The mission of The Sierra Fund is to increase and organize investment in the natural resources and communities of the Sierra Nevada.

THE SIERRA FUND

We do this through:

Headwaters Policy	Philanthropy	Headwaters Science
Water Bond Mining Law Reform	Fiscal Sponsorships Donor-Advised Funds	Addressing impacts of legacy mining

Reclaiming the Sierra

An Initiative to Address Historic Mining Impacts

Health Science Outreach Policy

Nevada City Legacy Mine Land Acquisition Project

Malakoff Diggins Assessment and Cleanup Project

Combie Reservoir Mercury and Sediment Removal

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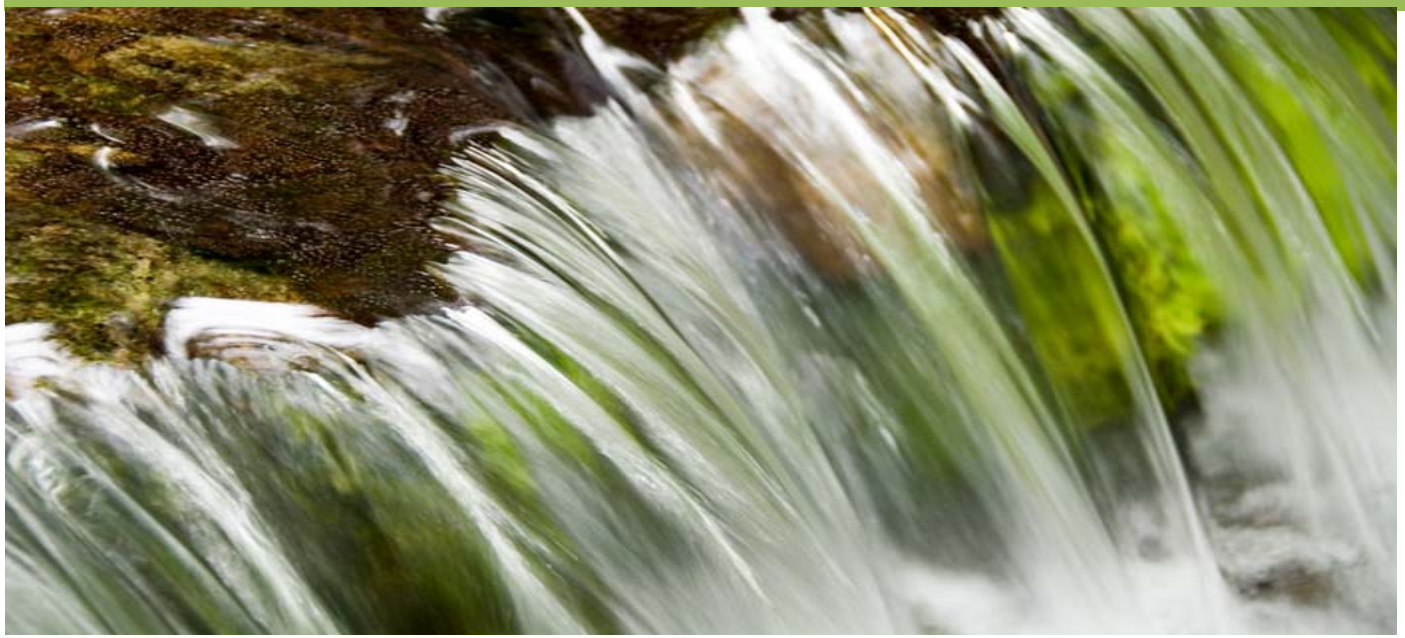
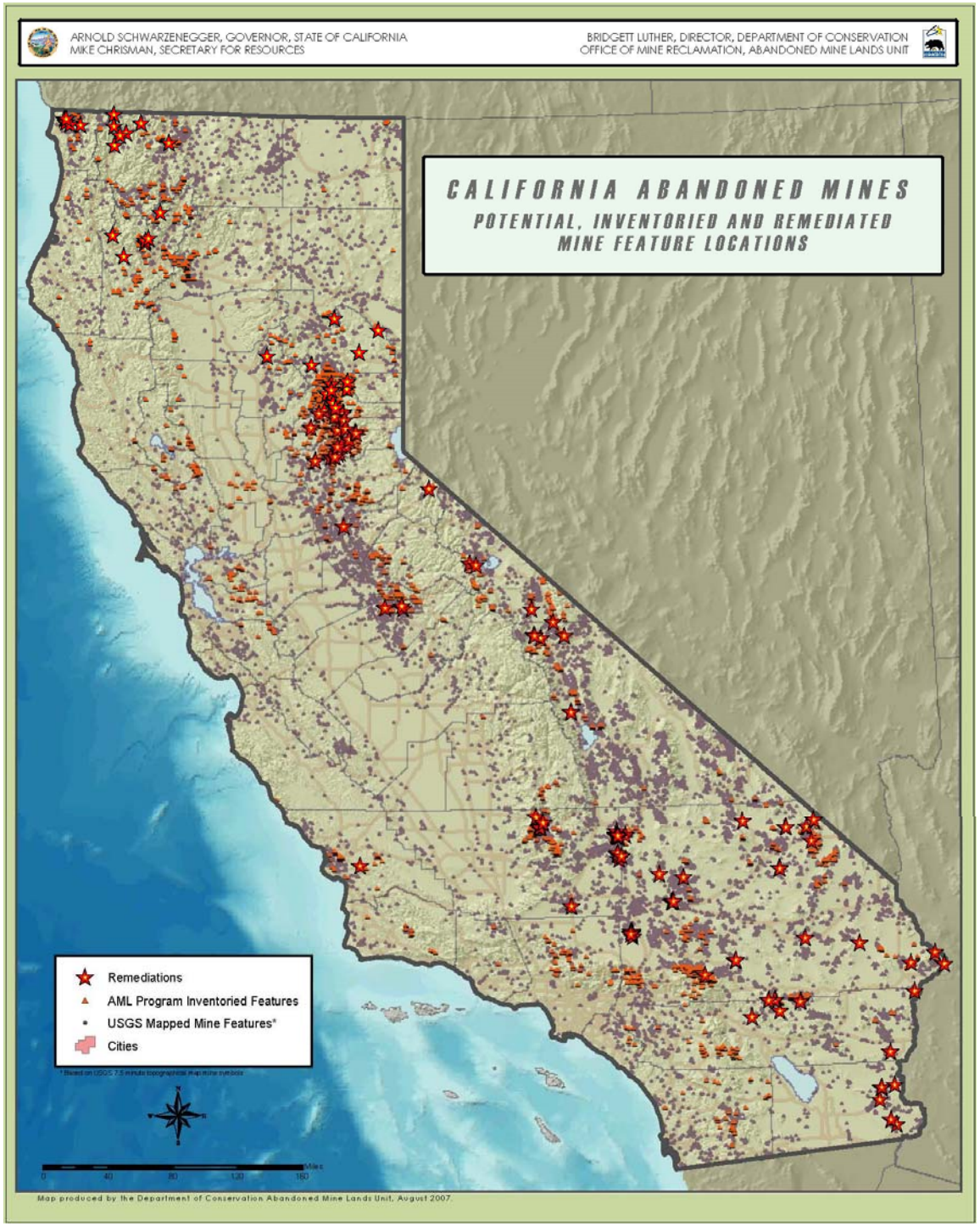
Humbug Creek Watershed Assessment and Management Recommendations

Malakoff Diggins State Historic Park

Presentation to
Nevada County Boards of Supervisors
March 22, 2016
By
Carrie Monohan, Ph.D.



