Sierra Nevada Conservancy-Progress Report

Sierra Nevada Conservancy Grant Program
Safe Drinking Water, Water Quality and Supply, Flood Control
River and Coastal Protection Act of 2008 (Proposition 84)

Grantee Name: **Friends of Deer Creek**

Project title: **Mercury Bioavailability and Transport in Deer Creek Over Lake Wildwood Reservoir**

SNC Reference Number: **SNC 070101** **Submittal Date: _2/29/2012**

Report Preparer: _Jane Sellen__ **Phone #: (530)265-6090 x202**

Check one:

_____ 6-Month Progress Report
__X___ Final Report

6-Month Progress Reports should reflect the previous six months. **Final Reports** should reflect the entire grant period.

A. **Progress Report Summary:** (Please provide a general description of work completed during this reporting period.)

Executive Summary:

The overall project consisted of data gathering and analysis focused on Lake Wildwood, a recreational dam and reservoir on Deer Creek located 4.25 miles upstream of its confluence with the Yuba River. Data collection efforts consisted of storm water sampling and analysis during selected major winter storms and during the periodic reservoir dewatering in October, which occurred twice during the project term, as well as biological sampling (macroinvertebrates, algae, sediment, plants, and fish). The purpose of the sampling effort was to determine the extent to which mercury, a legacy of historic gold mining, is able to accumulate in reservoirs and to be transported over dams during high flow events. Other major elements of the project included development of sampling protocols, installation of flow gauges and collection of flow data.

2008-2009:

During the initial phase, Friends of Deer Creek/Sierra Streams Institute purchased a Hydra-C mercury analyzer from Teledyne Leeman Labs in June 2008 using funds donated by the Richard and Rhoda Goldman Fund. The first tasks included training on

the new equipment, developing sampling protocols for collecting water samples in Lake Wildwood at the surface, thermocline, and the bottom of the lake. New protocols were developed to collect phytoplankton. We ran assays for mercury and sediment in water samples from Lake Wildwood, to give us baseline data with which to compare storm and release samples. While some of these data were not reliable because the protocols were in development, nevertheless they provided evidence that phytoplankton and suspended sediment would be viable indicators of the movement of mercury over the dam during the high flow events.

The Lake Wildwood Association performs a periodic drawdown release that lowers the lake level by 10-15'. The purpose of the release is to dry-dredge the lake and remove the prior year's accumulation of sediment in order to maintain viability of the reservoir for recreational purposes. During the project term, the release took place in October 2008 and 2011, with no release occurring in 2009 or 2010. In 2008, we sampled before, during and after the release to determine the amount of mercury that is passing through the Lake Wildwood reservoir and through the dam as a result of the release. Automatic water samplers were primarily used to collect samples, and nets were used to collect a daily phytoplankton sample. We were able to use these sampling results to develop a standard protocol for estimating the seasonal transport of mercury during the rainy season.

Lake Wildwood Reservoir Sediment Data - 2008				
	08911	**08912**	**08913**	**08914**
n	Hg (ng/g)	Hg (ng/g)	Hg (ng/g)	Hg (ng/g)
1	103.80	269.00	391.65	82.91
2	69.64	241.48	482.47	
3	115.43	257.61	338.76	1847.41
4	103.42	266.51	441.49	74.60
5	272.97	259.63	378.04	122.64
6	256.45	249.47	385.33	76.73
7	236.59	110.46	401.03	81.42
8	287.01	122.20	568.60	58.76
9	288.73	119.29	330.72	60.30
10		116.59	376.47	
11		109.86		
12				
Average	**192.67**	**192.92**	**409.46**	**300.60**
Std. Dev.	91.88	74.39	71.43	625.32
Description	8911- LWW Creek bay Surface Sample Sampled on 12/28/08 at 16:20 by JW	8912- LWW Creek bay Sample depth: 6-12" Sampled on 10/28/08 at 16:20 by JW	8913- LWW Inlet Surface Sample at location 1 on 10/28/08 at 14:20 by JW	8914- LWW Inlet Sample depth 6" at location 1 on 10/28/08 at 14:20 by JW

Table: Sediment data collected from Lake Wildwood reservoir during the 2008 drawdown release. This includes data from two locations, with surface (0-6") and depth (6-12") samples for each sample location. Data indicates that on average, all of the soil samples showed levels higher than the "Threshold Effect Concentration" for mercury toxicity of 180 ng/g (Scudder et al., 2009).

All of the sediment samples collected were above the global background of 0.08 mg/kg (0.08 ppm; 80 ng/g). Samples also exceeded the San Francisco Bay TMDL goal for sediment of 0.2 mg/kg (0.2 ppm; 200 ng/g), but none exceeded the USEPA Preliminary Remediation Goal (PRG) of 2.3 mg/kg (2.3 ppm; 2,300 ng/g) with a peak Hg concentration of 1.847 ppm.

The installed autosamplers below the dam and further downstream at site 10 where there is a USGS flow gauge allowed us to calculate the total load of sediment and mercury resulting from the release and from storms.

During the winter of 2008-2009, grab samples of stormwater containing algae-sediment mixture as well as phytoplankton samples using nets were collected at the Lake Wildwood weir below the dam and downstream just above the confluence with the Yuba at site 10 during the major storm events. Our initial data gave insight into the nature of mercury transport through the Lake Wildwood system. The material captured in grab samples during storm events showed peak concentrations of mercury at 200-650 ng/g (0.2-0.65 ppm). The material captured in phytoplankton nets ranged from 350 – 1000 ng/g (0.35 – 1.0 ppm).

The peak flows showed an average of 0.03g/hr of actual mercury transport during the Lake Wildwood release that took place October 8-25, 2008, with 50% of samples falling within 0.02 and 0.04 g/hr, and a maximum of 0.23 g/hr. Total transport during the release was about 9 grams of mercury at the Lake Wildwood weir directly below the spillway, and 13.5 grams of mercury past site 10, 3.35 miles downstream of the weir and below the confluence with Squirrel Creek, a major tributary.

It was hypothesized that a majority of the mercury being transported was coming directly from the reservoir, considering the small size of the watershed below the spillway from which additional mercury inputs may originate. During the Lake Wildwood release there was no precipitation contributing to surface runoff, and so the majority of the mercury collected at the weir would have come from the reservoir's discharge pipe. The composition of the transported material was 40-70% sediment (residual after muffling). At the weir, the lower quartile was 47% residual, the median was 60.15% residual, and the upper quartile was 65% residual after muffling. At site 10, the lower quartile was 41% residual, the median was 49.5% residual, and the upper quartile was 56% residual. The rest of the material is presumed to be organic phytoplankton and scoured organic matter. While our mercury analyzer cannot distinguish between organic (methyl) mercury and elemental mercury, it is theorized that inorganic mercury being transported in this way can easily methylate and enter the foodchain, because of its fine particulate nature.

In an effort to better understand the process of transportation, a student intern from UC Davis developed methodology to separate phytoplankton from sediment using a sucrose gradient, allowing us to determine where the mercury is concentrated. With practice, the method proved to be remarkably effective and allowed us to analyze the sediment and algae separately, beginning with the 2009-2010 storm year. Preliminary data indicated that approximately 60% of the mercury in phytoplankton samples was coming from entrained sediment.

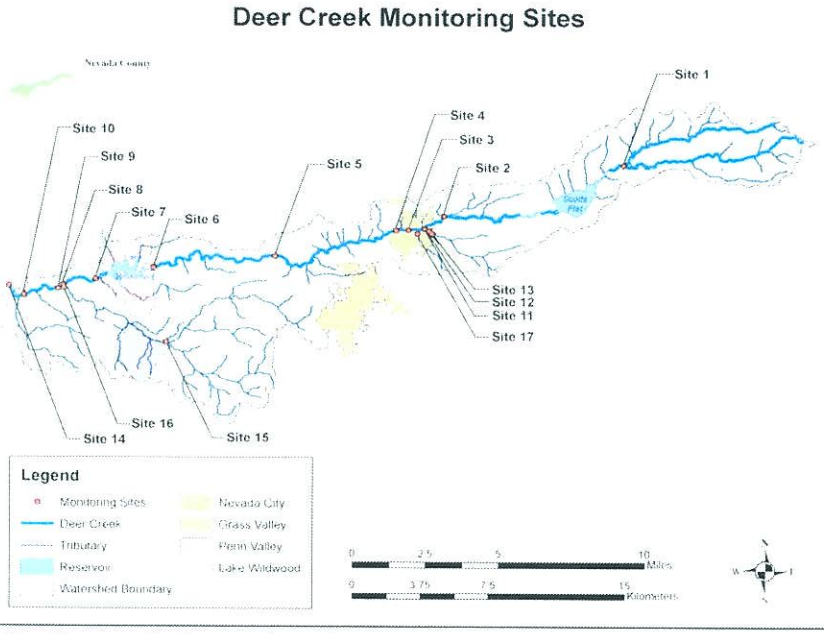

Figure: Deer Creek watershed map with FODC monthly monitoring sites. The Lake Wildwood weir site is directly downstream of Lake Wildwood reservoir, between the reservoir and Site 7.

