Identifying Spatial Patterns of Mercury and Methylmercury Concentrations and Loads Downstream of Historical Mining Areas in the Western USA

ICMGP 2024

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Objective

- To compare Hg and MeHg concentrations between three watersheds in the Pacific Northwest of the USA
- To compare Hg loading between three watersheds in the Pacific Northwest of the USA
- To identify patterns of MeHg production and THg loading associated with various watershed parameters

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Three Mines, Three Watersheds

- Black Butte Mine, Oregon – Superfund site with three operable units and approx. 25 yrs of assessment. Main risk - Hg in fish in Cottage Reservoir. (USEPA, USGS, CDM Smith, ODEQ,…others)
- Jordan Creek/Owyhee Mining District, Oregon/Idaho – Several studies of specific mine sites, Owyhee Reservoir, and 2 loading assessments. Main risk – Hg in fish in Antelope and Owyhee reservoir. (USEPA, USDOI, IDEQ, ODEQ, others)
- Cinnabar Mine, ID – Removal action, Preliminary assessment, and one loading study. Main risk – Hg in fish in downstream rivers (USEPA, USFS)

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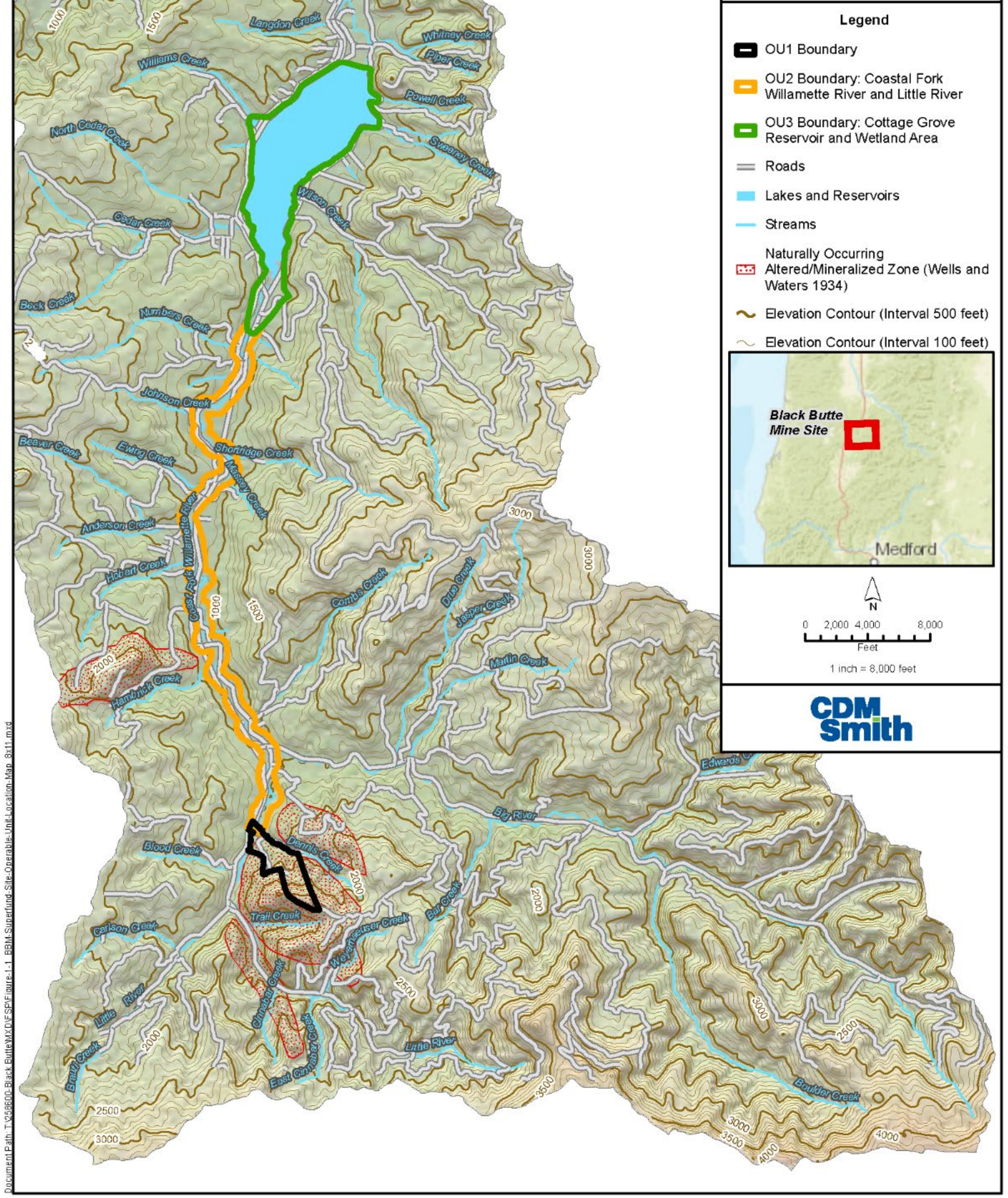
Black Butte Mine

