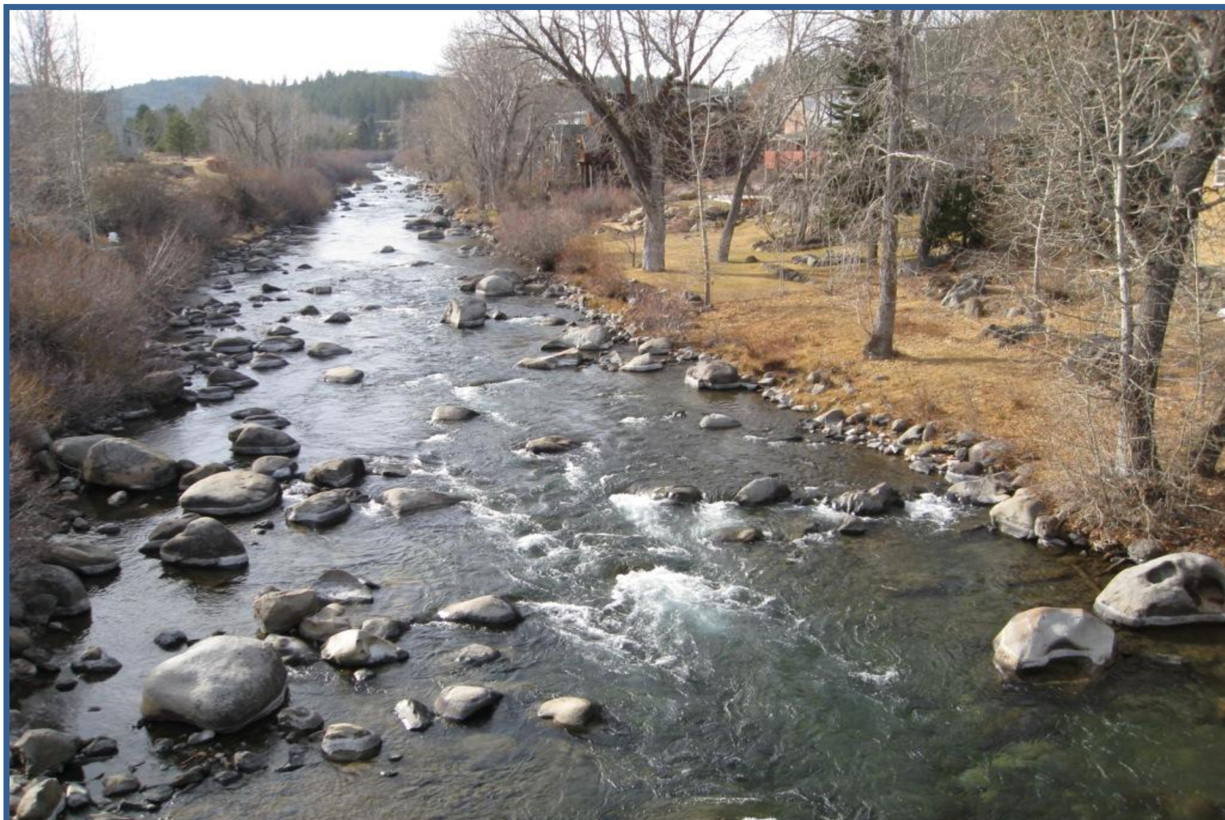
Town of Truckee/County of Placer

Joint Annual Monitoring Report for:

Implementation of the Truckee River Water Quality Monitoring Plan

Water Year 2013



Submitted: December 2013

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Table of Contents

List of Figures

List of Tables

Appendices

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Executive Summary

This report presents the results of implementing the fourth year of the Truckee River Water Quality Monitoring Plan (TRWQMP) which took place during the 2013 water year (October 1, 2012 – September 30, 2013). The report is a joint effort between Placer County (County) and the Town of Truckee (Town) and presents the results of both entities' monitoring activities.

Purpose and Objectives

As a Small Municipal Separate Storm Sewer System (MS4), the County and Town must comply with the State's general National Pollutant Discharge Elimination System (NPDES) Phase 2 permit (Permit) for stormwater discharges. In accordance with this permit and other requirements, the County and Town collaborated to develop a comprehensive water quality monitoring plan.

The overall purpose of the TRWQMP is to assess the effectiveness of various Stormwater Management Plan (SWMP) related actions implemented by the County and Town to protect natural surface waters from the impacts of stormwater runoff. The goals of the TRWQMP are as follows:

- TRWQMP Goal 1: Ensure regulatory compliance with the NPDES permit, Lahontan Board Orders, Middle Truckee River Sediment TMDL, Squaw Creek sediment TMDL, and the Martis Valley Community Plan.
- TRWQMP Goal 2: Develop water quality monitoring datasets that will be scientifically defensible and provide accurate data to evaluate the effectiveness of Stormwater Management Programs in protecting surface water resources.
- TRWQMP Goal 3: Develop a monitoring plan that is economically feasible to implement and maintain over time.
- TRWQMP Goal 4: Ensure that the TRWQMP allows collaboration, effort-sharing and integration of multiple independent private and public monitoring efforts.

Implementation Overview

Implementation of Phase 1 of the TRWQMP began during the 2010 water year (October 1, 2009 through September 30, 2010) and has been continuous through the 2013 water year. Information regarding the monitoring plan and protocols are found in the TRWQMP and the Sampling and Analysis Plans (SAP) that were prepared for the County and Town for the Phase 1 monitoring.

The 2013 water year (WY 2013) was well below average in terms of precipitation as compared to historical records. Precipitation was above average for the months of October, November, and December which accounted for approximately 75 percent of the total WY 2013 precipitation. Very little precipitation occurred from January through April with monthly totals being well below average. Snowfall totals during WY 2013 were also well below average.

There were no major fires, landslides, floods or other events during this period, and the spring runoff was less than normal due to the small amounts of snowfall during the winter. Data collected during the 2013 monitoring period are representative of existing conditions and will improve the baseline dataset which will be used to evaluate future changes in the watershed.

Year 4 TRWQMP implementation activities are the primary focus of this report. These included a set of select monitoring activities in the Martis Creek and Truckee River (Town corridor) sub-watersheds that included:

- Community level water quality sampling to characterize the quality of stormwater runoff from communities with varying land uses and characteristics,
- Tributary level water quality sampling to characterize the water quality of the tributaries within the Martis Creek sub-watershed,
- Stream discharge monitoring to characterize annual discharge patterns and volumes for the Truckee River and Martis Creek, and
- Near-continuous turbidity monitoring to develop annual suspended-sediment load estimates for the Truckee River and each monitored branch of Martis Creek.

Additional data, collected by the Truckee River Watershed Council (TRWC) and California Department of Water Resources (DWR), are also analyzed and presented in this report. The integration of this information is a result of a coordinated monitoring effort to identify and characterize the suspended sediment sources and trends within the Middle Truckee River and its tributaries.

Results and Discussion

Community Level Water Quality Monitoring

WY 2013 was the third year of data collection at the Lahontan and Northstar community level water quality monitoring sites. The three year dataset is sufficient for characterization, and the results should be considered typical of the water quality at each site. Statistical analyses indicate that samples collected at the Northstar site had statistically higher mean concentrations than samples from the Lahontan site for TSS and turbidity. Mean concentrations of total nitrogen, total phosphorus, and dissolved phosphorus were similar between the two sites with no statistical differences. Overall, the community level results from the Lahontan and Northstar sites tend to be lower than the Tahoe TMDL values for their respective land uses indicating that these sites are not major sources of water quality detriment in the Martis Creek watershed.

The drainage area of the Lahontan site consists of modern development that includes a golf course and low density residential area with minimal impervious area. This community also includes facilities that treat stormwater runoff prior to discharge including a long vegetated channel.

The Nothstar site receives runoff from multiple land uses including a large ski area parking lot, a dirt road, a paved residential road, natural wooded upland areas, and residential homes. The large parking lot for Northstar ski resort incorporates sediment traps in the drainage inlets and a large infiltration/ sedimentation basin. Erosion has been observed to occur during large runoff events when the upstream infiltration basin fills completely and discharges down the steep hillside, and when high flow rates occur on the residential street shoulder.

Tributary Level Water Quality Monitoring

The results of the first three years of tributary level water quality monitoring at the six Martis Creek sites are beginning to reveal information regarding the types of pollutants and their relative concentrations and loads at the various locations. The data indicate that pollutant concentrations within Martis Creek and its tributaries are below the water quality objectives defined for total nitrogen and TKN within Martis Creek at its mouth. All sites had mean total phosphorus concentrations that were above the water quality objective for Martis Creek. This includes East Martis Creek which has a relatively undeveloped watershed, indicating that the phosphorus source may be natural rather than a result of fertilizers use on golf courses and landscaping.

The largest pollutant yields in the Martis Creek watershed were observed in West Martis Creek and the upper main stem of Martis Creek (above all major confluences). These are the most developed Martis Creek sub-watersheds, and additional measures should be considered to help reduce pollutant loading.

Stream Flow Monitoring

Streamflow monitoring in WY 2013 was conducted at three locations within the Martis Creek watershed. At each location, a near-continuous record (15-minute) of streamflow was developed and used for evaluation of annual peak flows, annual mean flow, daily streamflow and total flow volume. In combination with water quality sampling, these metrics were used to compute a near-continuous record of suspended-sediment loading.

The lower main stem Martis Creek gauge has been in operation for three years, and WY 2013 had the least amount of total annual discharge with approximately 5,300 acre-feet. WY 2012 had a similar annual discharge of approximately 6,200 acre-feet, and WY 2011 had much more with approximately 23, 400 acre-feet.

Near-Continuous Turbidity Monitoring

During WY 2013, four near-continuous turbidity stations were operated in the project area; one in the Truckee River upstream of Truckee, one in the Truckee River downstream of Truckee at the Boca Reservoir Bridge, one in West Martis Creek, and one in the upper main stem of Martis Creek below the Northstar and Lahontan developments. Based on the first year of continuous-turbidity monitoring, the importance of high-intensity, short-duration, runoff events on suspended-sediment loading is evident. Rain-on-snow events or short-lived summer thunderstorms can generate loads an order of magnitude, or more, than loads generated by long-duration events such as spring snowmelt runoff.

Suspended-sediment loads in the Truckee River upstream and downstream of Truckee were compared against TMDL limits established for the Middle Truckee River, in which Farad is considered to be the point of compliance. Loads for partial water year 2013 suggest the near-continuous turbidity stations met the TMDL standard for suspended-sediment, while loads computed for the full water year at Farad also met the TMDL standard. It should be noted that WY2013 was a dry year, and data from other year types (i.e., wet, average) are needed to assess the variability across year types.

Near-continuous turbidity monitoring also enabled the estimation of suspended-sediment loads and yields for the major tributaries in the Martis Creek watershed. The largest suspended-sediment yields for WY 2013 occurred in West Martis Creek and the upper main stem of Martis Creek which are the most developed sub-watersheds. These results support the conclusions of the tributary level monitoring discussed above.

The total WY 2013 suspended-sediment load at the mouth of Martis Creek near the Martis Creek Reservoir was approximately 100 tons. This equates to approximately 3 percent of the total suspended-sediment load measured in the Truckee River at the Boca Reservoir bridge indicating that the Martis Creek watershed is not a large contributor of suspended-sediment to the Truckee River. Additional settling is also likely to occur in the Martis Creek Reservoir, and actual suspended-sediment loads to the Truckee River from Martis Creek are unknown.

Water Quality Areas of Concern

After four years of monitoring, the following areas were identified as areas of the highest concern for water quality:

- **Truckee River (Town Corridor):** Suspended-sediment results indicate approximately one third of the total suspended-sediment load being carried by the Truckee River at the Boca Bridge originates from within this watershed. In addition to the Truckee downtown areas, this very large watershed includes Martis Creek, Glenshire Creek, Prosser Creek, and the Little Truckee River which also contribute to suspended-sediment loads.

  Previous RAM results from the Truckee River main stem do not indicate high percentages of fine substrate despite a very high percentage in Trout Creek. Previous community level sampling indicates elevated TSS concentrations in stormwater runoff discharging into the Truckee River from the downtown area. Based on the data collected to date, the integrated results indicate significant amounts of sediment are discharged to the Truckee River from urban areas but are then mostly transported downstream rather than becoming permanently deposited on the channel bottom.

- **Donner Creek:** Suspended-sediment measurements indicate that Donner Creek had the highest suspended-sediment yield, when compared to other Truckee River tributaries monitored in WY 2013. The area within the Town of Truckee that drains to Donner Creek is small, but also urbanized, and includes high traffic roadways such as Highway 89 and Interstate 80. Impervious surfaces drain to Donner Creek through a large network of storm drains that transport particulates materials that are measured as suspended-sediment in Donner Creek. Cold Creek, a tributary to Donner Creek which is located primarily within Placer County, drains a watershed with many historic disturbances from gravel mining, logging and railroad activities and is also a source of suspended-sediment to the Truckee River.

- **West Martis Creek:** Results indicate that this tributary carried the largest suspended sediment, total phosphorus, and total nitrogen load per acre of Martis Valley watershed. Rapid Assessment Methodology (RAM) monitoring in previous years has also indicated a relatively high percentage of fine sediment substrate in West Martis Creek.

  This is likely a combined effect of the Northstar development including roadway shoulder erosion near creek crossings, ski run soil disturbance, commercial and residential construction, roadway abrasives and more. New community sites are recommended to help identify and prioritize source areas.

- **Trout Creek:** Previous RAM data indicate Trout Creek has very high percentages of fine substrate covering the streambed. The newly restored portion in the upper reaches of the RAM survey segment shows improvement over conditions during the previous survey, but also indicates a large amount of sediment is being transported from upstream.

- **Squaw Creek:** A large thunderstorm occurred on July 3, 2013, and was isolated in the upper Squaw Creek watershed. Results of suspended-sediment monitoring in the Truckee River above Truckee indicate that this event resulted in a suspended-sediment load of approximately 115 tons. This accounted for approximately 10 percent of the annual suspended-sediment load at this location.

  Previous RAM and bioassessment results indicate a continued impact to this stream by sediment deposition. The area of highest concern identified from 2012 bioassessment monitoring was the upper meadow site in Squaw Creek (site Bio-SC1). This site had the lowest IBI score of all sites sampled in 2012 (IBI score= 46), as well as the smallest median particle size (D50= 2 mm). The middle meadow (site Bio-SC2) and lower meadow (site Bio-SC3) sites in Squaw Creek also had very small median particle sizes (D50= 3 mm), although these sites scored well in terms of Biological Condition Scores (BCS= 25 and 27 out of a possible 35, respectively) and the Eastern Sierra IBI (93 and 90 out of a possible 100, respectively).

Effectiveness of MS4 Permit Activities

The effectiveness of implementing Permit related stormwater management activities can be evaluated through the comparisons presented herein. Because this is only the fourth year of implementation and relatively little changes to the watershed have occurred, spatial comparisons are most appropriate at this time. The temporal water quality trends identified in this report are likely related to differences in precipitation amounts rather than specific management actions and more data is required to evaluate their significance.

Previously collected community level discrete sampling does demonstrate the effectiveness of stormwater related management activities. The permanent stormwater treatment BMPs present in some of the drainage systems provide clear benefits as shown in the monitoring results. When compared to other sites, the water quality at the treated sites is clearly improved with respect to all the monitored pollutants in almost every runoff event.

Prioritization of Existing TRWQMP Elements

The TRWQMP is currently being implemented as planned. Overall, monitoring activities should be continued per the guidance in the TRWQMP and the adaptive management based modifications that have been made to the program over the initial four years of implementation. There is a continued need to develop more comprehensive and robust datasets that will help to identify specific areas of concern and evaluate stormwater management program performance.

For WY 2014, monitoring will consist of continuous turbidity monitoring and sediment load evaluations, tributary and community level water quality monitoring, RAM in Truckee River tributaries, and bioassessments in Martis and Squaw Creeks. Modifications to the program during WY 2014 will likely include the relocation of the two Placer County community level sites (DSC-MC2 and DSC-MC3) in Northstar and additional community level water quality monitoring by the Town within the Donner Creek watershed. Also, the two turbidity monitoring sites in the Martis Creek watershed at the West Martis Creek (TURB-MC1) and main stem Martis Creek (TURB-MC2) sites were upgraded with new probes in October, 2013 and relocated to avoid flow bypass and beaver dam issues.

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Section 1

Introduction

As Small Municipal Separate Storm Sewer Systems (MS4s), Placer County (County) and the Town of Truckee (Town) must comply with the State's general National Pollutant Discharge Elimination System (NPDES) Phase 2 General Permit (Permit) for stormwater discharges. In accordance with the 2003 Permit (Order No. 2003-0005-DWQ), the County and Town each developed Storm Water Management Programs (SWMPs) (Placer County, 2007 and Town of Truckee, 2007) which were required by the Lahontan Regional Water Quality Control Board (Lahontan) to include the development of a comprehensive water quality monitoring plan for the Middle Truckee River Watershed. Additionally, Clean Water Act 303(d) Total Maximum Daily Load (TMDL) programs are being implemented in both Squaw Creek and the Middle Truckee River. In response to these regulations, the Truckee River Water Quality Monitoring Plan (TRWQMP) (2NDNATURE, LLC, 2008) was developed collaboratively by the County and Town to cost-effectively assess the effectiveness of their ongoing SWMPs with respect to protecting downstream water resources. The SWMPs remained effective until July 1, 2013 when the new Phase 2 Permit was adopted (Order No. 2013-0001-DWQ). Under the new permit, SWMPs are no longer required to be developed and submitted by Permittees and the required storm water control measures are listed within the Permit itself. Annual reports are required to document compliance with these controls. Placer County and Town of Truckee compliance with the Middle Truckee River TMDL for sediment is now a part of the new permit.

The TRWQMP is a fifteen year comprehensive water quality monitoring plan that is intended to be implemented in three phases. Phase 1 consists of baseline data collection, and is scheduled to occur over a three to five year period. The County and Town began implementation of Phase 1 during the 2010 water year (WY 2010) (October 1, 2009 through September 30, 2010). Phase 2 is intended to occur over a two year period and will strategically expand on the monitoring activities conducted during Phase 1. Phase 3 will incorporate adaptive management of TRWQMP elements based on data and findings from Phases 1 and 2. Phase 3 will continue through the fifteenth and final year of TRWQMP implementation (WY 2024). The level of implementation during each phase will depend on a number of factors including cooperation by other independent entities conducting water quality monitoring in the watershed and the availability of funding.

Several documents have been previously produced during the planning and implementation of the initial Phase 1 monitoring program. These documents and a brief description of their content are as follows:

- *Evaluation of Existing Monitoring for Integration with the Truckee River Water Quality Monitoring Plan* (CDM Smith, 2010a) provides a review of the existing monitoring programs that were identified for potential integration in the TRWQMP and develops recommendations to begin their incorporation.
- *Truckee River Water Quality Monitoring Plan, Phase 1 Permitting and Approvals Requirements* (CDM Smith, 2010b). Identifies and tracks the permitting and approvals required for each type of assessment, their proposed location, property ownership, contact information, approvals schedule, required fees and required submittal information.

- *Truckee River Water Quality Monitoring Plan Monitoring Site Selection Report* (CDM Smith, 2010c) presents evaluations and recommendations for monitoring site locations to be used for the Phase 1 implementation.
- *Sampling and Analysis Plan, Water Year 2011* (CDM Smith, 2011a) and (CDM Smith, 2011b) describes the initial management strategy and the specific monitoring activities to be implemented under the first three years of Phase 1.
- *Equipment Installation Report* (CDM Smith, 2011c) documents the installation of the stream gauge and the tributary and community level water quality monitoring stations in the Martis Creek watershed.
- *Truckee River Water Quality Monitoring Plan Field Equipment Operations and Maintenance Manual* (CDM Smith, 2011d) provides an inventory of monitoring equipment as well as the protocols followed for operating and maintaining the equipment.
- *Sampling and Analysis Plan, Water Year 2013* (CDM Smith, 2013a) and (CDM Smith, 2013b) describes the revised management strategy and the specific monitoring activities to be implemented for the remainder of Phase 1. The Sampling and Analysis Plan will be updated annually as appropriate to document revisions to monitoring activities.

The results of WY 2010 monitoring activities were presented in two reports that were produced separately by the County and Town. To better document the program as a whole, the results of WY 2011and 2012 monitoring activities were presented in single documents produced jointly by the County and Town. These reports include the following:

- *Placer County: Annual Report for Implementation of the Truckee River Water Quality Monitoring Plan, Water Year 2010* (CDM Smith, 2010d);
- *Town of Truckee: Annual Report for Implementation of the Truckee River Water Quality Monitoring Plan, Water Year 2010* (CDM Smith, 2010e);
- *Town of Truckee/County of Placer: Joint Annual Monitoring Report for Implementation of the Truckee River Water Quality Monitoring Plan, Water Year 2011* (CDM Smith, 2011e); and
- *Town of Truckee/County of Placer: Joint Annual Monitoring Report for Implementation of the Truckee River Water Quality Monitoring Plan, Water Year 2012* (CDM Smith, 2013c).

This Joint Annual Monitoring Report describes the monitoring activities performed by Placer County and the Town of Truckee during WY 2013 and presents their results. Data collection activities during this fourth year of the TRWQMP's implementation included:

- Community level discrete water quality sampling within the Martis Creek sub-watershed,
- Tributary level discrete water quality sampling within the Martis Creek sub-watershed, and
- Continuous discharge and turbidity monitoring within the Truckee River and Martis Creek.

Figure 1-1
Truckee River in Truckee

Section 2

TRWQMP Summary

The purpose of the TRWQMP is to provide a strategy for assessing the effectiveness of the County and Town stormwater management programs in protecting downstream water resources. The TRWQMP provides guidelines for conducting multiple types of monitoring activities as necessary to evaluate the various actions that are being implemented to protect natural receiving waters from the impacts of stormwater runoff and illicit discharges. This section provides a summary of the TRWQMP's purpose and presents the goals and objectives that were defined to help guide its implementation.

2.1 Purpose

The County and Town SWMPs served as the guiding documents for development of the TRWQMP. The SWMPs outline two categories of assessment for evaluating the effectiveness of stormwater management programs as described below. Note that the SWMPs were effective until July 1, 2013, and requirements of the new 2013 Permit are applicable from that date forward.

- Compliance assessment focuses on inspections of activities that may contribute to poor quality of stormwater runoff with the goal of enforcing compliance with the guidelines delineated in the SWMP. Compliance monitoring is conducted by the County and Town staff as outlined in their respective SWMPs and is not addressed by the TRWMQP.

- Performance assessment involves directly evaluating the water quality of stormwater runoff and receiving waters in order to assess the success of the SWMP in protecting surface water resources. Results from the TRWQMP can inform strategies for stormwater management outlined in the SWMP by identifying sub-watersheds of concern and prioritizing pollutant sources that disproportionately affect water quality.

The second category, performance assessment, is the primary focus of the TRWQMP. The overall purpose of the TRWQMP is to assess the effectiveness of various SWMP related actions taken to protect natural surface waters from the impacts of stormwater runoff. The TRWQMP also promotes collaboration among the various independent groups performing monitoring in the Truckee River Watershed. The TRWQMP aims to create of a more unified data management and reporting structure which will help to identify and track pollutant sources and evaluate long-term water quality trends.

2.2 Goals and Objectives

The following set of goals and objectives were defined during the development of the TRWQMP to help describe its purpose and the guidelines under which it was developed.

TRWQMP Goal 1: Comply with regulatory NPDES permits, Lahontan Board Orders, Middle Truckee River Sediment TMDL, Squaw Creek sediment TMDL, and the Martis Valley Community Plan for Placer County and the Town of Truckee.

TRWQMP Goal 2: Develop water quality monitoring datasets that will be scientifically defensible and provide accurate and representative data to evaluate the effectiveness of Stormwater Management Programs in protecting surface water resources.

TRWQMP Goal 3: Develop a monitoring plan that is economically feasible to implement and maintain over time.

TRWQMP Goal 4: Facilitate collaboration, effort-sharing and integration of multiple independent private and public monitoring efforts.

To meet the goals of the TRWQMP, a more focused set of objectives were developed as follows:

- Provide a comprehensive and integrated data collection, data analysis and reporting framework to evaluate and track the status of surface water resources within the project area spatially and over time.
- Prioritize monitoring resources on spatial locations determined to be existing and/or future potential source areas.
- Focus monitoring resources on pollutants of concern and indicators that are clearly rationalized for each location of monitoring. Prioritize pollutants based on greatest risk to surface water resources due to specific land use activities.
- Maximize monitoring resources by including a range of monitoring types that vary in frequency of collection, relative cost to complete and statistical accuracy.
- Focus monitoring resources on times (season, storm events, etc.) when potential source area water quality is expected to deviate greatest from observations at minimally impacted locations.

The TRWQMP describes multiple assessment types to be implemented in a phased approach. Also, data collection and analysis activities are intended to be flexible from year to year to allow adjustments based on changes to available funding and new information that is developed through the program's implementation. To focus the monitoring activities and maximize their value, additional objectives, specific to each assessment type, were developed to focus implementation on answering specific water quality related questions. The following additional objectives were developed for the WY 2013 Phase 1 monitoring:

Community Discrete Samples

- Characterize the water quality of stormwater runoff from catchments with varying characteristics and stormwater management practices to identify problem locations within the project area.
- Conduct source area analysis for problem locations based on pollutants of concern present in the runoff.

Tributary Discrete Samples

- Characterize the water quality differences among the various Martis Creek tributaries.
- Conduct source area analysis based on pollutants present in the tributaries.

Stream Discharge and Turbidity Monitoring

- Collect turbidity and total suspended solids (TSS) data and develop correlations between these two parameters.

- Characterize annual discharge patterns and volumes for the Truckee River and Martis Creek.
- Utilize measured, and USGS stream discharge data, together with the turbidity:TSS correlation to calculate suspended sediment loads in the Truckee River upstream and downstream of the Town of Truckee and in West Martis Ck and the main stem of Martis Creek.
- Integrate similar Truckee River Watershed Council data to characterize suspended sediment loads delivered to the Truckee River from Donner and Trout Creeks.
- Conduct comparisons to suspended sediment load estimates presented in Truckee River TMDL and evaluate loads originating within Town boundary against TMDL defined load allocations.
- Apply the newly developed turbidity:TSS correlation to available historic turbidity data collected by the Department of Water Resources to identify and evaluate past and ongoing trends in the Truckee River suspended sediment loads.
- Develop and apply streamflow:TSS relationships to be used as a second method of calculating suspended sediment loading, as well as to evaluate temporal trends in sediment generation and supply.

The data from each of these assessment types will also provide existing conditions water quality information to be used for the comparison of future data and evaluation of water quality trends over time. Additionally, the data from sites exhibiting good water quality can provide realistic water quality targets when planning stormwater improvements for problem areas.

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Section 3

Summary of the 2013 Monitoring Period

This section presents a description of the WY 2013 monitoring period in terms of the precipitation patterns, stream discharge, land use activities and regulatory structure in place between October 1, 2012 and September 30, 2013.

3.1 Precipitation Summary

The Natural Resources Conservation Service (NRCS) SNOpack TELemetry (SNOTEL) Tahoe City Cross and Truckee #2 gauges were the two sources of precipitation data for WY 2013 (USDA, 2013). The data are presented graphically in Figures 3-1 and 3-2 which include cumulative precipitation and snow water equivalent (SWE) for WY 2013 as well as historical average precipitation and SWE at these gauges. Tables 3-1 through 3-4 present the monthly precipitation and SWE values measured at these gauges for each of the four years of Phase 1 monitoring implementation (2010-2013). These values are compared to historical averages to illustrate the relative magnitude of the water year (in terms of precipitation and snowfall) compared to an average or normal water year.

The total annual precipitation received during WY 2013 was approximately 76 and 85 percent of average at the Truckee #2 and Tahoe City Cross gauges, respectively. Precipitation was above average for the months of October, November, and December which accounted for approximately 75 percent of the total WY 2013 precipitation. The largest event of the season occurred from November 28, 2012 to December 2, 2012 when 6.8 inches of precipitation (mostly rain) fell over the project area within 96 hours. Very little precipitation occurred from January through April with monthly totals well below average. Snowfall totals and SWE during WY 2013 were very low with monthly SWE averages (November through May) at 19 and 54 percent of normal for the Tahoe City Cross and Truckee #2 gauges, respectively. This indicates that a large portion of the total precipitation fell in the form of rain with limited opportunity for snowfall accumulations.

During the first four years of TRWQMP implementation, annual precipitation amounts have been highly variable. Annual precipitation totals during WY 2010 were very close to average, while during WY 2011; annual totals were over 160 percent of average. Water years 2012 and 2013 were two consecutive drought years with precipitation totals ranging from 73 to 83 percent of average. Snowfall and SWE trends generally correlate with total precipitation, but WY 2012 and WY 2013 both resulted in a meager snowpack.

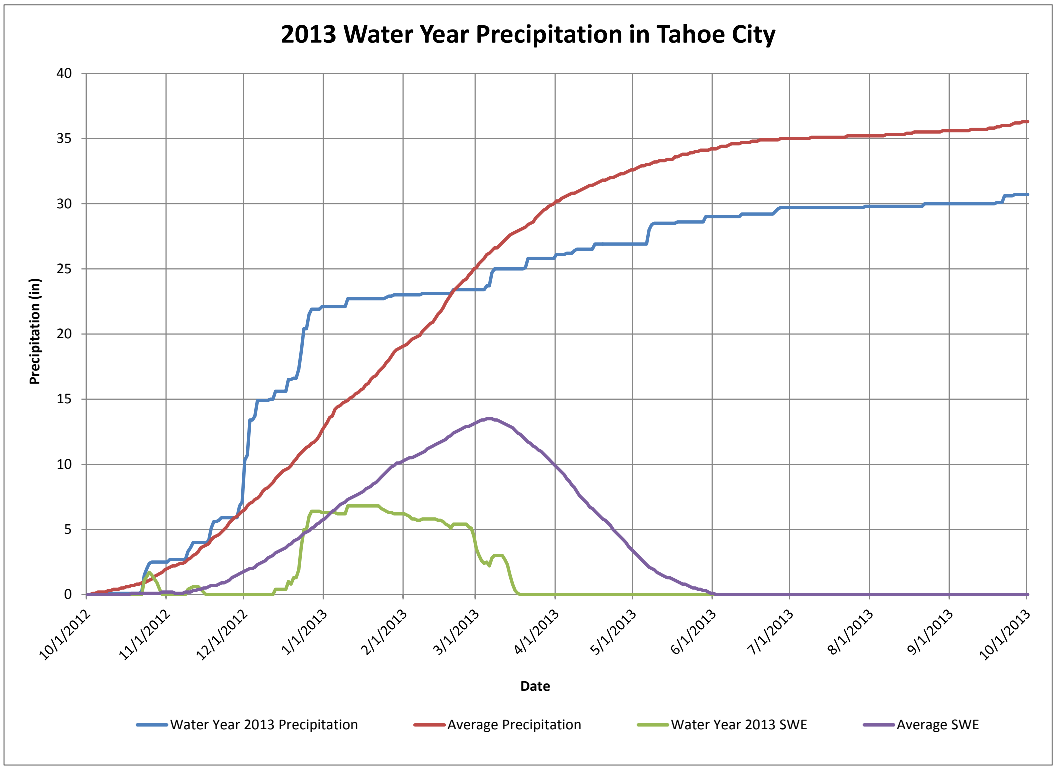


Figure 3-1
Daily Precipitation in Tahoe City, CA (USDA, 2013)

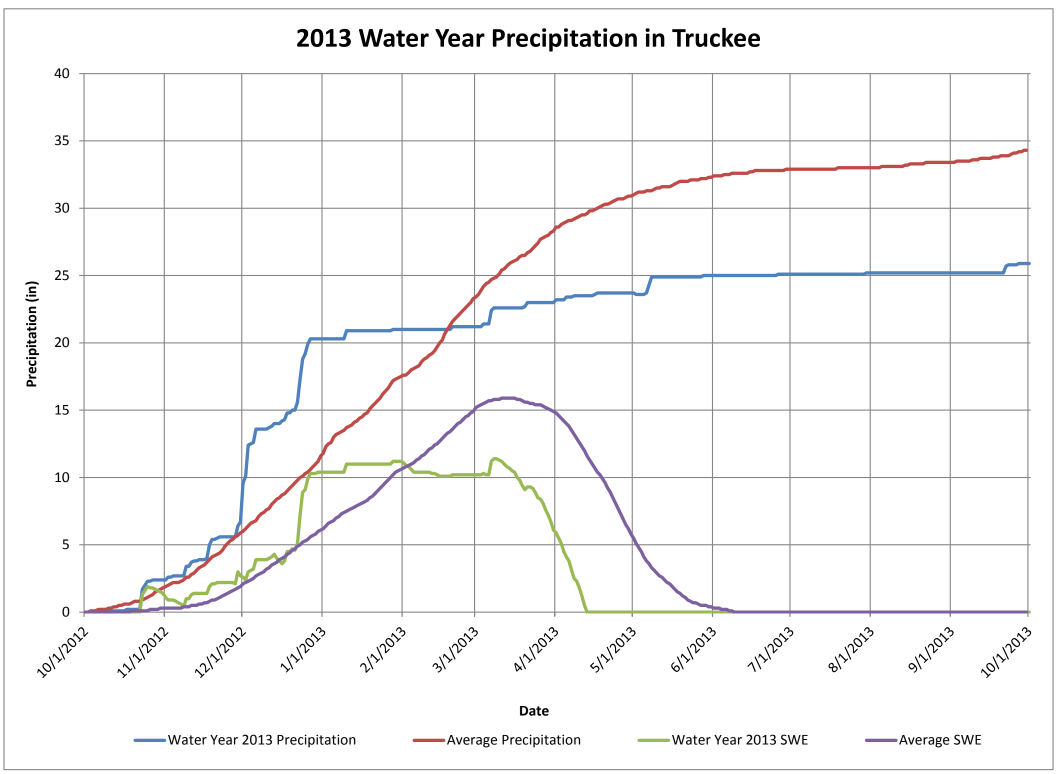


Figure 3-2
Daily Precipitation in Truckee, CA (USDA, 2013)

Table 3-1. Tahoe City Precipitation Totals for Water Years 2010-2013[1]

WY 2010	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Total
Monthly Precipitation Total	4.1	1.6	5.6	7.7	3.7	4.9	6.3	2.3	0.3	0.0	0.1	0.1	36.7
Percent of Average	216%	36%	90%	120%	62%	98%	242%	144%	37%	0%	25%	14%	101%
WY 2011	**Oct-10**	**Nov-10**	**Dec-10**	**Jan-11**	**Feb-11**	**Mar-11**	**Apr-11**	**May-11**	**Jun-11**	**Jul-11**	**Aug-11**	**Sep-11**	**Total**
Monthly Precipitation Total	8.6	7.4	13.9	1.0	8.0	13.7	2.1	2.6	0.9	0.2	0.1	0.7	59.2
Percent of Average	453%	164%	224%	16%	133%	274%	81%	163%	113%	100.0%	25%	100%	163%
WY 2012	**Oct-11**	**Nov-11**	**Dec-11**	**Jan-12**	**Feb-12**	**Mar-12**	**Apr-12**	**May-12**	**Jun-12**	**Jul-12**	**Aug-12**	**Sep-12**	**Total**
Monthly Precipitation Total	2.1	1.5	0.1	5.8	1.8	9.1	4.1	0.5	0.5	0.1	0.5	0.3	26.4
Percent of Average	111%	33%	2%	91%	30%	182%	158%	31%	63%	50%	125%	43%	73%
WY 2013	**Oct-12**	**Nov-12**	**Dec-12**	**Jan-13**	**Feb-13**	**Mar-13**	**Apr-13**	**May-13**	**Jun-13**	**Jul-13**	**Aug-13**	**Sep-13**	**Total**
Monthly Precipitation Total	2.5	7.8	11.8	0.9	0.4	2.7	0.8	2.1	0.7	0.1	0.2	0.7	30.7
Percent of Average	132%	173%	190%	14%	7%	54%	31%	131%	88%	50%	50%	100%	85%
Average Monthly Precipitation[2]	*1.9*	*4.5*	*6.2*	*6.4*	*6.0*	*5.0*	*2.6*	*1.6*	*0.8*	*0.2*	*0.4*	*0.7*	*36.3*

[1] Data acquired from the SNOTEL Tahoe City Cross Site (USDA, 2013)
[2] Based on data recorded from 1981 through 2010

Table 3-2. Truckee Precipitation Totals for Water Years 2010-2013[1]

WY 2010	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Total
Monthly Precipitation Total	3.7	2	5.6	7.3	3.7	4.8	5.7	1.1	0.2	0.0	0.5	0.1	34.7
Percent of Average	206%	49%	98%	124%	64%	96%	219%	79%	33%	0%	125%	11%	101%
WY 2011	**Oct-10**	**Nov-10**	**Dec-10**	**Jan-11**	**Feb-11**	**Mar-11**	**Apr-11**	**May-11**	**Jun-11**	**Jul-11**	**Aug-11**	**Sep-11**	**Total**
Monthly Precipitation Total	8.0	6.8	11.0	0.9	8.0	13.5	1.9	2.7	2.3	0.8	0.1	0.2	56.2
Percent of Average	444%	166%	193%	15%	138%	270%	73%	193%	383%	800%	25%	22%	164%
WY 2012	**Oct-11**	**Nov-11**	**Dec-11**	**Jan-12**	**Feb-12**	**Mar-12**	**Apr-12**	**May-12**	**Jun-12**	**Jul-12**	**Aug-12**	**Sep-12**	**Total**
Monthly Precipitation Total	2.0	1.6	0.2	5.1	2.8	7.4	2.7	0.3	0.3	0.3	1.9	0.3	24.9
Percent of Average	111%	39%	4%	86%	48%	148%	104%	21%	50%	300%	475%	33%	73%
WY 2013	**Oct-12**	**Nov-12**	**Dec-12**	**Jan-13**	**Feb-13**	**Mar-13**	**Apr-13**	**May-13**	**Jun-13**	**Jul-13**	**Aug-13**	**Sep-13**	**Total**
Monthly Precipitation Total	2.4	7.2	10.7	0.7	0.2	2.0	0.5	1.3	0.1	0.1	0.0	0.7	25.9
Percent of Average	133%	176%	188%	12%	3%	40%	19%	93%	17%	100%	0%	78%	76%
Average Monthly Precipitation[2]	*1.8*	*4.1*	*5.7*	*5.9*	*5.8*	*5.0*	*2.6*	*1.4*	*0.6*	*0.1*	*0.4*	*0.9*	*34.3*

[1] Data acquired from the SNOTEL Truckee #2 Site (USDA, 2013)
[2] Based on data recorded from 1981 through 2010

Table 3-3. Tahoe City Snow Water Equivalent for Water Years 2011-2013[1]

WY 2010	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Average
Snow Water Equivalent	0	0.6	5.5	11.7	13.1	9.9	5.3	6.6
Percent of Average	0%	11%	54%	89%	97%	101%	161%	73%
WY 2011	**Nov-10**	**Dec-10**	**Jan-11**	**Feb-11**	**Mar-11**	**Apr-11**	**May-11**	**Average**
Snow Water Equivalent	1.3	7.1	12.8	14.8	24.5	20.2	2.8	11.9
Percent of Average	78%	124%	126%	113%	182%	206%	86%	131%
WY 2012	**Nov-11**	**Dec-11**	**Jan-12**	**Feb-12**	**Mar-12**	**Apr-12**	**May-12**	**Average**
Snow Water Equivalent	0.1	0.1	0.8	2.4	3.4	2.2	0.0	1.3
Percent of Average	6%	2%	8%	18%	25%	22%	0%	12%
WY 2013	**Nov-12**	**Dec-12**	**Jan-13**	**Feb-13**	**Mar-13**	**Apr-13**	**May-13**	**Average**
Snow Water Equivalent	0.0	0.0	6.3	6.2	3.5	0.0	0.0	2.3
Percent of Average	0%	0%	62%	47%	26%	0%	0%	19%
Historical Snow Water Equivalent[2]	*1.7*	*5.7*	*10.2*	*13.1*	*13.5*	*9.8*	*3.3*	*8.2*

[1] Data acquired from the SNOTEL Tahoe City Cross Site (USDA, 2013)
[2] Based on monthly averages from 1981 through 2010

Table 3-4. Truckee Snow Water Equivalent for Water Years 2011-2013[1]

WY 2010	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Average
Snow Water Equivalent	0.0	1.9	7.2	14.3	18.7	19.2	13.6	10.7
Percent of Average	0%	31%	68%	96%	118%	130%	247%	99%
WY 2011	**Nov-10**	**Dec-10**	**Jan-11**	**Feb-11**	**Mar-11**	**Apr-11**	**May-11**	**Average**
Snow Water Equivalent	1.6	9.2	15.3	18.4	31.6	32.9	10.6	17.1
Percent of Average	84%	151%	145%	123%	199%	222%	193%	159%
WY 2012	**Nov-11**	**Dec-11**	**Jan-12**	**Feb-12**	**Mar-12**	**Apr-12**	**May-12**	**Average**
Snow Water Equivalent	1.2	1.9	2.8	5.2	8.9	7.3	0.0	3.9
Percent of Average	63%	31%	26%	35%	56%	49%	0%	37%
WY 2013	**Nov-12**	**Dec-12**	**Jan-13**	**Feb-13**	**Mar-13**	**Apr-13**	**May-13**	**Average**
Snow Water Equivalent	1.1	2.6	10.4	11.1	10.2	5.9	0.0	5.9
Percent of Average	58%	43%	98%	74%	64%	40%	0%	54%
Historical Snow Water Equivalent[2]	***1.9***	***6.1***	***10.6***	***14.9***	***15.9***	***14.8***	***5.5***	***10.0***

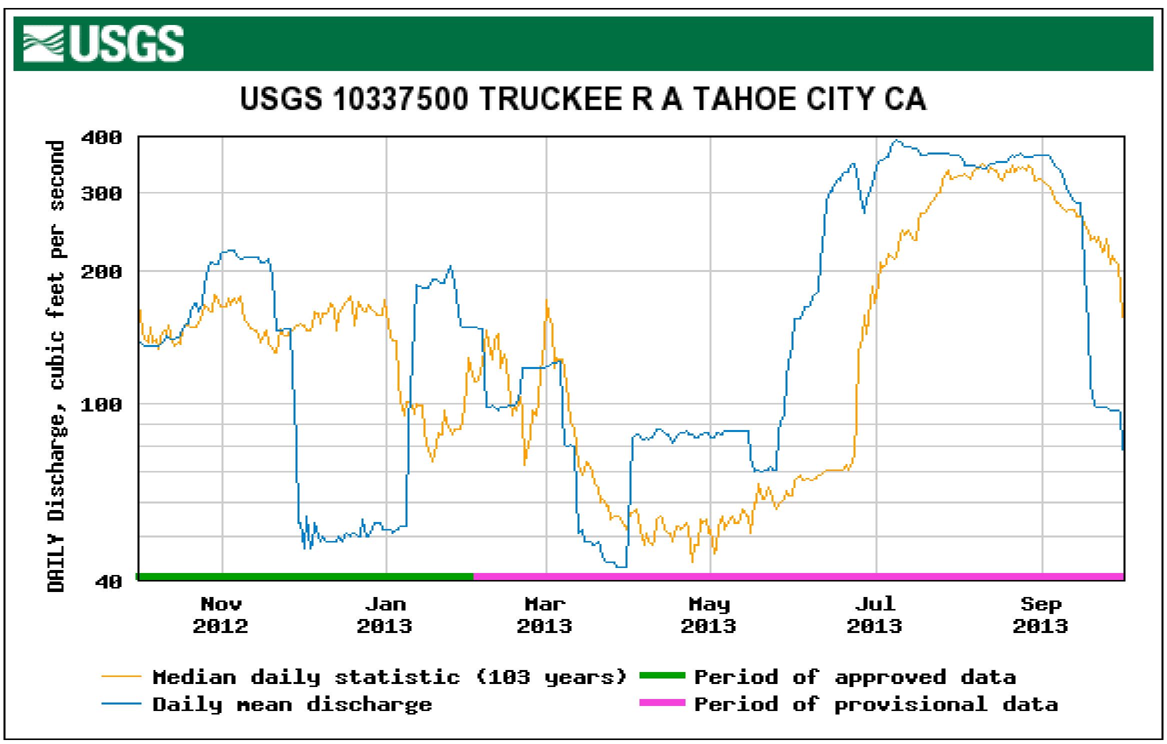
[1] Data acquired from the SNOTEL Truckee #2 Site (USDA, 2013)
[2] Based on monthly averages from 1981 through 2010

3.2 Streamflow Summary

Streamflow in the Middle Truckee River are partially regulated by dam operations on Lake Tahoe and Donner Lake. Additional flow is contributed by several unregulated tributaries including Bear, Squaw, Silver, Deer, Pole, Deep, Cabin, and Cold Creeks. Below downtown Truckee, additional flows are contributed by Martis, Union Valley and Prosser Creeks and the Little Truckee River. Discharge from Martis Creek, Prosser Creek, and the Little Truckee River are also regulated by dams.

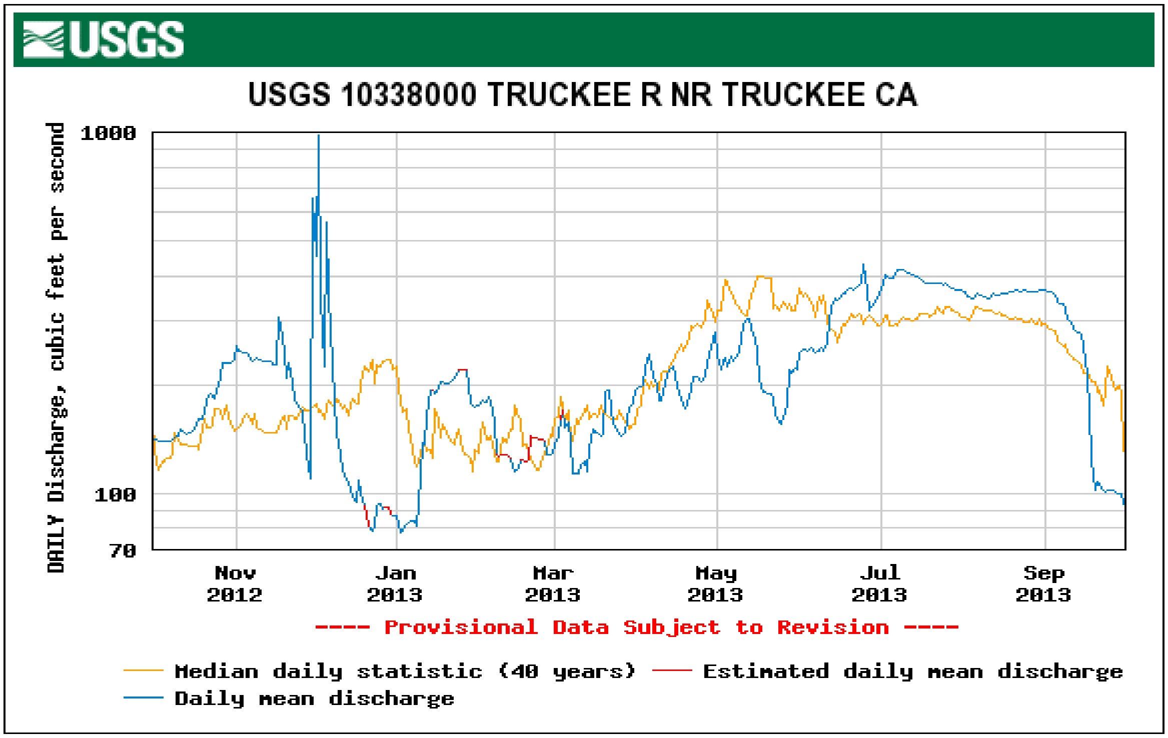
Figures 3-3, 3-4, and 3-5 present WY 2013 hydrographs of the Truckee River at Tahoe City (gauge # 10337500), the Truckee River 2.5 miles upstream of Truckee (gauge # 10338000), and Donner Creek at Hwy 89 (gauge # 10338700), respectively. These gauges are maintained by the United States Geological Survey (USGS), and the data include daily mean discharge and historic median daily discharge values.

The streamflow of the Truckee River fluctuated based on releases from the Lake Tahoe dam in Tahoe City. The dam release decreased in late November prior to heavy precipitation event. The runoff from these events resulted in the WY 2013 peak discharges at the Truckee River near Truckee and Donner Creek sites. Beginning in January, precipitation was limited and the dam was reopened to produce greater discharge in the Truckee River. Discharge at these three sites during the spring generally followed the typical snowmelt cycle. Discharge rose as temperatures warmed in the spring and then decreased throughout the summer as the snowpack subsided.



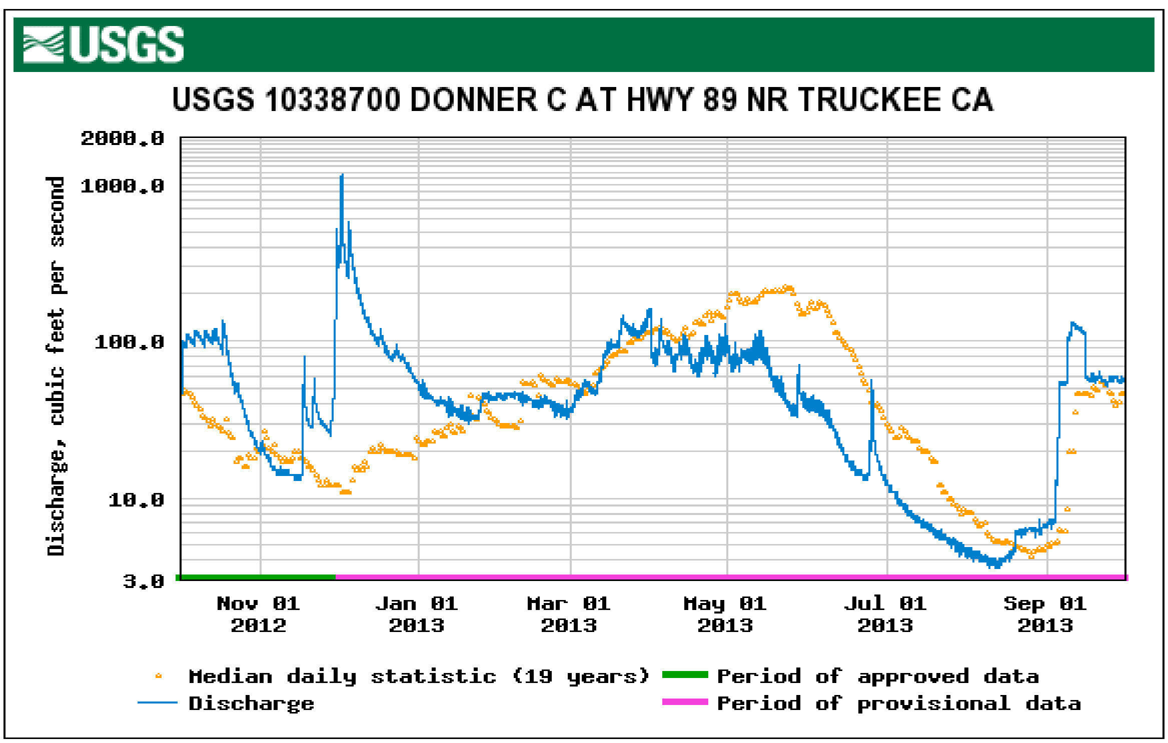
Source: http://waterdata.usgs.gov/nwis/dv?referred_module=sw&site_no=10337500

Figure 3-3
Truckee River Discharge at Tahoe City (USGS, 2013)



Source: http://waterdata.usgs.gov/nwis/dv?referred_module=sw&site_no=10338000

Figure 3-4
Truckee River Discharge near Truckee (USGS, 2013)



Source: http://waterdata.usgs.gov/nwis/dv?referred_module=sw&site_no=10338700

Figure 3-5
Donner Creek Discharge at Highway 89 (USGS, 2013)

3.3 Land Use Conditions

Fifteen sub-watersheds drain to the Truckee River within the TRWQMP project area (Placer County and Town of Truckee). Based on the preliminary GIS analysis conducted during the development of the TRWQMP, seven of these sub-watersheds are classified as having high disturbance and three of them are classified as having moderate disturbance (disturbance is a measure of the level of urban development and/or construction activity present within the subarea). These sub-watersheds are presented in Table 3-5 along with information on area size, land use, and relative disturbance rating. The remaining five sub-watersheds (Cabin Creek, Deep Creek, Deer Creek, Pole Creek, and Silver Creek) are classified with low disturbance and are not included in this table.

New construction activities in the project area during WY 2013 occurred primarily in the Martis Creek watershed. These included roadway repair and drainage improvements on SR 267 and Hwy 89, residential construction, and new construction at Northstar-at-Tahoe. In 2011 and 2012, new construction at Northstar-at-Tahoe included new ski trails, a new chairlift and a 700-seat on-mountain restaurant. Additional construction is planned at Northstar-at-Tahoe in years to come.

During the summer of 2011, a restoration project was implemented by the Town of Truckee on Trout Creek near downtown Truckee. Additionally, the Truckee River Watershed Council began a restoration project in Coldstream Canyon during the summer of 2012.

The Friends of Squaw Creek have collected stream discharge data between 2003 and 2010 from three locations along Squaw Creek. The data are available from their website at http://squaw.soundwatershed.com/. A restoration project for Squaw Creek is currently in the early planning stages.

There were no major fires, landslides, floods or other events during this period, and the spring runoff was less than normal due to the small amounts of snowfall during the winter. Data collected during the 2013 monitoring period are representative of existing conditions and will improve the baseline dataset which will be used to evaluate future changes in the watershed.

Table 3-5. Summary of TRWQMP Sub-Watersheds with High and Moderate Disturbance Ratings[1]

Sub-Watershed	Size (mi^2)	Land Uses	Disturbance Rating
Squaw Creek	8.2	Forest, meadow, ski resort, commercial, residential, dirt roads, golf course, secondary roadways	High
Martis Creek	40.9	Forest, meadow, ski resort, commercial, residential, dirt roads, golf course, primary roadway, secondary roadways	High
Truckee Town Corridor	14.1	Forest, commercial, residential, primary roadways, secondary roadways, legacy sites	High
Bear Creek	5.3	Forest, ski resort, commercial, residential, secondary roadways	High
Donner/Cold Creeks	17.0	Forest, residential, commercial, dirt roads, primary roadway, secondary roadways, legacy sites	High
Trout Creek	4.9	Forest, commercial, residential, primary roadway, secondary roadways, golf courses	High
Big Chief Corridor	23.4	Forest, commercial, residential, primary roadway	High
Glenshire/Union Valley	4.1	Forest, residential, secondary roadways	Moderate
Prosser/Alder Creeks	54	Forest, residential, ski area, dirt roads, secondary roadways	Moderate
Juniper Creek	10.8	Forest, residential commercial, dirt roads, secondary roadways	Moderate

[1] Information acquired from the TRWQMP (2NDNATURE, LLC, 2008)

3.4 Regulatory Requirements

The development and implementation of the TRWQMP is guided by regulations to protect the beneficial uses defined for the Truckee River. The regulatory documents guiding the County and Town's development and implementation of the TRWQMP are summarized as follows:

- Section 13267 Lahontan Regional Water Quality Control Board Orders required the County and Town to develop a comprehensive water quality monitoring plan (LRWQCB, 2007a).
- Water Quality Control Plan for the Lahontan Region (Lahontan Basin Plan). March 31, 1995. The Lahontan Basin Plan took effect in 1995 and sets forth water quality standard for surface waters and ground waters within the Region. The Lahontan Basin Plan identifies general types of water quality problems and requires or recommends control measures for these problems. In some cases, it prohibits certain types of discharges in particular areas. The most recent amendments to the Lahontan Basin Plan were adopted in 2005 (LRWQCB, 2005).
- Total Maximum Daily Load (TMDL) for Sediment, Squaw Creek, Placer County. April 2006. The objective of the Squaw Creek TMDL is to attain sediment-related water quality objectives that focus on the protection of in-stream aquatic life. The TMDL establishes indicators for biologic health and physical habitat. Responsible entities are required by the TMDL to implement monitoring programs (LRWQCB, 2006).
- Total Maximum Daily Load for Sediment, Middle Truckee River, Placer, Nevada and Sierra Counties. May 2008. The objective of the Middle Truckee River TMDL is to attain sediment-related water quality objectives that focus on the protection of in-stream aquatic life. The TMDL establishes a water column indicator and target value as an annual 90th percentile suspended sediment concentration (SSC) of less than or equal to 25 milligrams per liter (mg/L) at Farad (USGS gauge 10346000). Additional implementation based indicators for the TMDL include road sand application BMPs and recovery tracking, ski area BMPs and maintenance, dirt road improvement or decommissioning, and legacy site BMPs and restoration. Responsible entities are required to implement these programs. The estimated time frame for meeting the numeric targets and achieving the TMDL is 20 years (LRWQCB, 2008b).
- The renewed MS4 Permit incorporates the required storm water control measures directly and requires the Permittees to submit annual reports summarizing activities and certifying compliance with all requirements. At the time of the second year Annual Report, Permittees are required to submit Program Effectiveness Assessments and Improvement Plans for their stormwater programs that include water quality monitoring data.

In addition to the development and implementation of the TRWQMP, the County and Town have developed the following programs and plans:

- Town and County Stormwater Management Programs (SWMP). These documents provide a comprehensive plan to implement their respective SWMPs for the years 2007-2012. They describe the six minimum control measures (MCMs) required by the program as well as funding, monitoring, and evaluation. The six MCMs are public education and outreach, public involvement/participation, illicit discharge detection and elimination, construction site stormwater runoff control, post-construction stormwater management, and pollution prevention (Truckee, 2007) and (Placer, 2007). Although the written SWMPs are no longer required to be updated and submitted under the renewed MS4 Permit, the elements of the stormwater program continue to be implemented and reporting on their effectiveness will be conducted per the Permit requirements.

- Martis Valley Community Plan. December 16, 2003. Prepared by Placer County. The Martis Valley Community Plan (MVCP), in combination with the Placer County General Plan, is the official statement of Placer County setting forth goals, policies, assumptions, guidelines, standards, and implementation measures that will guide the physical, social, and economic development of the Martis Valley area to at least the year 2020. The MVCP includes the goals, policies, standards, implementation programs, the Land Use Diagram, the Circulation Plan Diagram, and the Recreation and Trails Diagram which together constitute Placer County's formal policies for land use, development, and environmental quality (Pacific Municipal Consultants, 2003a).

- Martis Valley Community Plan Environmental Impact Report. The Environmental Impact Report (EIR) identified environmental resources, including water quality, which would potentially be impacted by implementing the MVCP. (Pacific Municipal Consultants, 2003b). One of the mitigations for potential water quality impacts included the development of a comprehensive water quality monitoring program by the County.

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Section 4

Data Collection and Analysis Methodologies

This section presents the data collection and analysis methodologies that were implemented during the fourth year of monitoring under the TRWQMP (WY 2013). The monitoring activities conducted during WY 2013 included:

- Community level discrete water quality sampling,
- Tributary level discrete water quality sampling,
- Stream flow monitoring, and
- Near-continuous turbidity monitoring.

The TRWQMP serves as the overarching guidance document for the implementation of this monitoring program and contains documentation of field protocols, data analysis and reporting procedures. This section provides detailed descriptions of activities performed during WY 2013 and any modifications that were made to the TRWQMP guidance.

Table 4-1 presents a summary of the types of assessments conducted by both the County and Town, the locations where monitoring was conducted, and a short description of each. The following subsections then present more detailed descriptions of the monitoring site locations and the data collection and analysis methodologies. Additional subsections are included to present the data quality objectives that have been developed for this program, the statistical analyses conducted on the various data groups and, finally, a summary of modifications that were made to the data collection and/or analysis methodologies.

Additional information regarding specific monitoring protocols, site selection, equipment installation, and equipment operation and maintenance may be found in the Sampling and Analysis Plans (SAPs) and other supporting documents listed in Section 1 of this report.

Table 4-1. WY 2013 TRWQMP Monitoring Summary

	Assessment Type	Locations	Performance Assessment Description
Placer County	Discrete Tributary	Six sites in the Martis Creek Watershed.	Collection of in-stream discrete water quality samples to characterize and track water quality in the various branches of Martis Creek.
	Discrete Community	Two sites in the Martis Creek Watershed	Collection of discrete samples of stormwater runoff to characterize and track the impacts of upstream land uses and water quality improvements.
	Stream Flow Gauging Station	Three sites in the Martis Creek Watershed.	A continuous record of stream discharge for Martis Creek to evaluate trends and develop annual pollutant load estimates.
	Near-Continuous Turbidity	Two sites in the Martis Creek Watershed.	A continuous record of stream turbidity for Martis Creek to evaluate trends, determine turbidity/suspended sediment relationships, and develop annual suspended sediment load estimates
Town of Truckee	Near-Continuous Turbidity	Two sites in the Truckee River.	A continuous record of stream turbidity for the Truckee River to evaluate trends, determine turbidity/suspended sediment relationships, and develop annual suspended sediment load estimates

4.1 Community Level Water Quality Monitoring

Two sites (DSC-MC2 and DSC-MC3) were monitored by Placer County in the Martis Creek sub-watershed, and WY 2013 was the third year that Placer County monitored these two sites. The Town of Truckee did not perform community level water quality monitoring during WY 2013. Planning and preparation activities including site selection, environmental analysis and documentation, and the development of access agreements with private landowners were conducted during the initial year (WY 2010) of TRWQMP implementation.

4.1.1 Monitoring Site Descriptions

The TRWQMP provided general locations and guidance for selecting the community level discrete sampling sites. Per this guidance, monitoring sites should represent both highly developed areas to monitor impacts of human activities, as well as minimally developed areas to provide baseline data and an understanding of realistic water quality objective goals. Potential sites were evaluated with consideration of safety and access, representativeness, permitting requirements, and ease of installation. The sites were then scored and ranked based on these criteria and recommendations were developed for the final monitoring locations. Each site is described below with general explanations on how the water quality data from the site is initially planned to be used.

- **Lahontan Golf Club (DSC-MC2)** – This site is located within the County's jurisdiction in the Martis Creek sub-watershed. It is located within the private Lahontan Golf Club community and represents stormwater runoff from multiple land uses including a golf course, single family residential homes, paved roads, foot trails, and natural forested upland areas. This community is a modern development and includes facilities that treat stormwater runoff prior to discharge.

- **Northstar (DSC-MC3) –** This site is located within the County's jurisdiction in the Martis Creek sub-watershed. It is located on public property within the Skidder Trail Right-of-Way. The site receives runoff from multiple land uses including a large ski area parking lot, a dirt road, a paved residential road, natural wooded upland areas, and residential homes. Some portions of the drainage area, such as the large parking lot for Northstar ski resort, do have some facilities that treat a portion of stormwater prior to discharge including sediment traps in the drainage inlets and a large infiltration/sedimentation basin. The residential and roadway runoff at this site does not receive treatment prior to passing the sample collection point, but does receive additional downstream treatment prior to entering West Martis Creek.

Table 4-2 presents the key characteristics of the community level monitoring sites including: station ID, locations and jurisdictions, latitude, longitude, elevations and information about the drainage area. Aerial maps showing the sampling point locations and their tributary drainage areas are presented in Figure 4-1.

Table 4-2. Discrete Monitoring Site Characteristics

	Lahontan Golf Club Outfall	Northstar Outfall
Station ID	DSC-MC2	DSC-MC3
Receiving Water	Martis Creek	West Martis Creek
County	Placer	Placer
Regional Water Board	Lahontan Region 6	Lahontan Region 6
Latitude	39° 17' 45.15" N	39° 17' 21.85" N
Longitude	120° 8' 39.93" W	120° 6' 45.07" W
Elevation (ft)	5,878	6,000
Roadway Access	Lahontan Drive	Skidder Trail
Monitoring Location	Drainage Channel	24-inch Pipe
Runoff Type	• Residential • Secondary Roadway • Forested Uplands • Golf Course and Trails	• Residential • Secondary Roadway • Forested Upland • Parking Lot • Dirt Road
Approximate Drainage Area (acres)	131	15.4
% Impervious Area	10%	20%
Installation Date	Fall 2010	Fall 2010

Source: Aerial imagery from Bing, Microsoft 2010

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Figure 4-1

Discrete Community Water Quality Sampling

Placer County Monitoring Locations

4.1.2 Field Evaluation Protocols

The community level sampling protocols include the use of passive sampling devices at stormwater drainage outfalls or other appropriate locations for the collection of discrete stormwater runoff samples (grab samples) from targeted communities. This water quality monitoring targets stormwater runoff from developed areas generated from events considered to have the highest potential for mobilizing and transporting the pollutants of concern. Examples are runoff events that occur after extended dry periods or that result in substantial increases of stormwater runoff flows at the monitoring locations. The use of passive samplers allows the collection of samples from the same part of the rising hydrograph limb during each event resulting in higher quality comparisons among sites and over time.

The monitoring team tracks weather conditions and potential storms that may produce stormwater runoff at the monitoring stations. Events are characterized by their type (snowmelt, winter rain/snow (mixed), and spring, summer or fall rain) and the number of days prior to the event without rainfall or runoff (dry antecedent conditions). The events to be monitored are selected based on the antecedent conditions and the predicted amount of precipitation, or the predicted temperature and amount of snow in the drainage area if snowmelt flows are being targeted.

To collect the samples, clean samplers and containers are installed at the monitoring sites prior to the targeted event. Runoff enters the container when the flow reaches a predetermined depth at the sampling point. When the container is full, a floating ball valve seals the bottle. After the event, the passive samplers are carefully examined to ensure the samples were collected as planned and the bottles sealed adequately to prevent contamination. After retrieving the samples, *t*he site is secured and samples are prepared for shipment to the laboratory*.*

4.1.3 Data Management and Analysis

Samples are delivered to the laboratory under chain of custody documentation to track the samples and the requested analyses. Lab analysis is performed in accordance with standardized analytical and QA/QC methods. Lab reports containing the analytical results and QA/QC documentation are then validated prior to entering into project database. Each analytical report is thoroughly reviewed and the data evaluated to determine if its data met the data quality objectives described below. Once the data has been validated, it is ready for statistical analyses, evaluation and comparisons. The results will be compared across sites and over time to identify potential pollutant sources, determine how community discharges are impacting water quality objectives and if SWMP actions are reducing pollutant discharges.

The list of laboratory analytical constituents was developed based on land uses in the upgradient catchment area, the water quality pollutants of concern for the Truckee River and the available funding. Table 4-3 lists the constituents, sample type (sample collection method), U.S. Environmental Protection Agency (EPA) analytical method, sample bottle type, target reporting limit, volume required for analysis, sample preservation, and maximum holding times. These are also the standard operating procedures for Western Environmental Testing Laboratory (WETLAB). WETLAB was the selected analytical laboratory for community stormwater samples.

Table 4-3. Analytical List for Community Level Water Quality Samples

Constituent[1]	Sample Type	EPA Method	Sample Collection Bottle Type (Nalgene Cat No)	Target Reporting Limit[2]	Volume (mL)	Preservation[3]	Holding Time
TSS	Discrete	SM 2540D	HDPE[4] (1100-1000)	1 mg/L	1000	4°C	7 days
Turbidity		180.1		0.1 NTU	50		48 hours
Ammonia		SM 4500NH3 D		0.05 mg/l	500	H_2SO_4 (added at lab)	28 days
TKN		351.2		0.05 mg/L	100	H_2SO_4 (added at lab)	28 days
NO_3-N + NO_2-N		353.2		0.01 mg/L	100	4°C	48 hours
Total Nitrogen (calculated)		--		0.07 mg/L	--		--
Total Phosphorus		365.3		0.01 mg/L	100		28 days
Dissolved Phosphorus		365.3		0.01 mg/L	100		28 days
Dissolved Ortho-Phosphate		365.3		0.01 mg/L	100		48 hours

[1] TSS = total suspended solids; NO_3-N = nitrate as nitrogen; NO_2-N = nitrite as nitrogen; TKN – total Kjeldahl nitrogen.
[2] mg/L = milligrams per liter; NTU = nephelometric turbidity units.
[3] H_2SO_4 = Sulfuric acid, °C = Celsius
[4] HDPE = High-density polyethylene

4.2 Tributary Level Water Quality Sampling

Tributary level water quality data collection and analysis activities were performed at six sites along multiple branches of Martis Creek within Placer County during WY 2013. This was the second year of data collection at these sites.

4.2.1 Monitoring Site Descriptions

The Martis Creek tributary sampling locations are sited to provide water quality information on the receiving waters in the Martis Creek watershed. The monitoring sites are located in each of the major branches of Martis Ck with the goal of identifying potential pollutant source areas and identifying and tracking water quality trends. The upstream and downstream configuration of some of these sampling locations will also be helpful to characterize any water quality changes that occur as flow travels through the Martis Valley floodplain and meadow system.

The key characteristics of the Martis Creek tributary monitoring locations are presented in Table 4-4 and the locations are shown in Figure 4-2. Figure 4-2 also includes the location of the Martis Creek stream gauging station which is discussed below in Section 4.5. Photographs of the each of the tributary monitoring sites are presented in Figure 4-3.

