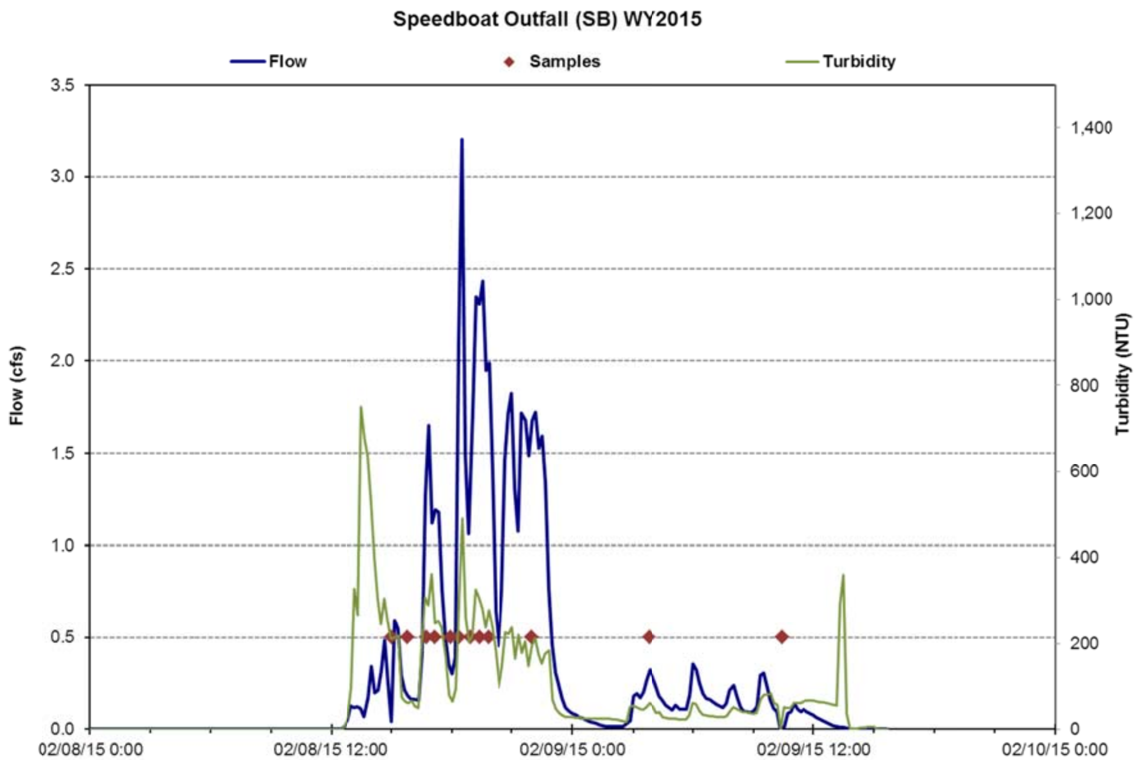

Figure I5: Continuous hydrology, continuous turbidity, and water quality samples for the 2/8/2015 event.
Total volume sampled: 41,394 cf.

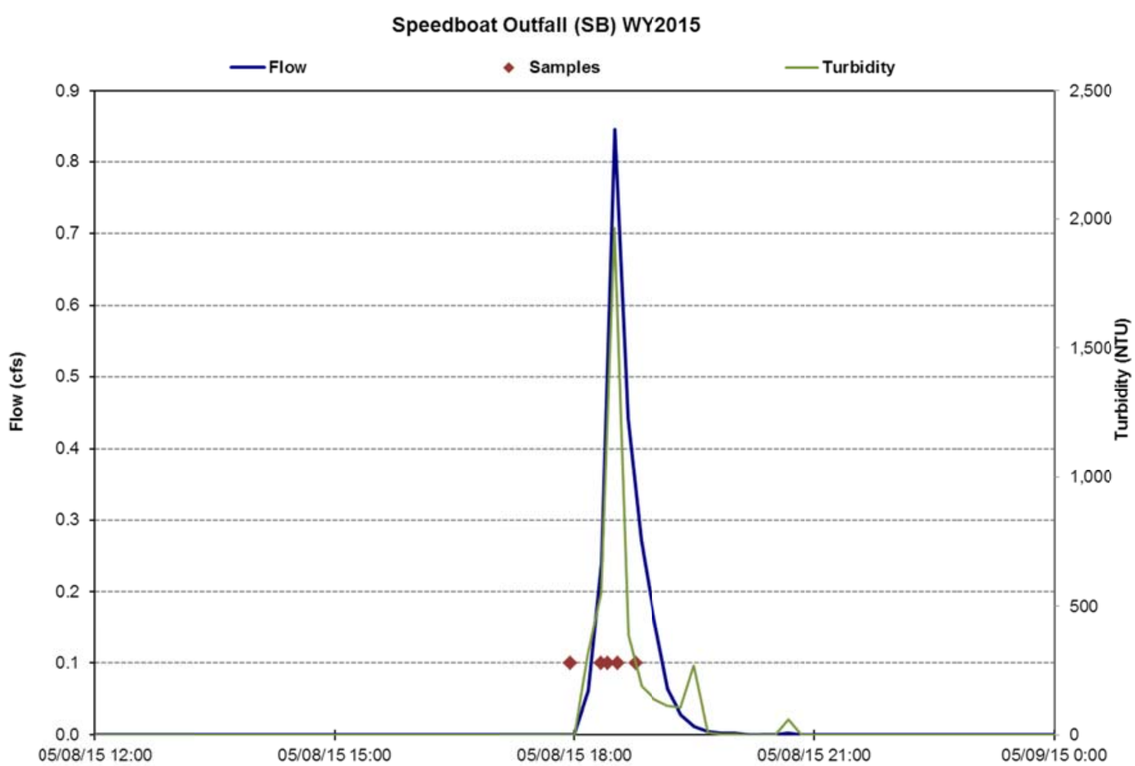

Figure I6: Continuous hydrology, continuous turbidity, and water quality samples for the 5/8/2015 event.
Total volume sampled: 1,284 cf.

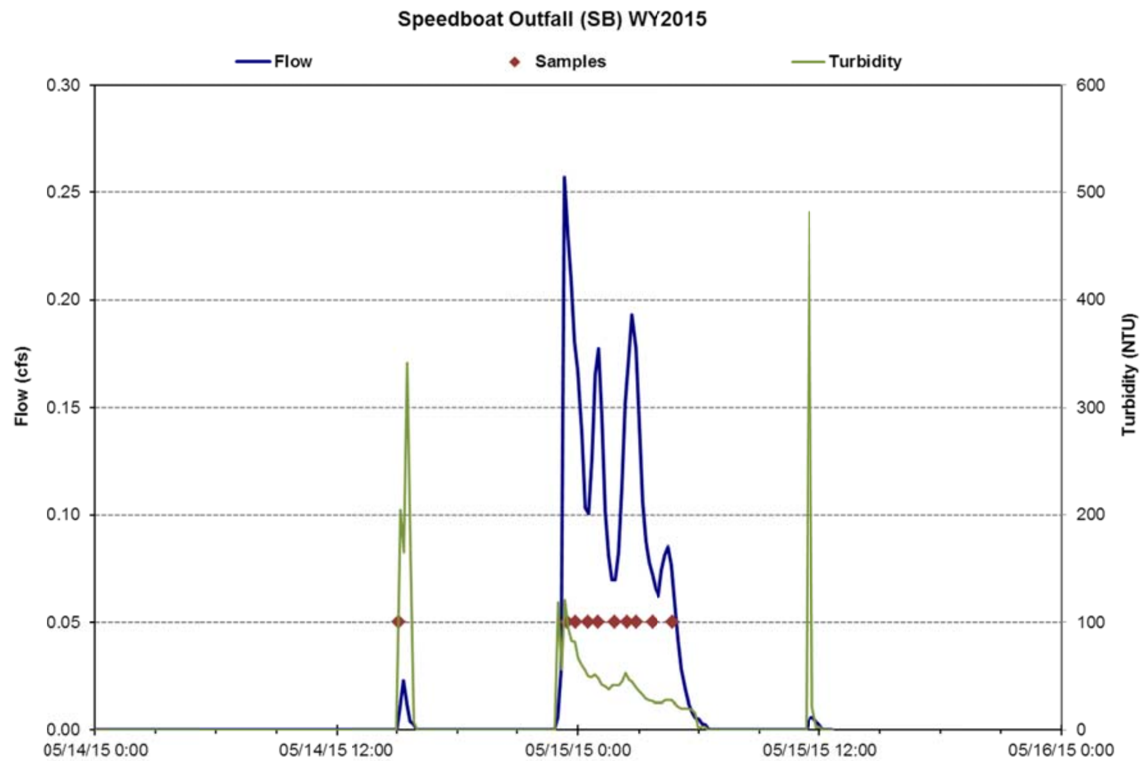

Figure I7: Continuous hydrology, continuous turbidity, and water quality samples for the 5/14/2015 event. Total volume sampled: 2,660 cf.

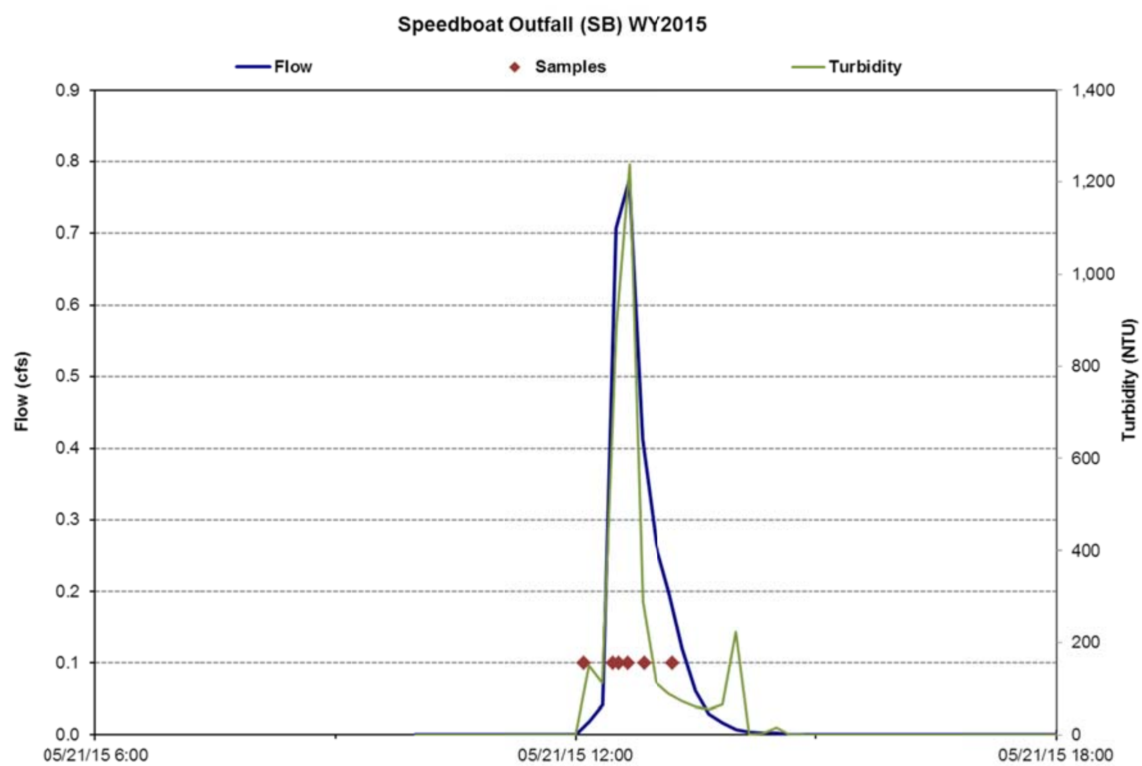

Figure I8: Continuous hydrology, continuous turbidity, and water quality samples for the 5/21/2015 event. Total volume sampled: 1,599 cf.

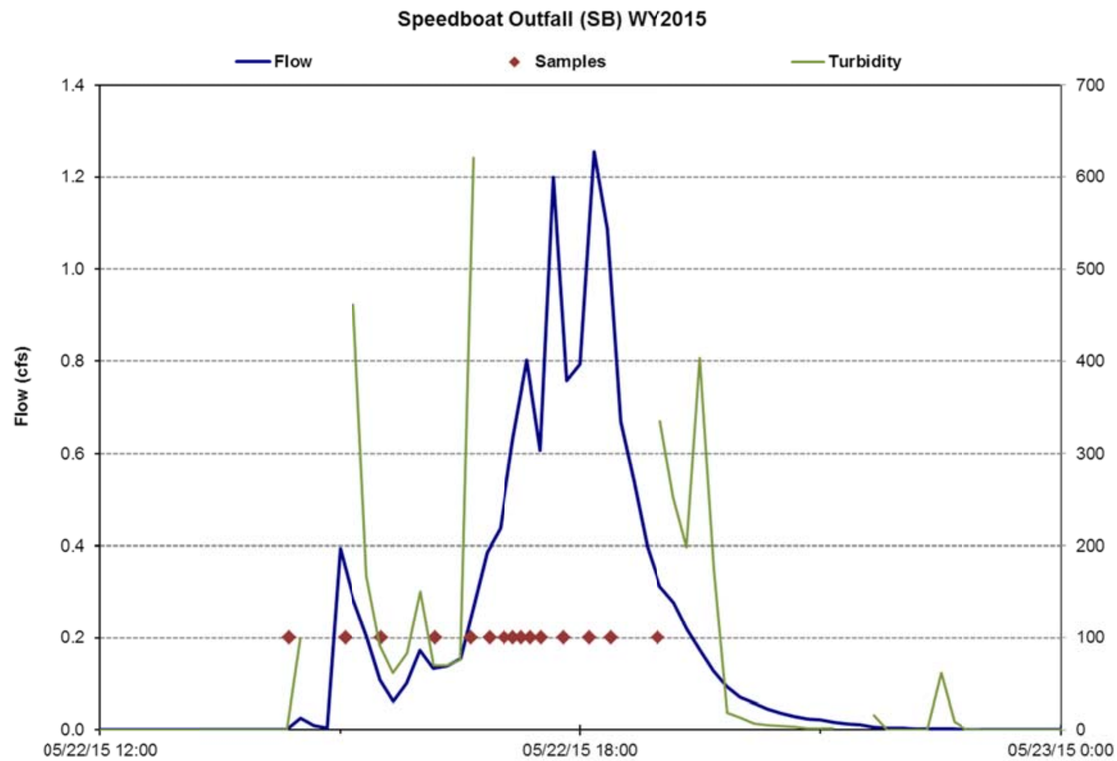

Figure I9: Continuous hydrology, continuous turbidity, and water quality samples for the 5/22/2015 event. Debris on turbidity sensor caused erroneous readings that were removed. Total volume sampled: 7,905 cf.

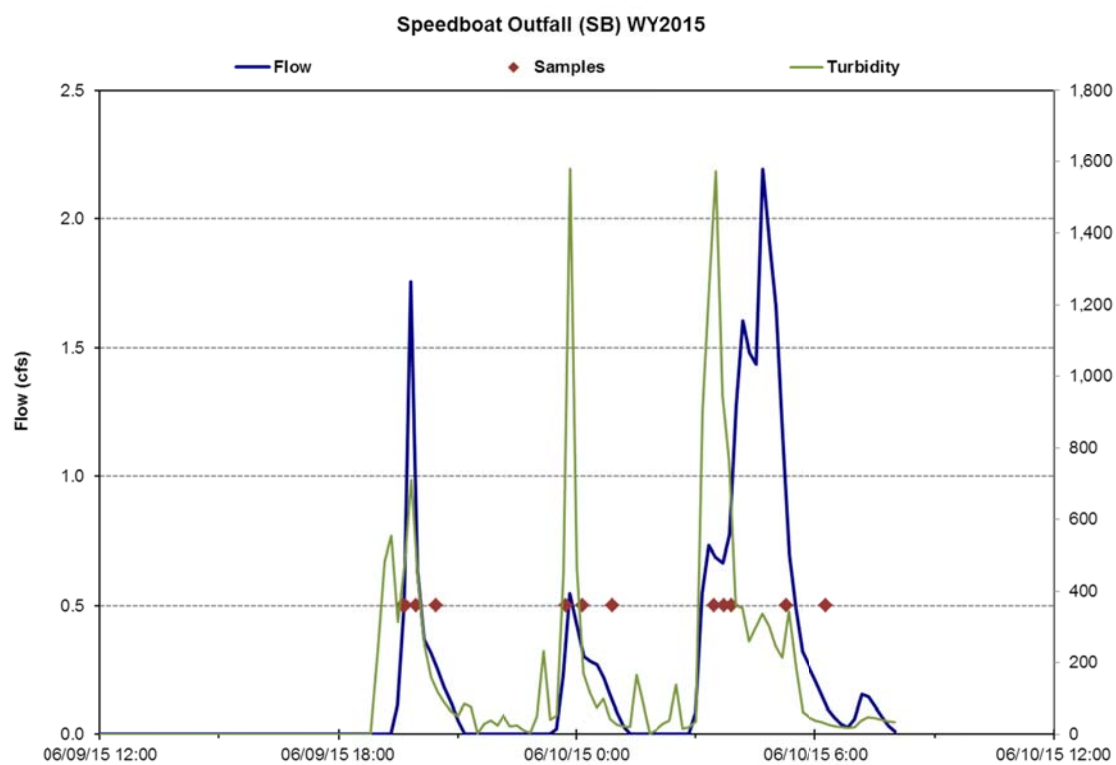

Figure I10: Continuous hydrology, continuous turbidity, and water quality samples for the 6/9/2015 event. Total volume sampled: 15,626 cf.

