

North Fork Iron Creek Copper Study

**Investigation of Copper Concentrations in Surface Water,
Sediment, and Soil.**



**State of Idaho
Department of Environmental Quality**



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Acknowledgements

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Cover Photo: North Fork Iron Creek within the patent mining claim, looking downstream.

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Executive Summary

North Fork Iron Creek is a copper-impaired mountain stream in the Middle Salmon River–Panther Creek subbasin in central Idaho. The Idaho Department of Environmental Quality (DEQ) collected surface water, soil, and stream sediment samples upstream, within, and downstream of an existing mine site to investigate spatial variation and potential sources of copper. Surface water copper concentrations within and downstream of the mining claim property were approximately 50 times higher than the upstream background concentrations. Similarly, sediment and soil copper concentrations were approximately 100 to 200 times higher than background. DEQ’s results confirm the continued copper impairment of North Fork Iron Creek and provide higher spatial resolution of surface water copper concentrations. These results also show that copper-contaminated streambed sediment and bank material likely serve as primary sources of copper to surface water.

Introduction

Copper (Cu) is an uncommon but important contaminant of concern for surface waters in Idaho. Approximately 50 miles of rivers and stream are currently known to exceed Idaho's water quality criteria for Cu, and these water bodies are typically associated with historical mining and active Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) remediation sites. Beyond natural weathering of Cu rich minerals, Cu can enter surface waters through several pathways, including direct seepage connection, shallow groundwater interaction, and runoff from exposed mining wastes. The subsequent fate and transport of copper in the freshwater system can be very complex and dependent on several physical, chemical, and hydrologic conditions of a given site (Smith 2007).

Cu contamination in surface water is a concern because Cu can be highly toxic to aquatic organisms, even at low concentrations. The gill surface tissue in aquatic biota can provide biological receptors for bioavailable Cu, which makes this metal particularly toxic to aquatic organisms (Eisler 1998, Scannell 2009). The bioavailability of Cu is highly dependent on water chemistry and Cu speciation (Scannell 2009). To account for this, Idaho's numeric copper criteria for aquatic life are derived using the Biotic Ligand Model (BLM), which requires site-derived chemistry data (Windward 2019, DEQ 2024).

North Fork Iron Creek (NFIC; AU ID17060203SL049_02) is a copper-impaired stream in the Middle Salmon River-Panther Creek subbasin in central Idaho. In 2019, the Idaho Department of Environmental Quality (DEQ) determined unpermitted discharges from historical mining adits were reaching NFIC. These mining adits are located within patented mining claims adjacent to NFIC. Water sampling upstream and downstream of the mining claim revealed Cu exceeded both acute and chronic Cu criteria downstream of the mining property—Cu did not exceed the criteria above the mining property. As a result, DEQ added NFIC to the Clean Water Act § 303(d) list as impaired by copper in 2022 (DEQ 2022).

To eliminate the unpermitted discharge of adit water, an adit infiltration system was constructed and installed in 2023. To assess the impact of removing the adit discharge from NFIC, additional surface water monitoring was conducted in 2023 (VSE 2024). Despite the completion of the infiltration system, copper concentrations in NFIC continue to exceed water quality criteria downstream of the mining property throughout the season (VSE 2024).

The objective of this study was to better understand the spatial variation and potential sourcing of Cu within the known Cu impairment area of NFIC. We examined the spatial extent of surface water Cu by collecting samples at finer spatial scales than previous efforts. We collected surface water Cu samples at 23 sites in the project area. Sediment and soil were examined as possible sources of Cu. We collected sediment and soil samples at various distances from surface water along five transects, with sites upstream and downstream of the mining claim property. We anticipated water column, sediment, and soil copper concentrations would correspond to the distance from adits and adit waste in the project area.

Methods

Study Area

The majority of NFIC flows through Salmon-Challis National Forest, except for a reach of about 375 meters (m), which flows through the patent mining claim. The mining property is within the headwaters of NFIC, approximately 18 miles southwest of the city of Salmon, Idaho. Little No Name Creek (LNNC) is a small 1st-order perennial tributary of NFIC that also flows through the project area. LNNC consists of several seeps and is not included in the national hydrography dataset or the DEQ assessment database. Within the patented mining claim, there are three adits originally established in the 1970s. Adits 1 and 2 have open portals while Adit 3 is collapsed.

Sample Locations and Collection Methods

Surface Water Sampling

To estimate the linear distribution of Cu in NFIC and LNNC, we collected samples from 20 sites in NFIC and from three sites in LNNC on September 17, 2025. Water samples were collected in new 100-milliliter high-density polyethylene bottles that were triple rinsed in stream water at each site prior to sample collection. All water samples were placed on ice and stored at 4 °C. The samples were shipped to Idaho Bureau of Laboratories, filtered (0.45 micrometer [μm]) in the lab prior to analysis, and analyzed for dissolved Cu using US Environmental Protection Agency (EPA) method 200.8. Water quality sampling sites were assigned with alphanumeric site identification numbers (IDs) where increasing water quality site numbers correspond to sites located sequentially upstream. For example, in NFIC, the first and most downstream sample location was assigned the ID of WQ-01, and IDs progressed to the final and most upstream sampling location of WQ-20.