THE SIERRA FUND



Legacy Mines in California

Map by California Department of Conservation 2007

THE SIERRA FUND

Get the Mercury Out:
Strategic Mercury Clean up Targets

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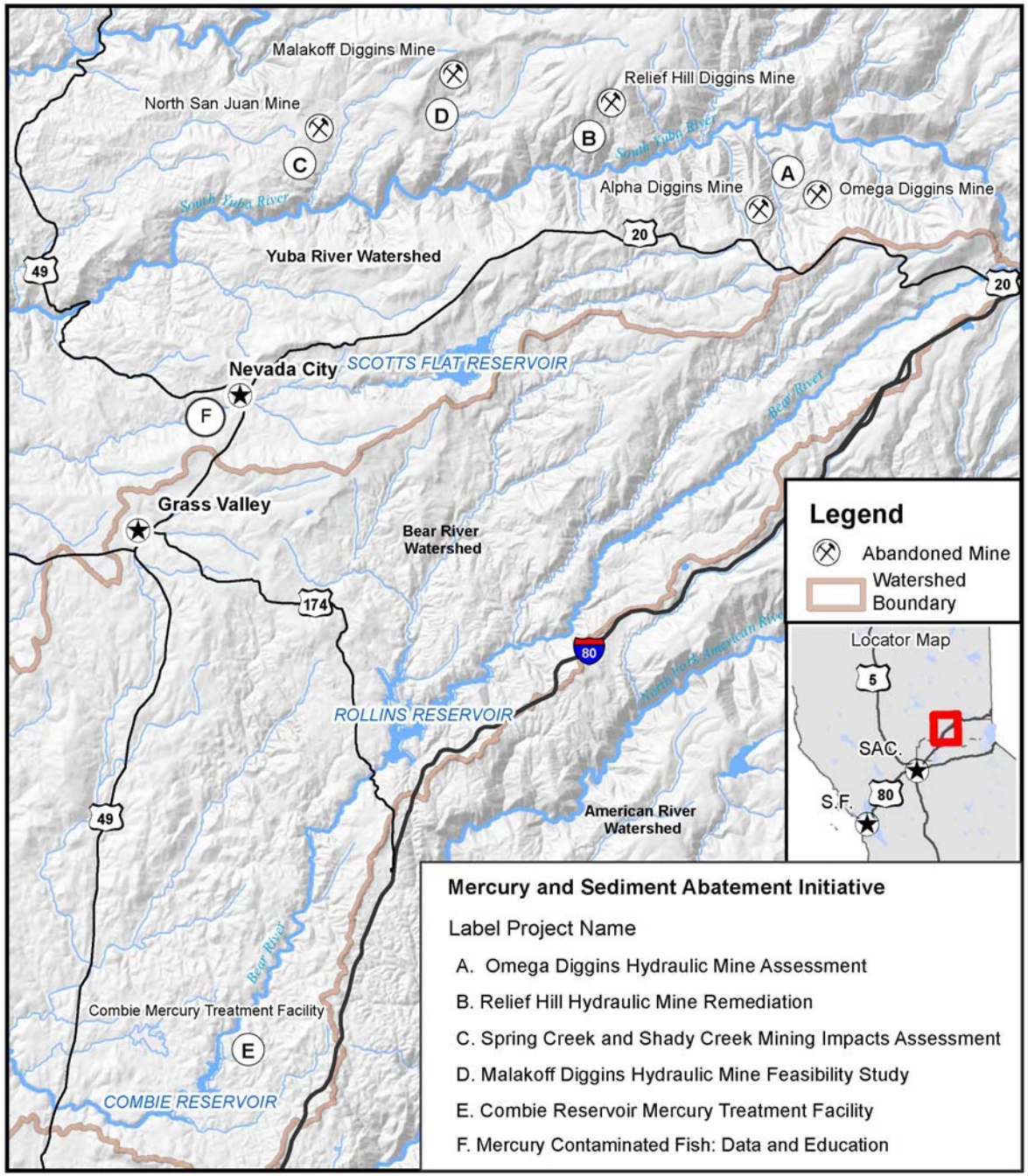
DRAFT Conceptual Design by Courtney Chatha for The Sierra Fund 3/1/2013

Regional approach to Abandoned Mine Clean-up

CABY IRWMP Partners

- USFS
- DPR
- NID
- SYRCL



Malakoff Diggins State Historic Park
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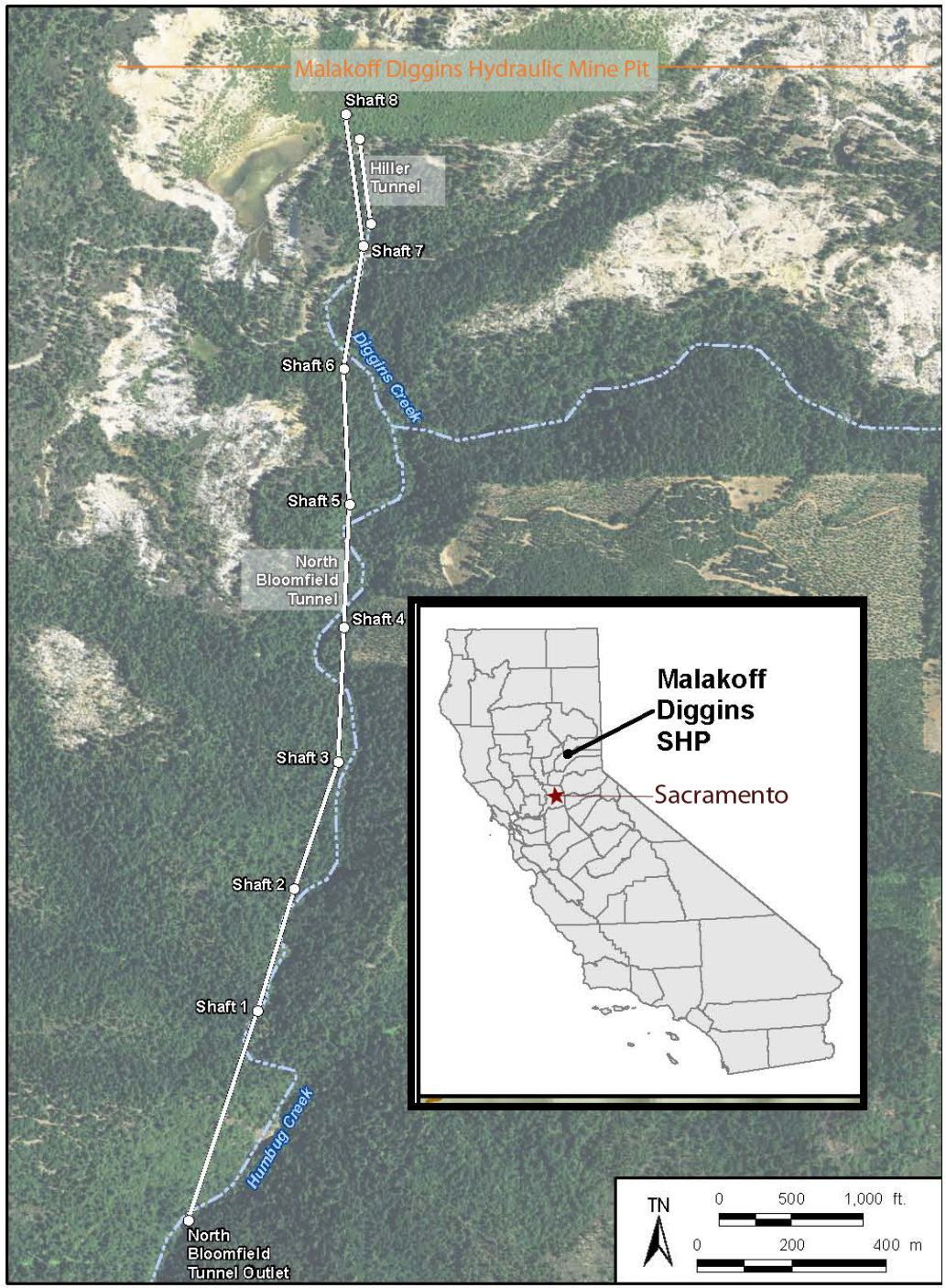
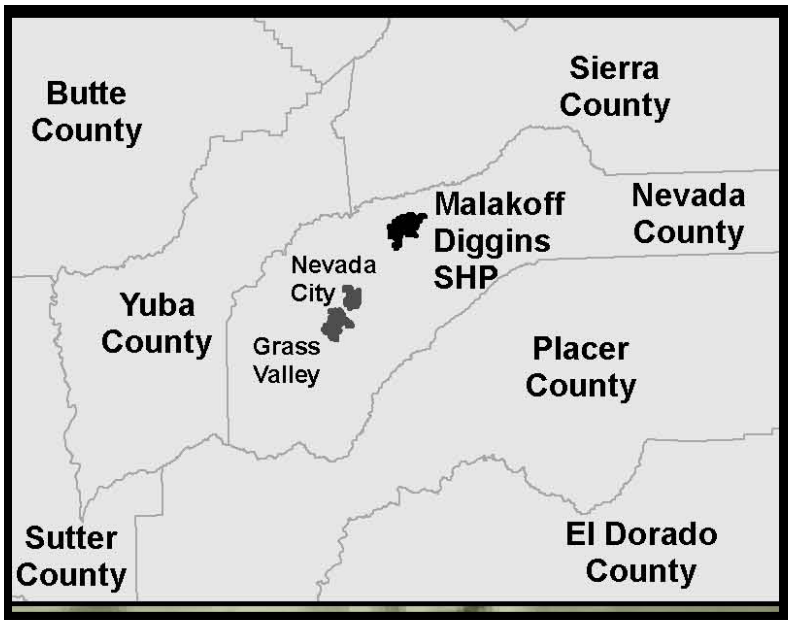


Key Features and Orientation

1) The Malakoff Diggins hydraulic mine pit
2) Hiller Tunnel
3) North Bloomfield Tunnel
4) Access shafts that are associated with the North Bloomfield Tunnel
5) Diggins Creek which drains the pit into Humbug Creek



Scope of Assessment / Critical Questions

- Water Quality Critical Questions
- Biotic Sampling Critical Questions
- Erosion, Deposition and Soil Conditions in the Pit Critical Questions

Purpose of Assessment:

Identify recommendations for addressing water quality impairments and physical hazards in the Humbug Creek watershed that resulted from historic mining activities