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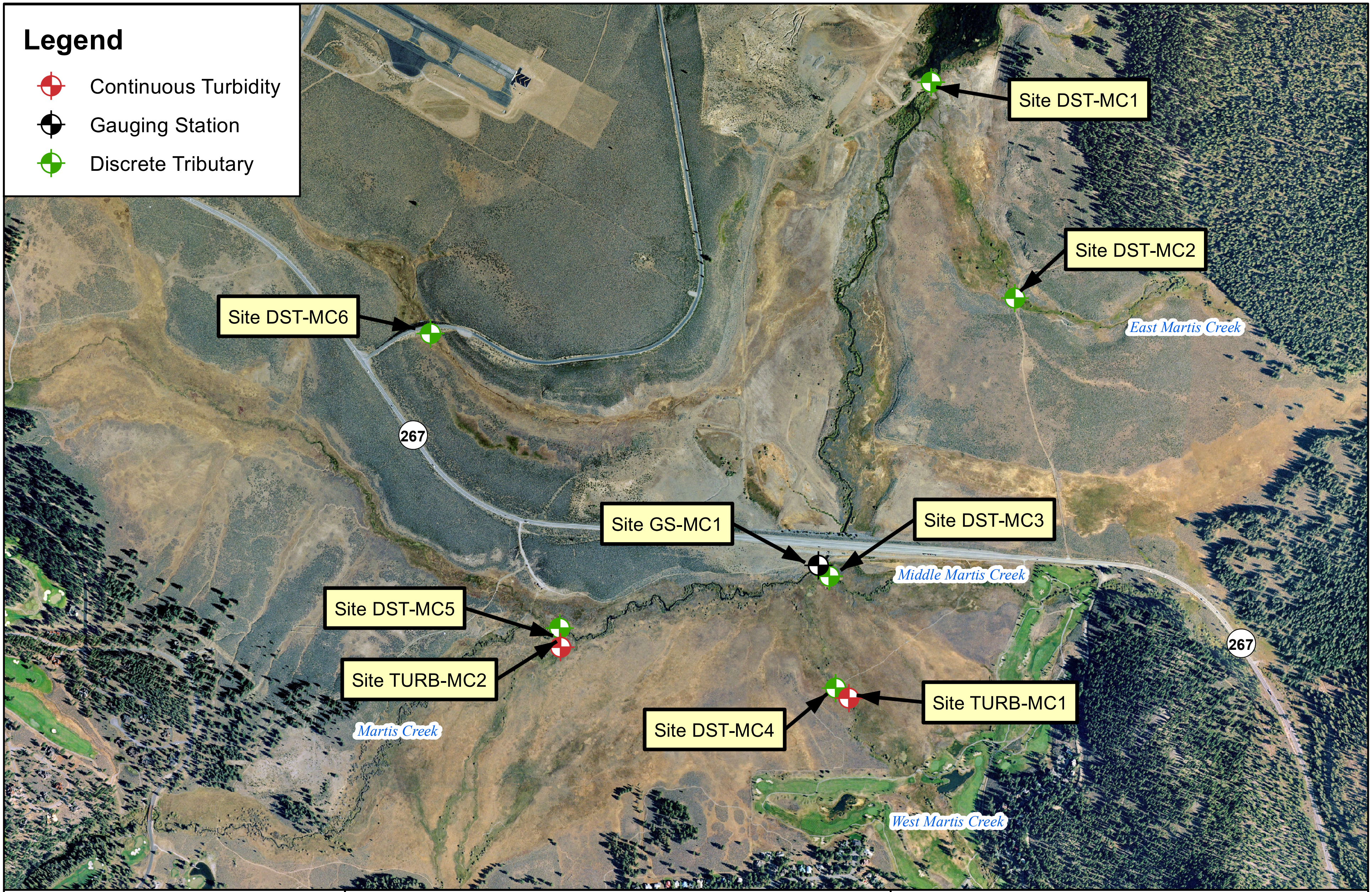
Table 4-4. Tributary Level Discrete Monitoring Site Characteristics

Water Body	Martis Creek Main Stem Outfall	East Martis Creek	Middle Martis Creek	West Martis Creek	Martis Creek Main Stem	Unnamed Martis Tributary
Station ID	DST-MC1	DST-MC2	DST-MC3	DST-MC4	DST-MC5	DST-MC6
Location Description	Mouth of creek at Martis Creek Lake	Downstream of concrete bridge	Upstream of confluence with main stem	Downstream of Northstar Golf Course	Downstream of Lahontan and Martis Camp	Downstream of Martis Ck Rd.
Latitude(1)	N 39° 18' 53.48"	N 39° 18' 32.63"	N 39° 18' 6.67"	N 39° 17' 55.67"	N 39° 18' 1.54"	N 39° 18' 30.39"
Longitude(1)	W 120° 7' 1.54"	W 120° 6' 51.70"	W 120° 6' 58.16"	W 120° 7' 14.90"	W 120° 7' 50.42"	W 120° 8' 3.71"
Elevation (ft)	5,830	5,840	5,845	5,845	5,850	5,850
Major land use descriptions in tributary watershed	Ski Area; Commercial; Single and Multi-Family Residential; Primary and Secondary Roadway; Forested Uplands; Golf Courses; Unpaved Roads and Trails	Forested Uplands; Unpaved Roads and Trails	Primary Roadway; Forested Uplands; Unpaved Roads and Trails	Ski Area; Commercial; Single and Multi-Family Residential; Secondary Roadway; Forested Uplands; Golf Course; Unpaved Roads and Trails	Ski Area; Single Family Residential; Secondary Roadway; Forested Uplands; Golf Courses; Unpaved Roads and Trails	Airport; Commercial; Secondary Roadway;
Drainage Area Size (ac)	21,900	4,550	3,000	3,200	8,800	200

[1] Coordinate System: NAD 1983 State Plane California II FIPS 0402 Feet



Source: Aerial imagery from Bing, Microsoft 2010

N W E S

0 0.125 0.25 0.5 Miles

Figure 4-2

Discrete Tributary Water Quality Sampling, Stream Gauging, and Near-Continuous Turbidity Monitoring Locations

FIGURE 4-3a. DST-MC1 monitoring location on Martis Creek near Martis Creek Lake.

FIGURE 4-3b. DST-MC2 monitoring location on East Martis Creek.

FIGURE 4-3c. Middle Martis Creek confluence. DST-MC3 monitoring location is just upstream.

FIGURE 4-3d. DST-MC4 monitoring location on West Martis Creek.

FIGURE 4-3e. DST-MC5 monitoring location is on Martis Creek just downstream of its confluence with an unnamed tributary.

FIGURE 4-3f. DST-MC6 monitoring location on unnamed tributary near Martis Creek Road.

Figure 4-3
Tributary Level Discrete Monitoring Sites

4.2.2 Field Evaluation Protocols

The TRWQMP methodology for tributary level discrete snowmelt sampling has been adapted for all tributary level sampling events. The sampling method follows USGS equal width increment (EWI) protocols for collecting depth-integrated, discharge-weighted samples from targeted flow conditions. To collect the samples, a transect is established across the stream channel and the wetted width is divided into a series of equally spaced increments. Sub-samples are collected at the center of each increment using a depth-integrated suspended sediment sampler that is lowered and raised through the water column at a constant rate. The subsample volumes produced are proportional to the amount of flow occurring in each increment and are composited into a single composite sample to be submitted to the lab.

Similar to the community level sampling, these in-stream water quality measurements focus on events when high pollutant concentrations and/or loads are expected to be present within surface waters (i.e., the worst-case scenarios). Sampling times target the rising limb of the event hydrograph and are coordinated across the project area to allow for the most direct comparisons between tributary stations. A range of runoff event types and magnitudes are typically sampled during the monitoring season.

4.2.3 Data Management and Analysis

The data management and analysis procedures for the community and tributary level water quality monitoring are generally similar although modified laboratory analytical methods are needed to detect the very low pollutant concentrations typically present in the regions natural surface waters. Table 4-5 lists the constituents, sample type, U.S. Environmental Protection Agency (EPA) analytical method, sample bottle type, target detection limit, volume required for analysis, sample preservation requirements, and maximum holding times for each constituent.

Table 4-5. Analytical List for Tributary Level Water Quality Samples

Constituent[1]	Sample Type	EPA Method	Sample Collection Bottle Type (Nalgene Cat No)	Detection Limit[2]	Volume (mL)	Preservation[3]	Holding Time to Lab
TSS	Depth integrated, discharge weighted	SM 2540	HDPE[5] (1100-1000)	1 mg/L	A total volume of 1000 mL is sufficient for all analysis	4°C	48 hours
Turbidity		180.1		0.1 NTU		4°C	48 hours
Ammonia[4]		SM 4500		50 µg/L		4°C	48 hours
NO_3-N, NO_2-N[4]		300.0		10 µg/L		4°C	48 hours
TKN		351.2		100 µg/L		4°C & H_2SO_4 (added at lab)	28 days
Total Phosphorus		365.3		10 µg/L		4°C & H_2SO_4 (added at lab)	28 days
Dissolved Phosphorus[4]		365.3		10 µg/L		4°C & H_2SO_4 (added at lab)	28 days
Dissolved Ortho-Phosphate[4]		365.3		10 µg/L		4°C	48 hours

[1] TSS = total suspended solids; NO_3-N = nitrate as nitrogen; NO_2-N = nitrite as nitrogen; TKN – total Kjeldahl nitrogen.
[2] µg/L = micrograms per liter; mg/L = milligrams per liter; NTU = nephelometric turbidity units.
[3] H_2SO_4 = Sulfuric acid, °C = Celsius
[4] Filtered immediately with a 0.45 micron nylon filter for the dissolved portions of the assay
[5] HDPE = High-density polyethylene

4.3 Martis Valley Discharge Monitoring

A stream gauging station was installed in the fall of 2010 to measure discharge in the main stem of Martis Creek below the confluences with Middle and West Martis Creek. In the fall of 2012, two additional stream gauging stations were installed; one is located within West Martis Creek and the other is located in the main stem of Martis Creek above the confluences with Middle and West Martis Creek. Together, these three gauging stations will provide more detailed information on the hydrology of the Martis Creek watershed and will be useful in developing pollutant load estimates at the monitored locations.

Station operations during WY 2013 included the collection of data for the development of stage to discharge rating curves at each site. This was the third year of data collection at the original site and the first year of monitoring at the new sites.

4.3.1 Monitoring Site Description

The locations of the Martis Valley stream gauging stations are shown in Figure 4-2. The lower Martis Creek gauging station (GS-MC1) is located approximately 150 ft upstream of the State Route 267 crossing at Frank's Fish Bridge. The West Martis Creek gauging station is located approximately 100 feet upstream of Jim's Loch Bridge and is part of the near-continuous turbidity site TURB-MC1. The upper Martis Creek gauging station is located downstream of the Lahontan and Martis Camp developments and is part of the near-continuous turbidity site TURB-MC2. Sites TURB-MC1 and TURB-MC2 are located adjacent to the tributary level monitoring sites DST-MC4 and DST-MC5, respectively.

4.3.2 Installation and Operation

Installation activities performed in 2010 and 2012 included surveying channel cross-sections and longitudinal profile, establishment of a local benchmark, and installation of a staff gauge and pressure transducer.

Type A staff plates were installed in the stream channel to allow visual depth measurements by field personnel from the bank and confirmation of automated stage measurements by the pressure transducers. A vented *In-Situ Level Troll 500* pressure transducer was installed at site GS-MC1 and *Instrumentation Northwest, Inc. PS9805* pressure transducers with Campbell Scientific dataloggers were installed at sites TURB-MC1 and TURB-MC2. The pressure transducers were programmed to measure and log 15-minute average stage data at the measurement locations. The pressure transducers are securely mounted to the same posts as the staff gauges with the cable installed in conduit leading to an accessible location on the bank. The conduits are perforated along the bottom 2 feet and anchored to the bank by stakes and rocks. Photographs of the three gauging stations are provided in Figure 4-4.

FIGURE 4-4a. GS-MC1 monitoring location on lower Martis Creek.

FIGURE 4-4b. TURB-MC1 monitoring location on West Martis Creek.

FIGURE 4-4c. TURB-MC2 monitoring location on Upper Martis Creek.

Figure 4-4
Staff Gauges at the Martis Valley Gauging Stations

Prior to installation, pressure transducers were factory calibrated and tested. Sensor calibration continued during operation by recording water levels at the time of each visit as well as the height of any observed high-water marks deposited since the last visit. These measurements were compared and the electronic record was adjusted, as necessary.

Field staff made routine visits to each gauging station during WY 2013. During periods of rain or peak snowmelt, site visits were made more frequently. Activities during site visits consisted of manual flow and stage measurements, observation of recent high-water marks (if visible), downloading data, inspecting the probes, and replacing datalogger batteries and desiccant as necessary. In the event that any component was malfunctioning (i.e., pressure transducer), it was repaired or replaced as soon as possible.

4.3.3 Development of Discharge Rating Curves

Stage to discharge rating curves were developed during WY 2013. To develop the rating curves, velocity measurements were obtained using a *Swoffer 2100* current velocity meter at various stream stages. Velocity measurements were collected using the 0.6 depth methodology outlined in the USGS Measurement and Computation of Streamflow Manual (USGS, 1982). Velocity measurements were collected at equal intervals along a transect to account for varying flow conditions across the stream channel. Flow was then calculated for each interval by multiplying the measured velocity by the cross-sectional area of that interval. The summation of all incremental flow rates was used to obtain the stream discharge at the time the measurements were taken.

A best fit curve was developed for the stage and discharge data and the results were used to calculate continuous discharge using the logged stage data from the pressure transducers at each site.

During rating curve development, an effort was made to obtain velocity data at a range of stages including upper and lower extremes. This limits extrapolation requirements to stages that were very high where velocity measurements could not be safely collected.

4.3.4 Data Management and Analysis

After downloading the stage data from the pressure transducer, it is reviewed for any anomalies or data gaps and then imported into a spreadsheet to calculate the discharge. The data is checked against manual stage measurements and any unusual conditions observed in the field to confirm the quality of data and make adjustments if deemed necessary. Precipitation data is also reviewed and compared to stream discharge to help define the runoff response times used to guide the timing of the tributary water quality sampling.

Data anomalies are typically associated with channel scour, fill, and/or ice. Channel scour and fill are common in alluvial streambeds and can result in an inaccurate stage-discharge rating. These inaccuracies are typically addressed using ‘stage-shifts’ or adjustments in stage to match manual measurements of discharge. Stage shifts have been applied to the records of discharge where necessary.

Similarly, ice can commonly affect stage. When ice forms, the stream cross-section generally becomes constricted, causing backwater, which results in a higher stage than would exist during ice-free periods under the same discharge conditions. Because the amount of backwater will vary significantly more complex procedures involving meteorological and hydrological data from other stations in the area are required to estimate discharge at ice-affected stations (USGS, 1996). These procedures are applied during review of data. Periods of estimated discharge for ice-affected stations are indicated where applied.

Once a preliminary record of discharge is reviewed and corrected for the anomalies described above, daily, monthly and annual hydrologic metrics are computed. These include daily maximum, mean, and minimum discharges (cubic feet per second, cfs), monthly and annual maximum, mean, and minimum discharge (cfs), total-annual discharge volume (cfs-days; acre-feet), and annual peak instantaneous-discharge (cfs).

One of the main purposes of collecting the stream discharge data is to provide a means of estimating pollutant loads carried by Martis Creek and its major tributaries. Using the discharge data and the water quality data collected at the tributary discrete monitoring locations, annual load estimates are calculated using the following equation:

Annual Load = Total Annual Discharge x Mean Annual Pollutant Concentration

This method for load calculation is most appropriate for normally distributed data and may not account for extreme variability in water quality. This approach is being refined based on the results of near-continuous turbidity monitoring which is described in the following section.

4.4 Near-Continuous Turbidity Monitoring

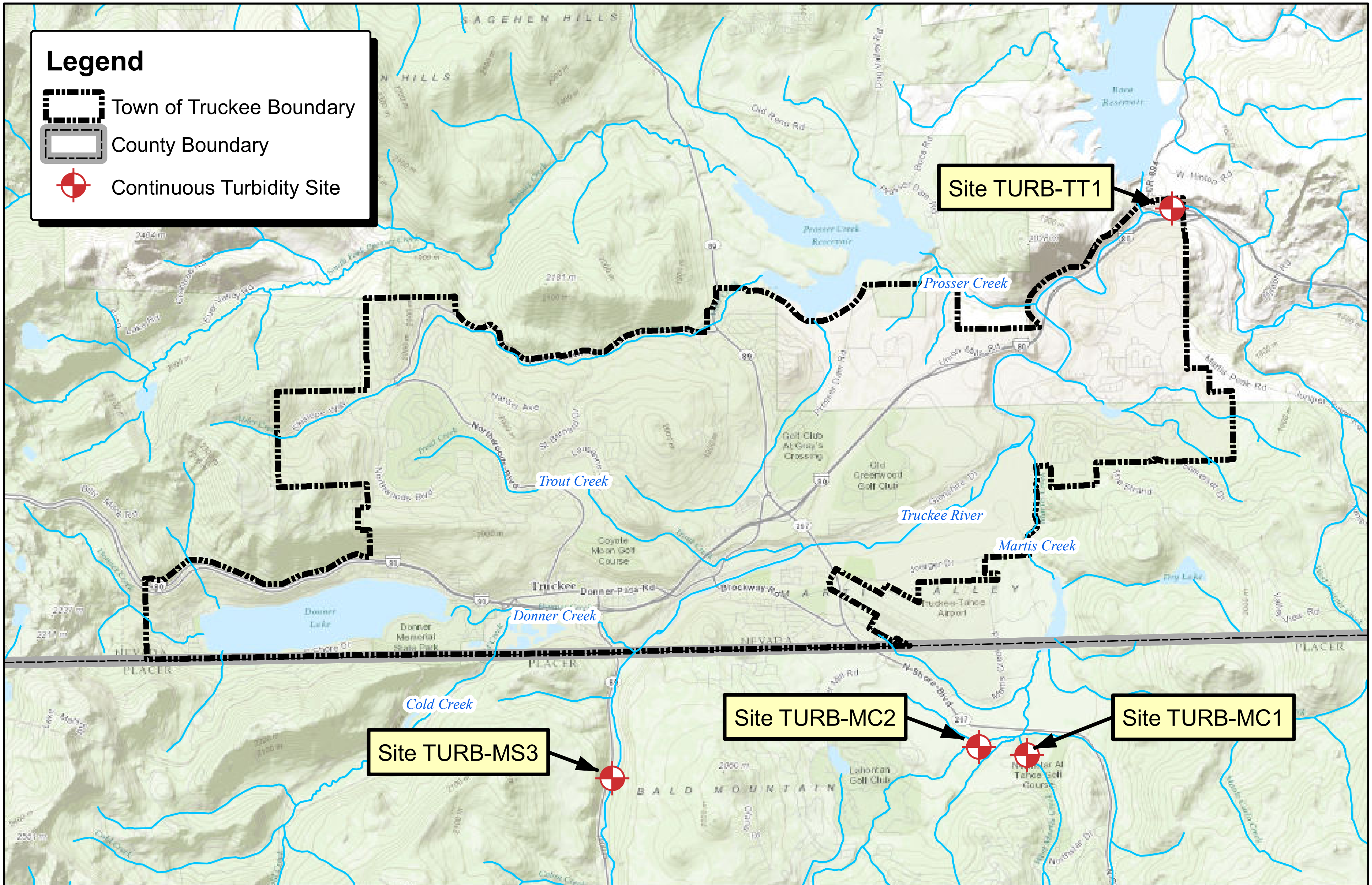
Near-continuous turbidity monitoring stations were installed in the Truckee River in January, 2013 and the Martis Creek watershed in September, 2012. These monitoring sites provide a continuous record of stream turbidity which can be used to estimate suspended sediment loading. This is being conducted in an effort to understand suspended sediment loading from tributaries in the Middle Truckee River Basin and along the Truckee River Corridor as outlined in the TRWQMP and for evaluation of the Middle Truckee River TMDL for Sediment.

Station operations during WY 2013 included the collection of data for the development of turbidity to TSS and turbidity to discharge rating curves at each site. This was the first year of data collection at these sites.

4.4.1 Monitoring Site Description

The locations of the near-continuous turbidity stations are shown in Figures 4-2 and 4-5. Two stations were installed in the Truckee River; one is located in the Truckee River above Truckee near the Granite Flat campground (site TURB-MS3), and the other is located downstream of Truckee at the Boca Reservoir bridge (site TURB-TT1). These two sites are in the same location as USGS stream gauging stations that provide a continuous record of steam discharge.

Two additional near-continuous turbidity monitoring stations were installed in the Martis Creek watershed. One is located within West Martis Creek approximately 100 feet upstream of Jim's Loch Bridge and is identified as site TURB-MC1. The other is located in upper Martis Creek downstream of the Lahontan and Martis Camp developments and is identified as site TURB-MC2. Sites TURB-MC1 and TURB-MC2 are co-located with the tributary level monitoring sites DST-MC4 and DST-MC5, respectively.



Source: Topographic Map from Esri, 2013

CDM Smith

Figure 4-5

Near-Continuous Turbidity Monitoring Locations

4.4.2 Installation and Operation

Turbidity is measured using Optical Back-Scatter (OBS 3+) submersible turbidity probes with a range of up to 4,000 nephelometric turbidity units (NTUs). The OBS 3+ turbidity probes are connected to a Campbell Scientific datalogger which operate on a solar-powered 12-volt battery contained within a locked, water-resistant and sealed, hard-case enclosure. Turbidity sensors were either factory calibrated or calibrated prior to installation using laboratory standards covering the range of anticipated turbidity levels. Data are collected every 15-minutes together with measurements of stream stage. The stations are visited weekly and the probes are inspected and cleaned of algae, ice or debris. The dataloggers are downloaded monthly.

4.4.3 Fluvial Sediment Measurements

Suspended sediment samples are collected at the turbidity stations to provide a means for developing a turbidity:suspended sediment correlation and estimating suspended sediment loads using the continuous turbidity measurements. Suspended-sediment consists primarily of fine sand, silt, and clay supported by turbulence within the water column and transported at a rate approaching the mean velocity of flow. Bedload sediment, material which rolls along the streambed, is not sampled or analyzed for this study.

4.4.3.1 Suspended-Sediment Sampling Equipment

Suspended sediment samples are collected using standard equipment and methods adopted by the Federal Interagency Sedimentation Project (FISP) to make measurements of suspended-sediment transport. This equipment includes a hand-held DH-48 suspended-sediment sampler with a 1/4-inch nozzle for use when flows were wadeable, and a bridge board with a D-95 suspended-sediment sampler for sampling high (unwadeable) flows from the Boca Reservoir bridge.

4.4.3.2 Suspended-Sediment Sampling and Analysis

Suspended-sediment samples were collected at channel locations exhibiting the most ideal characteristics (i.e., relatively straight and uniform) for the flow event sampled, but always in close proximity to the gauging station. The sampling method follows USGS equal width increment (EWI) protocols for collecting depth-integrated, discharge-weighted samples from targeted flow conditions. To collect the samples, a transect is established across the stream channel and the wetted width is divided into a series of equally spaced increments. Sub-samples are collected at the center of each increment using a depth-integrated suspended sediment sampler that is lowered and raised through the water column at a constant rate. The subsample volumes produced are proportional to the amount of flow occurring in each increment and are composited into a single composite sample to be submitted to the lab. Following this protocol avoids the confounding effects of significant changes in sediment transport rates in different locations in the channel and in different discharges.

Each sample is transferred to a clean 500 milliliter (mL) or 1,000 mL high-density polyethylene (HDPE) bottle and transported to WETLAB in Sparks, Nevada for analysis of total suspended solids (TSS) using EPA method 160.2 (gravimetric method).

McGraw and others (2001) evaluated the relationship between TSS and suspended-sediment concentration (SSC) at monitoring sites in the Middle Truckee River watershed, and found a nearly one-to-one relationship between the two parameters, suggesting that both TSS and SSC are reliable for calculating suspended sediment loads. For the remainder of this report, the term SSC is used when referring to suspended-sediment concentrations of samples collected and analyzed for TSS for this study.

4.4.4 Data Management and Analysis

This section describes the two methods used in this study to calculate annual records of suspended-sediment load: 1) using site-specific, discharge-to-suspended-sediment load relationships, herein referred to as the "discharge-based method"; and 2) using the relationship between the turbidity and SSC, herein referred to as the "turbidity-based method."

Based on calculations of suspended-sediment loads from both methods, results are presented as daily and annual loads (i.e., tons per day or tons). In an effort to make comparisons between tributaries of different contributing watershed areas, results are also presented as suspended-sediment yields (i.e., tons per square mile).

4.4.4.1 Discharge-Based Method for Calculating Suspended-Sediment Load

To calculate suspended-sediment loads using the discharge-based method, suspended-sediment samples collected in the field are correlated with instantaneous discharge at the time of sampling, either from concurrent manual measurements or from the near-continuous record. Samples are analyzed at the laboratory for SSC, then the results are converted to suspended-sediment loads by multiplying the concentration (mg/L) by the instantaneous discharge (cfs) and applying a factor of 0.0027 to convert the units into tons/day. This approach allows suspended-sediment loading data to be plotted against instantaneous discharge data to develop a relationship using best-fit, empirical equations (typically a power function). The resulting relationship is then applied to the (15-minute) record of discharge to compute a 15-minute record of suspended-sediment load.

The error associated with discharge-based suspended-sediment rating curves is generally assumed to have an inherent uncertainty of at least 25 to 50 percent (Walling, 1977, MacDonald and others, 1991). Significant scatter in rates of suspended sediment loads can produce results differing by an order of magnitude at any given discharge. In order to address this variation and error in sediment load computations, potential temporal patterns in the data were evaluated. Data were separated by event type (e.g., snowmelt runoff, rain-on-snow, thunderstorm, or first flush) and position on the storm hydrograph (e.g., rising limb vs. falling limb). Where differences were observed, separate relationships (equations) were developed, and separate power functions were applied to the record. Since ongoing sampling efforts may help define and extend the existing rating curves and improve their accuracy, the data presented in this report should be considered provisional and subject to revision when additional data become available.

4.4.4.2 Turbidity-Based Method for Calculating Suspended-Sediment Load

Measurement of instantaneous turbidity at the time of suspended-sediment sample collection typically results in a definable relationship that can be applied to the 15-minute record of turbidity to compute a 15-minute record of SSC. The continuous record of turbidity can then be converted into a 15-minute record of suspended-sediment concentration (mg/L per 15 min.) and, through application of the discharge record, converted into a daily suspended-sediment load (tons/day). Because turbidity can fluctuate independent of discharge variations, continuous turbidity monitoring can help identify discrete events not related to rainfall or snowmelt runoff, such as bank failures or dam releases, and has been found to explain at least 80 percent of the temporal variation in suspended sediment concentration (MacDonald and others, 1991).

There are several factors that can complicate collection and interpretation of continuous-logging turbidity data: a) algal growth on the optical sensor; b) ice or debris collecting on the probe; c) sedimentation of the probe; and/or d) probe exposure above the water column (unsubmerged) due to extreme low-flows. To reduce the chances of these conditions and to minimize instrument error, field teams made frequent site visits to evaluate site conditions and instrument integrity. If data appeared to be erroneous in any way, individual data points were manually adjusted based on observations in the field.

4.5 Data Quality Objectives

Data quality objectives (DQOs) for the program were developed to establish acceptable measures of quality for monitoring data and increase its defensibility. The DQOs developed for this project include specifications for field sampling and analytical procedures and performance criteria for laboratory analytical work. The DQOs are applied to all data collection activities and analyses conducted under the implementation of the TRWQMP.

For water quality sampling activities, field precision was determined through the collection of field triplicates and the calculation of the average percent error. Laboratory accuracy was evaluated by reviewing Matrix Spike/Matrix Spike Duplicate (MS/MSD) and Laboratory Control Spike (LCS) recoveries. Laboratory precision was evaluated by reviewing MSD and laboratory sample duplicate relative percent differences (RPDs). Field QA/QC samples were analyzed for the same analytical suite as the water quality samples collected at the respective site. Laboratory performance control limit criteria for precision and accuracy is provided in the TRWQMP and presented below in Table 4-6.

Table 4-6. Control Limits for Precision and Accuracy for Water Samples

Constituent[1]	EPA Method	Accuracy	Precision	Recovery
TSS	SM 2540D[2], 160.2[3]	70-130% recovery	Replicates within +/- 10%	70-130%
Turbidity	180.1			
Ammonia	SM 4500NH3 D[2], 350.1[3]	Standard Reference Materials (SRM, CRM) within 95% of CI stated by provider of material.	Laboratory control sample; Blind field triplicate; Replicates within +/- 20%	Matrix spike 80-120 % or control limits +/- 3 standard deviations based on actual lab data.
NO_3-N + NO_2-N	353.2[2], 353.1[3]			
TKN	351.2			
Total Phosphorous	365.3			
Dissolved Phosphorous	365.3			
Dissolved Orthophosphate	365.3[2], SM 4500-PE[3]			

[1] TSS = total suspended solids; NO_3-N = nitrate as nitrogen; NO_2-N = nitrite as nitrogen; TKN – total Kjeldahl nitrogen.
[2] WETLAB EPA Test Method
[3] High Sierra Lab EPA Test Method

4.6 Statistical Analyses

Statistical testing is conducted to further characterize the data sets and determine whether various groups of data exhibit significant differences or trends. In cases where results are inconclusive, power analyses can be conducted to estimate the sample size (number of total measurements) required to discern a statistical difference. Statistical testing was performed to compare data from the community level and tributary level water quality monitoring assessment types. This section describes the statistical methodology that was applied for the standard water quality results (TSS, turbidity, total phosphorus, and total nitrogen). Statistical analyses were not conducted on discharge and suspended-sediment relationships; these data were evaluated independently and a best "eye-fit" approach was applied.

To compare water quality results, a test was performed of the statistical hypotheses that the two data groups exhibit significant differences. Basic statistics (mean, standard deviation, coefficient of variation, median) were calculated for each group included in a given test. Additional statistical analyses included:

- Shapiro-Wilk and Lilliefors Normality Tests, including probability plots, to determine the data distribution;
- t-Tests to compare two data sets or to compare a data set to a regulatory standard;
- Power Analysis to determine whether additional samples are needed to discern a statistically significant difference in two data sets,
- Mann-Kendall Trend Tests to determine whether concentrations are significantly increasing or decreasing over time.

A statistical spreadsheet workbook was developed for these analyses and is provided, along with the relevant output files, in Appendix A.

4.6.1 Normality Tests

Normality tests were conducted to formally test whether the grouped data sets are normally distributed. Several different types of normality test methods are available. For this study, the method known as the Lilliefors test was used primarily. The Lilliefors test is evaluated by examining a probability value, known as a p-value, which indicates the probability of obtaining the particular Lilliefors statistic given that the data represent random samples from a normally distributed population. The Lilliefors normality test results are used to confirm the results derived from the graphical displays (box plots and parallel probability plots). In addition to the Lilliefors test, results from another normality test method, known as the Shapiro-Wilk method, were also examined. Generally, the Shapiro-Wilk method tends to be more sensitive to a few extreme values (possible outliers) than the Lilliefors method. Thus, if a data set passed the Lilliefors test but did not pass the Shapiro-Wilk test, this indicated that the data set contained extreme values but is otherwise normally distributed. This served as a flag to further evaluate whether the extreme values are statistical outliers.

4.6.2 t-Tests

Data comparison t-tests were conducted to test the null hypothesis that the mean difference (Delta) is equal to zero against the alternative that it is either less than or greater than zero, i.e., a two-sided test. To account for non-detects or left-censored data, the mean differences and their standard deviations are calculated on paired difference intervals using the maximum likelihood estimation (MLE) method. From the mean and standard deviation, a t-statistic and a critical t-value are determined. The critical t-value is determined from the corresponding value of the noncentral t-distribution using the effect size (mean divided by the standard deviation) as the noncentrality parameter. From the t-statistic and effect size, a p-value is calculated, which is compared to a critical value (α) of 0.05, i.e., a p-value less than or equal to 0.05 is indicative of a significant difference at the 95 percent confidence level. From the p-value, the power of the test is also calculated to allow subsequent estimation of the sample size (number of additional data measurements) that will be required to obtain a significant difference given the current mean and standard deviation. For sample size estimation purposes, a critical power of 0.80 is assumed. The t-test procedure is conducted on the original untransformed data (Delta), the natural log transformed data (LnDelta), and the ranked data (RkDelta). The appropriate results used to evaluate the particular data set are based on the normality test results. For example, if the differences are determined to be normally distributed, then the data t-test results conducted on the untransformed data are used. The comparison test conducted on the ranked data is essentially a censored data equivalent of the nonparametric Wilcoxon rank test.

4.6.3 Power Analysis

The power analysis was performed for those data groups exhibiting a difference that was not declared statistically significant (i.e. the p-value was greater than 0.05). A power analysis was conducted in order to estimate the sample size (amount of additional data) required to establish a statistically significant difference for the comparison tests, given the assumption that group means and standard deviations, and distributional shapes, would remain the same (at current values) following subsequent collection of the additional data. For power analysis purposes, a Type II error rate (ß) of 0.20 was used, i.e., power (1- ß) = 0.80. Basically, the amount of additional data required was determined by incrementing the number of samples in each group until a power of 0.80 was attained.

4.6.4 Trend Analysis

Trends in analytical concentrations over time were evaluated visually using time-series plots and formally using the Mann-Kendall test method. The Mann-Kendall test is a nonparametric method that looks at each data point in chronological order and compares the point to all the previous data, noting if the data point has increased or decreased. The test counts the number of increases and decreases. A p-value is calculated which is then compared to critical value (α) of 0.1, i.e., a p-value less than or equal to 0.1 is indicative of a significant trend at the 90 percent confidence level. If the p-value was greater than 0.1 but less than 0.2, the observed trend was acknowledged to be either "Slightly Increasing" or "Slightly Decreasing."

4.7 Monitoring Modifications

The methodologies presented in Section 4 were developed using guidance provided in the TRWQMP, and are consistent with the protocols and methods described in the Sampling and Analysis Plans prepared for Placer County and the Town of Truckee. WY 2013 modifications to the monitoring approaches are documented in the SAPs and summarized below:

- **Community Level Water Quality Sampling** – No changes were made to the community level water quality sampling during WY 2013.
- **Tributary Level Water Quality Sampling** – No changes were made to the tributary level water quality sampling during WY 2013.
- **Stream Gauging Stations** – Velocity measurements were continued at site GS-MC1 during WY 2013 to support the development of a revised rating curve due to the establishment of a beaver dam that continues to influence the stream stage.

- **Near-Continuous Turbidity Monitoring** – The Martis Creek turbidity monitoring stations were installed at the same locations as the tributary level discrete water quality sampling sites. They also act as gauging stations to collect Martis Creek discharge data for use in developing pollutant load estimates. The Truckee River monitoring stations were installed adjacent to USGS stream gauging stations which eliminated the need to establish and operate new stream gauges at these locations.

Section 5

Water Year 2013 Monitoring Results

This section presents the results of the first four years of TRWQMP implementation activities with a focus on monitoring conducted during WY 2013. This included community and tributary level discrete water quality sampling, stream gauging and near-continuous turbidity monitoring. Pollutant load evaluations for the Martis Creek and Truckee River watersheds are also presented.

5.1 Community Level Water Quality Monitoring

This section describes the community level runoff events that were monitored by Placer County at the two locations in the Martis Creek watershed and then presents the water quality data, statistical analyses and QA/QC documentation.

5.1.1 Monitored Events

During WY 2013, discrete stormwater runoff samples were collected from the two County sites described in Section 4. WY 2013 was the third year of sampling at these two sites, and eight separate runoff events were monitored between November, 2012 and September, 2013. Seven samples were collected at the Lahontan site (DSC-MC2) and eight samples were collected at the Northstar site (DSC-MC3. A summary of all monitored runoff events at these two sites from WY 2011 through WY 2013 are presented in Table 5-1. Included in Table 5-1 are the event date, event type, antecedent dry time, and total precipitation.

Table 5-1 documents the variation in the monitored event characteristics which can affect the water quality of the runoff. For example, the antecedent dry time is the period without measurable precipitation prior to each monitored event. Longer dry antecedent periods allow more pollutants to accumulate and wash off with stormwater runoff. Precipitation type, depth, intensity and duration also strongly influence pollutant concentrations in stormwater runoff. For example, large rain on snow events can mobilize large amounts of sediment due to erosion and increased deicer and abrasives applications on roadways. Collecting and analyzing samples from events with varying characteristics produces a stronger dataset that is more representative of stormwater quality.

Table 5-1. 2011 - 2013 Water Years Community Level Water Quality Monitoring Event Summary

Event Date	Event Type[1]	Antecedent Dry Time (Days)	Total Precip (inches)	County Lahontan (DSC-MC2)	County Northstar (DSC-MC3)
Water Year 2011					
12/14/2010	M	7	1.3	X	X
12/18/2010	M	2	3	X	X
1/17/2011	S	4	NA	X	
3/2/2011	M	4	0.3	X	
3/10/2011	M	3	0.2	X	
3/14/2011	S	0	NA	X	X
3/31/2011	S	4	NA	X	X
4/17/2011	M	4	0.1		X
5/25/2011	R	6	0.8	X	
6/6/2011	M	2	0.5		X
Water Year 2012					
10/5/2011	R	21	0.75		X
1/20/2012	M	23	1.8	X	
1/25/2012	S	2	NA	X	
3/5/2012	S	4	NA	X	
3/13/2012	M	7	0.5	X	
3/16/2012	M	0	1.8	X	X
3/21/2012	S	3	NA	X	X
3/28/2012	M	1	0.8	X	
4/26/2012	R	11	0.8	X	X
8/14/2012	R	23	0.8		X
Water Year 2013					
11/17/2012	M	9	0.8	X	X
11/28/2012	R	10	0.8	X	X
11/30/2012	M	1	3.2	X	X
12/5/2012	R	1	0.8	X	X
3/20/2013	M	14	0.5	X	X
3/31/2013	M	11	0.25	X	X
5/8/2013	R	1	0.3	X	X
9/21/2013	R	54	0.5		X
			Total	**23**	**19**

[1] M = Mixed Snow/Rain; R = Rain; S = Snowmelt; X = Sample Collected

5.1.2 Water Quality Results

Tables containing the complete analytical results for all community level water quality monitoring conducted to date are presented in Appendix B. The results for TSS, turbidity, total nitrogen, and total phosphorus are also presented graphically in Figures 5-1, 5-2, 5-3, and 5-4, respectively. These figures present a single data point for each sample collected at sites DSC-MC2 and DSC-MC3 over a three year period (WY 2011 – WY 2013). The data are color coded according to event type to allow visual comparison of results from rain, mixed, and snowmelt events.

The figures indicate that samples from the Northstar site (DSC-MC3) tend to have much higher levels of TSS and turbidity than samples from the Lahontan site (DSC-MC2). Samples from the Northstar site also have higher mean concentrations of total nitrogen and total phosphorus, but these differences are not as large. Mixed rain/snow events tended to produce the highest pollutant concentrations at the Lahontan site, while rain events tended to produce the highest pollutant concentrations at the Northstar site. Concentrations from snowmelt events are usually lower, but fewer snowmelt events have been sampled due to their typically lower runoff volumes.

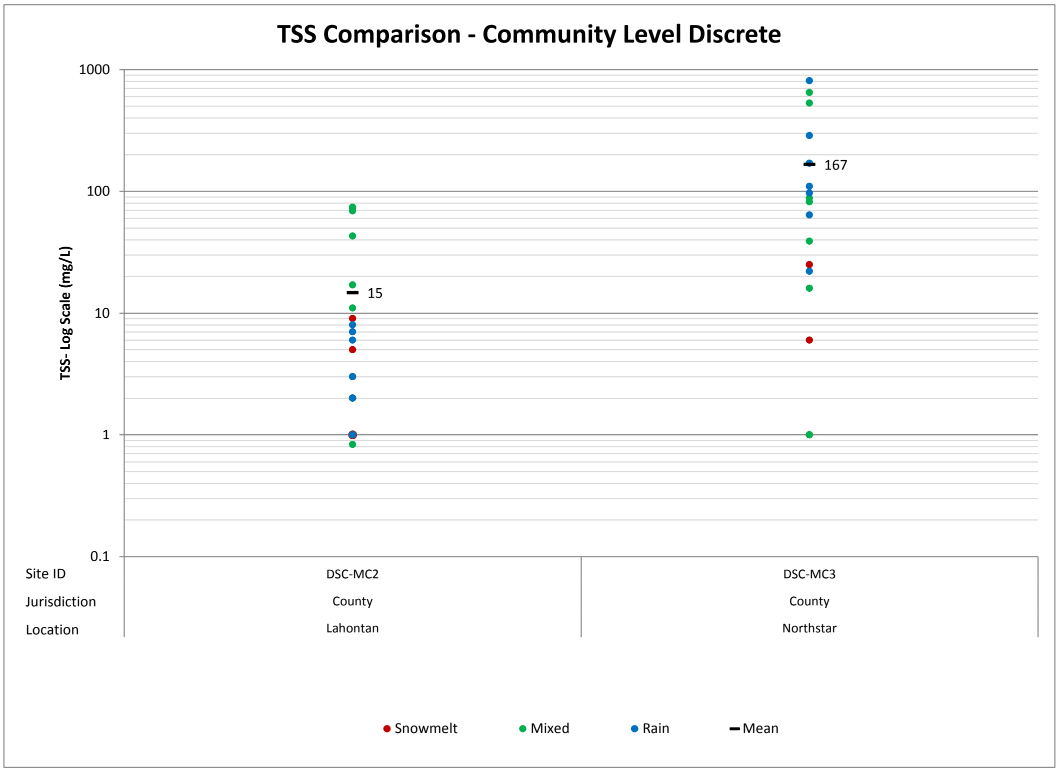


Figure 5-1
Site Comparisons – TSS

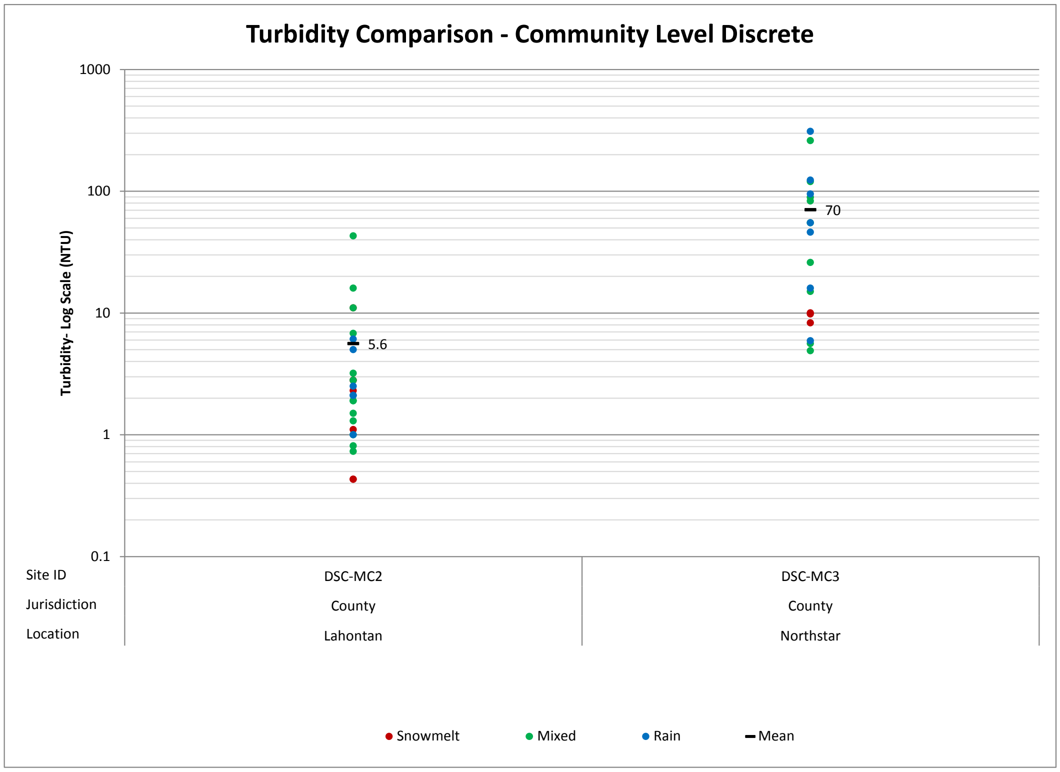


Figure 5-2
Site Comparisons – Turbidity

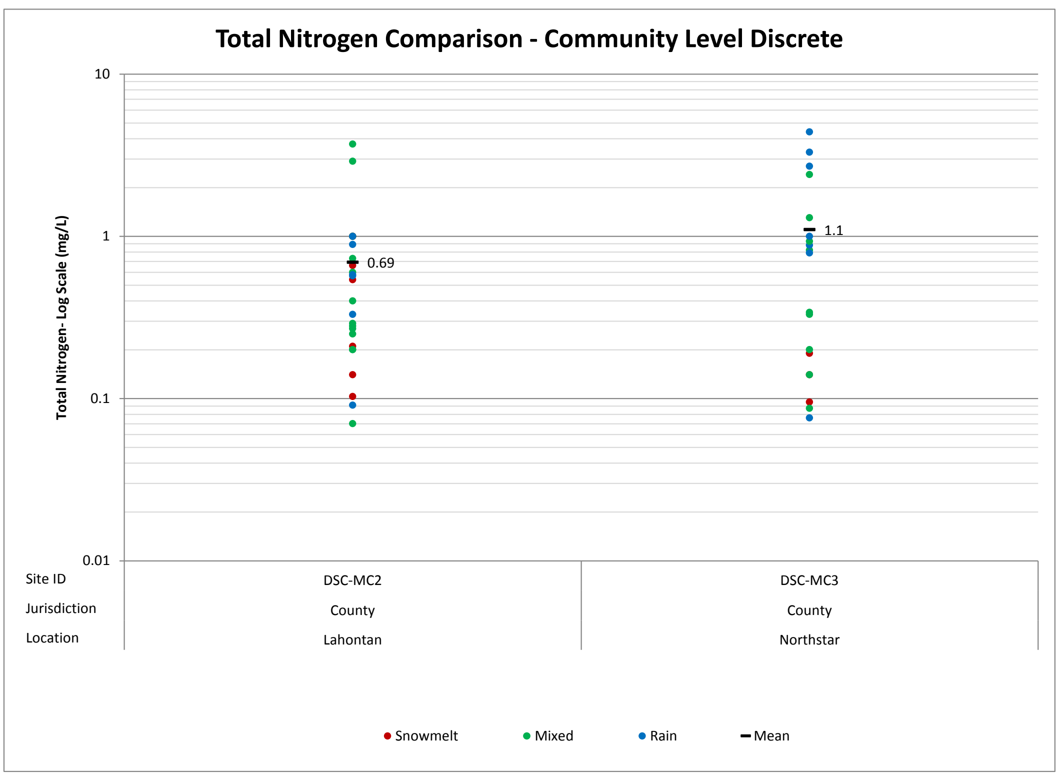


Figure 5-3
Site Comparisons – Total Nitrogen

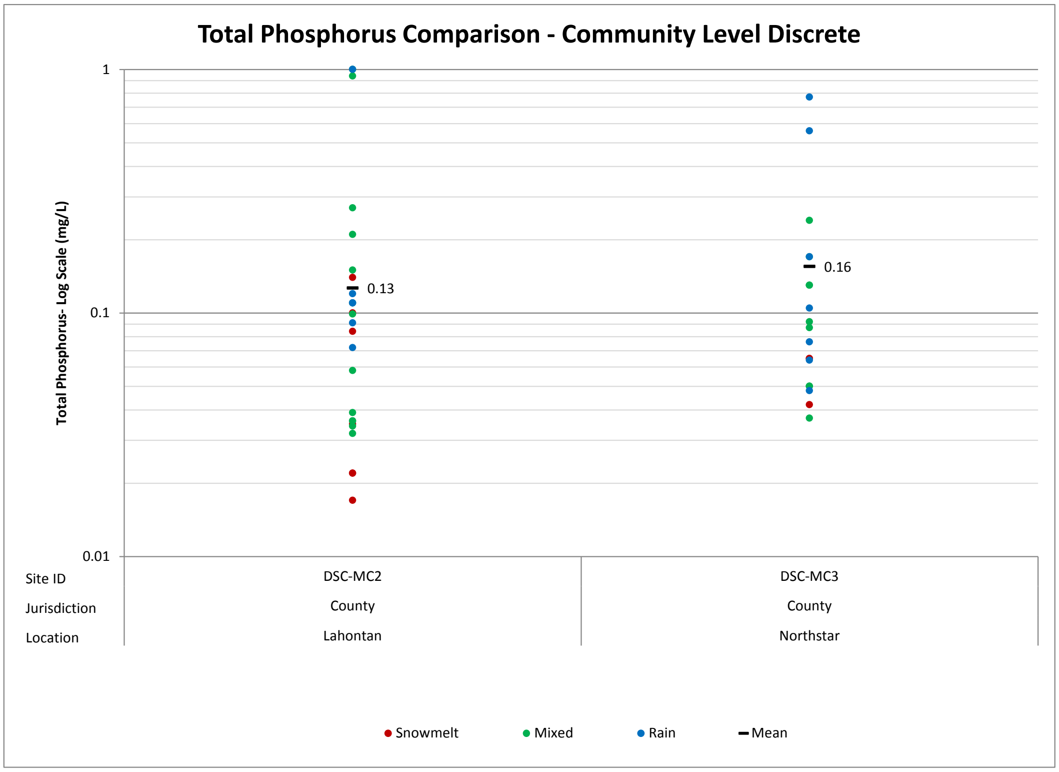


Figure 5-4
Site Comparisons – Total Phosphorus

5.1.3 Statistical Analyses

A series of statistical analyses were performed to further evaluate the community level monitoring results. These included the calculation of summary level statistics, t-tests at the 95 percent confidence level, and Mann-Kendall trend analyses.

5.1.3.1 Summary Statistics

Summary level statistics were generated to characterize and summarize the data set for each site and are presented below in Tables 5-2 and 5-3. The summary statistics tables include: the number of samples, percent of samples with detected pollutant concentrations, minimum, maximum, mean and median concentrations, the standard deviation and the coefficient of variation (CV).

An evaluation of the summary statistics shows that nitrogen species (nitrate, nitrite, ammonia and TKN) had the highest number of non-detectable concentrations. Samples with non-detectable concentrations of TSS and dissolved orthophosphate were also collected at both sites. The coefficients of variation (CVs) are high at both sites indicating large variability in the data as expected for stormwater runoff.

Table 5-2. Lahontan Golf Club Community Level Summary Statistics (Site DSC-MC2)

Constituent	Units	n	Percent Detection	Range		Mean	Median	Standard Deviation	CV
				Min	Max				
Total Suspended Solids	mg/L	23	83%	0.83	74	15	3.0	24	1.7
Turbidity	NTU	23	100%	0.43	43	5.6	2.5	9.0	1.6
Nitrate as N	mg/L	20	75%	0.01	2.2	0.22	0.090	0.48	2.2
Nitrite as N	mg/L	20	15%	0.01	0.05	0.005	0.010	0.012	2.5
Ammonia as N	mg/L	23	22%	0.05	0.08	0.039	0.05	0.02	0.42
Total Kjeldahl Nitrogen (TKN)	mg/L	23	87%	0.05	3.7	0.49	0.28	0.74	1.5
Total Nitrogen as N	mg/L	23	87%	0.07	3.7	0.69	0.40	0.89	1.3
Dissolved Phosphorus as P	mg/L	23	100%	0.01	0.96	0.10	0.038	0.20	2.0
Dissolved Orthophosphate as P	mg/L	23	91%	0.01	1.1	0.092	0.028	0.23	2.5
Total Phosphorus as P	mg/L	23	100%	0.02	0.94	0.13	0.091	0.19	1.5

Notes:
mg/L =milligrams per liter, NTU = nephelometric turbidity units.
n = Number of samples
Total Nitrogen is the sum of nitrite (as N), nitrate (as N) and total Kjeldahl nitrogen
NC = Not calculated; insufficient number of detections to generate statistics
The robust regression on order statistical (ROS) method was used for datasets containing detectable concentrations
Percent Detection = percent of samples that were detected above the reporting limit
CV = coefficient of variation

Table 5-3. Northstar Community Level Summary Statistics (Site DSC-MC3)

Constituent	Units	n	Percent Detection	Range		Mean	Median	Standard Deviation	CV
				Min	Max				
Total Suspended Solids	mg/L	19	95%	1.00	810	167	82	237	1.4
Turbidity	NTU	19	100%	4.90	310	70	46	86	1.2
Nitrate as N	mg/L	16	69%	0.01	0.81	0.10	0.021	0.21	2.2
Nitrite as N	mg/L	16	31%	0.01	0.09	0.014	0.010	0.025	1.7
Ammonia as N	mg/L	19	32%	0.05	0.24	0.072	0.050	0.068	0.95
Total Kjeldahl Nitrogen (TKN)	mg/L	19	95%	0.10	3.6	0.97	0.77	1.0	1.1
Total Nitrogen as N	mg/L	19	95%	0.10	4.4	1.1	0.79	1.2	1.1
Dissolved Phosphorus as P	mg/L	19	100%	0.01	0.47	0.084	0.040	0.13	1.5
Dissolved Orthophosphate as P	mg/L	19	84%	0.01	0.58	0.084	0.030	0.15	1.8
Total Phosphorus as P	mg/L	19	100%	0.04	0.77	0.16	0.087	0.19	1.2

Notes:
mg/L =milligrams per liter, NTU = nephelometric turbidity units.
n = Number of samples
Total Nitrogen is the sum of nitrite (as N), nitrate (as N) and total Kjeldahl nitrogen
NC = Not calculated; insufficient number of detections to generate statistics
The robust regression on order statistical (ROS) method was used for datasets containing detectable concentrations
Percent Detection = percent of samples that were detected above the reporting limit
CV = coefficient of variation

5.1.3.2 Statistical Comparisons

Statistical comparisons (t-tests at the 95 percent confidence level and Mann-Kendall trend analyses) were conducted on select data groups to determine whether observed spatial or temporal differences in water quality were significant. The results of the individual t-tests and trend analyses are included in Appendix A, and are summarized in Table 5-4.

The statistical analyses allowed for the following conclusions to be made:

- The results of the t-tests indicate that samples collected at the Northstar site (DSC-MC3) had significantly higher mean concentrations than samples from the Lahontan site (DSC-MC2) for TSS and turbidity at the 95 percent confidence level. Mean concentrations of total nitrogen, total phosphorus, and dissolved phosphorus were similar between the two sites and no statistical difference can be discerned at this time. The results of a power analysis indicated that at least 47 additional samples would be required to discern a statistical difference between these two sites for these parameters.

- The results of the trend analyses indicate increasing concentrations of total nitrogen at both sites and increasing concentrations of total phosphorus and dissolved phosphorus at the Lahontan site. These results are sensitive to the more extreme values in this limited dataset and are not clearly indicative of changes/activities in the watersheds. As the program continues, these tests will become more reliable in determining if long-term trends exist. If long-term trends are identified, correlations between these results and changes to the conditions or management in the watersheds can be investigated.

Table 5-4. Statistical Trends of Constituents of Concern at Community Monitoring Sites[1]

	TSS	Turbidity	Total Nitrogen	Total Phosphorus	Diss. Phosphorus
Lahontan DSC-MC2 Mean	15	5.6	0.69	0.13	0.10
Northstar DSC-MC3 Mean	167	70	1.1	0.16	0.08
t-test Statistical Difference	Yes	Yes	No	No	No
Power Analysis Additional Samples[2]	0	0	47	64	>300
DSC-MC2 Trend Analysis	None	None	Slightly Increasing	Slightly Increasing	Slightly Increasing
DSC-MC3 Trend Analysis	None	None	Increasing	None	None

[1] See Appendix A for detailed results. Mean concentrations are reported in mg/L with the exception of turbidity which is presented in NTU.

[2] Estimated number of additional samples required to discern a statistically significant difference.

5.1.4 Community Level Discussion

WY 2013 was the third year of data collection at the Lahontan and Northstar community level water quality monitoring sites. The three year dataset is considered to be sufficient for the characterization of the water quality at each site. To put these results into a regional context, the event mean concentrations (EMCs) that were developed for the Lake Tahoe TMDL (LRWQCB and NDEP, 2008) for TSS, total nitrogen, and total phosphorus for various land use categories are provided in Table 5-5. This comparison shows that concentrations at the Lahontan site are much lower than the Tahoe TMDL values. The TSS concentrations at the Northstar site are higher than the Tahoe TMDL values, while the total nitrogen and total phosphorus concentrations are lower.

Table 5-5. Tahoe TMDL Event Mean Concentrations

Land Use Category	TSS (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
Vegetation/Turf	12	4.88	1.50
Single Family Residential	56	1.75	0.47
Multi-Family Residential	150	2.84	0.59
Commercial/Institutional/ Communications/Utilities	296	2.47	0.70
Primary Roads	952	3.92	1.98
Secondary Roads	150	2.84	0.59

Lahontan Golf Club (DSC-MC2)

Three years of data at this site indicate it has low mean values for TSS, turbidity, total phosphorus, dissolved phosphorus, and total nitrogen. The drainage area consists of modern development that includes a golf course and residential area with minimal impervious area. This community also includes facilities that treat stormwater runoff prior to discharge including a long vegetated channel. The sampling location is within a drainage channel that experiences a large amount of continuous baseflow in the winter and spring as shown in Figure 5-5. The baseflow appears to be very clean, and likely dilutes the stormwater runoff that is sampled. In the summer and fall when no baseflow exists, runoff tends to infiltrate prior to reaching the sampling location unless the event is very large (Figure 5-6).

Figure 5-5
Baseflow at the Lahontan Site on March 14, 2012

Unusually high nutrient concentrations were observed during one large event on January 20, 2012 when no baseflow existed. This could be attributed to the amount of decaying vegetation that existed in the channel at this time (Figure 5-6) or possibly from fertilizer applications on the upstream golf course.

Figure 5-6
Dry Conditions at the Lahontan Site on January 18, 2012

Northstar (DSC-MC3)

The site receives runoff from multiple land uses including a large ski area parking lot, a dirt road, a paved residential road, natural wooded upland areas, and residential homes. The large parking lot incorporates sediment traps in the drainage inlets and a large infiltration/ sedimentation basin which is shown in Figure 5-7. This basin must fill completely before runoff from the parking lots is conveyed downstream to the sample location. During large events, runoff is conveyed down a steep hill where erosion has been observed as shown in Figure 5-8. The runoff then travels along an unpaved road where loose soil is present prior to being conveyed in an earthen channel that leads to the sample location. Groundwater seepage occurs in the earthen channel during the winter and spring which dilutes the stormwater runoff being sampled. The residential and roadway runoff at the Northstar site does not receive treatment prior to reaching the sample collection point.

The results from this site are highly variable depending on runoff event characteristics. The highest pollutant concentrations were observed during high intensity rain events such as the thunderstorm event that was sampled on August 14, 2012. During such events, the upstream infiltration basin fills completely and discharges down the steep hillside, and high flow rates occur on the shoulder of a residential street (Skidder Trail) as shown in Figure 5-9. This results in soil erosion and elevated pollutant concentrations.

Figure 5-7
Infiltration/Sedimentation Basin at Northstar Parking Lots

Figure 5-8
Erosion Downstream of Infiltration/Sedimentation Basin

Figure 5-9
High Flow Rates at Northstar Site during Thunderstorm on August 14, 2012

5.1.5 QA/QC Results

Upon receipt from the laboratory, each analytical report was thoroughly reviewed and the data evaluated to determine if the data met the study objectives. Initially, the data were screened for the following major items:

- A 100 percent check between electronic data provided by the laboratory and the hard copy reports;
- Conformity check between the chain-of-custody forms, compositing protocol, and laboratory reports;
- A check for laboratory data report completeness; and,
- A check for typographical errors on the laboratory reports.

After performing the aforementioned data screening, the laboratory was notified of any deficiencies, if any, detailing the problems encountered during the initial screening process.

Following the initial screening, a more complete QA/QC review was performed, which included an evaluation of method holding times, method blank contamination, and accuracy and precision. Accuracy was evaluated by reviewing MS, MSD, and LCS recoveries; precision was evaluated by reviewing field duplicate, spike duplicate and laboratory sample duplicate RPDs.

Data quality assessment was based upon review of holding times, laboratory blanks, laboratory control samples, laboratory duplicates, matrix spikes and matrix spike duplicates, reporting limits, and field duplicates. Based on the data review, none of the constituent results were rejected. Appendix C provides the detailed descriptions of specific items that were evaluated during the QA/QC review process and data that were qualified as estimated due to QC exceedences.

5.2 Tributary Level Discrete Water Quality Monitoring

In this section the results of the WY 2013 tributary level water quality monitoring are presented including a description of the monitored events, water quality results, statistical analysis results, and a discussion of the QA/QC Results. Data and results from the two previous years of monitoring are also presented and discussed relative to the current year's data.

5.2.1 Monitored Events

During WY 2013, tributary level discrete samples were collected from all six of the monitoring locations described in Section 4. A summary of the events that were successfully monitored during WY 2013 is presented in Table 5-6. An effort was made to collect the tributary samples during the rising limb of an event, when possible, to provide data for "worst-case-scenarios." Figures 5-10 thru 5-18 illustrate when the samples were collected in relation to stream stage at the Martis Creek gauging station (Station GS-MC1). These figures show that eight of the nine events were sampled during the rising limb or near the peak stage of the runoff event. One event (April 26, 2013) was collected during a lower flow, spring snowmelt event.

