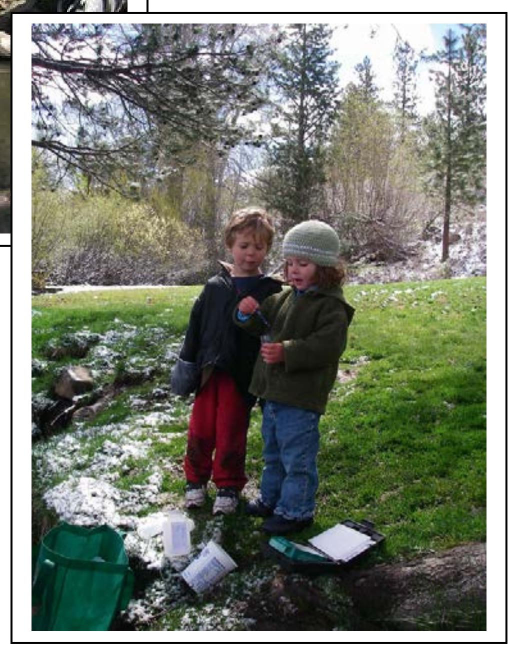
Truckee River Watershed Council
2014 Annual Monitoring Data Report
February 10, 2015



Truckee River Watershed Council
Collaborative solutions to protect, enhance and restore the Truckee River Watershed

Table of Contents

LIST OF TABLES

LIST OF FIGURES

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1.0 INTRODUCTION

The Adopt a Stream Program of the Truckee River Watershed Council is a volunteer based water quality monitoring program. The program began in 1999 and has expanded through the present day. The purpose of this report is to report water quality data for the Truckee River watershed, outline the monitoring objectives for the monitoring program, and relate data back to those monitoring objectives.

The Truckee River Watershed

The watershed area covered under the Adopt a Stream program is the Middle Truckee River. This includes all drainages to the Truckee River, from below the dam at Lake Tahoe to the California/Nevada state line. The watershed includes 26 major sub-basins (or sub-watersheds) and covers an area of 435 square miles. A map of the watershed, including monitoring locations, is included as Figure 1.

The Truckee River watershed has a 170-year history of significant human disturbance. Timber harvests (including multiple clear cuts) began early to support silver mining and the transcontinental railroad; railroad construction and operation were (and still are) the source of many watershed problems; the native trout species (Lahontan cutthroat trout) was fished to extinction as a food source for California expansion by 1930; gravel mining to support large scale road construction including Interstate 80 have left behind degraded areas; and the largest subdivision in the United States – Tahoe Donner - was built in the 1960s and 1970s before stormwater and erosion regulation. A series of dams in the Truckee River system were established for water supply and flood control.

More recent impacts of concern in the Truckee River watershed include extensive construction particularly in the Town of Truckee and Martis Valley. Ski resorts are expanding to year-round resorts with an increase in golf course use and residential development. Additionally, the flow regime in the Truckee River may see significant changes as the Truckee River Operating Agreement is implemented.

The Truckee River and three tributaries (Bronco Creek, Gray Creek, and Squaw Creek) are listed as impaired for excessive sediment under the Clean Water Act. Sediment sources include road and highway salting and sanding, construction, ski runs, and natural sediment sources including landslides and debris flows. Donner Lake is listed as impaired for priority organics, arsenic, and chlordane.

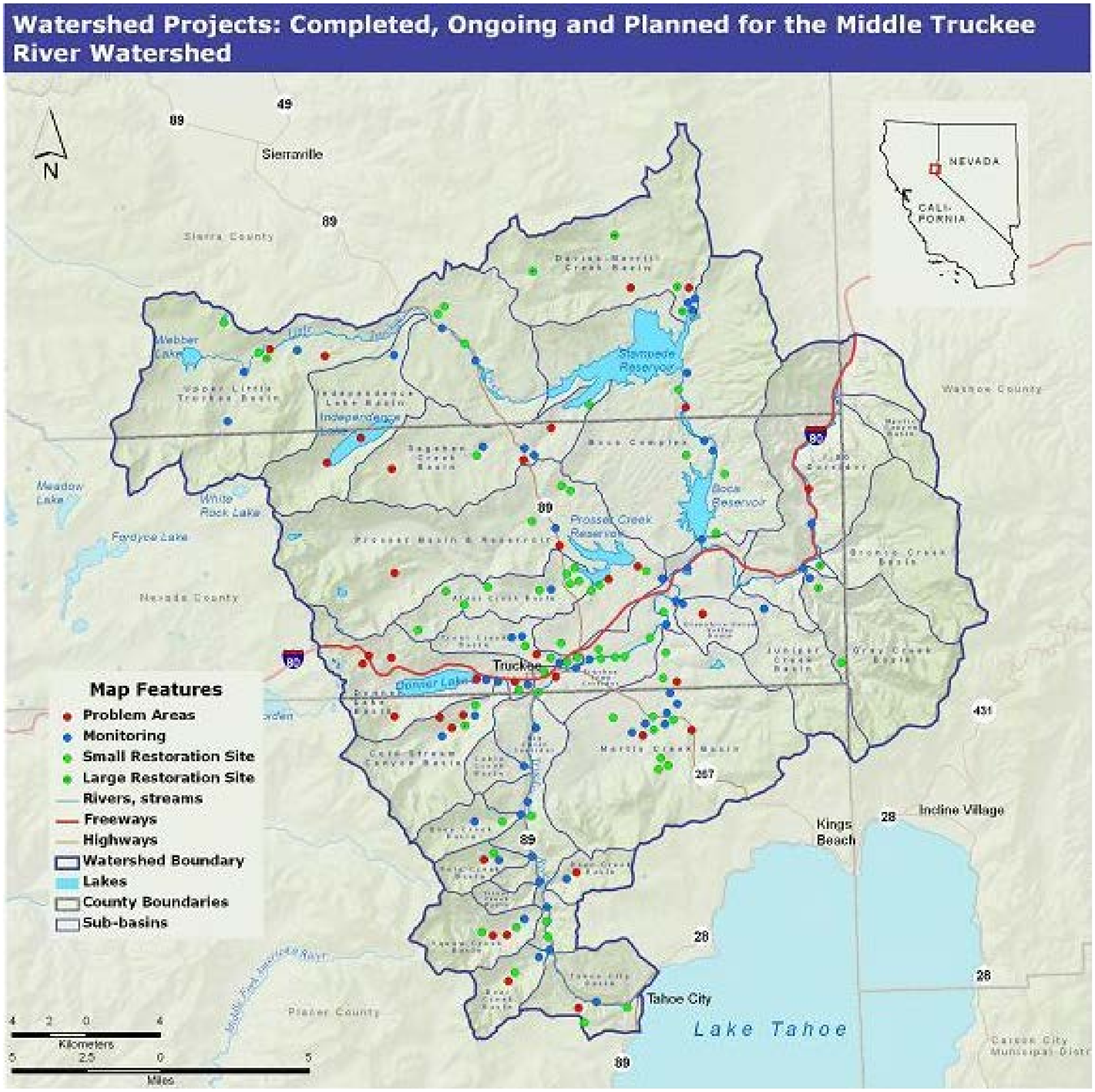

Figure 1. Middle Truckee River watershed with major stream sub-basins outlined. Monitoring locations are indicated by blue dots. Map created by Digital Mapping Solutions.

Monitoring goals and objectives

The primary goals of the Adopt a Stream program are:

- To assess the condition of the Truckee River ecosystem.
- To screen for water quality problems typically associated with common land use practices in the Truckee River watershed.

- To empower citizens to be responsible stewards and decision-makers.
- To support the Truckee River sediment TMDL monitoring program.
- To collect pre-implementation data related to the Truckee River Operating Agreement (TROA)

The Adopt a Stream (AS) program is designed to supplement existing agency monitoring efforts in the Truckee River watershed. The focus of AS is on measuring chemical, habitat and biological parameters in order to assess land use impacts on water quality and watershed health.

The primary objectives of AS are:

1. To better understand and document the relationship between water quality, hydrologic function, river system management, and land use.
2. To identify land use practices that negatively impact the Truckee River watershed, the extent of impact, and the geographic locations of concern.
3. To engage and educate residents about local watershed processes and strengthen their understanding of watershed stewardship.
4. To enhance the quality and quantity of data available for resource managers and decision makers in the Truckee River watershed.
5. To provide data that can be used to help monitor the implementation of the Truckee River sediment Total Maximum Daily Load (TMDL).
6. To collect data to help provide pre-Truckee River Operating Agreement (TROA) implementation data, and to establish a program that will help to track changes in the condition of biological resources in the Truckee River watershed once TROA is implemented.

Funding Sources

Adopt a Stream is currently funded by the donors to the Truckee River Watershed Council and the California Resources Agency, Department of Conservation. Coliform sample analysis was donated by the U.S. Geologic Survey (USGS), and some nutrient analyses were donated by High Sierra Water Lab.

Program Description

The Truckee River Watershed Council (TRWC) has conducted water quality monitoring since 1999. Parameters monitored, timing, and frequency have all changed over the years as the monitoring program has matured. All monitoring activities are contained under the umbrella of “Adopt a Stream”; however there are three primary components to the monitoring program:

1. Snapshot Day. This program has existed since 2001 and is a one-day watershed wide (Lake Tahoe and Truckee River) monitoring event. Basic physical and chemical parameters are measured. The focus of Snapshot Day is to cover as much geographic area as possible in order to capture a “snapshot” in time of water quality for the entire Truckee River watershed. Several different groups are involved in

Snapshot Day; TRWC manages the event for the Middle Truckee River watershed. Snapshot Day takes place in the spring of each year during snowmelt run-off (high flow).

2. Adopt a Stream – Stream Teams. Regular monitoring of basic physical and chemical parameters began in 2007. Up to 19 streams are monitored by volunteers four times per year (including Snapshot Day).

3. Truckee River Aquatic Monitors (TRAM). This group has collected bioassessment and basic habitat data since 1999. Approximately five streams are monitored each year, with a different selection of streams monitored each year. Streams are only monitored once in any given year.

This report includes data from all three components of Adopt a Stream.

2.0 FIELD AND LAB METHODS

Monitoring locations and parameters monitored can be found in Table 1 for physical and chemical monitoring and Table 2 for bioassessment sites.

Physical and chemical monitoring includes measurement of water temperature, dissolved oxygen, pH, electrical conductivity, and turbidity. On Snapshot Day, grab samples are also collected and sent to a laboratory for nutrient and coliform analysis. In 2014, we added one additional nutrient sample collection in September. Bioassessment monitoring includes collection of benthic macroinvertebrates following the State Water Resources Control Board 2007 SWAMP protocol (Ode, 2007). Prior to 2007, the California State Bioassessment Protocol was followed (Harrington and Born, 1999).

Table 1. Sites monitored for basic physical and chemical parameters (temperature, electrical conductivity, dissolved oxygen, pH, and turbidity). Each year, some of these sites are tested for nutrients and/or coliform bacteria. All sites listed here may be monitored on Snapshot Day (spring runoff) depending on volunteer turnout. The Stream Team sites are monitored on Snapshot Day and an additional three times during the year.

Site ID	**Site Name**
Stream Team Sites - including Snapshot Day	
MTR-ALDR	Alder Creek
MTR-BEAR-00	Bear Creek at mouth
MTR-BOCA-00	Little Truckee below Boca Dam
MTR-BOCA-01	Little Truckee at Boyington Mill
MTR-COLD-00	Cold Creek
MTR-DONN-01	Donner Creek at Hwy 89
MTR-DONN-03	Donner Creek below Donner Lake
MTR-EMAR	East Martis Creek at bridge
MTR-GLEN-00	Union Creek below Glenshire
MTR-MART-00	Martis near mouth
MTR-MART-01	Martis at COE boundary
MTR-POLE-00	Pole Creek
MTR-PROS-01	Prosser Creek below dam
MTR-PROS-02	Prosser Creek at Highway 89
MTR-SAGE-00	Sagehen Creek at Highway 89
MTR-SQCR-00	Squaw Creek near mouth
MTR-TROU-00	Trout Creek near mouth
MTR-TROU-02	Trout Creek in Tahoe Donner
MTR-ULTB	Upper Little Truckee at Highway 89 bridge
Snapshot Day Only Sites	
MTR-BIGC	Truckee River in Big Chief Corridor
MTR-BOCA-02	Worn Mill Creek
MTR-CABN	Cabin Creek subbasin
MTR-DEEP	Deep Creek
MTR-DMCB	Davies Creek
MTR-GLEN-02	Union Valley Creek above Glenshire Pond
MTR-GRAY	Gray Creek
MTR-I80C	Truckee River in I-80 Corridor-Floriston
MTR-INDE	Independence Creek
MTR-JUNI	Juniper Creek at Iceland road
MTR-SAGE-02	Sagehen Creek at Field Station
MTR-SILV	Silver Creek
MTR-TOWN	Truckee River in Town Corridor
MTR-TR01	Truckee River near Tahoe City
MTR-TROU-01	Trout Creek in Town

Table 2. Bioassessment monitoring locations including years monitored.

Stream	Location	Years Monitored
Alder Creek	Above Highway 89	2014
Bear Creek	Near confluence with Truckee River	2002, 2003, 2004, 2006, 2009, 2012
Cold Creek - lower	Just above confluence with Donner Creek	2008, 2010, 2011, 2012, 2013, 2014
Cold Creek - upper	Near horseshoe bend in railroad	2000
Cold Stream	0.5 mile upstream of confluence with Little Truckee River	2002
Davies Creek	Just below confluence with Merrill Creek	2003, 2005, 2006, 2008, 2010, 2011
Deep Creek	1.75 miles from confluence with Truckee River	2005
Deer Creek	About 1 mile upstream of confluence with Truckee River	2004
Donner Creek	Immediately downstream of Highway 89	2005, 2008
East Martis Creek	At bridge on Waddle Ranch	2003, 2008
Gray Creek	Near mouth	2001, 2002, 2005, 2006
Independence Creek	Below road crossing, near campground	2007
Independence Creek - lower	On Ranz Property in Meadow	2009
Independence Creek tributary	About 2.5 miles downstream of lake, 1.3 miles upstream of confluence with Little Truckee (at road crossing)	1999, 2001
Juniper Creek	About 1.3 miles upstream of confluence with Truckee River	2004
Little Truckee River	Along highway 89, approximately 0.6 miles downstream of turnoff to Kyburz Flat	1999, 2011
Little Truckee River	Above Boyington Mill	2013, 2014
Little Truckee River	Between Boca and Stampede – downstream of USGS gage	2006, 2007
Little Truckee River – Lower Perazzo	In Lower Perazzo Meadow, downstream most reach	2010, 2011, 2012, 2013
Little Truckee River – Perazzo Meadows	In Middle meadow restoration site near old road	2009
Lower Martis Creek	Near confluence with Truckee River	2006
Martis Creek - Main	In Wildlife Area (upstream of Hwy 267)	2001, 2002, 2003, 2004, 2005, 2007
Martis Creek – Main	Main branch, downstream of highway 267	2000
Martis Creek – West	Below golf course, on USACE land	2003
Upper Perazzo Creek	About 1.5 miles upstream of confluence with Little Truckee River	2003

Perazzo Creek	Near confluence with Little Truckee River	2005, 2008, 2009, 2014
Pole Creek	About 1.4 miles upstream of confluence with Truckee River	2004
Prosser Creek	Below dam, above USGS gage	2013, 2014
Prosser Creek	Below the dam – just upstream of I-80	2003, 2007, 2008
Prosser Creek	Immediately upstream of Highway 89	2012
Sagehen Creek	Downstream of Highway 89	1999, 2000, 2010, 2012
Sagehen Creek	Just downstream of the field station	2004, 2006, 2007
Silver Creek	Approximately 0.1 miles upstream of Highway 89	2011
Squaw Creek	Lower end of Squaw Meadow	2002, 2003, 2007
Trout Creek	At Bennett Flat	2003
Trout Creek	At mouth	2000, 2003, 2007
Truckee River at Granite Flat	Granite Flat Campground	2001, 2004
Truckee River at Horseshoe Bend	Near Hirschdale	2001, 2004

Table 3. Field methods used for each parameter. Analysis location refers to whether the measurement is taken in the field ("Field") or collected and analyzed later ("grab sample").

Parameter	Method	Analysis location
Dissolved Oxygen	Winkler Titration method, Chemet, or YSI meter	Field
pH	Meter or pH strips	Field
Conductivity	Hand held conductivity meter	Field
Turbidity	Turbidity Meter – kept in office	Grab sample
Temperature	Thermometer (-5 to 50 °C)	Field
Nutrients	NH_3-N, NO_3 & NO_2-N, SRP, TP	Grab sample
Coliform	Colony forming units/100 mL	Grab sample
Benthic Macroinvertebrates	2007 SWAMP protocol	Grab sample

Nutrient samples are analyzed by either High Sierra Water Lab in Tahoe City (formerly Truckee), or the Tahoe Environmental Research Center in Incline Village. Coliform samples are analyzed by the U.S. Geologic Survey in Truckee (formerly Carnelian Bay).

Benthic macroinvertebrate samples are collected by volunteers and are processed one of two ways. TRWC volunteers identify the samples from 1-2 streams per year and the remainder is sent out for professional identification, either to the California Department of Fish and Wildlife Aquatic Bioassessment Laboratory or Aquatic Biology Associates in Oregon. Samples identified by volunteers are only identified to family level, whereas the professionally processed samples are identified to SAFIT Level II (species or genus; Richards and Rogers 2011). This varying level of taxonomic resolution affects several metrics; therefore data from volunteer- and professionally-identified samples are presented separately where appropriate. Prior to the adoption of the 2007 SWAMP protocol, the number of organisms in a subsample from each stream varied as well. Volunteers counted out and identified 300 organisms from each stream and professional labs counted out and identified 900 organisms. The number of organisms present also skews some metrics.

In 2009 an Index of Biological Integrity (IBI) was published for the Eastern Sierra (Herbst and Silldorff, 2009). An IBI gives each stream a "score" based on the species diversity found in a sample. IBIs are derived from multiple taxonomic metrics. The IBI is designed to use 500 count data (the current 2007 SWAMP standard), and requires genus or species level identification. Therefore, IBI scores can be easily calculated for a subset of TRAM collected data from 2008 forward. Data analyzed by professional laboratories prior to 2008 used a 900 count standard. These data can be subsampled down to 500 count, however this is an exceedingly time consuming analysis and has not been completed for our data yet. Simply plugging the 900 count data into the IBI will skew richness metrics and yield a higher IBI score.

3.0 RESULTS AND ANALYSIS

The following parameters were monitored.

1.) Temperature: To identify areas of concern for thermal pollution.

2.) Dissolved Oxygen: To determine health of aquatic ecosystem. Dissolved oxygen availability affects photosynthesis, and the metabolic rates of organisms and their sensitivity to toxic wastes, parasites, and diseases in addition to their distribution. Also used to identify areas of concern for hypoxia/anoxia.

3.) Conductivity: To determine potential sources of dissolved solids or salts. High conductivity indicates impaired water quality. Common anthropogenic sources in the Truckee River watershed include road salt and sand.

4.) pH: To determine if a stream will support aquatic life. pH can be affected by many types of sources, both natural and anthropogenic and indicates whether water is acidic or basic.

5.) Turbidity: To identify areas of increased erosion. Turbidity is an indicator of the amount of suspended particles in the water.

6.) Nutrients: Nitrogen and phosphorus are used to identify sources of nutrient loading. Excess nutrients, particularly phosphorus, can lead to algal blooms and eventual anoxic conditions.

7.) Benthic Macroinvertebrates: To determine the ability of the water body to support aquatic communities. Different types of benthic macroinvertebrates respond differently to pollution in aquatic ecosystems. By sampling the stream community directly, it is possible to determine water quality.

The purpose of the Status and Trends section of this report is to present monitoring results for all sites to give an overview of the water quality in the Middle Truckee River watershed. Data are typically grouped by high flow and low flow results. Stream flow has a strong effect on several parameters, as discussed below. Many sites only are monitored during Snapshot Day in May, when flows are high (with some exceptions in dam controlled tributaries). Therefore, only high flow data are available from many sites.

The second part of the Results and Analysis section will focus on relating data back to the Monitoring Plan objectives.

Status and Trends

Box plots of ambient monitoring parameters can be found in Figures 2-6. These plots show the range of variability and central tendency for the standard parameters of water temperature, electrical conductivity, dissolved oxygen concentration, and pH. Average value is indicated by the "X" symbol. The graphed points correspond to (from highest to lowest) maximum observed value, 3rd quartile value, mean (X), median, 1st quartile value, and minimum observed value.

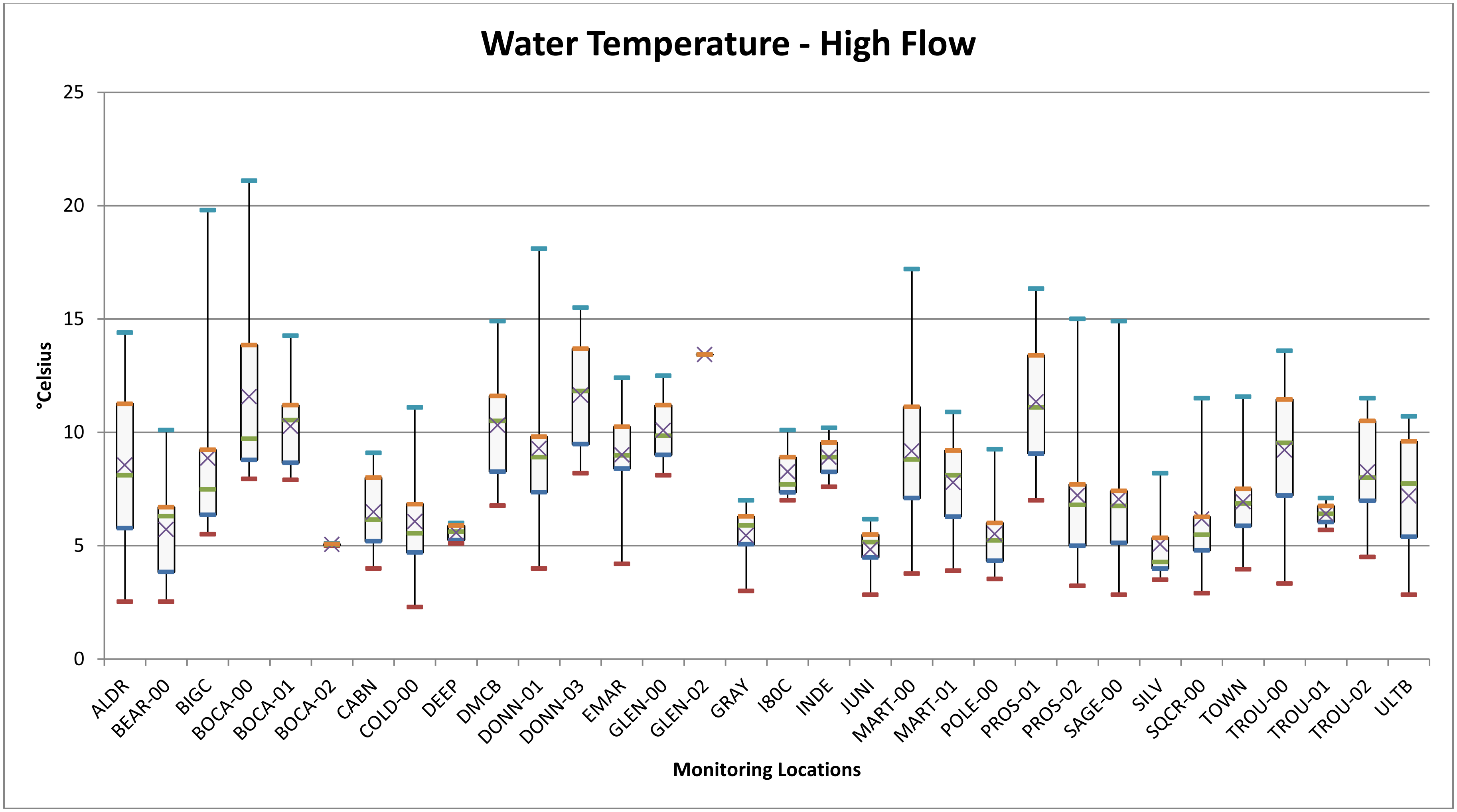

Figure 2a. Water Temperature measured during high flows.

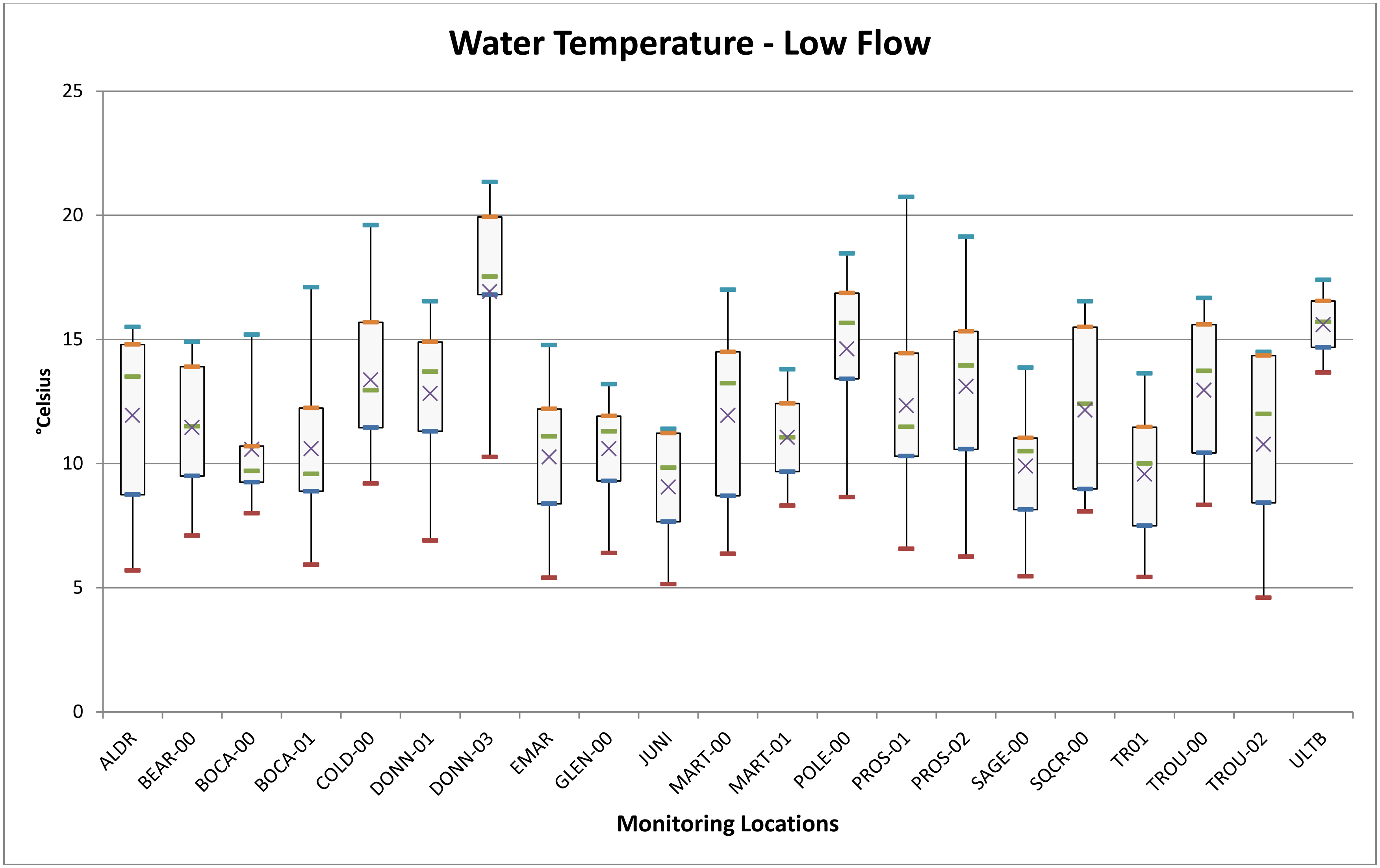

Figure 2b. Water temperature measured during low flows for sites measured quarterly and some dam-controlled sites measured only on Snapshot Day.