- Hg Source – Legacy Hg mine (1890s to 1960s, intermittent operation)
- Source Material – Roasted ore/tailings, historic Hg vapor deposition
- Annual Precipitation ≈ 46 inches/117 cm
- Study Area Water Body – Coast Fork Willamette River
  - Max Discharge – 3040 cfs (USGS gage 2023/2024)
  - Min Discharge – 6 cfs (USGS gage 2023/2024)
- Stream Length ≈ 9 miles/15 km (not including reservoir)
- Elevation change in study area about 500 ft/150 m – average stream gradient ≈ 0.027 ft/ft
- Source material uncontrolled for approx. 100 yrs, deposited in Coast Fork Willamette River and in Cottage Grove Reservoir. CGR is used for flood control and recreation reservoir (about 9 miles downstream of mine)
- Significant Hg loading from high discharge events

Figure 1-1

Black Butte Mine Operable Unit Location Map



Jordan Creek/Owyhee Mining Area

- Hg Source – Legacy Au and Ag mining with amalgamation (late 1800s to 1950s).
- Source material – Elemental Hg use for amalgamation, minor natural cinnabar deposit
- Annual Precipitation ≈ 11 inches/28 cm (lowland area), 22 inches/56 cm (mining area)
- Study area water body – Jordan Creek, Antelope Reservoir
  - Max Discharge – 1800 cfs (USGS gage 2002/2004)
  - Min Discharge – 1 cfs (USGS gage 2002/2004)
- Stream Length ≈ 75 miles/120 km
- Elevation change in study area about 4200 ft/1300 m – average stream gradient ≈ 0.011 ft/ft
- Source material is elemental Hg in sediment in Owyhee Mining Area, uncontrolled for approx. 100 yrs, Jordan Creek flows to Owyhee River which flows to Owyhee Reservoir used for flood control and recreation aprox. 125 miles/200 km downstream of mining area. Jordan Creek flow is significantly affected by irrigation withdrawal.

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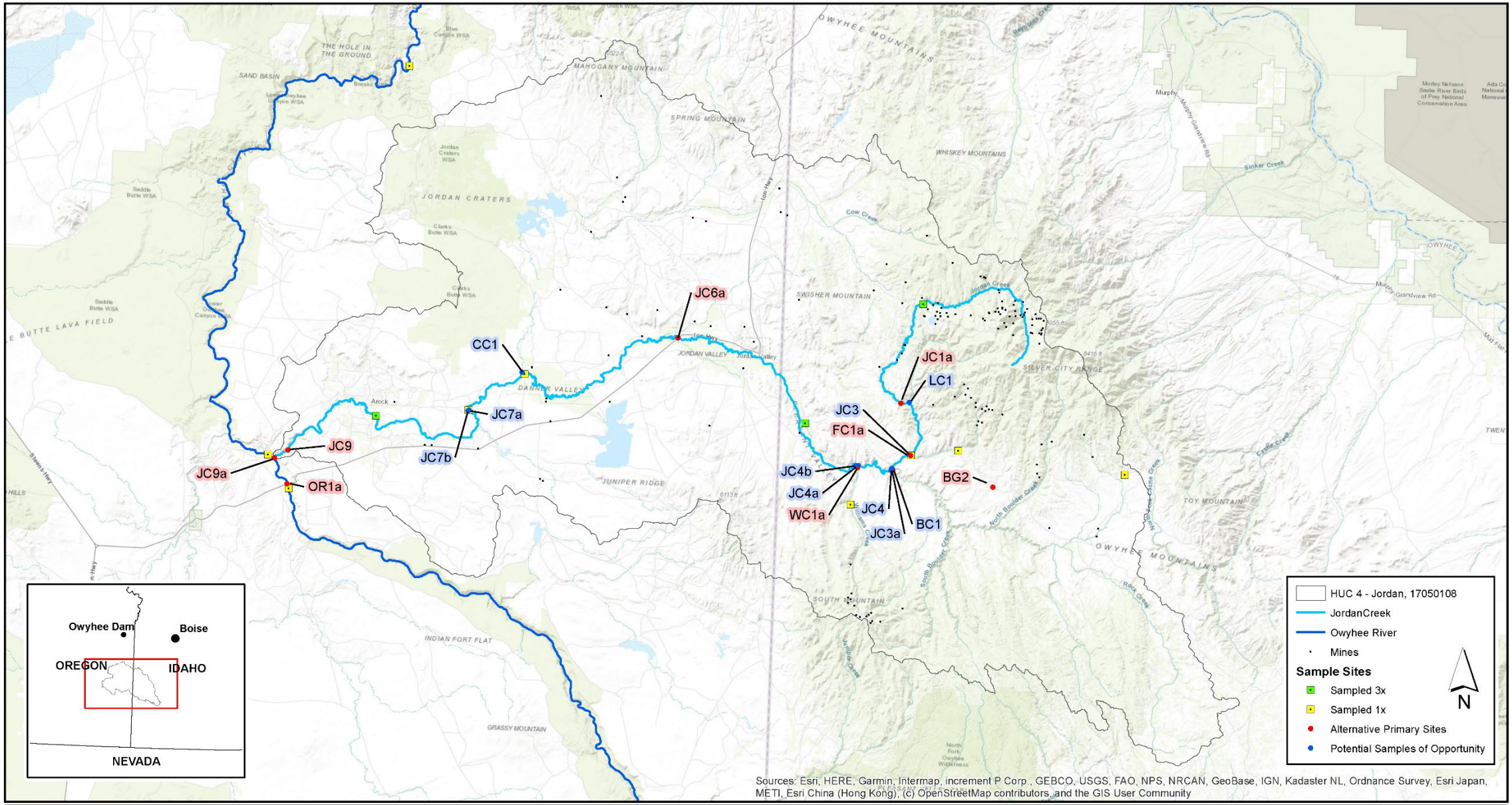