Table 5-6. 2011 - 2013 Water Years Tributary Level Water Quality Monitoring Event Summary[1]

Event Date	Event Type[1]	Antecedent Dry Time (Days)	Total Precip (inches)
2011 Water Year			
12/14/2010	M	6	1.6
12/18/2010	M	1	2
3/15/2011	M	4	1.3
4/1/2011	S	6	NA
5/5/2011	S	10	NA
6/6/2011	M	1	1.5
6/29/2011	R	20	0.4
2012 Water Year			
1/21/2012	M	23	1.8
3/14/2012	M	7	0.7
3/16/2012	M	1	2.1
3/21/2012	S	3	NA
4/20/2012	S	7	NA
4/23/2012	S	10	NA
4/26/2012	R	11	0.9
2013 Water Year			
11/17/2012	M	9	0.8
11/30/2012	M	1	3.2
12/5/2012	R	1	0.8
12/17/2012	M	1	0.5
3/13/2013	S	7	NA
3/20/2013	M	14	0.5
3/31/2013	M	11	0.25
4/26/2013	S	11	NA
5/7/2013	R	0	0.4

[1] M = Mixed Snow/Rain, R = Rain, S = Snowmelt.
NA = not applicable

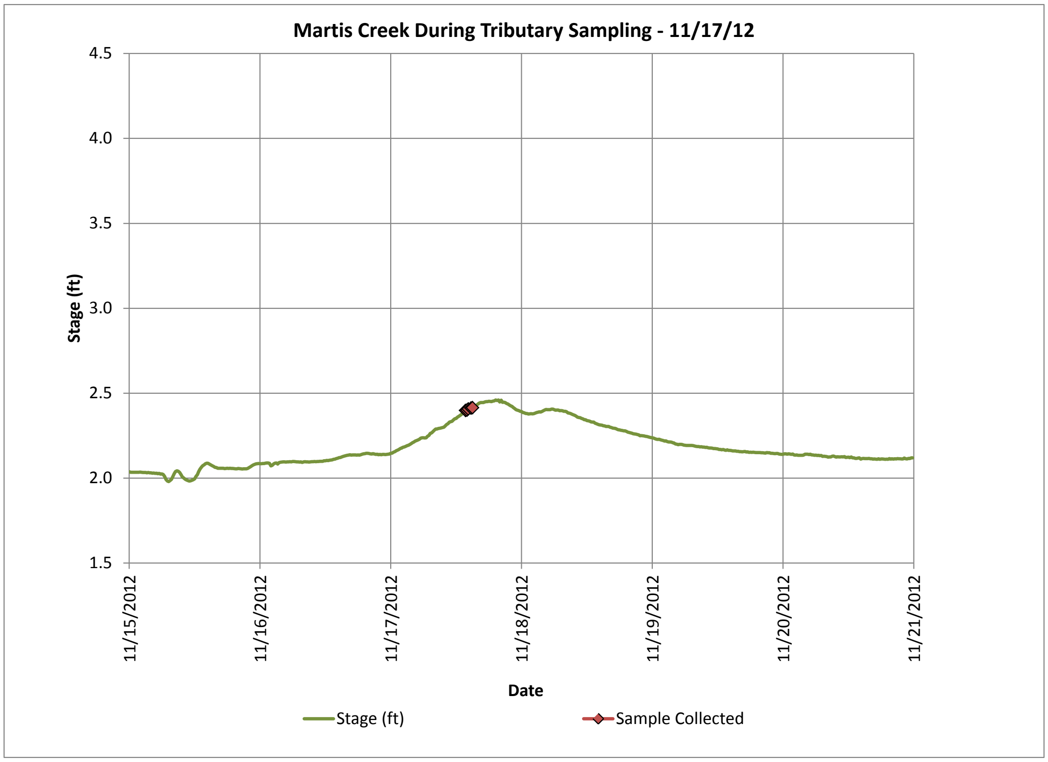


Figure 5-10
Tributary Event 11/17/13

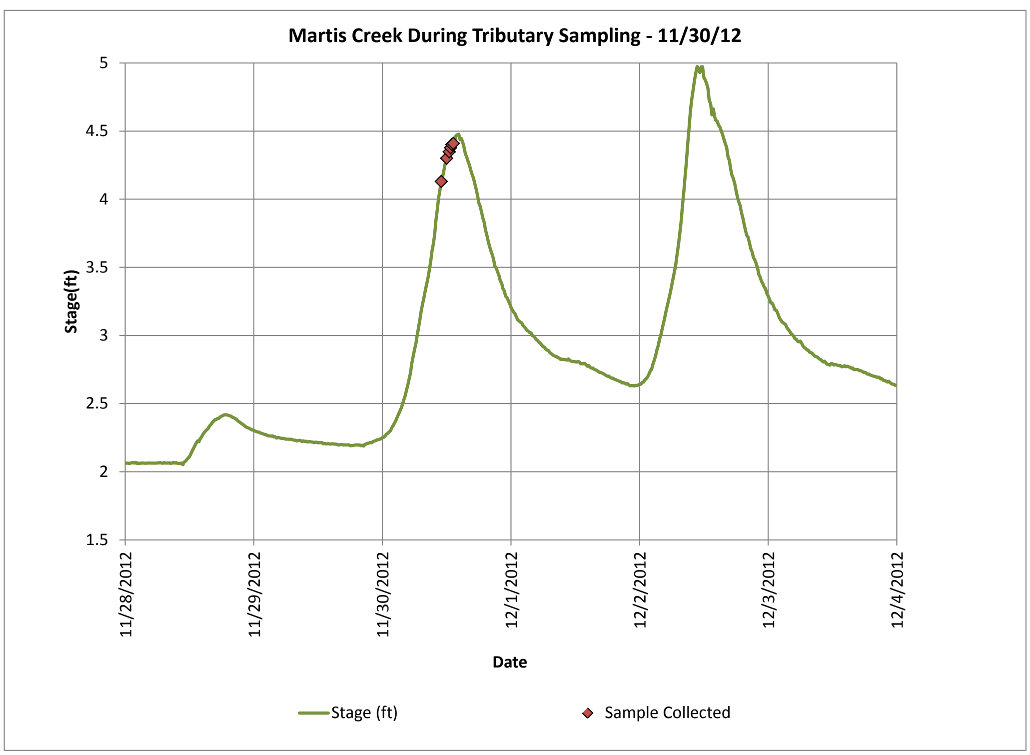


Figure 5-11
Tributary Event 11/30/13

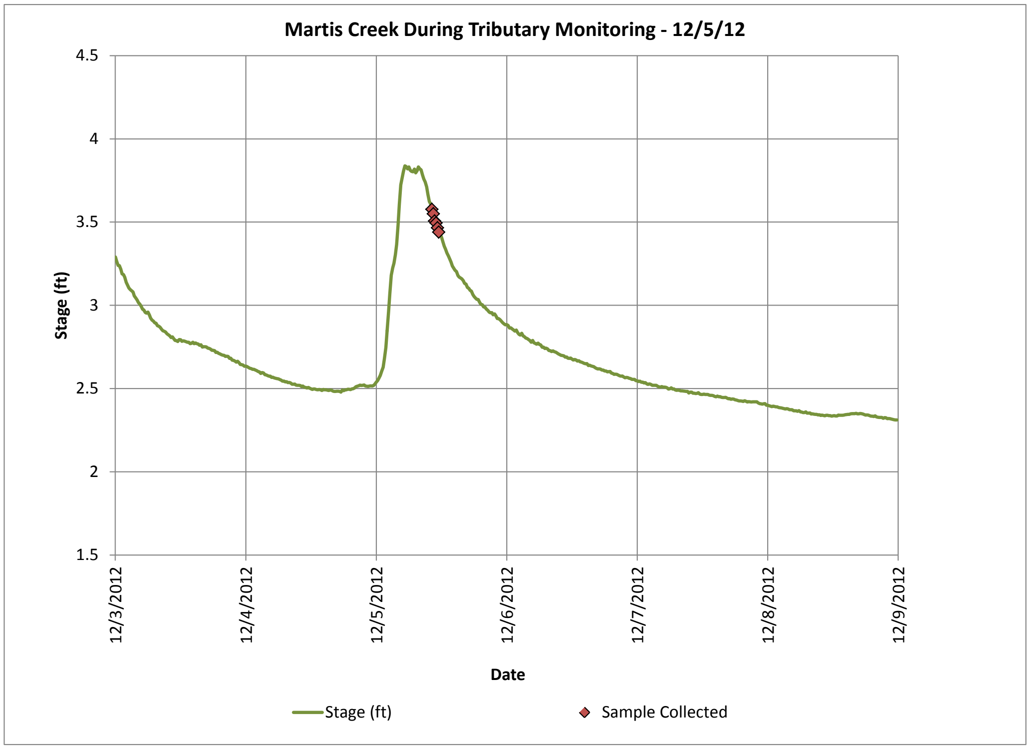


Figure 5-12
Tributary Event 12/5/13

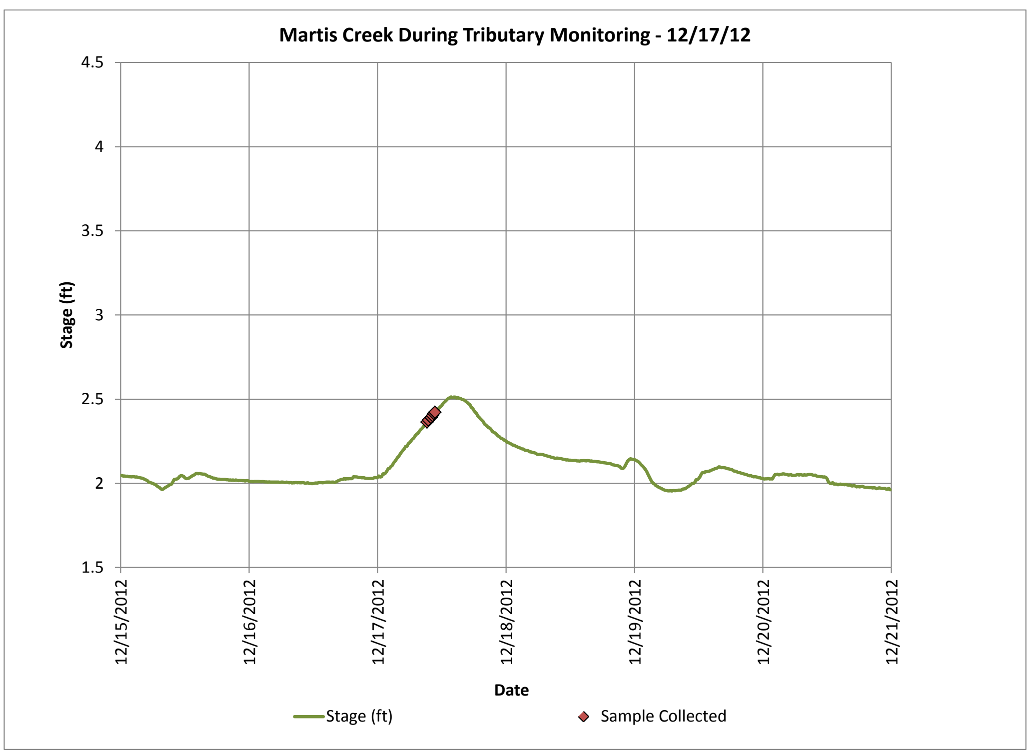


Figure 5-13
Tributary Event 12/17/13

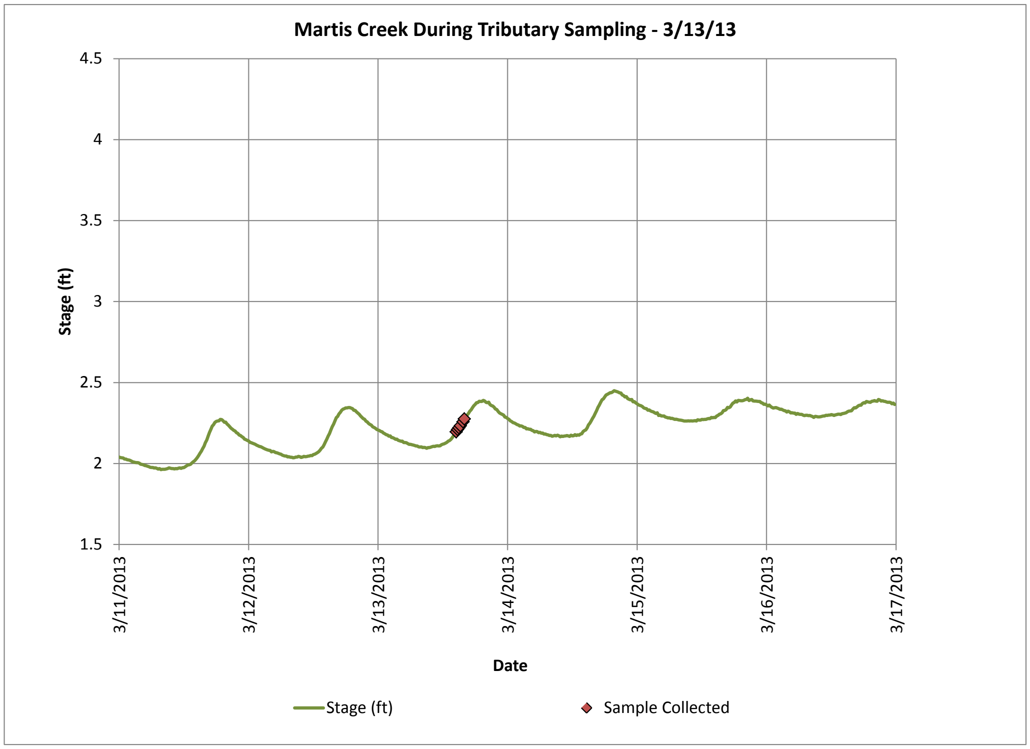


Figure 5-14
Tributary Event 3/13/13

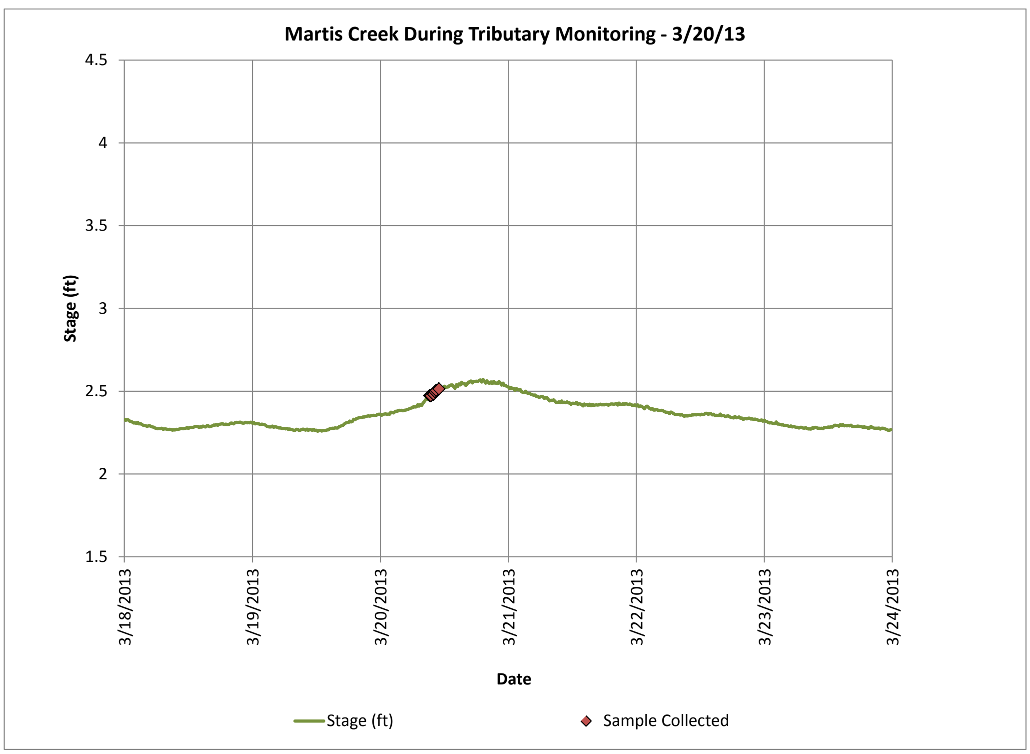


Figure 5-15
Tributary Event 3/20/13

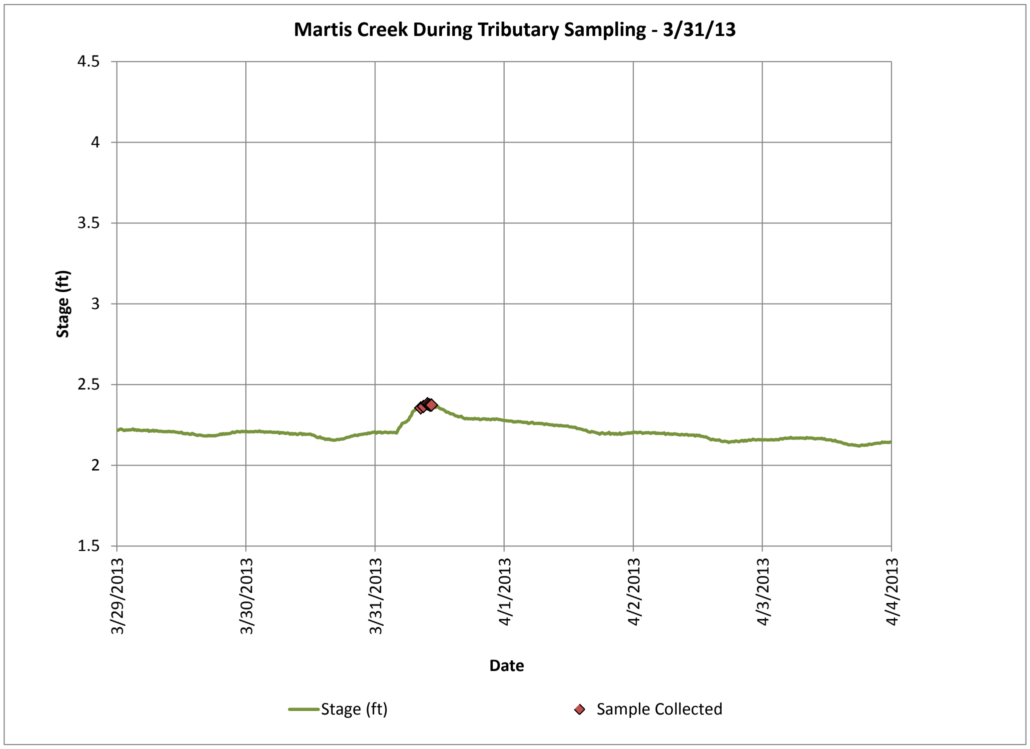


Figure 5-16
Tributary Event 3/13/13

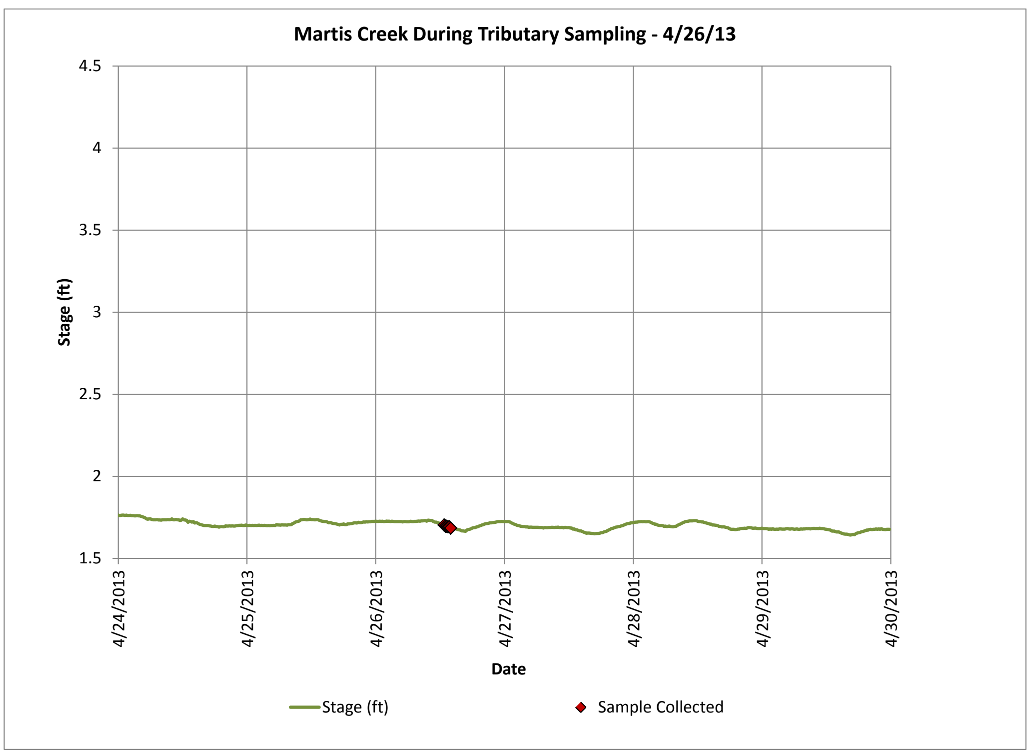


Figure 5-17
Tributary Event 4/26/2013

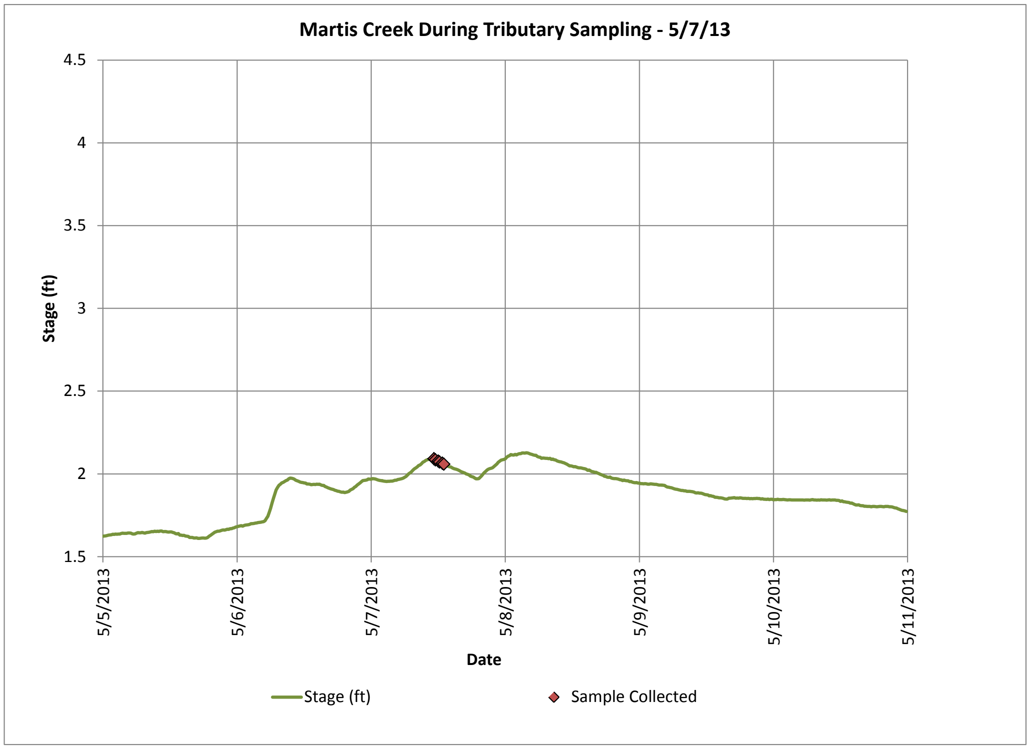


Figure 5-18
Tributary Event 5/7/13

5.2.2 Water Quality Results

The results for TSS, turbidity, total nitrogen, and total phosphorus are presented graphically in Figures 5-19, 5-20, 5-21, and 5-22, respectively. The figures show that the differences in mean concentrations are relatively small and no sites had consistently higher or lower mean concentrations. A review of Figures 5-10 through 5-18 indicates the largest increase in stream discharge occurred during the November 30th, 2012 storm event. This was a large mixed rain/snow event that represented the largest storm that occurred during WY 2013. As expected, pollutant concentrations were elevated during this event relative to the other smaller monitored events. This event had a steep increase in stream discharge, little to no snowpack in much of the tributary watershed, a large amount of precipitation (3.2 inches), and a short period of dry antecedent conditions (1 day). The complete analytical results for the tributary level water quality monitoring are presented in Appendix B.

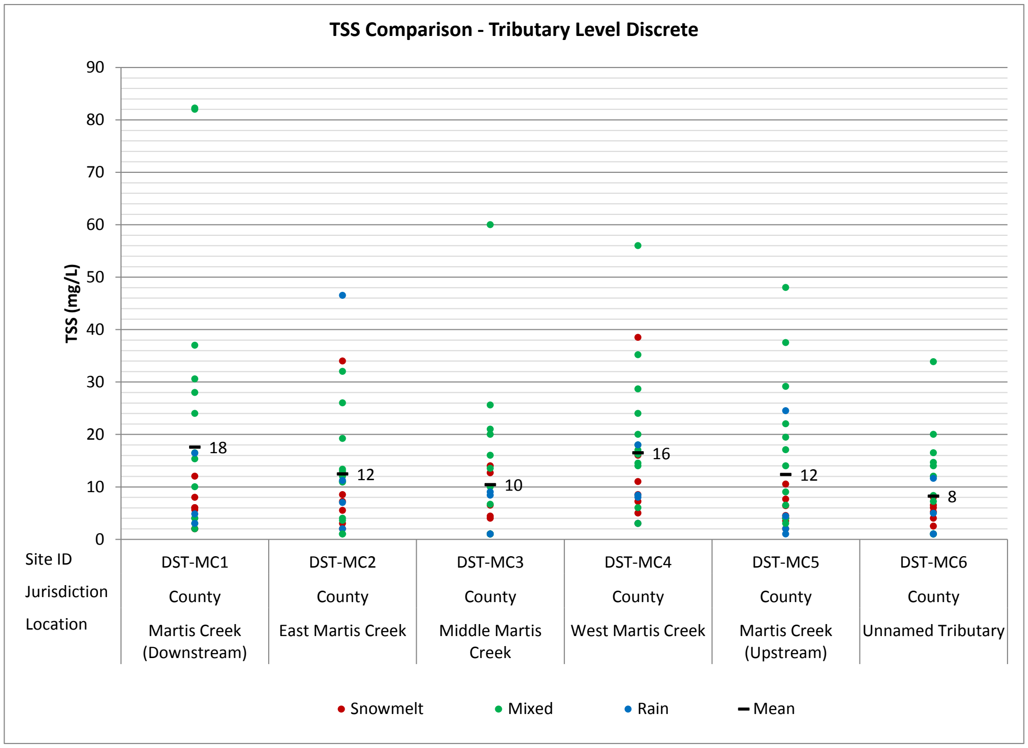


Figure 5-19
Tributary Site Comparisons – TSS

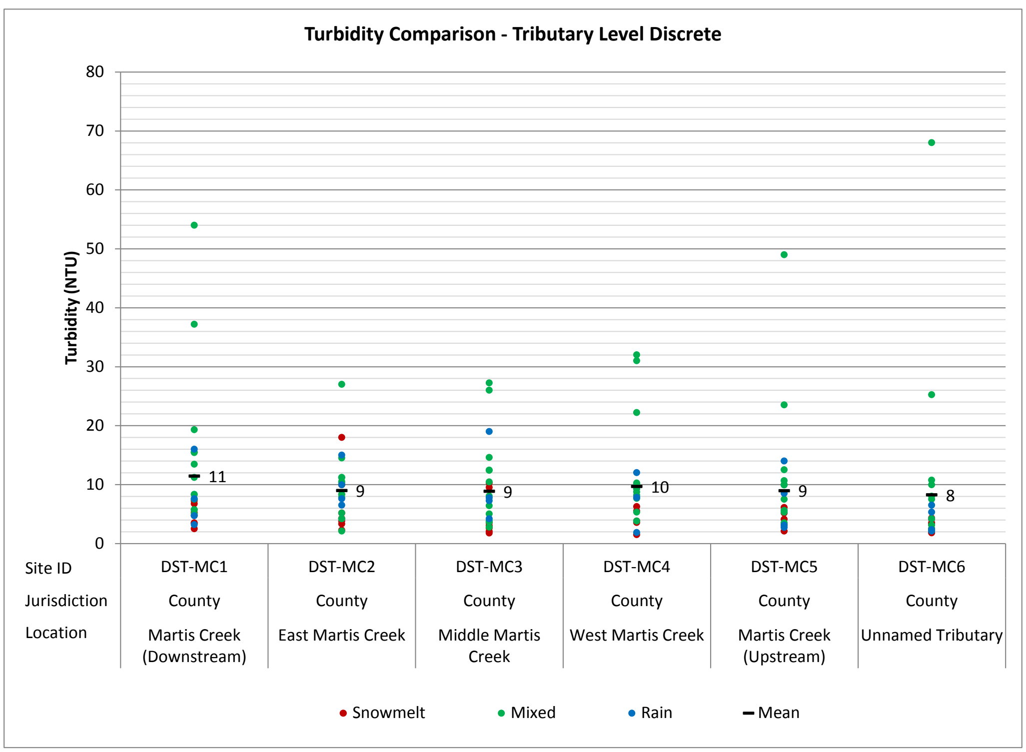


Figure 5-20
Tributary Site Comparisons – Turbidity

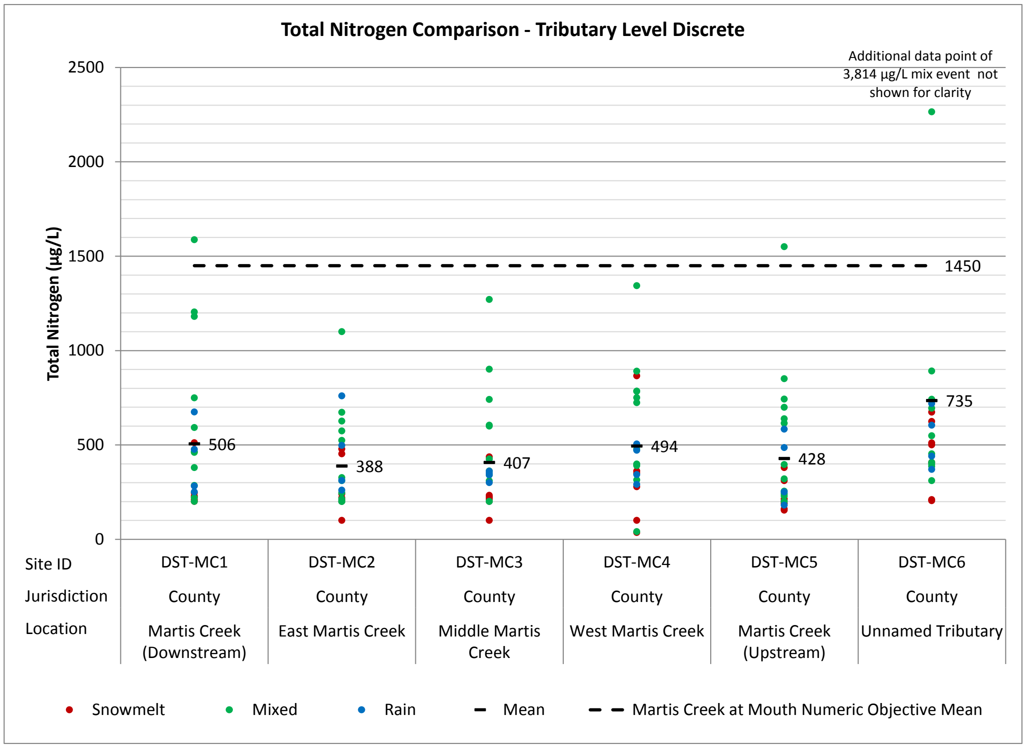


Figure 5-21
Tributary Site Comparisons – Total Nitrogen

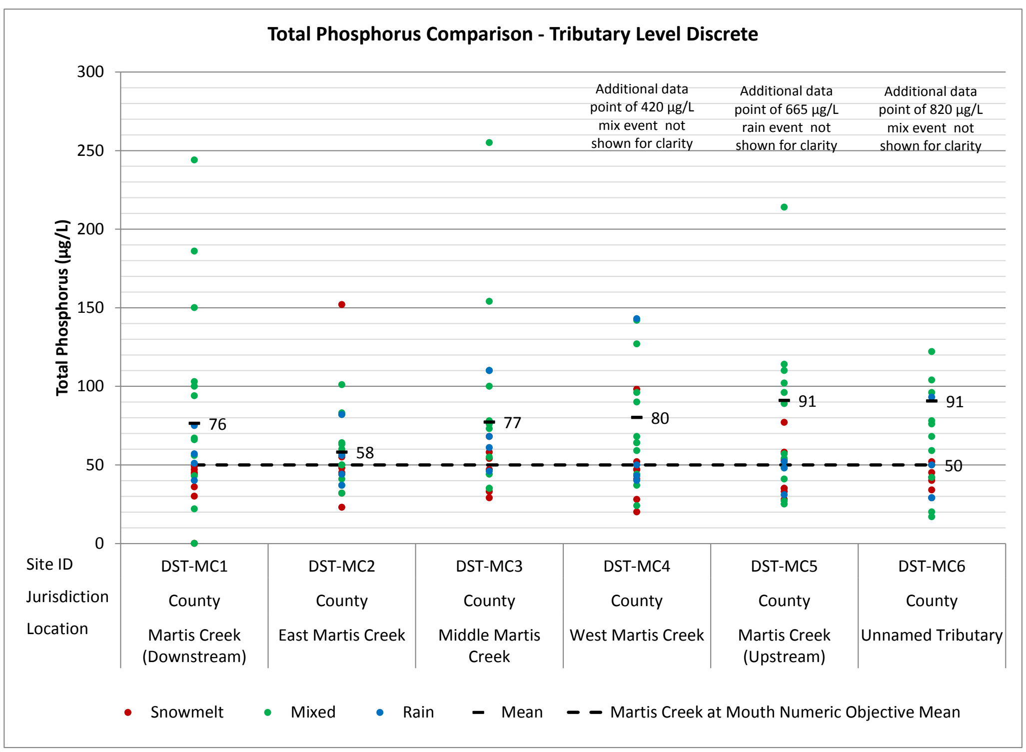


Figure 5-22
Tributary Site Comparisons – Total Phosphorus

5.2.3 Statistical Analyses

Statistical analyses were performed to further evaluate the tributary level monitoring results. These analyses consisted of summary statistics, t-tests at the 95 percent confidence level, and Mann-Kendall trend analyses.

5.2.3.1 Summary Statistics

Summary level statistics were generated for the 2011 - 2013 combined dataset and are presented in Tables 5-7 thru 5-12. These summary statistics characterize the data from each site and include the number of samples, percent detection, minimum, maximum, mean, median, standard deviation and CV. An evaluation of the summary statistics shows that nitrogen species (nitrate, nitrite, ammonia and TKN) had the highest number of non-detectable concentrations. Samples with non-detectable concentrations of TSS and dissolved orthophosphate were also collected. The CV values for all sites were high for most constituents, but less than those observed in the community level data.

Table 5-7. Water Years 2011 & 2012 Martis Creek Tributary Summary Statistics (DST-MC1)

Constituent	Units	n	Percent Detection	Range		Mean	Median	Standard Deviation	Coefficient of Variation
				Min	Max				
Total Suspended Solids	mg/L	23	100%	2.0	82	18	8.0	23	1.3
Turbidity	NTU	23	100%	2.5	54	11	7.3	12	1.1
Nitrate as N	µg/L	8	50%	10.0	180	56	17	74	1.31
Nitrite as N	µg/L	8	13%	10.0	44	NA	10	NA	NA
Nitrate as N / Nitrite as N	µg/L	13	100%	4.0	435	85	25	128	1.50
Ammonia as N	µg/L	12	100%	1.0	6.0	3.8	4.0	1.5	0.38
Total Kjeldahl Nitrogen (TKN)	µg/L	21	90%	200	1152	425	290	295	0.69
Total Nitrogen as N	µg/L	21	95%	200	1587	501	379	390	0.78
Dissolved Phosphorus as P	µg/L	23	96%	20	153	38	33	28	0.73
Dissolved Orthophosphate as P	µg/L	21	86%	10	140	28	14	37	1.31
Total Phosphorus as P	µg/L	21	100%	22	244	76	56	55	0.73

Notes:
mg/L =milligrams per liter. NTU = nephelometric turbidity units. µg/L = micrograms per liter
n = Number of samples
Total Nitrogen is the sum of nitrate (as N), nitrite (as N), and total Kjeldahl nitrogen
Percent Detection = percent of samples that were detected above the reporting limit

Table 5-8. Water Years 2011 & 2012 Martis Creek Tributary Summary Statistics (DST-MC2)

Constituent	Units	n	Percent Detection	Range		Mean	Median	Standard Deviation	Coefficient of Variation
				Min	Max				
Total Suspended Solids	mg/L	23	96%	1.0	47	12	11	12	1.0
Turbidity	NTU	23	100%	2.1	27	9.0	8.3	5.7	0.6
Nitrate as N	µg/L	8	38%	10.0	260	41	11.5	90	2.19
Nitrite as N	µg/L	8	13%	10.0	46	NA	10.0	NA	NA
Nitrate as N / Nitrite as N	µg/L	15	93%	2.0	183	21	6.0	46	2.23
Ammonia as N	µg/L	23	65%	1.0	51.0	5.3	4.0	10.1	1.90
Total Kjeldahl Nitrogen (TKN)	µg/L	23	87%	100	840	352	309	203	0.57
Total Nitrogen as N	µg/L	23	87%	100	1100	380	310	245	0.64
Dissolved Phosphorus as P	µg/L	23	100%	15	72	35	32	14	0.40

Dissolved Orthophosphate as P	µg/L	23	91%	10	61	20	16	13	0.65
Total Phosphorus as P	µg/L	23	100%	23	152	58	50	28	0.48

Notes:
mg/L =milligrams per liter. NTU = nephelometric turbidity units. µg/L = micrograms per liter
n = Number of samples
Total Nitrogen is the sum of nitrate (as N), nitrite (as N), and total Kjeldahl nitrogen
Percent Detection = percent of samples that were detected above the reporting limit

Table 5-9. Water Years 2011 & 2012 Martis Creek Tributary Summary Statistics (DST-MC3)

Constituent	Units	n	Percent Detection	Range		Mean	Median	Standard Deviation	Coefficient of Variation
				Min	Max				
Total Suspended Solids	mg/L	23	83%	1.0	60	10	6.7	13	1.3
Turbidity	NTU	23	100%	1.8	27	8.9	7.3	7.2	0.81
Nitrate as N	µg/L	8	50%	10.0	140	29	16.0	47	1.63
Nitrite as N	µg/L	8	13%	10.0	43	NA	10.0	NA	NA
Nitrate as N / Nitrite as N	µg/L	15	93%	1.0	302	33	5.0	76	2.29
Ammonia as N	µg/L	14	100%	2.0	10	4.1	3.5	2.3	0.56
Total Kjeldahl Nitrogen (TKN)	µg/L	23	83%	100	968	367	330	223	0.61
Total Nitrogen as N	µg/L	23	83%	100	1270	399	340	275	0.69
Dissolved Phosphorus as P	µg/L	23	100%	16	200	47	35	39	0.82
Dissolved Orthophosphate as P	µg/L	23	96%	10	181	32	22	36	1.14
Total Phosphorus as P	µg/L	23	100%	29	255	77	68	50	0.64

Notes:
mg/L =milligrams per liter. NTU = nephelometric turbidity units. µg/L = micrograms per liter
n = Number of samples
Total Nitrogen is the sum of nitrate (as N), nitrite (as N), and total Kjeldahl nitrogen
Percent Detection = percent of samples that were detected above the reporting limit

Table 5-10. Water Years 2011 & 2012 Martis Creek Tributary Summary Statistics (DST-MC4)

Constituent	Units	n	Percent Detection	Range		Mean	Median	Standard Deviation	Coefficient of Variation
				Min	Max				
Total Suspended Solids	mg/L	23	100%	3.0	56	16	15	13	0.79
Turbidity	NTU	23	100%	1.5	32	9.7	7.8	8.1	0.84
Nitrate as N	µg/L	8	88%	10	180	75	67	52	0.69
Nitrite as N	µg/L	8	25%	10	51	NA	10	NA	NA
Nitrate as N / Nitrite as N	µg/L	15	93%	16	661	127	100	157	1.24
Ammonia as N	µg/L	14	100%	1.0	15	4.6	4.5	3.5	0.75
Total Kjeldahl Nitrogen (TKN)	µg/L	23	87%	100	780	401	333	200	0.50
Total Nitrogen as N	µg/L	23	96%	35	1343	502	398	300	0.60
Dissolved Phosphorus as P	µg/L	23	100%	10	340	48	24	69	1.44
Dissolved Orthophosphate as P	µg/L	23	87%	4.0	160	26	12	35	1.36
Total Phosphorus as P	µg/L	23	100%	20	420	80	52	82	1.02

Notes:
mg/L =milligrams per liter. NTU = nephelometric turbidity units. µg/L = micrograms per liter
n = Number of samples
Total Nitrogen is the sum of nitrate (as N), nitrite (as N), and total Kjeldahl nitrogen
Percent Detection = percent of samples that were detected above the reporting limit

Table 5-11. Water Years 2011 & 2012 Martis Creek Tributary Summary Statistics (DST-MC5)

Constituent	Units	n	Percent Detection	Range		Mean	Median	Standard Deviation	Coefficient of Variation
				Min	Max				
Total Suspended Solids	mg/L	23	100%	1.0	48	12	6.5	13	1.0
Turbidity	NTU	23	100%	2.1	49	8.9	5.5	10	1.1
Nitrate as N	µg/L	8	50%	10.0	140	44	19	54	1.22
Nitrite as N	µg/L	8	25%	10.0	55	9	11	19	2.03
Nitrate as N / Nitrite as N	µg/L	15	100%	5.0	361	72	48	95	1.32
Ammonia as N	µg/L	14	100%	1.0	8.0	3.7	3.2	2.0	0.54
Total Kjeldahl Nitrogen (TKN)	µg/L	23	91%	149	1189	362	257	252	0.70
Total Nitrogen as N	µg/L	23	91%	154	1550	423	310	326	0.77
Dissolved Phosphorus as P	µg/L	23	100%	14	603	65	31	122	1.86
Dissolved Orthophosphate as P	µg/L	23	83%	10	222	35	19	50	1.43
Total Phosphorus as P	µg/L	23	100%	25	665	91	53	132	1.45

Notes:
mg/L =milligrams per liter. NTU = nephelometric turbidity units. µg/L = micrograms per liter
n = Number of samples
Total Nitrogen is the sum of nitrate (as N), nitrite (as N), and total Kjeldahl nitrogen
Percent Detection = percent of samples that were detected above the reporting limit

Table 5-12. Water Years 2011 & 2012 Martis Creek Tributary Summary Statistics (DST-MC6)

Constituent	Units	n	Percent Detection	Range		Mean	Median	Standard Deviation	Coefficient of Variation
				Min	Max				
Total Suspended Solids	mg/L	22	82%	1.0	34	8.2	6.3	8.1	1.0
Turbidity	NTU	22	100%	1.8	68	8.2	3.8	14	1.7
Nitrate as N	µg/L	7	43%	10.0	2400	353	17	903	2.55
Nitrite as N	µg/L	7	29%	10.0	50	11	14	18	1.54
Nitrate as N / Nitrite as N	µg/L	15	100%	2.0	419	96	36	129	1.34
Ammonia as N	µg/L	22	68%	2.0	179	17	5.5	42	2.44
Total Kjeldahl Nitrogen (TKN)	µg/L	22	100%	188	1845	556	468	380	0.68
Total Nitrogen as N	µg/L	22	100%	204	3814	735	505	802	1.09
Dissolved Phosphorus as P	µg/L	22	100%	13	112	35	29	24	0.68
Dissolved Orthophosphate as P	µg/L	22	82%	5.0	78	17	10	19	1.10
Total Phosphorus as P	µg/L	22	100%	17	820	91	50	165	1.82

Notes:
mg/L =milligrams per liter. NTU = nephelometric turbidity units. µg/L = micrograms per liter
n = Number of samples
Total Nitrogen is the sum of nitrate (as N), nitrite (as N), and total Kjeldahl nitrogen
Percent Detection = percent of samples that were detected above the reporting limit

5.2.3.2 Statistical Comparisons

Trends in concentrations over time are evaluated visually using time-series plots and formally using the Mann-Kendall test method. T-tests are used to determine if two groups of data have a statistically significant difference. The statistical outputs from the trend analyses are included in Appendix A and the results are summarized in Table 5-13 below. All statistical comparisons were conducted on the combined three year dataset.

Table 5-13. Statistical Trends of Constituents of Concern at Tributary Monitoring Sites

	TSS	Turbidity	Total Nitrogen	Total Phosphorus	Diss. Phosphorus
DST-MC1	Decreasing	Decreasing	Decreasing	Decreasing	
DST-MC2	Decreasing	Decreasing	Slightly Decreasing	Decreasing	Slightly Decreasing
DST-MC3	Decreasing	Decreasing	Decreasing	Decreasing	Slightly Decreasing
DST-MC4	Decreasing	Slightly Decreasing	Decreasing	Decreasing	
DST-MC5	Decreasing	Decreasing	Decreasing	Decreasing	Slightly Decreasing
DST-MC6	Decreasing	Decreasing	Decreasing	Decreasing	

Note: Mann-Kendall (MK) Trend Analyses used to determine significance.
A blank cell signifies no discernible trends or insufficient data points to analyze.

Table 5-13 shows a decreasing trend for almost all constituents of concern at each tributary site. To put these results in context, WY 2011 was an above average precipitation year with samples being representative of large runoff events. WY 2012 and WY 2013 were both below average in terms of precipitation and discharge which resulted sample collection from smaller runoff events. Some of the smallest events were sampled during the spring of 2013 as illustrated in Figures 5-10 through 5-18.

Since there have been no major changes within the watershed and management strategies have been similar over the three year monitoring period, the results of the trend analyses are likely reflective of the seasonal precipitation amounts and discharge. This is to be expected as higher discharge has more erosive energy and tends to keep pollutants in suspension for longer periods of time and distances. A longer-term dataset is needed to identify and assess any trends caused by development or stormwater management activities in the watershed

In additional to the trend analyses, statistical comparisons (t-tests at the 95 percent confidence level) were conducted for select data groups according to the results presented in Figures 5-19 through 5-22. Site DST-MC6 (unnamed tributary) was found to have total nitrogen concentrations that were significantly greater than total nitrogen concentrations at sites DST-MC2 (East Martis), DST-MC3 (Middle Martis), and DST-MC5 (Upper Martis). Site DST-MC6 was also found to have turbidity and TSS levels that were significantly less than levels at sites DST-MC1 (Lower Martis) and DST-MC4 (West Martis), respectively. In addition, TSS concentrations at DST-MC4 were found to be significantly greater than the TSS concentrations at DST-MC3.

The differences among mean concentrations at all of the tributary sites are not large and, except for the two instances mentioned above, statistical differences cannot yet be discerned with the amount of data collected to date. The number of samples required to determine significance increases if the mean values between the two groups are similar and there is large variability in the data.

5.2.4 Tributary Level Discussion

The results for each of the tributary sites are discussed further in terms of watershed characteristics and land uses and how they may relate to pollutant concentrations in Martis Creek. Table 5-14 summarizes the tributary level results by presenting mean concentrations for TSS, turbidity, TKN, total nitrogen, and total phosphorus at each of the monitoring sites and provides a comparison to the regulatory water quality objectives that have been defined for the mouth of Martis Creek. The results to date indicate that Martis Creek is exceeding the water quality objective for total phosphorus at all monitored locations including those draining from minimally developed areas.

Table 5-14. Tributary Level Site Rankings Based on Mean Pollutant Concentrations

Sites		Jurisdiction	Mean TSS (mg/L)	Mean Turbidity (NTU)	Mean Total Kjeldahl Nitrogen (TKN) (µg/L)	Mean Total Nitrogen (µg/L)	Mean Total Phosphorus (µg/L)
Martis Creek at Mouth	Water Quality Objectives		N/A	N/A	450	1450	50
Martis Creek at Mouth	DST-MC1	County	18	11	425	501	76
East Martis Creek	DST-MC2	County	12	9.0	352	380	58
Middle Martis Creek	DST-MC3	County	10	8.9	367	399	77
West Martis Creek	DST-MC4	County	16	10	401	502	80
Martis Creek (Upstream)	DST-MC5	County	12	8.9	362	423	91
Unnamed Tributary	DST-MC6	County	8.2	8.2	556	735	91

Notes: A ranking of 1 equals the lowest mean value; a ranking of 2 equals the second lowest mean value, and so on.

Ranking of 1 =	(dark green)
Ranking of 2 =	(light green)
Ranking of 3 =	(yellow)
Ranking of 4 =	(orange)
Ranking of 5 =	(red)
Ranking of 6 =	(dark red)

DST-MC1 (Martis Creek at Martis Creek Lake)

This monitoring site is located in Martis Creek near Martis Creek Lake, and is downstream of all tributary confluences. The larger flows produced by rain and mixed events at this site (Figure 5-23) produced the highest concentrations at this location relative to the smaller snowmelt induced flows. This site had the highest levels of TSS and turbidity and the concentrations of TKN and total nitrogen were all in the higher range when compared to the other tributary sites. The mean concentration of total phosphorus exceeded the established water quality objective at this location (as it did at all locations) while the TKN and total nitrogen concentrations where below the water quality objectives.

Figure 5-23
Sampling at Site DST-MC1

DST-MC2 (East Martis Creek)

This site is located on East Martis Creek approximately 0.5 mile upstream of its confluence with the main stem. The sub-watershed for this site consists of 100 percent pervious, upland meadow and forest with some dirt roads. This site had the lowest mean concentrations for TKN, total nitrogen and total phosphorus. The mean TSS and turbidity concentrations at this site ranked in the middle to higher levels when compared to the other sites. The higher particulate concentrations at this site are somewhat unexpected given the minimal development in the sub-watershed. A photograph of East Martis Creek at the sampling location is presented in Figure 5-24.

Figure 5-24
Site DST-MC2 Looking Upstream toward Undeveloped Meadow and Forest

DST-MC3 (Middle Martis Creek)

This monitoring site is located on Middle Martis Creek approximately 250 feet upstream of its confluence with the main stem. The sub-watershed for this site consists of upland forest and meadow with some dirt roads as well as an approximately four mile section of SR 267. This portion of SR 267 includes a steep grade to Brockway Summit where traction sand is applied. Caltrans installed a series of new sand traps on SR 267prior to WY 2012 which may have resulted in decreased pollutant loading from their facilities. During larger spring snowmelt flows, the stream sometimes overtops its banks upstream of the monitoring location and a portion of the stream flow bypasses the site; however, this was not observed during WY 2013. When the stream banks are breached, flows travel along preferential paths formed by previous overflow conditions at this location as shown in Figure 5-25. Most of the flow from the breach returns to the main channel (line of willows) upstream of the monitoring site, but some flows into the main stem of Martis Creek just downstream of the monitoring location. The mean concentrations of TSS, turbidity, TKN, and total phosphorus were all in the mid to lower levels relative to other tributary level sites.

Figure 5-25
Middle Martis Creek Bypass

DST-MC4 (West Martis Creek)

DST-MC4 is located on West Martis Creek approximately 0.25 miles upstream of its confluence with the main stem. West Martis Creek originates within the Northstar ski resort and flows through the Northstar residential development and golf course (Figure 5-67). The mean concentrations of TSS, turbidity, TKN, total nitrogen, and total phosphorus were all in the mid to higher levels when comparing this site to the other tributary sites.

Figure 5-26
Site DST-MC4 Looking Upstream Towards Golf Course and Northstar

DST-MC5 (Martis Creek)

This site is located on the main stem of Martis Creek approximately 100 feet downstream of an unnamed tributary that receives flow from a portion of the Lahontan development and a dirt road. This site is located upstream of all major tributary confluences, and its sub-watershed consists of a portion of the Northstar ski resort, upland forest and meadow with some dirt roads, and the developed residential areas of Lahontan Golf Club and Martis Camp. This site has a large sub-watershed and receives more flow than the other tributary sites (except for DST-MC1). This site had mean concentrations of TSS, turbidity, TKN, and total nitrogen that were in the mid to lower range relative to the other tributary sites. However, the mean total phosphorus concentration was tied with DST-MC6 for being the highest. The high mean total phosphorus value is likely due to a rain event on April 26, 2012 which produced a total phosphorus concentration of 665 µg/L, which is much higher than any other monitored event.

Figure 5-27
Site DST-MC5 Breaching its Banks on November 30, 2012

DST-MC6 (Unnamed Tributary)

This site is located on an unnamed tributary of Martis Creek approximately 100 feet downstream of Martis Lake Road. This site had the lowest flow rates of all of the tributary sites due to its relatively small sub-watershed which consists of commercial development, a portion of the Truckee Tahoe Airport and open meadow areas. After discharging from the developed areas, runoff flows through a meadow where infiltration and treatment can occur as shown in Figure 5-28. This site had the lowest mean concentrations for TSS and turbidity, but it had the highest mean concentrations of TKN, total nitrogen, and total phosphorus. These high mean nutrient concentrations could be attributed to decaying vegetation within the meadow.

Figure 5-28
Low Flow Event at Site DST-MC6

5.2.5 QA/QC Results

Upon receipt from the laboratory, each analytical report was thoroughly reviewed and the data evaluated to determine if the data met the study objectives. Initially, the data were screened for the following major items:

- A 100 percent check between electronic data provided by the laboratory and the hard copy reports;
- Conformity check between the chain-of-custody forms, compositing protocol, and laboratory reports;

- A check for laboratory data report completeness; and,
- A check for typographical errors on the laboratory reports.

After performing the aforementioned data screening, the laboratory was notified of any deficiencies, if any, detailing the problems encountered during the initial screening process.

Following the initial screening, a more complete QA/QC review was performed, which included an evaluation of method holding times, method blank contamination, and accuracy and precision. Accuracy was evaluated by reviewing MS, MSD, and LCS recoveries; precision was evaluated by reviewing field duplicate, spike duplicate and laboratory sample duplicate RPDs.

Data quality assessment was based upon review of holding times, laboratory blanks, laboratory control samples, laboratory duplicates, matrix spikes and matrix spike duplicates, reporting limits, and field duplicates. Based on the data review, none of the constituent results were rejected. Appendix C provides the detailed descriptions of specific items that were evaluated during the QA/QC review process and data that were qualified as estimated due to QC exceedences.

5.3 Stream Gauging Stations: WY 2013 Hydrologic Summary

The 2013 stream discharge monitoring results from the Martis Creek gauging stations (GS-MC1 and TURB-MC2) and West Martis Creek gauging station (TURB-MC1) are presented in this section. The gauge GS-MC1 was installed in November of 2010 and has been operated continuously since that time. Gauges at Turb-MC1 and Turb-MC2 were installed in October 2012 as described in Section 4. The discharge at gauging stations operated and maintained by the USGS is also presented. These data provide complete and near-continuous records (15-minute) of discharge to be used for evaluation of annual peak flows, annual mean flow, annual and daily total discharge volumes. In combination with water quality sampling, these metrics were used to compute a near-continuous record of suspended-sediment loading.

5.3.1 Martis Creek: Site GS-MC1

This station was installed during WY 2011 and has been in continuous operation since that time. During the first week of July 2011, a beaver dam/pond approximately 600 ft. downstream of the Martis Creek stream gauge became established and resulted in the ponding of water at the stream gauge location. This rendered the initial rating curve developed during WY 2011 inaccurate for the time period after the dam's establishment.

Several alternatives were considered to address the problem including installing a pond leveler device, and relocating the stream gauge. After evaluating the alternatives, it was decided to continue collecting velocity measurements to develop a revised rating curve for the new condition. The beaver dam remained in place and affected stage measurements throughout the 2013 monitoring season. Separate rating curves were developed for each water year to account for the varying effects of the beaver dam over the monitoring period.

The three rating curves developed to date were applied to the pressure transducer stage data to produce a semi-continuous record of discharge at the Martis Creek gauging station for water years 2011, 2012 and 2013. This three year discharge record is presented in Figure 5-29. The difference between the three years is readily apparent due to the large differences in precipitation amounts received. The total discharge volume in WY 2011 (23,420 acre-feet) was almost six times as large as in

WY 2012 (4,041 acre-feet). The annual discharge during WY 2013 (5,305 acre-feet) was approximately 30 percent greater than the annual discharge during WY 2012. The maximum measured stage during the entire monitored period was 5.0 feet which correlates to a discharge of approximately 450 cfs. This occurred on December, 2 2012 after nearly 6 inches of precipitation fell over a 72 hour period. The temperatures during this storm cycle were relatively warm which elevated snow levels and increased runoff. The lowest stage at the gauging station varied due to the effects of the beaver dam, and the minimum measured discharge was approximately 0.5 cfs.

The discharge rates shown in the graph are estimated for the periods of instability caused by the beaver dam construction or deterioration processes. During these time periods the water levels in the pond were changing and the rating curves are not applicable. Flows values were estimated by interpolating between the manual measurement points. This is apparent in the graph during the summer months. Developing discharge rating curves in a backwatered reach of a stream channel is not recommended. This gauging station should be moved to an unimpeded section of the stream channel.

5.3.2 West Martis Creek: Site TURB-MC1

A stage versus discharge rating curve for West Martis Creek was developed during WY 2013, and daily and monthly discharge is presented in Appendix D. Daily discharge is presented graphically in Figure 5-30, and a description of the WY 2013 discharge in West Martis Creek is presented below.

This station is located in an anastomosing (braided) channel on an active alluvial fan, and therefore only captures 30 to 40 percent of the total flow in West Martis Creek, as measured during detailed field assessments. As a result, discharge values and associated loading calculations presented in this report should be scaled upwards to more accurately represent the total flow emanating from West Martis Creek. This station was relocated in WY2014 to capture more than 90 percent of the total flow in West Martis Creek.

Baseflow in the beginning of WY 2013 was approximately 1.0 cfs, which fell rapidly in November to between 0.25 cfs and 0.5 cfs and may be associated with known diversions upstream. Discharge increased to approximately 3.6 cfs as the result of rainfall on November 17-18, 2012, before slowly returning to near baseflow conditions in late November. A significant rain-on-snow event, which began on November 30 and persisted through December 2, 2012, resulted in the annual peak flow of 18.3 cfs on December 2, 2012. Additional rainfall on December 5, 2012 generated another rise in discharge near the annual peak magnitude. A cold, snowy period occurred through the end of December followed by cold and dry conditions through January and February. The onset of snowmelt and associated runoff began in early March. Peak snowmelt runoff of 3.5 cfs occurred on March 31, 2013 slightly later than peak snowmelt runoff on Upper Martis Creek. This delay may be associated with additional snowmelt from snow-making activities at Northstar Ski Resort. Discharge rates decreased through the summer months and responded slightly to occasional summer thunderstorms, reaching an annual low flow of 0.1 cfs on July 2, 2013. By the end of September, baseflow (0.3 cfs) was lower than in October 2012, but increased slightly from July. The annual mean discharge for West Martis Creek in WY2013 was 0.8 cfs and the total annual discharge was 597 acre-feet.

5.3.3 Upper Martis Creek: Site TURB-MC2discharge

A stage versus discharge rating curve for Upper Martis Creek was developed during WY 2013, and daily and monthly discharge is presented in Appendix D. Daily discharge is presented graphically in Figure 5-31, and a description of the WY 2013 discharge in Upper Martis Creek is presented below.

Baseflow in early WY 2013 was approximately 1.6 cfs, which increased to approximately 9.5 cfs as the result of rainfall on November 17-18, 2012, before slowly returning to slightly-higher baseflow conditions in late November. A rain-on-snow event, which began on November 30 and persisted through December 2, 2012, resulted in rises in discharge and the annual peak flow of approximately 198 cfs on December 2, 2012. Additional rainfall on December 5, 2012 generated another rise in discharge. A cold, snowy period occurred through the end of December followed by cold and dry conditions through January and February. The onset of spring snowmelt and associated runoff began in early March. Warmer than average temperatures and below average snowpack in WY 2013 resulted in an early peak snowmelt runoff of approximately 27.7 cfs on March 21, 2013. Afterwards, discharge receded through the summer months and responded slightly to occasional summer thunderstorms. By the end of the water year, baseflow (roughly 1.0 cfs) was lower than the beginning of the water year (approximately 1.6 cfs). The annual mean flow for Martis Creek in WY 2013 was 5 cfs with total annual runoff of 3,610 acre-feet.

Beaver activity between August and October resulted in elevated stage at this station. The record of daily stage was adjusted using stage shifts to develop a flow record that is consistent with manual discharge measurements during this period. This station was relocated in the beginning of WY 2014 to minimize beaver interference in the future.

5.3.4 Truckee River above Truckee (USGS 10338000)

Discharge for the Truckee River above Truckee is reported by the USGS; data are provisional at the time of this report and subject to revision. Appendix D presents USGS reported daily flow values for WY 2013 at this station, and Figure 5-32 exhibits a hydrograph of daily discharge.

Baseflows in early WY 2013 were approximately 140 cfs. October and November rainfall increased flows to a peak flow of 330 cfs on November 18, 2012. A rain-on-snow event between November 30 and December 2, 2012 resulted in the annual peak flow of 1,810 cfs on December 2, 2012. Additional rain and snow resulted in an additional peak flow (760 cfs) on December 5, 2012. A cold, snowy period followed through the end of December and flows receded to the lowest annual values (76 cfs). Slight increases in discharge were observed in January with some variability through the early spring. Regionally, peak snowmelt occurred between late March and late April; however, discharge at this station reached a peak of 330 cfs on May 13, 2013 and then quickly receding to a low of 139 cfs on May 25, 2013. In early June, discharge gradually increased as the result of releases from Lake Tahoe to an average 330 cfs at Tahoe City (USGS 10337500), increasing flows at this station to between 350 cfs and 450 cfs through early September. On July 3, 2013, a significant thunderstorm, centered over the Squaw Creek Watershed, increased flows to approximately 512 cfs at this station. By late September, Lake Tahoe regulated releases were largely reduced and daily mean flows at this station approximated 100 cfs through the end of the water year. The annual mean flow for Truckee River above Truckee in WY 2013 was 228 cfs with a total annual runoff of 165,142 acre-feet.

5.3.5 Truckee River at Boca Bridge (USGS 10344505)

Discharge for Truckee River at Boca Bridge is reported by the USGS; data are provisional at the time of this report and subject to revision. Appendix D presents USGS reported daily flow values for WY 2013 at this station, and Figure 5-33 exhibits a hydrograph of daily discharge. Discharge at this station is regulated by 7 upstream dams on the main stem and tributaries, including 1) Lake Tahoe, 2) Donner Lake, 3) Martis Creek Reservoir, 4) Prosser Reservoir on Prosser Creek, and 5) Boca and Stampede Reservoirs on the Little Truckee River, and 6) Independence Lake. Releases from one or more of these reservoirs/lakes may have more influence on discharge at this station than natural runoff events.

Flows in the beginning of WY 2013 were approximately 430 cfs at this station. October and November rainfall increased flows to a peak flow of 640 cfs on November 17, 2012. A rain-on-snow event between November 30 and December 2, 2012 resulted in the annual peak flow of 3,320 cfs on December 2, 2012. Additional rain and snow resulted in a smaller peak flow (1,940 cfs) on December 5, 2012. Daily mean flows quickly receded to the lowest annual values (311 cfs) on December 15, 2012. Variable releases from Boca and Prosser Reservoirs resulted in fluctuating discharge at Boca Bridge through the winter. Most notably, Boca Reservoir gradually increased releases from 35 cfs to 400 cfs between April 1 and late May 2013. Regionally, peak snowmelt occurred between late March and late April; however, peak snowmelt runoff of 883 cfs occurred on May 13, 2013 at this station. By late June, both Boca and Prosser Reservoirs greatly reduced releases which resulted in daily mean flows at Boca Bridge below 475 cfs. In early September, releases from Boca Reservoir and Donner Lake increased, with decreases elsewhere in the system, so daily mean flows remained near constant at Boca Bridge near 450 cfs. The annual mean flow for Truckee River above Truckee in WY 2013 was 505 cfs with a total annual runoff of 365,916 acre-feet.

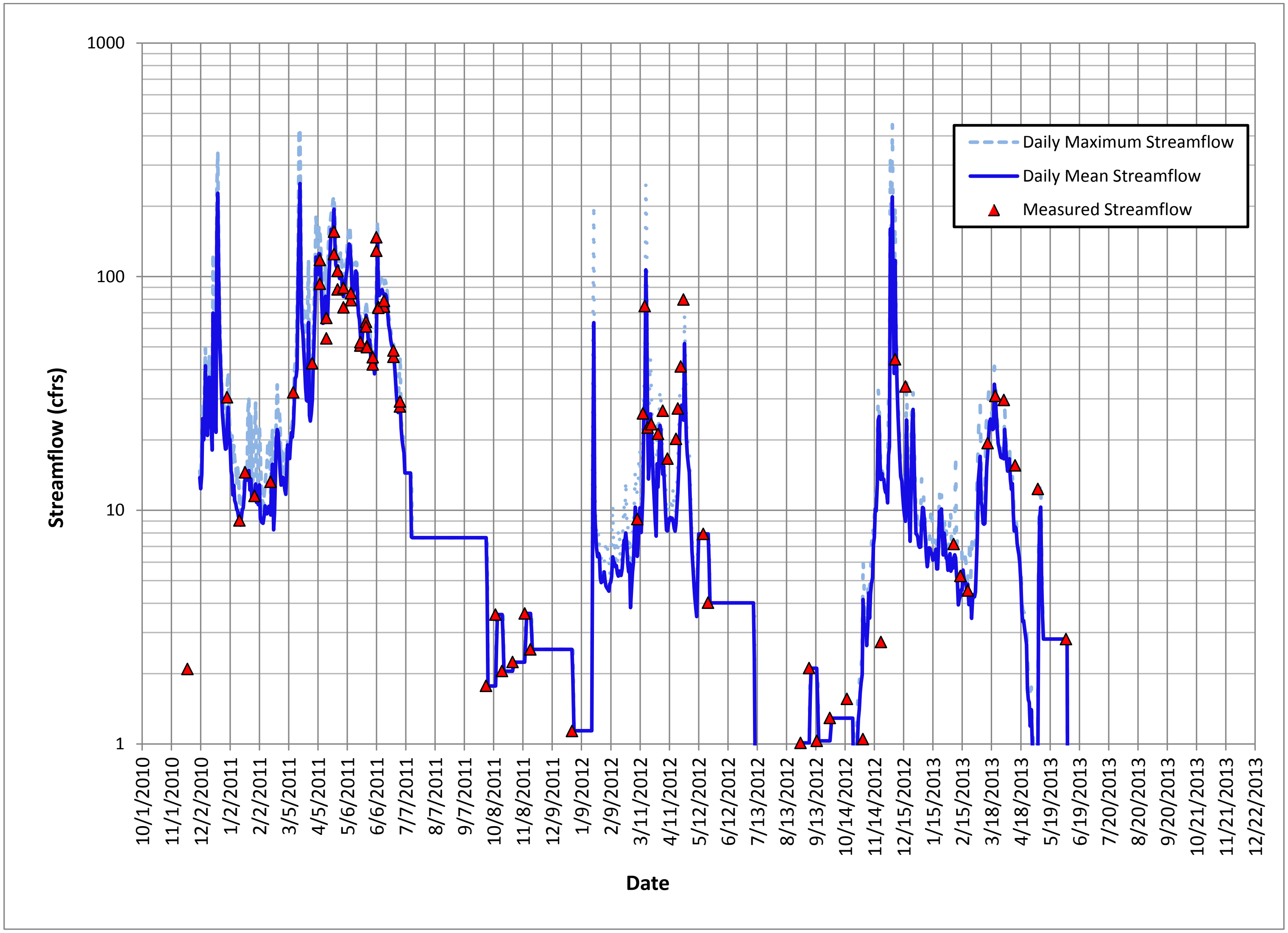


Figure 5-29
Daily Mean and Maximum Discharge Hydrograph
Martis Creek, Site GS-MC1, WY 2011-2013

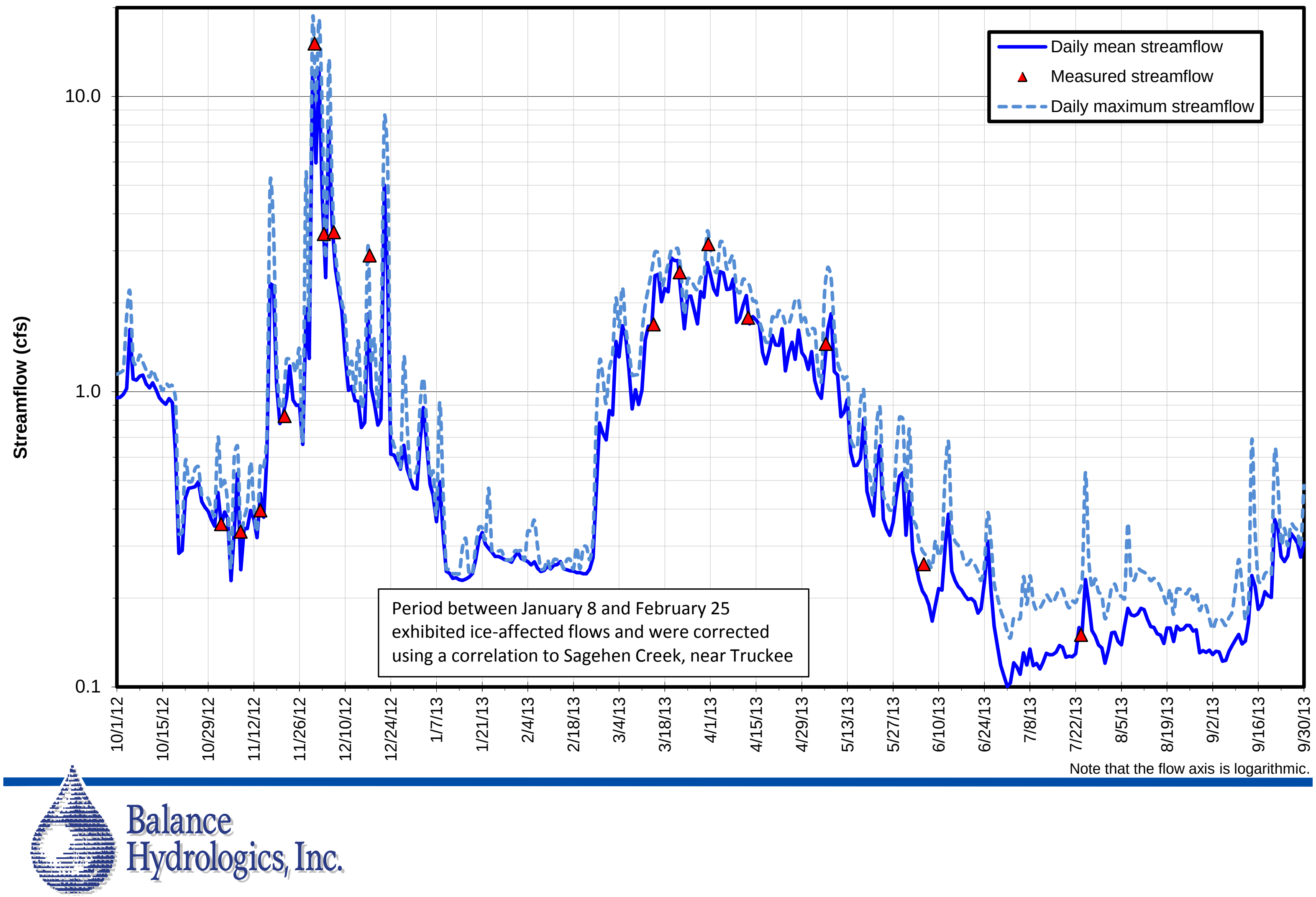
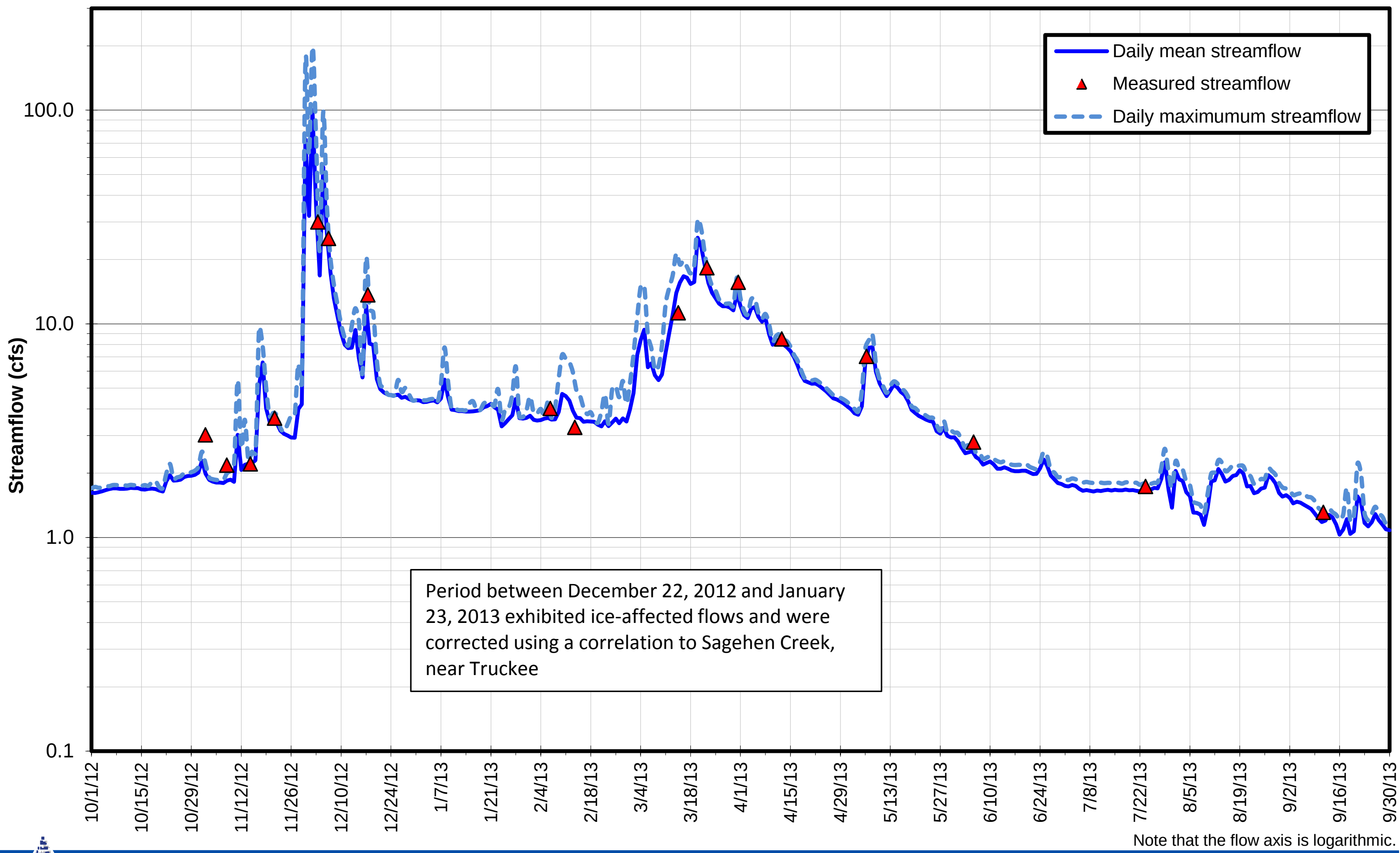
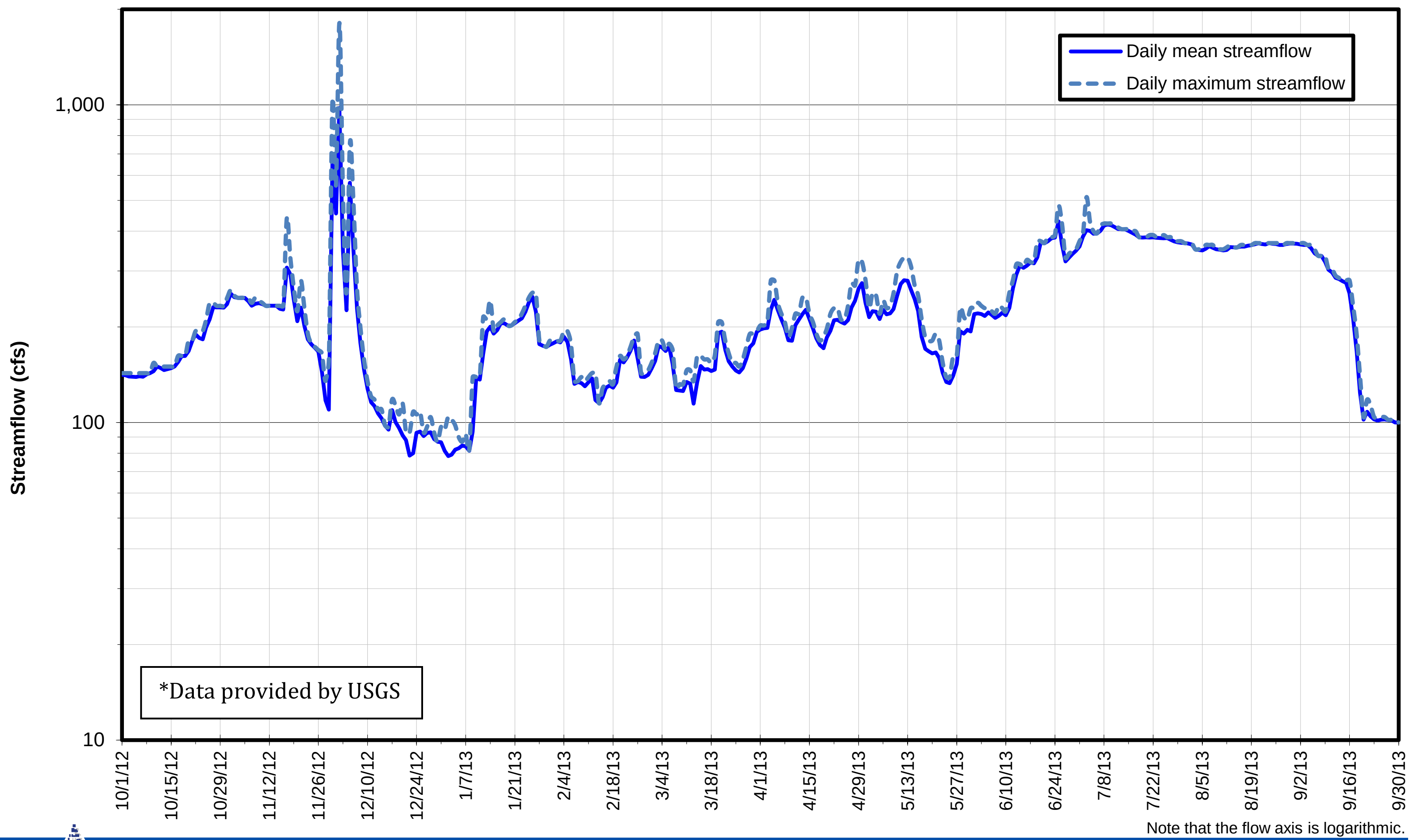


Figure 5-30
Daily Mean and Maximum Discharge Hydrograph
West Martis Creek, Site TURB-MC1, WY 2013



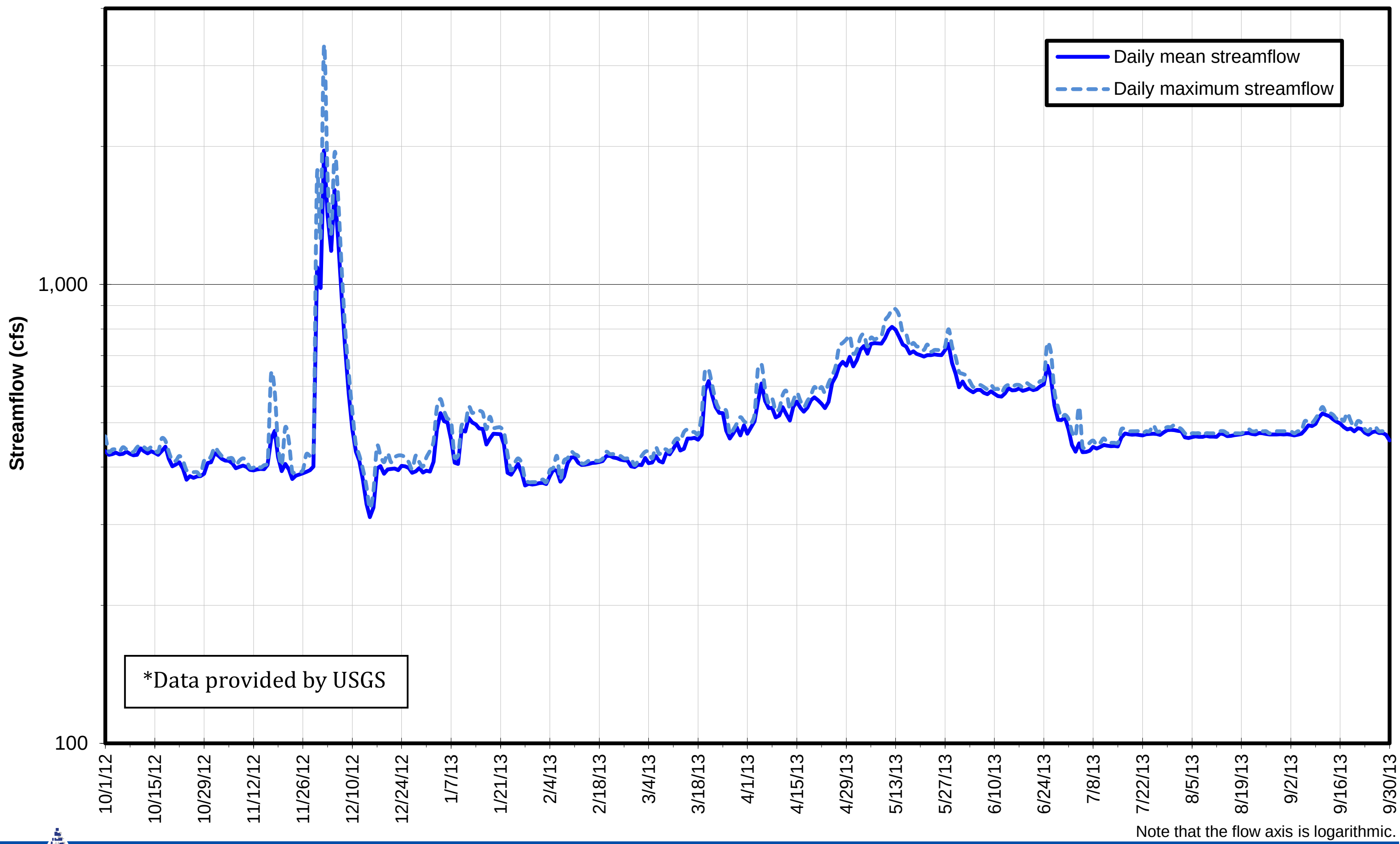
Balance Hydrologics, Inc.

