



Wadeable Streams Monitoring

2014 results from Whiskeytown National Recreation Area and Lassen Volcanic National Park

Natural Resource Report NPS/KLMN/NRR—2017/1536



**ON THIS PAGE**

Photograph of Hollund Rudolph, laying out stream reach on Clear Creek, sample site WHISWQ25.
Photograph courtesy of the National Park Service (Photo by: Kathleen Doran)

ON THE COVER

Photograph of Hat Creek, sample site LAVOWQ29, in the Reading Fire burn area.
Photograph courtesy of the National Park Service (Photo by: Hollund Rudolph)

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Executive Summary

The Klamath Inventory and Monitoring Network established Wadeable Stream Vital Signs monitoring in 2011, with the peer reviewed protocol finalized in 2012. The protocol measures the ecological condition at a probabilistic sample (random-based) of wadeable streams across the park landscape that are: perennial, accessible, and can be safely sampled. Sampling consists of physical habitat measurements, water quality, water chemistry, riparian measures, and both invertebrate and vertebrate stream communities. Sampling is generally accomplished with a crew of four individuals, working in the summer months.

Sampling was undertaken to determine the ecological condition status of streams in two park units: Whiskeytown National Recreation Area, and Lassen Volcanic National Park. Sampling previously occurred in 2011, and 2014 marks the second sampling event for these park units. Ecological condition, “the state of the physical, chemical and biological characteristics, and the processes and interactions that connect them,” was assessed by measuring an array of stream biota, in-stream characteristics, water quality, and stream bank variables and metrics. These measures were then either used singularly or integrated to assign sites to condition categories of “Least Disturbed,” “Intermediate,” and “Most Disturbed”. These condition categories are based on Environmental Protection Agency (EPA) thresholds, which offer broad regional perspectives on condition, and the latter two categories do not necessarily reflect impairment for park streams. Rather, prevalence of Intermediate or Most Disturbed categories should be seen as an indicator for targeted investigations.

A more complete description of indices is provided in the methods, but a short description is provided here, in three categories (chemical, physical, and biological):

Chemistry: (1) Total phosphorous, (2) Total nitrogen – these are both nutrients indicative of pollution, (3) Salinity – an indicator of water withdrawal, and (4) Acid Neutralizing Capacity – indicative of acid deposition, either through rain or acid mine drainages.

Physical: (1) Relative Bed Stability (RBS) – a measure of sediment supply and transport, (2) In-stream Habitat Cover – a measure of habitat complexity, (3) Riparian Cover – a measure of how complex and multi-layered the streamside vegetation is, and (4) Riparian Disturbance – a measure of observed, potential anthropogenic disturbances streamside.

Biological: (1) EPA Regional Vertebrate Multi-Metric Index (MMI) – a composite measure of the fish and amphibian ecological integrity, (2) EPA Regional Invertebrate Multi-Metric Index – a similar measure using invertebrates for assessing ecological integrity, (3) Observed/Expected ratio – a measure of the amount of observed biodiversity to the expected biodiversity, and (4) a regional, state-based Invertebrate Multi-Metric Index.

Values this year at both park units appear related to low water availability – 2014 was a low precipitation year. New this year, an automated scripted software was used to increase repeatability and transparency and to improve efficient reporting.

Whiskeytown National Recreation Area

A total of 21 sites were sampled and assessed for ecological condition at Whiskeytown from 16 June to 5 August, 2014. Due to a hard-drive crash of our field tablet computer, not all assessments are available for all sites, and sample sizes vary among assessments in some cases. In response to the crash, we have instituted new methodologies to prevent future data loss.

Using **physical habitat measures**, the majority of streams are in the Least Disturbed category (77% of the combined physical assessments). **For Relative Bed Stability**, eight streams (50%) were assigned to the Intermediate assessment category and three streams (19%) to the Most Disturbed category (N=16 streams). These assignments may be related to the natural character of the rather than an indication of active impairment. **Riparian disturbance** was also high for two streams (11% [N=19]).

Using **chemical indicators**, most streams were assigned to the Least Disturbed category for all parameters except **Total Phosphorus**. For total phosphorous, 14 sample sites (67%) were assigned to the Intermediate category (N=21 streams) – although many of these measurements barely exceeded the upper level for the Least Disturbed category. For **Salinity**, one site (5.9% of 17 streams) was assessed as Intermediate. For **Nitrogen**, three (14%) were assessed as Intermediate, and two (9.5%) were assessed as Most Disturbed (N=21 streams).

Biota-based conditions revealed mixed results. Using vertebrates (fish and amphibians), 13 sites (81%) were categorized as Least Disturbed and three (19%) as Intermediate (N=16). A total of three amphibian and five fish species (including non-native brook and brown trout) were recorded. These species have all been previously identified on the park's certified species lists. Using the EPA benthic macroinvertebrates Multi-Metric Index, 15 sites (71%) were categorized as Least Disturbed, and six (29%) as Intermediate (N=21). The park-wide average for the benthic macroinvertebrate MMI was 76.8, falling in the Least Disturbed category. The use of the EPA Observed/Expected ratio of biodiversity loss averaged 0.85 for the park (or 85% of the expected biodiversity was encountered), also in the Least Disturbed category. A total of 11,965 benthic macroinvertebrates were collected, comprising 279 separate taxa.

Lassen Volcanic National Park

A total of 22 sites were sampled and assessed for ecological condition at Lassen Volcanic from 6 August to 24 September 2014. An additional two sites from 2011 were revisited, but were dry. They will be removed from the future sampling list because they are not perennial streams.

For physical habitat indicators, 29% of combined assessments for the 22 streams were in the Intermediate category. Individual metrics indicated the following:

Riparian Cover was in the Intermediate category for 19 sites (86%) and in the Most Disturbed category for one site. These results are partly due to the character of the montane, sub-alpine meadow streams common in Lassen Volcanic National Park, and are not a sign of degradation; the stream-side riparian zone is dominated by shrubs and grasses with reduced overstory. During 2014, the Riparian Cover characteristics are combined with low stream discharge to further reduce riparian

scores. **Riparian Disturbance** was assessed for 16 sites and was elevated to Intermediate in three sites (13.6%) on Hat Creek, Manzanita Creek, and Kings Creek, as well as two sites (9%) rated Most Disturbed on Manzanita Creek and Kings Creek. There were also two sites (9%) noted as having smaller than expected substrate sizes base on the **Relative Bed Stability** measure.

Using **chemical indicators**, all stream sites were assigned to Least Disturbed, except for **Total Phosphorous**, which showed 13 measurements (59%) in the Intermediate category, although many are borderline with Least Disturbed, as well as five (23%) in the Most Disturbed category (N=22 sites). This is indicative of the volcanic nature of the local geology, and not a sign of impairment. The 2014 phosphorous values likely increased over 2011 due to the lower amounts of water.

Biota-based condition estimates showed mixed results. Using **vertebrates** (fish and amphibians), most sites (12, or 70.5%) were Intermediate, (N=17 for vertebrate analyses because five sites had no vertebrates). The remaining five sites (29.4%) were in the Least Disturbed category. Only two amphibian species were found, and three fish species were recorded (native rainbow trout, and the non-native brook and brown trout). All species were already on certified park species lists. Condition using **benthic macroinvertebrate metrics** showed most sites (53, or 80.3%) in the Least Disturbed category (N=66 assessments), especially the EPA Multi-Metric Index, and averaged 75.6, falling in the Least Disturbed category. **Observed/Expected ratios of invertebrate biodiversity** had a park-wide average of 0.92, or 92% of the expected species were encountered (in the Least Disturbed category). When applying the Eastern Sierra Multi-Metric Index (developed for the Eastern Sierra, but potentially applicable to Lassen), four sites (4.5%) were Intermediate, and two sites (9%) were Most Disturbed (N=22). A total of 13,888 individuals were collected, comprising 175 separate taxa.

For both of these parks, we are beginning to understand the annual variation of the physical, chemical, and biological attributes of streams, however, it is important to interpret early years of data with caution. Additional years of monitoring data will provide a better understanding of unique characteristics of stream reaches, and increase our ability to differentiate anthropogenic impacts from natural variation.

Acknowledgments

This project is the result of many thoughtful discussions with park staff during the development of the streams monitoring protocol, including discussions of reporting strategies. For this field season, we especially acknowledge the diligence of the streams field crew: Kathleen Doran, Hollund Rudolph, and Leah Roper. Joe Nichols and Matt Romeyn of Whiskeytown also helped during the crew time in Whiskeytown. Park specialists and resource managers were also invaluable in implementing the monitoring. At Whiskeytown National Recreation Area, special thanks go to Sean Denniston, Jennifer Gibson, Brian Rasmussen, and Russ Weatherbee; at Lassen Volcanic National Park, special thanks to Michael Magnuson. Additional thanks to Tom Philippi for early assistance in compiling the R Code, Allison Snyder for database management work, and Alice Chung-MacCoubrey for guidance and support.

Introduction

The Klamath Network (KLMN) vital signs selection process identified two freshwater aquatic resource vital signs for monitoring: Aquatic Communities and Water Quality ([Sarr et al. 2007](#)). Prioritization of these vital signs was driven by potential natural and anthropogenic disturbance of freshwater habitats and resources.

Initial selection of aquatic communities and water quality did not differentiate between lentic (lake and pond) versus lotic (stream) habitats. Fundamental differences in ecosystem structure and process between streams and lakes dictated a basic division in sampling methodology. Lentic sampling is covered in a separate protocol ([Dinger et al. 2012](#)).

Because streams are integrated ecosystems central to park landscapes, we have chosen to monitor physical, biological, and chemical parameters in concert. These varied parameters allow measurement of change on multiple scales in time and space. For instance, macroinvertebrate assemblages respond rapidly to impacts, while fish and amphibians (with longer life cycles) will demonstrate longer duration, time-integrated responses. Changes in geomorphic and riparian vegetation features will likely manifest at yet longer time scales. The use of multiple indicators for measuring ecosystem change provides an integrated and robust system for interpreting natural dynamics, and for detecting trends in key ecological features and diverse impacts over time.

Sampling was undertaken to determine the ecological condition status of streams in two network parks: Whiskeytown National Recreation Area (hereafter “Whiskeytown”) and Lassen Volcanic National Park (hereafter “Lassen Volcanic”). To meet this goal, two definitions are important:

- “Ecological condition” – From the Environmental Protection Agency (EPA) Report on the Environment, “ecological condition” is defined as “the state of the physical, chemical and biological characteristics of the environment, and the processes and interactions that connect them” ([USEPA 2008](#)).
- “Status” –defined as “some statistic (e.g., a mean/median/proportion) of a parameter over all monitoring sites within a single or well-bounded window of time. Status will always have some measure of statistical precision (e.g., a confidence interval, standard error, variance)...” ([Sarr et al. 2007](#)).

For determining the common conceptual use of “ecological condition” and “status” we use condition thresholds of 12 metrics used by the EPA or states. These thresholds are used to categorize sites into condition classes: “Least Disturbed”, “Intermediate”, and “Most Disturbed”. Other reports by the EPA use “Good”, “Fair”, and “Poor” for the same classes and metrics. These classes, based on west-wide and mountainous reference conditions, are meant to be guides and not absolutes in defining park condition. Final assessment may require follow-up investigations or consultation with park specialists.

Methods

The methods used for monitoring KLMN streams were adapted from the EPA Environmental Monitoring and Assessment Program—now the National Rivers and Streams Assessment program (USEPA 2009)—with modifications to fit KLMN time, logistics, and budgetary constraints. The methods described below are abbreviated descriptions of the methods used in data and sample collection. Full descriptions of methodology are contained in the protocol for Integrated Aquatic Community and Water Quality Monitoring of Wadeable Streams in the Klamath Network (Dinger et al. 2013). Additionally, methods are provided for some field sampling that is not analyzed or reported herein—they are included here for providing an overview of the portfolio of data that will be available in future Analysis and Synthesis reports (Dinger et al. 2013), or upon request.

Implementation Schedule

KLMN aquatics monitoring was initiated in 2011 and occurs on a three-year rotation. The wadeable streams monitoring occurs in years 1 and 2, and the lakes and ponds monitoring occurs in year 3 (Table 1). Wadeable streams were sampled at Whiskeytown and Lassen Volcanic for the first time in 2011 (Dinger and Sarr 2014), were resampled in 2014 (the subject of this report), and will be revisited again in 2017.

Table 1. Parks and aquatic vital signs monitored on the three year rotation schedule.

Monitoring	Year 1	Year 2	Year 3
Streams	Whiskeytown	Oregon Caves	–
	Lassen Volcanic	Redwood NSP	–
	–	Crater Lake	–
Lakes	–	–	Lassen Volcanic
	–	–	Crater Lake
	–	–	Redwood NSP

Site Selection

For each park, a target goal of 25 to 30 sites was identified in the wadeable streams protocol (Dinger et al. 2013). However, due to particular circumstances of field season logistics, the total number sampled in a year may or may not meet that number. Sample sites were located probabilistically using Generalized Random Tessellation Stratified (GRTS) spatially balanced design (Stevens and Olson 2004) in the spsurvey package (Kincaid 2012) for R statistical software (version 2.11.1; R Core Development Team, Vienna, Austria). The sampling frame included all perennial streams within a park unit that were: (1) <1000 m from an established road or trail, (2) had a streambed gradient less than 15% based on data that were obtained from the USGS National Hydrography Dataset (www.nhd.usgs.gov). This sample frame then defines the population to which the presented status estimates can be applied.

The final selection or rejection of sample sites upon initial visitation was determined by the field crew leader on site, who considered access and safety issues. All sites had been previously visited in

2011. If a crew comes to a site previously sampled that is dry, it is dropped from the sampling list, and a replacement from the GRTS generated list is used in its place (if the target number of stream sites is obtained). A total of 43 sites were sampled in 2014: 21 sites in Whiskeytown and 22 sites in Lassen Volcanic.

Site Layout

At each selected sample site, a sample reach 40 times longer than the typical wetted width of the stream was established and 11 equally spaced transects perpendicular to stream flow were marked with temporary flagging (Figure 1). A minimum reach length of 150 m and a maximum reach length of 500 m were imposed.

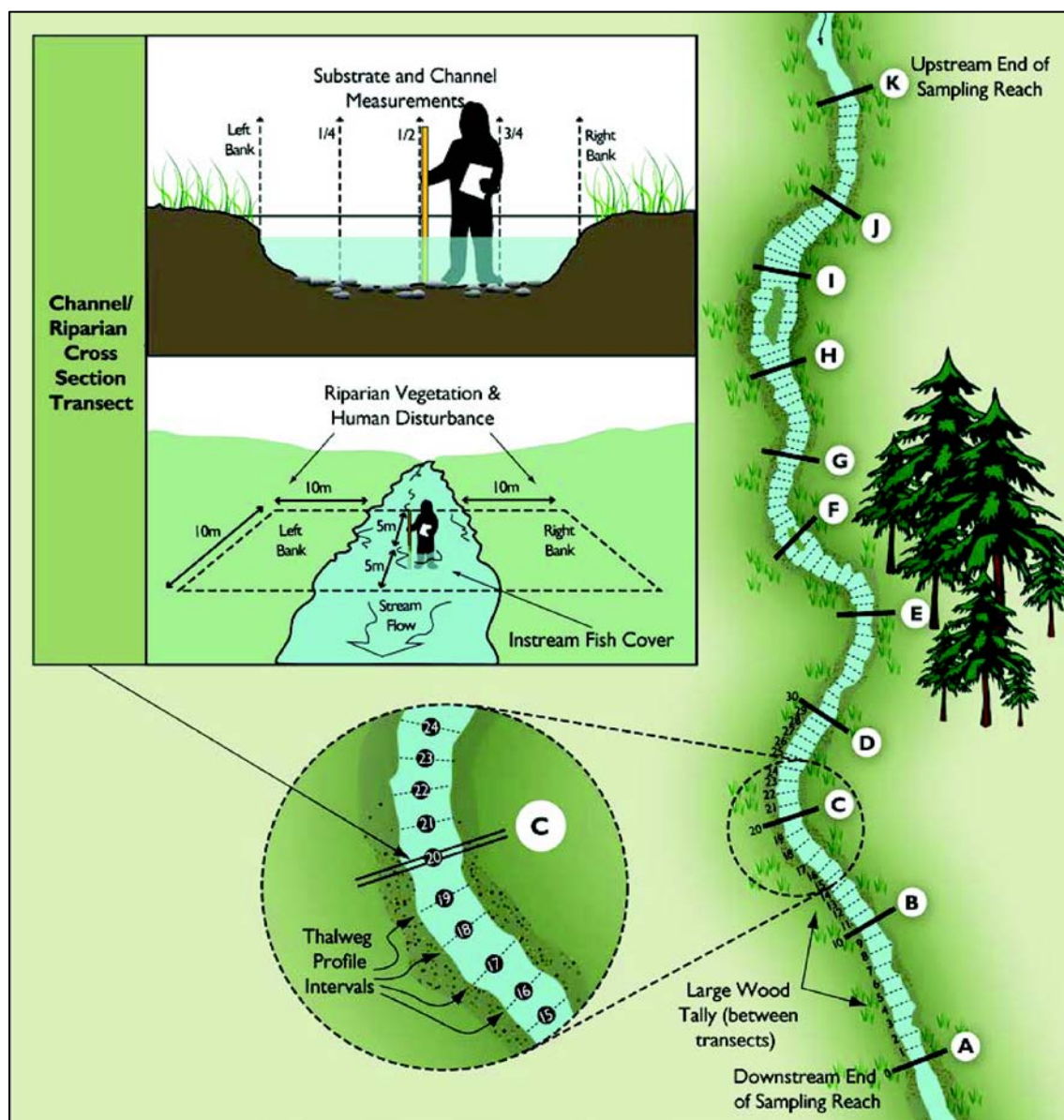


Figure 1. Schematic of sampling site reach layout (from EPA Wadeable Streams Assessment, 2006, Figure 11).

Water Chemistry and Quality

Measurements of temperature ($^{\circ}\text{C}$), pH, specific conductivity ($\mu\text{S cm}^{-1}$), dissolved oxygen (mg L^{-1}), and turbidity (NTU) were made at mid-depth in seven locations along a cross-section that extended perpendicular to stream flow in a well-mixed riffle using an Eureka Environmental “Manta” water quality probe. Specific conductivity was used to ensure that the riffle was well mixed by assessing the seven cross-section measurements for variability. If the specific conductivity varied more than a $5 \mu\text{S cm}^{-1}$ differential across the stream, the measurement was repeated in an upstream riffle until a well-mixed riffle was confirmed.

When a well-mixed riffle was confirmed, a 2 L amber high-density poly-ethylene (HDPE) sample bottle was submerged to collect a water sample. On shore, using a 60 ml syringe and filter holder, a portion of each water sample was filtered through a $0.45 \mu\text{m}$ nylon membrane filter into an amber, acid washed 250 ml HDPE bottle for cation (Ca^{2+} , Na^{+} , K^{+} , and Mg^{2+}) and anion (SO_4^{2-} and Cl^{-}) analyses. An additional unfiltered 250 ml of water was decanted into an identical bottle for nutrient analyses (Total Nitrogen, Total Phosphorous). Both bottles were kept on ice until we were able to freeze them (generally <4 hours). Additionally, 120 mL of water were filtered through precombusted glass fiber filters into an acid-washed, precombusted glass vial for Dissolved Organic Carbon (also kept on ice and later refrigerated). These samples were then shipped to the Cooperative Chemical Analytical Laboratory at Oregon State University, Corvallis. See Dinger et al. (2013) for details on detection limits and analytical techniques for each parameter.

Stream Habitat/Riparian Corridor Characteristics

For the length of the reach, we assessed the following geomorphic characteristics: channel constraint type and percent constrained, channel pattern (braided, anastomosing, single), and evidence of recent torrents. Anastomosing channels are multithreaded, but are much more stable than braided channels and commonly have thick clay and silt banks and occur at lower gradients of stream bed.

At each of the 11 transects, we measured cross-sectional information including wetted width, bank angles, undercut banks, presence and height of incised banks, and bankfull width and height. Across the transect (left bank, $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, and right bank), we measured depth, substrate embeddedness (proportion of large substrate encased in fine substrates), substrate size, and algal periphyton thickness (as in [Fetscher et al. 2010](#)).

On each bank and in the middle of the stream at each transect, we collected measures of overhead shading with a convex, spherical densiometer. Areal categorization of fish habitat cover 5 m above and 5 m below the transect in the following classes were estimated: artificial substrate, boulders, filamentous algae, large wood, macrophytes, overhanging banks, roots, small wood, and undercut banks. In a 10×10 m quadrat next to the transect, we also estimated measures of riparian structure (dominant vegetation type; cover classes [sparse, moderate, heavy, very heavy] of small trees and large trees, herbs, grasses, etc.) in the ground layer (<0.5 m), understory (0.5 to 5.0 m), and overhead canopy (>5 m). In this same quadrat, we quantified the presence of human influences (e.g., walls, dikes, inlet/outlet pipes, camping, etc.).

We also measured thalweg depths along a longitudinal profile that extended throughout the length of the reach, taking equally spaced measurements of max depth, presence of soft or small sediments, and channel form type (pool, glide, riffle, rapid, etc.) (see Figure 1). At the midpoint between transects, we repeat the cross-section measurements (as above) of substrate type and algal thickness.

Inter-transect measures of downed woody debris were also made for the length of the reach. Woody debris was tallied for categories of length and diameter, both within the bankfull stream channel and in adjacent areas above bankfull height.

Stream gradient is measured between transects using a stadia rod and handheld level. An observer with the hand level stands at the approximate halfway point, and a stadia rod is placed at the transects; the difference between upstream and downstream is recorded for the rise. In this way, the total slope and variation in stream gradient can be measured.

The height and broad taxonomic grouping (Alder/Birch, Willow, Maple, Oak, Pine, Spruce, etc.) of the dominant tree located at each cross-sectional transect were also assessed and recorded.

Aquatic Communities

Benthic macroinvertebrates were collected using the EPA reach-wide benthos technique (USEPA 2009). At each transect, a 1 ft. wide D-frame net (500 μ m pore size) was used; in fast water habitats, the upstream substrate in a 1 ft.² area was disturbed so that organisms flowed into the net for collection. In slack water habitats, an active sweep was used in a 1 ft.² area to collect the organisms. The 11 collections were composited and elutriated (i.e., the lighter debris/macroinvertebrates are separated from the heavier inorganic substrates). The sample was then preserved in 90% ethanol and sent to a contract taxonomy lab for enumeration and identification. (For this sampling year, the samples were sent to Rhithron Associates, Inc.).

Aquatic vertebrates were sampled with a Smith-Root LR-24 electrofisher, using single pass. The time spent on a particular reach varies, but total targeted shock time was between 900 and 1,200 seconds. Fish and amphibians netted were stored in a bucket with a battery powered aerator. Specimens were recorded to species, enumerated, and the total lengths of the longest and smallest specimen were recorded. For salmonid species, the number in each size class was also recorded (<60 mm, 60–90 mm, 90–120 mm, 120–150 mm, and >150 mm).

Algal biomass was collected by taking a sample from each transect, following the reach-wide benthic technique. Collection technique varied based on dominant substrate at each transect: (1) if cobble, then a 12.6 cm² area was scrubbed using a stiff brush and a rubber delimiter to mark the area, (2) if gravel/sand, then a 12.6 cm² core was used to collect the substrate, and (3) if bedrock, then a 5.3 cm² sample was taken with a disposable scrubber in situ. Samples from each transect were processed, and composited into a single container. An aliquot was then taken for Ash Free Dry Mass and filtered onto a glass-fiber filter. A second aliquot was filtered on nylon membrane filters for chlorophyll *a* analysis. Filters were then kept on ice and frozen as soon as possible (along with water samples). Chlorophyll processing (extraction and measurement of concentration with fluorometer) was

completed at a contract laboratory; in this sample year we worked with Cascade Research (John Salinas of Grants Pass, Oregon).

Metric calculation and data processing

The protocol produces large amounts of data that are entered into a Microsoft Access database in the field on a ruggedized tablet computer (Dinger et al. 2012). After the data are verified and validated, computer code compiled for R statistical software (R Core Team 2016) was used to provide summary statistics. R is a powerful software to accomplish not only statistical analyses, but also data manipulation; and in this case is used to do batch processing of multiple metrics calculated from raw physical, chemical, and biological measures. The R code used to compose the tables in the Results section of this report is publically available, so that the calculated metrics can be recreated by others and offers full transparency on how the status assessments were determined (NPS 2017, includes link to downloadable data and R-code).

Because use of the automated code improves several aspects of metric calculation, the code was also used to recreate the data tables from the 2011 report (Dinger and Sarr 2014). These revised tables are presented in Appendix D, including an itemized list of improvements and changes associated with using the code.

Calculating Indicators of Ecological Condition

Following the EPA established “indicators of aquatic stress” in its Wadeable Streams Assessment (USEPA 2006) and the EPA EMAP (Environmental Monitoring and Assessment Program) Ecological Assessment of Western Streams and Rivers (Stoddard, Peck, Paulsen et al. 2005a), we use 12 indicators of condition, including a state indicator for macroinvertebrates. These indicators cover three broad categories of assessment: 1) biological, 2) chemical, and 3) physical habitat conditions of a stream. For each indicator, the EPA uses thresholds for determining three condition classes: Least Disturbed, Intermediate, and Most Disturbed. Additionally, a regional macroinvertebrate Multi-Metric Index using state of California thresholds was used in assessing condition. Each indicator and its calculation are described briefly below (text adapted from Stoddard, Peck, Paulsen et al. 2005a).

Total Phosphorous

Phosphorous is a nutrient and is usually considered to be the most likely nutrient limiting algal growth in freshwaters throughout the United States. It is a common ingredient in fertilizers, and high concentrations may be associated with agricultural and urban land use. In the KLMN, this sample is taken at a single, well-mixed riffle near the midpoint of the stream reach, and an unfiltered portion is frozen and sent to an analytical laboratory for analysis.

Total Nitrogen

Nitrogen is another nutrient and is particularly important as a contributor to coastal and estuarine algal blooms. Sources include fertilizers, wastewater, animal wastes, and atmospheric deposition. In the KLMN, this sample is taken at a single, well-mixed riffle near the midpoint of the stream reach, and an unfiltered portion is frozen and sent to an analytical laboratory.

Salinity

Excessive salinity occurs in areas with high evaporative losses of water, and can be exacerbated by repeated use of water for irrigation, or by water withdrawals (by slowing transit time of flowing waters). Both electrical conductivity and total dissolved solids (TDS) can be used as measures of salinity; for KLMN monitoring we follow NPS Water Resources Division (WRD) guidance and measure specific conductivity.

Acid Neutralizing Capacity

From the Wadeable Streams Assessment (USEPA 2006), streams and rivers can become acidic through the effect of acid deposition (e.g., acid rain) or acid mine drainage, particularly from coal mining. In assessing acid pollution (either acid rain or mine drainage), the KLMN relies on a measure of water's ability to buffer inputs of acid (Acid Neutralizing Capacity; ANC). When ANC falls below zero, the water is considered acidic and can be directly or indirectly toxic to biota (i.e., by mobilizing toxic metals, such as aluminum). When ANC is between 0 and 25 $\mu\text{eq/L}$ (0 and 1.25 mg/L CaCO_3), a stream is considered sensitive to episodic acidification.

Streambed Stability (aka Relative Bed Stability)

Streams and rivers adjust their channel shape and streambed particle size in response to the supply of water and sediments from their drainage areas. One measure of this interplay between sediment supply and transport is relative bed stability (RBS). The measure of RBS used here is a ratio comparing the particle size of observed sediments to the size of sediment each stream can move or scour during flood stage, based on the size, slope and other physical characteristics of the stream channel. The RBS ratio differs naturally among regions, depending upon landscape characteristics that include geology, topography, hydrology, natural vegetation, and natural disturbance history. Values of the RBS can be substantially lower (prevalence of fine sediments) or higher (coarser, more stable streambeds) than those expected based on the range of the least disturbed sites—both high (stressor-altered flow) and low (stressor-increased sedimentation) values are considered to be indicative of impairment (Figure 2). Currently we utilize an RBS value based purely on stream gradient and average stream depth (Kaufmann et al. 1999). A more refined RBS, incorporating residual pool depth, woody debris, and bankfull characteristics will be used in later reports when reporting and analysis tools are available from the EPA.

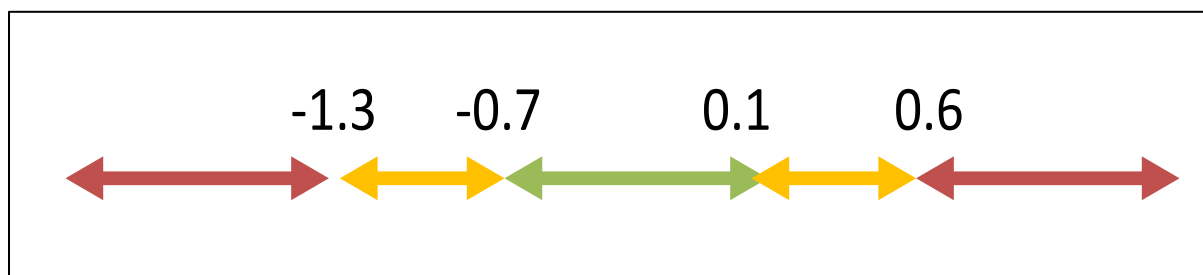


Figure 2. Numeric range and thresholds for RBS condition assessment. Red line = Most Disturbed, yellow line = Intermediate, and green line = Least Disturbed. Higher values suggest stable streambeds with altered flow regimes (e.g., upstream dams) and lower values suggest increased sediments from human landscape use. See text for more details.

In-stream Habitat Cover

This metric is termed “habitat complexity” in Stoddard, Peck, Paulsen et al. (2005b), but is synonymous with In-stream Fish Habitat in USEPA (2006), and Fish Cover in Kaufmann et al. (1999). We follow the terminology of Stoddard, Peck, Paulsen et al (2005).

The most diverse fish and macroinvertebrate assemblages are found in streams and rivers that have complex forms of habitat: large wood, boulders, undercut banks, tree roots, etc. Human use of streams and riparian areas often results in the simplification of this habitat, with potential effects on biotic integrity. We use a measure that sums the amount of in-stream habitat consisting of undercut banks, boulders, large pieces of wood, and cover from overhanging vegetation within a meter of the water surface. It is a scalar metric for which the highest values represent the highest habitat complexity. Because multiple categories of areal coverage are summed, values can exceed 100% (or 1.0 on a decimal scale).

Riparian Cover

The presence of a complex, multilayered vegetation corridor along streams and rivers is an indication of how well the stream network is buffered against sources of stress in the watershed. Intact riparian areas can help reduce nutrient and sediment runoff from the surrounding landscape, prevent bank erosion, provide shade to reduce water temperature, and provide leaf litter and large wood that serve as food and habitat for stream organisms. The presence of canopy trees in the riparian corridor indicates longevity; the presence of smaller woody vegetation typically indicates that riparian vegetation is reproducing, and suggests the potential for future sustainability of the riparian corridor. As in Stoddard, Peck, Paulsen et al. (2005b), we use a measure of riparian complexity that sums the amount of woody cover provided by three layers of riparian vegetation: ground layer, woody shrubs (understory layer), and the overhead canopy. Because multiple categories of areal coverage are summed, values can exceed 100% (or 1.0 on a decimal scale).

Riparian Disturbance

The vulnerability of the stream network to potentially detrimental human activities increases with the proximity of those activities to the streams themselves. For this assessment, we use a direct measure of riparian human disturbance that tallies 11 specific forms of human activities and disturbances (e.g., roads/trails, landfills, piping, building, farming, etc.), and weights them according to how close to the stream channel they are observed. The index generally varies from 0 (no observed disturbance) to 6 (multiple types observed in the stream, throughout the reach). Note that the presence of a “disturbance” does not equate to a known impact. For example, a well-designed trail along a stream is an indicator of riparian disturbance, but does not necessarily equate to impacts upon the ecological integrity of the stream.

Biological Indicators

Ecological condition can be assessed using biological assemblages because of the inherent capacity of organisms to integrate chemical and physical stressors that affect them over varying spatial and temporal time scales (Rosenberg and Resh 1993, Karr and Chu 1999, Brousseau and Randall 2008). We use three Multi-Metric Indices (MMIs) to assess each stream: 1) Aquatic Vertebrates index; 2) West-wide Macroinvertebrates index, 3) Observed to Expected ratios of macroinvertebrate diversity,

and 4) a regional or state-based Macroinvertebrate index. Multi-Metric Indices use a sum of scores for a variety of individual measures that make up the key characteristics of biotic integrity (e.g., taxonomic richness, habitat/trophic composition, sensitivity to human disturbance, etc.). Examples of how the metrics were calculated are presented in Appendix A.

Aquatic Vertebrate MMI

Aquatic vertebrates were assessed using the Aquatic Vertebrate MMI that included measures chosen to represent selected key characteristics of biological integrity: taxonomic richness, taxonomic composition, habitat use, reproductive strategies, pollution tolerance, feeding groups, and the presence of nonnative species. The resulting MMI combines all the measures into an index for which values range from 0 to 100, with 100 denoting the best possible condition. The development process is given in more detail in the EMAP West statistical summary (Stoddard, Peck, Olsen et al. 2005b).

West-Wide Macroinvertebrate MMI

Characteristics used for the West-Wide Macroinvertebrate MMI were: taxonomic richness, taxonomic compositions, taxonomic diversity, feeding groups, habits, and pollution tolerance. Like the Vertebrate MMI, the scores in each category are summed, and scaled to a 0 to 100 range, with 100 denoting the best possible condition.