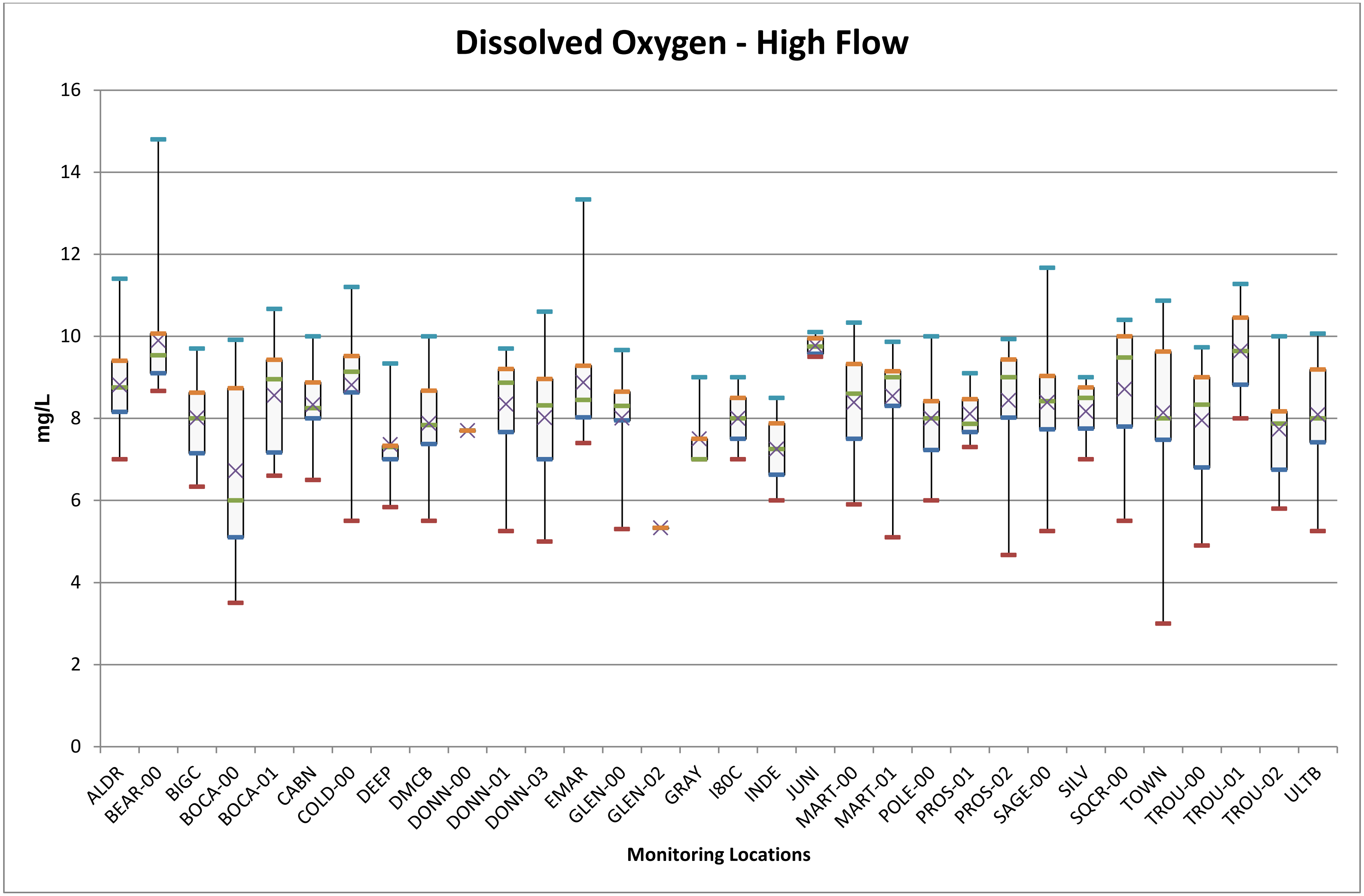

Figure 3a. Dissolved oxygen measured during high flows.

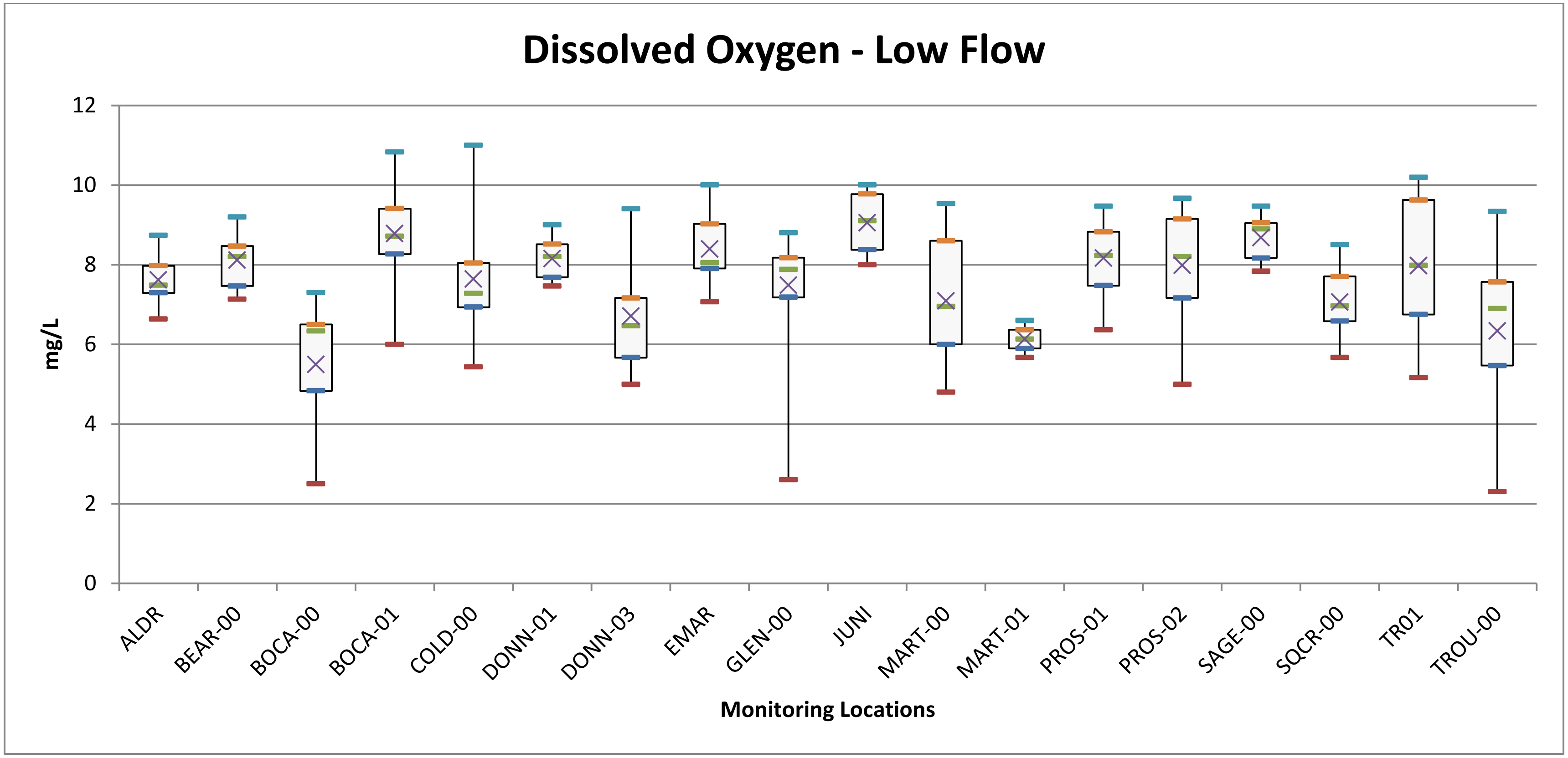

Figure 3b. Dissolved oxygen measured during low flows for sites measured quarterly and some dam-controlled sites measured only on Snapshot Day.

Water Temperature Results

Figures 2a and 2b show water temperature data, separated by flow levels. In unregulated tributaries, high flow corresponds to early season monitoring (May and June) and low flow corresponds to late season monitoring (July, August, and September). Dam regulated tributaries often follow the same pattern, but not always. In the case of dam-regulated tributaries, USGS-reported flow rates for the monitoring date are used to classify the data into high and low flow categories. In general, water temperature is higher during low flow and lower during high flows. There is less variation in the data for low flow events; this is partially due to the fact that the low flow data set is smaller than the high flow data set.

Generally speaking, water temperatures in the Middle Truckee River watershed are capable of supporting aquatic life (Figures 2a, 2b, Table 4). Donner Creek below the dam (site code DONN-03) was just recently "adopted" by a Stream Team, so data throughout the summer are now available. The low flow water temperature is on the higher side, although well below the critical level for salmonids. The dam on Donner Lake is a top release dam, so the warmer surface water is released during the summer. The other dammed tributaries exhibit lower temperatures on average below the dams (PROS-01, BOCA-00, BOCA-01); the dams on Prosser, Boca, and Stampede are all bottom release dams. We will continue to monitor Donner Creek below the dam to determine if the site regularly exhibits warm water temperature.

We added a new site on Snapshot Day 2013 – GLEN-02, Union Valley Creek above Glenshire Pond. The measured temperature was fairly high. We were unable to repeat monitoring on Snapshot Day 2014 as the stream was already dry. When conditions allow, we will continue to monitor this site in the spring for Snapshot Day; this site is usually dry by early June.

Rainbow trout *(Oncorhynchus mykiss)* are most sensitive to water temperature during spawning and embryo survival (Table 4), which take place during the spring and early summer. For most of the sites in the Middle Truckee River, that corresponds to high flow and water temperatures supporting of these life stages. The native salmonid in the Truckee River system – Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) – also spawns in the spring and is similar to rainbow trout for temperature tolerances. Brown trout (*Salmo trutta*) spawn in the fall, but have slightly higher thermal tolerance than rainbow trout.

Table 4. Temperature ranges required for rainbow trout survival and reproduction. These temperature ranges are representative of those required by most salmonids.

Species	Growth	Maxima	Spawning*	Embryo Survival**
Rainbow Trout	19°C (66 °F)	24°C (75 °F)	9°C (48 °F)	13°C (55 °F)

* The optimum or mean of the range of spawning temperatures reported for the species.
** The upper temperature for successful incubation and hatching reported for the species.
Adapted from EPA's Draft Volunteer Stream Monitoring: A Methods Manual.

Dissolved Oxygen Results

Figures 3a and 3b show dissolved oxygen concentration, separated by flow levels. Dissolved oxygen concentration is related to water temperature. Cold water holds more dissolved gas; therefore dissolved oxygen is expected to be higher at lower water temperature. Comparing data site by site, dissolved oxygen concentration in the Middle Truckee River watershed is lower during the warmer times of year (low flow).

Cold, clean water usually has levels of dissolved oxygen averaging above 6.0 mg/L, and single-measurement levels below 5 mg/L are considered dangerous for cold water aquatic life.

We experienced another low water year in 2014, following up on low water years in 2012 and 2013. Despite these challenging conditions, most sites had relatively high dissolved oxygen readings, with no single measurements below 5.0 mg/L. Throughout the year, both Martis Creek monitoring locations (MART-00 and MART-01) had somewhat low dissolved oxygen readings (5.0 mg/L – 6.6 mg/L). We will continue to monitor these locations. Prior to 2014, we only monitored Station MART-01 (Mainstem Martis Creek at the upstream COE boundary) on Snapshot Day so we have relatively few low flow measurements at this site. We will continue monitoring this site regularly.

Electrical Conductivity Results

Figures 4a and 4b show electrical conductivity, separated by flow levels. Electrical conductivity is also sensitive to flows – at high flows, the charged particles that make up conductivity are diluted, and so measured conductivity should be lower. At low flows, the particles are more concentrated, and conductivity measurements will often be higher. Primary sources of charged particles in the Middle Truckee River watershed are road sands, road de-icers, and natural sources. Typically urban areas or sites adjacent to high traffic roads will show higher electrical conductivity readings (see Figures 20-21).

At high flow, electrical conductivity is primarily centered between 50-100 microsiemens/cm (µS/cm). During low flow, the distribution of measured values shifts to primarily above 100. This scale of variation is to be expected between flow levels because of concentrated ions at low flows. Trout Creek (TROU-00), East Martis Creek (EMAR), Gray Creek (GRAY), Squaw Creek (SQCR-00), and Union Valley Creek (GLEN-00) frequently have high conductivity measurements. Trout, Squaw, and Union Valley Creeks are all fairly urbanized watersheds. East Martis and Gray are undeveloped but both have a system of poorly developed historic logging roads and are in naturally erosive areas.

pH Results

pH is a ratio of ions and is therefore not strongly affected by flow. Therefore, all pH data were graphed together. Low pH indicates acidic water; high pH indicates basic water, with a measurement of 7 being neutral. In the Middle Truckee River watershed, pH is typically very consistent with measurements between 6 and 8 (Figure 5). Very low or very high pH measurements are dangerous for aquatic life. A pH value of 6-8 will support the widest range of biota. Several monitored streams have exhibited pH of 5 on at least one occasion, but the average pH measurements for most streams fall between 6 and 8.

Turbidity Results

Turbidity is highly related to flow. Turbidity is a measure of the amount of suspended particles in the water. Algae, suspended sediment, organic matter and some pollutants can all increase turbidity in water. Suspended particles diffuse sunlight and absorb heat, which can increase temperature and decrease light available for algal photosynthesis. Turbidity caused by suspended sediment can be an indicator of erosion. If sedimentation is extreme, fish and invertebrate populations can be affected. Because erosion is higher during high flows, spring runoff measurements will tend to be higher than during low flow.

In general, turbidity is fairly low during ambient conditions in the Middle Truckee River watershed, with a few exceptions (Figures 6a, 6b, 6c). The most notable exception is Gray Creek (Fig. 6b). Gray Creek is a steep, volcanic watershed with naturally erosive soils (Northwest Hydraulic Consultants, 2006). The watershed was extensively burned in 2001 during the Martis Fire. Prior to that, the watershed had been logged, grazed, and a poorly developed road network was in place. Although Gray Creek has recovered to some extent from the Martis Fire, it is still a significant source of fine sediment. Due to problems with access, Gray Creek has not been monitored by volunteers since 2006.

Other tributaries that periodically demonstrate high turbidity levels are: Donner Creek at Highway 89 (DONN-01), Prosser Creek at Highway 89 (PROS-02), Squaw Creek (SQCR-00), Juniper Creek (JUNI), and Little Truckee River below Boca Dam (BOCA-00). Union Valley Creek above Glenshire Pond (GLEN-02) was added in 2013 and the single reading obtained was quite high. Monitoring will continue at this site when flows allow. In 2014, the site was already dry by May.

The monitoring location for Donner Creek at Highway 89 (DONN-01) is below the confluence with Cold Creek. Cold Creek is a known sediment source, whereas Donner Creek drains Donner Lake, and would be expected to have low turbidity. However, our turbidity monitoring data do not show Cold Creek as being particularly high in turbidity during our monitoring events. The reach of Donner Creek between the confluence of Cold Creek and Highway 89 has been highly manipulated and was channelized during the construction of Interstate 80. The creek through this reach is fairly erosive – so the elevated turbidity that we sometimes observe at this location may be coming from instream erosion from immediately upstream of the monitoring location. Turbidity monitoring conducted in support of the Truckee River TMDL also indicates that Donner Creek is a substantial sediment producer (Balance Hydrologics, 2012, 2013, and 2014). Results of the TMDL monitoring are further discussed in reports posted at: www.truckeeriverwc.org.

The Prosser Creek watershed above the monitoring site is largely undeveloped, but is steep and has a substantial road network. In 2011, the Forest Service conducted an analysis of the dirt roads in Prosser Creek on their land, attempting to identify areas of potential erosion. Future work may help to reduce erosion from this watershed.

Squaw Creek is also 303(d) listed as impaired for excess sediment and has its own TMDL for sediment control. The watershed is naturally erosive and has been extensively disturbed through roads, development, and graded ski runs.

Juniper Creek also exhibits elevated turbidity relative to other area streams. Juniper Creek is adjacent to Gray Creek and was partially affected by the Martis Fire. The underlying geology of Juniper Creek is similar to that of Gray Creek.

As mentioned above, stream flow is often extremely low at the monitoring location for the Little Truckee River below Boca Dam (BOCA-00). If no water is being released from the dam, the only water present is a stagnant pool. In measurements categorized as "low flow", BOCA-00 has exhibited fairly high turbidity. The turbidity is likely due to algal growth in the still water.

Trout Creek near the mouth (TROU-00) has also yielded high turbidity measurements during low flow conditions. Flow in Trout Creek at the monitoring location can be minimal during the summer months, so algae may contribute to the high turbidity measurements.

Cold Creek, Trout Creek, and Donner Creek have all been identified as potentially significant contributors of suspended sediment to the Truckee River (Amorfini and Holden, 2008). As such, TRWC has implemented more detailed turbidity and suspended sediment studies in these watersheds. The results of these studies are available at: http://www.truckeeriverwc.org/about/documents.

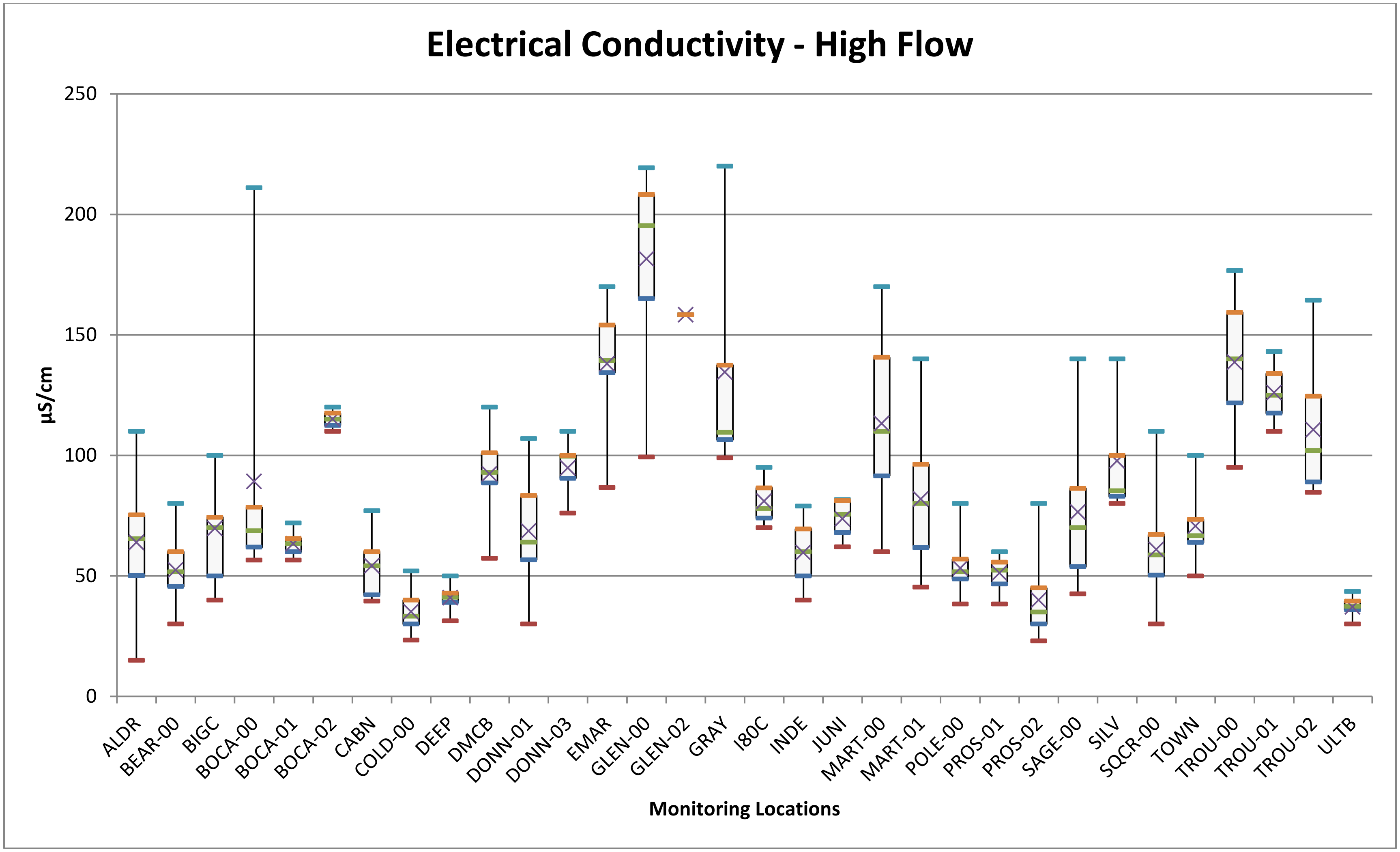

Figure 4a. Electrical conductivity measured during high flows.

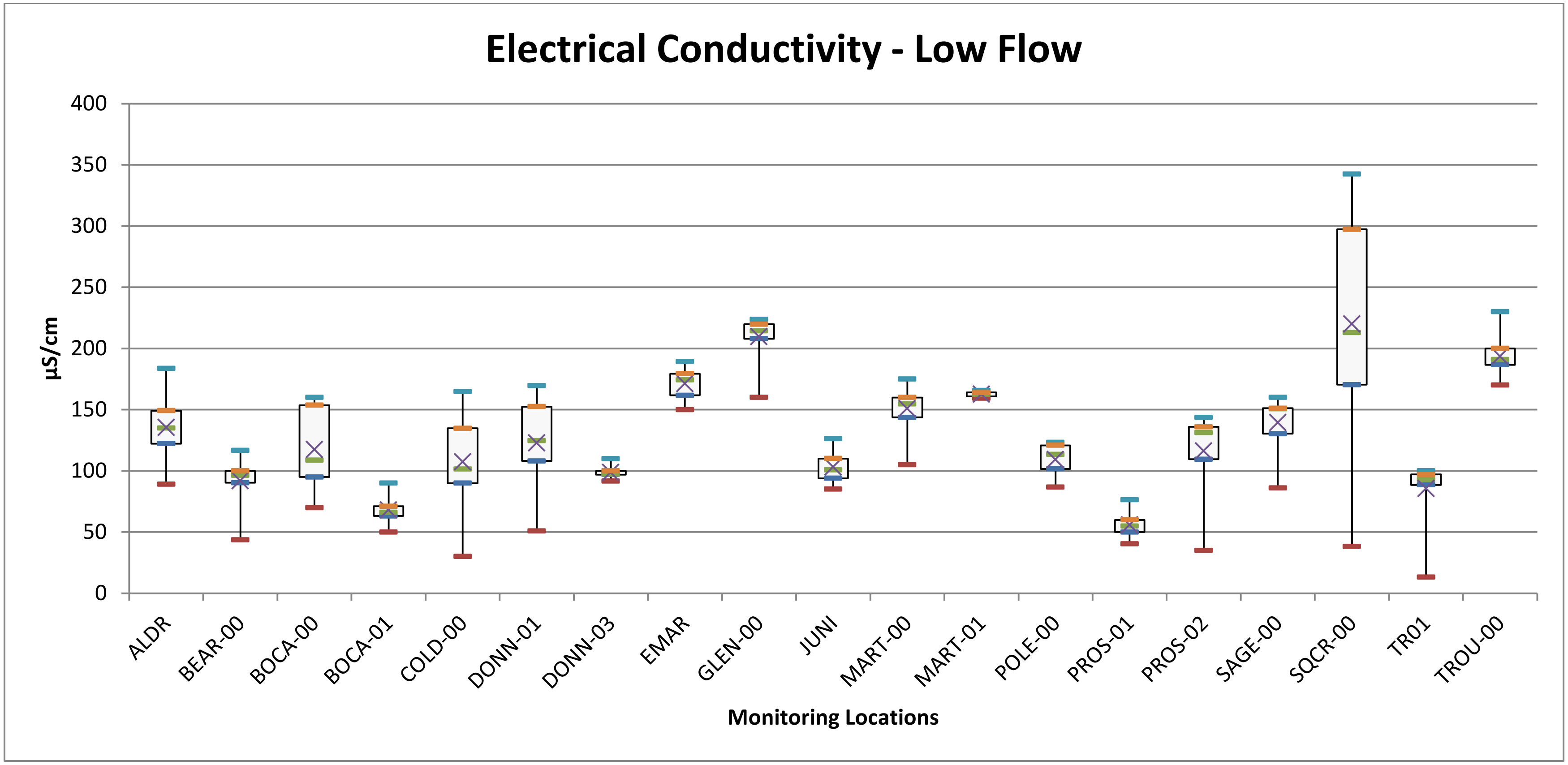

Figure 4b. Electrical conductivity measured during low flows.

