Annual Stormwater Monitoring Report

Water Year 2021

Prepared by

Tahoe Resource Conservation District

for the

Implementers' Monitoring Program

component of the

Regional Stormwater Monitoring Program

Submitted to the

Lahontan Regional Water Quality Control Board and the

Nevada Division of Environmental Protection

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Annual Stormwater Monitoring Report

Implementers' Monitoring Program (IMP), component of the Regional Stormwater Monitoring Program (RSWMP)

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Submitted by:

California

El Dorado County

Placer County

City of South Lake Tahoe

California Department of Transportation

Nevada

Douglas County

Washoe County

Nevada Department of Transportation

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List of Acronyms

AC	Autosampler Composite Sample
Autosamplers	ISCO brand automated samplers
BMP	Best Management Practice
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
CRC	Characteristic Runoff Concentration
DMS	Data Management System
EC	Elks Club
EDCY	El Dorado County Yard meteorological station
EMC	Event Mean Concentration
FB	Field Blank
FIG	Framework and Implementation Guidance document for RSWMP
FSP	Fine Sediment Particles
GS	Grab Sample
IMP	Implementers' Monitoring Program
JI	Jellyfish Inflow
JO	Jellyfish Outflow
Lahontan	Lahontan Regional Water Quality Control Board
LS	Lakeshore
MS	Manual Sample
NDEP	Nevada Division of Environmental Protection
NDOT	Nevada Department of Transportation
NPDES	National Pollutant Discharge Elimination System
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
ROW	Right-of-Way
RSWMP	Regional Stormwater Monitoring Program
SAP	Sampling and Analysis Protocol
SB	Speedboat
SR431	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

Stormwater monitoring began in 2013 under the Implementers' Monitoring Program (IMP) to collectively fulfill California National Pollutant Discharge Elimination System (NPDES) Permit requirements and Nevada Interlocal Agreement commitments. IMP is a partnership between the California and Nevada implementing jurisdictions and 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 City of South Lake Tahoe, El Dorado County, Placer County, the California Department of Transportation (Caltrans), Douglas County, Washoe County, 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. The Regional Stormwater Monitoring Program (RSWMP) was developed by Tahoe Resource Conservation District (Tahoe RCD) in partnership with IMP in 2015. A new NPDES permit was issued to California jurisdictions on March 9, 2017 for the second five-year term and aligned all monitoring activities with the 2017 update of the RSWMP Framework and Implementation Guidance Document (FIG, Tahoe RCD et al 2017). In the second permit term (water years 2017-2021), California jurisdictions are collectively required to monitor urban catchment outfalls at a minimum of six sites and Best Management Practices (BMPs) at a minimum of two sites for flow volumes and pollutant loads. The renewed Nevada Interlocal Agreements require participation in IMP. Monitoring provides empirical data that will be used to assess nutrient and sediment loading in chosen catchments and evaluate BMP effectiveness at chosen BMPs.

All data has been collected in a manner consistent with RSWMP monitoring protocols outlined in the RSWMP FIG designed to provide consistent data collection, management, analysis, and reporting approaches so that results can easily align with RSWMP objectives. 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. Long-term data are useful in identifying status and trends in the watershed.

2. Study Design

During Water Year 2021 (WY21), nine catchments (monitoring sites) were monitored for continuous flow and sampled for water quality at twelve monitoring stations. The monitoring stations include seven catchment outfall monitoring sites (seven catchments - seven stations), one BMP monitoring site at the outfall of the Elks Club catchment (one catchment - one station), and one BMP monitoring site at SR431, a side-by-side BMP study that monitors the inflows and outflows of two BMPs (one catchment - four stations). This exceeds the minimum regulatory requirement of six monitored catchment outfalls and two monitored BMPs in the second term by one additional outfall. At the August 2019 IMP meeting, it was agreed that all seven outfalls would continue to be monitored during WY20 and WY21 to support continuity of data. The two side-by-side BMPs at SR431 are supported through additional funding from the Nevada Department of Transportation. 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 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. Eight meteorological stations, each located within two miles of their paired monitoring site, are monitored for precipitation and temperature. One of the meteorological stations is shared by two monitoring sites. See Figure 1 for stormwater monitoring sites and meteorological station locations.

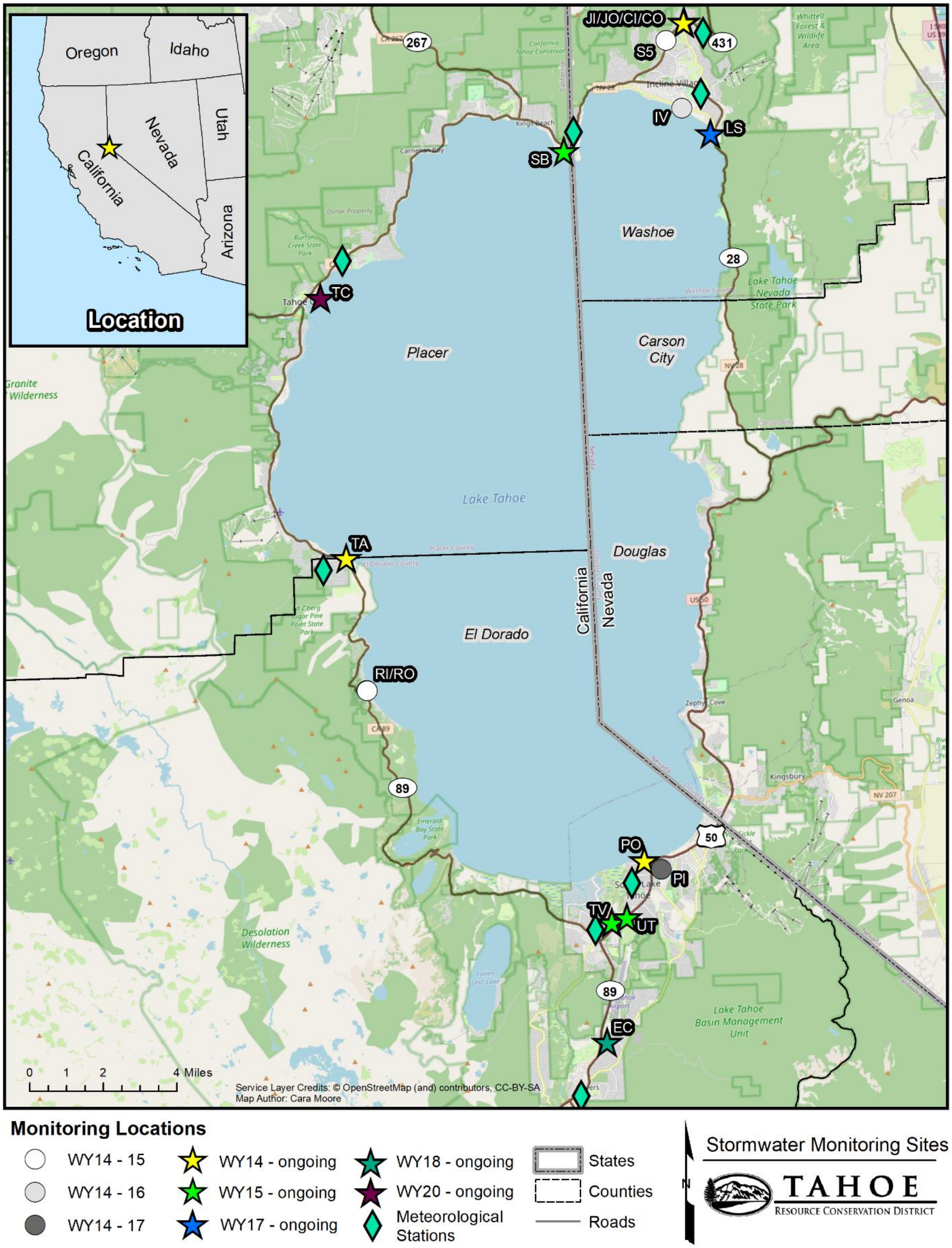

Figure 1 Past and current stormwater monitoring sites and ongoing meteorological stations. Jellyfish Inflow (JI), Jellyfish Outflow (JO), Contech MFS Inflow (CI), Contech MFS Outflow (CO), SR431 outfall (S5), Incline Village (IV), Lakeshore (LS), Speedboat (SB), Tahoma (TA), Rubicon Inflow (RI), Rubicon Outflow (RO), Tahoe City (TC), Tahoe Valley (TV), Upper Truckee (UT), Pasadena Inflow (PI), Pasadena Outflow (PO), and Elks Club (EC).

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 the 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 treatment types at this site.

							Landuse					
Catchment Name	Outfall	BMP	# Monitoring Stations	Jurisdiction	Total Acres	Impervious Area	Single Family Residential	Multi-Family Residential	CICU*	Primary Roads	Secondary Roads	Vegetated
SR431		√√	4	NDOT	1.4	89%	0%	0%	0%	89%	0%	11%
Elks Club		√	1	El Dorado	14.4	29%	50%	0%	0%	9%	19%	22%
Lakeshore	√		1	Washoe	97.8	41%	2%	43%	31%	1%	10%	13%
Pasadena	√		1	CSLT	78.8	39%	52%	13%	5%	0%	16%	14%
Speedboat	√		1	Placer	29.0	30%	49%	3%	9%	4%	10%	25%
Tahoe City	√		1	Placer, Caltrans	4.4	62%	12%	10%	23%	49%	0%	6%
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 SR431 Catchment Description

The SR431 monitoring site was established WY14 and 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 and ice may occasionally block stormwater infrastructure (like drop inlets) this catchment area may increase, though this is difficult to verify. This is the smallest catchment monitored and the 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 was monitored as a catchment outfall site for two years (WY14-15), but this site gave very little useful information due to a variety of factors including redundancy with vault discharge measurements and it being poorly configured for monitoring equipment. SR431 is now only monitored for evaluating and comparing the effectiveness of two adjacent stormwater treatment vaults, the Contech MFS and the Jellyfish. The Contech MFS vault contains media filled cartridges and the Jellyfish vault contains filtering membranes (WY14 - ongoing). There are currently four monitoring stations at SR431: the inflow and outflow to the Contech MFS vault (CI, CO), and the inflow and outflow to the Jellyfish vault (JI, JO). 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 treatment types can be performed. In October of 2020, NDOT installed a Jensen Deflective Separator (hydrodynamic separator) between the existing drop inlet and the diversion manhole as a pre-treatment system to capture bulk sediment, trash, and debris before it enters the splitter chamber. With this system in place the existing media filtration systems should no longer be overwhelmed with coarse sediment and will more effectively treat fine sediment.

Runoff enters a transverse drain across a parking pull-out directly adjacent to SR431. As of WY21, runoff then flows into the hydrodynamic separator installed in October 2020. It then flows through a pipe to a splitter chamber that should theoretically route equal amounts of flow through two inflow pipes, one to the Contech MFS inflow flume and then to the Contech MFS vault, and one to the Jellyfish inflow flume and then to the Jellyfish vault. In the past, this splitter chamber filled quickly with accumulated sediment and without proper consistent maintenance the volume often did not get split evenly. Though the hydrodynamic separator should alleviate this problem to some extent, flows are not necessarily always split evenly. After the runoff has been treated in each vault, the flow exits the vaults through respective pipes that lead either to the Contech MFS outflow flume or the Jellyfish outflow flume and then to Deer Creek.

2.2 Elks Club Catchment Description

The Elks Club monitoring site was established WY18 and is located on the northwest corner of Elks Club Drive and Bel Aire Circle in El Dorado County. It is monitored as a catchment outfall and a BMP at one monitoring station (EC). At 14.4 acres, it is a relatively small catchment comprised primarily of single family residential and secondary road land uses. Elks Club Drive is fairly steep and serves as the primary access road for this neighborhood. Runoff is channelized along the north side of the road and routed directly to the monitoring location adjacent to the roadside.

Prior to the summer of 2018, Elks Club Drive was in poor condition, covered in cracks and potholes. Visual observations and a pilot study on Pioneer Trail in El Dorado County from 2012-2014 suggested that the degraded road surface itself was contributing a substantial amount of fine sediment to stormwater runoff. The Elks Club monitoring site was established to determine if improving road condition would result in decreased FSP loads in stormwater runoff from this catchment. In the summer of 2018, El Dorado County completed an erosion control project in this catchment that included completely reconstructing Elks Club Drive and armoring the road shoulders and roadside channels with asphalt and rocks. A repaved road is more durable and less likely to deteriorate under the heavy equipment and plow blades used for snow removal operations. The smooth surface is easier to sweep and therefore more road abrasives can be recovered. New roads also look nicer and provide a better driving experience. The primary purpose of this monitoring site is to conduct pre- and post-project monitoring and perform source apportionment analyses on runoff samples from WY18 (pre project) and WY19 (post project) to determine what portion of the fine sediment originates from native soil (road shoulder erosion), traction abrasives (road sand), and asphalt plus asphalt binder (the road itself).

Post project data collected at Elks Club in WY19 indicates that repaving a road contributes to improved water quality (less sediment). Improved pavement condition should be recognized as a water quality BMP, not only to garner credits for the Lake Tahoe TMDL Clarity Crediting Program but also to potentially open up water quality improvement funds for road maintenance and vice versa. New roads would be beneficial for public safety, vehicle maintenance costs, aesthetic appeal, driving pleasure, road maintenance and sweeping operations, long term durability, snow removal operations, stormwater quality, and lake clarity.

2.3 Lakeshore Catchment Description

The Lakeshore monitoring site was established WY17 and is located in the roadside channel on the northern side of Lakeshore Boulevard, near Third Creek, replacing the old Incline Village site. Incline Village is no longer monitored because it rarely receives any flow. Lakeshore is monitored as a catchment outfall at one monitoring station (LS). At 97.8 acres, this is the second largest catchment monitored and 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-one 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 into Third Creek which discharges into Lake Tahoe.

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 catchment include: (1) a series of three upstream infiltration basins that receive 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 treatment vault similar to the one installed at SR431 (see section 2.1) was also installed downstream of the new infiltration features. A Vortechnics treatment vault routes low flow through the Jellyfish to be discharged to the lake through a 30-inch corrugated metal pipe (CMP) that passes through the old Incline Village monitoring site. High flows are routed through the roadside channel to the new Lakeshore monitoring site. The drainage area for this outfall is similar to the old Incline Village catchment but receives additional flow from Lakeshore Boulevard east of Village Boulevard as well as some overland flow originating upslope of Lakeshore Boulevard.

2.4 Pasadena Catchment Description

The Pasadena monitoring site was established WY14 is located at the northernmost end of Pasadena Avenue in the City of South Lake Tahoe (City). It was monitored as a catchment outfall and BMP effectiveness site beginning WY14. Beginning WY18 it was monitored as a catchment outfall only as inflow monitoring was suspended because it wasn't truly monitoring pretreatment inflow as it was located downstream of the in-situ infiltration BMPs described below. 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. The dominant land uses are moderate density single-family residential, 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 (in-situ infiltration BMPs), 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). BMP RAM results and manufacturer's inspection method indicate that replacing the filters again is not yet necessary as of WY21. This may be due, in part, to the fact that City has been sweeping streets and vactoring sediment traps to maintain the whole system. Pasadena Inflow (PI) was 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.

2.5 Speedboat Catchment Description

The Speedboat monitoring site was established WY15 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 road land uses. After passing through a Palmer-Bowlus 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 Pollutant Load Reduction Model (PLRM) used to estimate pollutant loading from urban catchments.

2.6 Tahoe City Catchment Description

The Tahoe City monitoring station was established WY20 is located at the outflow from a Delaware Sandfilter installed by Caltrans along highway 28, half a mile to the east of the Tahoe City commercial corridor. The 4.4-acre catchment is the second smallest and is monitored as a catchment outfall at a single monitoring station (TC). The catchment is 62% impervious and dominant land uses include primary roads, CICU, and single-family residential. Curb and gutter along highway 28 direct flow to the Sandfilter. The outflow from the Sandfilter enters a small, shallow infiltration basin before discharging into Lake Tahoe. The Sandfilter was installed in approximately 2015 to reduce concentrations of fine sediment in stormwater runoff from a section of highway 28. Monitoring at this site began WY20, not to assess the effectiveness of the Sandfilter, only to track the quality of the stormwater after treatment and before discharge to Lake Tahoe.

2.7 Tahoe Valley Catchment Description

The Tahoe Valley monitoring site was established WY15 is located on the eastern side of Tahoe Keys Boulevard just north of the intersection with Sky Meadows Court in South Lake Tahoe, 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 commercial/industrial/communications/utilities (CICU), single family residences, secondary roads, and vegetation land uses. 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.

2.8 Tahoma Catchment Description

The Tahoma monitoring site was established WY14 and is located at the bottom of Pine Street right at the lake's edge in Tahoma. It 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 runoff 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 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.

2.9 Upper Truckee Catchment Description

The Upper Truckee monitoring site was established WY15 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. 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 third 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. 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. Runoff originating from City streets flows through these treatments, and discharges through a high-density polyethylene (HDPE) pipe to a small rock-lined basin installed by Caltrans in 2019. However, since the majority of runoff in this catchment originates from Highway 50, under Caltrans' jurisdiction, volume and pollutant reductions attributable to the improvements made by the City are hard to detect.

In the summer of 2019 Caltrans completed installation of a large underground concrete vault (dimensions: 54′ long x 11′7″ wide x 10′ deep) that captures and treats Caltrans Highway 50 runoff only. A 6′ wall about halfway down the 54′ chamber separates it into 2 parts (total volume capacity 3,753 cubic feet). The first half is for settling out the larger particles. Once the water reaches a depth of 6′ it spills over the wall into the second half which contains a sand filter to filter out FSP. It then goes over a weir and out the same HDPE pipe used by City runoff described above. The pipe discharges into the small rock-lined basin installed by Caltrans which overflows onto an unarmored slope that leads directly to the Upper Truckee River and eventually to Lake Tahoe. The vault was designed to be large enough to capture the estimated amount of flow that could enter the vault in any given storm. This site offers the unique opportunity to monitor pre and post project conditions. Rainfall normalized annual FSP loads for WY20 and WY21 are lower than any previous pre-project year (see section 8.9). Though two years of post-project data are not enough state conclusively that this is due to treatment of Highway 50 runoff in the vault, it is an indication that treatment may be effective.

3. Data Collection Methods, Sampling Protocols, Analytic Methods

Continuous hydrology and stormwater samples are collected using ISCO brand automated samplers (autosamplers) per RSWMP protocols (RSWMP FIG 2015 section 10.2.1, Tahoe RCD et al 2017) at all twelve monitoring stations in WY21 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. Continuous turbidity was collected at all sites 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 fine sediment particle (FSP) concentration have been developed specifically for the Tahoe Basin and were applied to estimate FSP loads (2NDNATURE et al 2014). Continuous meteorological data is recorded using a Davis Instruments Vantage Pro weather station or weather station equipment sold by Campbell Scientific. The weather stations are installed at eight locations in the vicinity of the nine monitored catchments and maintained following recommendations in the RSWMP FIG sections 10.2.3.1 and 10.2.3.2. All weather stations are maintained by Tahoe RCD, with the exception of Shakori, which is maintained by El Dorado County. 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).

Continuous data (flow, turbidity, and meteorology) are logged at a constant time interval, generally every 5 minutes. 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 September/early October 2016, June 2017, and May/June 2018. Starting in 2019, all turbidimeters are being sent to the manufacturer for annual calibration. Tahoe RCD does not have an extra set of turbidimeters for all sites, so it is not possible to send all turbidimeters in for calibration at the same time. To maintain data continuity, turbidimeters were sent in for calibration in batches of 3-5 at a time during the summer and fall of 2019, 2020, and 2021.

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. Individual aliquots from single samples are combined into flow-weighted composites (RSWMP FIG section 10.2.1.10) based on their occurrence in the hydrograph. 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 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 Oakland, OR. 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
AC	**A**uto-sampler **C**omposite, flow-weighted composite of whole or part of hydrograph
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)

Table 3 Analytical methods and detection limits.

Analyte	Methods	Description	Detection Limit	Target Reporting Limit
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
Total Kjeldahl Nitrogen	EPA 351.1; or EPA 351.2	Colorimetric, block digestion, phenate	35 µg/L	100 µg/L
Nitrate + Nitrite	TERC Low Level Method	Colorimetric, NO3 + NO2 Hydrazine Method, low level	2 µg/L	10 µg/L
Total Nitrogen as N	N/A	Total Kjeldahl Nitrogen + Nitrate + Nitrite	35 µg/L	100 µg/L
Total Phosphorus as P	TERC Low Level Method	Colorimetric, Total Phosphorus, Persulfate digestion, low level	2 µg/L	10 µg/L
Particle Size Distribution	SM 2560 or RSWMP addendum SOP	Laser backscattering	0.5 mg/L	1 mg/L

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 individual aliquots from 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 the proper holding time. A minimum of 10% of all samples analyzed were QAQC samples to identify any potential 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 collected through the RSWMP Data Management System (DMS) at the time samples are collected, when maintenance is required, or every two weeks during dry periods. The RSWMP DMS is a proprietary two-component online system housed, hosted, and maintained by the Desert Research Institute and Geosyntec. All data are input into Excel workbooks for storing continuous parameters and sample dates and times. Any other field measurements and observations are recorded in a field notebook or the ArcGIS Survey123 app and transcribed into Excel workbooks. Samples are transported to a processing lab immediately after collection. The DMS automatically calculates the recipe for compositing individual aliquots from single samples into an event composite for each monitoring station. All composite samples are measured for turbidity using a benchtop turbidimeter (Hach 2100N or TL2300) or a portable turbidimeter (Hach 2100P) 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 analytical laboratories within appropriate holding times for TSS, TN, TP, 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. 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 pipe to flow), and turbidity recorded every 5 minutes throughout the water year. Data gaps are 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 flow volumes are calculated by the DMS in accordance with RSWMP FIG sections 10.2.1.8 and 10.2.1.9. Results of particle size distribution analysis for the percent of particles less than 16 μm is multiplied by the TSS concentration to obtain FSP concentration from water quality samples. These results and the results of lab analysis for TN and TP concentration in water quality samples are used by the DMS to calculate a flow-weighted event mean concentration (EMC) as outlined in section 10.2.1.10 of the RSWMP FIG. The DMS groups EMCs by season and calculates a seasonal characteristic pollutant concentration for each site; the DMS then applies these concentrations to each hydrologic measurement for that season. The DMS calculates loads 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). Rainfall normalized seasonal and annual trends are calculated for catchments with at least five years of continuous data according to protocols outlined in the RSWMP FIG section 10.4.3.

Raw meteorological data include a precipitation and a temperature reading every 5 or 10 minutes (depending on the station) 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. Sites are inspected annually to ensure the equipment is working properly. Occasionally precipitation gauges will get clogged with debris (dirt, wasp nests, pine needles etc.) but with weekly review of the continuous data via the online DMS these issues are identified quickly and remedied. Data gaps are rare, but are filled with data from a neighboring station when they occur (RSWMP FIG section 10.2.3.4). The DMS calculates seasonal and annual precipitation totals for reporting purposes.

6. Catchment Outfall Monitoring

6.1 Summary Data for All Monitoring Sites

A meteorological station at the Tahoe City Dam located in the northwest corner of the lake at an elevation of 6,235 feet is maintained under the Truckee River Operating Agreement (TROA). Per RSWMP protocols, this station is 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 an 89-year precipitation record (water years 1933-2021) from this station, WY21, at **14.82 total inches**, falls within the first quartile for this period of record and is therefore designated a very dry year (Table 4, Figure 2). In WY21 approximately 80.5% of the precipitation fell during the fall/winter season, approximately 16.1% fell during the spring season, and approximately 3.4% fell during the summer season.

Table 4 Annual precipitation statistics from the Tahoe City meteorological reference station, water years 1933-2021.

WY 1933-2021	Annual Precipitation (in)	Designation
1st quartile	8.8 - 21.8	very dry
2nd quartile	21.9 - 28.9	dry
Median	29.0	average
3rd quartile	29.1 - 39.5	wet
4th quartile	39.6 - 69.8	very wet

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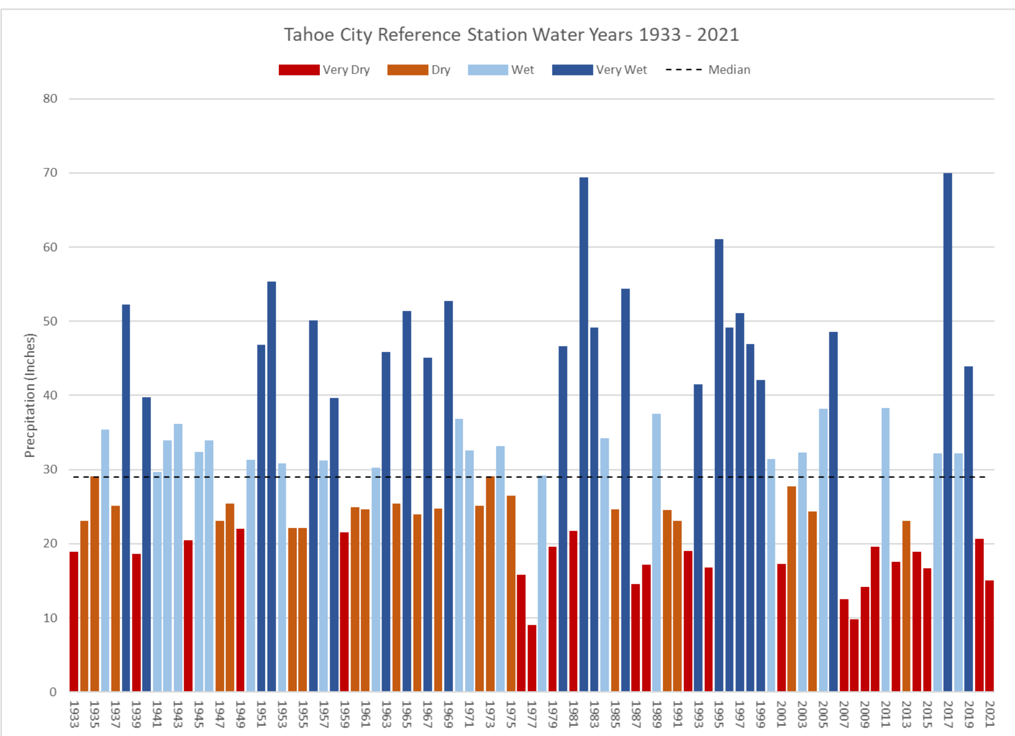

Figure 2 Long-term precipitation record at the Tahoe City meteorological station, water years 1933-2021.

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). These are the seasons used by RSWMP and 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 generally occurs in the spring when temperatures are greater than 50 degrees Fahrenheit and accumulated snowpack melts. Most monitoring sites do not receive sufficient spring non-event snowmelt to sample. Summer events are primarily thunderstorms and frontal rain storms.

The intention is to sample 6-12 runoff events per year in each catchment, and this target was met in WY21 for Contech MFS Inflow, Jellyfish Inflow, Jellyfish Outflow, Elks Club, Tahoma, Tahoe City, Tahoe Valley, and Upper Truckee. Because there was very little runoff, it was not possible to sample 6-12 events at Contech MFS Outflow (5 events), Lakeshore (1 event), Pasadena (1 event), and Speedboat (5 events). Sites differ in their ability to capture low flows. For instance, the Jellyfish Outflow may flow sooner than the Contech MFS Outflow because the large Contech MFS vault capacity retains about 3000 cf before it flows out. Contech MFS Outflow had one event in which sampling failed due to issues with sampler wiring, which has been fixed. Summary data for all sites are presented in Table 5. Figure 3- Figure 12 illustrate Table 5 in graphical form. Runoff volumes are calculated from instantaneous flow rates (cubic feet per second) taken every 5 minutes by assuming the flow rate was constant for the 5-minute period. FSP loads are calculated from event sampling and estimated 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 loads represent an average (volume weighted) load calculation for the respective period based on the events that were sampled in that period. FSP loads estimated from continuous turbidity include all periods of flow, not just those that were sampled. In Figure 3- Figure 12, SR431 is represented by its four sites: Contech MFS Inflow (CI), Contech MFS Outflow (CO), Jellyfish Inflow (JI), and Jellyfish Outflow (JO); Elk's Club is EC, Lakeshore is LS, Pasadena is PO, Speedboat is SB, Tahoe City is TC, Tahoe Valley is TV, Tahoma is TA, and Upper Truckee is UT.

Table 5 Summary statistics for all catchments for WY21. Top table shows seasonal and annual precipitation and runoff volumes; middle table shows seasonal and annual FSP concentrations and loads based on samples and estimated from continuous turbidity; bottom table shows seasonal and annual TN and TP concentrations and loads based on samples.

Water Year 2021 (October 1, 2020 - September 30, 2021)			Seasonal Precipitation (in)			Total Annual Precip (in)	Seasonal Runoff Volumes (cf)			Total Annual Runoff Volumes (cf)
Catchment 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)	
SR431	Contech In	CI	6.63	1.86	0.61	9.11	136	543	347	1,026
	Contech Out	CO	6.63	1.86	0.61	9.11	66	382	172	620
	Jellyfish In	JI	6.63	1.86	0.61	9.11	193	705	430	1,328
	Jellyfish Out	JO	6.63	1.86	0.61	9.11	78	418	127	622
Elk's Club	Elk's Club	EC	7.32	2.36	0.80	10.48	1,876	13,592	0	15,468
Lakeshore	Lakeshore	LS	5.63	0.87	0.72	7.22	108	0	0	108
Pasadena	Pasadena Out	PO	3.76	1.09	0.35	5.20	731	0	0	731
Speedboat	Speedboat	SB	5.83	0.82	0.38	7.03	18,002	313	29	18,344
Tahoe City	Tahoe City	TC	9.12	1.09	0.49	10.71	17,002	4,527	1,096	22,625
Tahoe Valley	Tahoe Valley	TV	6.55	1.70	0.39	8.64	18,146	20,393	432	38,971
Tahoma	Tahoma	TA	9.42	2.11	0.19	11.71	7,448	35,517	195	43,160
Upper Truckee	Upper Truckee	UT	6.55	1.70	0.39	8.64	14,862	6,285	0	21,147

Water Year 2021 (October 1, 2020 - September 30, 2021)			Average Seasonal FSP Concentrations (mg/L)			Average Annual FSP Concen-trations (mg/L)	Seasonal FSP Loads (lbs)			Total Annual FSP Loads (lbs)	Average Estimated Seasonal FSP Concentrations (mg/L)			Average Estimated Annual FSP Concen-trations (mg/L)	Seasonal Estimated FSP Loads (lbs)			Total Annual Estimated FSP Loads (lbs)	Seasonal Estimated FSP Loads (#particles)			Total Annual Estimated FSP Loads (#particles)
Catchment 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)	
SR431	Contech In	CI	1,364	862	466	794	11.6	29.2	10.1	50.9	896	386	237	403	7.6	13.1	5.1	25.9	9.76E+14	1.45E+15	4.18E+14	2.85E+15
	Contech Out	CO	na	471	126	325	na	11.2	1.4	12.6	555	251	183	264	2.3	6.0	2.0	10.2	2.71E+14	6.04E+14	1.54E+14	1.03E+15
	Jellyfish In	JI	987	970	421	795	11.9	42.7	11.3	65.9	617	287	208	309	7.4	12.6	5.6	25.6	9.23E+14	1.31E+15	4.63E+14	2.70E+15
	Jellyfish Out	JO	367	130	546	245	1.8	3.4	4.3	9.5	423	127	131	165	2.1	3.3	1.0	6.4	2.36E+14	3.07E+14	7.49E+13	6.18E+14
Elk's Club	Elk's Club	EC	3	54	na	48	0.4	46.1	na	46.4	7	30	na	27	0.8	25.5	na	26.3	5.69E+13	2.50E+15	na	2.55E+15
Lakeshore	Lakeshore	LS	30	na	na	30	0.2	na	na	0.2	45	na	na	45	0.3	na	na	0.3	2.68E+13	na	na	2.68E+13
Pasadena	Pasadena Out	PO	22	na	na	22	1.0	na	na	1.0	18	na	na	18	0.8	na	na	0.8	6.49E+13	na	na	6.49E+13
Speedboat	Speedboat	SB	90	255	377	93	101.4	5.0	0.7	107.0	340	145	170	336	381.5	2.8	0.3	384.7	4.30E+16	2.84E+14	3.49E+13	4.33E+16
Tahoe City	Tahoe City	TC	102	176	376	130	108.3	49.6	25.7	183.6	123	197	155	139	130.1	55.8	10.6	196.4	1.37E+16	5.43E+15	9.64E+14	2.01E+16
Tahoe Valley	Tahoe Valley	TV	34	36	93	36	38.7	46.2	2.5	87.5	59	31	185	46	66.7	39.4	5.0	111.1	6.47E+15	3.54E+15	4.70E+14	1.05E+16
Tahoma	Tahoma	TA	58	237	136	205	26.8	524.9	1.7	553.4	44	62	92	59	20.5	136.8	1.1	158.4	2.51E+15	1.51E+16	9.87E+13	1.77E+16
Upper Truckee	Upper Truckee	UT	121	96	na	114	112.1	37.8	na	149.9	92	115	na	99	85.7	44.9	na	130.7	9.09E+15	4.45E+15	na	1.35E+16

Water Year 2021 (October 1, 2020 - September 30, 2021)			Average Seasonal TN Concentrations (ug/L)			Average Annual TN Concen-trations (ug/L)	Seasonal TN Loads (lbs)			Total Annual TN Loads (lbs)	Average Seasonal TP Concentrations (ug/L)			Average Annual TP Concen-trations (ug/L)	Seasonal TP Loads (lbs)			Total Annual TP Loads (lbs)
Catchment 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	5,540	4,988	13,154	7,824	0.05	0.17	0.29	0.50	8,492	5,050	3,627	5,024	0.07	0.17	0.08	0.32
	Contech Out	CO	na	3,774	10,727	5,302	na	0.09	0.12	0.21	na	2,817	1,413	2,129	na	0.07	0.02	0.08
	Jellyfish In	JI	4,095	4,918	10,647	6,652	0.05	0.22	0.29	0.55	6,136	5,414	3,116	4,776	0.07	0.24	0.08	0.40
	Jellyfish Out	JO	3,379	2,178	4,819	2,866	0.02	0.06	0.04	0.11	2,610	789	911	1,042	0.01	0.02	0.01	0.04
Elk's Club	Elk's Club	EC	520	564	na	559	0.06	0.48	na	0.54	114	275	na	256	0.01	0.23	na	0.25
Lakeshore	Lakeshore	LS	1,495	na	na	1,495	0.01	na	na	0.01	494	na	na	494	<0.01	na	na	<0.01
Pasadena	Pasadena Out	PO	3,830	na	na	3,830	0.17	na	na	0.17	569	na	na	569	0.03	na	na	0.03
Speedboat	Speedboat	SB	1,818	2,573	23,163	1,864	2.04	0.05	0.04	2.13	759	1,562	5,568	780	0.85	0.03	0.01	0.89
Tahoe City	Tahoe City	TC	1,923	2,596	11,854	2,539	2.04	0.73	0.81	3.59	907	1,244	3,123	1,081	0.96	0.35	0.21	1.53
Tahoe Valley	Tahoe Valley	TV	3,230	1,250	7,670	2,243	3.66	1.59	0.21	5.46	667	336	1,339	501	0.76	0.43	0.04	1.22
Tahoma	Tahoma	TA	1,644	3,221	16,274	3,008	0.76	7.14	0.20	8.10	647	1,482	2,193	1,341	0.30	3.29	0.03	3.61
Upper Truckee	Upper Truckee	UT	2,863	2,571	na	2,776	2.66	1.01	na	3.67	960	661	na	871	0.89	0.26	na	1.15

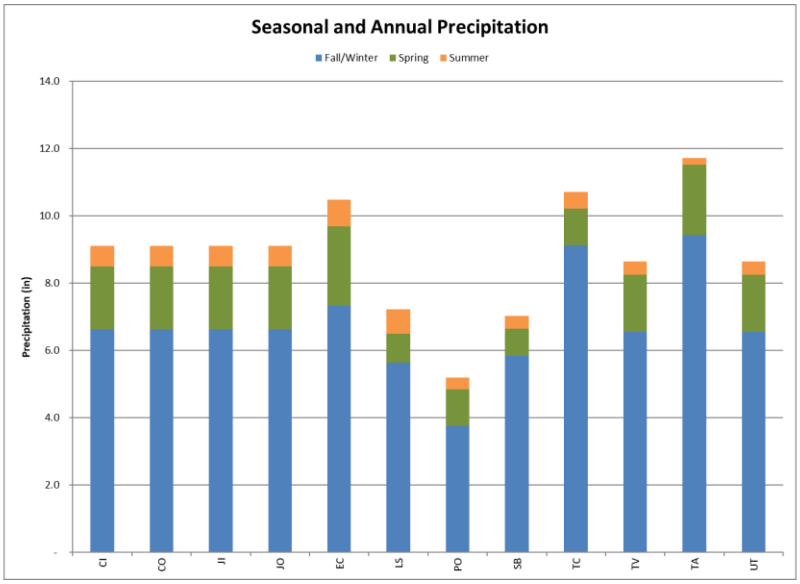

Figure 3 Precipitation totals at each monitoring station, WY21.

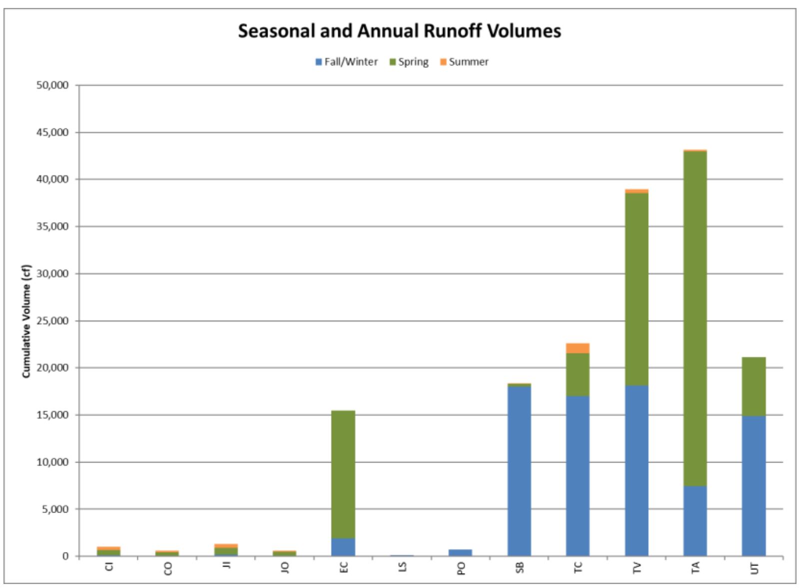

Figure 4 Runoff volumes at each monitoring station, WY21.

Precipitation

- The west shore received the most precipitation (TA).
- The eastern side of south shore (PO) received the least amount of precipitation.
- There are no stations on the east shore.
- All regions of the lake received the greatest amount of precipitation during the fall/winter season and least during the summer.

Runoff Volumes

- Catchment size influences runoff volume. Historically, Tahoe Valley (TV), the largest catchment, has had the most runoff. However, runoff volumes at all sites were very low in WY21, and TV had less runoff than Tahoma (TA). TV requires large storm events to produce flow so many of the smaller precipitation events did not produce any runoff and may have contributed to a lower total runoff volume than TA. SR431 (CI, CO, JI, CO) is the smallest catchment and has a correspondingly small runoff volume.
- Infiltration features influence runoff volume. Though TA is approximately half the size of Lakeshore (LS), its runoff volume is much greater. LS is downstream of numerous infiltration features and measured very little runoff in WY21.
- Impervious area influences runoff volumes. Though the Upper Truckee (UT) catchment area is about one eighth the size of Pasadena (PO), it has a much greater runoff volume. UT is 72% impervious and PO is 39% impervious.
- Precipitation totals influence runoff volumes. LS, PO, Speedboat (SB), Tahoe City (TC), and UT catchments had the most runoff in the fall/winter and the least runoff in the summer, mirroring seasonal precipitation totals. However, precipitation type (rain versus snow) and event size also influence runoff volumes. CI, CO, JI, JO had the most runoff in the spring and the least in the fall/winter, and Elks Club (EC), TV, and TA had the most runoff in the spring and the least in the summer. When precipitation falls as snow (likely in the winter) or when events were consistently very small (like the winter of 2021) runoff is less likely and spring runoff volumes can be higher than winter volumes due to snowmelt.

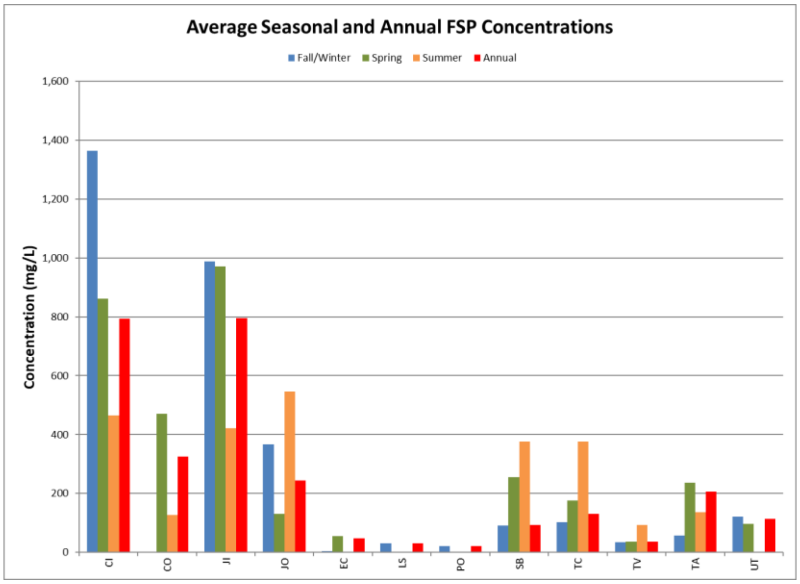

Figure 5 FSP concentrations based on samples at each monitoring station, WY21.

FSP Concentrations Based on Samples

- Average seasonal FSP concentrations were highest in the fall/winter at Contech MFS inflow (CI), Jellyfish Inflow (JI), Lakeshore (LS), Pasadena (PO, and Upper Truckee (UT); highest in the spring at Contech MFS outflow (CO), Elks Club (EC), and Tahoma (TA); and highest in summer at Jellyfish Outflow (JO), Speedboat (SB), Tahoe City (TC) and Tahoe Valley (TV).
- The highest average seasonal FSP concentration was observed during the fall/winter season at the SR431 Contech MFS inflow (CI) and Jellyfish inflow (JI). These sites are highly influenced by primary road.
- Average annual FSP concentrations were highest at the SR431 inflows (CI, JI).
- Average annual FSP concentrations were lowest at Elks Club (EC), Lakeshore (LS), Pasadena (PO), and Tahoe Valley (TV).

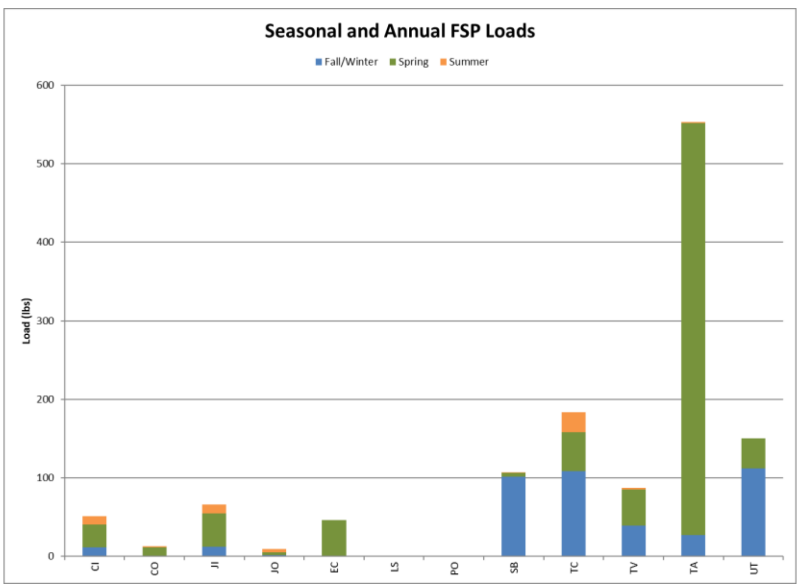

Figure 6 FSP loads based on samples at each monitoring station, WY21.

FSP Loads Based on Samples

- Runoff volumes influence loads. Tahoma, with the highest runoff volume, contributed the greatest FSP loads to the lake, yet had the 5th highest FSP concentration.
- Historically, concentrations have had a large influence on loads. However, with the low runoff volumes this year, the same pattern was not observed for FSP loads based on samples.

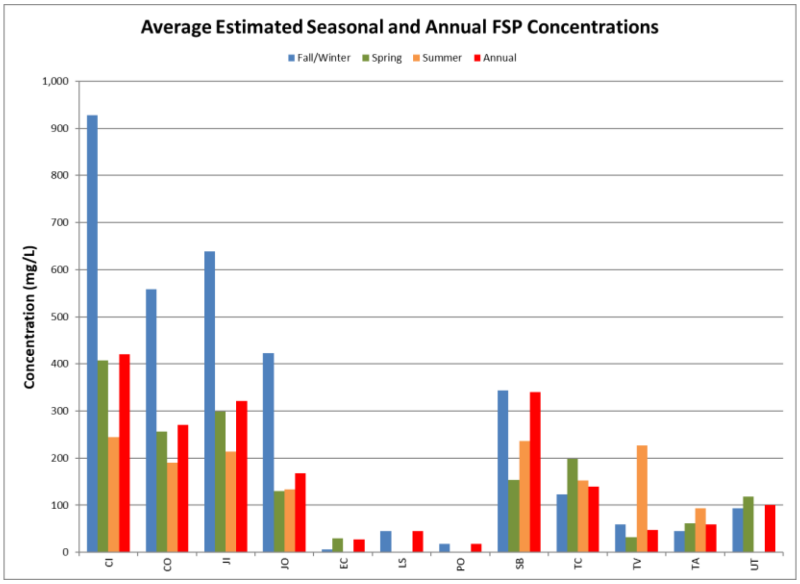

Figure 7 FSP concentrations estimated from turbidity at each monitoring station, WY21.