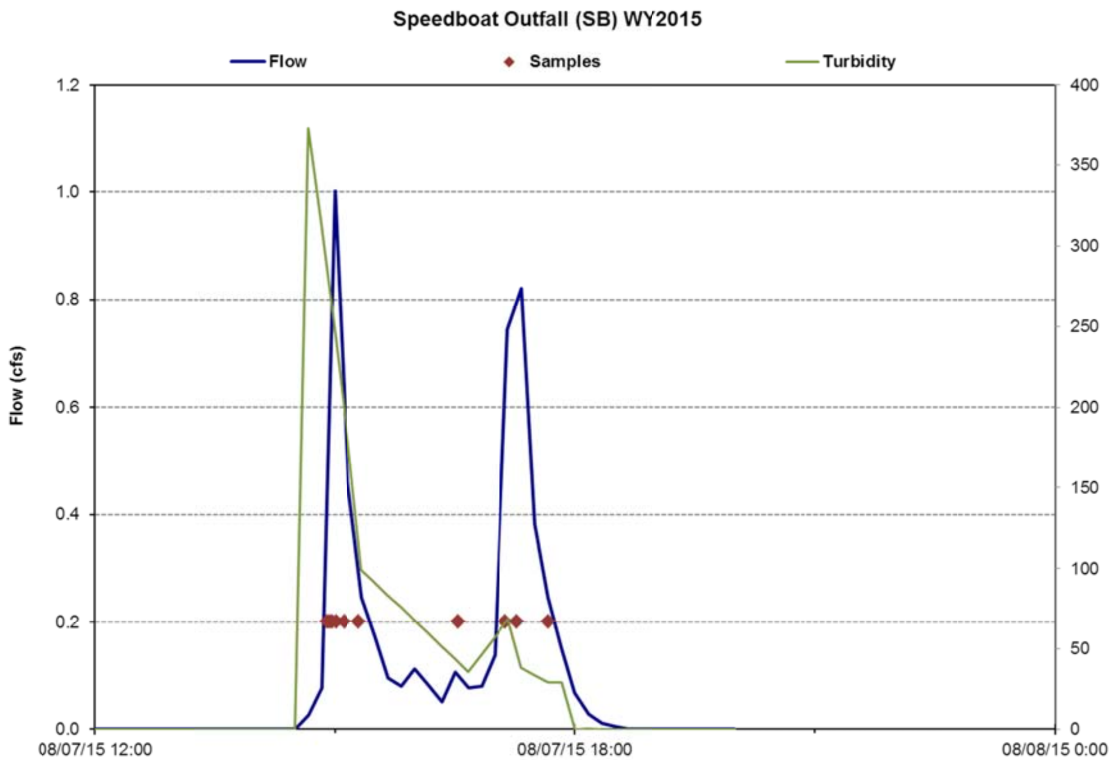

Figure I11: Continuous hydrology, continuous turbidity, and water quality samples for the 8/7/2015 event. Total volume sampled: 3,163 cf.

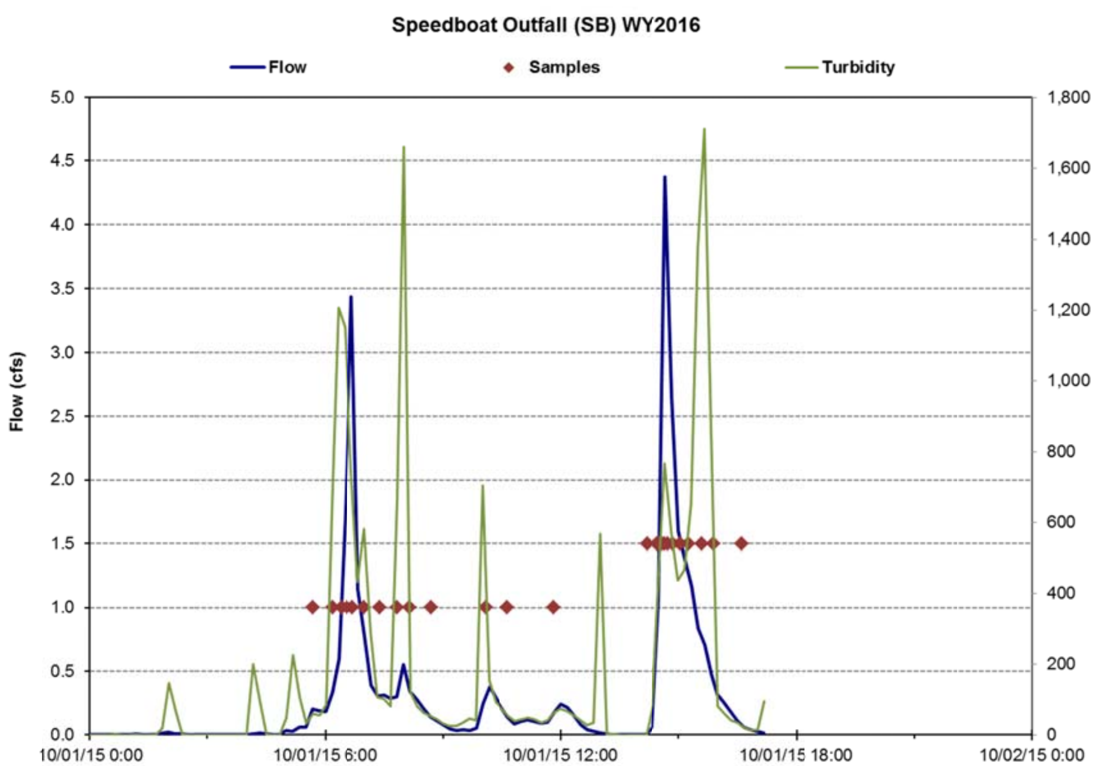

Figure I12: Continuous hydrology, continuous turbidity, and water quality samples for the 10/1/2015 event. Total volume sampled: 1,711 cf.

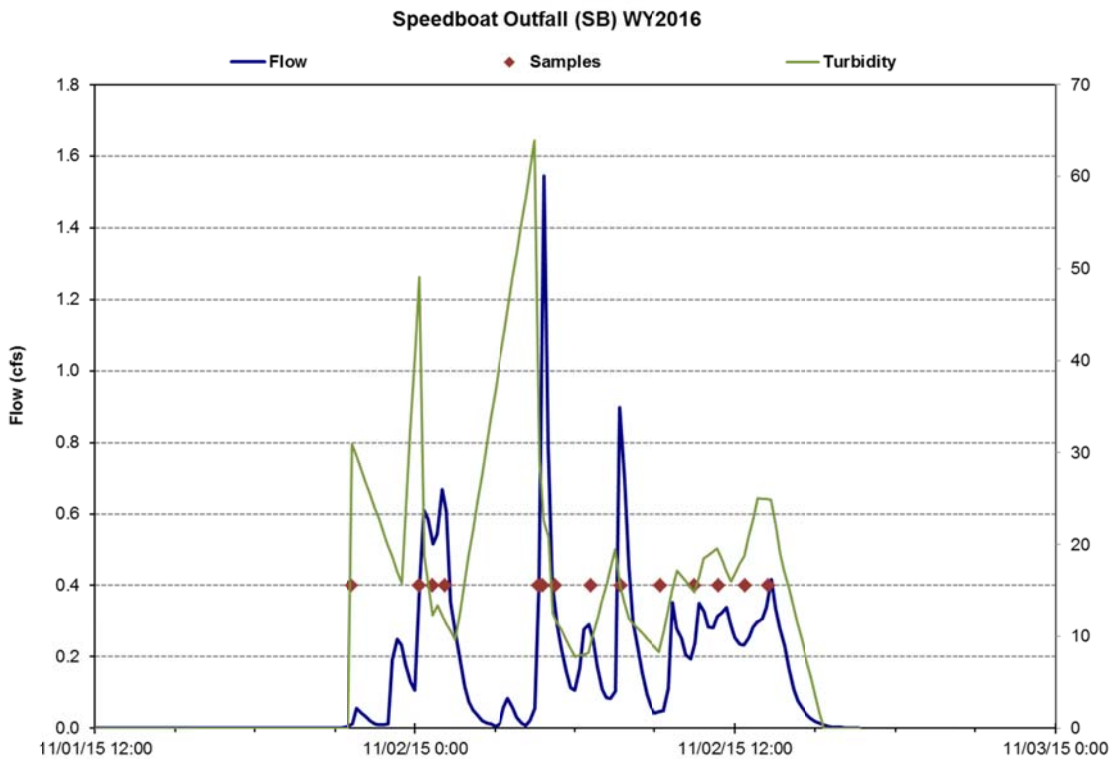

Figure I13: Continuous hydrology, continuous turbidity, and water quality samples for the 11/1/2015 event. Total volume sampled: 14,100 cf.

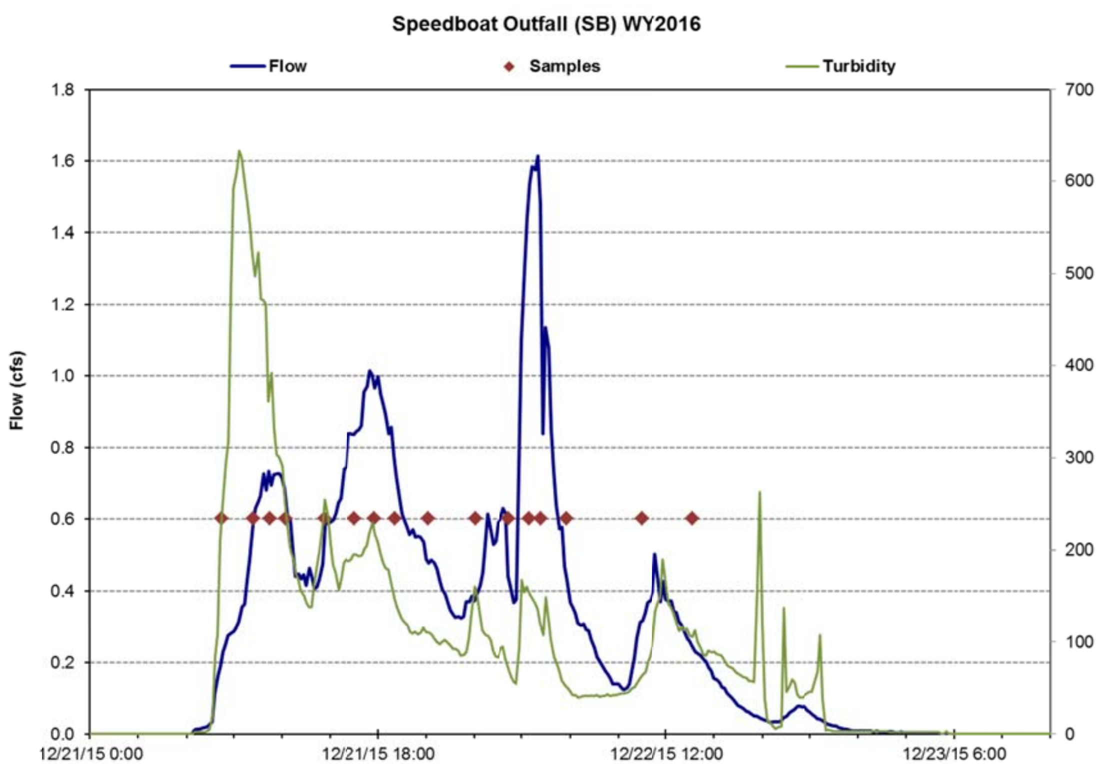

Figure I14: Continuous hydrology, continuous turbidity, and water quality samples for the 12/21/2015 event. Total volume sampled: 60,669 cf.

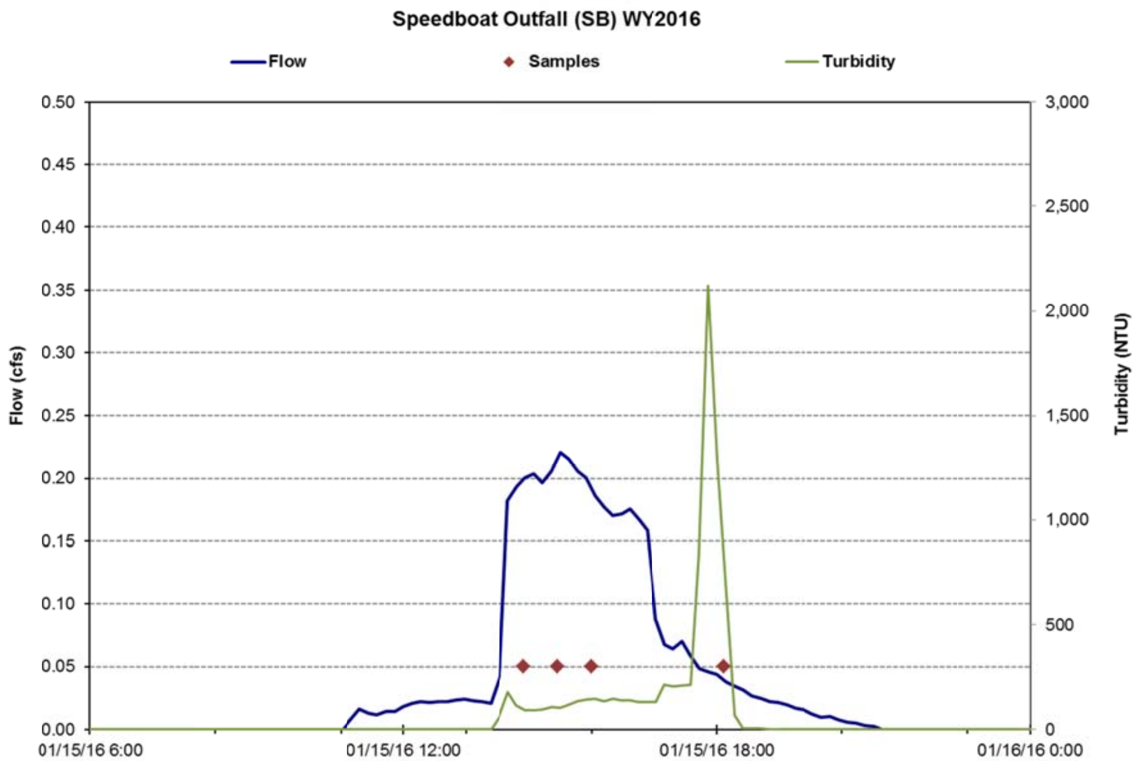

Figure I15: Continuous hydrology, continuous turbidity, and water quality samples for the 1/15/2016 event. Total volume sampled: 2,632 cf.

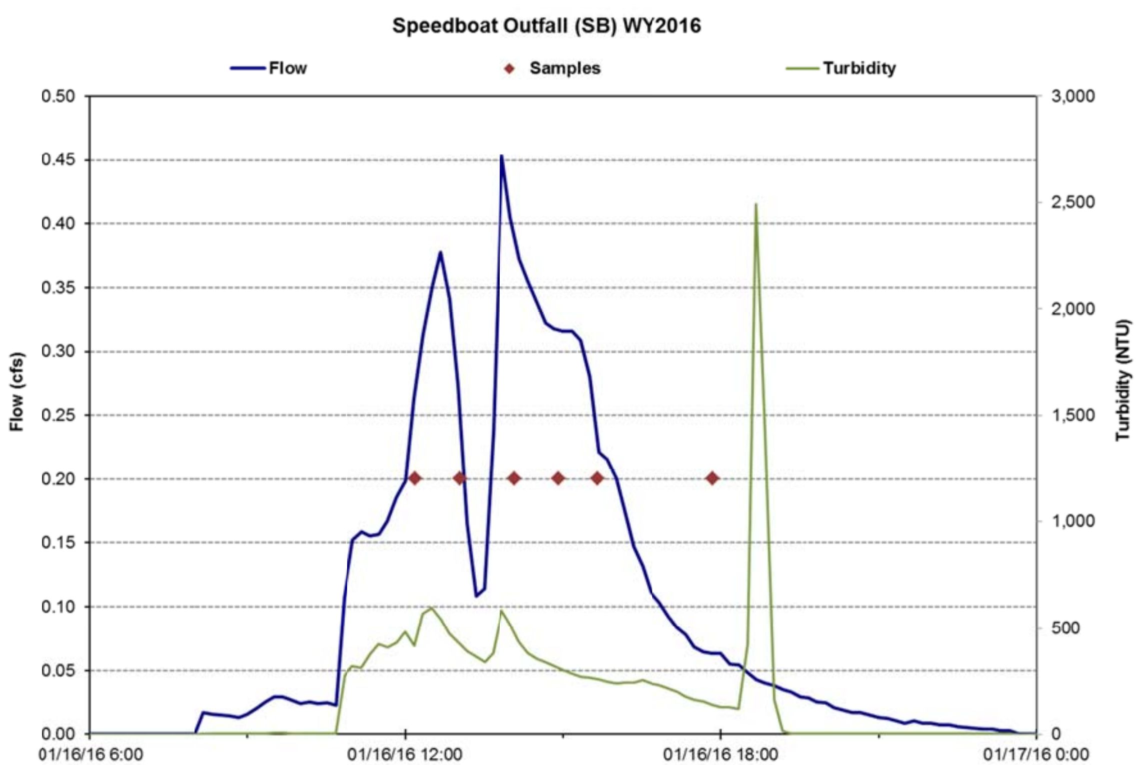

Figure I16: Continuous hydrology, continuous turbidity, and water quality samples for the 1/16/2016 event. Total volume sampled: 6,236 cf.

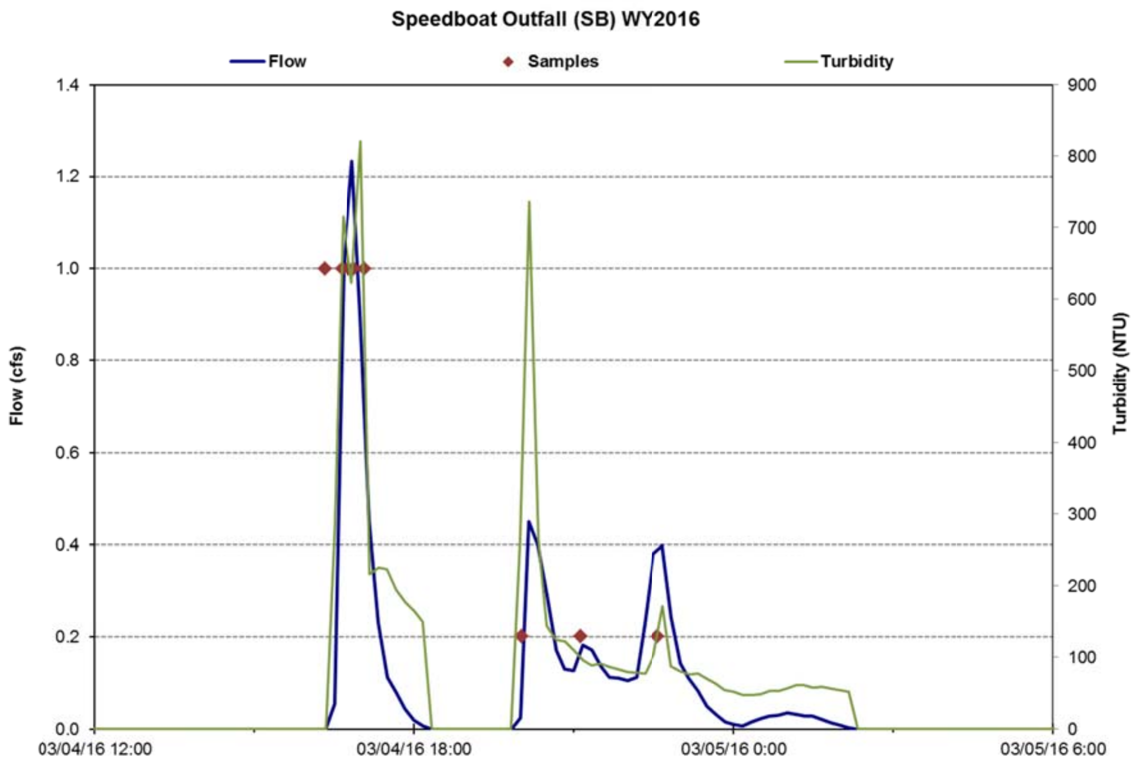

Figure I17: Continuous hydrology, continuous turbidity, and water quality samples for the 3/4/2016 event. Total volume sampled: 5,162 cf.