Figure 5-31
Daily Mean and Maximum Discharge Hydrograph
Martis Creek, Site TURB-MC2, WY 2013



Balance Hydrologics, Inc.

Figure 5-32
Daily Mean and Maximum Discharge Hydrograph
Truckee River above Truckee (USGS 10338000), WY 2013.



Balance Hydrologics, Inc.

Figure 5-33
Daily Mean Discharge Hydrograph
Truckee River at Boca Bridge (USGS 10344505), WY 2013.

5.4 Load Estimates

Pollutant load estimates for the Truckee River and Martis Creek watershed are presented in this section. Suspended-sediment loads were calculated using data collected at the near-continuous turbidity monitoring locations, and loads for other constituents were estimated using water quality results from the tributary level monitoring in conjunction with discharge.

5.4.1 Near-Continuous Turbidity Monitoring: WY 2013 Summary

Suspended-sediment loads were computed using two methods: a) a near-continuous record of turbidity, and b) discharge-based. This section compares and contrasts records of suspended-sediment loads using the two methods. Note that this is the first year of estimating suspended-sediment loads, and the various relationships presented herein are provisional and subject to change. As a result, differences in loads calculated for each method may vary widely. Additional data collection and analysis is subsequent years will strengthen these relationships.

5.4.1.1 West Martis Creek (TURB-MC1)

Monitoring Results

Appendix E is a log of samples collected and analyzed for SSC with associated computed suspended-sediment loading rates for West Martis Creek in WY 2013.

A continuous record of turbidity for West Martis Creek (TURB-MC1) in WY 2013 is provided in Figure 5-34. The 15-minute values of turbidity exhibit a wide range and are attributed to periodic instrument malfunction. For instance, values of over 500 NTU are measured by the probe on many occasions; however, manual measurements of turbidity rarely exceeded 30 NTU, and water samples collected and analyzed in the laboratory for turbidity during events exhibited maximum values of 31 NTU. Efforts were taken to correct erroneous values based on field and laboratory measurements. It has been concluded that the record of turbidity for WY 2013, and load calculated from this record, includes a large degree of uncertainty. This instrument was replaced in October 2013.

Suspended-Sediment Loads

Figure 5-35 shows the current relationship between turbidity and SSC at West Martis Creek (TURB-MC1). Due to the instrument errors described in the above section, laboratory-reported values for turbidity were used in place of instantaneous turbidity, and the 2013 dataset was augmented with historical data collected in WY 2011-WY 2012.

Figure 5-36 describes the relationship between instantaneous discharge and suspended-sediment load, computed from samples collected and analyzed for SSC during WY 2013.

A summary of daily and annual suspended-sediment loads in West Martis Creek is provided in Form 1 of Appendix E using the two methods described above. Results from both methods are graphically compared in Figure 5-37. Total annual loads were 260 tons computed using the turbidity-based method and 14.3 tons computed using the discharge-based method. The difference in loads between the two methods is likely associated with erroneous turbidity values as measured by the instrument and described above. In addition, limited SSC sample size (n=9) may also introduce significant error in computation of loads using the discharge-based method.

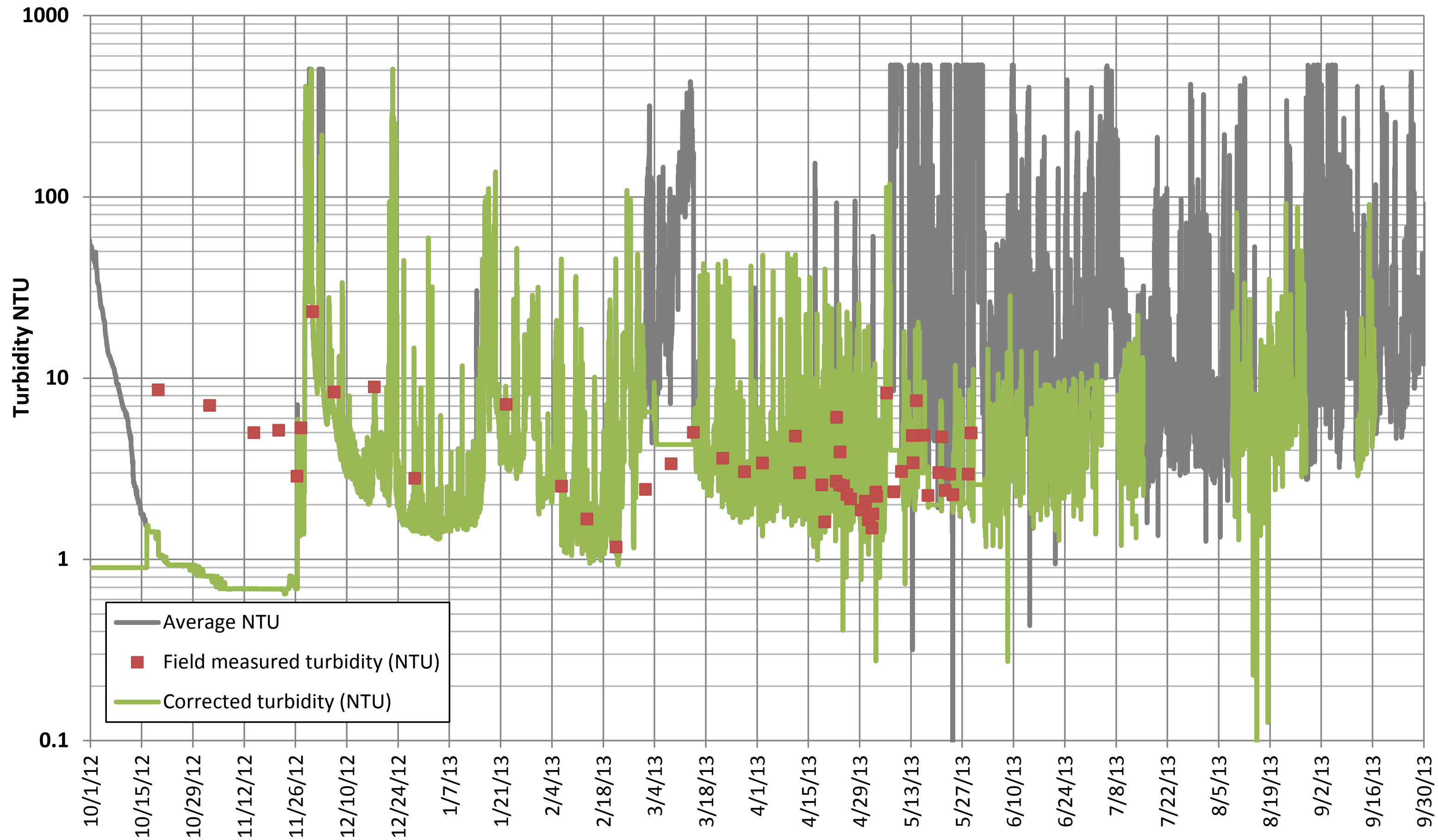


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Figure 5-34
Near-continuous record of turbidity, West Martis Creek (TURB-MC1), WY 2013.

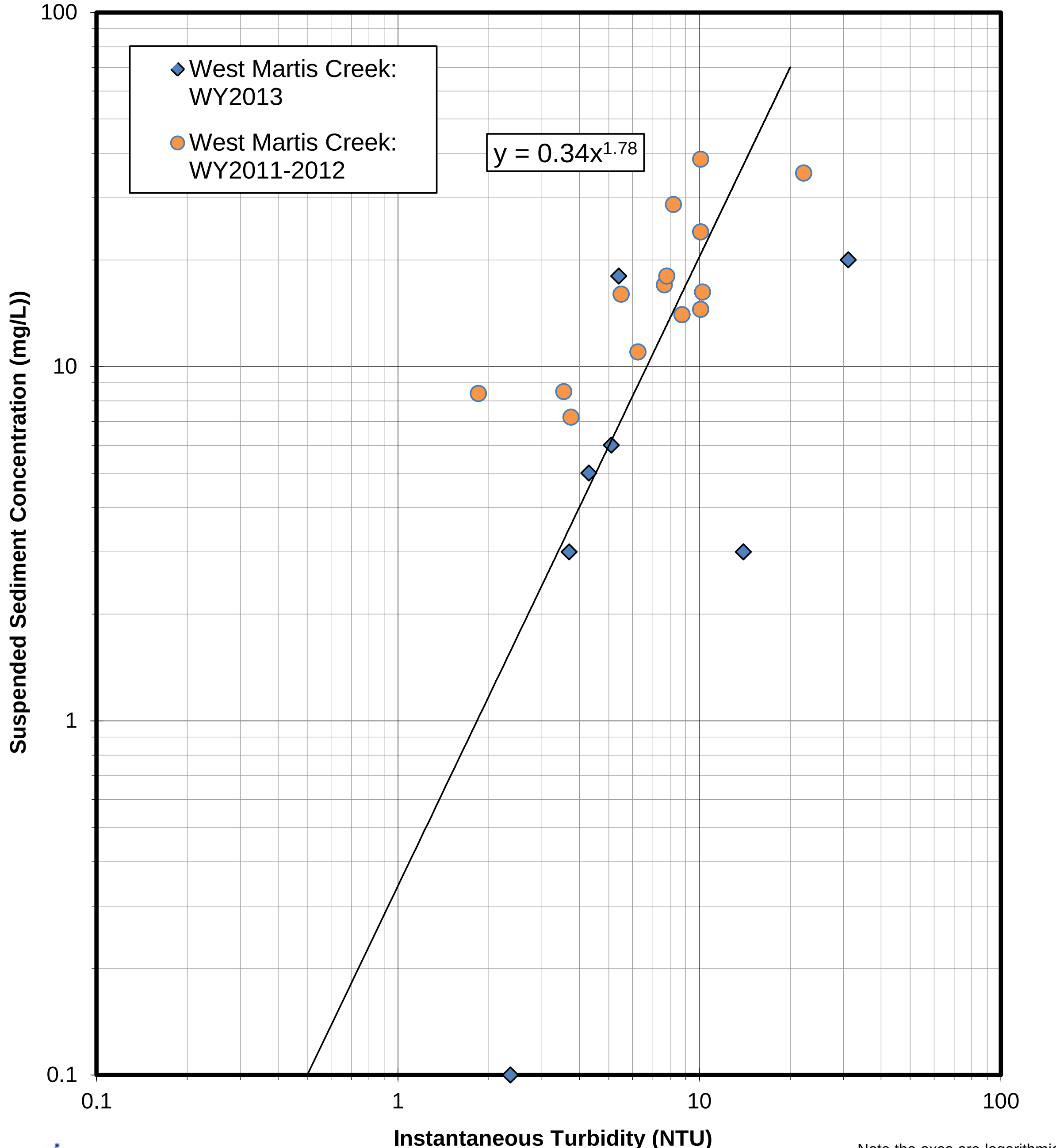

Figure 5-35
Relationship between turbidity and suspended-sediment concentration, West Martis Creek (TURB-MC1), WY 2013.

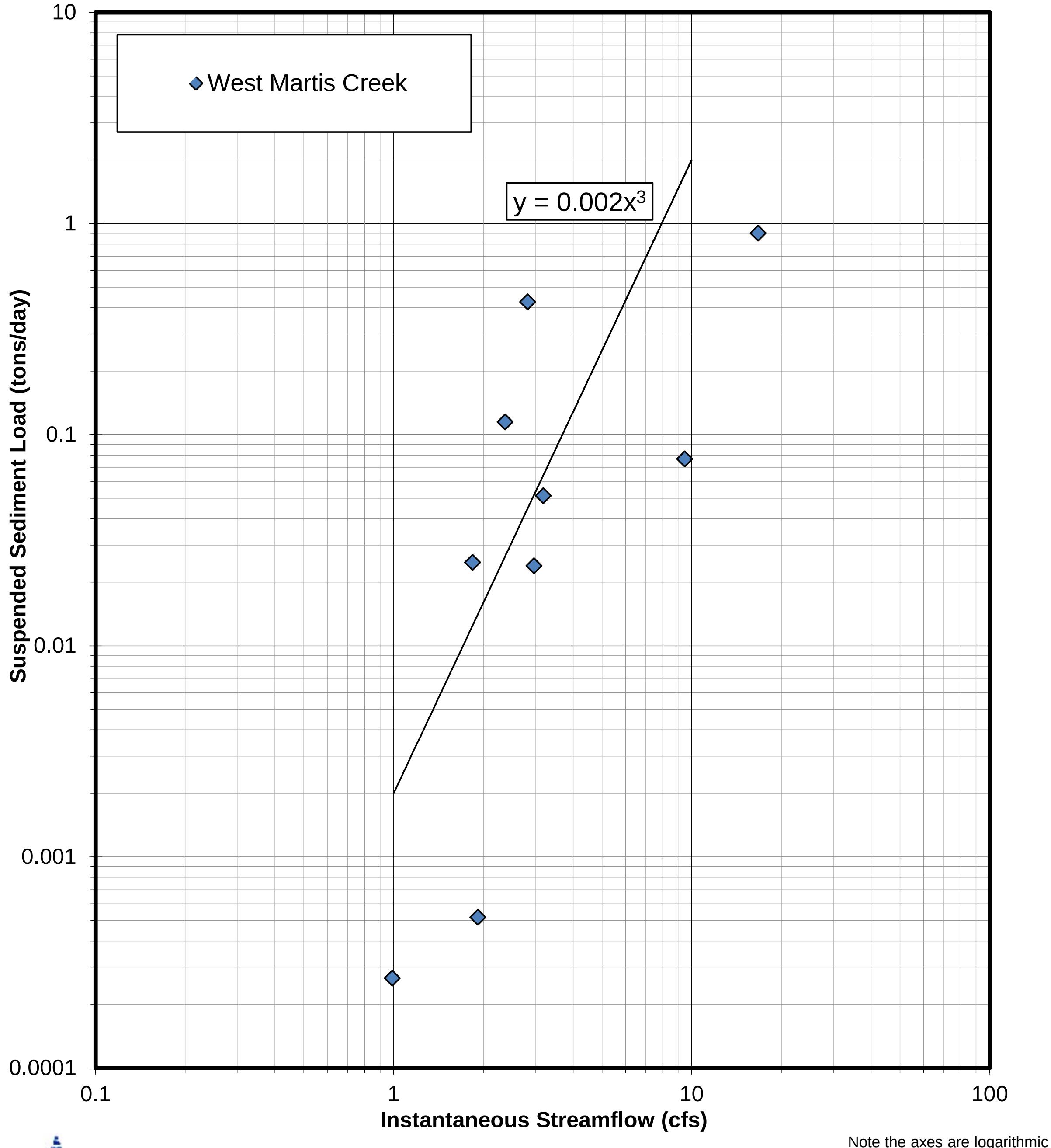

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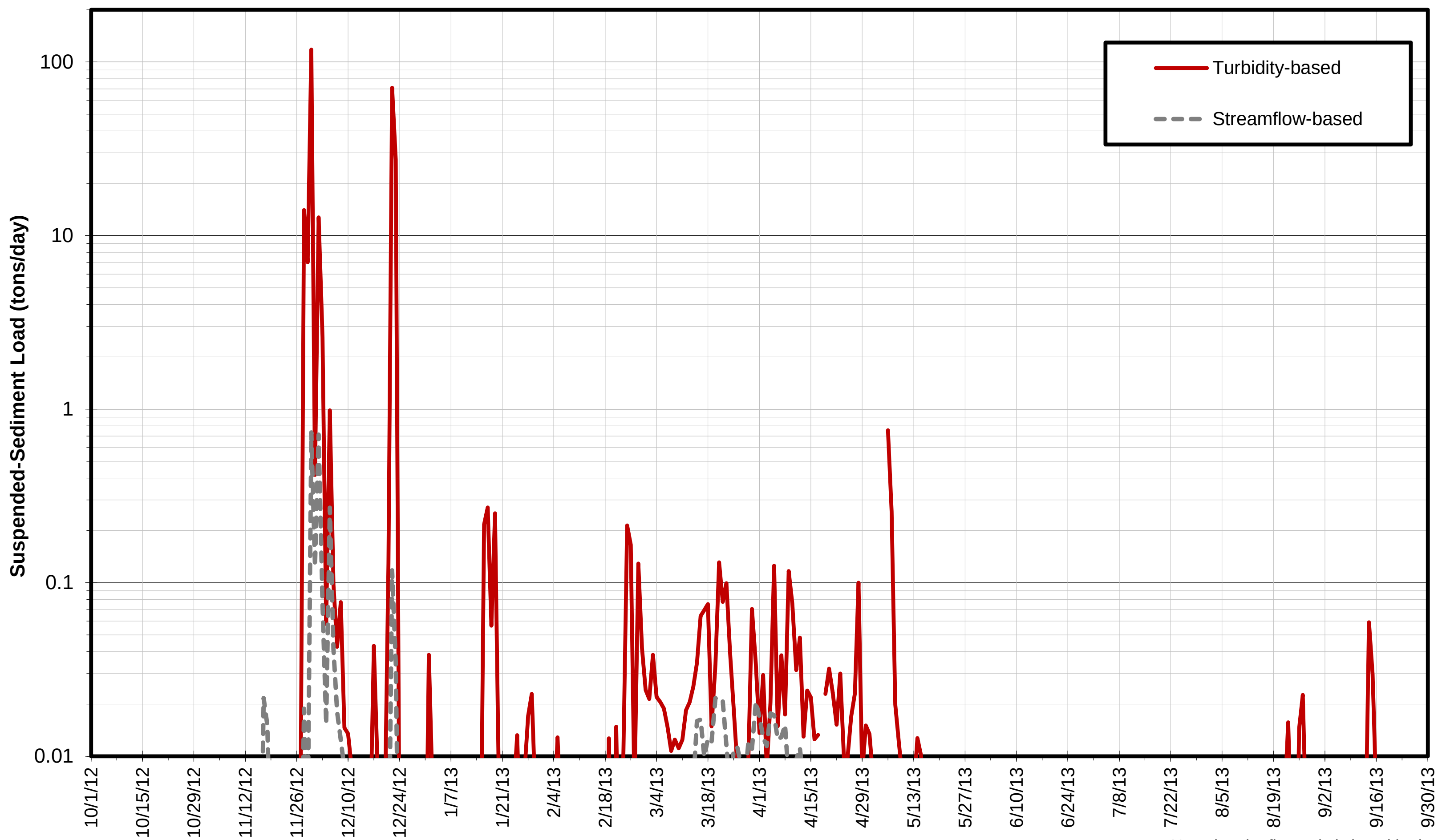
Figure 5-36
Relationship between discharge and suspended-sediment load, West Martis Creek (TURB-MC1), WY 2013.



Note that the flow axis is logarithmic.

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Figure 5-37
Daily suspended-sediment load, comparison between turbidity-based and discharge-based methods, West Martis Creek (TURB-MC1), WY 2013.

5.4.1.2 Upper Main Stem of Martis Creek (TURB-MC2)

Monitoring Results

Appendix E is a log of samples collected and analyzed for SSC with associated computed suspended-sediment loading rates at Upper Martis Creek for WY 2013.

A continuous record of turbidity for Upper Martis Creek (TURB-MC2) in WY 2013 is provided in Figure 5-38. The 15-minute values of turbidity exhibited a wide range of values, and are attributed to periodic instrument malfunction. As with the West Martis Creek station, efforts were taken to correct erroneous values based on field measurements; however, it was concluded that the record of turbidity for WY2013 at this station, and loads calculated from this record, include a large degree of uncertainty. This instrument was replaced in October 2014.

Suspended-Sediment Loads

Figure 5-39 shows the relationship between turbidity and SSC at Upper Martis Creek (TURB-MC2). Due to the instrument errors described in the above section, laboratory-reported values for turbidity were used in place of instantaneous turbidity. In addition, the WY 2013 dataset was augmented with historical data collected in WY 2011-WY 2012.

Figure 5-40 describes the relationship between instantaneous discharge and suspended-sediment load, computed from samples collected and analyzed for SSC for the first year of a multi-year study.

A summary of daily and annual suspended-sediment loads in Martis Creek is provided in Form 2 of Appendix E. Results from both methods are graphically compared in Figure 5-41. Total annual load is calculated to be 50 tons using the turbidity-based method and 52 tons using the discharge-based method. These loads, while similar, should be viewed as provisional until new instruments are installed and additional data can be collected. The annual peak flow which occurred on December 2, 2012 resulted in the maximum daily suspended-sediment load (17 to 24 tons) and represented almost half of the total annual load. Moreover, the storm period between November 30 and December 2, 2012 resulted in approximately 60 to 75 percent of the total annual suspended-sediment transport.

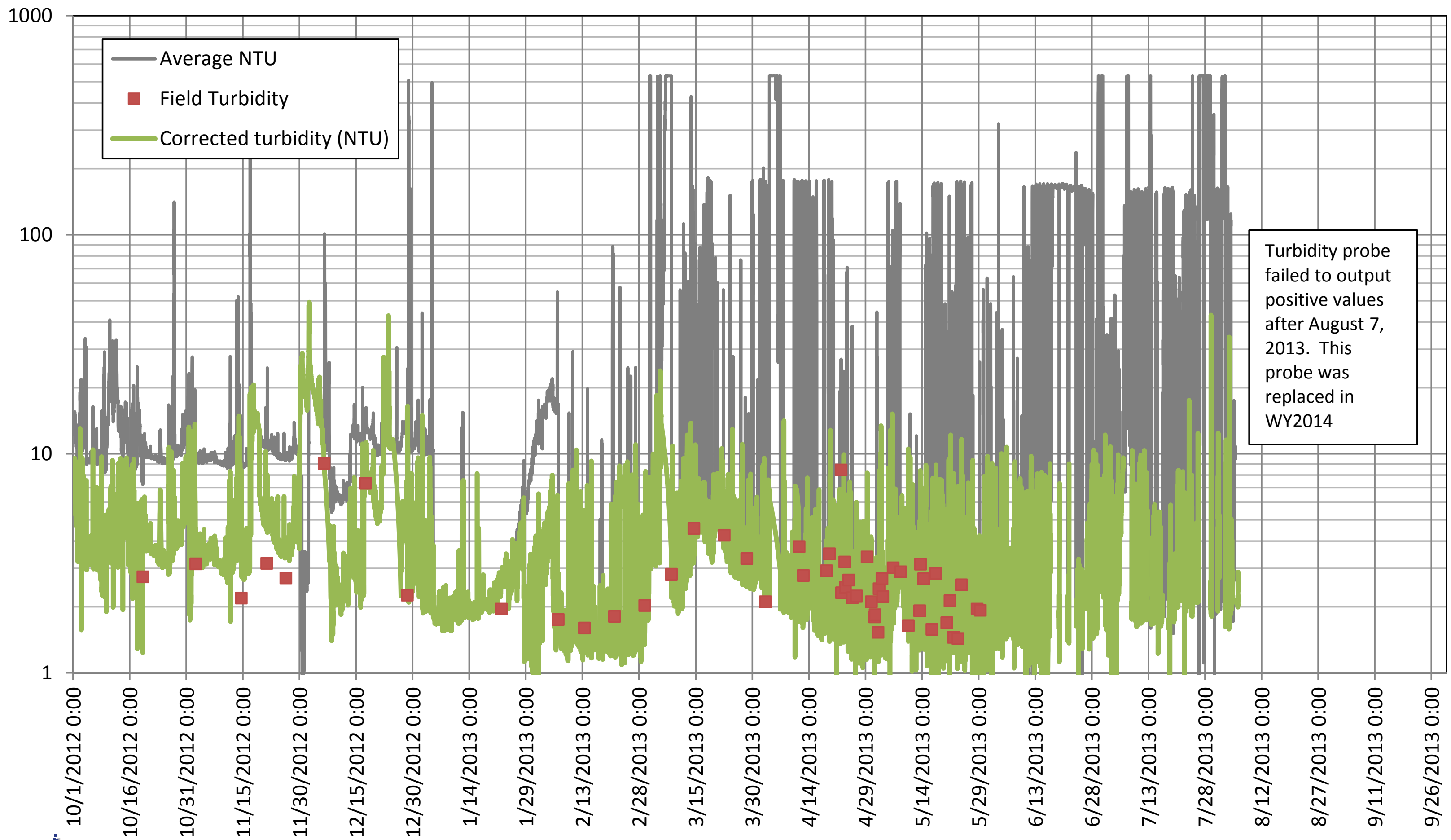

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Figure 5-38
Near-continuous record of turbidity, Martis Creek, WY 2013.

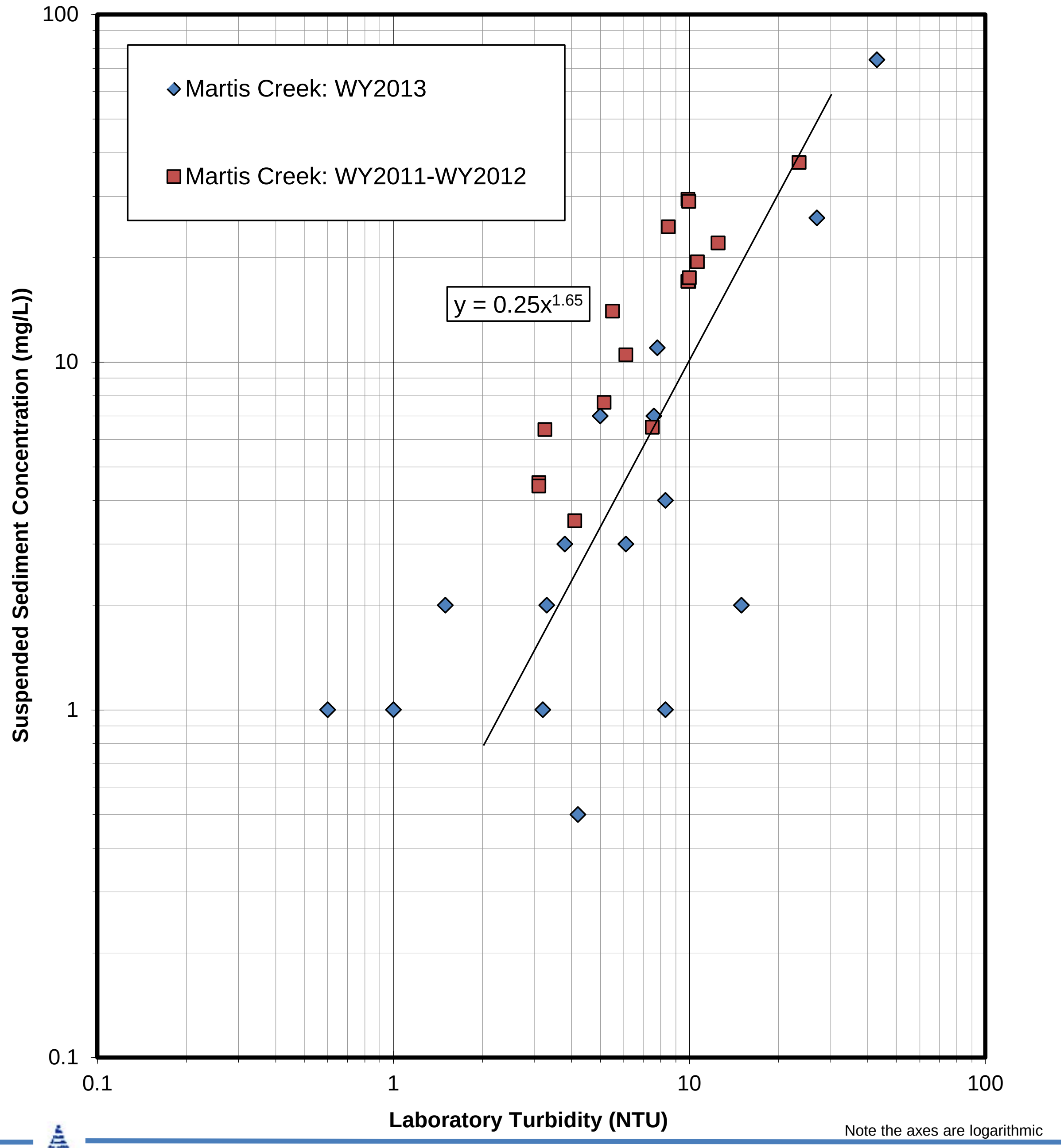

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Figure 5-39
Relationship between turbidity and suspended-sediment concentration, Martis Creek, WY 2013.

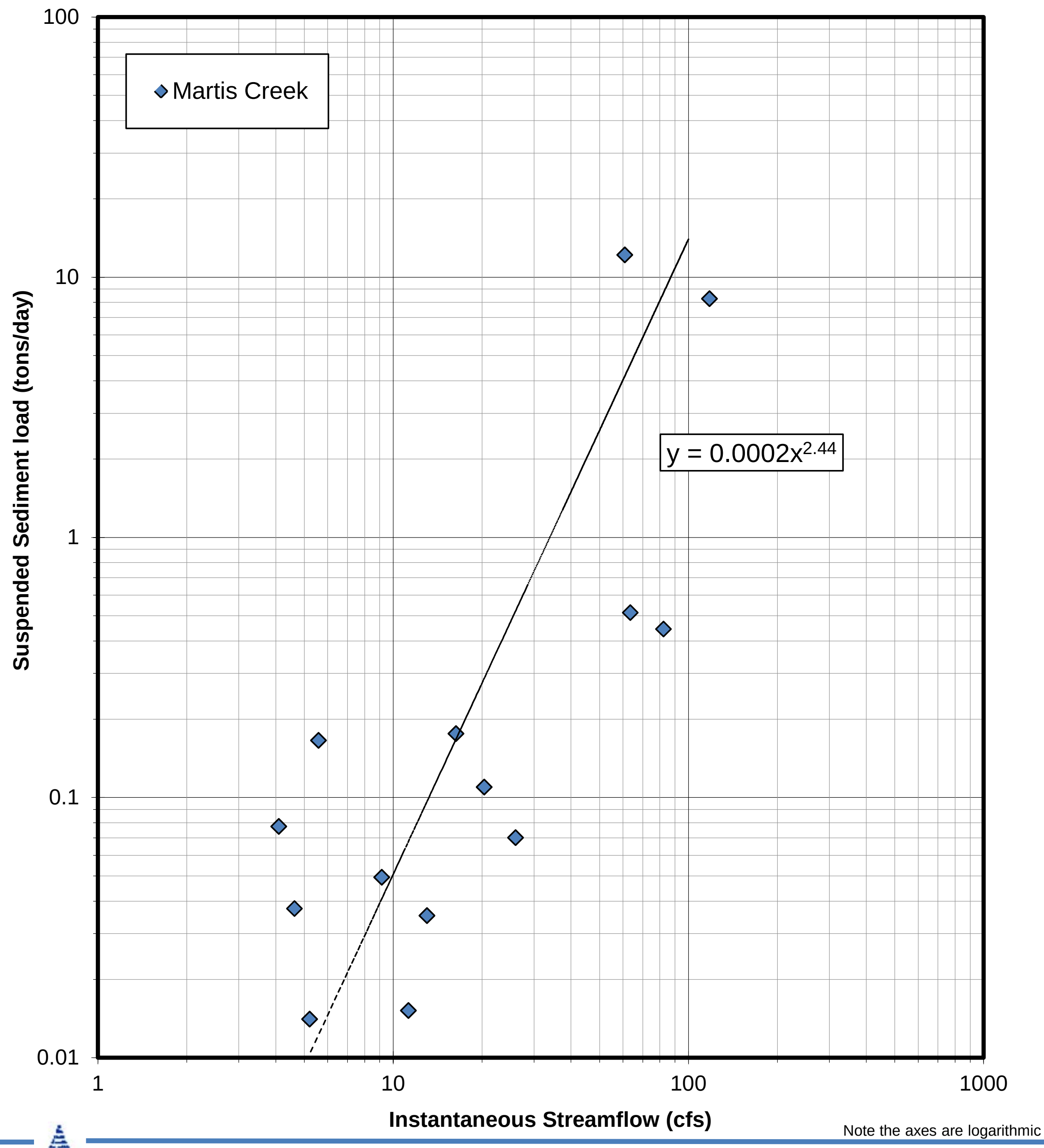

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Figure 5-40
Relationship between discharge and suspended-sediment load, Martis Creek, WY 2013.

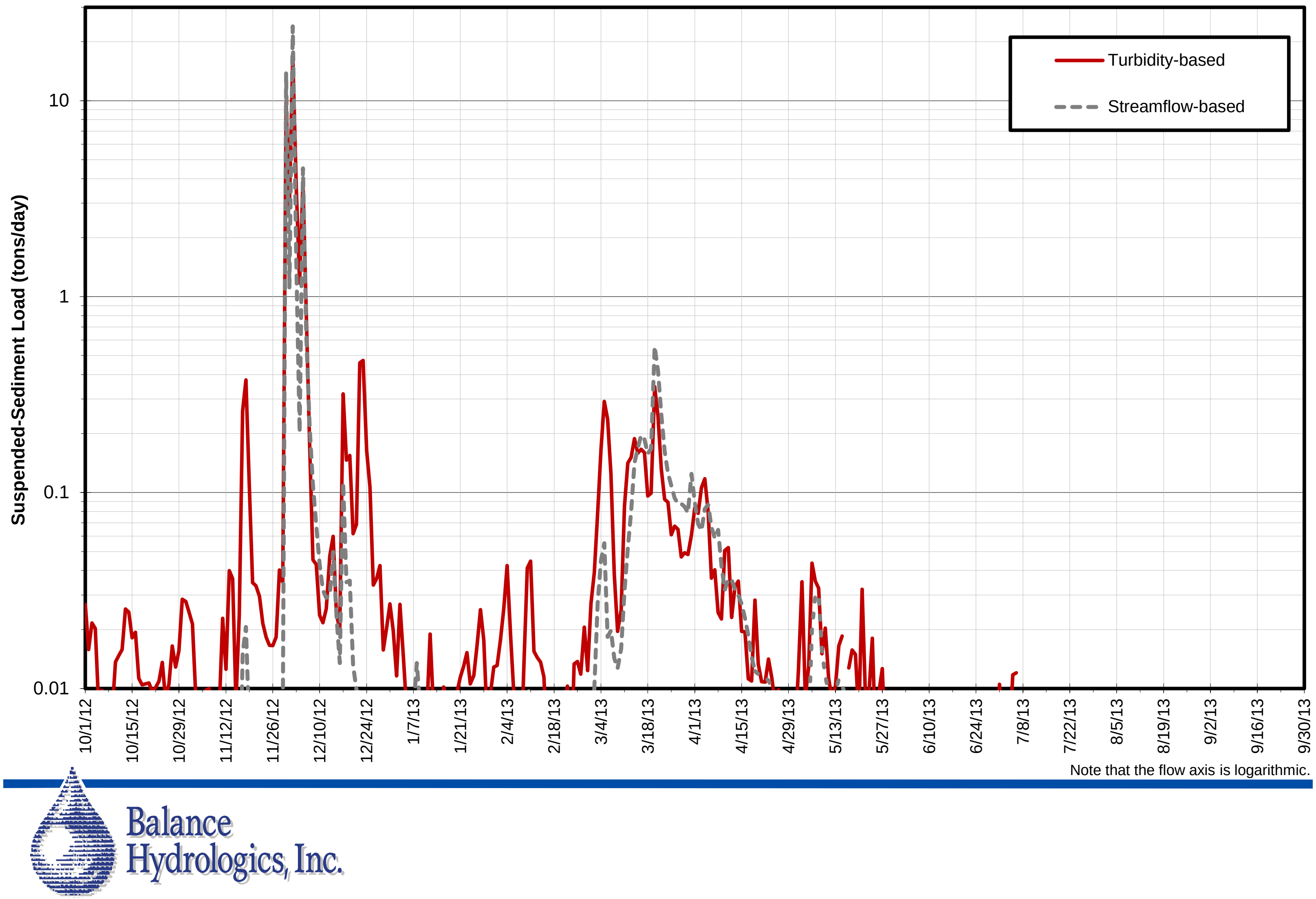

Figure 5-41
Daily suspended-sediment load, comparison between turbidity-based and discharge-based methods, Martis Creek (TURB-MC2), WY 2013.

5.4.1.3 Truckee River above Truckee (TURB-MS3)

Monitoring Results

Appendix E includes a log of samples collected and analyzed for SSC with associated computed suspended-sediment loading rates at Truckee River above Truckee for WY 2013.

A continuous record of turbidity for Truckee River above Truckee (TURB-MS3) for the period from January 18 to September 30, 2013 is provided in Figure 5-42. Initially, high biological activity in the river impeded accurate turbidity values, so weekly probe cleaning was initiated to minimize probe fouling. Similarly, short periods of high turbidity values were recorded on a daily basis at the same time. Subsequent observations identified values were artificial and caused by a short period of direct sunlight on the probe. In these cases, the turbidity record was corrected based on field measurements of turbidity. Turbidity values (corrected) ranged between 0.5 NTU during baseflow to over 325 NTU during the July 3, 2013 thunderstorm event. During the period of peak snowmelt runoff, turbidity rarely exceeded 10 NTU. Other small spikes in turbidity in the record, unassociated with increases in discharge or sunlight interference, may be associated with upstream disturbances, bank failures, tree fall, or releases from Lake Tahoe. Note that the partial record of turbidity does not include the annual peak flow on December 2, 2012.

Suspended-Sediment Loads

Figure 5-43 shows the current relationship, best described by an ‘eye’ fit power function, between turbidity and SSC at Truckee River above Truckee (TURB-MS3).

Figure 5-44 shows the relationship between instantaneous discharge and suspended-sediment load, computed from samples collected and analyzed for SSC during WY 2013.

A summary of daily and annual suspended-sediment loads in the Truckee River above Truckee is presented in Form 3 of Appendix E. It provides a comparison between the methods for the partial record when turbidity data were available, and we provide a total annual load computed using the record of discharge. Results from both methods are graphically compared in Figure 5-45.

For the partial record, when turbidity data were available, loads totaled 432 tons for the turbidity-based method, and 731 tons for the discharge-based method. The difference in loads calculated between the two methods may be associated with the limited sampling during releases from Lake Tahoe (early June through mid-September). As shown in Figure 5-45, Lake Tahoe releases after June 10, 2013 resulted in increases in calculated suspended-sediment loads using the discharge-based method, with limited increases according to the continuous record of turbidity, suggesting that discharge to suspended-sediment rating curve may be overestimating loads during periods of Lake Tahoe releases.

Total annual loads at this station in WY 2013 can only be computed using the discharge-based method and a preliminary rating curve, since near-continuous turbidity equipment was not installed until January. An estimated annual load of 1,297 tons was computed, of which 357 tons (27 percent) were measured on December 2, 2012, during the annual peak flow. This multi-day, rain-on-snow event (November 30 – December 2, 2012) generated approximately 450 tons of suspended-sediment or 34 percent of the total annual load. Suspended sediment transport during the peak snowmelt period (March 31-April 30, 2013) was calculated to be 32 tons, approximately 2 percent of the total annual load.

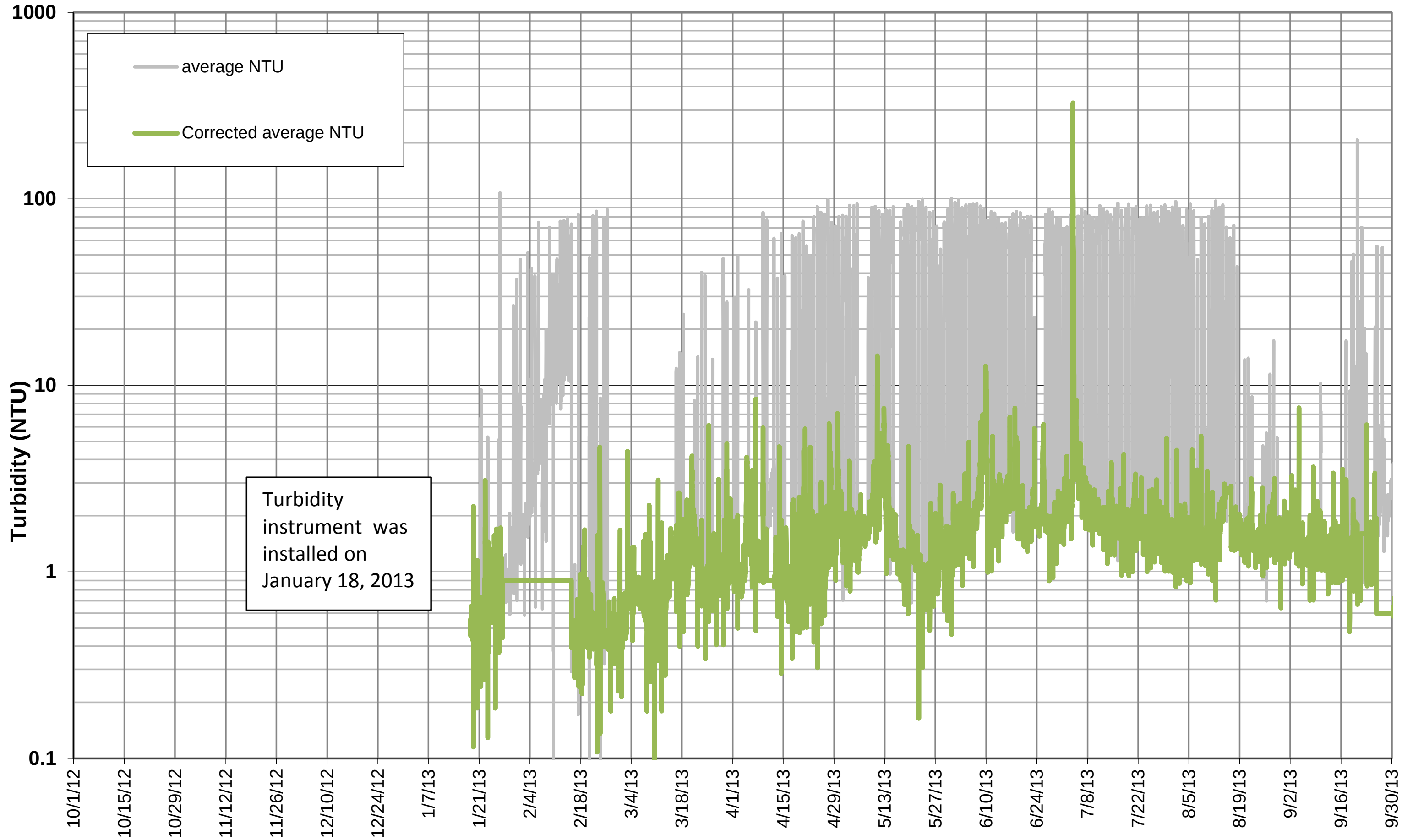

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Figure 5-42
Near-continuous record of turbidity, Truckee River above Truckee, WY 2013

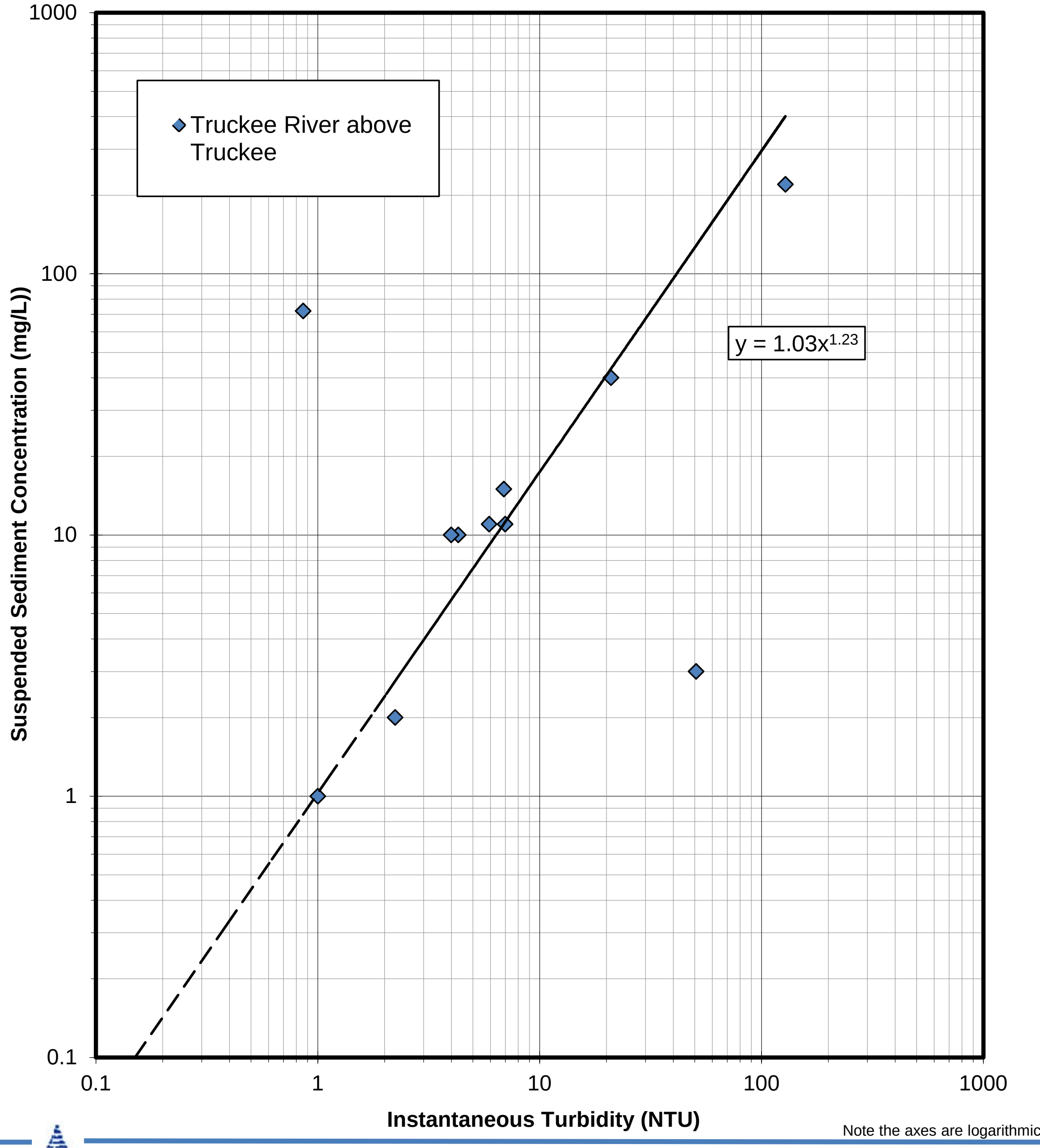

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Figure 5-43
Relationship between turbidity and suspended-sediment concentration, Truckee River above Truckee (TURB-MS3), WY 2013.

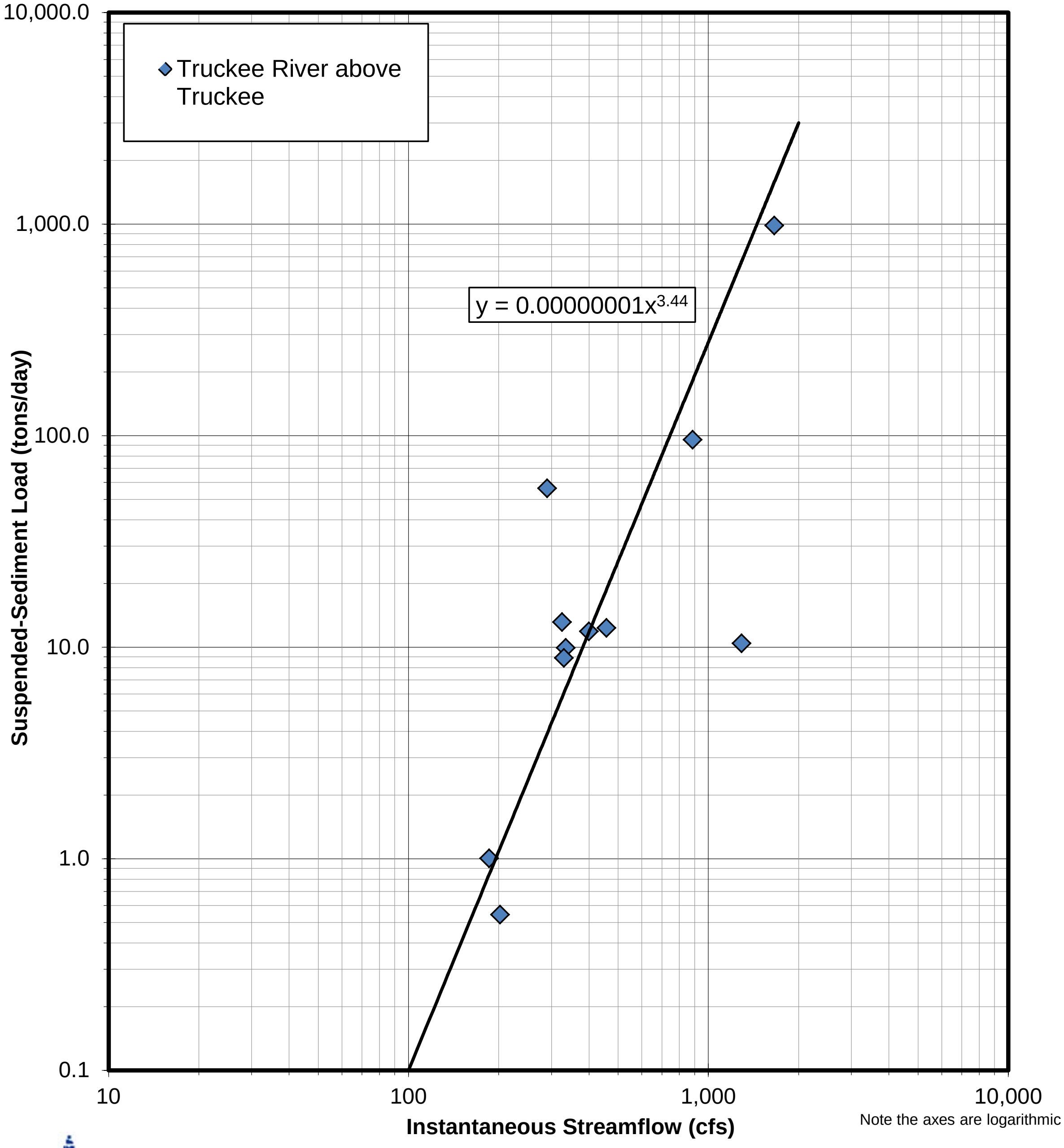

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Figure 5-44
Relationship between discharge and suspended-sediment load, Truckee River above Truckee (USGS 10338000), WY 2013.

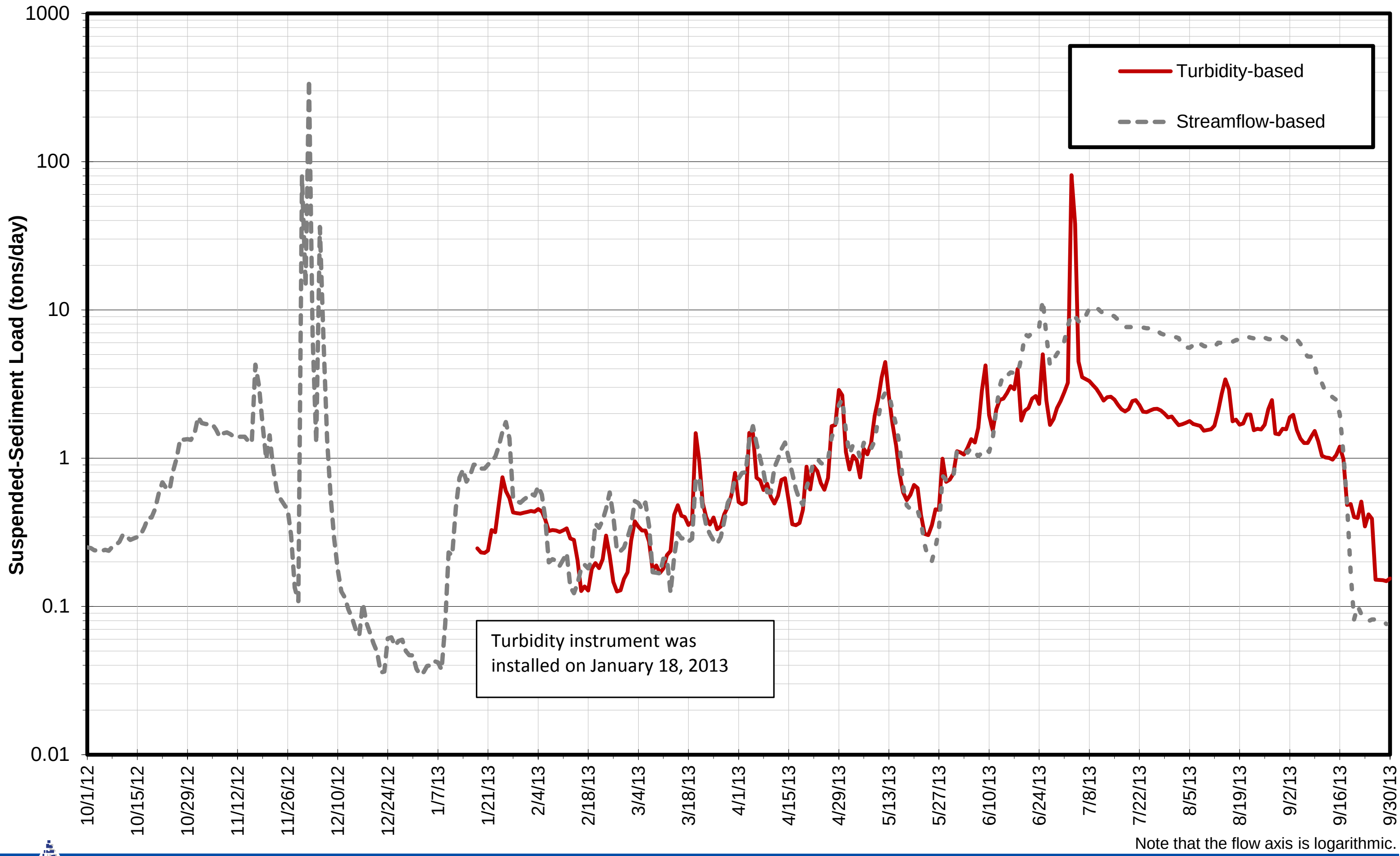

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Figure 5-45
Daily suspended-sediment load, comparison between turbidity-based and discharge-based methods, Truckee River above Truckee (TURB-MS3), WY 2013.

5.4.1.4 Truckee River at Boca Bridge (TURB-TT1)

Monitoring Results

Appendix E is a log of samples collected and analyzed for SSC with associated computed suspended-sediment loading rates at Truckee River at Boca Bridge in WY2013.

A continuous record of turbidity for Truckee River at Boca Bridge (TURB-TT1) for partial WY2013 (January 18 – September 30, 2013) is provided in Figure 5-46. Initially, high biological activity in the river impeded accurate turbidity values, so weekly probe cleaning was initiated to minimize probe fouling. Corrected turbidity values ranged between 1.5 NTU during baseflow to over 150 NTU during a thunderstorm event on July 3, 2013. Similar to the upstream location, the period of peak snowmelt runoff rarely exceeded 10 NTU and mostly registered below 5 NTU. Other small spikes in turbidity were also recorded, and may be associated with upstream disturbances, bank failures, and/or dam releases. Note that the partial record of turbidity does not include the annual peak flow on December 2, 2012 and, therefore, does not include a potentially large component of the total annual load.

Suspended-Sediment Loads

Figure 5-47 shows the current relationship between turbidity and SSC at the Truckee River at Boca Bridge (TURB-TT1) site for WY 2013.

Figure 5-48 describes the relationship between instantaneous discharge and suspended-sediment load computed from samples collected and analyzed for SSC during WY 2013. A single sample collected during a summer thunderstorm plots separate from the rest of the data set and suggests possible higher loading rates for this type of event. Future monitoring will focus on sampling during these events to evaluate if this trend continues.

A summary of daily and annual suspended-sediment loads in the Truckee River at Boca Bridge is provided in Form 4 of Appendix E. It provides a comparison between the methods for the partial record when turbidity data were available, and provides a total annual load computed using the record of discharge. Results from both methods are graphically compared in Figure 5-49.

For the partial record, when turbidity data were available, loads totaled 1,105 tons for the turbidity-based method, and 1,138 tons for the discharge-based method. While these totals are similar, the turbidity-based method captures discrete events that are not identified using the discharge-based method. At this station the isolated thunderstorm on July 3 generated an estimated 50 to 70 tons of suspended-sediment loading on that day based on the turbidity record, while the discharge-based record showed no increase. This comparison highlights the advantages of a near-continuous record of turbidity.

Total annual loads at the Truckee River at Boca Bridge in WY 2013 can only be computed using the discharge-based method and a preliminary rating curve, since near-continuous turbidity equipment was not installed until January. An estimated annual load of 3,104 tons was computed, of which 948 tons (31 percent) were measured on December 2, 2012, during the annual peak flow which was characterized as a rain-on-snow event. Similar to upstream stations, this is in contrast to the loads (164 tons) estimated during the peak snowmelt period (March 31-April 30, 2013) which translates into approximately 5 percent of the total annual load.

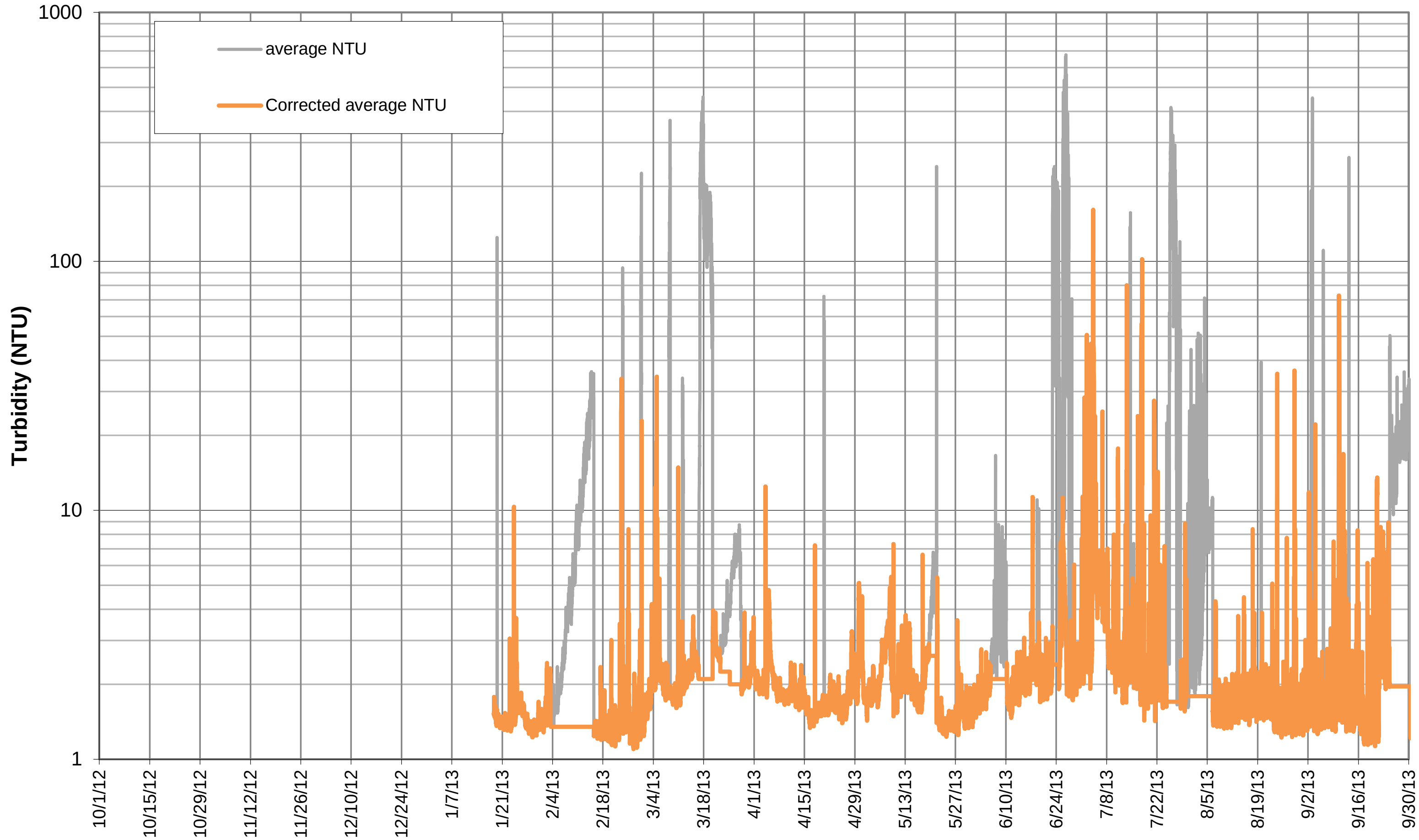

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Figure 5-46
Near-continuous record of turbidity, Truckee River at Boca Bridge (TURB-TT1),WY 2013.

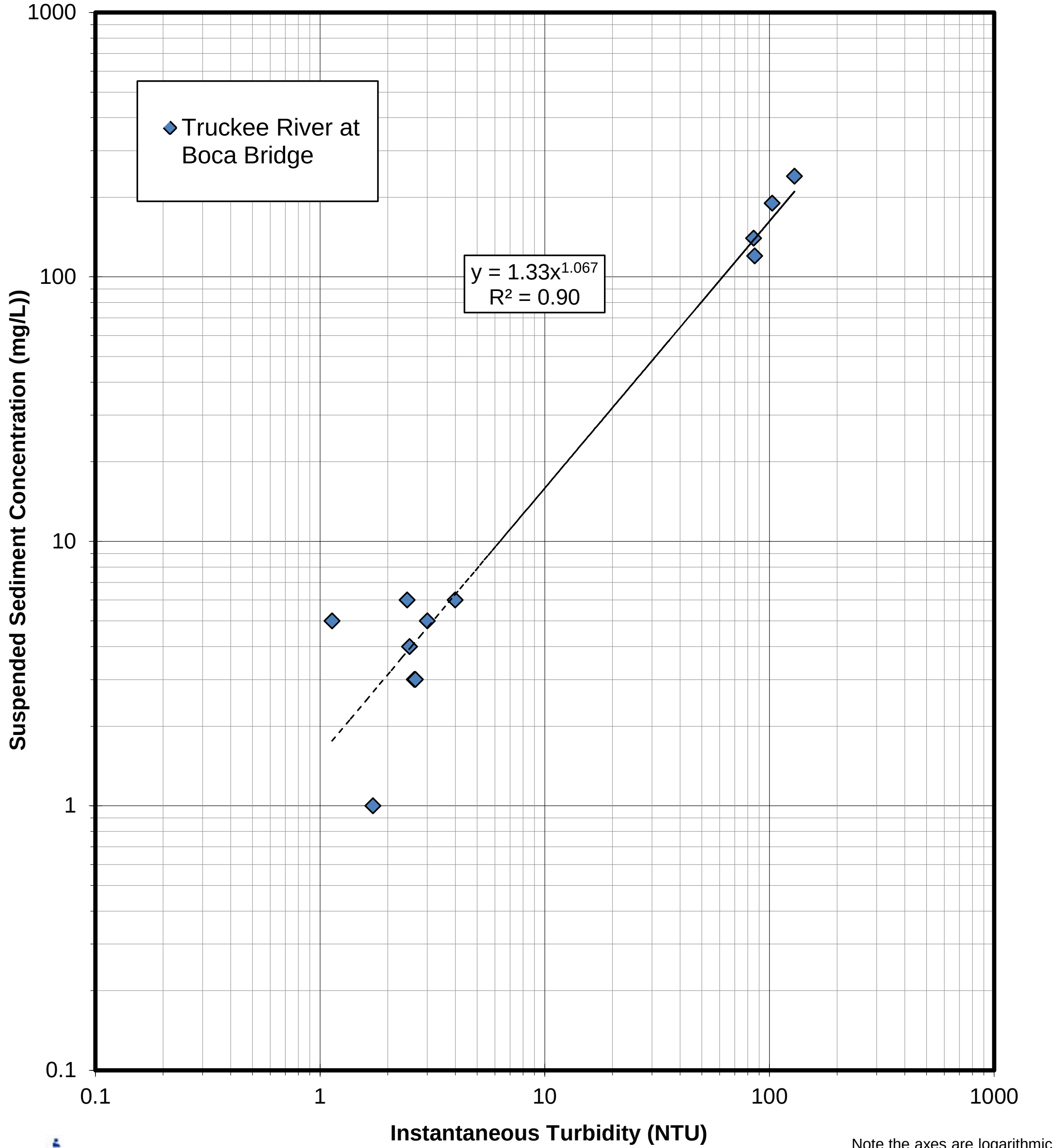

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Figure 5-47
Relationship between turbidity and suspended-sediment concentration, Truckee River at Boca Bridge (TURB-TT1), 2013.