FSP Concentrations Estimated from Turbidity

- Average estimated seasonal FSP concentrations were highest in the fall/winter at SR431 (CI, JI, CO, JO), Lakeshore (LS), Pasadena (PO), and Speedboat (SB) (both LS and PO only had samples in the winter); highest in the spring at Elk's Club (EC), Tahoe City (TC), and Upper Truckee (UT), and highest in the summer at Tahoe Valley (TV) and Tahoma (TA).
- The highest average estimated seasonal FSP concentrations were observed during the fall/winter at Contech MFS inflow (CI) and Jellyfish inflow (JI).
- Average estimated annual FSP concentrations were highest at Contech MFS inflow (CI).
- Average estimated annual FSP concentrations were lowest at Elk's Club (EC), Lakeshore (LS), Pasadena (PO), Tahoe Valley (TV), and Tahoma (TA).

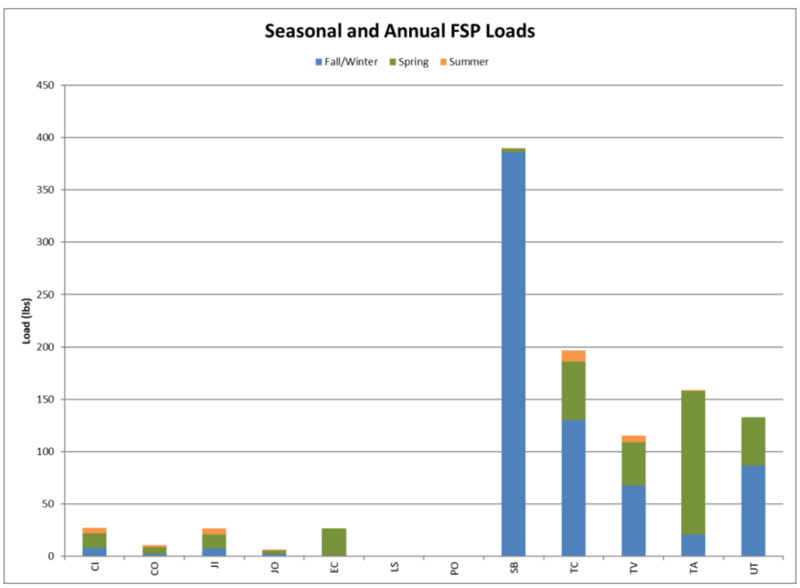

Figure 8 FSP loads estimated from turbidity at each monitoring station, WY21.

FSP Loads Estimated from Turbidity

- Generally, runoff volumes have the largest influence loads. However, with the low runoff volumes this year, the same pattern was not observed for FSP loads based on turbidity, instead, concentration seemed to have a larger influence on loads.
- Concentrations influence loads. Speedboat had the fifth highest flows, but the second highest estimated concentrations which resulted in the largest estimated load.

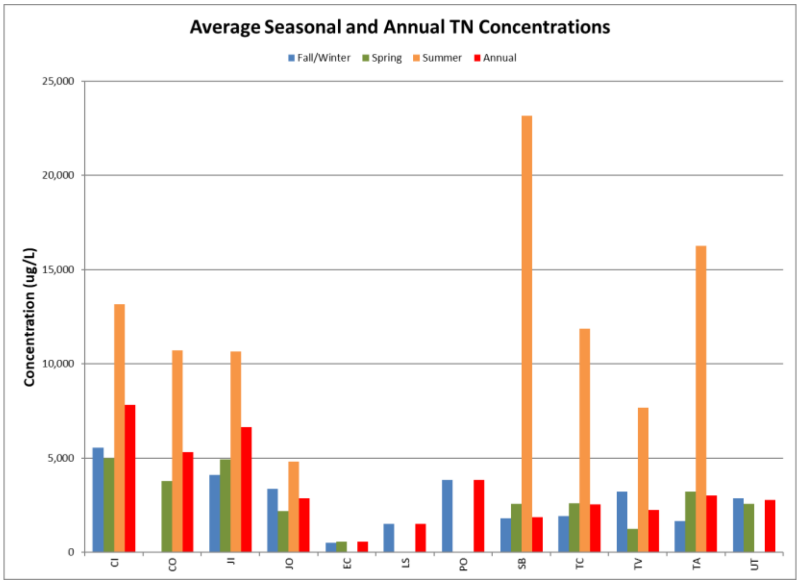

Figure 9 TN concentrations at each monitoring station, WY21.

TN Concentrations

- Average seasonal TN concentrations were substantially higher in the summer than any other season at all sites that were sampled during the summer. Though this is usually the case, it is possible that smoke and ash from the Caldor Fire (August 14 – October 21, 2021) contributed to high summer TN values WY21. No samples were collected in the summer at EC, LS, PO, and UT because there was no flow.
- The highest average seasonal TN concentration was observed during the summer at Speedboat.
- Average annual TN concentrations were highest at the SR431 inflows (CI, JI).
- Average annual TN concentrations were lowest at Elk's Club (EC) and Lakeshore (LS).

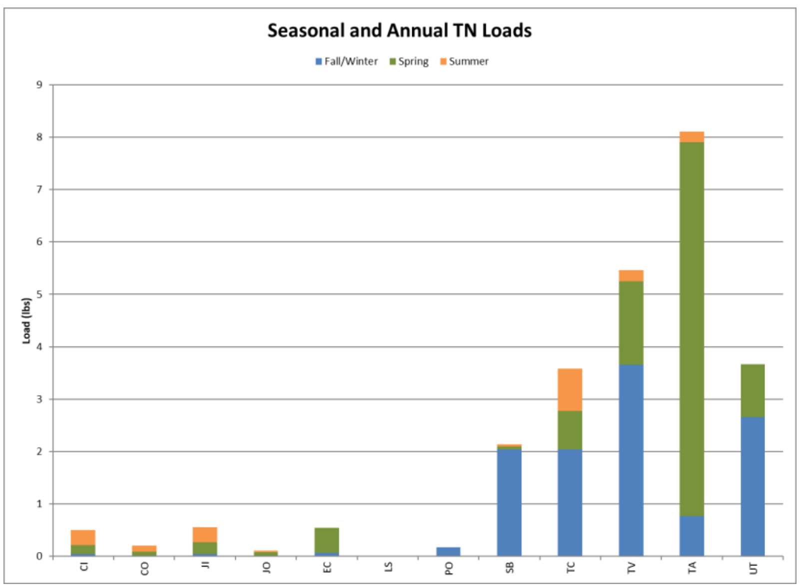

Figure 10 TN loads at each monitoring station, WY21.

TN Loads

- Runoff volume had the largest influence on loads. With the largest runoff volumes, Tahoma (TA) and Tahoe Valley (TV) had the largest TN loads, yet they had average annual TN concentrations similar to other sites.
- Concentrations influence loads. Though runoff volumes are universally low in the summer, high average seasonal TN concentrations generally result in proportionally high summer TN loads However, with the low runoff volumes this year, the same pattern was not always observed. This is especially apparent at Speedboat (SB), where very high summer concentrations did not result in proportionally large summer loads.

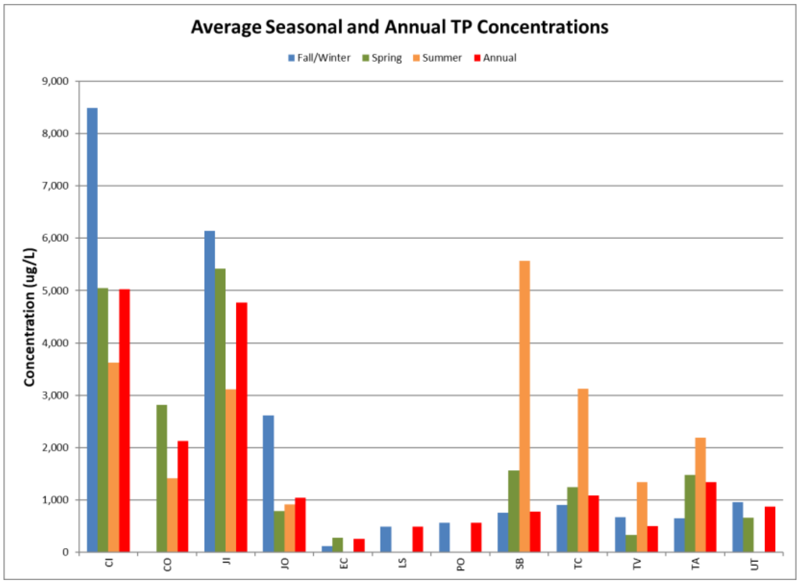

Figure 11 TP concentrations at each monitoring station, WY21.

TP Concentrations

- Average seasonal TP concentrations were highest in the fall/winter at CI, JI, JO, LS, PO, and UT (both LS and PO only had samples in the winter); highest in the spring at CO and EC, and highest in the summer at SB, TC, TV, and TA.
- The highest average seasonal TP concentration was observed during the fall/winter at CI.
- Average annual TP concentrations were highest at SR431 inflows (CI, JI).
- Average annual TP concentrations were lowest at Elks Club (EC), Lakeshore (LS), Pasadena (PO), and Tahoe Valley (TV).

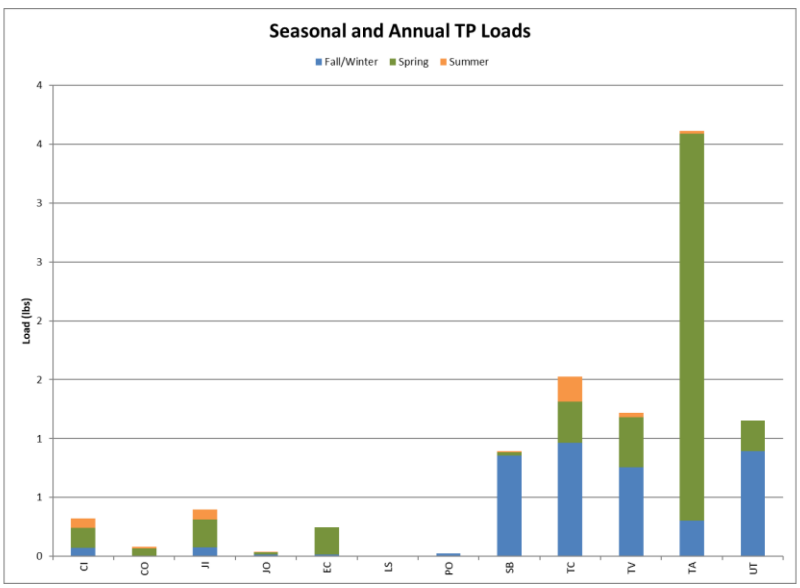

Figure 12 TP loads at each monitoring station, WY21.

TP Loads

- Runoff volume has the largest influence on loads. With the highest runoff volume, Tahoma (TA) contributed the greatest TP load to the lake, yet it didn't have the highest average annual TP concentration.
- Concentrations influence loads. Though runoff volumes are universally low in the summer, high average seasonal summer TP concentrations at SB, TC, TV, and TA usually result in proportionally high summer TP loads. However, with the low runoff volumes this year, the same pattern was not always observed. This is especially apparent at SB where high summer concentrations did not result in proportionally large summer loads.

6.2 Summary Data for Individual Catchments

6.2.1 SR431

Figure 13 shows the average daily inflow and cumulative precipitation for WY21 at the SR431 treatment vaults. The treatment vaults are not designed to reduce flows so outflows are roughly equal to inflows for the Jellyfish. However, the Contech MFS vault has a capacity of about 3,000 cf. This results in a substantial amount of runoff evaporating from the vault instead of passing through the outflow and accounts for the large difference between inflow and outflow volumes in Table 5 (compare CI annual volume to CO annual volume in Table 5).

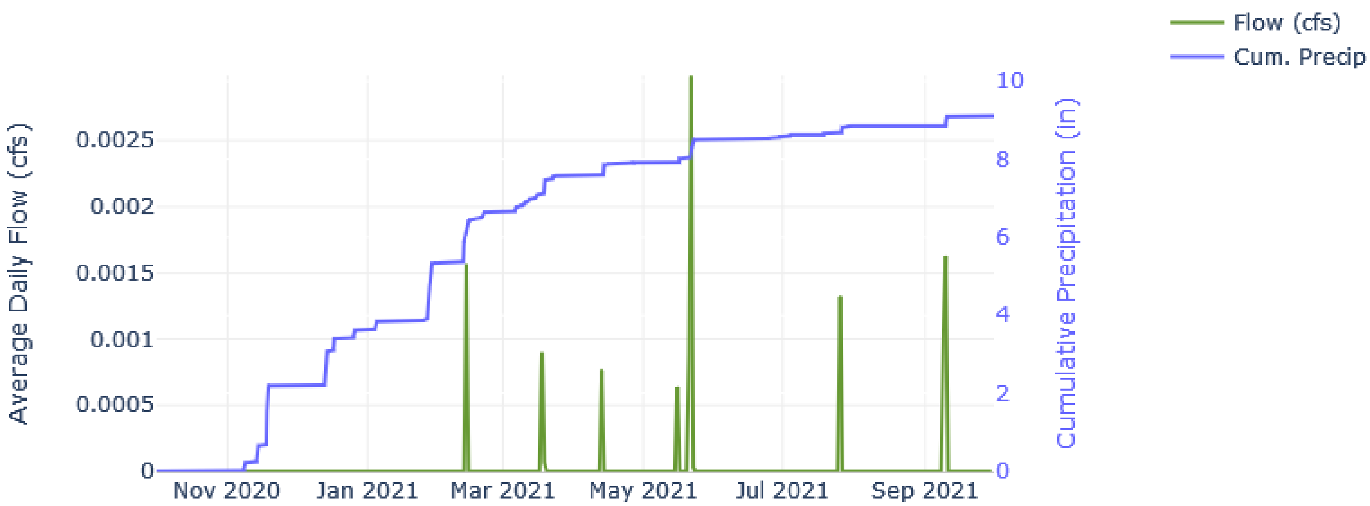

Figure 13 Average daily inflow and cumulative precipitation at the SR431 treatment vaults, WY21.

- Average daily flow in Figure 13 is from CI, but JI is similar so it is not shown. The occasional difference in inflow volume between CI and JI is attributable to unequal split of the flow in the splitter chamber when sediment accumulates.
- 9.1 inches of total precipitation (6.63 in the fall/winter, 1.86 in the spring, and 0.61 in the summer) were recorded at the NDOT weather station.
- 38 precipitation events occurred (16 fall/winter events, 12 spring events, 10 summer events).
- The largest storm event produced 1.54 inches of precipitation and occurred during a rain and snow event from November 17-18, 2020.
- 89% of storms were less than half an inch.
- Highest average daily flows occurred in during the May 21-23, 2021 event snowmelt.
- 4 days of snowmelt occurred in the fall/winter and spring seasons.
- The highest instantaneous peak precipitation was 0.04 inches in 5 minutes during a thunderstorm event on May 16, 2021.
- The highest instantaneous peak flow was 0.16 cfs during the thunderstorm event on July 26, 2021.
- The largest runoff event was an event snowmelt, which occurred May 21-26, 2021 (337 cf).

Contech MFS

Daily flow and FSP EMC summaries for the Contech MFS inflow and outflow are presented in Figure 14 and Figure 15, respectively. Table 6 presents EMC data in tabular form. Table 6 also presents the load data referenced in some bullet points below.

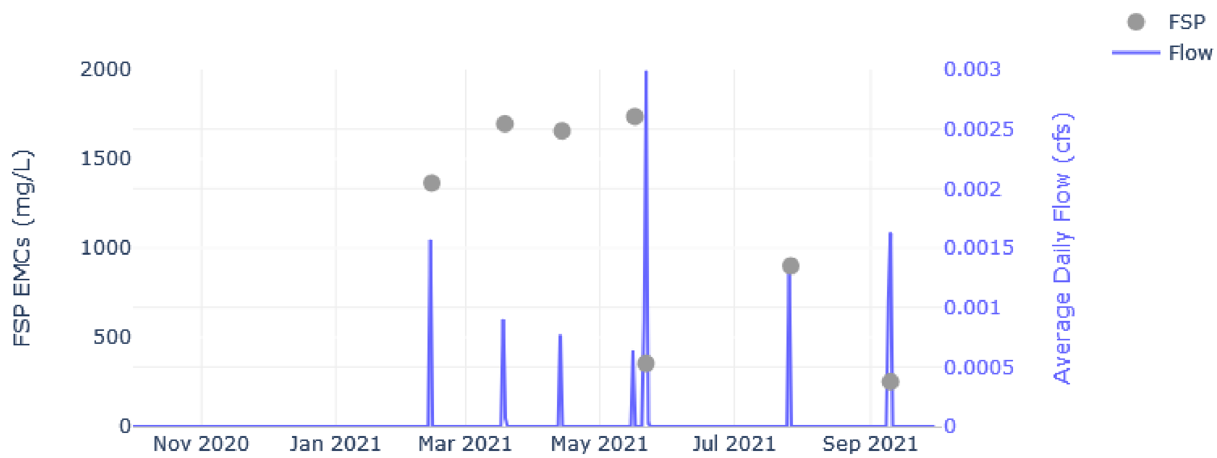

Figure 14 Daily inflow and FSP EMC summary at the Contech MFS, WY21.

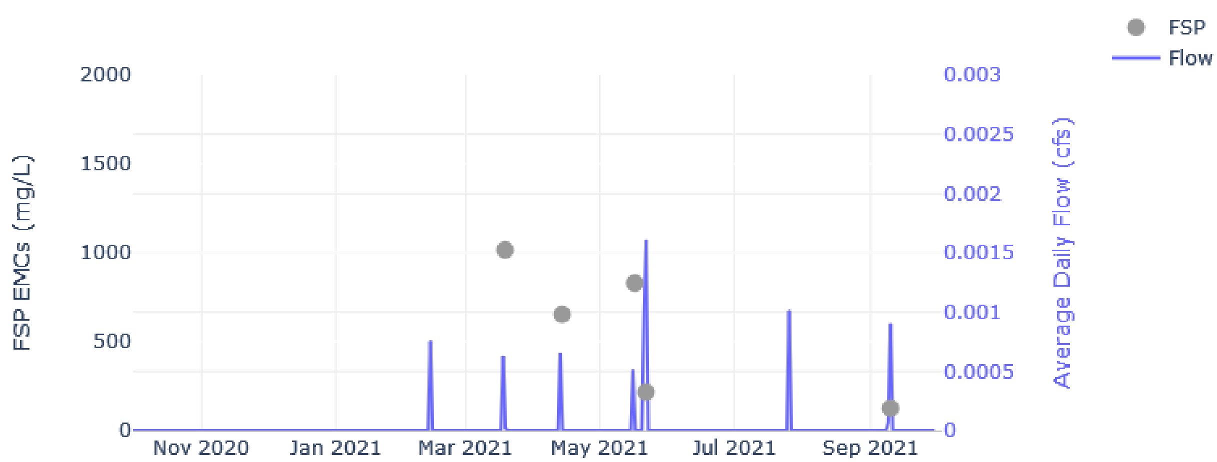

Figure 15 Daily outflow and FSP EMC summary at the Contech MFS, WY21.

- Seven events were sampled for FSP at Contech MFS inflow (one in the fall/winter, four in the spring, two in the summer) and five events were sampled for FSP at Contech MFS outflow (zero in the fall/winter, four in the spring, and one in the summer).
- Samples failed at Contech MFS outflow for the February 13, 2021 storm likely due to low flow.
- Electrical wires at Contech MFS outflow became disconnected in the summertime, likely due to the large earthquake in the region on July 8, 2021, which caused sampling for the July 26, 2021 thunderstorm event to fail.
- In all events with samples at both the inflow and outflow, FSP EMCs were lower at the outflow than the inflow indicating treatment occurred.
- The highest FSP EMC at the inflow occurred during the thunderstorm event on May 16, 2021.

- The highest FSP load at the inflow occurred during the event snowmelt on February 13, 2021.
- The highest FSP EMC and load at the outflow occurred during the rain on snow event on March 18-19, 2021.
- The lowest FSP EMC and load at the inflow and outflow occurred during the thunderstorm event from September 9-10, 2021.

Daily flow and TN EMC summaries for the Contech MFS inflow and outflow are presented in Figure 16 and Figure 17, respectively. Table 6 presents EMC data in tabular form. Table 6 also presents the load data referenced in some bullet points below.

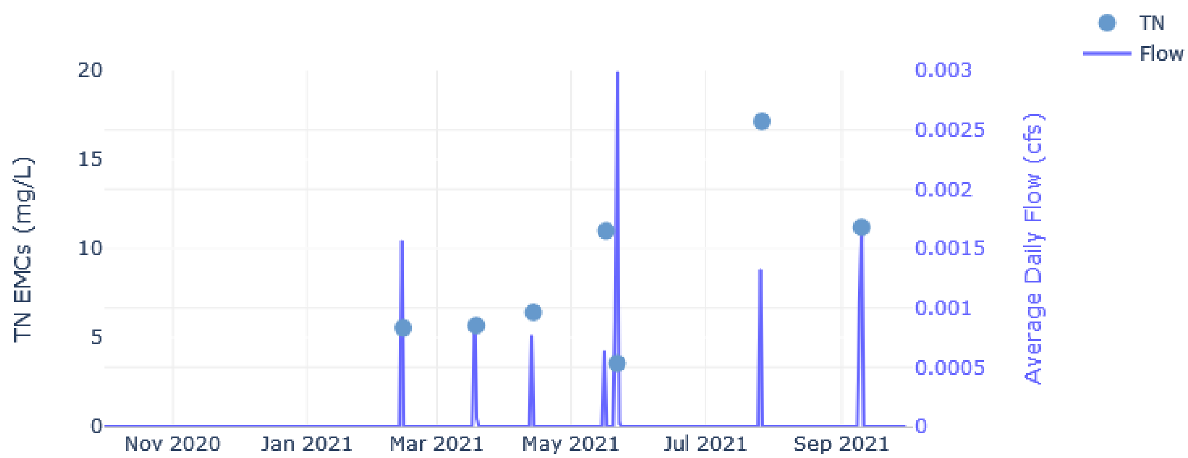

Figure 16 Daily inflow and TN EMC summary at the Contech MFS, WY21.

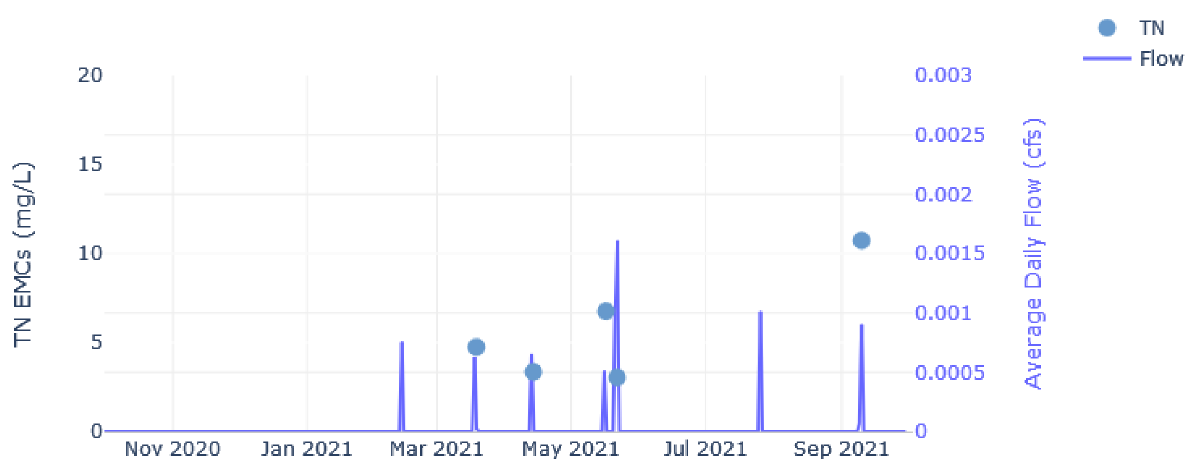

Figure 17 Daily outflow and TN EMC summary at the Contech MFS, WY21.

- Seven events were sampled for TN at Contech MFS inflow (one in the fall/winter, four in the spring, two in the summer) and five events were sampled for TN at Contech MFS outflow (zero in the fall/winter, four in the spring, and one in the summer).
- Samples failed at Contech MFS outflow for the February 13, 2021 storm likely due to low flow.

- Electrical wires at Contech MFS outflow became disconnected in the summertime, likely due to the large earthquake in the region on July 8, 2021, which caused sampling for the July 26, 2021 thunderstorm event to fail.
- In all events with samples at both the inflow and outflow, TN EMCs were lower at the outflow than the inflow indicating treatment occurred.
- The highest TN EMC at the inflow occurred during the thunderstorm event on July 26, 2021.
- The highest TN load at the inflow occurred during the thunderstorm event on September 9-10, 2021.
- The highest TN EMC and load at the outflow occurred during the thunderstorm event on September 9-10, 2021.
- The lowest TN EMC at the inflow and outflow occurred during the event snowmelt May 21-23, 2021.
- The lowest TN load at the inflow and outflow occurred during event snowmelt April 13, 2021.

Daily flow and TP EMC summaries for the Contech MFS inflow and outflow are presented in Figure 18 and Figure 19, respectively. Table 6 presents EMC data in tabular form. Table 6 also presents the load data referenced in some bullet points below.

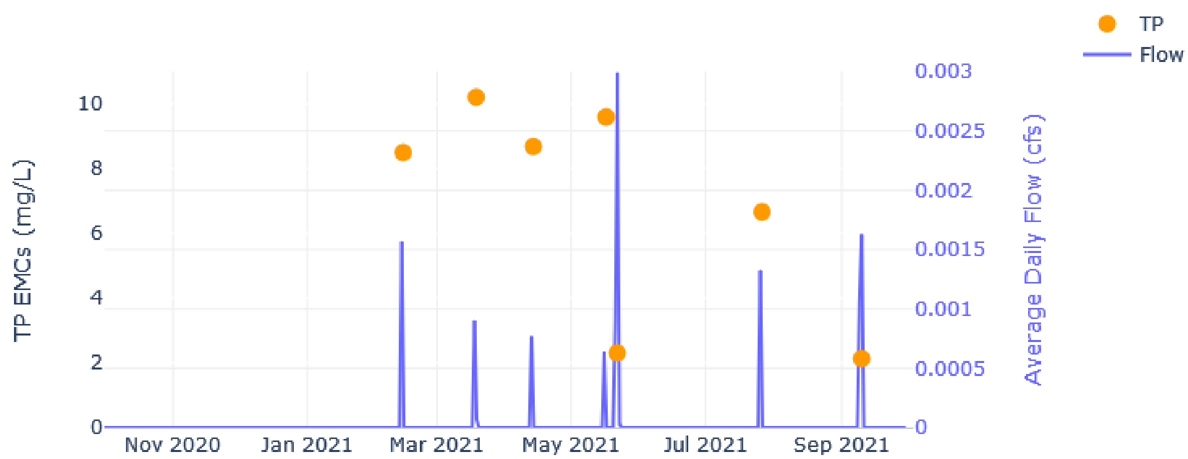

Figure 18 Daily inflow and TP EMC summary at the Contech MFS, WY21.

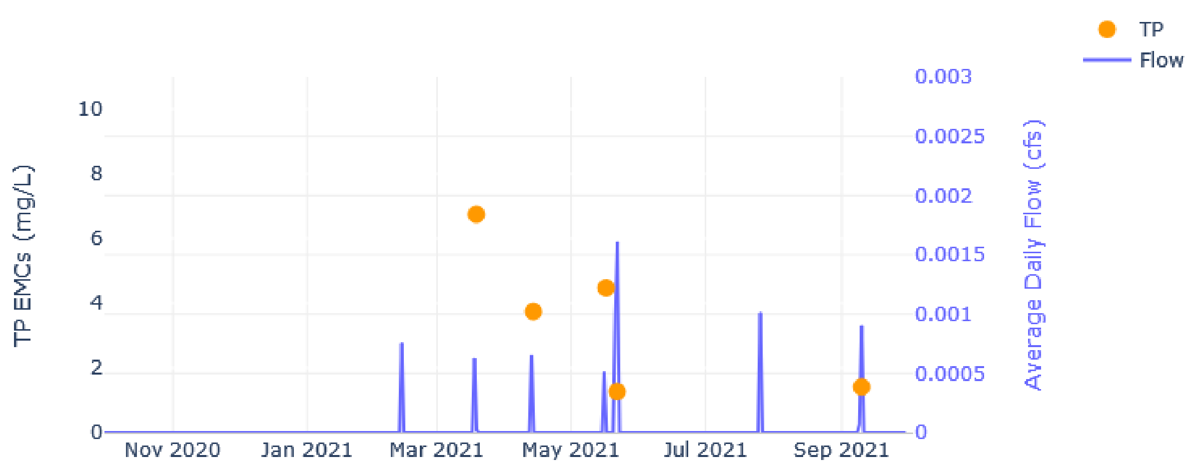

Figure 19 Daily outflow and TP EMC summary at the Contech MFS, WY21.

- Seven events were sampled for TP at Contech MFS inflow (one in the fall/winter, four in the spring, two in the summer) and five events were sampled for TP at Contech MFS outflow (zero in the fall/winter, four in the spring, and one in the summer).
- Samples failed at Contech MFS outflow for the February 13, 2021 storm likely due to low flow.
- Electrical wires at Contech MFS outflow became disconnected in the summertime, likely due to the large earthquake in the region on July 8, 2021, which caused sampling for the July 26, 2021 thunderstorm event to fail.
- In all events with samples at both the inflow and outflow, TP EMCs were lower at the outflow than the inflow indicating treatment occurred.
- The highest TP EMC at the inflow and outflow occurred during a rain on snow event March 18-19, 2021.
- The highest TP load at the inflow occurred during an event snowmelt on February 13, 2021.
- The highest TP load at the outflow occurred during a rain on snow event on March 18-19, 2021.
- The lowest TP EMC and load at the inflow occurred during the thunderstorm event on September 9-10, 2021.
- The lowest TP EMC at the outflow occurred during the event snowmelt May 21-23, 2021.
- The lowest TP load at the outflow occurred during the thunderstorm event on September 9-10, 2021.

Seasonal load as a fraction of the water year load for the Contech MFS inflow and outflow are presented in Figure 20 and Figure 21, respectively. Event loads are presented in tabular form in Table 6.

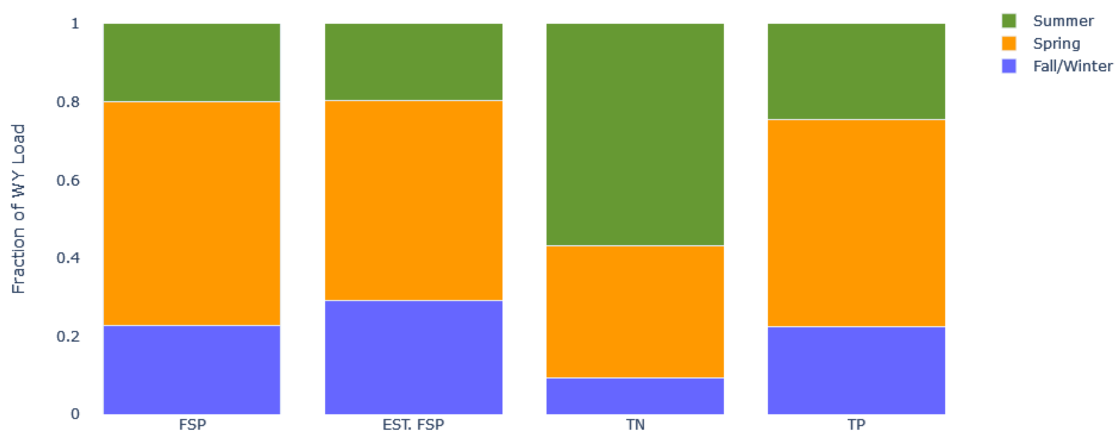

Figure 20 Seasonal load as a fraction of the water year load at the Contech MFS inflow, WY21. The first FSP column represents the FSP load calculated using event mean concentrations and the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

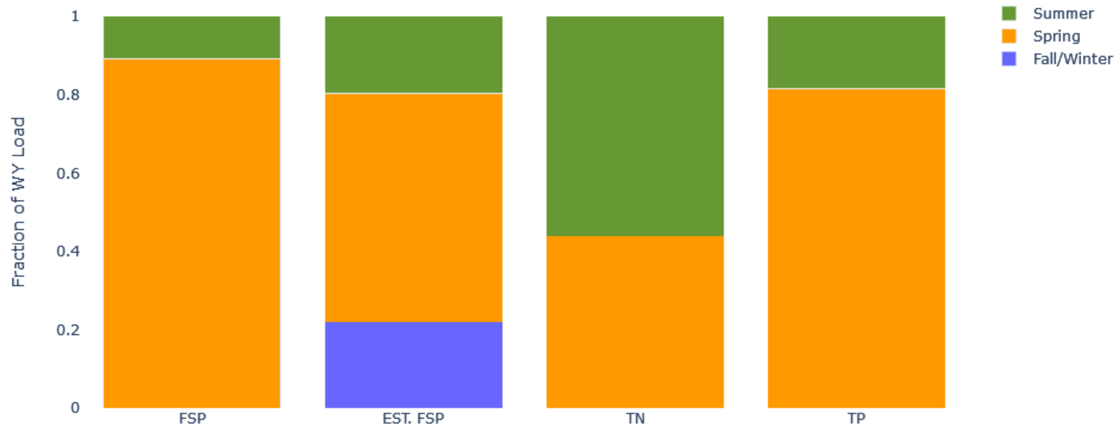

Figure 21 Seasonal load as a fraction of the water year load at the Contech MFS outflow, WY21. The first FSP column represents the FSP load calculated using event mean concentrations and the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP loads (based on samples and continuous turbidity) at the inflow and outflow was generated in the spring.
- The largest fraction of FSP loads (based on samples and continuous turbidity) at the outflow was generated in the spring.
- The largest fraction of TN loads at the inflow was generated in the summer.
- The largest fraction of TN loads at the outflow was generated in the summer.
- The largest fraction of TP loads at the inflow was generated in the spring.
- The largest fraction of TP loads at the outflow was generated in the spring.

Jellyfish

Daily flow and FSP EMC summaries for the Jellyfish inflow and outflow are presented in Figure 22 and Figure 23, respectively. Table 7 presents EMC data in tabular form. Table 7 also presents the load data referenced in some bullet points below.

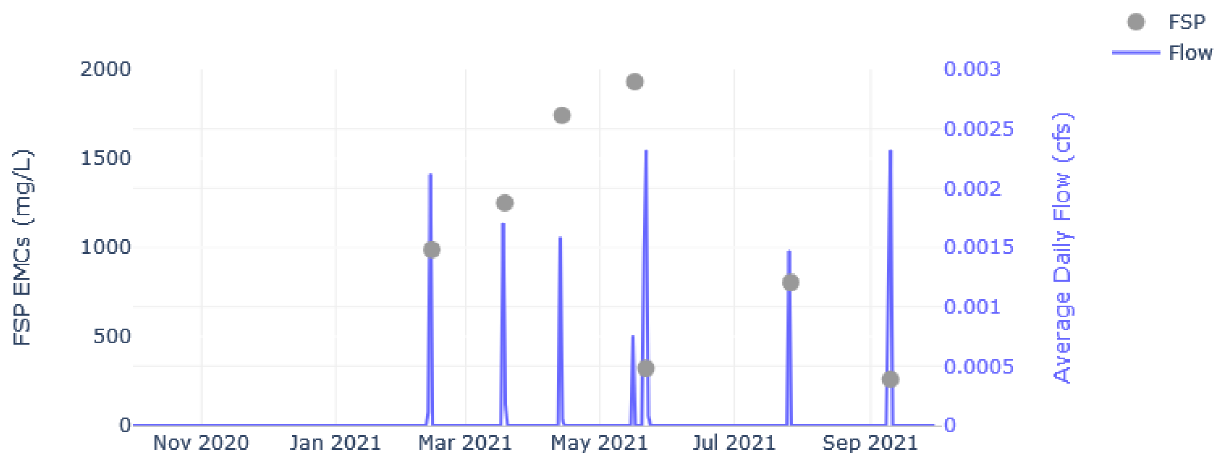

Figure 22 Daily inflow and FSP EMC summary at the Jellyfish, WY21.

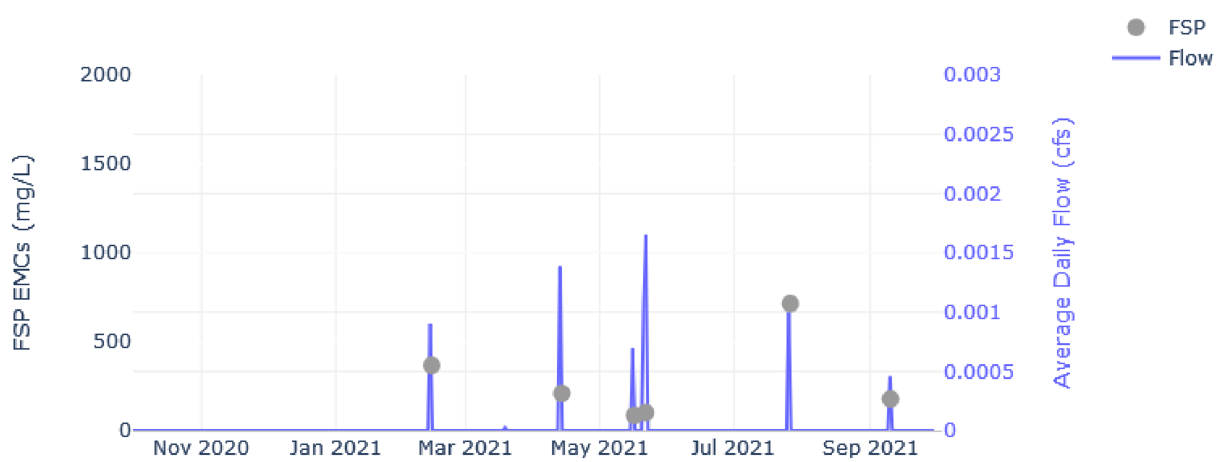

Figure 23 Daily outflow and FSP EMC summary at the Jellyfish, WY21.

- Seven events were sampled for FSP at Jellyfish inflow (one in the fall/winter, four in the spring, two in the summer) and six events were sampled for FSP at Jellyfish outflow (one in the fall/winter, three in the spring, and two in the summer). Samples for the spring event on March 18, 2021 were not successful at Jellyfish outflow due to low flow.
- In all sampled events with samples at both the inflow and outflow, FSP EMCs were lower at the outflow than the inflow indicating treatment occurred.
- The highest FSP EMC at the inflow occurred during the thunderstorm event on May 16, 2021.
- The highest FSP EMC at the outflow occurred during the thunderstorm event on July 26, 2021.
- The highest FSP load at the inflow occurred during an event snowmelt on April 13-14, 2021.
- The highest FSP load at the outflow occurred during the thunderstorm event on July 26, 2021.

- The lowest FSP EMCs and loads at the inflow occurred during the thunderstorm event on September 9-10, 2021.
- The lowest FSP EMCs and loads at the outflow occurred during a thunderstorm event on May 16, 2021.

Daily flow and TN EMC summaries for the Jellyfish inflow and outflow are presented in Figure 24 and Figure 25, respectively. Table 7 presents EMC data in tabular form. Table 7 also presents the load data referenced in some bullet points below.

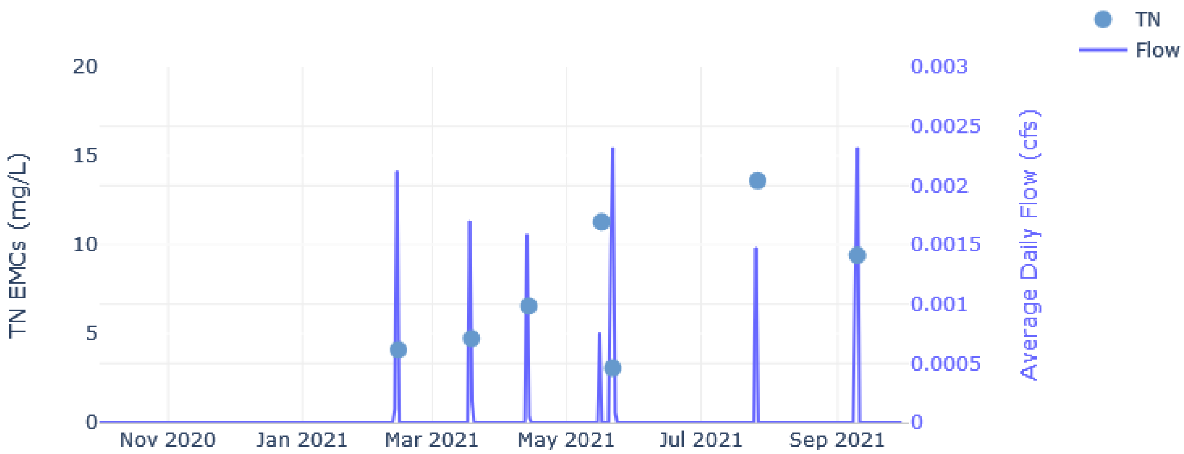

Figure 24 Daily inflow and TN EMC summary at the Jellyfish, WY21.

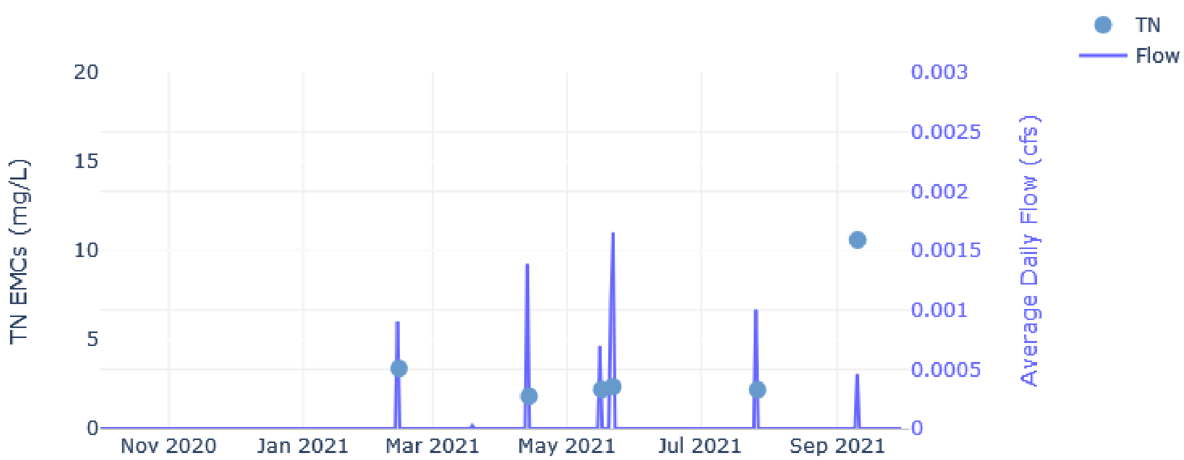

Figure 25 Daily outflow and TN EMC summary at the Jellyfish, WY21.

- Seven events were sampled for TN at Jellyfish inflow (one in the fall/winter, four in the spring, two in the summer) and six events were sampled for TN at Jellyfish outflow (one in the fall/winter, three in the spring, and two in the summer). Samples for the spring event on March 18, 2021 were not successful at Jellyfish outflow due to low flow.
- In five out of the six sampled events with samples at both the inflow and outflow, TN EMCs were lower at the outflow than the inflow indicating treatment occurred.
- The highest TN EMC at the inflow occurred during a thunderstorm event on July 26, 2021.
- The highest TN EMC at the outflow occurred during a thunderstorm event on September 10, 2021.
- The highest TN load at the inflow occurred during the thunderstorm event on September 10, 2021.

- The highest TN load at the outflow occurred during the event snowmelt on May 21-23, 2021.
- The lowest TN EMC at the inflow occurred during the event snowmelt on May 21-23, 2021.
- The lowest TN EMC at the outflow occurred during the event snowmelt on April 13, 2021.
- The lowest TN load at the inflow and outflow occurred during the thunderstorm event on May 16, 2021.

Daily flow and TP EMC summaries for the Jellyfish inflow and outflow are presented in Figure 26 and Figure 27, respectively. Table 7 presents EMC data in tabular form. Table 7 also presents the load data referenced in some bullet points below.