Water Quality Critical Questions

Water Quality Characterization and Assessment

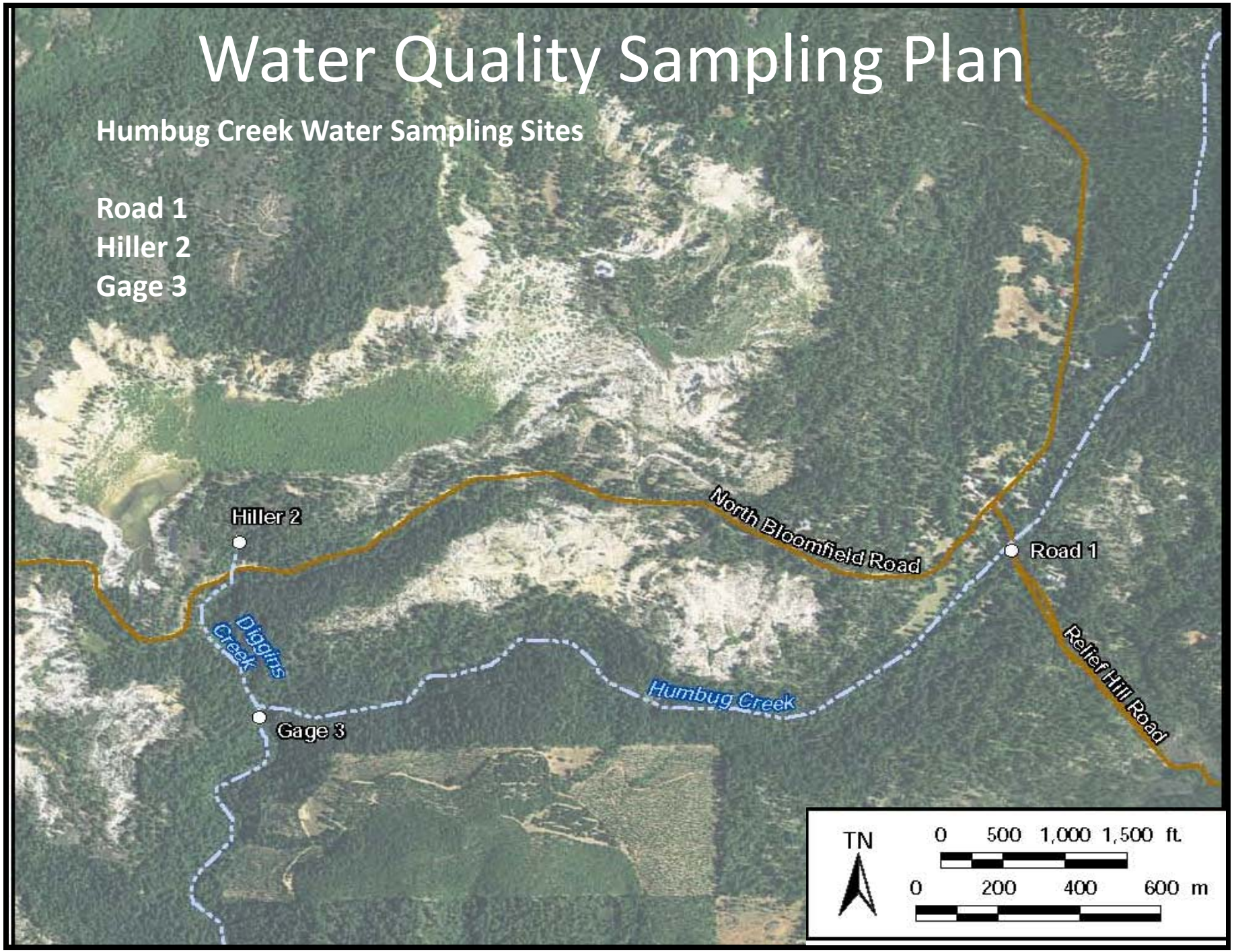
CQ1: What is the annual sediment and mercury load in Humbug Creek? How much of that load is from storm events?

CQ2: Is mercury in Humbug Creek transported primarily as particulate bound mercury rather than in its dissolved form?

CQ3: Is the quantity of suspended sediment in Humbug Creek directly correlated with mercury concentration in Humbug Creek?

CQ4: Is Diggins Creek a significant source of sediment, mercury and/or other metals to Humbug Creek? How is the water quality at the Gage3 site different than the Road1 site?

Water Quality Sampling Plan



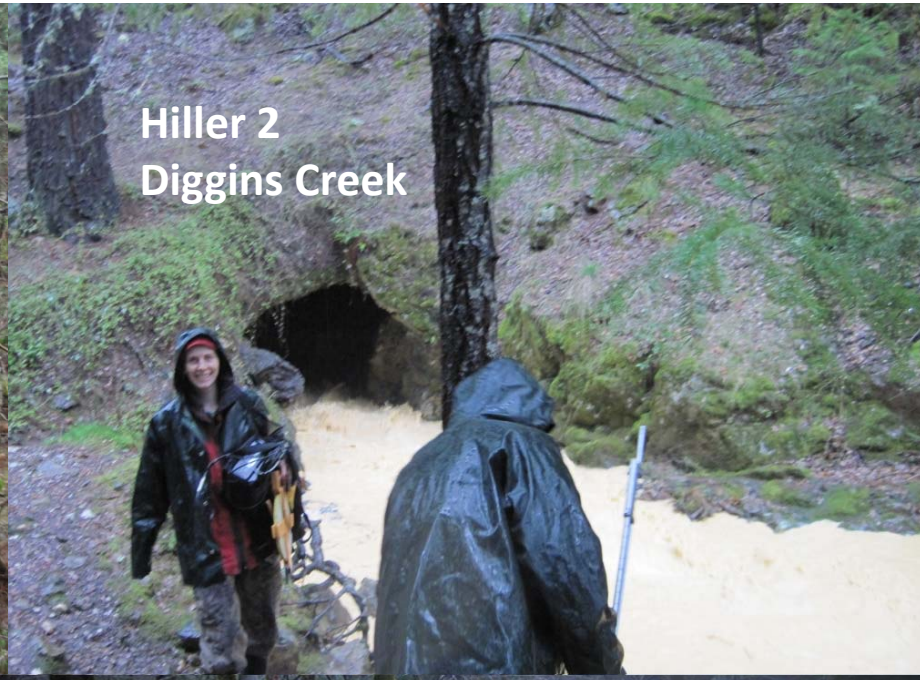
Monitoring Components
Humbug Gage Location

