Project Partners

This project is a collaborative effort of The Sierra Fund (TSF), TSF's Mining Toxins Working Group and California State Parks to assess and address the impacts of historic mining practices in the Humbug Creek watershed and it may provide useful lessons for assessing and mitigating mine-related impacts in neighboring watersheds with similar mining legacies and water quality characteristics. This project was made possible by funding from the Sierra Nevada Conservancy, Bella Vista Foundation, Teichert Foundation, Patagonia, and the Rose Foundation for Communities and the Environment, with funding for next steps provided by the CA Department of Water Resources.

About The Sierra Fund

The Sierra Fund is the only nonprofit community foundation dedicated solely to the Sierra Nevada. Our mission is to increase and organize investment in the region's natural resources and communities. We pursue this mission three ways: through Advocacy to bring public funding to the region, Philanthropy to provide a vehicle for private funding, and Strategic Campaigns that pursue critically needed programs in the Sierra.

Since 2006, the Reclaiming the Sierra Initiative has been our primary strategic campaign. The goal of this Initiative is to assess and address mining's toxic legacy: the ongoing cultural, environmental and human health impacts of toxins left over from the Gold Rush.

206 Sacramento Street, Suite 101, Nevada City, CA 95959
(530) 265-8454 - info@sierrafund.org

For more information, and to download a full copy of the Humbug Creek Watershed Assessment and Management Recommendations report, go to www.sierrafund.org

References Cited

1. Alpers, C.N., Hunerlach., M.P., Hothem, R.L., and May, J.T., 2005, Mercury contamination from historical gold mining in California: U.S. Geological Survey Fact Sheet 2005-3014, 6 p., http://water.usgs.gov/pubs/fs/2005/3014/.
2. California Regional Water Quality Control Board (CRWQCB), 1976, Order No. 76-258, Waste Discharge Requirements for Malakoff State Historic Park, California Department of Parks and Recreation, Nevada County, WSID No. 5A290802001, Central Valley Region.
3. Churchill, R.K., 2000, Contributions of Mercury to California's Environment from Mercury and Gold Mining Activities-Insights from the Historical Record, Extended abstracts for the U.S. EPA-Sponsored meeting, Assessing and Managing Mercury from Historic and Current Mining Activities.
4. Fleck, J.A., et al., 2011, The Effects of Sediment and Mercury Mobilization in the South Yuba River and Humbug Creek Confluence Area, Nevada County, California: Concentrations, Speciation, and Environmental Fate--Part 1: Field Characterization: U.S. Geological Survey Open-File Report 2010-3125A.
5. Marvin-DiPasquale, M., Agee, J.L., Kakouros, E., Kieu, L.H., Fleck, J.A., Alpers, C.N., 2011, The Effects of Sediment and Mercury Mobilization in the South Yuba River and Humbug Creek Confluence Area, Nevada County, California: Concentrations, Speciation, and Environmental Fate—Part 2: Laboratory Experiments: U.S. Geological Survey Open-File Report 2010-1325B, 66 p.
6. Singer, M.B., Aalto, R., James, L.A., Kilham, N.E., Higson, J.L., Ghoshal, S., 2013, Enduring legacy of a toxic fan via episodic redistribution of California gold mining debris: Proceedings of the National Academy of Science of the United States of America, v. 110, i. 46, p. 18436–18441, doi: 10.1073/pnas.1302295110.
7. Wood, M.L., Foe, C.G., Cooke, J., Louie, S.J., 2010, Amendments to the Water Quality Control Plan for The Sacramento River and San Joaquin River Basins for the Control of Methlymercury and Total Mercury in the Sacramento-San Joaquin Delta Estuary, p. 33.
8. State Water Resources Control Board (SWRCB), 2013c, Statewide Mercury Control Program for Reservoirs: http://www.waterboards.ca.gov/water_issues/programs/mercury/reservoirs/docs/factsheet.pdf.