Sediment and Soil Sampling

To estimate the spatial distribution of Cu in stream sediments and adjacent soils, samples were taken along three perpendicular transects in NFIC and two transects in LNNC. The transect locations were targeted to evaluate the sediment and adjacent soil Cu concentrations for upstream/background conditions, within site conditions, and, for NFIC, immediate downstream conditions. The NFIC transect within the mining claim was selected because of known concerns with adit mine waste rock at this location (Mitchell and Bennett 2014). Sediment samples were collected with a McNeil core sampler in three locations within the wetted width of each transect. Sediment was removed from the core sampler using a clean plastic cup and composited into a single sample for each transect.

In all transects, soil samples were collected from each wetted edge (WE) as well as 2, 5, and 10 meters extending perpendicular from each WE direction. The direction of the transects was based on an upstream-facing orientation. Samples were collected using a clean plastic scoop and placed in a quart-sized zip-top bags. Soil samples were placed on ice and stored at 4 °C.

Sediment and soil samples were shipped to SVL Analytical Inc., dried and sieved in the lab (2 millimeters), and analyzed for total dry weight Cu using EPA method 6010D. Soil sample site IDs include the letter to designate direction (L or R) and the code for transect position (WE, 2, 5, or 10). For example, R-10 means right side (facing upstream) and 10 m from the WE.

Applicable Water Quality Standards and Reference Thresholds

Idaho's copper criteria for aquatic life (IDAPA 58.01.02.210) are derived using EPA's BLM to calculate acute and chronic copper criteria. The BLM was used in *Idaho's 2022 Integrated Report* copper impairment determination for NFIC.

Idaho's water quality criteria for toxic substances have both short-term acute and longer-term chronic standards. In general, acute criteria focus on maximum instantaneous or 1-hour average concentration values and chronic criteria are based on a 4-day average concentration. Idaho's water quality standards presume adequate protection of sensitive aquatic life if these criteria are not exceeded more than once every 3 years.

Because it has previously been determined that Cu concentrations exceed copper criteria in NFIC, additional chemistry samples were not collected for the BLM for each sampling location. We derived estimates of applicable copper criteria from existing data for reference purposes, but these values should not be used to determine water body assessment outcomes.

Aquatic life criteria for Cu were estimated by averaging the water chemistry results of 12 sampling events conducted in 2023 (Table 1; VSE 2024). Water temperature was recorded in the field and default assumed values were used for humic acid fraction and sulfide: 10% and 1.0×10^{-8} milligrams per liter (mg/L), respectively.

To estimate background soil and sediment Cu concentrations, we averaged the concentrations measured from the background NFIC site (Transect 3). For a reference benchmark to indicate values meaningfully above background, the average background was multiplied by 3.

Table 1. Mean chemistry parameters used in the BLM and estimated criteria for each site. Each parameter was averaged from 12 sampling events reported in VSE (2023).

Site Name	pH	DOC	Ca	Mg	Na	K	SO ₄	Cl	Alkalinity	Acute Cu Criteria	Chronic Cu Criteria
	-	(mg/L)							(mg/L CaCO ₃)	µg/L	
North Fork Iron Creek	7.18	2.21	6.61	1.74	2.56	1.2	2.4	0.44	19.8	5.15	3.2
Little Noname Creek	7.28	1.96	20.08	4.18	4.48	1.7	7.4	1.61	64.2	5.35	3.32

Results

Surface Water Copper

In NFIC, dissolved Cu concentrations downstream and within the mining claim exceeded both acute and chronic criteria and were approximately 50 times higher than the upstream background concentrations (Figure 1). All sites near or upstream of the mining claim property boundary had concentrations below both criteria (Figure 2). The upstream sites (WQ-15–WQ-20) had Cu concentrations below the reporting detection limit (1.0 micrograms per liter [$\mu\text{g/L}$]) but still above the method detection limit (0.07 $\mu\text{g/L}$; Figure 2). In LNNC, only the downstream site had concentrations that exceeded chronic criterion (Figure 1 and Figure 3).