Preliminary Assessment Program
Idaho Department of Environmental Quality
1410 N. Hilton St., Boise, ID 83706
208-373-0502

Jordan Creek Expanded Site Inspection

Malhuer County, Oregon & Owyhee County, Idaho

Project in coordination wtih EPA Region 10 and Oregon Department of Environmental Quality

Alternate Sample Locations

See tables in related sampling plan for more detail.

0 2 4 8 Miles

Note: Some items may not be to scale.

Drawn by: *K. Kostka*

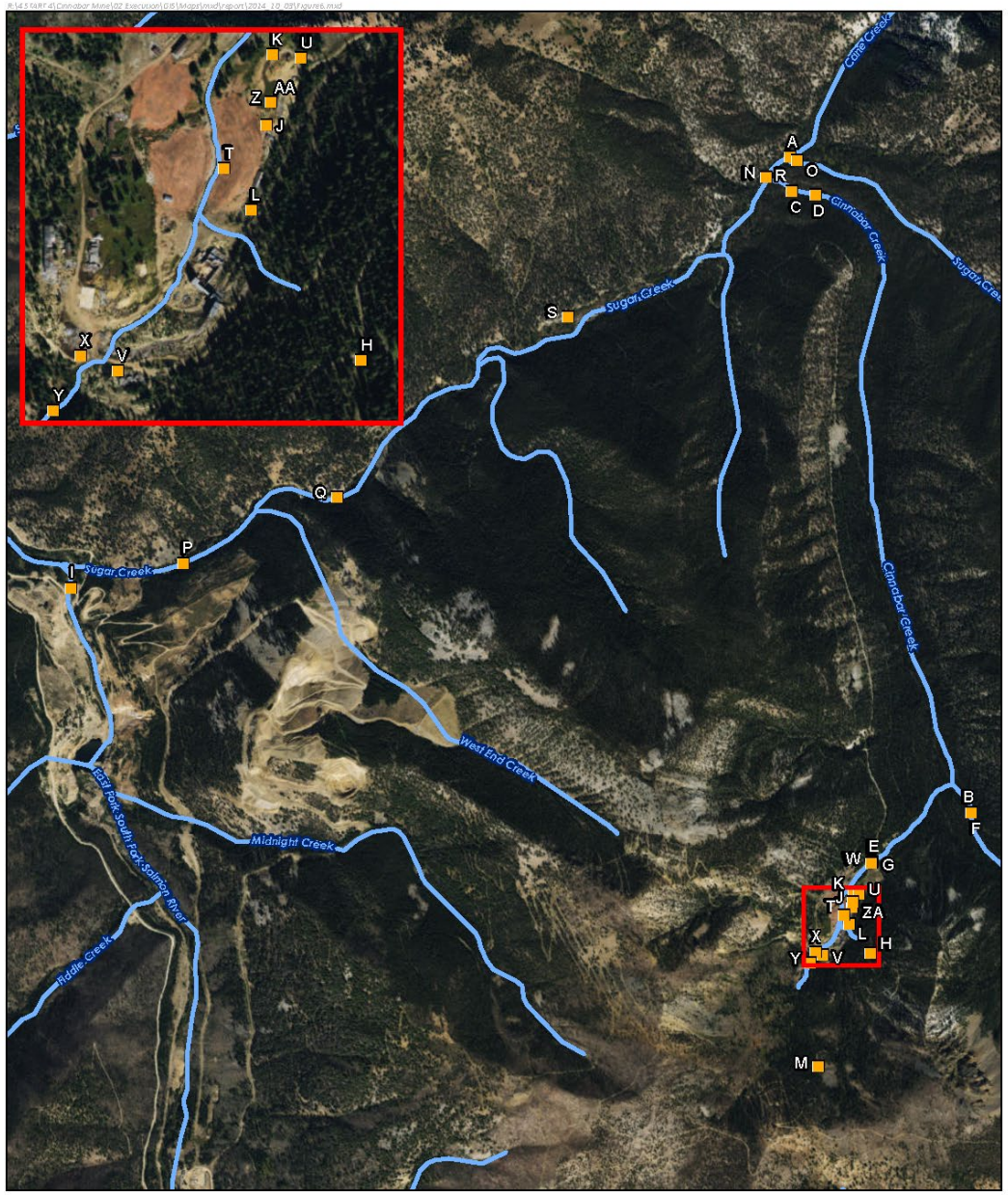
Date: *3/5/2021*

Silver City, Idaho

Jordan Creek below canyon stretch (between DeLamar bridge and Flint Rd bridge)

Cinnabar Mine

- Hg Source – Legacy Hg mine (1925 to 1958)
- Source material – Roasted ore/tailings, historic Hg vapor deposition
- Annual Precipitation ≈ 27 inches/70 cm
- Study area water body – Cinnabar Creek and Sugar Creek
  - Max Discharge – 92 cfs (USGS gage 2023/2024)
  - Min Discharge – 3 cfs (USGS gage 2023/2024)
- Stream Length ≈ 6 miles/10 km
- Elevation change in study area about 1700 ft/500 m – average stream gradient ≈ 0.056 ft/ft
- Source material uncontrolled for approx. 100 yrs, downstream transport of Hg into Sugar Creek and Salmon River.