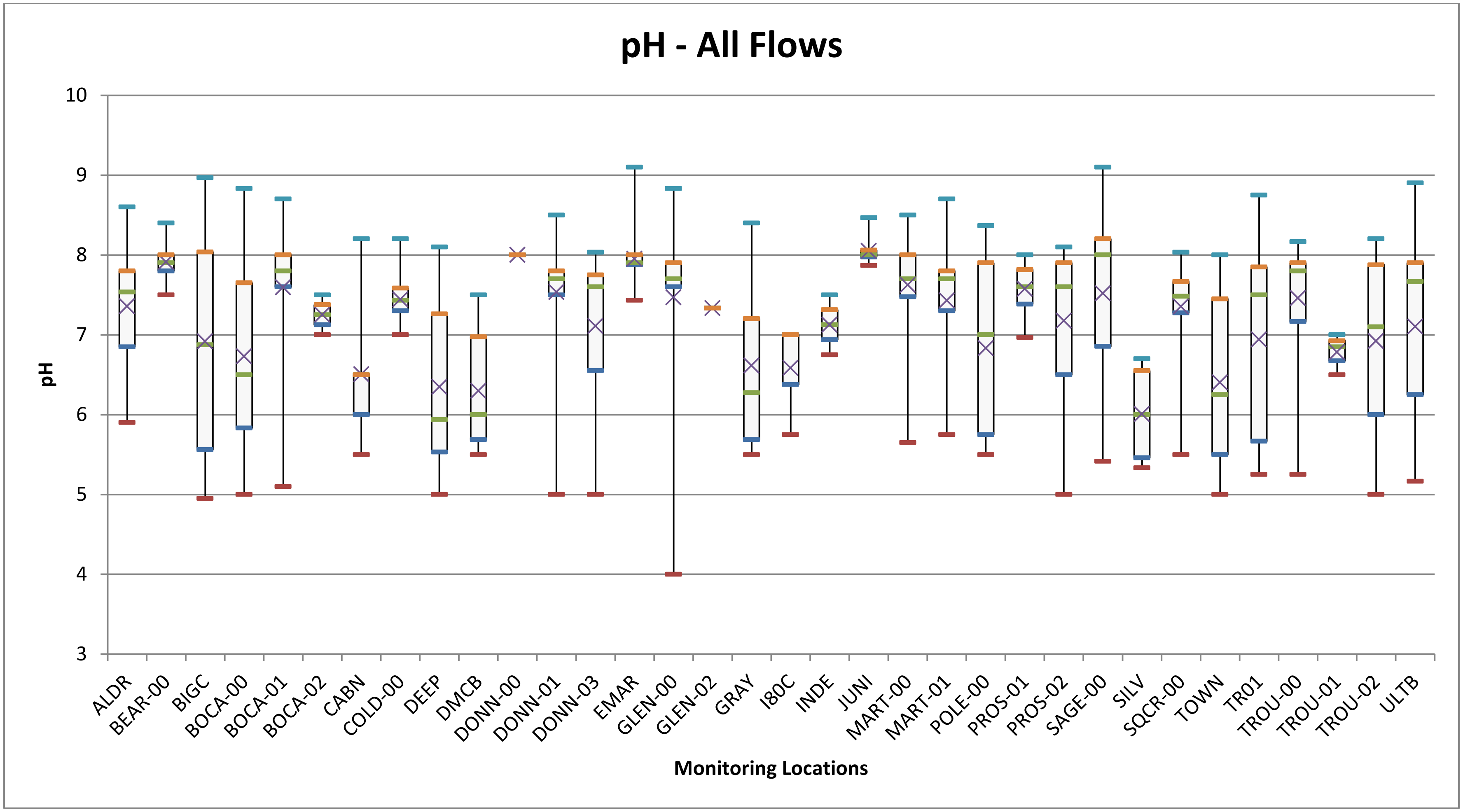

Figure 5. pH measurements. pH is not strongly affected by flows, therefore all data were graphed together.

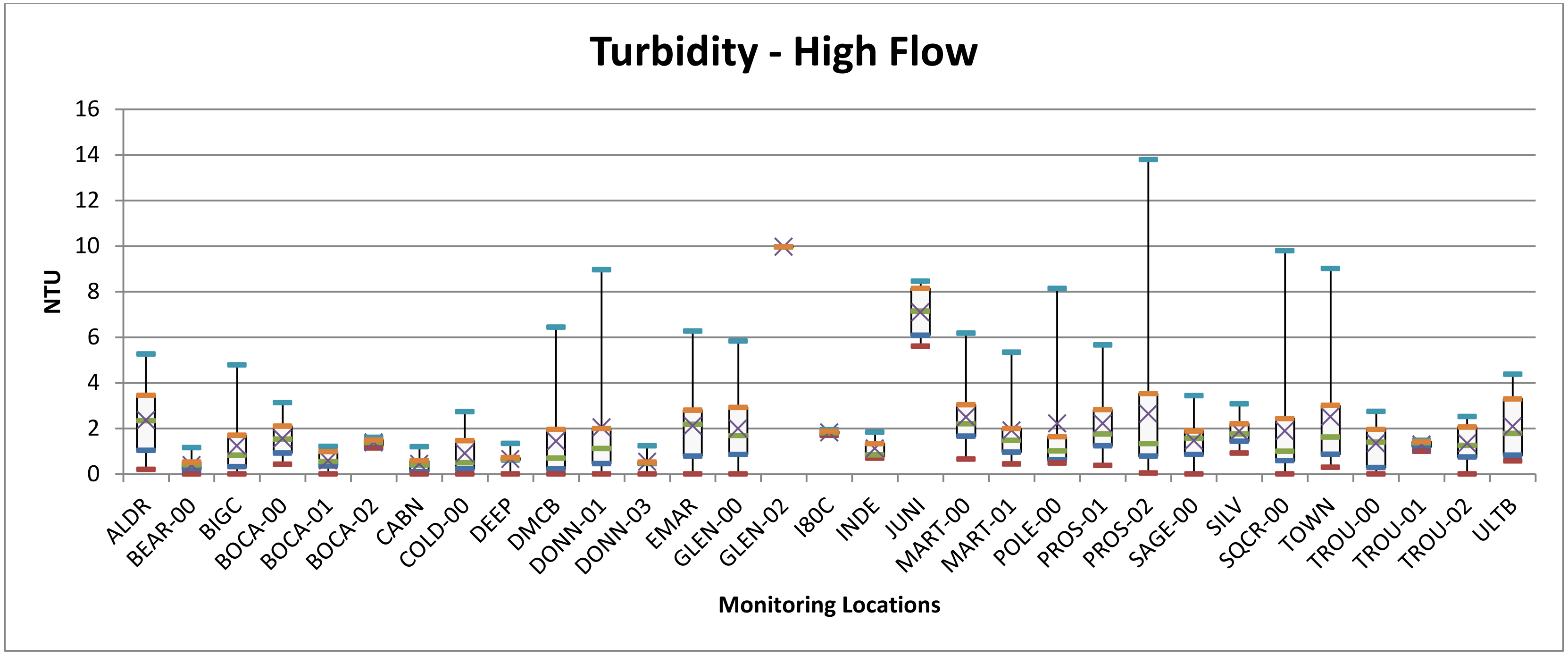

Figure 6a. Turbidity measured during high flow.

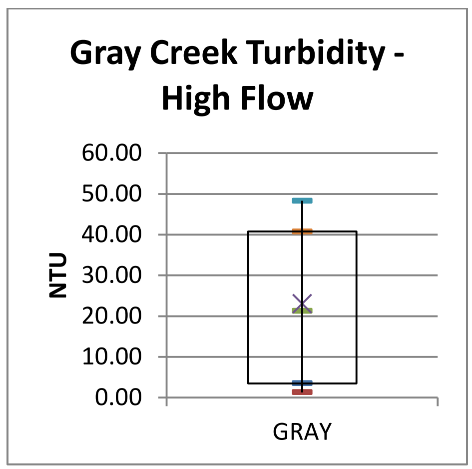

Figure 6b. Gray Creek turbidity. Note the scale, Gray Creek has much higher turbidity than other sites.

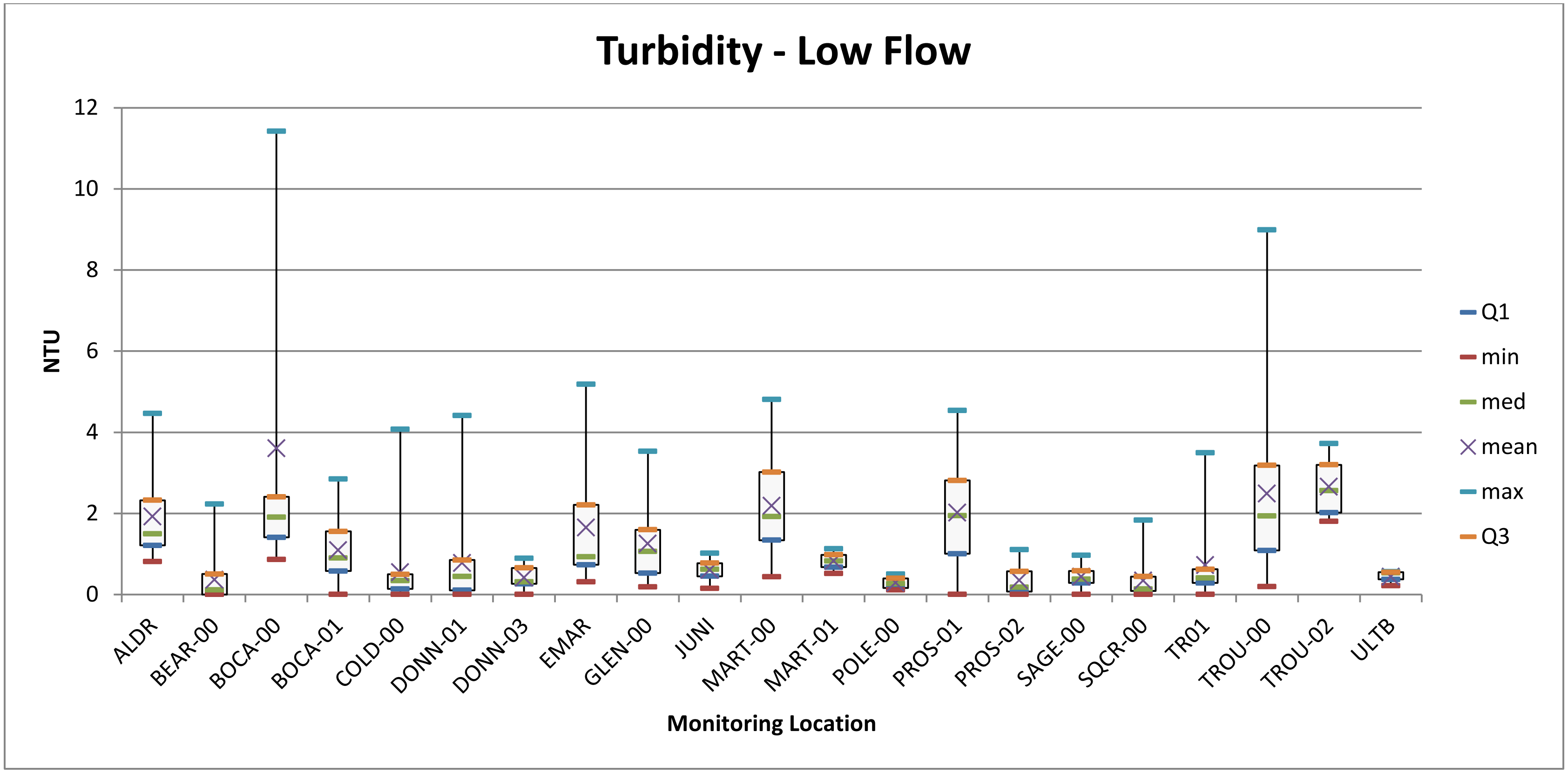

Figure 6c. Turbidity measured during low flow.

Nutrient Data

Each year, samples are taken from selected sites and analyzed for forms of nitrogen and phosphorus. Prior to 2014, samples were only taken on Snapshot Day during spring runoff. Starting in 2014, we added an additional low flow measurement in September. Nitrogen and phosphorus are necessary to support aquatic life, however high concentrations of either of these nutrients have negative impacts on water quality.

Nitrogen

Nitrogen occurs in several different forms: nitrate, nitrite, ammonia, and TKN or Total Kjeldahl Nitrogen. Funding has not been consistently available to analyze samples for all forms of nitrogen; therefore we only have total nitrogen data for a subset of years (2006, 2007, 2009-2014).

Nitrate-Nitrite (NO3/NO2-N)

Nitrate stimulates algal growth, which in turn can lead to eutrophication in aquatic systems. The most common source of nitrate is runoff from fertilized areas such as lawns or other landscaped areas. Nitrate is also a byproduct of septic systems – it is a naturally occurring chemical left after the decomposition of human (and other animal) waste. In the Middle Truckee River watershed, Union Valley Creek (GLEN-00 and GLEN-02) stands out as having extremely high nitrate measurements (Figure 7b). Squaw Creek (SQCR-00) has also exhibited high nitrate levels, and to a lesser degree so have Alder Creek (ALDR), Bear Creek (BEAR), Martis Creek (upper site, MART-01), and the mainstem of the Truckee River in the Town of Truckee (TOWN) (Figure 7a).

Ammonia

Ammonia is a reduced, toxic form of nitrogen and is usually associated with the decomposition of organic matter and wastes. Total ammonia consists of the un-ionized (NH_3) plus the ionized ($NH_4{}^+$) forms. Ionized ammonia is relatively nontoxic while un-ionized ammonia is toxic to fishes and aquatic invertebrates, even in low concentrations. Generally ammonia is very low in the Truckee River watershed, as can be seen in Figure 8. Even the higher measurements obtained from Union Valley Creek (GLEN-00 and GLEN-02) are still considered low from a water quality perspective. As a point of comparison, the EPA Ammonia water quality criteria are expressed in mg/L or parts per million, our measurements are expressed in μg/L or parts per billion.

Total Nitrogen

Total nitrogen includes Nitrate-Nitrite, Ammonia, and Total Kjeldahl Nitrogen (TKN). TKN is the organic portion of nitrogen and is more expensive to measure than nitrate or ammonia. However, many state standards are for total nitrogen, so since 2006, we have attempted to include analysis of TKN during spring runoff when possible. Union Valley Creek (GLEN-00 and GLEN-02) has had very high total nitrogen during monitoring events. Other sites that have somewhat high total nitrogen levels include Alder Creek (ALDR), Little Truckee River between Stampede and Boca (BOCA-01), Donner Creek below

Donner Lake (DONN-03), East Martis Creek (EMAR), Martis Creek (lower and upper, MART-00 and MART-01), Squaw Creek (SQCR-00), and Trout Creek (at mouth, TROU-00). Water quality standards are discussed later in this report.

Phosphorus

Phosphorus is also critical for stimulating algal growth in aquatic systems. Phosphorus is naturally present in the environment, in granitic and volcanic rocks. Anthropogenic sources include various soaps and detergents, fertilizers, and other household chemicals. Figure 10 shows results from 2001-2014. High phosphorus concentrations have been found at Union Valley Creek (GLEN-00 and GLEN-02), Martis Creek (MART-00 and MART-01), Trout Creek (TROU-00) and sites along the mainstem Truckee River (BIGC, TOWN). See Figure 32 and associated text for discussion of phosphorus standards.

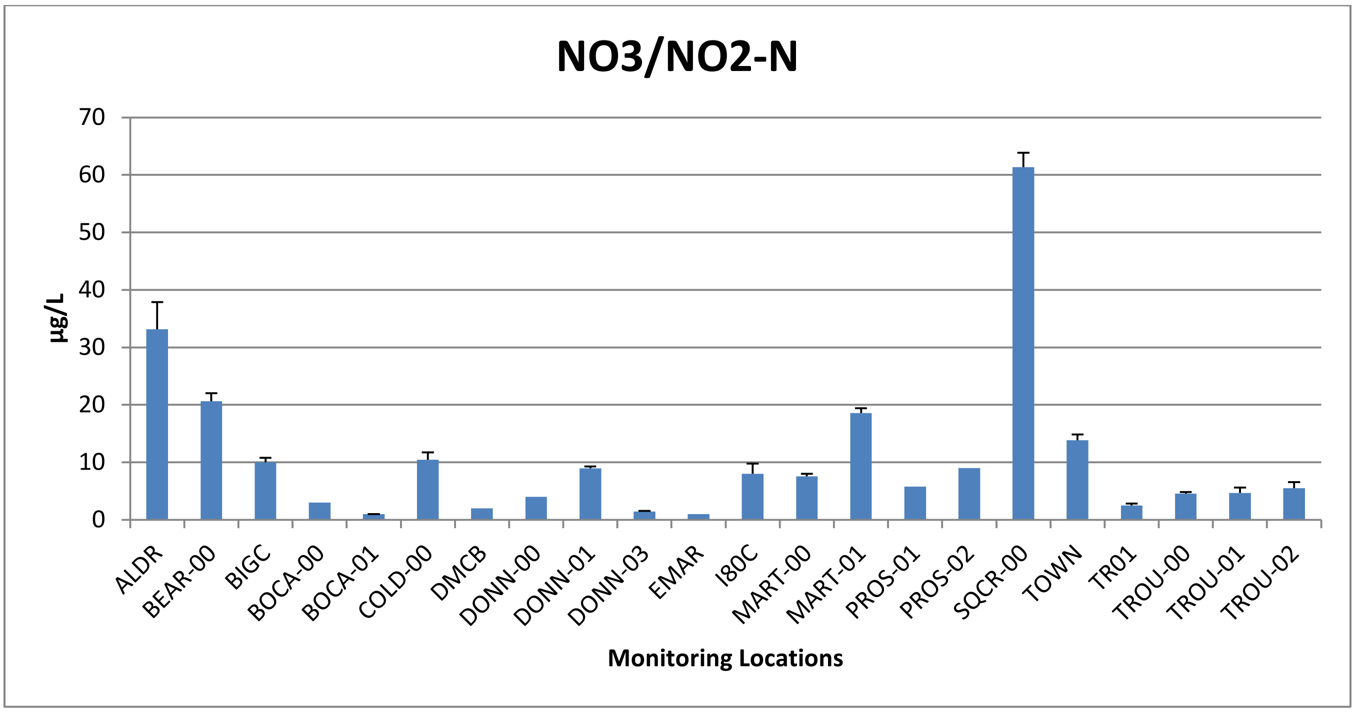

Figure 7a. Nitrate levels. The bars represent the average value, the error bars show standard error.

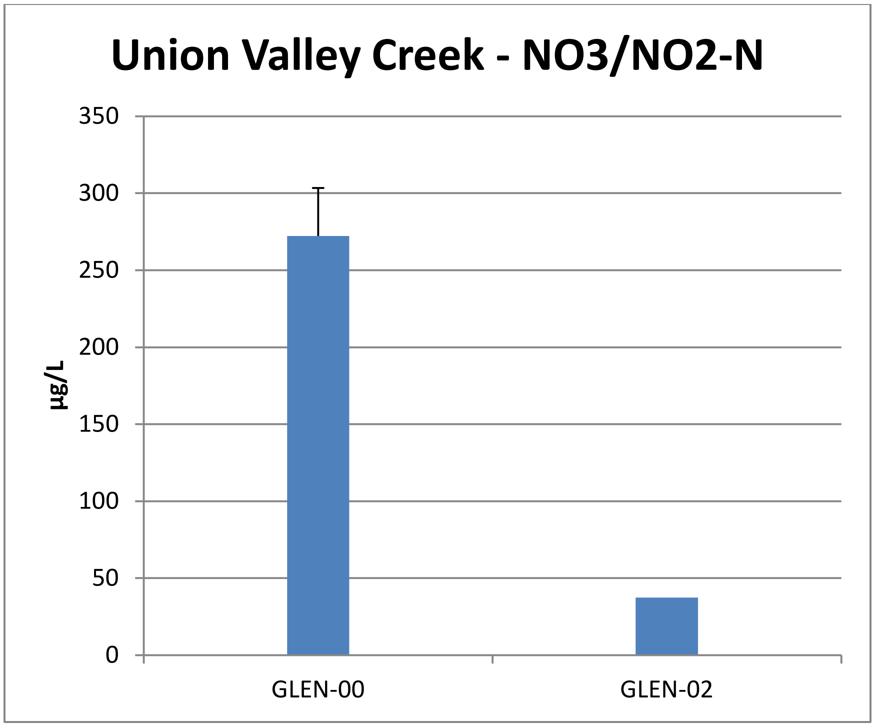

Figure 7b. Nitrate measurements for Union Valley Creek – two monitoring locations. The bar represents the average value, the error bar shows standard error.

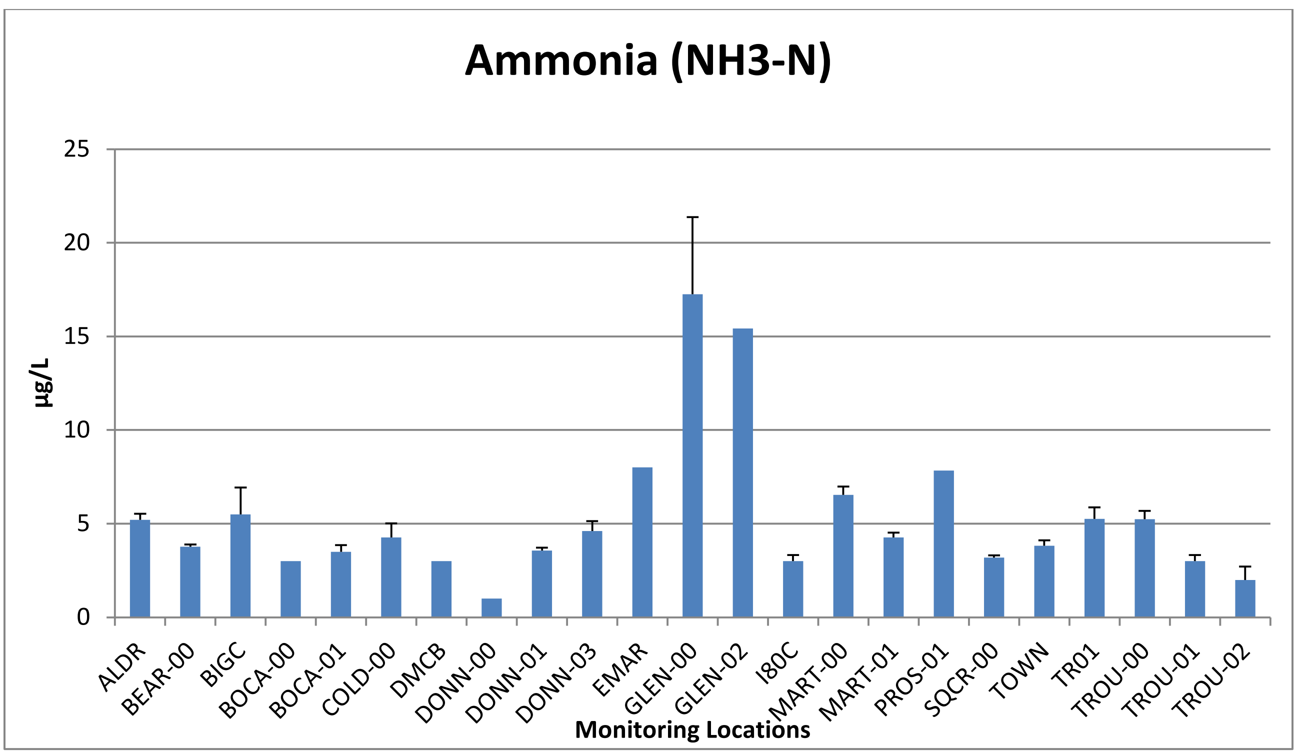

Figure 8. Ammonia measurements. The bars represent the average value, the error bars show standard error.

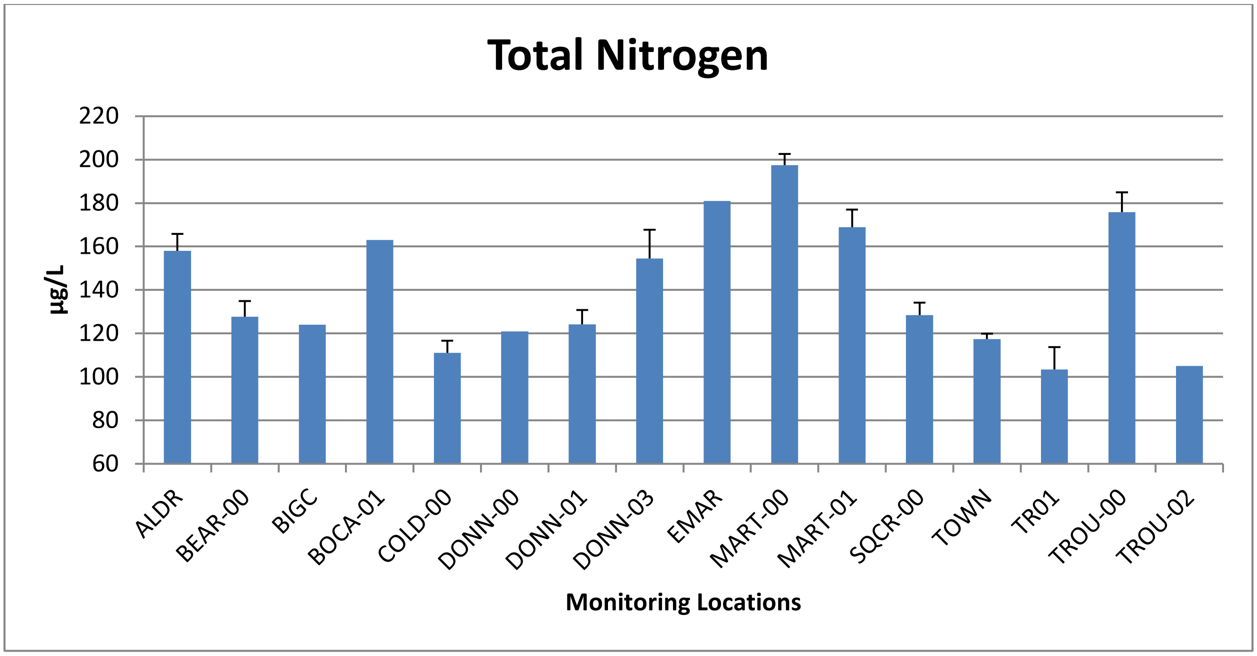

Figure 9a. Total Nitrogen. Total Nitrogen data are available from 2006, 2007, and 2009-2014. The bars represent the average value, the error bars show standard error. Note that the scale starts at 60 µg/L.

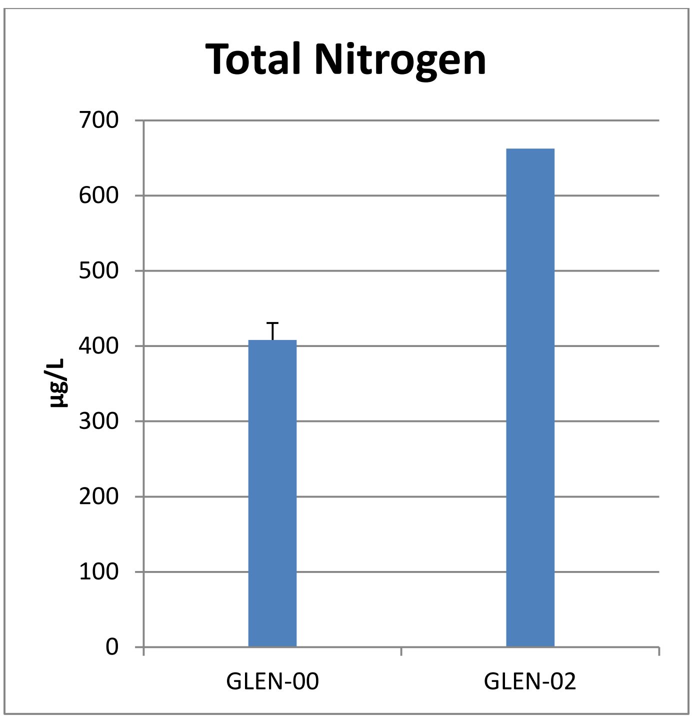

Figure 9b. Total Nitrogen for two sites on Union Valley Creek. Total Nitrogen data are only available from 2006, 2007, and 2009-2014 for GLEN-00 and 2013 for GLEN-02. The bar represents the average value, the error bar shows standard error.