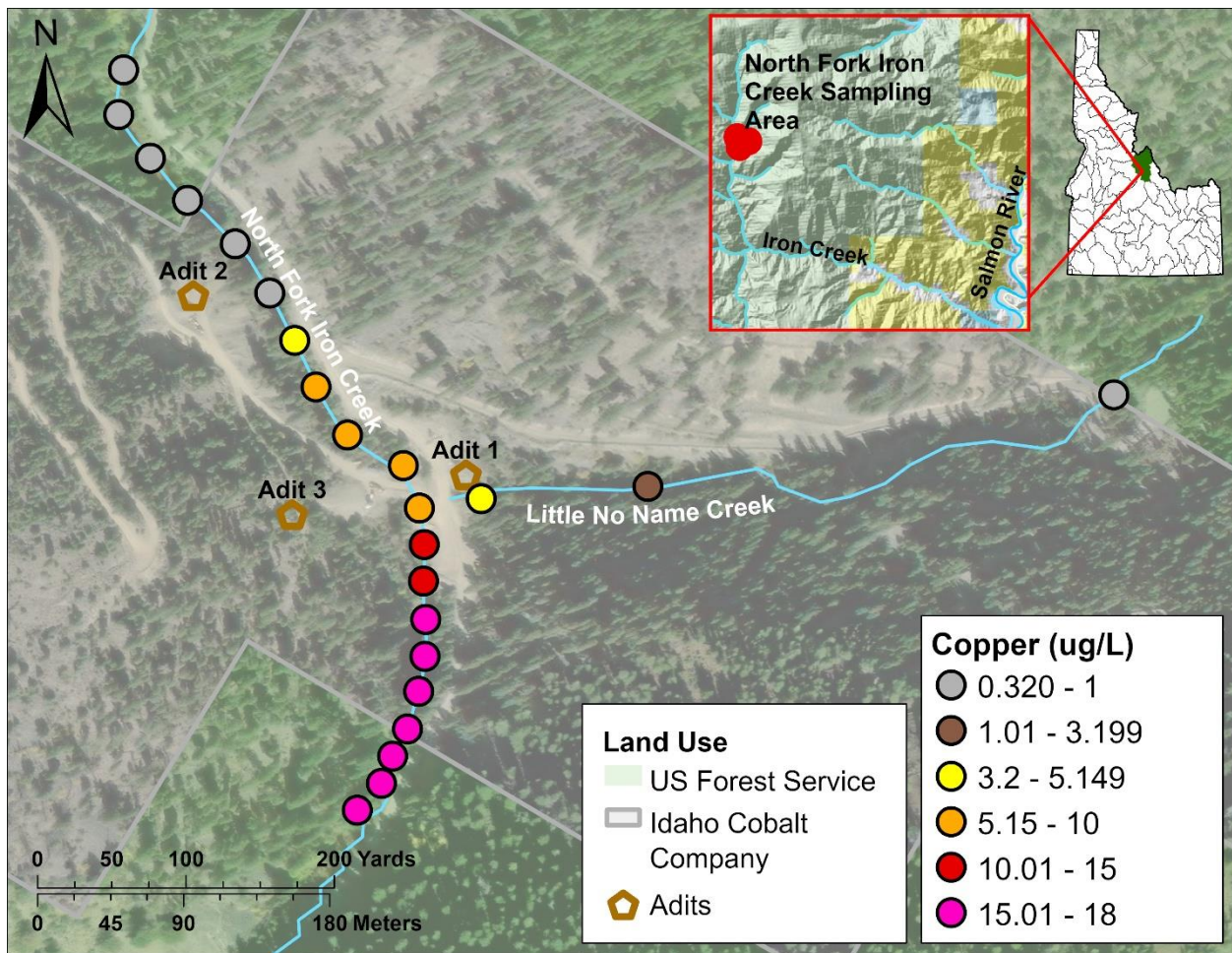


Figure 1. Map of surface water quality locations and dissolved Cu results for NFIC and LNNC. The color of the circles corresponds to the measured Cu concentration. The grey shaded area delineates the patented mining claim property boundaries with Forest Service land shaded in green.