California State University Chico Master's Theses Completed

- *Mercury and Suspended Sediment Sources and Loads in Humbug Creek in Malakoff Diggins State Historic Park* (Harihar Nepal, 2013)
- *Subsurface Waters at Malakoff Diggins Pit, North Bloomfield Tunnel and Hiller Tunnel* (David Holl Demaree, 2014)
- *Particle-Size Distribution Analysis and Sediment Deposition on the Pit Floor at Malakoff Diggins State Historic Park* (Cameron Lee Liggett, 2014)
- *Quantifying Surficial Processes in Malakoff Diggins, A Historic Hydraulic Mine* (Keith Landrum, 2015)

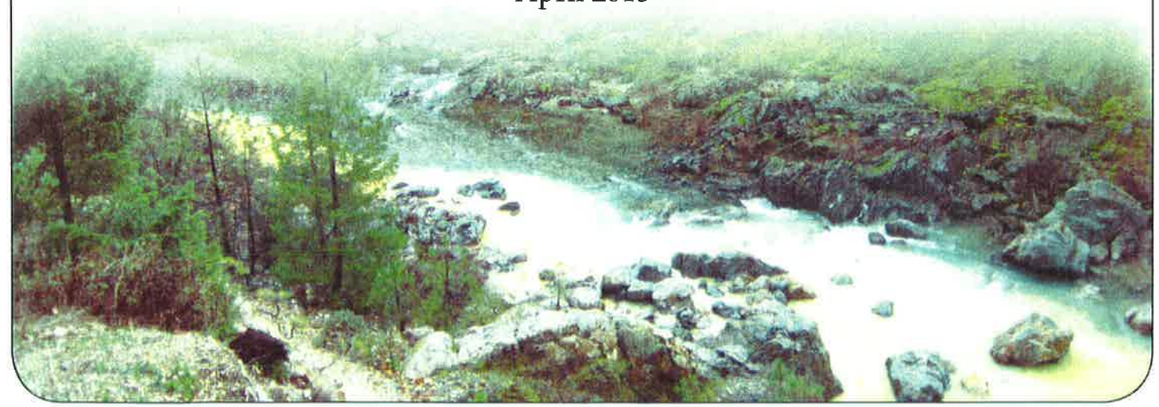
Executive Summary

Humbug Creek Watershed Assessment and Management Recommendations

A pilot assessment of mining impacts and recommendations for action to improve water quality at Malakoff Diggins State Historic Park

The Sierra Fund

April 2015



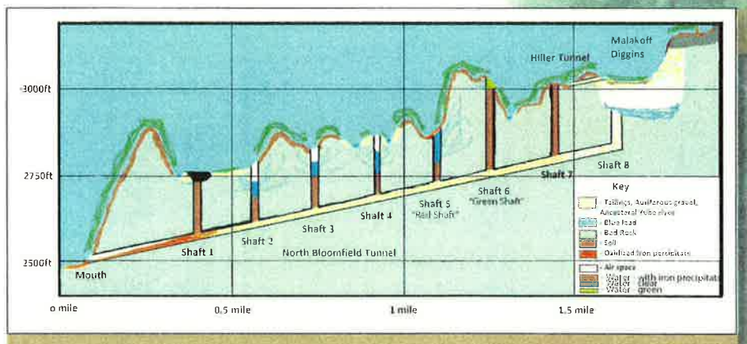
Humbug Creek Watershed History and Natural Features

The Humbug Creek Watershed encompasses Malakoff Diggins State Historic Park, including the Malakoff Diggins hydraulic mine pit and the headwaters of Humbug Creek, a tributary to the wild and scenic South Yuba River. Malakoff Diggins was once the site of California's largest hydraulic mine and today is a treasured State Historic Park and listed on the National Register of Historic Places.

The Malakoff Diggins Mine Pit - Then and Now: Hydraulic mining monitors were used to direct powerful streams of water to wash down hillsides in search of gold bearing gravels. Seven monitors ran day and night and large amounts of mercury were used to extract gold from the resulting slurry. Today, the steep walls left by the mine continue to erode, and in large rainstorms as much as a ton of sediment can be carried downstream.