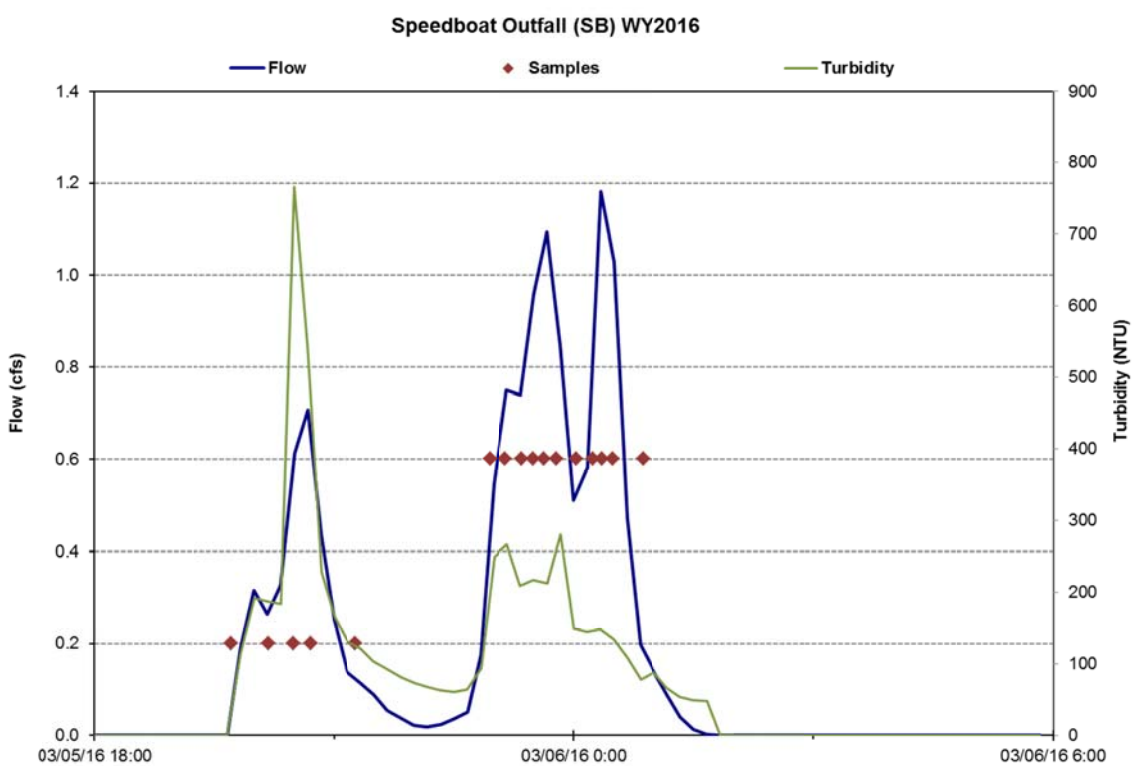

Figure I18: Continuous hydrology, continuous turbidity, and water quality samples for the 3/5/2016 event. Total volume sampled: 7,835 cf.

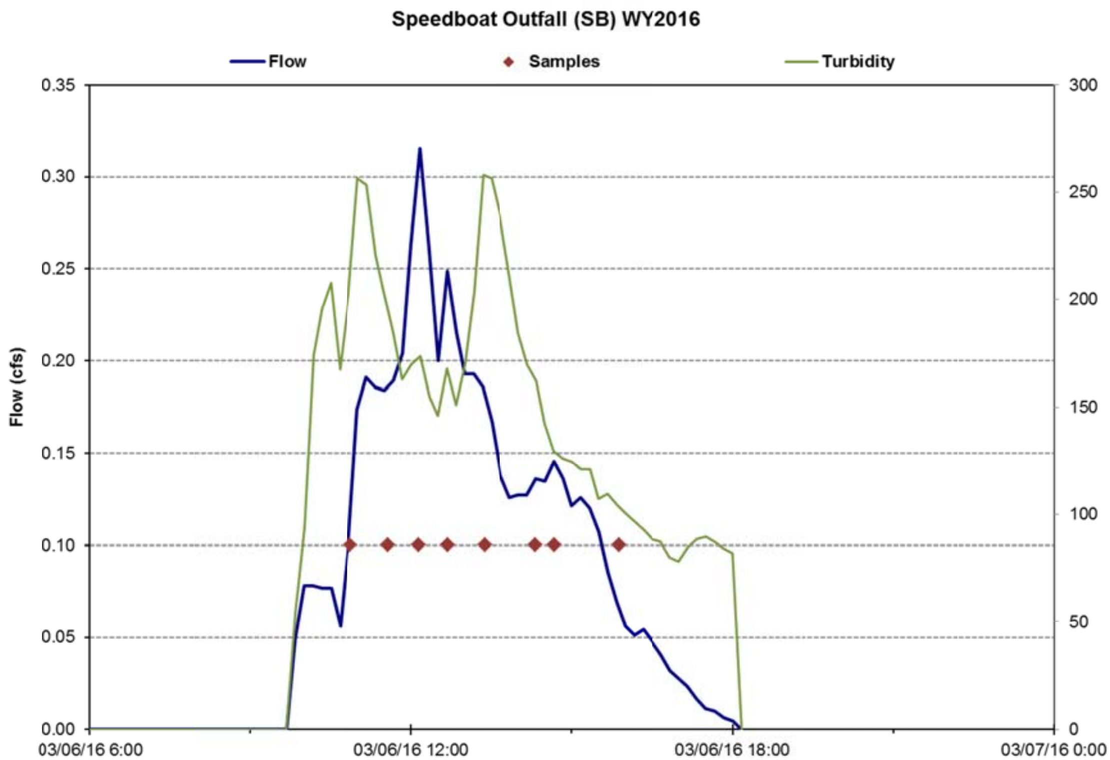

Figure I19: Continuous hydrology, continuous turbidity, and water quality samples for the 3/6/2016 event. Total volume sampled: 3,583 cf.

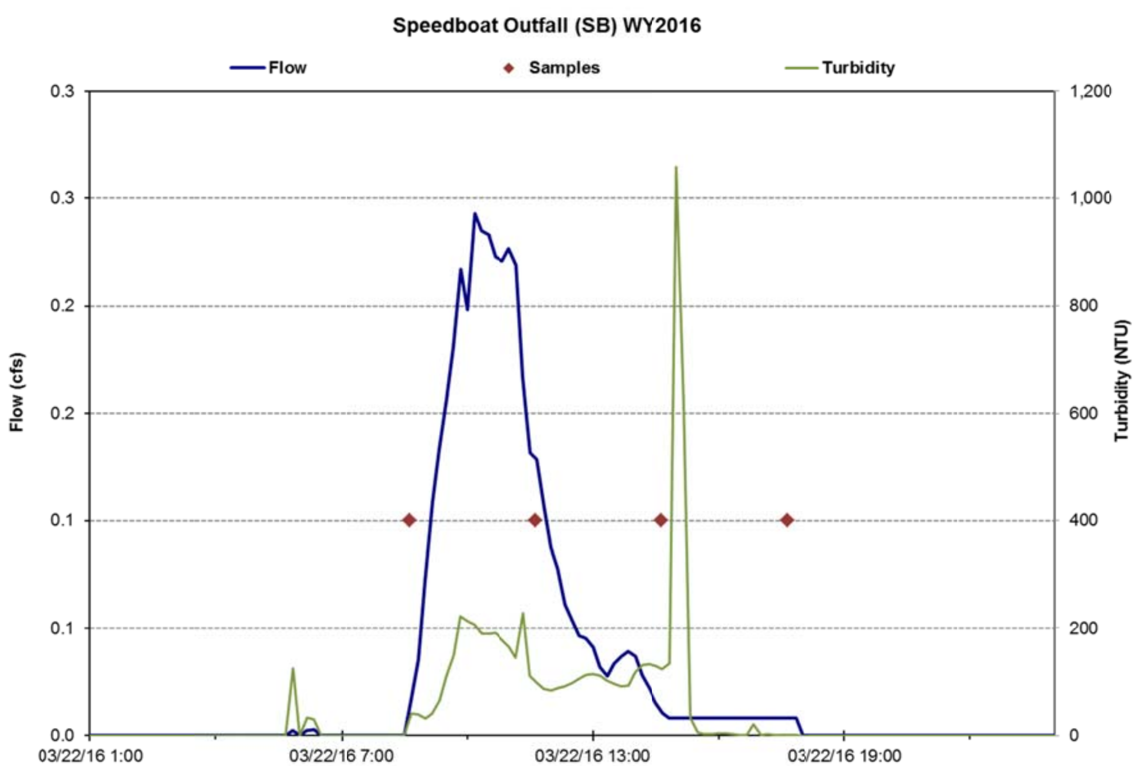

Figure I20: Continuous hydrology, continuous turbidity, and water quality samples for the 3/22/2016 event. Total volume sampled: 4,464 cf.

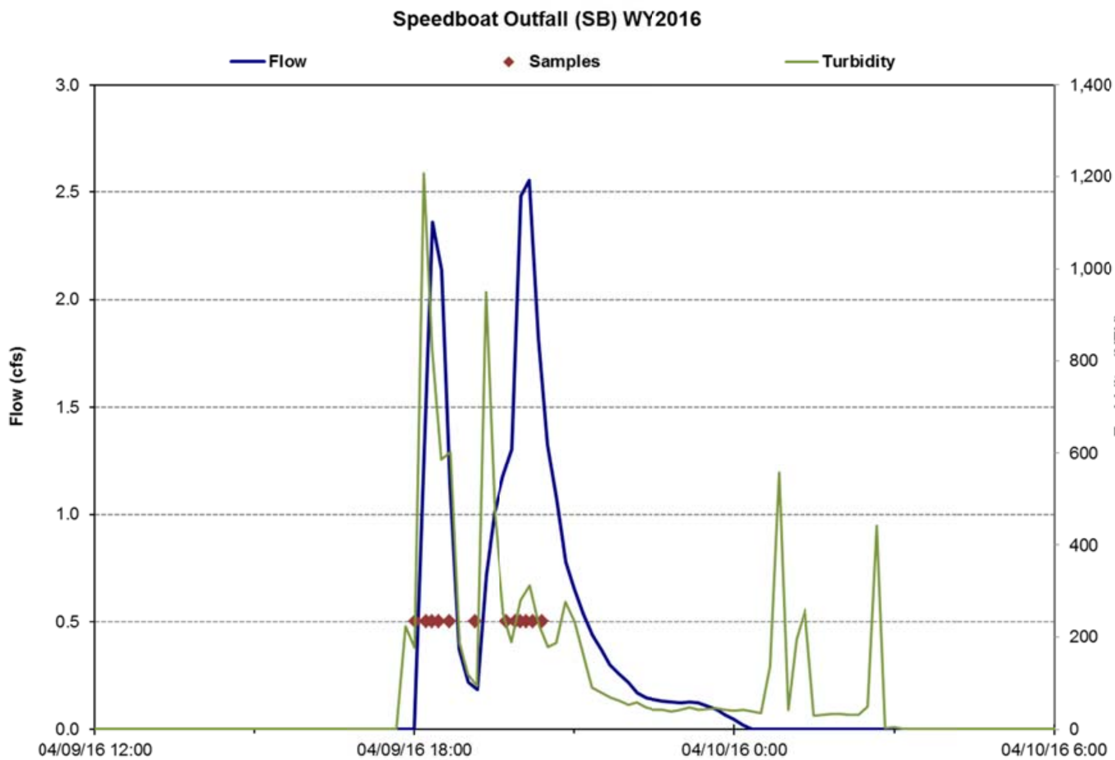

Figure I21: Continuous hydrology, continuous turbidity, and water quality samples for the 4/9/2016 event. Total volume sampled: 15,637 cf.

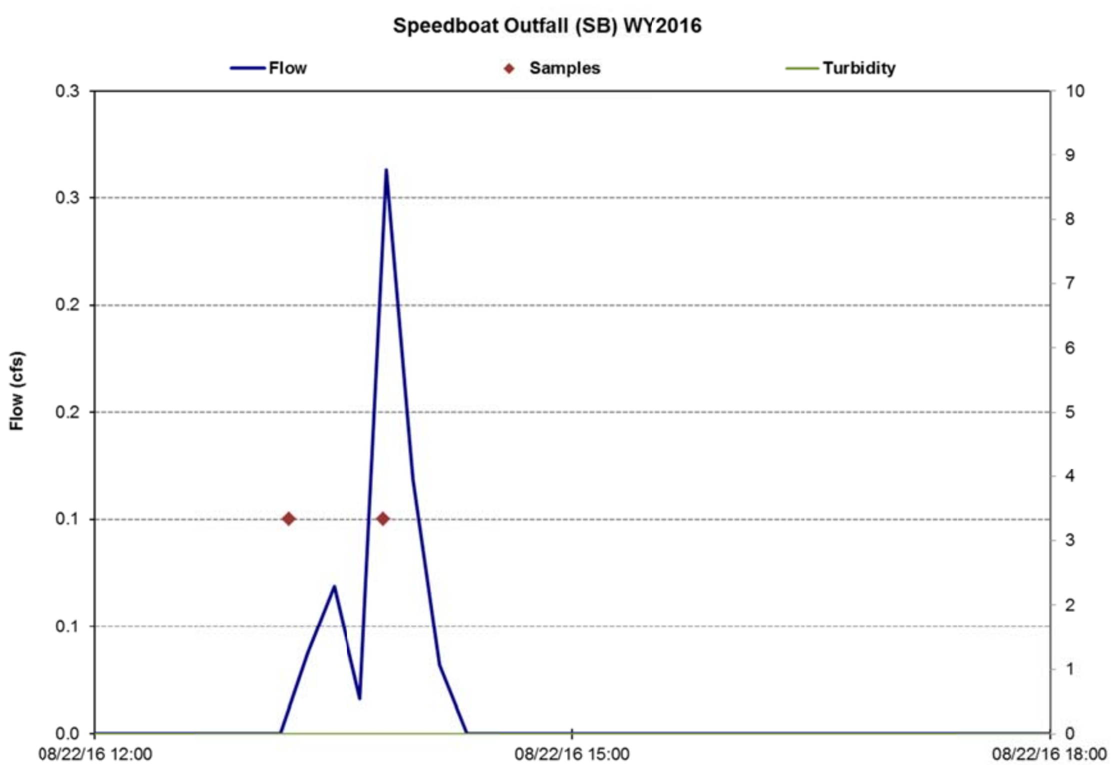

Figure I22: Continuous hydrology, continuous turbidity, and water quality samples for the 8/22/2016 event. Total volume sampled: 322 cf. The turbidity sensor failed during this event.

Appendix J: Tahoe Valley Event Graphs

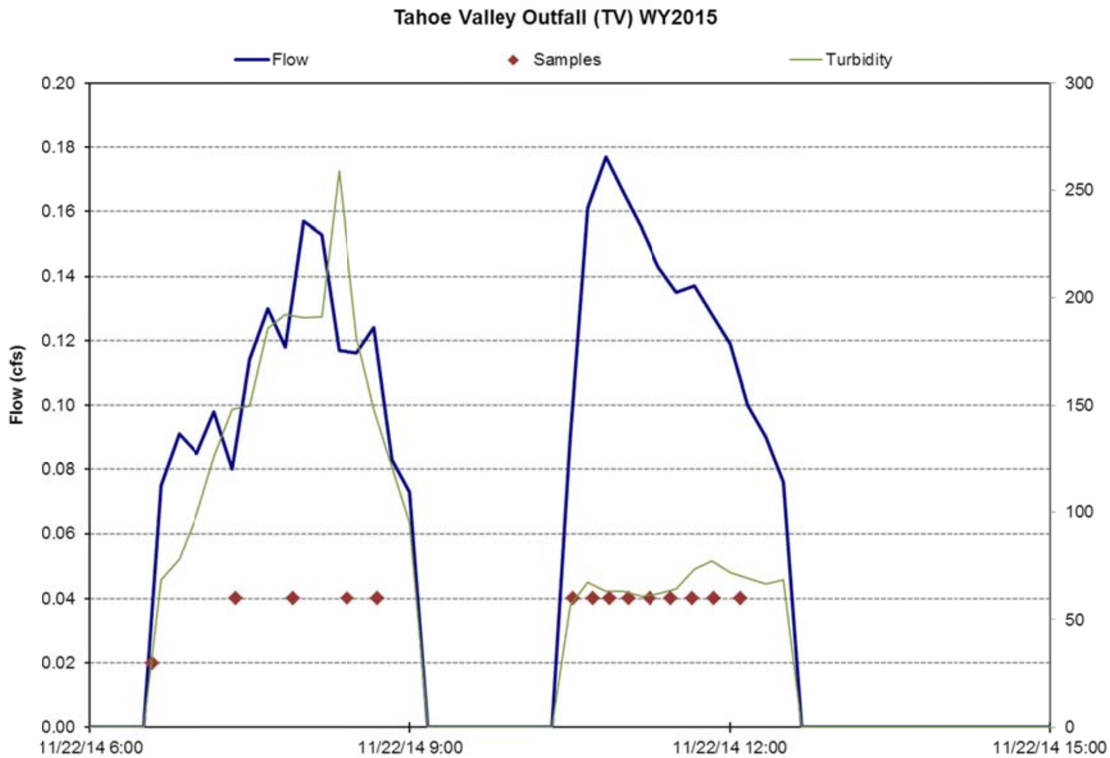

Figure J1: Continuous hydrology, continuous turbidity, and water quality samples for the 11/22/2014 event. Total volume sampled: 1,975 cf.