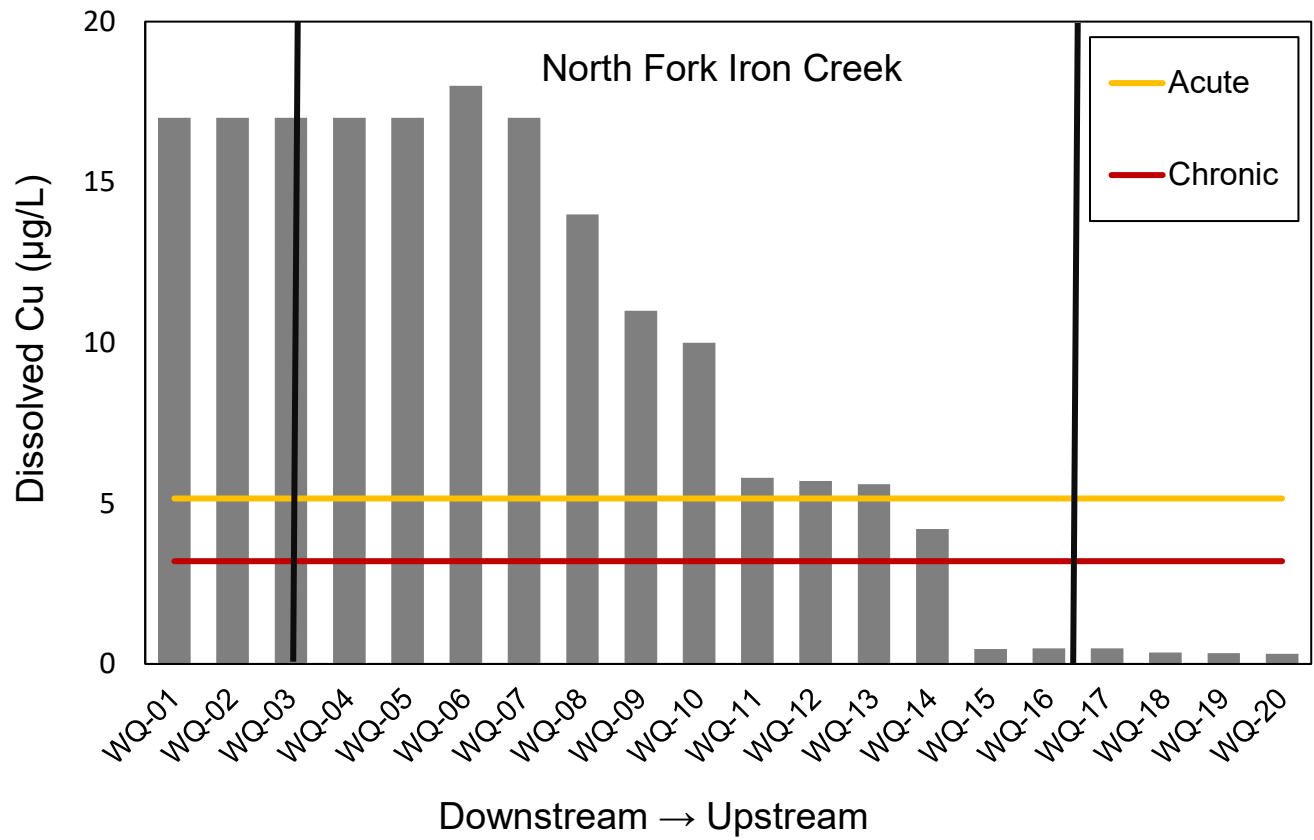


Figure 2. Dissolved Cu surface water concentrations in NFIC. The orange/yellow line designates the acute criterion, and the red line designates the chronic criterion. The black vertical lines designate the lower (left) and upper (right) boundaries of the mining claim property.

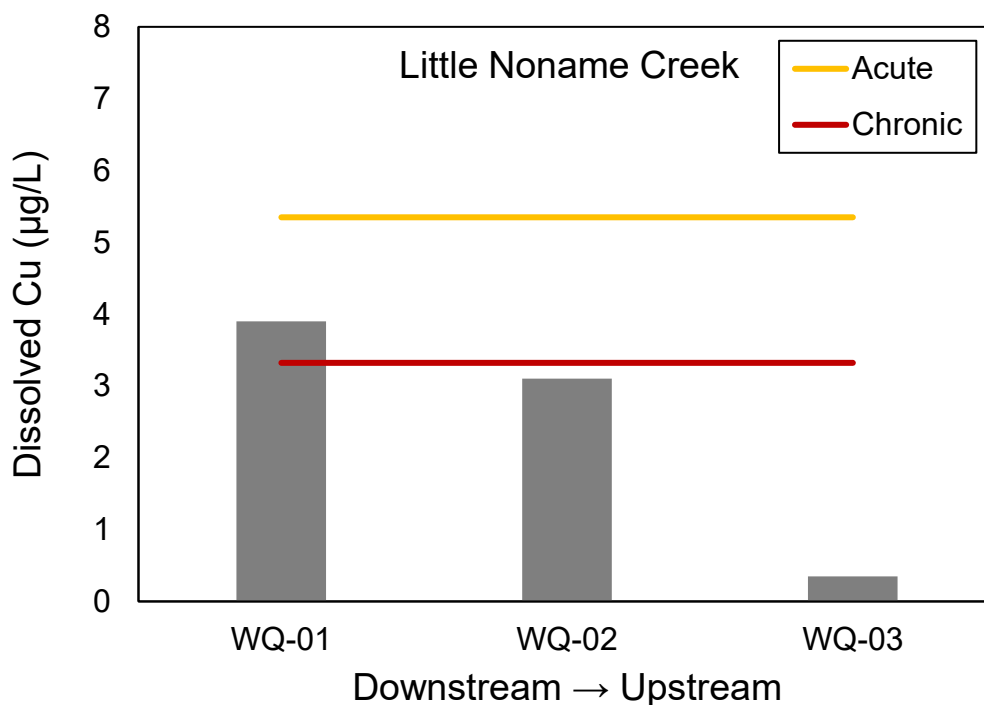


Figure 3. Dissolved Cu surface water concentrations in LNNC. The orange/yellow line designates the acute criterion, and the red line designates the chronic criterion.

Sediment and Soil Copper

The Cu concentrations in the background site were generally very low, except for the sample closest to the road (Figure 4). The R10 value was omitted for the final average calculation for the upstream background site (38.25 milligrams per kilogram [mg/kg]), which was multiplied by 3 to get a reference benchmark of 114.75 mg/kg.

The NFIC site with the highest single value of 5,240 mg/kg was collected from Transect 2, which was 10 meters from the left WE (Figure 4). Transect 2 also had the highest average Cu concentration of 2,213.6 mg/kg, and all individual sample sites exceeded three times background (Figure 5). NFIC Transect 1, downstream of the mining claim, also had an elevated average Cu concentration (252.4 mg/kg), but elevated Cu was spatially constrained to the stream sediments and WEs (Figure 5). Overall, the Cu concentrations were approximately 100 to 200 times higher than background within and downstream of the mining claim.