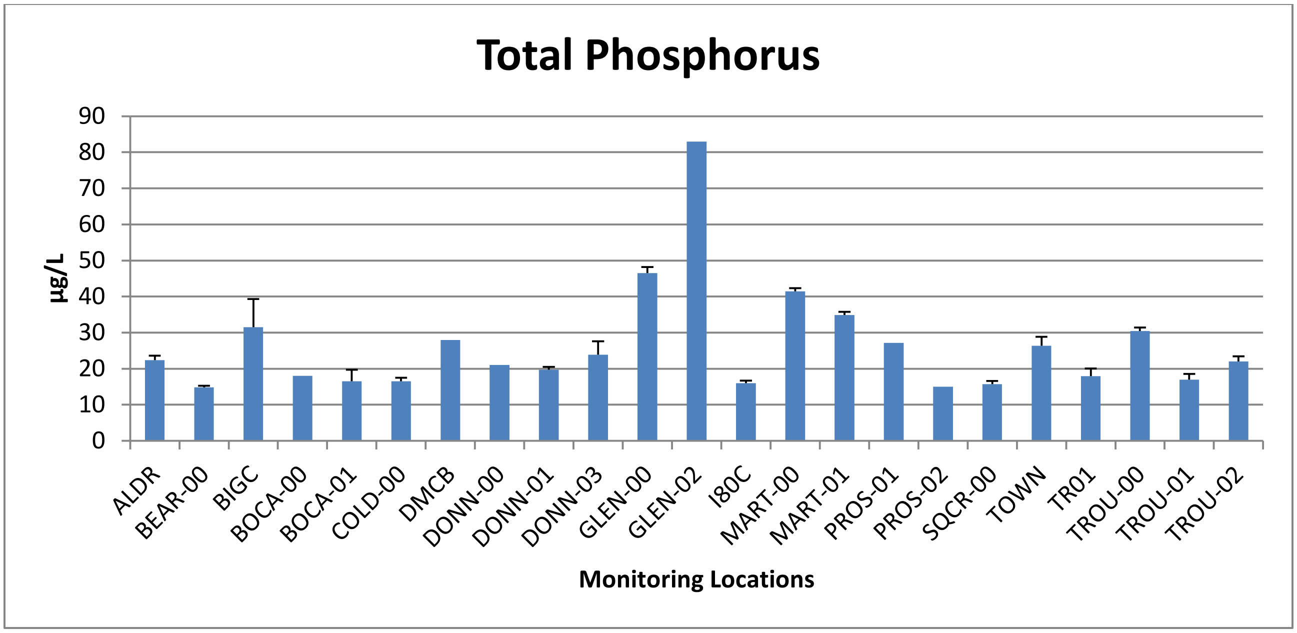

Figure 10. Total phosphorus. The bars represent the average value, the error bars show standard error.

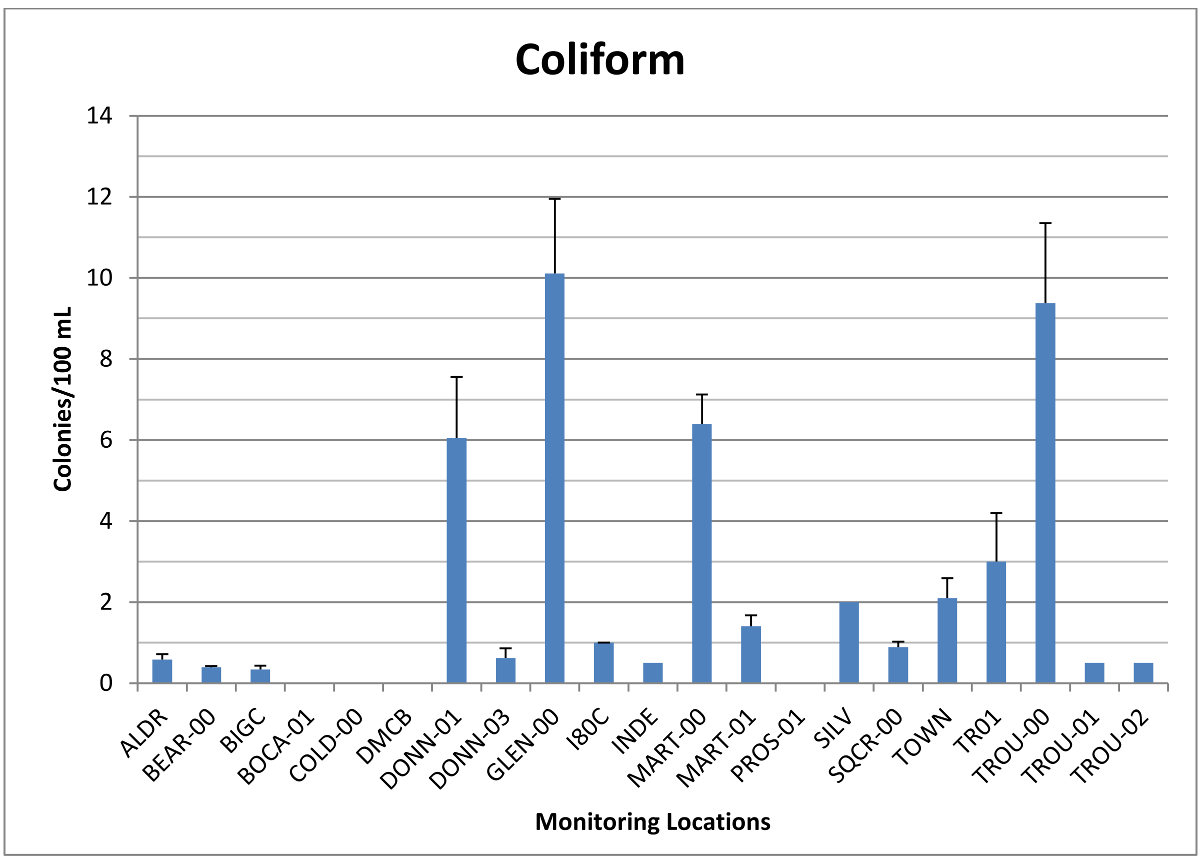

Figure 11a. Coliform measurements. Only sites that have been tested for coliform at least once between 2001 and 2014 are listed. Sites with no bar tested "non-detect" for coliform.

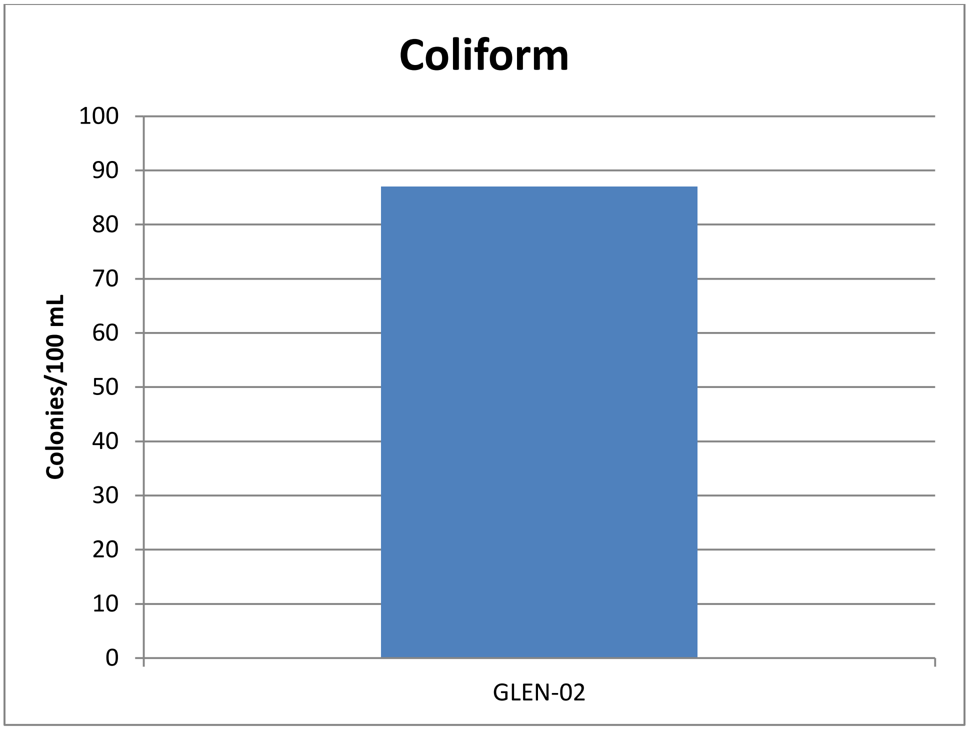

Figure 11b. Coliform measurements – Union Valley Creek above Glenshire Pond (GLEN-02). The site has only been monitored once, in 2013. We will continue to monitor this site as conditions allow.

Coliform

Coliform are a group of bacteria that are mostly found in the feces of warm-blooded animals, including humans, pets, livestock, beavers, and birds. Coliform is only monitored during spring runoff, and samples are taken from only a subset of sites. Figures 11a and 11b show the results of coliform monitoring since 2001. Most coliform monitoring has yielded measurements of "non-detect".

Union Valley Creek at the Truckee River (GLEN-00) consistently has measurable numbers of colonies, as do Martis Creek (MART-00 and MART-01), Donner Creek (DONN-01), and Trout Creek at the mouth (TROU-00). In 2013, we added an additional site on Union Valley Creek upstream of the Glenshire Pond, and the coliform levels from that location were quite high (87 colonies/100 mL). The Lahontan Basin Plan current water quality standard for coliform is 20 colonies/mL , but is based on a log mean for a 30-day period, with a minimum of five equally spaced samples. Most of our samples are regularly below 20 colonies/100 mL, but because we only collect grab samples it is not possible to directly compare our data to the water quality standard. However, the one-time measurement of 87 colonies/100 mL at GLEN-02 indicates that we should continue to monitor this site.

Bioassessment Data

Figures 12-16 show some results from monitoring benthic macroinvertebrate (BMI) communities. Because taxonomic resolution affects most metrics, the data analyzed professionally and by volunteers are presented separately. See discussion in "Methods" section for explanation of differences in the analyses.

Tolerance Measures

Each taxon of aquatic invertebrate is assigned a tolerance value which is an indication of the amount of pollution that it can survive. Taxa with high tolerance values are able to live in more degraded water (can tolerate more pollution) and taxa with a low tolerance values are less able to live in degraded streams (are intolerant of pollution). Tolerance values range from 0-10, with organisms like stoneflies on the low end and organisms like leeches on the high end. “Tolerant” taxa have tolerance values of 8-10 and “Intolerant” taxa have tolerance values of 0-2.

The Community Tolerance metric is a weighting of all the organisms in the sample by tolerance value. A high tolerance value means that in general, more tolerant taxa are found in that stream. The community tolerance metric includes all individuals in a sample, not just the highly tolerant or intolerant.

Figures 12a-c show the tolerance metrics for samples that were professionally identified. Due to the large number of samples, the data have been split into three graphs, organized by position in the watershed. In general, the biological condition of area streams is fairly high when looking at just these metrics. Percent Tolerant is generally low, and Percent Intolerant is generally high. A few streams stand out: West Martis and East Martis exhibited high percent tolerant during at least one sampling. On the other hand, the overall community tolerance value during these same sampling events was not much higher than most other monitored streams.

Several stream such as Independence Creek, Sagehen Creek, Cold Creek, and Pole Creek all have low community tolerance values and high percent Intolerant.

The data analyzed by volunteers are shown in Figure 13. Again, based on tolerance metrics, sampled streams are primarily in good condition. Most sampled creeks contain very few tolerant organisms (low % Tolerant). However, Trout Creek (at Bennett Flat), Prosser Creek, and the Truckee River (at Horseshoe Bend), and Davies Creek have measureable % Tolerant values and most of those streams have high community tolerance values. Deer Creek, Cold Creek, Cold Stream, Perazzo Creek, and the Upper Little Truckee River all show low % Tolerant, high % Intolerant, and low Community Tolerance values.

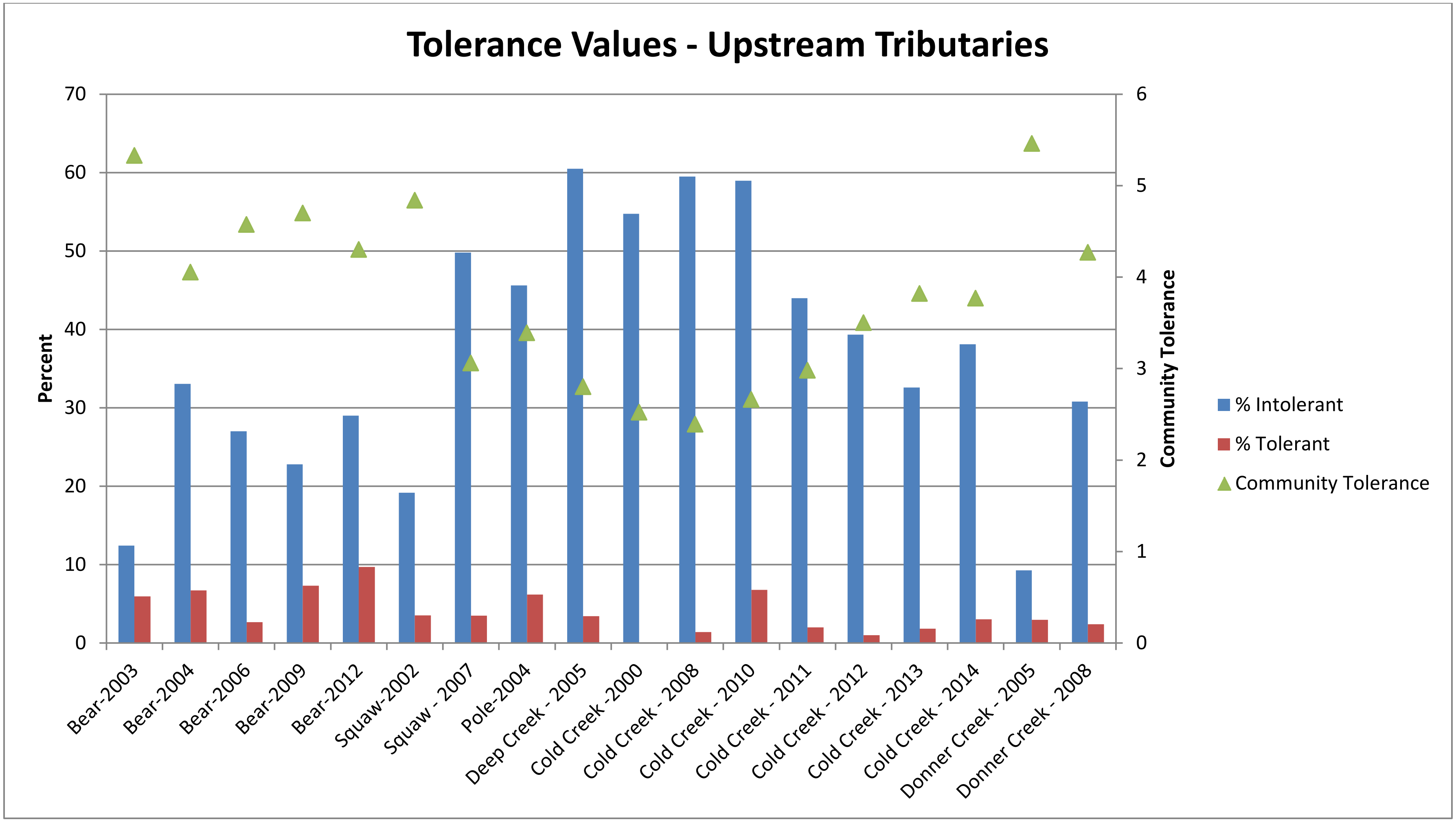

Figure 12a. Tolerance metrics, data analyzed at professional labs. Streams in the upstream part of the Middle Truckee River Watershed are shown in this figure (i.e. primarily above the Town of Truckee). Data from 2000-2007 were analyzed using the CSBP method (900 individuals identified from each stream) and data from 2008 on were analyzed using the 2007 SWAMP protocol (500 individuals identified). All samples were analyzed to the same taxonomic resolution, corresponding to SAFIT level II.

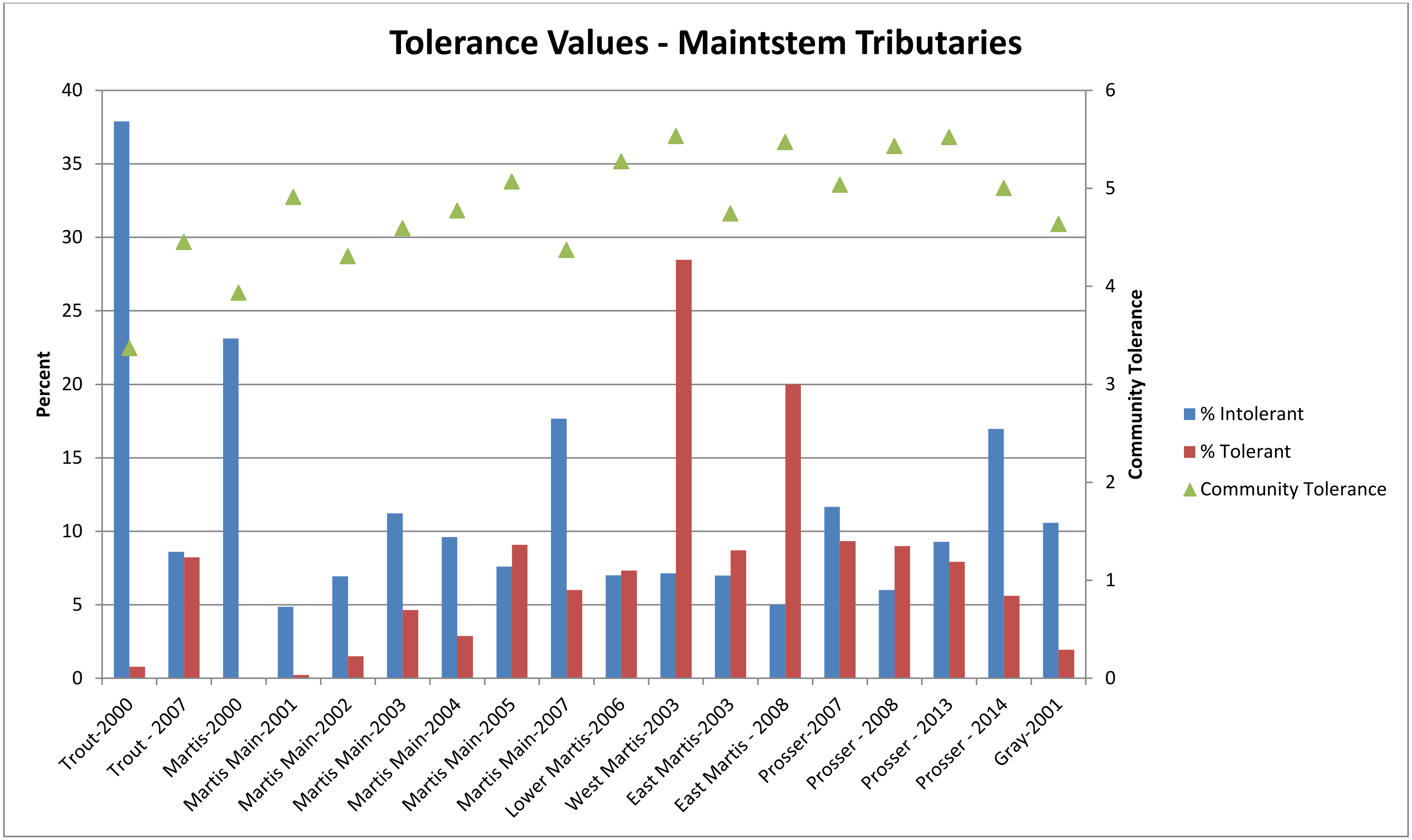

Figure 12b. Tolerance metrics, data analyzed at professional labs. Streams that drain to the Truckee through the town of Truckee and below are shown here (Martis, Trout, Prosser, etc.). Data from 2000-2007 were analyzed using the CSBP method (900 individuals identified from each stream) and data from 2008 on were analyzed using the 2007 SWAMP protocol (500 individuals identified). All samples were analyzed to the same taxonomic resolution, corresponding to SAFIT level II.

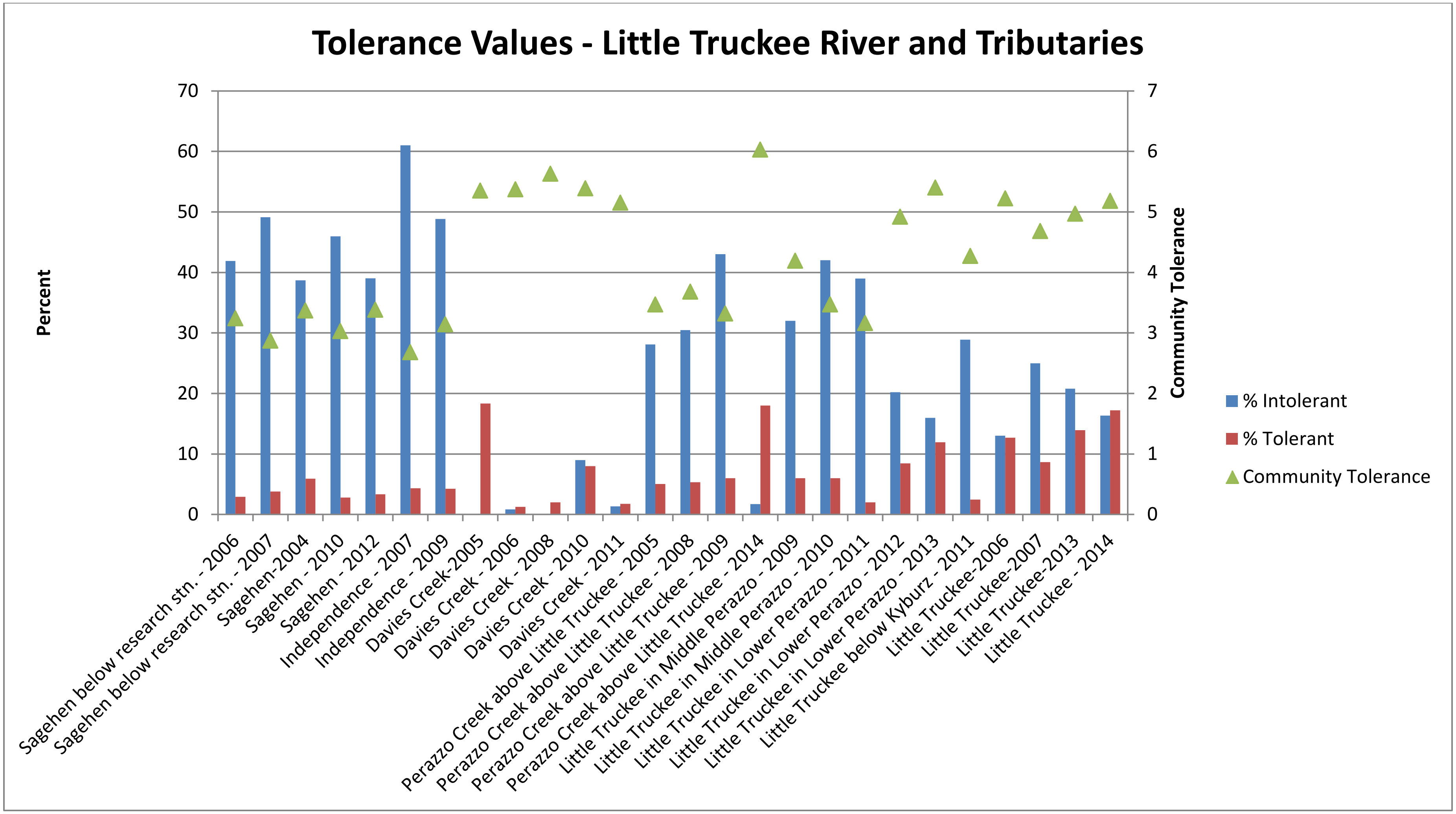

Figure 12c. Tolerance metrics, data analyzed at professional labs. Little Truckee River and tributaries to the Little Truckee River are shown here. Data from 2000-2007 were analyzed using the CSBP method (900 individuals identified from each stream) and data from 2008 on were analyzed using the 2007 SWAMP protocol (500 individuals identified). All samples were analyzed to the same taxonomic resolution, corresponding to SAFIT level II.

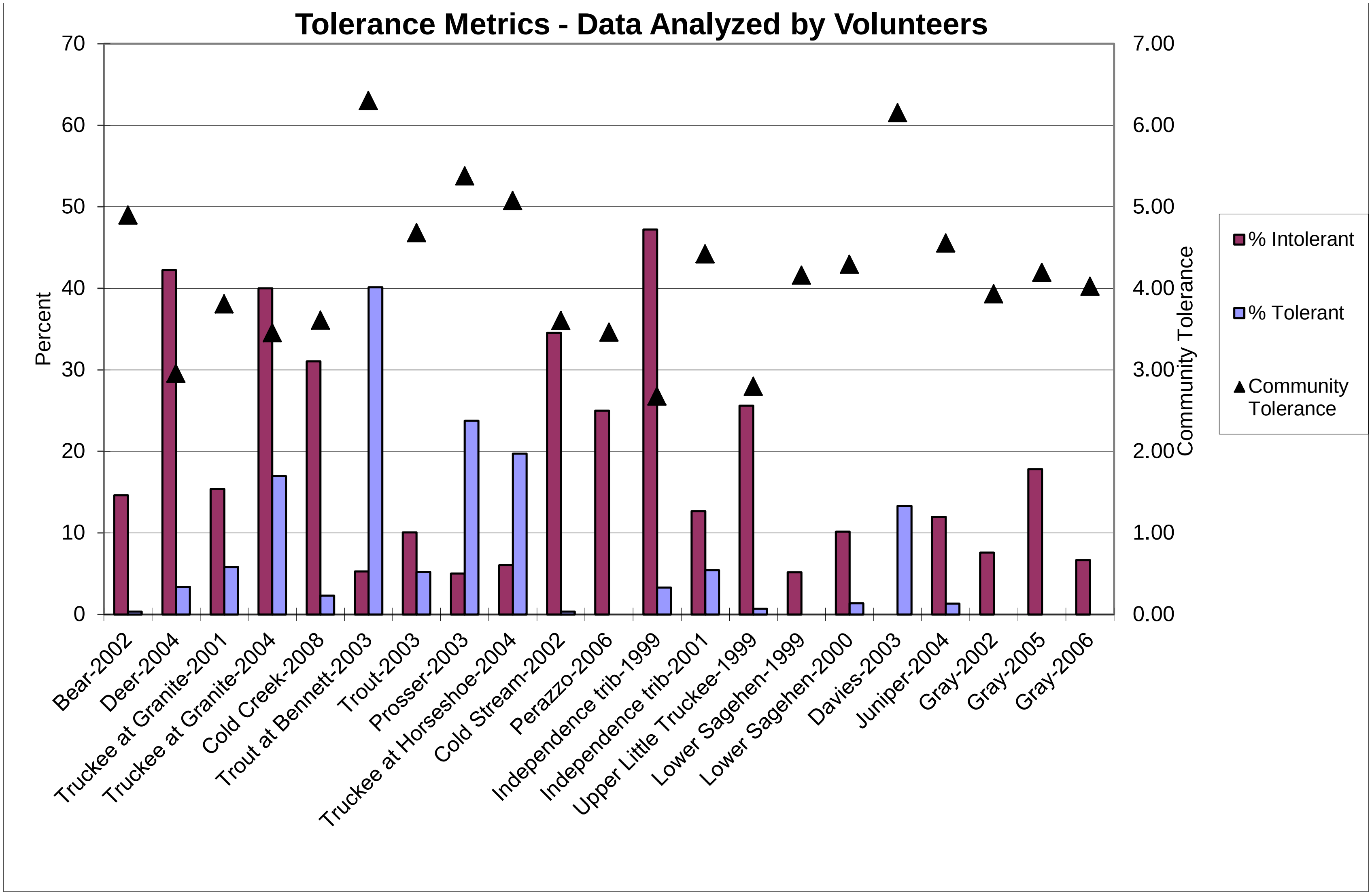

Figure 13. Tolerance metrics, data analyzed by volunteers. Data from 2000-2007 were analyzed using the CSBP method for volunteers (300 individuals identified from each stream) and data from 2008 on were analyzed using the 2007 SWAMP protocol (500 individuals identified). All samples were analyzed to the same taxonomic resolution: family for insects, order for other taxa.