CDM Smith

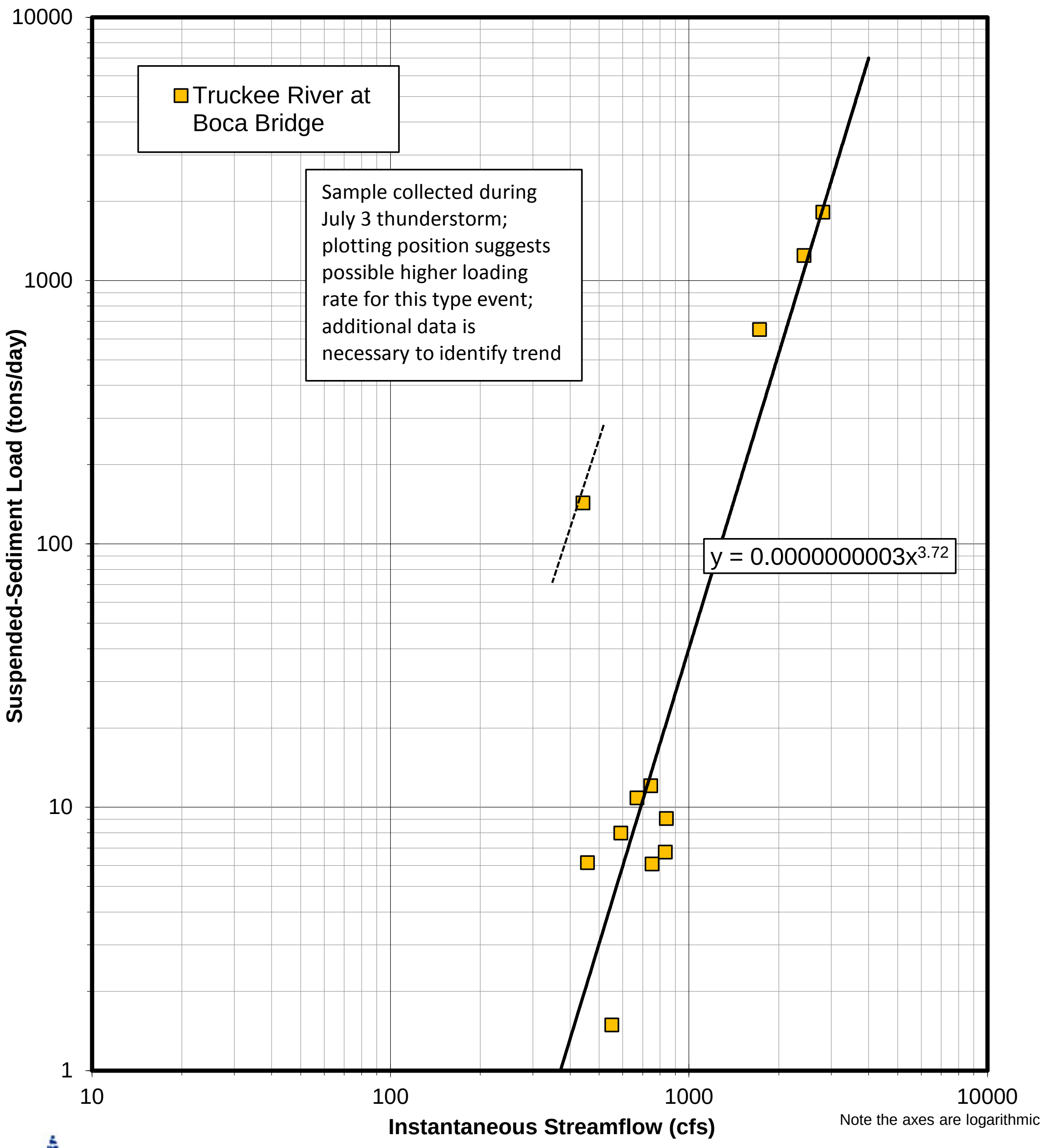

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Figure 5-48
Relationship between discharge and suspended-sediment load, Truckee River at Boca Bridge (TURB-TT1), WY 2013.

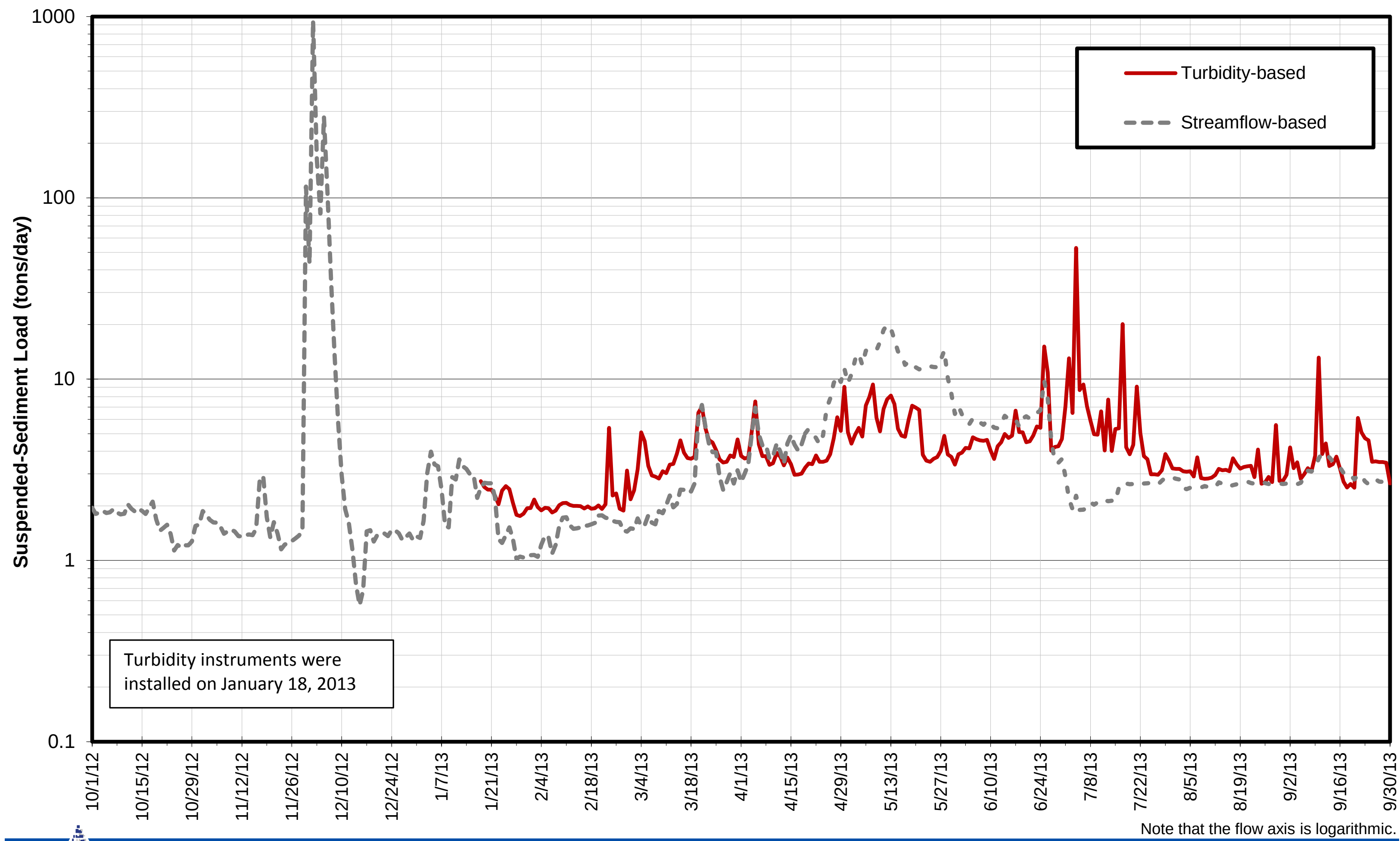

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Figure 5-49
Daily suspended-sediment load, comparison between turbidity-based and discharge-based methods, Truckee River at Boca Bridge (TURB-TT1), WY 2013.

5.4.2 Suspended-Sediment TMDL Comparison

In this section, the 15-minute, continuous record of discharge and turbidity is utilized to compute suspended-sediment load durations for WY2013. This enables the comparison of station values to benchmark load limits established under the Middle Truckee River Sediment TMDL. The Lahontan Regional Water Quality Control Board (LRWQCB) identified 25 mg/L as being at the lower end (most protective) of the range of values to protect juveniles, larvae, and eggs, as well as adult fish. The suspended sediment target is expressed as an annual 90th percentile value; therefore, up to 10 percent of the data could fall above 25 mg/L and still be within the benchmark limit. The 90th percentile was chosen because it allows for seasonal or short-term variability while still fully supporting aquatic life beneficial uses under USEPA policy (Amorfini and Holden, 2008).

The results from WY 2013, which is the first year of a multi-year study for suspended-sediment loading along the main stem of the Truckee River, is presented in this section. Benchmark load limits based on the 25 mg/L target were computed using continuous 15-minute discharge at this station. Each data point represents an average 15-minute turbidity value, converted to SSC and then to a load. These data are ranked by flow such that low magnitude, high frequency events are plotted towards the right end of the plot and high magnitude, low frequency events are plotted towards the left end of the plot. Data that plots above the benchmark load limit exceeds that limit. Note that since the turbidity instruments weren't installed until January 18, 2013, the evaluation is not for the full water year and excludes suspended sediment loads associated with annual peak flow on December 2, 2012. It is presumed that this event was likely a significant suspended-sediment loading event upon review of the preliminary discharge-based record of loading.

When considering the results presented below, it is important to note that that WY 2013 was a very dry year, and data from other year types (i.e., wet, average) are needed to assess seasonal variability. Furthermore, it is noted that although results demonstrate that the TMDL target was met in WY 2013, other assessments, such as the on-going benthic macroinvertebrate bioassessments (Herbst, 2011), suggest continued impairment of aquatic habitat in the Middle Truckee River.

5.4.2.1 Truckee River above Truckee

Figure 5-50 illustrates a suspended-sediment load duration curve for the Truckee River above Truckee using continuous 15-minute record of turbidity for partial WY2013 (January 18-September 30, 2013). In this case, only 0.09 percent of the data exceed the benchmark load limit, far below the allowable 10 percent exceedance. Data that did exceed this limit were associated with a summer thunderstorm event on July 3, 2013.

5.4.2.2 Truckee River at Boca Bridge

Figure 5-51 illustrates a suspended-sediment load duration curve for the Truckee River at Boca Bridge using continuous 15-minute record of turbidity for partial WY 2013 (January 18-September 30, 2013). In this case, only 0.3 percent of the data exceed the benchmark load limit, far below the allowable 10 percent exceedance. Data that did exceed this limit were associated with summer thunderstorms.

5.4.2.3 Truckee River at Farad

Figure 5-52 illustrates a suspended-sediment load duration curve for the Truckee River at Farad using continuous 15-minute record of turbidity collected by the California Department of Water Resources (DWR). DWR, with the Nevada Department of Environmental Protection (NDEP), operate and maintain a turbidity station at the USGS stream gauge station at Farad—the station where the TMDL benchmark limits were established.

As discussed further in Section 6, a turbidity-SSC correlation developed at Truckee River at Boca Bridge was used to compute a near-continuous record of suspended-sediment loading in the absence of a station correlation. In this case, roughly 1.3 percent of the data exceed the benchmark load limit, below the allowable 10 percent exceedance. Data that exceeded this limit were associated with rain-on-snow and summer thunderstorms.

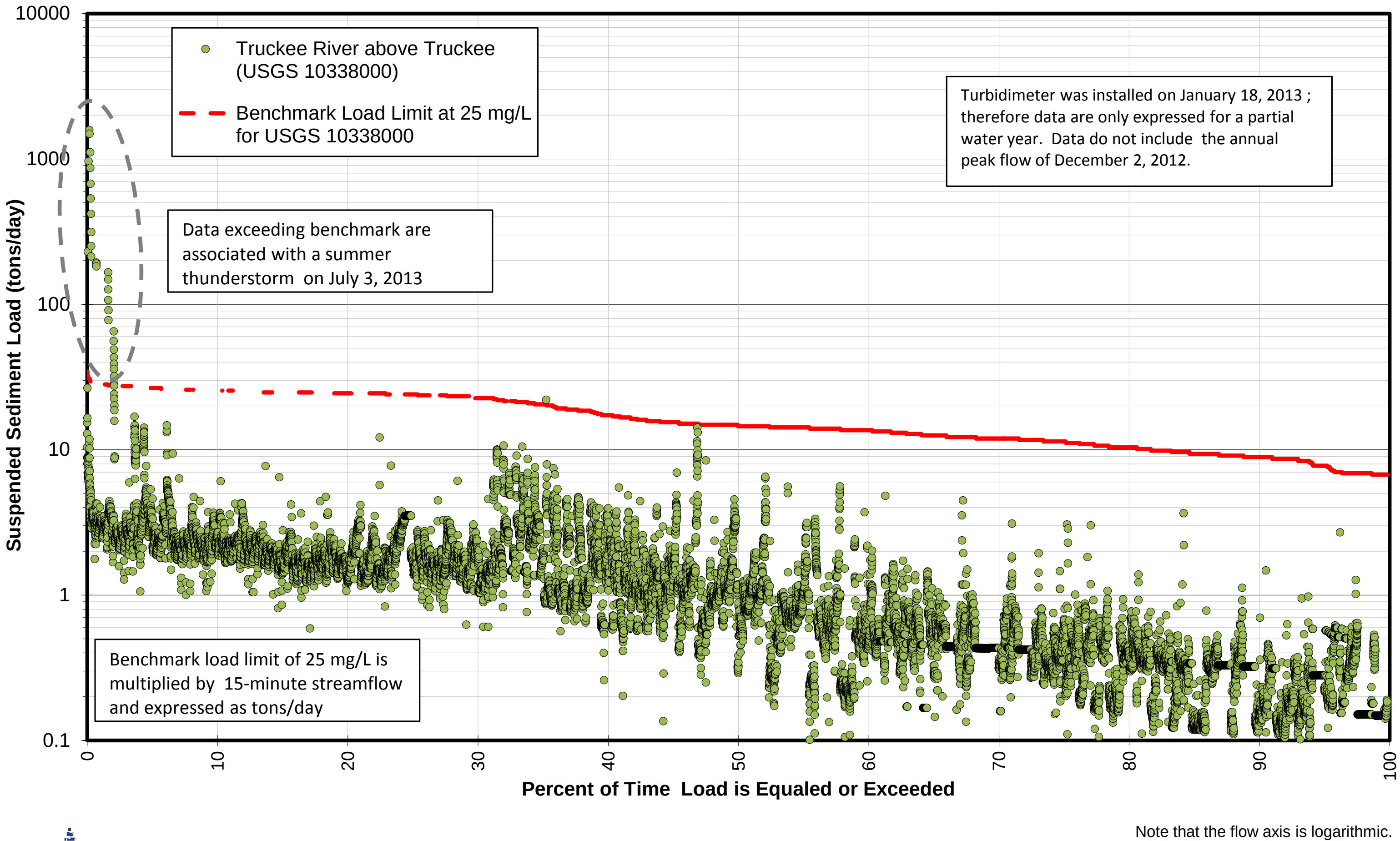

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Figure 5-50
Suspended-sediment load duration curve, Truckee River above Truckee (USGS 10338000), Placer County, California, partial water year 2013 (January 18 - September 30, 2013).

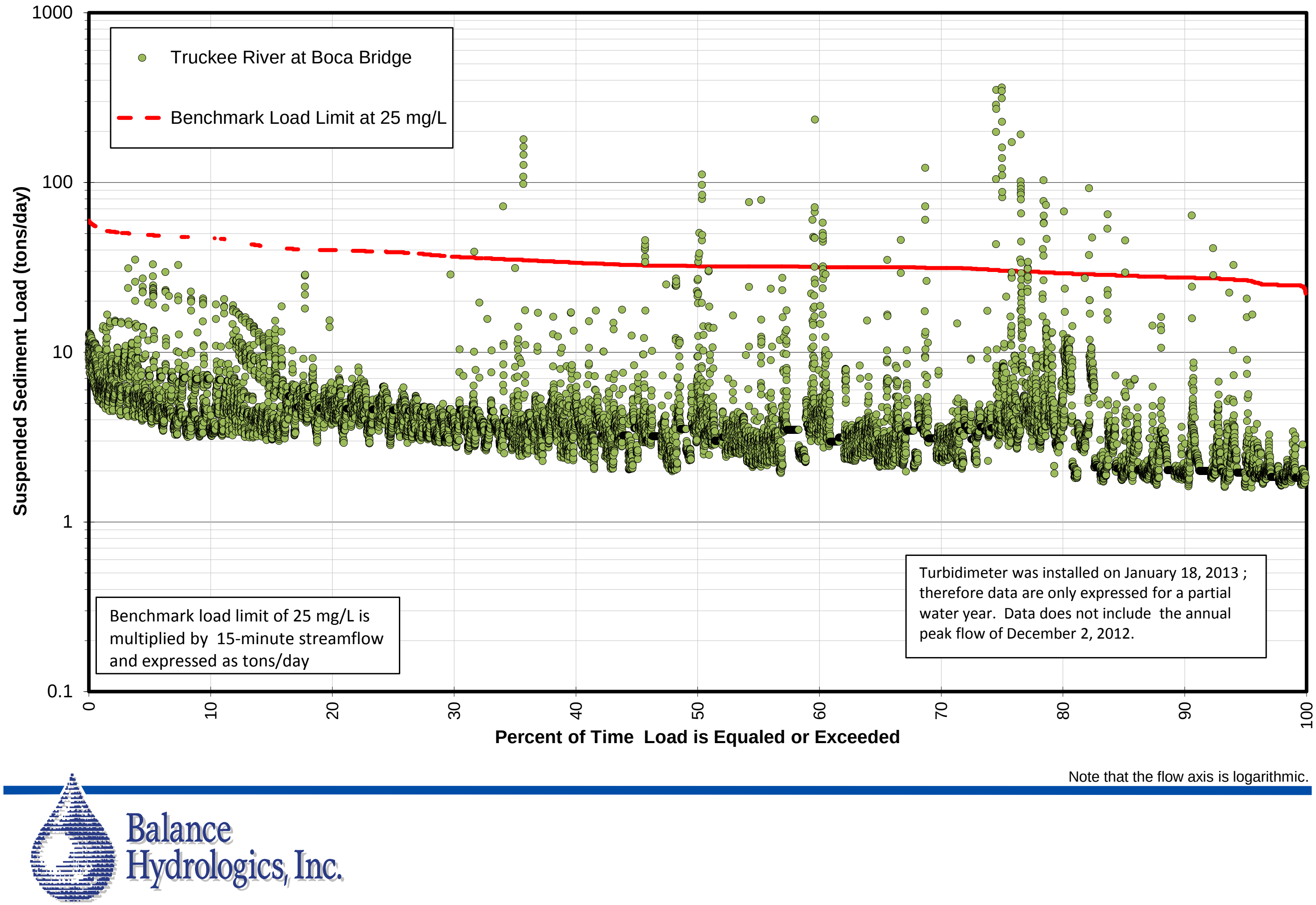
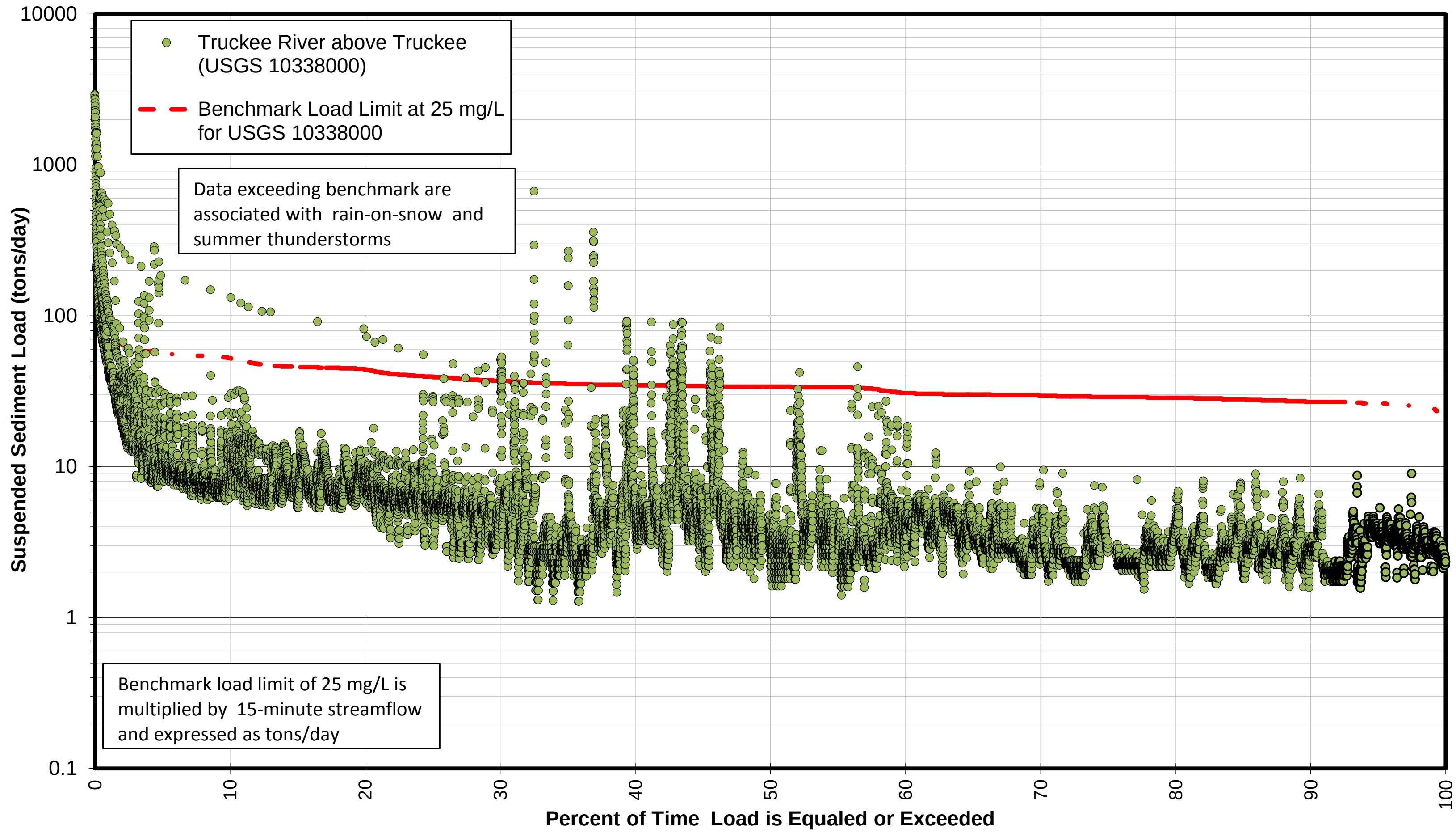


Figure 5-51
Suspended-sediment load duration curve, Truckee River at Boca Bridge (TURB-TT1), Nevada County, California, water year 2013.

CDM Smith



Note that the flow axis is logarithmic.

Figure 5-52
Suspended-sediment load duration curve, Truckee River at Farad (USGS 10346000), Placer County, California, water year 2013.

5.4.3 Additional Martis Creek Watershed Loads

In addition to the suspended-sediment loads presented above, pollutant loads for additional constituents were calculated for the Martis Creek Watershed based on annual discharge and results from the tributary level monitoring. The annual discharge at each tributary sampling location was estimated based on the measured discharge at the three Martis gauging stations (Sites GS-MC1, TURB-MC2, and TURB-MC3), and the size of each tributary's sub-watershed as a percentage of the total watershed size. This approach requires the assumption that the precipitation, and runoff response in the tributaries, was uniform over the entire watershed. Although differences in elevation, impervious area, land use, and other factors, likely caused variation in the amount of runoff produced in each watershed, this assumption is considered to be reasonable for the purpose of developing initial, relative annual load estimates. A map displaying the location of each tributary sampling location and their corresponding sub-watersheds is presented in Figure 5-53.

The tributary areas and relative discharge volumes for each of the Martis Creek sub-watersheds is presented in Table 5-15 and the pollutant load estimates for WY 2013 are presented in Table 5-16. The total load at each site is dependent on both the mean concentration from sampled runoff events and the discharge of the tributary. However, since the mean concentrations from tributary sampling are representative of peak flow periods, use of the mean concentration overestimates the actual loading of each tributary. To account for this, the WY 2013 load estimates presented in Table 5-16 were calibrated according to results of the near-continuous turbidity monitoring. This involved decreasing the TSS load at site DST-MC5 by 15 percent to match the 50 ton estimated annual load at site TURB-MC2. This 15 percent reduction was then applied to all constituents at all sites assuming that pollutant relationships are similar for each stream. This method will be refined in future years as data collection continues.

In Table 5-16, site DST-MC1 had the largest loads because it receives flow from the entire Martis Creek watershed. Each of the other tributary sites only receives a portion of this total flow. The pollutant loads at each tributary site generally correlated with each site's total annual discharge. A comparison of the total pollutant load per acre of watershed (the summation of TSS, total phosphorus, and total nitrogen) for WY 2013 shows DST-MC4 (West Martis Creek) and DST-MC5 (Upper Martis Creek) had the greatest pollutant loads with values of 13 and 12 pounds per acre, respectively. The remaining sites ranged from 5 to 10 pounds per acre. Of these values, TSS accounts for more than 90 percent of the pollutant loading at each site.

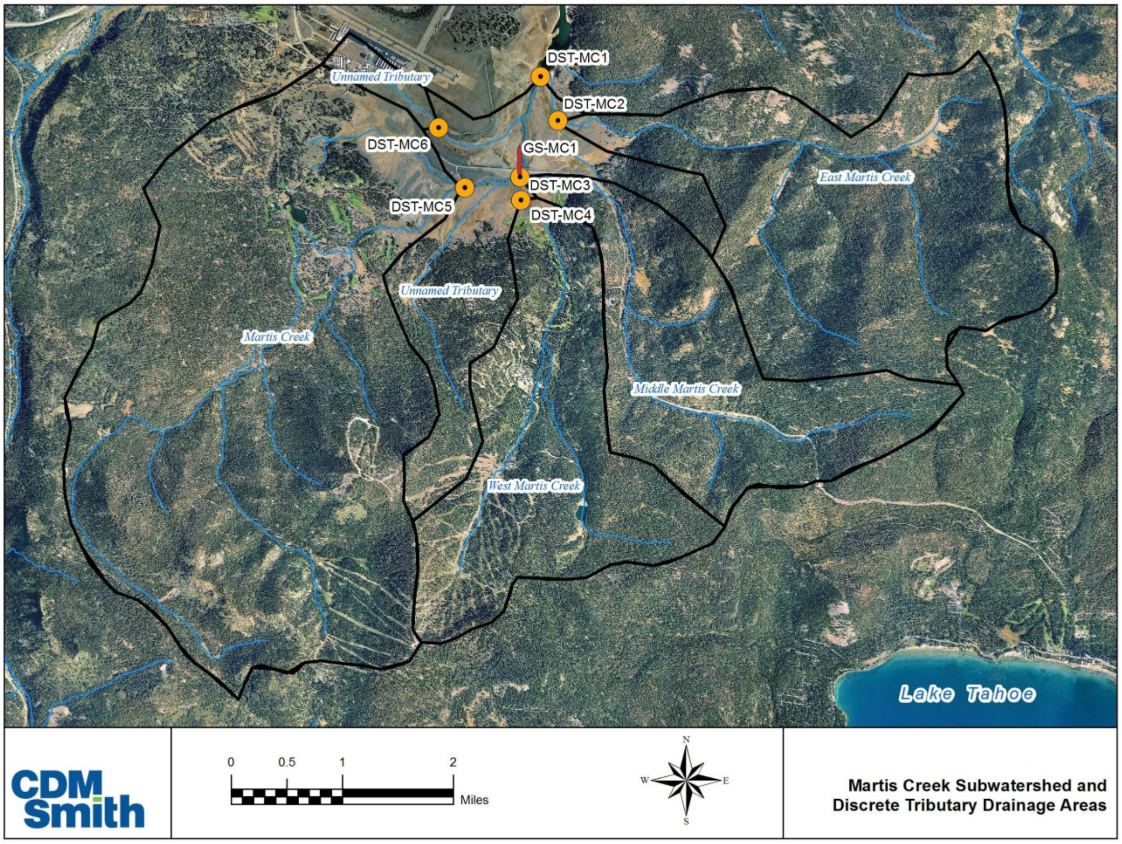


Figure 5-53
Martis Creek Tributary Monitoring Sites and Sub-Watersheds

Table 5-15. Martis Creek Tributary Annual Discharge Volumes

Station ID	Drainage Area (ac)	Percent of Martis Creek Sub-watershed	WY 2011 Total Flow (acre-ft)	WY 2012 Total Flow (acre-ft)	WY 2013 Total Flow (acre-ft)
DST-MC1	21,900	100%	31,334	8,370	7,150
DST-MC2	4,550	21%	6,510	1,739	1,486
DST-MC3	3,000	14%	4,292	1,147	979
DST-MC4	3,200	15%	4,578	1,223	1,045
DST-MC5	8,800	40%	12,591	3,363	***3,610***
DST-MC6	200	1%	286	76	65
GS-MC1	16,250	74%	***23,426***	***6,211***	***5,305***

Note: Bold italic values represent gauging station measurements.

Table 5-16. WY 2013 Martis Creek Tributary Load Estimates

Station ID	Drainage Area (ac)	TSS			Total Nitrogen			Total Phosphorus		
		Mean (mg/L)	Load (ton)	Yield (lb/ac)	Mean (µg/L)	Load (lb)	Yield (lb/ac)	Mean (µg/L)	Load (lb)	Yield (lb/ac)
DST-MC1	21,900	12	102	9.3	501	8,185	0.37	76	1,248	0.06
DST-MC2	4,550	6	11	4.7	380	1,291	0.28	58	197	0.04
DST-MC3	3,000	10	12	7.7	399	892	0.30	77	173	0.06
DST-MC4	3,200	16	14	12.3	502	1,197	0.37	80	191	0.06
DST-MC5	8,800	12	50	11.6	423	3,493	0.40	91	750	0.09
DST-MC6	200	8	0.6	6.1	735	110	0.55	91	14	0.07

Section 6

Discussion

The following discussion is based on an integration of results from the various assessment types performed during WPY 2013 and prior years. Information regarding water quality areas of concern, SWMP performance and the prioritization of the existing TRWQMP elements is also included.

6.1 Integration of the Assessment Data

The results of various assessment types were evaluated from a holistic perspective to determine whether they support, or conflict with, one another and if any additional conclusions or observations can be made. The discussions are organized by watershed including Martis Creek and the Town of Truckee corridor. Although RAM and bioassessments were not conducted during WY 2013, the results from previous years are also included in this discussion. The annual monitoring reports from previous water years should be reviewed for more detailed information regarding these assessment types.

6.1.1 Martis Creek

The monitoring assessment types conducted within the Martis Creek watershed include RAM and bioassessments (WY 2010, 2012), community level discrete water quality sampling (WY 2011-2013), tributary level discrete water quality sampling (WY 2011-2013), stream discharge monitoring (WY 2011-2013), and near-continuous turbidity monitoring (WY 2013).

In Martis Creek, the RAM surveys were conducted along stream intervals that either included, or were near, the bioassessment sites and community and tributary level water quality sampling sites. The RAM results for the Martis Creek watershed from WY 2012 indicate that West Martis Creek contains the highest percentage of fine substrate with a value of 38 percent.

The results of the community and tributary level water quality monitoring tend to support the RAM results in the Martis Creek watershed. The streams with high percentages of fine substrate identified in the RAM were also observed to contain the highest TSS concentrations at their respective tributary sites and in the stormwater runoff discharging to that channel. Site DST-MC4, which is in West Martis Creek, has the second highest mean concentration of TSS behind only DST-MC1 which is in the main stem of Martis Creek near the Martis Creek Reservoir. Also, while stormwater treatment controls upstream of site DSC-MC3 are providing benefits, moderate TSS concentrations have been observed at this site. This outfall, and others in the Northstar community that discharge into West Martis Creek, are likely contributing to the higher fine sediment percentages observed in the RAM and elevated TSS levels at site DST-MC4.

Stream discharge monitoring and near-continuous turbidity monitoring enabled the estimation of annual pollutant loads and yields for the major tributaries in the Martis Creek watershed. The largest pollutant yields for WY 2013 occurred at DST-MC4 and DST-MC5 which are the most developed sub-watersheds. The total WY 2013 suspended-sediment load at DST-MC1, at the mouth of Martis Creek, was approximately 100 tons, which may, overtime, impact the storage capacity in the reservoir. For comparison purposes, this load equates to approximately 3 percent of the total suspended-sediment load measured in the Truckee River at the Boca Reservoir bridge. This indicates that the Martis Creek watershed is not a large contributor of suspended-sediment to the Truckee River especially considering that settling is likely occurring in the Martis Creek Reservoir. No monitoring is being conducted downstream of the Martis Dam under this program and therefore the suspended sediment load entering the Truckee River from Martis Creek has not been determined.

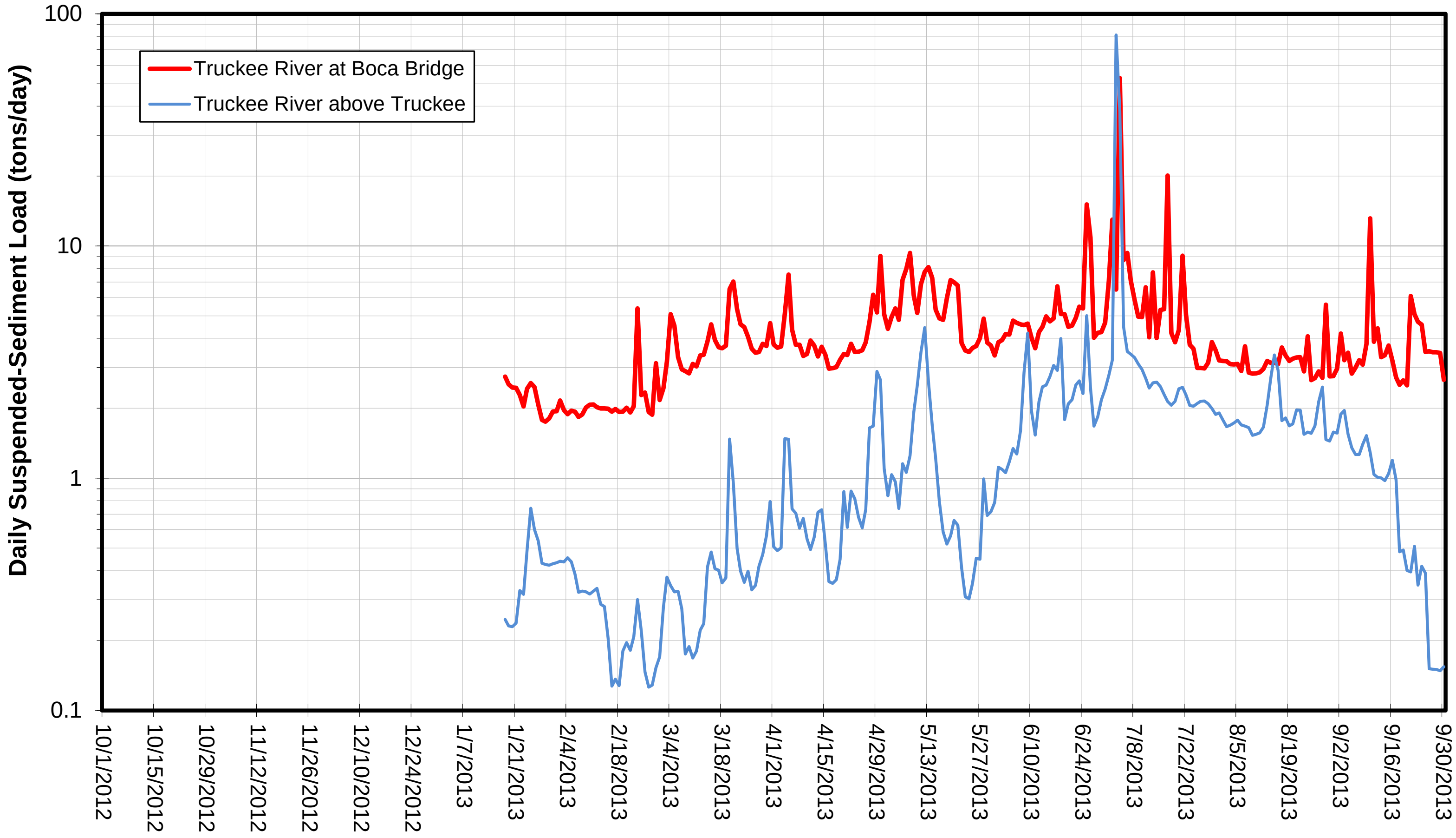
Bioassessment results from WY 2010 and WY 2012 indicate that the surveyed reaches that are located upstream of the developed areas ranked higher (more healthy) than the respective downstream reaches in terms of the biological metrics used to evaluate the streams.

6.1.2 Town of Truckee Corridor

The monitoring assessment types conducted in the Town of Truckee corridor include RAM (WY 2010 and WY 2012), community level discrete water quality monitoring (WY 2010-2012), and near-continuous turbidity monitoring (WY 2013).

RAM surveys were conducted during WY 2010 and WY 2012 on Donner Creek, Trout Creek, and prioritized locations of the Truckee River. The results of the Truckee River RAM did not indicate high percentages of fine substrate despite a very high percentage in Trout Creek and elevated TSS concentrations at the community level monitoring sites discharging into the Truckee River throughout the downtown corridor. Trout Creek had the highest percentages of fine sediment on the channel bottom of all surveyed stream segments. The results of the Donner Creek RAM did not indicate high percentages of fine substrate, despite turbid flows that were sometimes observed, likely due to the higher energy flows in this segment of Donner Creek. The integration of results indicates that most fine sediment is discharged to the Truckee River from areas of high vehicle traffic where traction sand is used and is then transported downstream where it settles in lower energy reaches downstream and along the channel fringes where velocities are slow.

A comparison of daily suspended-sediment loads (preliminary) above and below the Town of Truckee is presented in Figure 6-1 using the partial records of continuous turbidity for WY 2013. Based on the data, suspended-sediment loads in the Truckee River appear to increase in the downstream direction as it receives flow from tributaries and stormwater outfalls. In general, loads increase between 1.5 and 20 times from the upstream station (Truckee River above Truckee) to the downstream station (Truckee River at Boca Bridge). It should also be noted, however, that suspended-sediment loads were observed to decrease between the upstream and downstream monitoring sites during an isolated summer thunderstorm. On July 3, 2013, a highly intense thunderstorm, isolated over the Squaw Creek watershed upstream of Truckee, generated a storm event loading of approximately 120 tons above the Town of Truckee with a corresponding storm total of 60 tons below the Town of Truckee. Although preliminary and isolated to one recorded event, these data imply that settling and storage of suspended-sediment does occur within the Truckee River Corridor during some conditions. More detailed, and frequent, RAM, or other channel substrate, surveys may help to characterize these dynamic patterns; however, this level of monitoring intensity is beyond the scope of this study.



Note that the vertical axis is logarithmic.

Balance Hydrologics, Inc.

Figure 6-1
Comparison of daily suspended-sediment loads, Truckee River, above and below Town of Truckee, California, partial water year 2013 (January 18 - September 30, 2013).

6.1.3 Suspended-Sediment Data Integration

This section presents suspended-sediment data that has been collected within the project area for other studies and compares them to the results of the near-continuous turbidity stations in the Truckee River (TURB-MS3 and TURB-TT1). This includes comparisons to data collected from the Truckee River at Farad and data collected from Truckee River tributaries.

6.1.3.1 Comparison to Truckee River at Farad

A continuous record of turbidity was available for the Truckee River at Farad, located downstream of Boca Bridge near the Nevada state line. These data were downloaded from DWR and are provisional. Unfortunately, samples collected for turbidity and SSC analysis were not available over a wide range of discharges and, therefore, a correlation between turbidity and SSC could not be established for this station. As such, the turbidity to SSC relationship established at Boca Bridge was used to convert the available record of turbidity at Farad to an estimated record of suspended-sediment loading.

Form 5 of Appendix E shows the daily and monthly values for suspended-sediment loads for Truckee River at Farad. Figure 6-2 illustrates daily suspended-sediment loads for three stations along the Truckee River in WY 2013 based on a record of near-continuous turbidity. A comparison of monthly loads above Truckee to monthly loads at Farad when all three datasets are available indicates an increase in suspended-sediment loading through the town corridor ranging from 25 tons/month to 135 tons/month with an average of 75 tons/month. A wider range (-19 to 201 tons/month) with an average of 55 tons/month was observed using the Truckee River at Boca Bridge site suggesting that during some periods, loading is reduced below the Boca Bridge. These results may be attributed to the non-urbanized land uses along the Truckee River between Boca Bridge and Farad with the exception of Interstate-80 and the Union Pacific Railroad. However, variables other than land-use can influence suspended-sediment loading, such as geology and precipitation.

Changes in geology may be a controlling factor for loading downstream. The Truckee River originates in glaciated terrains of both volcanic and granitic geology and passes through outwash terraces and alluvium and into a largely bedrock controlled canyon. Hill and others (1989) measured 3.5 to 25 times greater suspended-sediment loads (normalized by watershed area) in tributaries draining glaciated terrains relative to non-glaciated terrains in the Tahoe Basin. The Truckee River below Boca Bridge becomes, to some degree, less influenced by glaciated terrains and landforms and more influenced by bedrock which may be reflected in the relative changes in loading seen between the monitoring stations.

Precipitation also changes between these stations and becomes increasingly drier in the downstream direction. Less rainfall, snowfall and associated runoff may also translate into less frequent loading events. Some discrete events registered at Farad and absent from upstream stations may be the result of thunderstorms over isolated portions of the lower Middle Truckee River.

In summary, due to an incomplete record of turbidity at all three stations and the uncertainty associated with variables that influence suspended-sediment loading, only general comparisons of loading between these stations can be stated at this time. The importance of these data is that when collected over longer time periods, trends can be evaluated and spatial and temporal variability can be better defined. Continued monitoring at these stations is ongoing through WY 2014.

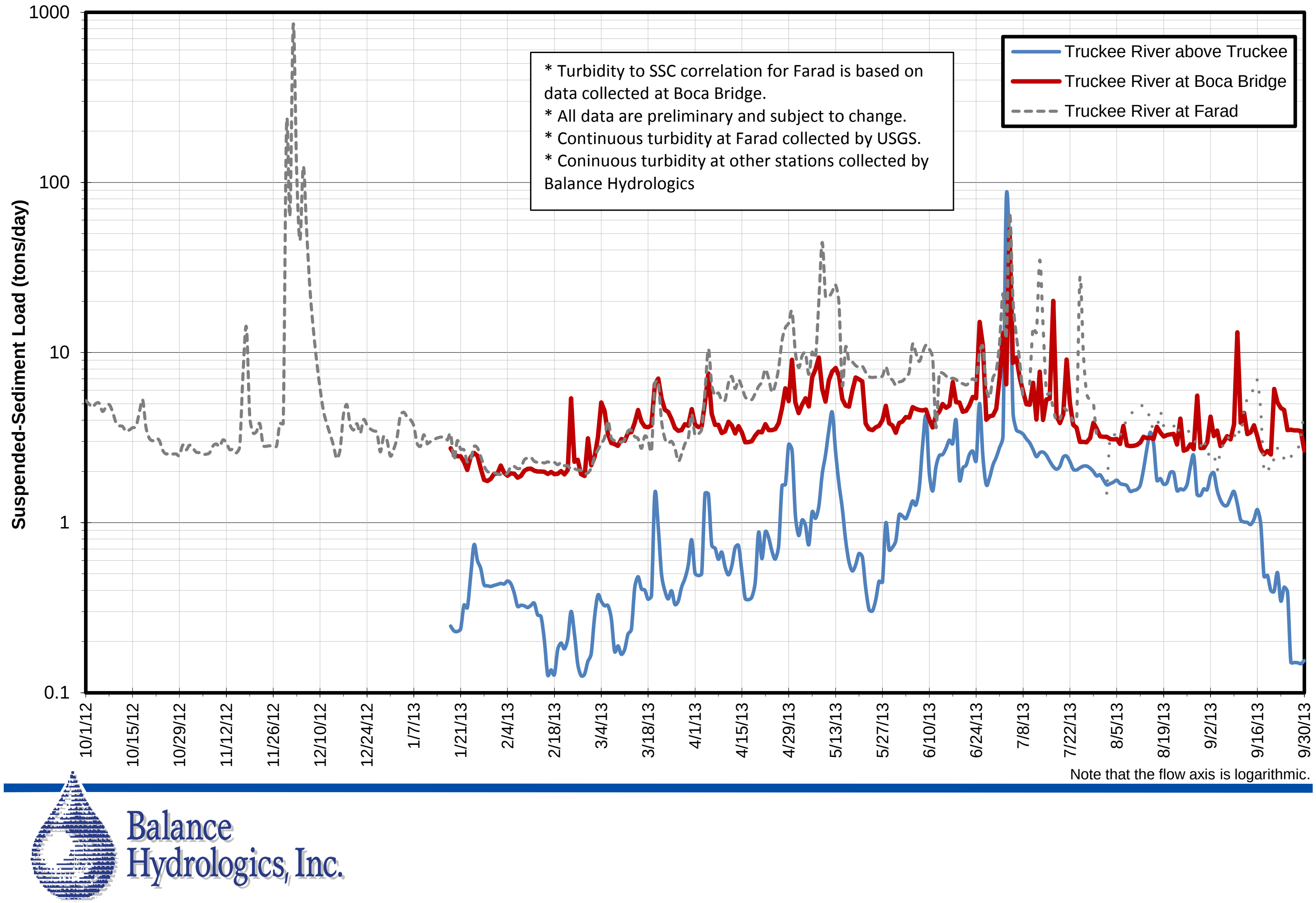


Figure 6-2
Daily suspended-sediment load based on a continuous record of turbidity, Middle Truckee River at three stations, Placer and Nevada Counties, California water year 2013.

6.1.3.2 Comparison to Middle Truckee River Tributaries

Contributions of suspended-sediment loads in tributaries to the Truckee River including Donner Creek, Cold Creek, and Trout Creek, were measured by Balance Hydrologics for the Truckee River Watershed Council (TRWC) in WY 2013. These data have not yet been published, but are used on a preliminary basis herein for initial comparison purposes. Loads were computed using near-continuous records of turbidity with the exception of Donner Creek, where loads are computed using the discharge-based method. Figure 6-3 compares total loads at these stations. The total pie-chart is equal to 3,104 tons or that measured in WY2013 at the Truckee River at Boca Bridge station. This total load can be divided into "pieces" from other upstream stations. In WY2013, assuming that Lake Tahoe does not discharge any significant suspended-sediment load implies that a large component of the load originates from the 46 square mile area contributing to the Truckee River above Truckee (1,297 tons). Assuming Donner Lake also does not discharge any significant suspended sediment load, the observed estimated sediment load of 819 tons from Donner Creek is derived from the 15.2 square mile contributing area downstream from the lake. Trout Creek, with contributing area a 4.6 square miles, had an estimated sediment load of 13.4 tons in WY2013. The remaining fraction of the sediment load, almost 1,000 tons, is likely from in-channel sources and non-point sources within the Town of Truckee Corridor. Loads from ungauged tributaries in the Town Corridor including Little Truckee River, Prosser Creek, and Martis Creek, all of which are dammed tributaries, have not been quantified.

Comparison of loads between tributaries and the main stem are better achieved by normalizing loads by contributing watershed area (i.e., tons/square mile) to develop suspended-sediment yields. In this analysis it was assumed that contributions of suspended-sediment from Lake Tahoe, Donner Lake, Boca Reservoir, Prosser Reservoir, and Martis Creek Reservoir are minor, and areas above these dams are excluded from load calculations. However, these conditions have not been verified.

Table 6-1 includes a preliminary comparison of annual flow metrics and suspended-sediment loads and yields across all stations and from multiple studies. Figure 6-4 exhibits suspended-sediment yields for the two stations on the Truckee River and two main tributaries, Trout Creek and Donner Creek. A station also exists on Cold Creek, and the yield from this tributary, as a portion of the Donner Creek yield, is also shown.

In WY 2013, results suggest that yields in the Truckee River at Boca Bridge (37.7 tons/square mile) were 25 percent higher than those measured in the Truckee River above Truckee (28.2 tons/square mile) indicating suspended-sediment concentrations increase through the Town of Truckee corridor. Measurements of suspended-sediment yields on tributaries suggest Donner Creek contributed 54 tons/square mile which is near twice the yield in the Truckee River above Truckee. The existence of a monitoring station on Cold Creek allows for further isolation of suspended-sediment sources. Figure 6-4 shows a high yield from Cold Creek (48 tons/square mile), but an even higher yield exists for Donner Creek below Cold Creek (81 tons/square mile). It is believed the higher yield may be related to the fact that Donner Creek below Cold Creek receives runoff from an urbanized area which is well connected to the creek via a storm drainage network. Non-point sources from urbanized areas within Truckee are also likely to contribute to the increased suspended-sediment yield in the Truckee River at Boca Bridge.

6.1.3.3 Turbidity Based Comparison to Previous Years

California Department of Water Resources (DWR) conducted near-continuous turbidity monitoring in water years 2002, 2003, 2006, 2010, 2011, and 2012 at the USGS discharge gaging station on the Truckee River near Truckee (USGS 10338000) also identified as TURB-MS3 in this report. These data were collected intermittently for periods ranging between 97 days and 330 days; therefore, total annual loads could not be computed. Historical records of suspended-sediment loads were computed using the relationship between instantaneous turbidity (NTU) and SSC established for this station using TRWQMP data collected by in WY2013. This approach assumes no change in this relationship over time. Daily discharge hydrographs and suspended-sediment loads for periods when turbidity were available are illustrated for WY2002, 2003, 2006, 2010, 2011, 2012 in Appendix F and summarized in Table 6-1[1].

DWR discontinued collection of turbidity at their stations each year, typically on the onset of winter, due to access limitations and effects of ice in the channel. Monitoring would typically resume in the spring between April and May and continue through the end of the water year (September 30). In many cases turbidity data was not collected during winter rain-on-snow events which are typically responsible for significant suspended sediment loading to the Truckee River. The effects of these data gaps are apparent in Table 6-1 and the much larger suspended sediment loads and yields calculated for WY2006 when DWR did capture the annual peak flood which occurred on December 31, 2005 as a rain-on-snow event. The effects of seasonal variability can be seen in years were similar time periods were monitored such as WY2011, 2012 and 2013 where loads and yields are reflective of the annual precipitation totals. The evaluation of historical data suggests that interpretation of suspended-sediment loading requires an understanding of event types and annual precipitation totals. A long-term dataset that includes data from similar water years and monitoring periods will be needed to identify and characterize changes in Truckee River suspended sediment load that are due to development, stormwater management or restoration activities in the contributing watershed.

[1] Instrument calibration, data review, verification, and QA/QC for historical turbidity data are carried out by California DWR. Data reported by DWR have not been independently reviewed for accuracy.

Table 6-1. Comparison of Suspended Sediment Loads and Yields from Previous Years

Water Year	Percent of water year NTU measured	Period(s) NTU measured	Suspended - sediment load during measured period	Partial annual suspended-sediment yield	Total annual flow volume	Annual peak flow, event type	Comments
WY	*%*		*tons*	*tons/1,000 ac-feet*	*ac-feet*		
2002	27	6/26/03-9/30/03	131	2	159,668	snowmelt	No major rain events in WY2002, annual peak flow occurred as snowmelt runoff; NTU not measured during peak snowmelt
2003	90	10/1/02-9/3/03	2,255	18	138,195	snowmelt	WY2003 registered some minor rain and rain-on-snow events, but their magnitudes were minor; annual peak flow occurred as peak snowmelt runoff
2006	27	10/26/05 – 1/1/06; 3/8/06 – 4/8/06	12,190	193	231,766	rain-on-snow	NTU record captured several rain and/or rain-on-snow events, including annual peak flow but instrument became damaged or data were erroneous shortly after; This record documents the importance of capturing rain-on-snow events relative to loads
2010	55	3/16/10 – 9/30/10	772	15	109,851	snowmelt	WY2009-WY2010 were very dry years with daily mean flows less than 20 cfs during the fall;
2011	50	10/2/10 – 11/2/10; 5/3/11 – 9/30/11	1,853	28	188,635	rain	NTU record captured the peak event and a significant portion of the snowmelt hydrograph.
2012	54	10/1/11 – 11/15/11; 5/3/12 – 9/30/12	307	6	180,693	rain-on-snow	NTU record did not capture the annual peak flow or peak snowmelt runoff
2013	81	10/1/12 – 11/7/12; 1/18/13 – 9/30/13	453	3	165,142	rain-on-snow	NTU record did not capture annual peak storm (rain-on-snow) event; Town of Truckee Station was established on January 18, 2013

Notes:
NTU: turbidity as nephelometric units
Suspended-sediment loads are partial annual loads for the periods reported
Suspended-sediment loads (tons/day) are calculated by converting a record of turbidity into suspended sediment concentration (mg/L) and multiplying by instantaneous discharge (cfs) and a conversion factor of 0.0027
Partial and annual flow volume and peak flow data are provided by USGS for the station: Truckee River near Truckee (USGS 10338000)

6.1.3.4 Discharge Based Comparison to Previous Years

Changes in suspended-sediment concentration or loading with time may result from landscape processes or human disturbances in a watershed (Warrick and Rubin, 2007), so suspended-sediment rating curves are perhaps the best tool for establishing sediment baselines prior to BMP implementation and for assessing the change in fine sediment supply as BMPs, restoration activities, or other watershed management actions are implemented (Hecht, 2008). As sediment supply within a watershed diminishes, suspended sediment concentration at a given discharge will also diminish, and a sediment rating curve shift to the right would be observed. Therefore, tracking changes in the relationship between suspended sediment transport and discharge (as shown by 'shifts' in the suspended sediment rating curves) allows for an evaluation of BMP effectiveness or improvements relative to historical conditions at a cumulative watershed scale.

For this analysis, we used historical grab samples collected and analyzed for SSC by the Desert Research Institute (DRI) (Dana et al, 2004) and corresponding USGS-reported instantaneous discharge values. We should note that these data are limited to discharge values less than 600 cfs, a magnitude flood that is typically less than annual flood for this station. 27 samples (n = 27) were collected over a range of flows during water years 2002 and 2003 and during various event types, such as snowmelt or thunderstorm runoff. Significant scatter is apparent in the historical data but the data can be grouped by event type: a) snowmelt runoff, and; b) rain-on-ground or rain-on-snow; and separate suspended-sediment rating curves may apply. Figure 6-3 shows these data, the separation of event types and their respective relationships.

Figure -6-3 compares the WY2013 TRWQMP Data (n = 11) with the corresponding daily sediment loads using the 2002-03 USGS-reported instantaneous discharge on the same graph (see Figure 6-3). When differentiated by event type these data do not clearly suggest patterns grouped by event types. Similarly, at this time, we cannot detect a shift in the rating curve when comparing the historical and recent data sets. Additional data collection may help elucidate whether detectable and statistically significant rating curve shifts have taken place, and should continue to be evaluated and reported as the monitoring program continues.

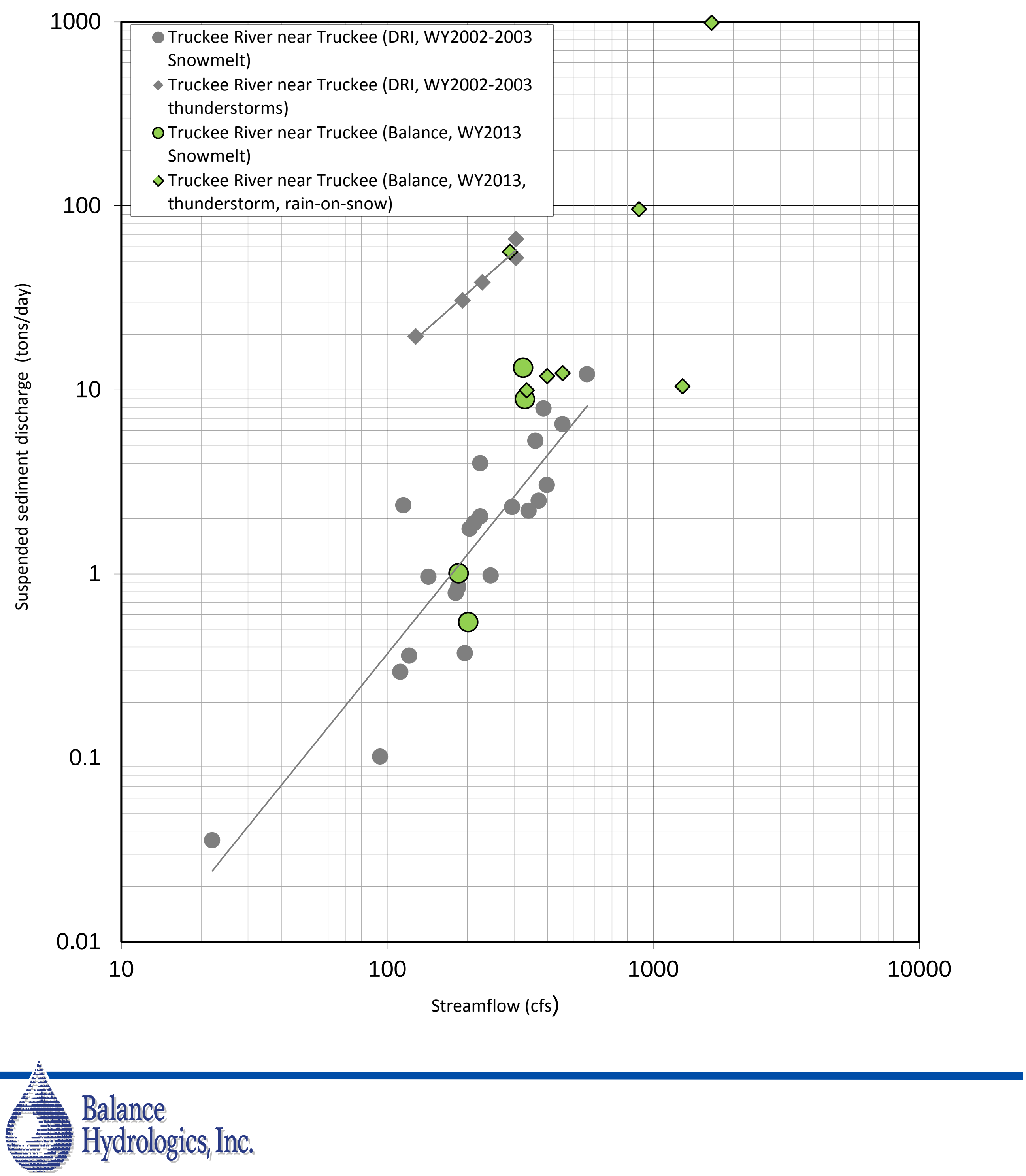
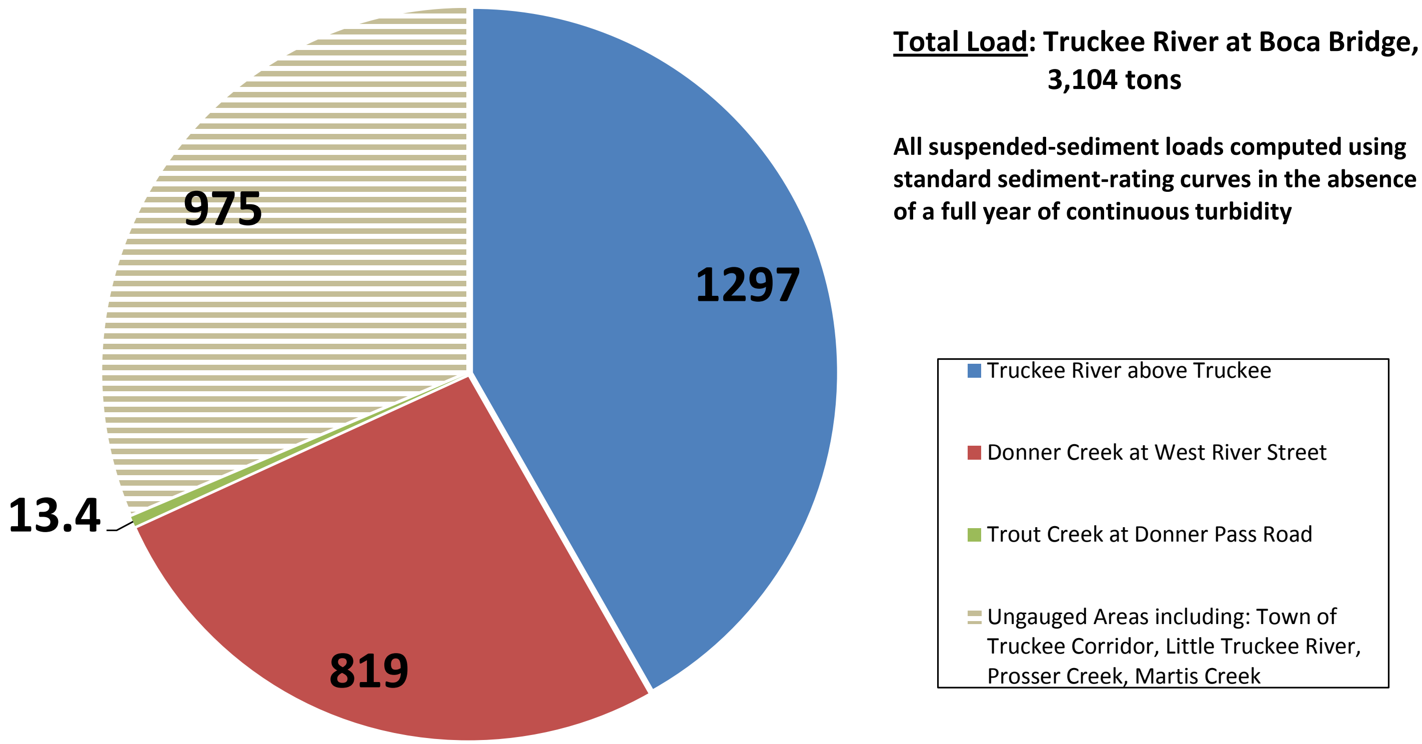


Figure 6-3 Relationship between discharge and suspended-sediment load, Truckee River near Truckee, California, water years 2002-2003, and 2013



Balance Hydrologics, Inc.

Figure 6-4
Suspended-sediment load, Truckee River at Boca Bridge, near Truckee California, water year 2013.

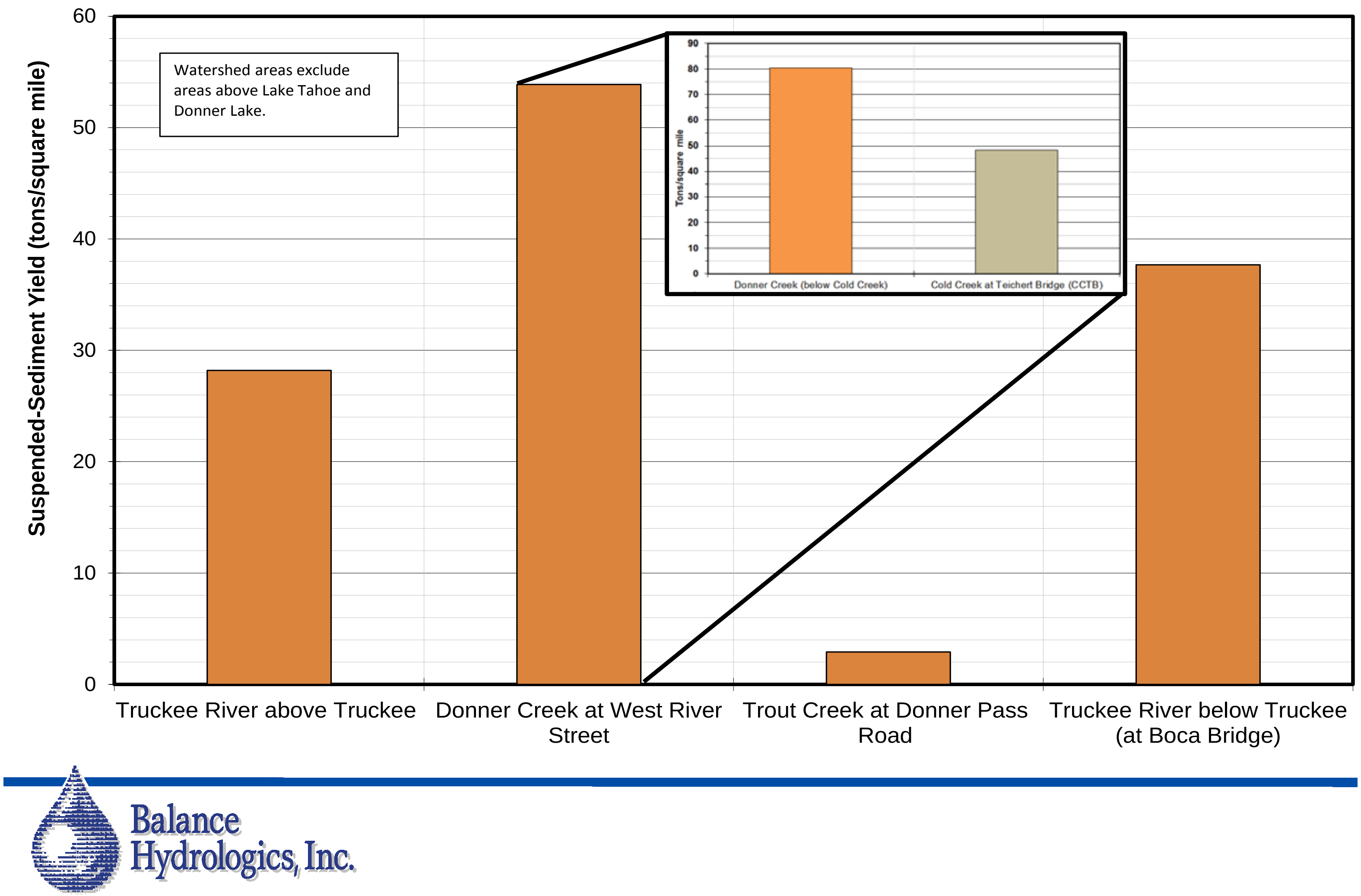


Figure 6-5

Total annual suspended-sediment yields, Middle Truckee River, Truckee, California, water year 2013.

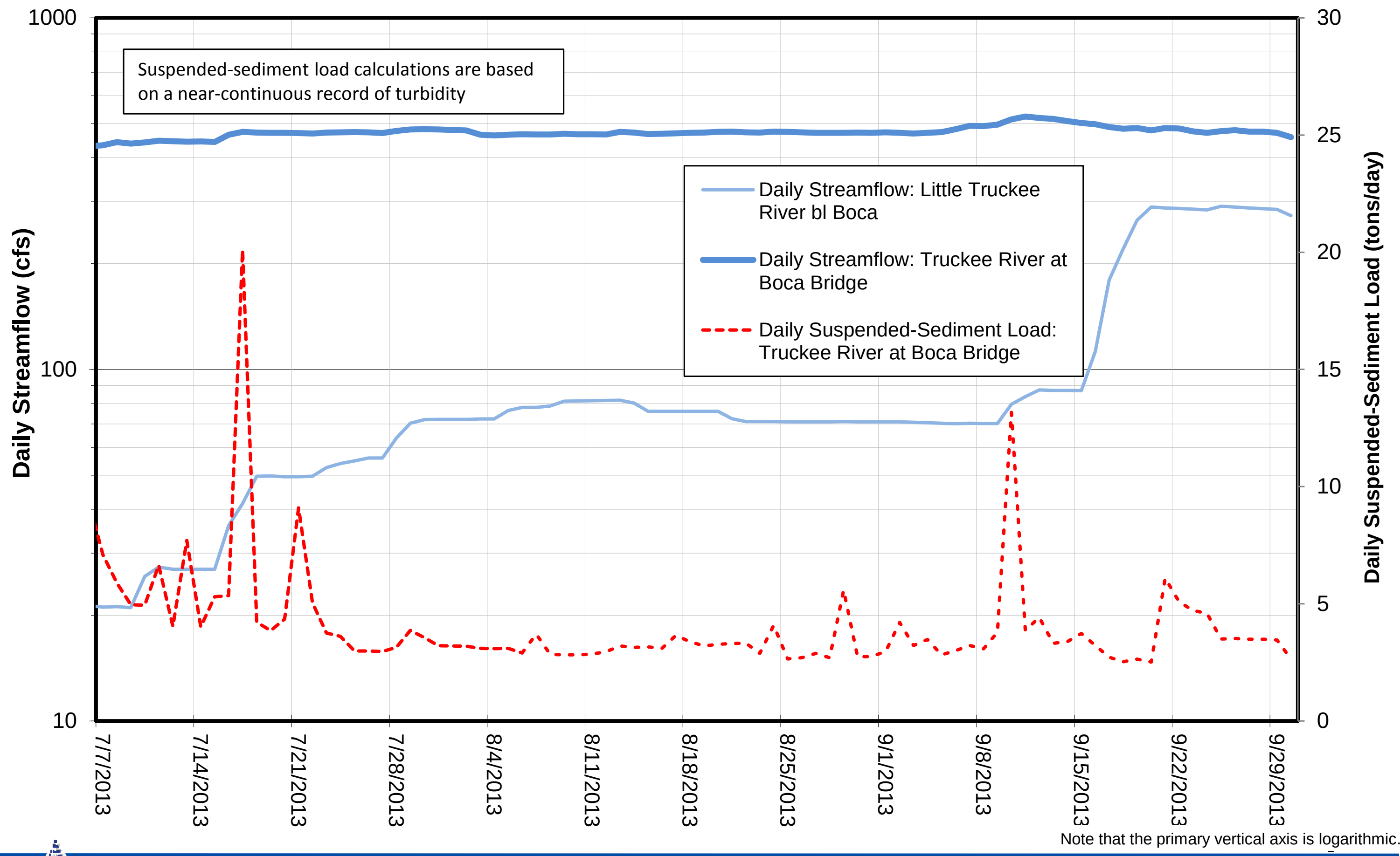
Table 6-2. Preliminary comparison of annual flow and suspended-sediment loads and yields Middle Truckee River and tributaries, water year 2013

		Annual Flow[2,3]				Peak Flow[2,3]			Suspended Sediment Load[4]			
Station	Watershed Area	Mean Daily Flow	Maximum Daily Flow	Minimum Daily Flow	Total Flow Volume	Peak Flow	Peak Stage	Date	Suspended Sediment Load	Percent exceedence for TMDL standard	Normalized Suspended Sediment	Normalized Suspended Sediment
	Square mile	(cfs)	(cfs)	(cfs)	(ac-ft)	(cfs)	(ft)	(mm/dd/yyyy)	(tons)	(%)	(tons/ ac-feet)	(tons/ sq. mile)
Truckee River above Truckee	46	228	977	78.4	165,142	1,810	4.02	12/2/2012	1297	1.3	0.01	28.2
Donner Creek at West River Street	15.2	58	676	3.7	42,125	1,150	--	12/2/2012	819	2.2	0.02	53.9
Donner Creek at Highway 89	14.8	58	676	3.7	42,125	1,150	--	12/2/2012	498	0.5	0.01	33.6
Cold Creek at Teichert Bridge	12.6	21	407	0.17	14,884	1004	6.6	12/2/2013	610	1.3	0.04	48.4
Trout Creek at Donner Pass Road	4.6	2.2	31.5	0.2	1,587	81	5.18	12/3/2012	13.4	1.6	0.01	2.9
West Martis Creek above Highway 267	5	0.8	12	0.1	597	18.3	3.23	12/2/2012	14.3	--	0.024	2.9
Martis Creek above Highway 267	15.7	5	100	1.0	3,610	165	3.47	12/2/2013	62	--	0.02	3.9
Truckee River below Truckee (at Boca Bridge)	82.4	505	1960	311	365,916	3,320	9.59	12/2/2012	3,104	0.5	0.01	37.7

Notes:
[1] Water years begin in October and end in September of the named water year; (WY 2013 began on October 1, 2012 and ended on September 30, 2013)
[2] Annual and peak flow statistics based on 15-minute record of flow; Stations CCTB and TCDP managed and maintained by Balance Hydrologics, Inc.; stations TURB-MC1 and TURB-MC2 are managed and maintained by CDM Smith, while stations at Donner Creek (USGS 10338700), Truckee River above Truckee (USGS 10338000) and Truckee River at Boca Bridge (USGS 10344505) are managed and maintained by USGS. Station DCWR discharge statistics are based on USGS 10338700 and confirmed by correlation to direct flow measurement comparisons at both stations
[3] Truckee River above Truckee (USGS 10338000) discharge affected by regulation at Lake Tahoe. For the purposes of load comparisons, watershed area for this station excludes Lake Tahoe
[4] Donner Creek discharge affected by regulation at Donner Lake; watershed area for Donner Creek stations exclude area above Donner Lake Dam (14.3 sq. miles) for purposes of comparing loads.
[5] Truckee River at Boca Bridge (USGS 10344505) discharge affected by regulation at Lake Tahoe, Donner Lake, Prosser Reservoir, Boca Reservoir, and Martis Reservoir. For the purposes of load comparisons, watershed areas above dams are not included in load calculations.
[6] West Martis gauge was potentially only capturing 1/3 of the total flow in the watershed; gauge was located on a distributary channel on the alluvial fan
[7] Values in italics are based on discharge-sediment rating curve if turbidity is not measured at a station or turbidity wasn't collected for the full year
[8] Martis Creek and West Martis Creek are located above Martis Dam; loads may not be relevant to Martis Creek below Martis Dam (not monitored)

6.2 Suspended-Sediment Computation Comparison

Two methods for computing suspended-sediment loads were used at each near-continuous turbidity monitoring station. Comparison between these methods found some important distinctions as to the advantages of one method over the other. For instance, loads computed using a near-continuous record of turbidity illustrated discrete loading events in the absence of rainfall or snowmelt. These periods were further examined and found to be related to other variables such as dam releases from upstream reservoirs. Figure 6-5 illustrates a daily record of suspended-sediment loads with daily discharge at the Truckee River at Boca Bridge site against daily discharge for the Little Truckee River below Boca Reservoir for the period July 7 – September 30, 2013. These data suggest that dam releases may generate increases in suspended-sediment loading to downstream reaches of the Truckee River at times. For instance, suspended sediment spikes on July 17 (20.1 tons) and September 10, 2013 (13.1 tons) at Boca Bridge are in parallel with releases on the Little Truckee River at Boca Dam. Conversely, a fairly large release from Boca Dam began on September 16, 2013 with no measurable loading at Boca Bridge, suggesting that the relationship between dam releases and sediment loading is not constant. Further analysis in subsequent years is necessary to assess the effects of dam releases on suspended-sediment loading in the Truckee River.