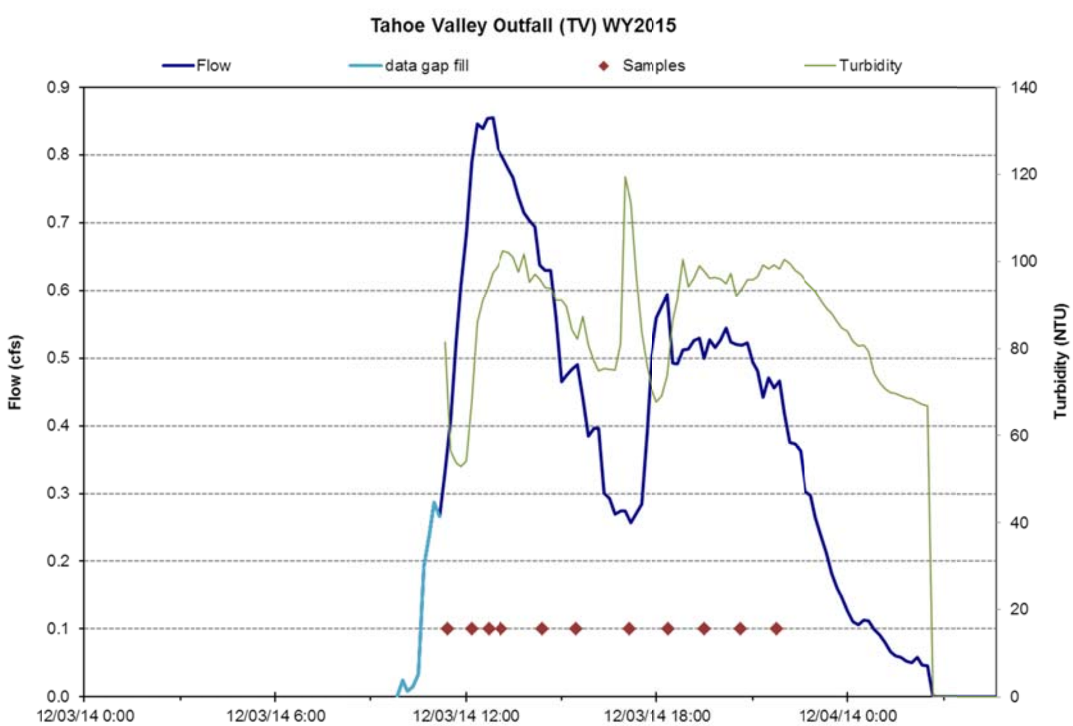

Figure J2: Continuous hydrology, continuous turbidity, and water quality samples for the 12/3/2014 event. Equipment failure caused the data gap, flow estimated from Upper Truckee site. Total volume sampled: 23,891 cf.

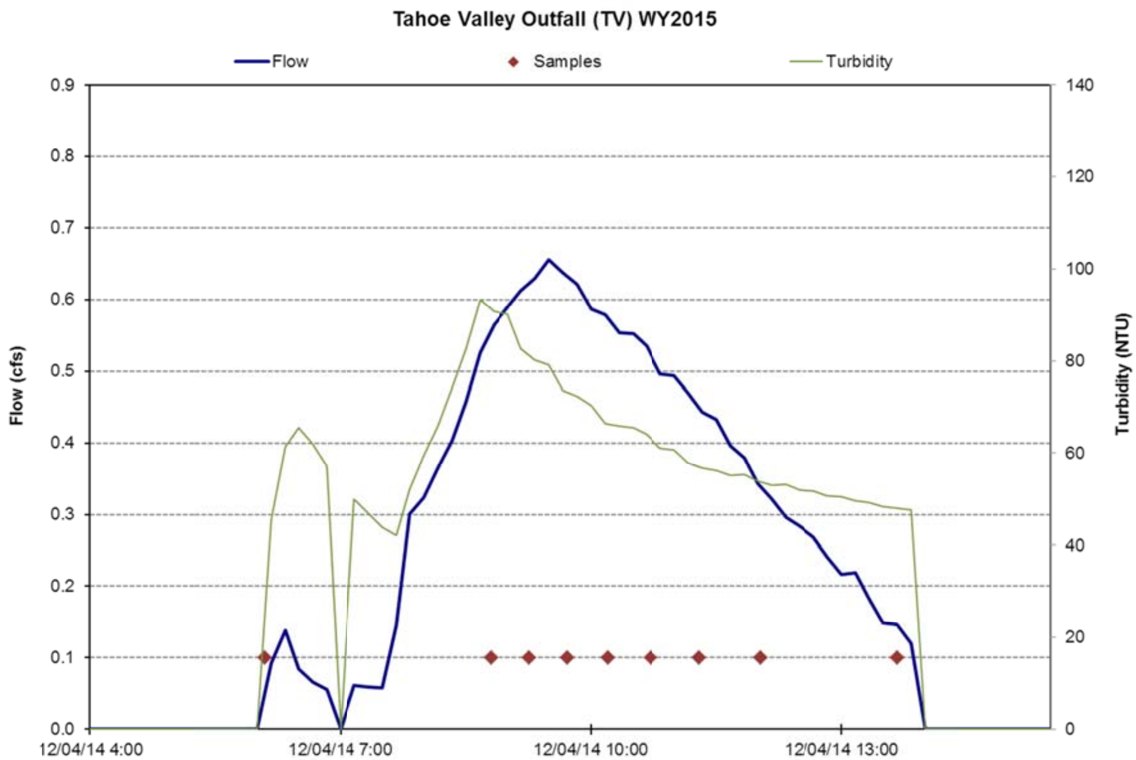

Figure J3: Continuous hydrology, continuous turbidity, and water quality samples for the 12/4/2014 event. Total volume sampled: 9,691 cf.

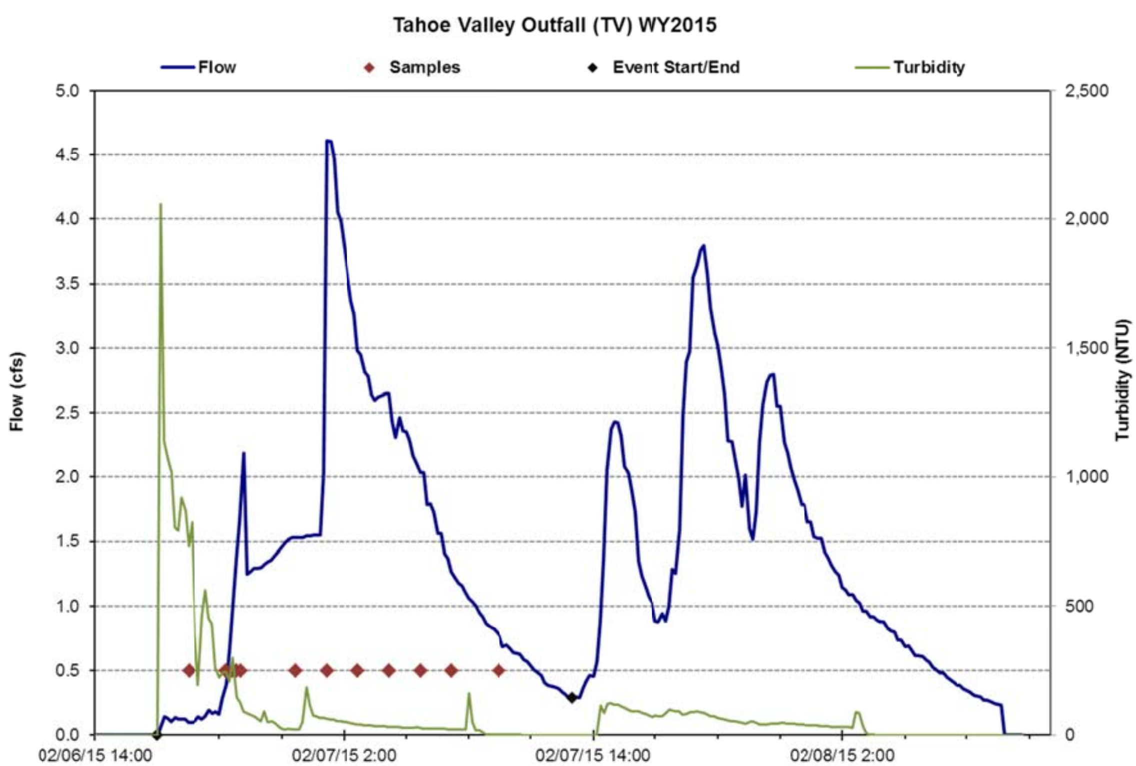

Figure J4: Continuous hydrology, continuous turbidity, and water quality samples for the 2/6/2015 event. Total volume sampled: 99,321 cf.

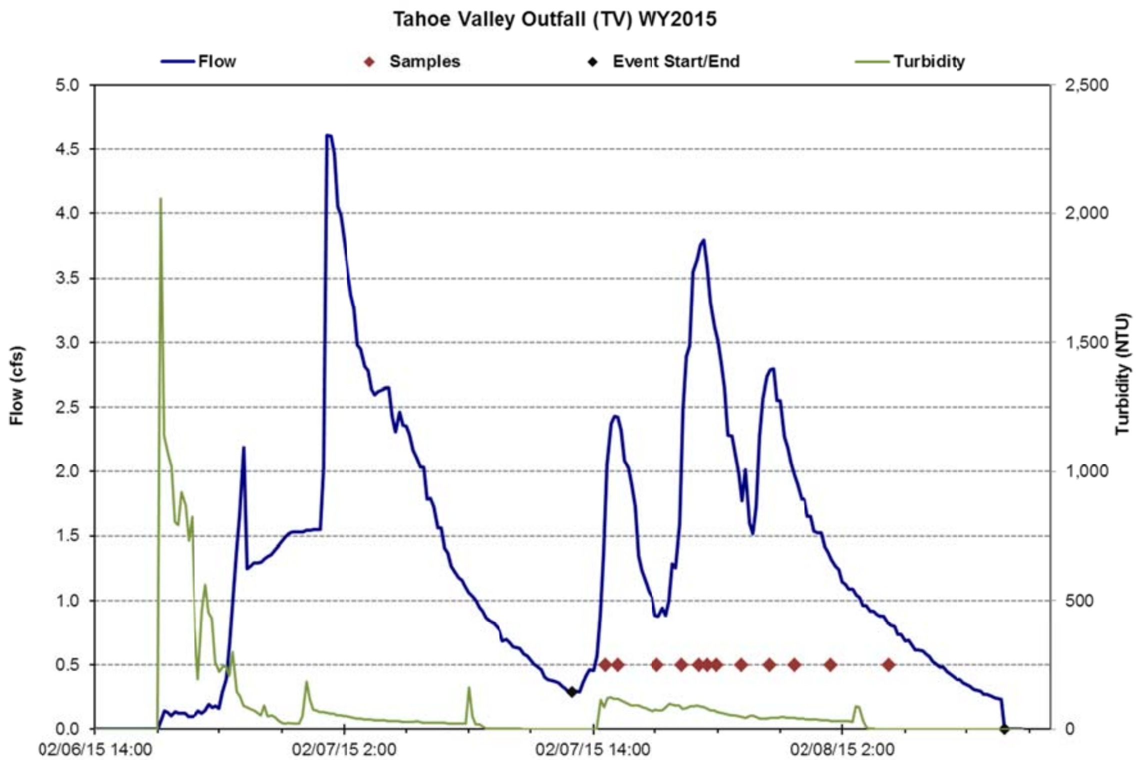

Figure J5: Continuous hydrology, continuous turbidity, and water quality samples for the 2/7/2015 event. Total volume sampled: 104,432 cf.

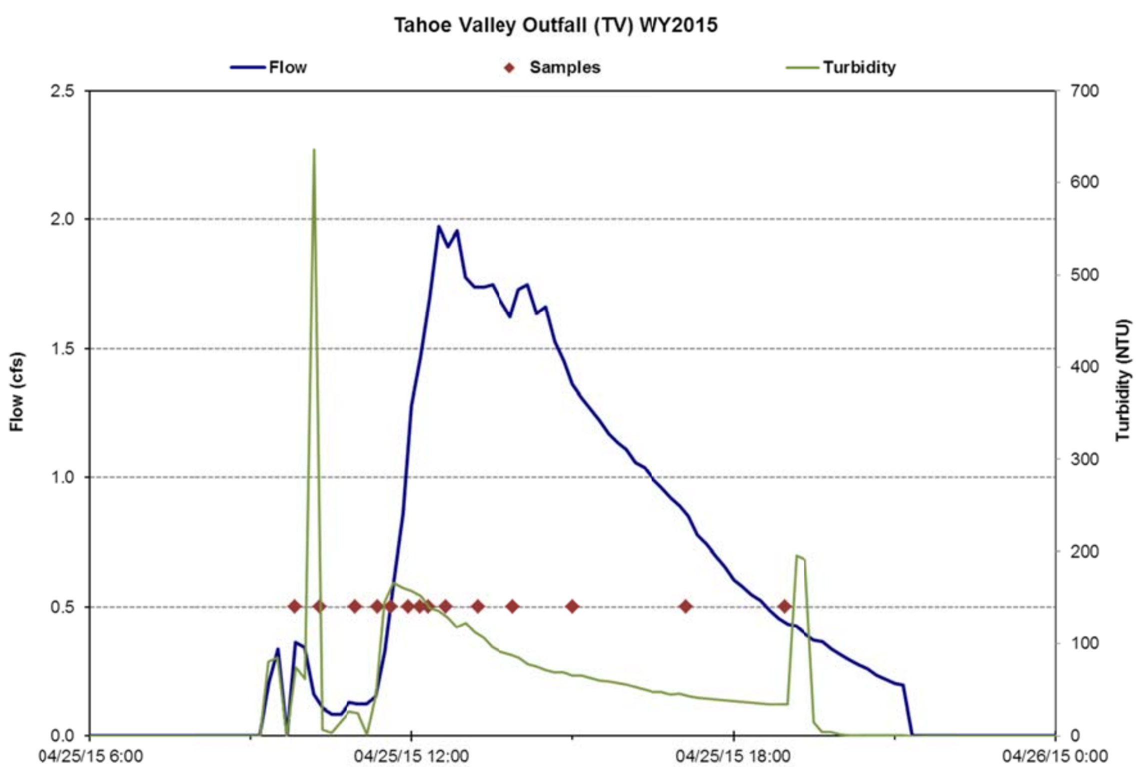

Figure J6: Continuous hydrology, continuous turbidity, and water quality samples for the 4/25/2015 event. Total volume sampled: 36,010 cf.

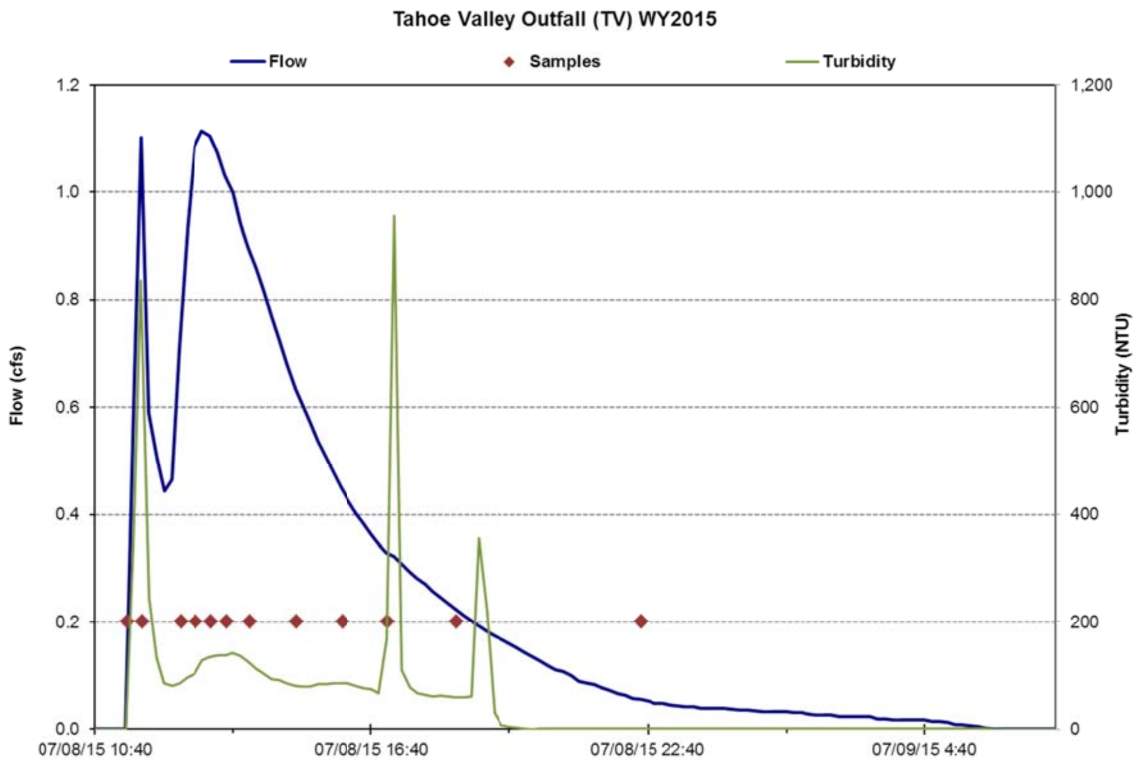

Figure J7: Continuous hydrology, continuous turbidity, and water quality samples for the 7/8/2015 event. Total volume sampled: 18,058 cf.