2009-2010:

During the winter of 2009-2010, grab samples of stormwater containing algae-sediment mixture were collected upstream of Lake Wildwood at site 6, immediately downstream at the Lake Wildwood weir, and further downstream just above the confluence with the Yuba at site 10 during storm events. An autosampler was used at site 10, in combination with the flow gage operated there by the USGS, to calculate algae-sediment and mercury loads transported downstream and out of the Deer Creek watershed into the Yuba River. In addition to sampling during storm events, monthly water samples were collected from Lake Wildwood reservoir at the surface, thermocline, and the bottom depth to characterize algae-sediment and mercury concentrations within the reservoir, as this is the material available for transport over the dam.

FODC Storm Flow Mercury Data

Retention of Total Suspended Solids (TSS) in LWW during Storm Flows

	Site 6 TSS		LWW Weir TSS		% TSS Retention
Date	n	mg/L	n	mg/L	in Lake
12/11/09	1	18.9	1	2.45	87.0
12/12/09	1	24.1	1	2.30	90.5
1/19/10	1	73.2	1	5.33	92.7
2/5/10	1	7.0	2	3.60	48.6
2/24/10	1	29.8	2	3.60	87.9
2/27/10	1	51.5	2	2.29	95.5
3/3/10	1	21.2	3	2.55	87.9
Mean	7	32.2	12	3.16	84.3

Retention of Mercury (Hg) in LWW during Storm Flows

	Site 6 Hg		LWW Weir Hg		% Hg Retention
Date	n	µg/L	n	µg/L	in Lake
12/11/09	1	0.017	1	0.0015	91.2
12/12/09	1	0.035	1	0.0013	96.3
1/19/10	1	0.056	1	0.0033	94.1
2/5/10	1	0.004	2	0.0013	67.5
2/24/10	1	0.027	2	0.0022	91.8
2/27/10	1	0.046	2	0.0017	96.3
3/3/10	1	0.018	3	0.0013	92.8
Mean	7	0.029	12	0.0018	90.0

Figure: Table showing total suspended solids and mercury concentration data for Site 6 and the Lake Wildwood Weir. The table provides information on how much sediment and mercury are potentially stored in the reservoir for individual storm events.

This second season of sampling provided further insight into the nature of mercury transport through the Lake Wildwood system. The material captured in grab samples at the Lake Wildwood weir during storm events showed that mercury concentrations ranged from 0.23 – 0.85 ng/g (0.23 – 0.85 ppm), with an average of 0.573 ng/g (0.573 ppm). This corresponds to mercury concentrations of 1.3 – 3.3 ng/L in water, with an average of 1.8 ng/L at the Lake Wildwood weir, and 4 – 56 ng/L in water with an average of 29 ng/L at Site 6 upstream of Lake Wildwood. A 2009 USGS study of mercury concentration in water across the United States found mercury concentrations between 0.27 – 446 ng/L in water with a mean of 8.22 ng/L and median of 2.09 ng/L. Our maximum and minimum values are within the range found in the USGS study, with average values at Site 6 greater than what was observed in the USGS study. The Great Lakes States 30-day standard for fish-eating wildlife, as set by the USEPA (1997), is 1.3 ng/L, with the standard for protection of eagles at 1.8 ng/L. Our average data at both sites indicated that our samples exceed the EPA standards for protection of wildlife and humans.

Our sampling in 2009-10 provided an approximation of how much mercury is being transported downstream over the dam, as the proper flow data did not exist to permit

mercury and algae-sediment load calculations. Friends of Deer Creek/Sierra Stream Institute scientists were able to determine algae-sediment and mercury loads leaving the watershed at site 10 for each individual storm event. Total transport during two storm events was as follows:

- October 12-15, 2009: 8,072.7 kg sediment/algae and 5.59g of mercury at site 10
- January 16-22, 2010: 192,587.9 kg sediment/algae and 320.8 g of mercury at site 10, with 8.7" rainfall

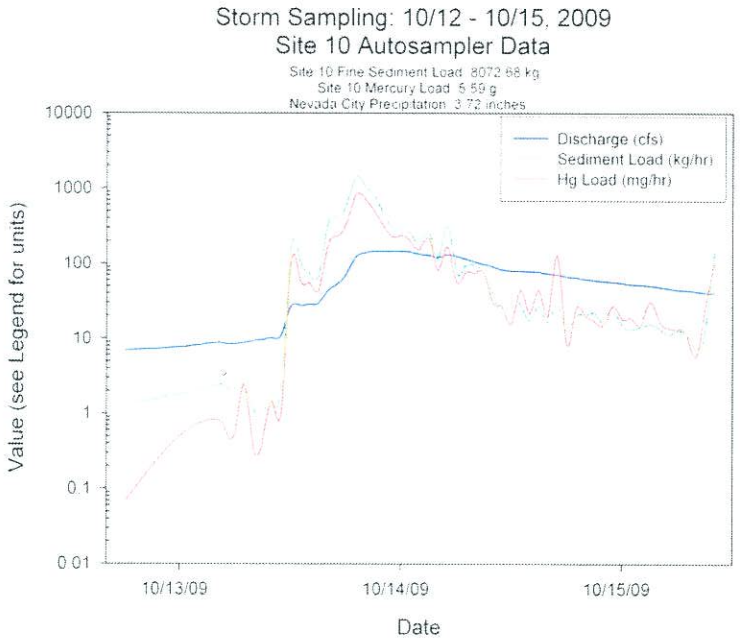

Figure: Graph of 10/12/2009 – 10/15/2009 Storm Event, with time series data for stream flow (Discharge), sediment load, and mercury load.

Site 10 is located downstream of Squirrel Creek, a major tributary, and thus does not accurately represent mercury and algae-sediment loads transported past the Lake Wildwood dam. To address this data gap, we were able to install additional flow gages at key locations, with grant funding from American Rivers' Sierra Water Trust Project. In November 2010, we installed flow gages on Squirrel Creek at Pleasant Valley Road (about 3 miles upstream from the Deer Creek confluence), which will allow us to determine loads in Squirrel Creek, and a second gage at the Lake Wildwood dam spillway to gage flows over the dam, and hence to determine loads of mercury and sediment over the dam. In August 2011 we installed a gage at the Lake Wildwood weir, so we can now more accurately determine flows and loads during drawdown releases. In October 2011 we installed a gage at the Lake Wildwood inlet, to gage flows and hence determine loads entering the reservoir. Flow data is logged every 15 minutes.

There was no Lake Wildwood drawdown release in October 2009 or 2010 and thus there was no opportunity to collect additional data on this unnatural transport event past the Lake Wildwood dam during those years. However, during the release in 2011, additional data was collected.

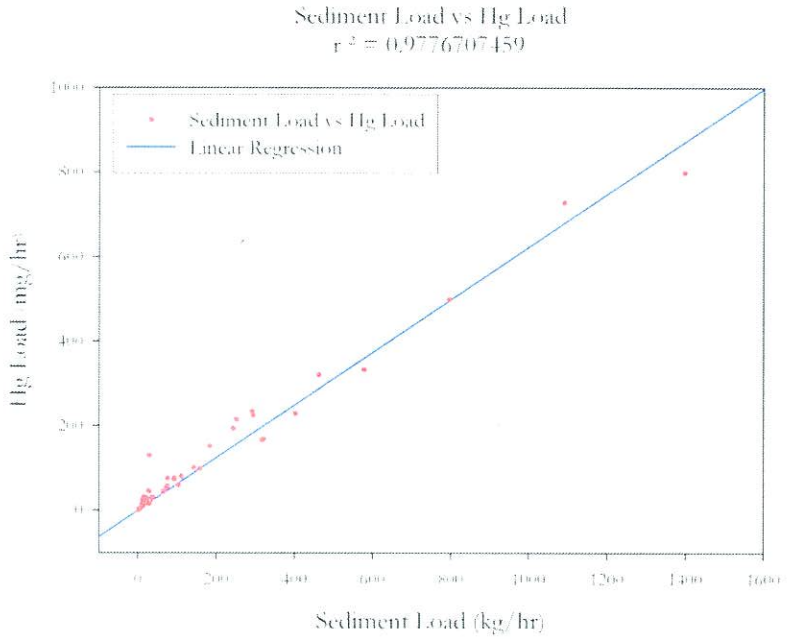

Figure: Graph showing the relationship between mercury load and sediment load. The R^2 value of 0.97767 indicates there is a strong relationship between mercury and sediment loads.