USGS Sample Locations

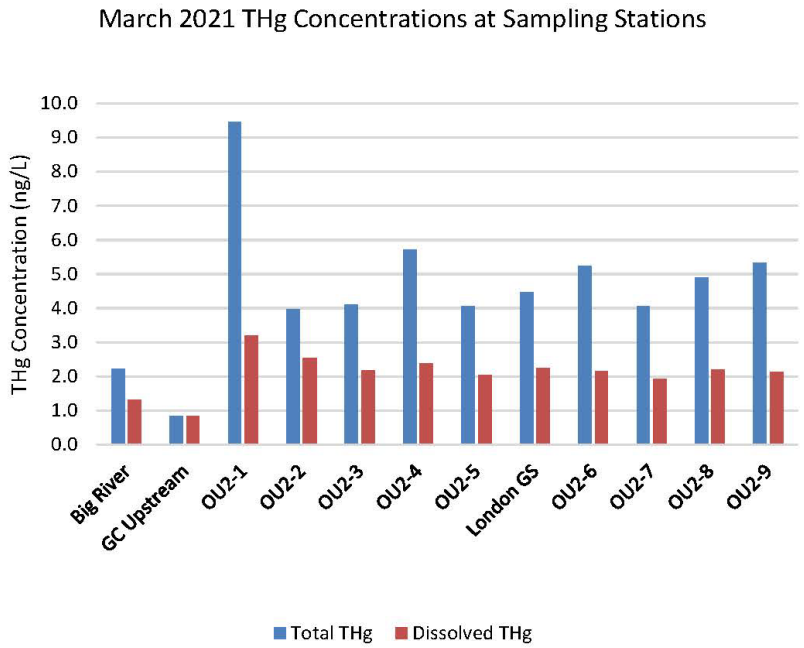
Figure 2-11
2014 USGS Sample Locations
Cinnabar Mine
Yellow Pine, Idaho

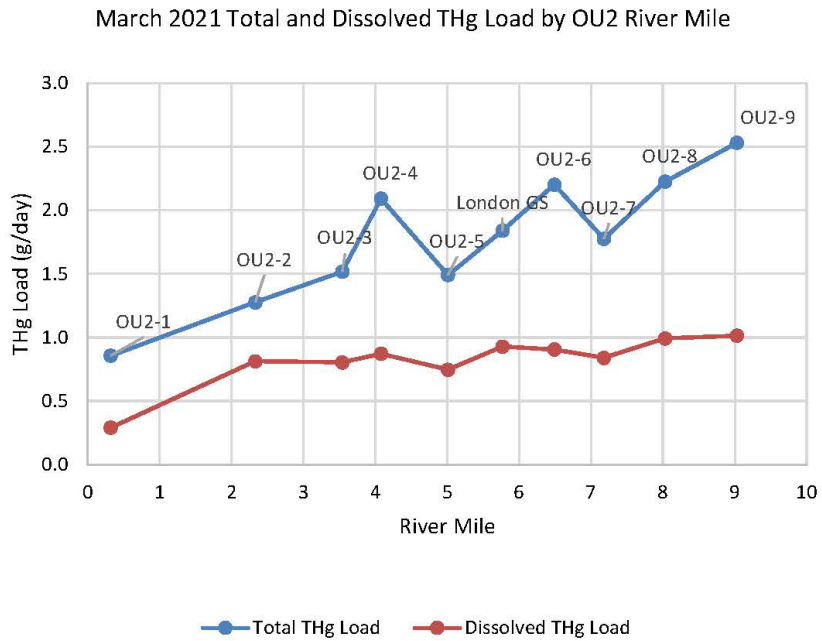
0 500 1,000 2,000 Feet

ecology and environment, inc.

(USGS, Holloway)

(USGS, Holloway)