Observed/Expected Ratios of Biodiversity

Observed/Expected ratios (O/E scores) operate on multi-variate modeling of reference, non-impacted sites using predictive models. Essentially, the model is able to predict what taxa of macroinvertebrates would occur given that a site is unimpaired, based on a large regional survey of reference sites. The collected (observed sample) taxa list is then compared to the predicted list to develop a ratio, which is a direct reflection of biodiversity loss (or gain). Hence, a value of 0.9 indicates that 90% of the expected biodiversity was present; indicating good condition. Full details of O/E scores and modelling is given in Wright et. al (1989) and also known as RIVPACS (River Invertebrate Prediction and Classification System). The model used here was developed for the US EPA EMAP (Environmental Monitoring and Assessment Program) by Utah State University for 11 western US states, using Chironomidae midge taxonomy to sub-family identifications.

Regional or State Macroinvertebrate Indices

We utilized two regionally relevant MMIs developed by state or academic researchers in different part of the Klamath Region: 1) the California Surface Water Ambient Monitoring Program (SWAMP) developed an MMI for the North Coast Region, including the coastal area of the Redwoods Parks (Rehn et al. 2005); and 2) a Sierra Nevada MMI developed by water quality researchers for montane streams of the Sierra Nevada – of which Lassen Volcanic National Park may share similar attributes (Herbst and Silldorff 2009). Both of these are briefly described below.

California Northern Coastal Region MMI for Whiskeytown National Recreation Area

This MMI was developed for three northern California Omernik Level III ecoregions (Omernik 1987): coast range, Klamath mountains, and the southern and central California chaparral and oak woodlands. The components used were: total richness of mayflies, stoneflies, and caddis flies; beetle richness; true fly richness, tolerant individuals, non-snail scraping individuals, predatory individuals,

and shredding functional feeding groups taxa; and the number of non-insect taxa. It is scored from 0 to 100 (100 denoting the best possible condition), and condition assessed using categories of Very Poor, Poor, Fair, Good, and Very Good.

Sierra Nevada MMI for Lassen Volcanic National Park

The application of this condition metric should be conservative since the development and calibration of this metric is based on streams that may be geomorphically similar, but the organisms may differ in their biogeography (e.g., Lassen Volcanic NP stream fauna may have more similarity to the Cascades than the Sierra Nevadas). Unfortunately, no other regional metric exists as of this report. The value of this metric may be in establishing a separate, integrative condition that can be assessed for change over time, but may not pertain to exact conditions. The Sierra Nevada MMI uses multiple measures of taxa richness, the amount of tolerant taxa, Shredder functional feeding groups abundance, dominance of taxa, and community tolerance. All the metrics are summed for a score of 0 to 100 (100 denoting the best possible condition).

Establishing Thresholds of Ecological Condition

The EPA derived three categories (Least Disturbed, Intermediate, and Most Disturbed) that can be used to describe the status of the ecological condition of a stream. These thresholds were established using data collected across the western United States and we applied these thresholds to determine the status of the streams sampled for this project (Table 2).

Table 2. Threshold for condition rating used in the Klamath Network. See text for further description and source of threshold values.

Category	Parameter	Most Disturbed	Intermidate Disturbed	Least Disturbed
Biological	EPA Invert West-wide MMI	<57	57 to 70	≥71
	EPA Vertebrate MMI	<37	37 to 61	≥62
	EPA Observed/Expected	<62	63 to 80	≥81
Chemical	Acid Neutralizing Capacity (µeq/L)	<0	Not Applicable	>0
	Specific Conductance (µS/cm)	>1000	1000 to 501	≤500
	Total Nitrogen (mg/L)	>0.2	0.2 to 0.126	≤0.125
	Total phosphorous (mg/L)	>0.04	0.04 to .011	≤0.01
Physical	In-stream Habitat Cover	<0.14	0.14 to 0.34	≥0.33
	Relative Bed Stability	<-1.3 or >0.6	-1.3 to -0.71 and 0.6 to 0.11	≥-0.7 or ≤0.1
	Riparian Cover	<0.23	0.23 to 0.66	≥0.67
	Riparian Disturbance	>0.95	0.95 to 0.36	≤0.35
State Regional Macroinvertebrate Metrics	Eastern Sierra MMI	<63.2	63.3 to 80.3	>80.4
	CA North Coast MMI	<60 (fair to poor)	Not Applicable	>60 (good to very good)

Additional Macroinvertebrate Measures

In addition to the metrics used for condition assessment, we report on two commonly used macroinvertebrate metrics (Shannon Index and Hilsenhoff Biotic Index). The Shannon Index (H') is a measure of community structure defined by the relationship between the number of distinct taxa and their relative abundance, incorporating both into a single number. It is calculated as: $H' =$

– $\sum p_i \ln p_i$ where p_i is the proportion of the i th species. Values generally range from 0 to 3. Higher values generally suggest a more balanced, diverse and cosmopolitan assemblage. The Hilsenhoff Biotic Index (HBI) is a weighted average of tolerance values derived from empirical observations of macroinvertebrate responses to pollution (Hilsenhoff 1987, 1988). It is calculated as $HBI = \frac{\sum n_i a_i}{N}$

where n_i = the number of individuals for taxa i , a_i = the assigned tolerance value of taxa i , and N = the total number of individuals for a sample. The HBI sums the overall tolerances of the taxa collected. This index is used to detect nutrient enrichment, high sediment loads, low dissolved oxygen, and thermal impacts. Shifts in HBI from low values to high values suggest a community change towards a more pollutant tolerant community. The source of tolerance values we used was the list developed by the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT) (<http://www.safit.org/index.php>). Despite the name, the taxa lists are broadly applicable to the entire western United States.

Relationship of KLMN Indicators to Water Quality Standards

States implement water quality criteria with strict methodologies (for example, a 4,5 or 7 day average water temperature, so there is no applicability using KLMN methods). This protocol, focused on ecological and environmental status and trends, is not a perfect fit for many of these parameters because it only collects single measurements triennially. However, when there is some indication of an exceedance, it should be reported with the suggestion that the park follow up with site-specific measurements, if warranted. The thresholds used are based on NPS criteria established by the NPS Water Resources Division, the State of California drinking water criteria, and EPA criteria for drinking water, health advisory, and National Ambient Water Quality Criteria (Table 3). However, note that although these are promulgated thresholds, their applicability is not strict; we provide the drinking water criteria and health advisory criteria only for comparative purposes, because the KLMN Wadeable Streams Protocol is an ecological integrity based methodology and not designed for monitoring drinking water.

Table 3. Available water quality criteria used for possible exceedances, including drinking water (not applicable for natural waters, but provided for comparative reasons). See Dinger et al. 2013 for sources.

Parameter	NPS Criteria	Oregon Department of Environmental Quality	California Drinking Water	EPA Criteria		
				Drinking Water	Health Advisory	National Ambient Water Quality Criteria
Alkalinity (mg/l)	>10	>20	–	–	–	>20
Chloride (mg/l)	–	–	<250	–	–	<230 ^a ; <860 ^b - when associated only with Sodium
Dissolved Oxygen (mg/l)	>4	>8	–	–	–	>8.0 1-day minimum (water column)
Total Nitrogen (as NO ₂ + NO ₃) (mg/l)	–	–	<10	<10	–	–
pH	>6.5	6.5–8.5		6.5 to 8.5	–	5 to 9 ^c , 6.5 to 9 ^a (max)
Sodium (mg/l)	–	–	–		20	–
Sulfate (mg/l)	–	–	–	500	–	250 ^c
Turbidity (NTU)	<50	<10% above natural	<1	<1	–	–

^aFreshwater aquatic life protection (4 day average)

^bMax concentration (1 hour average)

^cTaste and odor

Results

Whiskeytown National Recreation Area

Twenty-one sites were sampled at Whiskeytown between June 16 and August 5, 2014 (Figure 3). The original target number of sites was 25 to 30; however, several sites were unable to be sampled due to safety or logistical concerns (see 2011 report, Dinger and Sarr 2014). Table 4 provides the 26 sites originally scheduled to be sampled for the 2014 field season.

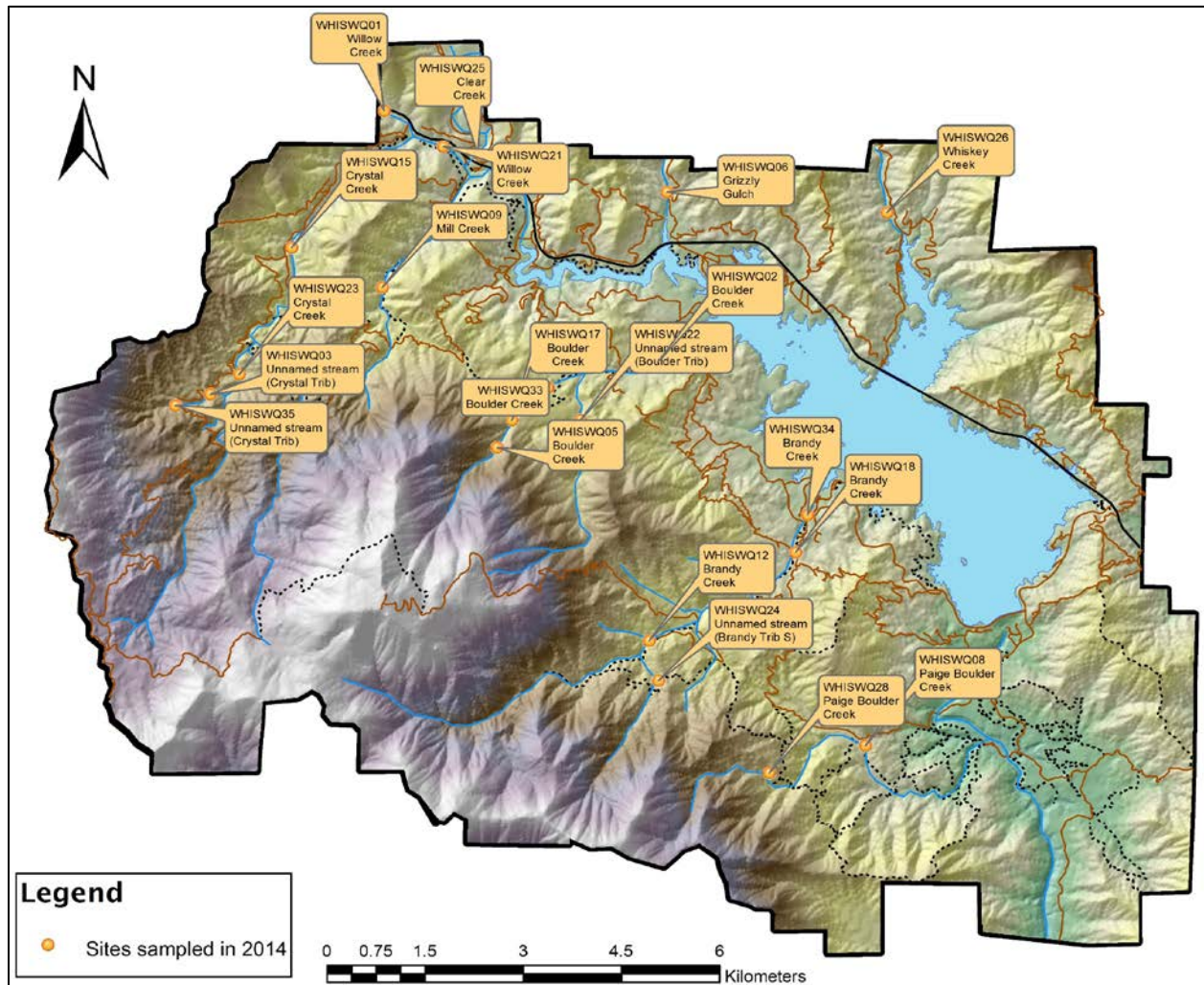


Figure 3. Sites sampled in Whiskeytown National Recreation Area, 2014.

Table 4. Original site list for streams to be sampled in Whiskeytown.

Stream Name	Site Code	Date Sampled	Sampling Notes	Reason for not sampling
Willow Creek	WHISWQ01	6/16/2014	–	–
Boulder Creek	WHISWQ02	7/28/2014	–	–
Unnamed stream (Crystal Trib)	WHISWQ03	7/10/2014	–	–
Boulder Creek	WHISWQ05	7/23/2014	–	–
Grizzly Gulch	WHISWQ06	6/26/2014	–	–
Paige Boulder Creek	WHISWQ08	6/19/2014	–	–
Mill Creek	WHISWQ09	8/5/2014	–	–
Brandy Creek	WHISWQ12	7/2/2014	–	–
Unnamed	WHISWQ14	— ^a	–	Was planned to be sampled later
Crystal Creek	WHISWQ15	7/7/2014	–	–
Boulder Creek	WHISWQ17	7/22/2014	Computer crash	–
Brandy Creek	WHISWQ18	6/30/2014	–	–
Willow Creek	WHISWQ21	7/29/2014	Unable to fish	–
Unnamed stream (Boulder Trib)	WHISWQ22	7/17/2014	Computer crash	–
Crystal Creek	WHISWQ23	7/8/2014	–	–
Unnamed stream (Brandy Trib S)	WHISWQ24	7/30/2014	Unable to fish	–
Clear Creek	WHISWQ25	7/14/2014	–	–
Whiskey Creek	WHISWQ26	6/24/2014	–	–
Paige Boulder Creek	WHISWQ28	6/25/2014	–	–
Clear Creek	WHISWQ29	— ^a	–	Was planned to be sampled later
Boulder Creek	WHISWQ30	— ^a	–	Too steep and distant from vehicle
Unnamed	WHISWQ31	— ^a	–	Was planned to be sampled later
Paige Boulder Creek	WHISWQ32	— ^a	–	Was planned to be sampled later
Boulder Creek	WHISWQ33 ^b	7/24/2014	–	–
Brandy Creek	WHISWQ34 ^b	7/31/2014	Unable to fish	–
Unnamed stream (Crystal Trib)	WHISWQ35 ^b	7/21/2014	Computer crash	–

^aSites were not sampled in 2014 due to a variety of reasons.

^bWhiskeytown sites WHISWQ33 – 35 were prioritized over WHISWQ29-32 because they had been sampled in 2011.

Due to hiring complications, only three of four crew members were able to fully participate in the full sampling period in both Whiskeytown and Lassen Volcanic. Furthermore, two equipment malfunctions impacted the workload and data availability: (1) The electrofisher malfunctioned from July 29 to July 31, so that three sites were not fished and (2) a field tablet computer suffered a hard

drive crash, losing both the original database and the backup database, resulting in incomplete records for sites sampled between July 17 and July 22.

The sampled streams of Whiskeytown are characterized by mostly high gradient streambeds (6.2% average gradient of sampled streams [despite a sampling frame limiting higher gradient streams]), boulder and other large substrate (average of stream median substrate size just over 0.5 meter in diameter), high amounts of riparian cover (average cover of 76%), and lingering evidence of legacy land use (e.g., pipes or other riparian disturbance). Examples of some typical streams are shown in Figure 4.



Figure 4. Examples of typical stream characteristics in Whiskeytown National Recreation Area. A, B = Unnamed tributary to Boulder Creek (WHISWQ22), C = Mill Creek (WHISWQ09), D = Brandy Creek (WHISWQ18). Note prevalence of large amounts of riparian cover and large substrates (e.g., boulders). Photos are selected to generally match photos in 2011 report (Dinger and Sarr 2014).

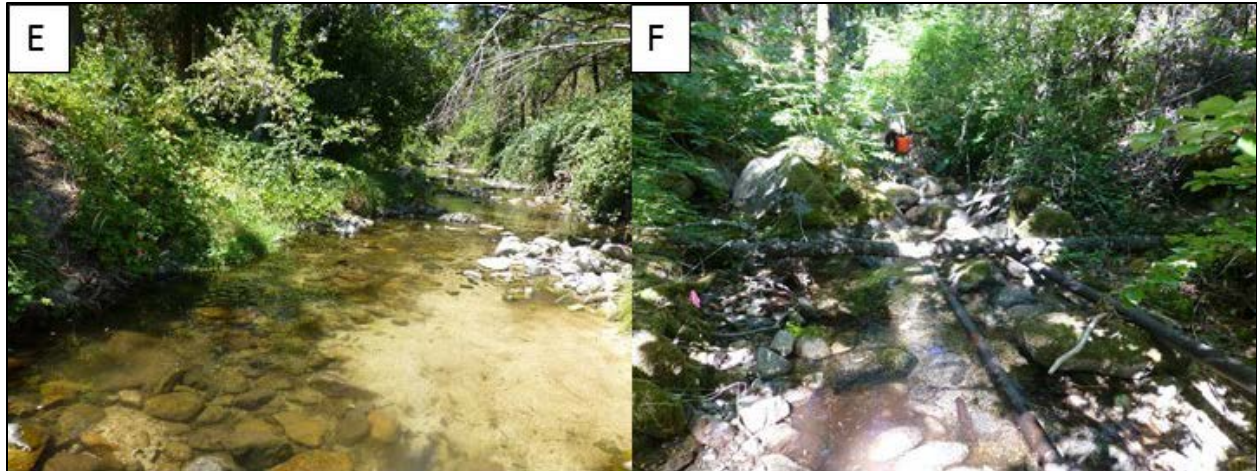


Figure 4 (continued). Examples of typical stream characteristics in Whiskeytown National Recreation Area. E = Willow Creek (WHISWQ21), F = Boulder Creek (WHISWQ33). Note prevalence of large amounts of riparian cover and large substrates (e.g., boulders). In E, large deposits of sand from the July 21, 2013 1600 CFS discharge are visible in the lower right. Photos are selected to generally match photos in 2011 report (Dinger and Sarr 2014).

Physical characteristics of Whiskeytown streams

Summary statistics for the monitored streams applicable to the sampling frame are presented in Table 5. These are general geomorphological summaries of the streams (e.g., location, elevation, slope, discharge) and do not impart any condition information. Clear Creek was the largest stream sampled, with the widest width, greatest average depth, and highest instantaneous discharge. Deeper, faster streams are generally more hazardous to sample. The smallest stream, with the lowest average depth and discharge, was an unnamed tributary to Boulder Creek (WHISWQ22).

Physical condition metrics of Whiskeytown streams

The four EPA physical condition metrics along with substrate size and average embeddedness for the Whiskeytown stream sampling frame are presented in Table 6. A stream's median substrate size is a more useful descriptor because the average substrate size can be significantly influenced by a few, very large pieces of substrate. Overall, as indicated above, Whiskeytown streams are typified by large boulder substrates. Although perhaps not intuitive, we also provide the park-wide median and average median for the surveyed streams. The higher prevalence of large substrates, and relative lack of smaller substrates (e.g., sand, silt, etc.), resulted in a relatively low embeddedness (compared to Lassen Volcanic, for example).

Riparian cover was uniformly high in all Whiskeytown streams; these streams were all rated as Least Disturbed based on EPA threshold criteria, except for three sites rated as Intermediate: Clear Creek (WHISWQ25), and Crystal Creek (WHISWQ15 and WHISWQ23). In-stream habitat cover was also high in most streams, with the exception of Clear Creek (WHISWQ25) rated as Intermediate. Riparian disturbance was rated as Most Disturbed in two sites Crystal Creek (WHISWQ23) and Willow Creek (WHISWQ21), generally based on roads/trails and residual/unused pipes, and, to a lesser degree pavement, a building, and other minor influences.

Table 5. Physical characteristics and location of streams sampled in Whiskeytown, 2014.

Stream Name	Site Code	Date Sampled	UTM Coordinates ^a		Elevation (m)	Reach Length (m)	Average Width (m)	Average Depth (cm)	Slope	Instantaneous Discharge	
			X	Y						m ³ s ⁻¹	ft ³ s ⁻¹
Boulder Creek	WHISWQ02	7/28/2014	533713	4498381	433	200	2.6	22.0	5.5%	0.005	0.18
Boulder Creek	WHISWQ05	7/23/2014	531254	4497037	781	160	4.0	6.8	17.3%	0.006	0.19
Boulder Creek	WHISWQ17	7/22/2014	531483	4497474	707	160	2.1	NA ^b	NA ^b	0.004	0.13
Boulder Creek	WHISWQ33	7/24/2014	532029	4497982	591	200	2.6	17.2	9.7%	0.004	0.13
Brandy Creek	WHISWQ12	7/2/2014	533580	4494004	624	360	7.8	21.9	NA ^b	0.104	3.66
Brandy Creek	WHISWQ18	6/30/2014	535818	4495397	432	400	6.7	20.8	NA ^b	0.059	2.09
Brandy Creek	WHISWQ34	7/31/2014	535996	4495980	389	280	7.2	19.9	3.5%	0.105	3.71
Clear Creek	WHISWQ25	7/14/2014	530961	4501656	388	400	8.6	30.7	0.1%	0.138	4.87
Crystal Creek	WHISWQ15	7/7/2014	528115	4500182	507	240	6.0	22.9	3.1%	0.052	1.85
Crystal Creek	WHISWQ23	7/8/2014	527316	4498190	702	240	4.6	15.6	4.4%	0.033	1.17
Grizzly Gulch	WHISWQ06	6/26/2014	533852	4501055	393	150	1.8	8.8	3.8%	NA ^b	NA ^b
Mill Creek	WHISWQ09	8/5/2014	529502	4499560	523	160	3.2	17.1	7.1%	0.005	0.18
Paige Boulder Creek	WHISWQ08	6/19/2014	536885	4492359	470	200	3.5	15.3	5.2%	0.011	0.40
Paige Boulder Creek	WHISWQ28	6/25/2014	535413	4491930	746	160	7.9	13.7	14.4%	0.007	0.24
Unnamed stream (Boulder Trib)	WHISWQ22	7/17/2014	532532	4497474	581	240	1.1	7.0	NA ^b	NA ^b	NA ^b
Unnamed stream (Brandy Trib S)	WHISWQ24	7/30/2014	533723	4493380	727	150	2.2	16.2	13.0%	0.008	0.28
Unnamed stream (Crystal Trib)	WHISWQ03	7/10/2014	526874	4497878	770	150	1.8	7.1	6.4%	0.011	0.39
Unnamed stream (Crystal Trib)	WHISWQ35	7/21/2014	526340	4497702	822	150	NA ^b	NA ^b	7.1%	0.002	0.06

^aUTM = Universal Transverse Mercator, Zone 10N.^bNA indicates data Not Available

Table 5 (continued). Physical characteristics and location of streams sampled in Whiskeytown, 2014.

Stream Name	Site Code	Date Sampled	UTM Coordinates ^a		Elevation (m)	Reach Length (m)	Average Width (m)	Average Depth (cm)	Slope	Instantaneous Discharge	
			X	Y						m ³ s ⁻¹	ft ³ s ⁻¹
Whiskey Creek	WHISWQ26	6/24/2014	537214	4500736	395	200	4.8	16.4	0.8%	NA ^b	NA ^b
Willow Creek	WHISWQ01	6/16/2014	529532	4502329	422	160	4.1	18.4	2.3%	0.023	0.82
Willow Creek	WHISWQ21	7/29/2014	530429	4501766	396	320	4.8	23.0	1.0%	0.028	1.00
Average					562	223	4.4	16.9	6.2%	0.034	1.186
SD					154	83	2.3	6.3	4.9%	0.042	1.475
Median					523	200	4.1	17.1	5.2%	0.011	0.395
Range					388 - 822	150 - 400	1.1 - 8.6	6.8 - 30.7	0.1% - 17.3%	0.002 - 0.138	0.06 - 4.87

^aUTM = Universal Transverse Mercator, Zone 10N.^bNA indicates data Not Available**Table 6.** Physical condition metrics for Whiskeytown streams sampled in 2014.

Stream Name	Site Code	Date Sampled	Stream Substrate diameter		Average Embeddedness (%)	Pool (%)	Riffle (%)	Physical Habitat Condition Metrics			
			Average (mm)	Median (mm)				In-Stream Habitat Complexity	Riparian Cover	Relative Bed Stability	Riparian Disturbance
Boulder Creek	WHISWQ02	7/28/2014	406	1047.1	40.7	40%	25%	0.50 ^a	0.86 ^a	0.52 ^b	0.00 ^a
Boulder Creek	WHISWQ05	7/23/2014	533.9	1047.1	43.7	16%	70%	0.47 ^a	0.75 ^a	0.33 ^b	0.00 ^a
Boulder Creek	WHISWQ17	7/22/2014	NA ^d	NA ^d	NA ^d	NA ^d	NA ^d	NA ^d	NA ^d	NA ^d	NA ^d
Boulder Creek	WHISWQ33	7/24/2014	76.2	38.0	58.5	22%	63%	0.86 ^a	0.89 ^a	-0.27	0.14 ^a
Brandy Creek	WHISWQ12	7/2/2014	289.9	1047.1	42.5	26%	63%	0.73 ^a	0.79 ^a	NA ^d	0.16 ^a
Brandy Creek	WHISWQ18	6/30/2014	428	1047.1	37.7	12%	63%	0.47 ^a	0.77 ^a	NA ^d	0.00 ^a

^aSites are Least Disturbed (also with light sage background).^bSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).^cSites meeting EPA criteria for Most Disturbed (also with dark red background).^dNA indicates data Not Available.

Table 6 (continued). Physical condition metrics for Whiskeytown streams sampled in 2014.

Stream Name	Site Code	Date Sampled	Stream Substrate diameter		Average Embeddedness (%)	Pool (%)	Riffle (%)	Physical Habitat Condition Metrics			
			Average (mm)	Median (mm)				In-Stream Habitat Complexity	Riparian Cover	Relative Bed Stability	Riparian Disturbance
Brandy Creek	WHISWQ34	7/31/2014	192.3	1047.1	23.9	21%	65%	0.84 ^a	1.08 ^a	0.34 ^b	0.00 ^a
Clear Creek	WHISWQ25	7/14/2014	222.8	114.8	16.7	0%	21%	0.07 ^c	0.48 ^b	2.15 ^c	0.17 ^a
Crystal Creek	WHISWQ15	7/7/2014	343.1	1047.1	25.8	6%	75%	0.40 ^a	0.65 ^b	0.62 ^c	0.15 ^a
Crystal Creek	WHISWQ23	7/8/2014	176.8	1047.1	43.4	26%	61%	0.43 ^a	0.62 ^b	0.25 ^b	3.65 ^c
Grizzly Gulch	WHISWQ06	6/26/2014	40.1	38.0	64.5	26%	46%	0.48 ^a	0.77 ^a	0.06 ^a	0.00 ^a
Mill Creek	WHISWQ09	8/5/2014	128.9	114.8	43.2	10%	80%	0.75 ^a	0.84 ^a	0.18 ^b	0.03 ^a
Paige Boulder Creek	WHISWQ08	6/19/2014	78.5	114.8	47.1	27%	48%	0.50 ^a	0.69 ^a	-0.06 ^a	0.00 ^a
Paige Boulder Creek	WHISWQ28	6/25/2014	420.4	1047.1	34.5	33%	58%	0.75 ^a	0.71 ^a	0.35 ^b	0.00 ^a
Unnamed stream (Boulder Trib)	WHISWQ22	7/17/2014	100	114.8	66.4	43%	25%	1.16	0.86	NA ^d	0.00
Unnamed stream (Brandy Trib S)	WHISWQ24	7/30/2014	506.5	1047.1	28.5	34%	60%	0.85 ^a	0.71 ^a	0.36 ^b	0.00 ^a
Unnamed stream (Crystal Trib)	WHISWQ03	7/10/2014	42.3	114.8	46.1	5%	76%	1.05 ^a	0.79 ^a	-0.10 ^a	0.00 ^a
Unnamed stream (Crystal Trib)	WHISWQ35	7/21/2014	NA ^d	NA ^d	NA ^d	NA ^d	NA ^d	NA ^{a, d}	NA ^{a, d}	NA ^{a, d}	NA ^{a, d}
Whiskey creek	WHISWQ26	6/24/2014	25.4	38.0	45.0	3%	35%	0.41 ^a	0.81 ^a	0.34 ^a	0.00 ^a
Willow Creek	WHISWQ01	6/16/2014	21.1	38.0	41.0	53%	33%	0.45 ^a	0.72 ^a	-0.29 ^a	0.34 ^a
Willow Creek	WHISWQ21	7/29/2014	100.1	114.8	49.6	3%	49%	0.36 ^a	0.73 ^a	0.70 ^a	1.56 ^a
Average			217.5	540.2	42.0	21%	53%	0.61^a	0.76^a	0.34^a	0.33^a
SD			173.3	494.8	12.9	15%	18%	0.27^a	0.12^a	0.56^a	0.88^a
Median			176.8	114.8	43.2	22%	60%	0.50^a	0.77^a	0.34^a	0.00^a
Range			21.1 - 533.9	38.0 - 1047.1	16.7 - 66.4	0 - 53%	21 - 80%	0.07 - 1.16^a	0.48 - 1.08^a	-0.29 - 2.15^a	0 - 3.65^a

^aSites are Least Disturbed (also with light sage background).

^bSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^cSites meeting EPA criteria for Most Disturbed (also with dark red background).

^dNA indicates data Not Available.

Relative Bed Stability (RBS) in Whiskeytown indicates 8 Intermediate sites and 3 Most Disturbed sites. These are values based on the rapid calculation of RBS, and do not incorporate the effects of woody debris, bankfull characteristics, or residual pool depth on the expected median particle size – these are more complex equations not available yet. Although preliminary, there was a prevalence of positive values in a majority of the sites as would be expected with a prevalence of larger substrates. Likewise the average and median park-wide RBS values were also elevated into the Intermediate category.

Chemical characteristics and condition estimates of Whiskeytown streams

Selected water chemistry results are presented in Table 7. Parameters measured in-situ with a water probe (see methods) are listed under “water quality” and parameters measured in an analytical laboratory or with a stream-side assay (Acid Neutralizing Capacity) are presented as “water chemistry”.

At four sites, malfunctions in the water probe or a computer hard drive crash prevented the collection of water quality data (but not water chemistry).

pH was found to be circum-neutral (pH of 7 = neutral), to slightly alkaline with an average of 7.94. Values did not exceed any water quality criteria (Table 2), except Clear Creek (WHISWQ25) where the average pH was solidly within the acceptable range. However, pH was reported by crew to not be calibrating correctly, but with no indication of when pH was not properly working. All pH values for 2014 should be considered suspect.

Acid Neutralizing Capacities were all positive, indicating Least Disturbed.

Temperature is presented as a descriptor of conditions during sampling, but varies on a daily, monthly, and seasonal basis. As such, no status or condition should be inferred from temperature readings. However, most of the streams harboring Tailed Frogs (*Ascaphus truei*) had temperatures above their average optimum of 11 °C (de Vlaming and Bury 1970, Bury 2009); but our measurements were generally at mid-day in the middle of the summer and presumably represent nearly maximal annual temperatures. **Specific conductivity** was uniformly low, and well under the EPA threshold criteria for Least disturbed at all but one site (WHISWQ21; Willow Creek) (used as a surrogate for salinity by the EPA). The average **dissolved oxygen** values appear well within regulatory criteria for available water quality criteria (Table 2), however the observed warm temperatures (average temperature = 18.7 °C) have the effect of lowering dissolved oxygen at five sites below 8mg/L, which is a threshold for certain monitoring programs (but is at least a 1-day minimum value for the EPA criteria). Readings during morning, evening, and night would likely meet criteria.

Turbidity readings were generally low, with an average of 1.8 NTU. Based on available water quality criteria, many values are elevated with respect to *drinking water* criteria.

Table 7. Water chemistry parameters for streams sampled in Whiskeytown, 2014.

Stream Name	Site Code	Water Quality ^a					Water Chemistry ^b					Acid Neutralizing Capacity ^b	
		pH ^g	Temp (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity ^h (NTU)	Sodium (mg/L)	Sulfate (mg/L)	Chloride mg/L	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)	(µeq/L)	(mg/L)
Boulder Creek	WHISWQ02	7.87	19.2	79 ^c	7.6	0.0	5.51	0.41	0.63	0.10 ^c	0.011 ^d	1642 ^c	82 ^c
Boulder Creek	WHISWQ05	7.96	14.6	66 ^c	7.9	1.4	4.43	0.21	0.76	0.06 ^c	0.011 ^d	778 ^c	39 ^c
Boulder Creek	WHISWQ17	NA ^f	NA ^f	NA ^f	NA ^f	NA ^f	4.46	0.23	0.70	0.06 ^c	0.011 ^d	NA ^f	NA ^f
Boulder Creek	WHISWQ33	7.63	15.1	63 ^c	8.8	0.2	4.56	0.26	0.69	0.07 ^c	0.008 ^c	989 ^c	50 ^c
Brandy Creek	WHISWQ12	NA ^f	NA ^f	NA ^f	NA ^f	NA ^f	3.83	0.15	0.43	0.07 ^c	0.011 ^d	587 ^c	29 ^c
Brandy Creek	WHISWQ18	7.85	19.7	68 ^c	9.0	0.0	4.53	0.16	2.62	0.06 ^c	0.007 ^c	586 ^c	29 ^c
Brandy Creek	WHISWQ34	7.66	19.8	71 ^c	8.5	0.0 ^f	5.41	0.16	4.13	0.13 ^d	0.010 ^c	676 ^c	34 ^c
Clear Creek	WHISWQ25	9.19	28.9	124 ^c	9.8	6.1	5.19	3.71	0.75	0.15 ^d	0.027 ^d	1558 ^c	78 ^c
Crystal Creek	WHISWQ15	7.85	20.1	80 ^c	8.7	0.0	5.00	0.28	0.52	0.09 ^c	0.013 ^d	680 ^c	34 ^c
Crystal Creek	WHISWQ23	8.01	18.4	85 ^c	9.1	4.8	5.13	0.29	0.55	0.06 ^c	0.013 ^d	735 ^c	37 ^c
Grizzly Gulch	WHISWQ06	7.96	21.9	241 ^c	7.1	0.0	8.64	3.11	1.11	0.08 ^c	0.006 ^c	2882 ^c	144 ^c
Mill Creek	WHISWQ09	7.92	17.2	116 ^c	8.4	0.0	5.56	0.43	0.87	0.06 ^c	0.015 ^d	1992 ^c	100 ^c
Paige Boulder Creek	WHISWQ08	NA ^f	NA ^f	NA ^f	NA ^f	NA ^f	3.82	0.28	0.55	0.06 ^c	0.006 ^c	422 ^c	21 ^c
Unnamed (Boulder Trib)	WHISWQ22	7.71	18.6	99 ^c	7.4	1.8	6.02	1.42	0.90	0.23 ^e	0.014 ^d	846 ^c	42 ^c

^aData collected with water probe.