Functional Feeding Groups

Available food sources in a stream vary depending upon the distance from the headwaters. The River Continuum Concept addresses how this different availability of food sources will affect the types of organisms found at different points along a stream. In headwater streams, the input of organic matter is primarily from terrestrial sources, these streams tend to be small and shaded, so very little sunlight can reach the stream to stimulate primary productivity (plant and algae growth). Leaves falling from streamside vegetation will provide the majority of the food base to these types of stream. Therefore, we predict to see many "shredders" and "coarse particulate organic matter collectors", organisms that feed off of leaves or other types of terrestrial inputs. Some "scrapers" (organisms that graze on algae attached to rocks) will be present as well as some predators.

Further down the stream in "mid-reach" sections, the streams are larger and solar radiation can reach the water. The food base becomes a mix of terrestrial and in-stream primary productivity. Aquatic plants and algae form a significant part of the food web. The types of functional feeding groups that should be found in these types of streams are primarily grazers that feed on the algae and plants, and a wider range of collectors than are seen in the headwaters. More medium and fine particulate matter is present in the mid-reach streams. Shredders are found in much lower abundance, and a small number of predators will be present.

In very large river systems (like the lower Mississippi) the energy base for the food web is primarily leakage from upstream. In these systems, fine particulate organic matter collectors dominate the species assemblage, and a small number of predators will be present.

Locally, most of our streams would be considered headwater streams. The main stem of the Truckee River would even be considered a headwater stream according to how streams are classified, but has many of the characteristics of a mid-reach stream. In the tributary streams, we should see communities that have large percentages of both shredders and collectors, with small numbers of scrapers and predators.

Figures 14a-c show the percentages of functional feeding groups seen in samples analyzed to a higher taxonomic level (by professional laboratories) and Figure 15 shows the same data for samples analyzed to family level (by volunteers). Generally speaking, most streams are dominated by collectors with low percentages of shredders. Low numbers of shredders often indicate that there is a reduced availability of terrestrial vegetation as a food source. The percent of scrapers should be low in our headwater streams, which is mostly the case. High levels of scrapers typically indicate significant algal populations. Interestingly, high algae production was common in 2014 (most likely due to several years of low flows) but we did not observe greater numbers of scrapers in our samples from 2014.

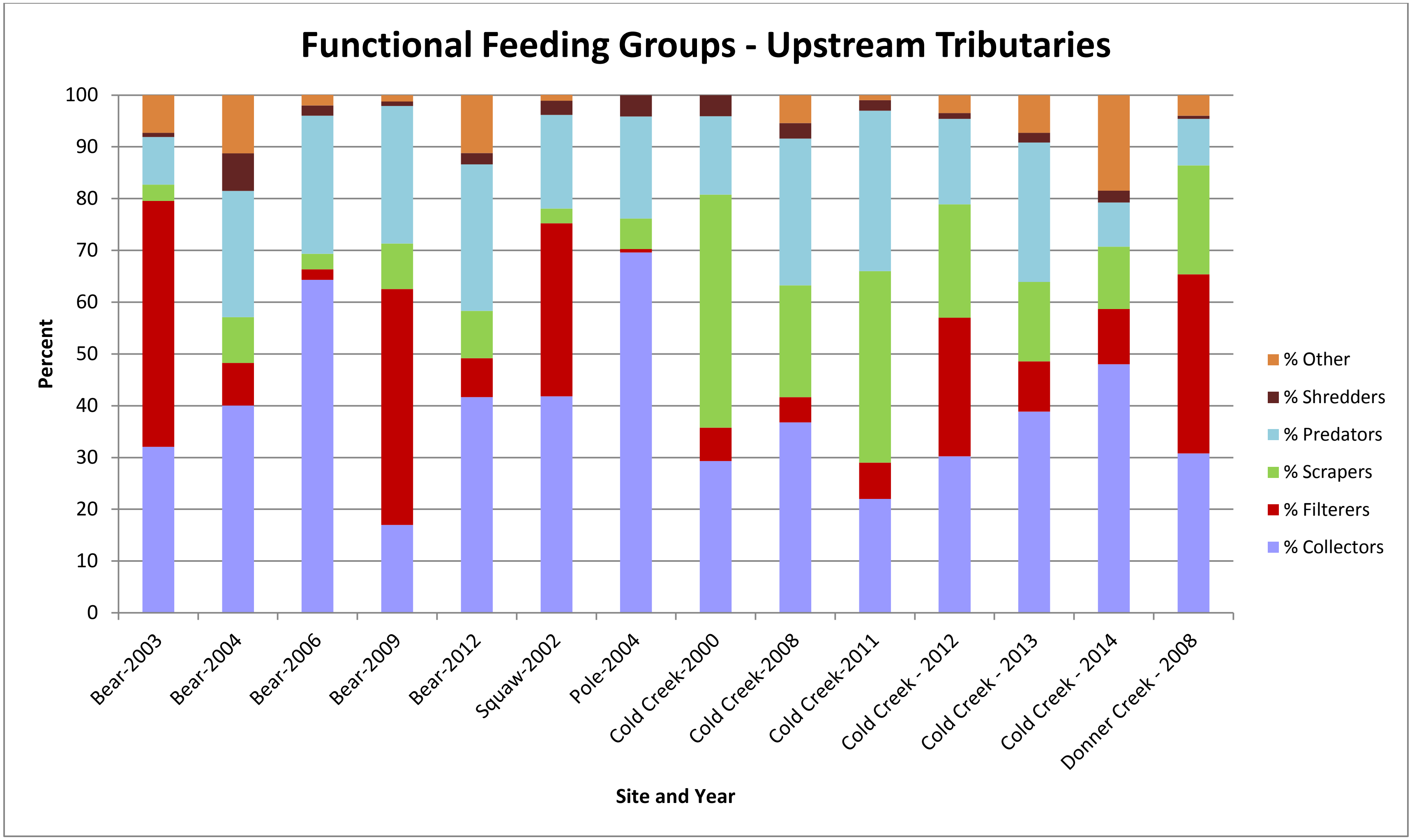

Figure 14a. Functional feeding groups, data analyzed by professionals – upstream tributaries. Streams are organized from upstream to downstream by confluence with the Truckee River. Streams in the upstream part of the Middle Truckee River Watershed are shown in this figure (i.e. primarily above the Town of Truckee).

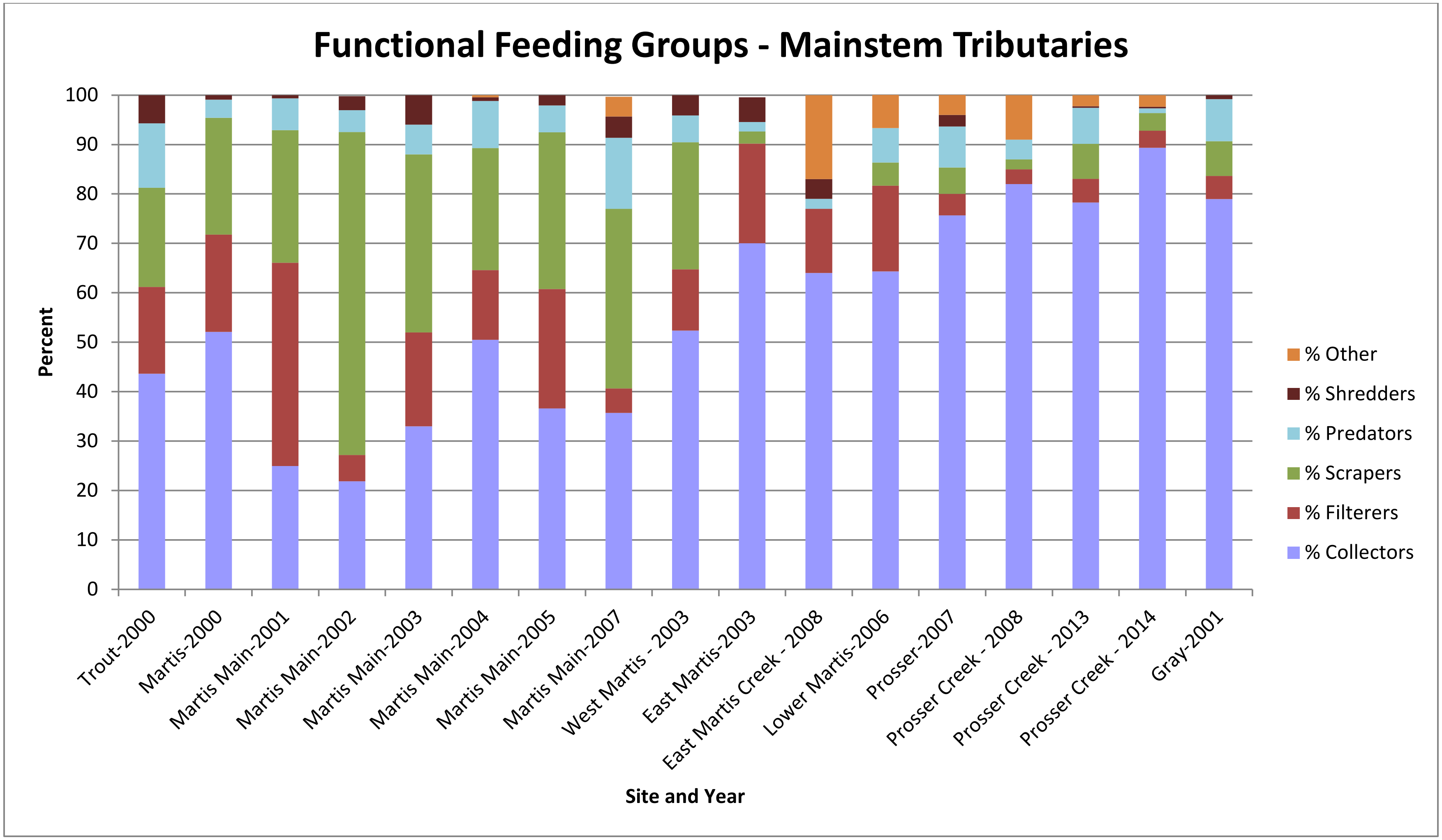

Figure 14b. Functional feeding groups, data analyzed by professionals – mainstem tributaries. Streams are organized from upstream to downstream by confluence with the Truckee River. Streams that drain to the Truckee through the town of Truckee and below are shown here (Martis, Trout, Prosser, etc.).

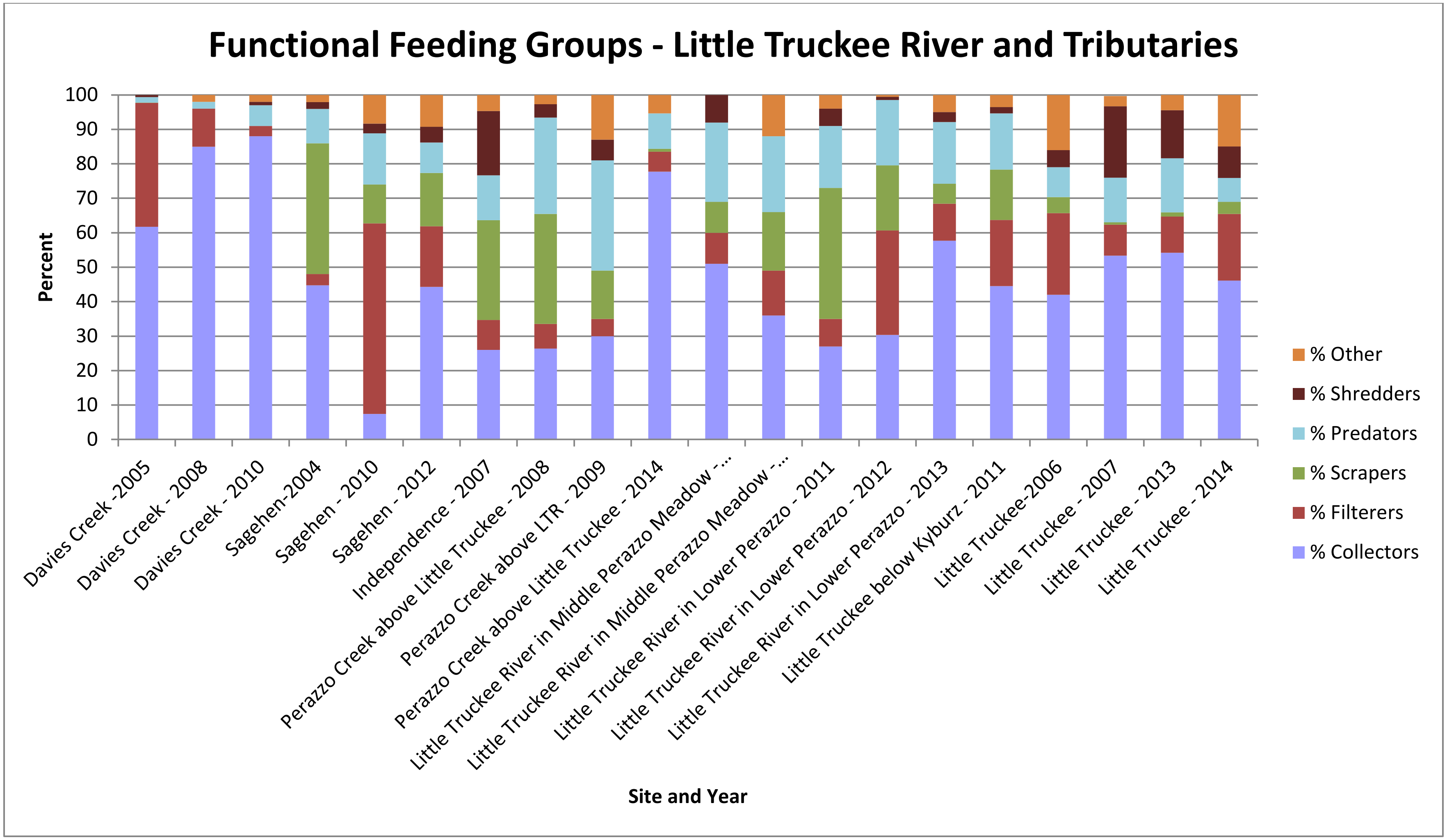

Figure 14c. Functional feeding groups, data analyzed by professionals. Little Truckee River and tributaries to the Little Truckee River are shown here.

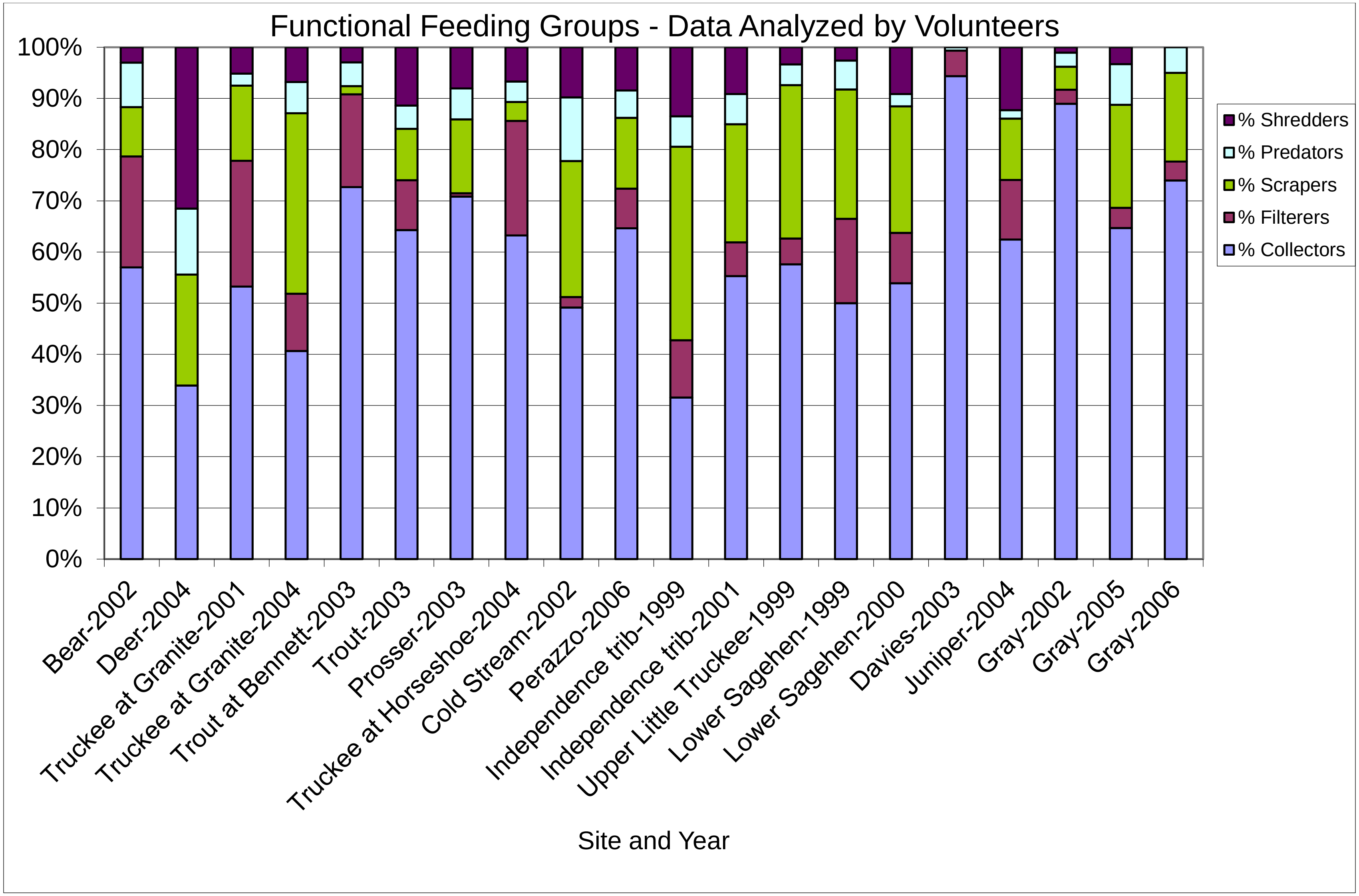

Figure 15. Functional feeding groups, data analyzed by volunteers. Streams are organized from upstream to downstream (point of entry to Truckee River).

Index of Biological Integrity

In 2009 an Index of Biological integrity (IBI) for the Eastern Sierra was published (Herbst and Silldorff, 2009). An IBI allows for the comparison of the biological condition of streams based on a single score. An IBI is an index composed of multiple metrics that can be used to accurately and cost-effectively assess stream health.

IBIs are region- or even watershed-specific. To generate an IBI, data must be collected from many different streams of varying "known" condition. Streams are separated into reference and test streams with reference streams being relatively high quality, and test streams of varying quality. Many different metrics are typically considered for evaluation, and a subset are selected for inclusion in the IBI.

For the Eastern Sierra IBI, component metrics were selected for inclusion based on performance indicators such as sensitivity in response to disturbance stressors, high signal-to-noise ratio (strong response to stress with low variation), and little redundancy with other metrics. Thresholds for assessment of biological impairment were based on reference streams of the region, defined as those least influenced by land use disturbances. To identify reference streams, the developers of the IBI used criteria such as low levels of exposure both to the density of upstream road crossings in the watershed, and local reach-scale bank erosion. Streams not conforming to the reference site selection criteria were designated as test sites. The IBI scores of test sites were evaluated relative to the distribution of IBI scores for reference sites to determine whether biological integrity was impaired (according to 5 condition classes). A detailed description of the Eastern Sierra IBI development is included in Herbst and Silldorff, 2009.

The Eastern Sierra IBI was developed for 500-count data, with taxonomy done to genus/species level. Therefore, only our professionally identified data from 2008 forward can be easily inserted into the IBI. It is possible to subsample previously collected 900 count data; however we have not completed that time intensive analysis yet. Simply plugging the 900 count data into the IBI will give higher richness values and skew the IBI scores.

In 2010, Placer County implemented bioassessment monitoring as part of the Truckee River Water Quality Monitoring Plan (TRWQMP, 2ND Nature, 2008). We have included their IBI data for Squaw Creek and Martis Creek in our annual reports since that time. Prior to the development and implementation of the TRWQMP, TRAM had monitored both Martis and Squaw. To avoid excess impacts to the instream fauna of the streams and maximize limited monitoring resources, TRAM will not monitor Martis or Squaw while Placer County continues to implement the TRWQMP. The Placer County data are collected and analyzed using the same protocols as TRAM uses, therefore all the data are comparable.

Tables 5 and 6 include the metrics used to calculate the IBI for 2014 samples (TRWC and Placer County). Figures 16a – 16c show IBI scores for all streams sampled and analyzed to the 500-count standard.

Table 5. IBI input data for streams monitored by TRWC and Placer County in 2014, excluding branches of Martis Creek (CDM Smith and Balance Hydrologics, 2014). Please see http://www.placer.ca.gov/Departments/Works/StrmWtr/StmWtrMonitoring.aspx for the entire Placer County Truckee River monitoring report.

	Squaw Upper Meadow	Squaw Middle Meadow	Squaw Lower Meadow	Cold Creek	Prosser Creek	Perazzo Creek above LTR	LTR above Boyington
Sampling Date	6/27/2014	6/27/2014	6/26/2014	6/25/2014	7/9/2014	7/14/2014	8/2/2014
Sampled By	Placer Co.	Placer Co.	Placer Co.	TRWC	TRWC	TRWC	TRWC
Total Taxa Richness	42	47	39	65	40	51	57
Ephemeroptera richness	9	9	6	17	7	4	8
Plecoptera richness	6	7	5	5	1	1	3
Tricoptera richness	1	2	1	11	4	2	9
Acari richness	4	6	4	2	2	4	6
% Chironomidae richness	15	15	17	29	33	57	33
Tolerant taxa richness %	10	8	13	12	23	35	18
Shredder abundance %	13	14	15	2	0.3	0	9
% Dominant 3 Taxa	51	39	66	37	52	42	25
Biotic index	4.4	4.3	4.4	4	5	6.0	5.2
IBI Score	52	84	71	87	43	28	82

Table 6. IBI input data for various branches of Martis Creek, samples collected in 2014 (CDM Smith and Balance Hydrologics, 2014). Please see http://www.placer.ca.gov/Departments/Works/StrmWtr/StmWtrMonitoring.aspx for the entire Placer County Truckee River monitoring report.

	Martis Schaeffer Branch	Martis Middle Mainstem	Martis Upper West Branch	Martis Lower West Branch	Martis Lower Mainstem	Martis East Branch
Sampling Date	9/12/2014	9/5/2014	9/12/2014	9/4/2014	9/5/2014	9/11/2014
Sampled By	Placer Co.	Placer Co.	Placer Co.	Placer Co.	Placer Co.	Placer Co.
Total Taxa Richness	55	36	45	47	43	34
Ephemeroptera richness	9	4	7	4	9	7
Plecoptera richness	10	5	8	4	4	4
Tricoptera richness	8	2	8	6	3	3
Acari richness	5	4	2	4	4	0
% Chironomidae richness	11	28	16	28	26	21
Tolerant taxa richness %	4	3	4	6	7	6
Shredder abundance %	21	30	24	18	4	10
% Dominant 3 Taxa	30	68	39	44	54	56
Biotic index	2.8	3.4	3.1	4.2	3.6	4.8
IBI Score	98	58	86	77	75.2	56

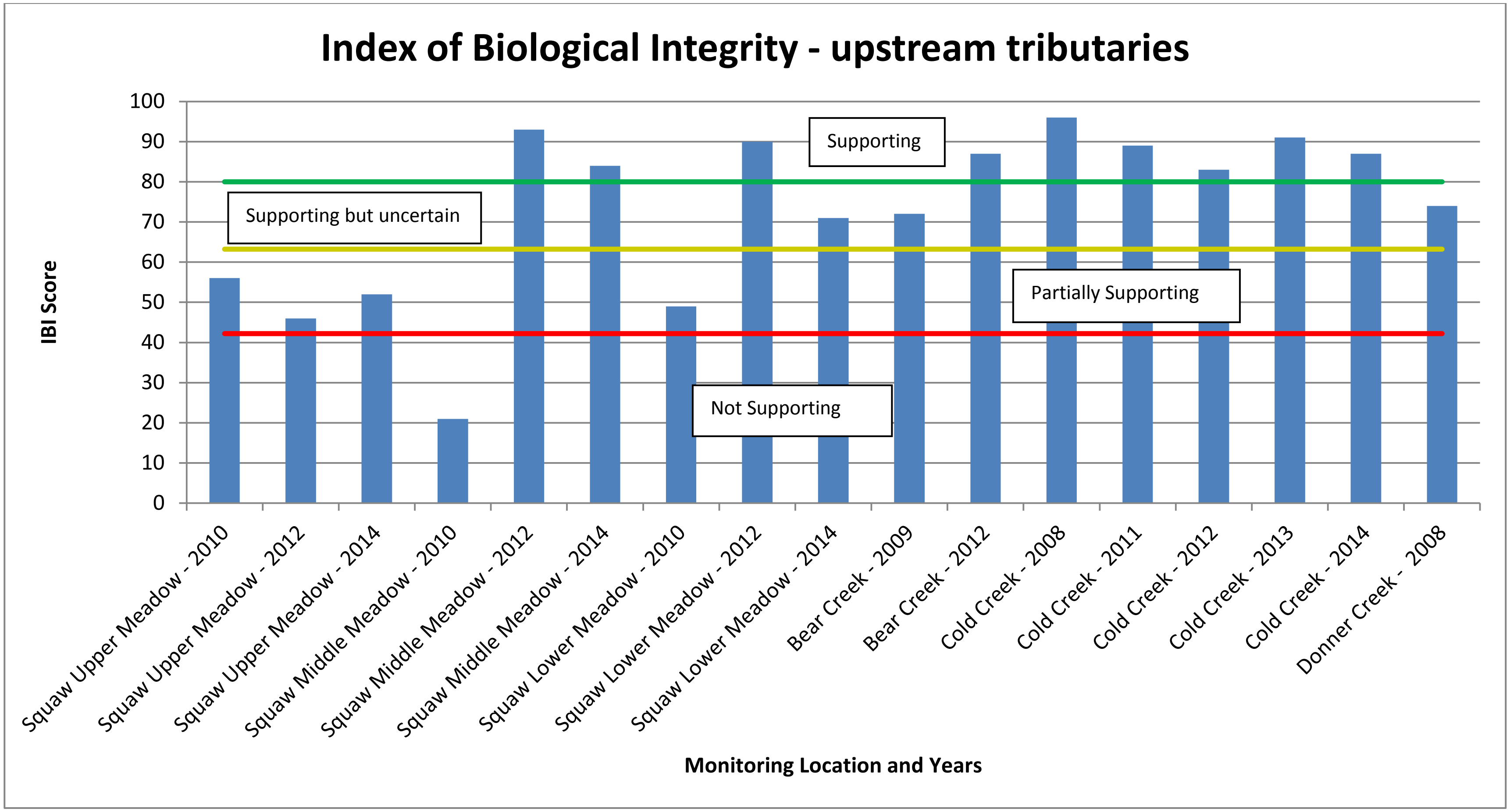

Figure 16a. IBI scores for streams in the upstream part of the Middle Truckee River Watershed (i.e. primarily above the Town of Truckee). See Table 7 for further description of the tiers; note that no distinction is made between the top two tiers. Both tiers support beneficial uses, so only the break between fully supporting and below was made.