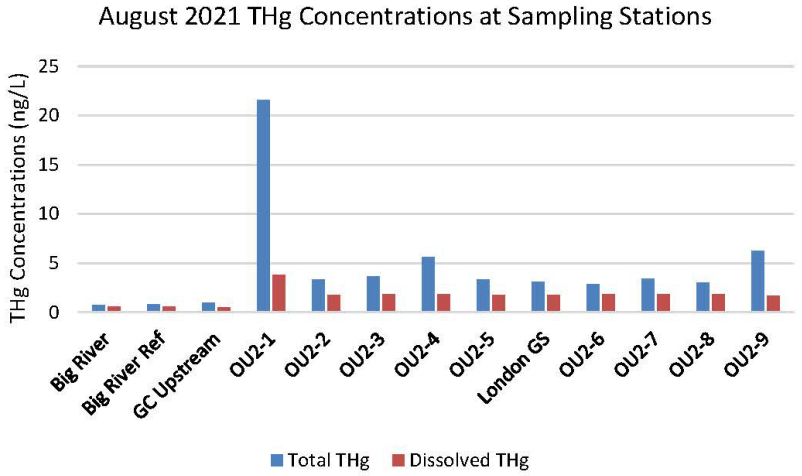


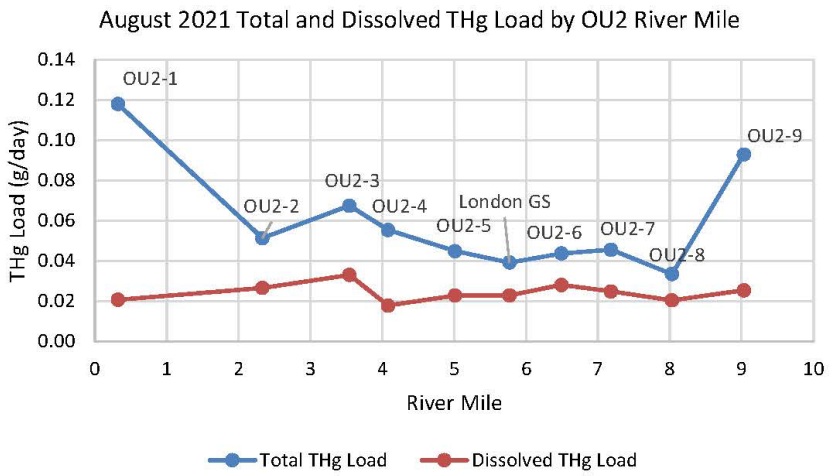


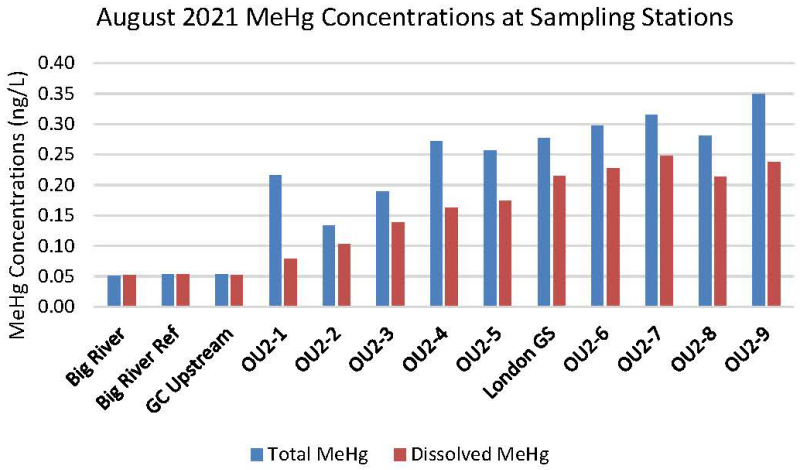
Notes:
1. Total and dissolved MeHg were not detected in any of the samples collected during the March 2021 sampling event.

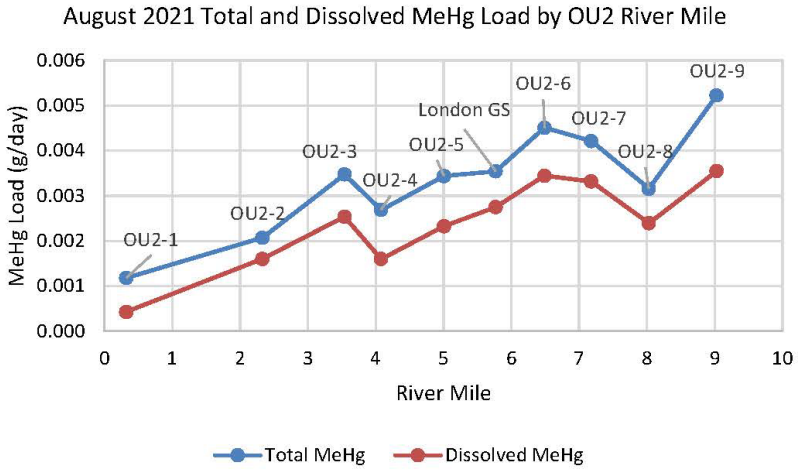
CDM Smith

Figure 14
March 2021 THg Concentrations and Loading Spatial Variation
Black Butte Mine Superfund Site