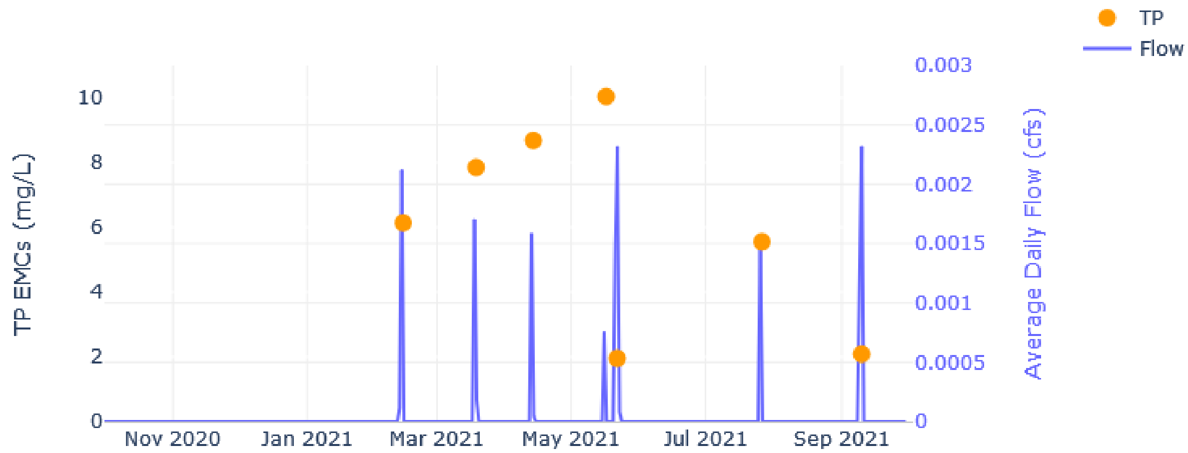

Figure 26 Daily inflow and TP EMC summary at the Jellyfish, WY21.

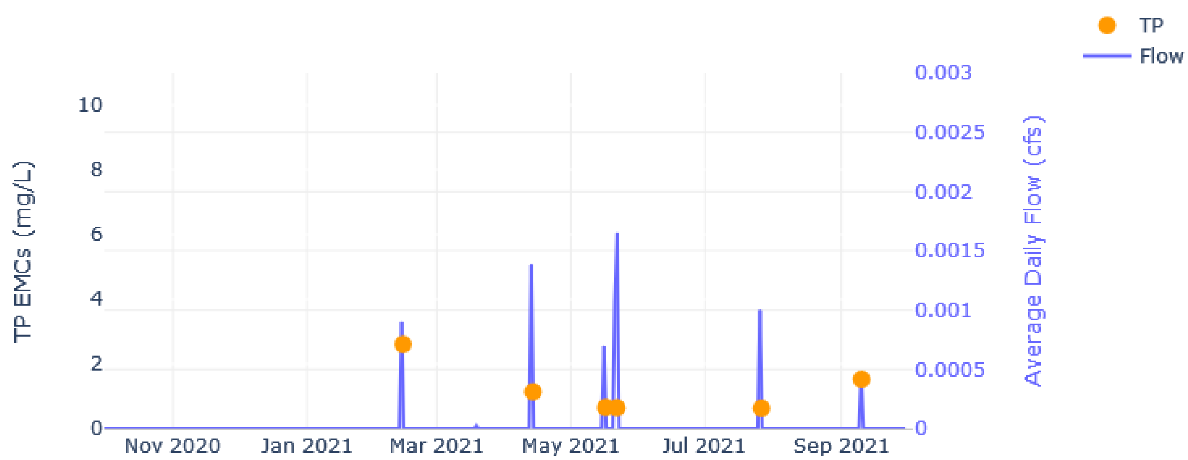

Figure 27 Daily outflow and TP EMC summary at the Jellyfish, WY21.

- Seven events were sampled for TP at Jellyfish inflow (one in the fall/winter, four in the spring, two in the summer) and six events were sampled for TP at Jellyfish outflow (one in the fall/winter, three in the spring, and two in the summer). Samples for the spring event on March 18, 2021 were not successful at Jellyfish outflow due to low flow.
- In all sampled events, TP EMCs were lower at the outflow than the inflow indicating treatment occurred.
- The highest TP EMC at the inflow occurred during the thunderstorm event on May 16, 2021.
- The highest TP EMC at the outflow occurred during the event snowmelt on February 13, 2021.

- The highest TP load at the inflow occurred during the rain on snow event on March 18, 2021.
- The highest TP load at the outflow occurred during the event snowmelt on February 13, 2021.
- The lowest TP EMC at the inflow occurred during the event snowmelt May 21-23, 2021.
- The lowest TP EMC at the outflow occurred during the thunderstorm event on July 26, 2021.
- The lowest TP load at the inflow occurred during the thunderstorm event on September 9-10, 2021.
- The lowest TP load at the outflow occurred during the thunderstorm event on May 16, 2021.

Seasonal load as a fraction of the water year load for the Jellyfish inflow and outflow are presented in Figure 28 and Figure 29, respectively. Event loads are presented in tabular form in Table 7.

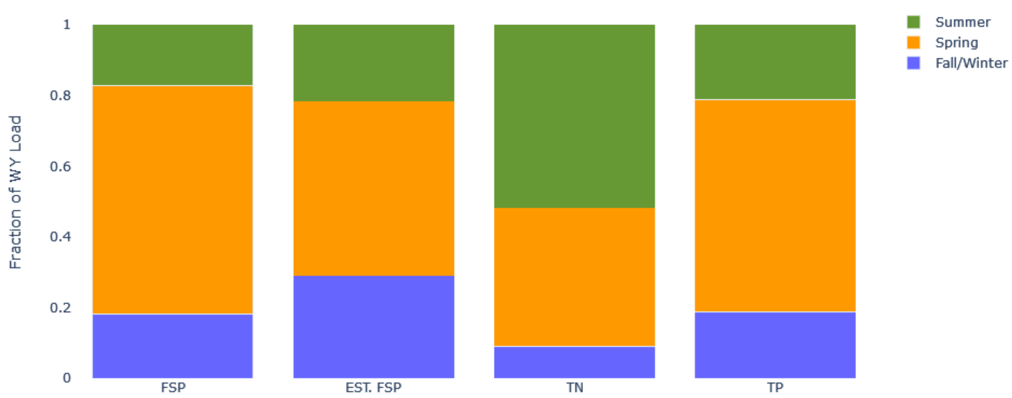

Figure 28 Seasonal load as a fraction of the water year load at the Jellyfish inflow, WY21. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

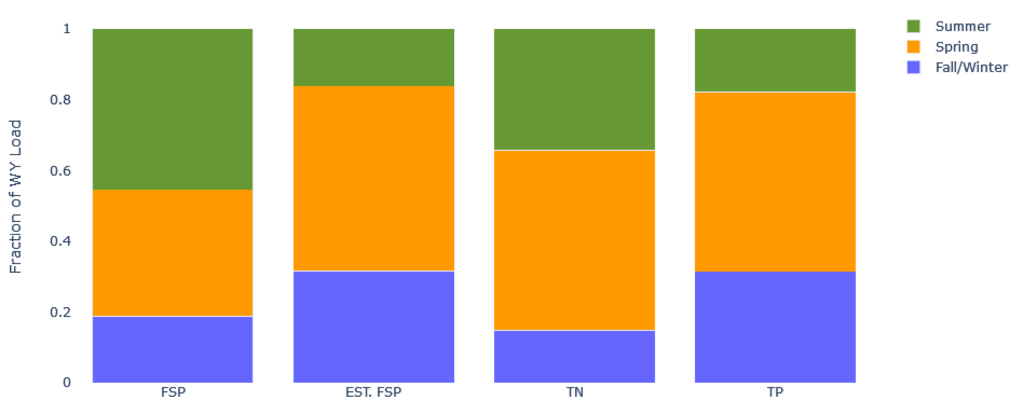

Figure 29 Seasonal load as a fraction of the water year load at the Jellyfish outflow, WY21. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP loads (based on samples) at the inflow was generated in the spring.
- The largest fraction of FSP loads (based on samples) at the outflow was generated in the summer.

- The largest fraction of FSP loads (based on continuous turbidity) at the inflow was generated in the spring.
- The largest fraction of FSP loads (based on continuous turbidity) at the outflow was generated in the spring.
- The largest fraction of TN loads at the inflow was generated in the summer.
- The largest fraction of TN loads at the outflow was generated in the spring.
- The largest fraction of TP loads at the inflow was generated in the spring.
- The largest fraction of TP loads at the outflow was generated in spring.

Seven and five events were sampled at the Contech MFS inflow and outflow respectively, and seven and six events were sampled at the Jellyfish inflow and outflow respectively, in WY21. Event summary data for the Contech MFS and Jellyfish treatment vaults is presented in Table 6 and Table 7 respectively.

Table 6 Event summary data at the Contech MFS treatment vault, WY21.

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	2/13/2021 13:55	2/13/2021 15:00	1:05	136	0.07	1,846	1.05	Event Snowmelt	100%	1,365	11.56	5,544	0.05	8,498	0.07
CI	Spring	3/18/2021 19:05	3/19/2021 0:55	5:50	84	0.03	1,643	0.23	Rain on snow	100%	1,697	8.88	5,673	0.03	10,208	0.05
CO	Spring	3/18/2021 20:50	3/19/2021 1:00	4:10	56	0.02	1,017	0.23	Rain on snow	100%	1,016	3.57	4,750	0.02	6,751	0.02
CI	Spring	4/13/2021 18:00	4/13/2021 21:25	3:25	67	0.05	1,339	0.27	Event Snowmelt	100%	1,657	6.90	6,415	0.03	8,684	0.04
CO	Spring	4/13/2021 18:10	4/13/2021 21:50	3:40	57	0.03	609	0.27	Event Snowmelt	100%	654	2.31	3,355	0.01	3,745	0.01
CI	Spring	5/16/2021 19:25	5/16/2021 19:50	0:25	55	0.10	1,534	0.10	Thunderstorm	100%	1,737	6.01	10,994	0.04	9,597	0.03
CO	Spring	5/16/2021 19:25	5/16/2021 20:25	1:00	44	0.04	954	0.10	Thunderstorm	100%	830	2.30	6,764	0.02	4,477	0.01
CI	Spring	5/21/2021 20:55	5/23/2021 1:45	28:50	337	0.10	735	0.48	Event Snowmelt	100%	354	7.44	3,553	0.07	2,305	0.05
CO	Spring	5/21/2021 21:00	5/23/2021 0:00	27:00	224	0.04	321	0.48	Event Snowmelt	100%	217	3.04	3,046	0.04	1,269	0.02
CI	Summer	7/26/2021 15:55	7/26/2021 16:30	0:35	115	0.16	1,224	0.13	Thunderstorm	100%	900	6.44	17,148	0.12	6,663	0.05
CI	Summer	9/9/2021 23:35	9/10/2021 6:15	6:40	232	0.11	422	0.24	Thunderstorm	100%	252	3.65	11,195	0.16	2,131	0.03
CO	Summer	9/9/2021 23:50	9/10/2021 5:50	6:00	84	0.02	435	0.24	Thunderstorm	100%	126	0.66	10,734	0.06	1,414	0.01

Table 7 Event summary data at the Jellyfish treatment vault, WY21.

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	2/13/2021 13:55	2/13/2021 15:15	1:20	184	0.08	1,346	1.05	Event Snowmelt	100%	988	11.32	4,098	0.05	6,140	0.07
JO	Fall/Winter	2/13/2021 14:20	2/13/2021 15:50	1:30	78	0.05	951	1.05	Event Snowmelt	100%	367	1.78	3,381	0.02	2,612	0.01
JI	Spring	3/18/2021 19:05	3/19/2021 1:00	5:55	163	0.04	819	0.23	Rain on snow	100%	1,251	12.73	4,732	0.05	7,851	0.08
JI	Spring	4/13/2021 17:55	4/14/2021 1:40	7:45	141	0.07	443	0.27	Event Snowmelt	100%	1,743	15.32	6,560	0.06	8,684	0.08
JO	Spring	4/13/2021 18:00	4/13/2021 22:25	4:25	120	0.07	302	0.27	Event Snowmelt	100%	210	1.57	1,817	0.01	1,141	0.01
JI	Spring	5/16/2021 19:25	5/16/2021 19:55	0:30	66	0.11	1,451	0.10	Thunderstorm	100%	1,932	7.93	11,287	0.05	10,043	0.04
JO	Spring	5/16/2021 19:25	5/16/2021 20:20	0:55	60	0.07	997	0.10	Thunderstorm	100%	86	0.32	2,198	0.01	657	<0.01
JI	Spring	5/21/2021 20:55	5/23/2021 1:55	29:00	335	0.07	774	0.48	Event Snowmelt	100%	322	6.72	3,074	0.06	1,952	0.04
JO	Spring	5/21/2021 21:00	5/23/2021 0:00	27:00	235	0.06	273	0.48	Event Snowmelt	100%	101	1.49	2,359	0.03	645	0.01
JI	Summer	7/26/2021 15:55	7/26/2021 16:35	0:40	128	0.17	926	0.13	Thunderstorm	100%	804	6.41	13,608	0.11	5,557	0.04
JO	Summer	7/26/2021 16:00	7/26/2021 16:35	0:35	87	0.11	560	0.13	Thunderstorm	100%	714	3.88	2,185	0.01	631	<0.01
JI	Summer	9/9/2021 23:35	9/10/2021 6:25	6:50	302	0.12	586	0.24	Thunderstorm	100%	260	4.90	9,405	0.18	2,087	0.04
JO	Summer	9/10/2021 4:50	9/10/2021 5:50	1:00	40	0.03	187	0.24	Thunderstorm	100%	178	0.44	10,596	0.03	1,527	<0.01

6.2.2 Elks Club

Figure 30 shows the average daily flow and cumulative precipitation for WY21 at the Elks Club catchment outfall.

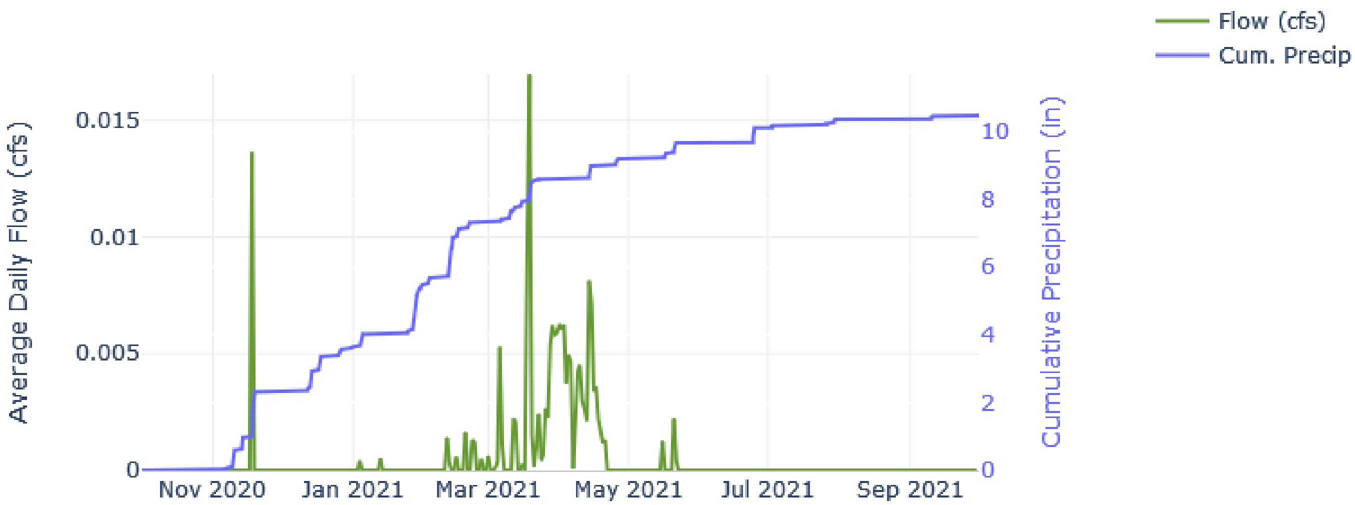

Figure 30 Average daily flow and cumulative precipitation at the Elks Club catchment outfall, WY21.

- 10.48 inches of total precipitation (7.32 in the fall/winter, 2.36 in the spring, 0.80 in the summer) were recorded at the Shakori (SHK) weather station.
- 39 precipitation events occurred (19 fall/winter events, 12 spring events, 8 summer events).
- The largest storm, with 1.35 inches of precipitation, occurred during a rain and snow event that occurred from November 17-19, 2020.
- 87% of storms were less than half an inch.
- Highest average daily flows occurred during the March 19, 2021 rain on snow event.
- 50 days of snowmelt runoff occurred in the fall/winter and spring.
- The highest instantaneous peak precipitation was 0.16 inches in 10 minutes during a thunderstorm event on June 24, 2021.
- The highest instantaneous peak flow was 0.36 cfs during a rain and snow event on March 18, 2021.
- The largest runoff event was produced by *snowmelt*, which occurred in April (3,068 cf). The most runoff caused by a precipitation event occurred during the March 18-20, 2021 rain and snow event (2,430 cf).

Daily flow and the FSP EMC summary at Elks Club are presented in Figure 31. Table 8 presents EMC data in tabular form. Table 8 also presents the load data referenced in some bullet points below.

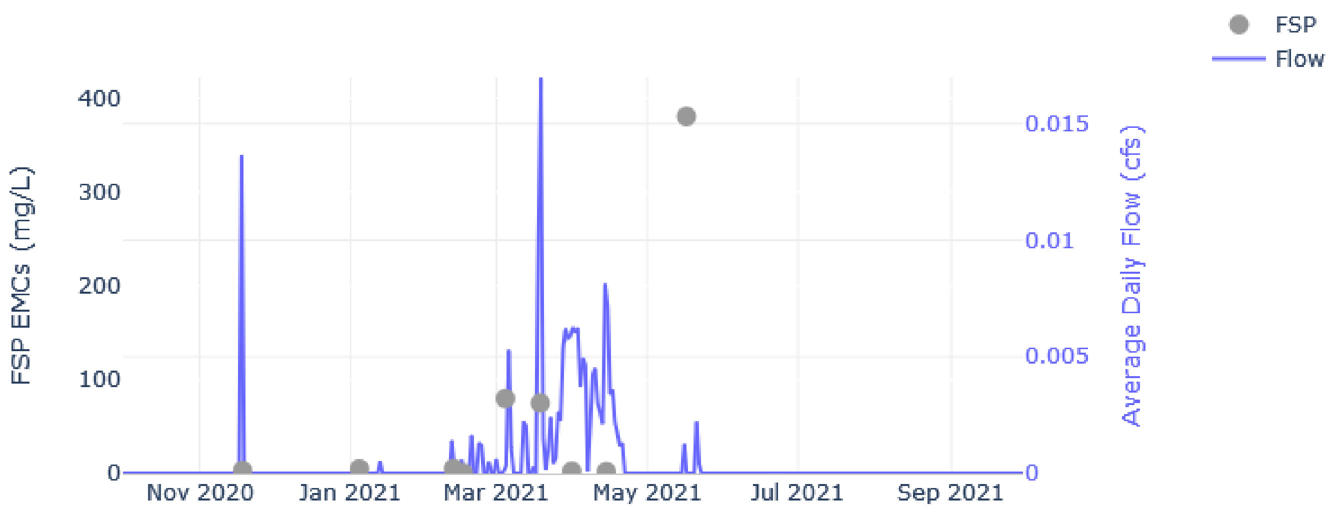

Figure 31 Daily flow and FSP EMC summary at the Elks Club catchment outfall, WY21.

- Nine events were sampled for FSP (four in the fall/winter, five in the spring, and zero in the summer).
- The highest FSP EMC occurred during the thunderstorm event on May 16, 2021.
- The highest FSP load occurred during the rain on snow event March 18-20, 2021.
- The lowest FSP EMC and load occurred during the rain on snow event February 15, 2021.

Daily flow and the TN EMC summary at Elks Club are presented in Figure 32. Table 8 presents EMC data in tabular form. Table 8 also presents the load data referenced in some bullet points below.

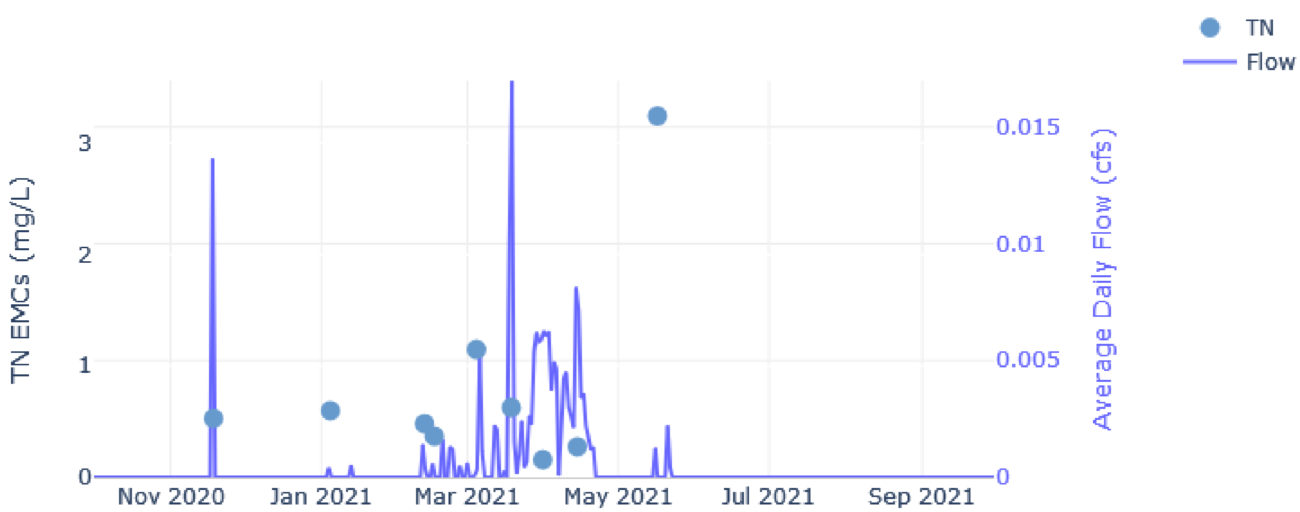

Figure 32 Daily flow and TN EMC summary at the Elks Club catchment outfall, WY21.

- Nine events were sampled for TN (four in the fall/winter, five in the spring, and zero in the summer).
- The highest TN EMC occurred during a thunderstorm event on May 16, 2021
- The highest TN load occurred during a rain on snow event March 18-20, 2021.
- The lowest TN EMC occurred during a snowmelt event from March 31, 2021 to April 3, 2021.
- The lowest TN load occurred a rain on snow event February 15, 2021.

Daily flow and the TP EMC summary at Elks Club are presented in Figure 33. Table 8 presents EMC data in tabular form. Table 8 also presents the load data referenced in some bullet points below.

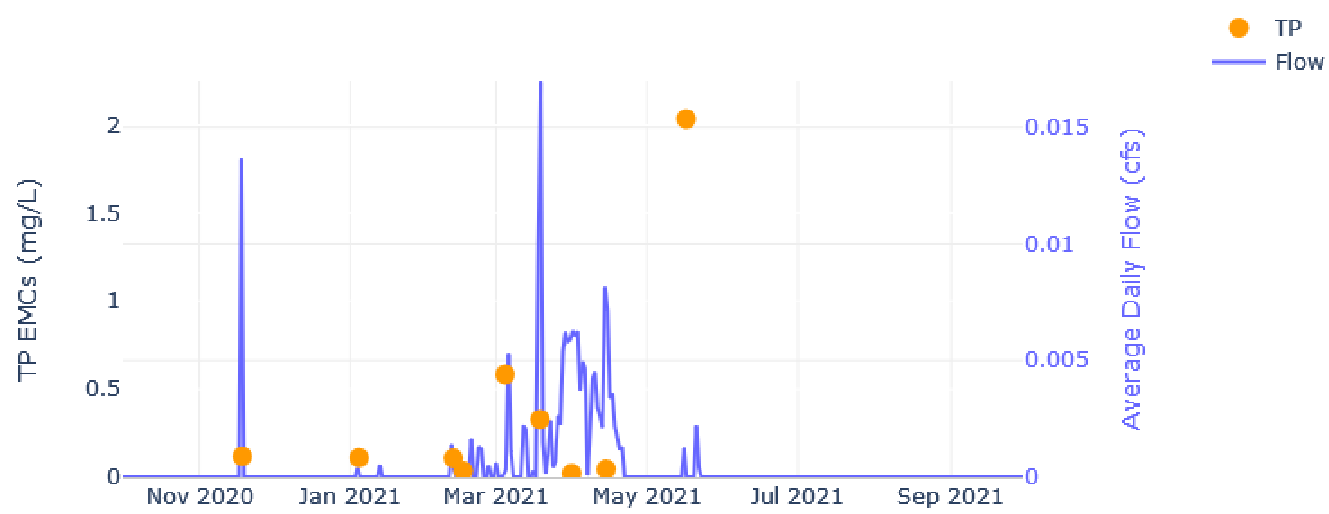

Figure 33 Daily flow and TP EMC summary at the Elks Club catchment outfall, WY21.

- Nine events were sampled for TP (four in the fall/winter, five in the spring, and zero in the summer).
- The highest TP EMC occurred during a thunderstorm event on May 16, 2021.
- The highest TP load occurred during a rain on snow event March 18-20, 2021.
- The lowest TP EMC occurred during a non-event snowmelt from March 31, 2021 to April 3, 2021.
- The lowest TP load occurred during a rain on snow event on February 15, 2021.

Seasonal load as a fraction of the water year load at Elks Club is presented in Figure 34. Event loads are presented in tabular form in Table 8.

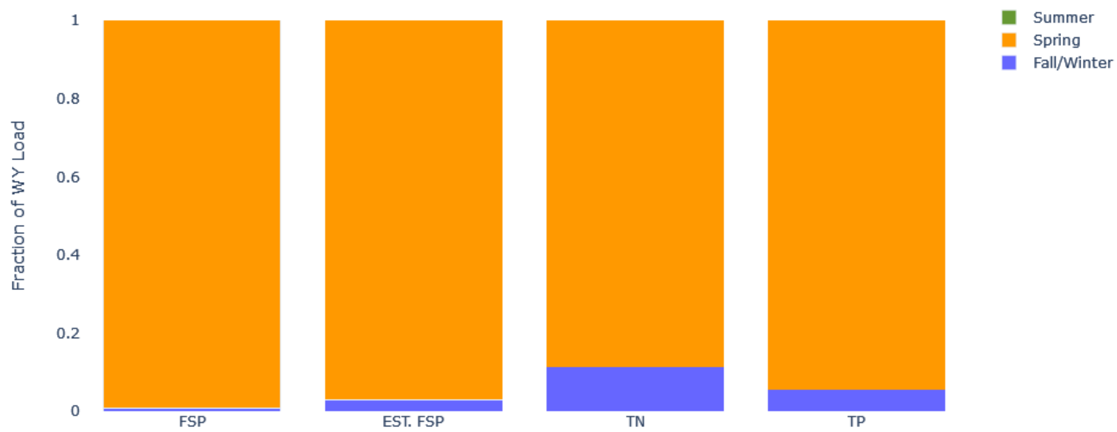

Figure 34 Seasonal load as a fraction of the water year load at the Elks Club catchment outfall, WY21. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP loads from samples and continuous turbidity was generated in the spring.
- The largest fraction of TN loads was generated in the spring.
- The largest fraction of TP loads was generated in the spring.

Nine events were sampled at Elks Club in WY21. Event summary data is presented in Table 8.

Table 8 Event summary data at the Elks Club catchment outfall, WY21

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)
EC	Fall/Winter	11/18/2020 7:45	11/18/2020 18:35	10:50	1,180	0.08	46	1.26	Rain on snow	100%	3	0.23	530	0.04	119	0.01
EC	Fall/Winter	1/4/2021 13:55	1/4/2021 16:45	2:50	36	0.01	59	0.24	Rain on snow	100%	5	0.01	599	<0.01	111	<0.01
EC	Fall/Winter	2/11/2021 16:30	2/12/2021 19:00	26:30	151	0.01	57	0.82	Event Snowmelt	100%	5	0.05	482	<0.01	108	<0.01
EC	Fall/Winter	2/15/2021 15:50	2/15/2021 18:30	2:40	52	0.01	4	0.26	Rain on snow	100%	0.4	<0.01	370	<0.01	36	<0.01
EC	Spring	3/4/2021 15:35	3/6/2021 19:35	52:00	497	0.09	472	0.09	Non-Event Snowmelt	100%	80	2.48	1,147	0.04	583	0.02
EC	Spring	3/18/2021 18:05	3/20/2021 6:50	36:45	2,430	0.36	1,162	0.61	Rain on snow	100%	75	11.40	627	0.10	329	0.05
EC	Spring	3/31/2021 13:10	4/3/2021 11:00	69:50	1,577	0.01	4	0.00	Non-Event Snowmelt	100%	3	0.25	159	0.02	22	<0.01
EC	Spring	4/14/2021 11:15	4/14/2021 21:30	10:15	345	0.01	8	0.39	Event Snowmelt	100%	2	0.04	275	0.01	46	<0.01
EC	Spring	5/16/2021 20:15	5/16/2021 22:55	2:40	111	0.09	728	0.12	Thunderstorm	100%	381	2.64	3,242	0.02	2,035	0.01

6.2.3 Lakeshore

Figure 35 shows the average daily flow and cumulative precipitation for WY21 at the Lakeshore catchment outfall.

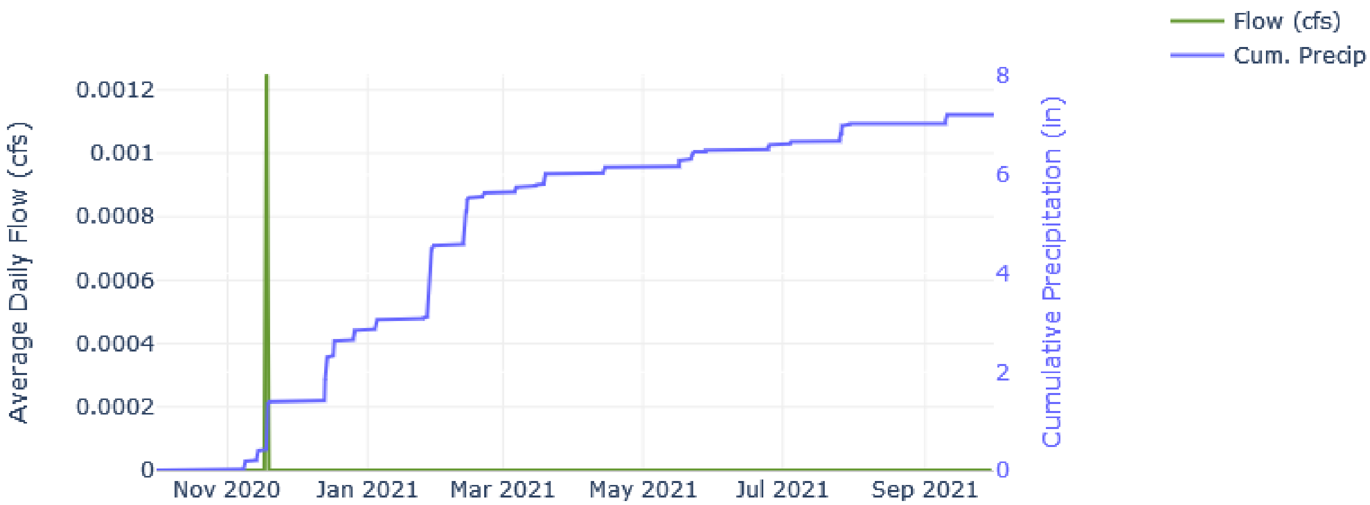

Figure 35 Average daily flow and cumulative precipitation at the Lakeshore catchment outfall, WY21.

- 7.22 inches of total precipitation (5.63 in the fall/winter, 0.87 in the spring, and 0.72 in the summer) were recorded at the TERC weather station.
- 34 precipitation events occurred (16 fall/winter events, 10 spring events, 8 summer events).
- The largest storm, with 1.47 inches of precipitation, was a snow event that occurred on January 26-29, 2021.
- 88% of storms were less than half an inch.
- WY21 was a very dry year and only produced one runoff event.
- Highest average daily flows occurred in during the rain on snow event on November 18, 2020.
- There were zero days of snowmelt.
- The highest instantaneous peak precipitation was 0.08 inches in 5 minutes during the thunderstorm event on July 25, 2021.
- The highest instantaneous peak flow was 0.04 cfs during the rain on snow event on November 18, 2020.
- The November 18, 2020 rain on snow event produced the most runoff (108 cf).

Daily flow and FSP EMC summaries at Lakeshore are presented in Figure 36. Table 9 presents EMC data in tabular form. Table 9 also presents the load data referenced in some bullet points below.

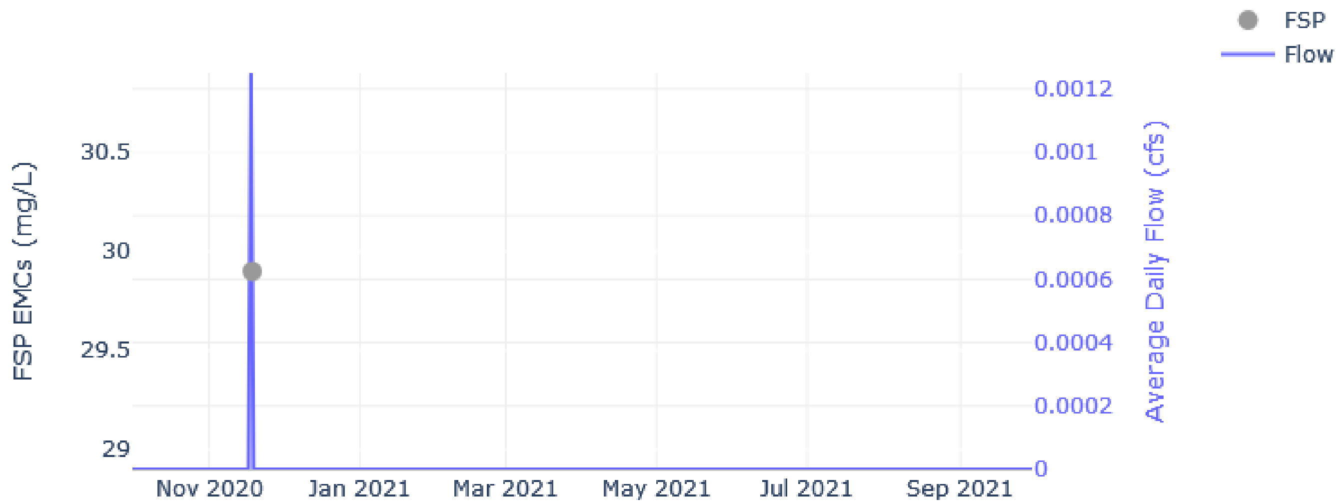

Figure 36 Daily outflow and FSP EMC summary at the Lakeshore catchment outfall, WY21.

- Only one event was sampled for FSP (one in the fall/winter) because it was a very dry water year and only one period of flow was observed.
- The highest FSP EMC and load occurred during the rain on snow event on November 18, 2020, as this was the only event that resulted in flow.

The daily flow and TN EMC summaries at Lakeshore are presented in Figure 37. Table 9 presents EMC data in tabular form. Table 9 also presents the load data referenced in some bullet points below.

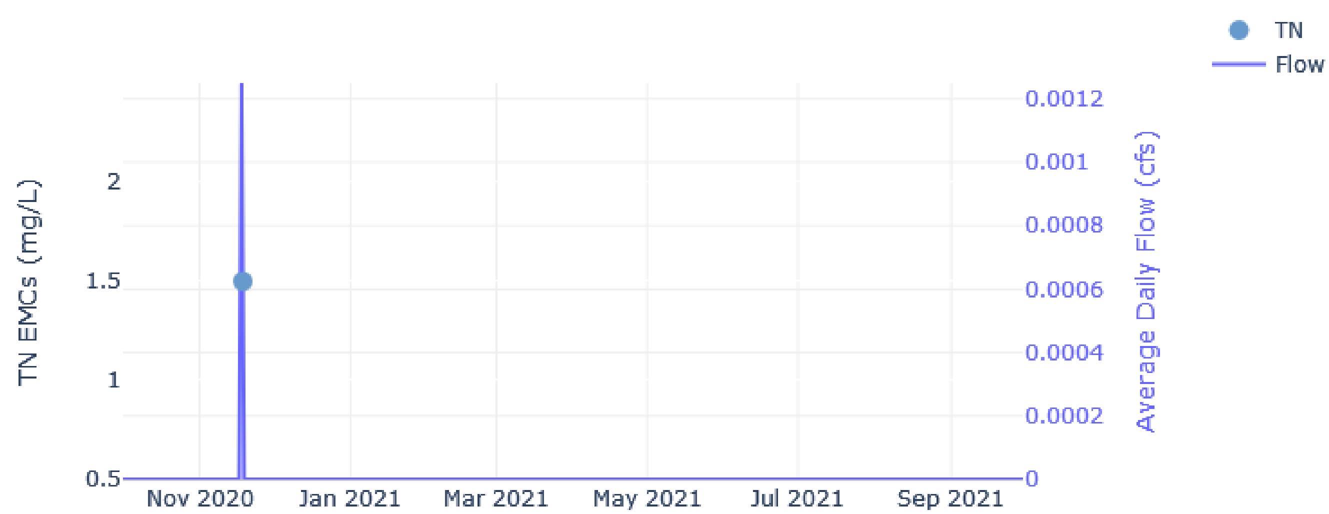

Figure 37 Daily outflow and TN EMC summary at the Lakeshore catchment outfall, WY21.

- Only one event was sampled for TN (one in the fall/winter) because it was a very dry water year and only one period of flow was observed.
- The highest TN EMC and load occurred during the rain on snow event on November 18, 2020, as this was the only event that resulted in flow.

The daily flow and TP EMC summary at Lakeshore are presented in Figure 38. Table 9 presents EMC data in tabular form. Table 9 also presents the load data referenced in some bullet points below.

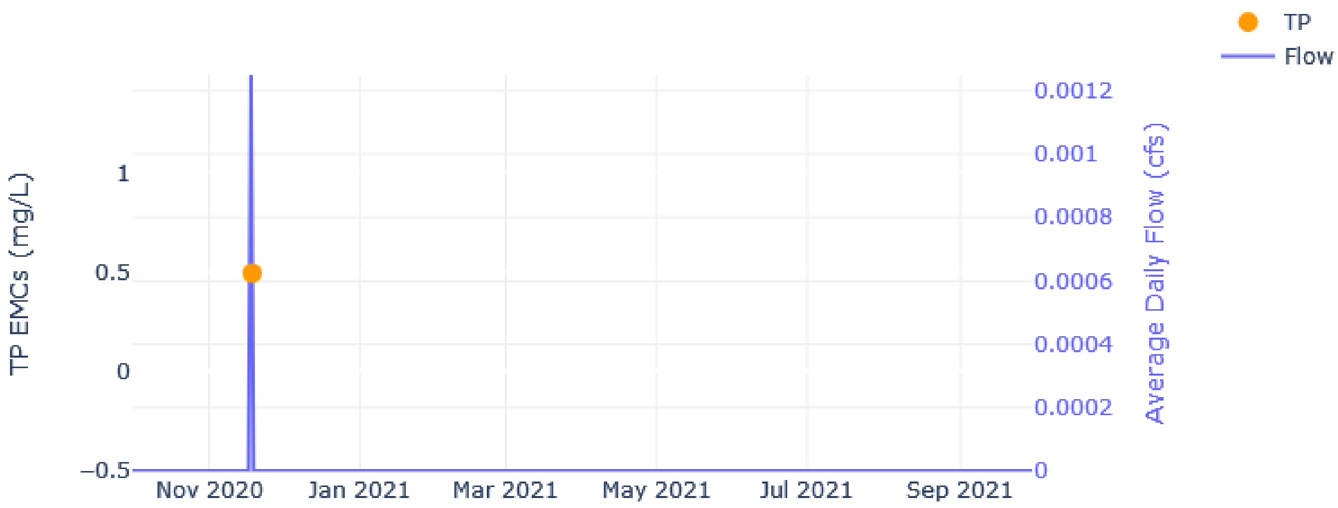

Figure 38 Daily outflow and TP EMC summary at the Lakeshore catchment outfall, WY21.

- Only one event was sampled for TP (one in the fall/winter) because it was a very dry water year and only one period of flow was observed.
- The highest TP EMC and load occurred during the rain on snow event on November 18, 2020, as this was the only event that resulted in flow.

Seasonal load as a fraction of the water year load at Lakeshore are presented in Figure 39. Event loads are presented in tabular form in Table 9.

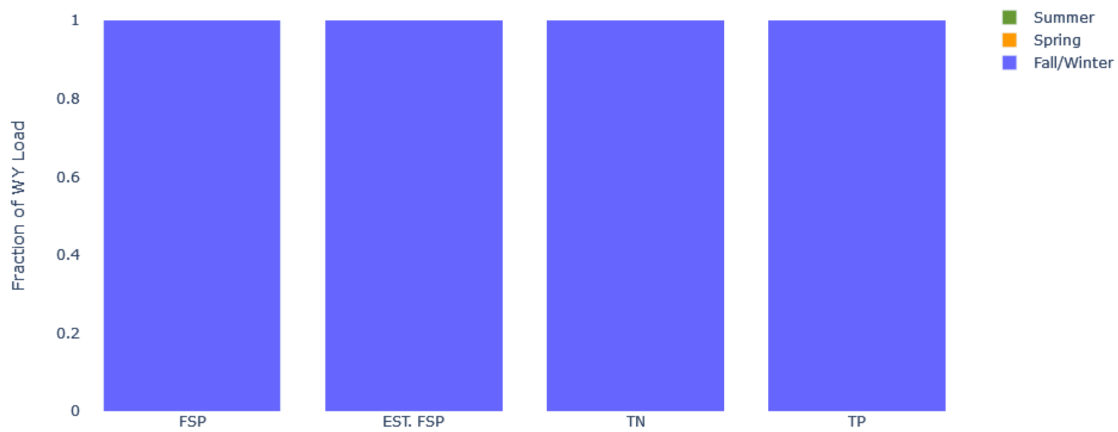

Figure 39 Seasonal load as a fraction of the water year load at the Lakeshore catchment outfall, WY21. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP, TN, and TP load was generated in the fall/winter because there was only one period of runoff for the year that occurred in November.
- No FSP, TN, or TP loads were generated in the spring or summer because there was no runoff.

One event was sampled at Lakeshore catchment outfall in WY21. Event summary data for the Lakeshore catchment outfall is presented in Table 9.

Table 9 Event summary data at the Lakeshore catchment outfall, WY21.

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)
LS	Fall/Winter	11/18/2020 9:15	11/18/2020 11:40	2:25	108	0.04	135	0.96	Rain on snow	100%	30	0.20	1,496	0.01	494	<0.01

6.2.4 Pasadena

Figure 40 shows the average daily flow and cumulative precipitation for WY21 at the Pasadena outfall.

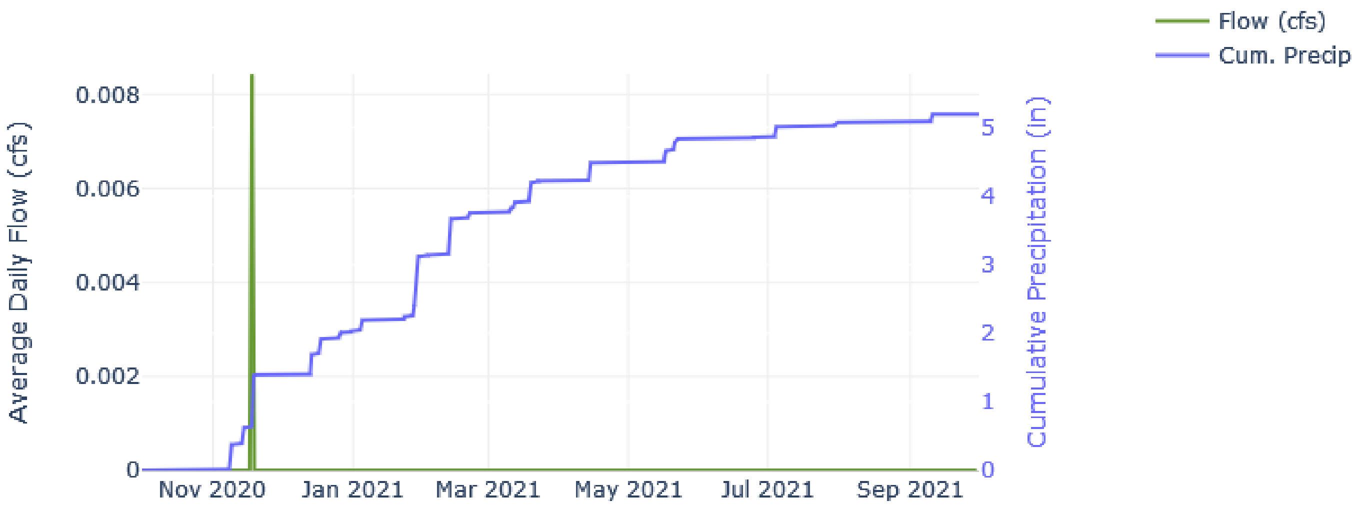

Figure 40 Average daily flow and cumulative precipitation at the Pasadena outfall, WY21.

- 5.20 inches of total precipitation (3.76 in the fall/winter, 1.09 in the spring, and 0.35 in the summer) were recorded at the Bellevue (BV) weather station. The Bellevue weather station is located at the edge of a meadow and likely gets high winds during precipitation events, and therefore may be subject to undercatch.
- 31 precipitation events occurred (14 fall/winter events, 11 spring events, 6 summer events).
- The largest storm, with 0.87 inches of precipitation, was a snow event that occurred from January 27-29, 2021.
- 90% of storms were less than half an inch.
- Highest average daily flow occurred during a rain on snow event on November 18, 2020.
- There were zero days of snowmelt.
- The highest instantaneous peak precipitation was 0.06 inches in 5 minutes during a snow event on January 27, 2021.
- The highest instantaneous peak flow was 0.1 cfs during the rain on snow event on November 18, 2020.
- The November 18, 2020 rain on snow event produced the most runoff (729 cf).