^bData from laboratory analysis.

^cSites are Least Disturbed (also with light sage background).

^dSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^eSites meeting EPA criteria for Most Disturbed (also with dark red background).

^fNA indicates data Not Available.

^g See text for qualifiers on interpreting pH data.

^hCrew reported turbidity probe not working.

Table7 (continued). Water chemistry parameters for streams sampled in Whiskeytown, 2014.

Stream Name	Site Code	Water Quality ^a					Water Chemistry ^b					Acid Neutralizing Capacity ^b	
		pH ^g	Temp (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity ^h (NTU)	Sodium (mg/L)	Sulfate (mg/L)	Chloride mg/L	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)	(µeq/L)	(mg/L)
Paige Boulder Creek	WHISWQ28	7.91	17.0	51 ^c	8.7	7.0	3.86	0.18	0.57	0.06 ^c	0.009 ^c	464 ^c	23 ^c
Unnamed (Brandy Trib S)	WHISWQ24	7.69	16.4	44 ^c	8.6	0.0	3.74	0.12	0.51	0.10 ^c	0.010 ^c	1019 ^c	51 ^c
Unnamed Crystal Trib)	WHISWQ03	8.08	15.2	157 ^c	9.6	1.8	7.30	0.63	0.66	0.07 ^c	0.018 ^d	1687 ^c	84 ^c
Unnamed (Crystal Trib)	WHISWQ35	7.88	14.6	112 ^c	8.1	2.5	8.10	0.45	0.99	0.11 ^c	0.02 ^d	2028 ^c	102 ^c
Whiskey Creek	WHISWQ26	7.98	22.0	151 ^c	8.2	4.2	4.51	6.13	0.73	0.08 ^c	0.021 ^d	1013 ^c	51 ^c
Willow Creek	WHISWQ01	NA ^f	NA ^f	NA ^f	NA ^f	NA ^f	49.64	19.12	88.33	0.18 ^d	0.016 ^d	1032 ^c	52 ^c
Willow Creek	WHISWQ21	7.86	19.2	671 ^d	7.8	0.0	81.49	0.54	176.37	0.45 ^e	0.011 ^d	838 ^c	42 ^c
Average		7.94	18.7	134 ^c	8.4	1.8	10.99	1.82	13.49	0.11 ^c	0.013 ^d	1123 ^c	56 ^c
SD		0.35	3.5	147	0.7	2.4	18.88	4.24	41.90	0.09	0.005	642	32
Median		7.88	18.6	85	8.5	0.2	5.13	0.29	0.73	0.08	0.011	917.5	46
Range		7.63 - 9.19	14.6 - 28.9	44 - 671	7.1 - 9.8	0 - 7	3.74 - 81.49	0.12 - 19.12	0.43 - 176.37	0.06 - 0.45	0.006 - 0.27	422 - 2882	21 - 144

^aData collected with water probe.

^bData from laboratory analysis.

^cSites are Least Disturbed (also with light sage background).

^dSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^eSites meeting EPA criteria for Most Disturbed (also with dark red background).

^fNA indicates data Not Available.

^g See text for qualifiers on interpreting pH data.

^hCrew reported turbidity probe not working.

The **anions and cations** with available thresholds for water quality were all far below promulgated values, although the highest values of these salts were uniformly in Willow Creek, a stream listed as state of California Clean Water Act 303(d) listed site for 1) Acid Mine Drainage, 2) Zinc, and 3) Copper ([California Environmental Protection Agency State Water Resources Control Board 2010](#)). **Total nitrogen** values were all well below EPA thresholds for Least Disturbed, in 16 of the 21 sites. Three sites were Intermediate, and two sites were Most Disturbed. **Total phosphorous** values, however, had 14 of the 21 sites falling within the classification for Intermediate. Some of these however, were only 0.001 mg/L above the Least Disturbed threshold. The median and average park values for the total phosphorous were elevated into the Intermediate category.

Riparian characteristics of Whiskeytown streams

The riparian zones of Whiskeytown are characterized by deciduous trees and a diverse community providing high overall shading (89% average, 92% median; see Table 8 for stream side shading). The site with the least shading was Clear Creek (WHISWQ25), which was the widest stream sampled, which will naturally have less shading than narrow streams. The canopy cover was often mixed community (10% or more of multiple groups; Deciduous, Coniferous, Broadleaf Evergreen), but some sites were also dominated by strictly deciduous trees.

Vertebrate assemblage and condition of Whiskeytown streams

Results of electrofishing and visual encounters of vertebrate species, along with summaries of abundance, richness, and the EPA Vertebrate MMI are presented in Table 9. A total of five amphibian species and six fish species were encountered, with at least one species found at each site. The most widespread amphibian was the Pacific Giant Salamander (*Dicamptodon tenebrosus*), occurring at 13 of the 16 sites with data available (some sites were unable to be fished; some data were lost in the hard-drive crash). Note that *D. tenebrosus* was mistakenly referred to as *D. ensatus* in Dinger and Sarr (2014). The most widespread fish was Rainbow Trout (*Oncorhynchus mykiss*), occurring at 11 of the 16 sites with data available. All species had been previously recorded in the park.

Condition assessments using the EPA Vertebrate MMI ranked most sites in the Least disturbed category, with three sites classified as Intermediate. All three sites meeting this criterion were driven by an absence of species indicative of fast-water habitat. Non-native brook trout were encountered at only one site, in Crystal Creek (WHISWQ15). The park wide average of 83.1 is firmly in the Least disturbed condition.

Table 8. Riparian characteristics of Whiskeytown streams sampled in 2014.

Stream Name	Site Code	Bank Shading	Center Shading	Legacy Tree Height (m)	Canopy			Understory		
					Big Tree	Small Tree	Composition ^a	Woody	Non-Woody	Composition ^a
Boulder Creek	WHISWQ02	78%	61%	14.2	7%	30%	23% D,77% M	32%	22%	32% D,68% M
Boulder Creek	WHISWQ05	95%	90%	32.3	12%	30%	100% M	20%	22%	9% D,91% M
Boulder Creek	WHISWQ17	NA ^b	NA ^b	NA ^b	NA ^b	NA ^b	NA ^b	NA ^b	NA ^b	NA ^b
Boulder Creek	WHISWQ33	93%	89%	28.2	17%	22%	100% M	26%	27%	5% D,95% M
Brandy Creek	WHISWQ12	87%	74%	22.1	15%	28%	9% D,91% M	24%	14%	45% D,55% M
Brandy Creek	WHISWQ18	94%	68%	21.6	16%	23%	9% D,91% M	23%	16%	9% D,91% M
Brandy Creek	WHISWQ34	84%	72%	24.1	47%	20%	82% D,18% M	21%	10%	100% D
Clear Creek	WHISWQ25	63%	14%	22.4	1%	19%	100% M	16%	12%	100% M
Crystal Creek	WHISWQ15	94%	78%	20.9	11%	21%	100% M	19%	22%	5% E,95% M
Crystal Creek	WHISWQ23	87%	82%	31.3	12%	23%	5% C,14% D,82% M	17%	19%	50% D,50% M
Grizzly Gulch	WHISWQ06	87%	86%	16.3	21%	27%	86% D,14% M	18%	27%	86% D,14% M
Mill Creek	WHISWQ09	92%	81%	35.0	11%	25%	100% M	27%	41%	32% D,68% M
Paige Boulder Creek	WHISWQ08	94%	91%	31.3	14%	26%	5% D,95% M	23%	19%	11% D,89% M
Paige Boulder Creek	WHISWQ28	92%	93%	28.3	14%	28%	8% D,92% M	17%	17%	29% D,71% M
Unnamed stream (Boulder Trib)	WHISWQ22	91%	92%	–	19%	26%	100% M	28%	25%	100% M
Unnamed stream (Brandy Trib S)	WHISWQ24	85%	71%	40.2	14%	26%	100% M	17%	24%	5% C,9% D,86% M
Unnamed stream (Crystal Trib)	WHISWQ03	96%	90%	50.3	22%	22%	100% M	21%	16%	100% M
Unnamed stream (Crystal Trib)	WHISWQ35	NA ^b	NA ^b	NA ^b	NA ^b	NA ^b	NA ^b	NA ^b	NA ^b	NA ^b
Whiskey creek	WHISWQ26	93%	79%	13.8	3%	37%	8% D,92% M	23%	41%	22% D,78% M

^aFor compositions: D = Deciduous, C = Coniferous, E = Broadleaf Evergreen, N = None, and M = Mixed (10% or more of multiple types).

^bNA indicates data not available.

Table 8 (continued). Riparian characteristics of Whiskeytown streams sampled in 2014.

Stream Name	Site Code	Bank Shading	Center Shading	Legacy Tree Height (m)	Canopy			Understory		
					Big Tree	Small Tree	Composition ^a	Woody	Non-Woody	Composition ^a
Willow Creek	WHISWQ01	96%	88%	14.4	10%	28%	64% D,36% M	20%	29%	100% D
Willow Creek	WHISWQ21	81%	68%	23.0	8%	26%	18% C,5% D,77% M	20%	50%	27% C,36% D,36% M
Average		89%	77%	26.1	14%	26%	n/a	22%	24%	n/a
SD		8%	18%	9.6	10%	4%	n/a	4%	10%	n/a
Median		92%	81%	23.6	14%	26%	n/a	21%	22%	n/a
Range		63 - 96%	14 - 93%	13.8 - 50.3	1 - 47%	19 - 37%	n/a	16 - 32%	10 - 50%	n/a

^aFor compositions: D = Deciduous, C = Coniferous, E = Broadleaf Evergreen, N = None, and M = Mixed (10% or more of multiple types).

^bNA indicates data not available.

Table 9. Vertebrate species and metrics for Whiskeytown streams sampled in 2014.

Stream Name	Site Code	Sampled? (Yes or No)	Total Abundance	Total Richness	EPA Vertebrate MMI	Brook Trout	California Roach	Pacific Giant Salamander	Rainbow Trout	Tailed Frog	Unknown Frog	Unknown Sculpin	Unknown Sucker	Yellow-legged Frog
Boulder Creek	WHISWQ02	Yes	23	2	100.0 ^a	–	–	4	19	–	–	–	–	–
Boulder Creek	WHISWQ05	Yes	17	2	85.3 ^a	–	–	8	–	9	–	–	–	–
Boulder Creek	WHISWQ17	Yes	28	3	94.2 ^a	–	–	5	21	2	–	–	–	–
Boulder Creek	WHISWQ33	Yes	48	3	93.7 ^a	–	–	8	35	5	–	–	–	–
Brandy Creek	WHISWQ12	Yes	30	2	100.0 ^a	–	–	11	19	–	–	–	–	–
Brandy Creek	WHISWQ18	Yes	29	3	75.6 ^a	–	–	1	15	–	–	13	–	–
Brandy Creek	WHISWQ34	No	–	–	–	–	–	–	–	–	–	–	–	–
Clear Creek	WHISWQ25	Yes	162	4	45.9 ^b	–	45	–	–	10	1	104	2	–

^aSites are Least Disturbed (also with light sage background).

^bSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^cNA indicates data Not Available.

Table 9 (continued). Vertebrate species and metrics for Whiskeytown streams sampled in 2014.

Stream Name	Site Code	Sampled? (Yes or No)	Total Abundance	Total Richness	EPA Vertebrate MMI	Brook Trout	California Roach	Pacific Giant Salamander	Rainbow Trout	Tailed Frog	Unknown Frog	Unknown Sculpin	Unknown Sucker	Yellow- legged Frog
Crystal Creek	WHISWQ15	Yes	78	3	66.5 ^a	1	–	–	31	–	–	46	–	–
Crystal Creek	WHISWQ23	Yes	13	2	100.0 ^a	–	–	8	5	–	–	–	–	–
Grizzly Gulch	WHISWQ06	Yes	50	4	70.7 ^a	–	5	1	33	–	–	11	–	–
Mill Creek	WHISWQ09	No	4	1	–	–	–	–	–	–	–	–	–	4
Paige Boulder Creek	WHISWQ08	Yes	45	3	85.9 ^a	–	–	6	35	–	–	–	–	4
Paige Boulder Creek	WHISWQ28	Yes	10	1	100.0 ^a	–	–	10	–	–	–	–	–	–
Unnamed stream (Boulder Trib)	WHISWQ22	NA ^c	–	NA ^c	NA ^c	–	–	–	–	–	–	–	–	–
Unnamed stream (Brandy Trib S)	WHISWQ24	No	–	–	–	–	–	–	–	–	–	–	–	–
Unnamed stream (Crystal Trib)	WHISWQ03	Yes	21	1	100.0 ^a	–	–	21	–	–	–	–	–	–
Unnamed stream (Crystal Trib)	WHISWQ35	Yes	5	1	100.0 ^a	–	–	5	–	–	–	–	–	–
Whiskey creek	WHISWQ26	Yes	40	6	60.3 ^b	–	1	1	12	–	–	16	8	2
Willow Creek	WHISWQ01	Yes	92	4	51.1 ^b	–	–	–	2	–	–	77	12	1
Willow Creek	WHISWQ21	No	–	–	–	–	–	–	–	–	–	–	–	–
Average		n/a	40.9	2.6	83.1^a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SD		n/a	39.5	1.4	18.9	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Median		n/a	29	3	89.8	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Range		n/a	4 - 162	1 - 6	45.9 - 100	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

^aSites are Least Disturbed (also with light sage background).

^bSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^cNA indicates data Not Available.

Invertebrate assemblage and condition of Whiskeytown streams

A total of 11,965 individual macroinvertebrates were collected, sorted, and identified from Whiskeytown streams (a complete taxa list for the Whiskeytown samples is given in Appendix B). A conservative estimate of the total species richness is 279 separate species (many taxa are only identified to family or genus level, hence the true species richness is likely higher; likewise there are instances where a specific individual was only able to be identified to family, but a separate individual was identified to genus or species, duplicating the “taxonomic units.” See the full protocol [Dinger et al. 2013] or Cuffney et al. 2007 for more detail on ambiguous taxa). Summary statistics (Taxa Richness and measures of biological integrity) for each site are provided in Table 10. The most diverse site was the Boulder Creek (WHISWQ05) with 94 total taxa, while the most depauperate site was Paige Boulder Creek (WHISWQ08) with 42 taxa.

Table 10. Invertebrate results and metrics for Whiskeytown streams, 2014.

Stream Name	Site Code	Total Taxa Richness	Shannon Diversity	HBI ^a	O/E ^b	EPA West-Wide Invertebrate MMI	CA North Coast MMI
Boulder Creek	WHISWQ02	57	2.49	5.12	0.80 ^d	65 ^d	72 ^f
Boulder Creek	WHISWQ05	94	3.83	3.63	1.09 ^c	87 ^c	88 ^f
Boulder Creek	WHISWQ17	81	3.60	4.46	0.77 ^d	79 ^c	82 ^f
Boulder Creek	WHISWQ33	77	3.44	3.67	0.99 ^c	87 ^c	85 ^f
Brandy Creek	WHISWQ12	72	3.23	3.29	0.92 ^c	88 ^c	78 ^f
Brandy Creek	WHISWQ18	83	3.67	4.18	1.21 ^c	85 ^c	86 ^f
Brandy Creek	WHISWQ34	77	3.42	4.56	0.95 ^c	74 ^c	86 ^f
Clear Creek	WHISWQ25	70	3.43	5.22	0.69 ^d	59 ^d	63 ^f
Crystal Creek	WHISWQ15	72	3.32	2.93	1.05 ^c	87 ^c	86 ^f
Crystal Creek	WHISWQ23	74	3.20	5.24	0.69 ^d	66 ^d	76 ^f
Grizzly Gulch	WHISWQ06	64	3.27	4.14	0.71 ^d	68 ^d	77 ^f
Mill Creek	WHISWQ09	82	3.58	4.42	0.93 ^c	83 ^c	86 ^f
Paige Boulder Creek	WHISWQ08	42	2.81	3.59	0.58 ^e	63 ^d	75 ^f
Paige Boulder Creek	WHISWQ28	73	3.48	3.88	0.68 ^d	75 ^c	83 ^f
Unnamed stream (Boulder Trib)	WHISWQ22	67	3.52	4.23	0.84 ^c	75 ^c	91 ^f

^aHBI = Hilsenhoff Biotic Index

^bO/E = Observed/Expected ratio; MMI = Multi-Metric

^cSites in the O/E and EPA West-Wide Invertebrate MMI columns are Least Disturbed (also with light sage background).

^dSites in the O/E and EPA West-Wide Invertebrate MMI columns meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^eSites in the O/E and EPA West-Wide Invertebrate MMI columns meeting EPA criteria for Most Disturbed.

^fSites in the CA North Coast MMI column, cells are equal “good to very good” condition (also with light sage background).

Table 10 (continued). Invertebrate results and metrics for Whiskeytown streams, 2014.

Stream Name	Site Code	Total Taxa Richness	Shannon Diversity	HBI ^a	O/E ^b	EPA West-Wide Invertebrate MMI	CA North Coast MMI
Unnamed stream (Brandy Trib S)	WHISWQ24	64	3.16	4.01	0.79 ^d	90 ^c	78 ^f
Unnamed stream (Crystal Trib)	WHISWQ03	85	3.84	3.52	0.84 ^c	88 ^c	88 ^f
Unnamed stream (Crystal Trib)	WHISWQ35	74	3.32	4.27	0.64 ^d	80 ^c	82 ^f
Whiskey creek	WHISWQ26	61	3.28	4.02	0.80 ^d	61 ^d	79 ^f
Willow Creek	WHISWQ01	69	3.51	4.18	0.87 ^c	78 ^c	81 ^f
Willow Creek	WHISWQ21	72	2.95	4.97	1.05 ^c	74. ^c	67 ^f
Average		71.9	3.35	4.17	0.85^c	76.8^c	80.4^f
SD		11.0	0.32	0.63	0.16	9.9	7.1
Median		72.0	3.42	4.18	0.84	78	82.0
Range		42.0 – 94.0	2.49 - 3.84	2.93 - 5.24	0.58 - 1.21	59 – 90	63 – 91

^aHBI = Hilsenhoff Biotic Index

^bO/E = Observed/Expected ratio; MMI = Multi-Metric

^cSites in the O/E and EPA West-Wide Invertebrate MMI columns are Least Disturbed (also with light sage background).

^dSites in the O/E and EPA West-Wide Invertebrate MMI columns meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^eSites in the O/E and EPA West-Wide Invertebrate MMI columns meeting EPA criteria for Most Disturbed.

^fSites in the CA North Coast MMI column, cells are equal “good to very good” condition (also with light sage background).

For calculating Hilsenhoff Biotic Index (HBI), tolerance values were available for all but 15 of the 393 taxonomic units (which include individuals only identified to higher taxonomic units due to poor keys, damaged specimens, or immature life stages) in the combined Whiskeytown and Lassen Volcanic dataset. Taxa with no tolerance value were excluded from HBI calculations. The lowest HBI (indicating a preponderance of intolerant, clean-water indicating organisms) was Crystal Creek (WHISWQ15), while the highest HBI (indicating more organisms tolerant of poor water quality) was also Crystal Creek (WHISWQ23), but higher in the watershed.

Six sites were rated as Intermediate using the EPA West-wide Invertebrate MMI. The remainder of sites (15 out of 21) were rated in the Least Disturbed condition.

A single site, Paige Boulder Creek (WHISWQ08) was rated as Most Disturbed using the O/E metric of biodiversity loss. The result of 0.58 for Paige Boulder Creek can be interpreted as the site only having 58% of the expected taxa; or a loss of 42% of potential biodiversity. Several other sites were in the Intermediate range, but the majority of sites (11) were in the Least Disturbed category.

The California Regional Water Quality Control Board North Coast MMI rates stream condition as either good (9 sites) or very good (12 sites) for the streams of Whiskeytown. Additionally, the index can be used for designation of “impaired” or “unimpaired” status; all sampled streams were rated “unimpaired.”

Overall, all park-wide invertebrate metric averages were Least Disturbed or “Very Good” (for the CA North Coast MMI).

Lassen Volcanic National Park

Sampling began on August 6, 2014 following the arrival of the field crew from Whiskeytown and continued until September 24, 2014. A total of 22 sites were sampled on seven streams (Figure 5), with the original target of 25 to 30 sites. Two sites sampled in 2011 were found to be dry upon visiting in 2014 (Table 11). See Dinger et al. (2014) for the initial list of sites. For the two dry sites (Summit Creek, LAVOWQ13; NA Rice Creek, LAVOWQ22) the date represents when the crew visited and found the site dry. The final 22 sites are concentrated in the western part of the park, with no sampleable sites in the eastern portion. One site, LAVOWQ43, was planned to be sampled later, but the field season ended before we could include it.

The streams of Lassen Volcanic are subalpine streams (average elevation of sampled streams = 1997 m [6549 ft.] above sea level), in both meadow and mixed conifer forest habitats. They are lower gradient streams (average of 2.7%) than those of Whiskeytown. Because a number of the stream reaches traverse meadows, Lassen Volcanic has streams with more open riparian cover than Whiskeytown. Examples of these characteristics in Lassen Volcanic are presented in Figure 6.

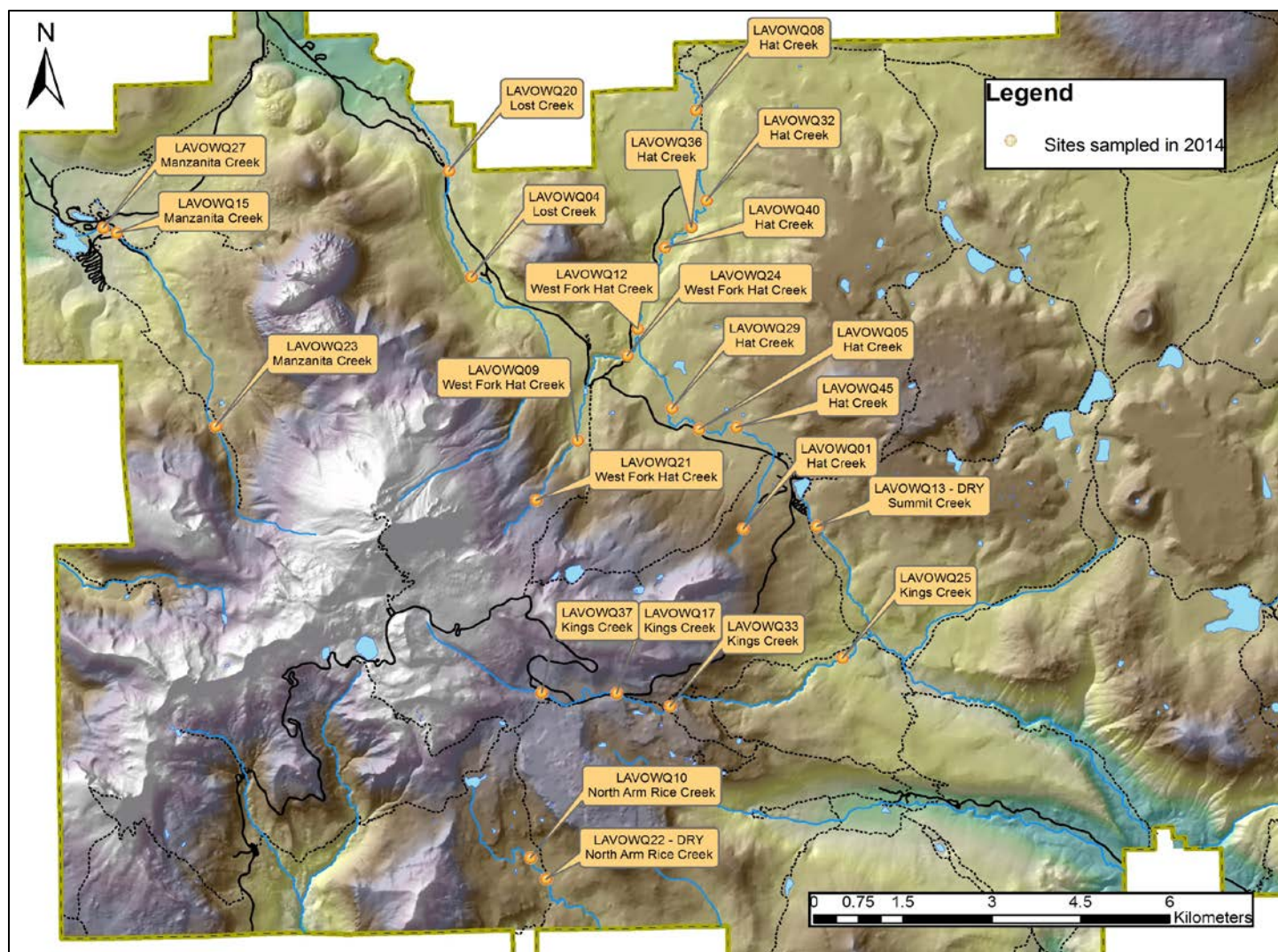


Figure 5. Stream sites sampled in Lassen Volcanic, 2014.

Table 11. Original site list for streams to be sampled in Lassen Volcanic.

Stream Name	Site Code	Date Sampled	Reason for not sampling
Hat Creek	LAVOWQ01	8/27/2014	–
Lost Creek	LAVOWQ04	8/6/2014	–
Hat Creek	LAVOWQ05	9/17/2014	–
Hat Creek	LAVOWQ08	8/11/2014	–
WF Hat Creek	LAVOWQ09	8/12/2014	–
NA Rice Creek	LAVOWQ10	9/23/2014	–
WF Hat Creek	LAVOWQ12	9/2/2014	–
Summit Creek	LAVOWQ13	8/13/2014 ^a	Site Dry - Site sampled in 2011
Manzanita Creek	LAVOWQ15	9/4/2014	–
Kings Creek	LAVOWQ17	8/19/2014	–
Lost Creek	LAVOWQ20	9/8/2014	–
WF Hat Creek	LAVOWQ21	8/7/2014	–
NA Rice Creek	LAVOWQ22	9/10/2014 ^a	Site Dry - Site Sampled in 2011
Manzanita Creek	LAVOWQ23	8/26/2014	–
WF Hat Creek	LAVOWQ24	8/28/2014	–
Kings Creek	LAVOWQ25	8/18/2014	–
Manzanita Creek	LAVOWQ27	8/21/2014	–
Hat Creek	LAVOWQ29	9/24/2014	–
Hat Creek	LAVOWQ32	9/9/2014	–
Kings Creek	LAVOWQ33	8/20/2014	–
Hat Creek	LAVOWQ36	9/3/2014	–
Kings Creek	LAVOWQ37	9/15/2014	–
Hat Creek	LAVOWQ40	9/22/2014	–
Lost Creek	LAVOWQ43 ^b	– ^a	Was planned to be sampled later
Hat Creek	LAVOWQ45 ^b	9/16/2014	–

^aSites were not sampled either due to the site being dry or was planned to be sampled later.

^bSite LAVOWQ45 was prioritized over LAVOWQ43 because LAVOWQ45 was sampled in 2011.



Figure 6. Examples of typical stream characteristics in Lassen Volcanic National Park. A = WF Hat Creek (LAVOWQ21), B = Hat Creek (LAVOWQ08), C = Summit Creek (LAVOWQ13 - DRY), D, E = Kings Creek (LAVOWQ17), F = Hat Creek (LAVOWQ36). Note variety of riparian zone (forest vs. meadow), and prevalence of wide, shallow, low gradient streams. B and F show forest habitat affected by the 2012 Reading Fire. Photos are selected to generally match photos in 2011 report (Dinger and Sarr 2014).

Physical characteristics of Lassen Volcanic streams

Basic summary statistics of the monitoring streams are presented in Table 12. These are general geomorphological summaries of the streams (e.g., elevation, slope, discharge) and do not impart any condition information. North Arm of Rice Creek (LAVOWQ10) was the smallest stream sampled, with the lowest flow ($<0.00 \text{ m}^3/\text{s}$; there was flow but so little that rounding reduces it to zero). There was no one largest stream sampled (depending on how “largest” is defined); but downstream Hat Creek sites were generally wide with the most flow.

Physical condition metrics of Lassen Volcanic streams

The four EPA physical condition metrics along with substrate size and average embeddedness for Lassen Volcanic are presented in Table 13. The median substrate size for a stream is a more common descriptor, since the average can be influenced by a few, very large pieces of substrate. Overall, coarse gravel (diameter = 38 mm) is the predominant substrate. Several stream sites had a large number of small substrates (Kings Creek [LAVOWQ17, 33] and Lost Creek [LAVOWQ04]). Although perhaps not intuitive, we also provide the median of the median and the average median for the surveyed streams. Coincidental with higher amounts of fine sediments/sand/fine gravel, the average embeddedness was 53.1%.

Due to the nature of these montane and subalpine meadow streams, riparian cover tends to be dominated by shrubs and graminoid (i.e., grasses) vegetation. The limited riparian cover results in most sites being classified as Intermediate using EPA threshold criteria; however, this is likely not a result of degraded or impacted riparian zones, but is the natural character of Lassen Volcanic montane and subalpine streams. Adding to this prevalence is the reduced stream width in the relatively dry 2014 water year; the reduced stream width increases the dry streamside habitat. In-stream habitat cover was rated Least Disturbed at all but Lost Creek (LAVOWQ04). In-stream habitat is also partially composed of boulder substrate, so the overall scarcity of large substrates in Lassen Volcanic streams likely contributes to observed lower ratings. Riparian disturbance was only elevated to Intermediate in three sites, Hat Creek (LAVOWQ05), Kings Creek (LAVOWQ17), and Manzanita Creek (LAVOWQ15). Two sites, Kings Creek (LAVOWQ37) and Manzanita Creek (LAVOWQ27) were rated Most Disturbed. The Kings Creek site is a roadside stream, and Manzanita Creek is proximal to one of the park’s larger campsites.

Relative Bed Stability (RBS) in Lassen Volcanic indicates four sites rated Intermediate in terms of sediment supply relative to expected sediments. One of the sites was rated Intermediate due to smaller than expected sediments being present (silt, fines, sand) and three (NA Rice Creek, Kings Creek, and Hat Creek) were Intermediate due to larger than expected sediments being present. Overall park wide average of RBS was Least Disturbed. These are values based on rapid calculation of RBS, and do not incorporate the effects of woody debris, bankfull characteristics, or residual pool depth on the expected median particle size.

Table 12. Physical characteristics and location of streams sampled in Lassen Volcanic, 2014.

Stream Name	Site Code	Date Sampled	UTM Coordinates ^a		Elevation (m)	Reach Length (m)	Average Width (m)	Average Depth (cm)	Slope	Instantaneous Discharge	
			X	Y						m ³ s ⁻¹	ft ³ s ⁻¹
Hat Creek	LAVOWQ01	8/27/2014	632624	4482926	2124	150	2.1	14.5	6.10%	0.034	1.21
Hat Creek	LAVOWQ05	9/17/2014	631881	4484668	2012	160	3.2	24.2	1.80%	0.060	2.13
Hat Creek	LAVOWQ08	8/11/2014	631826	4490256	1879	320	5.8	35.3	0.80%	0.287	10.13
Hat Creek	LAVOWQ29	9/24/2014	631419	4485035	2001	200	3.7	18.6	1.10%	0.045	1.58
Hat Creek	LAVOWQ32	9/9/2014	632001	4488672	1893	240	7.2	27.1	0.80%	0.371	13.12
Hat Creek	LAVOWQ36	9/3/2014	631748	4488206	1896	320	7.9	32.7	0.80%	0.318	11.24
Hat Creek	LAVOWQ40	9/22/2014	631303	4487850	1907	280	5.6	26.6	0.80%	0.248	8.75
Hat Creek	LAVOWQ45	9/16/2014	632505	4484703	2017	150	2.0	12.8	2.40%	0.034	1.19
Kings Creek	LAVOWQ17	8/19/2014	630486	4480048	2226	150	2.0	28.8	1.10%	0.085	2.99
Kings Creek	LAVOWQ25	8/18/2014	634298	4480666	1901	200	4.4	17.4	4.00%	0.091	3.22
Kings Creek	LAVOWQ33	8/20/2014	631388	4479816	2209	240	4.1	27.7	1.30%	0.090	3.17
Kings Creek	LAVOWQ37	9/15/2014	629222	4480054	2242	150	2.3	16.5	2.50%	0.076	2.67
Lost Creek	LAVOWQ04	8/6/2014	628039	4487336	1883	150	1.6	13.1	1.80%	0.064	2.28
Lost Creek	LAVOWQ20	9/8/2014	627658	4489192	1842	150	2.2	14.3	3.60%	0.069	2.42
Manzanita Creek	LAVOWQ15	9/4/2014	622056	4488110	1817	160	3.8	19.6	4.70%	0.312	11.00
Manzanita Creek	LAVOWQ23	8/26/2014	623725	4484722	2060	150	3.0	22.6	6.00%	0.118	4.18
Manzanita Creek	LAVOWQ27	8/21/2014	621830	4488197	1801	160	3.7	18.6	2.00%	0.177	6.25
NA Rice Creek	LAVOWQ10	9/23/2014	629034	4477164	2103	160	2.7	12.2	3.80%	0.000	0.00
WF Hat Creek	LAVOWQ09	8/12/2014	629826	4484472	1996	160	3.4	21.9	4.90%	0.102	3.60
WF Hat Creek	LAVOWQ12	9/2/2014	630843	4486426	1923	240	7.6	26.3	1.00%	0.250	8.83
WF Hat Creek	LAVOWQ21	8/7/2014	629133	4483432	2252	150	2.7	11.9	5.50%	0.042	1.48
WF Hat Creek	LAVOWQ24	8/28/2014	630665	4485961	1940	200	5.1	23.2	2.30%	0.211	7.44

^aUTM = Universal Transverse Mercator, Zone 10N. NA = North Arm, WF = West Fork.

Table 12 (continued). Physical characteristics and location of streams sampled in Lassen Volcanic, 2014.