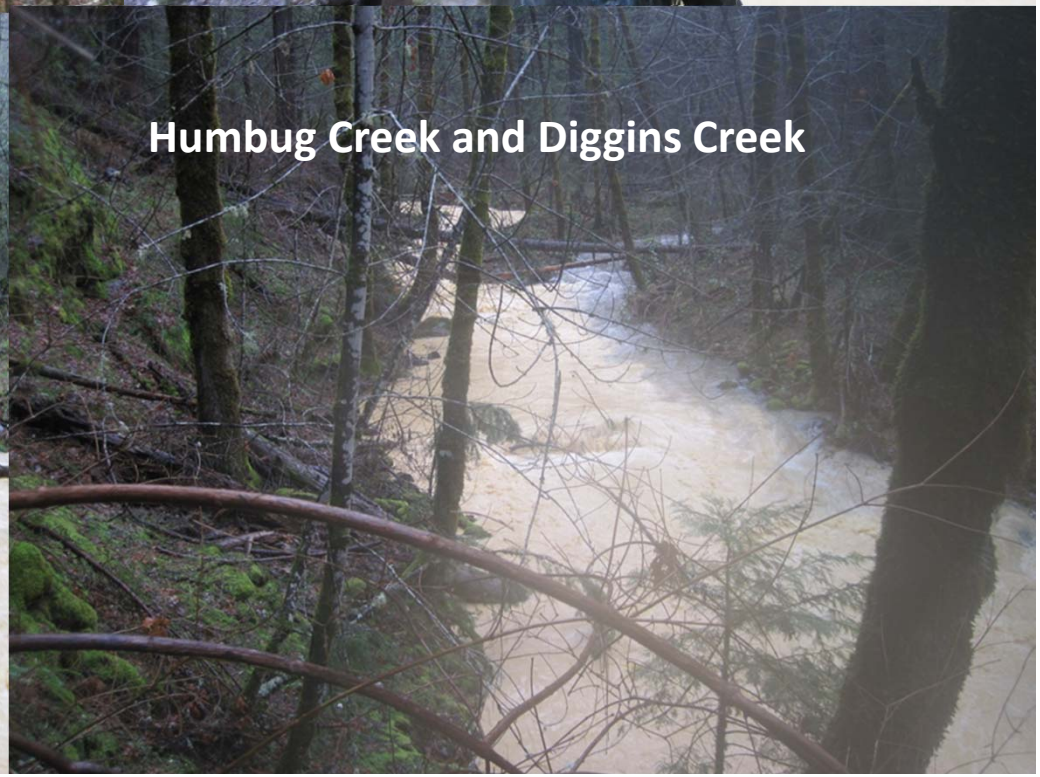
Stage

Turbidity

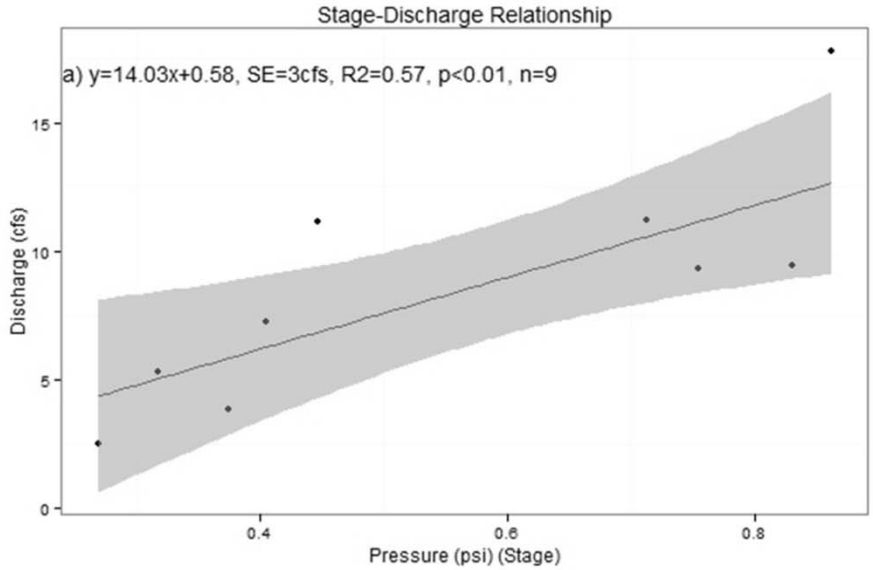
Automated Sampler

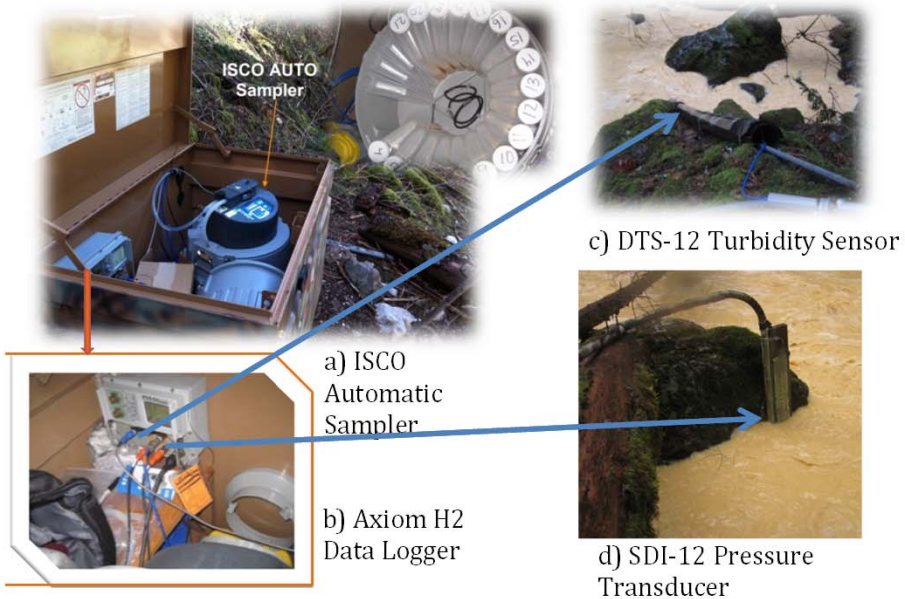
Power

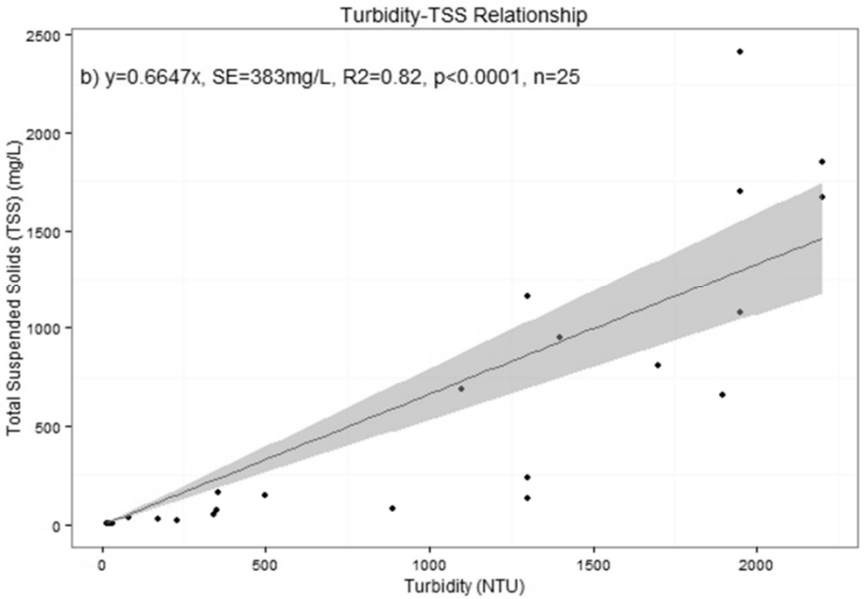


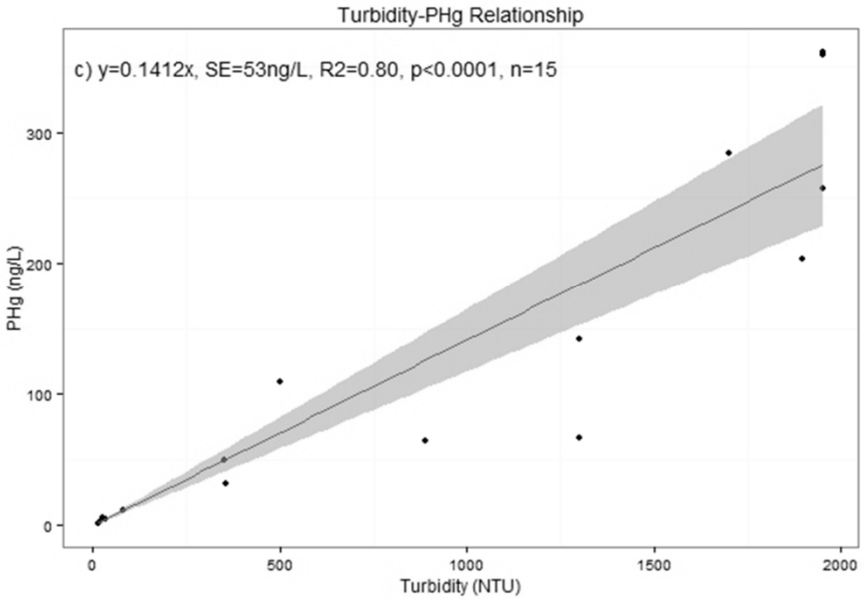


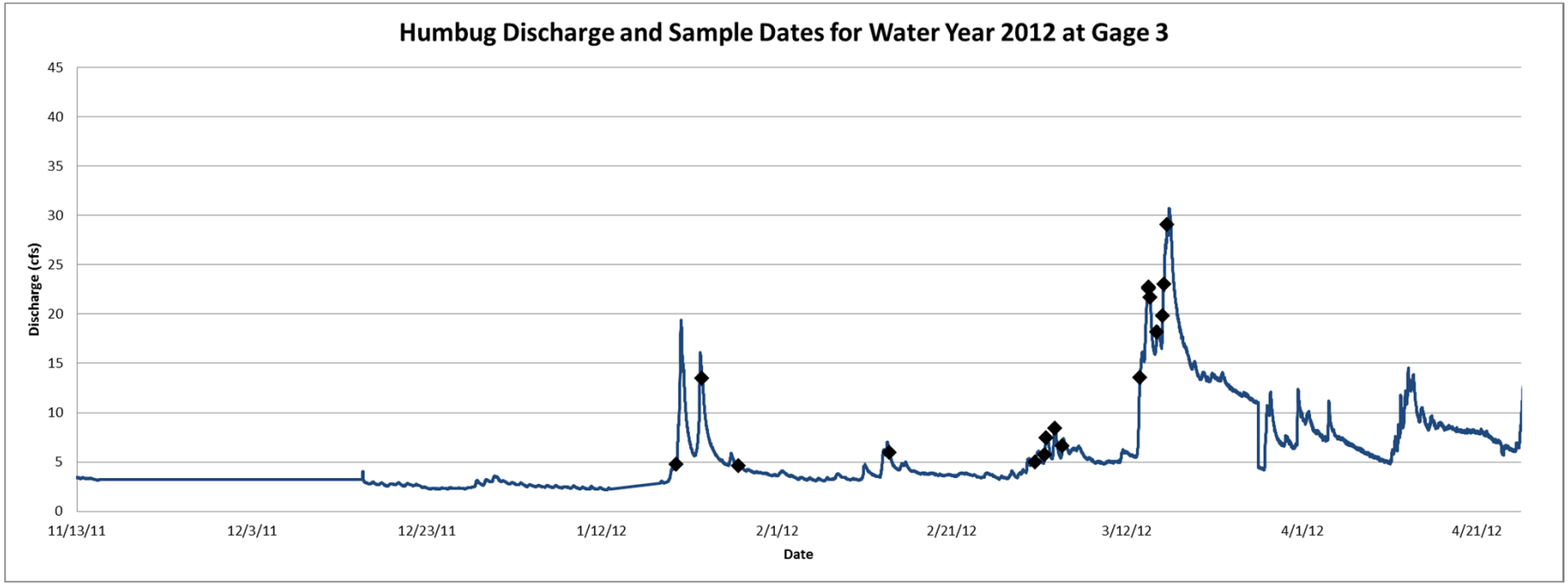
Photos taken by Dr. C. Monohan 3/14/2012

