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Russell Gulch 2022 Abandoned Mine Sampling and Project Planning

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Final Report – December 2023

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Project Background

Russell Gulch, a tributary of the North Fork of Clear Creek, is located in the Clear Creek Watershed near Central City in Gilpin County, CO. Prevalent legacy mining activity in the area has resulted in unnatural levels of sediment loading and loading of mine-impacted sediment to Russell Gulch and Willis Gulch, a tributary of Russell Gulch, resulting from the erosion of abandoned mine waste piles and degraded stream channels. The mobilized sediment contains metals, which are toxic to human and ecological receptors at elevated concentrations. Russell Gulch and Willis Gulch are intermittent streams.

In 2021, Trout Unlimited (TU) contracted Tailwater Limited to conduct a tabletop sediment study in the Russell Gulch and Willis Gulch drainages, which identified and prioritized the largest likely contributors of sediment to receiving waters from hillslope erosion processes and channel erosion processes. The hillslope sediment sources are waste piles from historic mining activity. Those sources were ranked based on (1) erosion rates, (2) connectivity to receiving waters (i.e., run-out modeling, visible flow path in aerial imagery, or observed flow path in the field), and (3) attenuating factors that may reduce sediment (e.g., vegetation and previous restoration efforts) (Figure 1). This assessment resulted in a prioritized list of potential project sites to improve watershed health through erosion and sediment control. TU pursued and obtained funding through this UCCWA grant to conduct site characterization activities at five (5) of the top-ranked bare areas (i.e., AML sites) contributing sediment to a stream channel from hillslope erosion.

The primary purpose of the monitoring effort funded by this UCCWA grant is to assess the AML sites for potential human health and environmental impacts and develop data-driven reclamation and restoration priorities in the greater Russell Gulch drainage. Subsequently, the site characterization data and observations can be used to evaluate, prioritize, and plan future reclamation and restoration activities. The objective is to enhance and restore water quality, environmental conditions, and associated ecological services and protect people, recreation, and fisheries in our state waters.

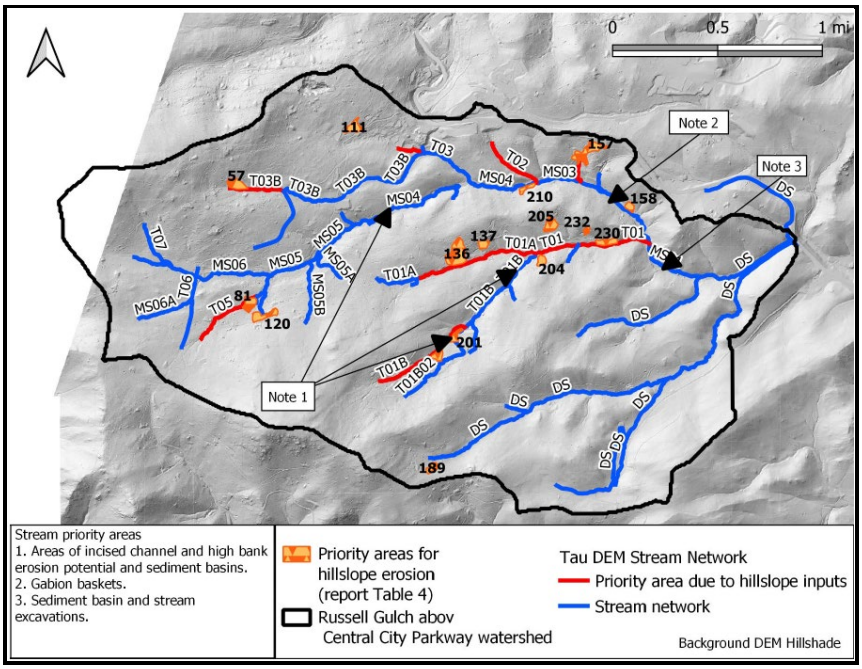


Figure 1. 2021 Russell Gulch Sediment Study - Largest likely contributors of sediment to the channels from hillslope processes.

Activities

Task 1 – Project Management

TU conducted project management activities such as records management, communications, contracting, invoicing, planning, task tracking, budget tracking, research, planning, reporting, fieldwork, data collection, data analysis, mapping, regulatory analysis, and outreach to project partners and community stakeholders. TU coordinated with UCCWA to extend the grant to December 31, 2023, to allow sufficient time to research property owners, obtain site access, complete sampling, conduct subsequent data analysis and reporting, and facilitate the project transition to a new TU Project Manager (PM) in early March 2023. TU prepared and submitted a final invoice and this final report to UCCWA in December 2023, by the grant expiration date. This final report includes a discussion of the project background, activities, accomplishments, and budget as requested by UCCWA and highlights the outcome of each task outlined in the grant and how TU completed the task objectives.