2011:

Friends of Deer Creek scientists worked closely with Lake Wildwood Lake Association to plan the release that took place in October 2011, and monitored the entire week-long release as well as conducting pre- and post-release monitoring, as follows:

- Sampled at the weir and site 10 for water quality (Hg, suspended sediment/algae loads, pH, specific conductivity, water temperature, turbidity).
    - Used automatic water samplers to collect continuous water quality data during the release at two locations
- Collected mud samples from upstream, downstream, and within Lake Wildwood reservoir.
- Conducted macroinvertebrate and algae monitoring before and after the release at 5 sites
- Conducted biological sampling of plants, fish and macroinvertebrates in August-September 2011 at Site 6 upstream of Lake Wildwood, within Lake Wildwood, and at the weir below Lake Wildwood

- Sampled riffles and side water habitat in an attempt to get a diverse sample of macroinvertebrates of all types, to investigate how each type uptakes mercury
- Used seine nets to sample the reaches directly upstream and downstream of Lake Wildwood reservoir, to collect fish for mercury analysis. This involved using nets to block off a reach and consolidate fish for easy collection.
- Conducted plant sampling directly upstream and downstream of Lake Wildwood reservoir. We targeted plants that were native and non-native, close to the water and with roots in the water, and included all parts of the plant (stems, seeds, roots, leaves.)

- Caught fish in Lake Wildwood using hook and line, guided by a Lake Wildwood Lake Committee member

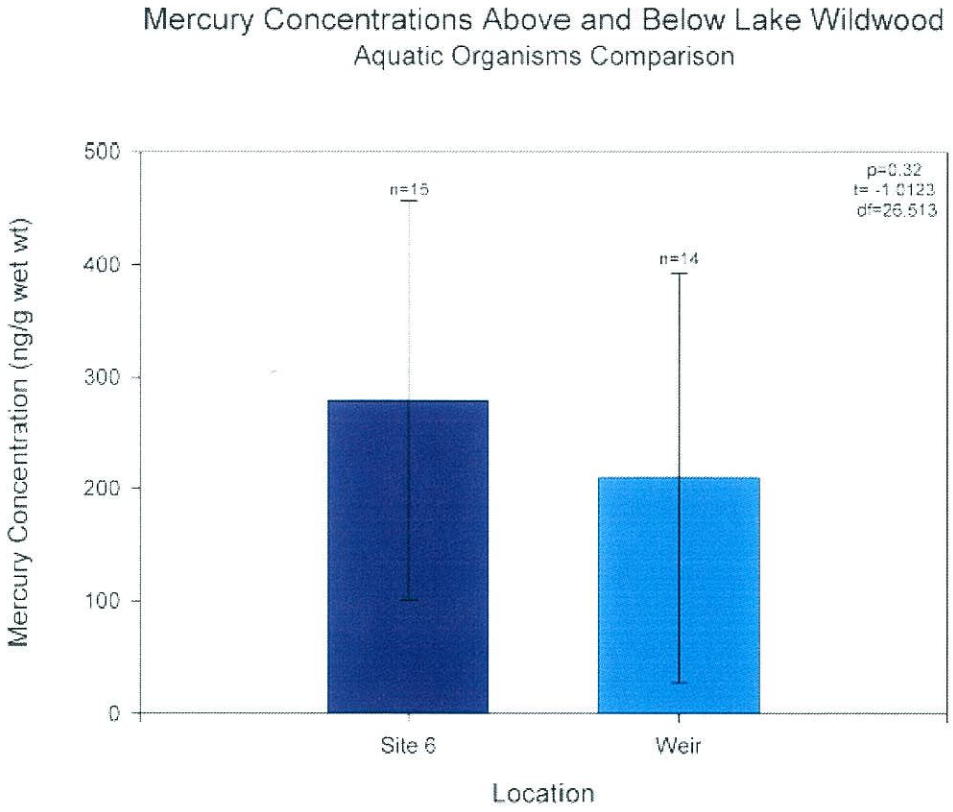

Figure: Mercury concentration in macroinvertebrates upstream (site 6) and downstream (weir) of Lake Wildwood reservoir. This graph shows all organisms analyzed for mercury at each site, and shows slightly higher mercury concentrations in organisms upstream of the reservoir.

The preliminary data from the project showed that there was not a statistically significant difference (n=29, p=0.32) between mercury concentrations in aquatic organisms above and below Lake Wildwood (see above Figure). These data indicate that mercury is being

transported over the dam and is available for uptake into the food chain by macroinvertebrates downstream of the dam at the weir site.

Previous investigation of macroinvertebrates on Deer Creek in 2005 found methyl mercury (MeHg) concentrations between 0.017 ppm (17 ng/g) and 0.23 ppm (230 ng/g) wet weight, with this current study analyzing macroinvertebrates for Total Hg with concentrations ranging from 56.9 ng/g (0.0569 ppm) to 758.8 ng/g (0.7588 ppm) wet weight. In the previous study the lowest mercury concentrations were observed in the upper locations of the watershed, while the highest mercury concentrations were observed at Site 6, a sample location in this current study. While the first study analyzed samples for MeHg and the current project analyzed samples for Total Hg, analysis of total mercury (THg) in aquatic organisms can serve as a proxy for methyl mercury (MeHg) in aquatic organisms. A study on California Roach (*Hesperoleucus symmetricus*) in Cache Creek showed a strong correlation between Total Hg and MeHg (R^2= 0.94) and found that on average 90% of the Total Hg concentration was present in tissue as MeHg (Schwarzbach, 2001). Although methyl mercury and total mercury concentration are being compared, the data indicates that the maximum and minimum mercury concentrations observed in macroinvertebrates during the current project were higher than in the 2005 study on Deer Creek, with minimum values in 2005 and 2011 of 0.017 ppm MeHg and 0.0569 ppm Hg, and maximum values in 2005 and 2011 of 0.23 ppm MeHg and 0.7588 ppm Hg.

Studies have shown that metal contamination is related to the size and age of an organism (Krantzberg 1989), so even with the same species, a large amount of the variation between mercury concentrations could be accounted for by differences in age and size. In future studies, measuring the size of the individual organism will help to produce data that is more comparable, and statistically meaningful.

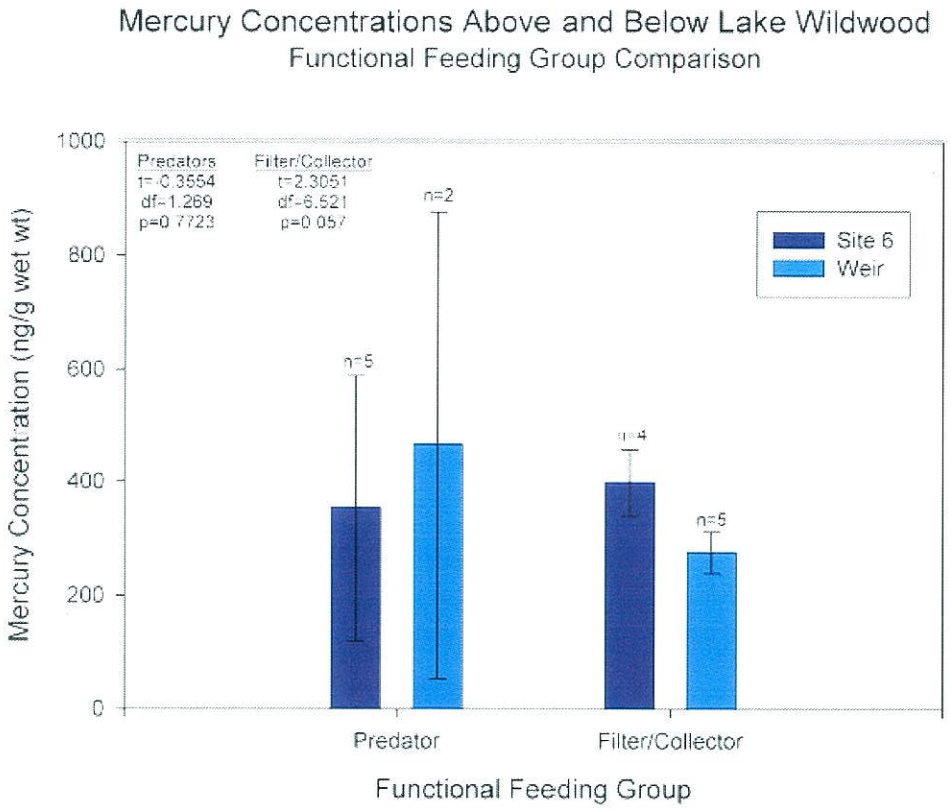

Figure: Mercury concentration in macroinvertebrates upstream (site 6) and downstream (weir) of Lake Wildwood reservoir. This Figure compares mercury concentrations for two macroinvertebrate functional feeding groups, including Predators and Filter/Collectors.