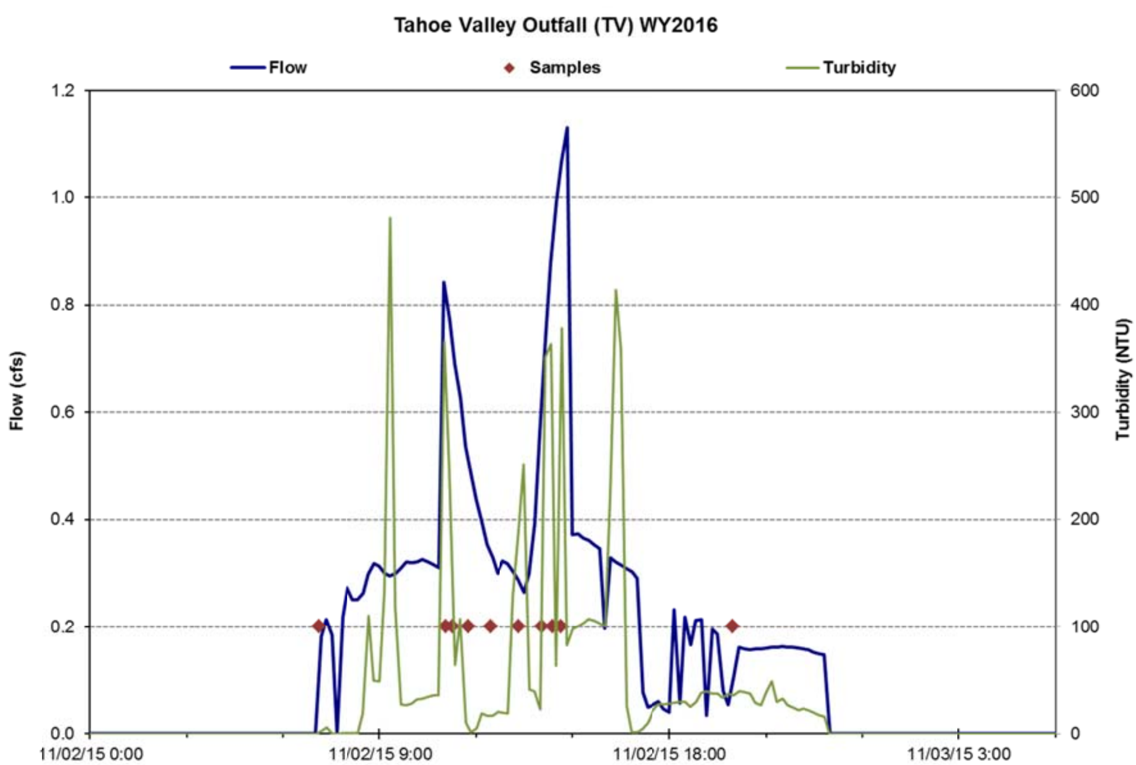

Figure J8: Continuous hydrology, continuous turbidity, and water quality samples for the 11/1/2015 event. Total volume sampled: 17,124 cf.

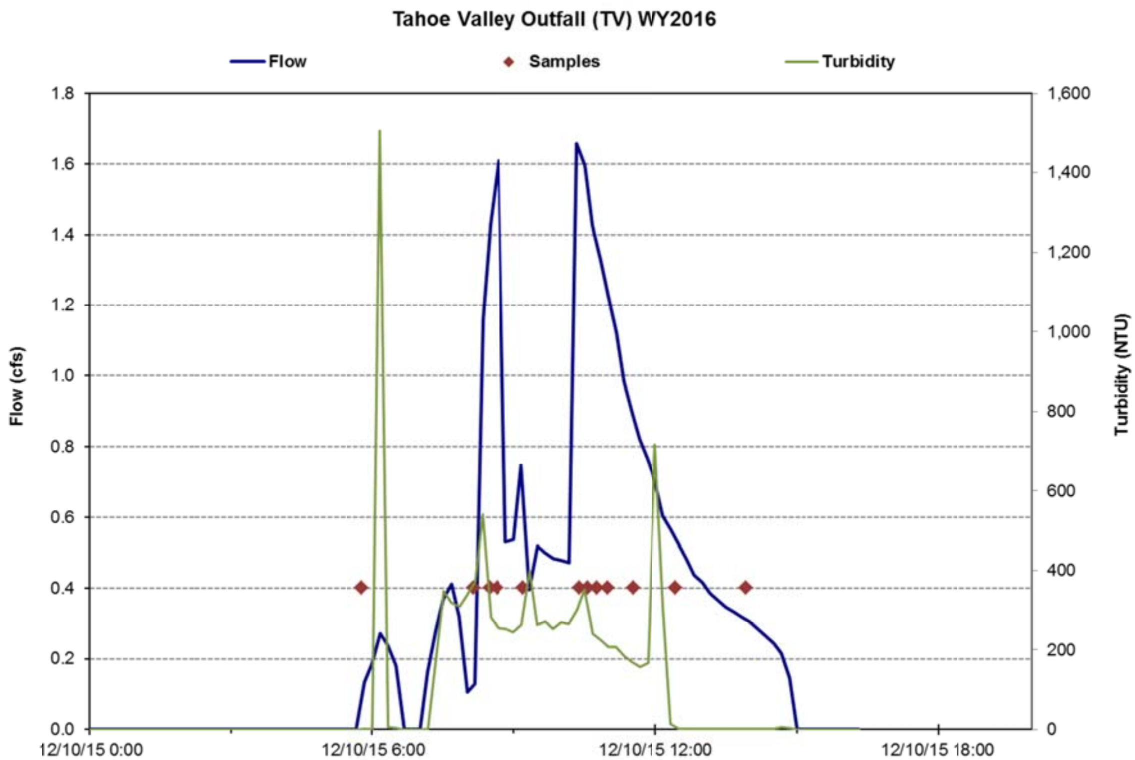

Figure J9: Continuous hydrology, continuous turbidity, and water quality samples for the 12/10/2015 event. Total volume sampled: 18,235 cf.

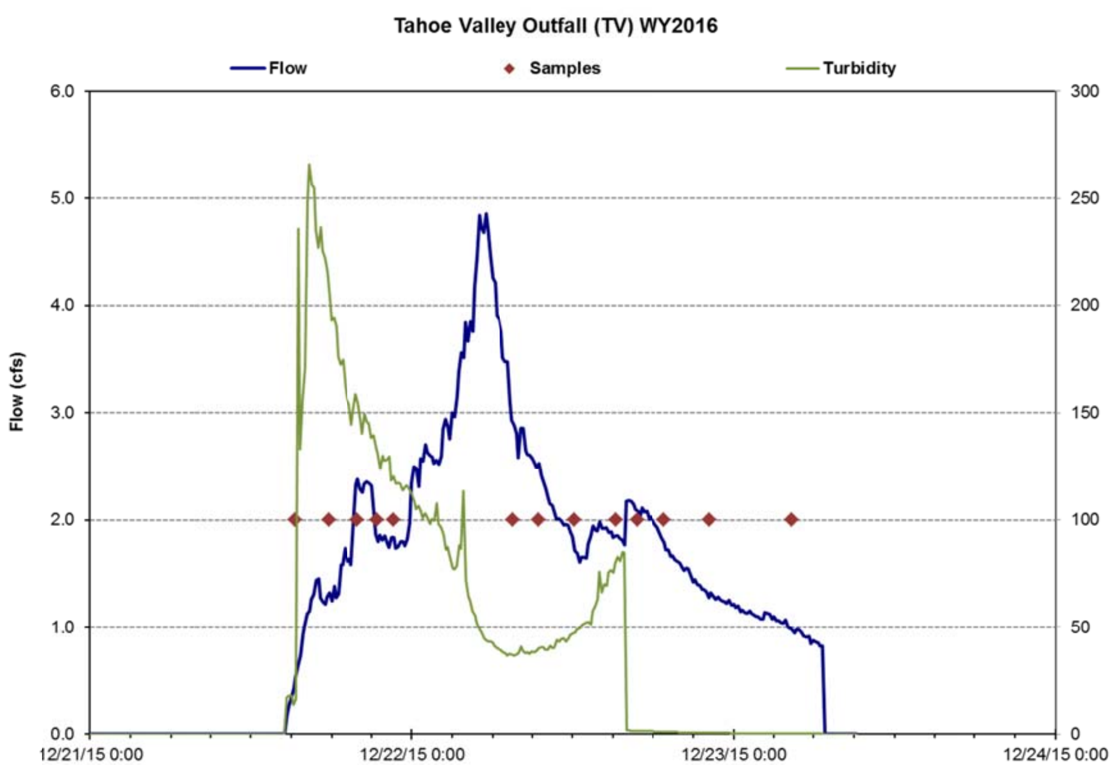

Figure J10: Continuous hydrology, continuous turbidity, and water quality samples for the 12/21/2015 event. Total volume sampled: 280,487 cf.

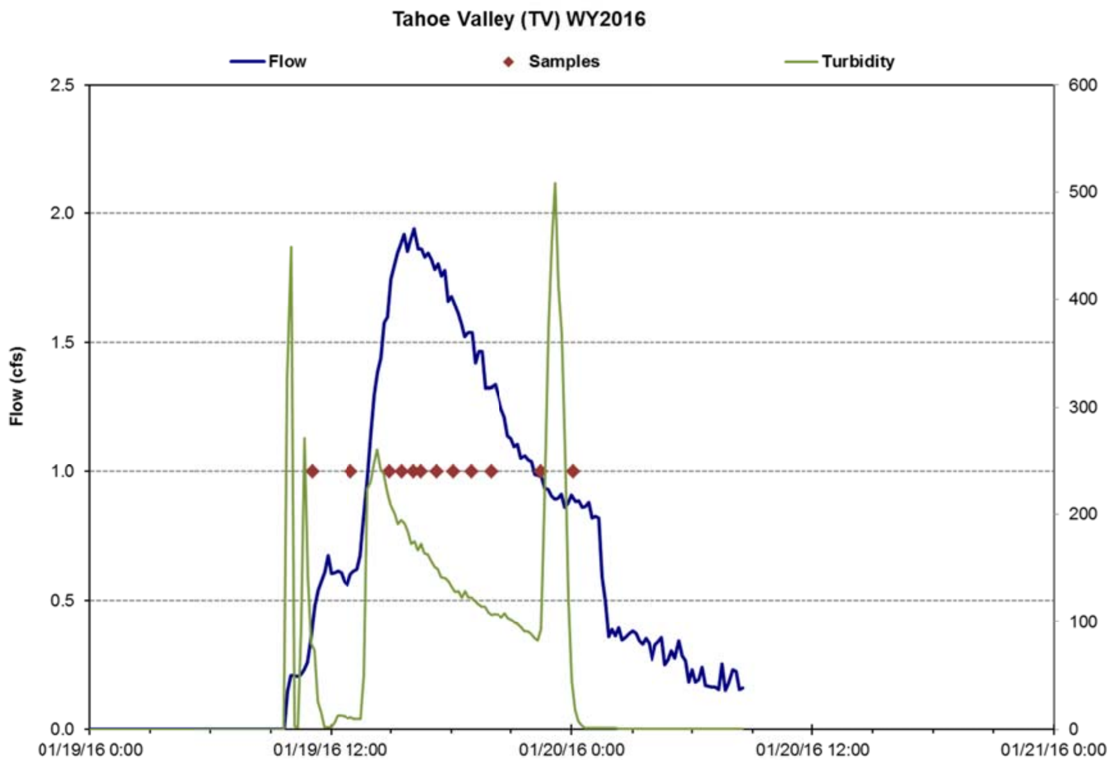

Figure J11: Continuous hydrology, continuous turbidity, and water quality samples for the 1/19/2016 event. Total volume sampled: 70,389 cf.

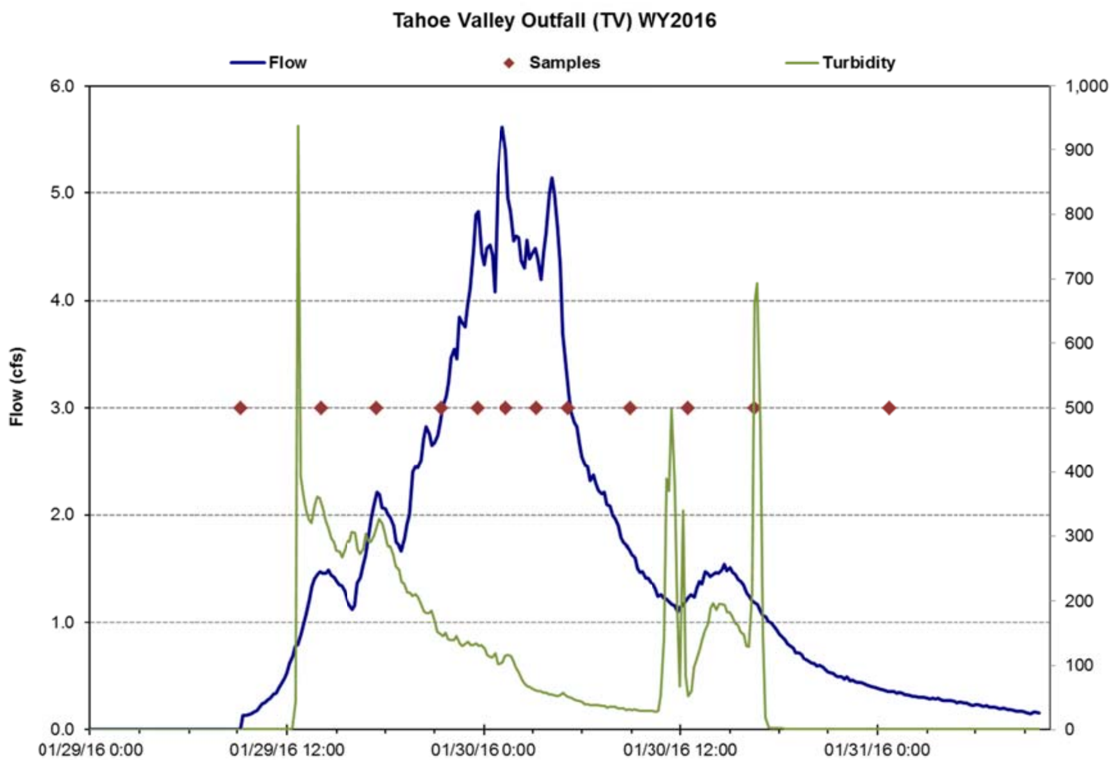

Figure J12: Continuous hydrology, continuous turbidity, and water quality samples for the 1/29/2016 event. Total volume sampled: 276,229 cf.

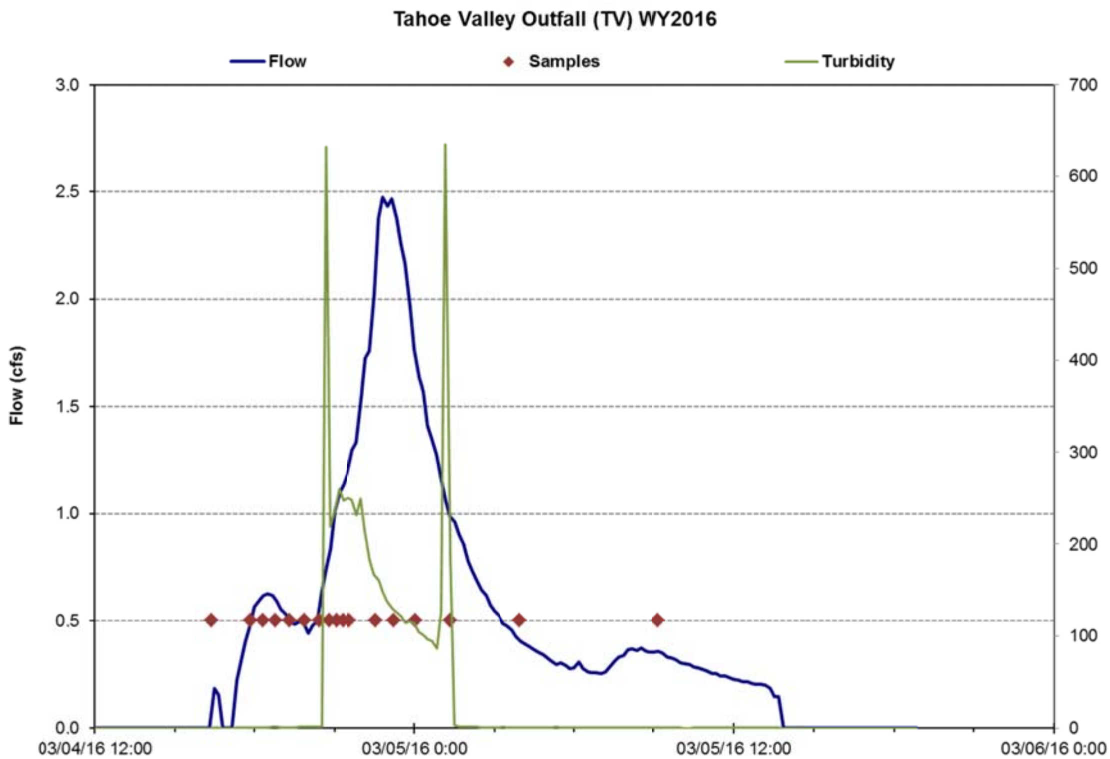

Figure J13: Continuous hydrology, continuous turbidity, and water quality samples for the 3/4/2016 event. Total volume sampled: 50,191 cf.

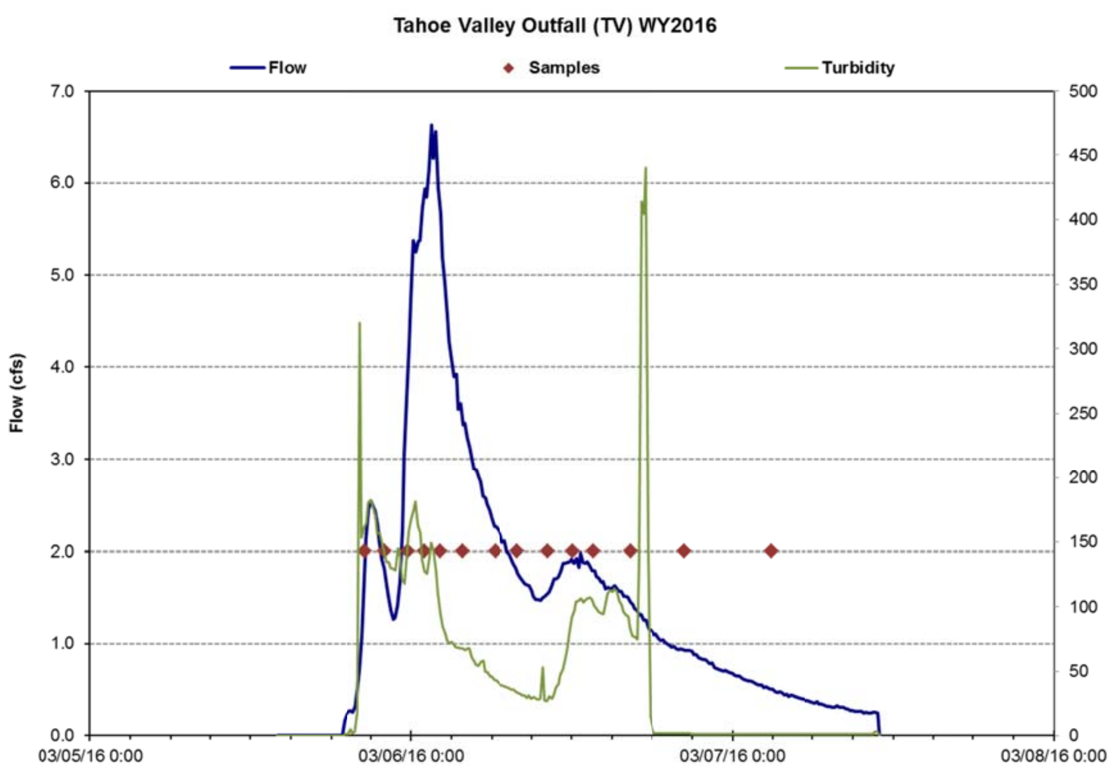

Figure J14: Continuous hydrology, continuous turbidity, and water quality samples for the 3/5/2016 event. Total volume sampled: 232,198 cf.