Stream Name	Site Code	Date Sampled	UTM Coordinates ^a		Elevation (m)	Reach Length (m)	Average Width (m)	Average Depth (cm)	Slope	Instantaneous Discharge	
			X	Y						m ³ s ⁻¹	ft ³ s ⁻¹
Average					1997	193	3.9	21.2	2.7%	0.140	4.95
SD					142	56	1.9	6.8	1.8%	0.111	3.92
Median					1968	160	3.55	20.75	2.2%	0.091	3.20
Range					1801 - 2252	150 - 320	1.6 - 7.9	11.9 - 35.3	0.8 - 6.1%	0 - 0.371	0 - 13.12

^aUTM = Universal Transverse Mercator, Zone 10N. NA = North Arm, WF = West Fork.

Table 13. Physical condition metrics for Lassen Volcanic streams sampled in 2014.

Stream Name	Site Code	Date Sampled	Stream Substrate Diameter (mm)		Average Embeddeness (%)	Pool (%)	Riffle (%)	Physical Habitat Condition Metrics			
			Average	Median				In-Stream Habitat Complexity	Riparian Cover	Relative Bed Stability	Riparian Disturbance
Hat Creek	LAVOWQ01	8/27/2014	25.6	38.0	58.9	8%	92%	0.72 ^a	0.58 ^b	-0.49 ^a	0.00 ^a
Hat Creek	LAVOWQ05	9/17/2014	39.3	114.8	47.5	12%	52%	0.86 ^a	0.44 ^b	0.06 ^a	0.39 ^b
Hat Creek	LAVOWQ08	8/11/2014	31.9	38.0	45.4	2%	62%	0.78 ^a	0.37 ^b	0.14 ^b	0.00 ^a
Hat Creek	LAVOWQ29	9/24/2014	24.0	38.0	55.1	16%	45%	0.79 ^a	0.47 ^b	0.05 ^a	0.00 ^a
Hat Creek	LAVOWQ32	9/9/2014	12.9	38.0	59.5	29%	49%	0.98 ^a	0.43 ^b	-0.25 ^a	0.00 ^a
Hat Creek	LAVOWQ36	9/3/2014	14.6	38.0	62.5	4%	44%	0.67 ^a	0.55 ^b	-0.26 ^a	0.00 ^a
Hat Creek	LAVOWQ40	9/22/2014	8.4	38.0	54.0	11%	46%	0.90 ^a	0.62 ^b	-0.5 ^a	0.00 ^a
Hat Creek	LAVOWQ45	9/16/2014	19.5	38.0	53.8	12%	63%	0.75 ^a	0.42 ^b	-0.23 ^a	0.00 ^a
Kings Creek	LAVOWQ17	8/19/2014	14.4	38.0	35.5	2%	24%	0.66 ^a	0.20 ^c	-0.23 ^a	0.76 ^b
Kings Creek	LAVOWQ25	8/18/2014	112.3	114.8	32.8	14%	86%	0.86 ^a	0.51 ^b	0.22 ^b	0.00 ^a
Kings Creek	LAVOWQ33	8/20/2014	7.20	4.2	73.5	7%	20%	0.49 ^a	0.37 ^b	-0.65 ^a	0.00 ^a
Kings Creek	LAVOWQ37	9/15/2014	36.4	38.0	49.1	11%	88%	0.70 ^a	0.45 ^b	-0.05 ^a	1.15 ^c

^aSites are Least Disturbed (also with light sage background).

^bSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^cSites meeting EPA criteria for Most Disturbed (also with dark red background).

Table 13 (continued). Physical condition metrics for Lassen Volcanic streams sampled in 2014.

Stream Name	Site Code	Date Sampled	Stream Substrate Diameter (mm)		Average Embeddeness (%)	Pool (%)	Riffle (%)	Physical Habitat Condition Metrics			
			Average	Median				In-Stream Habitat Complexity	Riparian Cover	Relative Bed Stability	Riparian Disturbance
Lost Creek	LAVOWQ04	8/6/2014	5.9	6.2	85.5	2%	98%	0.13 ^c	0.42 ^b	-0.60 ^a	0.00 ^a
Lost Creek	LAVOWQ20	9/8/2014	7.2	4.2	76.7	6%	94%	0.72 ^a	0.23 ^b	-0.90 ^b	0.33 ^a
Manzanita Creek	LAVOWQ15	9/4/2014	84.8	114.8	43.7	0%	100%	0.91 ^a	0.38 ^b	-0.03 ^a	0.67 ^b
Manzanita Creek	LAVOWQ23	8/26/2014	95.5	114.8	39.0	8%	88%	0.65 ^a	0.62 ^b	-0.11 ^a	0.00 ^a
Manzanita Creek	LAVOWQ27	8/21/2014	10.8	38.0	59.7	18%	71%	0.89 ^a	0.44 ^b	-0.59 ^a	2.9 ^c
NA Rice Creek	LAVOWQ10	9/23/2014	144.7	114.8	44.8	34%	59%	0.86 ^a	0.6 ^b	0.56 ^b	0.00 ^a
WF Hat Creek	LAVOWQ09	8/12/2014	56.0	114.8	44.6	25%	75%	0.98 ^a	0.76 ^a	-0.26 ^a	0.00 ^a
WF Hat Creek	LAVOWQ12	9/2/2014	28.6	38.0	57.1	3%	46%	0.49 ^a	0.44 ^b	0.09 ^a	0.00 ^a
WF Hat Creek	LAVOWQ21	8/7/2014	30.9	38.0	37.8	17%	83%	0.54 ^a	0.89 ^a	-0.37 ^a	0.00 ^a
WF Hat Creek	LAVOWQ24	8/28/2014	46.1	114.8	51.9	0%	83%	0.95 ^a	0.60 ^b	-0.08 ^a	0.00 ^a
Average			39.0	57.9	53.1	11%	67%	0.74 ^a	0.49 ^b	-0.20 ^a	0.28 ^a
SD			37.7	41.3	13.4	9%	24%	0.20	0.16	0.34	0.66
Median			27.1	38.0	52.9	10%	67%	0.77	0.45	-0.23	0.00
Range			5.9 - 144.7	4.2 - 114.8	32.8 - 85.5	0 - 34%	20 - 100%	0.13 - 0.98	0.2 - 0.89	-0.9 - 0.56	0 - 2.9

^aSites are Least Disturbed (also with light sage background).
^bSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).
^cSites meeting EPA criteria for Most Disturbed (also with dark red background).

Chemical characteristics and condition estimates of Lassen Volcanic streams

Selected water chemistry results are presented in Table 14. Parameters measured in-situ with a water probe (see methods) are listed under “water quality” and parameters measured in an analytical laboratory or with a stream-side assay (Acid Neutralizing Capacity) are presented as “water chemistry”.

All **Dissolved Oxygen** concentrations attained the water quality criteria in Table 3.

pH was found to be slightly alkaline to alkaline with an average of 8.43. However, pH was reported by crew to not be calibrating correctly, but with no indication of when pH was not properly working. All pH values for 2014 should be considered suspect.

Acid Neutralizing Capacities were all positive, indicating Least Disturbed.

Temperature is presented as a descriptor of conditions during sampling, but varies on a daily, monthly, and seasonal basis. As such, no status or condition should be inferred from temperature readings. Our measurements, taken generally at mid-morning or mid-day in the summer represent near maximal values. All measurements (many around 5 - 7 °C) are typical for high elevation, montane and subalpine streams, although warmer than 2011 values (Dinger and Sarr 2014). Hat Creek had the highest recorded temperature, at 11.2 °C. **Specific conductivity** (used as a surrogate for salinity by the EPA) was uniformly low, and well under EPA threshold criteria for Least Disturbed at all sites.

All measured **turbidity** readings were well below the NPS threshold of 50 NTU for water quality exceedances. The park-wide average was 0.3 NTU. However, the crew was unable to properly calibrate turbidity values after September 11, so these values should be seen as estimates. As mentioned in the Whiskeytown results, some of the Lassen Volcanic turbidity measurements exceed the drinking water criteria, but there is no basis for applying drinking water criteria to these water bodies.

Anion and **cation** measurements were all far below any available water quality criteria, except for high sodium levels in West Fork Hat Creek (LAVOWQ09) that exceeded EPA Health Advisory criteria (Table 2).

No sites had elevated **total nitrogen** values, and all values were rated Least Disturbed.

All but four sites and the overall park average were elevated for **total phosphorous** (three sites on Hat Creek, one site on NA Rice Creek), additionally, five sites were in the Most Disturbed criteria. The widespread distribution of Intermediate phosphorus levels suggests a geological or naturally occurring source.

Table 14. Water chemistry parameters for streams sampled in Lassen Volcanic, 2014.

Stream Name	Site Code	Water Quality ^a					Water Chemistry ^b					Acid Neutralizing Capacity ^b	
		pH	Temp (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Sulfate (mg/L)	Chloride mg/L	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)	(µeq/L)	(mg/L)
Hat Creek	LAVOWQ01	8.28	4.0	66 ^c	10.4	0.0	2.00	0.16	0.35	0.06 ^c	0.012 ^d	459 ^c	23 ^c
Hat Creek	LAVOWQ05	8.16	6.4	61 ^c	10.5	0.0 ⁱ	2.21	0.14	0.59	0.05 ^c	0.006 ^c	1139 ^c	57 ^c
Hat Creek	LAVOWQ08	9.64	11.2	131 ^c	9.1	0.2	4.87	1.20	0.64	0.12 ^c	0.026 ^d	1316 ^c	66 ^c
Hat Creek	LAVOWQ29	8.18	6.9	61 ^c	9.0	0.0 ⁱ	2.26	0.12	0.53	0.07 ^c	0.004 ^c	590 ^c	30 ^c
Hat Creek	LAVOWQ32	8.44	5.6	145 ^c	10.2	0.0	5.35	1.36	0.77	0.06 ^c	0.027 ^d	2458 ^c	123 ^c
Hat Creek	LAVOWQ36	8.44	6.8	144 ^c	10.2	0.0	5.43	1.35	0.93	0.06 ^c	0.028 ^d	1453 ^c	73 ^c
Hat Creek	LAVOWQ40	8.37	7.3	144 ^c	10.2	0.0 ⁱ	5.45	1.40	0.66	0.07 ^c	0.031 ^d	1788 ^c	90 ^c
Hat Creek	LAVOWQ45	8.13	4.6	67 ^c	11.2	0.0 ⁱ	2.18	0.16	0.55	0.04 ^c	0.009 ^c	1019 ^c	51 ^c
Kings Creek	LAVOWQ17	8.23	6.8	35 ^c	9.7	0.0	2.13	0.19	0.53	0.06 ^c	0.045 ^e	358 ^c	18 ^c
Kings Creek	LAVOWQ25	8.48	10.0	37 ^c	9.2	0.5	2.17	0.19	0.50	0.06 ^c	0.032 ^d	316 ^c	16 ^c
Kings Creek	LAVOWQ33	8.32	5.7	36 ^c	9.9	0.0	2.09	0.18	0.46	0.06 ^c	0.041 ^e	322 ^c	16 ^c
Kings Creek	LAVOWQ37	8.04	4.5	29 ^c	10.7	0.0 ⁱ	2.05	0.21	0.51	0.06 ^c	0.052 ^e	490 ^c	24 ^c
Lost Creek	LAVOWQ04	8.39	7.9	114 ^c	9.1	0.0	5.40	1.88	0.66	0.12 ^c	0.024 ^d	1033 ^c	52 ^c
Lost Creek	LAVOWQ20	8.26	7.8	119 ^c	10.3	0.0	5.31	1.74	0.61	0.07 ^c	0.016 ^d	1008 ^c	50 ^c

^aData collected with water probe.

^bData from laboratory analysis.

^cSites are Least Disturbed (also with light sage background).

^dSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^eSites meeting EPA criteria for Most Disturbed (also with dark red background).

^fNA = North Arm.

^gWF = West Fork

^hSee text for qualifiers on interpreting pH data.

ⁱ Indicates turbidity values that should be interpreted as estimates only.

Table 14 (continued). Water chemistry parameters for streams sampled in Lassen Volcanic, 2014.

Stream Name	Site Code	Water Quality ^a					Water Chemistry ^b					Acid Neutralizing Capacity ^b	
		pH	Temp (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Sulfate (mg/L)	Chloride mg/L	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)	(µeq/L)	(mg/L)
Manzanita Creek	LAVOWQ15	8.38	5.6	118 ^c	10.3	0.0	5.55	1.25	1.08	0.05 ^c	0.016 ^d	444 ^c	22 ^c
Manzanita Creek	LAVOWQ23	8.19	5.4	85 ^c	10.3	0.0	3.61	1.01	0.41	0.07 ^c	0.027 ^d	801 ^c	40 ^c
Manzanita Creek	LAVOWQ27	8.63	6.7	118 ^c	10.2	1.7	5.22	1.23	0.63	0.06 ^c	0.015 ^d	1000 ^c	50 ^c
NA Rice Creek ^f	LAVOWQ10	8.67	10.8	41 ^c	9.9	0.0 ⁱ	2.80	0.11	0.71	0.11 ^c	0.005 ^c	418 ^c	21 ^c
WF Hat Creek ^g	LAVOWQ09	8.7	6.1	163 ^c	9.9	4.4	22.04	3.41	41.38	0.08 ^c	0.042 ^e	1440 ^c	72 ^c
WF Hat Creek ^g	LAVOWQ12	8.44	7.0	149 ^c	10.4	0.0	5.40	1.40	1.09	0.06 ^c	0.033 ^d	1478 ^c	74 ^c
WF Hat Creek ^g	LAVOWQ21	8.73	6.0	173 ^c	9.8	0.0	7.20	2.87	1.09	0.08 ^c	0.051 ^e	1620 ^c	81 ^c
WF Hat Creek ^g	LAVOWQ24	8.46	6.5	167 ^c	10.3	0.0	6.48	1.70	0.80	0.06 ^c	0.04 ^d	1584 ^c	79 ^c
Average		8.43	6.8	100 ^c	10.0	0.3	4.87	1.06	2.52	0.07 ^c	0.026 ^d	1024 ^c	51 ^c
SD		0.33	1.9	49	0.6	1.0	4.20	0.93	8.68	0.02	0.015	576	29
Median		8.39	6.6	116	10.2	0.0	5.05	1.22	0.64	0.06	0.027	1014	51
Range		8.04 - 9.64	4 - 11.2	29 - 173	9 - 11.2	0 - 4.4	2 - 22.04	0.11 - 3.41	0.35 - 41.38	0.04 - 0.12	0.004 - 0.052	316 - 2458	16 - 123

^aData collected with water probe.

^bData from laboratory analysis.

^cSites are Least Disturbed (also with light sage background).

^dSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^eSites meeting EPA criteria for Most Disturbed (also with dark red background).

^fNA = North Arm.

^gWF = West Fork

^hSee text for qualifiers on interpreting pH data.

ⁱIndicates turbidity values that should be interpreted as estimates only.

Riparian characteristics of Lassen Volcanic streams

The riparian zones of Lassen Volcanic are overall characterized by coniferous trees and a diverse community providing moderate overall shading (75% average bank shading; Table 15). The site with the least shading was Hat Creek (LAVOWQ08). Both the canopy cover and understory were generally coniferous tree dominated, with only a few sites having a deciduous canopy cover component.

Vertebrate assemblage and condition of Lassen Volcanic streams

Results of electrofishing and visual encounters of vertebrate species, along with summaries of abundance, richness, and the EPA Vertebrate MMI are presented in Table 16. Two amphibian species (Pacific Tree Frog, *Pseudacris regilla*; and Western Toad, *Bufo boreas*), two species of non-native trout (Brook Trout, *Salvelinus fontinalis*; Brown Trout, *Salmo trutta*), and one native (but possibly stocked) species of trout (Rainbow Trout, *Oncorhynchus mykiss*) were observed. Of these, only brook trout, recorded from 15 sites, could be considered widespread. Five sites had no detected vertebrate species. All observed vertebrate species have been previously recorded in the park ([KLMN certified species lists](#)).

All but five of the sites with vertebrates were rated as Intermediate using the EPA's Vertebrate MMI threshold criteria; consequently the park-wide average was also in the Intermediate range at 60.2 out of 100. This is largely due to low species richness and the presence of non-native fish. Sites with no vertebrates encountered cannot be assessed or assigned scores as streams may be naturally devoid of species. Hence, these sites were not ranked or included in average and median calculations, and are listed as "null" in the table.

A total of 13,888 individual macroinvertebrates were collected, sorted, and identified from Lassen Volcanic streams (a complete taxa list for Lassen Volcanic samples is given in Appendix C). A conservative estimate for the total species richness is 175 separate species (many taxa are only identified to family or genus level, hence the true species richness is likely to be higher; also there are instances where a specific individual was only able to be identified to family, but a separate individual was identified to genus or species, duplicating the "taxonomic units." See the full protocol [Dinger et al. 2013] or Cuffney et al. 2007 for more detail on ambiguous taxa). Summary statistics (Taxa Richness and measures of biological integrity) for each site are provided in Table 17.

The most diverse site was King Creek (LAVOWQ25) with 84 total taxa, and the most depauperate site was Lost Creek (LAVOWQ04) with 38 taxa.

For calculating Hilsenhoff Biotic Index (HBI), tolerance values were available for all but 15 of the 393 taxonomic units (which include individuals only identified to higher taxonomic units due to poor keys, damaged specimens, or immature life stages) in the combined Whiskeytown and Lassen Volcanic dataset. Taxa with no tolerance value were excluded from HBI calculations. The lowest HBI (indicating a preponderance of intolerant, clean-water indicating organisms) was Lost Creek (LAVOWQ04), a site dominated by a single stonefly, *Yoraperla nigrisoma*. The highest HBI (indicating mostly tolerant organisms) was King Creek (LAVOWQ33) at 5.48.

Table 15. Riparian characteristics of Whiskeytown streams sampled in 2014.

Stream Name	Site Code	Bank Shading	Center Shading	Legacy Tree Height (m)	Canopy			Understory		
					Big Tree	Small Tree	Composition ^a	Woody	Non-Woody	Composition ^a
Hat Creek	LAVOWQ01	74%	51%	24.9	20%	23%	100% C	9%	0%	91% C,9% N
Hat Creek	LAVOWQ05	80%	53%	20.4	10%	15%	100% C	10%	10%	9% C,9% D,82% M
Hat Creek	LAVOWQ08	41%	12%	22.0	5%	16%	73% C,9% D,5% N,14% M	8%	21%	52% C,5% D,10% N,33% M
Hat Creek	LAVOWQ29	68%	41%	24.5	19%	14%	100% C	11%	17%	23% D,77% M
Hat Creek	LAVOWQ32	73%	30%	23.8	19%	19%	100% C	3%	6%	5% C,55% D,41% M
Hat Creek	LAVOWQ36	82%	25%	20.9	10%	23%	5% C,95% M	16%	2%	91% D,9% N
Hat Creek	LAVOWQ40	87%	33%	21.9	17%	15%	36% C,64% M	14%	20%	91% D,9% M
Hat Creek	LAVOWQ45	85%	48%	21.6	11%	14%	91% C,9% N	11%	11%	14% C,27% D,59% M
Kings Creek	LAVOWQ17	84%	22%	18.0	1%	7%	55% C,45% N	0%	0%	5% C,95% N
Kings Creek	LAVOWQ25	69%	48%	34.3	22%	20%	100% C	5%	9%	64% C,5% D,18% N,14% M
Kings Creek	LAVOWQ33	71%	37%	19.8	12%	17%	95% C,5% D	6%	0%	55% C,45% N
Kings Creek	LAVOWQ37	79%	29%	15.7	6%	9%	68% C,32% N	24%	5%	82% D,18% M
Lost Creek	LAVOWQ04	73%	61%	19.1	6%	11%	55% C,9% D,36% N	20%	3%	32% C,55% D,14% M
Lost Creek	LAVOWQ20	80%	36%	19.6	4%	8%	100% C	6%	1%	95% C,5% M
Manzanita Creek	LAVOWQ15	64%	33%	28.1	11%	8%	100% C	10%	3%	64% C,36% M
Manzanita Creek	LAVOWQ23	89%	73%	27.1	20%	9%	100% C	29%	1%	18% D,5% N,77% M
Manzanita Creek	LAVOWQ27	78%	59%	16.0	12%	16%	59% C,5% D,36% M	10%	0%	55% C,5% D,27% N,14% M
NA Rice Creek	LAVOWQ10	63%	42%	25.6	14%	17%	91% C,5% D,5% M	18%	7%	14% C,5% D,5% N,77% M
WF Hat Creek	LAVOWQ09	89%	65%	33.5	20%	18%	32% C,9% N,59% M	15%	17%	5% C,38% D,24% N,33% M
WF Hat Creek	LAVOWQ12	78%	37%	18.0	7%	25%	100% C	10%	0%	23% C,14% D,18% N,45% M
WF Hat Creek	LAVOWQ21	67%	44%	34.3	39%	31%	100% C	7%	3%	68% C,32% N
WF Hat Creek	LAVOWQ24	83%	34%	13.2	13%	24%	91% C,9% D	18%	5%	5% C,41% D,9% N,45% M

^aFor compositions: D = Deciduous, C = Coniferous, E = Broadleaf Evergreen, N = None, and M = Mixed (10% or more of multiple types).

Table 15 (continued). Riparian characteristics of Whiskeytown streams sampled in 2014.

Stream Name	Site Code	Bank Shading	Center Shading	Legacy Tree Height (m)	Canopy			Understory		
					Big Tree	Small Tree	Composition ^a	Woody	Non-Woody	Composition ^a
Average		75%	42%	22.8	14%	16%	n/a	12%	6%	n/a
SD		11%	15%	5.9	8%	6%	n/a	7%	7%	n/a
Median		78%	39%	21.8	12%	16%	n/a	10%	4%	n/a
Range		41 - 89%	12 - 73%	1 - 39%	7 - 31%	n/a	n/a	n/a	n/a	n/a

^aFor compositions: D = Deciduous, C = Coniferous, E = Broadleaf Evergreen, N = None, and M = Mixed (10% or more of multiple types).

Table 16. Vertebrate species and metrics for Lassen Volcanic streams sampled in 2014.

Stream Name	Site Code	Sampled: Yes or No	Total Abundance	Total Richness	EPA Vertebrate MMI	Brook Trout	Brown Trout	Pacific Tree Frog	Rainbow Trout	Unknown Trout	Western Toad
Hat Creek	LAVOWQ01	Yes	—	—	Null	—	—	—	—	—	—
Hat Creek	LAVOWQ05	Yes	65	1	57.1 ^b	65	—	—	—	—	—
Hat Creek	LAVOWQ08	Yes	39	1	57.1 ^b	39	—	—	—	—	—
Hat Creek	LAVOWQ29	Yes	154	2	46.9 ^b	149	—	5	—	—	—
Hat Creek	LAVOWQ32	Yes	55	1	57.1 ^b	55	—	—	—	—	—
Hat Creek	LAVOWQ36	Yes	144	1	57.1 ^b	144	—	—	—	—	—
Hat Creek	LAVOWQ40	Yes	60	2	46.9 ^b	59	—	1	—	—	—
Hat Creek	LAVOWQ45	Yes	51	1	57.1 ^b	51	—	—	—	—	—
Kings Creek	LAVOWQ17	Yes	6	2	54.1 ^b	5	—	—	—	—	1
Kings Creek	LAVOWQ25	Yes	12	2	81.0 ^a	5	—	—	7	—	—
Kings Creek	LAVOWQ33	Yes	16	2	46.9 ^b	15	—	1	—	—	—
Kings Creek	LAVOWQ37	Yes	—	—	Null	—	—	—	—	—	—

^aSites are Least Disturbed (also with light sage background).

^bSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^cSites meeting EPA criteria for Most Disturbed (also with dark red background).

Table 16 (continued). Vertebrate species and metrics for Lassen Volcanic streams sampled in 2014.

Stream Name	Site Code	Sampled: Yes or No	Total Abundance	Total Richness	EPA Vertebrate MMI	Brook Trout	Brown Trout	Pacific Tree Frog	Rainbow Trout	Unknown Trout	Western Toad
Lost Creek	LAVOWQ04	Yes	–	–	Null	–	–	–	–	–	–
Lost Creek	LAVOWQ20	Yes	3	1	100.0 ^a	–	–	–	3	–	–
Manzanita Creek	LAVOWQ15	Yes	3	3	66.7 ^a	1	1	–	1	–	–
Manzanita Creek	LAVOWQ23	Yes	–	–	Null	–	–	–	–	–	–
Manzanita Creek	LAVOWQ27	Yes	34	4	66.2 ^a	7	13	1	12	1	–
NA Rice Creek	LAVOWQ10	Yes	32	2	79.1 ^a	–	–	4	28	–	–
WF Hat Creek	LAVOWQ09	Yes	4	1	57.1 ^b	4	–	–	–	–	–
WF Hat Creek	LAVOWQ12	Yes	43	2	46.9 ^b	42	–	1	–	–	–
WF Hat Creek	LAVOWQ21	Yes	–	–	Null	–	–	–	–	–	–
WF Hat Creek	LAVOWQ24	Yes	14	2	46.9 ^b	13	–	1	–	–	–
Average		n/a	43.2	1.8	60.2^b	n/a	n/a	n/a	n/a	n/a	n/a
SD		n/a	45.0	0.8	14.6	n/a	n/a	n/a	n/a	n/a	n/a
Median		n/a	34	2	57.1	n/a	n/a	n/a	n/a	n/a	n/a
Range		n/a	3 -154	1 -4	46.9 - 100	n/a	n/a	n/a	n/a	n/a	n/a

^aSites are Least Disturbed (also with light sage background).

^bSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^cSites meeting EPA criteria for Most Disturbed (also with dark red background).

Table 17. Invertebrate results and metrics for Lassen Volcanic streams, 2014.

Stream Name	Site Code	Total Taxa Richness	Shannon Diversity	HBI ^a	O/E ^b	EPA West-Wide Invertebrate MMI ^c	East Sierra MMI ^c
Hat Creek	LAVOWQ01	46	3.20	3.48	1.12 ^d	71 ^d	90 ^d
Hat Creek	LAVOWQ05	58	2.86	3.49	0.85 ^d	77 ^d	96 ^d
Hat Creek	LAVOWQ08	67	3.6	4.41	1.03 ^d	79 ^d	82 ^d
Hat Creek	LAVOWQ29	62	3.19	3.53	0.88 ^d	76 ^d	96 ^d
Hat Creek	LAVOWQ32	72	3.37	3.27	1.18 ^d	82 ^d	89 ^d
Hat Creek	LAVOWQ36	64	3.30	5.48	0.86 ^d	71 ^d	64 ^e
Hat Creek	LAVOWQ40	55	3.18	2.88	1.09 ^d	86 ^d	92 ^d
Hat Creek	LAVOWQ45	57	3.29	4.13	1.00 ^d	81 ^d	86 ^d
Kings Creek	LAVOWQ17	45	3.07	4.39	0.71 ^e	71 ^d	65 ^e
Kings Creek	LAVOWQ25	84	3.59	4.53	1.06 ^d	79 ^d	83 ^d
Kings Creek	LAVOWQ33	51	2.97	5.48	0.71 ^e	61 ^e	54 ^f
Kings Creek	LAVOWQ37	45	2.73	5.19	0.89 ^d	76 ^d	83 ^d
Lost Creek	LAVOWQ04	38	1.77	2.36	0.77 ^e	55 ^f	57 ^f
Lost Creek	LAVOWQ20	46	2.99	3.92	0.74 ^e	71 ^d	85 ^d
Manzanita Creek	LAVOWQ15	44	2.33	4.81	0.85 ^d	78 ^d	75 ^e
Manzanita Creek	LAVOWQ23	62	3.40	3.41	1.06 ^d	84 ^d	81 ^d
Manzanita Creek	LAVOWQ27	51	2.98	5.2	0.91 ^d	77 ^d	67 ^e
NA Rice Creek	LAVOWQ10	60	3.17	4.54	0.60 ^f	71 ^d	83 ^d
WF Hat Creek	LAVOWQ09	55	2.73	2.71	1.00 ^d	75 ^d	81 ^d
WF Hat Creek	LAVOWQ12	66	3.15	4.57	0.85 ^d	81 ^d	83 ^d
WF Hat Creek	LAVOWQ21	50	3.03	3.86	0.90 ^d	79 ^d	91 ^d
WF Hat Creek	LAVOWQ24	67	3.41	3.47	1.08 ^d	83 ^d	89 ^d
Average		56.6	3.06	4.05	0.92^d	75.6^d	80.5^d
SD		11.0	0.41	0.89	0.15	7.3	12.0
Median		56	3.16	4.03	0.90	77.0	83
Range		38 -84	1.77 - 3.60	2.36 - 5.48	0.60 - 1.18	55 - 86	54 - 96

^aHBI = Hilsenhoff Biotic Index.

^bO/E = Observed/Expected ratio.

^cMMI = Multi=Metric Index.

^dSites are Least Disturbed (also with light sage background).

^eSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^fSites meeting EPA criteria for Most Disturbed (also with dark red background).

All but two sites were rated as Least disturbed using the EPA Invertebrate MMI, with Lost Creek (LAVOWQ04) being Most Disturbed and King Creek (LAVOWQ33) being Intermediate. The

highest rated site was Hat Creek (LAVOWQ40) at 86 out of 100. The park-wide average of 75.6 is rated Least Disturbed.

Sixteen sites were rated as “supporting, acceptable” and four sites as “supporting, intermediate” while two sites were rated “not supporting” using the East Sierra MMI. One site rated “not supporting” was Lost Creek (LAVOWQ04), the same site had the lowest taxa richness, although it also had the lowest HBI. See the discussion for more interpretation of multiple lines of evidence in determining ecological health with no vertebrates encountered cannot be assessed or assigned scores as streams may be naturally devoid of species. Hence, these sites were not ranked or included in average and median calculations, and are listed as “null” in the table.

A total of 13,888 individual macroinvertebrates were collected, sorted, and identified from Lassen Volcanic streams (a complete taxa list for Lassen Volcanic samples is given in Appendix C). A conservative estimate for the total species richness is 175 separate species (many taxa are only identified to family or genus level, hence the true species richness is likely to be higher); also there are instances where a specific individual was only able to be identified to family, but a separate individual was identified to genus or species, duplicating the “taxonomic units.” See the full protocol [Dinger et al. 2013] or Cuffney et al. 2007 for more detail on ambiguous taxa). Summary statistics (Taxa Richness and measures of biological integrity) for each site are provided in Table 17.

The most diverse site was King Creek (LAVOWQ25) with 84 total taxa, and the most depauperate site was Lost Creek (LAVOWQ04) with 38 taxa.

For calculating Hilsenhoff Biotic Index (HBI), tolerance values were available for all but 15 of the 393 taxonomic units (which include individuals only identified to higher taxonomic units due to poor keys, damaged specimens, or immature life stages) in the combined Whiskeytown and Lassen Volcanic dataset. Taxa with no tolerance value were excluded from HBI calculations. The lowest HBI (indicating a preponderance of intolerant, clean-water indicating organisms) was Lost Creek (LAVOWQ04), a site dominated by a single stonefly, *Yoraperla nigrisoma*. The highest HBI (indicating mostly tolerant organisms) was King Creek (LAVOWQ33) at 5.48.

All but two sites were rated as Least disturbed using the EPA Invertebrate MMI, with Lost Creek (LAVOWQ04) being Most Disturbed and King Creek (LAVOWQ33) being Intermediate. The highest rated site was Hat Creek (LAVOWQ40) at 86 out of 100. The park-wide average of 75.6 is rated Least Disturbed.

Sixteen sites were rated as “supporting, acceptable” and four sites as “supporting, intermediate” while two sites were rated “not supporting” using the East Sierra MMI. One site rated “not supporting” was Lost Creek (LAVOWQ04), the same site that had the lowest taxa richness, although it also had the lowest HBI. See the discussion for more interpretation of multiple lines of evidence in determining ecological health.

Discussion

General Issues

This was the second implementation of wadeable streams monitoring at both Whiskeytown and Lassen Volcanic. The first was in 2011, and the next implementation will be in 2017.

Of note is that the protocol has a goal of 30 sampling sites, but we were unable to meet this goal (21 sites in Whiskeytown, and 22 in Lassen Volcanic). Reasons for this were primarily twofold: (1) Due to hiring complications (notably, the unavailability of a qualified fourth crew member), the streams crew had to work with only three members most of the season; and (2) several sites in Lassen Volcanic were found to be dry, and were unable to be sampled. Additionally, status estimates from the sampling are intended to be applied to only streams matching the sampling frame of the protocol (e.g., accessible, perennial, and safe to sample).

The immediate outcome of sampling fewer than 30 sites is a reduction of precision in the annual status assessments (i.e., increased error bars/standard deviations). Longer-term issues, if follow-up years are unable to increase the sample size, will be a reduction in power to detect trends in park aquatic resources, although a total sample size of 20 is the minimum to achieve the goals of the protocol. Now that this sampling gives estimates of annual variation, future Analysis and Synthesis reports will re-examine the power of the protocol.

It should be reiterated that the field crew reported difficulties in the use of the pH probe; thus the collective pH readings from the sampling season should be interpreted with caution. The overall pH readings were substantially higher than 2011, which may indicate more alkaline (or basic) conditions or a consistent offset in the pH readings.

An additional concern is the computer hard-drive crash that occurred during the season. The computer database is backed up nightly, however it is backed up on the same hard-drive. This scheme works well in case of database corruption, but not a hard-drive failure. After the crash, the backup method was changed to an external storage solution (MicroSD card embedded in the tablet PC).

Status versus trends (or a cautionary note on changes from 2011...)

The above point about comparing 2014 data and condition to 2011 data as an assessment of accuracy is an important one. With only the second sampling of wadeable streams complete, the program is just beginning to understand annual variability inherent in the ecosystem. Observed differences at this point in the program should not be taken as a trend, but rather each year should be considered as separate status estimates. Indeed, a full comparison of 2011 data to 2014 data is beyond the scope of an annual status report.