Daily flow and FSP EMC summaries at the Pasadena outfall are presented in Figure 41. Table 10 presents EMC data in tabular form. Table 10 also presents the load data referenced in some bullet points below.

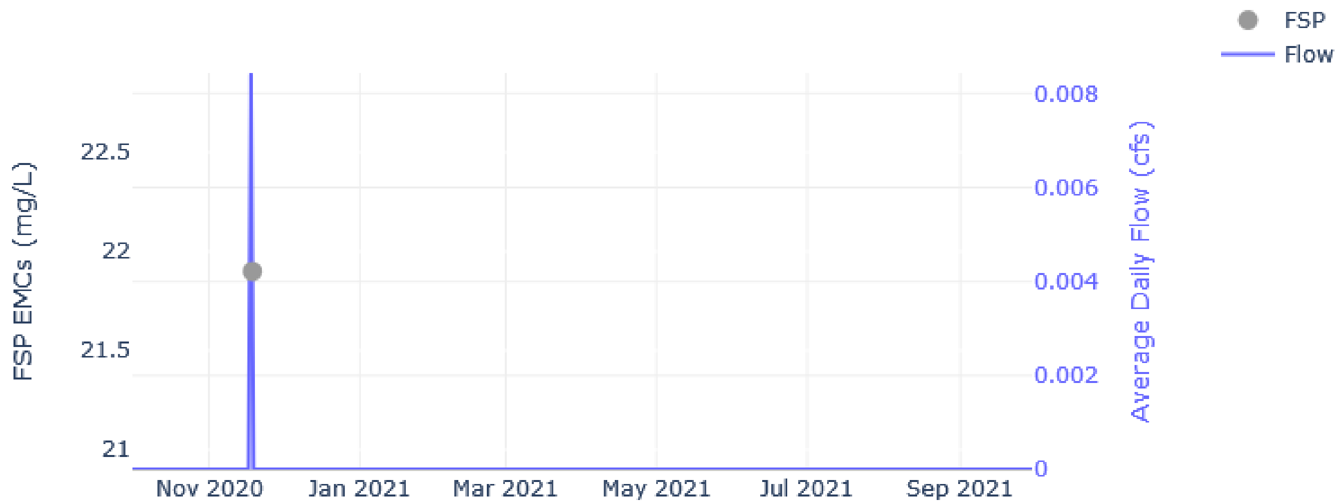

Figure 41 Daily outflow and FSP EMC summary at the Pasadena outfall, WY21.

- Only one event was sampled for FSP (one in the fall/winter) because it was a very dry water year.
- The highest FSP EMC and load occurred during the rain on snow event on November 18, 2020, as this was the only event that resulted in enough flow to sample.

The daily flow and TN EMC summaries at the Pasadena outfall are presented in Figure 42. Table 10 presents EMC data in tabular form. Table 10 also presents the load data referenced in some bullet points below.

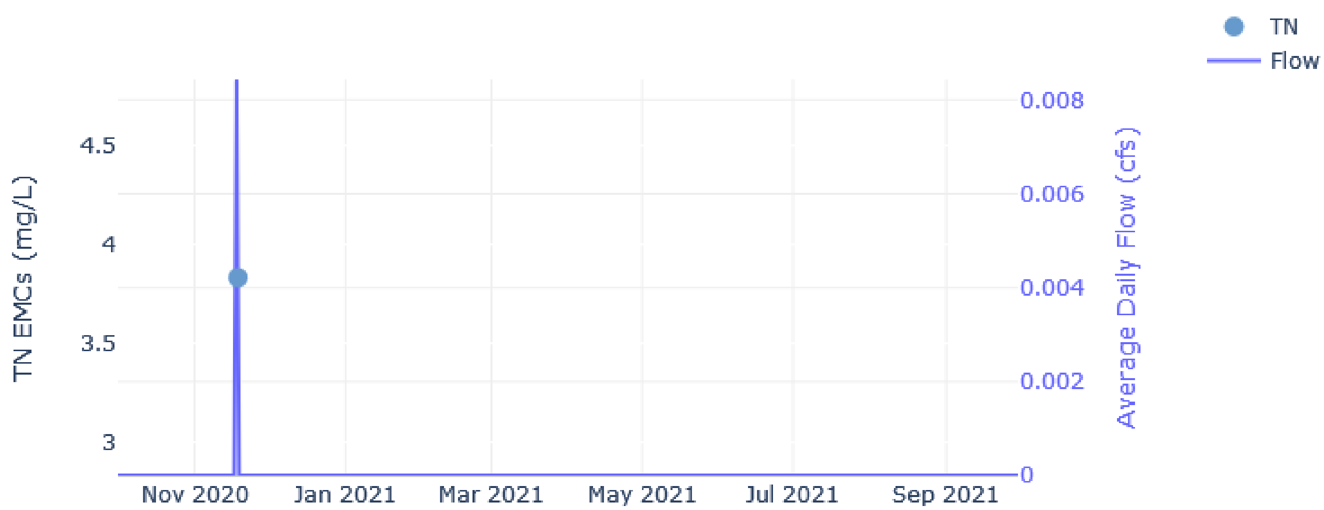

Figure 42 Daily outflow and TN EMC summary at the Pasadena outfall, WY21.

- Only one event was sampled for TN (one in the fall/winter) because it was a very dry water year.
- The highest TN EMC and load occurred during the rain on snow event on November 18, 2020, as this was the only event that resulted in enough flow to sample.

The daily flow and TP EMC summary at the Pasadena outflow are presented Figure 43. Table 10 presents EMC data in tabular form. Table 10 also presents the load data referenced in some bullet points below.

Figure 43 Daily outflow and TP EMC summary at the Pasadena outfall, WY21.

- Only one event was sampled for TP (one in the fall/winter) because it was a very dry water year.
- The highest TP EMC and load occurred during the rain on snow event on November 18, 2020, as this was the only event that resulted in enough flow to sample.

Seasonal load as a fraction of the water year load at the Pasadena outflow are presented in Figure 44. Event loads are presented in tabular form in Table 10.

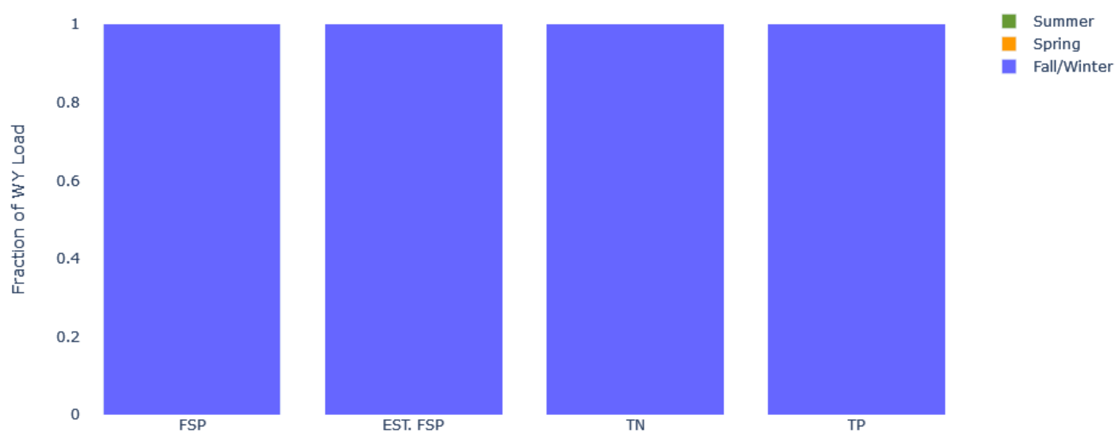

Figure 44 Seasonal load as a fraction of the water year load at the Pasadena outfall, WY21. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP, TN, and TP load was generated in the fall/winter.
- No FSP, TN, or TP loads were generated in the spring or summer because there was no runoff.

One event was sampled at Pasadena in WY21. Event summary data for the Pasadena outfall is presented in Table 10.

Table 10 Event summary data at the Pasadena outfall, WY21.

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)
PO	Fall/Winter	11/18/2020 11:50	11/18/2020 16:35	4:45	729	0.10	70	0.77	Rain on snow	100%	22	1.00	3,833	0.17	570	0.03

6.2.5 Speedboat

Figure 45 shows the average daily flow and cumulative precipitation for WY21 at the Speedboat catchment outfall.

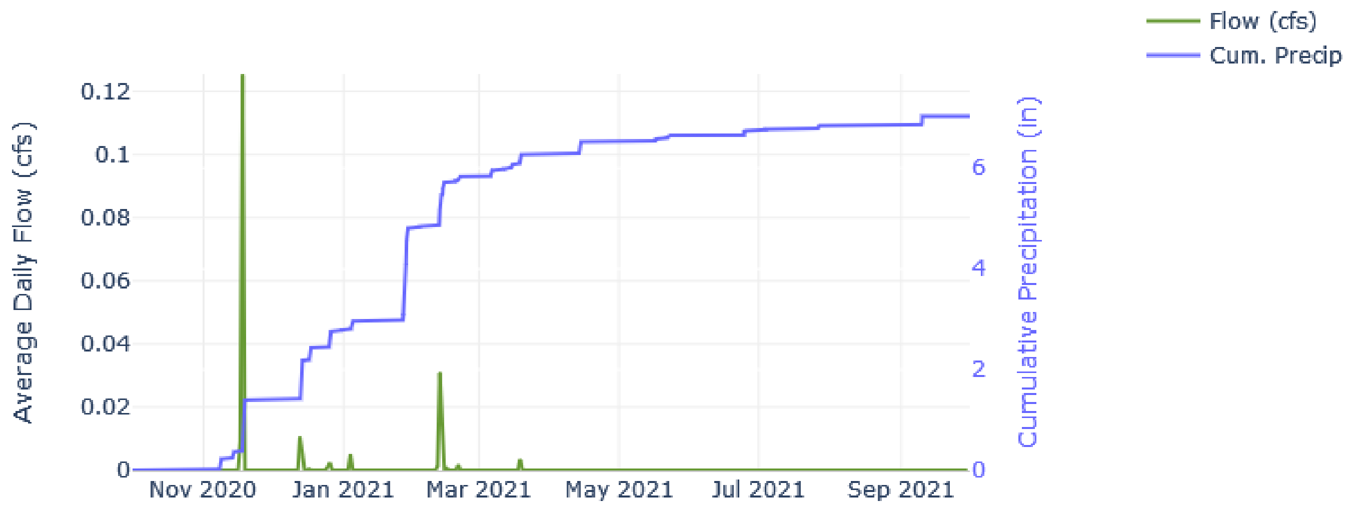

Figure 45 Average daily flow and cumulative precipitation at the Speedboat catchment outfall, WY21.

- 7.03 inches of total precipitation (5.83 in the fall/winter, 0.82 in the spring, and 0.38 in the summer) were recorded at the Nugget (NG) weather station.
- 36 precipitation events occurred (18 fall/winter events, 12 spring events, 6 summer events).
- The largest storm, with 1.83 inches of precipitation, was a snow event that occurred from January 26-29, 2021.
- 89% of storms were less than half an inch.
- Highest average daily flows occurred during the November 18, 2020 rain on snow event.
- 4 days of intermittent snowmelt occurred in the fall/winter.
- The highest instantaneous peak precipitation was 0.08 inches in 10 minutes during a thunderstorm on June 24, 2021.
- The highest instantaneous peak flow was 0.44 cfs during the rain on snow event on November 18, 2020.
- The November 17-18, 2020 rain on snow event produced the most runoff (11,632 cf).

Daily flow and the FSP EMC summary at Speedboat are presented in Figure 46. Table 11 presents EMC data in tabular form. Table 11 also presents the load data referenced in some bullet points below.

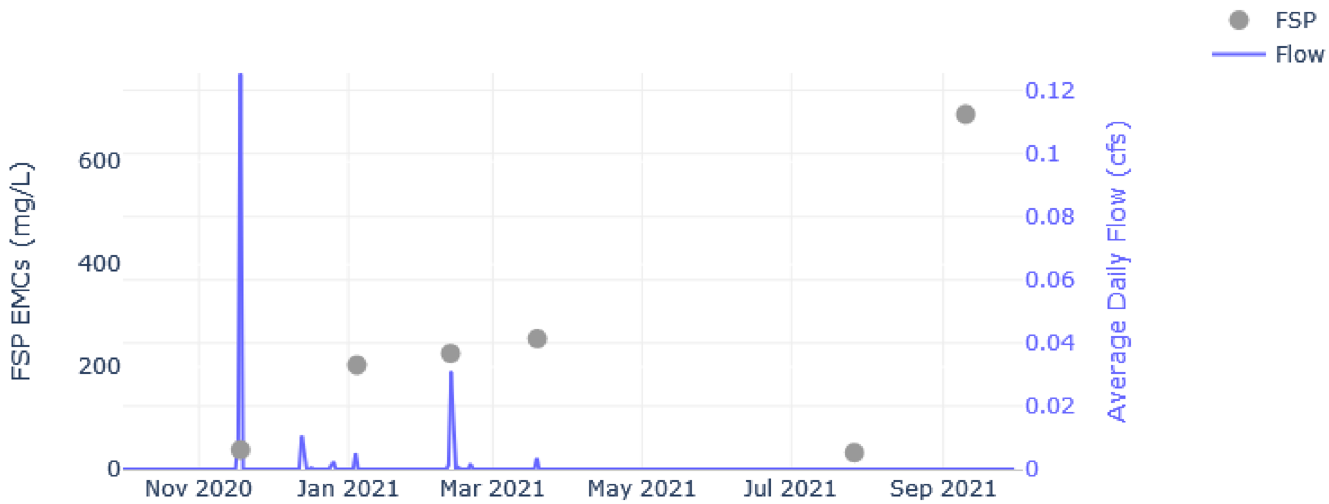

Figure 46 Daily flow and FSP EMC summary at the Speedboat catchment outfall, WY21.

- Six events were sampled for FSP (three in the fall/winter, one in the spring, and two in the summer).
- The highest FSP EMC occurred during a thunderstorm event on September 10, 2021.
- The highest FSP load occurred during an event snowmelt on February 11-13, 2021.
- The lowest FSP EMC and load occurred during thunderstorm event on July 26, 2021.

Daily flow and the TN EMC summary at Speedboat are presented in Figure 47. Table 11 presents EMC data in tabular form. Table 11 also presents the load data referenced in some bullet points below.

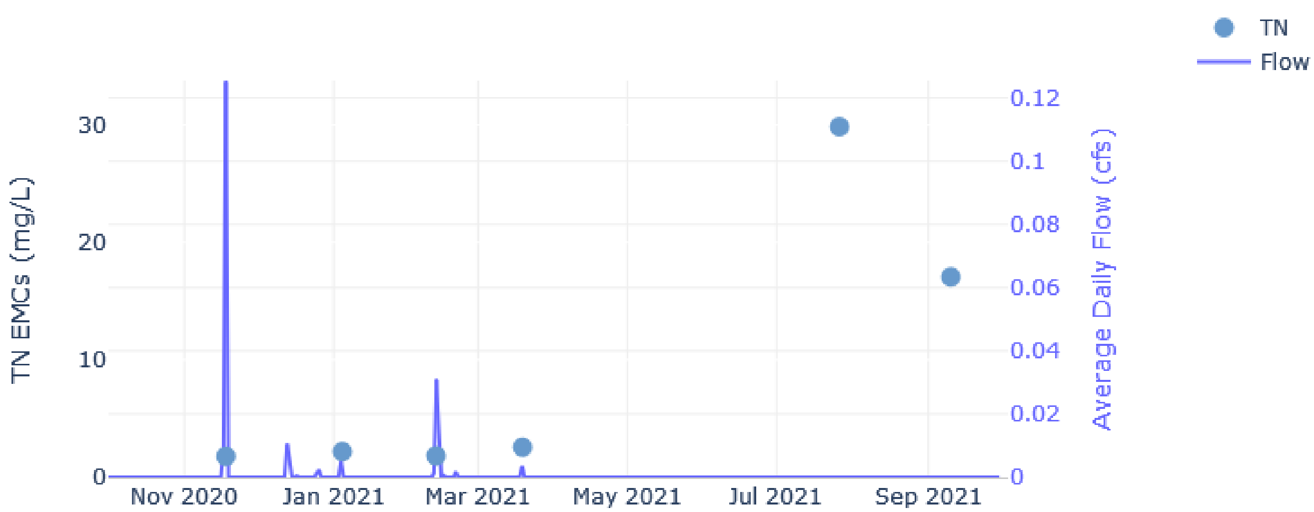

Figure 47 Daily flow and TN EMC summary at the Speedboat catchment outfall, WY21.

- Six events were sampled for TN (three in the fall/winter, one in the spring, and two in the summer).
- The highest TN EMC occurred during the thunderstorm event on July 26, 2021.
- The highest TN load occurred during the rain on snow event November 17-18, 2020.
- The lowest TN EMC occurred during the rain on snow event on November 17-18, 2020.
- The lowest TN load occurred during the thunderstorm event on September 10, 2021.

Daily flow and the TP EMC summary at Speedboat are presented in Figure 48. Table 11 presents EMC data in tabular form. Table 11 also presents the load data referenced in some bullet points below.

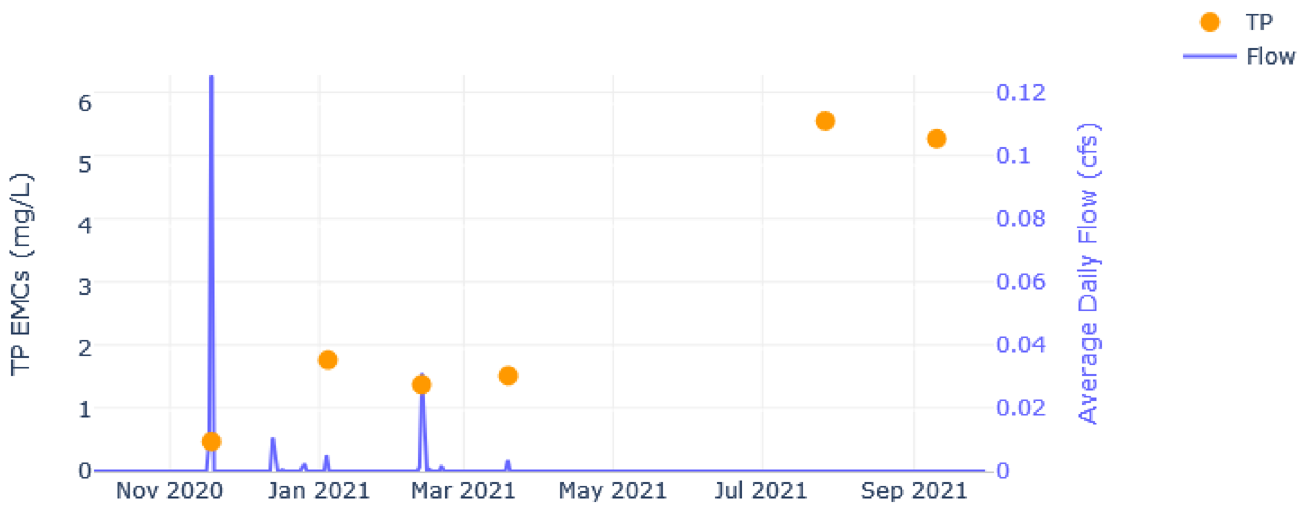

Figure 48 Daily flow and TP EMC summary at the Speedboat catchment outfall, WY21.

- Six events were sampled for TP (three in the fall/winter, one in the spring, and two in the summer).
- The highest TP EMC occurred during the thunderstorm event on July 26, 2021.
- The highest TP load occurred during the event snowmelt on February 11-13, 2021.
- The lowest TP EMC occurred during the rain on snow event on November 17-18, 2020.
- The lowest TP load occurred during the thunderstorm event on July 26, 2021.

Seasonal load as a fraction of the water year load at Speedboat is presented in Figure 49. Event loads are presented in tabular form in Table 11

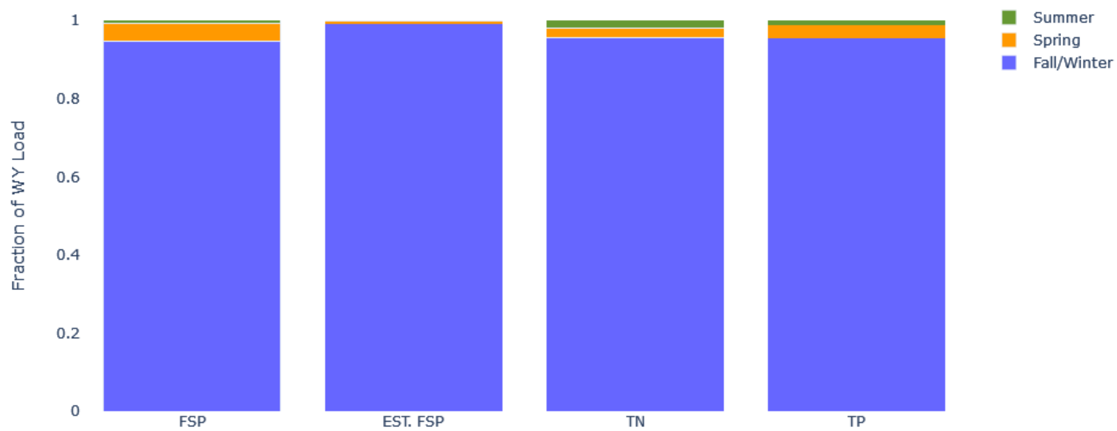

Figure 49 Seasonal load as a fraction of the water year load at the Speedboat catchment outfall, WY21. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP loads (based on samples) was generated in the fall/winter.
- The largest fraction of FSP loads (based on continuous turbidity) was generated in the fall/winter.
- The largest fraction of TN loads was generated in fall/winter.
- The largest fraction of TP loads was generated in the fall/winter.

Six events were sampled at Speedboat in WY21. Event summary data is presented in Table 11.

Table 11 Event summary data at the Speedboat catchment outfall, WY21.

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	11/17/2020 22:25	11/18/2020 14:25	16:00	11,632	0.44	1,823	1.00	Rain on snow	100%	38	27.72	1,798	1.30	488	0.35
SB	Fall/Winter	1/4/2021 12:10	1/4/2021 17:25	5:15	444	0.09	912	0.18	Rain on snow	100%	204	5.64	2,198	0.06	1,820	0.05
SB	Fall/Winter	2/11/2021 17:15	2/13/2021 17:25	48:10	4,086	0.33	1,185	0.87	Event Snowmelt	100%	226	57.67	1,838	0.47	1,418	0.36
SB	Spring	3/19/2021 3:40	3/19/2021 5:50	2:10	313	0.13	832	0.20	Rain on snow	100%	255	4.97	2,575	0.05	1,563	0.03
SB	Summer	7/26/2021 15:40	7/26/2021 16:00	0:20	14	0.03	646	0.02	Thunderstorm	100%	33	0.03	29,850	0.03	5,723	<0.01
SB	Summer	9/10/2021 4:30	9/10/2021 5:20	0:50	15	0.03	506	0.17	Thunderstorm	100%	693	0.65	17,070	0.02	5,434	0.01

6.2.6 Tahoe City

Figure 50 shows the average daily flow and cumulative precipitation for WY21 at the Tahoe City catchment outfall.

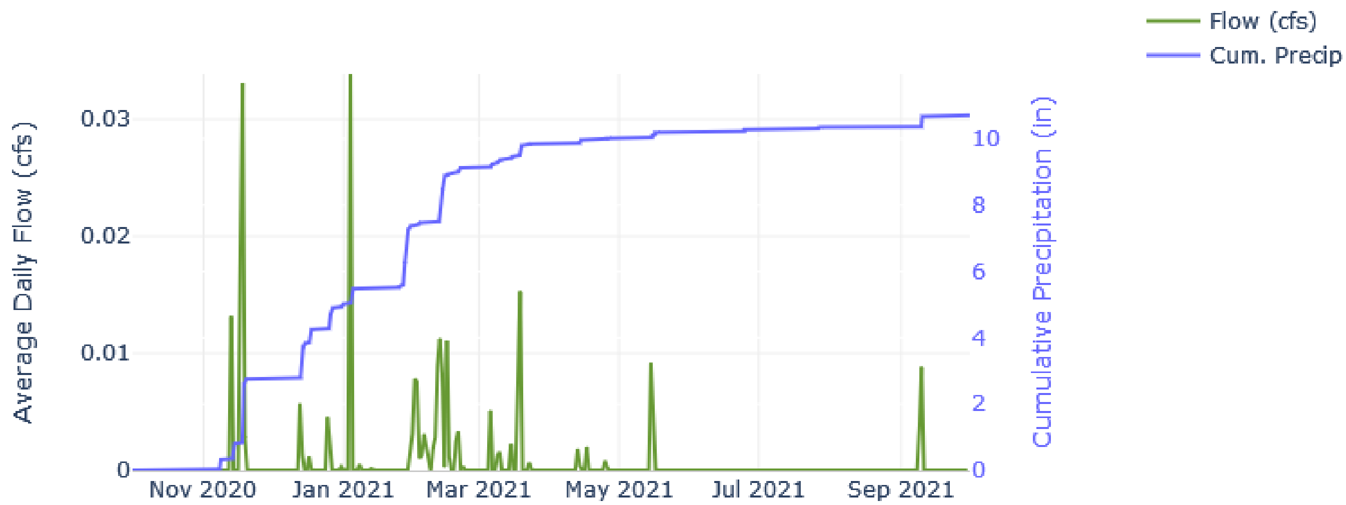

Figure 50 Average daily flow and cumulative precipitation at the Tahoe City catchment outfall, WY21.

- 10.71 inches of total precipitation (9.12 in the fall/winter, 1.09 in the spring, and 0.49 in the summer) were recorded at the Hatchery (HATCH) weather station.
- 38 precipitation events occurred (19 fall/winter events, 10 spring events, 9 summer events).
- The largest storm, with 1.95 inches of precipitation, was a rain and snow event that occurred from November 17-19, 2020.
- 87% of storms were less than half an inch.
- Highest average daily flows occurred during the rain on snow event on January 4, 2021.
- 29 days of intermittent snowmelt occurred in the fall/winter and spring.
- The highest instantaneous peak precipitation was 0.13 inches in 5 minutes during a thunderstorm event on September 9, 2021.
- The highest instantaneous peak flow was 0.42 cfs during a thunderstorm event on September 9, 2021.
- The November 17-18, 2020 rain on snow event produced the most runoff (4,352 cf).

Daily flow and the FSP EMC summary at Tahoe City are presented in Figure 51. Table 12 presents EMC data in tabular form. Table 12 also presents the load data referenced in some bullet points below.

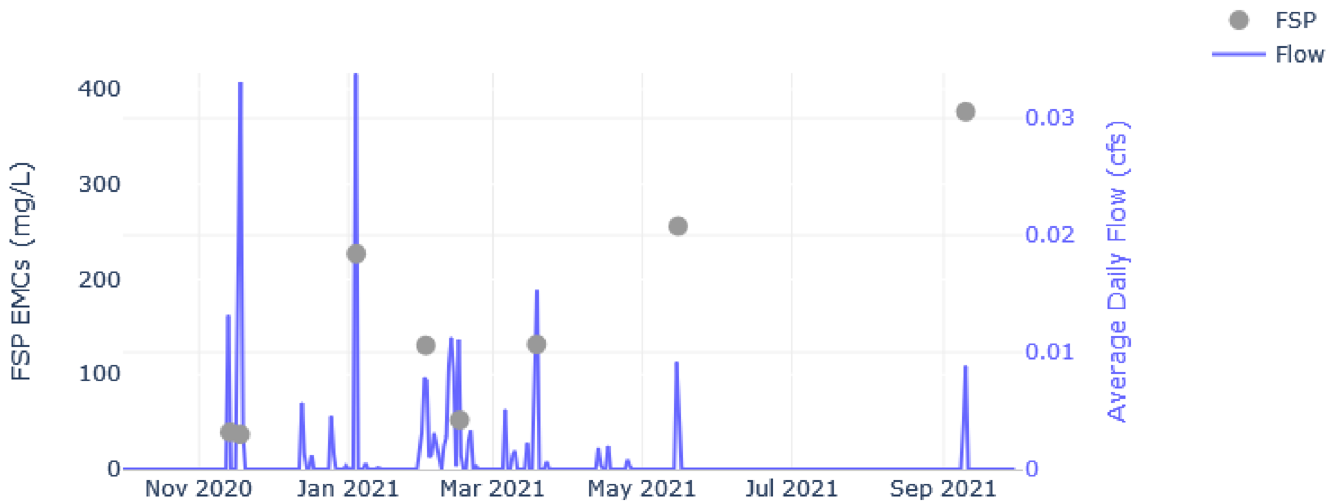

Figure 51 Daily flow and FSP EMC summary at the Tahoe City catchment outfall, WY21.

- Eight events were sampled for FSP (five in the fall/winter, two in the spring, and one in the summer).
- The highest FSP EMC occurred during a thunderstorm event September 9-10, 2021.
- The highest FSP load occurred during the rain on snow event January 4, 2021.
- The lowest FSP EMC occurred during the rain on snow event November 17-18, 2020.
- The lowest FSP load occurred during the rain on snow event November 13, 2020.

Daily flow and the TN EMC summary at Tahoe City are presented in Figure 52. Table 12 presents EMC data in tabular form. Table 12 also presents the load data referenced in some bullet points below.

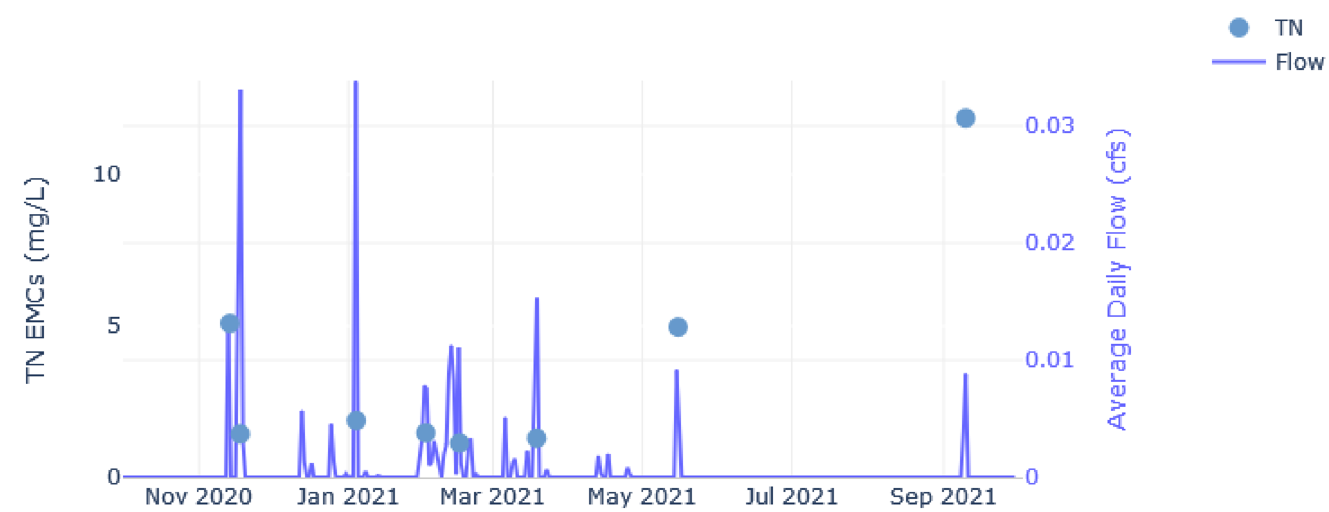

Figure 52 Daily flow and TN EMC summary at the Tahoe City catchment outfall, WY21.

- Eight events were sampled for TN (five in the fall/winter, two in the spring, and one in the summer).
- The highest TN EMC and load occurred during thunderstorm event on September 9-10, 2021.
- The lowest TN EMC and load occurred during the rain on snow event February 15, 2021.

Daily flow and the TP EMC summary at Tahoe City are presented in Figure 53. Table 12 presents EMC data in tabular form. Table 12 also presents the load data referenced in some bullet points below.

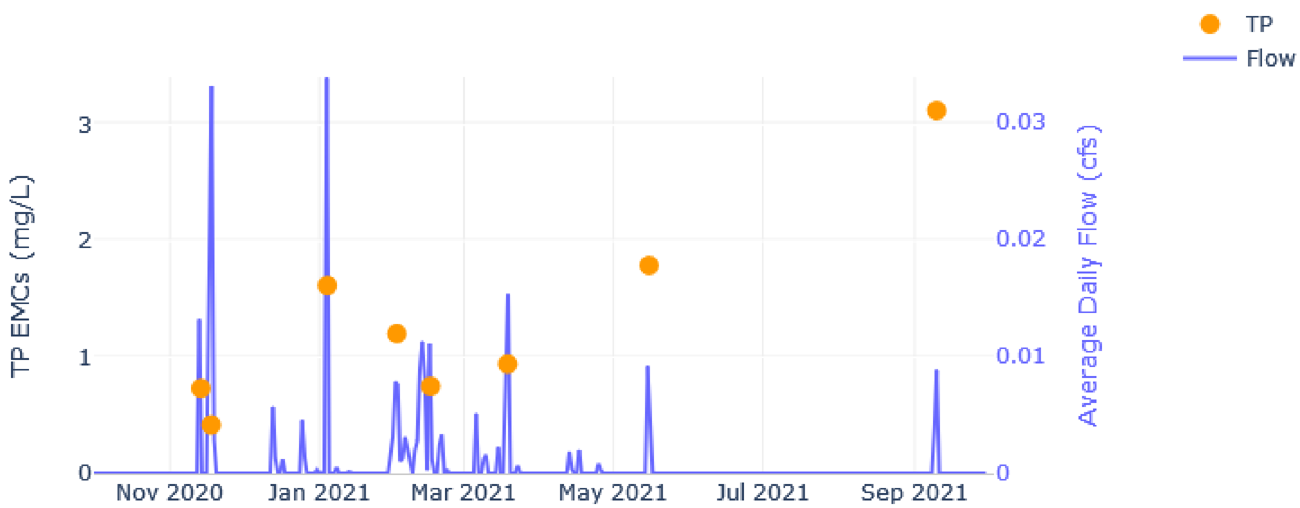

Figure 53 Daily flow and TP EMC summary at the Tahoe City catchment outfall, WY21.

- Eight events were sampled for TP (five in the fall/winter, two in the spring, and one in the summer).
- The highest TP EMC occurred during the thunderstorm event on September 9-10, 2021.
- The highest TP load occurred during the rain on snow event on January 4, 2021.
- The lowest TP EMC occurred during the rain on snow event November 17-18, 2020.
- The lowest TP load occurred during the rain on snow event February 15, 2021.

Seasonal load as a fraction of the water year load at Tahoe City is presented in Figure 54. Event loads are presented in tabular form in Table 12.

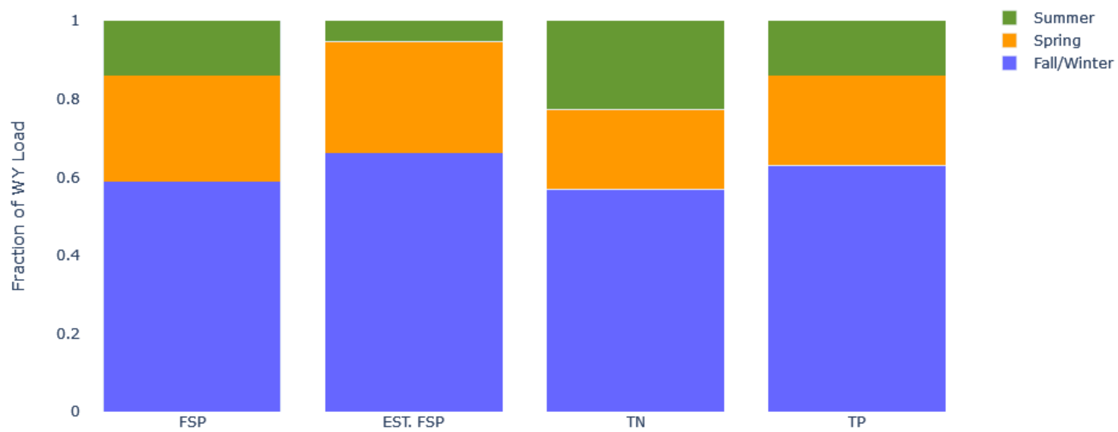

Figure 54 Seasonal load as a fraction of the water year load at the Tahoe City catchment outfall, WY21. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP loads (based on samples) was generated in the fall/winter.
- The largest fraction of FSP loads (based on continuous turbidity) was generated in the fall/winter.
- The largest fraction of TN loads was generated in the fall/winter.
- The largest fraction of TP loads was generated in the fall/winter.

Eight events were sampled at Tahoe City in WY21. Event summary data is presented in Table 12.

Table 12 Event summary data at the Tahoe City catchment outfall, WY21.

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)
TC	Fall/Winter	11/13/2020 15:10	11/13/2020 22:15	7:05	1,143	0.16	275	0.46	Rain on snow	100%	39	2.80	5,087	0.36	733	0.05
TC	Fall/Winter	11/17/2020 19:30	11/18/2020 23:20	27:50	4,352	0.19	827	1.94	Rain on snow	100%	37	10.02	1,438	0.39	419	0.11
TC	Fall/Winter	1/4/2021 5:20	1/4/2021 21:10	15:50	2,925	0.28	686	0.47	Rain on snow	100%	227	41.42	1,878	0.34	1,619	0.30
TC	Fall/Winter	2/1/2021 13:30	2/2/2021 21:20	31:50	1,332	0.05	1,181	0.08	Non-Event Snowmelt	100%	131	10.85	1,472	0.12	1,204	0.10
TC	Fall/Winter	2/15/2021 6:15	2/15/2021 23:30	17:15	958	0.02	416	0.08	Rain on snow	100%	52	3.11	1,133	0.07	751	0.04
TC	Spring	3/18/2021 19:20	3/19/2021 13:15	17:55	2,016	0.22	841	0.34	Rain on snow	100%	132	16.55	1,295	0.16	943	0.12
TC	Spring	5/15/2021 13:30	5/17/2021 0:40	35:10	1,110	0.36	672	0.18	Thunderstorm	100%	256	17.72	4,964	0.34	1,792	0.12
TC	Summer	9/9/2021 23:25	9/10/2021 11:10	11:45	1,096	0.42	1,021	0.31	Thunderstorm	100%	377	25.74	11,862	0.81	3,125	0.21

Tahoe City bypass flow is shown in Figure 55. When bypass occurs, untreated flow comingles with treated flow in the outflow from the Delaware Sandfilter, resulting in reduced overall treatment efficiency.

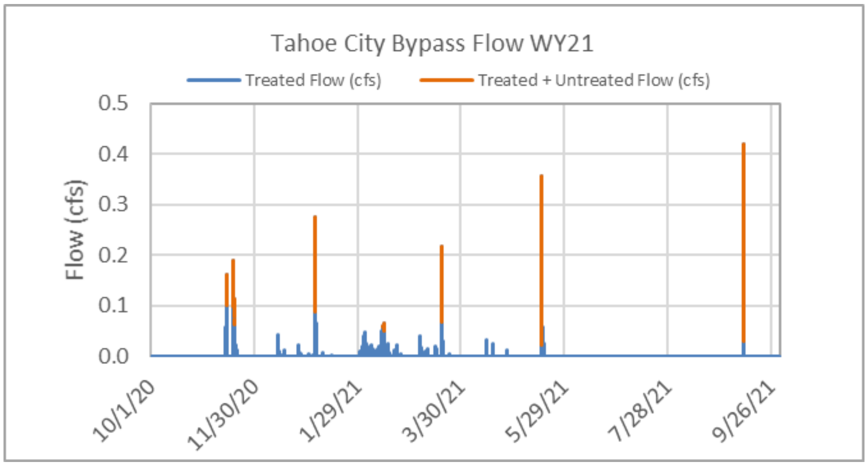

Figure 55 Bypass data for Tahoe City WY21. The orange line indicates bypass occurred.

- In WY21, the Delaware Sandfilter was in bypass mode 4% of the time there was flow at the TC site, which represents up to 26% of the total annual flow volume (5,797 cf bypassed of 22,625 cf total flow). During bypass mode treated flow is co-mingled with untreated (bypass) flow, so the exact amount of untreated flow is difficult to determine.
- Bypass occurred during 7 runoff events and 6 out of 8 sampled events had untreated (bypass) flow:
  - November 13, 2020 during a sampled rain on snow event that produced 0.46 inches of precipitation.
  - November 17-18, 2020 during a sampled rain on snow event that produced 1.94 inches of precipitation.
  - January 4, 2021 during a sampled rain on snow event that produced 0.47 inches of precipitation
  - February 12-13, 2021 during a rain on snow event that produced 1.42 inches of precipitation
  - March 18-19, 2021 during a sampled rain on snow event that produced 0.34 inches of precipitation.
  - May 15, 2021 during a sampled thunderstorm event that produced 0.18 inches of precipitation
  - September 9-10, 2021 during a sampled thunderstorm event that produced 0.31 inches of precipitation

6.2.7 Tahoe Valley

Figure 56 shows the average daily flow and cumulative precipitation for WY21 at the Tahoe Valley catchment outfall.

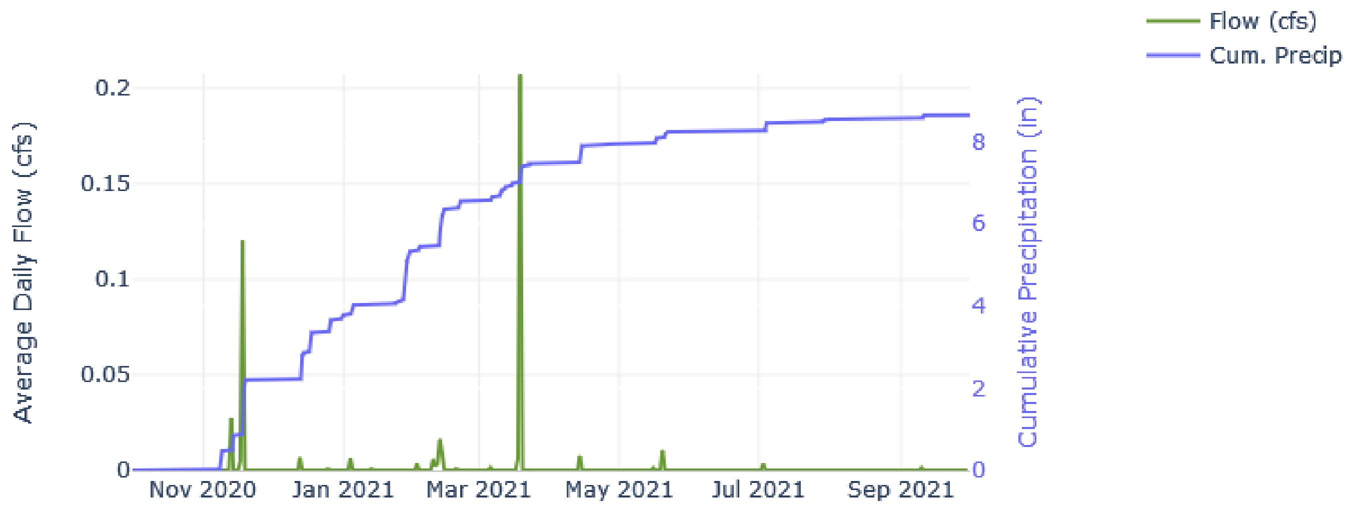

Figure 56 Average daily flow and cumulative precipitation at the Tahoe Valley catchment outfall, WY21.

- 8.64 inches of total precipitation (6.55 in the fall/winter, 1.70 in the spring, 0.39 in the summer) were recorded at the Raph's Shop (RAPH) weather station.
- 37 precipitation events occurred (16 fall/winter events, 12 spring events, 9 summer events).
- The largest storm, with 1.35 inches of precipitation, occurred during a rain and snow event from November 17-19, 2020.
- 89% of storms were less than half an inch.
- Highest average daily flows occurred during the March 18-19, 2021 rain on snow event.
- 15 days of intermittent snowmelt runoff occurred in the fall/winter and spring.
- The highest instantaneous peak precipitation was 0.05 inches in 5 minutes during a thunderstorm event on July 3, 2021.
- The highest instantaneous peak flow (0.67 cfs) occurred on March 19, 2021 during a rain on snow event.
- The most event runoff was generated by the March 18-19, 2021 rain on snow event (18,465 cf).

Daily flow and the FSP EMC summary at Tahoe Valley are presented in Figure 57. Table 13 presents EMC data in tabular form. Table 13 also presents the load data referenced in some bullet points below.