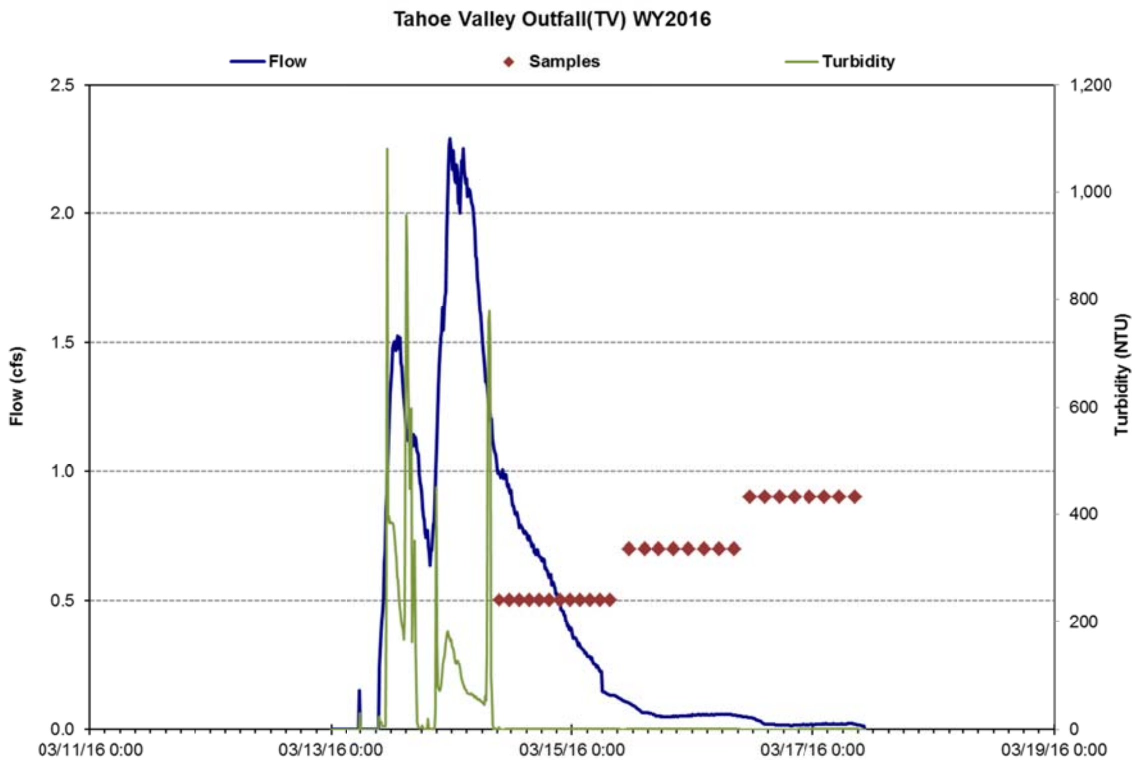

Figure J15: Continuous hydrology, continuous turbidity, and water quality samples for the 3/14/2016 event. Total volume sampled: 52,709 cf.

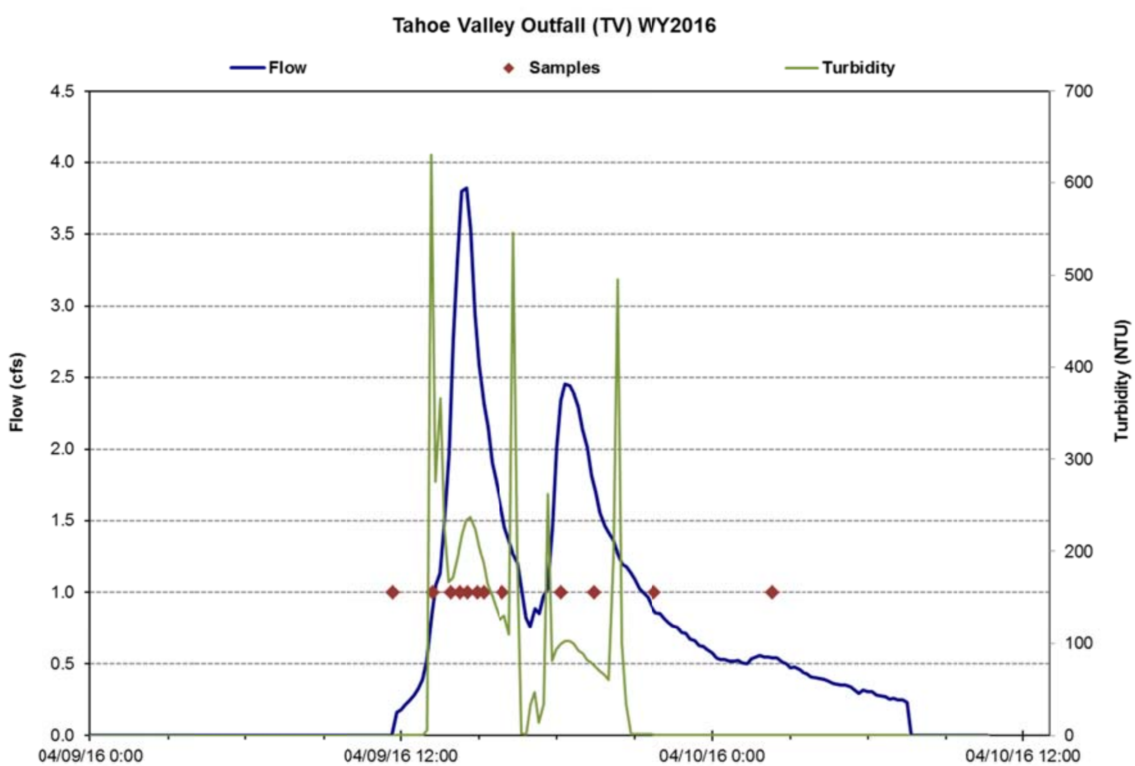

Figure J16: Continuous hydrology, continuous turbidity, and water quality samples for the 4/9/2016 event. Total volume sampled: 72,224 cf.

Appendix K: Upper Truckee Event Graphs

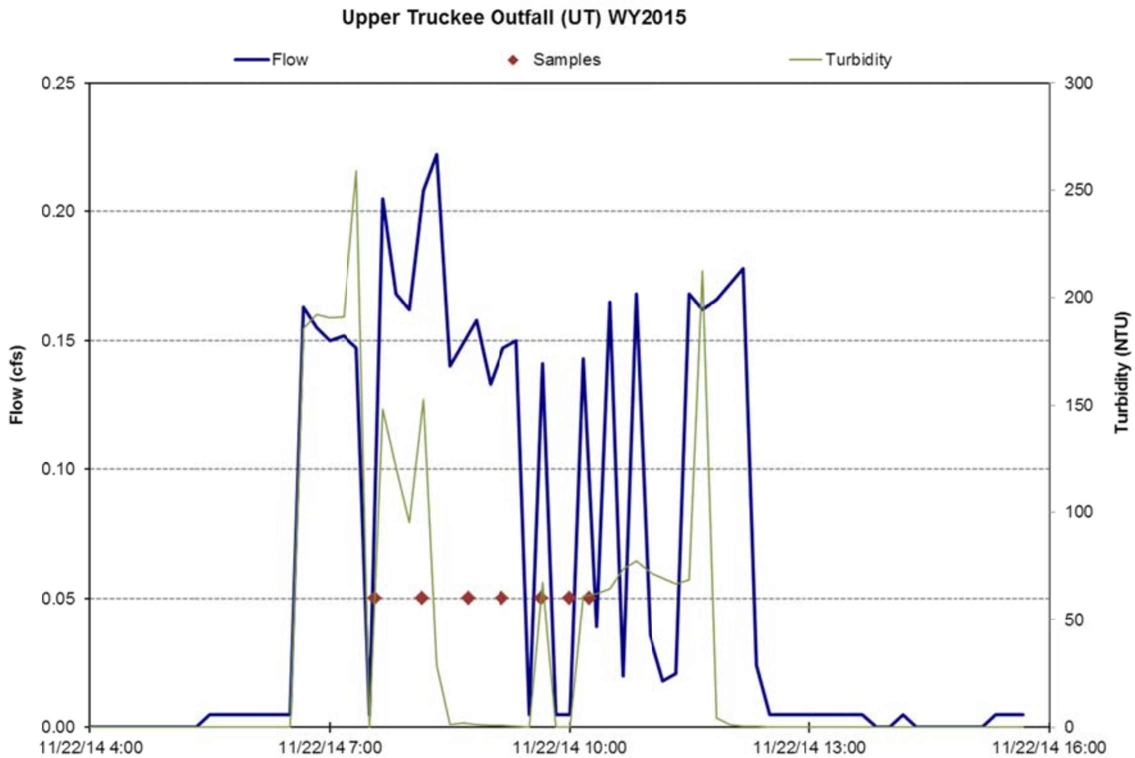

Figure K1: Continuous hydrology, continuous turbidity, and water quality samples for the 11/22/2014 event. Total volume sampled: 2,594 cf.

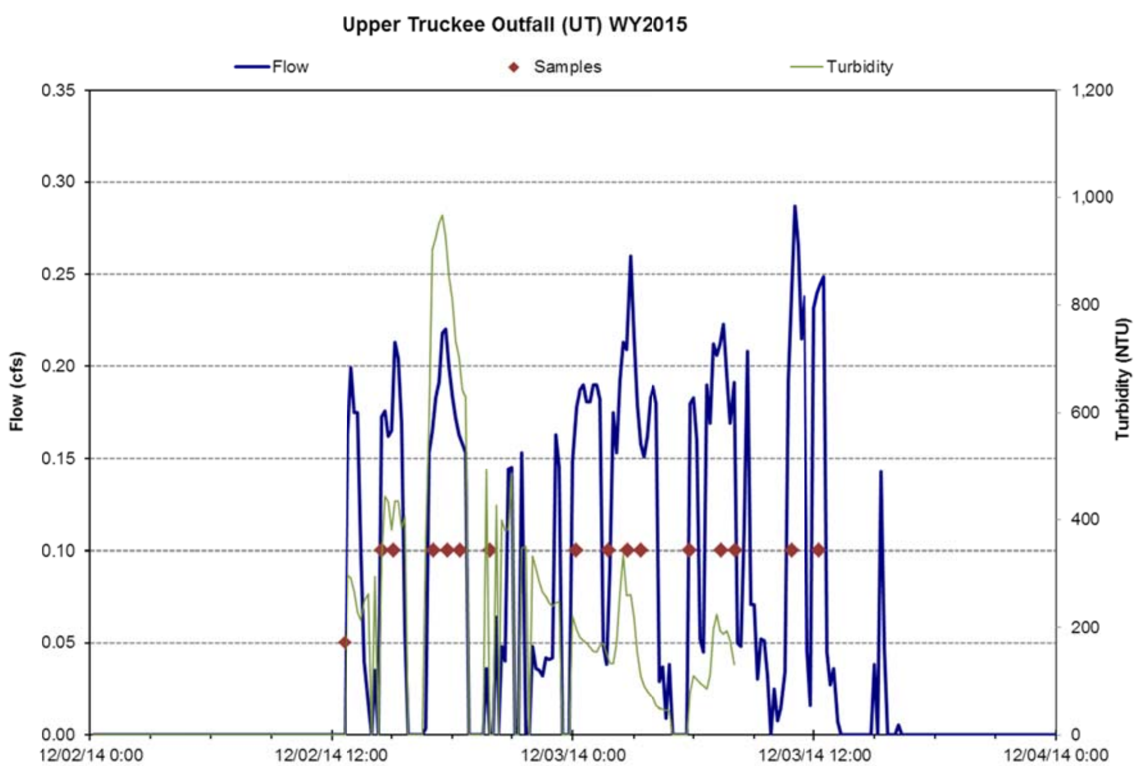

Figure K2: Continuous hydrology, continuous turbidity, and water quality samples for the 12/2/2014 event. Total volume sampled: 9,549 cf.

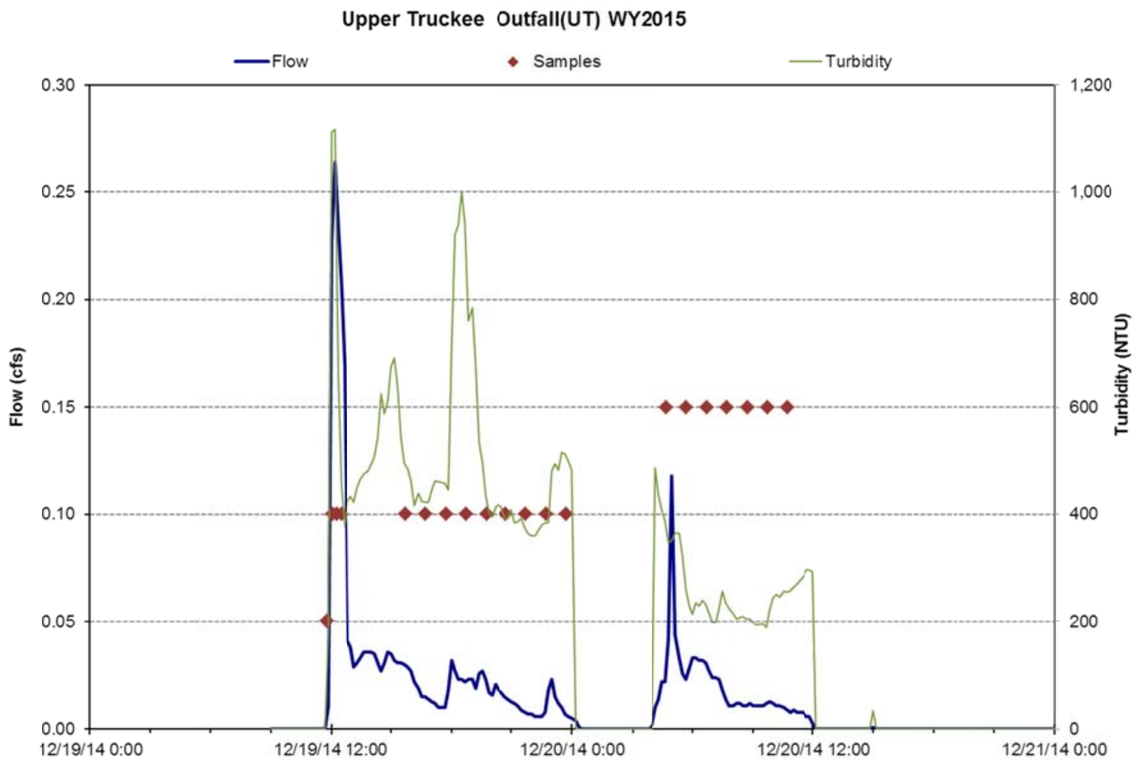

Figure K3: Continuous hydrology, continuous turbidity, and water quality samples for the 12/19/2014 event. Total volume sampled: 2,063 cf.

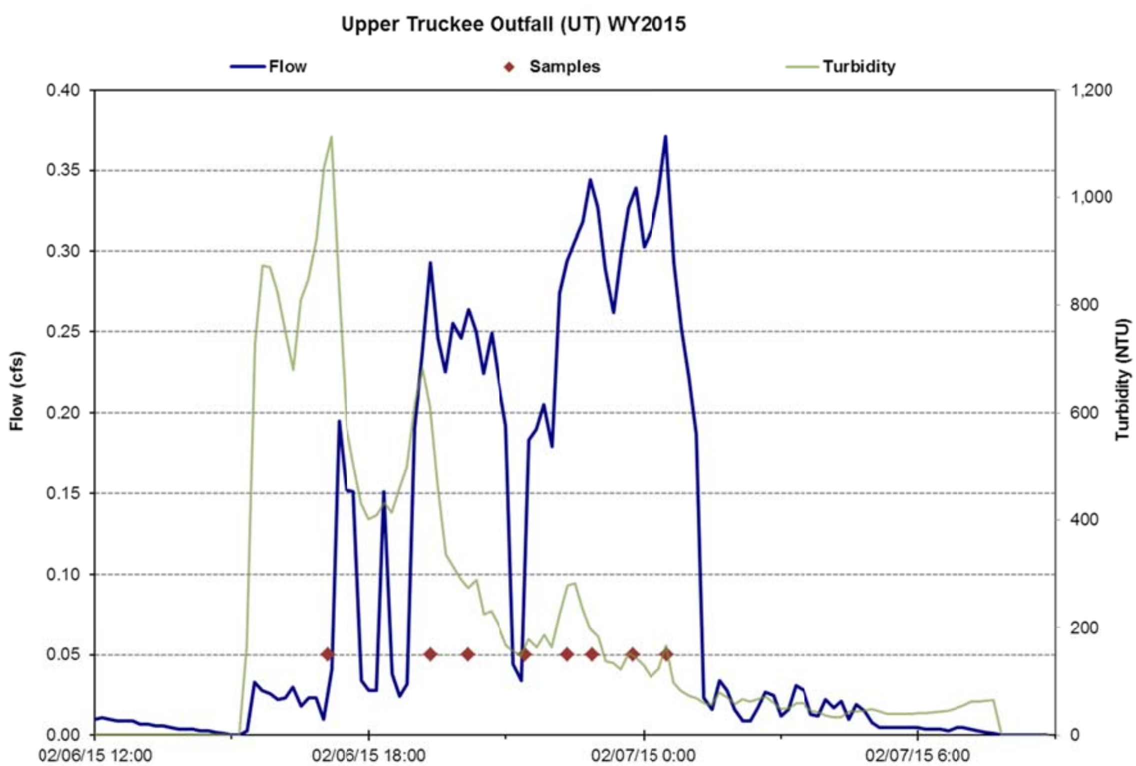

Figure K4: Continuous hydrology, continuous turbidity, and water quality samples for the 2/6/2015 event. Total volume sampled: 6,712 cf.