However, when interpreting status, we recognize that context is important. Considering this, there are three events/factors that are important to interpreting the 2014 data:

1) 2011 precipitation versus 2014 precipitation

The 2011 Whiskeytown water year (October 1st, 2010 to September 30th, 2011) was characterized by an average of 70.5 inches of precipitation (from the Advanced Hydrologic Prediction Service of the National Weather Service: water.weather.gov/precip; average of points surrounding the general sampling locales). 2014, in contrast had an average of 30.8 inches; or 56% less water in 2014 than 2011. For Lassen Volcanic, the 2011 water year precipitation was 86.2 inches; and 2014 had 51.9 inches of precipitation (40% less water in 2014 than 2011). The basic availability of water has cascading effects into discharge, stream depth, and stream width. Less water is also connected with warmer temperatures, lower dissolved oxygen, less riparian coverage, and higher solute concentrations.

2) Whiskeytown 2013 Crystal Creek Bureau of Reclamation 1600 CFS emergency release

On July 21, 2013 the Bureau of Reclamation released approximately 1600 cubic feet per second of water into the Crystal Creek watershed and lasted for approximately 11 hours. Such a discharge event, in the middle of July (outside the normal high flooding period), likely had a deleterious impact on certain elements of the stream ecosystem. Impacted sites are Crystal Creek (WHISWQ15) and Willow Creek (WHISWQ21). A full analysis of the impacts and recovery associated with the release is beyond the scope of this annual report, and may be the subject of a future report.

3) Lassen Volcanic 2012 Reading Fire

From July 23 to August 22, 2012 the Reading Fire burned 28,079 acres; including 16,925 acres in Lassen Volcanic. Numerous stream sites were impacted, especially on Hat Creek (LAVOWQ08, 33, 36, 40, 29, and 05) as well as West Fork Hat Creek (LAVOWQ12 and 24). Lost Creek sites (LAVOWQ04, and 20) bordered the burn area. A full analysis of the impacts and recovery associated with the Reading Fire is beyond the scope of this annual report, and may be the subject of a future report.

Notes about condition assessment

This protocol makes use of EPA-developed threshold criteria for assigning “condition” to ecological integrity from a diversity array of variable and metrics (physical, chemical, and biological). From a management perspective, three main points should be emphasized:

- 1) The programmatic goal of the Wadeable Streams Assessment is an assessment of the amount of overall impairment in the sampling frame, and not the identification of site-specific impairment. Hence, within the EPA program, errors in site-specific condition do occur, are recognized to occur, and hopefully minimized; but region-wide averages have still driven the development of threshold criteria. Intermediate or Most Disturbed sites identified by this program should be investigated, but are not an immediate call for “crisis mode.”
- 2) Threshold criteria are based on regional (mountain west-wide models) reference conditions. Localized values based on park reference sites may provide more accurate per-site and park-wide assessment. An example is the threshold criteria used for total phosphorous, where both Whiskeytown and Lassen Volcanic show possible influence of local geology, exhibiting naturally higher phosphorous than the EPA derived values. When a majority of park sites show increased values in a single metric, and the park can conclusively show that these sites

should be rated as Least Disturbed due to the lack of stressors, the creation of park-specific thresholds may be necessary through research programs or research partners.

- 3) The use of multiple indices allows for the potential of some indices to rate a stream condition as Least disturbed whereas others might rate it as Most Disturbed – creating a perceived paradox of a stream condition. Indeed, most sites in Whiskeytown had one or more “flags” (Intermediate or Most Disturbed). Rather than view this as a paradox, managers should consider two points; (a) a weight of evidence approach, and (b) a specificity of impact approach. In the weight of evidence approach, a stream site that has multiple “flags” across multiple categories (e.g., biological, chemical, and biological) would suggest a truly imperiled stream. In the specificity of impact approach, a stream that is Intermediate in one category and not the others can be used to help pinpoint what the impact is that might be affecting water quality. As an example, a stream or lake that has elevated phosphorous and low nitrogen may be indicative of a system impacted by agriculture, whereas a system with low phosphorous and high nitrogen may be indicative of a system impacted by depositional pollution (although nitrogen is also associated with fertilizer run-off).

Whiskeytown National Recreation Area

Two primary patterns emerged in the Whiskeytown data. One, the preliminary Relative Bed Stability (RBS – measure of observed sediments versus expected sediments) was higher than expected, so that bed substrates were dominated by large substrates with a paucity of smaller sediments. Two, a majority of sites had elevated Total Phosphorus levels above the Least Disturbed threshold.

As a management concern, high RBS values indicate stable, armored streambeds. Typical examples of impacted streams with high RBS values fall into two categories: (1) streams below dams where the dam interrupts the sediment supply and (2) streams with their channels artificially manipulated for flood control (e.g., lined with concrete). Neither example applies to the streams of Whiskeytown, where streams with higher RBS values occur across the landscape, and in both sites near roads/trails and isolated sites far from any apparent anthropogenic disturbance. One hypothesis is that recent high water spates from the 2010-11 winter flushed sediments and no recent erosion has occurred to replace flushed sediments. Another consideration is that the granitic pluton that comprises Shasta Bally is naturally a low producer of fine sediments so that the streams of Whiskeytown are naturally dominated by larger substrates (leading to streams being named “Boulder Creek,” for example).

Elevated total phosphorus in Whiskeytown streams has two potential explanations. First, higher phosphorus concentrations may be a natural state for the streams of Whiskeytown, owing to the volcanic history of the region. Second, there is concern that illicit marijuana plantations in Whiskeytown may be using artificial fertilizers, with run-off into Whiskeytown streams that will manifest as high nutrient levels, potentially causing nuisance algal blooms. New to 2014, two sites were observed to have high levels of nitrogen: Willow Creek (WHISWQ21) and an Unnamed tributary to Boulder Creek (WHISWQ22). However, the dry year with lower stream discharge could also increase overall nutrient levels. Both of these sites were also rate Intermediate for phosphorus, but within the range seen in other Whiskeytown sites. These sites, however, should be examined for known marijuana plantations from 2014 in their respective watershed as a potential causative factor.

Additionally, Whiskeytown data were affected by the loss of data due to a computer hard drive crash. The use of two computers to record field data meant that some amount of data was available for all sites, and the affected portion of the protocol may have varied from site to site.

Very little concern was elicited by vertebrate monitoring results. Although the KLMN procedures for amphibian and fish monitoring are a “rapid” assessment of the vertebrate assemblages, the overall diversity of the park was high with three species of amphibians, and five species of fish (one of which was the non-native Brook Trout). Total abundance of vertebrates is a highly variable assessment, dependent on the total reach length and total time spent shocking the stream.

Additionally, crews used a light touch on most amphibians, so that the total numbers may be much higher than those counted. The EPA vertebrate MMI indicated that most sites were in the Least disturbed category, and appeared to accurately reflect the condition of the site. One site that was Intermediate was Clear Creek, which was typified by larger, deeper, slower water than most of the steep, cascading streams of the park (and so had less fish characteristic of cold-water streams); as well as Whiskey Creek and Willow Creek (Sites WHISWQ26 and 01) with similar characteristics.

Overall averages of invertebrate metrics were in the Least Disturbed category, with some O/E scores and EPA MMI scores in the Intermediate category. However, one site was rated Most Disturbed using observed/expected score of biodiversity loss. This was Paige Boulder Creek (WHISWQ08), which also only had 42 total taxa collected. HBI scores for Paige Boulder Creek remained lower than many other Whiskeytown sites, showing that Paige Boulder is harboring relatively intolerant invertebrates. Paige Boulder Creek also had very few other “flags” (see below), suggesting that this low O/E score is simply an outlier. However, future years of monitoring should re-evaluate Paige Boulder Creek.

Overall estimation of potentially problematic water quality sites should be looked at using a weight of evidence approach, using information from all the available metrics (Table 18). Table 18 shows the summation of “flags”, each time a condition score was rated as Intermediate or Most Disturbed, but in this instance there is no weighting of Most Disturbed or Intermediate – they are treated as equal flags. There are 12 total metrics used (12 EPA and one state based metric), so maximally disturbed sites would be “12.”

While most sites in Whiskeytown have 0, 1, or 2 flags; mostly from mostly from the elevated phosphorous and elevated RBS scores already discussed. However, four sites were characterized by a higher number of flags: Clear Creek (WHISWQ25) with 8 flags; Crystal Creek (WHISWQ23) with 6 flags; Whiskey Creek (WHISWQ26) and Willow Creek (WHISWQ21) with 5 flags each.

Table 18. Condition summary for Whiskeytown streams, 2014.

Stream Name	Site Code	Number of Flags ^a			
		Physical	Chemical	Biological	Sum
Boulder Creek	WHISWQ02	1	1	2	4
Boulder Creek	WHISWQ05	1	1	0	2
Boulder Creek	WHISWQ17	Null ^b	1	1	2
Boulder Creek	WHISWQ33	0	0	0	0
Brandy Creek	WHISWQ12	0	1	0	1
Brandy Creek	WHISWQ18	0	0	0	0
Brandy Creek	WHISWQ34	1	1	0	2
Clear Creek	WHISWQ25	3	2	3	8
Crystal Creek	WHISWQ15	2	1	0	3
Crystal Creek	WHISWQ23	3	1	2	6
Grizzly Gulch	WHISWQ06	0	0	2	2
Mill Creek	WHISWQ09	1	1	0	2
Paige Boulder Creek	WHISWQ08	0	0	2	2
Paige Boulder Creek	WHISWQ28	1	0	1	2
Unnamed stream (Boulder Trib)	WHISWQ22	0	2	0	2
Unnamed stream (Brandy Trib S)	WHISWQ24	1	0	1	2
Unnamed stream (Crystal Trib)	WHISWQ03	0	1	0	1
Unnamed stream (Crystal Trib)	WHISWQ35	Null ^b	1	1	2
Whiskey creek	WHISWQ26	1	1	3	5
Willow Creek	WHISWQ01	0	2	1	3
Willow Creek	WHISWQ21	2	3	0	5

^aFlags indicate each incidence of Intermediate or Most Disturbed condition.

^b“Null” indicates that data loss prevents any calculation of Physical condition metrics for those sites.

Of these, Clear Creek is in the stretch above Whiskeytown Lake, and not below Whiskeytown Dam (previous crews found that attempted sites below the dam were too deep to sample). The site was characterized by being the widest (average 8.6 m), deepest (average 30.7 cm), and most instantaneous discharge (4.87 ft³/s) of any sampled stream. Some of these “flags” can be attributed to these geomorphological features; however, it is also a roadside stream with indicators of high riparian disturbance. Crystal Creek site is upstream of the 2013 BOR release, however it is next to an abandoned camp for boys, and potentially suffers from existing infrastructure and riparian disturbance. Whiskey Creek and Willow Creek are both in historic acid mine drainages, and observed flags may be a signal of past land-use effects.

Lassen Volcanic National Park

Several patterns were observed in the stream data for Lassen Volcanic National Park, that were also seen in 2011 (Dinger and Sarr 2014). First, the montane and subalpine nature of several streams led to some observations of lower amounts of riparian vegetation. Second, as with Whiskeytown, there was a high occurrence of elevated phosphorous levels. Third, the naturally depauperate fish fauna, coupled with a high prevalence of non-native trout in the streams, qualifies the interpretation of the EPA Vertebrate MMI. Fourth, the streams of Lassen Volcanic generally do not have an amphibian presence. Finally, the dry conditions of 2014 are a likely co-factor influencing the status estimates of this year.

Although 19 sites in Lassen Volcanic were rated as Intermediate for riparian cover, this is likely due to prevalence of montane and subalpine meadow systems along the park streams, and exacerbated by low stream discharge. As a high elevation stream meanders in a grassy meadow, a perceived paucity of woody overstory vegetation will drive the riparian cover metric down, suggesting an Intermediate condition. However, this is certainly a natural state for some of the streams of Lassen Volcanic and does not indicate impairment.

As with Whiskeytown, the streams of Lassen Volcanic were characterized by elevated phosphorous levels at 18 of 22 sites. In the absence of any identifiable anthropogenic pollution, no elevated nitrogen, and with the geologic influences and geothermal activity, the Intermediate ratings are likely natural and do not indicate any sort of impairment.

Only one species of native fish was encountered in the streams of Lassen Volcanic: rainbow trout. Two additional non-native salmonids were encountered, a remnant of fish stocking in the region (brook and brown trout). Although several of the fish species on the certified species list are potential stream dwellers (at least as migrants) we did not encounter them in our sampling. It is likely that the high elevation nature of the streams, along with occasional natural downstream barriers such as waterfalls, have limited the fish populations. This limitation, along with two species of non-native trout, resulted in low EPA Vertebrate MMI scores. The consideration of whether these scores and Intermediate condition assessment are valid is open to interpretation. They should be considered preliminary at this time. In the interpretation that the ecosystem is “impaired” or “imperiled” the presence of non-native trout does not signal an extrinsic threat or degradation; rather it is an indication of the legacy of non-native trout stocking for the region. Viewing the entire stream ecosystem, however, the presence on non-native trout can negatively impact the native biota. Notably, the EPA Vertebrate MMI index differs from the other condition assessments provided: the other indicators are symptomatic of the external impacts (e.g., anthropogenic disturbances), but for Lassen Volcanic the Vertebrate MMI signals the actual impact (non-native fish).

Seven sites recorded the presence of the Pacific tree frog, and one site contained the Western Toad. While there are four other confirmed amphibian species within the park (including the recently unobserved and possibly extirpated Cascades frog, *Rana cascadae*), none of these are generally found in stream environments, and are more likely to be found in mountain ponds, lakes, and wetlands. Hence, the scarcity of amphibians in these particular surveys is not a cause of concern. Threats to amphibians in Lassen Volcanic remain a real concern, owing to the lack of Cascades frog sightings (Fellers et al. 2008) and to the presence of ranavirus (Dinger 2009).

Overall estimation of potentially problematic Lassen Volcanic water quality sites should be looked at using a weight of evidence approach, using information from all the available metrics (Table 19). Table 19 shows the summation of “flags”, each time a condition score was rated as Intermediate or Most Disturbed, but in this instance there is no weighting of Most Disturbed or Intermediate – they are treated as equal flags. There are 12 total metrics used (12 EPA plus one state based metric), so maximally disturbed sites would be “12”. Most sites in Lassen Volcanic are limited to 2, 3, or 4 flags, mostly from the elevated phosphorous, EPA Vertebrate MMI scores, and less riparian cover already discussed. Two sites, however, stand out: Kings Creek (LAVOWQ17) and Lost Creek

(LAVOWQ04) with six flags each. The site on Kings Creek is proximal to park roads and a nearby trailhead to the Kings Creek Falls, and also likely experiences increased visitor use. Lost Creek is just downstream of the Hot Rock interpretive area, and had the lowest recorded aquatic macroinvertebrate biodiversity (38 taxa), which led to many of the flags.

Table 19. Condition summary for Lassen Volcanic streams, 2014.

Stream Name	Site Code	Number of Flags ^a			
		Physical	Chemical	Biological	Sum
Hat Creek	LAVOWQ01	1	1	0	2
Hat Creek	LAVOWQ05	2	0	1	3
Hat Creek	LAVOWQ08	2	1	1	4
Hat Creek	LAVOWQ29	1	0	1	2
Hat Creek	LAVOWQ32	1	1	1	3
Hat Creek	LAVOWQ36	1	1	2	4
Hat Creek	LAVOWQ40	1	1	1	3
Hat Creek	LAVOWQ45	1	0	1	2
Kings Creek	LAVOWQ17	2	1	3	6
Kings Creek	LAVOWQ25	2	1	0	3
Kings Creek	LAVOWQ33	1	1	4	6
Kings Creek	LAVOWQ37	2	1	0	3
Lost Creek	LAVOWQ04	2	1	3	6
Lost Creek	LAVOWQ20	2	1	2	5
Manzanita Creek	LAVOWQ15	2	1	2	5
Manzanita Creek	LAVOWQ23	1	1	0	2
Manzanita Creek	LAVOWQ27	2	1	1	4
NA Rice Creek	LAVOWQ10	2	0	1	3
WF Hat Creek	LAVOWQ09	0	1	1	2
WF Hat Creek	LAVOWQ12	1	1	1	3
WF Hat Creek	LAVOWQ21	0	1	0	1
WF Hat Creek	LAVOWQ24	1	1	1	3

^aFlags indicate each incidence of Intermediate or Most Disturbed condition.

^b"Null" indicates that data loss prevents any calculation of Physical condition metrics for those sites.

Conclusion

This was the second year of monitoring streams in the Klamath Network at Whiskeytown and Lassen Volcanic. Overall stream conditions in both parks surveyed appear to be mostly good, with specific concerns identified. Criteria set forth by the EPA Wadeable Streams Assessment provide some guidance and assessment for stream condition. Regional calibration to natural, localized reference conditions is desirable, but would require additional sampling effort at sites representing a range of disturbance regimes and is beyond the scope of this project. Sampling will continue in 2017, with annual reports and more comprehensive Analysis and Synthesis reports completed thereafter.

At this stage in the monitoring, we are beginning to understand the annual variation of the physical, chemical, and biological attributes of the streams and how they respond to annual climatic variables, such as precipitation. Also new this year was the adoption of automated computer code to produce metrics, which will speed future reporting, offer transparency, and repeatability. Lastly, this report also includes observed/expected ratios of macroinvertebrate diversity as a condition estimate.

In general, the application of broadly developed multi-metric and multi-variate indices should be approached cautiously in the early years such as this. Site-specific characteristics or distinctive disturbance histories may yield conflicting results. Interpretation should be cautious. In future years, a better understanding of the unique characteristics of the stream reaches in each park will hopefully allow us to better differentiate anthropogenic impacts from natural variation.

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Appendix A. Example of MMI Calculation and Scoring

To facilitate understanding of MMIs, below is an exposition on how a representative MMI, the California Northern Coastal Region Benthic Index of Biotic Integrity (Rehn et al. 2005), is calculated using data collected from Boulder Creek in Whiskeytown (WHISWQ02) in 2011 (Table A-1).

Metric calculations begin using the species list provided by the contractor, Rhithron Associates, Inc.

Table A-1. Representative MMI example from Boulder Creek in Whiskeytown (WHISWQ02) in 2011.

Category	Taxon	Count	Unique?
Non-insect taxa	Turbellaria	1	—
	Sphaeriidae - immature	1	—
	<i>Lebertia</i>	1	—
	<i>Torrenticola</i>	15	—
	<i>Mesenchytraeus</i>	2	—
	Lumbriculidae - damaged	1	—
	<i>Spirosperma</i>	4	—
Ephemeroptera	<i>Ameletus</i>	16	—
	<i>Baetis tricaudatus</i>	23	—
	<i>Dipheter hageni</i>	43	—
	<i>Caudatella</i> - early instar or damaged	4	no
	<i>Caudatella heterocaudata</i>	7	—
	<i>Drunella</i> - early instar	7	no
	<i>Drunella doddsii</i>	4	—
	<i>Drunella flavilinea</i>	3	—
	<i>Drunella pelosa</i>	1	—
	<i>Ephemerella excrucians</i>	5	—
	Ephemerellidae - early instar or damaged	4	no
	<i>Epeorus</i>	42	—
	<i>Ironodes</i>	2	—
	<i>Rhithrogena</i>	1	—
	<i>Paraleptophlebia</i>	3	—
Plecoptera	<i>Suwallia</i>	4	—
	<i>Moselia infuscata</i>	1	—
	<i>Zapada cinctipes</i>	2	—
	<i>Calineuria californica</i>	2	—
	Perlidae - early instar	1	no
Trichoptera	<i>Amiocentrus aspilus</i>	1	—
	<i>Micrasema</i>	5	—
	<i>Heteroplectron californicum</i>	4	—

Table A-1 (continued). Representative MMI example from Boulder Creek in Whiskeytown (WHISWQ02) in 2011.

Category	Taxon	Count	Unique?
Trichoptera (continued)	<i>Glossosoma</i>	3	—
	Glossosomatidae - damaged or pupa	9	no
	<i>Helicopsyche</i>	140	—
	<i>Hydropsyche</i>	14	—
	<i>Parapsyche</i>	6	—
	<i>Lepidostoma</i>	9	—
	<i>Allocosmoecus partitus</i>	1	—
	Limnephilidae - early instar or damaged	5	—
	<i>Polycentropus</i>	1	—
	<i>Rhyacophila</i> - early instar or damaged	4	—
	<i>Rhyacophila</i> Betteni Gr.	9	—
	<i>Gumaga</i>	18	—
	Sericostomatidae - pupa	5	—
	<i>Neophylax splendens</i>	9	—
Diptera	Ceratopogoninae - early instar	3	—
	Empididae - early instar, damaged, or pupa	1	—
	<i>Antocha monticola</i>	3	—
	<i>Cryptolabis</i>	14	—
	<i>Dicranota</i>	3	—
	<i>Hexatoma</i>	1	—
	Tipulidae - damaged or pupa	2	no
Diptera (Chironomidae)	<i>Brillia</i>	4	—
	<i>Cricotopus (Nostococladus) nostocicola</i>	3	—
	<i>Cryptochironomus</i>	1	—
	<i>Demicryptochironomus</i>	6	—
	<i>Eukiefferiella</i> Brevicalcar Gr.	1	—
	<i>Lopescladius</i>	1	—
	<i>Micropsectra</i>	5	—
	<i>Monodiamesa</i>	2	—
	<i>Pagastia</i>	5	—
	<i>Paratendipes</i>	3	—
	<i>Polypedilum</i>	10	—
	<i>Prodiamesa</i>	2	—
	<i>Rheotanytarsus</i>	5	—
	<i>Stempellinella</i>	7	—
	Tanypodinae - early instar or damaged	1	no
	Tanytarsini - early instar or damaged	3	no

Table A-1 (continued). Representative MMI example from Boulder Creek in Whiskeytown (WHISWQ02) in 2011.

Category	Taxon	Count	Unique?
Diptera (Chironomidae) (continued)	<i>Tanytarsus</i>	2	–
	Thienemannimyia Gr.	6	–
	Tvetenia Bavarica Gr.	1	–

The values for the eight metrics that comprise the MMI are then calculated (Table A-2). The first metric is EPT taxa richness (Ephemeroptera, Plecoptera, and Trichoptera). In this example, a quick count of the number of taxa in these three insect orders is 37; but this must be adjusted for non-unique taxa. There are often incomplete taxonomic determinations by the taxonomist, but who can determine that they do not represent other unique taxa. For EPT, there are 5 non-unique taxa, so the final EPT taxa richness is 32. Once the values for each eight metrics are calculated, they are scored according to the metric creation (either on a scale from the original authors or linearly interpreted).

Table A-2. Example of the eight MMI metrics calculated for Boulder Creek.

Component Metric	Boulder Creek Value	Score
EPT Richness	32	10
Coleoptera Richness	6	10
Diptera Richness	6	6
% Intolerant Individuals	63.90%	10
%Non-gastropod Individuals	35%	10
% Predator Individuals	7.1%	3
% Shredder Taxa	13.4%	8
% Non-insect Taxa	6.0%	10
Sum		67
Scaled to 100		83.75

The final step is to scale it to a 0 – 100 range for interpretation. In this example, the summed score is multiplied by 1.25 for a final score of “83.75”.

Interpretation is then based on a traditional scale; 100 = pristine; 10 = severely degraded. Furthermore, scores from 10 to 20 can be considered “very poor”, 20 – 40 are “poor”, 40 – 60 are “fair”, 60 – 80 are “good”, and 80 – 100 are “very good”. Secondly, scores below 52 are considered “impaired”.

Appendix B. Benthic Macroinvertebrates of Whiskeytown National Recreation Area

Table B-1 is an accounting of all macroinvertebrate taxonomic units reported by the contract laboratory. The Interagency Taxonomic Information System (ITIS) Serial Number is provided for each taxa when available.

Note that due to taxonomic ambiguity, taxa used in analyses may differ from the taxa presented here. See the full protocol for more on dealing with taxonomic ambiguity.

Table B-1. Taxonomic units of Benthic Macroinvertebrates encountered in Whiskeytown National Recreation Area, 2014. Total number of sites sampled was 21.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Acari	–	Acari	733321	6	4	19.0%
Basommatophora	Ancylidae	<i>Ferrissia</i>	76569	15	4	19.0%
Basommatophora	Lymnaeidae	<i>Galba</i>	NA ^b	12	1	4.8%
Basommatophora	Physidae	<i>Physella</i>	76698	38	4	19.0%
Basommatophora	Planorbidae	<i>Gyraulus</i>	76592	5	1	4.8%
Coleoptera	Dryopidae	<i>Helichus striatus</i>	114017	1	1	4.8%
Coleoptera	Dytiscidae	<i>Boreonectes striatellus</i>	NA ^b	4	2	9.5%
Coleoptera	Dytiscidae	Dytiscidae	111963	1	1	4.8%
Coleoptera	Dytiscidae	<i>Oreodytes</i>	112314	27	9	42.9%
Coleoptera	Dytiscidae	<i>Oreodytes abbreviatus</i>	112315	6	2	9.5%
Coleoptera	Dytiscidae	<i>Oreodytes congruus</i>	568828	1	1	4.8%
Coleoptera	Dytiscidae	<i>Oreodytes obesus</i>	112316	1	1	4.8%
Coleoptera	Dytiscidae	<i>Oreodytes picturatus</i>	728443	3	1	4.8%
Coleoptera	Dytiscidae	<i>Sanfilippodytes</i>	728253	3	2	9.5%
Coleoptera	Elmidae	<i>Ampumixis dispar</i>	114197	233	14	66.7%
Coleoptera	Elmidae	<i>Bryelmis</i>	945749	3	1	4.8%
Coleoptera	Elmidae	<i>Cleptelmis addenda</i>	114166	40	9	42.9%
Coleoptera	Elmidae	<i>Dubiraphia</i>	114126	1	1	4.8%
Coleoptera	Elmidae	Elmidae	114093	29	5	23.8%
Coleoptera	Elmidae	<i>Heterlimnius corpulentus</i>	114169	100	10	47.6%
Coleoptera	Elmidae	<i>Lara</i>	114137	16	8	38.1%
Coleoptera	Elmidae	<i>Microcylloepus</i>	114146	1	1	4.8%
Coleoptera	Elmidae	<i>Microcylloepus pusillus</i>	114147	1	1	4.8%

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Table B-1 (continued). Taxonomic units of Benthic Macroinvertebrates encountered in Whiskeytown National Recreation Area, 2014. Total number of sites sampled was 21.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Coleoptera	Elmidae	<i>Narpus</i>	114142	8	5	23.8%
Coleoptera	Elmidae	<i>Narpus concolor</i>	114144	1	1	4.8%
Coleoptera	Elmidae	<i>Optioservus</i>	114177	190	15	71.4%
Coleoptera	Elmidae	<i>Optioservus divergens</i>	114178	3	2	9.5%
Coleoptera	Elmidae	<i>Optioservus quadrimaculatus</i>	114180	2	1	4.8%
Coleoptera	Elmidae	<i>Optioservus seriatus</i>	114181	21	8	38.1%
Coleoptera	Elmidae	<i>Ordobrevia nubifera</i>	114236	104	16	76.2%
Coleoptera	Elmidae	<i>Zaitzevia</i>	114205	49	7	33.3%
Coleoptera	Elmidae	<i>Zaitzevia parvula</i>	NA ^b	16	6	28.6%
Coleoptera	Elmidae	<i>Zaitzevia posthonia</i>	NA ^b	1	1	4.8%
Coleoptera	Eulichadidae	<i>Stenocolus scutellaris</i>	114269	10	5	23.8%
Coleoptera	Gyrinidae	<i>Gyrinus</i>	112654	3	2	9.5%
Coleoptera	Hydraenidae	<i>Hydraena</i>	112757	22	10	47.6%
Coleoptera	Hydraenidae	<i>Ochthebius</i>	112777	1	1	4.8%
Coleoptera	Hydrophilidae	<i>Ametor</i>	112890	10	7	33.3%
Coleoptera	Hydrophilidae	<i>Ametor scabrosus</i>	112892	1	1	4.8%
Coleoptera	Hydrophilidae	<i>Anacaena</i>	112878	1	1	4.8%
Coleoptera	Hydrophilidae	Hydrophilidae	112811	1	1	4.8%
Coleoptera	Hydrophilidae	<i>Laccobius</i>	112858	1	1	4.8%
Coleoptera	Psephenidae	<i>Eubrianax edwardsii</i>	114086	117	13	61.9%
Coleoptera	Psephenidae	<i>Psephenus falli</i>	114074	34	1	4.8%
Coleoptera	Ptilodactylidae	<i>Anchyteis velutina</i>	114267	8	2	9.5%
Copepoda	–	Copepoda	85257	1	1	4.8%
Decapoda	Astacidae	<i>Pacifastacus leniusculus leniusculus</i>	650412	1	1	4.8%

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Table B-1 (continued). Taxonomic units of Benthic Macroinvertebrates encountered in Whiskeytown National Recreation Area, 2014. Total number of sites sampled was 21.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Diptera	Blephariceridae	Blephariceridae	121227	2	2	9.5%
Diptera	Ceratopogonidae	<i>Atrichopogon</i>	127113	7	6	28.6%
Diptera	Ceratopogonidae	<i>Bezzia</i> / <i>Palpomyia</i>	NA ^b	24	2	9.5%
Diptera	Ceratopogonidae	Ceratopogonidae	127076	8	6	28.6%
Diptera	Ceratopogonidae	Ceratopogoninae	127338	167	15	71.4%
Diptera	Ceratopogonidae	<i>Dasyhelea</i>	127278	8	1	4.8%
Diptera	Chironomidae	<i>Ablabesmyia</i>	128079	64	10	47.6%
Diptera	Chironomidae	<i>Alotanypus</i>	206646	42	9	42.9%
Diptera	Chironomidae	<i>Bilyjomyia algens</i>	NA ^b	2	2	9.5%
Diptera	Chironomidae	<i>Brillia</i>	128477	146	16	76.2%
Diptera	Chironomidae	<i>Brundiniella eumorpha</i>	128028	107	10	47.6%
Diptera	Chironomidae	<i>Chaetocladius</i>	128520	87	10	47.6%
Diptera	Chironomidae	Chironomini	129229	5	5	23.8%
Diptera	Chironomidae	<i>Chironomus</i>	129254	2	2	9.5%
Diptera	Chironomidae	<i>Cladotanytarsus</i>	129873	13	3	14.3%
Diptera	Chironomidae	<i>Conchapelopia</i>	128130	2	2	9.5%
Diptera	Chironomidae	<i>Corynoneura</i>	128563	13	6	28.6%
Diptera	Chironomidae	<i>Cricotopus</i>	128575	19	9	42.9%
Diptera	Chironomidae	<i>Cricotopus Bicinctus</i> Gr.	NA ^b	3	1	4.8%
Diptera	Chironomidae	<i>Cricotopus nostocicola</i>	128628	328	13	61.9%
Diptera	Chironomidae	<i>Cryptochironomus</i>	129368	4	3	14.3%
Diptera	Chironomidae	<i>Cryptotendipes</i>	129394	1	1	4.8%
Diptera	Chironomidae	<i>Demicrochironomus</i>	129421	1	1	4.8%
Diptera	Chironomidae	<i>Dicrotendipes</i>	129428	1	1	4.8%

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Table B-1 (continued). Taxonomic units of Benthic Macroinvertebrates encountered in Whiskeytown National Recreation Area, 2014. Total number of sites sampled was 21.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Diptera	Chironomidae	<i>Eukiefferiella</i>	128689	1	1	4.8%
Diptera	Chironomidae	<i>Eukiefferiella</i> Brehmi Gr.	NA ^b	31	6	28.6%
Diptera	Chironomidae	<i>Eukiefferiella</i> Brevicalcar Gr.	NA ^b	4	2	9.5%
Diptera	Chironomidae	<i>Eukiefferiella</i> Claripennis Gr.	NA ^b	16	5	23.8%
Diptera	Chironomidae	<i>Eukiefferiella</i> Devonica Gr.	NA ^b	11	4	19.0%
Diptera	Chironomidae	<i>Heterotrissocladius</i> Marcidus Gr.	NA ^b	4	3	14.3%
Diptera	Chironomidae	<i>Krenosmittia</i>	128771	2	2	9.5%
Diptera	Chironomidae	<i>Labrundinia</i>	128173	1	1	4.8%
Diptera	Chironomidae	<i>Larsia</i>	128183	25	5	23.8%
Diptera	Chironomidae	<i>Lauterborniella</i> agrayloides	129526	5	2	9.5%
Diptera	Chironomidae	<i>Limnophyes</i>	128776	7	4	19.0%
Diptera	Chironomidae	<i>Lopescladius</i>	128811	2	2	9.5%
Diptera	Chironomidae	<i>Micropsectra</i>	129890	495	18	85.7%
Diptera	Chironomidae	<i>Microtendipes</i>	129535	7	2	9.5%
Diptera	Chironomidae	<i>Microtendipes</i> Pedellus Gr.	NA ^b	203	17	81.0%
Diptera	Chironomidae	<i>Microtendipes</i> Rydalsensis Gr.	NA ^b	69	11	52.4%
Diptera	Chironomidae	<i>Natarsia</i>	128070	1	1	4.8%
Diptera	Chironomidae	<i>Nilotanytus</i>	128202	11	5	23.8%
Diptera	Chironomidae	<i>Odontomesa</i>	128446	3	1	4.8%
Diptera	Chironomidae	Orthoclatiinae	128457	7	5	23.8%
Diptera	Chironomidae	Orthoclatiinae sp. (RAI Taxon # 0004)	NA ^b	24	3	14.3%
Diptera	Chironomidae	<i>Orthoclatius</i>	128874	28	7	33.3%
Diptera	Chironomidae	<i>Orthoclatius</i> lignicola	128913	5	4	19.0%
Diptera	Chironomidae	<i>Pagastia</i>	128401	80	15	71.4%