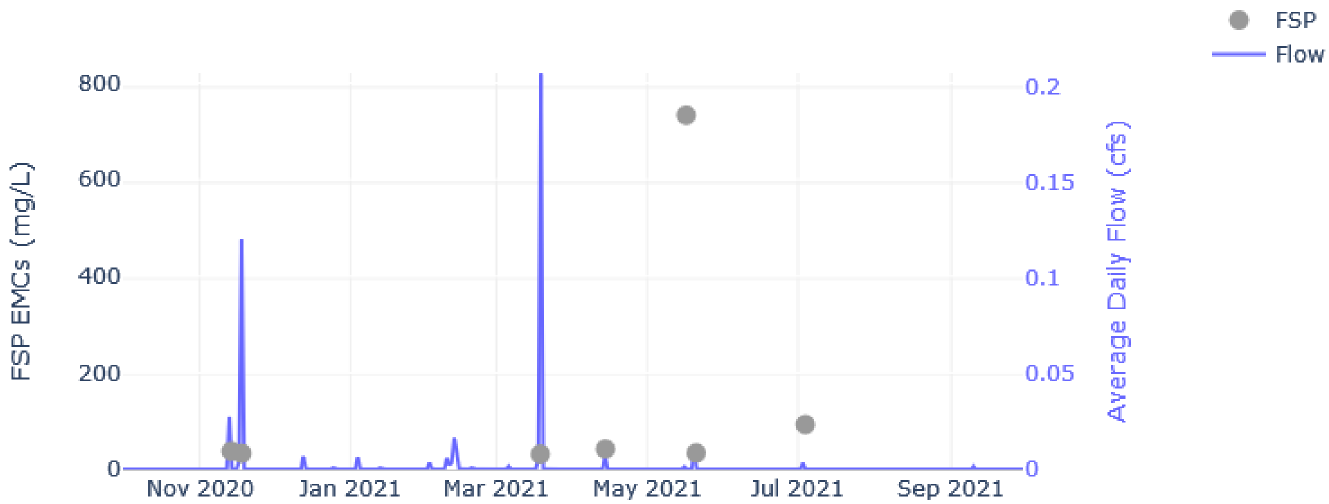

Figure 57	Daily flow and FSP EMC summary at the Tahoe Valley catchment outfall, WY21.

- Seven events were sampled for FSP (two in the fall/winter, four in the spring, and one in the summer).
- The highest FSP EMC occurred during the thunderstorm event on May 16, 2021.
- The highest FSP load occurred during the rain on snow event from March 18-19, 2021.
- The lowest FSP EMC occurred during the rain on snow event from March 18-19, 2021.
- The lowest FSP load occurred during the thunderstorm event on July 3, 2021.

Daily flow and the TN EMC summary at Tahoe Valley are presented in Figure 58. Table 13 presents EMC data in tabular form. Table 13 also presents the load data referenced in some bullet points below.

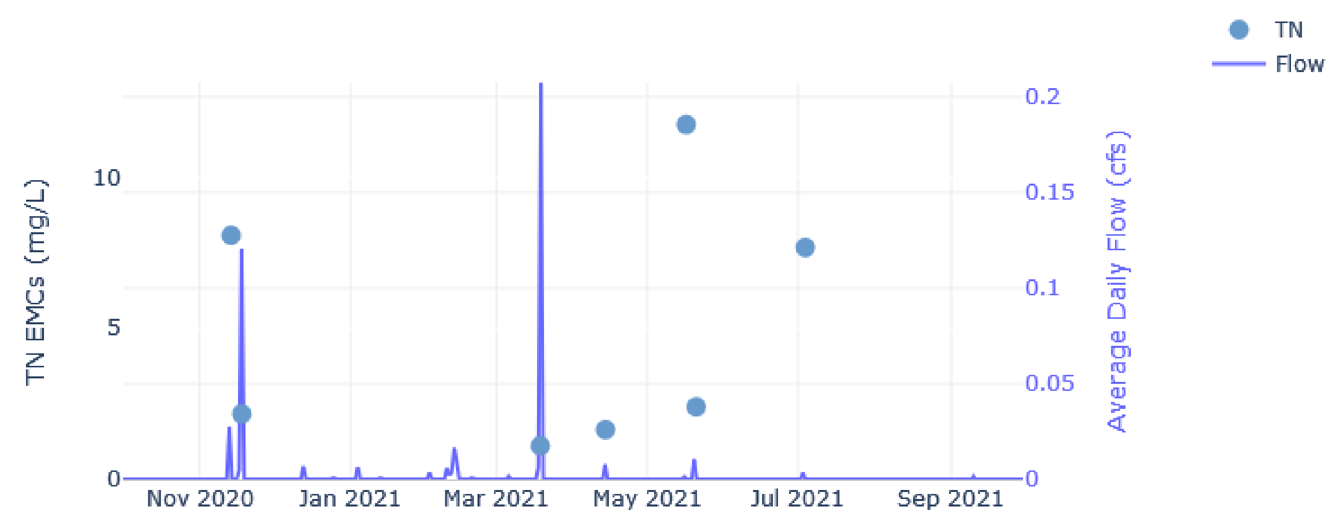

Figure 58	Daily flow and TN EMC summary at the Tahoe Valley catchment outfall, WY21.

- Seven events were sampled for TN (two in the fall/winter, four in the spring, and one in the summer).
- The highest TN EMC occurred during the thunderstorm event on May 16, 2021.
- The highest TN load occurred during the rain on snow event from November 17-18, 2020.
- The lowest TN EMC occurred during the rain on snow event March 18-19, 2021.
- The lowest TN load occurred during the event snowmelt on April 14, 2021.

Daily flow and the TP EMC summary at Tahoe Valley are presented in Figure 59. Table 13 presents EMC data in tabular form. Table 13 also presents the load data referenced in some bullet points below.

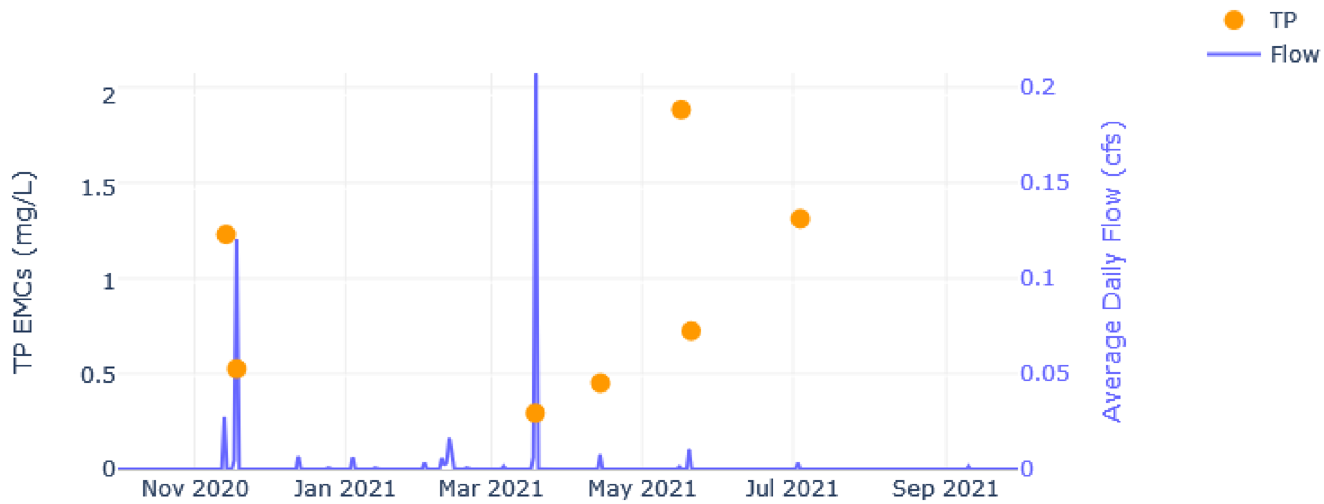

Figure 59 Daily flow and TP EMC summary at the Tahoe Valley catchment outfall, WY21.

- Seven events were sampled for TP (two in the fall/winter, four in the spring, and one in the summer).
- The highest TP EMC occurred during the thunderstorm event on May 16, 2021.
- The highest TP load occurred during rain on snow event from November 17-18, 2020.
- The lowest TP EMC occurred during the rain on snow event from March 18-19, 2021.
- The lowest TP load occurred thunderstorm event on May 16, 2021.

Seasonal load as a fraction of the water year load at Tahoe Valley is presented in Figure 60. Event loads are presented in tabular form in Table 13.

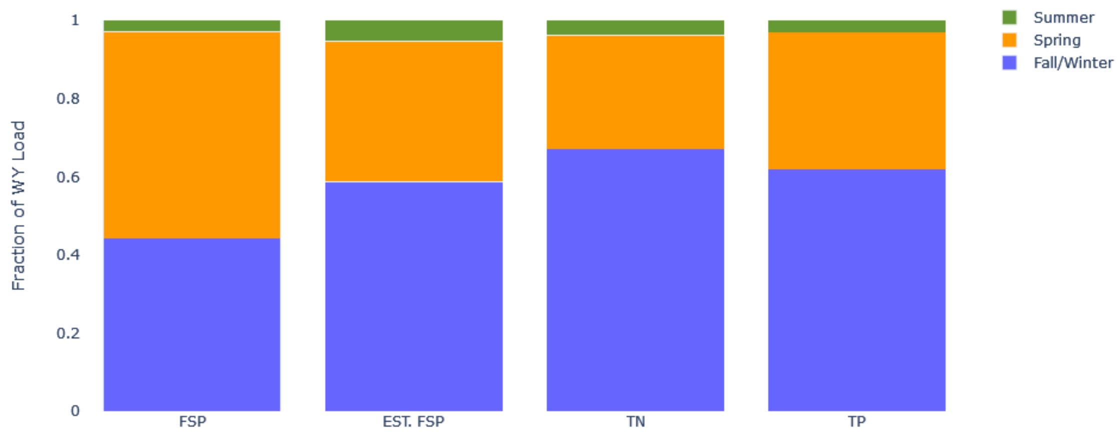

Figure 60 Seasonal load as a fraction of the water year load at the Tahoe Valley catchment outfall, WY21. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP loads (based on samples) was generated in the spring.
- The largest fraction of FSP loads (based on continuous turbidity) was generated in the fall/winter.
- The largest fraction of TN loads was generated in the fall/winter.
- The largest fraction of TP loads was generated in the fall/winter.

Seven events were sampled at Tahoe Valley in WY21. Event summary data is presented in Table 13.

Table 13 Event summary data at the Tahoe Valley catchment outfall, WY21.

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	11/13/2020 14:15	11/13/2020 21:45	7:30	2,377	0.17	160	0.37	Rain on snow	100%	38	5.63	8,076	1.20	1,256	0.19
TV	Fall/Winter	11/17/2020 22:30	11/18/2020 21:55	23:25	10,841	0.62	757	1.35	Rain on snow	100%	33	22.59	2,171	1.47	538	0.36
TV	Spring	3/18/2021 18:00	3/19/2021 23:30	29:30	18,465	0.67	763	0.41	Rain on snow	100%	32	36.63	1,112	1.28	301	0.35
TV	Spring	4/14/2021 2:25	4/14/2021 10:30	8:05	679	0.16	235	0.43	Event Snowmelt	100%	42	1.80	1,650	0.07	462	0.02
TV	Spring	5/16/2021 18:20	5/16/2021 20:15	1:55	117	0.21	741	0.14	Thunderstorm	100%	734	5.34	11,744	0.09	1,923	0.01
TV	Spring	5/20/2021 19:10	5/20/2021 21:05	1:55	928	0.23	221	0.08	Event Snowmelt	100%	34	1.98	2,402	0.14	740	0.04
TV	Summer	7/3/2021 22:35	7/3/2021 23:25	0:50	304	0.27	970	0.19	Thunderstorm	100%	93	1.77	7,675	0.15	1,340	0.03

6.2.8 Tahoma

Figure 61 shows the average daily flow and cumulative precipitation for WY21 at the Tahoma catchment outfall.

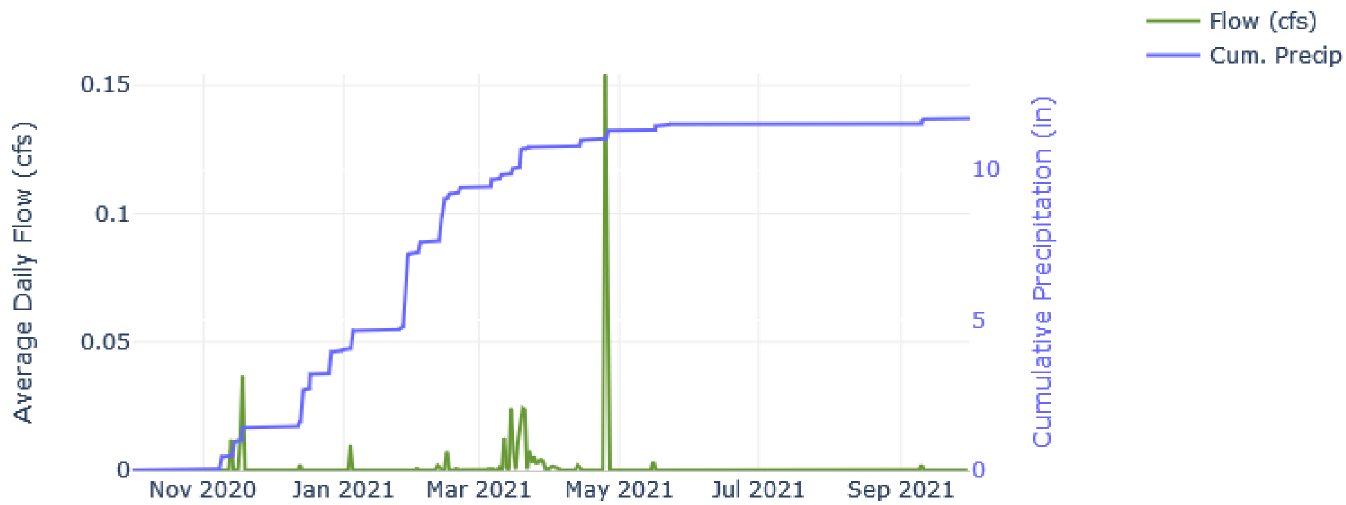

Figure 61 Average daily flow and cumulative precipitation at the Tahoma catchment outfall, WY21.

- 11.71 inches of total precipitation (9.42 in the fall/winter, 2.11 in the spring, 0.19 in the summer) were recorded at the El Dorado County Yard (EDCY) weather station.
- 36 precipitation events occurred (19 fall/winter events, 13 spring events, 4 summer events).
- The largest storm, with 2.47 inches of precipitation, occurred during a snow event from January 26-29, 2021.
- 78% of storms were less than half an inch.
- Highest average daily flows occurred during the April 26, 2021 snow event.
- 42 days of intermittent snowmelt runoff occurred in the fall/winter and spring.
- The highest instantaneous peak precipitation was 0.07 inches in 5 minutes during the thunderstorm event on May 16, 2021.
- The highest instantaneous peak flow was 1.32 cfs following the rain and snow event on April 25, 2021.
- The April 25, 2021 rain and snow event produced the most runoff in a single event (10,952 cf).

Daily flow and the FSP EMC summary at Tahoma are presented in Figure 62. Table 14 presents EMC data in tabular form. Table 14 also presents the load data referenced in some bullet points below.

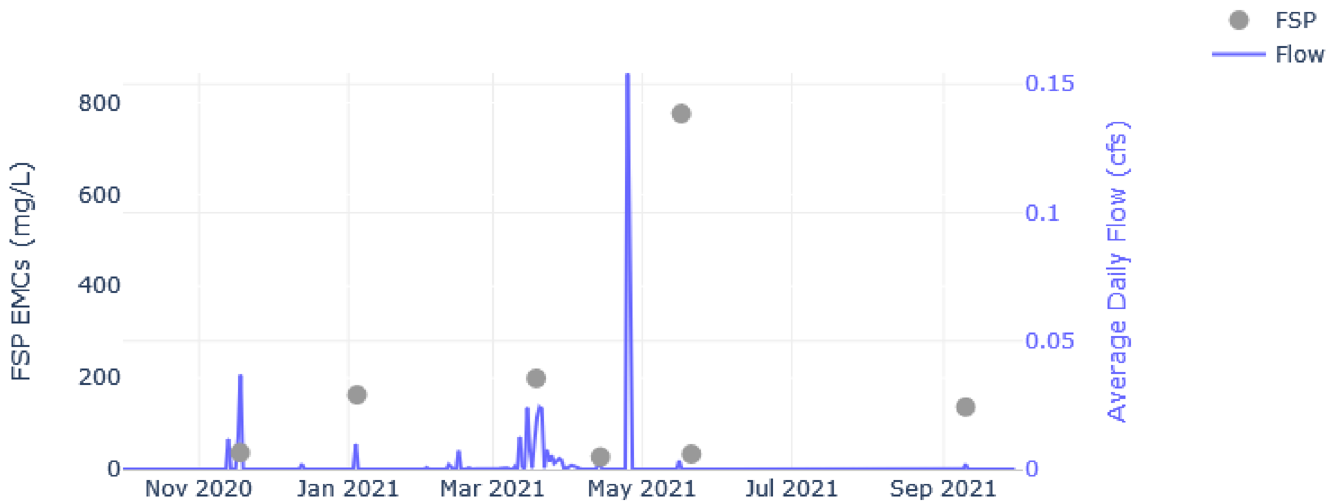

Figure 62 Daily flow and FSP EMC summary at the Tahoma catchment outfall, WY21.

- Seven events were sampled for FSP (two in the fall/winter, four in the spring, and one in the summer).
- The highest FSP EMC occurred during the thunderstorm event on May 16, 2021.
- The highest FSP load occurred during the rain on snow event March 18-20, 2021.
- The lowest FSP EMC occurred during the event snowmelt April 13-14, 2021.
- The lowest FSP load occurred during the event snowmelt on May 20-22, 2021.

Daily flow and the TN EMC summary at Tahoma are presented in Figure 63. Table 14 presents EMC data in tabular form. Table 14 also presents the load data referenced in some bullet points below.

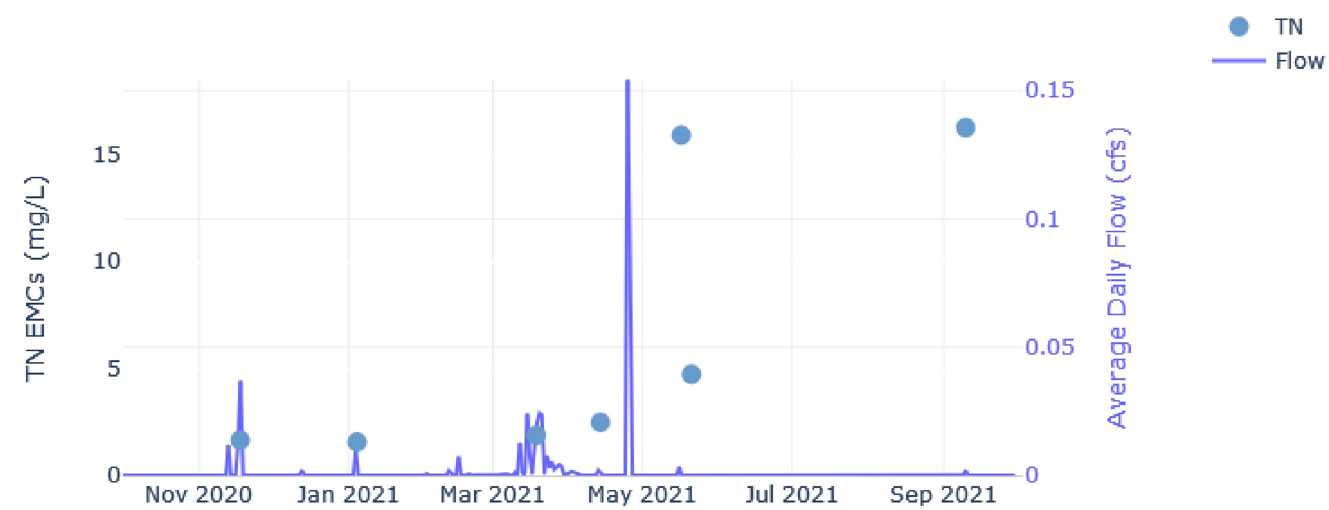

Figure 63 Daily flow and TN EMC summary at the Tahoma catchment outfall, WY21.

- Seven events were sampled for TN (two in the fall/winter, four in the spring, and one in the summer).
- The highest TN EMC occurred during the thunderstorm event September 9-10, 2021.
- The highest TN load occurred during the rain on snow event November 17-19, 2020.
- The lowest TN EMC occurred during the rain on snow event January 4, 2021.
- The lowest TN load occurred during the event snowmelt May 20-22, 2021.

Daily flow and the TP EMC summary at Tahoma are presented in Figure 64. Table 14 presents EMC data in tabular form. Table 14 also presents the load data referenced in some bullet points below.

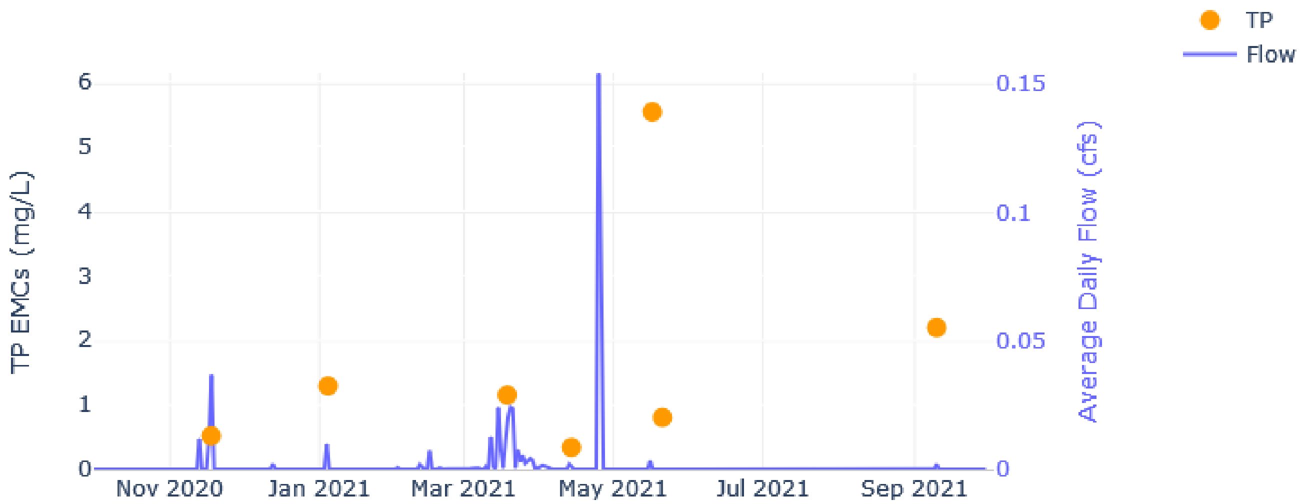

Figure 64 Daily flow and TP EMC summary at the Tahoma catchment outfall, WY21.

- Seven events were sampled for TP (two in the fall/winter, four in the spring, and one in the summer).
- The highest TP EMC occurred during the thunderstorm event on May 16, 2021.
- The highest TP load occurred during the rain on snow event March 18-20, 2021.
- The lowest TP EMC occurred during the event snowmelt from April 13-14, 2021.
- The lowest TP load occurred during the event snowmelt on May 20-22, 2021.

Seasonal load as a fraction of the water year load at Tahoma is presented in Figure 65. Event loads are presented in tabular form in Table 14.

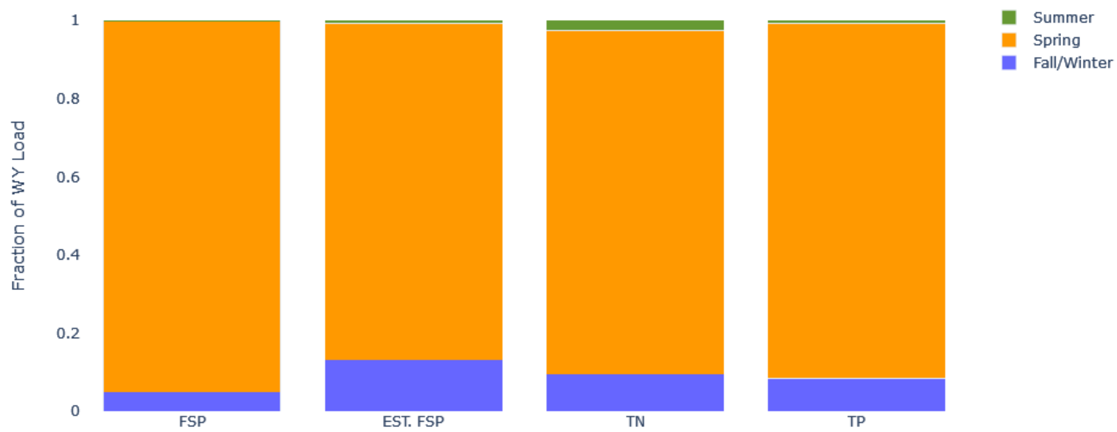

Figure 65 Seasonal load as a fraction of the water year load at the Tahoma catchment outfall, WY21. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP loads was generated in the spring.
- The largest fraction of TN loads was generated in the spring.
- The largest fraction of TP loads was generated in the spring.
- Very small fractions of FSP, TN, and TP were generated in the summer.

Seven events were sampled at Tahoma in WY21. Event summary data is presented in Table 14.

Table 14 Event summary data at the Tahoma catchment outfall, WY21.

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	11/17/2020 19:45	11/19/2020 0:35	28:50	4,312	0.46	945	0.44	Rain on snow	100%	37	9.87	1,660	0.45	519	0.14
TA	Fall/Winter	1/4/2021 5:25	1/4/2021 19:45	14:20	859	0.15	1,214	0.60	Rain on snow	100%	163	8.73	1,569	0.08	1,292	0.07
TA	Spring	3/18/2021 12:25	3/20/2021 3:45	39:20	2,770	0.12	206	0.67	Rain on snow	100%	199	34.39	1,891	0.33	1,152	0.20
TA	Spring	4/13/2021 20:20	4/14/2021 3:00	6:40	248	0.02	34	0.22	Event Snowmelt	100%	27	0.42	2,489	0.04	341	0.01
TA	Spring	5/16/2021 20:05	5/16/2021 22:35	2:30	301	0.26	1,087	0.14	Thunderstorm	100%	777	14.59	15,935	0.30	5,529	0.10
TA	Spring	5/20/2021 23:20	5/22/2021 18:10	42:50	28	0.01	137	0.06	Event Snowmelt	100%	33	0.06	4,739	0.01	804	<0.01
TA	Summer	9/9/2021 23:10	9/10/2021 7:45	8:35	195	0.05	195	0.16	Thunderstorm	100%	136	1.66	16,285	0.20	2,194	0.03

6.2.9 Upper Truckee

Figure 66 shows the average daily flow and cumulative precipitation for WY21 at the Upper Truckee catchment outfall.

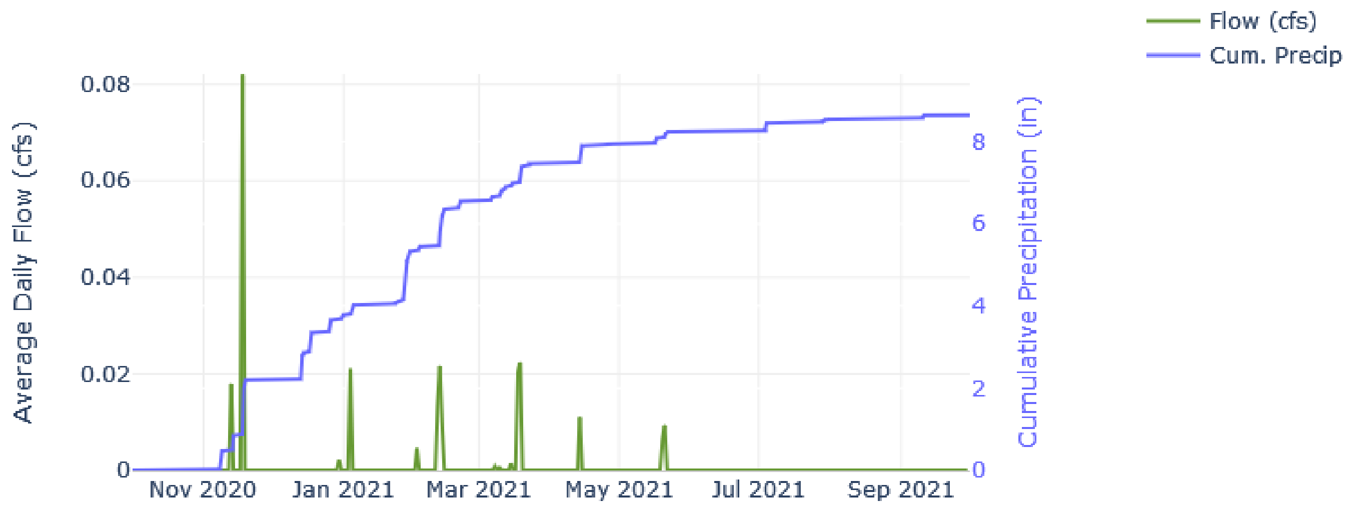

Figure 66 Average daily flow and cumulative precipitation at the Upper Truckee catchment outfall, WY21.

- 8.64 inches of total precipitation (6.55 in the fall/winter, 1.70 in the spring, 0.39 in the summer) were recorded at the Raph's Shop (RAPH) weather station.
- 37 precipitation events occurred (16 fall/winter events, 12 spring events, 9 summer events).
- The largest storm, with 1.35 inches of precipitation, occurred during a rain and snow event from November 17-19, 2021.
- 89% of storms were less than half an inch.
- Highest average daily flows occurred in during the November 18, 2020 rain on snow event.
- 10 days of intermittent snowmelt runoff occurred in the fall/winter and spring.
- The highest instantaneous peak precipitation was 0.05 inches in 5 minutes during a thunderstorm event on July 3, 2021.
- The highest instantaneous peak flow was 0.51 cfs during a rain and snow event on March 18, 2021.
- November 18, 2020 rain on snow event produced the most runoff (7,097 cf).

Daily flow and the FSP EMC summary at Upper Truckee are presented in Figure 67. Table 15 presents EMC data in tabular form. Table 15 also presents the load data referenced in some bullet points below.

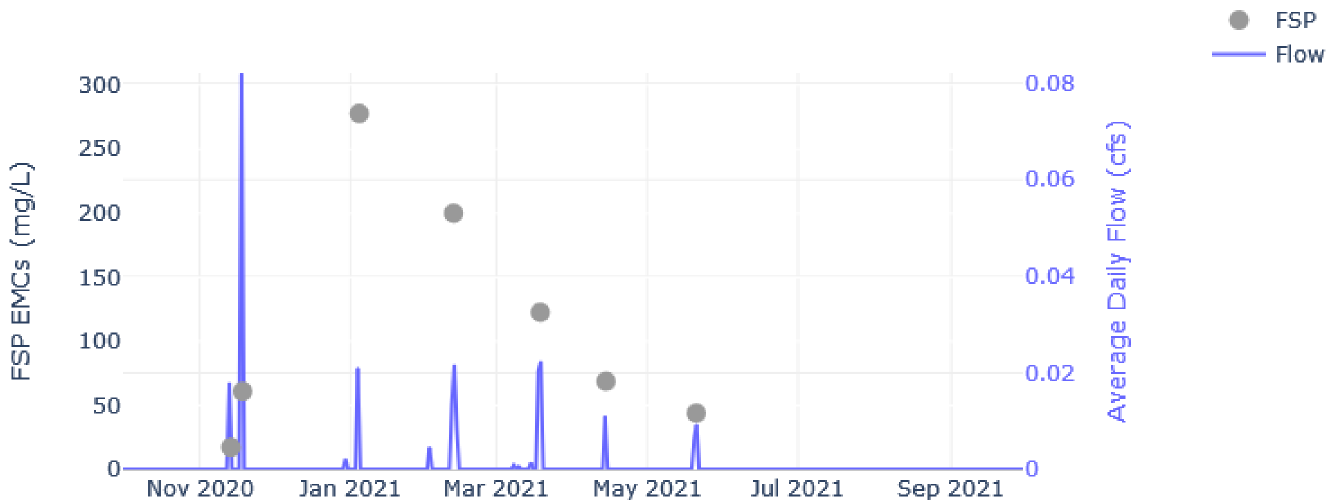

Figure 67 Daily flow and FSP EMC summary at the Upper Truckee catchment outfall, WY21.

- Seven events were sampled for FSP (four in the fall/winter, three in the spring, and zero in the summer).
- The highest FSP EMC occurred during the rain on snow event January 4, 2021.
- The highest FSP load occurred during event snowmelt February 11-13, 2021.
- The lowest FSP EMC and load occurred during the rain on snow event November 13, 2020.

Daily flow and the TN EMC summary at Upper Truckee are presented in Figure 68. Table 15 presents EMC data in tabular form. Table 15 also presents the load data referenced in some bullet points below.

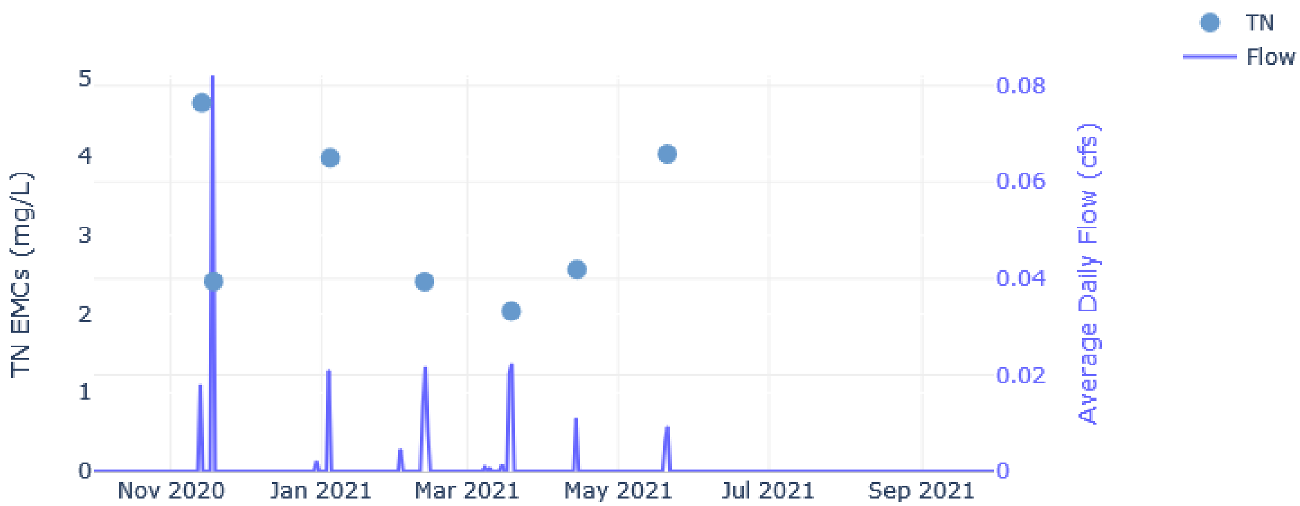

Figure 68 Daily flow and TN EMC summary at the Upper Truckee catchment outfall, WY21.

- Seven events were sampled for TN (four in the fall/winter, three in the spring, and zero in the summer).
- The highest TN EMC occurred during a rain on snow event November 13, 2020.
- The highest TN load occurred during a rain on snow event November 18, 2020.
- The lowest TN EMC occurred during a rain on snow event March 18-19, 2021.
- The lowest TN load occurred during the event snowmelt April 14, 2021.

Daily flow and the TP EMC summary at Upper Truckee are presented in Figure 69. Table 15 presents EMC data in tabular form. Table 15 also presents the load data referenced in some bullet points below.

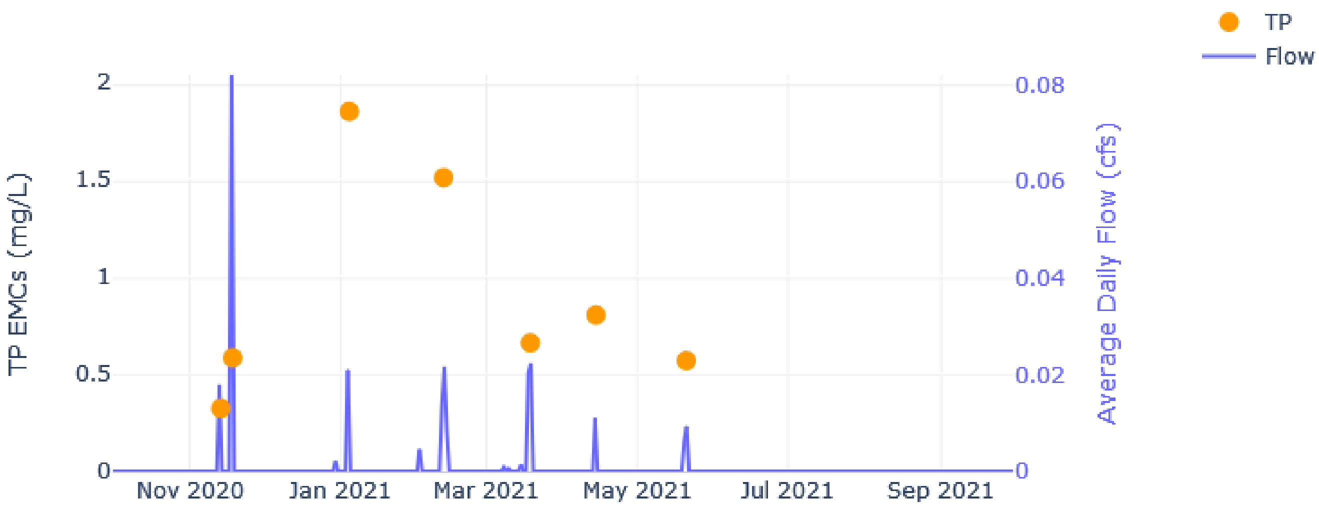

Figure 69 Daily flow and TP EMC summary at the Upper Truckee catchment outfall, WY21.

- Seven events were sampled for TP (four in the fall/winter, three in the spring, and zero in the summer).
- The highest TP EMC occurred during a rain on snow event January 4, 2021.
- The highest TP load occurred during an event snowmelt February 11-13, 2021.
- The lowest TP EMC and load occurred during the rain on snow event November 13, 2020.

Seasonal load as a fraction of the water year load at Upper Truckee is presented in Figure 70. Event loads are presented in tabular form in Table 15.

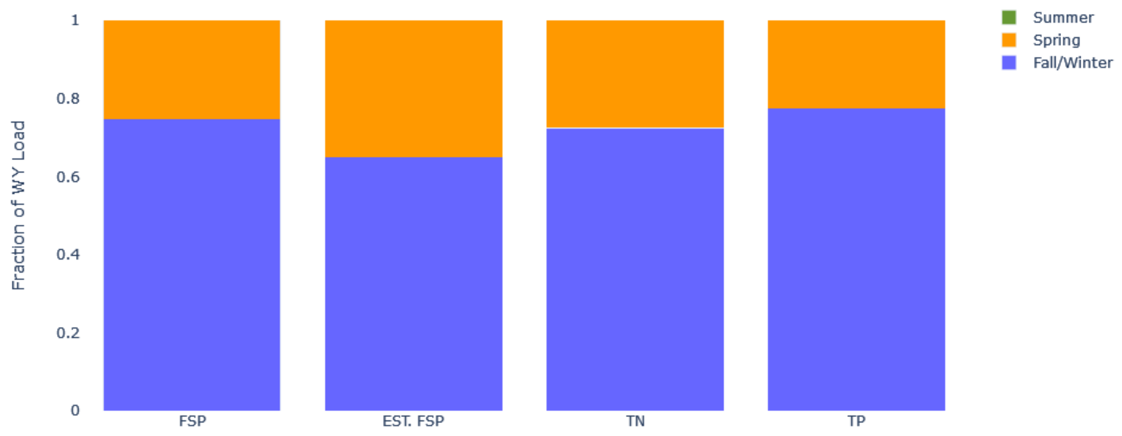

Figure 70 Seasonal load as a fraction of the water year load at the Upper Truckee catchment outfall, WY21. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction FSP load (based on samples) was generated in the fall/winter.
- The largest fraction of FSP load (based on turbidity) was generated in the fall/winter.
- The largest fraction of TN loads was generated in the fall/winter.
- The largest fraction of TP loads was generated in the fall/winter.
- Summer produced the no runoff and no load for FSP, TN, and TP.

Seven events were sampled at Upper Truckee in WY21. Event summary data is presented in Table 15.

Table 15 Event summary data at the Upper Truckee catchment outfall, WY21.

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	11/13/2020 14:30	11/13/2020 20:55	6:25	1,556	0.14	485	0.37	Rain on snow	100%	17	1.68	4,686	0.45	324	0.03
UT	Fall/Winter	11/18/2020 8:00	11/18/2020 22:35	14:35	7,097	0.35	596	1.35	Rain on snow	100%	61	27.01	2,419	1.07	582	0.26
UT	Fall/Winter	1/4/2021 12:35	1/4/2021 18:00	5:25	1,824	0.21	1,741	0.24	Rain on snow	100%	278	31.64	3,985	0.45	1,845	0.21
UT	Fall/Winter	2/11/2021 16:25	2/13/2021 14:50	46:25	3,788	0.19	1,768	0.91	Event Snowmelt	100%	200	47.29	2,414	0.57	1,506	0.36
UT	Spring	3/18/2021 18:20	3/19/2021 6:40	12:20	3,705	0.51	1,696	0.41	Rain on snow	100%	123	28.36	2,038	0.47	659	0.15
UT	Spring	4/14/2021 6:55	4/14/2021 11:15	4:20	965	0.20	948	0.43	Event Snowmelt	100%	69	4.15	2,569	0.15	802	0.05
UT	Spring	5/20/2021 20:05	5/21/2021 23:40	27:35	1,357	0.24	728	0.15	Event Snowmelt	100%	44	3.72	4,037	0.34	568	0.05

7. BMP Effectiveness Monitoring

7.1 SR431

Data collected from matched inflow and outflow sampling at the Contech MFS stormwater treatment vault and at the Jellyfish stormwater treatment vault at SR431 have historically shown variable removal efficiencies for sediment and nutrients. The variability is due, in large part, to system maintenance or lack thereof. Below is a summary of the maintenance that occurred during WY21.

- On October 19, 2020, installation of a pretreatment chamber was complete. The purpose of the pretreatment chamber is to capture bulk sediment, trash and debris so that existing media filtration systems will no longer be overwhelmed with coarse sediment and will more effectively treat fine sediment.
- On March 8, 2021, NDOT crews rinsed and vactored sediment from the hydrodynamic separator, splitter chamber, and both vaults. The filters were rinsed for both the Contech MFS and the Jellyfish.
- On June 17, 2021, Tahoe RCD staff rinsed both inflow and outflow pipes and the flumes, but they were not vactored. The mobilized sediment continued through the rest of the system.

Table 16 presents the seasonal and annual summary data on load removal efficiency for each treatment vault at SR431 in WY21 based on samples taken during sampled events (FSP, TN, TP) and continuous turbidity (estimated FSP).

Table 16 Seasonal and annual efficiency data from the Contech MFS and Jellyfish vaults at SR431, WY21.

Water Year 2021 (October 1, 2020 - September 30, 2021)			Seasonal FSP Loads (lbs)			Total Annual FSP Loads (lbs)	Estimated Seasonal FSP Loads (lbs)			Estimated Total Annual FSP Loads (lbs)	Seasonal TN Loads (lbs)			Total Annual TN Loads (lbs)	Seasonal TP Loads (lbs)			Total Annual TP Loads (lbs)
Catchment 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	11.6	29.2	10.1	50.9	7.9	13.8	5.3	27.0	0.05	0.17	0.29	0.50	0.07	0.17	0.08	0.32
	Contech Out	CO	0	11.2	1.4	12.6	2.3	6.1	2.0	10.5	0	0.09	0.12	0.21	0	0.07	0.02	0.08
		Load Reduction	11.6	18.0	8.7	38.3	5.6	7.7	3.3	16.5	0.05	0.08	0.17	0.30	0.07	0.10	0.06	0.24
		% Change	-100%	-62%	-87%	-75%	-71%	-56%	-61%	-61%	-100%	-47%	-60%	-59%	-100%	-61%	-81%	-74%
SR431	Jellyfish In	JI	11.9	42.7	11.3	65.9	7.7	13.1	5.8	26.6	0.05	0.22	0.29	0.55	0.07	0.24	0.08	0.40
	Jellyfish Out	JO	1.8	3.4	4.3	9.5	2.1	3.4	1.1	6.5	0.02	0.06	0.04	0.11	0.01	0.02	0.01	0.04
		Load Reduction	10.1	39.3	7.0	56.4	5.7	9.7	4.7	20.1	0.03	0.16	0.25	0.44	0.06	0.22	0.08	0.36
		% Change	-85%	-92%	-62%	-86%	-73%	-74%	-82%	-76%	-67%	-74%	-87%	-80%	-83%	-91%	-91%	-90%

- The Contech MFS reduced annual FSP loads by 75% and 61% based on samples and estimated from continuous turbidity respectively.
- The Contech MFS reduced annual TN by 59%.
- The Contech MFS reduced annual TP loads by 74%.
- The Contech MFS reduced all fall/winter seasonal loads based on samples by 100% because there was not enough outflow from the vault during that season to sample effectively. Estimated FSP load reductions during fall/winter were 71%.
- The Jellyfish reduced annual FSP loads by 86% and 76% based on samples and estimated from continuous turbidity respectively.
- The Jellyfish reduced annual TN loads by 80%. The greatest TN reduction efficiency occurred in the summer at 87%.
- The Jellyfish reduced annual TP loads by 90%. The greatest TP reduction efficiency occurred in the spring and summer at 91%.
- The Jellyfish was more efficient than the Contech MFS at reducing all annual pollutants loads in WY21 perhaps due to very low flows that didn't result in too much accumulated sediment and therefore higher performance.