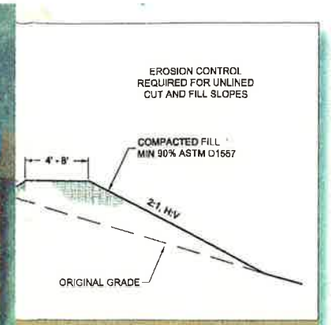
Mercury was used extensively at hydraulic mine sites including Malakoff Diggins during the Gold Rush, and contaminated discharge from these sites continues to impact streams and rivers. It is reported that more than 26,000,000 pounds of mercury were used throughout the Sierra Nevada to aid in gold recovery efforts.[3] Recent advancements in our understanding of mercury in the environment and how it can become part of the aquatic and terrestrial food chains has led to renewed efforts to identify and abate sources of mercury contamination.[4, 5, 6, 7 & 8]

Two mining tunnels are associated with the Malakoff Diggins pit: Hiller Tunnel and the North Bloomfield Tunnel. Surface water drains from the Malakoff Diggins pit via Hiller Tunnel to Diggins Creek, then to Humbug Creek and eventually to the South Yuba River. North Bloomfield Tunnel contributes a minimal amount of discharge as the tunnel is plugged. Mine-related discharge from the Park is currently regulated by a Waste Discharge Permit with the Central Valley Regional Water Quality Control Board (Order No. 76-258).[2]

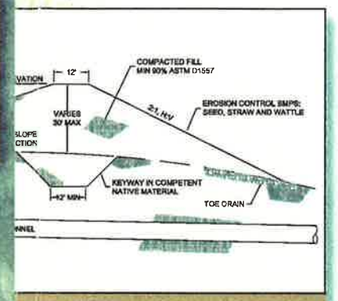


North Bloomfield Tunnel: This illustration presents the current understanding of the 7,847 ft North Bloomfield Tunnel and access shafts. The tunnel was built to drain the Malakoff Diggins pit during peak mining operations (1874-1884), but is currently blocked and has minimal discharge to the watershed.

In 2010, the Humbug Creek watershed was selected for a watershed assessment by The Sierra Fund, in partnership with California State Parks and others. These efforts culminated in management recommendations to remediate the environmental effects associated with the discharge from the Malakoff Diggins Hydraulic Mine. In addition to environmental assessement, project partners proactively incorporated cultural resources and historic landscape components into the evaluation of alternatives proposed as part of the Humbug Creek Watershed Assessment and Management Recommendations, in recognition of the Park's unique historical status and classifications.



proposed ditches that would
l Malakoff Diggins Pit could be
diversion ditch profile.