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Table B-1 (continued). Taxonomic units of Benthic Macroinvertebrates encountered in Whiskeytown National Recreation Area, 2014. Total number of sites sampled was 21.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Diptera	Chironomidae	<i>Pagastiella</i>	129561	17	1	4.8%
Diptera	Chironomidae	<i>Parachaetocladius</i>	128951	14	5	23.8%
Diptera	Chironomidae	<i>Paracladopelma</i>	129597	2	2	9.5%
Diptera	Chironomidae	<i>Parakiefferiella</i>	128968	2	2	9.5%
Diptera	Chironomidae	<i>Paralauterborniella nigrohalterale</i>	129619	1	1	4.8%
Diptera	Chironomidae	<i>Parametriocnemus</i>	128978	69	13	61.9%
Diptera	Chironomidae	<i>Paraphaenocladius</i>	128989	2	2	9.5%
Diptera	Chironomidae	<i>Paratanytarsus</i>	129935	11	3	14.3%
Diptera	Chironomidae	<i>Paratendipes</i>	129623	28	6	28.6%
Diptera	Chironomidae	<i>Pentaneura</i>	128215	45	15	71.4%
Diptera	Chironomidae	<i>Phaenopsectra</i>	129637	94	11	52.4%
Diptera	Chironomidae	<i>Polypedilum</i>	129657	92	15	71.4%
Diptera	Chironomidae	<i>Potthastia</i>	128408	1	1	4.8%
Diptera	Chironomidae	<i>Potthastia Gaedii</i> Gr.	NA ^b	46	3	14.3%
Diptera	Chironomidae	<i>Procladius</i>	128277	9	2	9.5%
Diptera	Chironomidae	<i>Prodiamesa</i>	128452	5	4	19.0%
Diptera	Chironomidae	<i>Pseudochironomus</i>	129851	3	1	4.8%
Diptera	Chironomidae	<i>Psilometriocnemus</i>	129083	28	3	14.3%
Diptera	Chironomidae	<i>Rheocricotopus</i>	129086	4	3	14.3%
Diptera	Chironomidae	<i>Rheotanytarsus</i>	129952	104	14	66.7%
Diptera	Chironomidae	<i>Robackia demeijerei</i>	129733	1	1	4.8%
Diptera	Chironomidae	<i>Stempellinella</i>	129969	43	7	33.3%
Diptera	Chironomidae	<i>Stenochironomus</i>	129746	11	5	23.8%
Diptera	Chironomidae	<i>Sublettea coffmani</i>	129976	1	1	4.8%

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Table B-1 (continued). Taxonomic units of Benthic Macroinvertebrates encountered in Whiskeytown National Recreation Area, 2014. Total number of sites sampled was 21.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Diptera	Chironomidae	<i>Symbiocladius</i>	129156	1	1	4.8%
Diptera	Chironomidae	<i>Synorthocladius</i>	129161	2	2	9.5%
Diptera	Chironomidae	Tanypodinae	127994	10	5	23.8%
Diptera	Chironomidae	Tanytarsini	129872	12	5	23.8%
Diptera	Chironomidae	<i>Tanytarsus</i>	129978	217	15	71.4%
Diptera	Chironomidae	<i>Thienemanniella</i>	129182	7	6	28.6%
Diptera	Chironomidae	<i>Thienemannimyia</i> Gr.	NA ^b	148	21	100.0%
Diptera	Chironomidae	<i>Tvetenia</i> Bavarica Gr.	NA ^b	16	8	38.1%
Diptera	Chironomidae	<i>Tvetenia</i> Discoloripes Gr.	NA ^b	2	2	9.5%
Diptera	Chironomidae	<i>Zavrelimyia</i>	128259	134	12	57.1%
Diptera	Dixidae	<i>Dixa</i>	125810	8	6	28.6%
Diptera	Dixidae	<i>Meringodixa chalonensis</i>	125874	2	2	9.5%
Diptera	Empididae	<i>Chelifera</i> / <i>Metachela</i>	NA ^b	8	4	19.0%
Diptera	Empididae	<i>Clinocera</i>	135849	5	4	19.0%
Diptera	Empididae	Empididae	135830	3	3	14.3%
Diptera	Empididae	Empididae sp. (RAI Taxon # 0001)	NA ^b	1	1	4.8%
Diptera	Empididae	Empididae sp. (RAI Taxon # 0002)	NA ^b	1	1	4.8%
Diptera	Empididae	<i>Hemerodromia</i>	136327	1	1	4.8%
Diptera	Empididae	<i>Neoplasta</i>	136352	22	12	57.1%
Diptera	Empididae	<i>Oreogeton</i>	136377	3	2	9.5%
Diptera	Empididae	<i>Roederiodes</i>	135893	5	5	23.8%
Diptera	Pelecorhynchidae	<i>Glutops</i>	130915	11	7	33.3%
Diptera	Psychodidae	<i>Maruina</i>	125392	8	5	23.8%
Diptera	Psychodidae	<i>Pericoma</i> / <i>Telmatoscopus</i>	NA ^b	18	5	23.8%

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Table B-1 (continued). Taxonomic units of Benthic Macroinvertebrates encountered in Whiskeytown National Recreation Area, 2014. Total number of sites sampled was 21.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Diptera	Sciomyzidae	<i>Sciomyzidae</i>	144653	1	1	4.8%
Diptera	Simuliidae	Simuliidae	126640	1	1	4.8%
Diptera	Simuliidae	<i>Simulium</i>	126774	173	17	81.0%
Diptera	Simuliidae	<i>Simulium (Nevermannia)</i>	NA ^b	1	1	4.8%
Diptera	Simuliidae	<i>Simulium canadense</i>	126795	4	2	9.5%
Diptera	Simuliidae	<i>Simulium conicum</i>	NA ^b	2	2	9.5%
Diptera	Simuliidae	<i>Simulium piperi</i>	126862	9	4	19.0%
Diptera	Simuliidae	<i>Simulium tuberosum</i> complex	NA ^b	7	4	19.0%
Diptera	Stratiomyidae	<i>Caloparyphus</i>	130409	3	2	9.5%
Diptera	Tabanidae	Tabanidae	130934	1	1	4.8%
Diptera	Thaumaleidae	Thaumaleidae	126624	4	1	4.8%
Diptera	Tipulidae	<i>Antocha monticola</i>	119660	53	8	38.1%
Diptera	Tipulidae	<i>Cryptolabis</i>	120488	5	2	9.5%
Diptera	Tipulidae	<i>Dicranota</i>	121027	35	13	61.9%
Diptera	Tipulidae	<i>Hexatoma</i>	120094	5	4	19.0%
Diptera	Tipulidae	<i>Rhabdomastix</i>	120968	1	1	4.8%
Diptera	Tipulidae	<i>Tipula</i>	119037	7	6	28.6%
Diptera	Tipulidae	Tipulidae	118840	7	3	14.3%
Enchytraeida	Enchytraeidae	<i>Enchytraeus</i>	68531	93	5	23.8%
Enchytraeida	Enchytraeidae	<i>Fridericia</i>	204785	126	11	52.4%
Enchytraeida	Enchytraeidae	<i>Mesenchytraeus</i>	68544	9	6	28.6%
Ephemeroptera	Ameletidae	<i>Ameletus</i>	100996	31	8	38.1%
Ephemeroptera	Baetidae	<i>Anafroptilum</i>	NA ^b	20	8	38.1%
Ephemeroptera	Baetidae	Baetidae	100755	9	3	14.3%

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Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Ephemeroptera	Baetidae	<i>Baetis</i>	100800	29	5	23.8%
Ephemeroptera	Baetidae	<i>Baetis alius</i>	100803	16	3	14.3%
Ephemeroptera	Baetidae	<i>Baetis Fuscatus</i> Gr.	NA ^b	5	1	4.8%
Ephemeroptera	Baetidae	<i>Baetis notos</i>	568579	25	4	19.0%
Ephemeroptera	Baetidae	<i>Baetis Rhodani</i> Gr.	NA ^b	96	2	9.5%
Ephemeroptera	Baetidae	<i>Baetis tricaudatus</i> complex	NA ^b	189	14	66.7%
Ephemeroptera	Baetidae	<i>Dipheter hageni</i>	568598	32	10	47.6%
Ephemeroptera	Baetidae	<i>Fallceon</i>	568551	3	1	4.8%
Ephemeroptera	Baetidae	<i>Proclleon</i>	206622	26	5	23.8%
Ephemeroptera	Ephemerellidae	<i>Attenella margarita</i>	101343	10	4	19.0%
Ephemeroptera	Ephemerellidae	<i>Caudatella</i>	101347	1	1	4.8%
Ephemeroptera	Ephemerellidae	<i>Caudatella heterocaudata</i>	101351	7	2	9.5%
Ephemeroptera	Ephemerellidae	<i>Drunella</i>	101365	23	8	38.1%
Ephemeroptera	Ephemerellidae	<i>Drunella doddsii</i>	698494	8	5	23.8%
Ephemeroptera	Ephemerellidae	<i>Drunella flavilinea</i>	101392	14	4	19.0%
Ephemeroptera	Ephemerellidae	<i>Drunella pelosa</i>	568634	3	2	9.5%
Ephemeroptera	Ephemerellidae	<i>Ephemerella</i>	101233	9	3	14.3%
Ephemeroptera	Ephemerellidae	<i>Ephemerella tibialis</i>	101401	3	1	4.8%
Ephemeroptera	Ephemerellidae	Ephemerellidae	101232	25	7	33.3%
Ephemeroptera	Ephemerellidae	<i>Matriella teresa</i>	776979	22	4	19.0%
Ephemeroptera	Ephemerellidae	<i>Serratella micheneri</i>	568639	21	6	28.6%
Ephemeroptera	Heptageniidae	<i>Cinygma</i>	100598	36	8	38.1%
Ephemeroptera	Heptageniidae	<i>Cinygmula</i>	100557	10	3	14.3%
Ephemeroptera	Heptageniidae	<i>Ecdyonurus criddlei</i>	698149	50	5	23.8%

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Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Ephemeroptera	Heptageniidae	<i>Epeorus</i>	100626	69	9	42.9%
Ephemeroptera	Heptageniidae	Heptageniidae	100504	5	4	19.0%
Ephemeroptera	Heptageniidae	<i>Ironodes</i>	100666	10	5	23.8%
Ephemeroptera	Leptohyphidae	Leptohyphidae	568545	3	2	9.5%
Ephemeroptera	Leptohyphidae	<i>Tricorythodes</i>	101405	115	1	4.8%
Ephemeroptera	Leptohyphidae	<i>Tricorythodes explicatus</i>	101419	277	6	28.6%
Ephemeroptera	Leptophlebiidae	Leptophlebiidae	101095	35	7	33.3%
Ephemeroptera	Leptophlebiidae	<i>Paraleptophlebia</i>	101187	214	9	42.9%
Ephemeroptera	Siphonuridae	Siphonuridae	100951	3	2	9.5%
Hemiptera	Corixidae	Corixidae	103364	1	1	4.8%
Hemiptera	Gerridae	Gerridae	103801	20	11	52.4%
Hemiptera	Naucoridae	<i>Ambrysus</i>	103614	15	1	4.8%
Hemiptera	Naucoridae	<i>Ambrysus mormon</i>	103626	1	1	4.8%
Hemiptera	Veliidae	<i>Microvelia</i>	103900	62	14	66.7%
Hemiptera	Veliidae	<i>Rhagovelia</i>	103886	2	1	4.8%
Hemiptera	Veliidae	Veliidae	103885	24	1	4.8%
Lepidoptera	Crambidae	<i>Petrophila</i>	117682	14	1	4.8%
Lumbriculida	Lumbriculidae	Lumbriculidae	68440	61	9	42.9%
Lumbriculida	Lumbriculidae	<i>Stylodrilus</i>	68450	1	1	4.8%
Megaloptera	Corydalidae	<i>Orohermes crepusculus</i>	115045	16	7	33.3%
Megaloptera	Sialidae	<i>Sialis</i>	115002	153	17	81.0%
Nemata	–	Nemata	563956	220	10	47.6%
Neotaenioglossa	Pleuroceridae	<i>Juga</i>	71570	27	4	19.0%
Odonata	Aeshnidae	<i>Aeshna</i>	101603	4	2	9.5%

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Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Odonata	Aeshnidae	Aeshnidae	101596	1	1	4.8%
Odonata	Coenagrionidae	<i>Argia</i>	102139	47	3	14.3%
Odonata	Cordulegastridae	<i>Cordulegaster</i>	102027	12	2	9.5%
Odonata	Cordulegastridae	<i>Cordulegaster dorsalis</i>	593042	66	9	42.9%
Odonata	Gomphidae	Gomphidae	101664	13	6	28.6%
Odonata	Gomphidae	<i>Octogomphus specularis</i>	101737	118	10	47.6%
Odonata	Lestidae	<i>Archilestes grandis</i>	102060	1	1	4.8%
Odonata	–	Anisoptera	101594	1	1	4.8%
Ostracoda	–	Ostracoda	84195	26	7	33.3%
Plecoptera	Chloroperlidae	Chloroperlidae	103202	2	2	9.5%
Plecoptera	Chloroperlidae	<i>Paraperla</i>	103233	3	2	9.5%
Plecoptera	Chloroperlidae	<i>Suwallia</i>	103254	1	1	4.8%
Plecoptera	Chloroperlidae	<i>Sweltsa</i>	103273	35	5	23.8%
Plecoptera	Leuctridae	Leuctridae	102840	11	6	28.6%
Plecoptera	Leuctridae	<i>Moselia infuscata</i>	102910	80	9	42.9%
Plecoptera	Nemouridae	<i>Malenka</i>	102567	265	18	85.7%
Plecoptera	Nemouridae	Nemouridae	102517	92	5	23.8%
Plecoptera	Nemouridae	<i>Soyedina</i>	102556	36	8	38.1%
Plecoptera	Nemouridae	<i>Visoka cataractae</i>	102615	11	1	4.8%
Plecoptera	Nemouridae	<i>Zapada cinctipes</i>	102594	9	4	19.0%
Plecoptera	Nemouridae	<i>Zapada columbiana</i>	102596	10	4	19.0%
Plecoptera	Nemouridae	<i>Zapada frigida</i>	102601	2	2	9.5%
Plecoptera	Nemouridae	<i>Zapada Oregonensis</i> Gr.	NA ^b	2	2	9.5%
Plecoptera	Peltoperlidae	<i>Sierraperla cora</i>	102515	1	1	4.8%

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Table B-1 (continued). Taxonomic units of Benthic Macroinvertebrates encountered in Whiskeytown National Recreation Area, 2014. Total number of sites sampled was 21.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Plecoptera	Peltoperlidae	<i>Yoraperla</i>	102510	1	1	4.8%
Plecoptera	Peltoperlidae	<i>Yoraperla nigrisoma</i>	568730	32	7	33.3%
Plecoptera	Perlidae	<i>Calineuria californica</i>	102986	72	13	61.9%
Plecoptera	Perlidae	<i>Doroneuria baumanni</i>	103123	8	3	14.3%
Plecoptera	Perlidae	Perlidae	102914	62	10	47.6%
Plecoptera	Perlodidae	<i>Diura knowltoni</i>	103096	3	3	14.3%
Plecoptera	Perlodidae	<i>Isoperla</i>	102995	14	2	9.5%
Plecoptera	Perlodidae	Perlodidae	102994	17	8	38.1%
Plecoptera	Perlodidae	<i>Skwala</i>	103102	88	8	38.1%
Plecoptera	Pteronarcyidae	<i>Pteronarcys</i>	102471	1	1	4.8%
Plecoptera	Pteronarcyidae	<i>Pteronarcys princeps</i>	102484	16	3	14.3%
Plecoptera	–	Plecoptera	102467	1	1	4.8%
Trepaxonemata	–	Trepaxonemata	914204	12	5	23.8%
Trichoptera	Apataniidae	<i>Apatania</i>	115935	37	10	47.6%
Trichoptera	Apataniidae	<i>Pedomoecus sierra</i>	115973	2	2	9.5%
Trichoptera	Brachycentridae	<i>Amiocentrus aspilus</i>	116934	1	1	4.8%
Trichoptera	Brachycentridae	<i>Brachycentrus americanus</i>	116912	11	1	4.8%
Trichoptera	Brachycentridae	<i>Brachycentrus occidentalis</i>	116918	1	1	4.8%
Trichoptera	Brachycentridae	<i>Micrasema</i>	116958	176	12	57.1%
Trichoptera	Calamoceratidae	<i>Heteroplectron californicum</i>	116538	585	15	71.4%
Trichoptera	Glossosomatidae	<i>Agapetus</i>	117121	12	6	28.6%
Trichoptera	Glossosomatidae	<i>Glossosoma</i>	117159	70	11	52.4%
Trichoptera	Glossosomatidae	Glossosomatidae	117120	10	6	28.6%
Trichoptera	Helicopsychidae	<i>Helicopsyche</i>	117016	215	9	42.9%

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Table B-1 (continued). Taxonomic units of Benthic Macroinvertebrates encountered in Whiskeytown National Recreation Area, 2014. Total number of sites sampled was 21.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Trichoptera	Hydropsychidae	<i>Arctopsyche</i>	115529	11	4	19.0%
Trichoptera	Hydropsychidae	<i>Arctopsyche californica</i>	115538	4	2	9.5%
Trichoptera	Hydropsychidae	Arctopsychinae	568763	2	2	9.5%
Trichoptera	Hydropsychidae	<i>Cheumatopsyche</i>	115408	25	2	9.5%
Trichoptera	Hydropsychidae	<i>Hydropsyche</i>	115453	207	15	71.4%
Trichoptera	Hydropsychidae	Hydropsychidae	115398	22	6	28.6%
Trichoptera	Hydropsychidae	<i>Parapsyche</i>	115556	50	5	23.8%
Trichoptera	Hydroptilidae	<i>Hydroptila</i>	115641	14	4	19.0%
Trichoptera	Hydroptilidae	Hydroptilidae	115629	15	5	23.8%
Trichoptera	Hydroptilidae	<i>Neotrichia</i>	115833	3	2	9.5%
Trichoptera	Hydroptilidae	<i>Ochrotrichia</i>	115714	3	2	9.5%
Trichoptera	Lepidostomatidae	<i>Lepidostoma</i>	116794	670	21	100.0%
Trichoptera	Leptoceridae	Leptoceridae	116547	4	3	14.3%
Trichoptera	Leptoceridae	<i>Mystacides</i>	116598	3	1	4.8%
Trichoptera	Leptoceridae	<i>Mystacides alafimbriatus</i>	116603	19	4	19.0%
Trichoptera	Leptoceridae	<i>Oecetis</i>	116607	11	3	14.3%
Trichoptera	Limnephilidae	<i>Cryptochia</i>	115907	1	1	4.8%
Trichoptera	Limnephilidae	<i>Dicosmoecus atripes</i>	116266	2	1	4.8%
Trichoptera	Limnephilidae	<i>Dicosmoecus gilvipes</i>	116268	1	1	4.8%
Trichoptera	Limnephilidae	Limnephilidae	115933	7	5	23.8%
Trichoptera	Limnephilidae	<i>Pseudostenophylax edwardsi</i>	115993	2	1	4.8%
Trichoptera	Limnephilidae	<i>Psychoglypha</i>	115974	7	4	19.0%
Trichoptera	Odontoceridae	<i>Namamyia plutonis</i>	116521	3	3	14.3%
Trichoptera	Odontoceridae	Odontoceridae	116496	7	1	4.8%

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Table B-1 (continued). Taxonomic units of Benthic Macroinvertebrates encountered in Whiskeytown National Recreation Area, 2014. Total number of sites sampled was 21.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Trichoptera	Philopotamidae	<i>Dolophilodes</i>	115319	5	1	4.8%
Trichoptera	Philopotamidae	Philopotamidae	115257	2	2	9.5%
Trichoptera	Philopotamidae	<i>Wormaldia</i>	115258	16	6	28.6%
Trichoptera	Phryganeidae	<i>Yphria californica</i>	115923	1	1	4.8%
Trichoptera	Polycentropodidae	Polycentropodidae	117043	51	11	52.4%
Trichoptera	Polycentropodidae	<i>Polycentropus</i>	117044	3	1	4.8%
Trichoptera	Psychomyiidae	<i>Tinodes</i>	115350	13	3	14.3%
Trichoptera	Rhyacophilidae	<i>Himalopsyche phryganea</i>	608146	1	1	4.8%
Trichoptera	Rhyacophilidae	<i>Rhyacophila</i>	115097	35	12	57.1%
Trichoptera	Rhyacophilidae	<i>Rhyacophila</i> Angelita Gr.	NA ^b	9	5	23.8%
Trichoptera	Rhyacophilidae	<i>Rhyacophila</i> Betteni Gr.	NA ^b	99	18	85.7%
Trichoptera	Rhyacophilidae	<i>Rhyacophila</i> Brunnea/Vemna Gr.	NA ^b	31	11	52.4%
Trichoptera	Rhyacophilidae	<i>Rhyacophila</i> Hyalinata Gr.	NA ^b	11	4	19.0%
Trichoptera	Rhyacophilidae	<i>Rhyacophila</i> Rotunda Gr.	NA ^b	1	1	4.8%
Trichoptera	Rhyacophilidae	<i>Rhyacophila</i> Sibirica Gr.	NA ^b	23	8	38.1%
Trichoptera	Rhyacophilidae	<i>Rhyacophila</i> Visor Gr.	NA ^b	3	2	9.5%
Trichoptera	Sericostomatidae	<i>Gumaga</i>	117003	317	17	81.0%
Trichoptera	Sericostomatidae	Sericostomatidae	116982	3	3	14.3%
Trichoptera	Uenoidae	<i>Farula</i>	116331	31	3	14.3%
Trichoptera	Uenoidae	<i>Neophylax</i>	116046	1	1	4.8%
Trichoptera	Uenoidae	<i>Neophylax rickeri</i>	116054	7	2	9.5%
Trichoptera	Uenoidae	<i>Neophylax splendens</i>	116063	5	4	19.0%
Trichoptera	–	Trichoptera	115095	12	5	23.8%
Trombidiformes	Arrenuridae	<i>Arrenurus</i>	82864	1	1	4.8%

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Table B-1 (continued). Taxonomic units of Benthic Macroinvertebrates encountered in Whiskeytown National Recreation Area, 2014. Total number of sites sampled was 21.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Trombidiformes	Hydrodromidae	<i>Hydrodroma</i>	83225	1	1	4.8%
Trombidiformes	Hydryphantidae	<i>Protzia</i>	83170	14	6	28.6%
Trombidiformes	Hygrobatidae	<i>Atractides</i>	83282	27	9	42.9%
Trombidiformes	Hygrobatidae	<i>Hygrobates</i>	83297	62	10	47.6%
Trombidiformes	Lebertiidae	<i>Estelloxus</i>	83048	1	1	4.8%
Trombidiformes	Lebertiidae	<i>Lebertia</i>	83034	31	10	47.6%
Trombidiformes	Mideopsidae	<i>Mideopsis</i>	83479	55	9	42.9%
Trombidiformes	Sperchontidae	<i>Sperchon</i>	83006	68	10	47.6%
Trombidiformes	Sperchontidae	<i>Sperchonopsis</i>	83029	24	9	42.9%
Trombidiformes	Torrenticolidae	<i>Monatractides</i>	NA ^b	215	19	90.5%
Trombidiformes	Torrenticolidae	<i>Testudacarus</i>	83250	3	2	9.5%
Trombidiformes	Torrenticolidae	<i>Torrenticola</i>	83254	189	18	85.7%
Tubificida	Naididae	<i>Aulodrilus</i>	68679	2	1	4.8%
Tubificida	Naididae	<i>Bothrioneurum</i>	68778	6	2	9.5%
Tubificida	Naididae	<i>Limnodrilus</i>	68638	2	1	4.8%
Tubificida	Naididae	Naididae	68854	22	4	19.0%
Tubificida	Naididae	<i>Nais</i>	68946	5	4	19.0%
Tubificida	Naididae	Tubificinae	974289	7	2	9.5%
Veneroida	Sphaeriidae	<i>Pisidium</i>	81400	13	3	14.3%
Veneroida	Sphaeriidae	Sphaeriidae	81389	2	2	9.5%

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Appendix C. Benthic Macroinvertebrates of Lassen Volcanic National Park

Table C-1 is an accounting of all macroinvertebrate taxonomic units reported by the contract laboratory. The Interagency Taxonomic Information System (ITIS) Serial Number is provided for each taxa when available.

Note that due to taxonomic ambiguity, taxa used in analyses may differ from the taxa presented here. See the full protocol for more on dealing with taxonomic ambiguity.

Table C-1. Taxonomic units of Benthic Macroinvertebrates encountered in Lassen Volcanic National Park, 2014. Total number of sites sampled was 22.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Acari	–	Acari	733321	2	2	9.1%
Coleoptera	Dytiscidae	Hydroporinae	678402	1	1	4.5%
Coleoptera	Dytiscidae	<i>Oreodytes</i>	112314	23	3	13.6%
Coleoptera	Dytiscidae	<i>Oreodytes obesus</i>	112316	15	3	13.6%
Coleoptera	Elmidae	<i>Cleptelmis addenda</i>	114166	93	2	9.1%
Coleoptera	Elmidae	Elmidae	114093	20	2	9.1%
Coleoptera	Elmidae	<i>Heterolimnius corpulentus</i>	114169	177	14	63.6%
Coleoptera	Elmidae	<i>Optioservus</i>	114177	1	1	4.5%
Coleoptera	Elmidae	<i>Optioservus quadrimaculatus</i>	114180	2	2	9.1%
Coleoptera	Psephenidae	<i>Eubrianax edwardsii</i>	114086	1	1	4.5%
Copepoda	–	Copepoda	85257	7	2	9.1%
Diptera	Ceratopogonidae	<i>Atrichopogon</i>	127113	1	1	4.5%
Diptera	Ceratopogonidae	Ceratopogoninae	127338	52	6	27.3%
Diptera	Ceratopogonidae	<i>Forcipomyia</i>	127152	1	1	4.5%
Diptera	Chironomidae	<i>Alotanypus</i>	206646	1	1	4.5%
Diptera	Chironomidae	<i>Apedilum</i>	206655	12	3	13.6%
Diptera	Chironomidae	<i>Brillia</i>	128477	52	16	72.7%
Diptera	Chironomidae	<i>Chaetocladius</i>	128520	38	6	27.3%
Diptera	Chironomidae	Chironomini	129229	5	2	9.1%
Diptera	Chironomidae	<i>Chironomus</i>	129254	1	1	4.5%
Diptera	Chironomidae	<i>Corynoneura</i>	128563	25	12	54.5%
Diptera	Chironomidae	<i>Cricotopus</i>	128575	36	6	27.3%
Diptera	Chironomidae	<i>Cricotopus Bicinctus</i> Gr.	NA ^b	24	4	18.2%
Diptera	Chironomidae	<i>Cricotopus nostocicola</i>	128628	439	16	72.7%

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Table C-1 (continued). Taxonomic units of Benthic Macroinvertebrates encountered in Lassen Volcanic National Park, 2014. Total number of sites sampled was 22.

Order (or higher)	Family	Taxon	TSN	Total No.	No. of Sites	Percent of Sites
Diptera	Chironomidae	<i>Diamesa</i>	128355	6	2	9.1%
Diptera	Chironomidae	Diamesinae	128341	1	1	4.5%
Diptera	Chironomidae	<i>Diplocladius</i>	128670	258	10	45.5%
Diptera	Chironomidae	<i>Eukiefferiella</i>	128689	16	9	40.9%
Diptera	Chironomidae	<i>Eukiefferiella</i> Brehmi Gr.	NA ^b	26	7	31.8%
Diptera	Chironomidae	<i>Eukiefferiella</i> Brevicalcar Gr.	NA ^b	5	1	4.5%
Diptera	Chironomidae	<i>Eukiefferiella</i> Claripennis Gr.	NA ^b	21	4	18.2%
Diptera	Chironomidae	<i>Eukiefferiella</i> Devonica Gr.	NA ^b	48	10	45.5%
Diptera	Chironomidae	<i>Eukiefferiella</i> Gracei Gr.	NA ^b	92	11	50.0%
Diptera	Chironomidae	<i>Heleniella</i>	128730	6	2	9.1%
Diptera	Chironomidae	<i>Heterotrissocladius</i> Marcidus Gr.	NA ^b	20	4	18.2%
Diptera	Chironomidae	<i>Hydrobaenus</i>	128750	530	20	90.9%
Diptera	Chironomidae	<i>Krenosmittia</i>	128771	12	6	27.3%
Diptera	Chironomidae	<i>Larsia</i>	128183	15	1	4.5%
Diptera	Chironomidae	<i>Limnophyes</i>	128776	15	4	18.2%
Diptera	Chironomidae	<i>Metriocnemus</i>	128821	1	1	4.5%
Diptera	Chironomidae	<i>Micropsectra</i>	129890	884	21	95.5%
Diptera	Chironomidae	<i>Microtendipes</i> Rydalensis Gr.	NA ^b	1	1	4.5%
Diptera	Chironomidae	<i>Monodiamesa</i>	128440	90	9	40.9%
Diptera	Chironomidae	<i>Odontomesa</i>	128446	14	6	27.3%
Diptera	Chironomidae	Orthoclaadiinae	128457	47	10	45.5%
Diptera	Chironomidae	Orthoclaadiinae sp. (RAI Taxon # 0001)	NA ^b	131	11	50.0%
Diptera	Chironomidae	<i>Orthocladius</i>	128874	863	21	95.5%
Diptera	Chironomidae	<i>Orthocladius lignicola</i>	128913	1	1	4.5%

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Table C-1 (continued). Taxonomic units of Benthic Macroinvertebrates encountered in Lassen Volcanic National Park, 2014. Total number of sites sampled was 22.

Order (or higher)	Family	Taxon	TSN	Total No.	No. of Sites	Percent of Sites
Diptera	Chironomidae	<i>Pagastia</i>	128401	340	21	95.5%
Diptera	Chironomidae	<i>Parachaetocladius</i>	128951	5	3	13.6%
Diptera	Chironomidae	<i>Paracladopelma</i>	129597	5	3	13.6%
Diptera	Chironomidae	<i>Parakiefferiella</i>	128968	26	7	31.8%
Diptera	Chironomidae	<i>Parametriocnemus</i>	128978	65	14	63.6%
Diptera	Chironomidae	<i>Parorthocladius</i>	129011	21	10	45.5%
Diptera	Chironomidae	<i>Pentaneura</i>	128215	8	4	18.2%
Diptera	Chironomidae	<i>Phaenopsectra</i>	129637	21	5	22.7%
Diptera	Chironomidae	<i>Platysmittia</i>	129013	14	1	4.5%
Diptera	Chironomidae	<i>Polypedilum</i>	129657	11	6	27.3%
Diptera	Chironomidae	<i>Prodiamesa</i>	128452	1	1	4.5%
Diptera	Chironomidae	<i>Psectrocladius</i>	129018	24	3	13.6%
Diptera	Chironomidae	<i>Pseudochironomus</i>	129851	8	2	9.1%
Diptera	Chironomidae	<i>Pseudodiamesa</i>	128416	10	6	27.3%
Diptera	Chironomidae	<i>Psilometriocnemus</i>	129083	9	4	18.2%
Diptera	Chironomidae	<i>Rheocricotopus</i>	129086	18	7	31.8%
Diptera	Chironomidae	<i>Rheotanytarsus</i>	129952	18	3	13.6%
Diptera	Chironomidae	<i>Stempellina</i>	129962	10	3	13.6%
Diptera	Chironomidae	<i>Stempellinella</i>	129969	60	11	50.0%
Diptera	Chironomidae	Tanypodinae	127994	2	2	9.1%
Diptera	Chironomidae	Tanytarsini	129872	20	4	18.2%
Diptera	Chironomidae	<i>Tanytarsus</i>	129978	106	9	40.9%
Diptera	Chironomidae	<i>Thienemanniella</i>	129182	31	9	40.9%
Diptera	Chironomidae	<i>Thienemannimyia</i> Gr.	NA ^b	110	8	36.4%

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Table C-1 (continued). Taxonomic units of Benthic Macroinvertebrates encountered in Lassen Volcanic National Park, 2014. Total number of sites sampled was 22.

Order (or higher)	Family	Taxon	TSN	Total No.	No. of Sites	Percent of Sites
Diptera	Chironomidae	<i>Tvetenia</i>	129197	2	1	4.5%
Diptera	Chironomidae	<i>Tvetenia</i> Bavarica Gr.	NA ^b	302	19	86.4%
Diptera	Chironomidae	<i>Tvetenia tshernovskii</i>	NA ^b	1	1	4.5%
Diptera	Chironomidae	<i>Zavreliomyia</i>	128259	22	6	27.3%
Diptera	Dixidae	Dixidae	125809	1	1	4.5%
Diptera	Empididae	<i>Chelifera / Metachela</i>	NA ^b	8	2	9.1%
Diptera	Empididae	<i>Clinocera</i>	135849	25	8	36.4%
Diptera	Empididae	Empididae	135830	6	3	13.6%
Diptera	Empididae	<i>Neoplasta</i>	136352	66	11	50.0%
Diptera	Empididae	<i>Oreogeton</i>	136377	3	1	4.5%
Diptera	Empididae	<i>Roederiodes</i>	135893	12	7	31.8%
Diptera	Empididae	<i>Trichoclinocera</i>	135903	3	1	4.5%
Diptera	Pelecorhynchidae	<i>Glutops</i>	130915	243	17	77.3%
Diptera	Psychodidae	<i>Pericoma / Telmatoscopus</i>	NA ^b	15	5	22.7%
Diptera	Simuliidae	<i>Helodon</i>	NA ^b	106	6	27.3%
Diptera	Simuliidae	<i>Helodon onychodactylus</i> complex	NA ^b	19	3	13.6%
Diptera	Simuliidae	<i>Simulium</i>	126774	75	11	50.0%
Diptera	Simuliidae	<i>Simulium (Eusimulium)</i>	NA ^b	1	1	4.5%
Diptera	Simuliidae	<i>Simulium (Nevermannia)</i>	NA ^b	4	2	9.1%
Diptera	Simuliidae	<i>Simulium canadense</i>	126795	1	1	4.5%
Diptera	Simuliidae	<i>Simulium</i> Malyschevi Gr.	NA ^b	2	1	4.5%
Diptera	Tipulidae	<i>Antocha monticola</i>	119660	13	5	22.7%
Diptera	Tipulidae	<i>Dicranota</i>	121027	20	6	27.3%
Diptera	Tipulidae	<i>Hesperoconopa</i>	120732	8	1	4.5%

^aTSN = Taxonomic Serial Number; see www.itis.gov for full taxonomy.