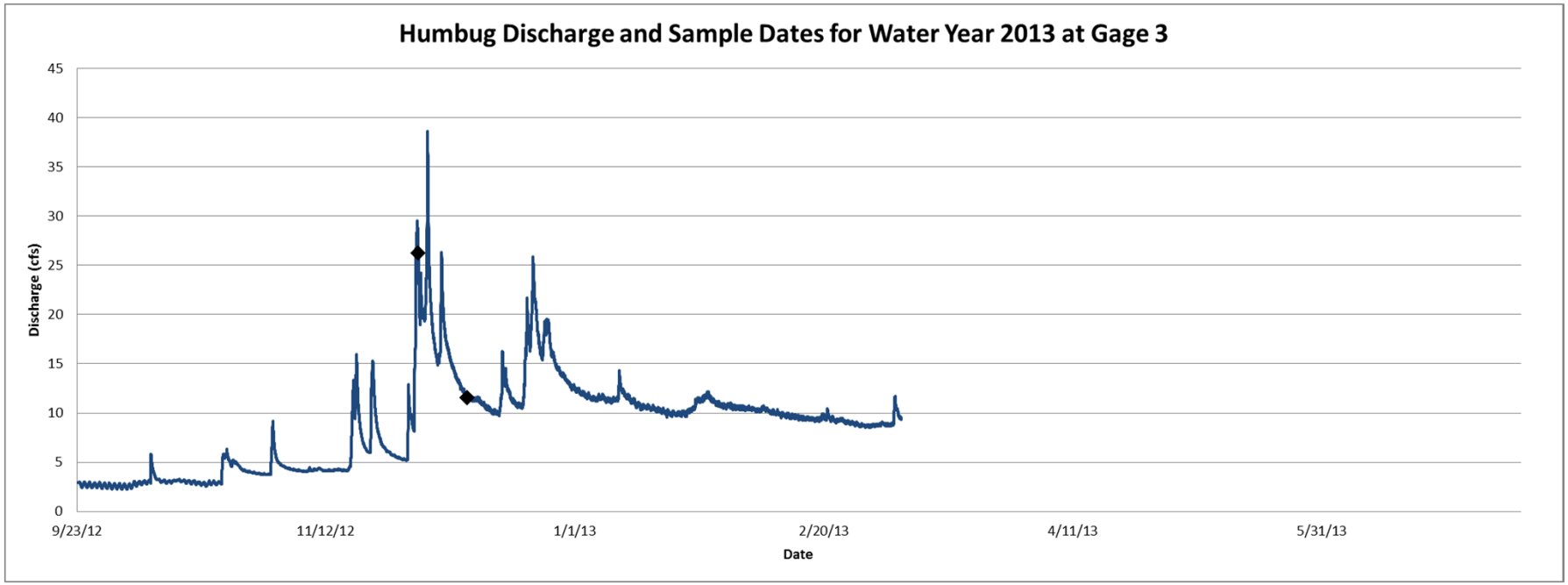

Stage-Discharge Relationship
a) y=14.03x+0.58, SE=3cfs, R2=0.57, p<0.01, n=9
Discharge (cfs)
Pressure (psi) (Stage)
0
5
10
15
0.4
0.6
0.8


ISCO AUTO
Sampler
a) ISCO Automatic Sampler
b) Axiom H2 Data Logger
c) DTS-12 Turbidity Sensor
d) SDI-12 Pressure Transducer

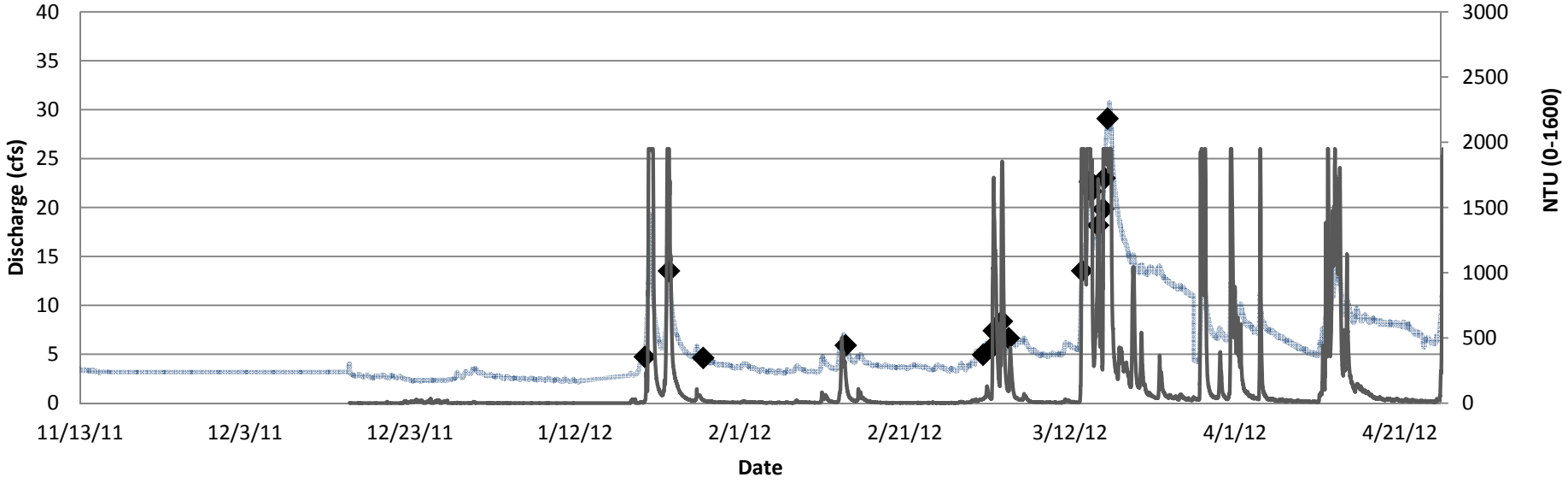

Turbidity-TSS Relationship
b) y=0.6647x, SE=383mg/L, R2=0.82, p<0.0001, n=25
Total Suspended Solids (TSS) (mg/L)
Turbidity (NTU)
0
500
1000
1500
2000
2500


Turbidity-PHg Relationship
c) y=0.1412x, SE=53ng/L, R2=0.80, p<0.0001, n=15
PHg (ng/L)
Turbidity (NTU)
0
100
200
300
500
1000
1500
2000

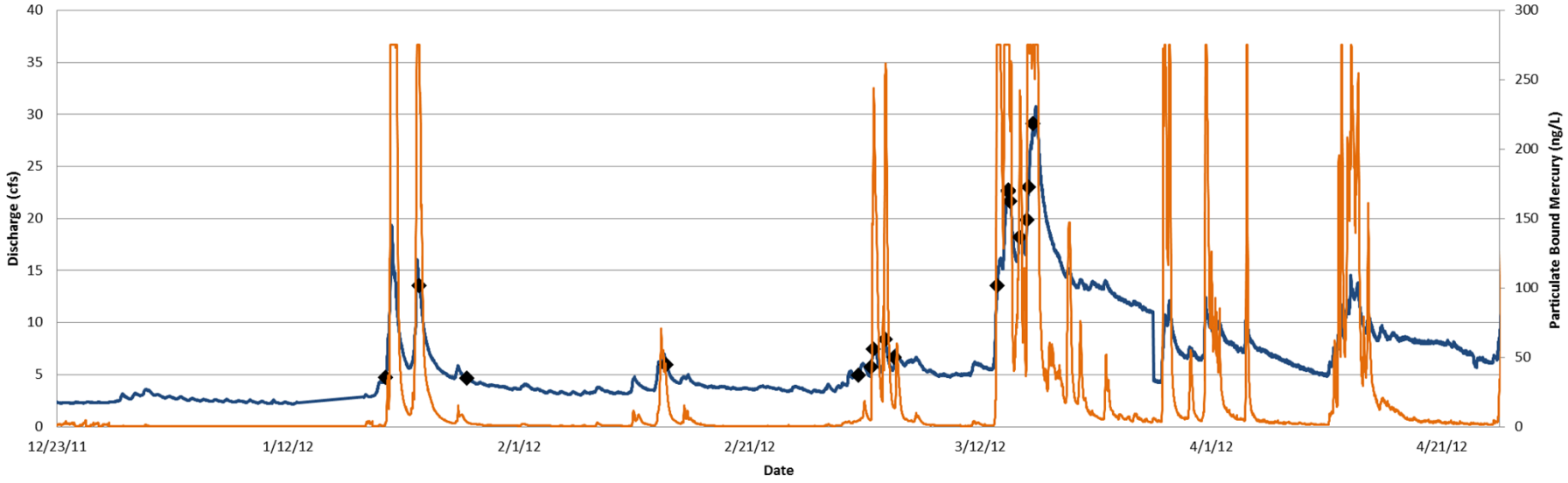

Humbug Discharge and Sample Dates for Water Year 2012 at Gage 3
Discharge (cfs)
45
40
35
30
25
20
15
10
5
0
11/13/11
12/3/11
12/23/11
1/12/12
2/1/12
2/21/12
3/12/12
4/1/12
4/21/12
Date


Humbug Discharge and Sample Dates for Water Year 2013 at Gage 3
Discharge (cfs)
45
40
35
30
25
20
15
10
5
0
9/23/12
11/12/12
1/1/13
2/20/13
4/11/13
5/31/13
Date

Humbug Discharge
Turbidity Data for Water Year 2012



Humbug Discharge
Particulate Bound Mercury Data for Water Year 2012



Loads for Humbug Creek

Time Period	Duration (Days)	Discharge (AF)	Error (AF) ±	Sediment Load (ton)	Error (ton) ±	Sediment Load (ton/day)	Mercury Load (g)	Error (g) ±	Mercury (g/day)
Total WY 2012	365	4,178	418	474	66	1	101	25	
Low Water, Fall	75	446	45	0			0.12		
Meter	128	2,804	280	473	66		100	25	
Low Water, Summer	156	928	93	1			0.24		
WY 2012 Storms									
January 23rd	12	172	17	66	9	6	14	4	1
February 13th	5	53	5	4	1	1	1		
March 2nd	10	129	13	22	3	2	5	1	
March 16th	14	466	47	243	34	17	52	13	4
WY 2012 Percent Storm		20%		71%			71%		
Total WY 2013	365	3,211	321	571	80	2	121	30	
Meter	158	2,890	289	567	79		121	30	
Low Water, Summer	54	321	32	4	1		0		
WY 2013 Storms									
December 2nd	17	547	55	269	38	16	57	14	3
WY 2013 Percent Storm		17%		47%			47%		

Notes:

Baseflow was estimated based on low water seasons (spring and fall 2012, summer 2013) when meter was not in place

Error was calculated as a percent of the quantity measured; it was assumed to be 10% for discharge, 14% for sediment load and 25% for mercury.