There was a trend of higher mercury concentration in filter collectors upstream of the reservoir than downstream (n=9, p=.057). Mercury concentrations can also vary seasonally in individual organisms, especially filter feeders due to change in feeding habits and food makes up (Snyder and Hendricks 1995), so in future sample endeavors it would be useful to take samples during several times of the year in order to better characterize mercury uptake by macroinvertebrates.

Predator populations show an opposite trend with slightly greater mercury concentrations in the organisms below the dam as compared to the ones above the dam. While the comparisons of Hg above and below the dam are not completely reliable due to the low number of organisms sampled, the project results have demonstrated that Hg is passing over the dam or through the reservoir and is bioaccumulating in organisms downstream of the dam and making its way up the food chain.

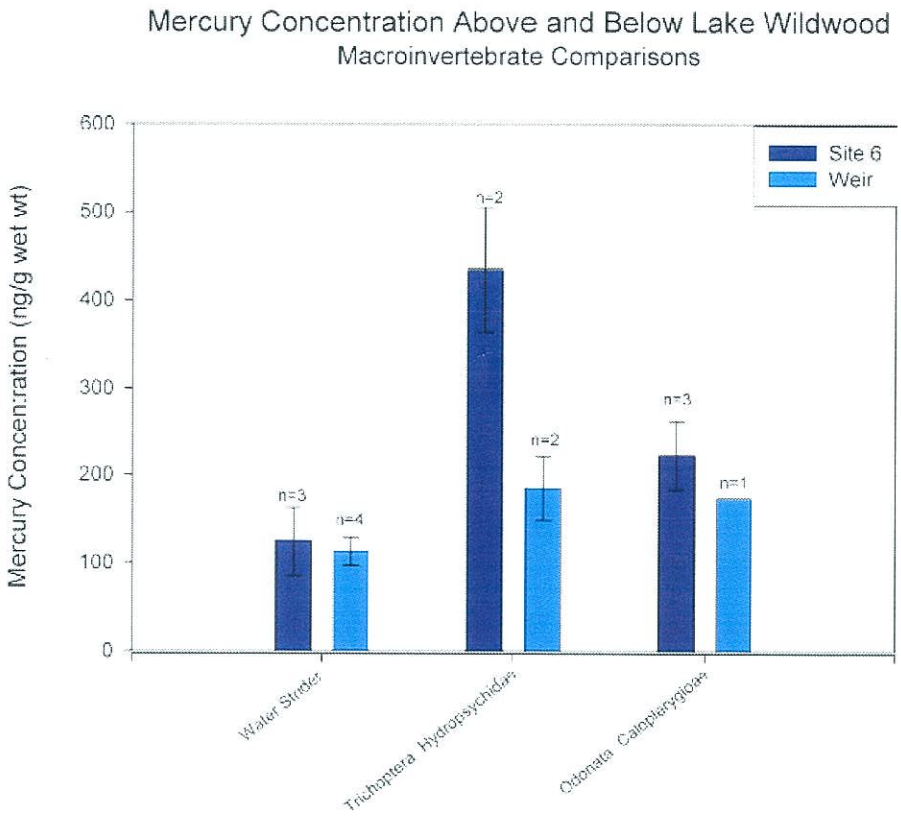

Figure: Mercury concentration in macroinvertebrates upstream (site 6) and downstream (weir) of Lake Wildwood reservoir. This Figure shows specific organisms both upstream and downstream of the reservoir, and shows that for each organism mercury concentrations were slightly greater upstream of the reservoir.

Reservoirs set up the ideal habitat for mercury methylation to occur, so it is suspected that they increase the amount of bioavailable mercury in downstream reaches. However, Slotten et al. 1995 found the opposite to be true, that although there is a higher amount of methyl mercury within a reservoir, it is quickly taken up into the food chain within the reservoir and thus not available for downstream transport. This means that reservoirs may act more as a sink of both methyl mercury and inorganic mercury as opposed to a source of them.

There are many variables that affect the levels of mercury in BMI. The macroinvertebrates that emerge from these reservoirs may significantly contribute to the increased amount of mercury in the surrounding areas when they emerge from the water leading to bioaccumulation of mercury in the riparian food chain (Blackwell & Drenner 2009) especially in the birds that prey on aquatic insects. So, the impacts of increased mercury methylation in reservoirs like Lake Wildwood may impact surrounding food chains more than downstream reaches. Although Slotten found that there is higher methyl mercury within a reservoir than downstream, and that methyl mercury is being taken up into the food chain within the reservoir, our study showed that there is still mercury

available for downstream transport with possible consequences for organisms downstream to the San Francisco bay.

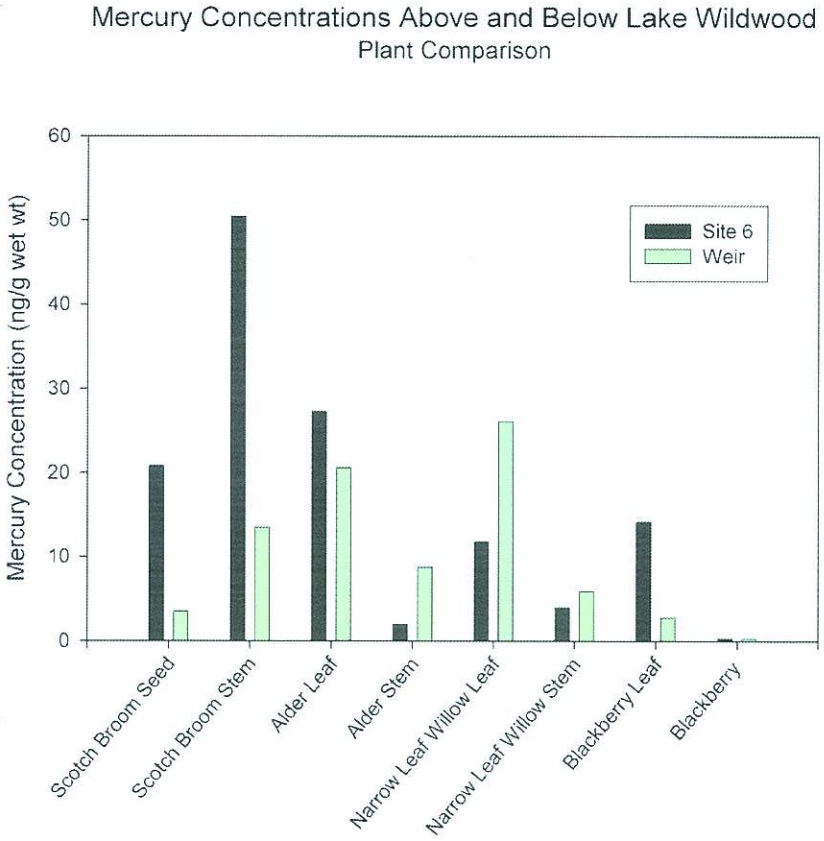

Figure: Mercury concentration in plants upstream (site 6) and downstream (weir) of Lake Wildwood reservoir. The graph shows all of the plants and plant parts that were sampled.

The results of our plant analysis are preliminary and do not show much of a pattern yet, but it has been shown that heavy metal uptake in plants is not always proportional to the amount that is in the soils (Rosner, 1998). There are many variables that can affect how easily plants can uptake heavy metals from soils, including pH and soil type, which may account for differences between heavy metal concentrations in plants between different sites. There can also be a root-shoot barrier where the roots are poisoned, leading to impaired growth of the plant before contaminants can be transported to the shoots. It is because of this that it would be beneficial to test more plant roots in future studies that investigate mercury uptake in plants.

B. Deliverables or Outcomes completed during this Reporting Period or Milestones Achieved: (Include specific information, such as public meetings held, agency participation, partnerships developed, or acres mapped, treated or restored.)