LNNC Transect 1 had the sample site with the highest recorded Cu concentration of 9,800 mg/kg and an overall average of 1,844.8 mg/kg, which is over 10 times higher than the background average (Figure 6). All but one of the individual sample sites within this transect exceeded three times background (Figure 7). The upstream LNNC transect had a much lower average Cu concentration of 26.3 mg/kg, which is within the estimated background range. The sediment sample site in the upstream LNNC transect was the only site within that transect that exceeded three times background (Figure 7).

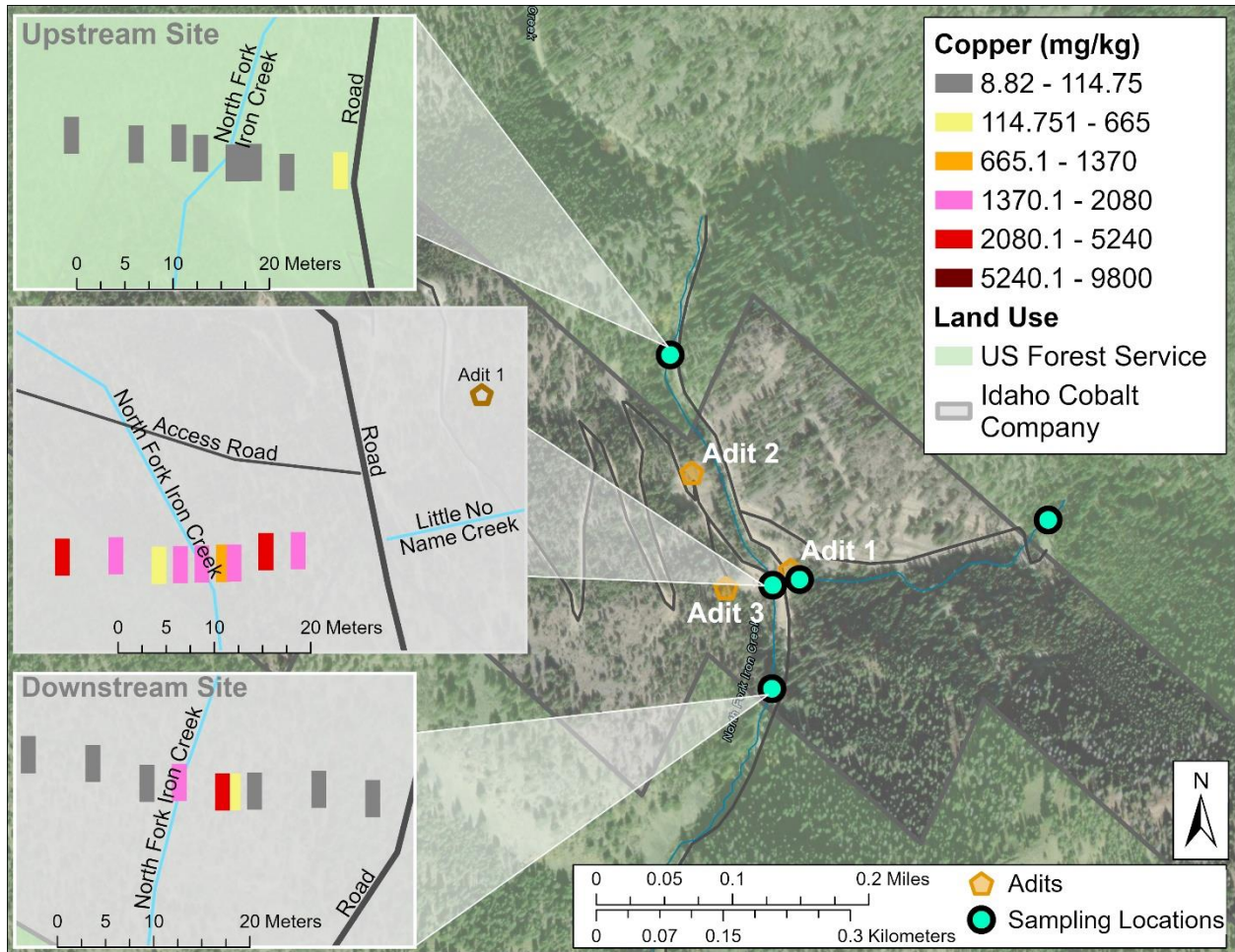


Figure 4. Map of sediment and soil transect sampling locations (green circles) and total Cu concentrations along NFIC.