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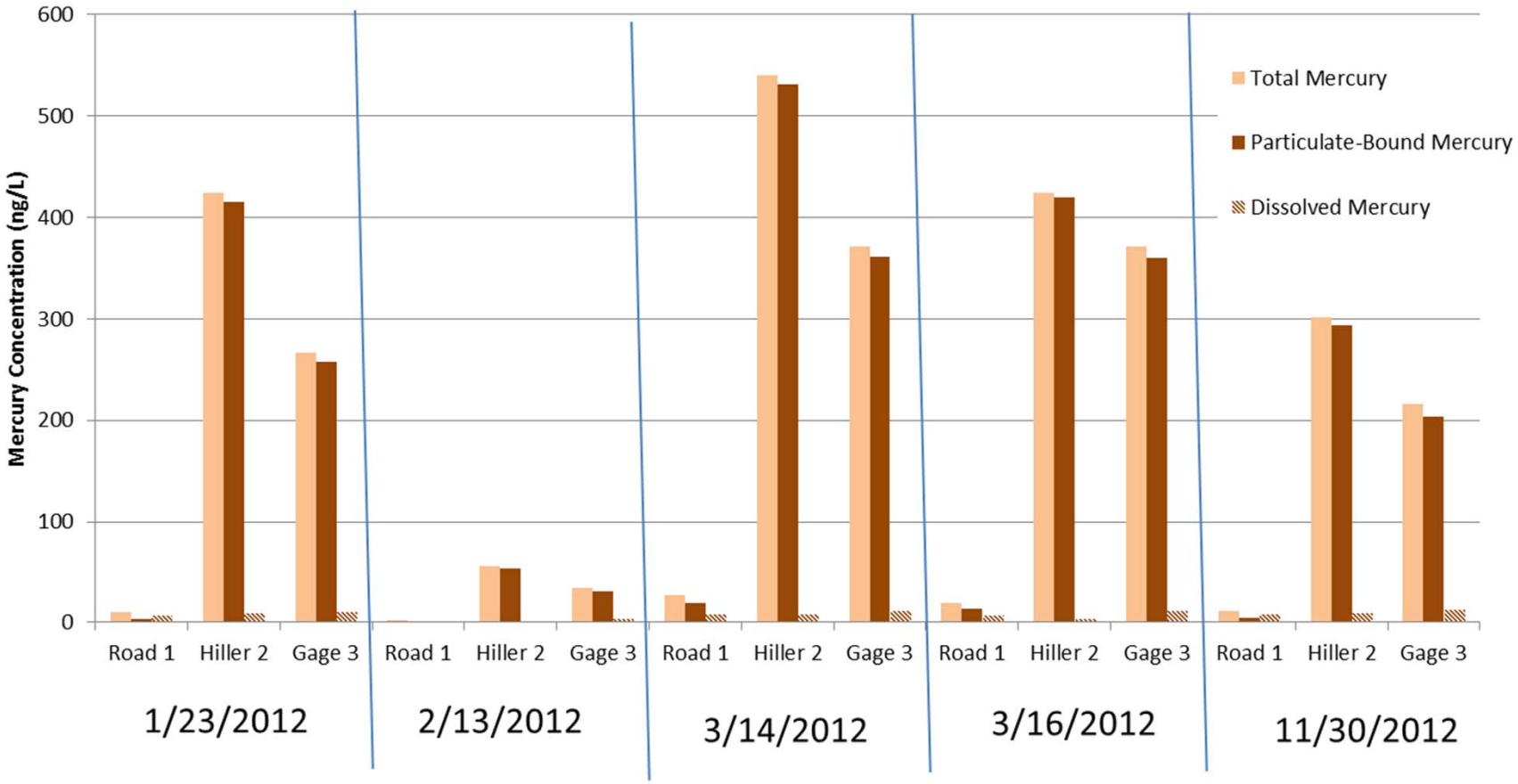
Storm Events
Humbug Creek WY 2012 and 2013



Water Quality Critical Questions

Water Quality Characterization and Assessment

CQ1: What is the annual sediment and mercury load in Humbug Creek? How much of that load is from storm events?

CQ 1: the annual sediment load is ~500 tons/year and the annual mercury load is 100 g/year.

CQ2: Is mercury in Humbug Creek transported primarily as particulate bound mercury rather than in its dissolved form?

CQ2: The mercury in Humbug Creek is primarily in particulate bound form-not dissolved

CQ3: Is the quantity of suspended sediment in Humbug Creek directly correlated with mercury concentration in Humbug Creek?

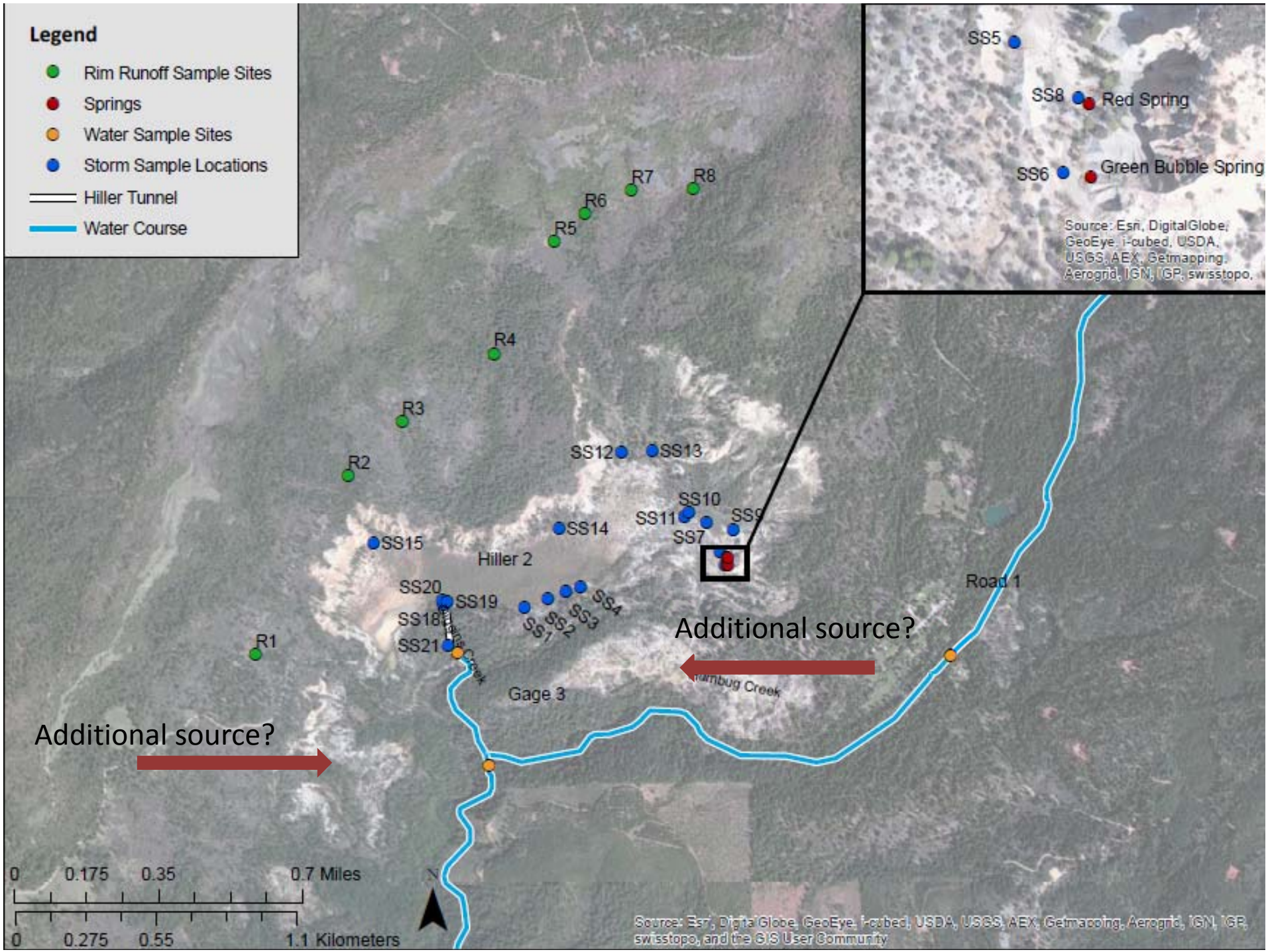
CQ3: The particulate bound mercury is highly correlated with total suspended sediment in Humbug Creek at Gage3 site ($R^2=0.88$, $n=16$).

CQ4: Is Diggins Creek a significant source of sediment, mercury and/or other metals to Humbug Creek? How is the water quality at the Gage3 site different than the Road1 site?

CQ4: Humbug Creek has lower levels of metals upstream of Diggins Creek (Road1) and significantly higher levels downstream of the confluence with Diggins Creek (Gage3). Diggins Creek is a significant source of impaired water quality to Humbug Creek, it is a source of sediment, mercury, copper, lead, nickel, zinc and iron to Humbug Creek during storm events.