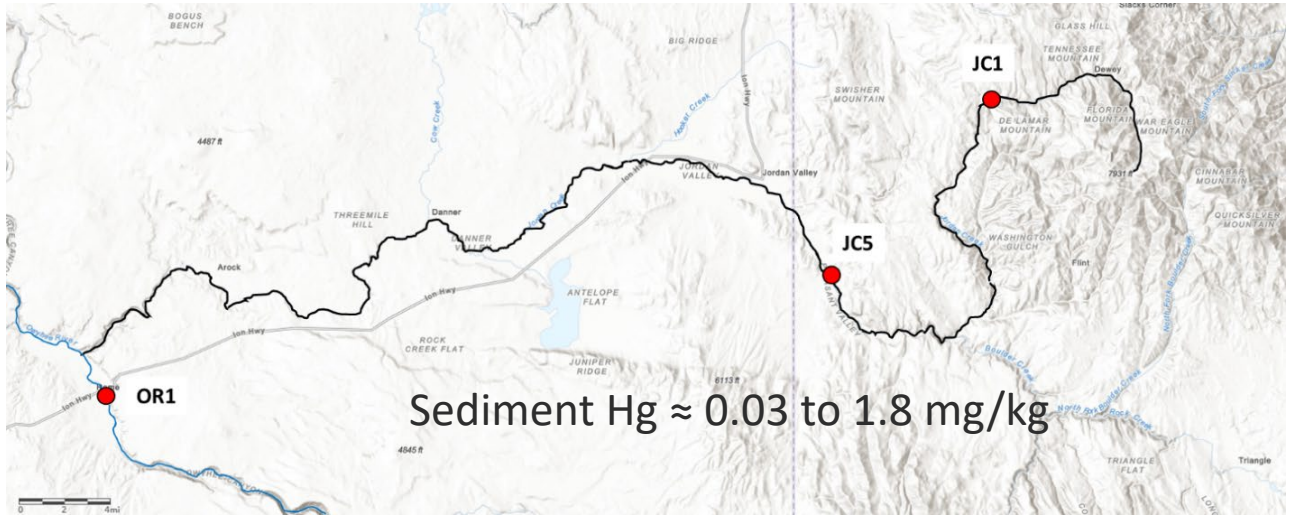


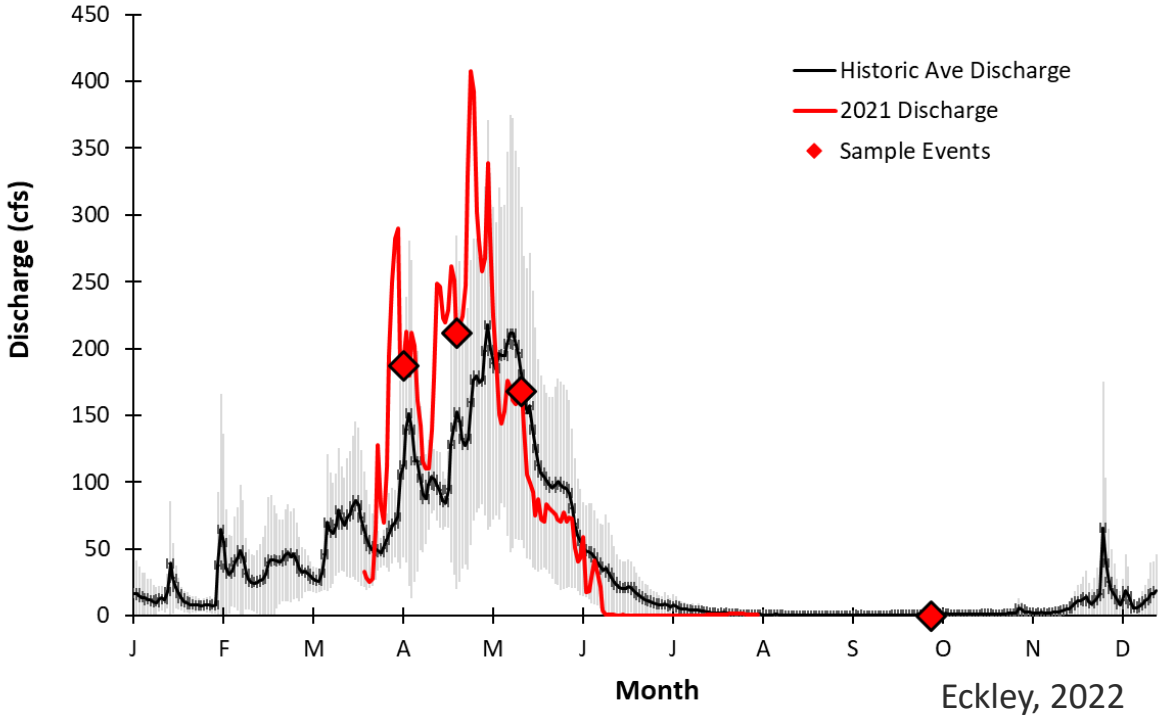
Notes:
1. Total and dissolved MeHg were not detected at the background stations (Big River, Big River Reference, and Garoute Creek Upstream) and concentrations are plotted at the method detection limit of 0.05 ng/L for those locations..