^bNA indicates cases where no TSN exists, either due to it being a “species group”, or a recently redescribed taxon with no number yet designated.

Table C-1 (continued). Taxonomic units of Benthic Macroinvertebrates encountered in Lassen Volcanic National Park, 2014. Total number of sites sampled was 22.

Order (or higher)	Family	Taxon	TSN	Total No.	No. of Sites	Percent of Sites
Diptera	Tipulidae	<i>Hexatoma</i>	120094	34	6	27.3%
Diptera	Tipulidae	<i>Limnophila</i>	120164	7	6	27.3%
Diptera	Tipulidae	<i>Pedicia</i>	121118	2	1	4.5%
Diptera	Tipulidae	Tipulidae	118840	1	1	4.5%
Enchytraeida	Enchytraeidae	<i>Enchytraeus</i>	68531	15	9	40.9%
Enchytraeida	Enchytraeidae	<i>Fridericia</i>	204785	33	12	54.5%
Enchytraeida	Enchytraeidae	<i>Mesenchytraeus</i>	68544	234	18	81.8%
Ephemeroptera	Ameletidae	<i>Ameletus</i>	100996	85	12	54.5%
Ephemeroptera	Baetidae	Baetidae	100755	5	3	13.6%
Ephemeroptera	Baetidae	<i>Baetis</i>	100800	7	1	4.5%
Ephemeroptera	Baetidae	<i>Baetis bicaudatus</i> complex	NA ^b	274	11	50.0%
Ephemeroptera	Baetidae	<i>Baetis</i> Rhodani Gr.	NA ^b	287	13	59.1%
Ephemeroptera	Baetidae	<i>Baetis tricaudatus</i> complex	NA ^b	205	10	45.5%
Ephemeroptera	Baetidae	<i>Dipheter hageni</i>	568598	39	6	27.3%
Ephemeroptera	Ephemerellidae	<i>Caudatella</i>	101347	237	15	68.2%
Ephemeroptera	Ephemerellidae	<i>Caudatella hystrix</i>	101348	39	3	13.6%
Ephemeroptera	Ephemerellidae	<i>Caudatella jacobii</i>	568632	1	1	4.5%
Ephemeroptera	Ephemerellidae	<i>Drunella</i>	101365	166	16	72.7%
Ephemeroptera	Ephemerellidae	<i>Drunella coloradensis</i>	101389	114	16	72.7%
Ephemeroptera	Ephemerellidae	<i>Drunella doddsii</i>	698494	44	8	36.4%
Ephemeroptera	Ephemerellidae	<i>Ephemerella</i>	101233	64	6	27.3%
Ephemeroptera	Ephemerellidae	<i>Ephemerella tibialis</i>	101401	16	5	22.7%
Ephemeroptera	Ephemerellidae	Ephemerellidae	101232	260	15	68.2%
Ephemeroptera	Heptageniidae	<i>Cinygmula</i>	100557	358	14	63.6%

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Table C-1 (continued). Taxonomic units of Benthic Macroinvertebrates encountered in Lassen Volcanic National Park, 2014. Total number of sites sampled was 22.

Order (or higher)	Family	Taxon	TSN	Total No.	No. of Sites	Percent of Sites
Ephemeroptera	Heptageniidae	<i>Epeorus</i>	100626	195	15	68.2%
Ephemeroptera	Heptageniidae	Heptageniidae	100504	64	4	18.2%
Ephemeroptera	Heptageniidae	<i>Rhithrogena</i>	100572	74	11	50.0%
Ephemeroptera	Leptophlebiidae	<i>Paraleptophlebia</i>	101187	65	10	45.5%
Megaloptera	Corydalidae	Corydalidae	115023	1	1	4.5%
Megaloptera	Sialidae	<i>Sialis</i>	115002	26	6	27.3%
Nemata	–	Nemata	563956	159	18	81.8%
Ostracoda	–	Ostracoda	84195	146	18	81.8%
Plecoptera	Capniidae	Capniidae	102643	25	8	36.4%
Plecoptera	Chloroperlidae	Chloroperlidae	103202	103	9	40.9%
Plecoptera	Chloroperlidae	Chloroperlinae	609855	29	1	4.5%
Plecoptera	Chloroperlidae	<i>Kathroperla</i>	103236	3	1	4.5%
Plecoptera	Chloroperlidae	<i>Paraperla</i>	103233	5	2	9.1%
Plecoptera	Chloroperlidae	<i>Sweltsa</i>	103273	241	19	86.4%
Plecoptera	Leuctridae	Leuctridae	102840	14	6	27.3%
Plecoptera	Leuctridae	<i>Moselia infusata</i>	102910	147	17	77.3%
Plecoptera	Nemouridae	Nemouridae	102517	31	9	40.9%
Plecoptera	Nemouridae	<i>Visoka cataractae</i>	102615	24	7	31.8%
Plecoptera	Nemouridae	<i>Zapada</i>	102591	34	6	27.3%
Plecoptera	Nemouridae	<i>Zapada cinctipes</i>	102594	60	10	45.5%
Plecoptera	Nemouridae	<i>Zapada columbiana</i>	102596	250	17	77.3%
Plecoptera	Nemouridae	<i>Zapada frigida</i>	102601	24	8	36.4%
Plecoptera	Nemouridae	<i>Zapada Oregonensis</i> Gr.	NA ^b	58	15	68.2%
Plecoptera	Peltoperlidae	Peltoperlidae	102488	2	2	9.1%

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Table C-1 (continued). Taxonomic units of Benthic Macroinvertebrates encountered in Lassen Volcanic National Park, 2014. Total number of sites sampled was 22.

Order (or higher)	Family	Taxon	TSN	Total No.	No. of Sites	Percent of Sites
Plecoptera	Peltoperlidae	<i>Sierraperla cora</i>	102515	30	5	22.7%
Plecoptera	Peltoperlidae	<i>Yoraperla</i>	102510	79	12	54.5%
Plecoptera	Peltoperlidae	<i>Yoraperla nigrisoma</i>	568730	1061	15	68.2%
Plecoptera	Perlidae	<i>Calineuria californica</i>	102986	2	1	4.5%
Plecoptera	Perlidae	<i>Doroneuria baumanni</i>	103123	30	6	27.3%
Plecoptera	Perlidae	Perlidae	102914	8	2	9.1%
Plecoptera	Perlodidae	<i>Isoperla</i>	102995	41	13	59.1%
Plecoptera	Perlodidae	<i>Kogotus nonus</i>	103150	24	12	54.5%
Plecoptera	Perlodidae	<i>Megarcys</i>	103110	31	5	22.7%
Plecoptera	Perlodidae	Perlodidae	102994	53	11	50.0%
Plecoptera	Perlodidae	<i>Skwala</i>	103102	1	1	4.5%
Plecoptera	Pteronarcyidae	Pteronarcyidae	102470	2	1	4.5%
Plecoptera	Taeniopterygidae	Taeniopterygidae	102788	25	5	22.7%
Plecoptera	–	Plecoptera	102467	1	1	4.5%
Sarcoptiformes	–	<i>Oribatida</i>	733326	1	1	4.5%
Stygothrombium	Stygothrombiidae	<i>Stygothrombium</i>	NA ^b	5	5	22.7%
Trepaxonemata	–	Trepaxonemata	914204	128	15	68.2%
Trichoptera	Apataniidae	<i>Allomyia</i>	116438	1	1	4.5%
Trichoptera	Apataniidae	<i>Apatania</i>	115935	29	10	45.5%
Trichoptera	Apataniidae	<i>Pedomoecus sierra</i>	115973	27	9	40.9%
Trichoptera	Brachycentridae	<i>Brachycentrus americanus</i>	116912	21	3	13.6%
Trichoptera	Brachycentridae	<i>Micrasema</i>	116958	106	14	63.6%
Trichoptera	Glossosomatidae	<i>Anagapetus</i>	117154	9	4	18.2%
Trichoptera	Glossosomatidae	<i>Glossosoma</i>	117159	5	4	18.2%

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Table C-1 (continued). Taxonomic units of Benthic Macroinvertebrates encountered in Lassen Volcanic National Park, 2014. Total number of sites sampled was 22.

Order (or higher)	Family	Taxon	TSN	Total No.	No. of Sites	Percent of Sites
Trichoptera	Glossosomatidae	Glossosomatidae	117120	1	1	4.5%
Trichoptera	Hydropsychidae	Arctopsychinae	568763	7	2	9.1%
Trichoptera	Hydropsychidae	<i>Hydropsyche</i>	115453	4	2	9.1%
Trichoptera	Hydropsychidae	<i>Parapsyche</i>	115556	40	11	50.0%
Trichoptera	Hydroptilidae	<i>Agraylea</i>	115635	5	2	9.1%
Trichoptera	Hydroptilidae	<i>Hydroptila</i>	115641	4	1	4.5%
Trichoptera	Lepidostomatidae	<i>Lepidostoma</i>	116794	26	7	31.8%
Trichoptera	Limnephilidae	<i>Cryptochia</i>	115907	5	3	13.6%
Trichoptera	Limnephilidae	<i>Ecclisomyia</i>	116025	376	12	54.5%
Trichoptera	Limnephilidae	Limnephilidae	115933	43	10	45.5%
Trichoptera	Limnephilidae	<i>Psychoglypha</i>	115974	2	1	4.5%
Trichoptera	Phryganeidae	<i>Yphria californica</i>	115923	11	3	13.6%
Trichoptera	Rhyacophilidae	<i>Rhyacophila</i>	115097	47	17	77.3%
Trichoptera	Rhyacophilidae	<i>Rhyacophila arnaudi</i>	115165	14	8	36.4%
Trichoptera	Rhyacophilidae	<i>Rhyacophila</i> Betteni Gr.	NA ^b	95	15	68.2%
Trichoptera	Rhyacophilidae	<i>Rhyacophila</i> Brunnea/Vemna Gr.	NA ^b	28	14	63.6%
Trichoptera	Rhyacophilidae	<i>Rhyacophila</i> Hyalinata Gr.	NA ^b	8	4	18.2%
Trichoptera	Rhyacophilidae	<i>Rhyacophila</i> Nevadensis Gr.	NA ^b	14	3	13.6%
Trichoptera	Rhyacophilidae	<i>Rhyacophila</i> Sibirica Gr.	NA ^b	49	12	54.5%
Trichoptera	Rhyacophilidae	<i>Rhyacophila</i> Vagrita Gr.	NA ^b	4	2	9.1%
Trichoptera	Rhyacophilidae	<i>Rhyacophila</i> Verrula Gr.	NA ^b	4	4	18.2%
Trichoptera	Rhyacophilidae	<i>Rhyacophila</i> Vofixa Gr.	NA ^b	94	12	54.5%
Trichoptera	Uenoidae	<i>Neothremma</i>	116388	209	4	18.2%
Trichoptera	Uenoidae	<i>Oligophlebodes</i>	116039	22	4	18.2%

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^bNA indicates cases where no TSN exists, either due to it being a “species group”, or a recently redescribed taxon with no number yet designated.

Table C-1 (continued). Taxonomic units of Benthic Macroinvertebrates encountered in Lassen Volcanic National Park, 2014. Total number of sites sampled was 22.

Order (or higher)	Family	Taxon	TSN	Total No.	No. of Sites	Percent of Sites
Trichoptera	Uenoidae	Uenoidae	568757	28	4	18.2%
Trichoptera	–	Limnephiloidea	598162	2	1	4.5%
Trichoptera	–	Trichoptera	115095	1	1	4.5%
Trombidiformes	Hydrovolziidae	<i>Hydrovolzia</i>	83119	7	2	9.1%
Trombidiformes	Hydryphantidae	<i>Protzia</i>	83170	3	3	13.6%
Trombidiformes	Hydryphantidae	<i>Thyopsella</i>	83202	1	1	4.5%
Trombidiformes	Hygrobatidae	<i>Atractides</i>	83282	3	3	13.6%
Trombidiformes	Hygrobatidae	<i>Hygrobates</i>	83297	2	2	9.1%
Trombidiformes	Lebertiidae	<i>Estelloxus</i>	83048	4	4	18.2%
Trombidiformes	Lebertiidae	<i>Lebertia</i>	83034	223	19	86.4%
Trombidiformes	Sperchontidae	<i>Sperchon</i>	83006	190	20	90.9%
Trombidiformes	Torrenticolidae	<i>Monatractides</i>	NA ^b	12	1	4.5%
Trombidiformes	Torrenticolidae	<i>Testudacarus</i>	83250	4	3	13.6%
Tubificida	Naididae	<i>Chaetogaster</i>	68934	4	1	4.5%
Tubificida	Naididae	Naididae	68854	6	4	18.2%
Tubificida	Naididae	<i>Nais</i>	68946	19	4	18.2%
Tubificida	Naididae	<i>Telmatodrilus vej dovskyi</i>	68760	1	1	4.5%
Veneroida	Sphaeriidae	<i>Pisidium</i>	81400	75	6	27.3%
Veneroida	Sphaeriidae	Sphaeriidae	81389	132	10	45.5%

^aTSN = Taxonomic Serial Number; see www.itis.gov for full taxonomy.

^bNA indicates cases where no TSN exists, either due to it being a “species group”, or a recently redescribed taxon with no number yet designated.

Appendix D. 2011 Data Tables

Included in this report are the data tables for Whiskeytown National Recreation Area and Lassen Volcanic National Park from the 2011 Annual Report (Dinger and Sarr 2014) (Tables D1-11). These are reproduced here as a result of instituting computer code for the calculations of metrics provided in the Wadeable Streams Annual Reports. These tables should be taken as the most accurate reporting of the streams parameters. Table numbering follows the numbering in the original 2011 Annual Report.

Prior, the tables and metrics were the result of large amounts of data crunching and manipulation in spreadsheet programs. This allowed sorting errors, was laborious and slow, and facilitated differing calculation methods from year to year. For example, previous reports would include laboratory duplicates and triplicates in the reporting of water chemistry values; or average stream width was calculated only with transect measures (and did not include half-transect measures).

The computer code used to analyze and report on the tables offer distinct advantages:

- 1) Reduces human error
- 2) Reduces rounding errors
- 3) Standardizes reporting techniques between years
- 4) Is easily reproducible
- 5) Lastly, the computer code is transparent and publically available through the Integrated Resource Management Applications (irma.nps.gov), allowing full repeatability and checking of metric methods to practioners and managers.
- 6) Although not exhaustive, the following is a list of known changes from the 2011 to 2014 reporting techniques, which are incorporated in the following tables.
- 7) Average depth and width calculations now include midpoint estimates.
- 8) Previous discharge calculations had conversion errors.
- 9) Acid Neutralizing Capacity has set rules to determine if three or two analyses are averaged for reporting.
- 10) Shading of stream now separated into Bank Shading and Center of Stream shading (previously was all incorporated into single measure).
- 11) Rounding errors are absent.
- 12) Clearer display of when stream sites were electrofished or not.
- 13) Observed/Expected ratios of macroinvertebrate diversity provided (were not included in prior reports).
- 14) EPA MMI standardized to use strict use of invertebrate character traits (e.g., tolerance values). (Note that the EPA MMI uses a random draw of 300 individuals so that each time it is calculated there is minor variance).

- 15) There is a standardized technique for determining if turbidity readings were erroneous (e.g., crew step above the meter and caused influx of sediments; or crew bumped stream bottom and caused rise in turbidity).
- 16) Duplicates and Triplicates removed from stream water chemistry results.
- 17) Use of Operational Taxonomic Units for determining invertebrate taxa standardized, and customized to specific metric (e.g., EPA uses genus level IDs for certain taxa, but Oregon state uses sub-family and tribe levels of taxonomy).
- 18) Database export error led to errors in the vertebrate abundances and metric calculations.
- 19) Coordinates for sites standardized to coordinates taken at the site by crews.
- 20) Any sorting errors fixed (e.g., Legacy trees for 2011 were mis-sorted, so that heights from one site were reported for different sites).
- 21) The crew in 2011 mislabeled site WHISWQ05 as WHISWQ30. The labels have been corrected to appropriately show the sampled site as WHISWQ05.

Table D-1. Physical characteristics and location of streams sampled in Whiskeytown, 2011. Table updated for 2016 computer code.

Stream Name	Site Code	Date Sampled	UTM ^a Coordinates ^a		Elevation ^b (m)	Reach Length (m)	Average Width (m)	Average Depth (cm)	Slope	Instantaneous Discharge	
			X	Y						m ³ s ⁻¹	ft ³ s ⁻¹
Boulder creek	WHISWQ02	6/20/2011	533723 ^c	4494841 ^c	437	200	4.8	48.7	5.90%	0.004	0.14
Boulder creek	WHISWQ17	6/30/2011	531478	4497477	727	160	5.4	35.0	11.50%	0.002	0.07
Boulder creek	WHISWQ05	6/22/2011	533055 ^c	4497896 ^c	779	160	5.4	40.2	7.40%	0.003	0.12
Boulder creek	WHISWQ33	8/1/2011	532031	4497974	574	200	3.3	29.2	9.30%	0.005	0.18
Brandy creek	WHISWQ12	7/13/2011	533565	4494015	629	360	7.4	41.2	7.00%	0.423	14.94
Brandy creek	WHISWQ18	7/11/2011	535797	4495485	411	400	8.0	41.1	4.50%	0.476	16.80
Brandy creek	WHISWQ34	8/11/2011	535906	4495842	433	280	7.3	31.1	4.20%	0.258	9.11
Clear creek	WHISWQ25	7/25/2011	530951	4501643	383	400	11.3	54.5	0.30%	1.459	51.52
Crystal creek	WHISWQ15	7/18/2011	528099	4500183	483	240	7.4	44.3	2.70%	0.500	17.67
Crystal creek	WHISWQ23	7/19/2011	527325	4498185	693	240	6.7	34.2	4.70%	0.260	9.17
Grizzly Gulch	WHISWQ06	7/7/2011	533871	4501109	403	150	2.6	14.5	4.40%	0.000	0.01
Mill creek	WHISWQ09	8/9/2011	529508	4499552	560	160	5.5	16.6	7.10%	0.056	1.98
Paige Boulder Creek	WHISWQ08	6/29/2011	536843 ^c	4492334 ^c	463	200	5.8	26.5	5.50%	0.002	0.05
Paige Boulder Creek	WHISWQ28	7/6/2011	535411	4491948	711	160	3.1	25.8	13.90%	0.001	0.02
Unnamed stream (Boulder Trib)	WHISWQ22	7/28/2011	532531	4497474	593	240	3.4	18.6	8.70%	0.031	1.09
Unnamed stream (Brandy Trib N)	WHISWQ14	7/5/2011	534005	4494528	569	150	2.3	7.7	6.10%	0.000	0.00
Unnamed stream (Brandy Trib S)	WHISWQ24	8/3/2011	533725	4493372	720	150	2.1	16.7	12.30%	0.000	0.01
Unnamed stream (Crystal Trib)	WHISWQ03	7/20/2011	526873	4497878	764	150	2.8	14.2	6.60%	0.025	0.89

^aUTM = Universal Transverse Mercator, Zone 10N.

^bData provided uses original GRTS coordinates and elevation.

^cIndicates coordinates not available through crew collected data.

Table D-1 (continued). Physical characteristics and location of streams sampled in Whiskeytown, 2011. Table updated for 2016 computer code.

Stream Name	Site Code	Date Sampled	UTM ^a Coordinates ^a		Elevation ^b (m)	Reach Length (m)	Average Width (m)	Average Depth (cm)	Slope	Instantaneous Discharge	
			X	Y						m ³ s ⁻¹	ft ³ s ⁻¹
Unnamed stream (Crystal Trib)	WHISWQ35	7/26/2011	526331	4497739	808	150	1.7	10.9	7.80%	0.000	0.00
Whiskey creek	WHISWQ26	7/1/2011	537219	4500746	379	200	6.6	23.0	0.80%	0.003	0.10
Willow Creek	WHISWQ01	6/27/2011	529525 ^c	4502317 ^c	421	160	4.5	28.9	2.40%	0.001	0.05
Willow Creek	WHISWQ21	8/4/2011	530433	4501776	387	320	6.7	31.6	0.80%	0.005	0.16
Average					560	220	5.2	28.8	6.1%	0.160	5.64
SD					148	83	2.4	12.8	3.6%	0.335	11.84
Median					565	200	5.4	29.1	6.0%	0.005	0.15
Range					379 - 808	150 - 400	1.7 - 11.3	7.7 - 54.5	0.3% - 14.0%	0 - 1.459	0 - 51.52

^aUTM = Universal Transverse Mercator, Zone 10N.
^bData provided uses original GRTS coordinates and elevation.
^cIndicates coordinates not available through crew collected data.

Table D-2. Physical condition metrics for Whiskeytown streams sampled in 2011. Table updated for 2016 computer code.

Stream Name	Site Code	Date Sampled	Stream Substrate diameter (mm)		Average Embeddeness (%)	Pool (%)	Riffle (%)	Physical Habitat Condition Metrics			
			Average	Median				In-Stream Habitat Complexity	Riparian Cover	Relative Bed Stability	Riparian Disturbance
Boulder creek	WHISWQ02	6/20/2011	423.5	1047.1	20.2	41%	48%	0.50 ^a	0.97 ^a	0.17 ^b	0.00 ^a
Boulder creek	WHISWQ17	6/30/2011	179.4	1047.1	59.1	21%	67%	0.89 ^a	0.55 ^a	-0.30 ^a	0.59 ^b
Boulder creek	WHISWQ05	6/22/2011	350.6	1047.1	28.0	11%	69%	1.01 ^a	1.49 ^a	0.07 ^a	0.00 ^a
Boulder creek	WHISWQ33	8/1/2011	147.0	114.8	42.5	29%	63%	0.42 ^a	0.77 ^a	-0.19 ^a	0.07 ^a
Brandy creek	WHISWQ12	7/13/2011	286.4	1047.1	47.8	24%	61%	0.85 ^a	1.17 ^a	-0.02 ^a	0.14 ^a
Brandy creek	WHISWQ18	7/11/2011	147.8	1047.1	48.5	22%	63%	0.90 ^a	1.57 ^a	-0.12 ^a	0.18 ^a
Brandy creek	WHISWQ34	8/11/2011	448.7	1047.1	37.0	13%	56%	0.71 ^a	1.32 ^a	0.50 ^b	0.29 ^a
Clear creek	WHISWQ25	7/25/2011	135.5	114.8	28.3	0%	35%	0.32 ^b	0.90 ^a	0.97 ^c	0.62 ^b
Crystal creek	WHISWQ15	7/18/2011	122.2	346.7	45.6	21%	60%	0.55 ^a	1.02 ^a	0.06 ^a	0.00 ^a
Crystal creek	WHISWQ23	7/19/2011	224.3	1047.1	43.5	33%	59%	0.67 ^a	0.97 ^a	0.14 ^b	0.86 ^b
Grizzly Gulch	WHISWQ06	7/7/2011	279.8	114.8	27.8	19%	59%	0.51 ^a	1.03 ^a	0.55	0.06 ^a
Mill creek	WHISWQ09	8/9/2011	116.1	114.8	54.9	10%	70%	0.61 ^a	1.21 ^a	-0.02 ^a	0.00 ^a
Paige Boulder Creek	WHISWQ08	6/29/2011	222.8	1047.1	30.3	15%	69%	0.96 ^a	1.05 ^a	0.11 ^b	0.00 ^a
Paige Boulder Creek	WHISWQ28	7/6/2011	1047.1	9549.9	19.1	26%	59%	0.69 ^a	0.98 ^a	0.51 ^b	0.00 ^a
Unnamed stream (Boulder Trib)	WHISWQ22	7/28/2011	243.3	1047.1	44.9	24%	54%	0.93 ^a	1.46 ^a	0.13 ^b	0.00 ^a
Unnamed stream (Brandy Trib N)	WHISWQ14	7/5/2011	127.6	114.8	37.1	11%	65%	1.02 ^a	0.74 ^a	0.33 ^b	0.14 ^a
Unnamed stream (Brandy Trib S)	WHISWQ24	8/3/2011	1103.7	1047.1	20.7	25%	54%	0.54 ^a	0.84 ^a	0.60 ^b	0.00 ^a
Unnamed stream (Crystal Trib)	WHISWQ03	7/20/2011	31.8	38.0	64.4	9%	69%	0.95 ^a	1.54 ^a	-0.50 ^a	0.00 ^a
Unnamed stream (Crystal Trib)	WHISWQ35	7/26/2011	35.2	38.0	55.5	13%	68%	0.73 ^a	1.32 ^a	-0.40 ^a	0.15 ^a

^aSites are Least Disturbed (also with light sage background).

^bSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^cSites meeting EPA criteria for Most Disturbed (also with dark red background).

Table D-2 (continued). Physical condition metrics for Whiskeytown streams sampled in 2011. Table updated for 2016 computer code.

Stream Name	Site Code	Date Sampled	Stream Substrate diameter (mm)		Average Embeddeness (%)	Pool (%)	Riffle (%)	Physical Habitat Condition Metrics			
			Average	Median				In-Stream Habitat Complexity	Riparian Cover	Relative Bed Stability	Riparian Disturbance
Whiskey creek	WHISWQ26	7/1/2011	37.2	38.0	30.9	11%	40%	0.22 ^b	0.93 ^a	0.33 ^b	0.00 ^a
Willow Creek	WHISWQ01	6/27/2011	79.7	114.8	51.0	20%	50%	0.35 ^a	0.95 ^a	0.04 ^a	0.00 ^a
Willow Creek	WHISWQ21	8/4/2011	263.0	114.8	35.5	1%	73%	0.16 ^b	0.74 ^a	1.00 ^c	0.04 ^a
Average			275.1	967.5	39.7	18%	60%	0.66 ^a	1.07 ^a	0.18 ^b	0.14 ^a
SD			283.7	1973.5	13.1	10%	10%	0.26	0.28	0.39	0.24
Median			201.1	696.9	39.8	20%	61%	0.68	1.00	0.12	0.02
Range			31.8 - 1103.7	38.0 - 9549.9	19.1 - 64.4	0 - 41%	35 - 73%	0.16 - 1.02	0.55 - 1.57	-0.50 - 1.00	0.00 - 0.86

^aSites are Least Disturbed (also with light sage background).
^bSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).
^cSites meeting EPA criteria for Most Disturbed (also with dark red background).

Table D-3. Riparian characteristics of Whiskeytown streams sampled in 2011. Table updated for 2016 computer code.

Stream Name	Site Code	Bank Shading	Center Shading	Legacy Tree Height (m)	Canopy			Understory		
					Big Tree	Small Tree	Composition ^a	Woody	Non-Woody	Composition ^a
Boulder creek	WHISWQ02	78%	59%	17.3	21%	7%	9% C,41% D,27% N,23% M	47%	0%	5% C,86% D,5% E,5% M
Boulder creek	WHISWQ17	98%	98%	28.0	16%	18%	5% C,64% D,32% M	9%	0%	5% C,95% D
Boulder creek	WHISWQ05	98%	92%	24.1	39%	29%	18% C,32% D,50% M	46%	0%	91% D,9% M
Boulder creek	WHISWQ33	100%	97%	35.4	24%	17%	5% C,64% D,32% M	26%	5%	91% D,5% N,5% M
Brandy creek	WHISWQ12	96%	74%	25.6	11%	36%	41% D,14% E,45% M	39%	2%	82% D,18% M
Brandy creek	WHISWQ18	99%	78%	25.5	27%	34%	9% D,9% E,82% M	47%	2%	68% D,32% M
Brandy creek	WHISWQ34	99%	84%	24.9	23%	28%	7% C,25% D,11% E,57% M	43%	3%	75% D,25% M
Clear creek	WHISWQ25	71%	12%	18.6	4%	13%	36% D,9% E,23% N,32% M	42%	12%	91% D,9% M
Crystal creek	WHISWQ15	97%	88%	27.1	18%	26%	59% D,41% M	35%	37%	82% D,18% M
Crystal creek	WHISWQ23	95%	89%	37.7	22%	22%	5% C,14% D,5% E,77% M	33%	2%	59% D,5% E,5% N,32% M
Grizzly Gulch	WHISWQ06	94%	93%	11.2	12%	24%	68% D,9% E,18% N,5% M	38%	9%	64% D,9% E,27% M
Mill creek	WHISWQ09	100%	95%	31.0	14%	20%	14% C,41% D,45% M	49%	11%	82% D,18% M
Paige Boulder Creek	WHISWQ08	91%	92%	29.3	9%	33%	5% C,77% D,18% M	37%	6%	86% D,14% M
Paige Boulder Creek	WHISWQ28	87%	87%	23.4	4%	39%	59% D,9% N,32% M	36%	1%	45% D,55% M
Unnamed stream (Boulder Trib)	WHISWQ22	100%	95%	38.6	31%	17%	23% D,5% N,73% M	53%	4%	82% D,18% M
Unnamed stream (Brandy Trib N)	WHISWQ14	95%	95%	29.0	19%	24%	18% C,14% D,68% M	16%	0%	14% C,45% D,41% M
Unnamed stream (Brandy Trib S)	WHISWQ24	93%	87%	30.2	8%	24%	82% D,9% N,9% M	26%	2%	5% C,77% D,18% M
Unnamed stream (Crystal Trib)	WHISWQ03	97%	90%	43.3	8%	31%	5% C,45% D,5% N,45% M	64%	2%	86% D,14% M
Unnamed stream (Crystal Trib)	WHISWQ35	99%	97%	34.4	16%	35%	5% C,64% D,32% M	43%	0%	68% D,32% M

^aFor compositions: D = Deciduous, C = Coniferous, E = Broadleaf Evergreen, N = None, and M = Mixed (10% or more of multiple types).

Table D-3 (continued). Riparian characteristics of Whiskeytown streams sampled in 2011. Table updated for 2016 computer code.

Stream Name	Site Code	Bank Shading	Center Shading	Legacy Tree Height (m)	Canopy			Understory		
					Big Tree	Small Tree	Composition ^a	Woody	Non-Woody	Composition ^a
Whiskey creek	WHISWQ26	91%	82%	13.8	7%	28%	77% D,23% M	29%	22%	91% D,9% M
Willow Creek	WHISWQ01	95%	90%	15.3	4%	34%	5% C,86% D,9% M	34%	0%	100% D
Willow Creek	WHISWQ21	100%	87%	26.6	20%	18%	68% D,14% N,18% M	27%	8%	91% D,9% M
Average		94%	85%	26.8	16%	25%	n/a	37%	6%	n/a
SD		7%	19%	8.3	9%	8%	n/a	12%	9%	n/a
Median		97%	90%	26.8	16%	25%	n/a	38%	2%	n/a
Range		71% -100%	12% - 98%	11.2 - 43.3	4% - 39%	7% - 39%	n/a	9% - 64%	0% - 37%	n/a

^aFor compositions: D = Deciduous, C = Coniferous, E = Broadleaf Evergreen, N = None, and M = Mixed (10% or more of multiple types).

Table D-4. Vertebrate species and metrics for Whiskeytown streams sampled in 2011. Table updated for 2016 computer code.

Stream Name	Site Code	Sampled: Yes or No	Total Abundance	Total Richness	EPA Vertebrate MMI	Brook Trout	California Roach	Hardhead	Pacific Giant Salamander	Pacific Tree Frog	Rainbow Trout	Riffle Sculpin	Sacramento Sucker	Tailed Frog	Western Toad	Yellow- legged Frog
Boulder creek	WHISWQ02	Yes	3	2	100.0 ^a	–	–	–	1	–	2	–	–	–	–	–
Boulder creek	WHISWQ17	Yes	18	3	86.8 ^a	–	–	–	2	–	12	–	–	–	4	–
Boulder creek	WHISWQ05	Yes	21	2	100.0 ^a	–	–	–	3	–	18	–	–	–	–	–
Boulder creek	WHISWQ33	Yes	55	3	88.5 ^a	–	–	–	13	–	16	–	–	26	–	–
Brandy creek	WHISWQ12	Yes	8	2	100.0 ^a	–	–	–	3	–	5	–	–	–	–	–
Brandy creek	WHISWQ18	Yes	37	2	54.7 ^b	17	–	–	–	–	–	20	–	–	–	–
Brandy creek	WHISWQ34	Yes	53	3	72.1 ^a	2	–	–	–	–	12	39	–	–	–	–
Clear creek	WHISWQ25	Yes	213	3	53.9 ^b	–	–	42	–	6	–	165	–	–	–	–
Crystal creek	WHISWQ15	Yes	38	3	76.4 ^a	–	–	–	1	–	5	32	–	–	–	–
Crystal creek	WHISWQ23	Yes	41	2	90.4 ^a	–	–	–	–	–	34	–	–	7	–	–
Grizzly Gulch	WHISWQ06	Yes	105	4	60.9 ^a	–	8	–	4	–	–	88	–	–	5	–
Mill creek	WHISWQ09	Yes	61	4	88.6 ^a	2	–	–	19	–	32	–	–	1	–	7
Paige Boulder Creek	WHISWQ08	Yes	40	3	87.0 ^a	–	1	–	3	–	36	–	–	–	–	–
Paige Boulder Creek	WHISWQ28	Yes	19	2	79.3 ^a	–	–	–	12	–	–	–	–	–	7	–
Unnamed stream (Boulder Trib)	WHISWQ22	Yes	39	5	90.3 ^a	1	–	–	9	–	28	–	–	1	–	–
Unnamed stream (Brandy Trib N)	WHISWQ14	Yes	6	1	100.0 ^a	–	–	–	6	–	–	–	–	–	–	–
Unnamed stream (Brandy Trib S)	WHISWQ24	Yes	15	2	78.8 ^a	–	–	–	13	2	–	–	–	–	–	–
Unnamed stream (Crystal Trib)	WHISWQ03	Yes	23	3	86.7 ^a	–	–	–	17	–	–	–	–	5	–	1
Unnamed stream (Crystal Trib)	WHISWQ35	Yes	21	1	100.0 ^a	–	–	–	21	–	–	–	–	–	–	–
Whiskey creek	WHISWQ26	Yes	122	3	65.2 ^a	34	–	–	–	–	–	86	2	–	–	–
Willow Creek	WHISWQ01	Yes	62	4	77.5 ^a	–	–	–	1	–	5	52	4	–	–	–
Willow Creek	WHISWQ21	Yes	35	4	60.7 ^b	–	–	–	–	3	3	29	–	–	–	–
Average		n/a	47.0	2.8	82 ^a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SD		n/a	47.4	1.0	15	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Median		n/a	37.5	3.0	87	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Range		n/a	3 - 213	1 - 5	53.9 – 100.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

^aSites are Least Disturbed (also with light sage background).
^bSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).
^cSites meeting EPA criteria for Most Disturbed (also with dark red background).