Balance Hydrologics, Inc.

Figure 6-6
Potential effects from dam releases on downstream turbidity, Truckee River at Boca Bridge, Nevada County, California, July 7 - September 15, 2013.

6.3 Water Quality Areas of Concern

After four years of monitoring, the following areas were identified as areas of the highest concern for water quality:

- **Truckee River (Town Corridor):** Suspended-sediment results indicate approximately one third of the total suspended-sediment load being carried by the Truckee River at the Boca Bridge originates from within this watershed. In addition to the Truckee downtown areas, this very large watershed includes Martis Creek, Glenshire Creek, Prosser Creek, and the Little Truckee River which also contribute to suspended-sediment loads.

  Previous RAM results from the Truckee River main stem do not indicate high percentages of fine substrate despite a very high percentage in Trout Creek. Previous community level sampling indicates elevated TSS concentrations in stormwater runoff discharging into the Truckee River from the downtown area. Based on the data collected to date, the integrated results indicate significant amounts of sediment are discharged to the Truckee River from urban areas but are then mostly transported downstream rather than becoming permanently deposited on the channel bottom.

- **Donner Creek:** Suspended-sediment measurements indicate that Donner Creek had the highest suspended-sediment yield, when compared to other Truckee River tributaries monitored in WY 2013. The area within the Town of Truckee that drains to Donner Creek is small, but also urbanized, and includes high traffic roadways such as Highway 89 and Interstate 80. Impervious surfaces drain to Donner Creek through a large network of storm drains that transport particulates materials that are measured as suspended-sediment in Donner Creek. Cold Creek, a tributary to Donner Creek which is located primarily within Placer County, drains a watershed with many historic disturbances from gravel mining, logging and railroad activities and is also a source of suspended-sediment to the Truckee River.

- **West Martis Creek:** Results indicate that this tributary carried the largest suspended sediment, total phosphorus, and total nitrogen load per acre of Martis Valley watershed. Rapid Assessment Methodology (RAM) monitoring in previous years has also indicated a relatively high percentage of fine sediment substrate in West Martis Creek.

  This is likely a combined effect of the Northstar development including roadway shoulder erosion near creek crossings, ski run soil disturbance, commercial and residential construction, roadway abrasives and more. New community sites are recommended to help identify and prioritize source areas.

- **Trout Creek:** Previous RAM data indicate Trout Creek has very high percentages of fine substrate covering the streambed. The newly restored portion in the upper reaches of the RAM survey segment shows improvement over conditions during the previous survey, but also indicates a large amount of sediment is being transported from upstream.

- **Squaw Creek:** A large thunderstorm occurred on July 3, 2013, and was isolated in the upper Squaw Creek watershed. Results of suspended-sediment monitoring in the Truckee River above Truckee indicate that this event resulted in a suspended-sediment load of approximately 115 tons. This accounted for approximately 10 percent of the annual suspended-sediment load at this location.

Previous RAM and bioassessment results indicate a continued impact to this stream by sediment deposition. The area of highest concern identified from 2012 bioassessment monitoring was the upper meadow site in Squaw Creek (site Bio-SC1). This site had the lowest IBI score of all sites sampled in 2012 (IBI score= 46), as well as the smallest median particle size (D50= 2 mm). The middle meadow (site Bio-SC2) and lower meadow (site Bio-SC3) sites in Squaw Creek also had very small median particle sizes (D50= 3 mm), although these sites scored well in terms of Biological Condition Scores (BCS= 25 and 27 out of a possible 35, respectively) and the Eastern Sierra IBI (93 and 90 out of a possible 100, respectively).

6.4 Effectiveness of MS4 Permit Activities

The effectiveness of implementing Permit related stormwater management activities can be evaluated through the comparisons presented herein. Because this is only the fourth year of implementation and relatively little changes to the watershed have occurred, spatial comparisons are most appropriate at this time. The temporal water quality trends identified in this report are likely related to differences in precipitation amounts rather than specific management actions and more data is required to evaluate their significance.

Previously collected community level discrete sampling does demonstrate the effectiveness of stormwater related management activities. The permanent stormwater treatment BMPs present in some of the drainage systems provide clear benefits as shown in the monitoring results. When compared to other sites, the water quality at the treated sites is clearly improved with respect to all the monitored pollutants in almost every runoff event.

6.5 Prioritization of Existing TRWQMP Elements

The TRWQMP is currently being implemented as planned. Overall, monitoring activities should be continued per the guidance in the TRWQMP and the adaptive management based modifications that have been made to the program over the initial four years of implementation. There is a continued need to develop more comprehensive and robust datasets that will help to identify specific areas of concern and evaluate stormwater management program performance.

For WY 2014, monitoring will consist of continuous turbidity monitoring and sediment load evaluations, tributary and community level water quality monitoring, RAM in Truckee River tributaries, and bioassessments in Martis and Squaw Creeks. Modifications to the program during WY 2014 will likely include the relocation of the two Placer County community level sites (DSC-MC2 and DSC-MC3) in Northstar and additional community level water quality monitoring by the Town within the Donner Creek watershed. Also, the two turbidity monitoring sites in the Martis Creek watershed at the West Martis Creek (TURB-MC1) and main stem Martis Creek (TURB-MC2) sites were upgraded with new probes in October, 2013 and relocated to avoid flow bypass and beaver dam issues.

Section 7

Fiscal Summary

This section provides a summary of costs incurred by Placer County and the Town of Truckee over the initial four years of TRWQMP implementation as described in this report. Costs to complete the Year 1 through Year 4 activities are presented in Table 7-1.

Table 7-1. Year 1 – 4 Implementation Costs

	Placer County	Town of Truckee
Administrative		
Year 1	$21,000	$10,000
Year 2	$26,000	$12,000
Year 3	$25,000	$11,000
Year 4	$25,000	$11,000
Planning and Permitting		
Year 1	$100,000	$13,000
Year 2	$0	$0
Year 3	$6,000	$7,000
Year 4	$15,000	$7,000
Data Collection		
Year 1	$65,000	$26,000
Year 2	$36,000	$15,000
Year 3	$70,000	$21,000
Year 4	$75,000	$26,000
Laboratory		
Year 1	$15,000	$3,000
Year 2	$10,000	$3,000
Year 3	$20,000	$3,000
Year 4	$15,000	$1,000
Reporting		
Year 1	$60,000	$20,000
Year 2	$50,000	$15,000
Year 3	$50,000	$20,000
Year 4	$55,000	$25,000
Total		
Year 1	$261,000	$72,000
Year 2	$122,000	$45,000
Year 3	$171,000	$62,000
Year 4	$185,000	$70,000

Section 8

Conclusions and Recommendations

This section presents the conclusions from WY 2013, and previous years, implementation of the TRWQMP. Based on these conclusions, this section also presents adaptive management recommendations for WY 2014 and the continued implementation of the TRWQMP.

Overall, monitoring activities should be continued per the guidance in the TRWQMP and the adaptive management based modifications that have been made to the program over the initial four years. There is a continued need to develop more comprehensive and robust datasets that will help to identify specific areas of concern and evaluate the performance of storm water management activities. As the monitoring dataset is further developed, it will provide a valuable tool for the identification and prioritization of potential future storm water management activities to protect water quality in the Truckee River.

8.1 Community Level Discrete Monitoring

The community level monitoring is an effective means of characterizing stormwater runoff and the effectiveness of the water quality controls in the monitored areas. The data also provides:

- a means of prioritizing these areas for water quality improvements,
- an important source of planning and design information, and
- justification for requests of grant funding for such projects.

Conclusions

The data from the two Placer County community level sites monitored in WY 2013 builds on the previous two years of data to provide an adequate dataset for making statistical comparisons between these sites and initial observations on water quality trends. Overall the water quality results indicate that these stormwater outfalls do not contribute unusually high pollutant loads to Martis Creek, or other downstream receiving waters. In addition, the following more specific statements can be made:

- Larger and higher intensity rain and rain/snow mixed precipitation events produce the highest pollutant concentrations in stormwater at both sites. Low flow snow melt events often infiltrate and/or evaporate prior to discharge resulting in a limited number of samples from this event type.

- Moderate erosion has been observed below the outlet of the infiltration basin at the Northstar parking lot which is in the catchment area of the Northstar community level monitoring station (DSC-MC3). The basin overflows during larger runoff events and there is no stabilized conveyance to carry these flows downstream. The overflows do receive additional downstream treatment prior to entering West Martis Creek. The basin infiltrates stored water effectively but will require periodic cleaning to maintain adequate rates and minimize the occurrence of overflows. Additional basins in this area also receive flows from the Northstar parking lots and are likely behaving similarly.

- Pollutant concentrations at the Lahontan site were generally low indicating effective stormwater management at this site. Decomposing vegetation and/or golf course fertilizer use in the upgradient catchment area may have contributed to elevated nutrient concentrations observed during one large event on January 20, 2012.

- Samples at the Northstar site had statistically higher mean TSS concentrations and turbidity levels than samples from the Lahontan site.

- Mean concentrations of total nitrogen, total phosphorus, and dissolved phosphorus were similar between the two sites and no statistical difference can be discerned at this time.

- The results of the trend analyses indicate slightly increasing concentrations of total nitrogen at both sites and total phosphorus and dissolved phosphorus at the Lahontan site. These results are sensitive to the more extreme values in this limited dataset should be considered preliminary.

Recommendations

To reduce sediment discharges from the higher priority outfalls, the following recommendations should be considered by the Town and County as funding and other constraints allow.

1. The overflow channels from the Northstar parking lot infiltration basins should be inspected and possibly stabilized with rip rap or another similar measure.
2. The infiltration basins at the Northstar parking lots should be inspected and cleaned regularly to maintain their infiltration capacity and reduce the frequency and magnitude of overflows.
3. Pave or otherwise stabilize bare soil areas within the public right-of-way, especially near drainage inlets and conveyances to limit erosion and tracking.
4. Install curb and gutter or improve the storm drain system to keep concentrated runoff flows separated from the bare soil areas.
5. Install deterrents to prevent parking on dirt shoulders.
6. Install improvements to promote infiltration and reduce storm water runoff volumes.
7. Install treatment controls such as drain inlet inserts or sediment traps to promote settling and provide sediment storage.
8. Regularly clean drain inlets and storm drain pipes and track the amount of material removed.
9. Sweep streets frequently to remove excess traction sand.

Given the limited resources for these types of activities, consider prioritizing high traffic areas, especially near the river and its tributaries. New community level monitoring locations should be considered by the County and Town with a focus on the water quality areas of concern including the Donner and West Martis Creek watersheds. New monitoring locations should be selected based on a modeled prioritization of outfalls. Future monitoring data should be used to calibrate the model which could eventually be used guide stormwater management activities.

8.2 Tributary Level Water Quality Monitoring

The results of the first three years of tributary level water quality monitoring at the six Martis Creek sites provide meaningful information regarding the types of pollutants and their relative concentrations and loads at the various locations. Continued monitoring will increase the statistical confidence in making comparisons among sites and evaluating water quality trends. Furthermore, the multi-year effort will be important in characterizing seasonal variability due to differences in annual precipitation patterns and the effects of continuing development, stormwater management and/or watershed restoration activities.

Conclusions

After three years of monitoring, the data indicate that mean total phosphorus concentrations at each of the monitored locations are higher than the defined water quality objectives at the mouth of Martis Creek, however; the mean total nitrogen and TKN concentrations are lower than these objectives. Although lower, the total phosphorus concentrations in East Martis Creek still exceed the objectives. This sub-watershed is relatively undeveloped compared to other areas draining to Martis Creek indicating that the phosphorus source may be due to historic disturbances or natural processes rather than a result of fertilizer use or other human activities. It is also important to note that sampling efforts focused on large runoff events where concentrations are typically elevated. This likely skewed the mean concentration values upwards.

A statistical trend analysis shows that concentrations at each monitoring locations are decreasing. This is likely due to the decreasing trend in precipitation amounts that has occurred during the three years of monitoring.

The following table presents the results of statistical t-tests indicating significant mean pollutant concentration differences at a 95% confidence level.

Table 8-1. Statistical Differences among Tributary Level Discrete Sampling Data

Constituent	Statistical Difference
Total Nitrogen	DST-MC6 > DST-MC2, DST-MC3, DST-MC5
Total Phosphorus	None
Turbidity	DST-MC1 > DST-MC6
TSS	DST-MC4 > DST-MC3, DST-MC6 DST-MC1 > DST-MC3, DST-MC6

Recommendations

A number of lower flow events should be sampled to increase representativeness of the range of conditions in the calculated mean concentrations and pollutant loads. Currently, the mean concentrations and the related load based evaluations are based on "worst-case" water quality data sampled from events likely to have caused higher than average pollutant mobilizations.

8.3 Martis Creek Stream Gauges

Stream discharge data has been collected for three subsequent water years at Station GS-MC1, which was installed in November, 2010, and for one water year at Stations Turb-MC1 and Turb-MC2, which were installed in October 2012. The data has been reviewed and validated and is considered reliable for use in conducting the pollutant load evaluations associated with the continuous turbidity monitoring discussed below.

Conclusions

The table below presents the key stream discharge related parameters from each of the locations monitored during WY 2013. USGS data is presented for the stations that were used to evaluate pollutant loading on the Truckee River main stem.

Table 8-2. TRWQMP WY 2013 Key Stream Discharge Parameters

Station/Location	Total Annual Discharge (Acre-ft.)	Annual Peak Discharge (CFS)	Annual Mean Discharge (CFS)
TURB-MS3/Truckee River above Truckee	165,142	1,810	228
TURB-TT1/Truckee River below Truckee	365,916	3,320	505
TURB-MC1/West Martis Ck	597	18	0.8
TURB-MC2/Upper Martis Ck Main Stem	3,610	198	5.0
GS-MC1/Lower Martis Ck Main Stem	5,305	450	7.3

Recommendations

As is common in mountain streams, stream gauge operations are often plagued by treefall, debris, beaver dams, and ice. In these cases, a gauging station may require relocation and a new stage-discharge rating curve developed. It is recommended that Station (GS-MC1) on Martis Creek at Frank's Fish Bridge be relocated due to the continued impacts of a downstream beaver dam. This station should be moved downstream to a location near the Martis Creek Reservoir where beaver interference is less likely. Furthermore, this location would allow for the measurement of discharge from the entire Martis Creek watershed and would provide more accurate pollutant loading results.

8.4 Load Estimates

The first year of continuous-turbidity monitoring has provided valuable information regarding suspended sediment loads within the Middle Truckee River and its major tributaries. The turbidity-based method of estimating suspended sediment loads has advantages over the discharge-based method due to its ability to detect load increases unrelated to discharge such as in-channel disturbances or non-stormwater related sediment discharges.

Conclusions

Although the dataset is limited and was collected during a very dry water year the following preliminary conclusions and observations can be made:

Truckee River

- An isolated, summer thunderstorm over the upper Squaw Creek watershed illustrated the importance of discrete, high-intensity runoff events. Large rain on snow or summer thunderstorm events can generate sediment loads an order of magnitude, or more, greater than loads generated by long-duration low intensity events such as spring snowmelt runoff.

- The total annual suspended sediment load in the Truckee River above and below the Town of Truckee was approximately 1,300 tons and 3,100 tons, respectively. Total annual loads at the Truckee River stations could only be computed using the discharge-based method and a preliminary rating curve, since near-continuous turbidity equipment was not installed until January.

- Of the total annual suspended sediment load estimated in the Truckee River at the Boca Bridge, approximately 1,300 tons originate from the 46 square mile area contributing to the Truckee River above Truckee, approximately 800 tons originates from the 15.2 square mile area draining to Donner Creek below Donner Lake and approximately 13 tons originates from the 4.6 square mile area draining to Trout Creek. The remaining fraction of the sediment load, almost 1,000 tons, is likely from in-channel sources and non-point sources within the Town of Truckee Corridor watershed.

- Suspended sediment yields in the Truckee River at Boca Bridge (37.7 tons/square mile) were 25 percent higher than those measured in the Truckee River above Truckee (28.2 tons/square mile).

- The suspended sediment yield from Cold Creek is estimated at 48 tons/square mile

- The suspended sediment yield from Donner Creek below Cold Creek is estimated at 81 tons/square mile.

- The suspended sediment data collected during the monitored portion of WY 2013 indicate that the Truckee River was in attainment of the defined TMDL compliance standard.

- The evaluation of historic DWR turbidity data and DRI suspended sediment sampling did not identify any significant trends or patterns in the Truckee River's suspended sediment load.

Martis Creek

- The total annual load suspended sediment load in West Martis Creek was approximately 14 tons computed using the discharge-based method. The turbidity based method yielded a much higher load but is considered inaccurate for this location due to periodic equipment malfunctions.

- The total annual load suspended sediment load in the main stem of Martis Creek was approximately 50 tons computed using the discharge-based method. The turbidity based method yielded a similar value but is considered inaccurate for this location due to periodic equipment malfunctions.

- The West Martis and the main stem Martis Creek sub-watersheds produce the sediment loads per acre. This includes most of the Northstar ski area, residential development and golf course.

- The Martis Creek main stem sub-watershed produces the highest total phosphorus loads per acre. This includes the Martis Camp and Lahontan developments and a portion of the Northstar ski area.

- An un-named tributary of Martis Creek that drains the Truckee Airport and surrounding commercial area produces the highest total nitrogen loads per acre.

Recommendations

Continued monitoring is recommended in order to increase understanding of suspended-sediment loading within and to the Truckee River, evaluate seasonal variability and characterize the effects from watershed development, restoration efforts or stormwater management practices.

Future turbidity probes should be equipped with wiping and anti-bacterial mechanisms to minimize the active bio-fouling that occurs throughout the year.

Section 9
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Appendix A
Statistical Results

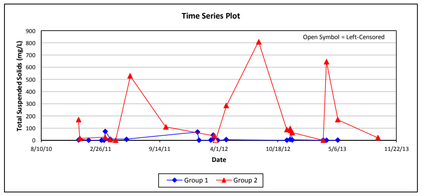
Group 1		
EventType	Year	Site
Mix Rain/Snow	2009-10	DSC-MC2
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Group 2		
EventType	Year	Site
Mix Rain/Snow	2009-10	DSC-MC3
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

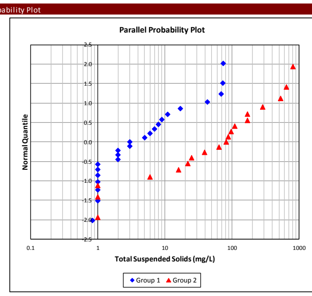
Statistical Comparison
Group 2 vs Group 1
Analyte
Total Suspended Solids
SW Standard
None
GW Standard
None
Standard Type
None
Alpha
0.05
Mean % Difference (robust ROS)
-1050.515247

Time Series - Mann-Kendall (MK) Trend Analyses

	Group 1	Group 2
Count (n)	23	19
Count (nondetects)	4	1
S	-24	11
VarS	1401	812
Trend	Decreasing	Increasing
p-value	0.26942447	0.36284699



Parallel Probability Plot

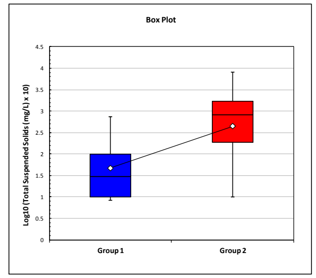


Shapiro-Wilk (SW) and Lilliefors (L) Normality Tests

	Group 1	Group 2
p-value (SW)	0.01081281	0.08517242
p-value (L)	0.19210405	0.68629459

Note: Values should be greater than alpha

Box Plot



t Test (Independent)

	Data	LogData	RkData
Mean (robust ROS)			
Group 1	14.71340671	1.67106160	15.76086957
Group 2	166.5708613	2.650950308	28.44736842
Delta	0.00000000	0.00000000	0.00000000
Std (robust ROS)			
Group 1	24.43387982	0.65797482	9.16870860
Group 2	236.9929246	0.917304902	11.97902651
degrees of freedom	18.31634540	31.84575200	33.26374762
Effect Size (d)	151.85745458	0.97988871	12.68649886
t Statistic	-2.78085988	-3.90057146	-3.78955016
t Critical	-1.73406359	-1.69551874	-1.69236026
p-value (2-sided)	0.01281079	0.00050147	0.00063015
Power	0.84547626	0.98250103	0.97814042
Power Analysis			
Beta	NA	NA	NA
Additional n (each Group)	NA	NA	NA

Summary Statistics

	Total Suspended Solids	n	% dect	min	max	mean	median	STDDEV	CV
Group 1	DSC-MC2	23	83%	0.833	74	14.713	3.000	24.434	1.661
Group 2	DSC-MC3	19	95%	1.0000	810.000	166.571	82.000	236.993	1.423

Group 1		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC1
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Group 2		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC2
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Statistical Comparison

Group 2 vs Group 1

Analyte

Total Suspended Solids

SW Standard

None

GW Standard

None

Standard Type

None

Alpha

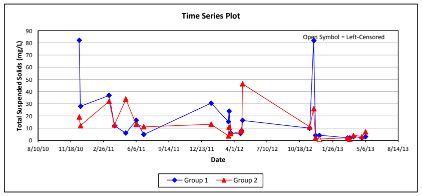
0.05

Mean % Difference (robust ROS)

29.62440966

Time Series - Mann-Kendall (MK) Trend Analyses

	Group 1	Group 2
Count (n)	23	23
Count (nondetects)	0	1
S	-141	-115
VarS	1427	1432
Trend	Decreasing	Decreasing
p-value	0.00010524	0.00129385



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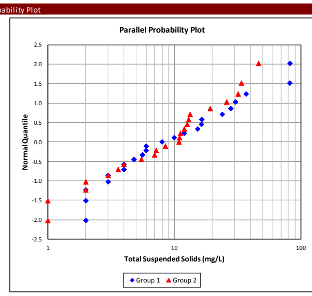
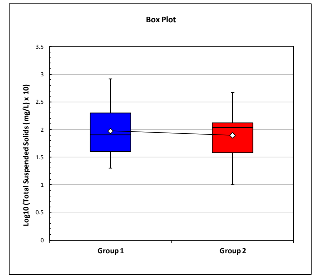


Shapiro-Wilk (SW) and Lilliefors (L) Normality Tests

	Group 1	Group 2
p-value (SW)	0.26486901	0.45166653
p-value (L)	0.37304543	0.89110821

Note: Values should be greater than alpha

Box Plot



t Test (Independent)

	Data	LogData	RkData
Mean (robust ROS)			
Group 1	17.58391304	1.97204116	24.10869565
Group 2	12.45038225	1.893963492	22.89130435
Delta	0.00000000	0.00000000	0.00000000
Std (robust ROS)			
Group 1	22.67506455	0.49051829	13.86211033
Group 2	11.85108778	0.464697944	13.22442345
degrees of freedom	33.18454368	43.87196366	43.90277482
Effect Size (d)	-5.13353079	-0.07807767	-1.21739130
t Statistic	0.96225421	0.55417313	0.30474414
t Critical	1.69236026	1.68107070	1.68107070
p-value (2-sided)	0.34313733	0.58239926	0.76206605
Power	0.23523846	0.13301765	0.08792299
Power Analysis			
Beta	0.2	0.2	0.2
Additional n (each Group)	52	197	>300

Summary Statistics

	Total Suspended Solids	n	% dect	min	max	mean	median	STDDEV	CV
Group 1	DST-MC1	23	100%	2.000	82.24	17.584	8.000	22.675	1.290
Group 2	DST-MC2	23	96%	1.0000	46.500	12.450	10.890	11.851	0.952

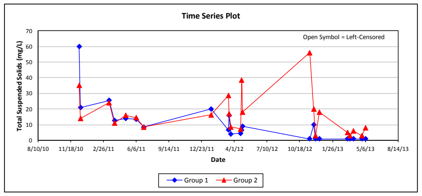
Group 1		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC3
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Statistical Comparison
Group 2 vs Group 1
Analyte
Total Suspended Solids
SW Standard
None
GW Standard
None
Standard Type
None
Alpha
0.05
Mean % Difference (robust ROS)
-63.61596548

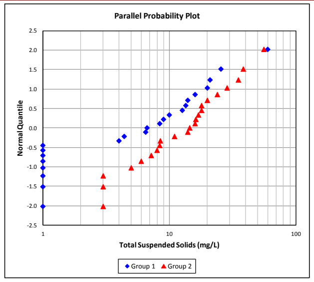
Group 2		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC4
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Time Series - Mann-Kendall (MK) Trend Analyses

	Group 1	Group 2
Count (n)	23	23
Count (nondetects)	4	0
S	-171	-71
VarS	1368	1429
Trend	Decreasing	Decreasing
p-value	0.00000216	0.03203100



Parallel Probability Plot

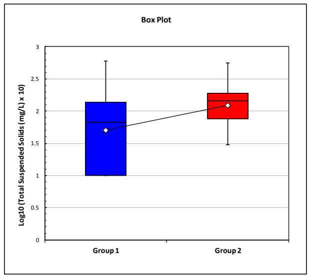


Shapiro-Wilk (SW) and Lilliefors (L) Normality Tests

	Group 1	Group 2
p-value (SW)	0.00627932	0.52457123
p-value (L)	0.00189228	1.00000000

Note: Values should be greater than alpha

Box Plot



t Test (Independent)

	Data	LogData	RkData
Mean (robust ROS)			
Group 1	10.33851359	1.70235836	19.04347826
Group 2	16.48608696	2.088930268	27.95652174
Delta	0.00000000	0.00000000	0.00000000
Std (robust ROS)			
Group 1	13.16358035	0.57914477	13.71455186
Group 2	13.02680619	0.355634938	11.69587441
degrees of freedom	43.99520083	36.52609503	42.92980172
Effect Size (d)	6.14757337	0.38657191	8.91304348
t Statistic	-1.59196973	-2.72789309	-2.37152028
t Critical	-1.68107070	-1.68829769	-1.68195236
p-value (2-sided)	0.11889100	0.00989876	0.02249372
Power	0.46470769	0.84726998	0.75287077
Power Analysis			
Beta	0.2	NA	NA
Additional n (each Group)	14	NA	NA

Summary Statistics

	Total Suspended Solids	n	% dect	min	max	mean	median	STDDEV	CV
Group 1	DST-MC3	23	83%	1.000	60	10.339	6.670	13.164	1.273
Group 2	DST-MC4	23	100%	3.0000	56.000	16.486	14.500	13.027	0.790

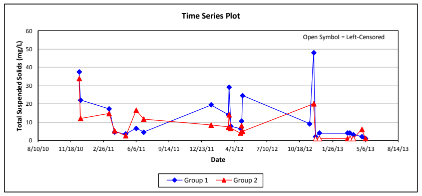
Group 1		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC5
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Group 2		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC6
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

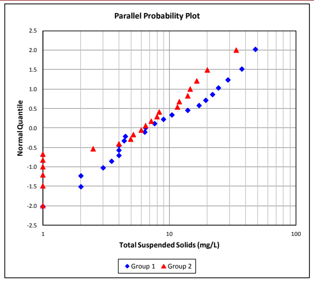
Statistical Comparison
Group 2 vs Group 1
Analyte
Total Suspended Solids
SW Standard
None
GW Standard
None
Standard Type
None
Alpha
0.05
Mean % Difference (robust ROS)
36.27600544

Time Series - Mann-Kendall (MK) Trend Analyses

	Group 1	Group 2
Count (n)	23	22
Count (nondetects)	0	4
S	-105	-118
VarS	1429	1229
Trend	Decreasing	Decreasing
p-value	0.00296915	0.00042350



Parallel Probability Plot

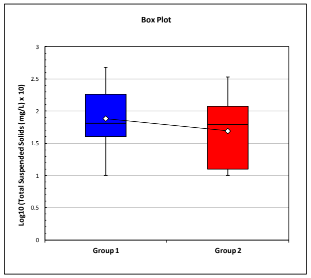


Shapiro-Wilk (SW) and Lilliefors (L) Normality Tests

	Group 1	Group 2
p-value (SW)	0.75267491	0.02359510
p-value (L)	0.37523373	0.03695597

Note: Values should be greater than alpha

Box Plot



t Test (Independent)

	Data	LogData	RkData
Mean (robust ROS)			
Group 1	12.35869565	1.88377560	24.93478261
Group 2	8.218031099	1.690264766	20.97727273
Delta	0.00000000	0.00000000	0.00000000
Std (robust ROS)			
Group 1	12.52578096	0.44706203	13.07956799
Group 2	8.058122006	0.496744535	13.12166263
degrees of freedom	37.75225035	42.05116303	42.89824794
Effect Size (d)	-4.14066455	-0.19351083	-3.95750988
t Statistic	1.32450957	1.37155857	1.01293890
t Critical	1.68709360	1.68195236	1.68195236
p-value (2-sided)	0.19368122	0.17766068	0.31703003
Power	0.35948933	0.37889832	0.25357391
Power Analysis			
Beta	0.2	0.2	0.2
Additional n (each Group)	17	14	43

Summary Statistics

	Total Suspended Solids	n	% dect	min	max	mean	median	STDDEV	CV
Group 1	DST-MC5	23	100%	1.000	48	12.359	6.500	12.526	1.014
Group 2	DST-MC6	22	82%	1.0000	33.850	8.218	6.250	8.058	0.981

Group 1		
EventType	Year	Site
Mix Rain/Snow	2009-10	DSC-MC2
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Group 2		
EventType	Year	Site
Mix Rain/Snow	2009-10	DSC-MC3
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Statistical Comparison

Group 2 vs Group 1

Analyte

Turbidity

SW Standard

None

GW Standard

None

Standard Type

None

Alpha

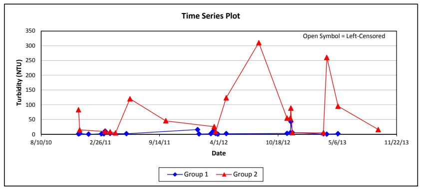
0.05

Mean % Difference (robust ROS)

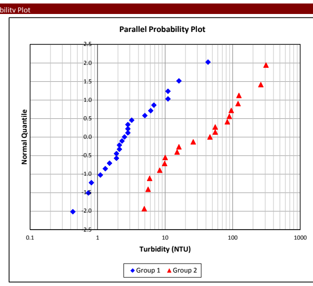
-1153.760514

Time Series - Mann-Kendall (MK) Trend Analyses

	Group 1	Group 2
Count (n)	23	19
Count (nondetects)	0	0
S	27	20
VarS	1427	816
Trend	Increasing	Increasing
p-value	0.24564013	0.25298270



Parallel Probability Plot

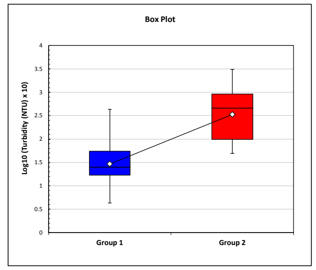


Shapiro-Wilk (SW) and Lilliefors (L) Normality Tests

	Group 1	Group 2
p-value (SW)	0.54030046	0.21369188
p-value (L)	0.08051697	0.51303838

Note: Values should be greater than alpha (C

Box Plot



t Test (Independent)

	Data	LogData	RkData
Mean (robust ROS)			
Group 1	5.61608696	1.46878800	13.54347826
Group 2	70.4122807	2.525315608	31.13157895
Delta	0.00000000	0.00000000	0.00000000
Std (robust ROS)			
Group 1	9.04002199	0.46443310	9.10034096
Group 2	85.83716008	0.579230033	7.90717344
degrees of freedom	18.33010213	34.28438533	39.87807722
Effect Size (d)	64.79619375	1.05652761	17.58810069
t Statistic	-3.27544569	-6.42548483	-6.69984749
t Critical	-1.73406361	-1.69092426	-1.68487512
p-value (2-sided)	0.00446029	0.00000028	0.00000006
Power	0.92968977	0.99998108	0.99999403
Power Analysis			
Beta	NA	NA	NA
Additional n (each Group)	NA	NA	NA

Summary Statistics

	Turbidity	n	% dect	min	max	mean	median	STDDEV	CV
Group 1	DSC-MC2	23	100%	0.430	43	5.616	2.500	9.040	1.610
Group 2	DSC-MC3	19	100%	4.9000	310.000	70.412	46.000	85.837	1.219

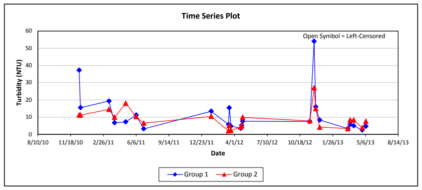
Group 1		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC1
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Group 2		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC2
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

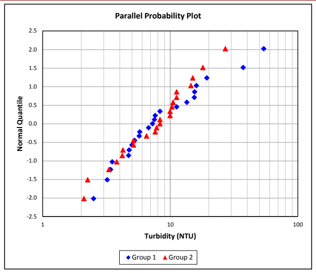
Statistical Comparison
Group 2 vs Group 1
Analyte
Turbidity
SW Standard
None
GW Standard
None
Standard Type
None
Alpha
0.05
Mean % Difference (robust ROS)
21.61854103

Time Series - Mann-Kendall (MK) Trend Analyses

	Group 1	Group 2
Count (n)	23	23
Count (nondetects)	0	0
S	-83	-65
VarS	1434	1430
Trend	Decreasing	Decreasing
p-value	0.01516869	0.04526276



Parallel Probability Plot

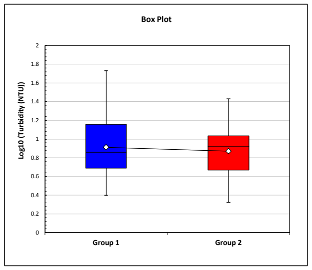


Shapiro-Wilk (SW) and Lilliefors (L) Normality Tests

	Group 1	Group 2
p-value (SW)	0.24180766	0.83429379
p-value (L)	0.23319597	1.00000000

Note: Values should be greater than alpha (C

Box Plot



t Test (Independent)

	Data	LogData	RkData
Mean (robust ROS)			
Group 1	11.44347826	0.91196095	23.67391304
Group 2	8.969565217	0.870614523	23.32608696
Delta	0.00000000	0.00000000	0.00000000
Std (robust ROS)			
Group 1	12.03074002	0.33813109	14.09836281
Group 2	5.741530108	0.280930169	13.01712918
degrees of freedom	31.52708380	42.57069392	43.72280072
Effect Size (d)	-2.47391304	-0.04134643	-0.34782609
t Statistic	0.89002028	0.45106302	0.08693178
t Critical	1.69551878	1.68195236	1.68107070
p-value (2-sided)	0.38053703	0.65432084	0.93113888
Power	0.21333384	0.11260652	0.05911494
Power Analysis			
Beta	0.2	0.2	0.2
Additional n (each Group)	64	>300	>300

Summary Statistics

	Turbidity	n	% dect	min	max	mean	median	STDDEV	CV
Group 1	DST-MC1	23	100%	2.500	54	11.443	7.250	12.031	1.051
Group 2	DST-MC2	23	100%	2.1000	27.000	8.970	8.300	5.742	0.640

Group 1		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC3
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Group 2		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC4
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Statistical Comparison

Group 2 vs Group 1

Analyte

Turbidity

SW Standard

None

GW Standard

None

Standard Type

None

Alpha

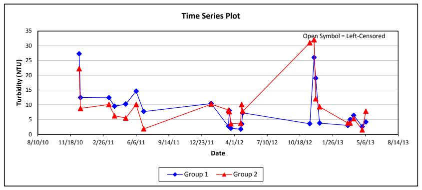
0.05

Mean % Difference (robust ROS)

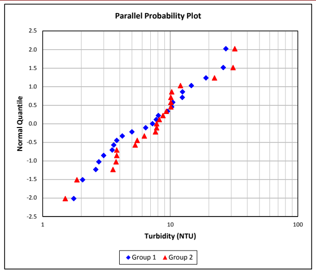
-9.307465619

Time Series - Mann-Kendall (MK) Trend Analyses

	Group 1	Group 2
Count (n)	23	23
Count (nondetects)	0	0
S	-89	-38
VarS	1434	1428
Trend	Decreasing	Decreasing
p-value	0.01005953	0.16375940



Parallel Probability Plot

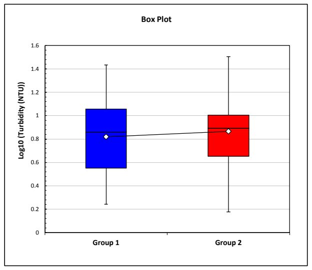


Shapiro-Wilk (SW) and Lilliefors (L) Normality Tests

	Group 1	Group 2
p-value (SW)	0.64498250	0.35542261
p-value (L)	0.75268558	0.14735159

Note: Values should be greater than alpha (C

Box Plot



t Test (Independent)

	Data	LogData	RkData
Mean (robust ROS)			
Group 1	8.85217391	0.81912214	22.67391304
Group 2	9.676086957	0.866325989	24.32608696
Delta	0.00000000	0.00000000	0.00000000
Std (robust ROS)			
Group 1	7.18256219	0.34387507	14.43292377
Group 2	8.114617416	0.330186575	12.59203274
degrees of freedom	43.36085446	43.92759787	43.20548154
Effect Size (d)	0.82391304	0.04720385	1.65217391
t Statistic	-0.36462318	-0.47486170	-0.41367990
t Critical	-1.68107070	-1.68107070	-1.68107070
p-value (2-sided)	0.71722225	0.63734561	0.68121337
Power	0.09749899	0.11716589	0.10591821
Power Analysis			
Beta	0.2	0.2	0.2
Additional n (each Group)	>300	>300	>300

Summary Statistics

	Turbidity	n	% dect	min	max	mean	median	STDDEV	CV
Group 1	DST-MC3	23	100%	1.750	27.25	8.852	7.250	7.183	0.811
Group 2	DST-MC4	23	100%	1.5000	32.000	9.676	7.800	8.115	0.839

Group 1		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC5
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Group 2		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC6
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Statistical Comparison

Group 2 vs Group 1

Analyte

Turbidity

SW Standard

None

GW Standard

None

Standard Type

None

Alpha

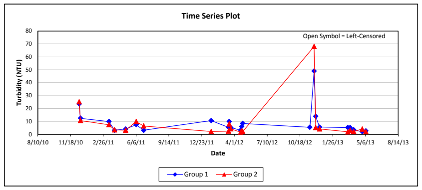
0.05

Mean % Difference (robust ROS)

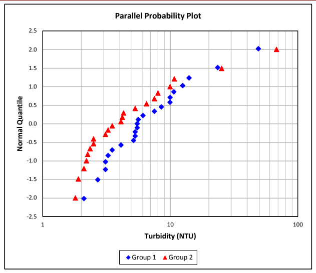
7.91534781

Time Series - Mann-Kendall (MK) Trend Analyses

	Group 1	Group 2
Count (n)	23	22
Count (nondetects)	0	0
S	-70	-90
VarS	1431	1257
Trend	Decreasing	Decreasing
p-value	0.03405857	0.00602607



Parallel Probability Plot

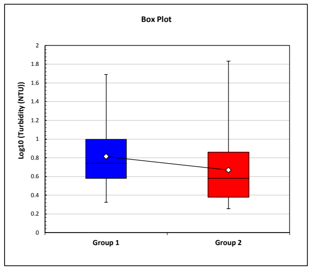


Shapiro-Wilk (SW) and Lilliefors (L) Normality Tests

	Group 1	Group 2
p-value (SW)	0.18189012	0.00464670
p-value (L)	0.22552868	0.08810005

Note: Values should be greater than alpha (C

Box Plot



t Test (Independent)

	Data	LogData	RkData
Mean (robust ROS)			
Group 1	8.94927536	0.81350843	26.47826087
Group 2	8.240909091	0.668816159	19.36363636
Delta	0.00000000	0.00000000	0.00000000
Std (robust ROS)			
Group 1	9.96665334	0.31922393	11.47277237
Group 2	14.30482466	0.391379486	14.00185516
degrees of freedom	37.34406873	40.55453928	40.63571572
Effect Size (d)	-0.70836627	-0.14469227	-7.11462451
t Statistic	0.19194063	1.35556940	1.85980173
t Critical	1.68709362	1.68385101	1.68385101
p-value (2-sided)	0.84886730	0.18303486	0.07046839
Power	0.07167778	0.37220555	0.43061021
Power Analysis			
Beta	0.2	0.2	0.2
Additional n (each Group)	>300	15	1

Summary Statistics

	Turbidity	n	% dect	min	max	mean	median	STDDEV	CV
Group 1	DST-MC5	23	100%	2.100	49	8.949	5.500	9.967	1.114
Group 2	DST-MC6	22	100%	1.8000	68.000	8.241	3.800	14.305	1.736

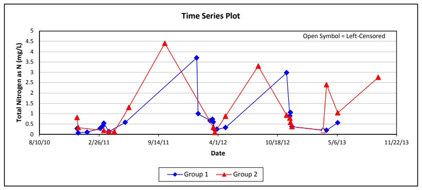
Group 1		
EventType	Year	Site
Mix Rain/Snow	2009-10	DSC-MC2
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Statistical Comparison
Group 2 vs Group 1
Analyte
Total Nitrogen as N
SW Standard
None
GW Standard
None
Standard Type
None
Alpha
0.05
Mean % Difference (robust ROS)
-64.04326098

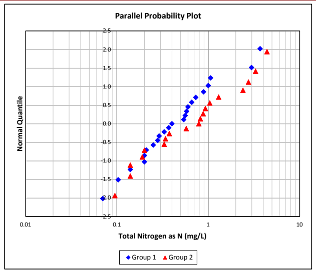
Group 2		
EventType	Year	Site
Mix Rain/Snow	2009-10	DSC-MC3
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Time Series - Mann-Kendall (MK) Trend Analyses

	Group 1	Group 2
Count (n)	23	19
Count (nondetects)	3	1
S	46	38
VarS	1433	816
Trend	Increasing	Increasing
p-value	0.11724241	0.09761544



Parallel Probability Plot

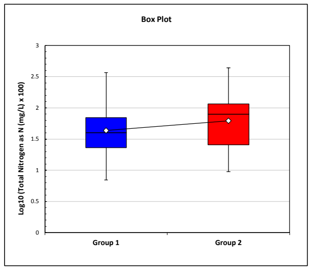


Shapiro-Wilk (SW) and Lilliefors (L) Normality Tests

	Group 1	Group 2
p-value (SW)	0.78603856	0.59250529
p-value (L)	1.00000000	1.00000000

Note: Values should be greater than alpha (0

Box Plot



t Test (Independent)

	Data	LogData	RkData
Mean (robust ROS)			
Group 1	0.69258517	1.63689429	19.76086957
Group 2	1.099731757	1.793219447	23.60526316
Delta	0.00000000	0.00000000	0.00000000
Std (robust ROS)			
Group 1	0.89073943	0.41641538	11.31759447
Group 2	1.227992956	0.497081118	13.32143109
degrees of freedom	32.08796448	35.23177297	35.52967487
Effect Size (d)	0.40714658	0.15632516	3.84439359
t Statistic	-1.20658909	-1.09065440	-0.99564057
t Critical	-1.69388875	-1.68957246	-1.68957246
p-value (2-sided)	0.23671784	0.28309430	0.32645830
Power	0.31468384	0.27654228	0.24615264
Power Analysis			
Beta	0.2	0.2	0.2
Additional n (each Group)	35	47	61

Summary Statistics

	Total Nitrogen as N	n	% dect	min	max	mean	median	STDDEV	CV
Group 1	DSC-MC2	23	87%	0.070	3.7	0.693	0.400	0.891	1.286
Group 2	DSC-MC3	19	95%	0.0950	4.400	1.100	0.790	1.228	1.117

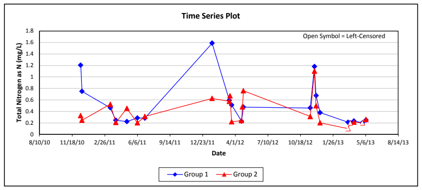
Group 1		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC1
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Group 2		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC2
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

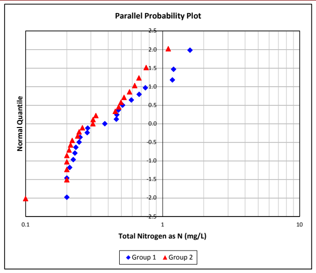
Statistical Comparison
Group 2 vs Group 1
Analyte
Total Nitrogen as N
SW Standard
None
GW Standard
None
Standard Type
None
Alpha
0.05
Mean % Difference (robust ROS)
29.38702153

Time Series - Mann-Kendall (MK) Trend Analyses

	Group 1	Group 2
Count (n)	21	23
Count (nondetects)	1	3
S	-69	-39
VarS	1096	1425
Trend	Decreasing	Decreasing
p-value	0.01997200	0.15705280



Parallel Probability Plot

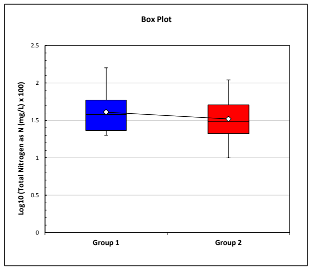


Shapiro-Wilk (SW) and Lilliefors (L) Normality Tests

	Group 1	Group 2
p-value (SW)	0.03195098	0.28372952
p-value (L)	0.04776684	0.28753859

Note: Values should be greater than alpha (0

Box Plot



t Test (Independent)

	Data	LogData	RkData
Mean (robust ROS)			
Group 1	0.50106008	1.61022428	24.50000000
Group 2	0.380380393	1.518625251	20.67391304
Delta	0.00000000	0.00000000	0.00000000
Std (robust ROS)			
Group 1	0.39012802	0.27889494	12.65800142
Group 2	0.245328475	0.249050855	12.98916392
degrees of freedom	33.12390208	40.30299924	41.81033115
Effect Size (d)	-0.12067969	-0.09159903	-3.82608696
t Statistic	1.21506323	1.14492341	0.98903461
t Critical	1.69236031	1.68385101	1.68287800
p-value (2-sided)	0.23323147	0.25921874	0.32859151
Power	0.31814833	0.29646193	0.24584654
Power Analysis			
Beta	0.2	0.2	0.2
Additional n (each Group)	23	29	45

Summary Statistics

	Total Nitrogen as N	n	% dect	min	max	mean	median	STDDEV	CV
Group 1	DST-MC1	21	95%	0.200	1.587	0.501	0.379	0.390	0.779
Group 2	DST-MC2	23	87%	0.1000	1.100	0.380	0.310	0.245	0.645

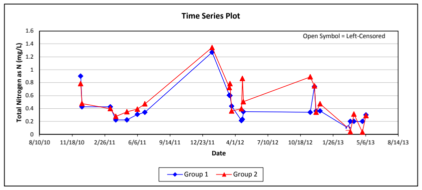
Group 1		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC3
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Group 2		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC4
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

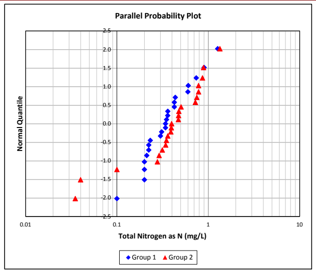
Statistical Comparison
Group 2 vs Group 1
Analyte
Total Nitrogen as N
SW Standard
None
GW Standard
None
Standard Type
None
Alpha
0.05
Mean % Difference (robust ROS)
-40.32704403

Time Series - Mann-Kendall (MK) Trend Analyses

	Group 1	Group 2
Count (n)	23	23
Count (nondetects)	4	1
S	-77	-70
VarS	1427	1433
Trend	Decreasing	Decreasing
p-value	0.02211641	0.03415492



Parallel Probability Plot

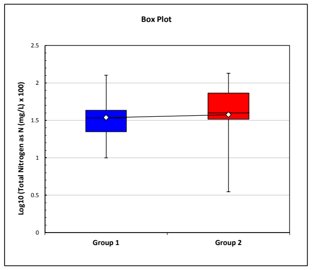


Shapiro-Wilk (SW) and Lilliefors (L) Normality Tests

	Group 1	Group 2
p-value (SW)	0.57438552	0.00144841
p-value (L)	0.48757024	0.02382868

Note: Values should be greater than alpha (0

Box Plot



t Test (Independent)

	Data	LogData	RkData
Mean (robust ROS)			
Group 1	0.39855467	1.53747510	20.65217391
Group 2	0.501534423	1.575545598	26.34782609
Delta	0.00000000	0.00000000	0.00000000
Std (robust ROS)			
Group 1	0.27469124	0.24843364	12.85799608
Group 2	0.299750501	0.391888591	13.63854396
degrees of freedom	43.66885000	37.22391830	43.84805805
Effect Size (d)	0.10297975	0.03807050	5.69565217
t Statistic	-1.21470806	-0.39349082	-1.45728619
t Critical	-1.68107070	-1.68709362	-1.68107070
p-value (2-sided)	0.23126273	0.69627787	0.15247414
Power	0.32165502	0.10191019	0.41199241
Power Analysis			
Beta	0.2	0.2	0.2
Additional n (each Group)	39	>300	20

Summary Statistics

	Total Nitrogen as N	n	% dect	min	max	mean	median	STDDEV	CV
Group 1	DST-MC3	23	83%	0.100	1.27	0.399	0.340	0.275	0.689
Group 2	DST-MC4	23	96%	0.0350	1.343	0.502	0.398	0.300	0.598

Group 1		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC5
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Group 2		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC6
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Statistical Comparison
Group 2 vs Group 1

Analyte
Total Nitrogen as N

SW Standard
None

GW Standard
None

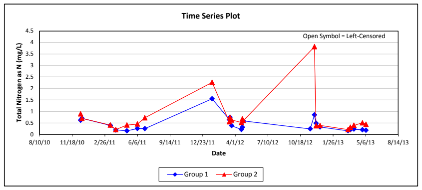
Standard Type
None

Alpha
0.05

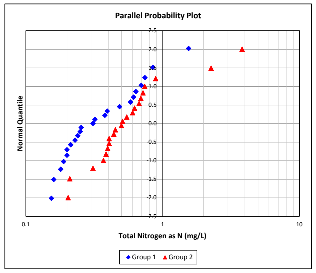
Mean % Difference (robust ROS)
-87.07545176

Time Series - Mann-Kendall (MK) Trend Analyses

	Group 1	Group 2
Count (n)	23	22
Count (nondetects)	2	0
S	-68	-48
VarS	1433	1257
Trend	Decreasing	Decreasing
p-value	0.03835374	0.09244802



Parallel Probability Plot

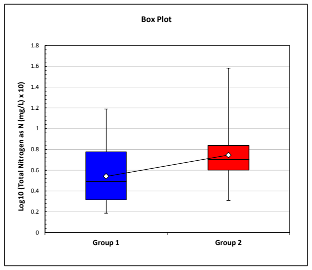


Shapiro-Wilk (SW) and Lilliefors (L) Normality Tests

	Group 1	Group 2
p-value (SW)	0.11116399	0.00877585
p-value (L)	0.08364267	0.02764882

Note: Values should be greater than alpha (C

Box Plot



t Test (Independent)

	Data	LogData	RkData
Mean (robust ROS)			
Group 1	0.42348115	0.54116101	18.58695652
Group 2	0.734772727	0.745371333	27.61363636
Delta	0.00000000	0.00000000	0.00000000
Std (robust ROS)			
Group 1	0.32646621	0.27234122	13.82492165
Group 2	0.802030099	0.287060426	10.83966681
degrees of freedom	27.52395580	42.59090978	41.43568667
Effect Size (d)	0.31129157	0.20421032	9.02667984
t Statistic	-1.69138590	-2.44595829	-2.44314640
t Critical	-1.70328845	-1.68195236	-1.68287800
p-value (2-sided)	0.10271719	0.01882605	0.01906893
Power	0.49529544	0.77543265	0.77427790
Power Analysis			
Beta	0.2	NA	NA
Additional n (each Group)	10	NA	NA

Summary Statistics

	Total Nitrogen as N	n	% dect	min	max	mean	median	STDDEV	CV
Group 1	DST-MC5	23	91%	0.154	1.55	0.423	0.310	0.326	0.771
Group 2	DST-MC6	22	100%	0.2040	3.814	0.735	0.505	0.802	1.092

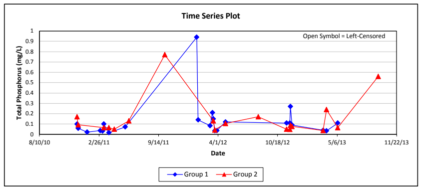
Group 1		
EventType	Year	Site
Mix Rain/Snow	2009-10	DSC-MC2
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Group 2		
EventType	Year	Site
Mix Rain/Snow	2009-10	DSC-MC3
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

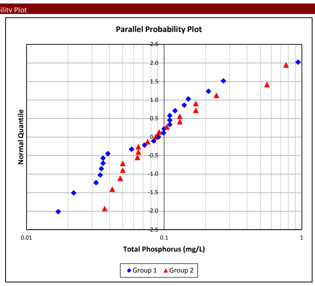
Statistical Comparison
Group 2 vs Group 1
Analyte
Total Phosphorus
SW Standard
None
GW Standard
None
Standard Type
None
Alpha
0.05
Mean % Difference (robust ROS)
-22.51976844

Time Series - Mann-Kendall (MK) Trend Analyses

	Group 1	Group 2
Count (n)	23	19
Count (nondetects)	0	0
S	37	-11
VarS	1429	813
Trend	Increasing	None
p-value	0.17046542	0.36290097



Parallel Probability Plot

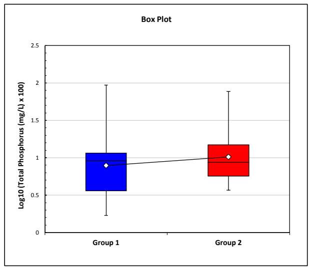


Shapiro-Wilk (SW) and Lilliefors (L) Normality Tests

	Group 1	Group 2
p-value (SW)	0.24588834	0.04530776
p-value (L)	0.40532583	0.55036874

Note: Values should be greater than alpha (0

Box Plot



t Test (Independent)

	Data	LogData	RkData
Mean (robust ROS)			
Group 1	0.12675362	0.89623831	19.95652174
Group 2	0.155298246	1.011065398	23.36842105
Delta	0.00000000	0.00000000	0.00000000
Std (robust ROS)			
Group 1	0.18779470	0.39258239	13.17100210
Group 2	0.190498433	0.361972761	11.1265974
degrees of freedom	38.30375618	39.47857438	39.97061368
Effect Size (d)	0.02854462	0.11482709	3.41189931
t Statistic	-0.48644687	-0.98474552	-0.90997717
t Critical	-1.68595446	-1.68487512	-1.68487512
p-value (2-sided)	0.62951937	0.33097787	0.36857062
Power	0.11887827	0.24400105	0.22153652
Power Analysis			
Beta	0.2	0.2	0.2
Additional n (each Group)	>300	64	79

Summary Statistics

	Total Phosphorus	n	% dect	min	max	mean	median	STDDEV	CV
Group 1	DSC-MC2	23	100%	0.017	0.94	0.127	0.091	0.188	1.482
Group 2	DSC-MC3	19	100%	0.0370	0.770	0.155	0.087	0.190	1.227

Group 1		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC1
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Group 2		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC2
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Statistical Comparison
Group 2 vs Group 1

Analyte
Total Phosphorus

SW Standard
None

GW Standard
None

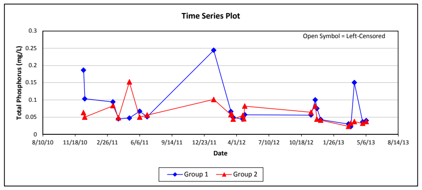
Standard Type
None

Alpha
0.05

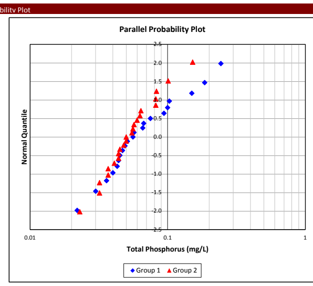
Mean % Difference (robust ROS)
23.88459976

Time Series - Mann-Kendall (MK) Trend Analyses

	Group 1	Group 2
Count (n)	21	23
Count (nondetects)	0	0
S	-76	-112
VarS	1097	1429
Trend	Decreasing	Decreasing
p-value	0.01176342	0.00165870



Parallel Probability Plot

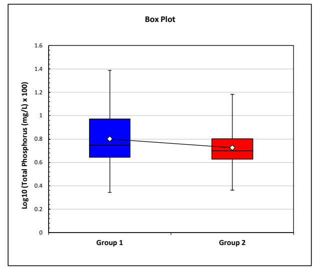


Shapiro-Wilk (SW) and Lilliefors (L) Normality Tests

	Group 1	Group 2
p-value (SW)	0.44779790	0.85312996
p-value (L)	0.34617816	0.66014348

Note: Values should be greater than alpha (C

Box Plot



t Test (Independent)

	Data	LogData	RkData
Mean (robust ROS)			
Group 1	0.07642857	0.80102887	24.11904762
Group 2	0.058173913	0.726151405	21.02173913
Delta	0.00000000	0.00000000	0.00000000
Std (robust ROS)			
Group 1	0.05548204	0.26042600	13.83916974
Group 2	0.027861104	0.181465534	11.97296031
degrees of freedom	28.87817913	35.34781288	39.78490875
Effect Size (d)	-0.01825466	-0.07487746	-3.09730849
t Statistic	1.35936399	1.09672074	0.79047932
t Critical	1.70113093	1.68957246	1.68487512
p-value (2-sided)	0.18527743	0.28047075	0.43415363
Power	0.36753907	0.27854595	0.18829842
Power Analysis			
Beta	0.2	0.2	0.2
Additional n (each Group)	15	33	82

Summary Statistics

	Total Phosphorus	n	% dect	min	max	mean	median	STDDEV	CV
Group 1	DST-MC1	21	100%	0.022	0.244	0.076	0.056	0.055	0.726
Group 2	DST-MC2	23	100%	0.0230	0.152	0.058	0.050	0.028	0.479

Group 1		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC3
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Group 2		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC4
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Statistical Comparison

Group 2 vs Group 1

Analyte

Total Phosphorus

SW Standard

None

GW Standard

None

Standard Type

None

Alpha

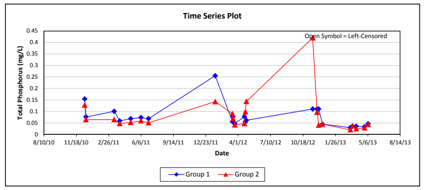
0.05

Mean % Difference (robust ROS)

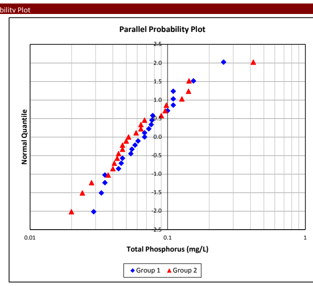
-3.828828829

Time Series - Mann-Kendall (MK) Trend Analyses

	Group 1	Group 2
Count (n)	23	23
Count (nondetects)	0	0
S	-100	-85
VarS	1428	1432
Trend	Decreasing	Decreasing
p-value	0.00439884	0.01320845



Parallel Probability Plot

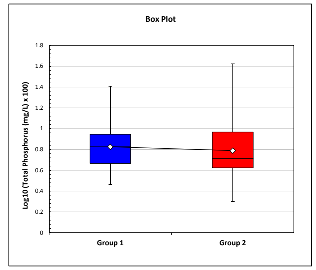


Shapiro-Wilk (SW) and Lilliefors (L) Normality Tests

	Group 1	Group 2
p-value (SW)	0.57054657	0.20330465
p-value (L)	0.48808276	0.33220075

Note: Values should be greater than alpha (C

Box Plot



t Test (Independent)

	Data	LogData	RkData
Mean (robust ROS)			
Group 1	0.07721739	0.82499344	25.06521739
Group 2	0.080173913	0.788072744	21.93478261
Delta	0.00000000	0.00000000	0.00000000
Std (robust ROS)			
Group 1	0.04951396	0.22770762	12.82691094
Group 2	0.082112812	0.293301785	14.0900548
degrees of freedom	36.13054399	41.45318298	43.61747201
Effect Size (d)	0.00295652	-0.03692070	-3.13043478
t Statistic	-0.14787314	0.47685728	0.78791579
t Critical	-1.68829771	1.68287800	1.68107070
p-value (2-sided)	0.88329151	0.63605872	0.43517044
Power	0.06610092	0.11736158	0.18837290
Power Analysis			
Beta	0.2	0.2	0.2
Additional n (each Group)	>300	274	87

Summary Statistics

	Total Phosphorus	n	% dect	min	max	mean	median	STDDEV	CV
Group 1	DST-MC3	23	100%	0.029	0.255	0.077	0.068	0.050	0.641
Group 2	DST-MC4	23	100%	0.0200	0.420	0.080	0.052	0.082	1.024

Group 1		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC5
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Group 2		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC6
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Statistical Comparison

Group 2 vs Group 1

Analyte

Total Phosphorus

SW Standard

None

GW Standard

None

Standard Type

None

Alpha

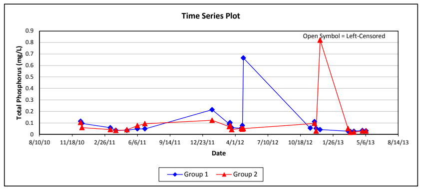
0.05

Mean % Difference (robust ROS)

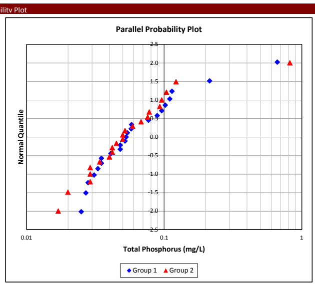
0.333777405

Time Series - Mann-Kendall (MK) Trend Analyses

	Group 1	Group 2
Count (n)	23	22
Count (nondetects)	0	0
S	-87	-64
VarS	1432	1252
Trend	Decreasing	Decreasing
p-value	0.01151655	0.03749829



Parallel Probability Plot

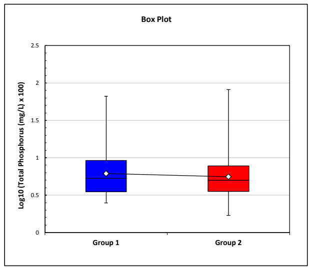


Shapiro-Wilk (SW) and Lilliefors (L) Normality Tests

	Group 1	Group 2
p-value (SW)	0.00796501	0.00652001
p-value (L)	0.04640056	0.48655870

Note: Values should be greater than alpha (C

Box Plot



t Test (Independent)

	Data	LogData	RkData
Mean (robust ROS)			
Group 1	0.09098551	0.78804569	23.82608696
Group 2	0.090681818	0.745913481	22.13636364
Delta	0.00000000	0.00000000	0.00000000
Std (robust ROS)			
Group 1	0.13215523	0.32794400	13.24730564
Group 2	0.165363204	0.346542335	13.25948162
degrees of freedom	40.18140245	42.56988899	42.90758655
Effect Size (d)	-0.00030369	-0.04213220	-1.68972332
t Statistic	0.00678679	0.41851327	0.42751664
t Critical	1.68385101	1.68195236	1.68195236
p-value (2-sided)	0.99461957	0.67775612	0.67124016
Power	0.05066453	0.10669992	0.10831005
Power Analysis			
Beta	0.2	0.2	0.2
Additional n (each Group)	>300	>300	>300

Summary Statistics

	Total Phosphorus	n	% dect	min	max	mean	median	STDDEV	CV
Group 1	DST-MC5	23	100%	0.025	0.665	0.091	0.053	0.132	1.452
Group 2	DST-MC6	22	100%	0.0170	0.820	0.091	0.050	0.165	1.824

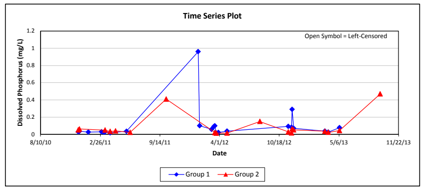
Group 1		
EventType	Year	Site
Mix Rain/Snow	2009-10	DSC-MC2
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Statistical Comparison
Group 2 vs Group 1
Analyte
Dissolved Phosphorus
SW Standard
None
GW Standard
None
Standard Type
None
Alpha
0.05
Mean % Difference (robust ROS)
15.15035404

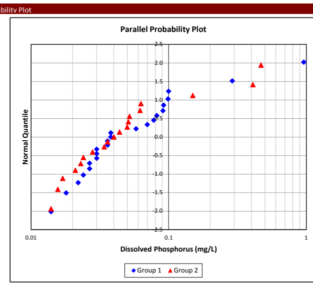
Group 2		
EventType	Year	Site
Mix Rain/Snow	2009-10	DSC-MC3
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Time Series - Mann-Kendall (MK) Trend Analyses

	Group 1	Group 2
Count (n)	23	19
Count (nondetects)	0	0
S	49	-1
VarS	1427	817
Trend	Increasing	None
p-value	0.10192487	0.50000000



Parallel Probability Plot

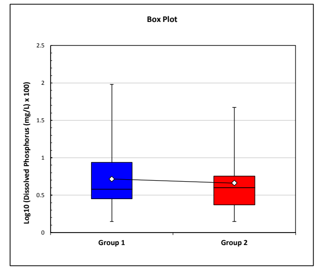


Shapiro-Wilk (SW) and Lilliefors (L) Normality Tests

	Group 1	Group 2
p-value (SW)	0.00932823	0.01312658
p-value (L)	0.02457891	0.01963791

Note: Values should be greater than alpha (0

Box Plot



t Test (Independent)