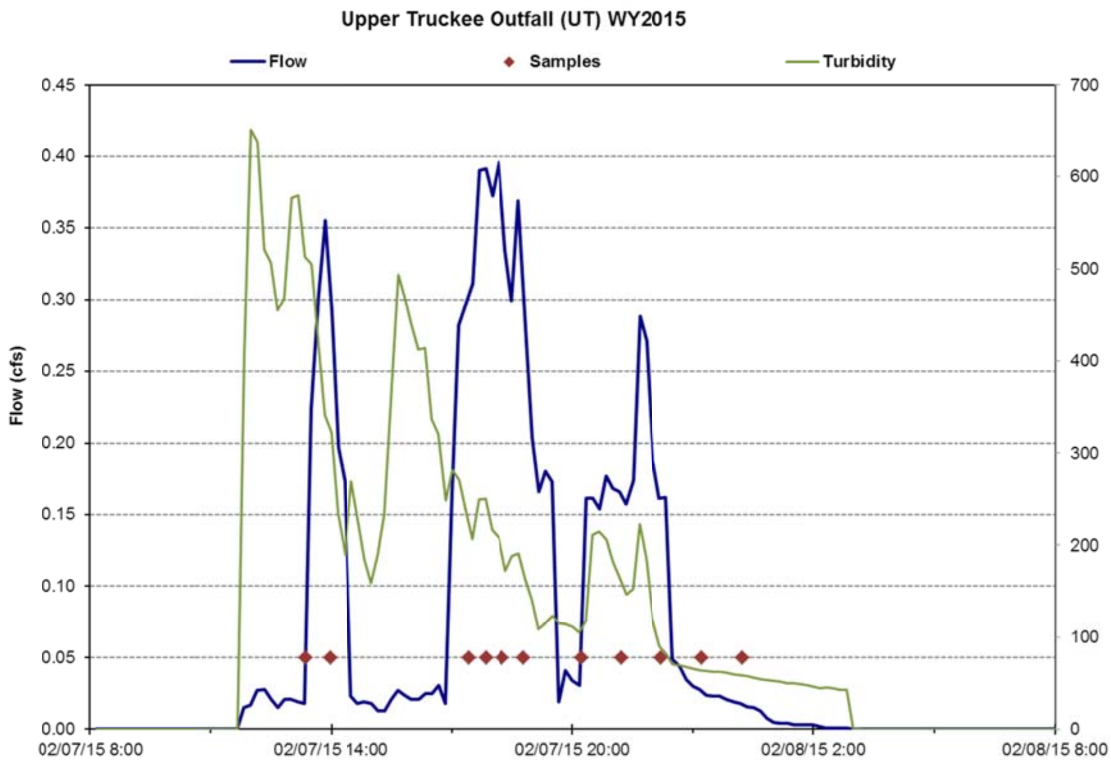

Figure K5: Continuous hydrology, continuous turbidity, and water quality samples for the 2/7/2015 event. Total volume sampled: 5,749 cf.

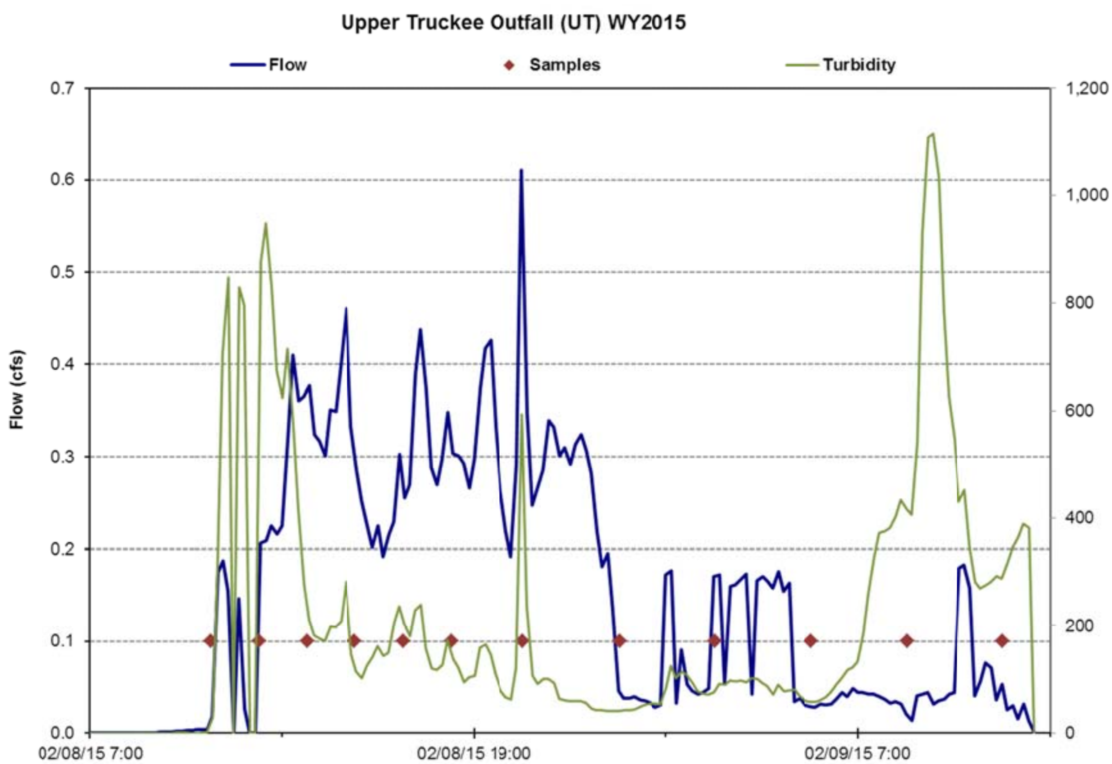

Figure K6: Continuous hydrology, continuous turbidity, and water quality samples for the 2/8/2015 event. Total volume sampled: 15,705 cf.

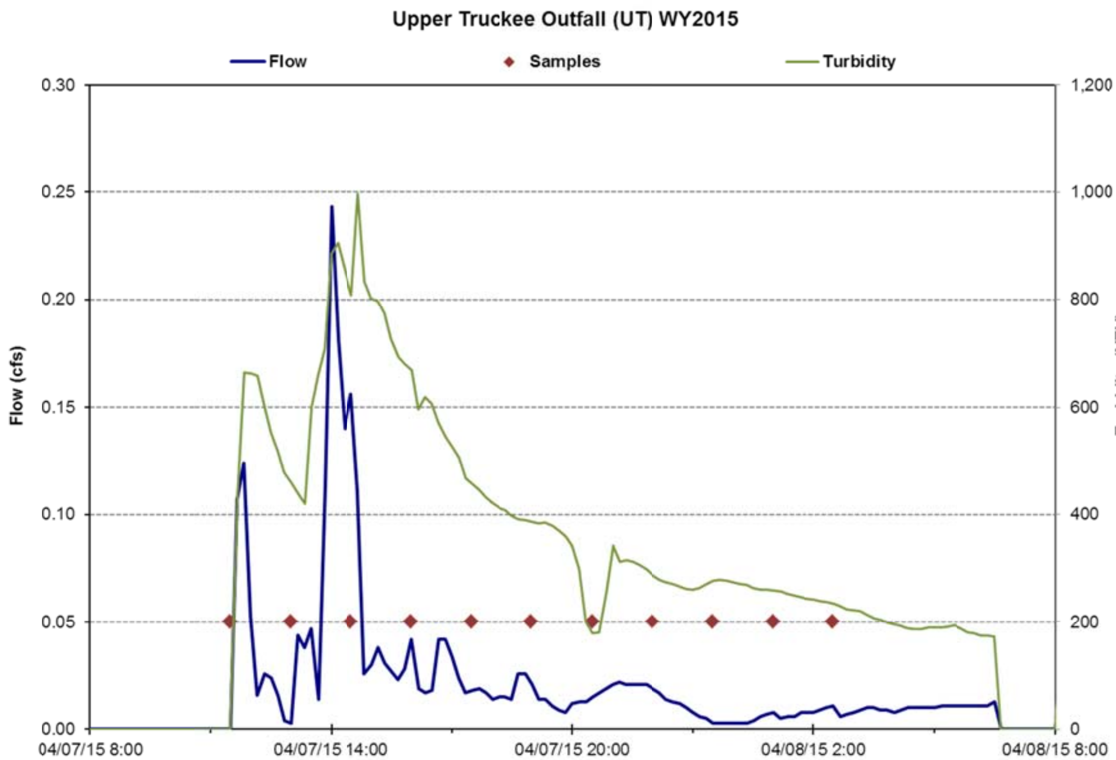

Figure K7: Continuous hydrology, continuous turbidity, and water quality samples for the 4/7/2015 event. Total volume sampled: 1,697 cf.

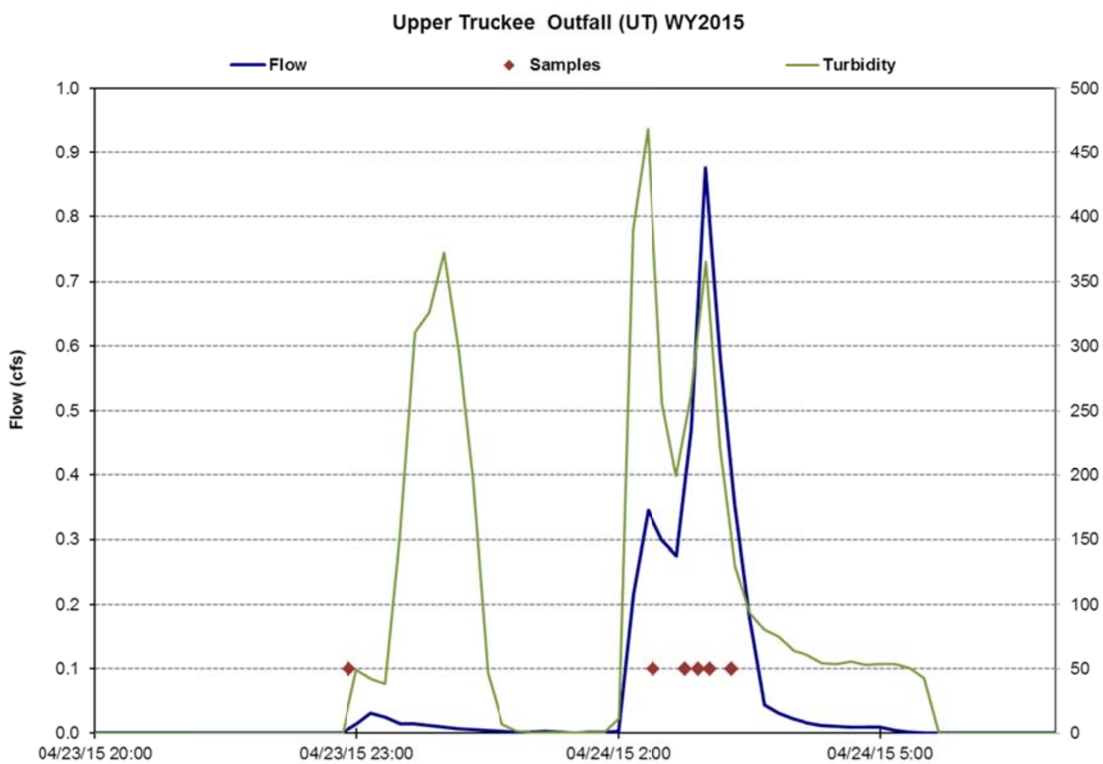

Figure K8: Continuous hydrology, continuous turbidity, and water quality samples for the 4/23/2015 event. Total volume sampled: 2,413 cf.

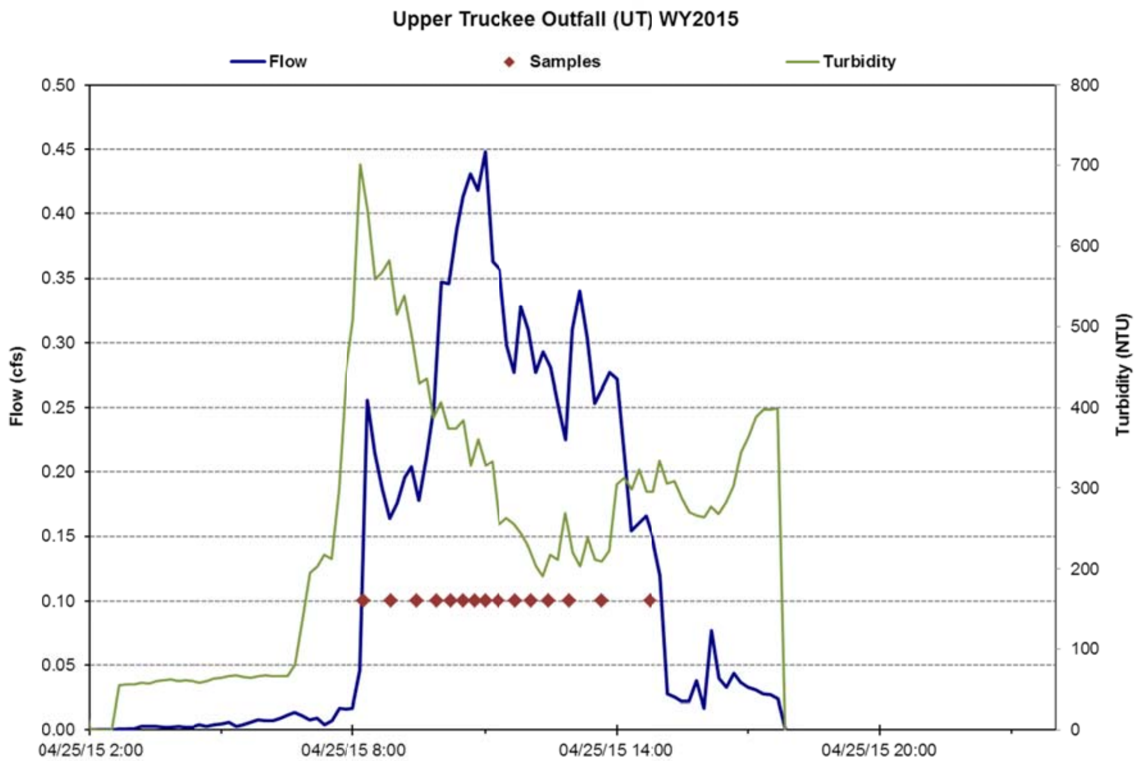

Figure K9: Continuous hydrology, continuous turbidity, and water quality samples for the 4/25/2015 event. Total volume sampled: 7,106 cf.

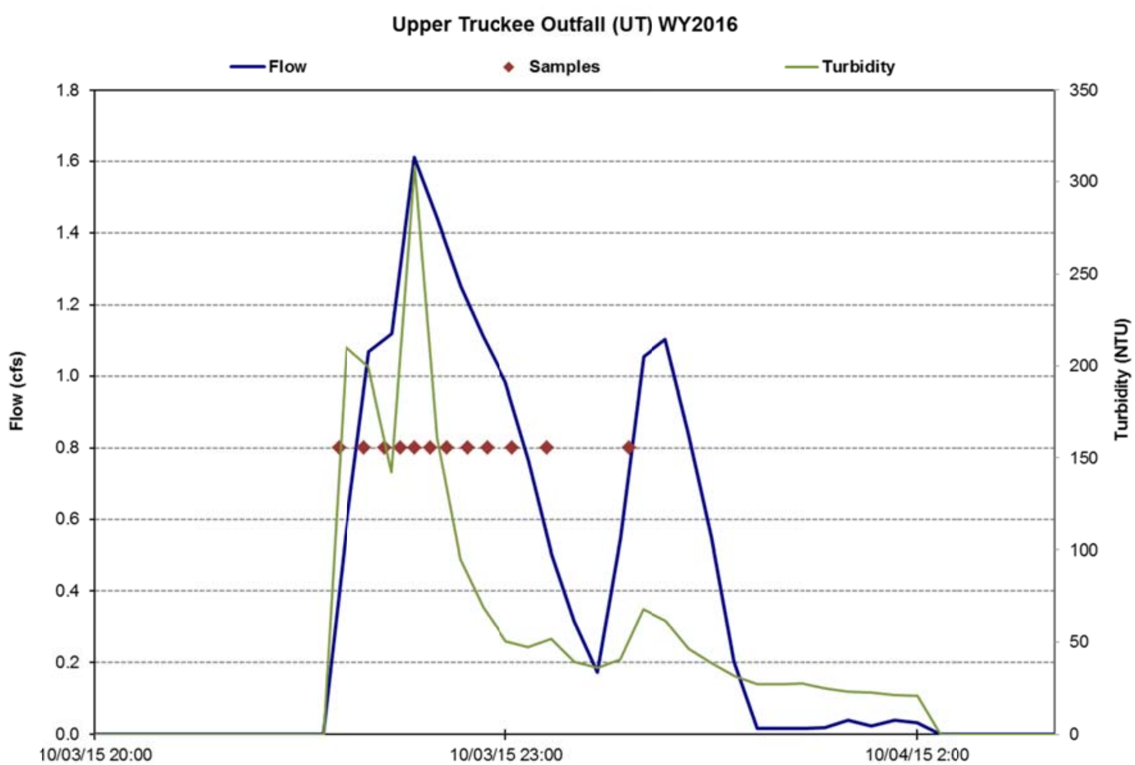

Figure K10: Continuous hydrology, continuous turbidity, and water quality samples for the 10/3/2015 event. Total volume sampled: 9,248 cf.

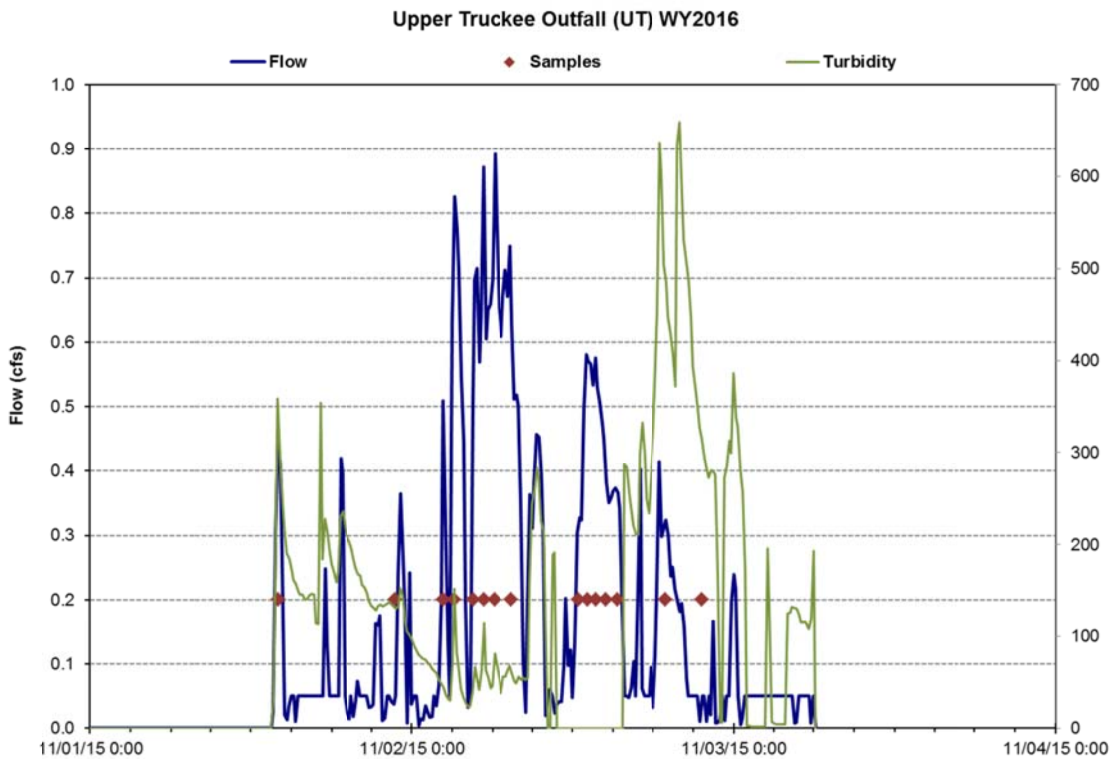

Figure K11: Continuous hydrology, continuous turbidity, and water quality samples for the 11/1/2015 event. Total volume sampled: 28,736 cf.