e. The proposed detention
ou'd serve to filter water before

0 0
00.1

Humbug Creek Watershed Management Recommendations

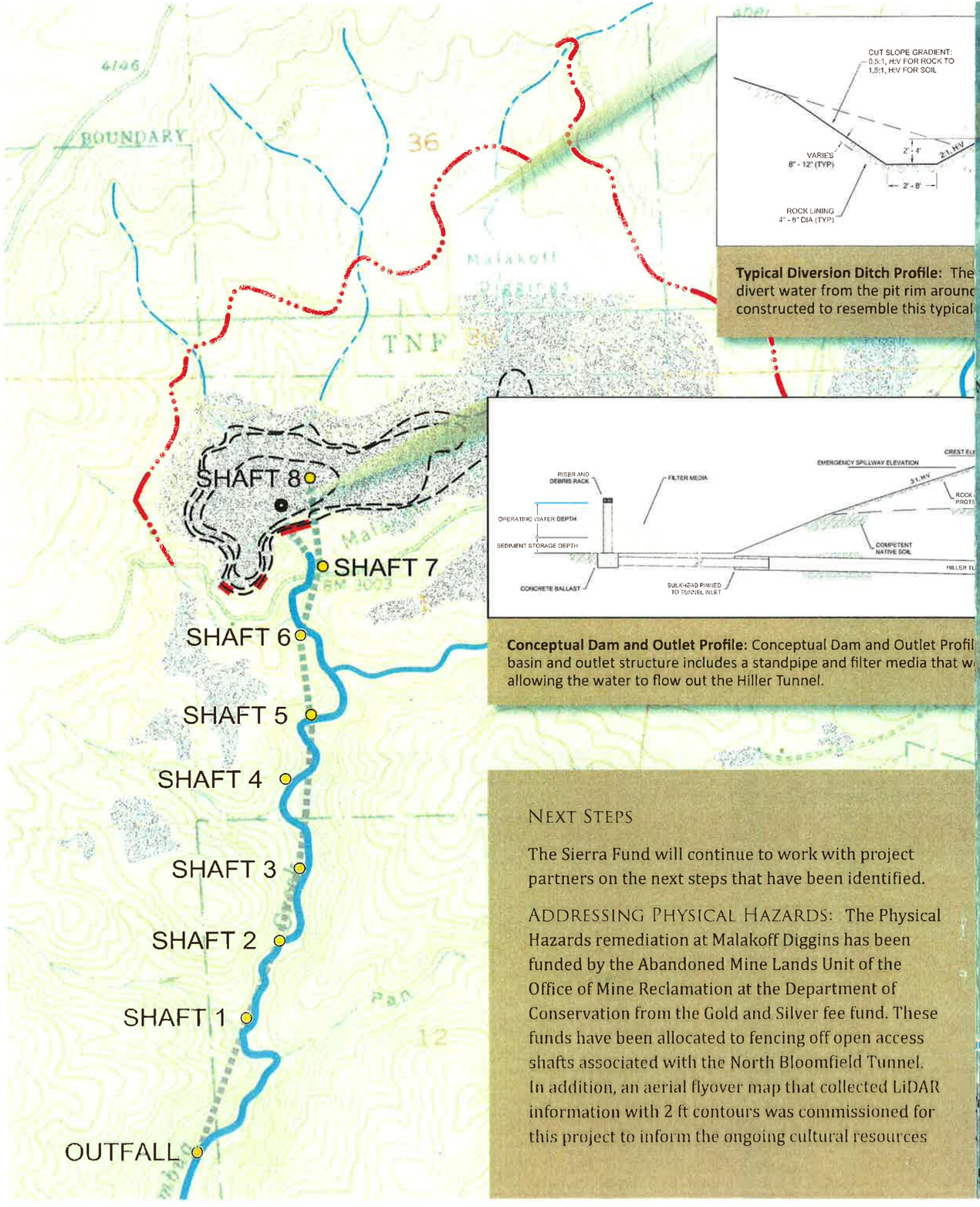
At the conclusion of the three-year assessment, the following potential management recommendations were prioritized by project partners as the best options to address water quality concerns while protecting cultural resources at the Park. Some recommendations require that data gaps be addressed in order to inform the selection and design of management strategies.

1. Sediment and metals discharge from the Malakoff Diggins hydraulic mining pit may be managed by:
   a. Constructing a detention pond at the western end of the pit to detain storm water flows within the pit, to equalize pit discharge, and to settle and retain suspended solids.
   b. Constructing a filtration outlet structure at the inlet to Hiller Tunnel with intent to filter sediment and particulate-bound mercury, copper, nickel, and zinc from the water discharge into Diggins Creek and subsequently Humbug Creek.
   c. Constructing diversion ditches above the Malakoff Diggins pit to direct surface water around the pit, thereby reducing the amount of surface water flow over the pit walls, reducing sediment transport, and reducing surface water discharge out of the pit.
2. Discharge from Shaft 5 can be addressed by constructing a boardwalk to re-route the Humbug Creek Trail around Shaft 5. A long-term management strategy to treat the water and metals discharge at Shaft 5 would necessitate monitoring the outflow both at Shaft 5 and the North Bloomfield Tunnel outlet to determine permitting requirements.
3. Physical hazards associated with tunnel access shafts and openings may be managed by limiting access, grading, plugs, installing fencing and/or bat-friendly gates depending on water level and bat presence and use.

inventory, environmental sampling and remediation design work.

Filling Data Gaps: U.S. Geological Survey researchers are using state-of-the-art assessment techniques to measure erosional rates, geochemistry, and mineralogy of the Malakoff Diggins pit walls and discharge. Part of this work is using terrestrial-based LiDAR images to measure changes in the pit walls over time. The ground-based LiDAR will help to inform critical components of the design of a sediment detention basin and/or site specific erosion control techniques. Additional assessment activities include identifying point sources of contamination. Finally, a comprehensive Cultural Resources Inventory is being conducted and a corresponding Evaluation is planned. This effort will be instrumental to determining the impacts of selected remediation alternatives to cultural resources

Regulation: Review of the Assessment findings by the Central Valley Regional Water Quality Control Board determined that the existing Waste Discharge Requirements for Malakoff Diggins State Historic Park from 1976 need to be updated, and a timeline towards compliance was requested. This will require an evaluation of impacts to cultural resources, as well as further development of the engineering solutions, activities which are unfunded or only partially funded.