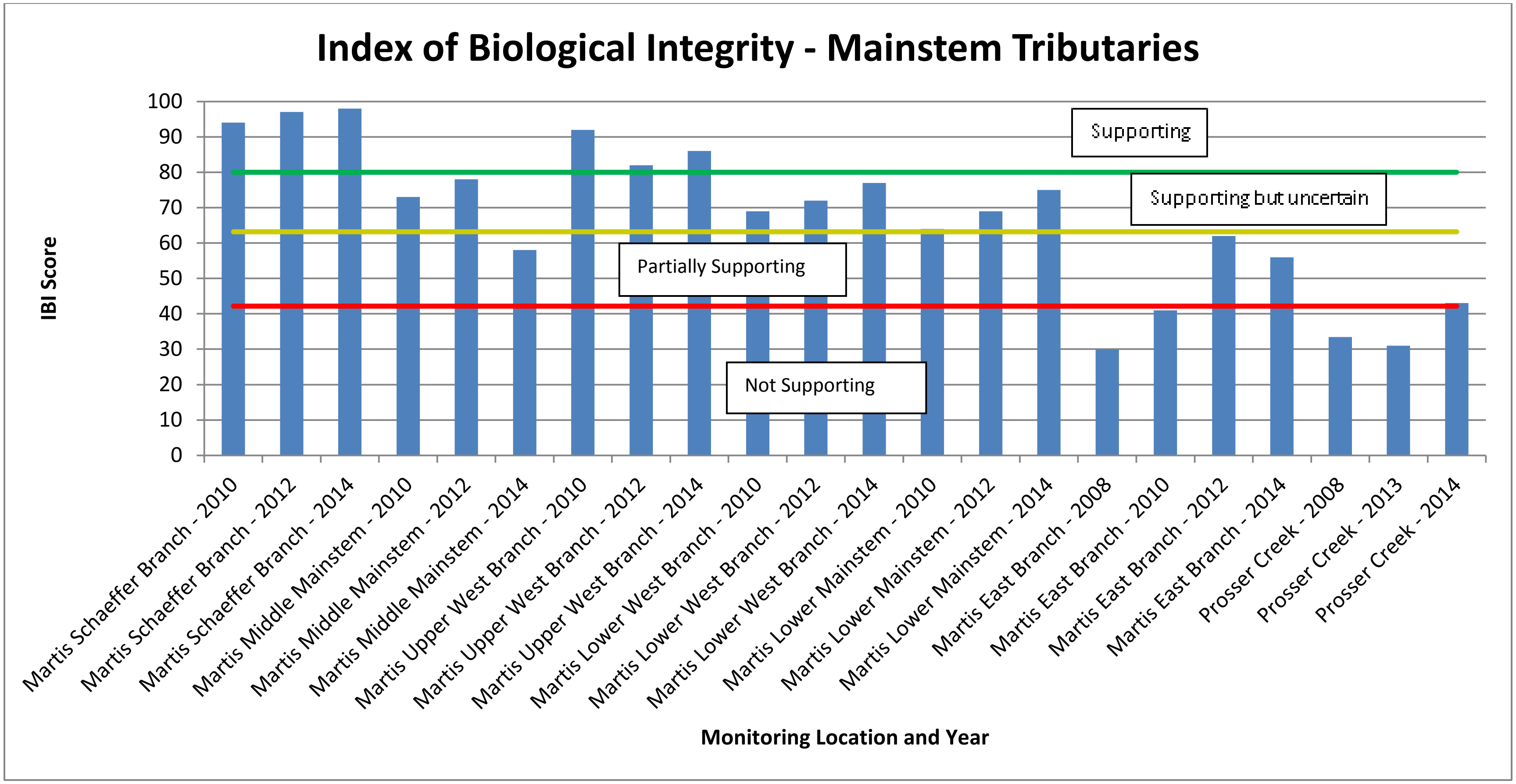

Figure 16b. IBI scores for streams that drain to the Truckee through the Town of Truckee and downstream. See Table 7 for further description of the tiers; note that no distinction is made between the top two tiers. Both tiers support beneficial uses, so only the break between fully supporting and below was made.

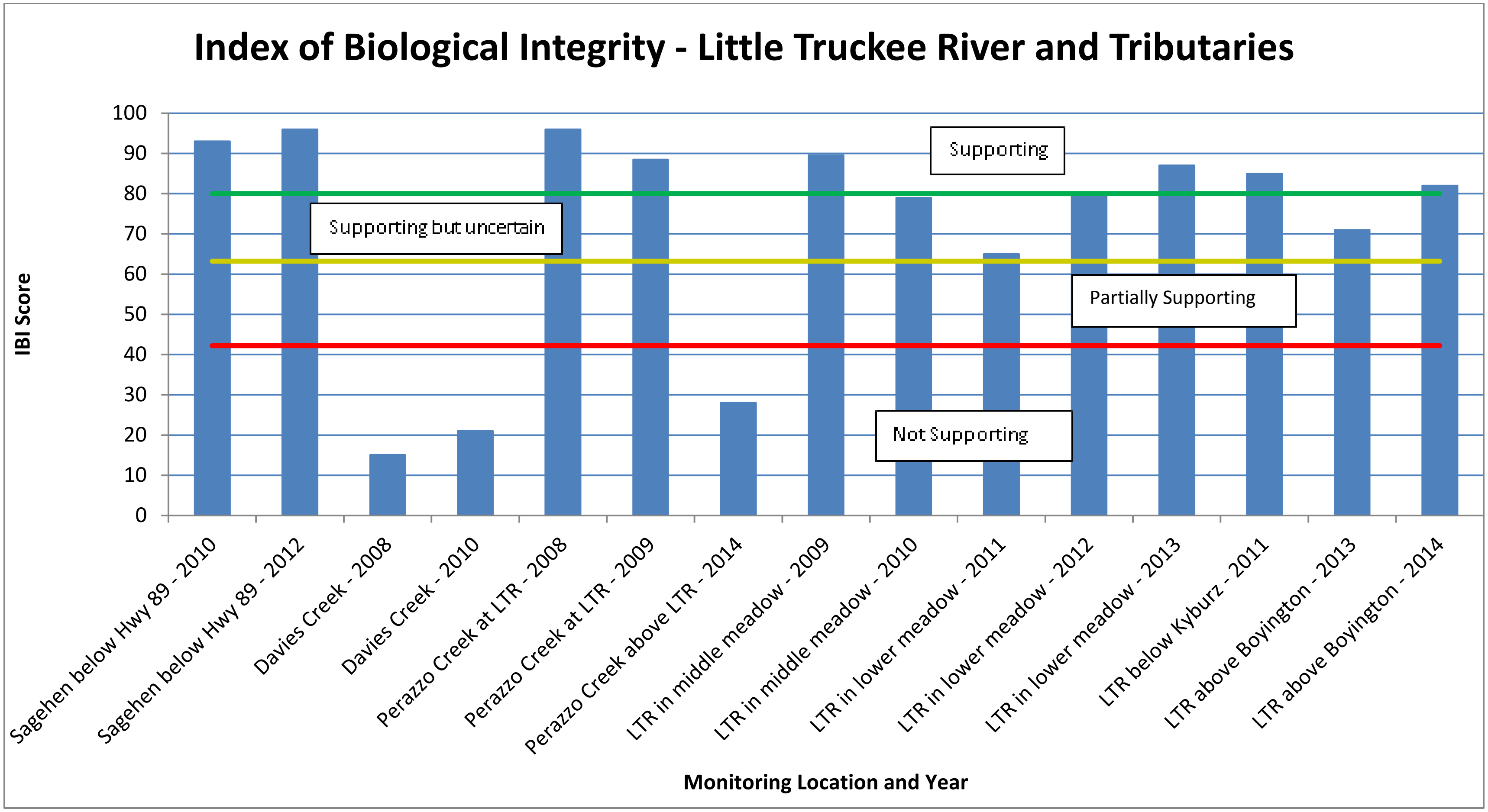

Figure 16c. IBI scores for streams in the Little Truckee River watershed. See Table 7 for further description of the tiers; note that no distinction is made between the top two tiers. Both tiers support beneficial uses, so only the break between fully supporting and below was made.

Scores derived from the Eastern Sierra IBI can be ranked in tiers or classes based on statistical criteria described in detail in the IBI report (Herbst and Silldorff, 2009). Table 7 outlines the scoring tiers. While very few streams yield scores in the lowest category during any one year, less than half the streams monitored (in any year) are fully supporting of aquatic life uses.

Table 7. Tiers of the Eastern Sierra IBI.

Tier	IBI Score	Designation
5/A	>89.7	Very Good – Supporting beneficial uses
4/B	80.4 - 89.7	Good – Supporting beneficial uses
3/C	63.2 -80.4	Fair – Supporting but uncertain
2/D	42.2 – 63.2	Poor – Partially supporting beneficial uses
1/F	<42.2	Very Poor – Not supporting beneficial uses

Monitoring Program Objectives

In developing the Adopt a Stream program, the Truckee River Watershed Council developed a series of monitoring objectives. Much of our data collected relating to specific objectives is “baseline” or current condition data. Over time, as our focused data collection efforts increase, we will be better able to address our stated monitoring objectives.

In this report, we will address each of our monitoring objectives with data collected thus far.

As listed earlier in the report, the primary objectives of AS are:

1. To better understand and document the relationship between water quality, hydrologic function, river system management, and land use.

2. To identify land use practices that negatively impact the Truckee River watershed, the extent of impact, and the geographic locations of concern.

3. To engage and educate residents about local watershed processes and strengthen their understanding of watershed stewardship.

4. To enhance the quality and quantity of data available for resource managers and decision makers in the Truckee River watershed.

5. To provide data that can be used to help monitor the implementation of the Truckee River sediment Total Maximum Daily Load (TMDL).

6. To collect data to help provide pre-Truckee River Operating Agreement (TROA) implementation data, and to establish a program that will help to track changes in the condition of biological resources in the Truckee River watershed once TROA is implemented.

Objectives 1 and 2 are focused on trying to understand how different land uses may be affecting different water quality parameters. These objectives are broadly stated, so in this report we will examine specific ways in which we can use our data to attempt to understand these relationships.

Comparison of Urban and Non-urban Sites

One land use change that is occurring in the Truckee River watershed is increased urbanization. The urban areas are fairly concentrated in a handful of sub-basins: Bear Creek, Squaw Creek, Donner Creek, Trout Creek, and Union Valley Creek (Figure 17). Urbanization is predicted to affect some ambient parameters more than others. In particular we expect to see:

- Increased temperature in more urbanized areas because of lack of streamside vegetation
- Increased electrical conductivity in more urbanized area because of influences of roads and urban run-off
- Increased turbidity in more urbanized areas because of increased erosion

Temperature, turbidity, and conductivity are all fairly sensitive to flow, so the data have been broken out into high flow and low flow sampling events. Because of the history of our monitoring program, there are more high flow data available than low flow data and low flow data are only available for a subset of monitoring locations.

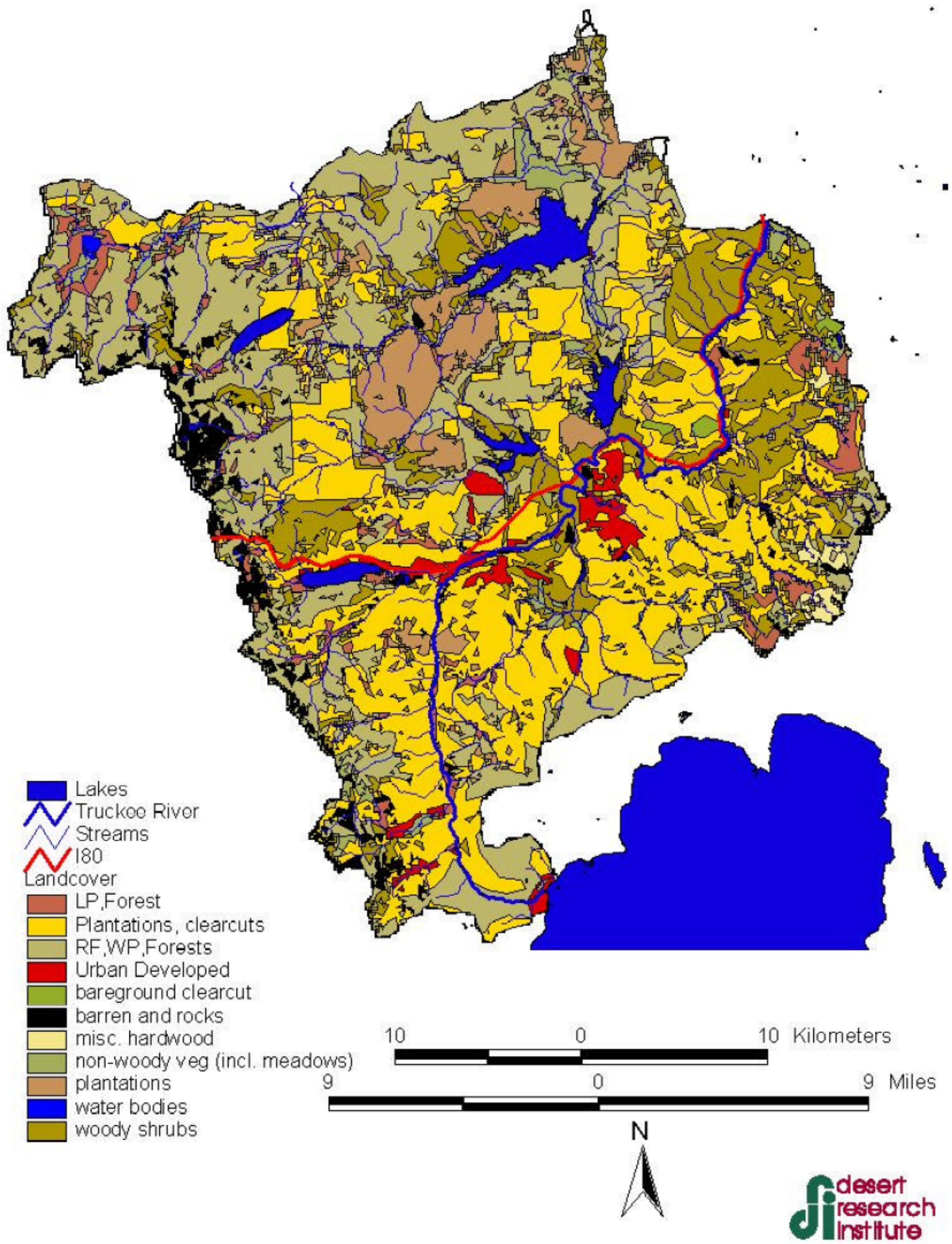

Figure 5. Land cover data layer.

Figure 17. Land cover in the Middle Truckee River watershed. Figure generated by Desert Research Institute, taken from McGraw, et al., 2001.

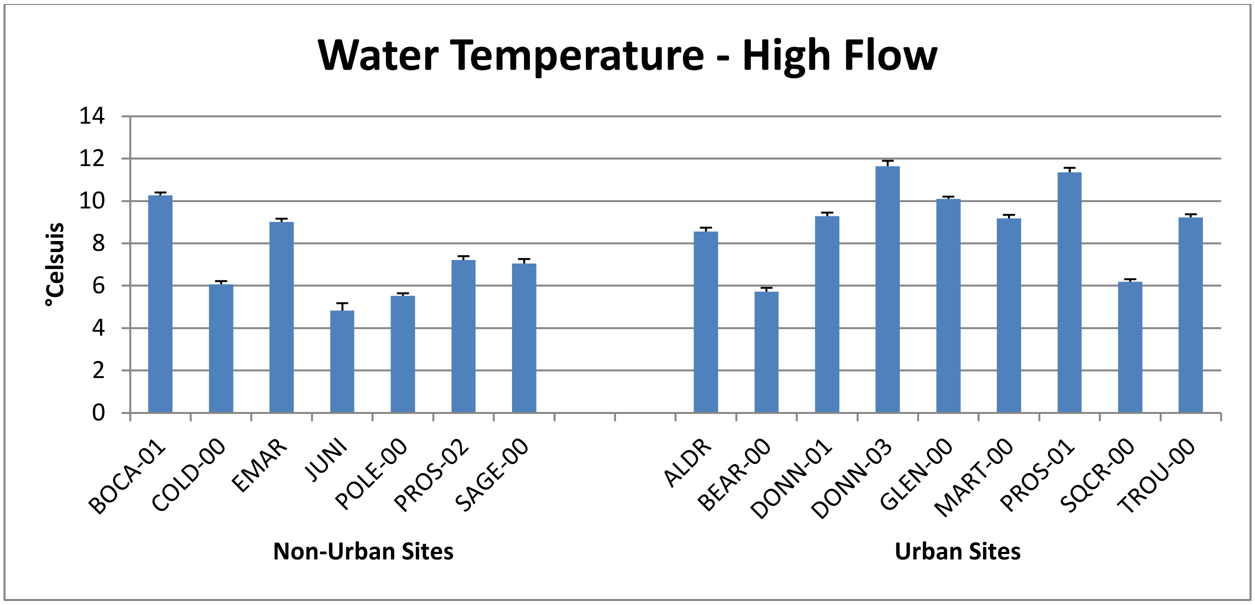

Figure 18. Average water temperature at urban and non-urban sites, measured during high flow. Error bars show standard error. Data are only shown from sites that have been monitored during both high and low flow conditions.

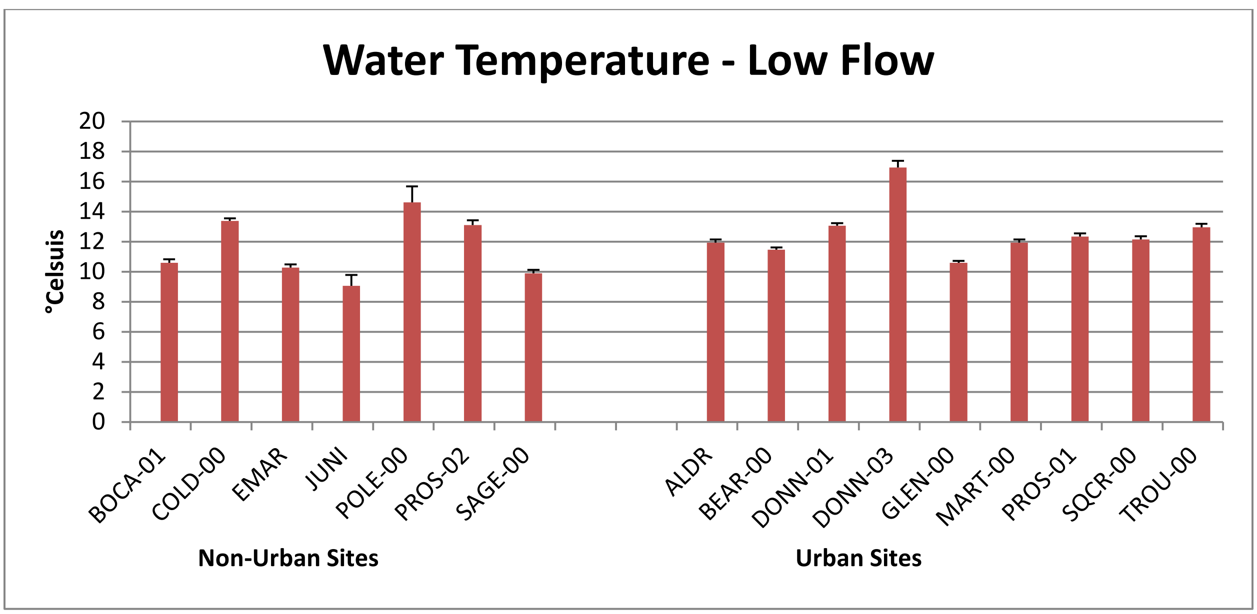

Figure 19. Average water temperature, at urban and non-urban sites, measured during low flow. Error bars show standard error. Data are only shown from sites that have been monitored during both high and low flow conditions.

Table 8. Average water temperature by site type (non-urban and urban) and flow (high or low). We predicted that water temperature should be higher in urban areas than non-urban.

	Average Water Temperature	
Site Type	High Flow	Low Flow
Non-Urban	7.1	11.6
Urban	9.0	12.6

When we performed this analysis in 2010, water temperature did not show a clear pattern between urban and non-urban sites. In 2011, a trend in the predicted direction emerged (urban sites exhibiting warmer water temperatures than non-urban sites) and has slightly increased through 2014.

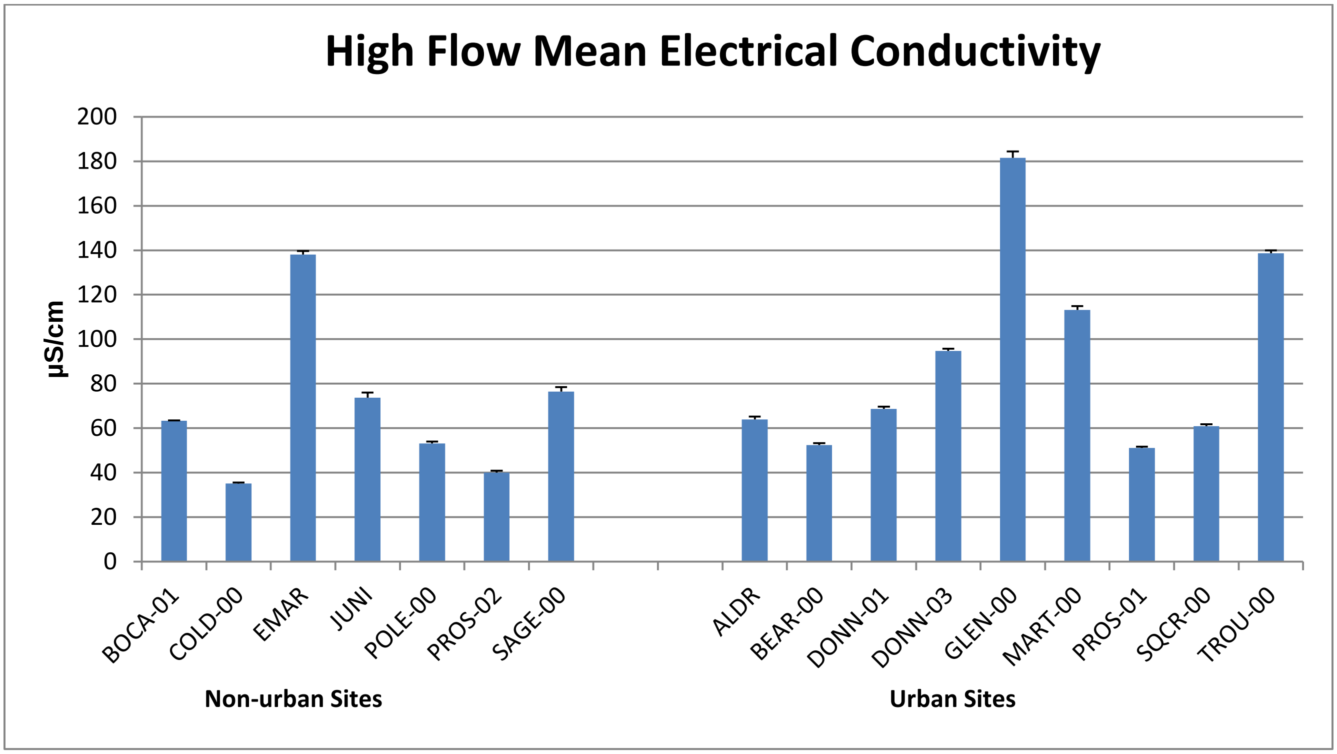

Figure 20. Average electrical conductivity measured during high flow for non-urban and urban sites. Error bars show standard error. Data are only shown from sites that have been monitored during both high and low flow conditions.

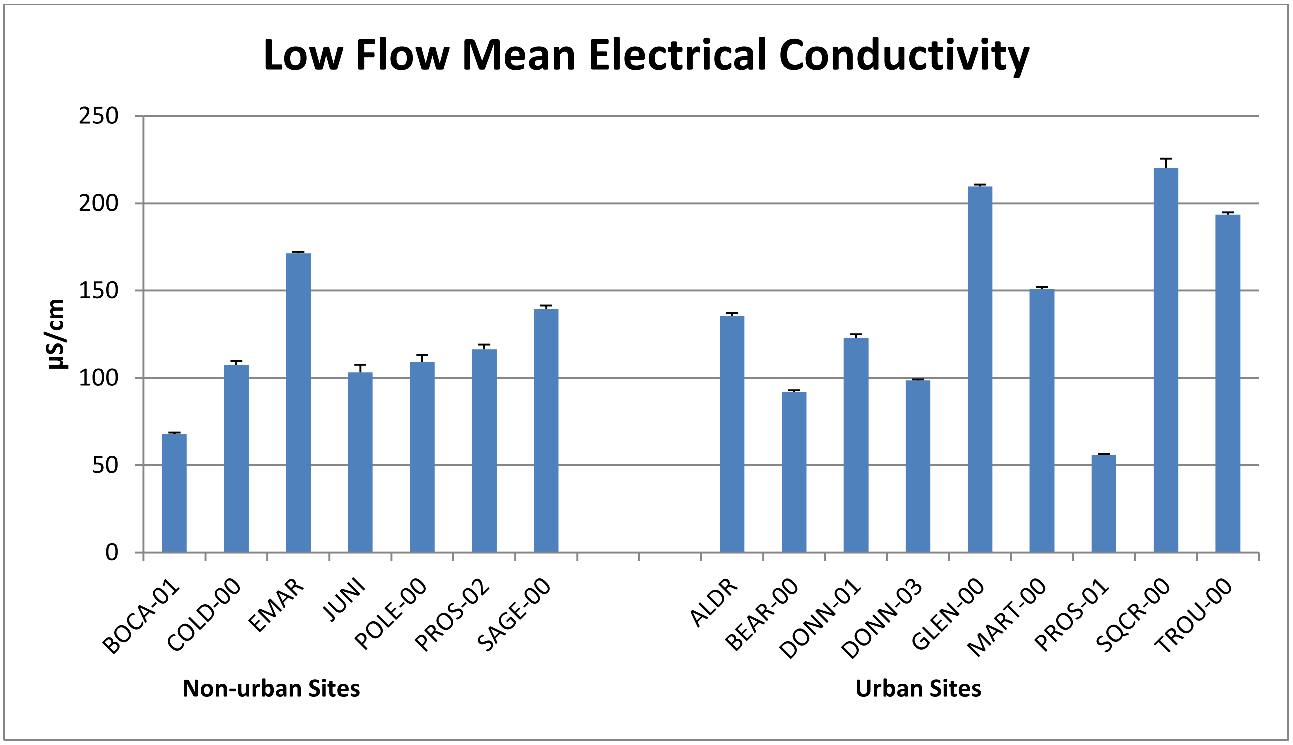

Figure 21. Average electrical conductivity measured during low flow for non-urban and urban sites. Error bars show standard error. Data are only shown from sites that have been monitored during both high and low flow conditions.