	Data	LogData	RkData
Mean (robust ROS)			
Group 1	0.09953623	0.71552504	22.54347826
Group 2	0.08445614	0.662705936	20.23684211
Delta	0.00000000	0.00000000	0.00000000
Std (robust ROS)			
Group 1	0.19617115	0.41263029	12.14206909
Group 2	0.129237613	0.425870615	12.61873433
degrees of freedom	38.27639723	38.03044550	37.91652439
Effect Size (d)	-0.01508009	-0.05281911	-2.30663616
t Statistic	0.29849861	0.40572100	0.59977103
t Critical	1.68595446	1.68595446	1.68709362
p-value (2-sided)	0.76699265	0.68728438	0.55241550
Power	0.08669319	0.10411159	0.14196346
Power Analysis			
Beta	0.2	0.2	0.2
Additional n (each Group)	>300	>300	149

Summary Statistics

	Dissolved Phosphorus	n	% dect	min	max	mean	median	STDDEV	CV
Group 1	DSC-MC2	23	100%	0.014	0.96	0.100	0.038	0.196	1.971
Group 2	DSC-MC3	19	100%	0.0140	0.470	0.084	0.040	0.129	1.530

Group 1		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC1
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Group 2		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC2
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Statistical Comparison

Group 2 vs Group 1

Analyte

Dissolved Phosphorus

SW Standard

None

GW Standard

None

Standard Type

None

Alpha

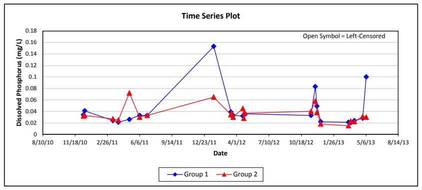
0.05

Mean % Difference (robust ROS)

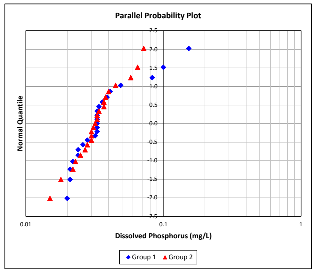
-6.924101198

Time Series - Mann-Kendall (MK) Trend Analyses

	Group 1	Group 2
Count (n)	23	23
Count (nondetects)	1	0
S	-16	-34
VarS	1403	1428
Trend	Decreasing	Decreasing
p-value	0.34442527	0.19125725



Parallel Probability Plot

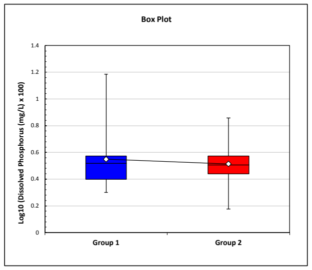


Shapiro-Wilk (SW) and Lilliefors (L) Normality Tests

	Group 1	Group 2
p-value (SW)	0.00096933	0.58619331
p-value (L)	0.00351021	0.48892040

Note: Values should be greater than alpha (0

Box Plot



t Test (Independent)

	Data	LogData	RkData
Mean (robust ROS)			
Group 1	0.03842103	0.54835975	23.86956522
Group 2	0.034913043	0.513630075	23.13043478
Delta	0.00000000	0.00000000	0.00000000
Std (robust ROS)			
Group 1	0.02812730	0.22058014	13.84181526
Group 2	0.013921576	0.161006344	13.20917157
degrees of freedom	32.16863157	40.25945039	43.90405071
Effect Size (d)	-0.00350799	-0.03472967	-0.73913043
t Statistic	0.53606038	0.60989827	0.18526703
t Critical	1.69388875	1.68385101	1.68107070
p-value (2-sided)	0.59574270	0.54546665	0.85391139
Power	0.12775155	0.14463999	0.07100440
Power Analysis			
Beta	0.2	0.2	0.2
Additional n (each Group)	212	159	>300

Summary Statistics

	Dissolved Phosphorus	n	% dect	min	max	mean	median	STDDEV	CV
Group 1	DST-MC1	23	96%	0.020	0.153	0.038	0.033	0.028	0.732
Group 2	DST-MC2	23	100%	0.0150	0.072	0.035	0.032	0.014	0.399

Group 1		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC3
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Group 2		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC4
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Statistical Comparison
Group 2 vs Group 1

Analyte
Dissolved Phosphorus

SW Standard
None

GW Standard
None

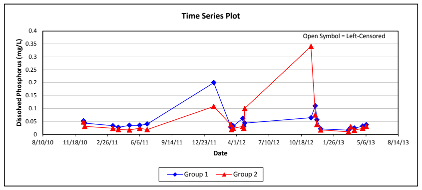
Standard Type
None

Alpha
0.05

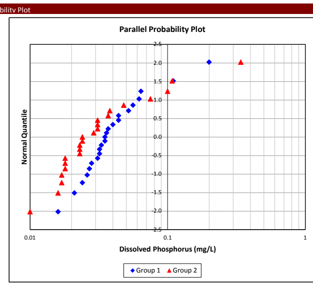
Mean % Difference (robust ROS)
-1.290322581

Time Series - Mann-Kendall (MK) Trend Analyses

	Group 1	Group 2
Count (n)	23	23
Count (nondetects)	0	0
S	-36	-8
VarS	1431	1421
Trend	Decreasing	Decreasing
p-value	0.17739594	0.42633330



Parallel Probability Plot

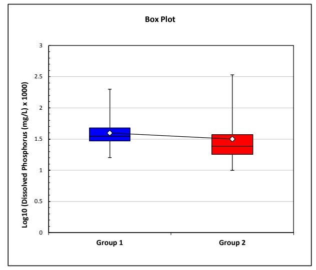


Shapiro-Wilk (SW) and Lilliefors (L) Normality Tests

	Group 1	Group 2
p-value (SW)	0.03208599	0.00517512
p-value (L)	0.12666605	0.01331677

Note: Values should be greater than alpha (0

Box Plot



t Test (Independent)

	Data	LogData	RkData
Mean (robust ROS)			
Group 1	0.04717391	1.59682664	27.50000000
Group 2	0.047782609	1.499222387	19.5
Delta	0.00000000	0.00000000	0.00000000
Std (robust ROS)			
Group 1	0.03863777	0.23535247	11.17118859
Group 2	0.068709505	0.339333653	14.47882466
degrees of freedom	34.64888490	39.18843902	41.33951495
Effect Size (d)	0.00060870	-0.09760425	-8.00000000
t Statistic	-0.03703249	1.13350102	2.09797404
t Critical	-1.69092426	1.68487512	1.68287800
p-value (2-sided)	0.97068222	0.26410476	0.04227064
Power	0.05367720	0.29226135	0.65988208
Power Analysis			
Beta	0.2	0.2	NA
Additional n (each Group)	>300	31	NA

Summary Statistics

	Dissolved Phosphorus	n	% dect	min	max	mean	median	STDDEV	CV
Group 1	DST-MC3	23	100%	0.016	0.2	0.047	0.035	0.039	0.819
Group 2	DST-MC4	23	100%	0.0100	0.340	0.048	0.024	0.069	1.438

Group 1		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC5
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Group 2		
EventType	Year	Site
Mix Rain/Snow	2009-10	DST-MC6
Snow melt	2010-11	
Rain	2011-12	
	2012-13	

Statistical Comparison

Group 2 vs Group 1

Analyte

Dissolved Phosphorus

SW Standard

None

GW Standard

None

Standard Type

None

Alpha

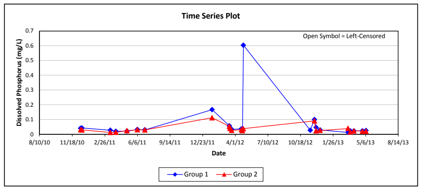
0.05

Mean % Difference (robust ROS)

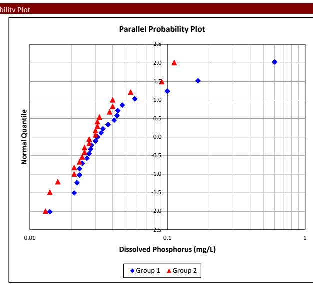
46.80004031

Time Series - Mann-Kendall (MK) Trend Analyses

	Group 1	Group 2
Count (n)	23	22
Count (nondetects)	0	0
S	-40	-29
VarS	1433	1252
Trend	Decreasing	Decreasing
p-value	0.15141883	0.21434593



Parallel Probability Plot

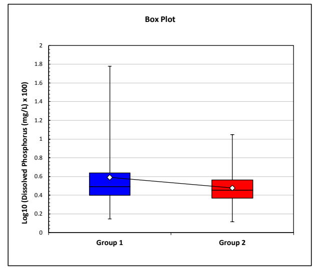


Shapiro-Wilk (SW) and Lilliefors (L) Normality Tests

	Group 1	Group 2
p-value (SW)	0.00015743	0.08117169
p-value (L)	0.00237783	0.07378770

Note: Values should be greater than alpha (C

Box Plot



t Test (Independent)

	Data	LogData	RkData
Mean (robust ROS)			
Group 1	0.06536232	0.58963167	25.21739130
Group 2	0.034772727	0.476174964	20.68181818
Delta	0.00000000	0.00000000	0.00000000
Std (robust ROS)			
Group 1	0.12162365	0.34607382	13.18300049
Group 2	0.023750553	0.22583642	12.95279475
degrees of freedom	23.74958170	38.04878236	42.96661997
Effect Size (d)	-0.03058959	-0.11345671	-4.53557312
t Statistic	1.18285254	1.30786011	1.16402852
t Critical	1.71387153	1.68595446	1.68195236
p-value (2-sided)	0.24949345	0.19898870	0.25114160
Power	0.30024827	0.35373223	0.30361452
Power Analysis			
Beta	0.2	0.2	0.2
Additional n (each Group)	28	18	28

Summary Statistics

	Dissolved Phosphorus	n	% dect	min	max	mean	median	STDDEV	CV
Group 1	DST-MC5	23	100%	0.014	0.603	0.065	0.031	0.122	1.861
Group 2	DST-MC6	22	100%	0.0130	0.112	0.035	0.029	0.024	0.683

Appendix B

Laboratory Analytical Data and Field Parameter Data

StationName	Sample Type	Sample Collection Date	Ammonia as N mg/L	Dissolved Phosphorus mg/L	Nitrate and Nitrite as N mg/L	Nitrate as N mg/L	Nitrite as N mg/L	Ortho-phosphate mg/L	Total Kjeldahl Nitrogen (TKN) mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Total Suspended Solids mg/L	Turbidity NTU	C10-C22 mg/L	C22-C36 mg/L	C6-C10 mg/L	Total Extractable Hydrocarbons (C6-C36) mg/L	pH	Electrical Conductivity µS
Water Year 2010																			
DSC-TC1		2/24/2010		0.018		0.11	0.073	0.016	0.49	0.68	0.24	82	120						
DSC-TC1		2/26/2010		0.078		0.36	0.034	0.081	0.71	1.1	0.16	71	63						
DSC-TC1		3/29/2010		0.1		0.21	0.01 U	0.044	0.49	0.7	0.13	14	24						
DSC-TC1		4/22/2010		0.057		0.69	0.01 U	0.044	0.27	0.96	0.18	20	30						
DSC-TC1		4/27/2010		0.049		0.39	0.01 U	0.042	0.42	0.81	0.27	38	48						
DSC-TC1		5/25/2010		0.13		1.6	0.01 U	0.089	0.28	1.9	0.14	2	5.1						
DSC-TC1	DUP	5/25/2010		0.077		1.6	0.01 U	0.092	0.27	1.9	0.11	3	5						
DSC-TT1		2/5/2010		0.01 U	0.22			0.037	3	3.2	0.44	1600	1300						
DSC-TT1		2/24/2010		0.058		0.12	0.1	0.068	1	1.2	0.12	270 J	990						
DSC-TT1	DUP	2/24/2010		0.045		0.11	0.073	0.07	1.2	1.4	0.14	480 J	940						
DSC-TT1		2/26/2010		0.084		0.28	0.045	0.1	2.9	3.3	0.26	2200	470						
DSC-TT1		3/12/2010		0.012		0.43	0.33	0.057	2.3	3.1	2	1500	770						
DSC-TT1		3/29/2010		0.055		0.15	0.01 U	0.092	0.39	0.54	0.076	33	58						
DSC-TT1		4/22/2010		0.028		0.12	0.015	0.042	1.5	1.7	0.42	470	400						
DSC-TT1		4/27/2010		0.081		0.14	0.01 U	0.084	1.7	1.9	1.5	1000	470						
DSC-TT1		5/10/2010		0.048		0.3	0.056	0.059	1.8	2.2	0.53	470	300						
Quality Control	BB	3/12/2010		0.01 U		0.01 U	0.01 U	0.01 U	0.05 U	0.07 U	0.01 U	1 U	0.1 U						
Water Year 2011																			
DSC-MC1		10/4/2010				0.17	0.01 U		0.31	0.48	0.25	4	7.9						
DSC-MC1		10/4/2010				0.17	0.01 U		0.31	0.48	0.25	4	7.9						
DSC-MC1		10/24/2010				0.27	0.01 U		0.31	0.58	0.088	190	54						
DSC-MC1		10/24/2010				0.27	0.01 U		0.31	0.58	0.088	190	54						
DSC-MC1		12/14/2010			0.25	0.25	0.01 U						140						
DSC-MC1		12/14/2010			0.25	0.25	0.01 U						140						
DSC-MC1		3/2/2011				0.17	0.01 U		0.7	0.87	0.19	250	220						
DSC-MC1		3/2/2011				0.17	0.01 U		0.7	0.87	0.19	250	220						
DSC-MC1		3/6/2011				0.23	0.01 U		0.62	0.85	0.19	240	120						
DSC-MC1		3/6/2011				0.23	0.01 U		0.62	0.85	0.19	240	120						
DSC-MC1		3/28/2011				0.59	0.01 U		0.055	0.65	0.048	15	13						
DSC-MC1		3/28/2011				0.59	0.01 U		0.055	0.65	0.048	15	13						
DSC-MC1		4/11/2011				0.49	0.01 U		0.1	0.59	0.051	11	7.3						
DSC-MC1		4/11/2011				0.49	0.01 U		0.1	0.59	0.051	11	7.3						
DSC-MC1		5/25/2011				0.01 U	0.025 U		1.4	1.4	0.33	640	230						
DSC-MC1		5/25/2011				0.01 U	0.025 U		1.4	1.4	0.33	640	230						
DSC-MC2		12/14/2010	0.05 U	0.03		0.012	0.01 U	0.028	0.27	0.28	0.099	3	1.3						
DSC-MC2		12/14/2010	0.05 U	0.03		0.012	0.01 U	0.028	0.27	0.28	0.099	3	1.3						
DSC-MC2		12/18/2010	0.05 U	0.036		0.04	0.01 U	0.046	0.05 U	0.07 U	0.058	11	2.8						
DSC-MC2		12/18/2010	0.05 U	0.036		0.04	0.01 U	0.046	0.05 U	0.07 U	0.058	11	2.8						
DSC-MC2		1/17/2011	0.05 U	0.025	0.01 U	0.01 U	0.01 U	0.012	0.16	0.16	0.024	1 U	0.35						
DSC-MC2	DUP	1/17/2011	0.05 U	0.03	0.01 U	0.01 U	0.01 U	0.011	0.08	0.08	0.022	1	0.42						
DSC-MC2	TRIPLICATE	1/17/2011	0.05 U	0.025	0.01 U	0.01 U	0.01 U	0.012	0.054	0.07 U	0.02	1 U	0.52						
DSC-MC2		1/17/2011	0.05 U	0.025	0.01 U	0.01 U	0.01 U	0.012	0.16	0.16	0.024	1 U	0.35						
DSC-MC2	DUP	1/17/2011	0.05 U	0.03	0.01 U	0.01 U	0.01 U	0.011	0.08	0.08	0.022	1	0.42						
DSC-MC2	TRIPLICATE	1/17/2011	0.05 U	0.025	0.01 U	0.01 U	0.01 U	0.012	0.054	0.07 U	0.02	1 U	0.52						
DSC-MC2		3/2/2011	0.063	0.03		0.13	0.01 U	0.015	0.16	0.29	0.036	1 U	1.9						
DSC-MC2		3/2/2011	0.063	0.03		0.13	0.01 U	0.015	0.16	0.29	0.036	1 U	1.9						
DSC-MC2		3/10/2011	0.082	0.024		0.18	0.01 U	0.02	0.22	0.4	0.032	1 U	1.9						
DSC-MC2		3/10/2011	0.082	0.024		0.18	0.01 U	0.02	0.22	0.4	0.032	1 U	1.9						
DSC-MC2		3/14/2011	0.05 U	0.03		0.18	0.01 U	0.025	0.36	0.54	0.1	73	11						
DSC-MC2		3/14/2011	0.05 U	0.03		0.18	0.01 U	0.025	0.36	0.54	0.1	73	11						
DSC-MC2		3/31/2011	0.05 U	0.018		0.01 U	0.01 U	0.016	0.14	0.14	0.017	9	2.8						
DSC-MC2		3/31/2011	0.05 U	0.018		0.01 U	0.01 U	0.016	0.14	0.14	0.017	9	2.8						
DSC-MC2		5/25/2011	0.05 U	0.036		0.21	0.025 U	0.023	0.37	0.58	0.072	8	2.1						
DSC-MC2		5/25/2011	0.05 U	0.036		0.21	0.025 U	0.023	0.37	0.58	0.072	8	2.1						

StationName	Sample Type	Sample Collection Date	Ammonia as N mg/L	Dissolved Phosphorus mg/L	Nitrate and Nitrite as N mg/L	Nitrate as N mg/L	Nitrite as N mg/L	Ortho-phosphate mg/L	Total Kjeldahl Nitrogen (TKN) mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Total Suspended Solids mg/L	Turbidity NTU	C10-C22 mg/L	C22-C36 mg/L	C6-C10 mg/L	Total Extractable Hydrocarbons (C6-C36) mg/L	pH	Electrical Conductivity µS
DSC-MC3		12/14/2010	0.05 U	0.051		0.01 U	0.01 U	0.039	0.82	0.82	0.17	170	83						
DSC-MC3		12/14/2010	0.05 U	0.051		0.01 U	0.01 U	0.039	0.82	0.82	0.17	170	83						
DSC-MC3		12/18/2010	0.053	0.062		0.01 U	0.01 U	0.088	0.33	0.33	0.092	16	15						
DSC-MC3		12/18/2010	0.053	0.062		0.01 U	0.01 U	0.088	0.33	0.33	0.092	16	15						
DSC-MC3		3/14/2011	0.05 U	0.05		0.011	0.01 U	0.034	0.17	0.19	0.065	25	10						
DSC-MC3		3/14/2011	0.05 U	0.05		0.011	0.01 U	0.034	0.17	0.19	0.065	25	10						
DSC-MC3		3/31/2011	0.05 U	0.034		0.013	0.01 U	0.038	0.12	0.14	0.065	6	8.3						
DSC-MC3		3/31/2011	0.05 U	0.034		0.013	0.01 U	0.038	0.12	0.14	0.065	6	8.3						
DSC-MC3		4/18/2011	0.05 U	0.04		0.01 U	0.01 U	0.026	0.14	0.14	0.05	1	4.9						
DSC-MC3		4/18/2011	0.05 U	0.04		0.01 U	0.01 U	0.026	0.14	0.14	0.05	1	4.9						
DSC-MC3		6/6/2011	0.05 U	0.023		0.019	0.01 U	0.013	1.3	1.3	0.13	530	120						
DSC-MC3		6/6/2011	0.05 U	0.023		0.019	0.01 U	0.013	1.3	1.3	0.13	530	120						
DSC-TC1		10/4/2010				0.07	0.01 U		0.37	0.44	1.5	20	36						
DSC-TC1		10/4/2010				0.07	0.01 U		0.37	0.44	1.5	20	36						
DSC-TC1		10/24/2010				0.021	0.01 U		0.18	0.21	0.072	140	42						
DSC-TC1		10/24/2010				0.021	0.01 U		0.18	0.21	0.072	140	42						
DSC-TC1		12/14/2010			0.055	0.055	0.01 U		0.81	0.92	0.22	240	120						
DSC-TC1		12/14/2010			0.055	0.055	0.01 U		0.81	0.92	0.22	240	120						
DSC-TC1		12/18/2010			0.079	0.073	0.01 U		0.71	0.86	0.072	58	96						
DSC-TC1		12/18/2010			0.079	0.073	0.01 U		0.71	0.86	0.072	58	96						
DSC-TC1		12/28/2010				1.1	0.01 U		0.24	1.3	0.058	6	12						
DSC-TC1		12/28/2010				1.1	0.01 U		0.24	1.3	0.058	6	12						
DSC-TC1		2/22/2011				0.82	0.01 U		0.26	1.1	0.064	1	5.8						
DSC-TC1	DUP	2/22/2011				0.82	0.01 U		0.3	1.1	0.077	1 U	6.5						
DSC-TC1	TRIPLICATE	2/22/2011				0.82	0.01 U		0.35	1.2	0.067	1 U	5.9						
DSC-TC1		2/22/2011				0.82	0.01 U		0.26	1.1	0.064	1	5.8						
DSC-TC1	DUP	2/22/2011				0.82	0.01 U		0.3	1.1	0.077	1 U	6.5						
DSC-TC1	TRIPLICATE	2/22/2011				0.82	0.01 U		0.35	1.2	0.067	1 U	5.9						
DSC-TC1		3/6/2011				0.7	0.01 U		0.28	0.98	0.054	34	29						
DSC-TC1		3/6/2011				0.7	0.01 U		0.28	0.98	0.054	34	29						
DSC-TC1		3/14/2011				0.64	0.01 U		0.6	1.2	0.13	150	100						
DSC-TC1		3/14/2011				0.64	0.01 U		0.6	1.2	0.13	150	100						
DSC-TT1		10/24/2010				0.16	0.01 U		0.21	0.37	0.098	1300	300						
DSC-TT1		10/24/2010				0.16	0.01 U		0.21	0.37	0.098	1300	300						
DSC-TT1		12/14/2010			0.031	0.031	0.01 U		2	2	0.63	1000	600						
DSC-TT1		12/14/2010			0.031	0.031	0.01 U		2	2	0.63	1000	600						
DSC-TT1		1/17/2011			0.14	0.1	0.044		2.7	2.8	0.25	1200	620						
DSC-TT1	DUP	1/17/2011			0.13	0.094	0.038		2.7	2.9	0.27	1200	660						
DSC-TT1		1/17/2011			0.14	0.1	0.044		2.7	2.8	0.25	1200	620						
DSC-TT1	DUP	1/17/2011			0.13	0.094	0.038		2.7	2.9	0.27	1200	660						
DSC-TT1		3/2/2011				0.13	0.021		1.6	1.8	0.26	220	530						
DSC-TT1		3/2/2011				0.13	0.021		1.6	1.8	0.26	220	530						
DSC-TT1		3/14/2011				0.79	0.01 U		0.5	1.3	0.37	900	910						
DSC-TT1		3/14/2011				0.79	0.01 U		0.5	1.3	0.37	900	910						
DSC-TT1		3/28/2011				0.09	0.01 U		1.7	1.8	0.36	580	370						
DSC-TT1		3/28/2011				0.09	0.01 U		1.7	1.8	0.36	580	370						
DSC-TT1		3/31/2011												1 U	1.5	1 U	1.5		
DSC-TT1		3/31/2011												1 U	1.5	1 U	1.5		
DSC-TT1		4/20/2011				0.16	0.01 U		1.3	1.4	0.46	1100	300						
DSC-TT1		4/20/2011				0.16	0.01 U		1.3	1.4	0.46	1100	300						
DSC-TT1		5/25/2011				0.19	0.025 U		1.9	2.1	0.36	870	350						
DSC-TT1		5/25/2011				0.19	0.025 U		1.9	2.1	0.36	870	350						

StationName	Sample Type	Sample Collection Date	Ammonia as N mg/L	Dissolved Phosphorus mg/L	Nitrate and Nitrite as N mg/L	Nitrate as N mg/L	Nitrite as N mg/L	Ortho-phosphate mg/L	Total Kjeldahl Nitrogen (TKN) mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Total Suspended Solids mg/L	Turbidity NTU	C10-C22 mg/L	C22-C36 mg/L	C6-C10 mg/L	Total Extractable Hydrocarbons (C6-C36) mg/L	pH	Electrical Conductivity µS
Water Year 2012																			
DSC-DC1		3/15/2012										750							
DSC-DC1	FIELD	3/15/2012											>1000					8	135.8
DSC-DC1		3/16/2012										140							
DSC-DC1	FIELD	3/16/2012											170 / 172					8.05	126.1
DSC-DC1		3/28/2012										960							
DSC-DC1	FIELD	3/28/2012											939					8.13	86.1
DSC-DC1		4/12/2012										1200							
DSC-DC1	FIELD	4/12/2012											>1000					8.55	211
DSC-DC1		4/26/2012										730							
DSC-DC1	FIELD	4/26/2012											152					8.39	99.6
DSC-MC1		10/5/2011			0.34	0.31	0.032		0.54	0.89	0.13	180	40						
DSC-MC1		1/21/2012				0.01 UJ	0.01 U		0.21	0.21	0.093	26	18						
DSC-MC1		1/26/2012				0.24	0.01 U		0.51	0.75	0.056	20	20						
DSC-MC2		1/20/2012	0.05 U	0.96		0.01 UJ	0.01 UJ	1.1	3.7	3.7	0.94	69	16						
DSC-MC2		1/25/2012	0.05 U	0.1		0.39	0.01 U	0.084	0.63	1	0.14	1 U	1.1						
DSC-MC2		3/5/2012	0.063	0.058		0.2	0.01 U	0.053	0.46	0.66	0.084	2	2.3						
DSC-MC2		3/13/2012	0.05 U	0.091		0.037	0.01 U	0.11	0.69	0.73	0.21	43	11						
DSC-MC2		3/16/2012	0.05 U	0.099		0.05	0.01 U	0.07	0.5	0.6	0.15	17	6.8						
DSC-MC2		3/21/2012	0.05 U	0.014		0.01 U	0.01 U	0.025	0.21	0.21	0.035	5	2.8						
DSC-MC2		3/28/2012	0.05 U	0.022		0.01 U	0.01 U	0.016	0.25	0.25	0.036	1	0.81						
DSC-MC2		4/26/2012	0.05 U	0.038		0.049	0.01 U	0.01 U	0.28	0.33	0.12	6	2.5						
DSC-MC3		10/5/2011	0.17	0.41	0.81	0.81	0.01 U	0.58	3.6	4.4	0.77	110	46						
DSC-MC3		3/16/2012	0.05 U	0.021		0.01 U	0.01 U	0.017	0.34	0.34	0.13	39	26						
DSC-MC3		3/21/2012	0.05 U	0.014		0.01 U	0.01 U	0.021	0.095	0.095	0.042	1 U	9.8						
DSC-MC3		4/26/2012	0.05 U	0.015		0.055	0.055	0.01 U	0.55	0.66	0.13	290	120						
DSC-MC3	DUP	4/26/2012	0.05 U	0.016		0.053	0.053	0.01 U	0.47	0.58	0.088	290	120						
DSC-MC3	TRIPLICATE	4/26/2012	0.05 U	0.016		0.072	0.051	0.01 U	1.3 J	1.4 J	0.096	280	130						
DSC-MC3		8/14/2012	0.17	0.15		0.13	0.012	0.15	3.2	3.3	0.17	810	310						
DSC-TC1		1/20/2012				0.056 J	0.01 UJ		1.2	1.3	0.25	360	98						
DSC-TC1		3/16/2012										68							
DSC-TC1	FIELD	3/16/2012											111 / 111					7.72	382
DSC-TC1	DUP	3/16/2012										69							
DSC-TC1	TRIPLICATE	3/16/2012										68							
DSC-TC1		3/21/2012										3							
DSC-TC1	FIELD	3/21/2012											12.1 / 12.7					7.81	182.9
DSC-TC1		3/28/2012										2							
DSC-TC1	FIELD	3/28/2012											13.8					8.58	280
DSC-TC1		4/26/2012										99							
DSC-TC1	FIELD	4/26/2012											103					8.76	243
DSC-TC2		3/13/2012										120							
DSC-TC2	FIELD	3/13/2012											112					7.51	3730
DSC-TC2		3/16/2012										440							
DSC-TC2	FIELD	3/16/2012											350 / 338					7.03	4060
DSC-TC2		3/21/2012										140							
DSC-TC2	FIELD	3/21/2012											278 / 285					7.55	687
DSC-TC2		3/28/2012										180							
DSC-TC2	FIELD	3/28/2012											518					7.86	1202
DSC-TC2		4/12/2012										570							
DSC-TC2	FIELD	4/12/2012											643					8.13	7260
DSC-TT1		10/5/2011			0.31	0.31	0.01 U		1.5	1.8	0.18	540	120						
DSC-TT1		1/20/2012				0.13 J	0.018 J		2.7	3	0.37 J	1300 J	600						
DSC-TT1	DUP	1/20/2012				0.12 J	0.01 UJ		2.8	3.1	0.79 J	2400 J	600						
DSC-TT1	TRIPLICATE	1/20/2012				0.11 J	0.01 UJ		2.1	2.3	0.14 J	2000 J	610						
DSC-TT1		1/26/2012				0.07	0.01 U		1.3	1.4	0.096	450	300						
DSC-TT1		3/16/2012										1100							

StationName	Sample Type	Sample Collection Date	Ammonia as N mg/L	Dissolved Phosphorus mg/L	Nitrate and Nitrite as N mg/L	Nitrate as N mg/L	Nitrite as N mg/L	Ortho-phosphate mg/L	Total Kjeldahl Nitrogen (TKN) mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Total Suspended Solids mg/L	Turbidity NTU	C10-C22 mg/L	C22-C36 mg/L	C6-C10 mg/L	Total Extractable Hydrocarbons (C6-C36) mg/L	pH	Electrical Conductivity µS
DSC-TT1	FIELD	3/16/2012											932 / 942					8.06	36.4
DSC-TT1		3/28/2012										1500							
DSC-TT1	FIELD	3/28/2012											>1000					7.96	184.9
DSC-TT2		3/1/2012										48							
DSC-TT2	FIELD	3/2/2012											116					7.8	1315
DSC-TT2		3/8/2012										63							
DSC-TT2	FIELD	3/8/2012											106					8.1	1240
DSC-TT2		3/13/2012										650							
DSC-TT2	FIELD	3/13/2012											426					7.87	593
DSC-TT2		3/16/2012										1400							
DSC-TT2	FIELD	3/16/2012											371 / 395					7.3	79.7
DSC-TT2		3/28/2012										26							
DSC-TT2	FIELD	3/28/2012											37.6					8.41	234
DSC-TT3		3/16/2012										360							
DSC-TT3	FIELD	3/16/2012											378 / 353					7.71	76.7
DSC-TT3		3/28/2012										330							
DSC-TT3	FIELD	3/28/2012											261					7.57	6790
DSC-TT3		4/12/2012										1600							
DSC-TT3	FIELD	4/12/2012											>1000					8.03	294
DSC-TT3		4/26/2012										340							
DSC-TT3	FIELD	4/26/2012											401					7.93	275
DSC-TT3		8/14/2012										80							
DSC-TT4		3/1/2012										1000							
DSC-TT4	FIELD	3/1/2012											>1000					8.11	2130
DSC-TT4		3/5/2012										96							
DSC-TT4	FIELD	3/5/2012											151 / 155					7.57	396
DSC-TT4		3/13/2012										470							
DSC-TT4	FIELD	3/13/2012											982					7.81	1890
DSC-TT4		3/16/2012										460							
DSC-TT4	FIELD	3/16/2012											654 / 630					7.23	247
DSC-TT4		3/21/2012										50							
DSC-TT4	FIELD	3/21/2012											45.3 / 47.6					7.58	171.2
DSC-TT4		3/28/2012										320							
DSC-TT4	FIELD	3/28/2012											900					8.22	745
DSC-TT5		3/2/2012										770							
DSC-TT5	FIELD	3/2/2012											>1000					8.27	362
DSC-TT5		3/5/2012										650							
DSC-TT5	FIELD	3/5/2012											705 / 701					7.9	104.3
DSC-TT5		3/13/2012										33							
DSC-TT5	FIELD	3/13/2012											98.6					8.36	118.3
DSC-TT5		3/16/2012										280							
DSC-TT5	FIELD	3/16/2012											264 / 242					7.31	95.3
DSC-TT5		3/28/2012										390							
DSC-TT5	FIELD	3/28/2012											272					8.26	107.7

StationName	Sample Type	Sample Collection Date	Ammonia as N mg/L	Dissolved Phosphorus mg/L	Nitrate and Nitrite as N mg/L	Nitrate as N mg/L	Nitrite as N mg/L	Ortho-phosphate mg/L	Total Kjeldahl Nitrogen (TKN) mg/L	Total Nitrogen as N mg/L	Total Phosphorus mg/L	Total Suspended Solids mg/L	Turbidity NTU	C10-C22 mg/L	C22-C36 mg/L	C6-C10 mg/L	Total Extractable Hydrocarbons (C6-C36) mg/L	pH	Electrical Conductivity µS
Water Year 2013																			
DSC-MC2		11/17/2012	0.055	0.092		2.2	0.01 U	0.029	0.78	2.98	0.11	1	3.2						
DSC-MC2		11/28/2012	0.05 U	0.082		0.38	0.012	0.06	0.5	0.89	0.11	7	5						
DSC-MC2		11/30/2012	0.05 U	0.29		0.18	0.011	0.27	0.87	1.061	0.27	74	43						
DSC-MC2		12/5/2012	0.056	0.07		0.16	0.052	0.045	0.15	0.37	0.091	3	6.1						
DSC-MC2		3/20/2013	0.05 U	0.038	0.1 U			0.01 U	0.2 U	0.2 U	0.039	2	1.5						
DSC-MC2		3/31/2013	0.05 U	0.026	0.1 U			0.013	0.2 U	0.2 U	0.032	1	0.59 J						
DSC-MC2	DUP	3/31/2013	0.05 U	0.027	0.1 U			0.013	0.2 U	0.2 U	0.033	1	0.6 J						
DSC-MC2	TRIPLICATE	3/31/2013	0.05 U	0.027	0.1 U			0.015	0.2 U	0.2 U	0.038	1 U	1 J						
DSC-MC2		5/8/2013	0.05 U	0.078	0.17			0.045	0.39	0.56	0.11	2	2.1						
DSC-MC3		11/17/2012	0.05 U	0.028		0.044	0.016	0.01 U	0.87	0.93	0.05	88	55						
DSC-MC3		11/28/2012	0.05 U	0.017		0.022	0.01 U	0.028	0.77	0.79	0.048	97	55						
DSC-MC3		11/30/2012	0.05 U	0.063		0.044	0.01 U	0.055	0.53	0.574	0.087	82	89						
DSC-MC3		12/5/2012	0.05 U	0.052		0.03	0.035	0.03	0.31	0.375	0.076	64	5.9						
DSC-MC3		3/20/2013	0.05 U	0.036	0.1 U			0.01 U	0.2 U	0.2 U	0.037	1	5.6						
DSC-MC3		3/31/2013	0.14	0.021	0.5			0.027 J	1.9	2.4	0.18 J	630	250						
DSC-MC3	DUP	3/31/2013	0.15	0.022	0.5			0.036 J	1.9	2.4	0.25 J	650	250						
DSC-MC3	TRIPLICATE	3/31/2013	0.17	0.029	0.5			0.045 J	1.9	2.4	0.29 J	660	280						
DSC-MC3		5/8/2013	0.14	0.044	0.22			0.023	0.82	1.04	0.064	170	95						
DSC-MC3		9/21/2013	0.24	0.47		0.37	0.09	0.4	2.3	2.76	0.56	22	16						

Notes:
U = not detected at concentration indicated
J = estimated value due to precision issue
Field parameters were not collected prior to 3/1/12 event.

StationName	Sample Type	Sample Collection Date	Ammonia as N µg/L	Dissolved Phosphorus µg/L	Nitrate and Nitrite as N µg/L	Nitrate as N mg/L	Nitrite as N mg/L	Ortho-phosphate µg/L	Total Kjeldahl Nitrogen (TKN) µg/L	Total Nitrogen as N µg/L	Total Phosphorus µg/L	Total Suspended Solids mg/L	Turbidity NTU
Water Year 2011													
DST-MC1		12/14/2010	5	34	205			18	999	1204	186	82.24	37.2
DST-MC1		12/14/2010	5	34	205			18	999	1204	186	82.24	37.2
DST-MC1		12/18/2010	3	41	215			28	534	749	103	28	15.5
DST-MC1		12/18/2010	3	41	215			28	534	749	103	28	15.5
DST-MC1		3/15/2011	4	24	88			18	376	464	94	37	19.3
DST-MC1		3/15/2011	4	24	88			18	376	464	94	37	19.3
DST-MC1		4/1/2011	3	21	15			12	231	246	45	12	6.75
DST-MC1		4/1/2011	3	21	15			12	231	246	45	12	6.75
DST-MC1		5/5/2011	1	26	4			19	219	223	47	6	7.25
DST-MC1		5/5/2011	1	26	4			19	219	223	47	6	7.25
DST-MC1		6/6/2011	5	33	10			22	274	284	67	16.5	11.2
DST-MC1		6/6/2011	5	33	10			22	274	284	67	16.5	11.2
DST-MC1		6/29/2011	4	33	7			20	275	282	51	4.8	3.2
DST-MC1		6/29/2011	4	33	7			20	275	282	51	4.8	3.2
DST-MC2		12/14/2010	3	32	7			14	319	326	63	19.23	11.2
DST-MC2		12/14/2010	3	32	7			14	319	326	63	19.23	11.2
DST-MC2		12/18/2010	4	33	13			13	233	246	50	12	11.2
DST-MC2		12/18/2010	4	33	13			13	233	246	50	12	11.2
DST-MC2		3/15/2011	4	27	48			23	475	523	83	32	14.5
DST-MC2		3/15/2011	4	27	48			23	475	523	83	32	14.5
DST-MC2		4/1/2011	2	25	6			14	202	208	48	12.67	9.95
DST-MC2		4/1/2011	2	25	6			14	202	208	48	12.67	9.95
DST-MC2		5/5/2011	1	72	6			61	446	452	152	34	18
DST-MC2		5/5/2011	1	72	6			61	446	452	152	34	18
DST-MC2		6/6/2011	4	30	8			17	192	200	50	13	10.3
DST-MC2		6/6/2011	4	30	8			17	192	200	50	13	10.3
DST-MC2		6/29/2011	3	33	2			22	309	311	56	11.2	6.5
DST-MC2		6/29/2011	3	33	2			22	309	311	56	11.2	6.5
DST-MC3		12/14/2010	10	52	29			34	872	901	154	60	27.25
DST-MC3		12/14/2010	10	52	29			34	872	901	154	60	27.25
DST-MC3		12/18/2010	4	44	42			27	383	425	76	21	12.45
DST-MC3		12/18/2010	4	44	42			27	383	425	76	21	12.45
DST-MC3		3/15/2011	6	33	48			26	377	425	100	25.61	12.4
DST-MC3		3/15/2011	6	33	48			26	377	425	100	25.61	12.4
DST-MC3		4/1/2011	2	27	3			18	220	223	58	12.67	9.5
DST-MC3		4/1/2011	2	27	3			18	220	223	58	12.67	9.5
DST-MC3		5/5/2011	2	35	5			28	218	223	68	14	10.25
DST-MC3		5/5/2011	2	35	5			28	218	223	68	14	10.25
DST-MC3		6/6/2011	5	35	7			24	302	309	73	13.5	14.6
DST-MC3		6/6/2011	5	35	7			24	302	309	73	13.5	14.6
DST-MC3		6/29/2011	2	40	3			31	337	340	68	8.4	7.75
DST-MC3		6/29/2011	2	40	3			31	337	340	68	8.4	7.75
DST-MC4		12/14/2010	5	48	133			31	651	784	127	35.19	22.2
DST-MC4		12/14/2010	5	48	133			31	651	784	127	35.19	22.2
DST-MC4		12/18/2010	3	31	83			20	394	477	64	14	8.75
DST-MC4		12/18/2010	3	31	83			20	394	477	64	14	8.75
DST-MC4		3/15/2011	3	23	102			16	296	398	64	24	10.1
DST-MC4		3/15/2011	3	23	102			16	296	398	64	24	10.1
DST-MC4		4/1/2011	1	18	37			9	241	278	47	11	6.25
DST-MC4		4/1/2011	1	18	37			9	241	278	47	11	6.25
DST-MC4		5/5/2011	1	17	16			4	333	349	52	16	5.5
DST-MC4		5/5/2011	1	17	16			4	333	349	52	16	5.5
DST-MC4		6/6/2011	4	23	61			11	329	390	59	14.5	10.1
DST-MC4		6/6/2011	4	23	61			11	329	390	59	14.5	10.1
DST-MC4		6/29/2011	1	18	80			12	391	471	50	8.4	1.85
DST-MC4		6/29/2011	1	18	80			12	391	471	50	8.4	1.85
DST-MC5		12/14/2010	4	41	99			21	515	614	114	37.5	23.5
DST-MC5		12/14/2010	4	41	99			21	515	614	114	37.5	23.5
DST-MC5		12/18/2010	3	43	196			32	503	699	96	22	12.5
DST-MC5		12/18/2010	3	43	196			32	503	699	96	22	12.5
DST-MC5		3/15/2011	3	28	90			20	305	395	57	17.07	9.95
DST-MC5	DUP	3/15/2011	3	27	87			20	301	388	57	17.07	9.9
DST-MC5	TRIPLICATE	3/15/2011	4	28	89			20	310	399	59	17.5	10
DST-MC5		3/15/2011	3	28	90			20	305	395	57	17.07	9.95
DST-MC5	DUP	3/15/2011	3	27	87			20	301	388	57	17.07	9.9
DST-MC5	TRIPLICATE	3/15/2011	4	28	89			20	310	399	59	17.5	10
DST-MC5		4/1/2011	1	21	15			12	174	189	35	4.5	3.1
DST-MC5		4/1/2011	1	21	15			12	174	189	35	4.5	3.1
DST-MC5		5/5/2011	3	22	5			16	149	154	35	3.5	4.1
DST-MC5		5/5/2011	3	22	5			16	149	154	35	3.5	4.1
DST-MC5		6/6/2011	3	33	9			18	245	254	48	6.5	7.5
DST-MC5		6/6/2011	3	33	9			18	245	254	48	6.5	7.5
DST-MC5		6/29/2011	2	31	7			21	243	250	48	4.4	3.1
DST-MC5		6/29/2011	2	31	7			21	243	250	48	4.4	3.1
DST-MC6		12/14/2010	6	31	246			10	645	891	104	33.85	25.25
DST-MC6		12/14/2010	6	31	246			10	645	891	104	33.85	25.25
DST-MC6		12/18/2010	5	30	268			15	426	694	59	12	10.75
DST-MC6		12/18/2010	5	30	268			15	426	694	59	12	10.75
DST-MC6		3/15/2011	3	13	126			8	281	407	42	14.63	7.5
DST-MC6		3/15/2011	3	13	126			8	281	407	42	14.63	7.5
DST-MC6		4/1/2011	6	14	16			5	188	204	34	5.2	3.5
DST-MC6		4/1/2011	6	14	16			5	188	204	34	5.2	3.5
DST-MC6		5/5/2011	4	25	4			9	403	407	40	2.5	3.25
DST-MC6		5/5/2011	4	25	4			9	403	407	40	2.5	3.25

StationName	Sample Type	Sample Collection Date	Ammonia as N µg/L	Dissolved Phosphorus µg/L	Nitrate and Nitrite as N µg/L	Nitrate as N mg/L	Nitrite as N mg/L	Ortho-phosphate µg/L	Total Kjeldahl Nitrogen (TKN) µg/L	Total Nitrogen as N µg/L	Total Phosphorus µg/L	Total Suspended Solids mg/L	Turbidity NTU
DST-MC6		6/6/2011	3	31	7			19	445	452	76	16.5	9.95
DST-MC6		6/6/2011	3	31	7			19	445	452	76	16.5	9.95
DST-MC6		6/29/2011	2	30	2			21	717	719	93	11.6	6.5
DST-MC6		6/29/2011	2	30	2			21	717	719	93	11.6	6.5
Water Year 2012													
DST-MC1		1/21/2012	6	153	435			121	1152	1587	244	30.56	13.45
DST-MC1		3/14/2012	2	39	18			27	574	592	66	15.33	5.75
DST-MC1		3/16/2012		33								24	15.4
DST-MC1		3/21/2012	5	33	25			14	486	511	49	6	4.75
DST-MC1		4/20/2012	5	32	7			11	222	229	44	5.6	3.5
DST-MC1		4/23/2012		33								8	5.25
DST-MC1		4/26/2012	3	36	25			14	451	476	57	16.4	7.6
DST-MC2		1/21/2012	4	65	183			45	443	626	101	13.33	10.5
DST-MC2		3/14/2012	1	34	2			22	572	574	57	3.6	2.1
DST-MC2		3/16/2012	2	37	14			16	658	672	60	10.89	5.15
DST-MC2		3/21/2012	2	30	4			12	215	219	44	5.5	2.25
DST-MC2		4/20/2012	6	45	3			13	237	240	55	7.2	4.25
DST-MC2		4/23/2012	4	28	3			12	475	478	45	8.5	5.15
DST-MC2		4/26/2012	3	37	6			16	753	759	82	46.5	9.95
DST-MC3		1/21/2012	3	200	302			181	968	1270	255	20	10.45
DST-MC3		3/14/2012	2	28	2			20	602	604	55	6.67	2.75
DST-MC3		3/16/2012	3	36	41			22	558	599	78	16	8.05
DST-MC3		3/21/2012	5	32	4			16	432	436	47	4	2.05
DST-MC3		4/20/2012	4	62	1			17	211	212	77	4.4	1.75
DST-MC3		4/23/2012	3	31	2			13	230	232	54	6.5	3.5
DST-MC3		4/26/2012	7	44	3			21	347	350	61	9	7.25
DST-MC4		1/21/2012	6	108	661			67	682	1343	142	16.22	10.25
DST-MC4		3/14/2012	6	37	45			26	678	723	90	28.67	8.2
DST-MC4		3/16/2012	15	18	242			7	542	784	68	17	7.65
DST-MC4		3/21/2012	6	24	78			11	283	361	41	8.5	3.55
DST-MC4		4/20/2012	5	31	109			6	286	395	47	7.2	3.75
DST-MC4		4/23/2012	5	23	100			8	765	865	98	38.5	10.1
DST-MC4		4/26/2012	4	100	102			62	402	504	143	18	7.8
DST-MC5		1/21/2012	6	167	361			138	1189	1550	214	19.44	10.65
DST-MC5		3/14/2012	2	58	5			49	633	638	89	14	5.5
DST-MC5		3/16/2012	2	43	86			31	660	746	103	29.41	9.9
DST-MC5	DUP	3/16/2012	1	43	85			31	654	739	102	29	9.95
DST-MC5	TRIPLICATE	3/16/2012	1	45	85			30	658	743	101	29	9.95
DST-MC5		3/21/2012	8	34	37			21	342	379	58	7.66	5.15
DST-MC5		4/20/2012	6	37	20			16	193	213	53	6.4	3.25
DST-MC5		4/23/2012	5	27	53			12	257	310	77	10.5	6.1
DST-MC5		4/26/2012	4	603	48			222	535	583	665	24.5	8.5
DST-MC6		1/21/2012	179	112	419			78	1845	2264	122	8.33	2.25
DST-MC6		3/14/2012	3	54	58			25	490	548	68	7.2	2.5
DST-MC6		3/16/2012	3	40	197			14	544	741	78	14	8
DST-MC6		3/21/2012	5	27	36			11	588	624	42	6.5	4.3
DST-MC6		4/20/2012	5	32	3			9	507	510	52	4	1.8
DST-MC6		4/23/2012	3	25	4			8	669	673	45	8	2.5
DST-MC6		4/26/2012	5	38	4			9	600	604	50	4.95	2.35

StationName	Sample Type	Sample Collection Date	Ammonia as N µg/L	Dissolved Phosphorus µg/L	Nitrate and Nitrite as N µg/L	Nitrate as N mg/L	Nitrite as N mg/L	Ortho-phosphate µg/L	Total Kjeldahl Nitrogen (TKN) µg/L	Total Nitrogen as N µg/L	Total Phosphorus µg/L	Total Suspended Solids mg/L	Turbidity NTU
Water Year 2013													
DST-MC1		11/17/2012	0.05 U	0.033		0.01 U	0.01 U	0.01 U	0.46	0.46	0.056	10	7.5
DST-MC1		11/30/2012	0.05 U	0.083		0.18	0.01 U	0.074	1	1.18	0.1	82	54
DST-MC1		12/5/2012	0.05 U	0.049		0.15	0.044	0.14	0.48	0.674	0.075	4	16
DST-MC1		12/17/2012	0.05 U	0.022		0.089	0.01 U	0.011	0.29	0.379	0.043	4	8.3
DST-MC1		3/13/2013	0.05 U	0.021		0.01 U	0.01 U	0.01	0.21	0.21	0.03	2	3.4
DST-MC1		3/20/2013	0.05 U	0.02		0.01 U	0.025 U	0.01 U	0.2 U	0.2	0.022	2	5.7
DST-MC1		3/31/2013	0.05 U	0.024		0.013	0.01 U	0.01 U	0.22	0.233	0.15	3	5
DST-MC1		4/26/2013	0.05 U	0.028		0.02 U	0.02 U	0.01	0.2 U	0.2 U	0.036	2	2.5
DST-MC1		5/7/2013	0.05 U	0.1 U	0.1 U			0.014	0.25	0.25	0.04	3	4.7
DST-MC2		11/17/2012	0.05 U	0.04		0.01 U	0.01 U	0.01 U	0.31	0.31	0.064	11	7.8
DST-MC2		11/30/2012	0.05 U	0.058		0.26	0.01 U	0.04	0.84	1.1	0.082	26	27
DST-MC2		12/5/2012	0.05 U	0.038		0.051	0.046	0.017	0.4	0.497	0.044	2	15
DST-MC2		12/17/2012	0.051	0.018		0.01 U	0.01 U	0.012	0.2	0.2	0.041	1 U	4.2
DST-MC2		3/13/2013	0.05 U	0.015		0.01 U	0.01 U	0.024	0.1 U	0.1 U	0.023	2	3.3
DST-MC2		3/20/2013	0.05 U	0.023		0.01 U	0.025 U	0.01 U	0.2 U	0.2 U	0.032	1	8.3
DST-MC2		3/31/2013	0.05 U	0.022		0.013	0.01 U	0.011	0.2	0.213	0.037	4	8.3
DST-MC2		4/26/2013	0.05 U	0.031		0.02 U	0.02 U	0.02	0.2 U	0.2 U	0.032	3	3.8
DST-MC2		5/7/2013	0.05 U	0.03	0.1 U			0.018	0.26	0.26	0.037	7	7.6
DST-MC3		11/17/2012	0.05 U	0.064		0.01 U	0.01 U	0.031	0.34	0.34	0.11	1 U	3.6
DST-MC3		11/30/2012	0.05 U	0.11		0.14	0.01 U	0.089	0.6	0.74	0.11	10	26
DST-MC3		12/5/2012	0.05 U	0.056		0.037	0.043	0.037	0.28	0.36	0.11	1	19
DST-MC3		12/17/2012	0.05 U	0.021		0.031	0.01 U	0.018	0.33	0.361	0.044	1	3.8
DST-MC3		3/13/2013	0.05 U	0.016		0.01 U	0.01 U	0.017	0.1 U	0.1 U	0.029	1 U	3
DST-MC3		3/20/2013	0.05 U	0.026		0.01 U	0.025 U	0.01 U	0.2 U	0.2 U	0.035	1	5
DST-MC3		3/31/2013	0.05 U	0.024		0.012 J	0.01 UJ	0.011	0.2 U	0.2 U	0.035	1 U	6.4
DST-MC3		4/26/2013	0.05 U	0.032		0.02 U	0.02 U	0.02	0.2 U	0.2 U	0.033	1	2.6
DST-MC3		5/7/2013	0.05 U	0.037	0.1 U			0.023	0.3	0.3	0.046	1 U	4.2
DST-MC4		11/17/2012	0.05 U	0.34		0.11	0.01 U	0.16	0.78	0.89	0.42	56	31
DST-MC4		11/30/2012	0.05 U	0.075		0.18	0.01 U	0.06	0.57	0.75	0.096	20	32
DST-MC4		12/5/2012	0.05 U	0.038		0.071	0.051	0.021	0.22	0.342	0.04	3	12
DST-MC4		12/17/2012	0.05 U	0.017		0.063	0.01 U	0.011	0.41	0.473	0.044	18	9.3
DST-MC4		3/13/2013	0.05 U	0.01		0.01 U	0.01 U	0.01 U	0.1 U	0.1 U	0.02	5	3.8
DST-MC4		3/20/2013	0.05 U	0.029		0.04	0.025 U	0.01 U	0.2 U	0.04	0.037	3	3.8
DST-MC4		3/31/2013	0.05 U	0.016		0.084 J	0.01 J	0.01 U	0.22	0.314	0.024	6	5.3
DST-MC4		4/26/2013	0.05 U	0.024		0.035	0.02 U	0.014	0.2 U	0.035	0.028	3	1.5
DST-MC4		5/7/2013	0.05 U	0.031	0.1 U			0.014	0.29	0.29	0.043	8	7.8
DST-MC5		11/17/2012	0.05 U	0.028		0.01 U	0.01 U	0.01 U	0.24	0.24	0.054	9	5.5
DST-MC5		11/30/2012	0.05 U	0.1		0.14	0.01 U	0.083	0.71	0.85	0.11	48	49
DST-MC5		12/5/2012	0.05 U	0.047		0.11	0.055	0.029	0.32	0.485	0.052	2	14
DST-MC5		12/17/2012	0.05 U	0.03		0.06	0.01 U	0.019	0.26	0.32	0.041	4	5.6
DST-MC5		3/13/2013	0.05 U	0.014		0.01 U	0.01 U	0.01 U	0.16	0.16	0.028	4	5.3
DST-MC5		3/20/2013	0.05 U	0.023		0.01 U	0.025 U	0.01 U	0.2 U	0.2 U	0.025	4	5.3
DST-MC5		3/31/2013	0.05 U	0.023		0.018 J	0.011 J	0.01 U	0.2	0.229	0.027	3	3.5
DST-MC5		4/26/2013	0.05 U	0.024		0.02 U	0.02 U	0.017	0.2 U	0.2 U	0.033	2	2.1
DST-MC5		5/7/2013	0.05 U	0.026	0.1 U			0.015	0.18 J	0.18	0.031	1	2.7
DST-MC6		11/30/2012	0.1	0.091		2.4	0.014	0.069	1.4	3.814	0.096	20	68
DST-MC6		12/5/2012	0.05 U	0.024		0.01 U	0.05	0.01 U	0.32	0.37	0.029	1 U	5.3
DST-MC6		12/17/2012	0.05 U	0.027		0.056	0.01 U	0.01	0.33	0.386	0.82	1 U	4.2
DST-MC6		3/13/2013	0.05 U	0.04		0.01 U	0.01 U	0.016	0.21	0.21	0.05	1	1.9
DST-MC6		3/20/2013	0.05 U	0.016		0.01 U	0.025 U	0.01 U	0.31	0.31	0.017	1 U	3.1
DST-MC6		3/31/2013	0.05 U	0.023		0.017 J	0.01 UJ	0.01 U	0.38	0.397	0.02	1 U	2.2
DST-MC6		4/26/2013	0.05 U	0.021		0.02 U	0.02 U	0.015	0.5	0.5	0.029	6	4.1
DST-MC6		5/7/2013	0.05 U	0.021	0.1 U			0.01 U	0.44	0.44	0.029	1	2.1

Notes:
U = not detected at concentration indicated
J = estimated value due to precision issue

StationName	Sample Type	Sample Collection Date	Total Suspended Solids mg/L
Water Year 2013			
TURB-MS3		11/17/2012	11
TURB-MS3		11/18/2012	72
TURB-MS3		11/30/2012	40
TURB-MS3		12/2/2012	220
TURB-MS3		12/2/2012	3
TURB-MS3		3/20/2013	2
TURB-MS3		4/24/2013	1 J
TURB-MS3		4/29/2013	15 J
TURB-MS3		5/13/2013	10 J
TURB-MS3		6/25/2013	10
TURB-MS3		7/4/2013	11
TURB-TT1		11/17/2012	5
TURB-TT1		11/30/2012	140
TURB-TT1		12/2/2012	190
TURB-TT1		12/2/2012	240
TURB-TT1		3/20/2013	5
TURB-TT1		4/24/2013	1 J
TURB-TT1		4/29/2013	6 J
TURB-TT1		4/29/2013	3 J
TURB-TT1		5/13/2013	4 J
TURB-TT1		5/13/2013	3 J
TURB-TT1		6/25/2013	6
TURB-TT1		7/4/2013	120

Notes:

U = not detected at concentration indicated

J = estimated value due to precision issue

Appendix C
Quality Assurance/Quality Control Documentation

Data Quality

C.1 Overview

This appendix summarizes the quality assurance/quality control (QA/QC) procedures that were implemented in the laboratory and field to ensure that the data collected during the 2012-2013 Truckee River Water Quality Monitoring Program for the Town of Truckee and Placer County. The purpose of the data review was to evaluate the data to ensure they were of known quality and met the project objectives. A general description of the laboratory and field QA/QC procedures is discussed in Section C.2. Upon receipt from the laboratory, a complete data quality evaluation was performed on all data generated during this program to ensure that the reported data accurately represent the concentrations of constituents present in the water samples. The process results of the data quality evaluation are discussed in Section C.3.

C.2 Laboratory Quality Assurance/Quality Control Procedures

Quality assurance is defined as the integrated program designed for assuring reliability of monitoring and measurement of data. Quality control is defined as the routine application of procedures for obtaining prescribed standards of performance in the monitoring and measuring process. This section presents quality control procedures that were conducted by the laboratory to ensure analytical data quality. A description of the general practices required of the laboratory is summarized below.

C.2.1 Standard Operating Procedures (SOPs)

Western Environmental Testing Laboratory (Wet Lab) performed all analyses and QA/QC procedures in accordance with published analytical methods and internal SOPs. The internal SOPs provide step-by-step instructions for performing analytical methods. Utilizing SOPs is a method to ensure uniformity and compliance in the measurement process.

C.2.2 Purity of Standards, Solvents and Reagents

The purity/quality of reagents, solvents and standards used in the analytical process is a critical component in the generation of high quality data. All reagents used were of reagent-grade (equivalent) or higher grade quality whenever obtainable. Where applicable, reference standard solutions were traceable to the National Institute of Standards Technology (NIST), the American Association for Laboratory Accreditation (AALA), or to an equivalent source. Each new lot of reagent-grade chemicals was tested for quality of performance, and laboratory records were kept to document the results of lot tests.

C.2.3 Calibration

Instrument calibration is performed to ensure that the instrument is capable of producing acceptable qualitative and quantitative data for target compounds. Calibration procedures vary by analytical method. In general, each instrument is calibrated initially using certified standards, followed by periodic (i.e., daily) calibration verifications to confirm that the initial calibration is valid.

C.2.4 Method Blank

A method blank (MB) is a QC sample that consists of all reagents specific to the method and is carried through every aspect of the procedure, including preparation, cleanup and analysis. The MB is used to identify any interferences or contamination of the analytical system that may lead to the reporting of elevated analyte concentrations or false positive data. Potential sources of contamination include solvent, reagents, glassware, or the laboratory environment. The MB is prepared with each group of samples processed. One batch of samples is generally defined as a group of 20 samples or less of the same sample matrix that are processed using the same procedures, reagents and standards within the same time period.

C.2.5 Laboratory Control Sample

A laboratory control sample (LCS) is a laboratory-generated clean matrix sample that is fortified with known concentrations of target analytes. The LCS is then carried along with the environmental samples through the entire sample preparation/ analysis sequence. Review of the LCS recovery data is used to monitor the performance of the analytical methods. The results of the LCS, used in conjunction with the matrix spike samples, can provide evidence that the laboratory performed the method correctly or the sample matrix affected the results.

C.2.6 Matrix Spike Sample

Matrix spikes (MS) and matrix spike duplicates (MSDs) are analyzed to evaluate the effect of the sample matrix on the accuracy of the analytical procedures. A matrix spike is an environmental sample that has been spiked with known concentrations of target analytes. The matrix-spiked sample is then carried through the entire analytical sequence like all other samples. The analyte concentrations detected during the analysis are compared to the known spike concentrations to obtain a percent recovery for each spiked analyte. The recoveries are compared to acceptance limits and the results are used to evaluate accuracy and the presence of matrix interferences.

The difference between the MS and the MSD analyses is expressed as the relative percent difference (RPD). RPDs are used to evaluate analytical precision and can also be a measure of relative sample heterogeneity.

C.3 Data Quality Evaluation

Upon receipt from the laboratory, each analytical report was thoroughly reviewed and the data evaluated to determine if the data met the project objectives. Data reviewed included storm water samples. Initially, the data were screened for the following major items:

- A 100 percent check between electronic data provided by the laboratory and the hard copy reports;
- Conformity check between the chain-of-custody forms, compositing protocol, and laboratory reports;
- A check for laboratory data report completeness; and,
- A check for typographical errors on the laboratory reports.

After performing the aforementioned data screening, the laboratory was notified of any deficiencies, if any, by way of a telephone call detailing the problems encountered during the initial screening process.

Following the initial screening, a more complete QA/QC review was performed, which included an evaluation of method holding times, method blank contamination, and accuracy and precision. Accuracy was evaluated by reviewing MS, MSD and LCS recoveries; precision was evaluated by reviewing field duplicate, spike duplicate and laboratory sample duplicate RPDs.

A total of 659 constituents were measured among 72 samples (including field QC samples). Data quality assessment was based upon review of holding times, laboratory blanks, laboratory control samples, laboratory duplicates, matrix spikes and matrix spike duplicates, reporting limits, and field duplicates. Based on the data review, none of the constituent results were rejected. The following sections describe specific items that were evaluated during the QA/QC review process and data that were qualified as estimated due to laboratory QC exceedances.

C.3.1 Holding Times

A sample holding time is defined as the maximum allowable time a sample can be stored after sample collection and preservation until analysis. During the data review process, it was determined that four samples were analyzed for two constituents past their technical holding time. Specifically, samples collected on March 31, 2013 were analyzed for nitrate and nitrate after their 48 hour hold time had expired due to a power outage at the laboratory. Therefore, these eight results should be qualified with “Js” or “UJs” to indicate estimated concentrations or non-detected concentrations due to holding time exceedances.

C.3.2 Blank Evaluation

As mentioned previously, analytical results from laboratory method blanks were evaluated during the QA/QC review process. Blanks can be used to identify the presence and potential source of sample contamination. If no contamination is present in the blanks, then no further action is required. Laboratory method blanks were analyzed with every batch of samples for most analyses.

In the 2012-2013 dataset, no analytes were detected in the laboratory method blanks at concentrations greater than their respective reporting limits. Therefore, none of the data were qualified as a result of laboratory or field contamination.

C.3.3 Accuracy and Precision

Accuracy is the degree of agreement between a measurement and the true or expected value or between the average of a number of measurements and the true or expected value. Systematic errors affect accuracy. For chemical properties, accuracy is expressed as percent recovery (%R), which is calculated as follows:

$$\%R = [(Cs - C)/S] * 100$$

where:

%R	=	percent recovery
Cs	=	spiked sample concentration
C	=	background sample concentration
S	=	concentration equivalent of spike added

MS, MSD and LCS results were checked to assess the accuracy of the analytical process. MS and MSD results provided an evaluation of accuracy in environmental sample matrices; whereas, LCS results provided a measure of accuracy throughout the entire recovery process.

Precision is an estimate of variability. In other words, precision is an estimate of agreement among individual measurements of the same physical or chemical property, under prescribed similar conditions. Precision can be calculated as the relative percent difference (RPD) as follows:

$$RPD = 2 * [(S - D)/(S + D)] * 100$$

where:

RPD	=	relative percent difference
S	=	concentration measured in original sample
D	=	concentration measured in duplicate sample

Duplicate sample results (laboratory duplicates) were checked to assess the variability and precision between samples. Depending on the analytical method, various types of laboratory duplicate results were compared to assess precision. For example, some methods require the analysis of an MS and an MSD sample pair, whereas other methods are not as specific. When MS/MSD analyses are not specified, the laboratory calculated precision using a sample and a duplicate of the same sample.

Control limits for spike recoveries and RPDs are shown on Table C-1. These are the acceptance limits used to evaluate the usability of the project data.

Table C-1
Accuracy and Precision Control Limits

Analyte	% Recovery (Accuracy)	RPD (Precision)
Ammonia	80 - 120	20
Nitrate/Nitrite (as N)	80 - 120	20
Orthophosphate	80 - 120	20
Phosphorus (total)	80 - 120	20
Phosphorus (dissolved)	80 - 120	20
TKN	80 - 120	20
TSS	80 - 120	20
Turbidity	--	20

The following sections discuss the results of accuracy and precision measurements.

Laboratory Duplicates

In the 2012-2013 dataset, no results were qualified as estimated due to laboratory duplicate exceedances.

Field Triplicates

There are no specific regulatory criteria available to evaluate field triplicate results. However, the TRWQMP specifies that the average percent error between field triplicates should be less than 20 percent. Average percent error is calculated by the following formula:

$$\text{Average Percent Error} = \frac{100 * \text{Standard Deviation of triplicates}}{\text{Average result of triplicates}}$$

In the 2012-2013 dataset, triplicate samples were collected from Sites DSC-MC2 and DSC-MC3 on March 31, 2013 to assess field and laboratory precision. The following tables summarize the triplicate sample results and average percent error results.

Site DSC-MC2

Analyte	Primary DSCMC2R1303310600	Duplicate DSCMC21R1303310600	Triplicate DSCMC22R1303310600	Average % Error
Ammonia, as Nitrogen	<0.050	<0.050	<0.050	0.0
Dissolved Orthophosphate as P	0.013	0.013	0.015	8.4
Dissolved Phosphorous as P	0.026	0.027	0.027	2.2
Nitrate + Nitrite Nitrogen	<0.10	<0.10	<0.10	0.0
Total Kjeldahl Nitrogen	<0.20	<0.20	<0.20	0.0
Total Nitrogen	<1.1	<1.1	<1.1	0.0
Total Phosphorous as P	0.032	0.033	0.038	9.4
Total Suspended Solids	1.0	<1.0	1.0	0.0
Turbidity	0.60	0.59	1.0	32.0

Site DSC-MC3

Analyte	Primary DSCMC3R1303310600	Duplicate DSCMC31R1303310600	Triplicate DSCMC32R1303310600	Average % Error
Ammonia, as Nitrogen	0.17	0.14	0.15	10.0
Dissolved Orthophosphate as P	0.027	0.045	0.036	25.0
Dissolved Phosphorous as P	0.021	0.022	0.029	18.2
Nitrate + Nitrite Nitrogen	0.5	0.5	0.5	0.0
Total Kjeldahl Nitrogen	1.9	1.9	1.9	0.0
Total Nitrogen	2.4	2.4	2.4	0.0
Total Phosphorous as P	0.25	0.18	0.29	23.2
Total Suspended Solids	630	650	660	2.4
Turbidity	250	280	250	6.7

Based on the data presented above for the the 2012-2013 dataset, average percent error was within 20 percent for all field triplicate results except three, as shown in red in the tables above. Specifically, turbidity triplicate results from Site DSC-MC2 and the dissolved orthophosphate and total phosphorus results from Site DSC-MC3 should be qualified with “Js” to indicate estimated concentrations as a result of precision. All other results are usable as reported without qualification.

Laboratory Control Samples

In the 2012-2013 dataset, no results were qualified due to out-of-range LCS recoveries.

Matrix Spike/Matrix Spike Duplicate Samples (MS/MSDs)

In the 2012-2013 dataset, recoveries for several analytes in several batches of samples were outside of acceptable limits. However, in all cases, the corresponding LCS recoveries were within acceptable limits. Therefore, in accordance with data review guidance, qualification is not warranted based on out-of-range MS and/or MSD results alone. Therefore, no further action was required.

Overall Summary

All results were evaluated against Truckee River Water Quality Monitoring Program specified quality control criteria. In total, four nitrate and two nitrite results were qualified with “Js”, and two nitrite results qualified with “UJs” due to holding time exceedances. Additionally, turbidity triplicate results from Site DSC-MC2 and the dissolved orthophosphate and total phosphorus results from Site DSC-MC3 were qualified with “Js” to indicate estimated concentrations as a result of precision. The QA/QC review of analytical results found all the data to be of acceptable quality and usable for the intended purposes, including sample data qualified as estimated due to holding time issues.