Table 17 presents the efficiency of the Contech MFS at reducing concentrations and loads of all three pollutants for the individual events sampled in WY21.

Table 17 Event efficiency data from the Contech MFS vault at SR431, WY21.

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
2/13/2021	13%	1,365	na	-100%	12	na	-100%	5,544	na	-100%	0.05	na	-100%	8,498	na	-100%	0.07	na	-100%
3/18/2021	8%	1,697	1,016	-40%	9	4	-60%	5,673	4,750	-16%	0.03	0.02	-44%	10,208	6,751	-34%	0.05	0.02	-56%
4/13/2022	7%	1,657	654	-61%	7	2	-67%	6,415	3,355	-48%	0.03	0.01	-56%	8,684	3,745	-57%	0.04	0.01	-63%
5/16/2021	5%	1,737	830	-52%	6	2	-62%	10,994	6,764	-38%	0.04	0.02	-51%	9,597	4,477	-53%	0.03	0.01	-63%
5/21/2021	33%	354	217	-39%	7	3	-59%	3,553	3,046	-14%	0.07	0.04	-43%	2,305	1,269	-45%	0.05	0.02	-63%
7/26/2021	11%	900	na	na	6	na	na	17,148	na	na	0.12	na	na	6,663	na	na	0.05	na	na
9/9/2021	23%	252	126	-50%	4	1	-82%	11,195	10,734	-4%	0.16	0.06	-65%	2,131	1,414	-34%	0.03	0.01	-76%

- Concentration and load reductions efficiencies of 100% for the February 13, 2021 event is due to the fact that there was not enough outflow to sample from the Contech MFS vault for that event.
- Concentration and load reduction efficiencies are not applicable for the July 26, 2021 event because outflow samples failed.
- All events showed a reduction in both concentration and load for all pollutants, perhaps because low flow volumes and the installation of a hydrodynamic separator meant the system was not overwhelmed with sediment and could function efficiently.

Contech MFS vault water level and bypass flow are presented in Figure 71. When bypass occurs, untreated flow comingles with treated flow in the outflow from the Contech MFS vault, resulting in reduced overall treatment efficiency.

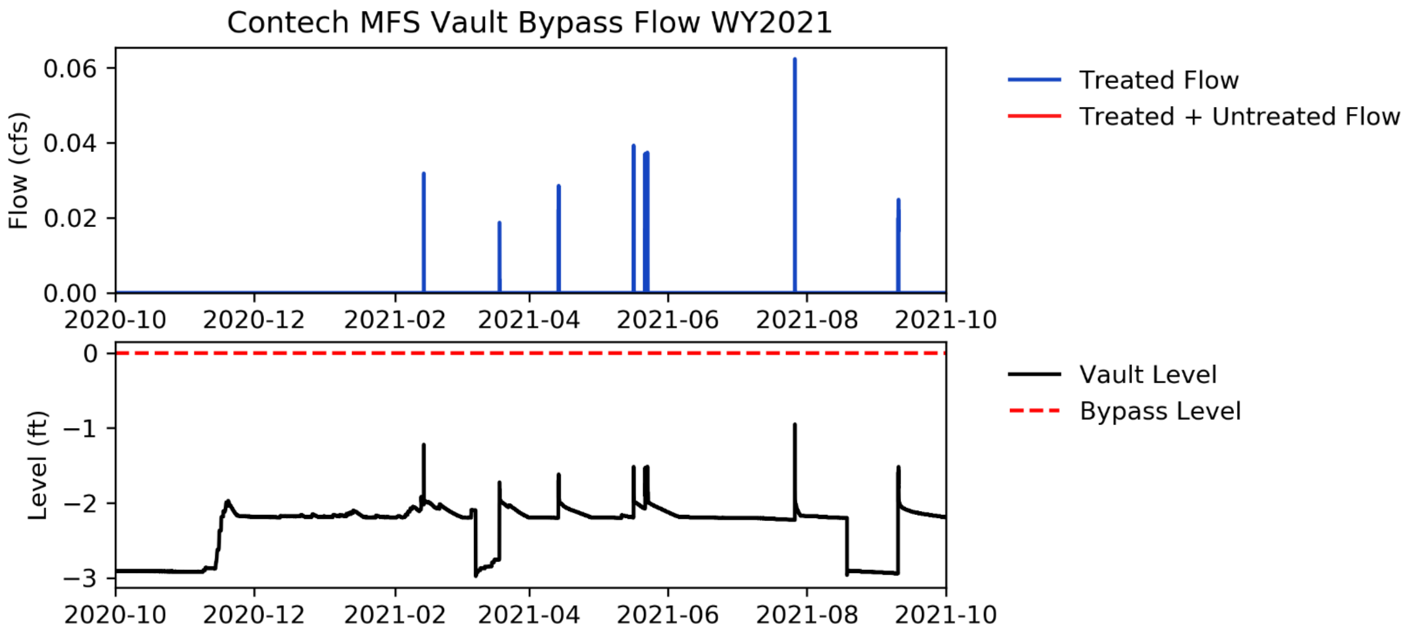

Figure 71 Contech MFS vault level at SR431, WY21 (bottom). Contech MFS outflow shown at top for reference. Vault level greater than 0 indicates bypass flow. The Contech MFS vault bypassed zero times in WY21.

- The Contech MFS vault bypassed zero times in WY21.

Table 18 presents the efficiency of the Jellyfish at reducing concentrations and loads of all three pollutants for the individual events sampled in WY21.

Table 18 Event efficiency data from the Jellyfish vault at SR431, WY21.

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
2/13/2021	14%	988	367	-63%	11	2	-84%	4,098	3,381	-17%	0.05	0.02	-65%	6,140	2,612	-57%	0.07	0.01	-82%
3/18/2021	12%	1,251	na	-100%	13	na	-100%	4,732	na	-100%	0.05	na	-100%	7,851	na	-100%	0.08	na	-100%
4/13/2022	11%	1,743	210	-88%	15	2	-90%	6,560	1,817	-72%	0.06	0.01	-76%	8,684	1,141	-87%	0.08	0.01	-89%
5/16/2021	5%	1,932	86	-96%	8	0	-96%	11,287	2,198	-81%	0.05	0.01	-82%	10,043	657	-93%	0.04	0.002	-94%
5/21/2021	25%	322	101	-68%	7	1	-78%	3,074	2,359	-23%	0.06	0.03	-46%	1,952	645	-67%	0.04	0.01	-77%
7/26/2021	10%	804	714	-11%	6	4	-39%	13,608	2,185	-84%	0.11	0.01	-89%	5,557	631	-89%	0.04	0.003	-92%
9/9/2021	23%	260	178	-31%	5	0	-91%	9,405	10,596	13%	0.18	0.03	-85%	2,087	1,527	-27%	0.04	0.004	-90%

- Concentration and load reductions efficiencies of 100% for the March 18, 2021 event is due to the fact that there was not enough outflow to sample from the Jellyfish vault for that event.
- All other events showed a reduction in both concentration and load for all pollutants (with one exception), perhaps because low flow volumes and the installation of a hydrodynamic separator meant the system was not overwhelmed with sediment and could function efficiently.

Jellyfish vault water level and bypass flow are presented in Figure 72. When bypass occurs, untreated flow comingles with treated flow in the outflow from the Jellyfish vault, resulting in reduced overall treatment efficiency.

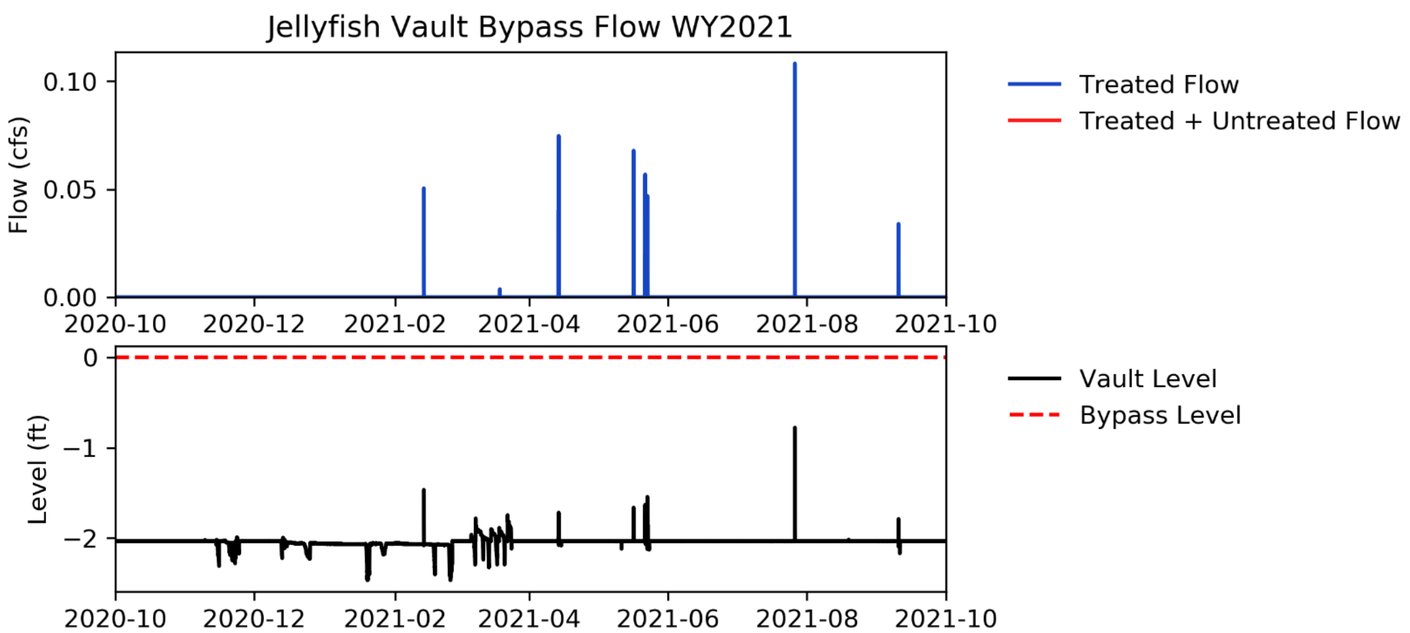

Figure 72 Jellyfish vault level at SR431, WY21 (bottom). Jellyfish outflow shown at the top for reference. Vault level greater than 0 indicates bypass flow. The Jellyfish vault bypassed zero times in WY21.

- The Jellyfish vault bypassed zero times in WY21.

7.2 Elks Club

Elks Club Drive was repaved in August 2018, right before the start of WY19. Data collected at Elks Club in WY18 represents pre-paving conditions. Data collected in WY19, WY20, and WY21 represent post-paving conditions. Prior to repaving, Elk's Club Drive was in poor condition, covered in cracks and potholes (Figure 73 - PCI*: 29). In August 2018 it was repaved to excellent conditions (Figure 74 - PCI*: 99).

Figure 73 Elks Club Drive prior to repaving. (R Wigart)

Figure 74 Elks Club Drive after repaving. (A Buxton)

Samples from all water years are analyzed for the same analytes as all other stormwater samples in accordance with RSWMP protocols. In addition to sediment and nutrients, Elks Club runoff samples from WY18 and WY19 also underwent a source apportionment analysis. Samples of asphalt aggregate, asphalt binder, roadside soil (i.e., soil that erodes off the adjacent road shoulder of adjoining land), traction abrasives (i.e., road sand), and vegetation debris collected near the monitoring site were submitted at the beginning of the project and molecular markers were identified for each of these sediment types. Subsequent runoff samples were then analyzed using the molecular markers and a chemical mass balance model to determine what portion of the sediment in each sample originated from each source.

* PCI is a numerical index between 0 and 100 used to indicate the general condition of pavement. It requires a manual survey and is widely used by transportation departments to evaluate road condition. PCI was developed by the United States Army Corps of Engineers and surveying and calculation methods were standardized by the American Society for Testing Materials (ASTM). The method is based on a visual survey of the number and types of distresses in the pavement including alligator cracking, block cracking, bumps and sags, corrugations, longitudinal and transverse cracking, patching and utility cut patching, potholes, swelling, weathering, raveling, etc. Assessing PCI on roads is the most widely used and accepted method for determining road surface condition so that condition can be tracked and roads can be prioritized for funding for repaving or resurfacing.

Table 19 shows that there was a statistically significant decrease in the relative contribution of particles from road sources (asphalt aggregate plus binder and traction abrasives), and a significant increase in relative contribution of particles from non-road sources (roadside soil, vegetation debris, and atmospheric deposition) before (WY18) and after (WY19) pavement condition improvement.

Table 19 Results of Elks Club study. P-values* less than 0.001 indicate highly significant results (highlighted in green). P-values less than 0.05 indicate significant results (highlighted in yellow).

Water Year	Statistic	Asphalt aggregate + binder (%)	Traction abrasives (%)	Road side soil (%)	Vegetation debris (%)	Atmos-pheric deposition (%)	TSS concen-tration (mg/L)	Normalized TSS load (lbs/acre/in)	FSP concen-tration (mg/L)	Normalized FSP load (lbs/acre/in)
Pre Paving 2018	Mean	45.00	16.60	34.00	3.00	2.70	83.90	6.30	32.50	1.50
	Standard Deviation	6.51	5.26	6.66	0.95	1.25	50.66	7.58	22.12	1.32
	Min	36.00	10.00	24.00	1.50	1.00	17.50	0.25	3.82	0.14
	Median	45.00	17.00	34.00	3.00	3.00	101.30	3.60	37.26	1.83
	Max	56.00	25.00	45.00	4.50	5.00	137.50	22.11	67.58	3.28
Post Paving 2019	Mean	24.90	8.20	42.20	16.50	5.00	22.70	0.60	6.90	0.10
	Standard Deviation	6.10	2.76	6.83	4.33	1.63	15.47	0.82	5.77	0.08
	Min	14.80	3.00	33.00	10.00	2.00	10.00	0.03	0.57	0.01
	Median	26.20	9.00	41.00	16.00	5.00	15.25	0.29	5.10	0.07
	Max	33.70	11.00	55.00	23.00	8.00	57.00	2.47	19.10	0.27
	T-test p-value	**0.000**	**0.004**	**0.023**	**0.000**	**0.003**	**0.018**	**0.050**	**0.013**	**0.026**

*A t-test is a statistical test, resulting in a p-value, that is used to determine if there is a significant difference between the means of two sets of data. If the p-value is less than 0.001, then results are highly significant, meaning that there is only a 0.1% chance that the differences between the two sets of data were by chance. If the p-value is less than 0.05, results are significant, meaning that there is only a 5% chance the differences between the two sets of data were by chance.

Figure 75 shows the percent composition of FSP in stormwater before and after paving. When relative contributions of asphalt aggregate plus binder and traction abrasives decrease, the relative contributions of naturally occurring roadside soil, vegetation debris, and atmospheric deposition increase as these contributions are not changed by improving pavement condition. Assuming that traction abrasive application practices remain fairly consistent from year to year, the decrease in the relative contribution of traction abrasives with improved pavement condition can be reasonably attributed to more efficient sweeping. Street sweeping on a smooth road surface is more effective than on a road surface marred by cracks and potholes allowing more sediment to be recovered. Percent contribution to FSP from each source category in the pre- and post- pave condition describes only how the composition of FSP in stormwater changed, it does not indicate if total sediment loads decreased. However, Table 19 also shows statistically significant decreases in total suspended sediment (TSS) concentration, FSP concentration, normalized TSS load, and normalized FSP load (pounds of sediment per acre per inch of rain).

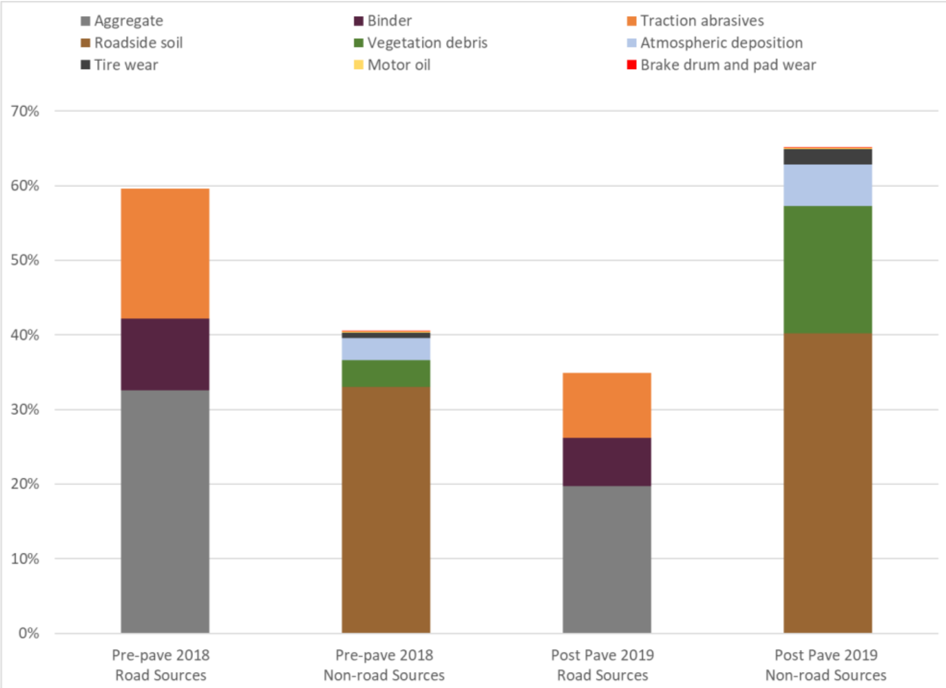

Figure 75 Average annual FSP load attributable to road and non-road sources at Elks Club, WY18 and WY19. 60% and 35% of the FSP in stormwater runoff from Elks Club Drive originated from road sources (asphalt aggregate, asphalt binder, and traction abrasives) in the pre- and post-pave conditions respectively.

Table 20 shows the substantial impact that improving pavement condition on Elk's Club Drive had on water quality in terms of reduced sediment concentrations and loads the first year after repaving. In WY19, mean annual TSS and FSP concentrations were reduced by 73% and 79% respectively, which resulted in mean annual normalized TSS and FSP load reductions of 90% and 93% respectively. (Normalized load values account for catchment size and remove year to year variability in precipitation frequency, size, intensity, and duration.) In WY20, mean annual TSS and FSP concentrations were reduced by 41% and 50% respectively, which resulted in mean annual normalized TSS and FSP load reductions of 95% and 93% respectively when compared to the pre-restoration condition of WY18. WY20 was a very dry year which may have contributed to higher concentrations but lower loads as compared to the previous post restoration data of WY19. WY21 was an extremely dry year, and TSS and FSP concentrations were reduced by 46% and 33% respectively, which resulted in mean annual normalized TSS and FSP load reductions of 89% and 67% when compared to the pre-paving condition of WY18. There has been some decrease in sediment reduction effectiveness, but this is expected as pavement ages, and all post-paving years show a significant improvement over the pre-paving condition of WY18.

Table 20 Mean annual sediment concentrations and normalized load reductions for WY19, WY20, and WY21 compared to WY18.

Water Year	TSS concen-tration (mg/L)	Normalized TSS load (lbs/acre/in)	FSP concen-tration (mg/L)	Normalized FSP load (lbs/acre/in)
Pre Paving 2018	83.90	6.30	32.50	1.50
Post Paving 2019	22.70	0.60	6.90	0.10
Post Paving 2020	49.30	0.30	16.30	0.10
Post Paving 2021	45.50	0.70	21.70	0.50
2019 % Reduction	**73%**	**90%**	**79%**	**93%**
2020 % Reduction	**41%**	**95%**	**50%**	**93%**
2021 % Reduction	**46%**	**89%**	**33%**	**67%**

8. Trends Analysis

In accordance with the RSWMP FIG section 2.1, monitoring for trends at urban catchment outfalls is important because it provides information needed for evaluating progress toward TMDL and other regulatory goals. The objective of the trends monitoring is to detect and report the cumulative load reduction benefits of all actions implemented within the catchment over long time frames and ultimately demonstrate a local and regional reduction in pollutant loading to the lake.

Trend analyses are only performed on monitoring sites with at least five years of continuous data. WY21 marked the eighth year of monitoring at SR431, Pasadena, and Tahoma, the seventh year of monitoring at Speedboat, Tahoe Valley, and Upper Truckee, and the fifth year of monitoring at Lakeshore. Trend analyses will only be reported for the inflow locations at SR431 (CI and JI) as these results will indicate trends in pollutant loading from the catchment. Trend analyses on the outflow locations (CO and JO) are an indication of how well the vaults are maintained over the years and will be included in the seasonal progress reports submitted to NDOT and available on Tahoe RCD's website. Elks Club and Tahoe City have four and two years of monitoring data respectively, therefore trends analyses were not performed on the data from these sites. They are included in this section for annual sediment and nutrient load comparisons to annual precipitation only.

Average annual loads for FSP, TN, and TP presented in this section are normalized by both catchment size (acres) and inches of precipitation. Normalizing by catchment size only allows for comparison between sites, but this analysis is not highlighted here as the objective of trends analysis is to detect load reductions resulting from improved management activities within each catchment, not between catchments. Normalizing by precipitation allows for comparison between water years in a particular catchment, which addresses the objective. Percent runoff (runoff coefficient) is a function of catchment size, the amount of rainfall received, and the volume measured at the catchment outfall. It represents the fraction of runoff that was measured at the outfall compared to what would theoretically be expected if all the rainfall that fell in the catchment were measured at the outfall as runoff.

Normalized average annual load charts for each site with five or more years of data show whether there is an upward, downward, or neutral trend in average annual loading of FSP, TN, and TP at each site. Also presented for each site with five or more years of data is a table that shows average annual percent runoff and normalized seasonal and average annual loads and trend statistics. The trend statistics (Tau, p-value, and Theil slope) indicate if there has been a statistically significant upward, downward, or neutral trend in pollutant loading in the selected catchments. Tau is a non-parametric measure of the relationship between data when data does not have a normal distribution, similar to the r^2 value in a regression on normally distributed data. Tau is a measure of the correspondence between two rankings, in this case are water year and pollutant load. Tau is a correlation coefficient that returns a value between -1 and 1 where 0 is no relationship, 1 is a perfect identical relationship and -1 is a perfect opposite relationship with regards to ranked pairs. The water years will always be ranked in order from 2014 through 2021. The pollutant loads are then ranked from least to most as well. The rankings of the pairs are then compared. If pollutant load steadily increases from year to year there will be a perfect identical ranking between the pairs, resulting in a Tau of 1. If pollutant load steadily decreases from year to year there will a perfect opposite ranking of the pairs, resulting in a Tau of -1. The p-value indicates the confidence level in Tau; a p-value less than 0.05 ($p<0.05$) denotes a significant relationship. The Theil slope is similar to the slope for a regression on normalized data, but used for data that is not normally distributed. Lastly, charts showing annual sediment and nutrient loads and annual precipitation totals for each site are included to help visualize how precipitation and loads have varied over the period of record for each site.

8.1 SR431 Contech MFS Inflow

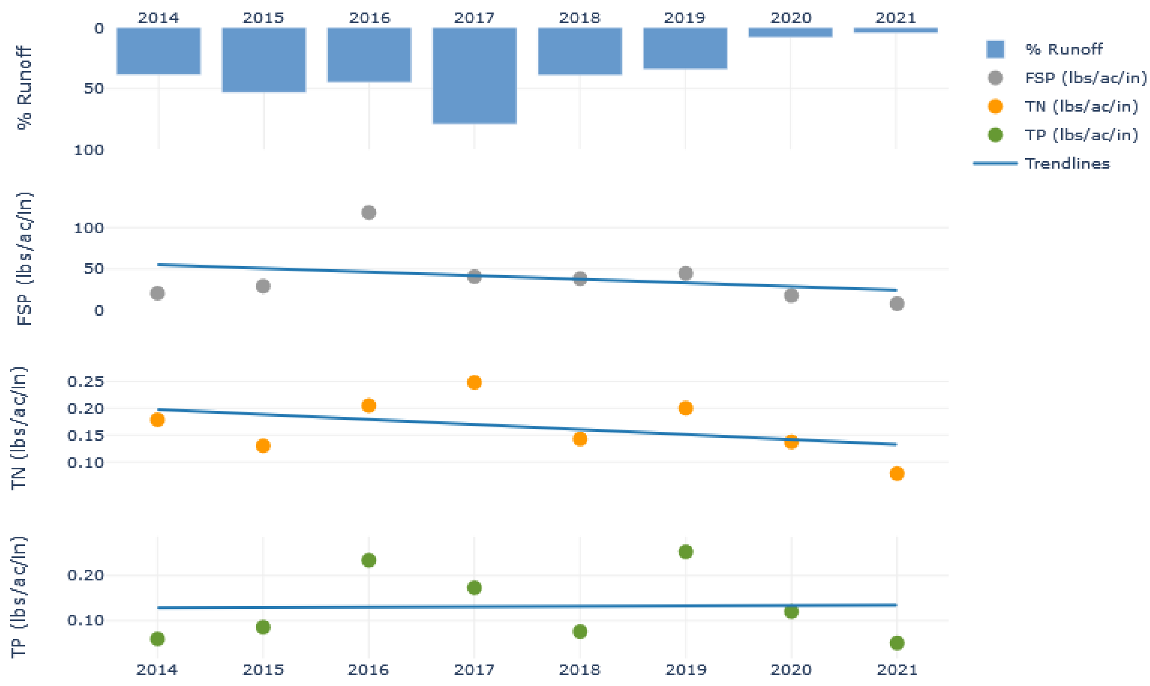

Figure 76 8-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at the Contech MFS Inflow, WY14-21.

- Percent runoff varied between 4.4% in WY21 to 78.9% in WY17. Differences in % runoff between CI and JI are attributed to sediment accumulation in the splitter chamber that caused an unequal division of runoff to each vault.
- There is no significant trend in normalized annual FSP loads (p>0.05).
- There is no significant trend in normalized annual TN loads (p>0.05).
- There is no significant trend in normalized annual TP loads (p>0.05).

Table 21 8-year seasonal and annual rainfall normalized pollutant loads at the Contech MFS Inflow, WY14-21.

Year	% Runoff	FSP (lbs/acre/inch)				TN (lbs/acre/inch)				TP (lbs/acre/inch)			
		Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual
2014	38.6%	8.358	43.467	23.094	20.612	0.065	0.230	0.386	0.179	0.021	0.122	0.079	0.060
2015	53.2%	29.875	41.461	7.517	29.122	0.127	0.164	0.086	0.130	0.097	0.110	0.015	0.086
2016	44.7%	84.812	183.564	0.000	118.153	0.179	0.260	0.000	0.205	0.149	0.399	0.000	0.234
2017	78.9%	19.239	139.993	20.235	40.646	0.178	0.611	0.048	0.248	0.064	0.688	0.035	0.173
2018	39.0%	23.391	51.881	20.808	38.173	0.136	0.116	0.554	0.143	0.083	0.068	0.113	0.076
2019	34.2%	11.578	153.825	8.569	44.624	0.083	0.565	0.227	0.200	0.066	0.866	0.070	0.253
2020	8.0%	9.896	26.907	39.794	17.783	0.040	0.148	0.723	0.138	0.068	0.175	0.288	0.120
2021	4.4%	2.493	22.475	23.756	8.003	0.010	0.130	0.671	0.079	0.016	0.132	0.185	0.051
Tau	na	-0.429	-0.286	0.357	-0.214	-0.429	-0.214	0.429	-0.286	-0.214	0.143	0.500	0.000
P-Value	na	0.138	0.322	0.216	0.458	0.138	0.458	0.138	0.322	0.458	0.621	0.083	1.000
Theil Slope (per year)	na	-4.091	-3.082	1.845	-2.370	-0.020	-0.014	0.066	-0.009	-0.007	0.006	0.026	0.001

Figure 77 through Figure 84 show sediment and nutrient loads for the Contech MFS compared to total annual precipitation for WY14 through WY21. This illustrates how loading and precipitation have varied over the monitored period.

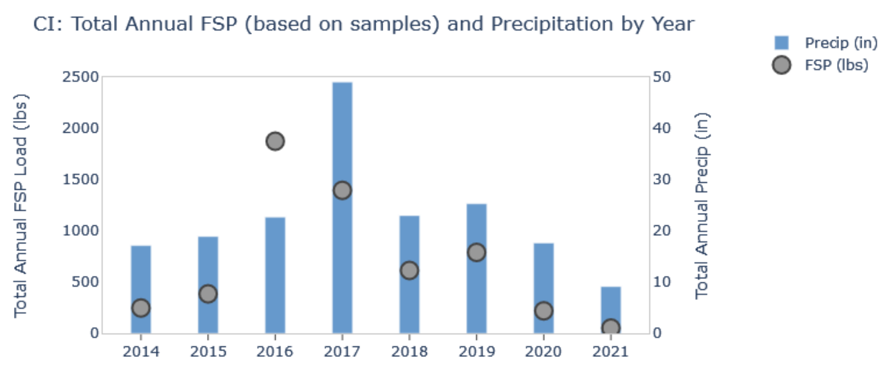

Figure 77 Total annual FSP load (based on samples) and precipitation by year for Contech MFS Inflow WY14-WY21.

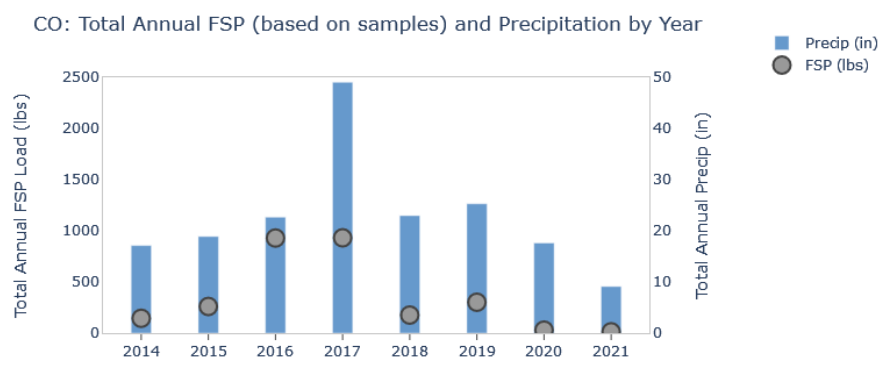

Figure 78 Total annual FSP load (based on samples) and precipitation by year for Contech MFS Outflow WY14-WY21.

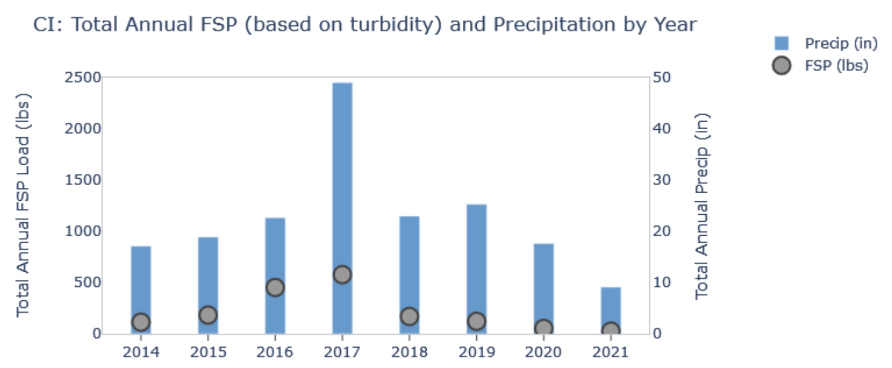

Figure 79 Total annual FSP load (based on continuous turbidity) and precipitation by year for Contech MFS Inflow WY14-WY21.

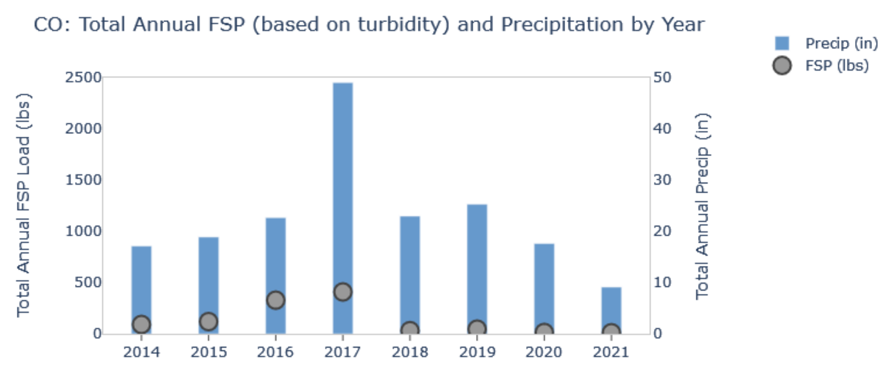

Figure 80 Total annual FSP load (based on continuous turbidity) and precipitation by year for Contech MFS Outflow WY14-WY21.

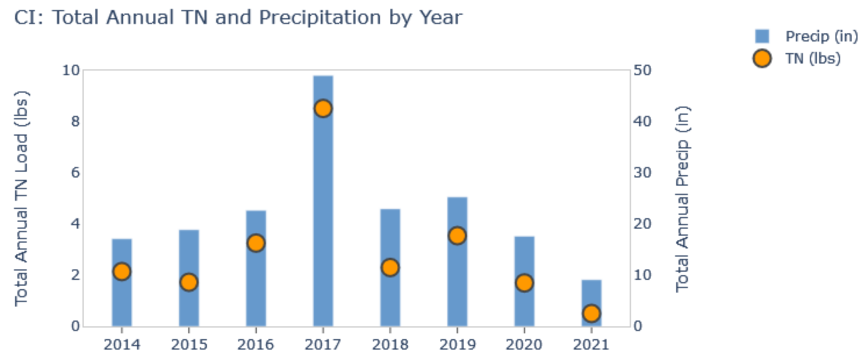

Figure 81 Total annual TN load and precipitation by year for Contech MFS Inflow WY14-WY21.

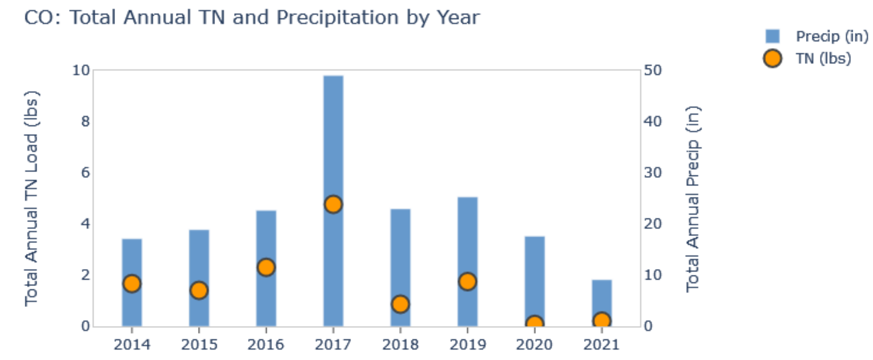

Figure 82 Total annual TN load and precipitation by year for Contech MFS Outflow WY14-WY21.

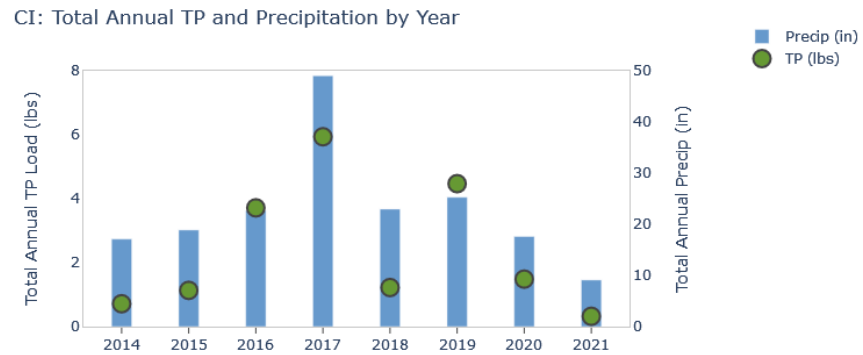

Figure 83 Total annual TP load and precipitation by year for Contech MFS Inflow WY14-WY21.

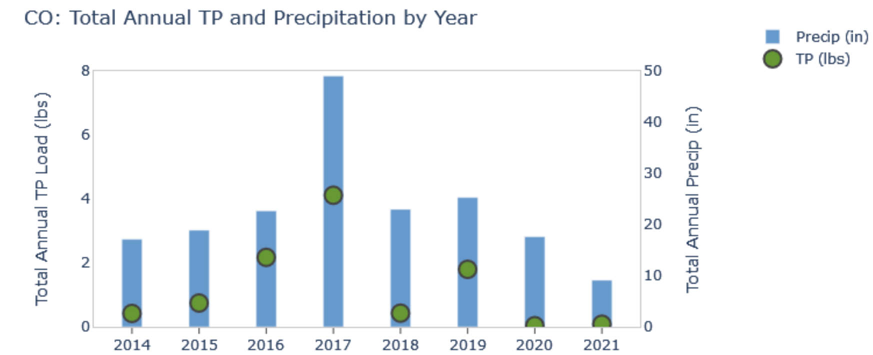

Figure 84 Total annual TP load and precipitation by year for Contech MFS Outflow WY14-WY21.

8.2 SR431 Jellyfish Inflow

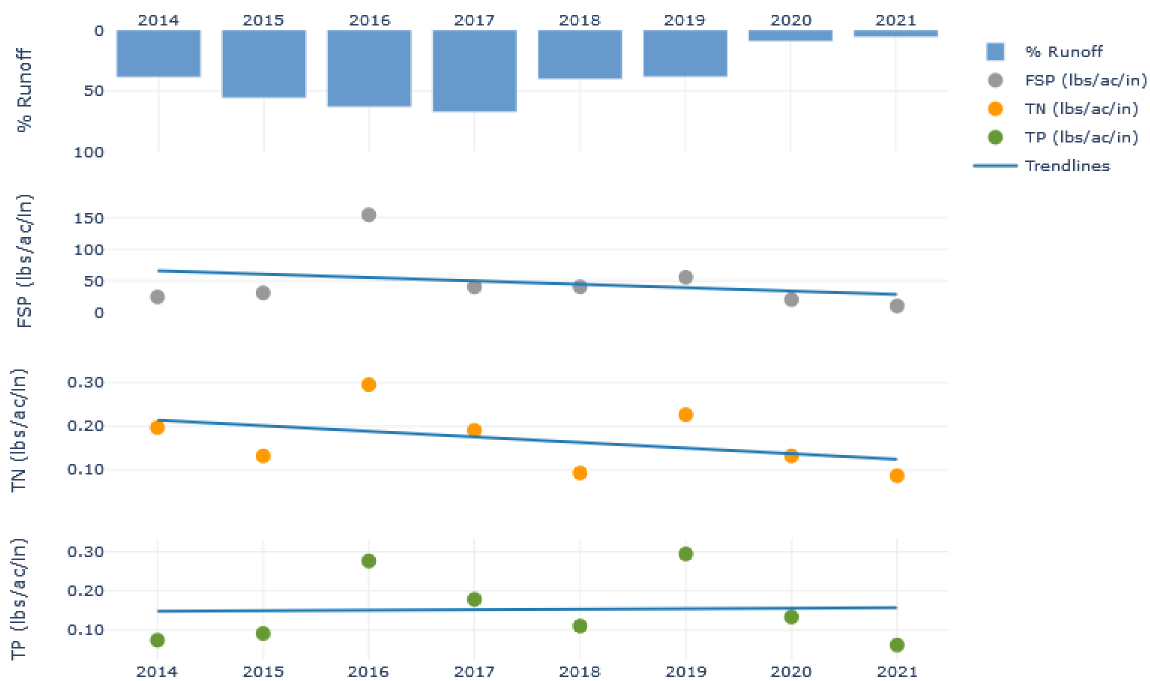

Figure 85 8-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at the Jellyfish Inflow, WY14-21.

- Percent runoff varied between 5.7% in WY21 to 67.2% in WY17. Differences in % runoff between CI and JI are attributed to sediment accumulation in the splitter chamber that caused an unequal division of runoff to each vault.
- There is no significant trend in normalized annual FSP loads (p>0.05), however, there is a significant decreasing trend for normalized fall/winter FSP loads (p=0.048 and Tau= -0.571)
- There is no significant trend in normalized annual TN loads (p>0.05).
- There is no significant trend in normalized annual TP loads (p>0.05).

Table 22 8-year seasonal and annual rainfall normalized pollutant loads at the Jellyfish Inflow, WY14-21.

Year	% Runoff	FSP (lbs/acre/inch)				TN (lbs/acre/inch)				TP (lbs/acre/inch)			
		Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual
2014	38.6%	13.733	51.563	18.989	24.558	0.060	0.313	0.384	0.197	0.033	0.160	0.075	0.075
2015	55.5%	30.438	46.614	8.065	31.038	0.116	0.174	0.109	0.132	0.095	0.133	0.017	0.092
2016	62.9%	117.285	228.200	0.000	154.437	0.214	0.457	0.000	0.296	0.223	0.385	0.000	0.276
2017	67.2%	19.818	137.664	15.455	40.456	0.096	0.643	0.061	0.191	0.065	0.714	0.033	0.179
2018	40.2%	20.067	59.455	18.262	40.577	0.072	0.076	0.526	0.093	0.070	0.146	0.105	0.111
2019	38.3%	12.118	199.427	9.225	55.670	0.090	0.649	0.263	0.227	0.059	1.068	0.071	0.294
2020	9.1%	7.699	43.672	29.192	20.335	0.034	0.172	0.630	0.132	0.057	0.263	0.221	0.134
2021	5.7%	2.562	32.779	26.575	10.351	0.011	0.166	0.672	0.087	0.016	0.183	0.197	0.062
Tau	na	-0.571	-0.286	0.357	-0.143	-0.500	-0.143	0.500	-0.357	-0.429	0.214	0.500	0.071
P-Value	na	0.048	0.322	0.216	0.621	0.083	0.621	0.083	0.216	0.138	0.458	0.083	0.805
Theil Slope (per year)	na	-4.484	-3.816	2.794	-2.085	-0.017	-0.003	0.056	-0.014	-0.008	0.010	0.027	0.006

Figure 86 through Figure 93 show sediment and nutrient loads for the Jellyfish compared to total annual precipitation for WY14 through WY21. This illustrates how loading and precipitation have varied over the monitored period.

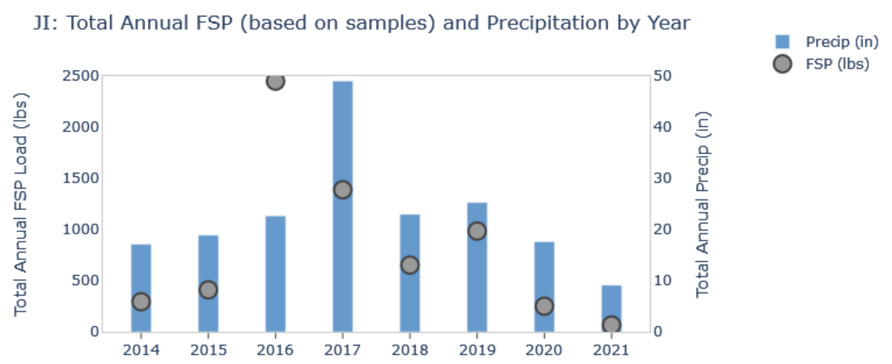

Figure 86 Total annual FSP load (based on samples) and precipitation by year for Jellyfish Inflow WY14-WY21.

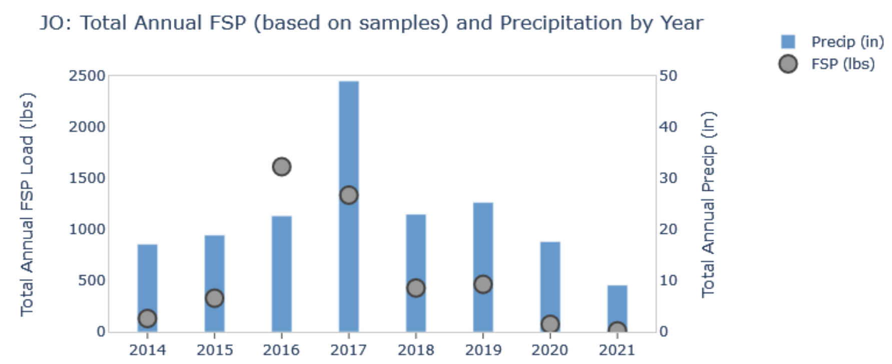

Figure 87 Total annual FSP load (based on samples) and precipitation by year for Jellyfish Outflow WY14-WY21.

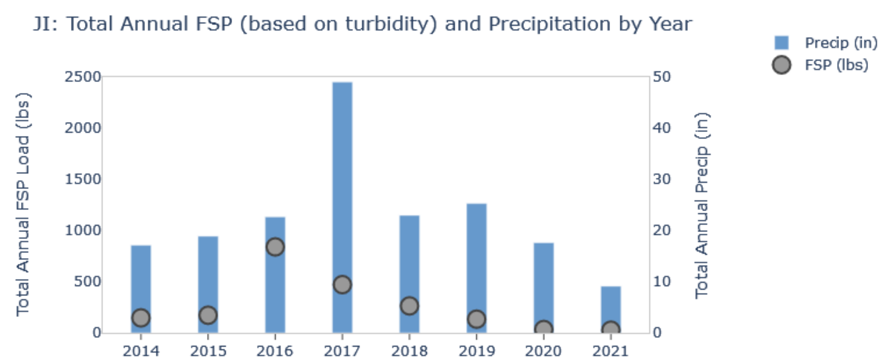

Figure 88 Total annual FSP load (based on continuous turbidity) and precipitation by year for Jellyfish Inflow WY14-WY21.