CDM Smith

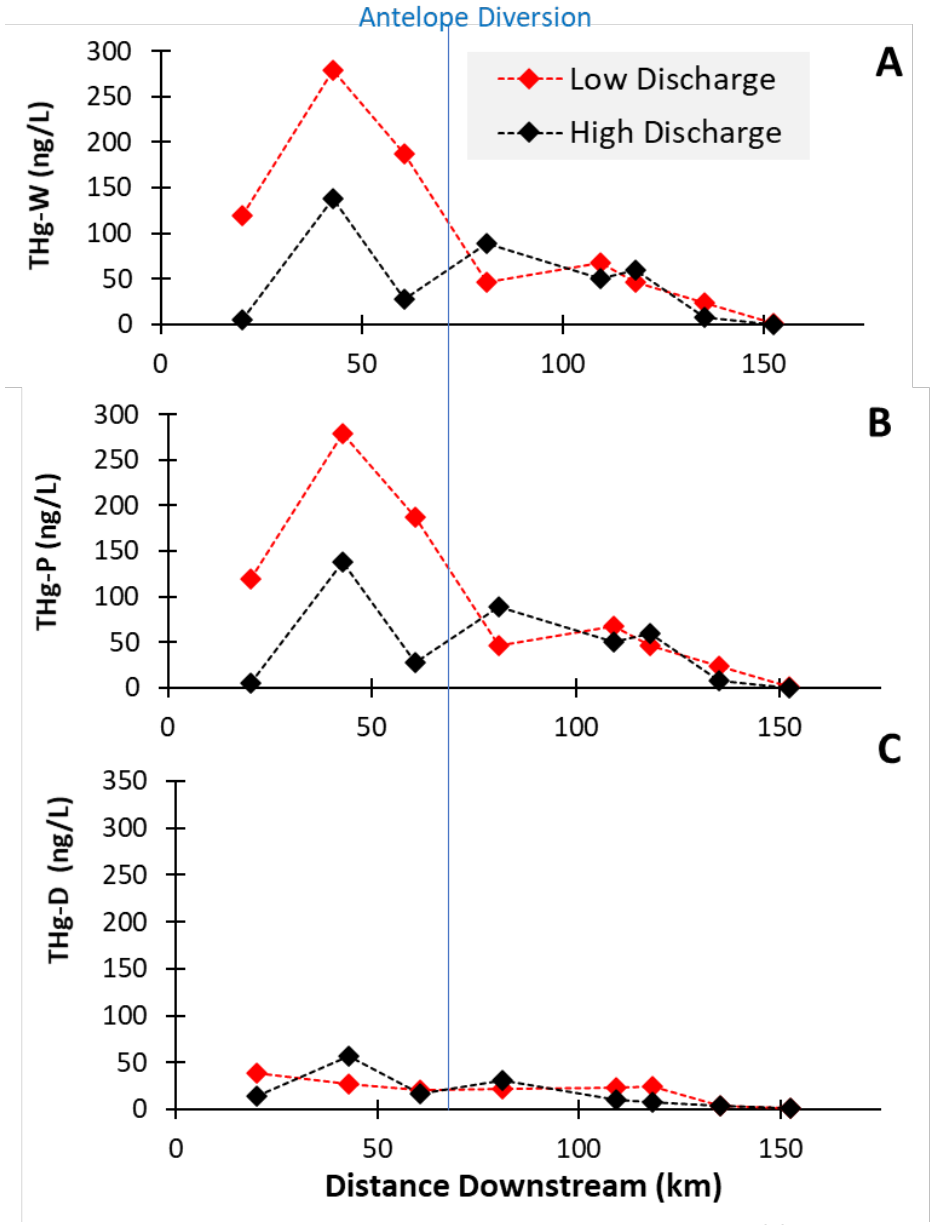
Figure 15
August 2021 THg and MeHg Concentrations and Loading Spatial Variation
Black Butte Mine Superfund Site