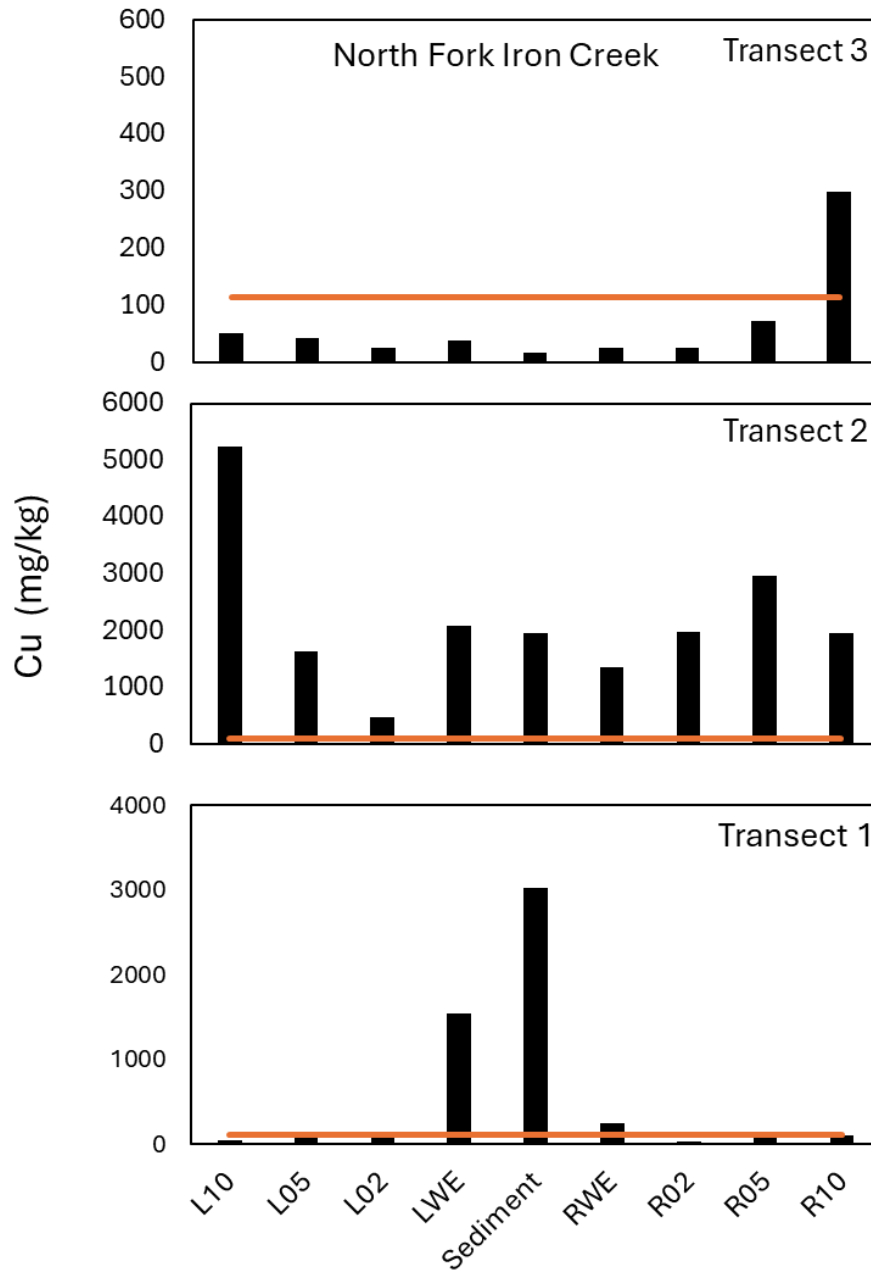


Figure 5. Total copper sediment and soil concentrations from NFIC. Transect 1 was downstream of the mining claim, Transect 2 was within it, and Transect 3 was upstream of it. L=left side; LWE=left-wetted edge; R=right side; RWE=right-wetted edge; numbers in site ID correspond to meter-length distances. Note the different axis scales in each transect. The orange line shows three times background.