Table 9. Average electrical conductivity by site type (non-urban or urban) and flow (high or low flow). Conductivity is higher, on average, at urban sites at both high and low flows.

	Average Conductivity	
Site Type	High Flow	Low Flow
Non-Urban	68.5 µS/cm	116.4 µS/cm
Urban	91.7 µS/cm	142.1 µS/cm

In a previous analysis of data through 2008, there was not a clear difference between urban and non-urban sites. Additional data, especially from low flow events, has helped to demonstrate that there does appear to be a difference between the two types of sites – the trend was apparent after 2010, and has strengthened with inclusion of data through 2014 (Table 9). As is apparent from the graphs, there is a lot of overlap and variation between individual sites. Many other factors are likely to be influencing conductivity readings besides relative urbanization in the watershed (for example, proximity of the sampling location to a road that is regularly sanded could have a much greater influence).

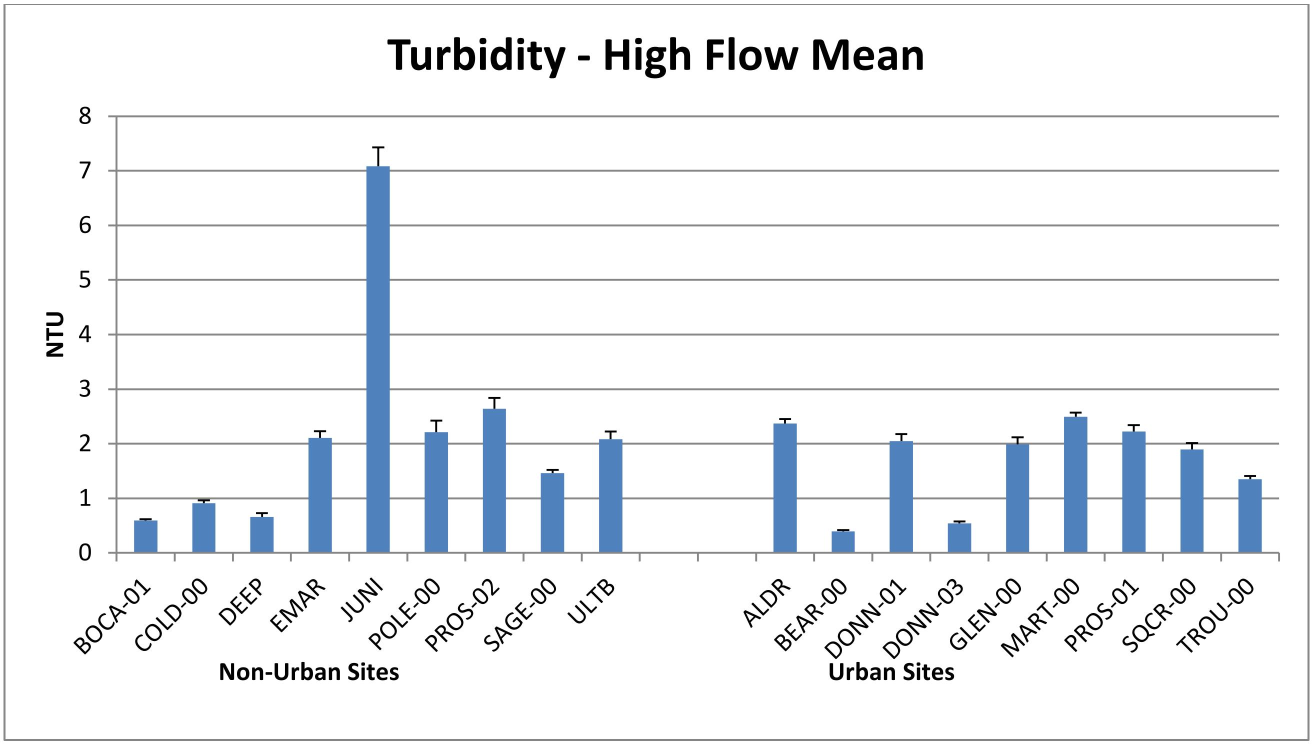

Figure 22. Average turbidity measured during high flow for non-urban and urban sites. Error bars show standard error. Data are only shown from sites that have been monitored during both high and low flow conditions.

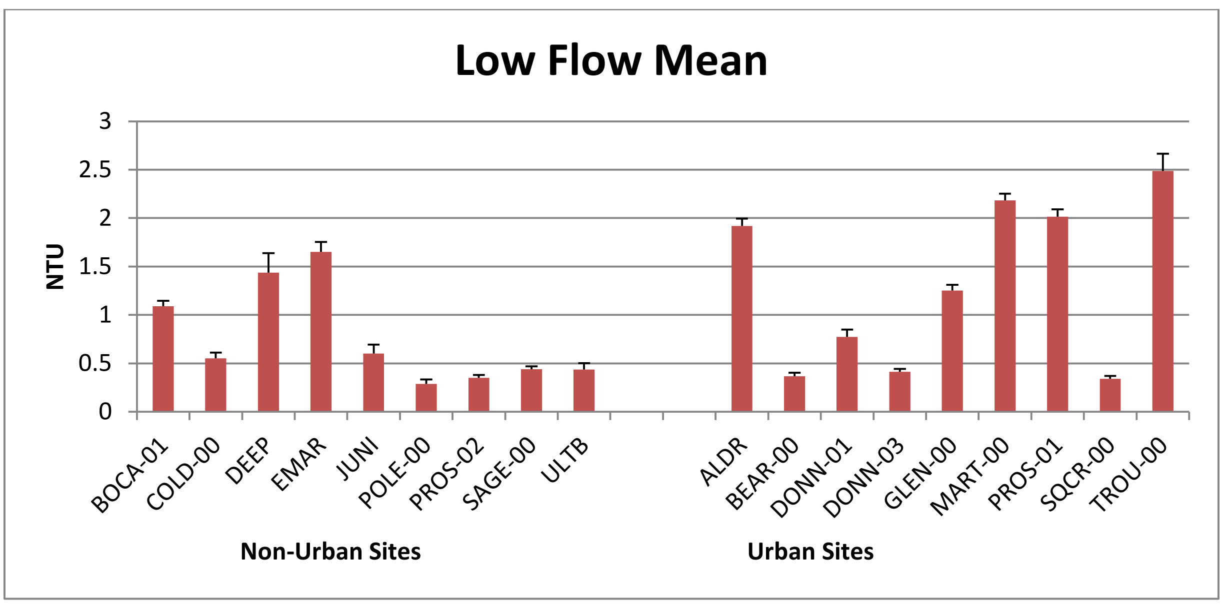

Figure 23. Average turbidity measured during low flow for non-urban and urban sites. Error bars show standard error. Data are only shown from sites that have been monitored during both high and low flow conditions.

Turbidity is highly variable among our sites. Some of the highest measurements come from non-urban sites – such as Juniper Creek (JUNI) and Prosser Creek at Highway 89 (PROS-02). Gray Creek (only measured during high flow; Figure 6b) has the highest turbidity readings in our watershed and is non-urban. The Juniper Creek and Prosser Creek watersheds have networks of poorly developed dirt roads, which may contribute significant amounts of fine sediment to the stream. The Juniper Creek watershed was partially burned during the 2001 Martis Fire, and some effects from that incident are still apparent.

Restoration Sites

Relating back to Objective 1, another land use we are tracking is the change in watershed condition achieved through restoration projects. Many of the restoration projects planned for the Truckee River watershed (either by TRWC or partners) are either in the planning phase or in very early implementation (Table 10). Therefore we have much more pre-project than post-project data. The majority of restoration projects are aimed at reducing fine sediment. Because we are interested in improving aquatic habitat through restoration, bioassessment data will be a good indicator of whether or not our restoration goals are being achieved.

Table 10. Sub-basins targeted for restoration, restoration goals, and metrics expected to improve after restoration.

Sub-basin	**Restoration Goals**	**Project Status**	**Metrics to monitor**
Upper Little Truckee River (Perazzo Meadows)	Reduce erosion, improve meadow and riparian habitat	Restoration began in 2009, project partially complete	% Chironomidae, % Baetidae, Community Tolerance, IBI Score
Trout Creek	Improve riparian habitat, reduce flood risk	Restoration began late in 2011, partially complete	% Chironomidae, % Baetidae, Community Tolerance, water temperature
Davies Creek	Reduce erosion, improve meadow and riparian habitat	Restoration completed in 2010, phase 2 work in planning phase	% Chironomidae, % Baetidae, Community Tolerance, water temperature, turbidity
Cold Creek	Reduce erosion	Restoration completed fall 2012; revegetation completed 2013	% Chironomidae, % Baetidae, Community Tolerance, water temperature, turbidity
Squaw Creek	Reduce erosion, improve meadow, aquatic, and riparian habitat	Planning phase	% Chironomidae, % Baetidae, Community Tolerance, IBI score, water temperature, turbidity
Martis Creek	Reduce erosion, improve meadow, aquatic, and riparian habitat	Planning phase	% Chironomidae, % Baetidae, Community Tolerance, IBI score, water temperature, turbidity

Restoration Sites – Bioassessment Data

Mayflies in the family Baetidae and true flies in the family Chironomidae can persist in streams that have an abundance of fine sediment. In the Truckee River watershed it has been found that abundance of these insect families decreases as the level of fine sediment in a stream decreases. Therefore, these are important metrics to track to determine if a biologically significant decrease in fine sediment is being achieved by restoration actions.

Community tolerance is a good overall metric that collapses data about how "tolerant" the overall condition of the biological community. We would expect that community tolerance would decrease as stream condition improves with restoration activities. Figure 24 is a graph of these sediment related bioassessment metrics for streams targeted for restoration.

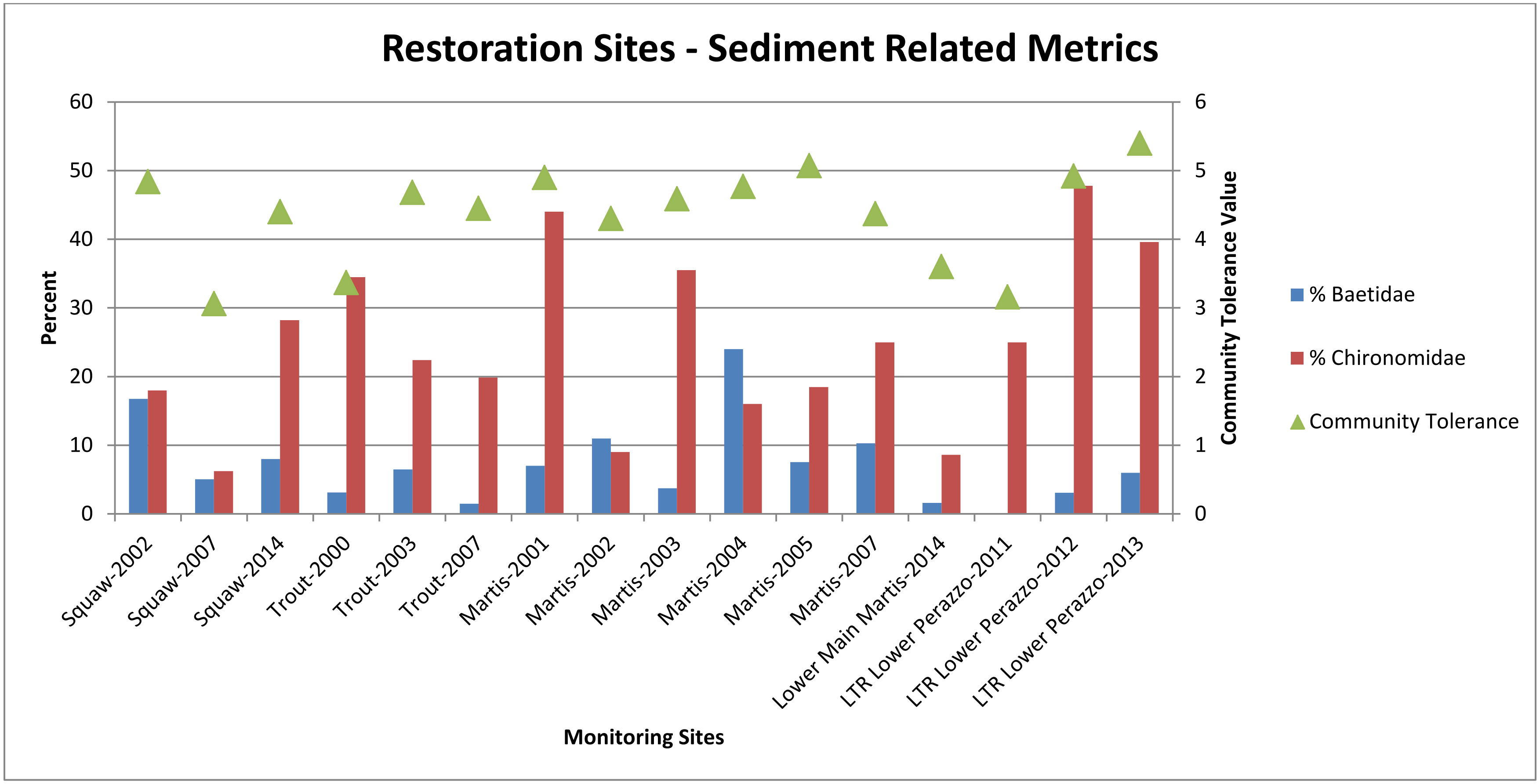

Figure 24. Bioassessment data from streams targeted for restoration, sediment related metrics.

We will continue to collect these data as restoration work is implemented at these sites. Most streams show elevated percentages of baetid mayflies or chironomid true flies. Community tolerance varies between about 3 to 6. Tolerance values of 3 are actually fairly good, compared to most streams in the watershed (Figures 12, 13).

The Davies Merrill stream and meadow restoration project began in 2005 and phase 1 was completed in 2010. By 2008, the majority of the restoration work had been completed. We can therefore begin to look at pre- and post-project data at this site. Figure 25 shows pre- and post-project bioassessment data for Davies Creek. The collection site is immediately below the confluence of Davies Creek and Merrill Creek, at the lowest point in the watershed.

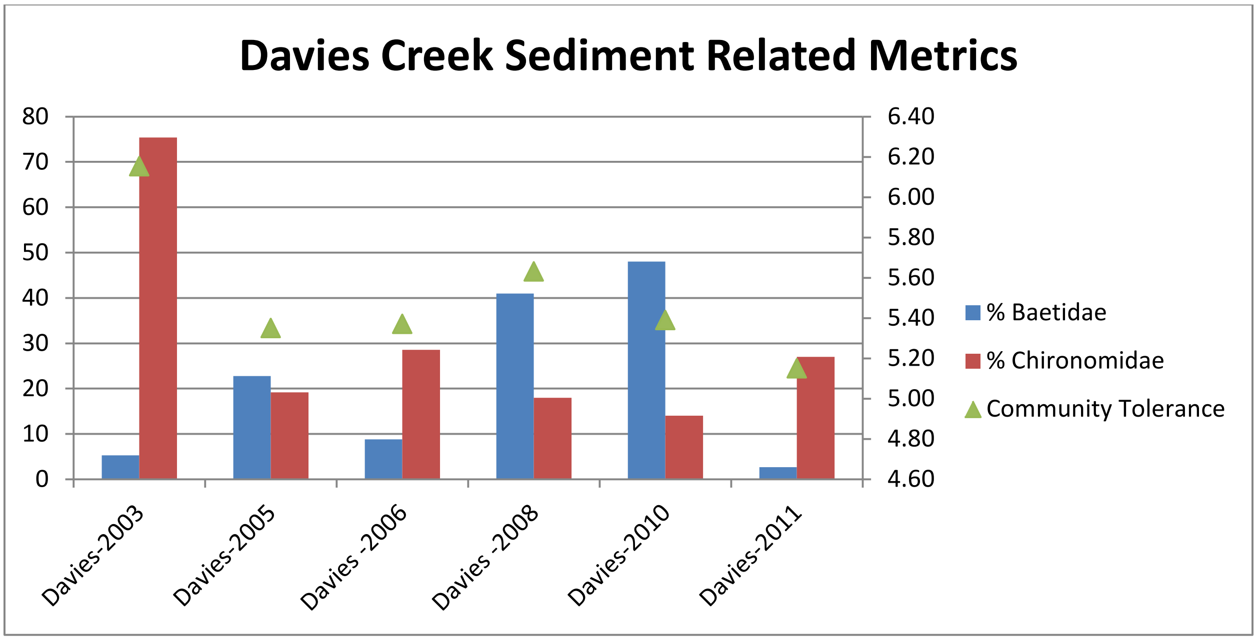

Figure 25. Bioassessment data for the Davies-Merrill Restoration Project, sediment related metrics. Restoration began in 2005 and was completed in 2010. Data collected in 2007 and later are considered post-restoration – the monitoring site is located immediately downstream of restoration work completed in 2006.

Pre- and post-project data collected from Davies Creek are not much different. However, we expect that a response may not be observed until several years after restoration. Streams in the watershed are still adapting to their new courses, and vegetation has yet to fully mature. We also may not see a very strong response in bioassessment metrics from this site. Many of the stream segments in the project area are ephemeral, which tends to skew most bioassessment data. We will continue to monitor Davies creek every 2-3 years.

We completed a major restoration project in Coldstream Canyon on Cold Creek in 2012, with final revegetation taking place in 2013. Figure 26 shows pre- and post-project bioassessment data for Cold Creek.

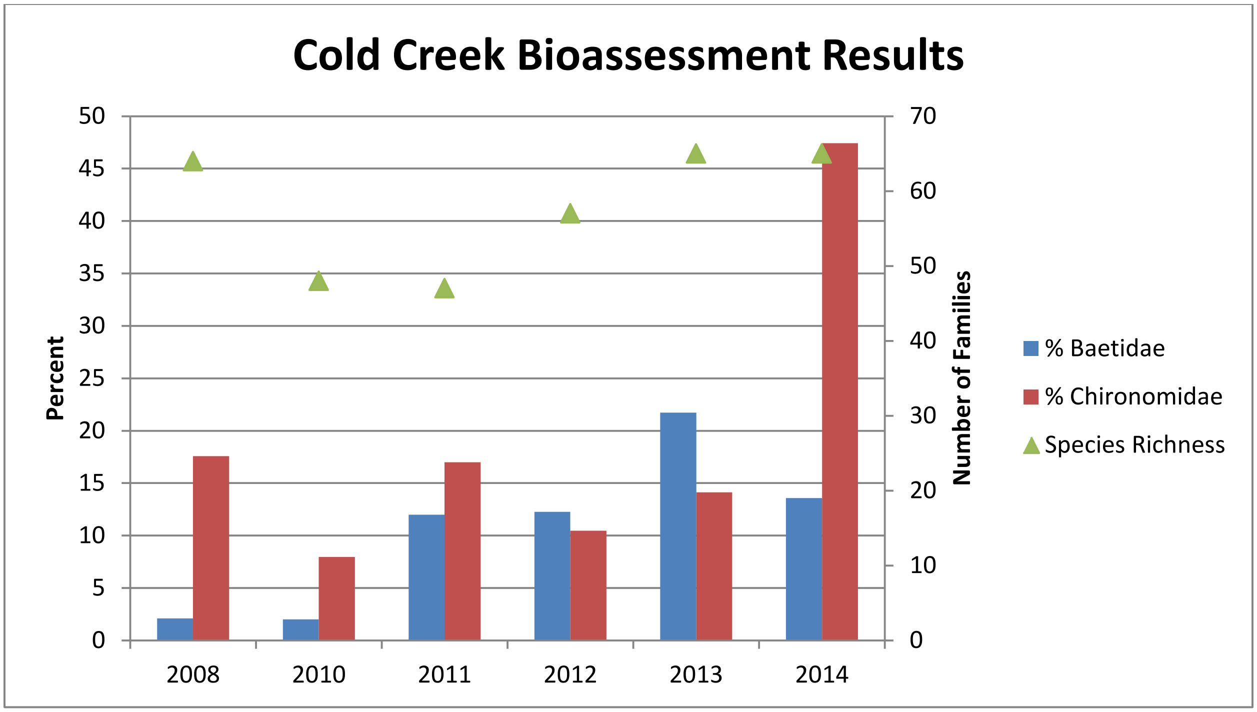

Figure 26. Bioassessment data for the Cold Creek Restoration Project, sediment related metrics. Restoration began in 2012 and was completed in 2013.

Although revegetation was completed late in the year in 2013 and survival was high through 2014, vegetation has not fully matured. However, the most striking result from monitoring in 2014 was the high percentage of the sample composed of Chironomidae. 2014 was the third year of drought in the Truckee River watershed, and during these low flow periods fine sediment accumulates on stream bottoms – which will favor sediment loving chironomid midges. We will continue to monitor this site periodically.

One other site we have some post-project data for is Perazzo Meadows. We collected pre-project samples from within the restoration area in 2008 - 2010. In 2014, we attempted to collect from within the restoration area again. As can be seen in Figure 16c the IBI score was extremely low - 28. When we sampled in 2014 there was barely any flow in the channel, although there was water. Between the low water and the presence of numerous beaver dams the aquatic habitat had converted to more of a marsh with standing water. The purpose of the restoration was to restore meadow hydrology with standing water and reduce in-channel erosion. In hindsight, we should have collected pre-project data from immediately below the restoration site. We predicted our restoration work would retain more sediment in the project area rebuilding meadow soils. Prior to restoration, the stream through Perazzo Meadows exported significant sediment downstream impacting the channel below.

IBI Scores

IBI scores are only available for a handful of streams in the Truckee River watershed as of yet. The Eastern Sierra IBI focuses on several sediment related metrics, as that is a pollutant of concern throughout the region. IBI scores will be a good way to track improvements in watershed condition over time. Both Martis Creek and Squaw Creek are targeted for restoration work, Table 6 and Figure 16 show IBI data from these watersheds. We will also be able use IBI data to track restoration progress in Davies Creek, Cold Creek, Perazzo Creek, and the Little Truckee River through Perazzo Meadows in upcoming years.

Restoration Sites - Water temperature and turbidity

One reason for increased water temperature is reduced streamside vegetation. Many of our restoration projects target improving riparian vegetation, which will increase shading and decrease water temperatures. Water temperature is also related to fine sediment – dark particles absorb more heat and therefore can increase water temperatures. In other restoration areas, stream channels have become wider and shallower; this also results in increased water temperature. Restoring streams to more appropriately sized channels will also decrease water temperature. Therefore, temperature is an important and easy to measure indicator of restoration success.

Turbidity is also a good indicator of restoration success at many of our sites. Turbidity is a measurement of fine sediment and other particles in water. Restoration aimed at reducing erosion should also result in lower turbidity measurements.

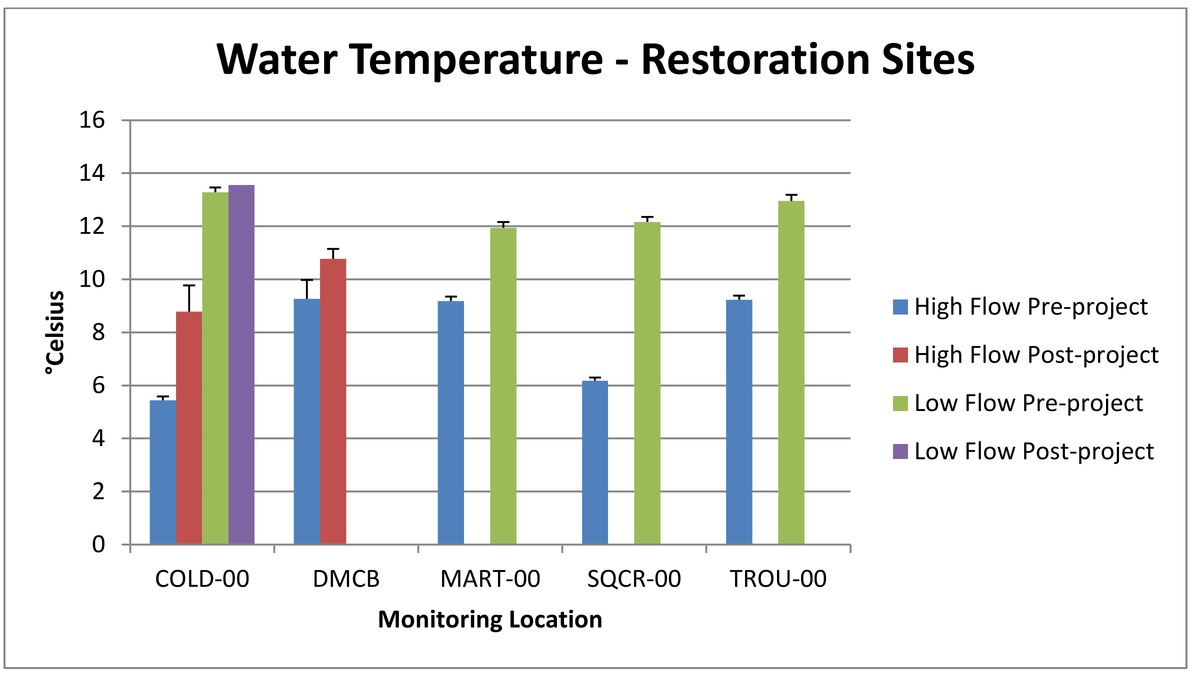

Figure 27. Water temperature from restoration sites.

Figure 27 shows pre-project and post-project temperature data, separated by high and low flow for restoration sites. We have some post-project data for Davies and Cold Creek, and only pre-project data for the remaining sites. Restoration has been partially completed at Trout Creek, but vegetation is still maturing, and several more phases of restoration are yet to be implemented. In general, temperatures during the warmer times of year (low flow) should show the most change between pre-restoration and post-restoration measurements. During high flow, snow melt is a major component of stream flow, leading to relatively cold temperatures across all monitoring locations. During base flow, influences such as stream side shading and width to depth ratio of the stream will have a much greater impact on water temperature.

There is not much difference between pre- and post-project temperatures for Cold Creek or Davies. In fact, post-project data for high flows are slightly higher. This is most likely due to the extremely low flow years that we have experienced starting in 2012. In the case of Cold Creek, riparian vegetation has yet to mature and provide stream shading.