Jordan Creek/Owyhee Mining Area

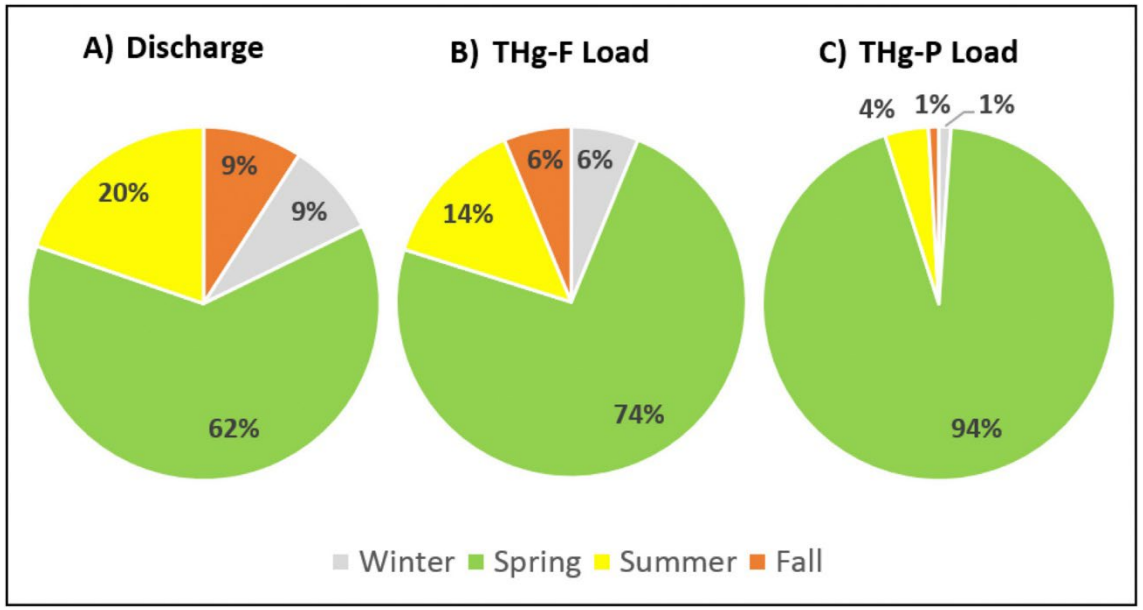




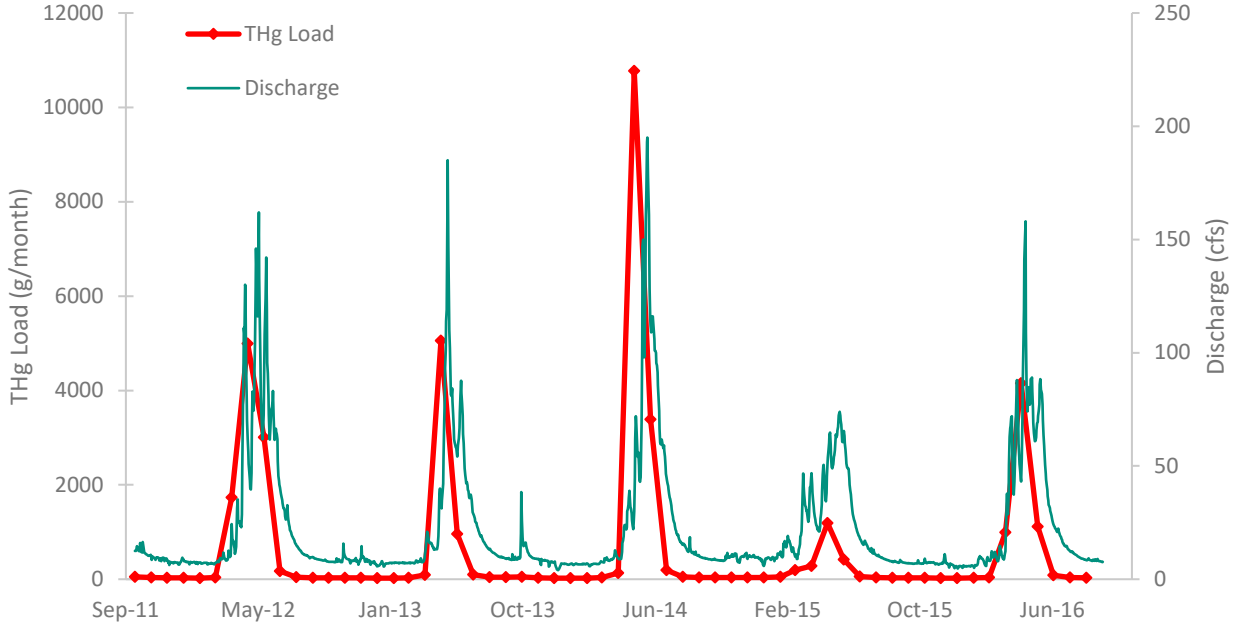
Eckley, 2022



Eckley, 2022



Eckley, et al, 2020



Eckley, et al, 2020

- MeHg concentrations near mine source material was low in Cinnabar Creek
- MeHg in on-site pond was elevated
- Total Hg concentrations are elevated in surface water near the source
- Small fraction of Total Hg in the creek is transformed to MeHg and exported in stream water
- No large reservoir downstream/proximal to site
- Largest discharge during spring when snowpack melts
- Site not fully characterized

Summary

- Uncontrolled source materials support migration of Hg, followed by deposition in potential methylating environments
- MeHg loading increases moving downstream
- Loading is dominated by episodic high discharge events
- Low energy/depositional areas have increased MeHg production
- Water withdrawal from creeks for both reservoir and for direct irrigation supports MeHg production in reservoir and residual creek
- Nutrient loading associated with agriculture supports MeHg production
- Understanding specific watershed parameters that influence MeHg production may support targeted remedies

Data Gaps/Future Study

Black Butte Mine

- Additional work on MeHg production in periphyton and depositional zones
- Treatability studies
- Reservoir management as a remedy
- Dendrochronology study to determine full source area

Jordan Creek/Owyhee Mining Area

- Historic spills in Owyhee Mining Area
- Hg fate and transport in terrestrial environment after irrigation
- Dredge spoils in Jordan Creek, source area, increased methylation with ponding
- Natural source of HgS at Cinnabar Butte SE of Au and Ag ore body
- Runoff from active mining at DeLamar mine, includes land application of treated wastewater

Cinnabar Mine

- Impacts of historic site drainage issues such as dam failures or wastewater disposal during operations
- Do loading assessment with MeHg analysis similar to BBM
- Performance of Removal Action
- Potential Superfund Listing

References

- CDM Smith; Mercury Loading and Surface Water Data Evaluations in Operable Unit 2, Black Butte Mine Superfund Site
- Eckley, Chris; Draft Data Quality Objective -1 Memo; Jordan Creek Historic Mining Area Reassessment; USEPA/ODEQ/IDEQ; 12/23/2022
- Ecology & Environment; Site Inspection Owyhee Mining District; USEPA Region 10 START; April 2020
- Ecology & Environment; Final Trip Report - Cinnabar Mine; USEPA Region 10 START; December 2014
- USEPA; Site Investigation Closure Memo - Cinnabar Mine – 2/13/2019
- Eckley, et al; Effect of Organic Matter Concentration and Characteristics on Mercury Mobilization and Methylmercury Production at an Abandoned Mine Site; 12/20/2020


Questions