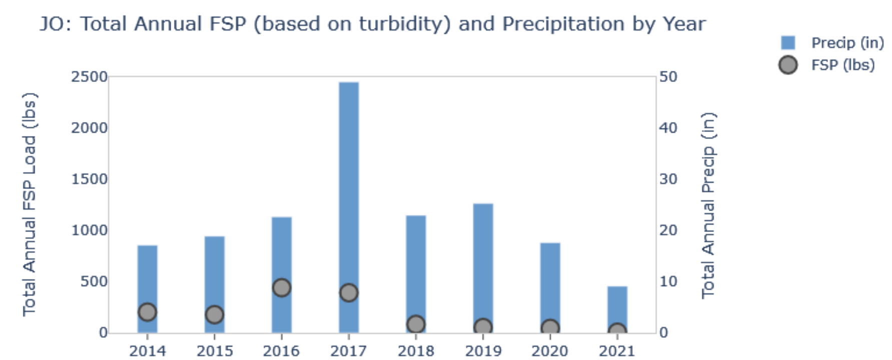

Figure 89 Total annual FSP load (based on continuous turbidity) and precipitation by year for Jellyfish Outflow WY14-WY21.

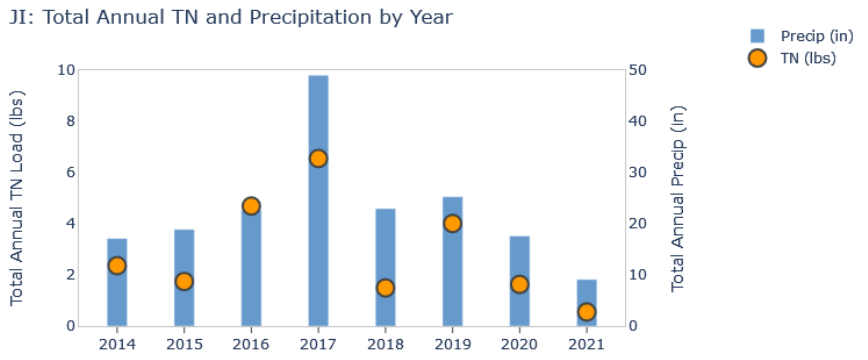

Figure 90 Total annual TN load and precipitation by year for Jellyfish Inflow WY14-WY21.

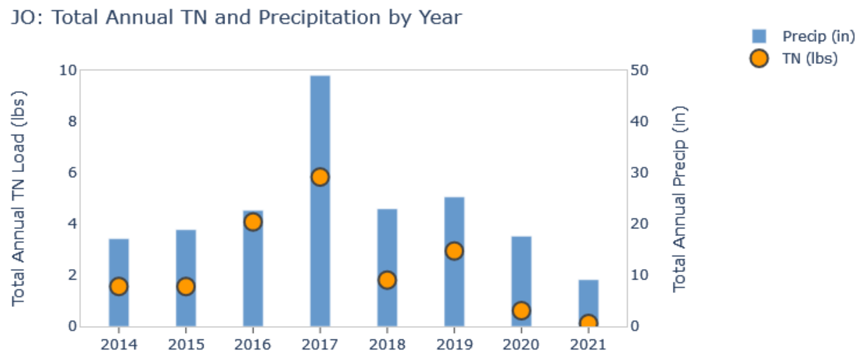

Figure 91 Total annual TN load and precipitation by year for Jellyfish Outflow WY14-WY21.

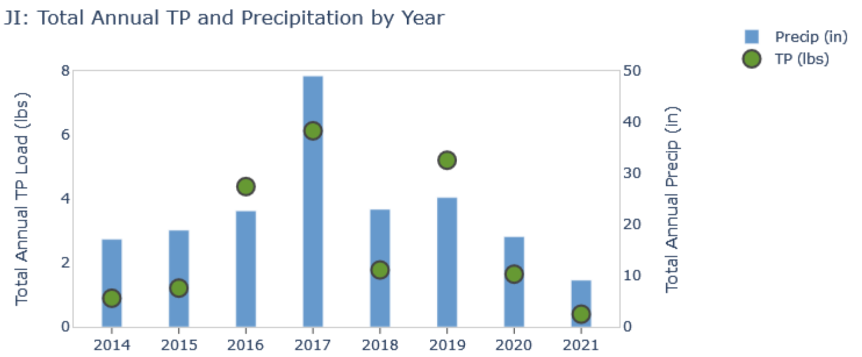

Figure 92 Total annual TP load and precipitation by year for Jellyfish Inflow WY14-WY21.

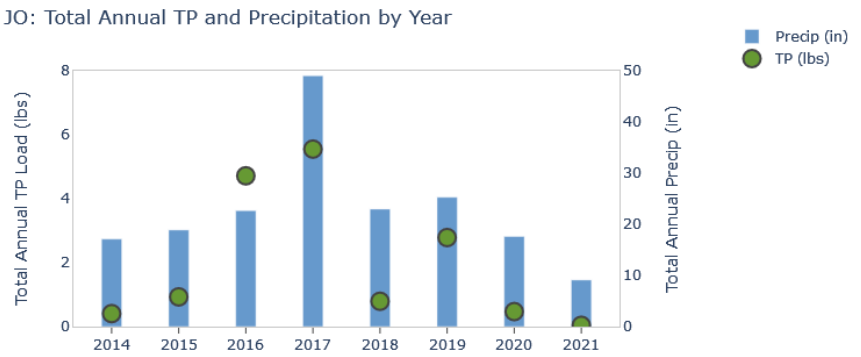

Figure 93 Total annual TP load and precipitation by year for Jellyfish Outflow WY14-WY21.

8.3 Elks Club

Figure 94 through Figure 97 show sediment and nutrient loads for Elks Club compared to total annual precipitation for WY18 through WY21. This illustrates how loading and precipitation have varied over the monitored period.

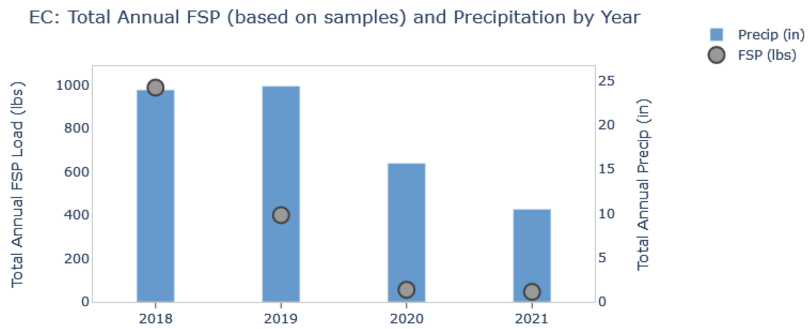

Figure 94 Total annual FSP load (based on samples) and precipitation by year for Elks Club WY18-WY21.

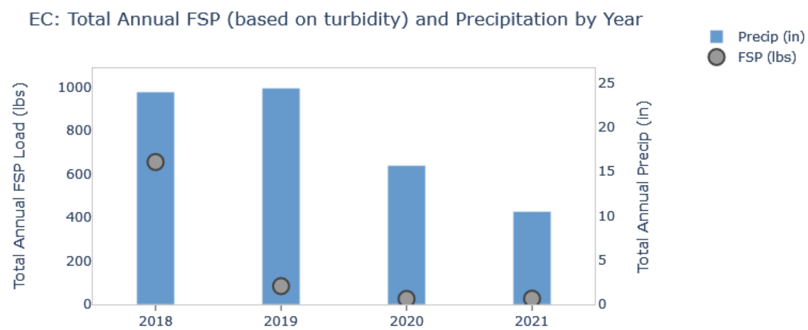

Figure 95 Total annual FSP load (based on continuous turbidity) and precipitation by year for Elks Club WY18-WY21.

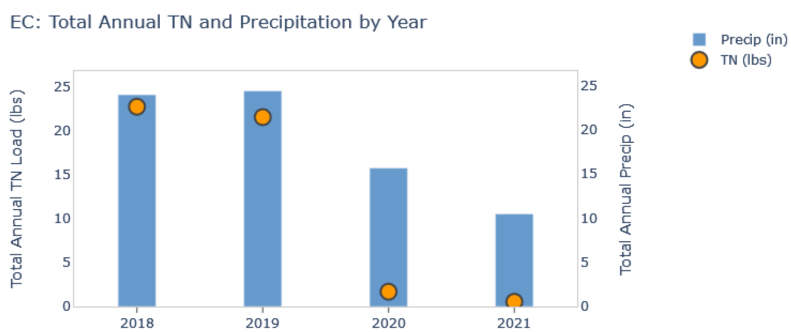

Figure 96 Total annual TN load and precipitation by year for Elks Club WY18-WY21.

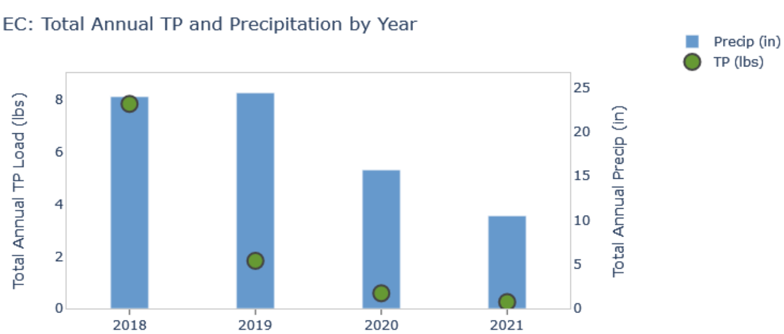

Figure 97 Total annual TP load and precipitation by year for Elks Club WY18-WY21.

8.4 Lakeshore

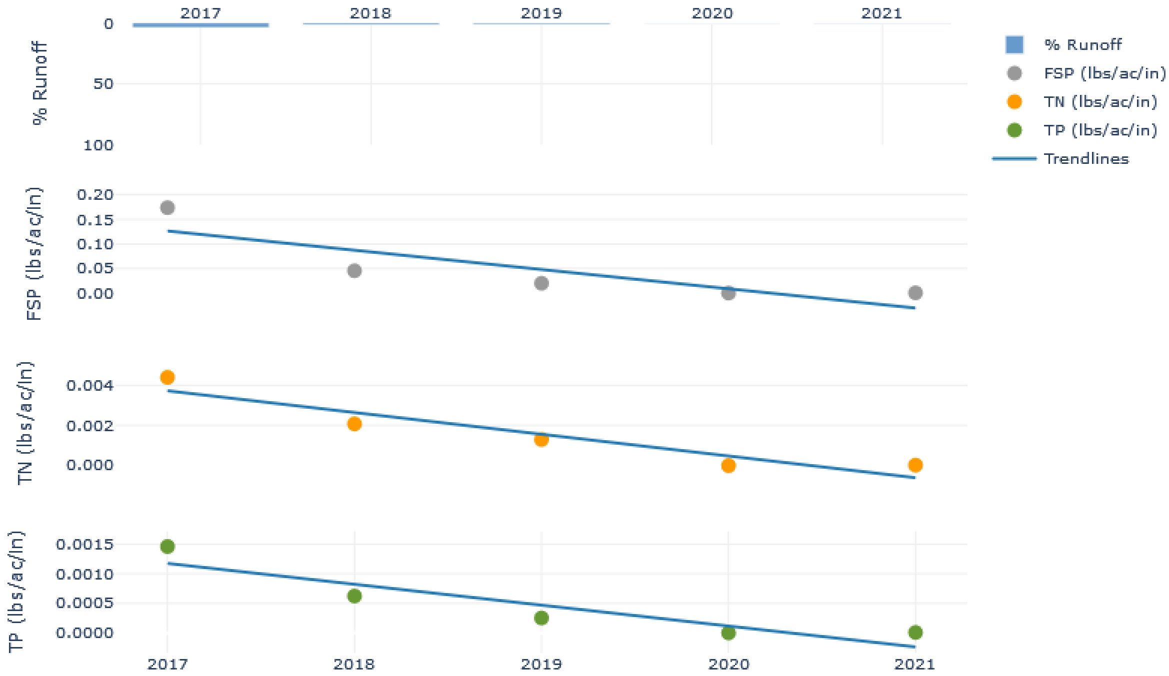

Figure 98 5-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at Lakeshore, WY17-21.

- Percent runoff varied between 0.0% in WY20 to 3.57% in WY17.
- There is a significant decreasing trend in normalized annual FSP loads (p=0.050 and Tau= -0.800), fall/winter FSP loads (p=0.050 and Tau= -0.800), and spring FSP loads (p=0.023 and Tau= -0.949).
- There is a significant decreasing trend in normalized annual TN loads (p=0.050 and Tau= -0.800), fall/winter TN loads (p=0.050 and Tau= -0.800), and spring TN loads (p=0.023 and Tau= -0.949).
- There is a significant decreasing trend in normalized annual TP loads (p=0.050 and Tau= -0.800), fall/winter TP loads (p=0.050 and Tau= -0.800), and spring TP loads (p=0.023 and Tau= -0.949).

Table 23 5-year seasonal and annual rainfall normalized pollutant loads at Lakeshore, WY17-21.

Year	% Runoff	FSP (lbs/acre/inch)				TN (lbs/acre/inch)				TP (lbs/acre/inch)			
		Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual
2017	3.57%	0.172	0.211	0.000	0.174	0.004	0.006	0.000	0.004	0.001	0.002	0.000	0.001
2018	1.25%	0.037	0.053	0.000	0.045	0.003	0.001	0.000	0.002	0.001	0.001	0.000	0.001
2019	0.98%	0.024	0.005	0.030	0.020	0.002	0.000	0.001	0.001	0.000	0.000	0.000	0.000
2020	0.00%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2021	0.01%	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Tau	na	-0.800	-0.949	0.000	-0.800	-0.800	-0.949	0.000	-0.800	-0.800	-0.949	0.000	-0.800
P-Value	na	0.050	0.023	1.000	0.050	0.050	0.023	1.000	0.050	0.050	0.023	1.000	0.050
Theil Slope (per year)	na	-0.021	-0.037	0.000	-0.024	-0.001	-0.001	0.000	-0.001	0.000	0.000	0.000	0.000

Figure 99 through Figure 102 show sediment and nutrient loads for Lakeshore compared to total annual precipitation for WY17 through WY21. This illustrates how loading and precipitation have varied over the monitored period.

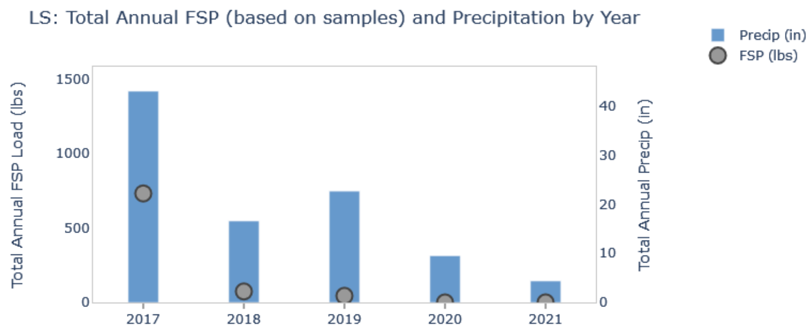

Figure 99 Total annual FSP load (based on samples) and precipitation by year for Lakeshore WY17-WY21.

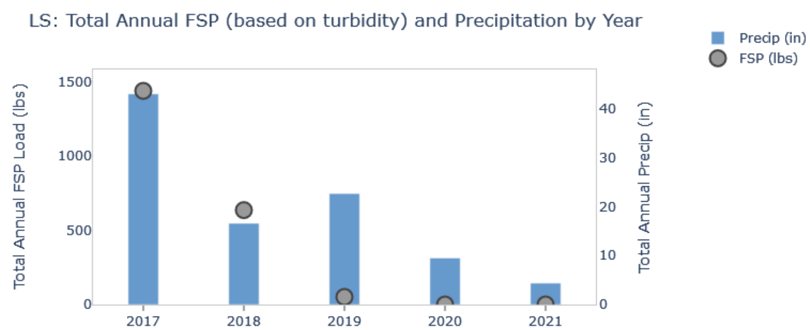

Figure 100 Total annual FSP load (based on continuous turbidity) and precipitation by year for Lakeshore WY17-WY21.

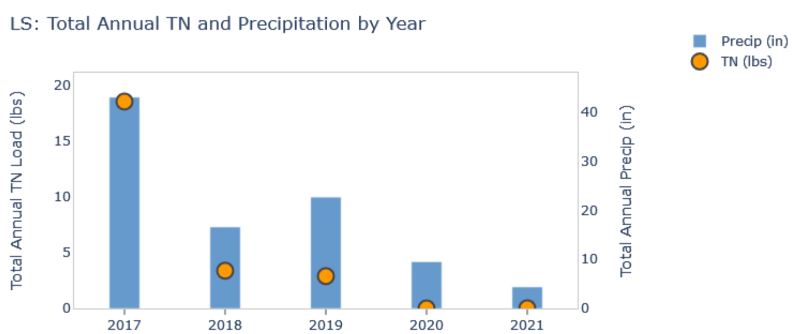

Figure 101 Total annual TN load and precipitation by year for Lakeshore WY17-WY21.

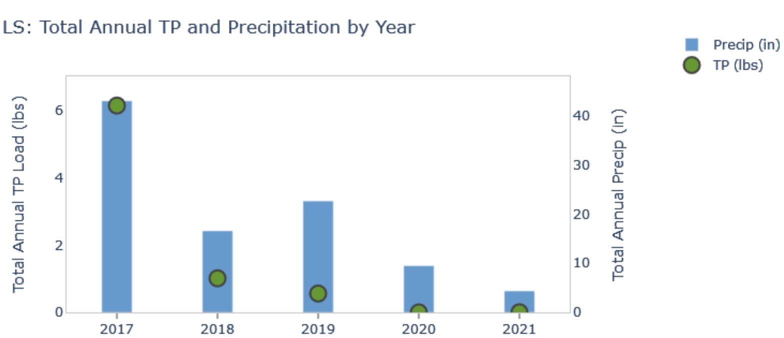

Figure 102 Total annual TP load and precipitation by year for Lakeshore WY17-WY21.

8.5 Pasadena

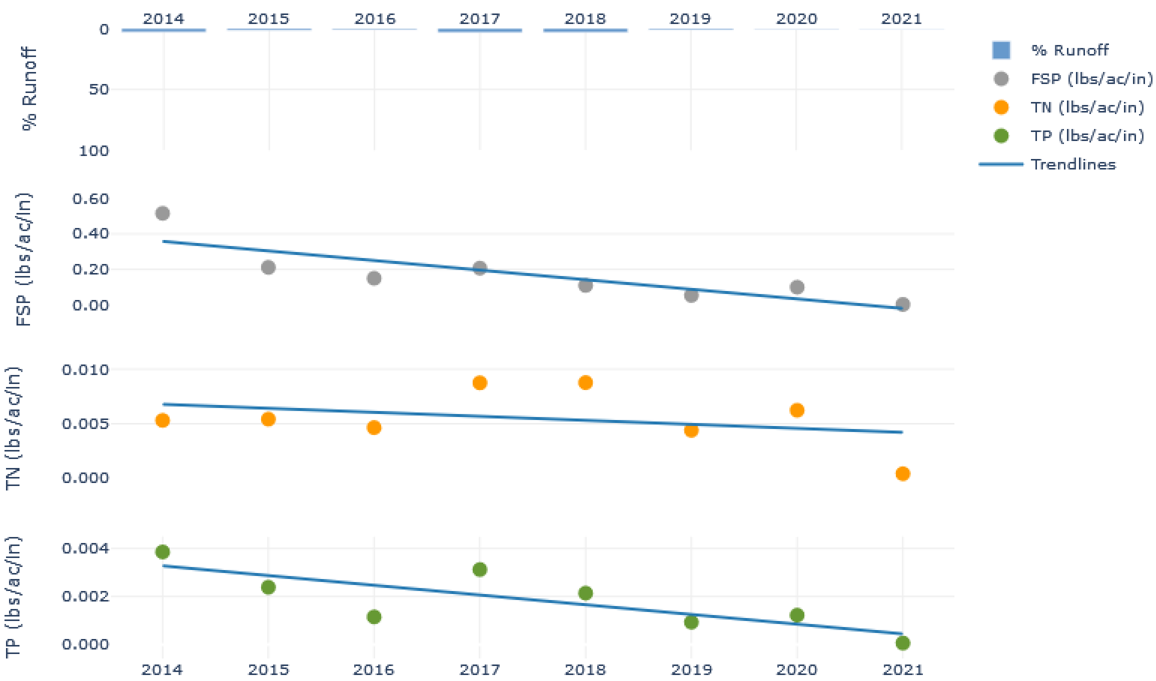

Figure 103 8-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at the Pasadena Outflow, WY14-21.

- Percent runoff was less than 4% in all 8 water years but varied between 0.05% in WY21 to 3.2% in WY17.
- There is a significant decreasing trend in normalized annual FSP loads (p=.003 and Tau= -0.857) and fall/winter FSP loads (p=0.013 and Tau= -0.714).
- There is no significant trend in normalized annual TN loads (p>0.05).
- There is a significant decreasing trend in normalized annual TP loads (p=0.026 and Tau= -0.643) and fall/winter TP loads (p=0.048 and Tau= -0.571).

Table 24 8-year seasonal and annual rainfall normalized pollutant loads at the Pasadena Outflow, WY14-21.

		FSP (lbs/acre/inch)				TN (lbs/acre/inch)				TP (lbs/acre/inch)			
Year	% Runoff	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual
2014	2.8%	0.453	0.000	1.042	0.517	0.006	0.000	0.009	0.005	0.004	0.000	0.007	0.004
2015	1.4%	0.166	0.038	0.495	0.212	0.004	0.001	0.013	0.005	0.002	0.000	0.006	0.002
2016	0.8%	0.129	0.178	0.000	0.150	0.006	0.002	0.000	0.005	0.001	0.001	0.000	0.001
2017	3.2%	0.213	0.137	0.307	0.207	0.009	0.003	0.020	0.009	0.003	0.001	0.004	0.003
2018	3.1%	0.140	0.082	0.090	0.110	0.014	0.003	0.012	0.009	0.003	0.001	0.002	0.002
2019	1.0%	0.074	0.003	0.039	0.053	0.006	0.001	0.005	0.004	0.001	0.000	0.000	0.001
2020	0.2%	0.001	0.000	1.240	0.100	0.000	0.000	0.077	0.006	0.000	0.000	0.015	0.001
2021	0.05%	0.003	0.000	0.000	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Tau	na	-0.714	-0.340	-0.327	-0.857	-0.143	-0.189	-0.036	-0.143	-0.571	-0.189	-0.327	-0.643
P-Value	na	0.013	0.252	0.262	0.003	0.621	0.524	0.901	0.621	0.048	0.524	0.262	0.026
Theil Slope (per year)	na	-0.049	-0.007	-0.080	-0.038	-0.001	0.000	0.000	0.000	0.000	0.000	-0.001	0.000

Figure 104 through Figure 107 show sediment and nutrient loads for Pasadena compared to total annual precipitation for WY14 through WY21. This illustrates how loading and precipitation have varied over the monitored period.

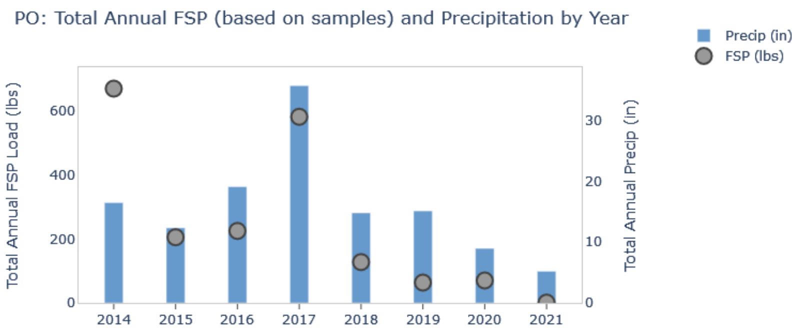

Figure 104 Total annual FSP load (based on samples) and precipitation by year for Pasadena WY14-WY21.

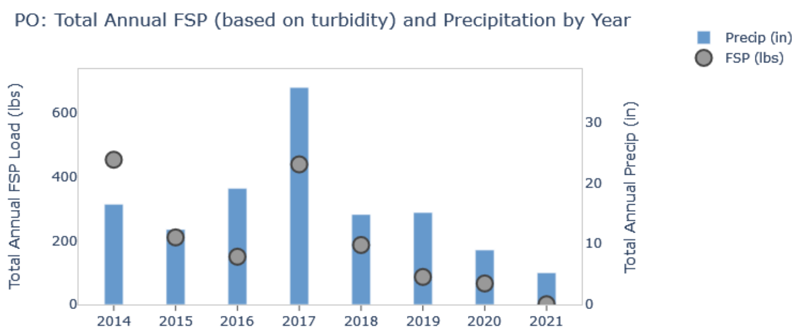

Figure 105 Total annual FSP load (based on continuous turbidity) and precipitation by year for Pasadena WY14-WY21.

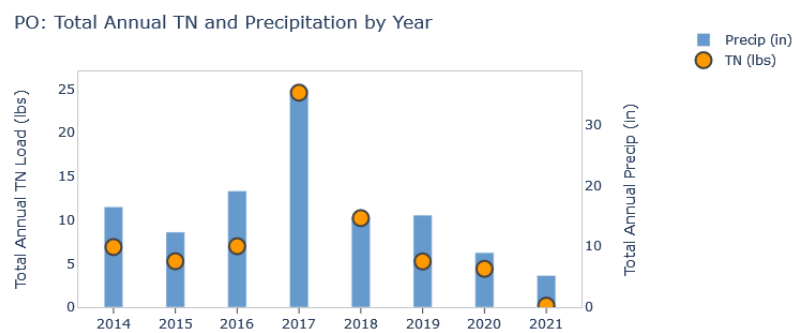

Figure 106 Total annual TN load and precipitation by year for Pasadena WY14-WY21.

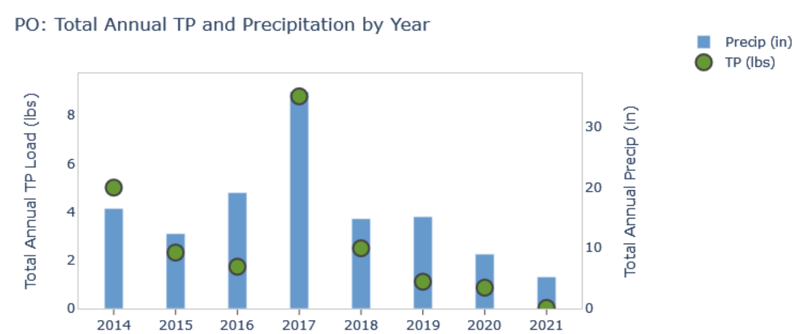

Figure 107 Total annual TP load and precipitation by year for Pasadena WY14-WY21.

8.6 Speedboat

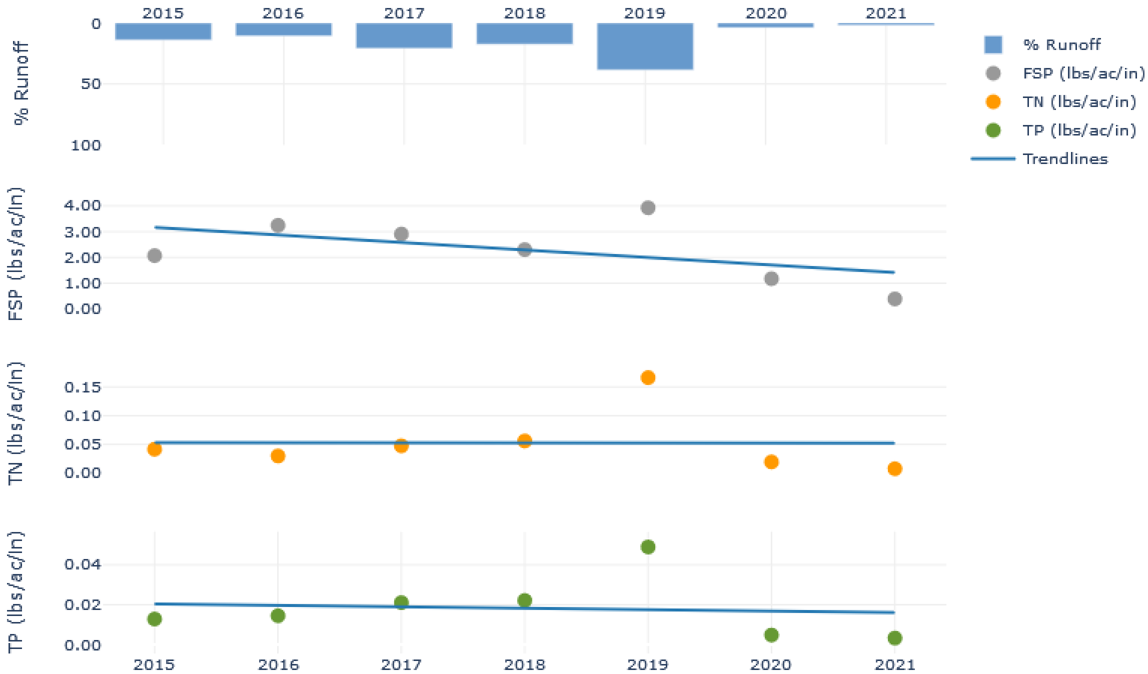

Figure 108 7-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at Speedboat, WY15-21.

- Percent runoff varied between 1.8% in WY21 to 38.4% in WY19.
- There is no significant trend in normalized annual FSP loads (p>0.05), however there is a significant decreasing trend in the normalized fall/winter FSP loads (p=0.024 and Tau= -0.714).
- There is no significant trend in normalized annual TN loads (p>0.05).
- There is no significant trend in normalized annual TP loads (p>0.05).

Table 25 6-year seasonal and annual rainfall normalized pollutant loads at Speedboat, WY15-21.

		FSP (lbs/acre/inch)				TN (lbs/acre/inch)				TP (lbs/acre/inch)			
Year	% Runoff	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual
2015	13.8%	2.342	2.125	1.110	2.071	0.039	0.037	0.060	0.042	0.015	0.010	0.008	0.013
2016	10.6%	2.532	4.798	0.317	3.247	0.031	0.028	0.035	0.030	0.014	0.015	0.007	0.014
2017	20.7%	2.379	6.468	0.270	2.909	0.037	0.113	0.021	0.048	0.017	0.049	0.004	0.021
2018	17.3%	1.171	3.236	0.000	2.303	0.081	0.037	0.000	0.056	0.017	0.027	0.000	0.022
2019	38.4%	1.262	7.682	14.491	3.925	0.191	0.107	0.158	0.166	0.045	0.054	0.069	0.049
2020	3.7%	0.514	0.249	14.011	1.176	0.010	0.002	0.233	0.020	0.005	0.002	0.023	0.005
2021	1.8%	0.446	0.156	0.046	0.391	0.009	0.002	0.003	0.008	0.004	0.001	0.001	0.003
Tau	na	-0.714	-0.238	-0.143	-0.333	-0.238	-0.333	-0.048	-0.143	-0.143	-0.143	-0.143	-0.048
P-Value	na	0.024	0.453	0.652	0.293	0.453	0.293	0.881	0.652	0.652	0.652	0.652	0.881
Theil Slope (per year)	na	-0.390	-0.375	-0.054	-0.472	-0.004	-0.006	-0.005	-0.004	-0.001	-0.002	-0.001	-0.002

Figure 109 through Figure 112 show sediment and nutrient loads for Speedboat compared to total annual precipitation for WY15 through WY21. This illustrates how loading and precipitation have varied over the monitored period.

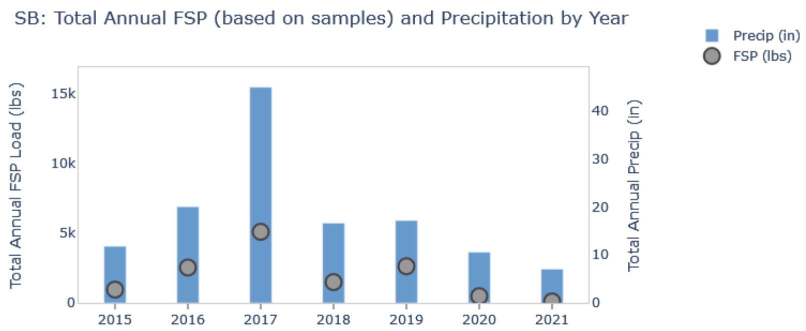

Figure 109 Total annual FSP load (based on samples) and precipitation by year for Speedboat WY15-WY21.

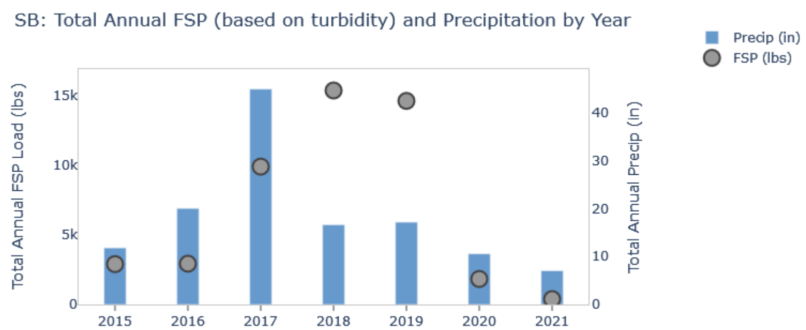

Figure 110 Total annual FSP load (based on continuous turbidity) and precipitation by year for Speedboat WY15-WY21.

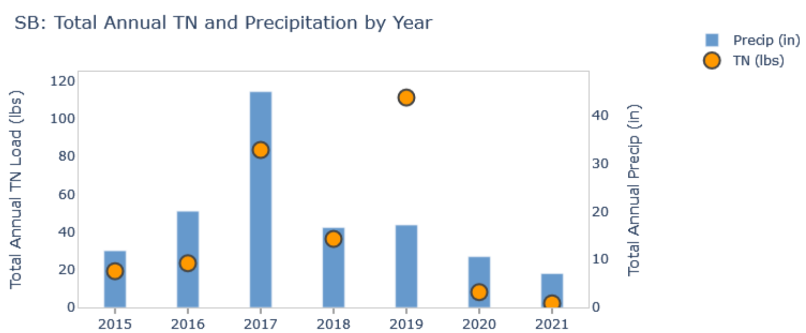

Figure 111 Total annual TN load and precipitation by year for Speedboat WY15-WY21.

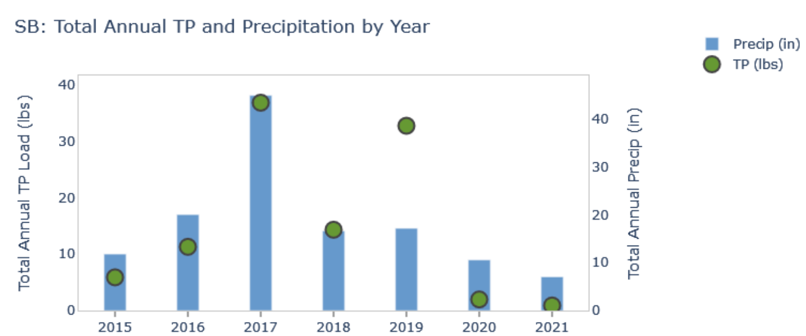

Figure 112 Total annual TP load and precipitation by year for Speedboat WY15-WY21.

8.7 Tahoe City

Figure 113 through Figure 117 show sediment and nutrient loads for Tahoe City compared to total annual precipitation for WY20 through WY21. This illustrates how loading and precipitation have varied over the monitored period.

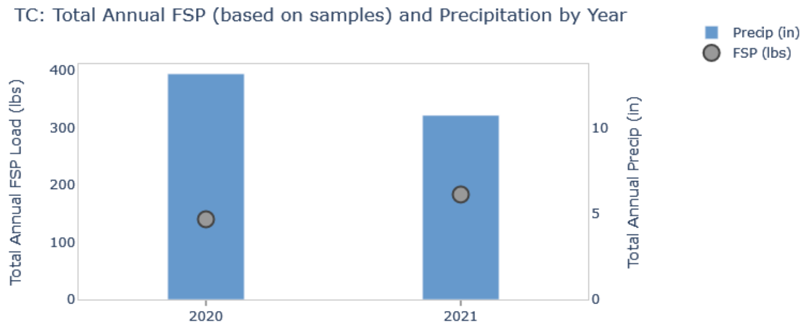

Figure 113 Total annual FSP load (based on samples) and precipitation by year for Tahoe City WY20-WY21.

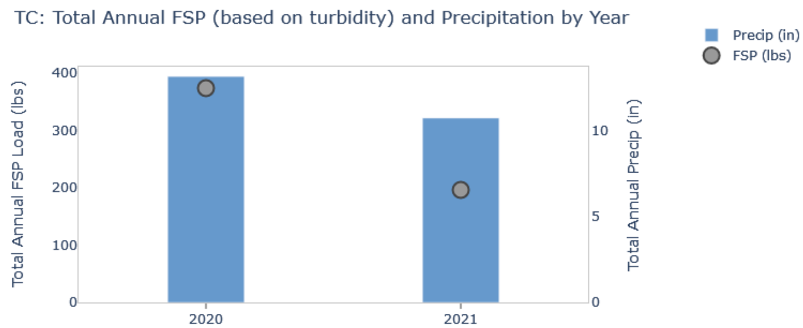

Figure 114 Total annual FSP load (based on continuous turbidity) and precipitation by year for Tahoe City WY20-WY21.

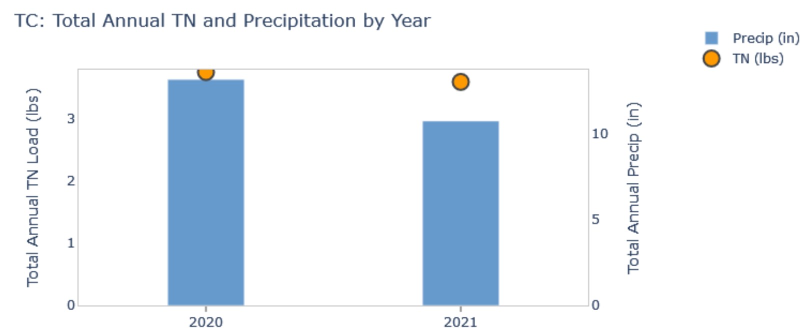

Figure 115 Total annual TN load and precipitation by year for Tahoe City WY20-WY21.

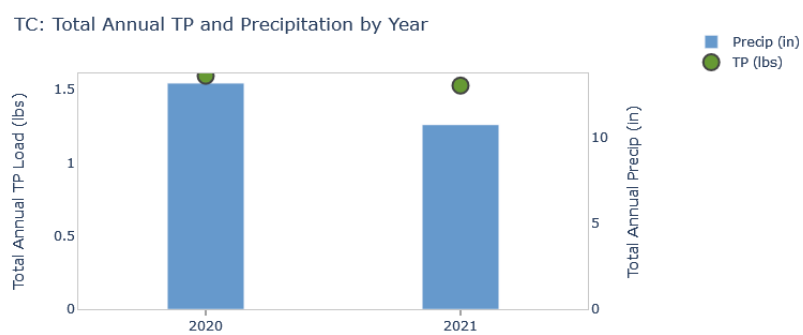

Figure 116 Total annual TP load and precipitation by year for Tahoe City WY20-WY21.

8.8 Tahoe Valley

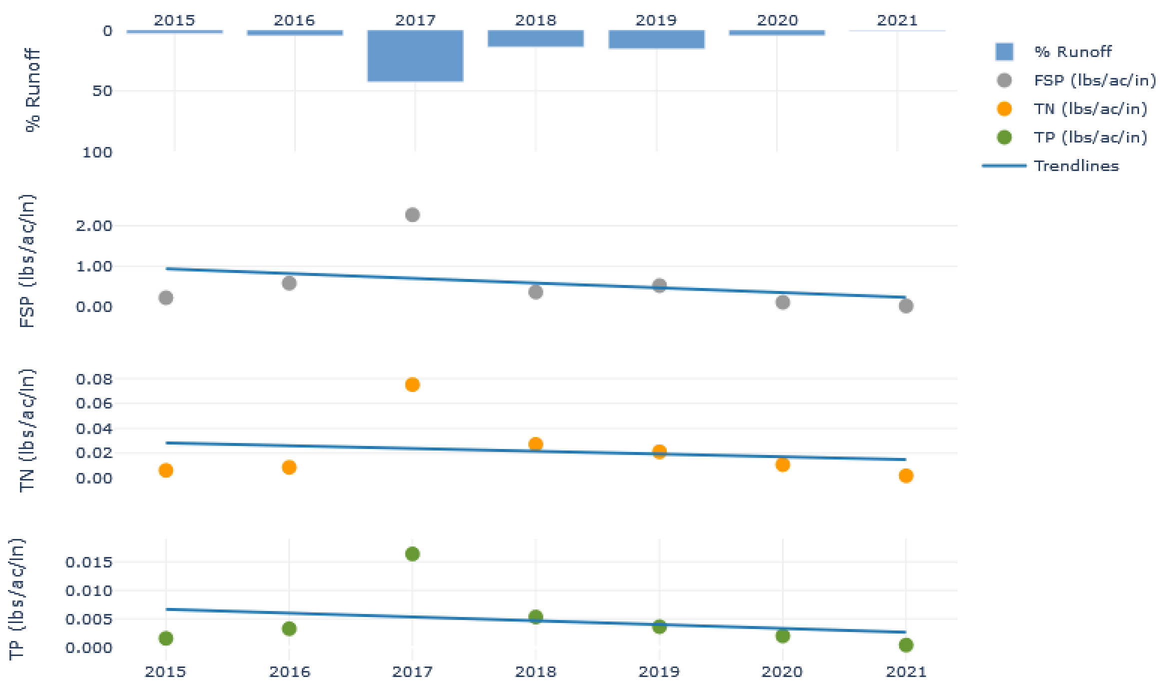

Figure 117 7-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at Tahoe Valley, WY15-21.

- Percent runoff varied between 0.4% in WY21 to 42.5% in WY17.
- There is no significant trend in normalized annual FSP loads (p>0.05).
- There is no significant trend in normalized annual TN loads (p>0.05).
- There is no significant trend in normalized annual TP loads (p>0.05).

Table 26 7-year seasonal and annual rainfall normalized pollutant loads at Tahoe Valley, WY15-21.

Year	% Runoff	FSP (lbs/acre/inch)				TN (lbs/acre/inch)				TP (lbs/acre/inch)			
		Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual
2015	2.7%	0.320	0.001	0.194	0.230	0.008	0.003	0.004	0.006	0.002	0.001	0.001	0.002
2016	4.7%	0.439	0.919	0.000	0.588	0.006	0.014	0.000	0.009	0.002	0.005	0.000	0.003
2017	42.5%	1.948	3.290	2.932	2.269	0.053	0.144	0.137	0.075	0.013	0.025	0.025	0.016
2018	13.9%	0.089	0.623	0.238	0.370	0.028	0.027	0.018	0.027	0.004	0.007	0.003	0.005
2019	15.5%	0.113	1.787	0.945	0.529	0.009	0.058	0.047	0.021	0.001	0.012	0.001	0.004
2020	4.6%	0.154	0.081	0.069	0.119	0.014	0.007	0.007	0.011	0.003	0.001	0.001	0.002
2021	0.4%	0.017	0.080	0.019	0.030	0.002	0.003	0.002	0.002	0.000	0.001	0.000	0.000
Tau	na	-0.429	-0.143	-0.143	-0.429	-0.143	-0.143	-0.048	-0.143	-0.238	-0.048	-0.143	-0.238
P-Value	na	0.176	0.652	0.652	0.176	0.652	0.652	0.881	0.652	0.453	0.881	0.652	0.453
Theil Slope (per year)	na	-0.052	-0.148	-0.029	-0.109	-0.001	-0.002	0.000	-0.001	0.000	0.000	0.000	-0.001

Figure 118 through Figure 121 show sediment and nutrient loads for Tahoe Valley compared to total annual precipitation for WY15 through WY21. This illustrates how loading and precipitation have varied over the monitored period.

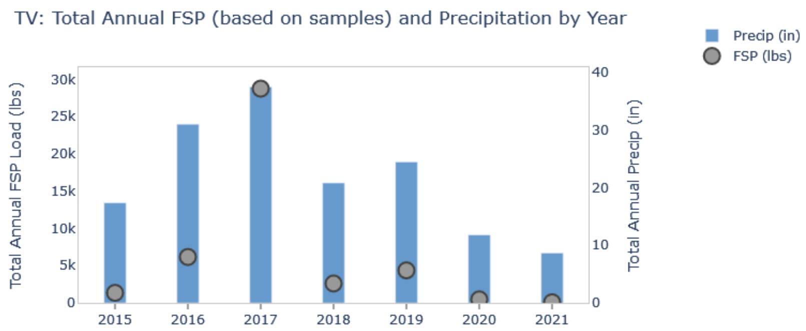

Figure 118 Total annual FSP load (based on samples) and precipitation by year for Tahoe Valley WY15-WY21.

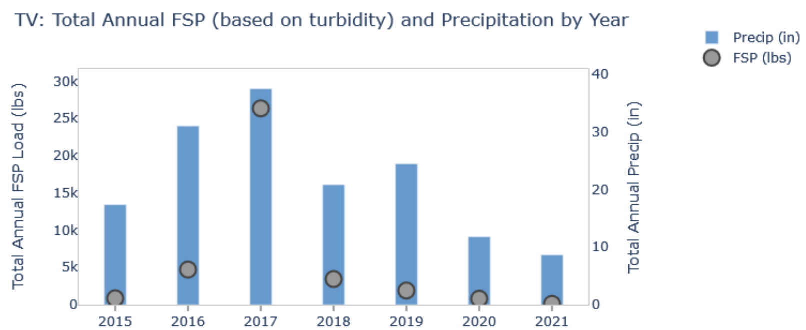

Figure 119 Total annual FSP load (based on continuous turbidity) and precipitation by year for Tahoe Valley WY15-WY21.