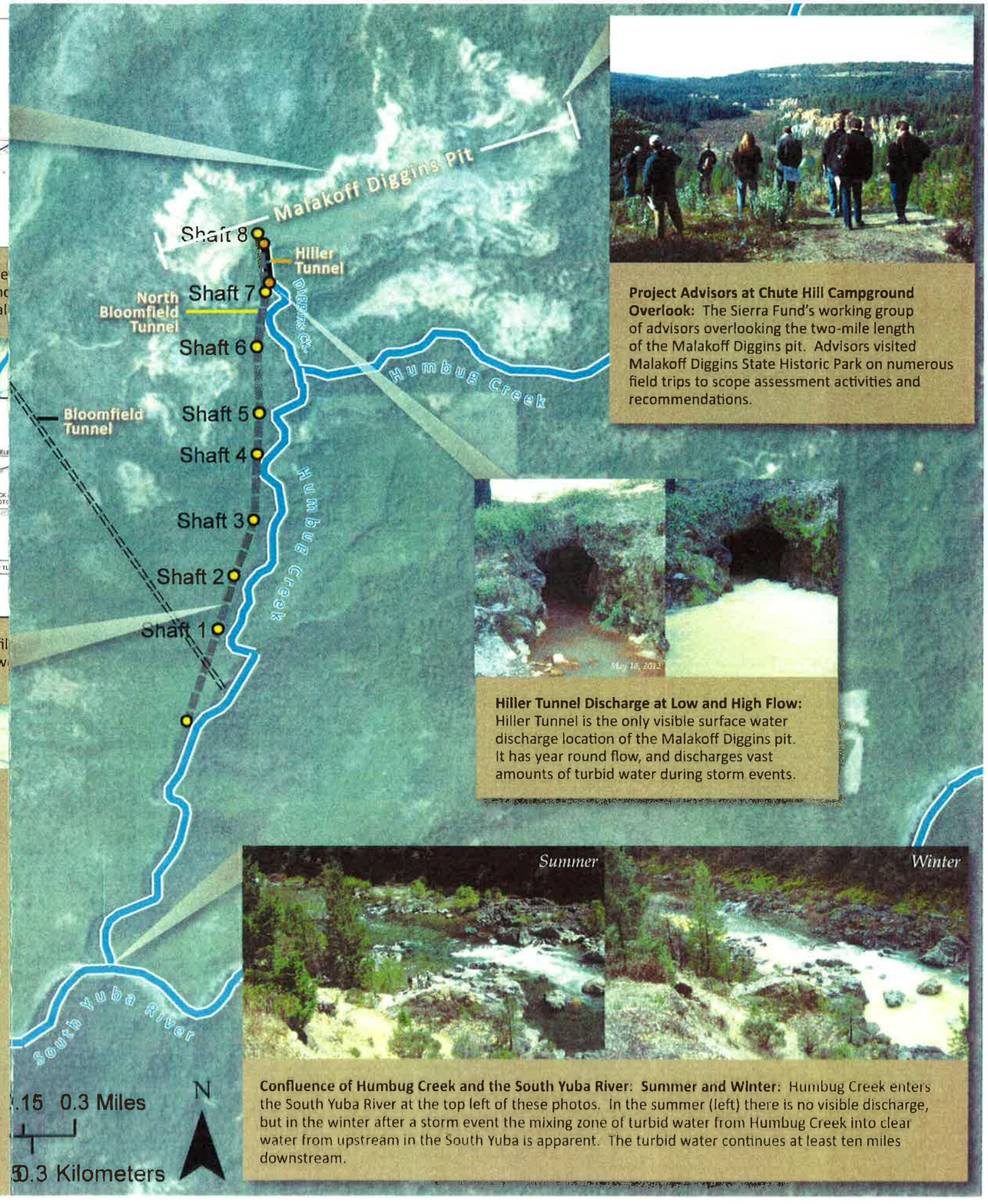
Typical Diversion Ditch Profile: The divert water from the pit rim aroun constructed to resemble this typical

Conceptual Dam and Outlet Profile: Conceptual Dam and Outlet Profil basin and outlet structure includes a standpipe and filter media that w allowing the water to flow out the Hiller Tunnel.