- We met regularly with Lake Wildwood throughout the project term, and on a monthly basis from June to November 2010 and January to November 2011, to plan and review the release in 2011. The outcome was a greatly improved management model for the release, including a more gradual beginning and ending to resemble a natural storm hydrograph; a more gradual overall release to avoid excessive flows and downstream scouring; and release from colder reservoir depths to avoid lethally high temperatures for spawning salmon downstream.
- We successfully collected storm data for three storm seasons (2008-9, 2009-10, and 2010-11); collected sampling data for two releases (October 2008 and October 2011); conducted reservoir sampling in collaboration with Lake Wildwood; and completed biological sampling in 2011.
- A major milestone was receiving permission to install a permanent stream flow gauge at the Lake Wildwood spillway, weir, and inlet bridge crossing. The spillway staff gauge allowed us to develop a rating curve that related water height above the spillway to a given flow volume, critical in our ability to quantify mercury transport over the spillway. The weir gauge is critical for measuring low flows, as well as flows (and hence loads) during the release. The inlet gauge measures flows into the reservoir and allows us to calculate storage of mercury and sediment in the reservoir. The installation of these gauges represented a major step forward in the development of trust between us and Lake Wildwood. Nevada Irrigation District's permission was also required for installation at the weir.
- Lake Wildwood Lake Committee and the Public Works Department provided us with detailed documents regarding the operation of their reservoir, specifically pertaining to the reservoir spillway and drawdown release pipes and valves. These documents provide us with the dimensions of the spillway and a spillway rating curve, so that with the installation of a depth sensor at this location, we could calculate mercury and algae-sediment loads transported over the dam during storm events. This works because the dimensions of the spillway are set and can be used as a weir, with increases in water height over the spillway corresponding to various volumes of water.
- We received grant funding to install flow gauges at 3 sites above, within and below Lake Wildwood (inlet, spillway, and weir.) An additional gauge was installed at Squirrel Creek, which flows into the lower watershed downstream of Lake Wildwood, important for gauging loads in the lower watershed that did not move through Lake Wildwood. Installation took place between November 2010 and November 2011. This marked the final step in needed infrastructure to be able to quantify loads of mercury that come through Lake Wildwood, since at the start of the project, our only flow measurement capacity, besides flow estimates

provided by the Lake Wildwood Public Works Department, was located at site 10, and included flow input from Squirrel Creek. We now have the ability to measure flow through time.

- We developed an internship program at Sierra Streams Institute/Friends of Deer Creek, recruiting science students from Sierra College and UC Davis to assist with monitoring, field work, and lab work.
- We met with Gold Country Fly Fishers on four occasions, to discuss the project, share data, receive their input, and recruit volunteers.
- We completed the statistical analysis of all of our sampling data gathered throughout the project term, and compared mercury levels in plants, macroinvertebrates, algae, water, and algae/sediment above and below the dam.
- We submitted our data to the State Water Resources Control Board for inclusion in their 2010 TMDL Integrated Report.
- We developed a heavy metal remediation strategy fact sheet and presented it to California DTSC.
- We developed a Recommendation Sheet for reducing mercury loads and impacts in Deer Creek, and for preventing mercury transport over dams.
- We produced a CD containing photos of the project results, and a report including data graphs, for distribution to irrigation districts and other groups, and to CABY (Cosumnes, American, Bear, Yuba) IRWMP.

C. Challenges or Opportunities Encountered: (Please describe what has worked and what hasn't; include any solutions you initiated to resolve problems. If your project is not on schedule, please explain why here.)

Over the course of the project term, the main challenges were technical issues relating to the use of the Hydra-C mercury analyzer, difficulties mastering the separation of algae and sediment, problems with protocol development, volunteer availability, and the state funding freeze.

Equipment difficulties were eventually resolved, with the lab director working closely with the manufacturer. The UC Davis student intern cleared a backlog of samples and developed a methodology for separating algae and sediment using a sucrose gradient and a centrifuge to spin the sediment from the algae.

The funding freeze was a severe challenge, threatening our entire organization and causing us to suspend storm sampling during the storm season of 2008-9. We were able to capture some representative storms that season with considerable help from volunteers, and used the impetus of the freeze to conduct a much-needed strategic assessment of the organization, which has left us far stronger and financially more sound. However, the dataset from 2008-9 is incomplete and lacks the full diversity of precipitation types of a full year's storms. We used this partial year to develop protocols

and to ready ourselves for a full year of data collection in 2009-10. Thanks to the SNC, we were able to get an extension on the project, allowing for more sampling as funds allowed.

It takes a special type of hardy volunteer to sign up for this type of field work, which involves going out into the creek at the peak of a storm at any time of day or night, and requires teams of two for reasons of safety. Recruiting and retaining such volunteers was a constant challenge. We were fortunate to find three reliable community volunteers, and were able to train our two AmeriCorps volunteers to lead sampling efforts.

Protocol development remained a challenge throughout the project, with each new phase of the project requiring reevaluation and updating of existing protocols. The assays of the plant samples remain in question because our lab lacks an ultrasound cleaner – which is in the budget for the coming year. All samples were frozen on dry ice and held at freezer temperatures until analysis. Samples were hand washed in 5% nitric acid prior to being dried and analyzed. It is doubtful whether all air-deposited mercury was removed from plant surfaces. Washed and unwashed leaves were statistically the same. However, further testing needs to be done to verify these results using a more vigorous cleaning method.

D. Unanticipated Successes Achieved: (Please describe any additional successes beyond completing scheduled tasks or meeting scheduled milestones.)

Once the equipment was working correctly, it proved to be remarkably accurate at determining reproducible mercury levels in tissue, water, and sediment. We have been able to expand our scope of work to include mercury sampling in macroinvertebrates, which are lower on the food chain than the fish tissue sampled in the past, and which are an excellent indicator of the extent of methyl mercury absorption in the watershed.

The funding freeze compelled us as an organization to develop creative strategies to fill the labor and funding gap. A UC Davis student intern was an important component of our ability to move the project forward. In addition, a professor from Sierra College approached us to participate in a new internship program being offered by the college, and we placed several key interns to help us with this and other projects through this program.

We secured a permit to conduct soil sampling at Anza Borrego Desert State Park and collected samples in April 2010. These soil samples, which were expected to have very low mercury values because of the low annual rain fall (3-4 inches) and therefore low atmospheric mercury deposition, served as a comparison for the samples collected in Deer Creek. The concentration of sediment samples found in Deer Creek was in the range of 200-1,000 ng/g, which is on average about 50 – 200 times greater than Anza Berrego

assays. The comparison revealed that air deposition in our local area may be a big factor in contamination as compared to the negligible air deposition rates in Anza Borrego. Furthermore, the low values (3-4 ng/g Hg) found at Anza Borrego give a lower baseline value of analytical mercury, indicating that contamination from sampling, equipment and analytical procedures is small. The Anza Borrego samples, run in conjunction with sediment samples from Deer Creek watershed, give confidence that contamination was small.

E. **Compare Actual Costs to Budgeted Costs:** (Please refer to your grant agreement to list your deliverables/budget categories and budgeted costs compared to actual costs incurred during this reporting period in the table below.)

PROJECT BUDGET CATEGORIES	Budgeted SNC Dollars	Actual Dollars
Data collection and study design	$30,317.00	$30,330.16
Analysis	$8,650.00	$8,639.75
Remediation strategy development	$3,500	$3,497.69
Dissemination/report and outreach materials	$2,000	$1,995
GRAND TOTAL	**$44,467.00**	**$44,462.60**

Explanation: (if needed)

F. **Were there any other relevant materials produced under the terms of this Agreement that are not a part of the budgeted deliverables? If so, please attach copies.** (Include digital photos, maps, media coverage of project, or other work products.)

Attached are:

- Recommendation Sheet for reducing mercury in the Deer Creek watershed and for reducing transport of mercury over dams
- DVD of photos
- Newspaper article from The Union about our work.

G. **Next Steps:** (Work anticipated in the next 6 months, including location and timing of any scheduled events related to the project.)

The project is now complete. Proposed next steps are outlined in the Final Report, below.

Please Complete this Section for FINAL Report ONLY

Capacity-Building Results and Collaboration and Cooperation with Stakeholders: (What partnerships did you initiate or strengthen as a result of this project? How did they affect the project outcome? If applicable, how did this grant increase your organization's capacity? What is your plan to sustain this increase?)

This project has been instrumental in strengthening our relationship with the Lake Wildwood Association (LWA), managers of the Lake Wildwood reservoir and dam on Deer Creek. The presence of the dam has many impacts on the creek, and a harmonious working relationship between Sierra Streams Institute as creek monitors and Lake Wildwood as reservoir managers is of critical importance for the health of the ecosystem. Prior to this project, we had already made great strides in this area, and had moved past some initial mistrust of our agenda, to increased trust and the beginnings of a collaborative relationship. Where we are now would scarcely have been imaginable seven years ago:

- LWA invites us to their monthly Lake Committee meetings
- LWA provided us with official access cards to enter Lake Wildwood, a gated residential community, for the purpose of monitoring and restoration
- LWA provided us with a boat and staff assistance for lake sampling
- LWA consults with us for their periodic reservoir release, during which the lake is lowered to allow for dredging. As a result of this partnership, the release in 2011 was designed to mimic a natural storm in order to minimize the impact to downstream spawning habitat. Prior to our collaboration, the release was managed in a way that took into account primarily economic and recreational considerations. Now, the release balances this approach with concern for environmental impacts as well.
- Unimpeded access to Lake Wildwood has allowed us to sample for fish, plants, phytoplankton and sediment; to collect samples during storms and during the release; to conduct physical habitat assessments, monthly water quality monitoring, and macroinvertebrate and algae sampling; and to measure flow.
- Lake Wildwood Association allowed us to install permanent flow gauges at the weir, spillway and inlet, allowing us to collect continuous flow data. This is a critical element in accurately quantifying mercury transport downstream and through the system and storage within the reservoir, as well as ensuring that minimum flow requirements are being met.
- As a result of this project, we are now exploring the possibility of salvaging gravels from the periodic dredging of the reservoir, and placing them downstream

of the dam so that they are available as habitat materials for three federally listed species of salmon and steelhead. Adoption of this approach as a routine element of the drawdown management would allow habitat restoration efforts to be sustainable indefinitely.