Table D-5. Invertebrate results and metrics for Whiskeytown streams sampled in 2011. Table updated for 2016 computer code.

Stream Name	Site Code	Total Taxa Richness	Shannon Diversity	HBI ^a	O/E ^b	EPA West-Wide Invertebrate MMI ^c	CA North Coast MMI ^c
Boulder creek	WHISWQ02	68	3.15	3.21	1.120 ^d	83 ^d	88 ^d
Boulder creek	WHISWQ17	76	3.75	3.27	0.95 ^d	85 ^d	91 ^d
Boulder creek	WHISWQ05	74	3.56	3.32	1.08 ^d	84 ^d	89 ^d
Boulder creek	WHISWQ33	65	3.54	3.62	0.99 ^d	87 ^d	84 ^d
Brandy creek	WHISWQ12	68	3.46	3.52	0.92 ^d	88 ^d	87 ^d
Brandy creek	WHISWQ18	48	3.04	3.87	0.79 ^e	80 ^d	79 ^d
Brandy creek	WHISWQ34	68	2.91	4.87	0.90 ^d	81 ^d	68 ^d
Clear creek	WHISWQ25	64	3.35	5.08	0.92 ^d	63 ^e	76 ^d
Crystal creek	WHISWQ15	77	3.57	3.26	0.93 ^d	85 ^d	87 ^d
Crystal creek	WHISWQ23	80	3.81	3.87	0.94 ^d	85 ^d	85 ^d
Grizzly Gulch	WHISWQ06	57	2.81	3.46	0.77 ^d	68 ^e	81 ^d
Mill creek	WHISWQ09	74	3.61	3.69	1.04 ^d	86 ^d	89 ^d
Paige Boulder Creek	WHISWQ08	72	3.54	3.74	1.06 ^d	89 ^d	85 ^d
Paige Boulder Creek	WHISWQ28	71	3.52	4.13	0.81 ^d	88 ^d	84 ^d
Unnamed stream (Boulder Trib)	WHISWQ22	71	3.49	3.40	0.98 ^d	86 ^d	91 ^d
Unnamed stream (Brandy Trib N)	WHISWQ14	54	2.59	3.80	0.70 ^e	65 ^e	73 ^d

^aHBI = Hilsenhoff Biotic Index.

^bO/E = Observed to Expected ratio of macroinvertebrate diversity.

^cMMI = MultiMetric Index.

^dSites are Least Disturbed (also with light sage background).

^eSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^fSites meeting EPA criteria for Most Disturbed (also with dark red background).

Table D-5 (continued). Invertebrate results and metrics for Whiskeytown streams sampled in 2011. Table updated for 2016 computer code.

Stream Name	Site Code	Total Taxa Richness	Shannon Diversity	HBI ^a	O/E ^b	EPA West-Wide Invertebrate MMI ^c	CA North Coast MMI ^c
Unnamed stream (Brandy Trib S)	WHISWQ24	72	3.39	4.00	0.97 ^d	82 ^d	79 ^d
Unnamed stream (Crystal Trib)	WHISWQ03	80	3.77	3.22	1.08 ^d	89 ^d	89 ^d
Unnamed stream (Crystal Trib)	WHISWQ35	83	3.64	3.20	0.73 ^e	87 ^d	88 ^d
Whiskey creek	WHISWQ26	65	2.97	4.96	0.85 ^d	76 ^d	74 ^d
Willow Creek	WHISWQ01	50	2.3	3.06	0.61 ^f	57 ^e	74 ^d
Willow Creek	WHISWQ21	67	3.49	4.29	1.05 ^d	88 ^d	82 ^d
Average		68.4	3.33	3.77	0.92^d	81.0^d	82.9^d
SD		9.4	0.40	0.59	0.14	9.3	6.5
Median		69.5	3.49	3.66	0.94	85.0	84.5
Range		48 - 83	2.3 - 3.81	3.06 - 5.08	0.61 - 1.12	57 - 89	68 - 91

^aHBI = Hilsenhoff Biotic Index.

^bO/E = Observed to Expected ratio of macroinvertebrate diversity.

^cMMI = MultiMetric Index.

^dSites are Least Disturbed (also with light sage background).

^eSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^fSites meeting EPA criteria for Most Disturbed (also with dark red background).

Table D-6. Physical characteristics and location of streams sampled in Lassen Volcanic, 2011. Table updated for 2016 computer code.

Stream Name	Site Code	Date Sampled	UTM ^a Coordinates ^a		Elevation ^b (m)	Reach Length (m)	Average Width (m)	Average Depth (cm)	Slope	Instantaneous Discharge	
			X	Y						m ³ s ⁻¹	ft ³ s ⁻¹
Hat creek	LAVOWQ01	8/31/2011	632630	4482923	2133	150	2.3	19.6	5.7%	0.085	3.02
Hat creek	LAVOWQ05	9/29/2011	631874	4484686	2025	160	3.9	25.7	2.0%	0.161	5.70
Hat creek	LAVOWQ08	8/18/2011	631825	4490253	1888	320	7.8	53.5	0.9%	0.892	31.49
Hat creek	LAVOWQ29	9/30/2011	631418	4485035	2003	200	4.0	27.2	1.2%	0.174	6.13
Hat creek	LAVOWQ32	9/13/2011	631993	4488672	1845	240	8.0	43.1	0.8%	0.841	29.70
Hat creek	LAVOWQ36	9/8/2011	631752	4488202	1890	320	7.6	42.6	0.7%	0.907	32.02
Hat creek	LAVOWQ40	9/14/2011	631301	4487852	1904	280	8.0	36.5	0.7%	0.854	30.15
Hat creek	LAVOWQ45	9/28/2011	632507	4484698	2014	150	2.1	22.8	2.1%	0.071	2.50
Kings creek	LAVOWQ17	8/29/2011	630480	4480039	2234	150	2.3	56.0	0.8%	0.507	17.90
Kings creek	LAVOWQ25	8/23/2011	634293	4480665	1911	200	5.5	36.5	4.1%	0.776	27.41
Kings creek	LAVOWQ33	8/30/2011	631388	4479814	2197	240	5.8	44.6	1.6%	0.391	13.80
Kings creek	LAVOWQ37	9/27/2011	629218	4480054	2248	150	2.0	28.9	2.4%	0.231	8.14
Lost creek	LAVOWQ04	8/15/2011	628042	4487334	1889	150	2.1	24.4	1.0%	0.221	7.80
Lost creek	LAVOWQ20	9/21/2011	627655	4489188	1855	150	2.4	28.8	2.7%	0.242	8.56
Manzanita creek	LAVOWQ15	9/16/2011	622055	4488111	1811	160	4.2	29.0	3.9%	0.654	23.09
Manzanita creek	LAVOWQ23	8/25/2011	623720	4484722	2058	160	3.5	27.3	5.7%	0.353	12.48
Manzanita creek	LAVOWQ27	9/1/2011	621827	4488196	1805	160	4.8	32.2	2.1%	0.543	19.18
North Arm Rice creek	LAVOWQ10	9/23/2011	629031	4477156	2073	160	4.4	18.8	3.7%	0.022	0.78
North Arm Rice creek	LAVOWQ22	9/22/2011	629303	4476823	2080	160	3.7	15.9	1.7%	0.030	1.06
Summit creek	LAVOWQ13	8/22/2011	633868	4482972	2029	150	1.6	17.4	5.7%	0.008	0.30
West Fork Hat creek	LAVOWQ09	8/17/2011	629829	4484477	2004	160	3.4	31.7	4.0%	0.251	8.87

^aUTM = Universal Transverse Mercator, Zone 10N.

^bData provided uses original GRTS coordinates and elevation.

^cIndicates coordinates not available through crew collected data.

Table D-6 (continued). Physical characteristics and location of streams sampled in Lassen Volcanic, 2011. Table updated for 2016 computer code.

Stream Name	Site Code	Date Sampled	UTM ^a Coordinates ^a		Elevation ^b (m)	Reach Length (m)	Average Width (m)	Average Depth (cm)	Slope	Instantaneous Discharge	
			X	Y						m ³ s ⁻¹	ft ³ s ⁻¹
West Fork Hat creek	LAVOWQ12	9/7/2011	630847	4486420	1927	240	7.5	45.5	1.1%	0.837	29.57
West Fork Hat creek	LAVOWQ21	8/16/2011	629130	4483432	2262	150	4.6	21.5	6.1%	0.178	6.3
West Fork Hat creek	LAVOWQ24	9/6/2011	630661	4485967	1967	200	5.3	33.1	1.8%	0.557	19.66
Average					2002	190	4.5	31.8	2.6%	0.41	14.4
SD					138	55	2.1	11.1	1.8%	0.31	11.1
Median					2004	160	4.1	29.0	2.1%	0.30	10.7
Range					1805 - 2262	150 -320	1.6 – 8.0	15.9 – 56.0	0.7% - 6.1%	0.008 - 0.907	0.30 - 32.02

^aUTM = Universal Transverse Mercator, Zone 10N.

^bData provided uses original GRTS coordinates and elevation.

^cIndicates coordinates not available through crew collected data.

Table D-7. Physical condition metrics for Lassen Volcanic streams sampled in 2011. Table updated for 2016 computer code.

Stream Name	Site Code	Date Sampled	Stream Substrate diameter (mm)		Average Embeddeness (%)	Pool (%)	Riffle (%)	Physical Habitat Condition Metrics			
			Average	Median				In-Stream Habitat Complexity	Riparian Cover	Relative Bed Stability	Riparian Disturbance
Hat creek	LAVOWQ01	8/31/2011	15.1	38.0	56.9	6%	83%	0.48 ^a	0.64 ^b	-0.85 ^b	0.00 ^a
Hat creek	LAVOWQ05	9/29/2011	21.0	38.0	57.6	14%	50%	0.30 ^b	0.70 ^a	-0.42 ^a	0.00 ^a
Hat creek	LAVOWQ08	8/18/2011	14.7	38.0	65.6	6%	50%	0.51 ^a	0.70 ^a	-0.41 ^a	0.00 ^a
Hat creek	LAVOWQ29	9/30/2011	18.5	38.0	69.6	5%	37%	0.40 ^a	0.43 ^b	-0.25 ^a	0.00 ^a
Hat creek	LAVOWQ32	9/13/2011	16.1	38.0	68.5	7%	51%	0.78 ^a	0.57 ^b	-0.32 ^a	0.00 ^a
Hat creek	LAVOWQ36	9/8/2011	19.8	38.0	63.8	4%	55%	0.68 ^a	0.95 ^a	-0.17 ^a	0.00 ^a
Hat creek	LAVOWQ40	9/14/2011	9.1	38.0	73.6	15%	47%	0.48 ^a	1.08 ^a	-0.52 ^a	0.00 ^a
Hat creek	LAVOWQ45	9/28/2011	12.2	38.0	58.2	0%	56%	0.37 ^a	0.46 ^b	-0.54 ^a	0.00 ^a
Kings creek	LAVOWQ17	8/29/2011	7.7	4.2	70.4	0%	11%	0.31 ^b	0.42 ^b	-0.68 ^a	0.45 ^b
Kings creek	LAVOWQ25	8/23/2011	105.2	114.8	42.2	9%	87%	0.65 ^a	0.82 ^a	-0.14 ^a	0.00 ^a
Kings creek	LAVOWQ33	8/30/2011	10.6	4.2	70.7	1%	18%	0.45 ^a	0.72 ^a	-0.78 ^b	0.14
Kings creek	LAVOWQ37	9/27/2011	15.5	38.0	63.5	3%	73%	0.30 ^b	0.57 ^b	-0.60 ^a	0.00 ^a
Lost creek	LAVOWQ04	8/15/2011	2.1	0.5	91.6	0%	97%	0.36 ^a	0.88 ^a	-1.00 ^b	0.00 ^a
Lost creek	LAVOWQ20	9/21/2011	20.3	38.0	63.8	1%	68%	0.37 ^a	0.63 ^b	-0.53 ^a	0.00 ^a
Manzanita creek	LAVOWQ15	9/16/2011	33.1	38.0	64.9	0%	98%	0.46 ^a	0.47 ^b	-0.52 ^a	0.10 ^a
Manzanita creek	LAVOWQ23	8/25/2011	107.8	114.8	44.0	9%	83%	0.93 ^a	1.43 ^a	-0.18 ^a	0.00 ^a
Manzanita creek	LAVOWQ27	9/1/2011	8.7	38.0	69.4	9%	62%	0.82 ^a	0.82 ^a	-0.85 ^b	0.61 ^b
North Arm Rice creek	LAVOWQ10	9/23/2011	103.3	114.8	42.2	1%	61%	0.70 ^a	0.90 ^a	0.20 ^b	0.00 ^a
North Arm Rice creek	LAVOWQ22	9/22/2011	44.1	38.0	39.6	4%	54%	0.21 ^b	0.75 ^a	0.16 ^b	0.00 ^a
Summit creek	LAVOWQ13	8/22/2011	30.3	38.0	64.7	5%	67%	0.82 ^a	0.87 ^a	-0.41 ^a	0.07 ^a
West Fork Hat creek	LAVOWQ09	8/17/2011	33.0	114.8	59.8	10%	78%	0.99 ^a	1.17 ^a	-0.55 ^a	0.00 ^a
West Fork Hat creek	LAVOWQ12	9/7/2011	27.3	38.0	60.4	8%	50%	0.58 ^a	1.00 ^a	-0.20 ^a	0.00 ^a

^aSites are Least Disturbed (also with light sage background).

^bSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^cSites meeting EPA criteria for Most Disturbed (also with dark red background).

Table D-7 (continued). Physical condition metrics for Lassen Volcanic streams sampled in 2011. Table updated for 2016 computer code.

Stream Name	Site Code	Date Sampled	Stream Substrate diameter (mm)		Average Embeddeness (%)	Pool (%)	Riffle (%)	Physical Habitat Condition Metrics			
			Average	Median				In-Stream Habitat Complexity	Riparian Cover	Relative Bed Stability	Riparian Disturbance
West Fork Hat creek	LAVOWQ21	8/16/2011	13.3	38.0	63.3	10%	85%	0.34 ^a	0.59 ^b	-0.94 ^a	0.00 ^a
West Fork Hat creek	LAVOWQ24	9/6/2011	46.4	114.8	59.3	4%	70%	0.64 ^a	1.05 ^a	-0.10 ^b	0.14 ^a
Average			30.6	49.6	61.8	5%	62%	0.54 ^a	0.78 ^a	-0.44 ^a	0.06 ^a
SD			30.9	36.1	11.5	4%	22%	0.22	0.25	0.32	0.15
Median			19.2	38.0	63.7	5%	62%	0.48	0.74	-0.47	0
Range			2.1 - 107.8	0.5 - 114.8	39.6 - 91.6	0% - 15%	11% - 98%	0.21 - 0.99	0.42 -0.1.43	-1.0 - 0.2	0 - 0.61

^aSites are Least Disturbed (also with light sage background).
^bSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).
^cSites meeting EPA criteria for Most Disturbed (also with dark red background).

Table D-8. Water chemistry parameters for streams sampled in Lassen Volcanic, 2011. Table updated for 2016 computer code.

Stream Name	Site Code	Water Quality ^a					Water Chemistry ^b					Acid Neutralizing Capacity ^b	
		pH ^f	Temp (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU) ^g	Sodium (mg/L)	Sulfate (mg/L)	Chloride mg/L	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)	(µeq/L)	(mg/L)
Hat creek	LAVOWQ01	7.76	3.2	50 ^c	10.2	0.0	1.57	0.12	0.21	0.03 ^c	0.011 ^d	475 ^c	24
Hat creek	LAVOWQ05	7.25	4.1	48 ^c	10.4	0.0	0.94	0.06	0.14	0.06 ^c	0.009 ^c	519 ^c	26
Hat creek	LAVOWQ08	8.00	5.1	72 ^c	9.7	0.0	1.47	0.33	0.18	0.05 ^c	0.018 ^d	641 ^c	32
Hat creek	LAVOWQ29	7.21	4.3	48 ^c	10.4	0.0	1.90	0.10	0.19	0.03 ^c	0.005 ^c	428 ^c	21
Hat creek	LAVOWQ32	7.89	5.3	95 ^c	10.4	0.6	3.35	0.76	0.39	0.04 ^c	0.021 ^d	909 ^c	46
Hat creek	LAVOWQ36	7.93	5.9	97 ^c	10.3	0.0	3.40	0.78	0.36	0.03 ^c	0.021 ^d	919 ^c	46
Hat creek	LAVOWQ40	8.2	5.5	97 ^c	10.1	0.8	3.92	0.89	0.39	0.05 ^c	0.022 ^d	929 ^c	46
Hat creek	LAVOWQ45	7.29	3.3	54 ^c	11.0	0.0	1.75	0.13	0.28	0.04 ^c	0.011 ^d	533 ^c	27
Kings creek	LAVOWQ17	7.23	3.4	34 ^c	10.3	0.0	1.96	0.16	0.26	0.03 ^c	0.027 ^d	265 ^c	13
Kings creek	LAVOWQ25	7.59	4.7	35 ^c	9.7	0.1	1.02	0.07	0.15	0.05 ^c	0.022 ^d	356 ^c	18
Kings creek	LAVOWQ33	7.47	3.7	34 ^c	10.4	0.0	0.83	0.08	0.12	0.04 ^c	0.026 ^d	232 ^c	12
Kings creek	LAVOWQ37	6.91	3.7	27 ^c	11.0	14.6	1.48	0.16	0.19	0.04 ^c	0.037 ^d	397 ^c	20
Lost creek	LAVOWQ04	7.90	5.7	84 ^c	10.4	0.0	3.97	1.26	0.46	0.15 ^d	0.016 ^d	849 ^c	42
Lost creek	LAVOWQ20	7.47	4.6	89 ^c	10.5	7.9	4.43	1.41	0.49	0.13 ^d	0.015 ^d	699 ^c	35
Manzanita creek	LAVOWQ15	8.23	4.5	105 ^c	10.1	2.2	3.60	1.07	0.30	0.04 ^c	0.015 ^d	1106 ^c	55
Manzanita creek	LAVOWQ23	7.81	4.5	69 ^c	10.4	0.1	3.16	0.95	0.46	0.07 ^c	0.018 ^d	618 ^c	31

^aData collected with water probe.

^bData from laboratory analysis.

^cSites are Least Disturbed (also with light sage background).

^dSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^eSites meeting EPA criteria for Most Disturbed (also with dark red background).

^fSee text for qualifiers on interpreting pH data.

^gIndicates turbidity values that should be interpreted as estimates only.

Table D-8 (continued). Water chemistry parameters for streams sampled in Lassen Volcanic, 2011. Table updated for 2016 computer code.

Stream Name	Site Code	Water Quality ^a					Water Chemistry ^b					Acid Neutralizing Capacity ^b	
		pH ^f	Temp (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU) ^g	Sodium (mg/L)	Sulfate (mg/L)	Chloride mg/L	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)	(µeq/L)	(mg/L)
Manzanita creek	LAVOWQ27	8.11	4.7	112 ^c	10.5	0.0	4.65	1.24	0.39	0.05 ^c	0.014 ^d	869 ^c	44
North Arm Rice creek	LAVOWQ10	7.01	7.2	38 ^c	9.6	13.0	2.20	0.60	0.16	0.04 ^c	0.008 ^c	330 ^c	16
North Arm Rice creek	LAVOWQ22	7.06	7.1	37 ^c	10.5	3.8	2.06	0.63	0.15	0.04 ^c	0.005 ^c	318 ^c	16
Summit creek	LAVOWQ13	7.44	9.8	26 ^c	8.5	0.0	1.24	0.18	0.16	0.15 ^d	0.009 ^c	365 ^c	18
West Fork Hat creek	LAVOWQ09	7.94	4.9	109 ^c	10.3	0.0	4.60	1.34	0.67	0.09 ^c	0.033 ^d	1029 ^c	52
West Fork Hat creek	LAVOWQ12	7.81	4.8	97 ^c	9.6	0.0	2.71	0.65	0.27	0.04 ^c	0.024 ^d	939 ^c	47
West Fork Hat cree	LAVOWQ21	7.67	4.3	106 ^c	12.1	0.0	3.56	1.26	0.60	0.07 ^c	0.029 ^d	949 ^c	48
West Fork Hat creek	LAVOWQ24	8.25	3.9	119 ^c	10.0	2.9	3.82	1.08	0.41	0.04 ^c	0.029 ^d	1119 ^c	56
Average		7.64	4.9	70 ^c	10.3	1.9	2.65	0.64	0.31	0.06 ^c	0.019 ^d	658 ^c	33
SD		0.40	1.5	32	0.6	4.1	1.25	0.48	0.15	0.04	0.009	290	15
Median		7.72	4.7	71	10.4	0.0	2.46	0.64	0.28	0.04	0.018	630	32
Range		6.91 - 8.25	3.2 - 9.8	26 - 119	8.5 - 12.1	0 - 14.6	0.83 - 4.65	0.06 - 1.41	0.12 - 0.67	0.03 - 0.15	0.005 - 0.037	232 - 1119	12 - 56

^aData collected with water proble.

^bData from laboratory analysis.

^cSites are Least Disturbed (also with light sage background).

^dSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^eSites meeting EPA criteria for Most Disturbed (also with dark red background).

^fSee text for qualifiers on interpreting pH data.

^gIndicates turbidity values that should be interpreted as estimates only.

Table D-9. Riparian characteristics of Lassen Volcanic streams sampled in 2011. Table updated for 2016 computer code.

Stream Name	Site Code	Bank Shading	Center Shading	Legacy Tree Height (m)	Canopy			Understory		
					Big Tree	Small Tree	Composition ^a	Woody	Non-Woody	Composition ^a
Hat creek	LAVOWQ01	76%	58%	27.7	19%	19%	95% C,5% N	13%	4%	77% C,23% M
Hat creek	LAVOWQ05	85%	65%	27.6	20%	7%	100% C	22%	1%	91% C,5% N,5% M
Hat creek	LAVOWQ08	52%	22%	21.1	13%	22%	95% C,5% M	19%	0%	86% C,5% N,9% M
Hat creek	LAVOWQ29	75%	51%	31.3	15%	4%	100% C	11%	3%	64% C,23% D,5% N,9% M
Hat creek	LAVOWQ32	89%	54%	28.7	15%	25%	95% C,5% M	9%	0%	86% C,14% M
Hat creek	LAVOWQ36	84%	53%	24.8	15%	24%	59% C,41% M	28%	0%	41% C,9% D,50% M
Hat creek	LAVOWQ40	80%	50%	26.5	22%	11%	59% C,9% N,32% M	38%	0%	14% C,23% D,64% M
Hat creek	LAVOWQ45	76%	62%	32.4	12%	8%	86% C,5% D,9% N	13%	8%	59% C,32% D,9% M
Kings creek	LAVOWQ17	16%	11%	18.7	2%	8%	41% C,59% N	15%	0%	55% C,45% N
Kings creek	LAVOWQ25	77%	53%	36.9	12%	17%	100% C	26%	0%	100% C
Kings creek	LAVOWQ33	63%	34%	25.2	16%	24%	95% C,5% N	19%	0%	86% C,14% N
Kings creek	LAVOWQ37	40%	32%	27.2	5%	6%	68% C,32% N	23%	4%	68% D,32% M
Lost creek	LAVOWQ04	77%	67%	11.8	7%	8%	46% C,4% D,46% N,4% M	41%	0%	18% C,57% D,4% N,21% M
Lost creek	LAVOWQ20	67%	43%	26.1	3%	12%	100% C	22%	0%	91% C,5% N,5% M
Manzanita creek	LAVOWQ15	74%	41%	42.6	6%	7%	95% C,5% N	16%	0%	73% C,27% M
Manzanita creek	LAVOWQ23	96%	85%	31.5	27%	6%	100% C	58%	0%	9% C,36% D,55% M
Manzanita creek	LAVOWQ27	93%	69%	28.8	19%	8%	50% C,18% D,5% N,27% M	31%	0%	41% C,32% D,5% N,23% M
Nort Arm Rice creek	LAVOWQ10	75%	41%	38.3	11%	7%	95% C,5% N	37%	2%	50% C,50% M
North Arm Rice creek	LAVOWQ22	47%	27%	33.6	10%	8%	77% C,23% N	29%	9%	50% C,50% M
Summit creek	LAVOWQ13	83%	62%	34.3	17%	12%	95% C,5% N	30%	1%	82% C,18% M
West Fork Hat creek	LAVOWQ09	86%	76%	25.4	25%	8%	73% C,18% N,9% M	50%	1%	32% C,55% D,14% M

^aFor compositions: D = Deciduous, C = Coniferous, E = Broadleaf Evergreen, N = None, and M = Mixed (10% or more of multiple types).

Table D-9 (continued). Riparian characteristics of Lassen Volcanic streams sampled in 2011. Table updated for 2016 computer code.

Stream Name	Site Code	Bank Shading	Center Shading	Legacy Tree Height (m)	Canopy			Understory		
					Big Tree	Small Tree	Composition ^a	Woody	Non-Woody	Composition ^a
West Fork Hat creek	LAVOWQ12	90%	47%	24.4	11%	36%	100% C	26%	1%	9% C,5% D,86% M
West Fork Hat creek	LAVOWQ21	76%	60%	30.7	23%	12%	91% C,9% N	13%	0%	73% C,27% N
West Fork Hat creek	LAVOWQ24	93%	53%	23.1	10%	22%	91% C,9% N	39%	0%	14% C,23% D,64% M
Average		74%	51%	28.3	14%	13%	n/a	26%	1%	n/a
SD		19%	17%	6.5	7%	8%	n/a	13%	3%	n/a
Median		77%	53%	27.7	14%	10%	n/a	25%	0%	n/a
Range		19% - 96%	11% - 85%	11.8 - 42.6	2% - 27%	4% - 36%	n/a	9% - 58%	0% - 9%	n/a

^aFor compositions: D = Deciduous, C = Coniferous, E = Broadleaf Evergreen, N = None, and M = Mixed (10% or more of multiple types).

Table D-10. Vertebrate species and metrics for Lassen Volcanic streams sampled in 2011. Table updated for 2016 computer code.

Stream Name	Site Code	Sampled: Yes or No	Total Abundance	Total Richness	EPA Vertebrate MMI	Brook Trout	Brown Trout	Pacific Tree Frog	Rainbow Trout
Hat creek	LAVOWQ01	Yes	1	1	42.9 ^b	–	–	1	–
Hat creek	LAVOWQ05	Yes	41	1	57.1 ^b	41	–	–	–
Hat creek	LAVOWQ08	Yes	40	1	57.1 ^b	40	–	–	–
Hat creek	LAVOWQ29	Yes	68	1	57.1 ^b	68	–	–	–
Hat creek	LAVOWQ32	Yes	43	1	57.1 ^b	43	–	–	–
Hat creek	LAVOWQ36	Yes	48	1	57.1 ^b	48	–	–	–
Hat creek	LAVOWQ40	Yes	47	2	56.8 ^b	46	1	–	–
Hat creek	LAVOWQ45	Yes	16	1	57.1 ^b	16	–	–	–
Kings creek	LAVOWQ17	Yes	1	1	57.1 ^b	1	–	–	–
Kings creek	LAVOWQ25	Yes	34	1	72.3 ^a	33	–	–	1
Kings creek	LAVOWQ33	Yes	11	1	57.1 ^b	11	–	–	–
Kings creek	LAVOWQ37	Yes	–	–	Null ^d	–	–	–	–
Lost creek	LAVOWQ04	Yes	–	–	Null ^d	–	–	–	–
Lost creek	LAVOWQ20	Yes	4	1	100.0 ^a	–	–	–	4
Manzanita creek	LAVOWQ15	Yes	4	2	82.1 ^a	–	1	–	3
Manzanita creek	LAVOWQ23	Yes	–	–	Null ^d	–	–	–	–
Manzanita creek	LAVOWQ27	Yes	18	3	69.8 ^a	7	4	–	7
North Arm Rice creek	LAVOWQ10	Yes	28	1	100.0 ^a	–	–	–	28
North Arm Rice creek	LAVOWQ22	Yes	17	1	100.0 ^a	–	–	–	17
Summit creek	LAVOWQ13	Yes	25	1	57.1 ^b	25	–	–	–
West Fork Hat creek	LAVOWQ09	Yes	1	1	57.1 ^b	1	–	–	–

^aSites are Least Disturbed (also with light sage background).

^bSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^cSites meeting EPA criteria for Most Disturbed (also with dark red background).

^dNull indicates no species present to calculate a metric.

Table D-10 (continued). Vertebrate species and metrics for Lassen Volcanic streams sampled in 2011. Table updated for 2016 computer code.

Stream Name	Site Code	Sampled: Yes or No	Total Abundance	Total Richness	EPA Vertebrate MMI	Brook Trout	Brown Trout	Pacific Tree Frog	Rainbow Trout
West Fork Hat creek	LAVOWQ12	Yes	53	1	57.1 ^b	53	–	–	–
West Fork Hat creek	LAVOWQ21	Yes	–	–	Null ^d	–	–	–	–
West Fork Hat creek	LAVOWQ24	Yes	10	1	57.1 ^b	10	–	–	–
Average		n/a	25.5	1.2	65.5 ^a	n/a	n/a	n/a	n/a
SD		n/a	20.2	0.5	16.8	n/a	n/a	n/a	n/a
Median		n/a	21.5	1.0	57.1	n/a	n/a	n/a	n/a
Range		n/a	1 - 68	1 - 3	42.9 - 100	n/a	n/a	n/a	n/a

^aSites are Least Disturbed (also with light sage background).
^bSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).
^cSites meeting EPA criteria for Most Disturbed (also with dark red background).
^dNull indicates no species present to calculate a metric.

Table D-11. Invertebrate results and metrics for Lassen Volcanic streams, 2011. Table updated for 2016 computer code.

Stream Name	Site Code	Total Taxa Richness	Shannon Diversity	HBI	O/E	EPA West-Wide Invertebrate MMI	East Sierra MMI
Hat creek	LAVOWQ01	42	2.75	3.10	1.05 ^a	78 ^a	75 ^b
Hat creek	LAVOWQ05	64	3.34	4.86	0.99 ^a	85 ^a	83 ^a
Hat creek	LAVOWQ08	48	3.10	4.86	0.95 ^a	69 ^a	65 ^b
Hat creek	LAVOWQ29	63	3.56	3.55	1.03 ^a	87 ^a	86 ^a
Hat creek	LAVOWQ32	73	3.71	3.19	1.25 ^a	87 ^a	94 ^a
Hat creek	LAVOWQ36	70	3.40	3.19	1.25 ^a	79 ^a	95 ^a
Hat creek	LAVOWQ40	50	2.76	4.88	0.86 ^a	77 ^a	75 ^b
Hat creek	LAVOWQ45	51	3.03	4.93	1.00 ^a	80 ^a	69 ^b
Kings creek	LAVOWQ17	43	3.09	3.68	0.90 ^a	81 ^a	79 ^b
Kings creek	LAVOWQ25	58	2.91	3.70	1.13 ^a	81 ^a	88 ^a
Kings creek	LAVOWQ33	55	3.31	4.10	0.90 ^a	79 ^a	73 ^b
Kings creek	LAVOWQ37	48	3.00	4.48	0.82 ^a	74 ^a	86 ^a
Lost creek	LAVOWQ04	39	2.93	4.58	0.69 ^b	67 ^b	60 ^b
Lost creek	LAVOWQ20	54	3.13	4.21	0.88 ^a	77 ^a	90 ^a
Manzanita creek	LAVOWQ15	51	2.80	4.85	0.77 ^b	77 ^a	78 ^b
Manzanita creek	LAVOWQ23	49	2.50	2.86	0.99 ^a	79 ^a	77 ^b
Manzanita creek	LAVOWQ27	46	3.06	4.03	0.82 ^a	76 ^a	73 ^b
NA Rice creek	LAVOWQ10	57	3.35	3.41	0.80 ^b	88 ^a	89 ^a
NA Rice creek	LAVOWQ22	55	3.12	4.05	0.84 ^a	79 ^a	90 ^a
Summit creek	LAVOWQ13	57	3.21	4.02	0.99 ^a	79 ^a	88 ^a
WF Hat creek	LAVOWQ09	46	2.32	3.52	1.00 ^a	70 ^b	73 ^b
WF Hat creek	LAVOWQ12	70	3.37	4.18	1.16 ^a	83 ^a	91 ^a
WF Hat creek	LAVOWQ21	45	3.07	4.68	0.77 ^b	72 ^a	67 ^b
WF Hat creek	LAVOWQ24	45	2.64	3.76	0.93 ^a	68 ^b	76 ^b
Average		53.3	3.06	4.03	0.95^a	78.0^a	80.0^b
SD		9.3	0.33	0.64	0.15	5.9	9.7
Median		51.0	3.08	4.04	0.94	79.0	78.5
Range		39 - 73	2.32 - 3.71	2.86 - 4.93	0.69 - 1.25	67 - 88	60 - 95

^aSites are Least Disturbed (also with light sage background).

^bSites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^cSites meeting EPA criteria for Most Disturbed (also with dark red background).

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