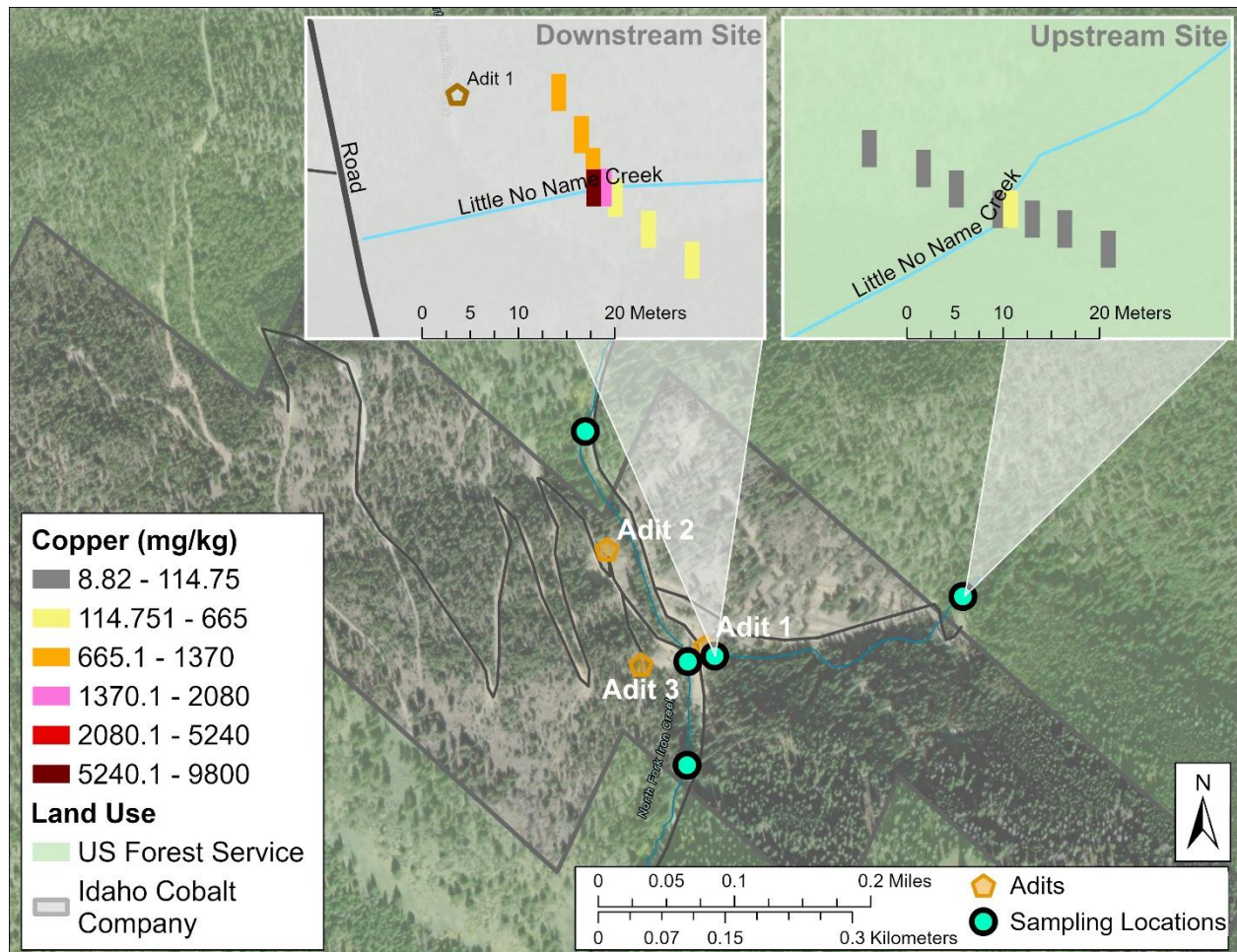


Figure 6. Map of sediment and soil transect sampling locations (green circles) and total Cu concentrations along LNNC.