We have also strengthened our relationship with Nevada County Sanitation District #1, managers of the wastewater treatment plant that serves the Lake Wildwood community. NCSD #1 are funding our pilot gravel augmentation, and have granted access to their private property at the weir for monitoring and restoration, including enabling us to create a new permanent monthly monitoring site at the weir. This will allow us to collect monitor the impacts of Lake Wildwood in perpetuity.

The project increased our capacity as an organization by enabling us to secure matching funds from the Goldman Fund to purchase a mercury analyzer so that we could process our own samples in-house at far lower cost and in a timely manner. In this way, we are able to process hundreds of samples of storm water, plants, fish, macroinvertebrates, sediment, algae, and human hair.

The project also provided an opportunity to strengthen our relationships with private property owners downstream of the reservoir. We have several key partnerships in place in the lower watershed, which provide critical access for monitoring and restoration. Our partnerships with the Sheatsley Trust and the Foster-Regan family are especially critical, with four of our monthly monitoring sites located on their properties. We also have a partnership with the owner of the property at the confluence with the Yuba, which enables us to work directly in the spawning reach. All of these property owners are actively involved in creek stewardship and have concerns about Lake Wildwood's impacts on the creek. In the course of this project, we engaged in outreach to these landowners, informing them of project progress and results.

This research-oriented project has given us a chance as a science institute to prove our ability to do excellent scientific studies, including the testing of an untested hypothesis and development of our own protocols. We will be sharing our results at the National Monitoring Conference in Portland, Oregon and we expect to generate significant interest.

Description of Project Accomplishments:

1. **Most Significant Accomplishment**
   Describe in one concise, well-written paragraph, the most significant accomplishment that resulted from this grant.

   The study was groundbreaking in that it enabled us to establish beyond question that mercury is being transported downstream past dams to the Bay/Delta, changing forever the way downstream mercury remediation is managed. It was previously thought that dams provided a total block to the passage of mercury, and therefore remediation efforts were focused downstream of dams, despite the fact that the abandoned mine sources are located upstream in the foothills. Our study established that mercury is being transported during storms and releases, trapped in the sediment/algae complex. Moreover, the mercury that is being transported is either methylated or floured and therefore highly methylation-prone. In its methylated form, mercury becomes bioavailable, working its way up the foodchain to macroinvertebrates, fish and to humans. Analysis of storm and release water samples combined with flow measurements allowed us to quantify the mercury loads being transported downstream from just one foothill subwatershed – with obviously grave implications for all foothill streams and for the cumulative total of mercury being transported from the Sierra to the Bay.

2. **WOW Factor**
   If applicable, please describe anything that happened as a result of the project or during the project that is particularly impressive.

   The amount of mercury being transported over one single dam in a single sub-watershed during each winter storm is a shocking and previously unknown revelation that has profound implications for all watersheds downstream of the Sierra's historical gold mining area, as well as for efforts to remediate mercury contamination of Pacific fisheries.

   It is impossible to overstate just how far our relationship with Lake Wildwood progressed over the course of this project, and what startling consequences this now highly collaborative partnership has for the management of the reservoir and hence for the health of the creek, the salmon and other life that inhabit it, and beyond it the entire connected waterway all the way to the Pacific. We believe the project is the ultimate vindication of the ability of rigorous, unbiased science to influence policy and win over seemingly intransigent opposition.

Patient data gathering, reporting and outreach ultimately transformed our relationship with Lake Wildwood from hostility to close collaboration, to the extent that our organization is now intimately engaged in the management of the reservoir, and in particular the management of the periodic release. The local paper The Union featured an article about the remarkable partnership between Sierra Streams Institute and Lake Wildwood and its beneficial effect on the management of the reservoir for the health of the overall creek ecosystem. Reliance on science without emotion or bias gave all stakeholders a common language and made possible a cooperative study conducted entirely on private land. The "WOW" factor is nothing less than the winning over of hearts and minds.

3. Design and Implementation

When considering the design and implementation of this project, what lessons did you learn that might help other grantees implement similar work?

- Protocol development: Protocol development is a critical element of project planning, and much time was spent on developing effective protocols that guide sampling and analysis, and reduce contamination of samples. Other organizations conducting a similar study are urged to contact our organization for assistance in protocol development or to adopt our protocols.
- Separation of algae and sediment: An important lesson learned was that algae was a significant component in the transport mechanism. At the outset, the project was focused on sediment only. It quickly became apparent that algae was a large part of the sediment complex, with potentially serious implications for the bioavailability of the transported mercury. Therefore, a strategy was needed for separating algae from sediment so that the two elements of the algae-sediment complex can be studied separately – an important consideration when dealing with organic matter (algae) in combination with inorganic matter (sediment), and in assessing the capacity for methylation. Over the course of the study, we acquired expertise in separation methods, using a sugar gradient processed in a centrifuge.
- Expansion of project scope: The study focused on Lake Wildwood in the Deer Creek watershed, using methods that can be applied throughout the region. We would like to add data from a second reservoir, with a special interest in a hydroelectric facility, to test the hypothesis that the hydroelectric generation process contributes to flouring and hence to mercury methylation. This expanded study would require sampling plans for sediment, algae, and other organisms, to determine how much mercury is available in the reservoir and how much is passed through the turbines during power generation.

4. **Indirect Impact**

Please describe any indirect benefits of the project such as information that has been developed as a result of the project is being used by several other organizations to improve decision-making, or a conservation easement funded by this grant that encouraged other landowners in the area to have conservation easements on their property.

- The primary indirect benefit as noted above is the fruitful collaboration with Lake Wildwood, and the tremendous impact of that relationship on management of all areas of the reservoir. The drawdown of October 2011 is the most striking example of this benefit in action: the reservoir was drained in a manner that took the downstream ecosystem into account, with a release schedule designed to resemble the hydrograph of a natural storm, and with cool water being released from depth. The great increase in monitoring capacity that resulted – new monthly monitoring sites, unfettered access within the gated community, and assistance with lake sampling – will likewise benefit lower Deer Creek long after the grant term and in ways that are far beyond the scope of the grant.
- Creating a collaboration with private landowners to conduct a study of this type has tremendous application in an area where ownership boundaries can often limit consideration of an ecosystem as an integrated whole. We believe this approach will enable the development of TMDLs for the Deer Creek watershed, by creating a consortium of private property owners along an impacted reach. Sierra Streams Institute is in a unique position to coordinate such an effort on behalf of the state, as a community-based organization that enjoys a high degree of trust in the scientific and regulatory community.
- Data from this project that was submitted to the State Water Resources Control Board is being used by the state to inform their decision making process. Our data have resulted in portions of Deer Creek including Lake Wildwood being 303(d) listed for mercury.

5. **Collaboration and Conflict Resolution**

If you worked in collaboration or cooperation with other organizations or institutions, describe those arrangements and their importance to the project. Also, describe if you encountered conflict in the project and how you dealt with it, or if there was conflict avoided as a result of the project.

As noted above, cooperation with Lake Wildwood, Nevada County Sanitation District #1, and other key landowners was critical to the success of this project. From an initial lack of trust, we were able to achieve the project goals successfully by

cultivating a high degree of trust through our reliance on accurate data and rigorous science.

An important role in the cultivation of this relationship was played by Sierra Streams Institute board member John Norton, a Lake Wildwood resident, member of the Lake Wildwood Lake Committee, retired executive at the State Water Resources Control Board and a skilled facilitator. Mr. Norton brought the parties together by hosting gatherings for staff scientists and Lake Wildwood Lake Committee members, enabling connections to be forged at the human and social level. He was also responsible for securing access cards for our staff.

Our collaboration with Sierra College and UC Davis yielded several interns, many of whom had important roles in this project. Interns were involved with all aspects of monitoring, and were especially critical during the intensive, round-the-clock monitoring effort during the week of the October 2011 release. As noted above, a UC Davis intern chemist had a key role in study design, perfecting the method for separating the algae from the sediment in storm samples.

Two more agency collaborations had an important role in the execution of the project: USGS loaned us equipment to monitor releases, and Nevada Irrigation District gave us permission to install stream flow gauges on the weir.