…. How could the Pit be a source of contamination?.....


Photo taken by Dr. David Brown CSU Chico 12/2/2013

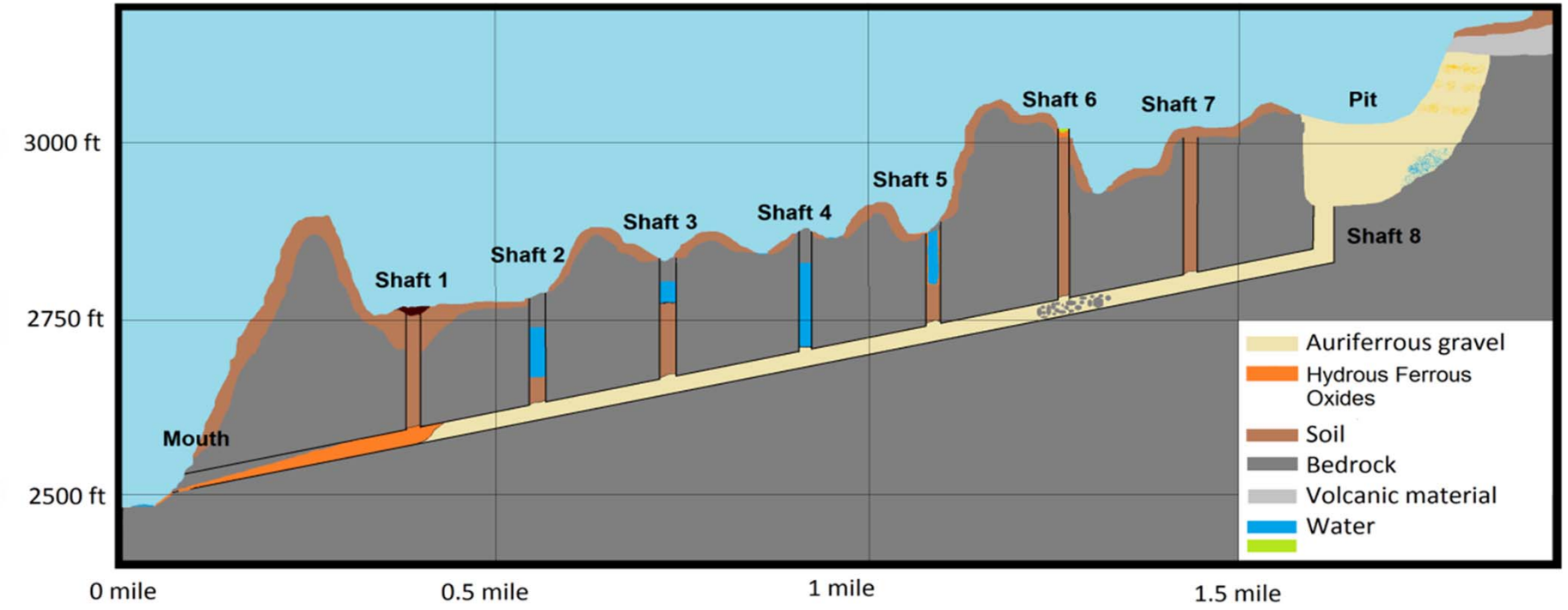

Legend
Rim Runoff Sample Sites
Springs
Water Sample Sites
Storm Sample Locations
Hiller Tunnel
Water Course
SS5
SS8
Red Spring
SS6
Green Bubble Spring
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo,
R1
R2
R3
R4
R5
R6
R7
R8
SS12
SS13
SS10
SS11
SS9
SS7
SS14
SS15
Hiller 2
SS20
SS19
SS18
SS21
SS1
SS2
SS3
SS4
Gage 3
Road 1
Additional source?
Additional source?
0 0.175 0.35 0.7 Miles
0 0.275 0.55 1.1 Kilometers
N
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Water Quality Critical Questions

Additional Features Attributed to Water Quality

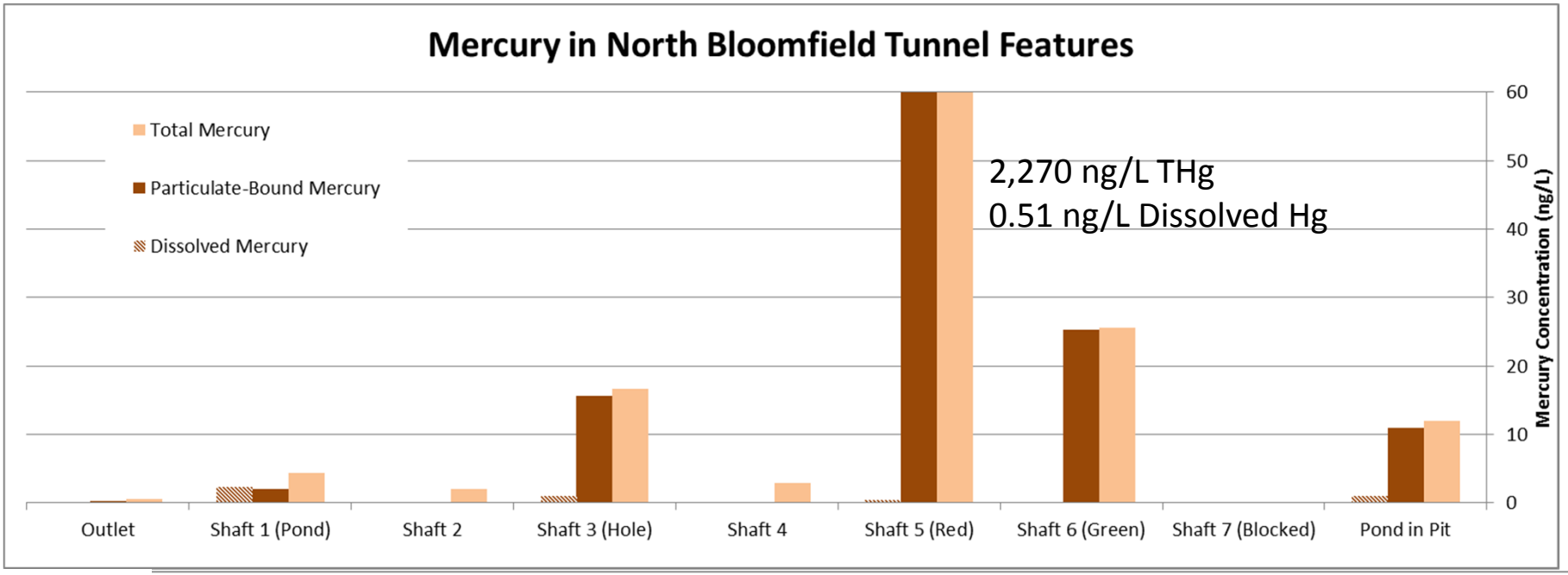
CQ10: Is the North Bloomfield Tunnel contributing to degraded water quality in Humbug Creek?

Conceptual Model
of the North Bloomfield Tunnel and associated access shafts

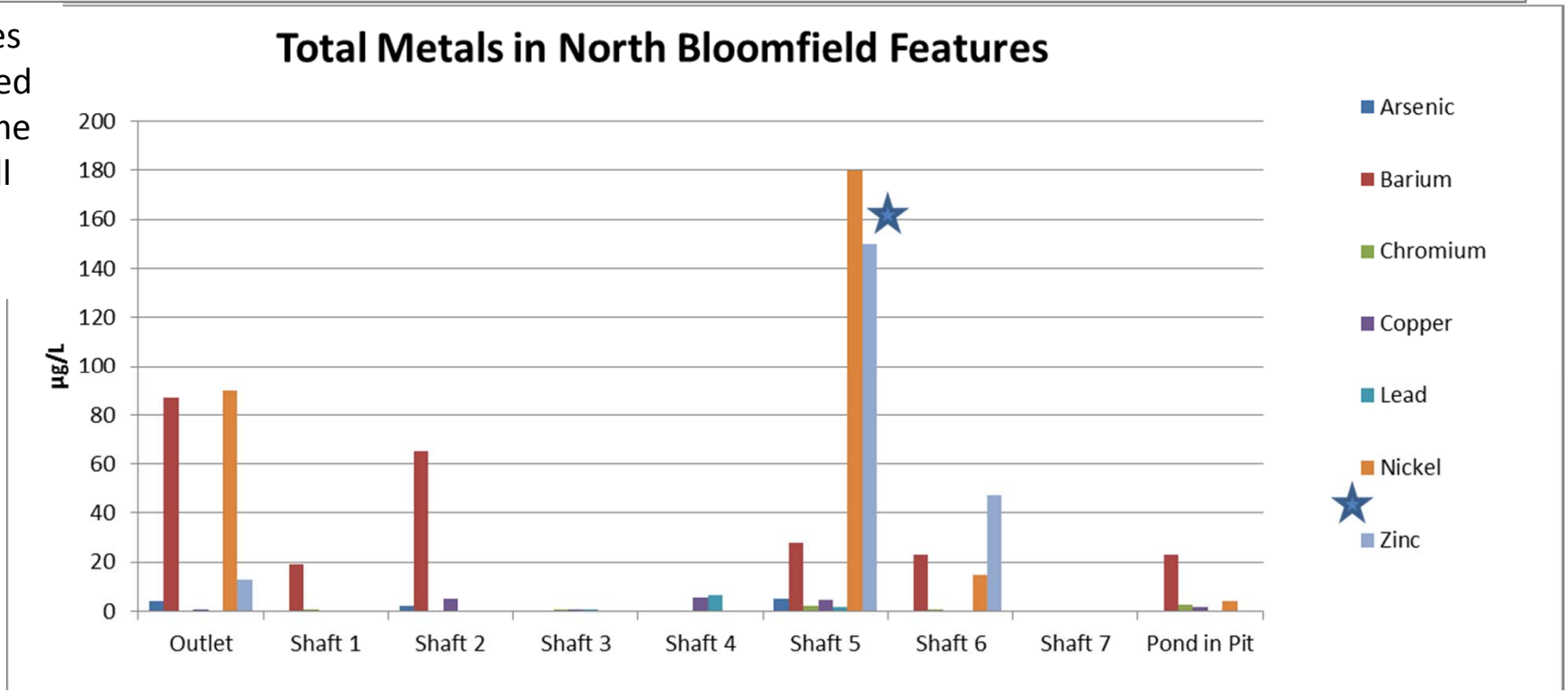


The Red Shaft

Photos taken by C. Monohan 5/20/2012



Samples collected one time from all access shafts.