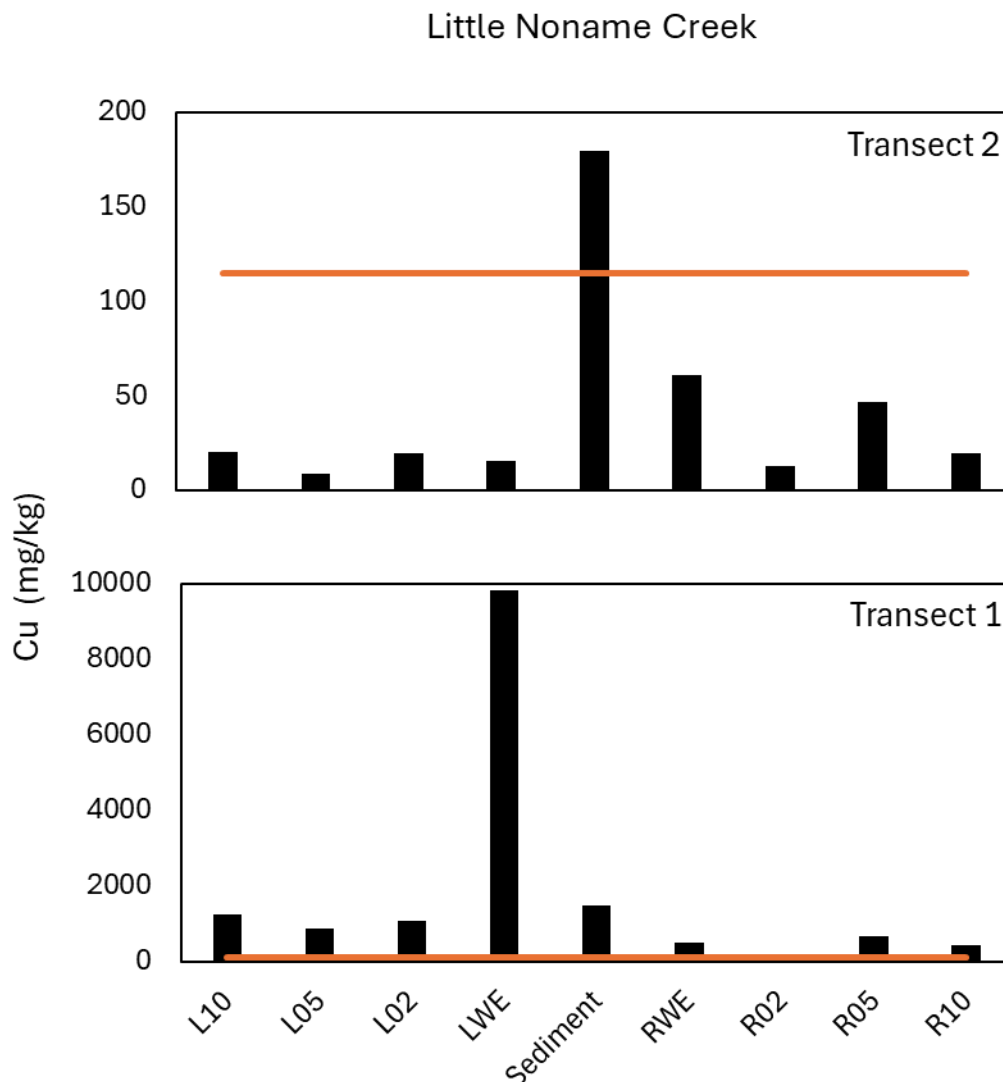


Figure 7. Total Cu sediment and soil concentrations from LNNC Creek. Transect 1 was located within the mining claim, near the confluence with NFIC. Transect 2 was located upstream near the mining claim property boundary. L=left side; LWE=left-wetted edge; R=right side; RWE=right-wetted edge; numbers in site ID correspond to meter-length distances. Note the different axis scales in each transect. The orange line shows three times background.

Quality Assurance and Quality Control

All quality assurance/quality control sampling met the data quality objectives from the field sampling plan. We collected one field water quality duplicate and three soil duplicates. All relative percent differences were below the target of $\pm 50\%$.

Field water quality blanks reported detections for Cu. However, these were below the reported detection limit for the method and have been j-flagged. The field blank water was commercial-grade distilled water, rather than lab-grade ultrapure water, which likely explains the trace quantities of Cu detected.

Summary

It has been previously documented that NFIC is Cu-impaired, but our results provide higher-spatial resolution of Cu exceedances in NFIC than previous monitoring efforts. We documented the upper extent of elevated Cu in NFIC, which occurs approximately 160 m downstream of the northern boundary of the patent mining claim. The point at which we detected the first signs of elevated Cu is immediately downstream of the Adit 2 waste material deposited on the western slope of NFIC. The highest Cu concentrations in NFIC were detected below the culvert crossing, where the banks, road, and terraces all appear to contain adit waste material from Adits 1 and 3. This pattern is similar in LNNC, where Cu was only elevated above criteria at the downstream site, which is closest to Adit 1.

We found very high Cu concentrations in soil and sediment samples collected within and downstream of the mining claim property. Transect 2, in NFIC, was selected to capture the most adit waste material adjacent to surface water in the project area. Both banks at this transect were primarily composed of barren, fine-to-medium-grain, yellowish-colored material, which was visually very different from the undisturbed bank material upstream of the mining property. As anticipated, this transect had the highest average Cu of any other site from this study. Elevated Cu in sediment and soil downstream of the mining property was limited to the streambed and wetted edges of the channel, likely indicating fluvial deposition from material mobilized from upstream.

The impacted soil and streambed sediment sites in the NFIC project area ranged from 1,470 to 9,800 mg/kg, which is within the range of concentrations documented from mining-impacted CERLA sites. Waste rock and surface deposits in the Big Deer Creek and Blackbird Creek drainages, impacted by the nearby Blackbird Mine, ranged from 171.0 to 20,200 mg/kg prior to remediation (Beltman et al. 1993). Silver Bow Creek, which has historically had the highest metals concentrations of sites within the Clark Fork River Superfund complex, has documented Cu concentrations in fine-grained streambed sediments ranging from 446 to 9,023 mg/kg from 1996 to 2016 (Eldridge and Hornberger 2023). The NFIC transect location within the mining claim was selected to target the most anticipated Cu-contaminated material, based on the existing concerns related to waste rock on the site (Mitchell and Bennett 2014) and the visual difference of streambank material and lack of vegetation compared to upstream conditions. It has been documented that the excavated parking area in the patent mining property was built on adit waste material containing chalcopyrite, a Cu-rich mineral (Ristorcelli and Schlitt 2019). Given that sampled adit waste material in NFIC is Cu-rich and located in areas that correspond to surface water Cu exceedances, adit waste likely serves as primary source of Cu contamination in NFIC. The mobility of Cu in these sources will vary with hydrologic regimes and chemical parameters, particularly pH and redox-potential (Smith 2007).

NFIC historically had a direct surface connection to adit-influenced water. In the absence of this direct discharge, the remaining potential Cu sources that would contribute to ongoing Cu exceedances include hydraulic connection of infiltrated adit water, runoff contaminated by historical mine waste, and fluvial deposits of metal-rich material. Each of these sources can have several potential pathways to enter NFIC. The prevalence of the Cu-rich adit waste

material confounds interpretation of the influence of other sources and pathways, in the absence of more sophisticated environmental forensic data.

These results provide a more detailed picture of Cu sourcing and areal extent of surface water Cu exceedances, but several factors related to the Cu exceedances remain unknown. Further monitoring is required to better understand the downstream extent of Cu exceedances in surface water, the areal extent of contaminated sediment and soils, the potential influence of shallow groundwater, and the variability of chemical conditions that influence Cu mobility in surface water.

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