6. Capacity-Building

SNC is interested in both the capacity of your organization, as well as local and regional capacity. Please describe the overall health of your organization including areas in need of assistance. SNC is interested in the strength and involvement of your board, significant changes to your staff, size and involvement of membership. In addition, describe how your project improved capabilities of partners, or the larger community.

In the three years since we were awarded this grant, Friends of Deer Creek has undergone a transformation and is now Sierra Streams Institute, a substantially strengthened organization. When the grant was first issued we had three paid staff members, no employee benefits and were housed in a 700 square foot office. In other examples, our accounting procedures were careful but simple, outreach and public relations were modest and our infrastructure was minimal. Today we have six fulltime staff and several contractors working on various projects, we offer partially employer paid health and dental benefits, we are housed in a 2200 square foot office and lab, we are using specifically designed non-profit accounting software, and we have expanded our outreach, education program, scope of scientific research, and

public relations significantly. The results of these changes are that we can attract and retain better employees, we have room to house staff and program activities on our premises, we are attracting the notice of more donors, private foundations, and volunteers, and we have much greater capacity for collaborating with other organizations to have a greater positive impact on the health of watersheds throughout the region and the state. In addition our board has participated in several development activities, additional members have been recruited and we are in the process of creating a Science Advisory Committee.

The funding of a scientific research project gave us the chance to show how capable we are as a scientific institute. Since this project began, we have greatly increased the number of conferences at which we share our research studies.

7. **Challenges**

Did the project face internal or external challenges? How were they addressed? Describe each challenge and any actions that you took to address it. Was there something that SNC did or could have done to assist you? Did you have to change any of your key objectives in response to conditions "on the ground"?

- Protocols: as noted above, there were challenges associated with developing protocols for all types of sampling. These were overcome through a lengthy process of trial and error. SNC could fill a role in this type of instance by acting as a clearinghouse, connecting projects to each other that could share expertise.
- Mercury analyzer: Friends of Deer Creek was extremely fortunate to be awarded a grant to purchase a mercury analyzer by the Goldman Fund, which enabled timely and comprehensive sampling. The challenge arose in mastering the equipment, which has proven to be extremely sensitive, expensive to run, and technically difficult to learn. We overcame this challenge through considerable effort on the part of our lab director, who worked tirelessly with the manufacturer to resolve issues as they arose, and to provide guidance for other staff who are trained to use the equipment. Ownership and use of this equipment provided an opportunity to broaden the scope of the sampling plan, resulting in more samples than would be possible using outside lab services.
- Fieldwork logistics: Several challenges arose in relation to the logistics of fieldwork. First was the nature of the project design, which involved sending volunteers out to collect stormwater samples at the very peak of a rain storm, anytime of the day or night. Calculation of the peak and placement of volunteers to catch the peak flow as it moved downstream involved meteorological expertise, which fortunately we acquired with the placement

early in the project term of an AmeriCorps member with such expertise, who has since gone on to be hired as a key member of our science team. This same staff member was tasked with recruiting and directing a team of hardy volunteers who were "on-call" for storm events, and who willingly collected samples in the middle of the night and pouring rain. Friends of Deer Creek is extremely fortunate to have such dedicated volunteers!

- Other fieldwork logistical issues: Because Lake Wildwood is a gated community with an internal security force, staff and volunteers were frequently stopped for questioning and even prevented from entering. We resolved this issue by requesting and receiving security clearance cards from the Lake Wildwood Association, which enabled volunteers and staff to enter freely and to show when questioned in the field. SNC perhaps has a role in facilitating access by providing official state-sanctioned recognition cards.
- Although this would not be a problem so far in the 2011-12 storm season, there was a big problem posed by the sheer number of large storms that occurred in the winters of the project term. Staff scientists determined which storms to sample based on a best forecast of the storms, and extrapolated results to all storm events of the winter season.

8. Photographs

Grantees are strongly encouraged to submit photos, slides or digital images whenever possible. These images will be used for SNC publications such as annual reports or on the website. Please make sure you clearly identify location, activity, and your project with each submitted image. Images will be credited to the submitting organization, unless specified otherwise.

Please see attached DVD.

9. Post Grant Plans

What are the post-grant plans for the project if it does not conclude with the grant? Include a description of the following (if applicable): (1) Changes in operations or scope; (2) Replication or use of findings; (3) Names of other organizations you expect to involve; (4) Plans to support the project financially, and; (5) Communication plans?

Although we do not currently have further funding for continuation of this study, we are by no means finished with our investigation of mercury transport in relation to dams. We view this study as just the beginning of a long process in which critical questions will be answered that relate to the health of connected watersheds all the way to the Pacific. Future plans for this study, pending further funding, are as follows:

- Expansion of scope: As noted above, we plan to expand the study to other watersheds to verify that the findings are generalizable, and specifically we plan to include a hydroelectric dam to investigate the hypothesis that the hydroelectric process contributes to passage of mercury downstream and to the Bay/Delta. We also plan to expand the study of bio-uptake of mercury by algae and plants especially in areas where there is known soil contamination. We plan to include a study of atmospheric deposition rates of mercury, and to distinguish these from transportation via water. We continue to refine sampling protocols, and are particularly concerned with the integrity of biological samples. Finally, we will continue to increase flow measurement capacity, by maintaining current gages and installing more.
- Use of findings: The study was a pilot that is intended to be replicated in other watersheds, in order to quantify the extent to which mercury in the Bay/Delta is originating in the Sierra and is being transported over dams. In addition, we plan to replicate the study in Deer Creek to compare mercury loads over time. The data gathered in this study will be submitted to the state for consideration in making 303(d) determinations. The fish data will be submitted to the state to assist in issuing health warnings. Unlike other comparable reservoirs in the vicinity, Lake Wildwood does not currently carry an official fish consumption advisory, owing to a lack of available data.
- Other organizations: Other organization that will be involved in our post-grant plans are: Wolf Creek Community Alliance, Nevada Irrigation District, South Yuba River Citizens League, American Rivers, Central Valley Regional Water Quality Control Board, US Environmental Protection Agency, Office of Environmental Health Hazard Assessment, Nevada County Environmental Health Department, California Department of Fish and Game, and US Geological Survey. We are currently in the process of assisting a nascent group of stakeholders in the Bear River watershed with the process of developing a CRMP, and will involve this group in future studies. The Bear River is significantly impacted by both mercury and dams/diversions, and monitoring data are needed from this watershed.
- Financial support for project: We are in the process of developing a paper for publication in order to disseminate the findings of this study. The publication of our findings will help us to attract further grant funding. We intend to apply to the National Science Foundation and other funding entities. We currently have a firm commitment from our volunteer lab director, who has overseen the project and will continue in that role in future phases.
- Communication plans: We intend to publish our findings and will present our data at conferences including the National Monitoring Conference in May. We will continue to participate in regular meetings of the Lake Wildwood Lake

Committee, Gold Country Fly Fishers, and the SYRCL science team, and will use these forums to continue to communicate our findings. We will continue to share data with the California Water Resources Control Board.

10. Post Grant Contact

Who can be contacted a few years from now to follow up on the project? Please provide name and contact information.

Joanne Hild, Executive Director, (530)265-6090 x200

Sierra Nevada Conservancy Grant Program
Project Reporting Guidelines

Progress Reports are required periodically throughout the term of the Grant Agreement (Refer to Exhibit B of the Grant Agreement). These reports will allow you and the Sierra Nevada Conservancy (SNC) to see the degree to which the project is on track and achieving your projected outcomes. Your Progress Reports will further provide the SNC with information that will help us to explain your work to the Board Members and various other audiences. Timing of Progress Reports is specified in the Project Schedule included in Exhibit A of the Grant Agreement, but generally every 6 months until completion of the project.

A Progress Reporting Form is provided to Grantees on the SNC Website. **Six-month Progress Reports** should reflect the previous 6-month period; **Final Reports** should address each question for the entire grant period – looking at the project as a whole.

The form specifies the items you will need to report on. For the Six-Month Interim Report these include, but are not limited to: *A Progress Report Summary of work completed, Deliverables or Outcomes Completed, Challenges or Opportunities Encountered, Unanticipated Successes Achieved, Actual Costs compared to Budgeted Costs, Any Additional Relevant Materials Produced, and Next Steps.*

The Final Report will include additional information, such as: *Resources Leveraged, Capacity-Building Results and Collaboration and Cooperation with Stakeholders, a Description of Project Accomplishments, and SNC Approved Performance Measures.*

Please make sure that you submit complete reports by the dates requested in your Grant Agreement.