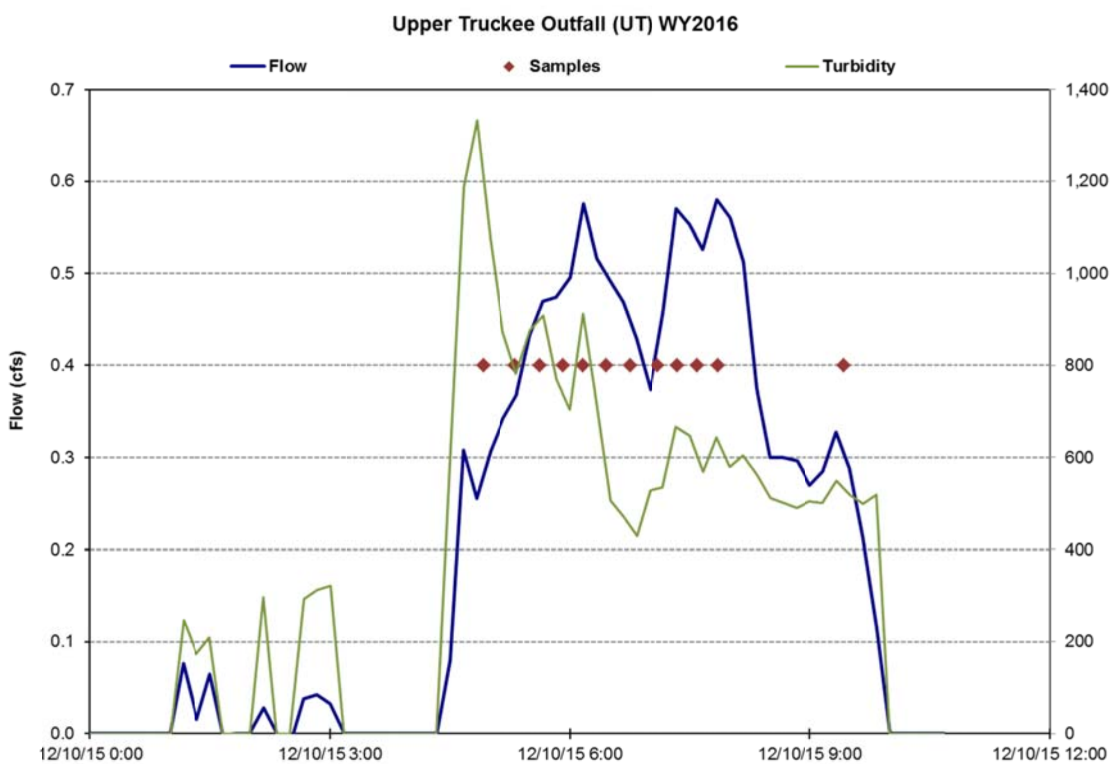

Figure K12: Continuous hydrology, continuous turbidity, and water quality samples for the 12/10/2015 event. Total volume sampled: 7,750 cf.

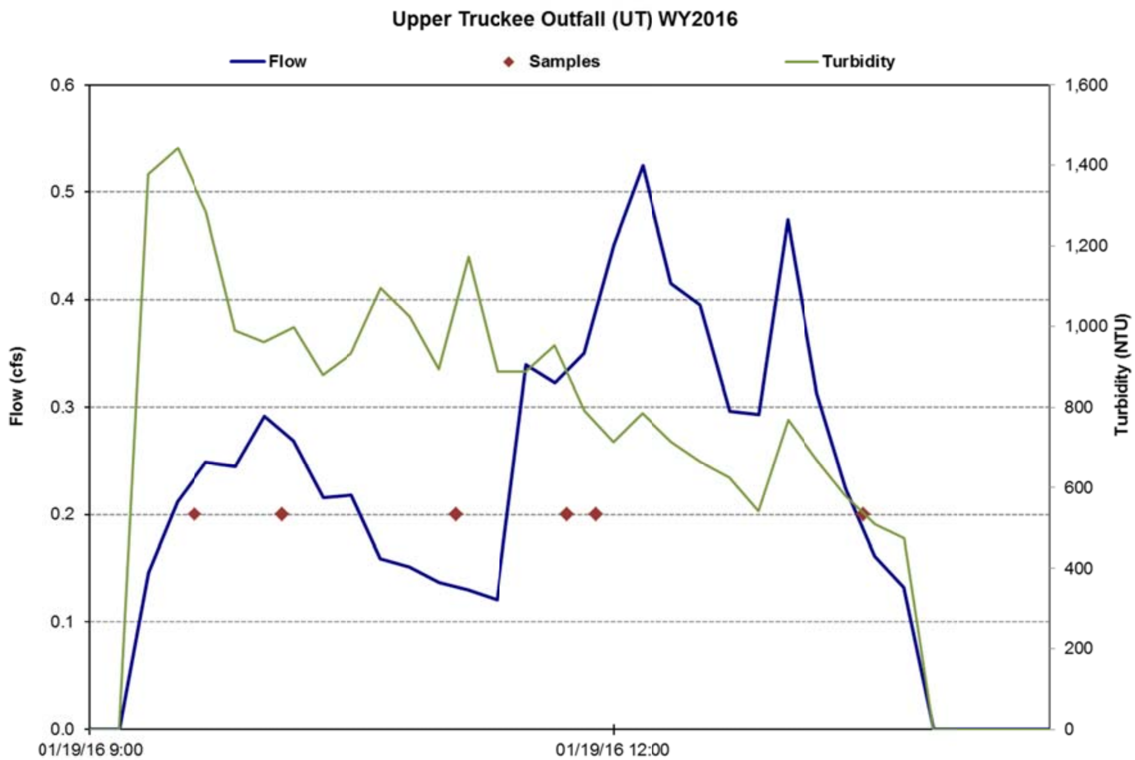

Figure K13: Continuous hydrology, continuous turbidity, and water quality samples for the 1/19/2016 event. Total volume sampled: 4,341 cf.

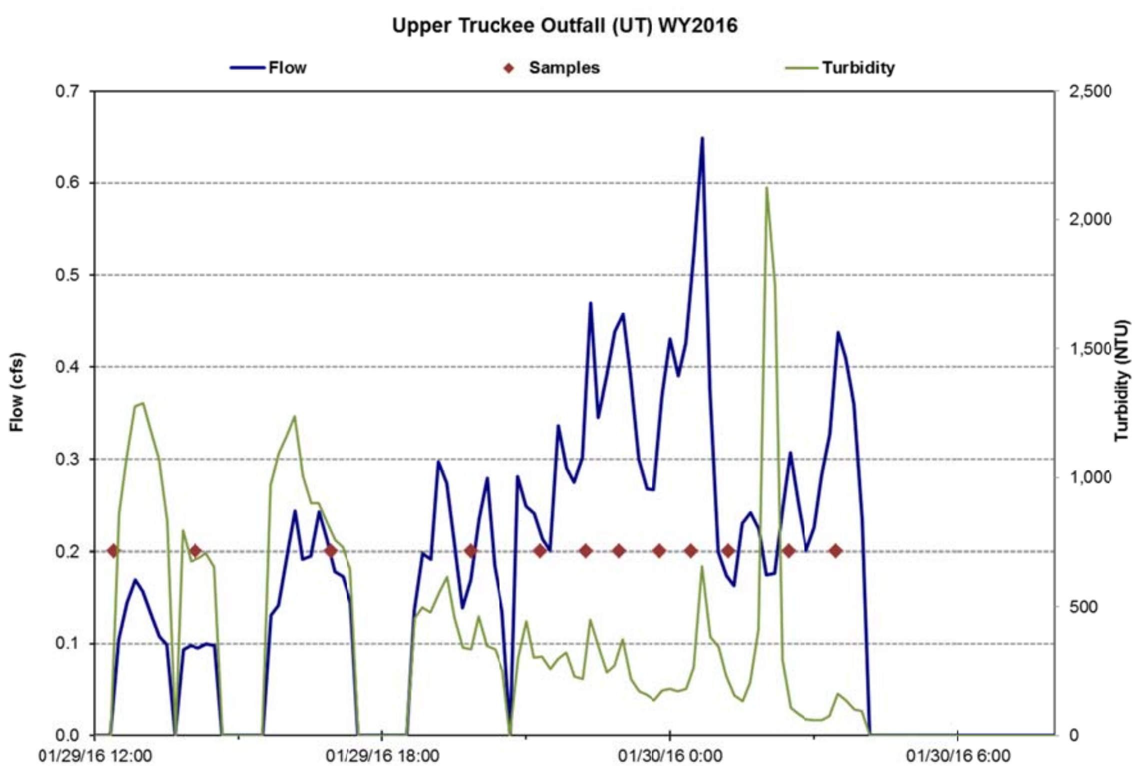

Figure K14: Continuous hydrology, continuous turbidity, and water quality samples for the 1/29/2016 event. Total volume sampled: 11,785 cf.

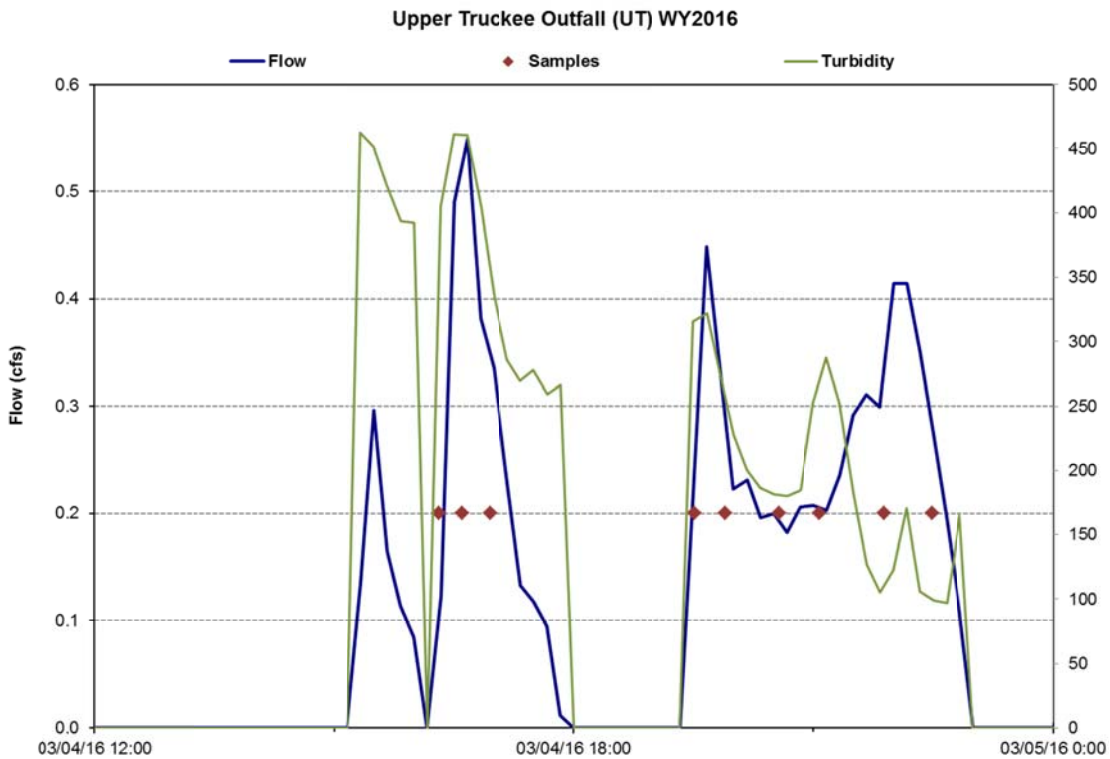

Figure K15: Continuous hydrology, continuous turbidity, and water quality samples for the 3/4/2016 event. Total volume sampled: 5,288 cf.

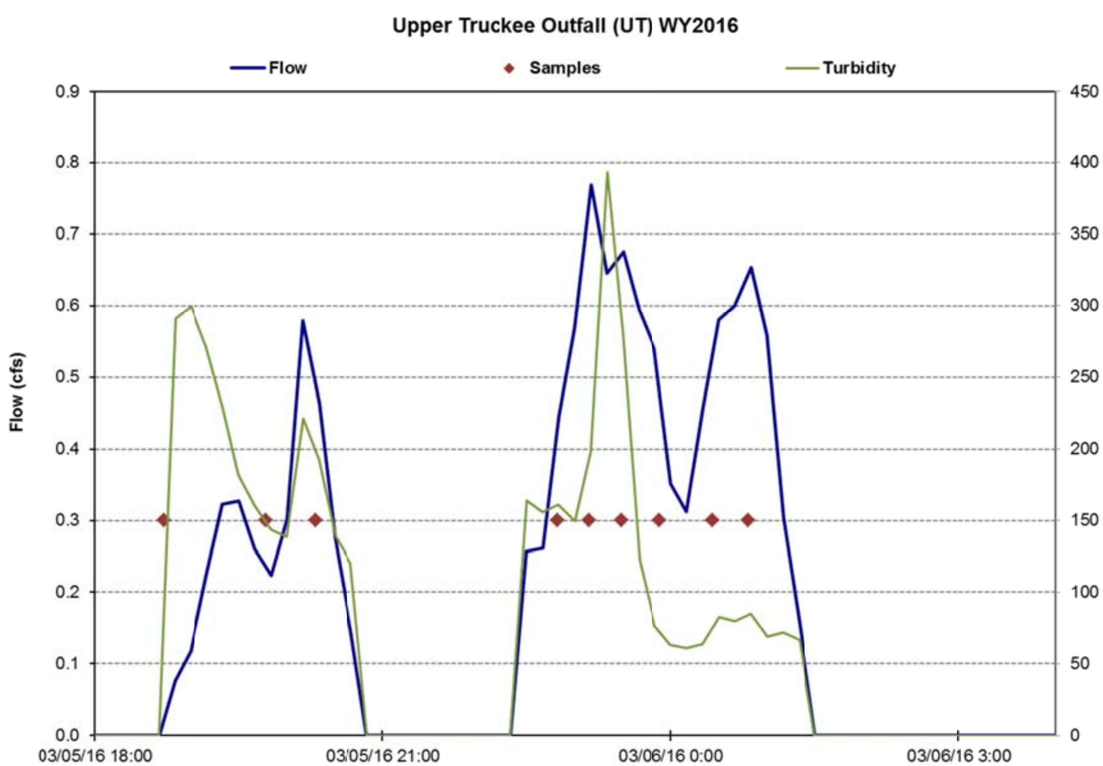

Figure K16: Continuous hydrology, continuous turbidity, and water quality samples for the 3/5/2016 event. Total volume sampled: 7,231 cf.

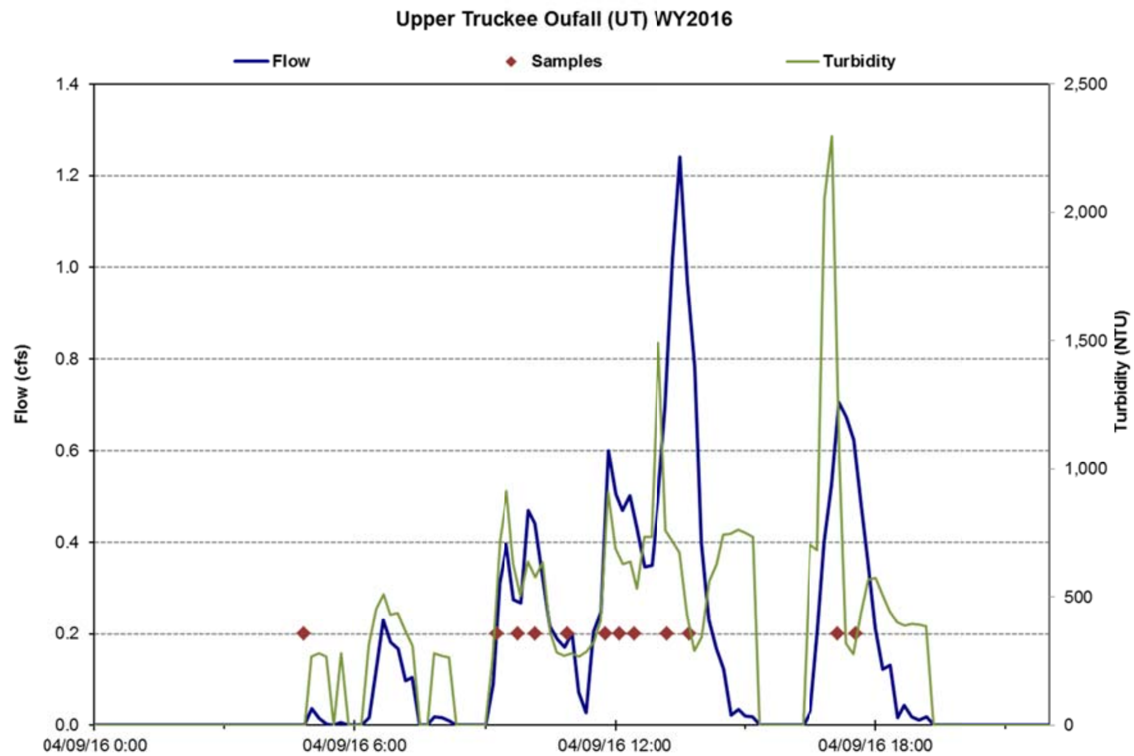

Figure K17: Continuous hydrology, continuous turbidity, and water quality samples for the 4/9/2016 event. Total volume sampled: 2,296 cf.