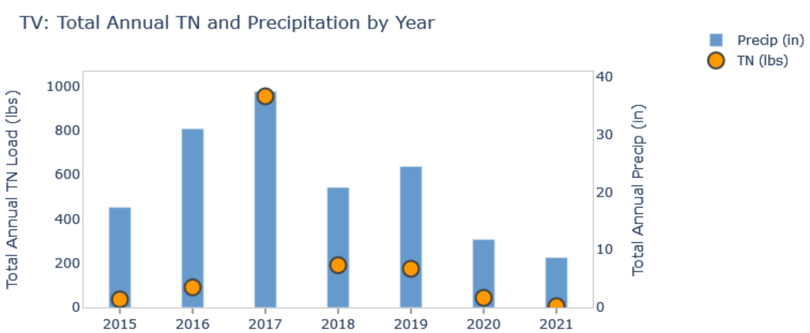

Figure 120 Total annual TN load and precipitation by year for Tahoe Valley WY15-WY21.

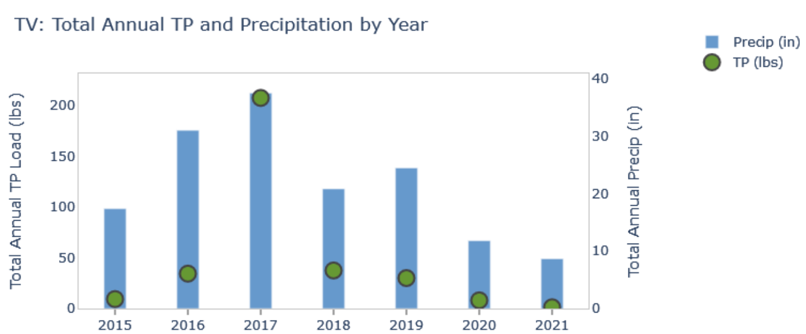

Figure 121 Total annual TP load and precipitation by year for Tahoe Valley WY15-WY21.

8.9 Tahoma

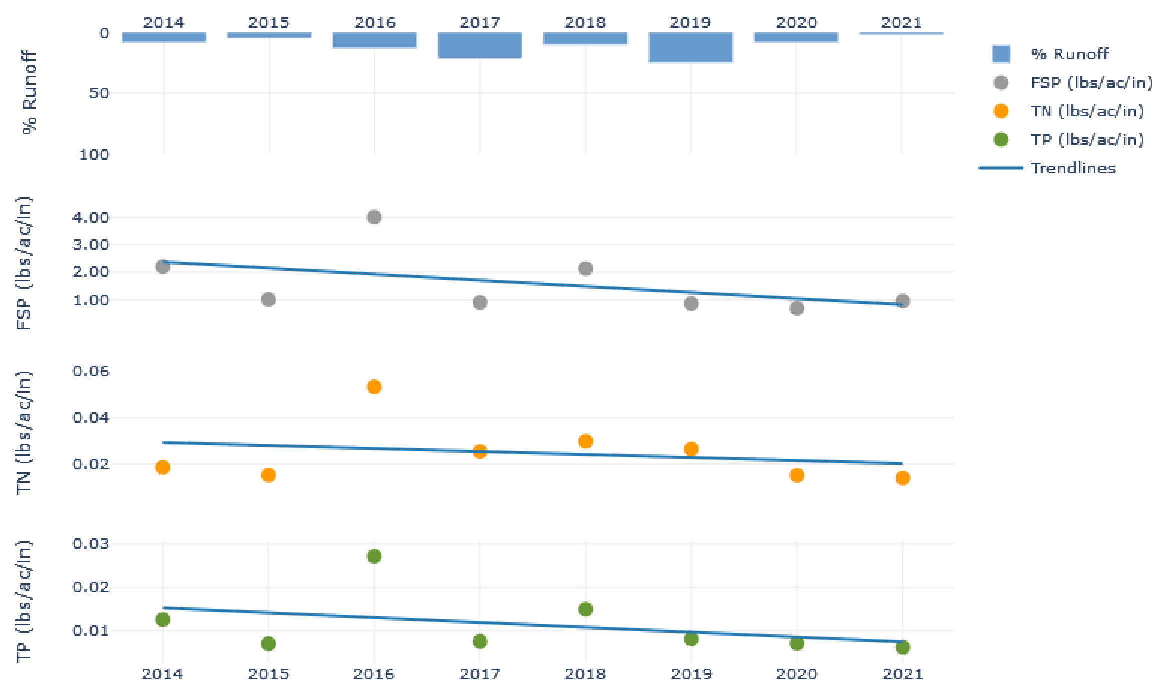

Figure 122 8-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at Tahoma, WY14-21.

- Percent runoff varied between 2.0% in WY21 to 21.5% in WY17. Backwatered conditions in WY19 may have resulted in a falsely elevated percent runoff.
- There is no significant trend in normalized annual FSP loads (p>0.05), however there is a significant decreasing trend in normalized fall/winter FSP loads (p=0.026 and Tau= -0.643).
- There is no significant trend in normalized annual TN loads (p>0.05).
- There is no significant trend in normalized annual TP loads (p>0.05).

Table 27 8-year seasonal and annual rainfall normalized pollutant loads at Tahoma, WY14-21. Percent runoff in 2019 highlighted in pink may be artificially high due to runoff volume errors associated with backwatering.

		FSP (lbs/acre/inch)				TN (lbs/acre/inch)				TP (lbs/acre/inch)			
Year	% Runoff	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual
2014	8.2%	1.231	3.876	4.412	2.205	0.009	0.031	0.042	0.019	0.006	0.022	0.029	0.013
2015	4.8%	0.971	0.567	1.858	1.020	0.006	0.009	0.067	0.015	0.006	0.003	0.015	0.007
2016	13.1%	4.410	2.797	9.639	4.002	0.036	0.016	0.634	0.053	0.028	0.010	0.181	0.027
2017	21.5%	0.970	0.810	0.000	0.908	0.026	0.029	0.000	0.025	0.008	0.008	0.000	0.008
2018	10.1%	0.220	4.032	0.000	2.132	0.020	0.041	0.000	0.030	0.004	0.027	0.000	0.015
2019	24.9%	0.296	2.689	0.251	0.861	0.016	0.062	0.015	0.027	0.005	0.019	0.000	0.008
2020	8.3%	0.719	0.733	0.026	0.697	0.017	0.010	0.043	0.015	0.008	0.006	0.003	0.007
2021	2.0%	0.057	5.031	0.179	0.954	0.002	0.068	0.021	0.014	0.001	0.032	0.003	0.006
Tau	na	-0.643	0.143	-0.327	-0.500	-0.214	0.429	-0.109	-0.286	-0.214	0.214	-0.255	-0.357
P-Value	na	0.026	0.621	0.262	0.083	0.458	0.138	0.708	0.322	0.458	0.458	0.383	0.216
Theil Slope (per year)	na	-0.168	0.080	-0.384	-0.117	-0.002	0.008	-0.004	-0.001	-0.001	0.001	-0.003	-0.001

Figure 123 through Figure 126 show sediment and nutrient loads for Tahoma compared to total annual precipitation for WY14 through WY21. This illustrates how loading and precipitation have varied over the monitored period.

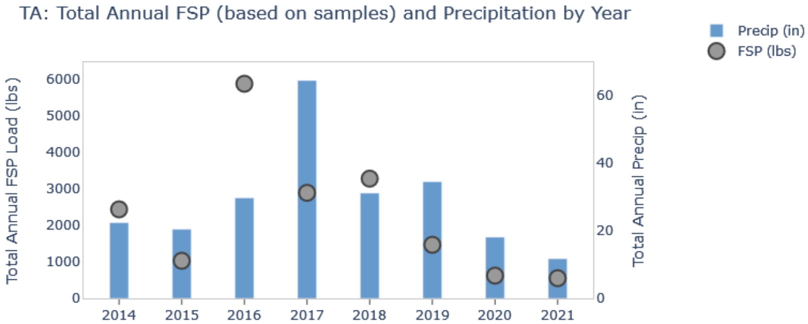

Figure 123 Total annual FSP load (based on samples) and precipitation by year for Tahoma WY14-WY21.

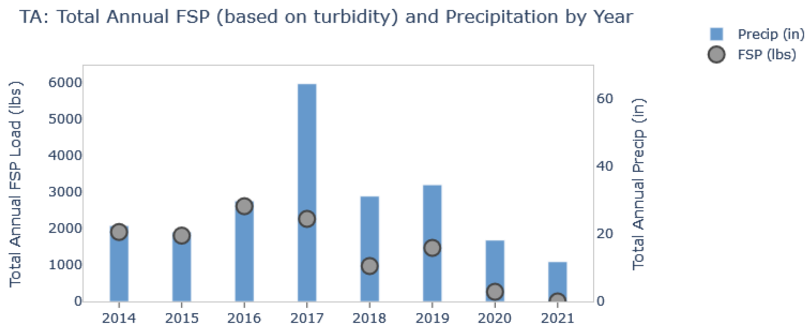

Figure 124 Total annual FSP load (based on continuous turbidity) and precipitation by year for Tahoma WY14-WY21.

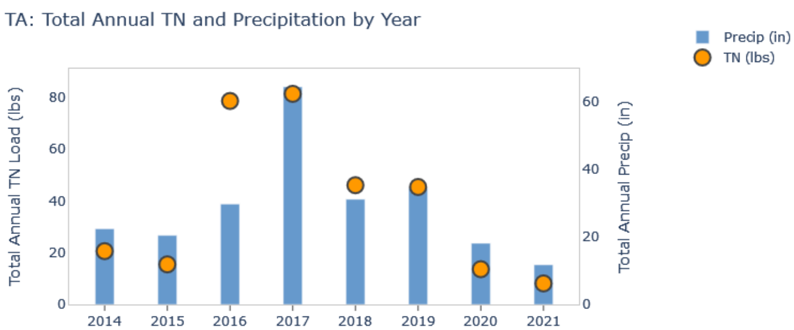

Figure 125 Total annual TN load and precipitation by year for Tahoma WY14-WY21.

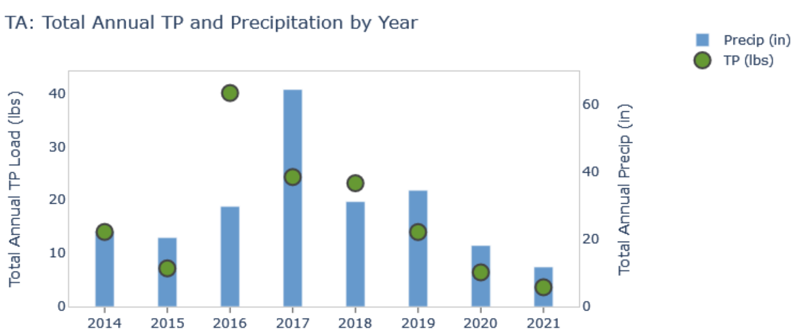

Figure 126 Total annual TP load and precipitation by year for Tahoma WY14-WY21.

8.10 Upper Truckee

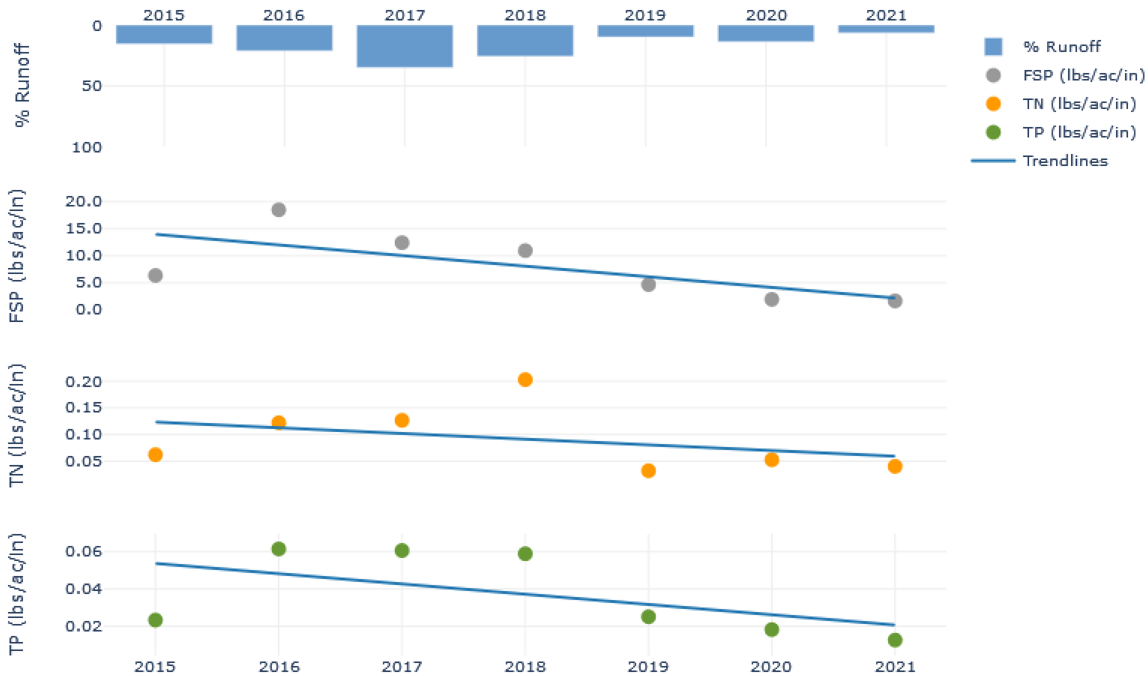

Figure 127 7-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at Upper Truckee, WY15-21.

- Percent runoff varied between 6.4% in WY21 to 34.8% in WY17.
- There is a significant decreasing trend in normalized annual FSP loads (p=0.024 and Tau= -0.714) and fall/winter FSP loads (p=0.024 and Tau= -0.714).
- There is no significant trend in normalized annual TN loads (p>0.05).
- There is no significant trend in normalized annual TP loads (p>0.05).

Table 28 7-year seasonal and annual rainfall normalized pollutant loads at Upper Truckee, WY15-21.

		FSP (lbs/acre/inch)				TN (lbs/acre/inch)				TP (lbs/acre/inch)			
Year	% Runoff	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual
2015	15.5%	6.297	11.878	0.000	6.367	0.049	0.151	0.000	0.062	0.022	0.047	0.000	0.023
2016	21.1%	14.220	28.052	0.000	18.498	0.121	0.128	0.000	0.122	0.053	0.081	0.000	0.061
2017	34.8%	11.427	13.739	22.486	12.420	0.095	0.137	0.579	0.127	0.055	0.062	0.143	0.061
2018	25.6%	7.244	15.326	0.000	10.956	0.350	0.100	0.000	0.203	0.048	0.075	0.000	0.059
2019	9.8%	4.188	6.599	0.000	4.673	0.027	0.053	0.000	0.032	0.022	0.037	0.000	0.025
2020	13.7%	1.728	2.150	2.339	1.940	0.045	0.054	0.115	0.053	0.015	0.022	0.019	0.018
2021	6.4%	1.631	2.118	0.000	1.652	0.039	0.057	0.000	0.040	0.013	0.015	0.000	0.013
Tau	na	-0.714	-0.619	0.066	-0.714	-0.333	-0.619	0.066	-0.238	-0.524	-0.619	0.066	-0.619
P-Value	na	0.024	0.051	0.849	0.024	0.293	0.051	0.849	0.453	0.099	0.051	0.849	0.051
Theil Slope (per year)	na	-2.460	-3.570	0.000	-2.733	-0.007	-0.018	0.000	-0.007	-0.007	-0.012	0.000	-0.006

Figure 128 through Figure 131 how sediment and nutrient loads for Upper Truckee compared to total annual precipitation for WY15 through WY21. This illustrates how loading and precipitation have varied over the monitored period.

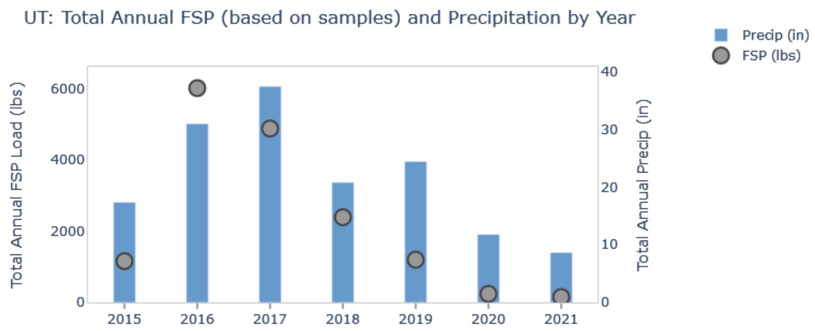

Figure 128 Total annual FSP load (based on samples) and precipitation by year for Upper Truckee WY15-WY21.

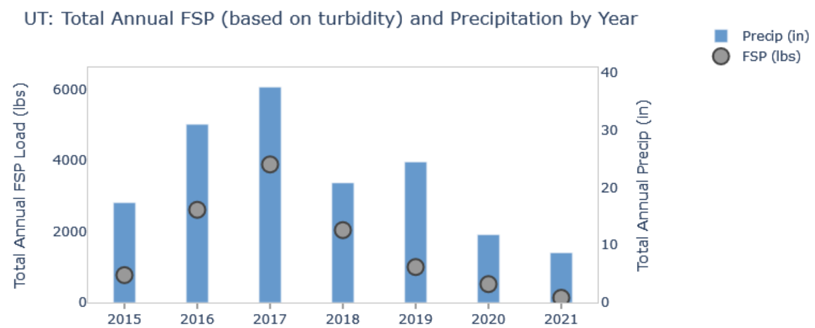

Figure 129 Total annual FSP load (based on continuous turbidity) and precipitation by year for Upper Truckee WY15-WY21.

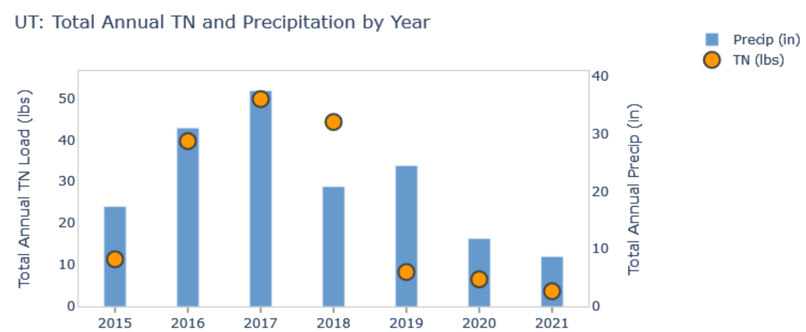

Figure 130 Total annual TN load and precipitation by year for Upper Truckee WY15-WY21.

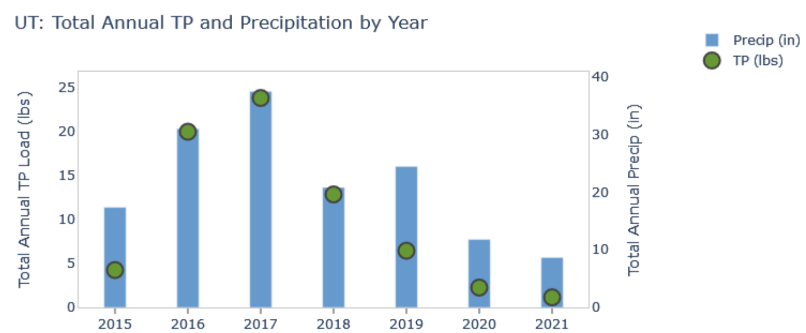

Figure 131 Total annual TP load and precipitation by year for Upper Truckee WY15-WY21.

9. PLRM Modeling Results

PLRM is the standard basin-wide model for pollutant load reduction estimates for the Lake Tahoe TMDL. All seven jurisdictions in two states are required to use the same modeling tool for estimating pollutant loads, allowing for comparisons of pollutant load reductions to be made across jurisdictions.

PLRM models in registered catchments were sourced from Washoe County (Lakeshore), NDOT (SR431), the City of South Lake Tahoe (Pasadena and Upper Truckee), and Caltrans (Upper Truckee) and include all registered BMPs and improved road operations (Lakeshore and SR431 models were built by the Nevada Tahoe Conservation District on behalf of Washoe County and NDOT, respectively). Models in unregistered catchments assume baseline conditions from 2004 and current parcel BMP status, with the exception of Elks Club Drive which uses the median Road RAM measurement from WY20.

Tahoe RCD compared average annual runoff volumes and pollutant loads predicted by PLRMv2.1 to annual volumes and pollutant loads measured in WY21 at all sites; results are presented in Table 29. 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.**

WY21 was a very dry precipitation year for the Tahoe basin, therefore field measured runoff volumes, and FSP, TN, and TP loads are expected to be lower than PLRM modeled values. As expected, all measured volumes and pollutant loads were lower than the PLRM modeled runoff volumes and pollutant loads.

It is unrealistic to expect the model to perform perfectly; however, PLRM estimates relative conditions. In this very dry water year, PLRM performed as expected and modeled values are greater than what was measured. Additionally, 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 to our basic understanding of Tahoe stormwater pollutant sources.

Table 29 PLRM predicted and WY21 measured values for all monitored catchments. The first FSP column represents the FSP load calculated using event mean concentrations based on samples, while the second FSP column represents the FSP load estimated using continuous turbidity data. Registered catchments use models that include BMPs and improved road operations. Unregistered catchments use models based on baseline (2004) conditions with current parcel BMP status.

Water Year 2021 Oct. 1, 2020 - Sept. 30, 2021		Catchment Registered for BMPs?	Catchment Registered for Roads?	Annual Runoff Volumes (cf)		Annual FSP Loads (Based on Samples) (lbs)		Annual FSP Loads (Based on Turbidity) (lbs)		Annual TN Loads (lbs)		Annual TP Loads (lbs)	
Catchment Name	Station Name			PLRM	Measured	PLRM	Measured	PLRM	Measured	PLRM	Measured	PLRM	Measured
SR431	Contech Inflow	No	Yes	43,560	1,026	810	51	810	26	10.0	0.50	3.0	0.32
	Contech Outflow	No	Yes	43,560	620	810	13	279	10	4.0	0.21	3.0	0.08
	Jellyfish Inflow	No	Yes	43,560	1,328	810	66	810	26	10.0	0.55	3.0	0.40
	Jellyfish Outflow	No	Yes	43,560	622	810	10	318	6	4.0	0.11	3.0	0.04
Elk's Club	Elk's Club	No	No	187,308	15,468	2,265	46	2,265	26	33.0	0.54	9.0	0.25
Lakeshore	Lakeshore	Yes	Yes	357,192	108	2,885	0.2	2,885	0.3	56.0	0.01	14.0	<0.01
Pasadena	Pasadena Out	No	No	139,392	731	430	1	430	1	12.0	0.17	5.0	0.03
Speedboat	Speedboat	No	No	322,344	18,344	4,966	107	4,966	385	59.0	2.13	17.0	0.89
Tahoe City	Tahoe City	No	No	213,444	22,625	2,868	184	2,868	196	32.0	3.59	8.0	1.53
Tahoe Valley	Tahoe Valley	No	No	5,906,736	38,971	58,511	87	58,511	111	833.0	5.46	215.0	1.22
Tahoma	Tahoma	No	No	662,112	43,160	10,784	553	10,784	158	126.0	8.10	37.0	3.61
Upper Truckee	Upper Truckee	Yes*	Yes*	352,836	21,147	2,875	150	2,875	131	46.0	3.67	10.0	1.15

* The Upper Truckee catchment contains areas within the Caltrans and City of South Lake Tahoe jurisdictions. The "YES"s in this table refer to the fact that City roads and BMPs are registered. Caltrans roads and BMPs are not registered.

10. Lessons Learned

Monitoring stations should be checked 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. Beginning WY17 all monitoring and weather stations are remotely accessible. This enables access to the stations and their status during all weather conditions and any time of day or night and allows for problems to be detected and remedied earlier than was previously possible when site visits were required to know station status. Additionally, alarms are set to send email alerts when certain parameters reach a pre-determined threshold.

The biggest cause of data gaps is 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 (especially during winter), and during periods of extended cloud cover or snow blockage and subsequent decrease in solar recharge, all stations are subject to power failure. Checking battery voltage remotely on a regular basis and having alerts sent when charge drops below a voltage threshold has alleviated this problem but batteries must be continuously checked and changed.

When snow accumulation is frequent and excessive, it is very important to stay on top of site maintenance (See Figure 132 and Figure 133). Keeping the sites dug out and unfrozen is a continuous task necessary to maintain data integrity. The remote access system is beneficial in identifying when the sites are frozen and in need of maintenance.

High lake levels following WY17 and WY19 caused intermittent backwatered conditions at Tahoma. Previously, under backwatered conditions flow monitoring was not possible. On August 1, 2019 a replicate set of monitoring sensors were installed about 50 feet upstream of the original sensors at Tahoma. They are now available for use during backwatered conditions.

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.

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 requisite summer events can easily be missed or do not produce enough runoff to sample, but the remote equipment makes successfully sampling these events more feasible. One mitigating method is to sample based on time rather than flow. Even with time-based sampling, flow weighted composites can be made.

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). **All efforts are made to successfully sample several events during each season**

so that average seasonal pollutant concentrations and loads can be calculated. However, annual precipitation patterns are highly variable, and in some years, there is insufficient runoff for sampling in any given season. Approval of the annual permit/ILA monitoring requirement should not be withheld for this reason. Fortunately, estimated FSP concentrations and loads can be calculated from the continuous turbidity data, so these values should never be missing from any season unless there is no runoff at all.

Figure 132 Tahoma on February 1, 2021. It is critical to stay on top of snow removal after snowfall events to maintain access to stormwater monitoring sites.

Monitoring equipment at SR431 is located under the pavement in a wide pull-out and accessed through two hatches, one for the inflow locations and one for the outflow locations. Often, the hatches are located under many feet of hard icy snow that has been plowed off SR431 and stored in the pull-out making access impossible (Figure 133). NDOT maintenance crews must be called ahead of sample collection to remove the snow with heavy equipment.

Figure 133 Snow berms covering access to monitoring equipment at SR431, February 14, 2021. Even in low snow years, single snow events can make access to the sampling equipment difficult.

11. Changes: Accepted and Proposed

Changes Accepted

A new NPDES permit was issued to California jurisdictions in 2017. The new permit aligned all monitoring activities with the Regional Stormwater Monitoring Program (RSWMP) Framework and Implementation Guidance Document (Tahoe RCD et al 2015), most notably that six (rather than four) catchment outfalls and two (rather than three) BMPs must be monitored. Additionally, the first flush sampling requirement was dropped as sample analysis costs are high and continuous turbidimeter readings can replace this information. The Nevada Inter-local Agreements (ILAs) were issued in 2016 and require participation in IMP.

In the spring of WY17 Tahoe RCD proposed a new BMP monitoring site. The new location was approved by IMP, Lahontan, NDEP and monitoring equipment was removed from the Pasadena Inflow and installed at Elks Club Drive as described in section 2.2. Monitoring at Elks Club began in WY18. Elks Club Drive is considered a BMP site as resurfacing the road with a polymer enhanced asphalt mixture should be considered a best management practice for reducing FSP in stormwater runoff since it will be easier to sweep and less prone to degradation from chains, heavy equipment, plow blades, and the freeze/thaw cycle.

In the winter of WY19 the California Department of Transportation (Caltrans) joined IMP. A new site capturing only stormwater runoff from state route 89 in Tahoe City was installed in August of 2019. Monitoring of this site began October 1, 2019 at the commencement of WY20.

Changes Proposed

Because annual precipitation during all seasons is highly variable, and summer thunderstorms in particular tend to be very episodic in nature, not all sites receive sufficient runoff to sample the requisite number of events in every season, especially in the summer. **It may be advisable to amend permit and agreement language to acknowledge that all efforts are made to successfully sample several events during each season so that average seasonal pollutant concentrations and loads can be calculated. However, this is not always possible, and approval of the annual permit/ILA monitoring requirement should not be withheld for this reason.**

The Lakeshore monitoring site receives very little flow. In an especially dry years like WY20, it did not flow at all. In WY21 it only flowed once. Due to the difficulty of finding suitable monitoring sites, it was decided that nothing would change for WY22, but RSWMP recommends replacing Lakeshore with another site beginning WY23.

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Appendix A: Raw Analytical Data

Table A.1-Table A.10 present all available raw analytical data for autosampler composite (AC) samples. Other than QAQC samples, only AC samples were analyzed in WY21. Raw analytic data shows turbidity; TSS, FSP, TN, and TP concentrations; and particle size distribution.

Table A.1 Raw analytical data for samples taken at the inflow and outflow of the SR431 Contech MFS in WY21.

Sample	Sample Start (Date/Time)	Total 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	2/13/2021 14:05	2,034	3,980	1,365	5,544	8,498	0.43	4.57	13.10	25.6	45.2	67.1	73.6	93.4	98.7	100	100	100	100
CI-AC	3/18/2021 19:14	2,198	3,540	1,697	5,673	10,208	0.44	4.87	15.10	31.0	54.5	77.2	82.9	97.3	99.9	100	100	100	100
CI-AC	4/13/2021 18:07	2,122	3,240	1,657	6,415	8,684	0.41	4.47	13.70	28.4	52.2	78.1	85.2	99.4	100	100	100	100	100
CI-AC	5/16/2021 19:32	2,489	2,000	1,737	10,994	9,597	0.35	3.89	12.00	25.1	46.3	69.8	76.7	94.7	99.1	100	100	100	100
CI-AC	5/21/2021 21:06	555	742	354	3,553	2,305	0.33	3.63	11.00	22.4	40.7	63.7	71.1	92.3	97.6	100	100	100	100
CI-AC	7/26/2021 16:03	2,050	1,857	900	17,148	6,663	0.22	2.27	6.46	13.2	25.8	43.9	50.3	78.3	95.3	100	100	100	100
CI-AC	9/9/2021 22:43	442	438	251	11,195	2,131	0.24	2.58	7.76	17.1	34.1	56.9	64.7	89.8	97.7	100	100	100	100
CO-AC	3/18/2021 21:05	1,254	2,882	1,016	4,750	6,751	0.48	5.39	16.90	35.0	60.0	81.0	85.8	97.5	99.9	100	100	100	100
CO-AC	4/13/2021 18:18	794	1,424	653	3,355	3,745	0.42	4.63	14.20	29.6	54.8	82.3	89.0	100	100	100	100	100	100
CO-AC	5/16/2021 19:35	1,012	880	830	6,764	4,477	0.40	4.47	13.90	29.4	55.1	82.0	88.5	98.9	100	100	100	100	100
CO-AC	5/21/2021 21:11	288	401	217	3,046	1,269	0.47	5.07	14.90	29.2	50.2	75.4	83.3	99.5	100	100	100	100	100
CO-AC	9/9/2021 22:56	202	226	126	10,734	1,414	0.25	2.86	9.51	22.0	41.3	62.5	69.0	89.4	95.0	99.0	100	100	100

Table A.2 Raw analytical data for samples taken at the inflow and outflow of the SR431 Jellyfish in WY21.

Sample	Sample Start (Date/Time)	Total 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	2/13/2021 14:05	1,451	3,072	988	4,098	6,140	0.49	5.28	15.30	29.0	47.9	68.1	74.1	94.3	99.2	100	100	100	100
JI-AC	3/18/2021 19:14	1,668	3,959	1,251	4,732	7,851	0.43	4.73	14.70	30.0	52.4	75.0	81.0	96.4	99.6	100	100	100	100
JI-AC	4/13/2021 18:06	2,192	3,076	1,743	6,560	8,684	0.41	4.56	14.10	29.4	53.7	79.5	86.2	98.5	99.8	100	100	100	100
JI-AC	5/16/2021 19:32	2,717	2,000	1,932	11,287	10,043	0.36	3.92	12.00	25.1	46.7	71.1	78.1	95.1	99.2	100	100	100	100
JI-AC	5/21/2021 21:06	482	642	321	3,074	1,952	0.37	4.00	12.10	24.7	43.9	66.7	73.9	92.4	97.7	100	100	100	100
JI-AC	7/26/2021 16:03	1,620	1,938	804	13,608	5,557	0.24	2.57	7.41	15.2	29.6	49.6	56.5	84.4	97.8	100	100	100	100
JI-AC	9/9/2021 22:43	474	394	260	9,405	2,087	0.23	2.49	7.52	16.5	32.7	54.8	62.4	88.8	97.0	100	100	100	100
JO-AC	2/13/2021 14:30	533	1,710	367	3,381	2,612	0.48	5.11	14.70	28.0	47.3	68.9	75.2	90.3	97.2	100	100	100	100
JO-AC	4/13/2021 18:09	282	434	210	1,817	1,141	0.40	4.23	12.60	26.2	48.8	74.5	81.1	95.8	99.3	100	100	100	100
JO-AC	5/16/2021 19:32	129	119	86	2,198	657	0.40	4.10	11.40	22.0	40.4	66.8	75.1	93.6	98.6	100	100	100	100
JO-AC	5/21/2021 21:08	142	214	101	2,359	645	0.52	5.58	16.30	31.3	51.6	71.4	77.0	93.2	98.8	100	100	100	100
JO-AC	7/26/2021 16:06	1,584	72	714	2,185	631	0.21	2.22	6.35	12.8	24.2	45.1	53.7	87.5	96.6	100	100	100	100
JO-AC	9/10/2021 3:59	222	259	178	10,596	1,527	0.32	3.62	12.40	29.6	55.9	80.3	86.4	98.2	99.6	100	100	100	100

Table A.3 Raw analytical data for samples taken at Elks Club in WY21.

Sample	Sample Start (Date/Time)	Total 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
EC-AC	11/18/2020 7:48	25	20	3	530	119	0.08	0.75	1.88	3.3	6.0	12.4	15.6	31.0	36.8	47.4	76.7	98.3	100
EC-AC	1/4/2021 13:58	29	39	5	599	111	0.11	1.00	2.28	4.0	8.2	17.4	21.2	36.3	41.8	50.5	77.5	97.6	100
EC-AC	2/11/2021 16:36	21	29	5	482	108	0.15	1.42	3.42	6.1	11.9	25.2	31.7	69.5	87.6	98.6	99.5	100	100
EC-AC	2/15/2021 15:58	8	5	0.4	370	36	0.01	0.11	0.26	0.6	1.8	5.3	7.8	26.9	44.7	67.6	87.3	100	100
EC-AC	3/4/2021 15:41	145	189	80	1,147	583	0.30	3.03	8.21	16.1	31.0	55.2	64.4	95.8	98.5	100	100	100	100
EC-AC	3/18/2021 18:13	88	128	75	627	329	0.55	6.10	18.90	38.3	63.2	85.4	90.4	98.4	99.6	100	100	100	100
EC-AC	3/31/2021 12:31	32	2	3	159	22	0.00	0.02	0.15	0.5	2.1	7.9	11.7	39.6	65.5	93.4	99.1	100	100
EC-AC	4/14/2021 11:20	16	8	2	275	46	0.01	0.08	0.34	0.9	3.2	12.7	18.2	60.6	87.6	100	100	100	100
EC-AC	5/16/2021 20:21	516	770	381	3,242	2,035	0.36	3.76	11.10	24.2	47.2	73.8	81.5	100	100	100	100	100	100

Table A.4 Raw analytical data for samples taken at Lakeshore in WY21.

Sample	Sample Start (Date/Time)	Total 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
LS-AC	11/18/2020 10:26	72	79	30	1,496	494	0.24	2.48	6.98	13.6	24.0	41.5	49.1	87.3	96.8	100	100	100	100

Table A.5 Raw analytical data for samples taken at Pasadena in WY21.

Sample	Sample Start (Date/Time)	Total 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
PO-AC	11/18/2020 11:58	51	79	22	3,833	570	0.15	1.52	4.27	9.6	21.3	43.0	51.8	90.1	97.4	100	100	100	100

Table A.6 Raw analytical data for samples taken at Speedboat, WY21.

Sample	Sample Start (Date/Time)	Total 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	11/17/2020 22:55	94	55	38	1,798	488	0.23	2.34	6.68	13.4	23.9	40.6	47.6	82.8	94.1	100	100	100	100
SB-AC	1/4/2021 12:56	339	906	204	2,198	1,820	0.38	4.04	11.80	23.0	39.4	60.1	67.4	93.9	98.8	100	100	100	100
SB-AC	2/11/2021 19:16	304	664	226	1,838	1,418	0.54	5.78	16.90	32.3	53.3	74.4	80.5	95.8	99.4	100	100	100	100
SB-AC	3/19/2021 4:03	387	300	255	2,575	1,563	0.38	4.20	12.70	25.4	44.0	65.9	72.7	93.9	99.2	100	100	100	100
SB-AC	7/26/2021 15:48	114	1,101	33	29,850	5,723	0.15	1.48	4.07	8.4	16.4	28.8	33.2	60.4	84.1	91.3	94.2	100	100
SB-AC	9/10/2021 3:35	1,808	998	692	17,070	5,434	0.17	1.75	4.84	10.1	20.9	38.3	45.0	77.5	93.3	99.9	100	100	100

Table A.7 Raw analytical data for samples taken at Tahoe City, WY21

Sample	Sample Start (Date/Time)	Total 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
TC-AC	11/13/2020 15:30	83	84	39	5,087	733	0.18	2.01	7.15	17.4	31.4	47.3	53.6	86.4	97.1	100	100	100	100
TC-AC	11/17/2020 19:48	64	68	37	1,438	419	0.36	3.78	10.90	21.6	36.5	57.6	66.0	93.6	99.2	100	100	100	100
TC-AC	1/4/2021 5:41	317	842	227	1,878	1,619	0.59	6.26	17.80	32.4	50.6	71.6	78.7	98.3	100	100	100	100	100
TC-AC	2/1/2021 14:15	229	639	131	1,472	1,204	0.65	6.61	17.20	28.1	40.4	57.0	64.2	94.1	98.9	100	100	100	100
TC-AC	2/15/2021 9:30	103	311	52	1,133	751	0.57	5.78	14.90	24.8	36.4	50.6	56.6	87.0	97.8	100	100	100	100
TC-AC	3/18/2021 20:25	170	224	132	1,295	943	0.59	6.55	20.30	38.7	59.3	77.4	82.6	95.7	99.5	100	100	100	100
TC-AC	5/15/2021 13:41	391	246	256	4,964	1,792	0.30	3.23	10.00	22.1	41.9	65.4	73.0	99.2	100	100	100	100	100
TC-AC	9/9/2021 22:33	636	771	377	11,862	3,125	0.29	3.01	8.92	19.2	37.2	59.2	65.6	84.9	95.7	99.8	100	100	100

Table A.8 Raw analytical data for samples taken at Tahoe Valley, WY21.

Sample	Sample Start (Date/Time)	Total 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	11/13/2020 17:23	112	145	38	8,076	1,256	0.16	1.67	4.53	8.84	17.4	33.9	40.7	77.9	89.0	96.7	98.5	100	100
TV-AC	11/17/2020 23:31	80	125	33	2,171	538	0.23	2.29	6.15	12.0	22.8	41.7	49.7	89.4	96.5	100	100	100	100
TV-AC	3/18/2021 18:16	58	84	32	1,112	301	0.43	4.34	11.30	20.6	35.4	54.9	60.6	79.1	87.1	96.1	99.3	100	100
TV-AC	4/14/2021 2:38	118	205	42	1,650	462	0.18	1.92	5.63	11.7	21.5	35.9	41.4	68.4	77.9	85.2	94.1	100	100
TV-AC	5/16/2021 18:30	1,382	940	734	11,744	1,923	0.25	2.59	7.45	15.9	31.6	53.1	60.0	85.1	95.4	99.8	100	100	100
TV-AC	5/20/2021 19:21	80	79	34	2,402	740	0.21	2.20	6.68	14.6	27.0	42.9	48.9	76.6	87.9	94.7	98.0	100	100
TV-AC	7/3/2021 22:58	358	217	93	7,675	1,340	0.16	1.58	4.34	8.6	15.7	26.0	30.1	55.4	70.7	81.6	89.3	97.8	100

Table A.9 Raw analytical data for samples taken at Tahoma, WY21.

Sample	Sample Start (Date/Time)	Total 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	11/17/2020 19:58	123	86	37	1,660	519	0.15	1.57	4.43	8.9	16.5	29.8	35.9	75.6	91.3	99.9	100	100	100
TA-AC	1/4/2021 12:45	315	633	163	1,569	1,292	0.32	3.38	9.52	18.3	32.3	51.7	59.0	88.7	96.6	100	100	100	100
TA-AC	3/18/2021 15:45	329	278	199	1,891	1,152	0.38	3.99	11.40	22.1	39.0	60.5	67.4	91.4	97.9	100	100	100	100
TA-AC	4/13/2021 20:26	69	194	27	2,489	341	0.22	2.34	6.77	13.4	23.2	39.6	46.7	84.4	96.3	100	100	100	100
TA-AC	5/16/2021 20:13	2,038	1,206	776	15,935	5,529	0.20	2.02	5.38	10.7	21.6	38.1	43.8	69.1	89.1	99.8	100	100	100
TA-AC	5/20/2021 23:31	133	137	33	4,739	804	0.14	1.34	3.46	6.7	13.0	25.2	31.1	70.0	91.0	100	100	100	100
TA-AC	9/9/2021 22:18	292	263	136	16,285	2,194	0.18	1.85	5.64	13.3	27.2	46.7	53.7	84.2	95.5	99.9	100	100	100

Table A.10 Raw analytical data for samples taken at Upper Truckee, WY21.

Sample	Sample Start (Date/Time)	Total 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	11/13/2020 14:46	60	86	17	4,686	324	0.19	1.83	4.51	7.58	13.6	28.8	36.6	83.2	95.7	100	100	100	100
UT-AC	11/18/2020 8:06	148	231	61	2,419	582	0.20	2.08	5.89	12.1	23.4	41.2	48.1	83.6	96.1	100	100	100	100
UT-AC	1/4/2021 12:45	385	970	278	3,985	1,845	0.52	5.56	16.30	31.2	50.9	72.2	78.6	95.4	98.8	100	100	100	100
UT-AC	2/11/2021 16:35	327	867	200	2,414	1,506	0.45	4.76	13.90	26.5	43.4	61.2	67.1	91.9	98.2	100	100	100	100
UT-AC	3/18/2021 18:26	144	249	123	2,038	659	0.77	8.03	22.40	41.0	64.1	85.2	90.0	97.9	99.3	100	100	100	100
UT-AC	4/14/2021 8:05	170	339	69	2,569	802	0.23	2.47	7.55	15.4	26.4	40.5	46.2	80.2	93.8	99.2	100	100	100
UT-AC	5/20/2021 20:15	115	139	44	4,037	568	0.28	2.86	7.79	14.5	24.5	38.2	43.3	61.8	84.7	98.5	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). Differences in paired samples greater than 20% indicate a problem. 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 conditions equivalent to the standard sample bottles.

Paired sample results with a difference between them of greater than 20% are highlighted in pink in Table B.1. The difference between the paired MS/MS samples for Total Nitrogen at Tahoma on March 19, 2021 may be due to slight fluctuations in nitrogen concentrations from minute to minute. The difference between the paired MS/MS samples for several sediment indicators at Tahoe Valley on March 19, 2021 may be due to fluctuations in sediment concentrations from minute to minute. Two MS samples cannot be triggered at the same time and end up occurring 1-3 minutes apart.

Table B.1 MS and GS sample data from WY21. Paired sample results with a difference between them of greater than 20% are highlighted pink.

Sample	Sample Start (Date/Time)	Total 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-MS	3/19/2021 9:35	207	294	142	1,123	1,000	0.52	5.55	15.90	29.8	48.6	68.5	74.3	92.0	98.4	100	100	100	100
TA-MS	3/19/2021 9:38	223	291	139	1,359	1,120	0.45	4.79	13.80	26.0	43.4	62.2	67.8	87.9	96.8	100	100	100	100
TV-MS	3/19/2021 11:48	26	28	13	944	153	0.53	4.98	11.40	18.5	30.5	48.1	53.6	70.1	78.1	86.8	94.7	100	100
TV-MS	3/19/2021 11:49	19	21	7	820	146	0.59	4.73	9.50	14.9	24.1	36.9	41.9	53.9	61.7	72.7	87.0	100	100

Table B.2 Field blank sample data from all sites in WY21. No values were greater than the method detection limit indicating no contamination. All samples were too clear for PSD analysis.

Sample	Sample Start (Date/Time)	Total 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
EC-FB	2/12/2021 13:30	<0.4	0.3	na	<40	<2	na	na	na	na	na	na	na	na	na	na	na	na	na
SB-FB	2/12/2021 13:00	<0.4	0.3	na	<40	<2	na	na	na	na	na	na	na	na	na	na	na	na	na
SB-FB	9/10/2021 9:00	<0.4	0.7	na	<40	<2	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-FB	9/10/2021 10:00	<0.4	0.7	na	<40	<2	na	na	na	na	na	na	na	na	na	na	na	na	na
TC-FB	9/10/2021 9:35	<0.4	0.3	na	<40	<2	na	na	na	na	na	na	na	na	na	na	na	na	na
UT-FB	2/11/2021 17:00	<0.4	0.2	na	<40	<2	na	na	na	na	na	na	na	na	na	na	na	na	na