Appendix D

Measured Stream Discharge and USGS Data

Appendix D. Annual hydrologic record, West Martis Creek above State Route 267 (TURB-MC1), near Truckee, California Water Year 2013 (Preliminary)

WY 2013 Daily Mean Flow (cubic feet per second)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1	1.0	0.5	6.0	0.5	*0.3*	0.9	2.5	1.2	0.5	0.1	0.1	0.1
2	1.0	0.4	12.4	0.7	*0.3*	0.8	2.2	1.4	0.3	0.1	0.2	0.1
3	1.0	0.4	4.5	0.9	*0.3*	1.5	2.1	1.1	0.3	0.1	0.2	0.1
4	1.0	0.4	2.4	0.7	*0.3*	1.3	2.5	1.0	0.2	0.1	0.1	0.1
5	1.6	0.2	8.0	0.5	*0.3*	1.7	2.5	0.9	0.2	0.1	0.1	0.1
6	1.1	0.3	3.7	0.4	*0.3*	1.5	2.2	1.2	0.2	0.1	0.2	0.1
7	1.1	0.5	2.6	*0.4*	*0.3*	1.2	2.2	1.6	0.2	0.1	0.2	0.1
8	1.1	0.2	2.2	*0.5*	*0.2*	0.9	2.4	1.8	0.2	0.1	0.2	0.1
9	1.1	0.3	1.9	*0.3*	*0.2*	1.0	1.7	1.2	0.2	0.1	0.2	0.1
10	1.1	0.3	1.3	*0.2*	*0.3*	0.9	1.8	1.1	0.2	0.1	0.2	0.2
11	1.0	0.4	1.0	*0.2*	*0.3*	1.0	2.0	0.8	0.2	0.1	0.2	0.1
12	1.1	0.4	1.0	*0.2*	*0.3*	1.5	2.1	0.9	0.3	0.1	0.2	0.1
13	1.0	0.3	0.9	*0.2*	*0.3*	1.7	1.7	0.9	0.4	0.1	0.2	0.2
14	1.0	0.5	0.9	*0.2*	*0.3*	1.7	1.8	0.6	0.2	0.1	0.2	0.2
15	0.9	0.4	0.8	*0.2*	*0.3*	2.5	1.7	0.6	0.2	0.1	0.2	0.2
16	0.9	0.6	0.8	*0.2*	*0.2*	2.5	1.7	0.6	0.2	0.1	0.2	0.2
17	0.9	2.3	1.8	*0.2*	*0.2*	2.0	1.4	0.6	0.2	0.1	0.1	0.2
18	0.9	2.3	1.0	*0.2*	*0.2*	2.2	1.2	0.8	0.2	0.1	0.1	0.2
19	0.6	1.1	0.9	*0.3*	*0.2*	2.2	1.4	0.5	0.2	0.1	0.2	0.2
20	0.3	0.8	0.8	*0.3*	*0.2*	2.8	1.6	0.4	0.2	0.1	0.2	0.2
21	0.3	0.8	0.8	*0.3*	*0.2*	2.8	1.4	0.4	0.2	0.1	0.1	0.4
22	0.4	1.0	5.0	*0.3*	*0.2*	2.8	1.4	0.6	0.2	0.1	0.2	0.3
23	0.5	1.2	2.5	*0.3*	*0.3*	2.1	1.6	0.7	0.2	0.2	0.2	0.3
24	0.5	0.9	0.6	*0.3*	*0.3*	1.6	1.2	0.4	0.2	0.2	0.2	0.3
25	0.5	0.9	0.6	*0.3*	*0.5*	2.1	1.4	0.3	0.3	0.2	0.2	0.3
26	0.5	0.9	0.6	*0.3*	0.8	2.1	1.5	0.3	0.2	0.2	0.2	0.3
27	0.4	0.7	0.5	*0.3*	0.7	1.9	1.3	0.4	0.2	0.2	0.2	0.3
28	0.4	1.9	0.7	*0.3*	0.7	1.7	1.6	0.4	0.1	0.1	0.2	0.3
29	0.4	1.3	0.5	*0.3*		2.2	1.4	0.5	0.1	0.1	0.1	0.3
30	0.4	12.2	0.5	*0.3*		2.1	1.3	0.5	0.1	0.1	0.1	0.3
31	0.4		0.5	*0.3*		2.7		0.3		0.1	0.1	
MEAN	0.8	1.1	2.2	0.3	0.3	1.8	1.8	0.8	0.2	0.1	0.2	0.2
MAX. DAY	1.6	12.2	12.4	0.9	0.8	2.8	2.5	1.8	0.5	0.2	0.2	0.4
MIN. DAY	0.3	0.2	0.5	0.2	0.2	0.8	1.2	0.3	0.1	0.1	0.1	0.1
cfs days	24.3	34.4	67.9	10.7	8.8	55.9	52.9	24.0	6.7	4.1	4.9	6.3
ac-ft	48.2	68.3	134.6	21.2	17.5	110.9	104.9	47.7	13.2	8.2	9.6	12.5

Monitor's Comments

1. Gage maintained and operated by CDM Smith, provisional data, subject to revision
2. Gaging station location:39° 17' 55.3"N, 120° 07' 14.5"W (WGS84), elev. 5,837, Placer County, California, above Martis Dam
3. Drainage area is approximately 5.0 square mile; land use includes open space, golf course, timber harvesting, ski area and some residential
4. Station is located on an alluvial fan and may not capture 100% of streamflow during most flows
6. Gaging station period of record: October 1, 2012 to present
7. Daily values in italics are ice-corrected flows, correlated with streamflow from Sagehen Creek, California

Water Year 2013 Totals:		
Mean flow	**0.8**	(cfs)
Max. daily flow	**12**	(cfs)
Min. daily flow	**0.1**	(cfs)
Annual total	**301**	(cfs-days)
Annual total	**597**	(ac-ft)

Appendix D. Annual hydrologic record, Martis Creek (TURB-MC2), near Truckee, California
Water Year 2013 (Preliminary)

WY 2013 Daily Mean Flow (cubic feet per second)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1	1.6	2.3	32.0	*4.4*	3.7	4.0	12.2	4.1	2.8	1.7	2.0	1.6
2	1.6	2.0	100.2	*4.3*	3.5	4.8	11.0	4.0	2.6	1.7	1.9	1.5
3	1.6	1.9	35.3	*4.3*	3.5	7.1	10.6	3.8	2.5	1.8	1.8	1.4
4	1.6	1.8	16.9	*4.4*	3.5	8.4	11.8	3.8	2.5	1.7	1.6	1.5
5	1.7	1.8	54.3	*4.4*	3.6	9.4	12.0	4.1	2.5	1.7	1.6	1.5
6	1.7	1.8	26.8	*4.3*	3.6	6.3	10.8	6.5	2.4	1.7	1.3	1.4
7	1.7	1.8	17.5	*4.5*	3.6	6.5	10.2	7.7	2.3	1.7	1.3	1.4
8	1.7	1.8	13.2	*5.5*	3.6	5.7	10.7	7.8	2.2	1.7	1.3	1.4
9	1.7	1.9	10.9	*4.6*	3.9	5.4	9.0	6.0	2.2	1.6	1.1	1.3
10	1.7	1.8	9.0	*4.0*	4.7	5.8	8.0	5.3	2.3	1.7	1.4	1.2
11	1.7	3.0	8.0	*3.9*	4.6	7.3	8.4	4.9	2.2	1.7	1.8	1.2
12	1.7	2.1	7.7	*3.9*	4.4	9.1	8.4	4.6	2.1	1.7	1.8	1.2
13	1.7	2.2	7.7	*3.9*	3.9	11.0	8.0	4.9	2.1	1.7	2.1	1.3
14	1.7	2.2	9.4	*3.9*	3.6	13.9	7.8	5.2	2.1	1.7	2.0	1.2
15	1.7	2.2	6.9	*3.9*	3.6	15.6	7.5	5.0	2.1	1.7	1.8	1.2
16	1.7	2.3	5.6	*3.9*	3.5	16.7	7.0	4.8	2.1	1.7	1.9	1.0
17	1.7	5.1	12.1	*3.9*	3.5	16.5	6.4	4.6	2.0	1.7	1.9	1.1
18	1.7	6.6	8.1	*3.9*	3.5	15.4	5.8	4.3	2.0	1.7	2.0	1.2
19	1.7	4.0	8.0	*4.1*	3.5	15.7	5.4	4.0	2.1	1.7	2.1	1.0
20	1.7	3.5	5.5	*4.1*	3.4	25.3	5.3	3.8	2.1	1.7	2.0	1.1
21	1.6	3.7	4.9	*4.2*	3.3	22.8	5.3	3.7	2.0	1.7	1.7	1.6
22	1.8	3.4	*4.8*	*4.1*	3.5	18.6	5.3	3.6	2.0	1.6	1.7	1.5
23	2.0	3.2	*4.7*	*4.0*	3.3	15.6	5.2	3.6	2.0	1.7	1.6	1.2
24	1.8	3.1	*4.6*	3.3	3.5	14.0	5.0	3.5	2.1	1.7	1.6	1.1
25	1.8	3.0	*4.6*	3.4	3.6	13.2	4.8	3.5	2.3	1.7	1.7	1.2
26	1.9	2.9	*4.7*	3.6	3.4	12.4	4.6	3.1	2.2	1.7	1.7	1.3
27	1.9	2.9	*4.5*	3.7	3.6	12.1	4.5	3.1	1.9	1.7	2.0	1.2
28	1.9	4.0	*4.6*	4.4	3.5	12.1	4.4	3.3	1.9	1.9	1.9	1.1
29	1.9	4.2	*4.5*	3.6		11.9	4.3	3.0	1.8	2.3	1.8	1.1
30	2.0	73.0	*4.4*	3.6		11.6	4.2	2.9	1.8	1.7	1.6	1.1
31	2.0		*4.4*	3.6		13.9		2.9		1.4	1.6	
MEAN	2	5.2	14	4.1	3.7	11.9	7	4	2	2	1.7	1.3
MAX. DAY	2	73.0	100	5.5	4.7	25	12	8	3	2	2.1	1.6
MIN. DAY	1.6	1.8	4.4	3.3	3.3	4.0	4	3	2	1.4	1.1	1.0
cfs days	54	156	446	126	102	368	224	135	65	53	54	38
ac-ft	108	309	884	249	203	730	444	269	129	104	107	75

Monitor's Comments

1. Station maintained and managed by CDM Smith, provisional data, subject to revision
2. Gaging station location: 39° 18' 01.6"N, 120° 07' 48"W (WGS84), elev. 5,832 feet, Placer County, California, above Martis Dam
3. Drainage area is 15.7 square miles above the gaging station; land use includes residential, open space, golf course, timber harvesting, and a ski area.
4. There are known diversions upstream for golf course ponds and irrigation
5. Period of record is from October 1, 2012 to present
6. Daily values in italics are ice-corrected flows using a correlation with Sagehen Creek, California
7. Beaver activity downstream of this gage caused an artificial rise in stage after July 25, 2013, daily values are approximate

Water Year 2013 Totals:		
Mean flow	**5.0**	(cfs)
Max. daily flow	**100**	(cfs)
Min. daily flow	**1.0**	(cfs)
Annual total	**1,820**	(cfs-days)
Annual total	**3,610**	(ac-ft)

Appendix D. Annual hydrologic record, Truckee River above Truckee (USGS 10338000), near Truckee, California
Water Year 2013 (Preliminary)

WY 2013 Daily Mean Flow (cubic feet per second)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1	141	255	455	81	178	148	196	237	219	358	366	365
2	141	248	977	78	180	156	198	215	221	384	364	364
3	140	247	347	79	179	174	199	224	219	403	351	362
4	139	246	226	82	186	172	226	223	217	401	349	362
5	139	247	568	83	179	168	243	212	222	393	348	354
6	140	241	349	85	158	173	226	226	218	393	352	341
7	139	233	228	84	132	153	211	219	213	402	359	335
8	142	237	179	81	134	126	199	221	217	416	355	334
9	143	238	147	94	133	126	181	227	222	420	351	321
10	145	236	128	138	130	126	181	250	218	418	350	303
11	150	233	116	136	134	134	202	273	229	412	348	297
12	149	233	113	164	138	133	211	281	264	406	349	286
13	146	233	107	194	118	115	220	279	292	406	356	283
14	147	233	103	200	115	134	226	261	312	405	356	279
15	148	228	98	190	120	151	212	244	307	401	356	275
16	150	227	95	196	129	147	198	224	312	396	358	255
17	155	307	109	205	131	147	184	186	319	390	358	213
18	162	292	100	205	129	145	175	171	317	383	361	168
19	162	244	96	202	134	147	171	168	331	382	361	124
20	168	208	91	202	157	191	185	165	370	382	364	102
21	181	230	88	205	155	193	194	166	367	382	366	108
22	190	201	79	209	160	169	210	160	372	382	365	105
23	185	183	80	213	168	156	211	143	380	382	363	102
24	183	176	93	223	181	150	207	134	382	380	367	101
25	199	172	94	238	159	146	205	133	430	380	365	102
26	211	167	91	249	139	144	210	141	364	380	365	102
27	231	144	93	223	139	148	230	153	321	376	362	102
28	230	117	93	177	141	159	242	194	330	371	362	101
29	230	110	89	175		173	264	190	339	369	364	100
30	230	660	87	173		177	275	196	347	368	366	100
31	236		87	176		193		193		367	366	
MEAN	169	234	181	163	148	154	210	204	296	390	359	225
MAX. DAY	236	660	977	249	186	193	275	281	430	420	367	365
MIN. DAY	139	110	79	78	115	115	171	133	213	358	348	100
cfs days	5251	7026	5603	5041	4135	4773	6290	6309	8871	12089	11124	6745
ac-ft	10416	13936	11115	9999	8202	9468	12477	12514	17595	23978	22064	13378

Monitor's Comments

1. USGS provisional data, subject to revision
2. Gaging station location: 39° 17' 46.7"N, 120° 12' 19.7"W (WGS84), elev. 5,871 feet, near Truckee, California.
3. Drainage area is 46 square miles above the gaging station, excluding the area above Lake Tahoe Dam; land use includes timber harvesting, ski resorts, State Route 89, rural residential and limited commercial areas, and open space.
4. Gaging station period of record: October 1, 1945 to present
5. Streamflow is regulated by Tahoe City Dam

Water Year 2013 Totals:		
Mean flow	**228**	(cfs)
Max. daily flow	**977**	(cfs)
Min. daily flow	**78.4**	(cfs)
Annual total	**83,258**	(cfs-days)
Annual total	**165,142**	(ac-ft)

United State Geological Survey (USGS), Truckee Field Office

Appendix D. Annual hydrologic record, Truckee River at Boca Bridge (USGS 10344505), Nevada County, California
Water Year 2013 (Preliminary)

WY 2013 Daily Mean Flow (cubic feet per second)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1	433	429	983	391	369	405	473	663	615	483	480	472
2	425	424	1960	411	370	404	488	685	596	447	479	471
3	427	417	1416	484	367	419	503	720	588	432	465	469
4	430	413	1184	525	382	408	555	735	583	451	463	471
5	427	413	1609	503	395	410	609	707	589	431	465	473
6	428	407	1252	500	392	423	558	742	590	432	467	482
7	432	398	934	459	372	412	538	746	581	434	466	493
8	428	401	728	409	382	409	538	745	577	443	465	492
9	425	403	579	406	408	429	513	744	585	439	468	497
10	426	401	484	482	420	426	518	764	578	443	466	514
11	440	394	432	478	421	438	541	796	571	447	466	524
12	433	394	413	512	409	453	522	809	570	446	466	519
13	429	396	375	500	404	435	505	797	579	444	474	516
14	433	396	332	496	405	439	541	768	594	445	472	509
15	430	396	311	486	406	462	556	739	588	444	467	503
16	426	404	327	485	408	462	539	732	589	465	468	498
17	434	461	397	448	409	463	528	707	594	473	469	489
18	443	480	402	462	410	459	539	715	587	472	471	483
19	417	421	387	473	412	470	560	706	589	471	472	486
20	402	392	395	472	423	588	568	702	593	471	474	478
21	406	406	396	472	423	616	560	697	589	470	475	486
22	410	395	397	448	420	573	549	702	591	469	473	485
23	397	377	394	389	418	540	538	701	600	472	471	475
24	375	383	402	385	415	525	555	704	606	472	475	471
25	382	385	402	395	414	525	610	702	666	473	474	476
26	379	388	398	406	414	480	630	702	628	473	473	479
27	382	391	389	389	402	462	664	719	546	470	471	475
28	382	394	391	365	400	474	679	743	507	477	471	475
29	387	401	398	368		489	666	674	507	482	471	471
30	408	1091	389	366		469	696	639	513	482	472	457
31	410		393	367		493		597		482	471	
MEAN	416	428	621	443	403	466	561	719	583	459	470	486
MAX. DAY	443	1091	1960	525	423	616	696	809	666	483	480	524
MIN. DAY	375	377	311	365	367	404	473	597	507	431	463	457
cfs days	12,883	12,851	19,253	13,733	11,272	14,461	16,839	22,303	17,488	14,232	14,577	14,588
ac-ft	25,554	25,490	38,188	27,240	22,357	28,684	33,400	44,238	34,687	28,229	28,913	28,935

Monitor's Comments

1. USGS provisional data, subject to revision
2. Location of streamgage: 39 23' 6.5"N, 120 05' 16.8"W (WGS84), elev. 5,502 feet, near Truckee, California
3. Drainage area is 505 square miles above the gaging station excluding the area above Lake Tahoe Dam and Donner Lake Dam; land use includes historical quarrying, timber harvesting, Union Pacific RR, portions of Interstate Highway 80, residential and commercial zoned areas, and open space.
4. The Middle Truckee River is regulated by 7 dams

Water Year 2013 Totals:		
Mean flow	**505**	(cfs)
Max. daily flow	**1960**	(cfs)
Min. daily flow	**311.2**	(cfs)
Annual total	**184,480**	(cfs-days)
Annual total	**365,916**	(ac-ft)

United State Geological Survey (USGS), Truckee Field Office

Appendix E
Suspended-Sediment Concentration Sample Log

Appendix E. Suspended-sediment concentration and loading rates: West Martis Creek (TURB-MC1), water year 2013

Sample Date:Time	Observer(s)	Gage Height	Streamflow Discharge	Streamflow Value Source	Stream Condition	Suspended-Sediment Concentration	15-minute Turbidity	Suspended-Sediment Transport Rate
	Site Conditions					*Suspended Sediment*		
		(ft)	*(cfs)*	*M,R,E*	*R,F,B,U,S*	*(mg/l)*	*(NTU)*	*(tons/day)*
WY2013								
11/17/12 14:07	CDM Smith	1.91	2.82	R	R	56.0	0.56	0.43
11/30/12 12:30	CDM Smith	3.12	16.73	R	R	20	31.2	0.90
12/5/12 10:44	CDM Smith	2.73	9.49	R	R	3.0	14	0.08
12/17/12 9:55	CDM Smith	1.97	2.37	R	R	18	5.4	0.11
3/13/13 15:15	CDM Smith	1.88	1.84	R	S	5.00	4.30	0.02
3/20/13 10:07	CDM Smith	1.98	2.96	R	S	3.00	3.70	0.02
3/31/13 9:45	CDM Smith	1.98	3.18	M	F	6.00	5.10	0.05
4/26/13 13:15	CDM Smith	1.68	0.99	R	F	*0.10*	2.36	0.0003
5/7/13 12:00	CDM Smith	1.97	1.92	R	F	*0.10*	n/a	0.001

Notes

Streamflow is the measured or 15-minute recorded flow when sediment was sampled, and usually differs from the daily streamflow.

Streamflow Value Source: M = measured; R = rating curve; E = estimated

Stream Condition: R = rising, F = falling, B = baseflow, U = uncertain, S = steady

Turbidity is the 15-minute recorded value when sediment was sampled;

Suspended-sediment load (tons/day) is calculated by multiplying SSC by streamflow (cfs) and a conversion factor of 0.0027

Values are preliminary and subject to revision; SSC with values of 0.1 are used for plotting, laboratory results are ND

Appendix E. Suspended-sediment concentration and loading rates: Martis Creek (TURB-MC2), near Truckee, California Partial Water Year 2013

	Site Conditions					Suspended Sediment		
Sample Date:Time	Observer(s)	Gage Height	Streamflow Discharge	Streamflow Value Source	Stream Condition	Suspended-Sediment Concentration	15-minute Turbidity	Suspended-Sediment Transport Rate
WY2013		*(ft)*	*(cfs)*	*M,R,E*	*R,F,B,U,S*	*(mg/l)*	*(NTU)*	*(tons/day)*
11/17/2012 14:00	CDM Smith	0.81	0.0	*R*	*R*	1.0	*3.2*	0.0
11/17/2012 14:42	CDM Smith	0.83	0.0	*R*	*R*	11.0	*7.80*	0.0
11/28/2012 15:00	CDM Smith	0.72	0.0	*R*	*R*	7.0	*5.0*	0.0
11/30/2012 10:30	CDM Smith	2.56	0.0	*R*	*R*	74	*43*	0
11/30/2012 13:00	CDM Smith	3.18	0.0	*R*	*R*	26	*27*	0.0
12/5/2012 11:20	CDM Smith	2.77	0.0	*R*	*F*	2.0	*15.00*	0.0
12/5/2012 14:00	CDM Smith	2.54	0.0	*R*	*F*	3.0	*6.10*	0.0
12/17/2012 10:30	CDM Smith	1.15	0.0	*R*	*R*	0.5	*4.20*	0.0
3/3/2013 15:40	CDM Smith	1.04	0.0	R	R	2.0	*3.30*	0.0
3/20/2013 6:00	CDM Smith	1.55	0.0	R	R	2.0	*1.50*	0.0
3/20/2013 10:37	CDM Smith	1.77	0.0	R	R/S	1.0	*8.30*	0.00
3/31/2013 6:00	CDM Smith	1.25	0.0	R	R	1.0	*1.00*	0.00
3/31/2013 10:18	CDM Smith	1.38	0.0	R	R	4.0	*8.30*	0.00
4/26/2013 13:49	CDM Smith	0.75	0.0	R	F	3.0	*3.80*	0.00
5/7/2013 12:38	CDM Smith	0.98	0.0	R	S	7.0	*7.60*	0.00

Notes

Streamflow is the measured or 15-minute recorded flow when sediment was sampled, and usually differs from the daily streamflow.

Streamflow Value Source: M = measured; R = rating curve; E = estimated

Stream Condition: R = rising, F = falling, B = baseflow, U = uncertain, S = steady

In this case, turbidity values (in *italics)* are based on laboratory analysis

Suspended-sediment load (tons/day) is calculated by multiplying SSC by streamflow (cfs) and a conversion factor of 0.0027

Values are preliminary and subject to revision

Appendix E: Suspended-sediment concentration and loading rates:
Truckee River above Truckee, USGS #10338000, (TURB-MS3), water year 2013

	Site Conditions					*Suspended Sediment*		
Sample Date:Time	**Observer(s)**	**Gage Height**	**Streamflow Discharge**	**Streamflow Value Source**	**Stream Condition**	**Suspended-Sediment Concentration**	**15-minute Turbidity**	**Suspended-Sediment Transport Rate**
		(ft)	*(cfs)*	*M,R,E*	*R,F,B,U,S*	*(mg/l)*	*(NTU)*	*(tons/day)*
WY2013								
11/17/12 15:15	ds	2.25	335	USGS	R	11.0	*5.9*	9.9
11/18/12 14:30	bkh	2.16	290	USGS	S/F	72.0	*0.9*	56.3
11/30/12 16:45	bkh	3.10	886	USGS	F	40.0	*21.0*	95.5
12/2/12 10:05	ds, cs	3.98	1,660	USGS	R	220	*128*	984
12/2/12 14:30	bkh, cs	3.59	1,290	USGS	F	3.0	*50.8*	10.4
3/20/13 11:00	bkh	1.93	186	USGS	R	2.0	2.2	1.0
4/24/13 14:45	bkh, jo	1.97	202	USGS	S	1.0	1.0	0.5
4/29/13 22:10	bkh, cs	2.23	325	USGS	R/P	15.0	6.9	13.1
5/13/13 20:45	bkh	2.24	330	USGS	R	10.0	4.3	8.9
6/25/13 14:15	bkh	2.43	457	USGS	R	10.0	4.0	12.3
7/4/13 8:05	ss	2.32	400	USGS	S	11.0	7.0	11.9

Notes

Observer Key: (ds) is David Shaw, (bkh) is Brian Hastings, (cs) is Collin Strasenburgh, (jo) is Jon Owens, (ss) Stefan Schuster of CDM

Streamflow is the measured or 15-minute recorded flow when sediment was sampled, and usually differs from the daily streamflow.

Streamflow Value Source: USGS gage #10338000 accessed online at USGS.gov

Stream Condition: R = rising, F = falling, B = baseflow, U = uncertain, S = steady

Turbidity is the 15-minute recorded value when sediment was sampled; turbidity values in *italics* are estimates from laboratory analysis

Suspended-sediment load (tons/day) is calculated by multiplying SSC by streamflow (cfs) and a conversion factor of 0.0027

Values are preliminary and subject to revision

Appendix E. Suspended-sediment concentration and loading rates:
Truckee River at Boca Bridge (TURB-TT1), USGS #10344505, water year 2013

	Site Conditions					Suspended Sediment		
Sample Date:Time	**Observer(s)**	**Gage Height**	**Streamflow Discharge**	**Streamflow Value Source**	**Stream Condition**	**Suspended-Sediment Concentration**	**15-minute Turbidity**	**Suspended-Sediment Transport Rate**
		(ft)	*(cfs)*	*M,R,E*	*R,F,B,U,S*	*(mg/l)*	*(NTU)*	*(tons/day)*
WY2013								
11/17/12 16:30	ds	6.45	457	USGS	R	5.0	*1.1*	6.2
11/30/12 16:10	bkh, ds	8.19	1725	UGSS	Peak	140	*85.0*	651
12/2/12 10:30	cs, ds	8.86	2430	USGS	R	190	*103*	1244
12/2/12 14:55	bkh, cs	9.19	2810	USGS	F	240	*129*	1818
3/20/13 11:30	bkh	6.70	592	USGS	R	5.0	3.0	8.0
4/24/13 15:15	bkh, jo	6.63	552	UGSS	R	1.0	1.7	1.5
4/29/13 22:45	bkh, cs	6.95	746	USGS	R	6.0	2.4	12.1
4/29/13 23:05	bkh, cs	6.96	753	USGS	R	3.0	2.6	6.1
5/13/13 22:20	bkh, ds	7.09	840	USGS	R	4.0	2.5	9.1
5/13/13 22:45	bkh, ds	7.08	834	USGS	F	3.0	2.7	6.7
6/25/13 14:35	bkh	6.83	670	USGS	R	6.0	4.0	10.8
7/4/13 7:50	ss	6.42	442	USGS	F	120	86	143

Notes

Observer Key: ds = Dave Shaw, bkh = Brian Hastings, cs = Collin Strasenburgh, ss = Stefan Schuster of CDM

Streamflow is the measured or 15-minute recorded flow when sediment was sampled, and usually differs from the daily streamflow.

Streamflow Value Source: USGS gage #10344505, accessed online at USGS.gov

Stream Condition: R = rising, F = falling, B = baseflow, U = uncertain, S = steady

Turbidity is the 15-minute recorded value when sediment was sampled; turbidity values in *italics* are estimates from laboratory analysis

Suspended-sediment load (tons/day) is calculated by multiplying SSC by streamflow (cfs) and a conversion factor of 0.0027

Values are preliminary and subject to revision

Water Year: 2013
Stream: West Martis Creek
Station: TURB-MC1
County: Placer County

Form 1. Annual Suspended-Sediment Load Record WY 2013

WY 2013 Daily Suspended-Sediment Load *(tons)*
Streamflow-based sediment rating-curve method

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	
1	0.00	0.00	0.48	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	
2	0.00	0.00	4.89	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	
3	0.00	0.00	0.27	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	
4	0.00	0.00	0.03	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	
5	0.01	0.00	1.41	0.00	0.00	0.01	0.03	0.00	0.00	0.00	0.00	0.00	
6	0.00	0.00	0.11	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	
7	0.00	0.00	0.04	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	
8	0.00	0.00	0.02	0.00	0.00	0.00	0.03	0.01	0.00	0.00	0.00	0.00	
9	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	
10	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	
11	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	
12	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	
13	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	
14	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	
15	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.00	
16	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.00	
17	0.00	0.06	0.02	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	
18	0.00	0.03	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	
19	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	
20	0.00	0.00	0.00	0.00	0.00	0.05	0.01	0.00	0.00	0.00	0.00	0.00	
21	0.00	0.00	0.00	0.00	0.00	0.04	0.01	0.00	0.00	0.00	0.00	0.00	
22	0.00	0.00	0.49	0.00	0.00	0.04	0.01	0.00	0.00	0.00	0.00	0.00	
23	0.00	0.00	0.11	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	
24	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	
25	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	
26	0.00	0.00	0.00	0.00	0.00	0.02	0.0	0.00	0.00	0.00	0.00	0.00	
27	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	
28	0.00	0.05	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	
29	0.00	0.00	0.00	0.00		0.02	0.01	0.00	0.00	0.00	0.00	0.00	
30	0.00	5.15	0.00	0.00		0.02	0.00	0.00	0.00	0.00	0.00	0.00	**Qss**
31	0.00		0.00	0.00		0.04		0.00		0.00	0.00		**Annual**
TOTAL	0.1	5.3	7.9	0.0	0.0	0.5	0.4	0.1	0.0	0.0	0.0	0.0	**14.3**
Max.day	0.0	5.1	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**5.1**

WY 2013 Daily Suspended-Sediment Load *(tons)*
Continuous record of turbidity

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	
1	0.00	0.00	0.42	0.04	0.00	0.02	0.01	0.01	0.00	0.00	0.00	0.00	
2	0.00	0.00	12.75	0.01	0.00	0.02	0.03	0.01	0.00	0.00	0.00	0.00	
3	0.00	0.00	2.59	0.00	0.00	0.04	0.01	0.01	0.00	0.00	0.00	0.00	
4	0.00	0.00	0.06	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	
5	0.00	0.00	0.98	0.00	0.01	0.02	0.13	0.00	0.00	0.00	0.00	0.00	
6	0.00	0.00	0.10	0.00	0.00	0.02	0.01	0.76	0.00	0.00	0.00	0.00	
7	0.00	0.00	0.04	0.00	0.00	0.01	0.04	0.26	0.00	0.00	0.00	0.00	
8	0.00	0.00	0.08	0.00	0.00	0.01	0.02	0.02	0.00	0.00	0.00	0.00	
9	0.00	0.00	0.01	0.00	0.00	0.01	0.12	0.01	0.00	0.00	0.01	0.00	
10	0.00	0.00	0.01	0.00	0.01	0.01	0.08	0.01	0.00	0.00	0.00	0.00	
11	0.00	0.00	0.01	0.00	0.00	0.01	0.03	0.01	0.00	0.00	0.00	0.00	
12	0.00	0.00	0.01	0.00	0.00	0.02	0.05	0.01	0.00	0.00	0.01	0.00	
13	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.00	0.01	0.01	0.00	
14	0.00	0.00	0.01	0.00	0.00	0.03	0.02	0.01	0.00	0.00	0.00	0.06	
15	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.01	0.00	0.00	0.00	0.03	
16	0.00	0.00	0.00	0.22	0.00	0.06	0.01	0.00	0.00	0.00	0.00	0.01	
17	0.00	0.00	0.04	0.27	0.00	0.07	0.01	0.00	0.00	0.00	0.00	0.00	
18	0.00	0.00	0.01	0.06	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	
19	0.00	0.00	0.01	0.25	0.01	0.01	0.02	0.00	0.00	0.00	0.01	0.00	
20	0.00	0.00	0.00	0.01	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	
21	0.00	0.00	0.13	0.00	0.01	0.13	0.02	0.00	0.00	0.00	0.01	0.00	
22	0.00	0.00	71.01	0.00	0.00	0.08	0.02	0.00	0.00	0.00	0.01	0.00	
23	0.00	0.00	27.33	0.00	0.01	0.10	0.03	0.00	0.00	0.00	0.02	0.00	
24	0.00	0.00	0.00	0.01	0.21	0.04	0.01	0.00	0.00	0.00	0.00	0.00	
25	0.00	0.00	0.01	0.01	0.16	0.02	0.01	0.00	0.00	0.00	0.00	0.00	
26	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.00	0.00	0.00	0.01	0.00	
27	0.00	0.00	0.00	0.01	0.13	0.01	0.02	0.00	0.00	0.00	0.02	0.00	
28	0.00	14.03	0.00	0.02	0.04	0.01	0.10	0.00	0.00	0.00	0.00	0.00	
29	0.00	7.01	0.00	0.02		0.01	0.01	0.01	0.00	0.00	0.00	0.00	
30	0.00	117.99	0.00	0.01		0.07	0.02	0.00	0.00	0.00	0.00	0.00	**Qss**
31	0.00		0.00	0.01		0.03		0.00		0.00	0.00		**Annual**
TOTAL	0.0	139.0	115.6	1.0	0.6	1.1	0.9	1.2	0.0	0.0	0.1	0.1	**260**
Max.day	0.0	118.0	71.0	0.3	0.2	0.1	0.1	0.8	0.0	0.0	0.0	0.1	**118**

Daily values are based on calculations of suspended-sediment load at 15-minute intervals.
Streamflow-based suspended-sediment load computation uses a correlation between streamflow and suspended-sediment concentration and is based on a provisional streamflow record
Turbidity-based suspended-sediment load computation uses a correlation between instantaneous turbidity (NTU) and suspended-sediment concentration (mg/L) and is converted to tons/day
Turbidity-based suspended-sediment loads are preliminary and may include significant error due to frequent instrument malfunction.

Balance Hydrologics, Inc. PO Box 1077, Truckee, CA 96161, (530) 550-9776, Berkeley, CA (main office) (510) 704-1000

Water Year: 2013
Stream: Martis Creek
Station: TURB-MC2
County: Placer County

Form 2. Annual Suspended-Sediment Load Record WY 2013

WY 2013 Daily Suspended-Sediment Load *(tons)*
Streamflow-based sediment rating-curve method

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	
1	0.00	0.00	1.11	0.01	0.00	0.01	0.09	0.01	0.00	0.00	0.00	0.00	
2	0.00	0.00	23.99	0.01	0.00	0.01	0.07	0.01	0.00	0.00	0.00	0.00	
3	0.00	0.00	1.48	0.01	0.00	0.03	0.06	0.01	0.00	0.00	0.00	0.00	
4	0.00	0.00	0.20	0.01	0.00	0.04	0.08	0.01	0.00	0.00	0.00	0.00	
5	0.00	0.00	4.51	0.01	0.00	0.06	0.09	0.01	0.00	0.00	0.00	0.00	
6	0.00	0.00	0.64	0.01	0.00	0.02	0.07	0.02	0.00	0.00	0.00	0.00	
7	0.00	0.00	0.22	0.01	0.00	0.02	0.06	0.03	0.00	0.00	0.00	0.00	
8	0.00	0.00	0.11	0.01	0.00	0.01	0.06	0.03	0.00	0.00	0.00	0.00	
9	0.00	0.00	0.07	0.01	0.01	0.01	0.04	0.02	0.00	0.00	0.00	0.00	
10	0.00	0.00	0.04	0.01	0.01	0.02	0.03	0.01	0.00	0.00	0.00	0.00	
11	0.00	0.00	0.03	0.01	0.01	0.03	0.04	0.01	0.00	0.00	0.00	0.00	
12	0.00	0.00	0.03	0.01	0.01	0.05	0.04	0.01	0.00	0.00	0.00	0.00	
13	0.00	0.00	0.03	0.01	0.01	0.08	0.03	0.01	0.00	0.00	0.00	0.00	
14	0.00	0.00	0.05	0.01	0.00	0.14	0.03	0.01	0.00	0.00	0.00	0.00	
15	0.00	0.00	0.02	0.01	0.00	0.17	0.03	0.01	0.00	0.00	0.00	0.00	
16	0.00	0.00	0.01	0.01	0.00	0.20	0.02	0.01	0.00	0.00	0.00	0.00	
17	0.00	0.02	0.11	0.01	0.00	0.19	0.02	0.01	0.00	0.00	0.00	0.00	
18	0.00	0.02	0.03	0.01	0.00	0.16	0.01	0.01	0.00	0.00	0.00	0.00	
19	0.00	0.01	0.04	0.01	0.00	0.17	0.01	0.01	0.00	0.00	0.00	0.00	
20	0.00	0.00	0.01	0.01	0.00	0.56	0.01	0.01	0.00	0.00	0.00	0.00	
21	0.00	0.00	0.01	0.01	0.00	0.42	0.01	0.00	0.00	0.00	0.00	0.00	
22	0.00	0.00	0.01	0.01	0.00	0.25	0.01	0.00	0.00	0.00	0.00	0.00	
23	0.00	0.00	0.01	0.01	0.00	0.16	0.01	0.00	0.00	0.00	0.00	0.00	
24	0.00	0.00	0.01	0.00	0.00	0.13	0.01	0.00	0.00	0.00	0.00	0.00	
25	0.00	0.00	0.01	0.00	0.00	0.11	0.01	0.00	0.00	0.00	0.00	0.00	
26	0.00	0.00	0.01	0.00	0.00	0.09	0.0	0.00	0.00	0.00	0.00	0.00	
27	0.00	0.00	0.01	0.01	0.00	0.09	0.01	0.00	0.00	0.00	0.00	0.00	
28	0.00	0.01	0.01	0.01	0.00	0.09	0.01	0.00	0.00	0.00	0.00	0.00	
29	0.00	0.01	0.01	0.00		0.08	0.01	0.00	0.00	0.00	0.00	0.00	
30	0.00	13.88	0.01	0.00		0.08	0.01	0.00	0.00	0.00	0.00	0.00	**Qss**
31	0.00		0.01	0.00		0.12		0.00		0.00	0.00		**Annual**
TOTAL	0.0	14.0	32.8	0.2	0.1	3.6	1.0	0.3	0.0	0.0	0.0	0.0	**52**
Max.day	0.0	13.9	24.0	0.0	0.0	0.6	0.1	0.0	0.0	0.0	0.0	0.0	**24.0**

WY 2013 Daily Suspended-Sediment Load *(tons)*
Continuous record of turbidity

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	
1	0.03	0.02	2.90	0.02	0.01	0.03	0.08	0.01	0.01	0.01			
2	0.02	0.02	17.46	0.01	0.02	0.04	0.08	0.01	0.00	0.01	0.00		
3	0.02	0.01	3.54	0.03	0.03	0.08	0.11	0.04	0.00	0.01	0.01		
4	0.02	0.01	1.17	0.01	0.04	0.16	0.12	0.01	0.01	0.01			
5	0.01	0.01	3.92	0.01	0.02	0.29	0.08	0.01	0.01	0.01			
6	0.01	0.01	0.81	0.01	0.01	0.24	0.04	0.04	0.00	0.01			
7	0.01	0.01	0.18	0.01		0.12	0.04	0.04	0.01				
8	0.01	0.01	0.05	0.01		0.04	0.02	0.03	0.00	0.01			
9	0.01	0.01	0.04	0.01	0.01	0.02	0.02	0.02	0.01	0.00			
10	0.01	0.01	0.02	0.01	0.04	0.03	0.05	0.02	0.00	0.00			
11	0.01	0.02	0.02	0.01	0.04	0.09	0.05	0.01	0.00	0.01			
12	0.02	0.01	0.03	0.02	0.02	0.14	0.02	0.01	0.00	0.00			
13	0.03	0.04	0.05	0.01	0.01	0.15	0.03	0.01	0.00				
14	0.02	0.04	0.06	0.01	0.01	0.19	0.04	0.02	0.01	0.00			
15	0.02	0.01	0.02	0.01	0.01	0.16	0.02	0.02	0.00				
16	0.02	0.02	0.02	0.01	0.00	0.17	0.02		0.01				
17	0.01	0.26	0.32	0.01	0.00	0.16	0.01	0.01					
18	0.01	0.38	0.15	0.01	0.01	0.10	0.01	0.02					
19	0.01	0.11	0.15	0.01		0.10	0.03	0.01					
20	0.01	0.03	0.06	0.01		0.35	0.01	0.01		0.00			
21	0.01	0.03	0.07	0.01	0.01	0.25	0.01	0.03					
22	0.01	0.03	0.46	0.01	0.01	0.13	0.01	0.01		0.00			
23	0.01	0.02	0.47	0.02	0.00	0.09	0.01	0.01		0.01			
24	0.01	0.02	0.16	0.01	0.01	0.09	0.01	0.02	0.00	0.00			
25	0.01	0.02	0.11	0.01	0.01	0.06	0.01	0.01	0.00	0.00			
26	0.01	0.02	0.03	0.02	0.01	0.07	0.01	0.01	0.00	0.00			
27	0.02	0.02	0.04	0.03	0.02	0.06	0.01	0.01	0.00				
28	0.01	0.04	0.04	0.02	0.01	0.05	0.01		0.01				
29	0.02	0.03	0.02	0.01		0.05	0.01		0.01	0.01			
30	0.03	9.87	0.02	0.01		0.05	0.01	0.01	0.00	0.00			**Qss**
31	0.03		0.03	0.01		0.06		0.01					**Annual**
TOTAL	0.5	11.1	32.4	0.4	0.4	3.6	1.0	0.4	0.1	0.1	0.0	0.0	**50**
Max.day	0.0	9.9	17.5	0.0	0.0	0.3	0.1	0.0	0.0	0.0	0.0	0.0	**17**

Daily values are based on calculations of suspended-sediment load at 15-minute intervals.
Streamflow-based suspended-sediment load computation uses a correlation between streamflow and suspended-sediment concentration and is based on a provisional streamflow record
Turbidity-based suspended-sediment load computation uses a correlation between instantaneous turbidity (NTU) and suspended-sediment concentration (mg/L) and is converted to tons/day
Tubidity-based suspended-sediment loads are extremely preliminary, incomplete and possibly erroneous due to instrument failure

Balance Hydrologics, Inc. PO Box 1077, Truckee, CA 96161, (530) 550-9776, Berkeley, CA (main office) (510) 704-1000

Water Year: 2013
Stream: Truckee River above Town of Truckee
Station: TURB-MS3
County: Placer County

Form 3. Annual Suspended-Sediment Load Record WY 2013

WY 2013 Daily Suspended-Sediment Load *(tons)*
Streamflow-based sediment rating-curve method

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	
1	0.25	1.90	14.43	0.04	0.55	0.29	0.73	1.53	1.13	6.14	6.57	6.33	
2	0.25	1.72	356.58	0.03	0.58	0.35	0.80	1.05	1.16	7.81	6.44	6.44	
3	0.24	1.70	6.66	0.04	0.56	0.51	0.80	1.24	1.14	9.40	5.69	6.34	
4	0.24	1.69	1.27	0.04	0.64	0.50	1.33	1.21	1.09	9.01	5.59	6.34	
5	0.24	1.70	36.22	0.04	0.57	0.45	1.64	1.00	1.18	8.38	5.54	5.88	
6	0.24	1.56	6.32	0.04	0.39	0.50	1.25	1.27	1.11	8.16	5.78	5.16	
7	0.24	1.39	1.34	0.04	0.20	0.35	0.99	1.13	1.03	9.10	6.17	4.85	
8	0.25	1.47	0.57	0.04	0.21	0.17	0.81	1.16	1.09	10.25	5.92	4.82	
9	0.26	1.49	0.29	0.08	0.20	0.17	0.59	1.30	1.17	10.55	5.69	4.21	
10	0.27	1.45	0.18	0.23	0.19	0.17	0.59	1.86	1.10	10.39	5.63	3.32	
11	0.31	1.39	0.13	0.22	0.21	0.21	0.86	2.48	1.36	9.89	5.55	3.20	
12	0.30	1.39	0.11	0.46	0.23	0.21	0.99	2.76	2.17	9.42	5.61	2.80	
13	0.28	1.39	0.10	0.74	0.14	0.12	1.15	2.74	3.05	9.38	6.00	2.71	
14	0.29	1.39	0.08	0.84	0.12	0.22	1.27	2.10	3.69	9.32	5.98	2.58	
15	0.29	1.30	0.07	0.69	0.14	0.31	1.00	1.67	3.59	9.01	5.98	2.47	
16	0.31	1.27	0.06	0.76	0.18	0.29	0.79	1.23	3.79	8.61	6.10	1.96	
17	0.34	4.26	0.11	0.90	0.19	0.29	0.62	0.64	3.74	8.19	6.10	1.07	
18	0.40	3.07	0.08	0.90	0.18	0.27	0.53	0.48	3.69	7.67	6.25	0.49	
19	0.40	1.67	0.07	0.85	0.21	0.29	0.49	0.45	4.72	7.65	6.30	0.17	
20	0.46	0.98	0.06	0.85	0.36	0.72	0.63	0.43	6.84	7.65	6.47	0.08	
21	0.58	1.43	0.05	0.90	0.34	0.74	0.76	0.45	6.62	7.62	6.61	0.10	
22	0.69	0.85	0.04	0.96	0.38	0.46	0.98	0.37	7.00	7.66	6.51	0.09	
23	0.63	0.60	0.04	1.02	0.46	0.35	0.99	0.26	7.50	7.61	6.42	0.08	
24	0.61	0.53	0.06	1.21	0.59	0.31	0.93	0.21	7.63	7.52	6.63	0.08	
25	0.82	0.49	0.06	1.51	0.41	0.28	0.89	0.20	11.69	7.50	6.55	0.08	
26	1.00	0.45	0.05	1.75	0.24	0.26	1.0	0.25	6.71	7.52	6.50	0.08	**Qss**
27	1.35	0.30	0.06	1.36	0.24	0.29	1.38	0.33	4.21	7.24	6.35	0.08	**Partial**
28	1.34	0.13	0.06	0.54	0.25	0.37	1.62	0.76	4.63	6.93	6.34	0.08	731
29	1.34	0.11	0.05	0.52		0.50	2.28	0.71	5.06	6.79	6.48	0.08	
30	1.33	79.44	0.05	0.50		0.55	2.52	0.77	5.50	6.68	6.58	0.08	**Qss**
31	1.46		0.05	0.53		0.73		0.75		6.64	6.56		**Annual**
TOTAL	17.0	118.5	425.3	19	8.9	11	31	33	114	255.7	190.9	72.0	**1,297**
Max.day	1.5	79.4	356.6	2	0.6	0.7	3	3	11.7	10.5	6.6	6.4	**357**

WY 2013 Daily Suspended-Sediment Load *(tons)*
Continuous record of turbidity

Turbidity instruments were installed on January 18, 2013

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	
1					0.43	0.17	0.51	1.10	1.11	2.78	1.78	1.56	
2					0.44	0.28	0.49	0.84	1.09	3.23	1.67	1.88	
3					0.44	0.37	0.50	1.04	1.06	81.11	1.69	1.96	
4					0.45	0.34	1.48	0.96	1.18	38.01	1.73	1.55	
5					0.44	0.32	1.47	0.74	1.34	4.49	1.78	1.35	
6					0.39	0.33	0.74	1.15	1.27	3.51	1.70	1.27	
7					0.32	0.27	0.71	1.06	1.60	3.42	1.68	1.27	
8					0.33	0.17	0.61	1.25	2.85	3.31	1.65	1.40	
9					0.32	0.19	0.67	1.92	4.22	3.11	1.53	1.53	
10					0.32	0.17	0.55	2.51	1.95	2.94	1.55	1.29	
11					0.33	0.18	0.49	3.50	1.53	2.69	1.57	1.04	
12					0.34	0.22	0.56	4.45	2.14	2.44	1.66	1.01	
13					0.29	0.24	0.71	2.61	2.48	2.58	2.06	1.00	
14					0.28	0.41	0.73	1.70	2.52	2.60	2.72	0.98	
15					0.20	0.48	0.52	1.22	2.74	2.48	3.40	1.05	
16					0.13	0.41	0.36	0.79	3.06	2.29	2.91	1.19	
17					0.14	0.40	0.35	0.59	2.92	2.14	1.77	0.98	
18				0.25	0.13	0.35	0.37	0.52	3.99	2.06	1.82	0.48	
19				0.23	0.18	0.37	0.45	0.56	1.79	2.14	1.68	0.49	
20				0.23	0.20	1.47	0.88	0.66	2.09	2.43	1.72	0.40	
21				0.24	0.18	0.95	0.61	0.63	2.18	2.46	1.97	0.40	
22				0.33	0.21	0.50	0.88	0.41	2.52	2.28	1.96	0.51	
23				0.32	0.30	0.40	0.82	0.31	2.63	2.06	1.54	0.35	
24				0.49	0.22	0.36	0.68	0.30	2.32	2.04	1.58	0.42	
25				0.74	0.15	0.40	0.61	0.35	5.02	2.10	1.56	0.39	
26				0.60	0.13	0.33	0.73	0.45	2.46	2.15	1.68	0.15	**Qss**
27				0.54	0.13	0.35	1.65	0.45	1.68	2.15	2.13	0.15	**Partial**
28				0.43	0.15	0.42	1.68	0.99	1.84	2.09	2.47	0.15	432
29				0.43		0.47	2.88	0.69	2.18	2.00	1.47	0.15	
30				0.42		0.56	2.65	0.72	2.42	1.88	1.45	0.15	**Qss**
31				0.43		0.79		0.79		1.91	1.58		**Annual**
TOTAL	0	0.0	0.0	6	7.5	13	26	35	68	192.9	57.4	26.5	**n/a**
Max.day	0.0	0.0	0.0	1	0.5	1	3	4	5	81.1	3.4	2.0	**81**

Daily values are based on calculations of suspended-sediment load at 15-minute intervals.
Streamflow-based suspended-sediment load computation uses a correlation between streamflow and suspended-sediment concentration and is based on a provisional streamflow record
Turbidity-based suspended-sediment load computation uses a correlation between instantaneous turbidity (NTU) and suspended-sediment concentration (mg/L) and is converted to tons/day
Partial water year loads are presented for comparison between methods for the period beginning January 18, 2013
Total annual loads are not available for the record of turbidity since instruments were installed on January 18, 2013

Balance Hydrologics, Inc. PO Box 1077, Truckee, CA 96161, (530) 550-9776, Berkeley, CA (main office) (510) 704-1000

Water Year: 2013

Stream: Truckee River at Boca Bridge
Station: TURB-TT1
County: Nevada County

Form 4. Annual Suspended-Sediment Load Record WY 2013

WY 2013 Daily Suspended-Sediment Load *(tons)* Streamflow-based sediment rating-curve method

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	
1	1.95	1.87	43.40	1.33	1.07	1.50	2.71	9.50	7.12	2.90	2.82	2.66	
2	1.81	1.78	948.08	1.66	1.07	1.49	3.01	10.64	6.37	2.18	2.80	2.63	
3	1.83	1.68	162.47	3.01	1.04	1.70	3.38	12.82	6.02	1.91	2.51	2.59	
4	1.88	1.62	81.93	3.97	1.22	1.55	4.98	13.83	5.64	2.27	2.47	2.63	
5	1.82	1.62	279.86	3.38	1.37	1.57	6.98	11.93	6.07	1.90	2.52	2.68	
6	1.84	1.54	106.69	3.30	1.34	1.77	4.96	14.33	6.08	1.90	2.55	2.88	
7	1.92	1.40	35.41	2.45	1.09	1.61	4.32	14.55	5.76	1.95	2.53	3.12	
8	1.84	1.45	13.65	1.56	1.22	1.58	4.34	14.49	5.60	2.09	2.52	3.09	
9	1.79	1.47	5.83	1.52	1.55	1.87	3.62	14.44	5.90	2.03	2.57	3.21	
10	1.81	1.45	2.96	2.88	1.72	1.82	3.76	16.04	5.66	2.09	2.54	3.65	
11	2.04	1.36	1.92	2.79	1.73	2.02	4.41	18.67	5.40	2.17	2.54	3.93	
12	1.93	1.35	1.62	3.61	1.56	2.28	3.97	19.95	5.35	2.14	2.53	3.79	
13	1.86	1.38	1.13	3.31	1.50	1.96	3.43	19.01	5.69	2.12	2.69	3.70	
14	1.93	1.39	0.73	3.19	1.50	2.05	4.42	16.49	6.27	2.13	2.65	3.51	
15	1.87	1.38	0.57	2.98	1.52	2.46	4.89	14.21	6.02	2.11	2.56	3.35	
16	1.81	1.49	0.69	2.94	1.55	2.45	4.35	13.66	6.05	2.52	2.57	3.25	
17	1.95	2.76	1.44	2.21	1.56	2.48	4.04	11.97	5.99	2.69	2.60	3.03	
18	2.11	2.91	1.47	2.52	1.58	2.40	4.37	12.50	5.46	2.65	2.63	2.91	
19	1.68	1.74	1.27	2.68	1.61	2.65	5.02	11.90	6.07	2.63	2.65	2.96	
20	1.46	1.34	1.38	2.66	1.77	6.14	5.32	11.64	6.23	2.64	2.70	2.79	
21	1.51	1.62	1.39	2.66	1.77	7.20	5.03	11.33	6.04	2.61	2.72	2.97	
22	1.57	1.40	1.41	2.23	1.72	5.47	4.73	11.66	6.15	2.59	2.67	2.93	
23	1.40	1.15	1.36	1.31	1.70	4.39	4.37	11.59	6.50	2.65	2.64	2.73	
24	1.13	1.22	1.47	1.25	1.65	3.96	4.91	11.78	6.72	2.67	2.71	2.63	
25	1.22	1.25	1.46	1.38	1.63	3.94	6.91	11.65	9.79	2.68	2.70	2.75	
26	1.18	1.28	1.41	1.52	1.62	2.89	7.8	11.64	7.81	2.67	2.67	2.80	**Qss**
27	1.21	1.32	1.29	1.31	1.46	2.45	9.52	12.74	4.60	2.62	2.64	2.72	**partial**
28	1.21	1.37	1.35	1.02	1.44	2.70	10.45	14.40	3.49	2.76	2.64	2.71	
29	1.27	1.45	1.41	1.05		3.03	9.66	10.14	3.46	2.86	2.64	2.63	**1,138**
30	1.55	115.22	1.30	1.04		2.65	11.45	8.30	3.62	2.88	2.66	2.38	
31	1.57		1.36	1.05		3.14		6.43		2.86	2.64		**Annual**
TOTAL	51.9	160.3	1707.7	70	41.5	85	161	404	177	74.9	81.2	89.6	**3,104**
Max.day	2.1	115.2	948.1	4	1.8	7.2	11	20	9.8	2.9	2.8	3.9	**948**

WY 2013 Daily Suspended-Sediment Load *(tons)* Continuous record of turbidity

Turbidity instruments were installed on January 18, 2013

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	
1					1.9	2.2	3.8	5.1	3.9	7.1	3.2	3.0	
2					2.2	2.4	3.6	4.4	3.9	13.0	3.2	4.2	
3					2.0	3.2	3.7	4.9	4.2	6.5	3.1	3.2	
4					1.9	5.1	5.1	5.4	4.2	52.9	3.1	3.5	
5					2.0	4.5	7.5	4.8	4.8	8.7	3.1	2.8	
6					1.9	3.3	4.4	7.1	4.7	9.3	2.9	3.0	
7					1.8	2.9	3.8	8.0	4.6	7.1	3.7	3.2	
8					1.9	2.9	3.8	9.3	4.6	5.9	2.8	3.1	
9					2.0	2.8	3.4	6.1	4.6	5.0	2.8	3.8	
10					2.1	3.1	3.4	5.2	4.0	4.9	2.8	13.2	
11					2.1	3.0	3.9	6.9	3.6	6.6	2.9	3.9	
12					2.0	3.4	3.7	7.7	4.3	4.0	3.0	4.4	
13					2.0	3.4	3.3	8.1	4.5	7.7	3.2	3.3	
14					2.0	3.9	3.7	7.3	5.0	4.0	3.1	3.4	
15					2.0	4.6	3.4	5.3	4.7	5.3	3.2	3.7	
16					1.9	3.9	3.0	4.9	4.9	5.3	3.1	3.2	
17					2.0	3.7	3.0	4.8	6.7	20.1	3.7	2.7	
18				2.5	1.9	3.6	3.0	6.0	5.1	4.2	3.4	2.5	
19				2.5	1.9	3.7	3.2	7.1	5.1	3.9	3.2	2.6	
20				2.5	2.0	6.5	3.4	7.0	4.5	4.3	3.3	2.5	
21				2.5	1.9	7.0	3.4	6.8	4.5	9.1	3.3	6.1	
22				2.3	2.0	5.3	3.8	3.8	4.9	5.0	3.3	5.1	
23				2.0	5.4	4.6	3.5	3.5	5.5	3.8	2.9	4.7	
24				2.4	2.3	4.5	3.5	3.5	5.4	3.6	4.1	4.6	
25				2.6	2.3	4.1	3.6	3.6	15.1	3.0	2.6	3.5	
26				2.5	1.9	3.6	3.8	3.7	10.9	3.0	2.7	3.5	**Qss**
27				2.1	1.9	3.5	4.7	4.0	4.0	3.0	2.9	3.5	**partial**
28				1.8	3.1	3.5	6.2	4.9	4.2	3.1	2.7	3.5	
29				1.8		3.8	5.2	3.8	4.3	3.9	5.6	3.5	**1,105**
30				1.8		3.7	9.1	3.7	4.7	3.6	2.7	2.7	
31				1.9		4.6		3.4		3.2	2.8		**Annual**
TOTAL				*31*	60.4	121	123	170	155	230.2	98.3	115.9	**n/a**
Max.day				*3*	5.4	7	9	9	15	52.9	5.6	13.2	**53**

Daily values are based on calculations of suspended-sediment load at 15-minute intervals.
Streamflow-based suspended-sediment load computation uses a correlation between streamflow and suspended-sediment concentration and is based on a provisional streamflow record
Turbidity-based suspended-sediment load computation uses a correlation between instantaneous turbidity (NTU) and suspended-sediment concentration (mg/L) and is converted to tons/day

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Water Year:	2013
Stream:	Truckee River at Farad
Station:	DWR #G7119500
County:	Placer County

Form 5. Annual Suspended-Sediment Load Record WY 2013

WY 2013 Daily Suspended-Sediment Load *(tons)*
Streamflow-based sediment rating-curve method

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													
22													
23													
24													
25													
26													
27													
28													
29													
30													**Qss**
31													**Annual**
TOTAL	0.0	0.0	0.0	0	0.0	0	0	0	0	0.0	0.0	0.0	**0**
Max.day	0.0	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	**0**

WY 2013 Daily Suspended-Sediment Load *(tons)*
Continuous record of turbidity

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	
1	5.2	2.9	64.1	2.7	1.9	2.1	3.3	10.0	6.7	11.5	1.2	2.5	
2	5.0	2.7	851.3	3.2	1.9	2.4	3.3	8.1	6.8	22.2	1.5	2.6	
3	4.8	2.6	118.7	4.3	1.9	2.7	3.5	9.6	7.2	12.4	3.2	2.6	
4	5.0	2.6	45.6	4.5	2.0	2.9	5.9	9.9	7.7	65.0	3.2	2.0	
5	5.0	2.5	124.2	4.2	2.1	3.2	10.5	7.4	11.2	20.3	3.5	2.7	
6	4.5	2.5	51.6	4.0	2.1	4.0	6.4	10.1	9.9	12.6	3.3	2.9	
7	4.8	2.6	23.3	3.7	2.1	3.2	5.6	9.4	8.9	8.9	3.5	3.2	
8	4.9	2.8	13.7	2.9	2.1	3.0	5.8	20.0	10.0	5.3	4.0	3.0	
9	4.5	2.9	8.8	2.8	2.3	3.0	5.2	44.3	11.0	0.4	3.5	3.2	
10	3.9	2.8	6.2	3.3	2.4	3.0	5.3	21.3	10.4	6.5	0.0	3.6	
11	3.7	3.1	4.6	2.9	2.4	3.1	6.6	21.3	9.3	14.1	0.0	3.3	
12	3.7	2.9	3.8	0.6	2.3	3.5	7.2	22.8	3.6	13.1	0.0	4.6	
13	3.4	2.7	3.3	0.0	2.3	3.5	6.1	25.0	7.6	34.9	2.6	5.3	
14	3.5	2.7	2.8	0.0	2.3	3.2	6.9	19.6	7.6	14.1	5.7	5.5	
15	3.6	2.6	2.4	1.6	2.2	3.1	6.3	6.4	7.3	5.7	3.8	6.3	
16	3.7	2.8	2.7	3.3	2.3	2.7	5.5	10.8	7.0	5.8	3.6	6.8	
17	4.4	7.6	4.3	3.1	2.2	3.2	5.3	8.9	7.1	4.7	3.6	4.6	
18	5.3	14.1	4.9	3.3	2.3	3.1	5.3	8.8	6.9	3.9	4.5	2.0	
19	3.6	4.2	3.7	2.3	2.2	2.6	5.8	8.4	6.6	4.1	3.7	2.1	
20	3.1	3.4	3.5	3.0	2.3	6.6	6.3	8.2	6.6	4.7	3.8	2.1	
21	3.0	3.4	3.8	2.7	2.2	6.8	6.7	8.3	6.4	4.6	3.8	2.4	
22	3.1	3.8	3.4	2.7	2.2	4.0	8.0	7.7	6.7	4.4	3.7	2.7	
23	3.0	2.8	4.0	2.3	2.1	3.1	7.0	7.2	7.0	3.9	3.3	2.4	
24	2.7	2.8	3.8	2.4	2.1	2.9	5.8	7.1	6.9	3.9	3.6	2.4	
25	2.5	2.8	3.6	2.8	2.0	3.0	6.5	7.2	10.1	27.6	0.1	2.3	
26	2.6	2.8	3.5	2.8	2.0	2.7	8.1	7.2	10.9	10.0	0.0	2.4	**Qss**
27	2.5	2.8	3.4	2.4	1.9	2.3	11.7	7.3	6.2	5.7	0.2	2.6	**Partial**
28	2.5	3.8	2.6	2.2	2.0	2.5	14.0	8.2	5.4	5.2	3.3	2.7	1,549
29	2.5	3.8	3.2	2.0		2.9	14.9	7.2	7.1	5.0	2.7	3.3	
30	2.9	222.1	3.0	2.0		3.1	17.3	6.9	7.8	3.3	2.8	4.5	**Qss**
31	2.7		2.5	2.0		4.3		6.4		3.5	3.1		**Annual**
TOTAL	116	324	1380	82	60	102	216	371	234	347	85	99	**3,416**
Max.day	5	222	851	4	2	7	17	44	11	65	6	7	**65**

Daily values are based on calculations of suspended-sediment load at 15-minute intervals.
Streamflow-based suspended-sediment load is not available for this station.
Turbidity-based suspended-sediment load computation uses a correlation between instantaneous turbidity (NTU) and suspended-sediment concentration (mg/L) developed at Truckee River at Boca Bridge
Partial water year loads are presented for comparison across Truckee River for the period beginning January 18, 2013
Data are provisional and subject to revision

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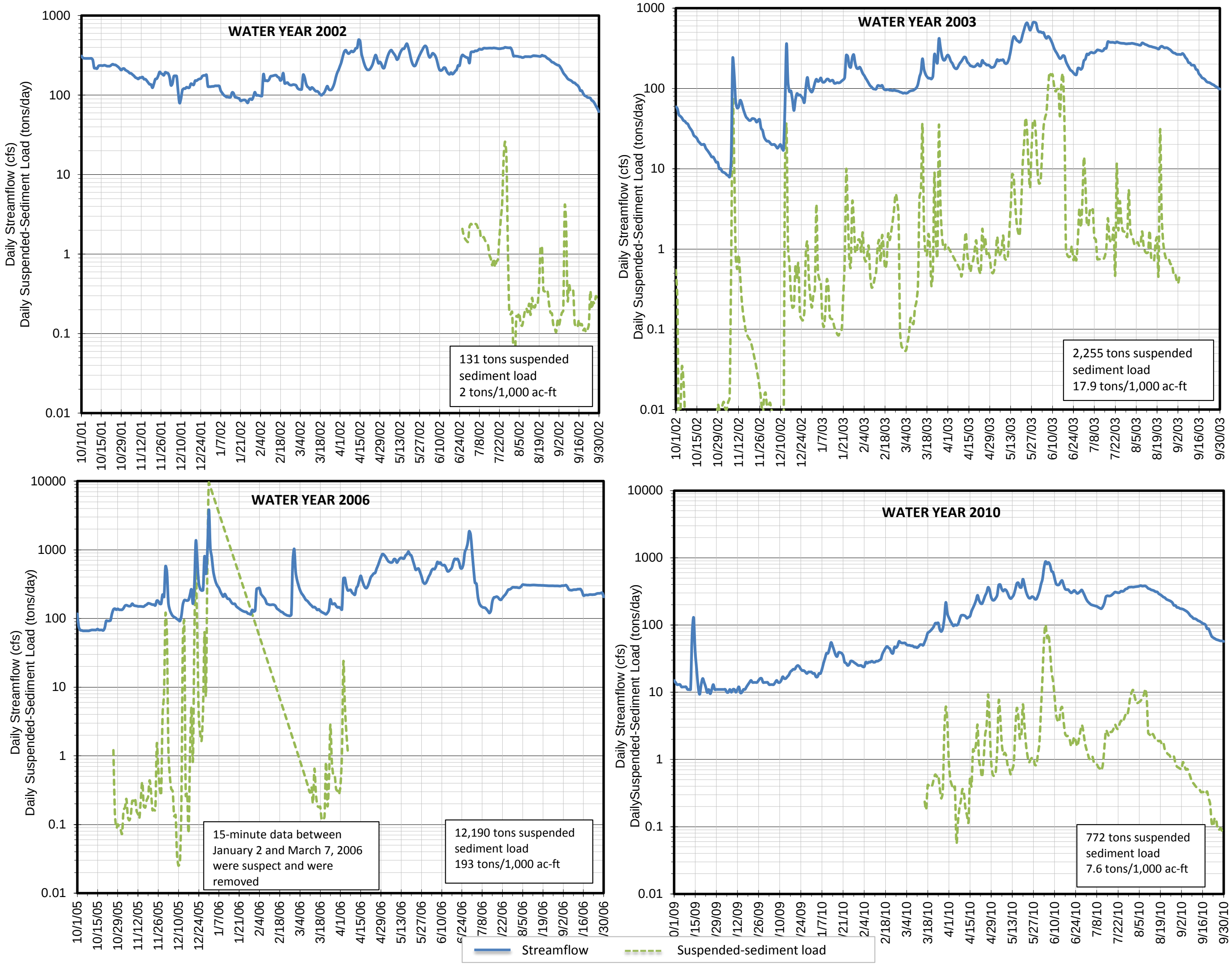
Appendix F
Historic DWR Data and Comparisons



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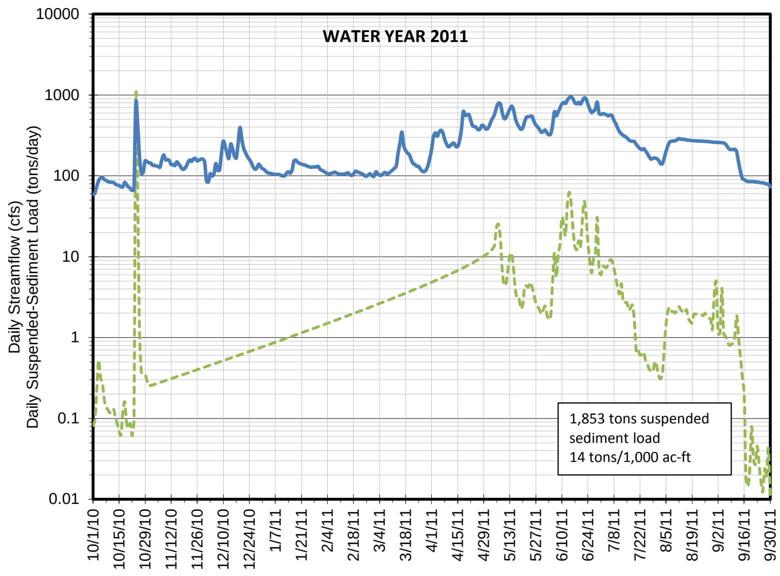

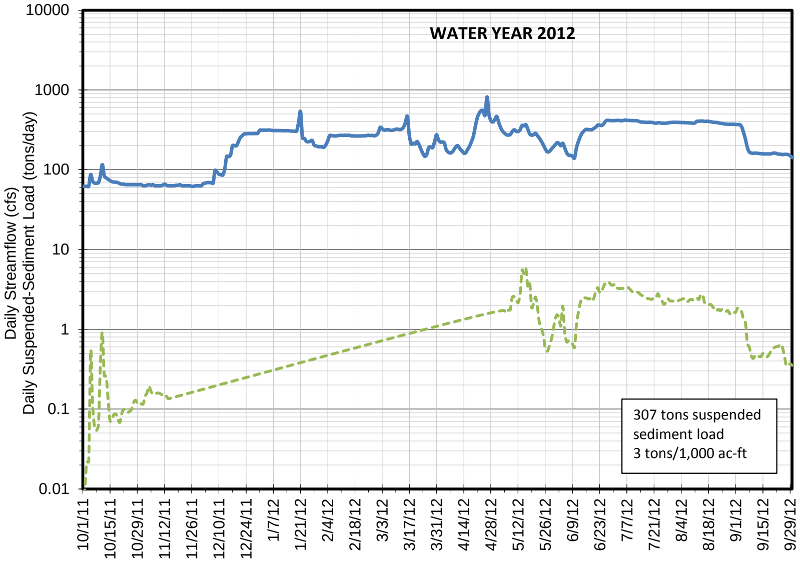

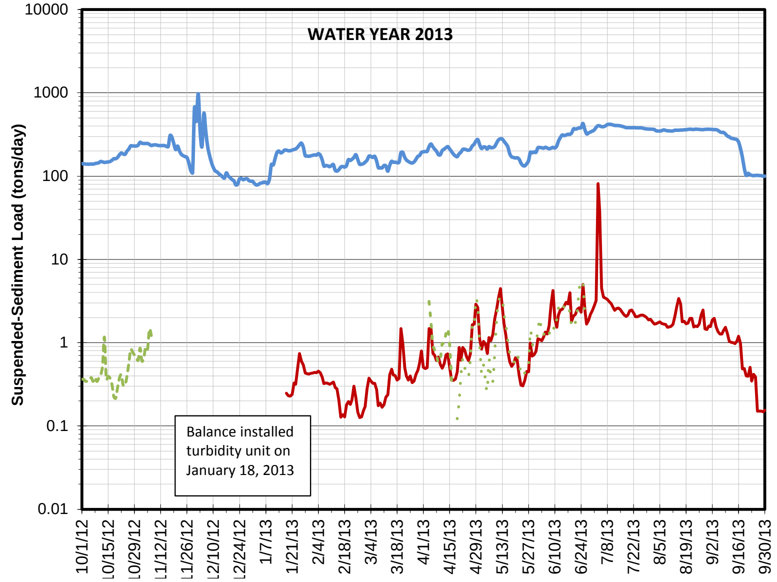

Streamflow — Suspended-sediment load

Suspended-sediment load measured and computed by Balance Hydrologics

Notes: Turbidity data provided by DWR
Streamflow data provided by USGS
Suspended-sediment loads computed from a continuous record of turbidity and converted to SSC and subsequently to a load by multiplying by instantaneous streamflow and a conversion of 0.0027

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