Water Quality Critical Questions

Assessment of Attributing Features

CQ10: Is the North Bloomfield Tunnel contributing to degraded water quality in Humbug Creek?

CQ10: The North Bloomfield Tunnel at Shaft 5 (the Red Shaft) has elevated levels of mercury, arsenic, nickel, and zinc and at the outfall has elevated levels of nickel and zinc.

Parameter	**Units**	**Peak Measured Value**			**Background Value**	Example Benchmark Values	
		Hiller Tunnel Outfall	Shaft 5	NB Tunnel Outfall		Fish and Ag	Source
TSS	mg/L	2,940			55	450	Narrative Chemical Constituents Objective
Copper	µg/L	130	4.5	0.6	7	9	CTR Criterion Continuous Concentration
Iron	µg/L	39,000			2,800		
Lead	µg/L	30	1.5	<1	0.7	2.5	CTR Criterion Continuous Concentration
Mercury	µg/L	540	2.7	<0.001	27	95%	Reduction of existing input, Cash Creek TMDL
Nickel	µg/L	110	180	90	12	52	CTR Criterion Continuous Concentration
Zinc	µg/L	130	150	13	<10	120	CTR Criterion Continuous Concentration

Preliminary Management Recommendations

- Reduce Turbidity in Humbug Creek
- Reduce Metal Contamination in Humbug Creek
- Reduce Erosion in the Pit
- Address Physical Hazards

Where?

1) Hydraulic Mining Pit
2) Red Shaft
3) North Bloomfield Tunnel –water and metals
4) North Bloomfield Tunnel-physical hazards

1) Hydraulic Mining Pit

– Management of Sediment and Metals Discharge

Option A) Divert Surface Water Inflow to Hydraulic Pit

Option B) Retain Sediment in Hydraulic Pit

Option C) Dewater Hydraulic Pit

Option D) Treat the Discharged Water

Option E) Some combination of all of the above

2) Shaft 5 (Red Shaft)

– Management of Water and Metals Discharge

Option A) Monitor Water Quality

Option B) Re-route Trail

Option C) Fence Access Shaft

3) North Bloomfield Tunnel Outfall

– Management of Water and Metals Discharge

Option A) Monitor Water Quality

Option B) Bat Friendly Gate

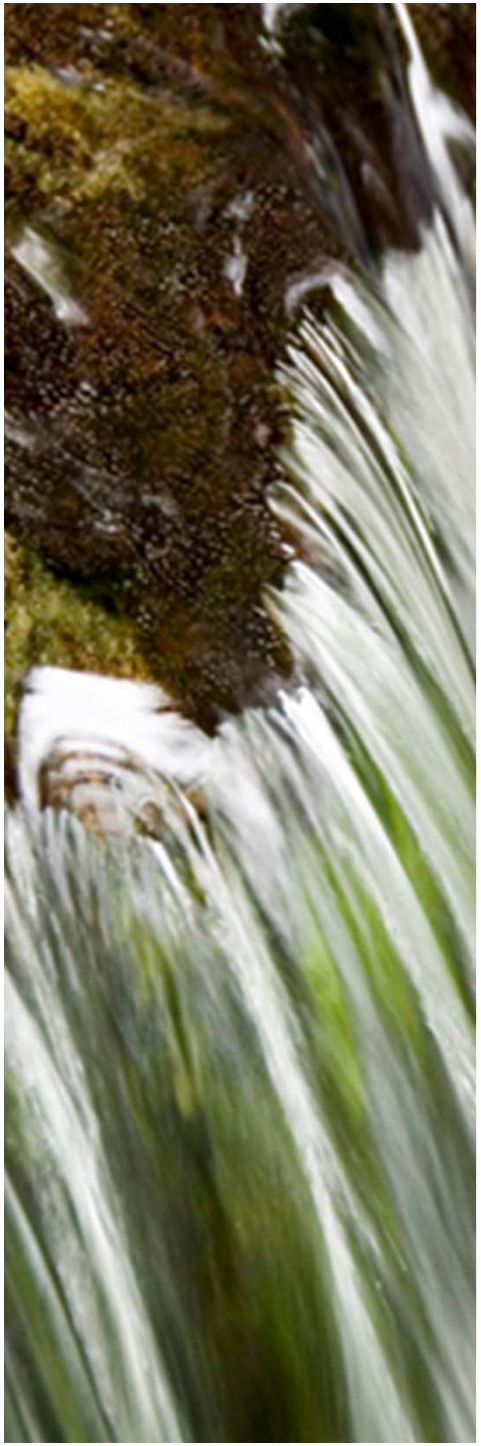
4) Tunnel and Access Shafts

– Management of Physical Hazards

Option A) Fence Hazardous Features

Option B) Plug Hazardous Features

Photo taken by C. Monohan 3/9/12



Current Status

- Watershed Assessment Document is complete
- DWR funded work on erosion and metal sources with USGS is on-going
- Cultural Inventory is underway
- Preliminary Management Recommendations have been proposed for consideration by Parks
- Work with Parks to seek funding to identify and fill data gaps, conduct planning and permitting and to implement solutions.

Acknowledgements

- Department of Parks and Recreation
- California State University Chico
- Sierra Nevada Conservancy
- Department of Conservation
- Sonoma State University
- Department of Water Resources
- United States Geological Survey
- Holdrege and Kull


Thank You
US EPA
HUMBUG TRAIL

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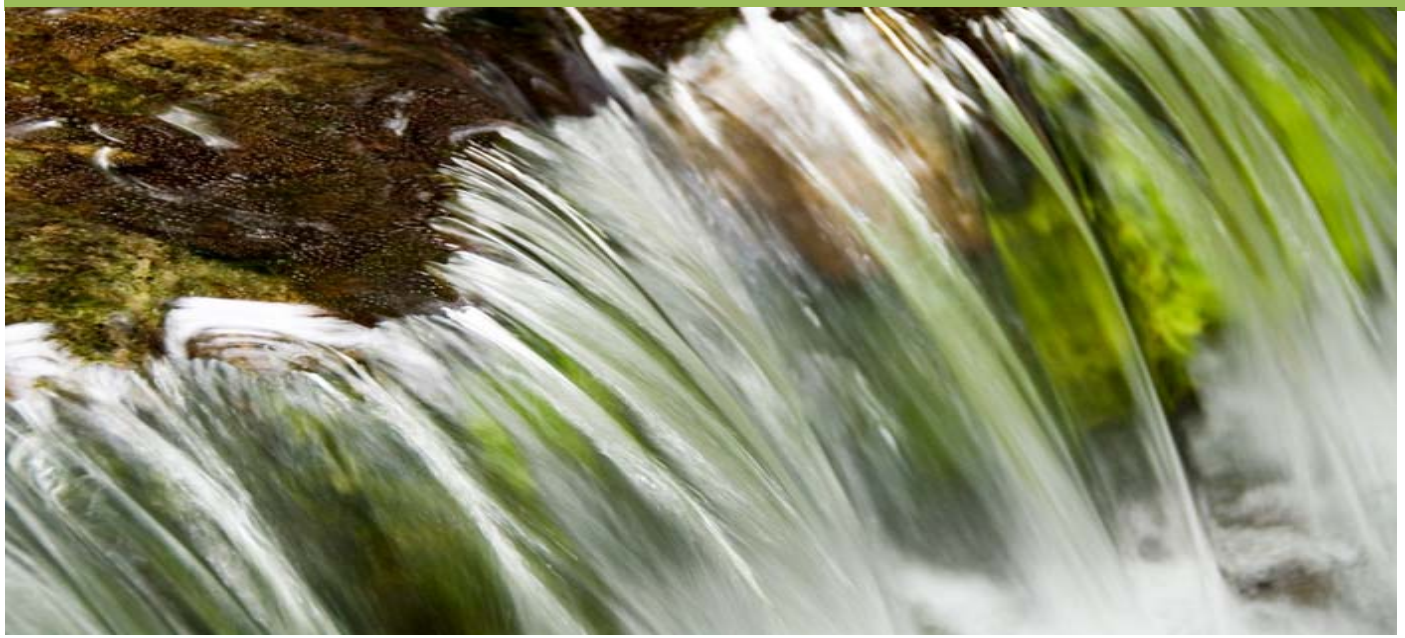

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