References

Snyder, C.D., and Hendricks, A.C. "Effect of seasonally changing feeding habits on whole-animal mercury concentrations in Hydropsyche morose(Trichoptera: Hydropsychidea)." Hydrobiologia 299 (1995): 115-123

Krantzberg, Gail. "Metal accumulation by chironomid larvae: the effects of age and body on metal body burdens." Hydrobiologia 188/189 (1989): 497-506

Slotton, D.G. et al. "Gold mining impacts on food chain Mercury in Northwestern Sierra Nevada streams." Technical Completion Reports, University of California Water Resources Center, UC Berkeley (http://escholarship.org/uc/item/58h617dr) 1995

Blackwell, B.D., and Drenner, R.W. "Mercury contamination of macroinvertebrates in fishless grassland ponds."The Southwestern Naturalist 54.4 (2009): 468-474

Rosner, Ulrike. " Historical mining and its impact on the vegetation an example from the Cerbar Mountains, Mohave County, Arizona." Journal of the Arizona-Nevada Academy of Science31.1 (1998):37-55

Scudder, B.C. et al. " Mercury in fish, bed sediment, and water from streams across the United States, 1998-2005" Scientific Investigations Report 2009-5109, USGS

Schwarzbach, A., Thompson, L., Adelsbach., T. 2001. Cache Creek Mercury Investigation USFWS Final Report. United States Fish and Wildlife Service. Off Refuge Investigations Reports. FFS # 1130 1F22, DEC ID # 199710005.

Drawdown will simulate storm flow at Lake Wildwood

BY MICHAEL O'CONNOR
Special to The Union

Most Nevada County residents are familiar with Lake Wildwood, the Penn Valley lake community where residents enjoy boating, fishing and swimming.

What some people may not realize, however, is that the lake is technically a reservoir, the result of a dam constructed in 1970 by Boise Cascade on Deer Creek — the same Deer Creek that flows through downtown Nevada City.

In a mutual effort to ensure that the health of Deer Creek is protected, Sierra Streams Institute (formerly Friends of Deer Creek) and the Lake Wildwood Association have been meeting for the past 10 years to develop ways to manage the reservoir with the least impact on the creek.

One topic that has dominated many of these meetings is the planning of periodic lake drawdowns, during which the water level is lowered 10-12 feet in mid-October in order to remove accumulated sediment.

Without periodic sediment removal, the reservoir would eventually become filled with silt.

A 2011 drawdown is scheduled for Sunday. The goal during this drawdown is to simulate the water flows during a natural October storm.

This is accomplished by releasing cold water from the lowest release valve over an eight-day period, ramping up flows to peak levels over 34 hours and then tapering off gradually.

If successful, the plan is to repeat this strategy for subsequent drawdowns.

Before the two groups began collaborating, the drawdown strategy was to release the

Read more on the Web at TheUnion.com

water as quickly as possible to enable the maximum time for silt removal before fall rains began.

During mutual discussions, it was agreed that this type of release could possibly send the wrong signal to the spawning salmon and steelhead that arrive each fall at the mouth of Deer Creek, four miles downstream from Lake Wildwood.

Beginning in 2001, the two partners have been researching and testing ways to manage the release in a way that minimizes the downstream impact not only to salmon and steelhead but to all of the living organisms that make their home in the creek.

Michael O'Connor is a river scientist and AmeriCorps member with Sierra Streams Institute.

Sierra Streams Institute
February 2012

Recommendations to Reduce Impacts from Legacy Mercury Contamination in the Deer Creek Watershed

- ✓ Implement site cleanup measures at known mine sites and other upstream sources of contamination to prevent mercury transport from tailings piles, waste rock, sluices, and other mining features, using the following methods:
  - Erosion control (grading, runoff controls, revegetation)
  - Excavation of mercury-contaminated wastes and burial onsite or in an engineered landfill; installation of erosion controls in excavated area

- ✓ Implement additional onsite pollution prevention measures, as applicable, including the following methods:
  - Protection of erosive areas from vehicles, grazing, etc.
  - Construction of downstream settling basins to collect and sequester contaminated sediment
  - Restoration of temporary or unmaintained roads and trails to native forest conditions with natural hydrologic function (recontouring, soil restoration, seeding, blocking of vehicle access)

- ✓ Participate in the ongoing statewide process, the Statewide Mercury Control Program for Reservoirs. The state is currently developing a framework for remediating reservoirs, which will include pilot studies and remediation recommendations. Our participation in this process would enable us to take the information already being developed by the state and apply it to our watershed. There are three reservoirs in the Deer Creek watershed (Scotts Flat, Lower Scotts Flat, Lake Wildwood), all of which are 303(d) listed for mercury contamination.

- ✓ Implement changes to the way reservoirs are managed, in order to reduce the potential for methylation. When reservoirs stratify they create conditions below the thermocline that are conducive to methylmercury production. Management strategies include:
  - Water aeration and circulation to increase oxygen and hence to reduce methylation
  - Removal or capping of mercury-contaminated sediment in the reservoir and in upstream tributaries

- Monitoring to identify areas within reservoir where mercury accumulates in sediment
- Development of sediment management plans to reduce releases of mercury during reservoir maintenance
- Modification of channel geometry to direct flows away from mercury contaminated areas
- Where possible, modification of water storage and discharge patterns to reduce methylmercury production

✓ Explore the possibility of using floating turbidity booms to capture mercury-bearing sediment during times when the water is spilling over reservoir spillways. Determine if the booms also capture or reduce downstream mercury transport.

✓ Determine the feasibility of harvesting algae blooms during summer months to prevent them from settling in the lake mud or being available during fall storms to pass over the spillway. Algae have been shown to provide a means by which mercury is uptaken and transported.

✓ Determine how much mercury is transported through electric generating power plants. Investigate methods, such as using aerogels, to reduce or eliminate mercury transport through these facilities.

✓ Remove contaminated sediment from reservoirs and streambeds in the Deer Creek watershed. Work with Lake Wildwood to map areas of contamination in the reservoir and identify priority areas for dredging and removal of contaminated sediments. This would remove the sediments and mercury from the system, and reduce the potential for methylation within the reservoir and bioaccumulation of mercury up the food chain. Lake Wildwood captures about 2/3 of the watershed runoff and is downstream of numerous large gold mines. Scotts Flat reservoir should also be targeted, as it captures approximately ¼ of the watershed runoff, although the extent of historic mining upstream is far smaller than upstream of Lake Wildwood.

✓ Reduce the amount of erosion entering into Deer Creek by establishing BMPs (Best Management Practices) with city and county for all road work, construction sites (contractor's responsibilities) and restoration activities. SSI should also work with NID irrigation district to reduce

erosion at their storm release sites and canals by developing specific BMPs for this type of activity.

✓ Work with public and private landowners, including city, county, irrigation districts (NID), and federal agencies, to map, identify, and remediate abandoned mine sites and lands, and to reduce the amount of erosion entering into Deer Creek by establishing and implementing Best Management Practices.

- SSI is currently under contract to stabilize, cap and/or remove heavy metal contamination from two abandoned mine sites within Nevada City. These pilot projects will guide future remediation efforts in the Deer Creek watershed.
- Continue to work with the City of Nevada City and Nevada County to install drains that capture the sediment before going to Deer Creek. The City of Nevada City and the County recently completed a pilot project with the goal of reducing storm water runoff at the County administration building. Participate in this ongoing process and expand it to other areas of the watershed, including Lake Wildwood and Penn Valley.
- Reduce mercury in urban stormwater actions such as: vacuum street sweeping, stormwater vaults with media filters, and sediment traps
- Work with the BLM, U.S. Forest Service (Tahoe National Forest), State and county to investigate potential opportunities for reducing the number of dirt roads and to establish BMP's for all service roads to be left, particularly out-of-service logging roads and operations. Prioritize dirt roads for investigation on the field; map and sample to identify the most contaminated areas or areas with the most significant erosion; remediate contaminated areas or areas of significant erosion.
- Work with private landowners that are in immediate proximity to Deer Creek or major drainages that enter Deer Creek, to identify and map areas of contamination or erosion that might need remediation or restoration.
- Provide private property owners with general recommendations landowners could take to prevent erosion off their property. This pamphlet should be modeled after the "Stream bank repair guidance manual for the private landowner" developed by the

SWRCB for the Guadalupe watershed, which details how private landowners can reduce erosion and mercury pollution.

- Promote and encourage landscaping practices that contain erosion and keep water on-site, and potentially help landowners design landscaping that reduces erosion using native plants.

✓ Conduct further study of mercury and sediment loading in the Deer Creek watershed. Determination of loads throughout the watershed and sub watersheds will allow us to identify where the greatest loading of mercury into Deer Creek occurs, and help to prioritize remediation efforts.

✓ Investigate the use of phytoremediation to reduce the mercury loads in the Deer Creek watershed.

✓ Expand these recommendations to additional watersheds throughout the State of California, including the nearby Bear and Yuba Rivers.