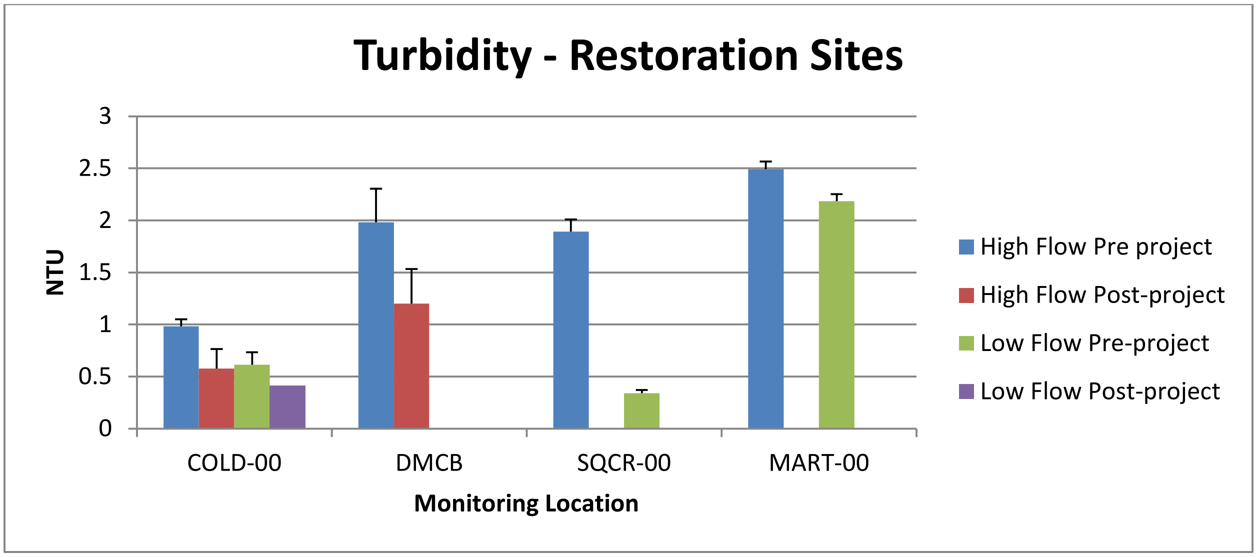

Figure 28. Turbidity measured at restoration sites.

Figure 28 shows turbidity data collected from sites targeted for restoration. As mentioned above, we have some post-project data for Davies and Cold Creek, and only pre-project data for the remaining sites. Both Cold Creek and Davies show slightly decreased turbidity after restoration was completed, however as mentioned in the temperature discussion 2012 and 2013 were extremely low water years, and flow has a strong effect on turbidity as well as temperature (lower turbidity during lower flows).

Objective:

2. To identify land use practices that negatively impact the Truckee River watershed, the extent of impact, and the geographic locations of concern.

To address Objective 2, we can look for “hot spots” or areas that exhibit poor water quality in more than one aspect and we can also compare our data against state established water quality standards. These analyses will help us to pin-point locations of concern, and we may be able to then identify the causes of poor water quality.

“Hot Spots”

Union Valley Creek (GLEN-00) consistently shows elevated nutrients – nitrate, soluble reactive phosphorus, and total phosphorus (Figures 7b, 8, 9b, and 10). It has also had positive results for coliform bacteria (Figures 11a and 11b). This stream drains the Glenshire Pond which is a shallow eutrophic body of water in the subdivision of Glenshire. This stream was added to our quarterly monitoring program in 2008 in order to better track water quality, and in 2013 we added an additional site on Union Valley Creek (GLEN-02). The new monitoring location is upstream of the Glenshire Pond, and also exhibited overall poor water quality. This implies that the pond may not be the biggest influence on Union Valley Creek. Of course, it is not possible to draw conclusions from a single monitoring event, so we will continue to monitor at both locations along Union Valley Creek (GLEN-00 and GLEN-02) as conditions allow. In 2014, we were unable to monitor GLEN-02 as the stream was dry at the beginning of the sampling season in May.

Squaw Creek has had consistently high electrical conductivity, turbidity, nitrate levels, and has had an elevated phosphorus reading (Figures 4a, 4b, 6a, 6c, 7a, and 10). Bioassessment data also indicate impairment in some reaches in some years (Figure 16a). A sediment TMDL has been developed for this stream, but continued monitoring of other constituents such as nitrogen concentration should continue. The stream runs through a ski area, parking lot, and golf course. A restoration plan for the creek is in development, which should improve water quality once implemented.

Martis Creek has shown slightly elevated soluble reactive phosphorus at both monitoring stations. Total phosphorus at the lower station (MART-00) has consistently been high during our monitoring events. The MART-00 station is located immediately above Martis Lake on the mainstem of Martis Creek. There have been concerns over nutrient levels in Martis Lake, particularly phosphorus. A preliminary study of phosphorus in the Martis watershed was undertaken by the Truckee Tahoe Sanitation Agency in 2004, however it was determined that further study was necessary. Martis Valley is a major focus area for Placer County, and several monitoring stations have been established in the Martis watershed (2nd Nature, 2008). Their monitoring also shows elevated phosphorus at several monitoring locations within the Martis watershed as well (CDM Smith and Balance Hydrologics, 2014). The Truckee River Watershed Council recently completed a watershed assessment of the Martis watershed and we have developed a conceptual restoration plan. Over the next several years, we will design and implement restoration projects in the Martis watershed which may help to improve water quality.

In general, coliform readings in the Middle Truckee River watershed have been low, but in most years, there may be one location that has high coliform. In 2014, the only site with measurable coliform was Martis Creek above Martis (Lake) with 17 colonies/100 mL. We will continue annual monitoring for coliform. If additional high readings are obtained, the next step would be to determine the source. It is possible to analyze coliform to determine whether the source is geese, beaver, human, dog, etc. We do not regularly do this analysis due to cost.

State Water Quality Standards

The easiest standards against which to compare our data are those for nutrients. Table 11 contains standards for the Truckee River. Standards have only been established for a subset of our monitoring locations.

Table 11. California State Water Quality Objectives for the Truckee River Hydrologic Unit

Surface Water	Site ID	Total P (µg/L)	NO3-N (µg/L)	Total N (µg/L)	TKN (µg/L)
Trout Creek at Mouth	MTR-TROU-00	40	50	150	100
Squaw Creek at Mouth	MTR-SQCR-00	20	50	180	130
Bear Creek at Mouth	MTR-BEAR	20	50	150	100
Truckee River at Lake Tahoe outlet	MTR-TR01	10	20	120	100

Figures 29-31 show nitrogen data with standards indicated. Figure 32 shows total phosphorus data.

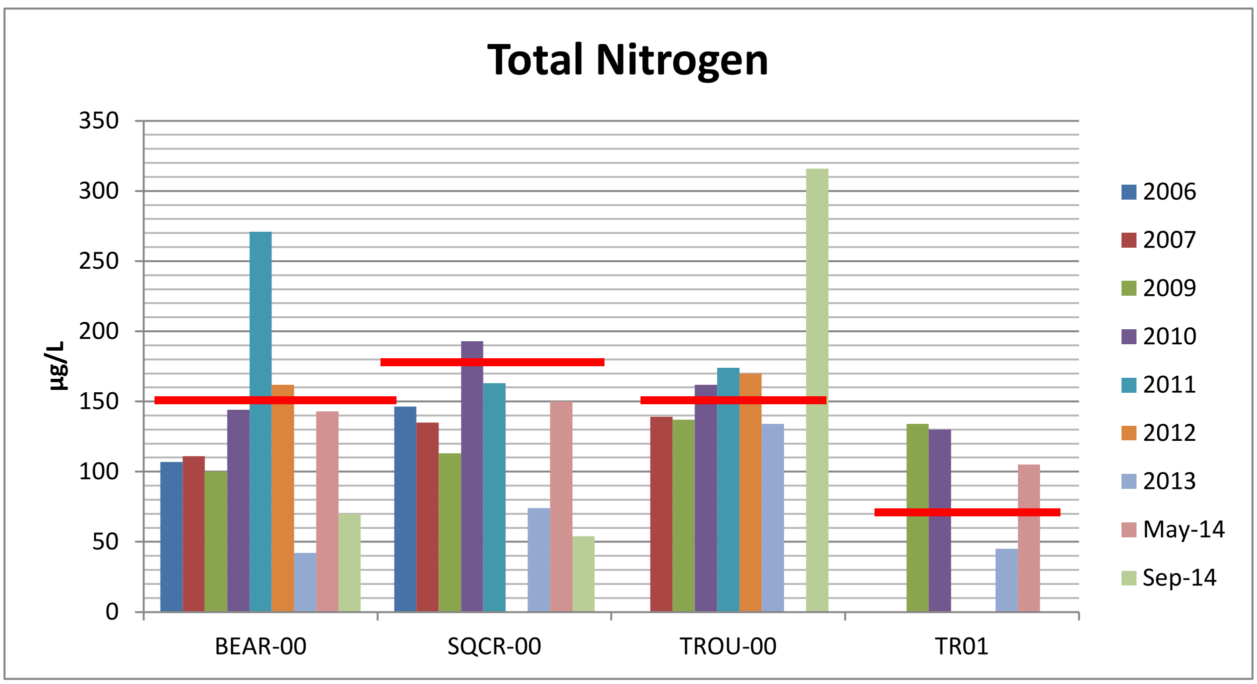

Figure 29. Total Nitrogen data for streams with California state standards. The red lines indicate the standard for each stream. Total nitrogen was only measured in 2006, 2007, 2009 - 2014.

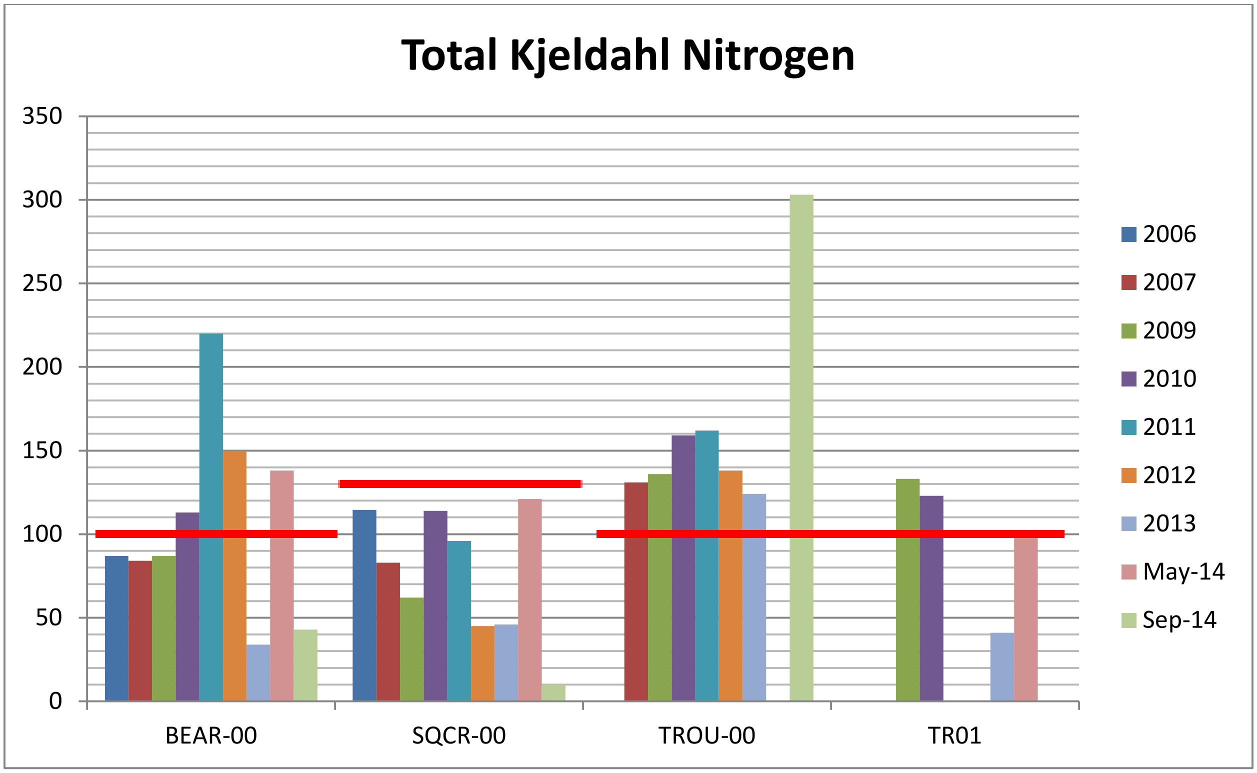

Figure 30. Total Kjeldahl nitrogen (TKN) for streams with California state standards. The red lines indicate the standard for each stream. TKN was only measured in 2006, 2007, 2009 – 2014.

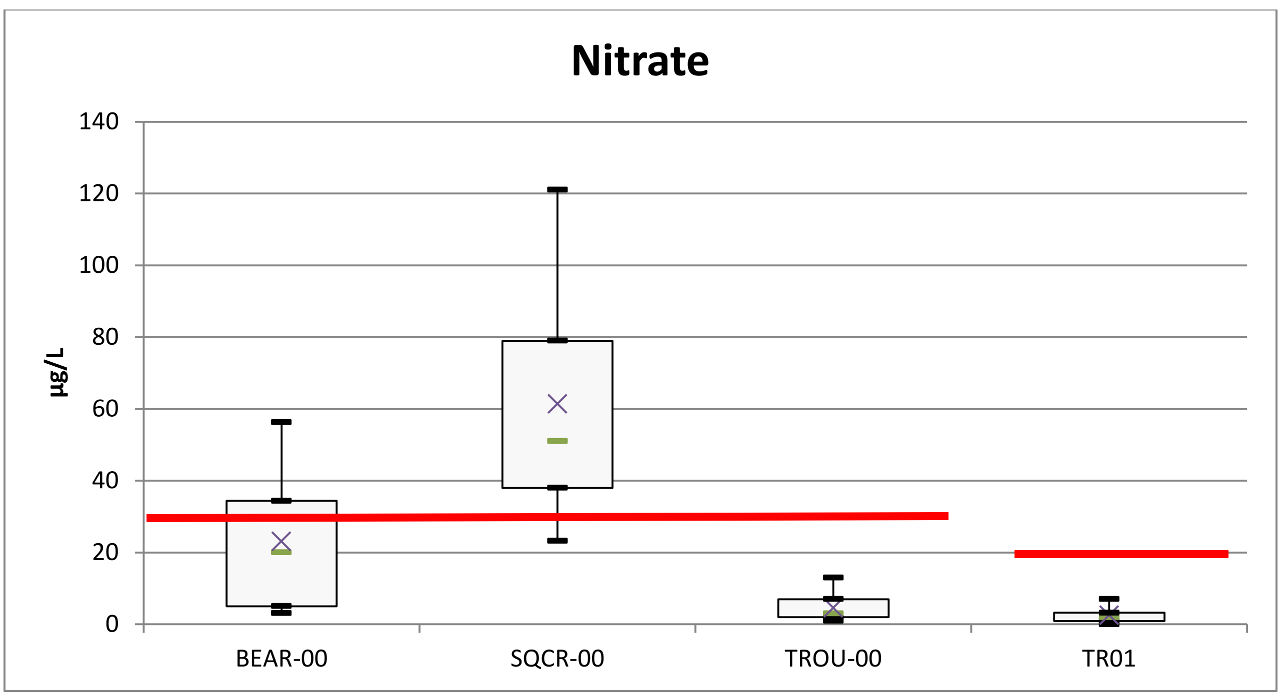

Figure 31. Nitrate for streams with California state standards. Nitrate has been measured since 2001; the box plots show the mean (X), median, maximum, minimum, 3rd quartile, and 1st quartile.

All of the streams monitored have exhibited at least one exceedance for one or more forms of nitrogen. TKN is an expensive analysis; therefore it has not always been possible to complete that analysis every year. However, these graphs point to the importance of analyzing all forms of nitrogen. If only nitrate is examined, then Trout Creek appears to be in good condition. However, once TKN is measured and total nitrogen can be calculated, a different picture emerges. Trout Creek has consistently exceeded the standard for TKN and has exceeded the standard for total nitrogen on one occasion. A similar picture emerges for the Truckee River at Lake Tahoe outlet (TR01).

Bear Creek has exceeded the nitrate standard on 3 occasions and Squaw Creek has exceeded the nitrate standard several times. However, both of these streams typically meet standards for both TKN and total nitrogen, with a couple exceptions.

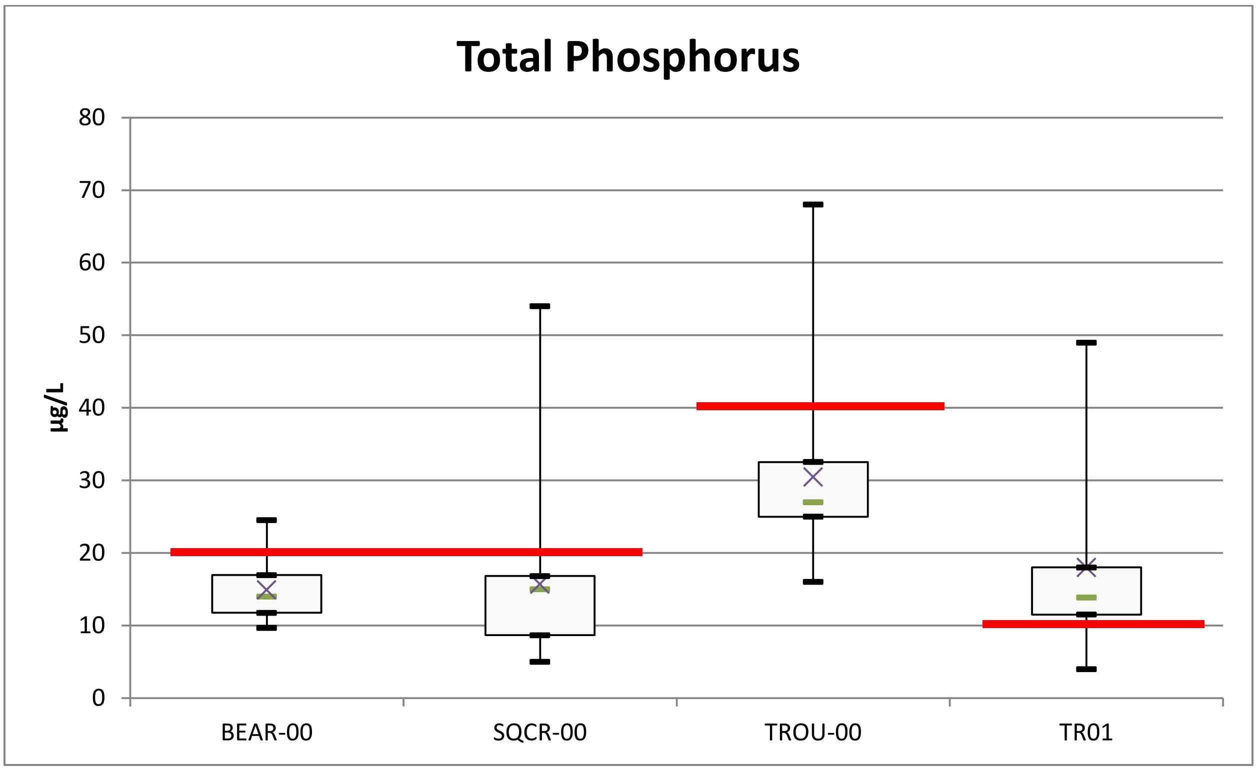

Figure 32. Total phosphorus for streams with California state standards. Total phosphorus has been measured since 2001; the box plots show the mean (X), median, maximum, minimum, 3rd quartile, and 1st quartile.

Bear Creek, Squaw Creek, Trout Creek and the Truckee River at Tahoe City have all exceeded the state standard for phosphorus on at least one occasion.

Comparisons with state standards show that most of the time, streams are meeting nutrient standards. However, all streams have exceeded at least one nutrient standard on at least one occasion with the Truckee River regularly exceeding the phosphorus limit. To better gain an understanding of the extent of excess nutrient concentrations, we collected two samples at some locations in 2014 – targeting the high flow and low flow. We will continue to collect multiple nutrient samples from target streams as we are able.

Objective:

3. To engage and educate residents about local watershed processes and strengthen their understanding of watershed stewardship.

Over 80 volunteers participated in at least one monitoring activity in 2014. Forty volunteers have committed to regular monitoring of 19 streams and 12 volunteers regularly participated with the bioassessment team. Education is stressed at monitoring trainings and events and the level of awareness among participants has increased.

Objective:

4. To enhance the quality and quantity of data available for resource managers and decision makers in the Truckee River watershed.

The Town of Truckee and Placer County developed a water quality monitoring plan for a portion of the Truckee River watershed (2nd Nature, 2008), and are in the first phase of implementation. The Truckee River Watershed Council participated in plan development and we are participating in the citizen's advisory committee for implementation. We have been able to tighten up the coordination between TRWC monitoring efforts and the Town's to better leverage resources.

TRWC conducted additional monitoring in support of the Truckee River sediment TMDL between 2010 - 2014, described below. We worked with an advisory committee for the project, with members from the Town of Truckee, Placer County, Lahontan Regional Water Quality Control Board, and U.S. Geologic Survey. The advisory committee ensured coordination and data sharing among various monitoring efforts.

Objective:

5. To provide data that can be used to help monitor the implementation of the Truckee River sediment Total Maximum Daily Load (TMDL).

Most of these data should be considered baseline in terms of tracking implementation of the TMDL. The TMDL was adopted in 2008. TRWC completed additional monitoring between 2010 and 2014 to support tracking of the TMDL, including establishment of continuous turbidity monitoring stations on two key tributaries (Cold Creek and Trout Creek) and further bioassessment studies, completed by contractors. Volunteer collected data will help to track implementation of the TMDL as well. Turbidity values and sediment related bioassessment metrics will be analyzed over time. IBI scores will also help to assess impacts to aquatic communities from sediment.

The TMDL monitoring demonstrated that although suspended sediment concentration was meeting standards defined in the Truckee River TMDL, we observed clear biological impacts from excess deposited sediment. Preliminary surveys indicated that deposited sediment may be widespread in certain habitat types along the river. Future work should focus on examining the extent of sediment deposition in the Truckee River.

Reports produced for the TMDL monitoring project are available at: www.truckeeriverwc.org/about/documents.

Objective:

6. To collect data to help provide pre-TROA implementation data, and to establish a program that will help to track changes in the condition of biological resources in the Truckee River watershed once TROA is implemented.

The Truckee River Operating Agreement (TROA) is a plan for river management, awaiting legal authorization. TROA will affect dam operations in the Middle Truckee River watershed and one of the goals of TROA is to improve aquatic habitat in the river. However, at present, there is no monitoring program designed to assess current conditions in the Truckee River and tributaries below dams. To help provide at least some baseline data, TRWC has collected benthic macroinvertebrate data from sites below dams that will be affected by TROA. The dams included in TROA are: Lake Tahoe, Donner Lake, Prosser, Independence Lake, Boca, and Stampede. Martis Lake is not included in TROA.

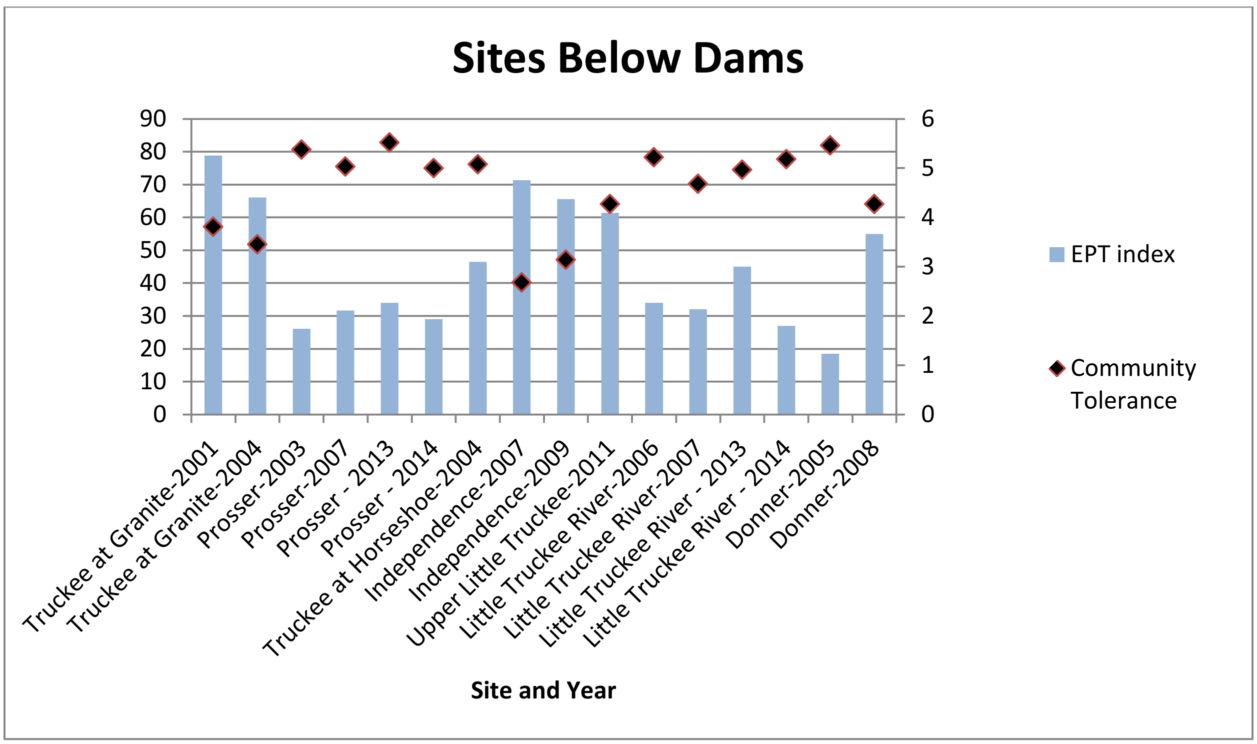

Figure 33. Community composition and tolerance data for sites below dams.

One commonly used metric of community composition is the “EPT Index”. This metric is simply the percent of the sample composed of insects in the order Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). Organisms in these orders tend to be less tolerant of poor water quality than other taxa. Additionally, this metric can be compared using both professionally and volunteer identified data. Community tolerance is also a good metric for looking at the overall biotic condition of the stream. Some of these below-dam sites are in fairly good condition based on these metrics (Figure 33), with the exception of Prosser Creek and the Little Truckee River. Instream habitat enhancement projects are being planned for both these locations.

Index of Biological Integrity scores are available for a few sites below dams – primarily Prosser Creek and Little Truckee River. Prosser Creek scores consistently “poor” on the IBI, whereas Little Truckee River above Boyington scored “fair” or “good” (Figure 16).

4.0 CONCLUSIONS

The majority of water quality data indicate that the Middle Truckee river watershed is in fairly good condition. There are streams that have exhibited evidence of impairment, and we will continue to monitor these sites. Some of these sites such as Squaw, Martis, and Trout have been targeted for restoration work, so we expect to see improvement over time.

We feel that it is important to continue monitoring the high quality sites as well. Protecting high value streams provides refugia for invertebrates and life stages of fish that are sensitive to pollution. The only means we have of assessing whether water quality is preserved at these sites in our watershed is the TRWC monitoring program. No other entities are monitoring these streams.

In 2014 we were able to collect an additional nutrient sample during low flow conditions. In the past, we have recognized that monitoring for both nutrients and coliform during low flows should be considered. Both nutrients and coliform concentrate with decreased flow, and we may find some impairment. We only monitor coliform Snapshot Day, when stream flow is at its peak. We were able to collaborate with the Lahontan Regional Water Quality Control Board in 2014 and include some Truckee River watershed sites in their coliform monitoring plan.

There continues to be strong volunteer involvement in our monitoring program. We anticipate being able to sustain and grow our existing programs to include more monitoring locations and volunteers while maintaining data quality. As we continue to monitor against our objectives, we will gain a greater understanding of our watershed.

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