Next Steps

The Sierra Fund will continue to work with project partners on the next steps that have been identified.

Addressing Physical Hazards: The Physical Hazards remediation at Malakoff Diggins has been funded by the Abandoned Mine Lands Unit of the Office of Mine Reclamation at the Department of Conservation from the Gold and Silver fee fund. These funds have been allocated to fencing off open access shafts associated with the North Bloomfield Tunnel. In addition, an aerial flyover map that collected LiDAR information with 2 ft contours was commissioned for this project to inform the ongoing cultural resources



Project Advisors at Chute Hill Campground Overlook: The Sierra Fund's working group of advisors overlooking the two-mile length of the Malakoff Diggins pit. Advisors visited Malakoff Diggins State Historic Park on numerous field trips to scope assessment activities and recommendations.

Hiller Tunnel Discharge at Low and High Flow: Hiller Tunnel is the only visible surface water discharge location of the Malakoff Diggins pit. It has year round flow, and discharges vast amounts of turbid water during storm events.

Confluence of Humbug Creek and the South Yuba River: Summer and Winter: Humbug Creek enters the South Yuba River at the top left of these photos. In the summer (left) there is no visible discharge, but in the winter after a storm event the mixing zone of turbid water from Humbug Creek into clear water from upstream in the South Yuba is apparent. The turbid water continues at least ten miles downstream.

Surface Flow in the Malakoff Diggins Pit: Surface water samples were collected from 20 locations in the pit during surface runoff. There were many areas where flow was unconfined and discharge was difficult to measure.

Humbug Creek Watershed Assessment Findings

The Sierra Fund's Humbug Creek Watershed Assessment and Management Recommendations (Assessment) identified deleterious sediment and metals from historic mining practices at the Park that impact water quality in the watershed. The Assessment document reports the findings of the watershed assessment activities and presents possible management actions as recommendations to abate the ongoing degradation to water quality while preserving the cultural resources of the Park.

Specific findings of the study include:

1. The Malakoff Diggins pit drains via Diggins Creek and contributes sediment and particulate bound mercury, and other metals to Humbug Creek.
2. **Humbug Creek contributes an estimated 500 tons of sediment and an estimated 100 g of mercury to the South Yuba River per year, during a dry or below normal year.**
3. **As the walls of the Malakoff Diggins hydraulic mine pit continue to erode,** material is deposited on the pit floor and is effectively filling in the pit. Although the vegetation that has established on the pit floor retains a lot of sediment, it does not retain all **the silts and clays, which continue to pass over the pit floor and create turbid water discharge with elevated concentrations of particulate-bound metals.**
4. Shaft 5 of the North Bloomfield Tunnel contributes elevated concentrations of mercury, nickel and zinc to Humbug Creek; however the effective contribution is small because the discharge from the shaft is minimal (0.008 cms (0.03 cfs)).
5. There are a number of physical hazards in the Park associated with tunnel access shafts and openings.

Water Quality Monitoring Sites

Water quality monitoring sites were established on Humbug Creek upstream of the discharge from Hiller Tunnel at the Relief Hill Road crossing (Road 1), from the Hiller Tunnel discharge (Hiller 2) and downstream of the confluence of Diggins Creek on Humbug Creek (Gage 3). Monitoring equipment including stage and turbidity meters shown to the right was installed at the Gage 3 site. This equipment, shown to right during low and stormflow, was used to measure turbid surface water runoff containing particulate-bound metals during storm events, caused by ongoing erosion from the Malakoff Diggins pit.

Humbug Creek Annual Load Estimates

Advancement of Science

The Sierra Fund's Humbug Creek Watershed Assessment Project benefited from certified trace metal laboratories and state-of-the-art stream gage and monitoring equipment to characterize discharge in a storm event-driven system contaminated with mercury. In cooperation with California State Parks, studies continue to be conducted to address data gaps and critical questions regarding water quality and erosion in the Humbug Creek watershed with project partners including California State University at Chico, Geological and Environmental Sciences Department, and U.S. Geological Survey research scientists. In coordination with this assessment , a total of four master's student theses have been completed to date and three more are in progress, all associated with assessment activities and questions in the Humbug Creek watershed. The master's theses increased the depth and breadth of this assessment's scope.