TU oversaw sampling design and execution, which guided the scope of work and utilization of grant funds. Four site visits were completed in 2023 to identify waste pile locations and site accessibility. Simultaneously, TU conducted extensive research with GIS tools and collaborated with the Gilpin County Assessor's Office to identify and verify the property owner, MS#, mine name, and account# associated with the parcels at each site. TU created a summary spreadsheet to evaluate and track site access status. Roughly thirty-six (36) parcels and twenty (20) property owners were identified across seven (7) sample locations. TU researched property owner contact information and solicited feedback on site access through the Gilpin County Assessor's Office, Colorado Department of Public Health & Environment (CDPHE), Colorado Division of Reclamation, Mining, & Safety (DRMS), and the Colorado Secretary of State.

TU prepared landowner-specific cover letters (including imagery depicting the access request) and access agreements and mailed the documents in business envelopes (i.e., TU logo, printed labels, and a self-addressed stamped return envelope). Through collaboration with CDPHE, TU learned that soil sampling was conducted in 2022 within Operable Unit 5 (OU5) for the Central City/Clear Creek Superfund Site, which includes the Russell Gulch area. TU crosschecked CDPHE’s actual sample locations with TU’s planned sample locations. Based on the outcome of site access requests and sample location overlap with CDPHE's work, a few sample locations were modified. The new sample locations were identified based on the 2021 Russell Gulch Sediment Study priority ranking of bare areas (i.e., AML sites) identified as contributing the largest amount of impaired sediment to receiving waters. Sample location modifications were communicated to and approved by UCCWA. Ultimately, TU obtained site access from three private landowners and the City of Black Hawk and filed documentation of site access approvals.

TU generated a spreadsheet with project-specific analytes, methods, and MDLs and requested cost estimates from three laboratories to maximize the use of limited project funds. The laboratory for this project was selected based on analytical capabilities. TU then developed and submitted a project-specific quote request, reviewed and modified the quote, and reviewed the bottle order packing list. TU procured sample kits and other supplies, coordinated sampling with property owners, and completed sampling in October 2023. The analytical report was received on November 28, 2023. Subsequently, TU created

numerous graphs depicting the analytical results by Site #, sample location, and analyte/parameter, evaluated the data, and summarized findings in this final report.

Public outreach has included communications with landowners, municipalities, partnerships, nonprofits, and federal, state, and local government agencies. Specifically, TU engaged the Clear Creek Watershed community by sharing the UCCWA partnership, project background, site characterization efforts, and future reclamation and restoration goals for the watershed with local landowners, CDPHE, DRMS, Colorado Parks & Wildlife (CPW), Gilpin County, the Clear Creek Watershed & Forest Health Partnership (CCWFHP), and U.S. Environmental Protection Agency (EPA).

Task 2 – Surface Soil and Water Sampling

The grant application outlined five priority bare area hillslope sites (i.e., "waste piles" from historic mining activity) for site characterization (i.e., Site #57, Site #210, Site #81/120, Site #136, and Site #230), with a total of nineteen (19) sample locations across five (5) AML sites, specifically, eight (8) soil samples and eleven (11) water quality samples bracketing each waste pile and the Russell Gulch drainage. Following the outcome of site access requests and review of CDPHE's 2022 sample locations, Site #57, Site #210, and Site #81/120 were removed from the scope of work and replaced with Site #158 and Site #204, resulting in an updated total of ten (10) sample locations across four (4) AML sites, specifically, four (4) soil sample locations of the waste piles and six (6) sediment samples (in place of water quality samples) bracketing each waste pile and the Russell Gulch drainage. Water quality samples were not collected because water was not present during sampling. Table 1 provides a summary of the 2023 sample locations. Figure 2 provides a visual overview of the 2023 sample locations. In the map, sites with SED in the sample ID are sediment samples from the streambed, and sites with SO in the sample ID are soil samples from a waste pile.

Table 1. Summary of Sample Locations

Site Name	Sample ID	Site Description	# of Sub-samples	Sample Depth	Cross Section Length	Sample Date
US Bracket	UPS-RG-SED	Sediment sample at the upper limit of the project area and source of Russell Gulch, below the Virginia Canyon Rd. culvert.	15	0-6"	na - no defined channel	10/9/2023
	136-MP-SO	Soil sample of the Site #136 mine waste pile, adjacent to and near the source of Willis Gulch.	15	0-6"	na	10/9/2023
Site #136	136-WGDS-SED	Sediment sample from Willis Gulch downstream of the Site #136 mine waste pile, upstream of the confluence with South Willis Gulch and Site #204.	15	0-6"	31'	10/9/2023
	204-MP-SO	Soil sample of the Site #204 mine waste pile, adjacent to South Willis Gulch and Willis Gulch.	16	0-6"	na	10/9/2023
Site #204	204-WGDS-SED	Sediment sample from Willis Gulch downstream of the Site #204 mine waste pile, downstream of the confluence with South Willis Gulch and upstream of Site #230.	15	0-6"	56'	10/9/2023
	230-MP-SO	Soil sample of the Site #230 mine waste pile, adjacent to Willis Gulch and the furthest downstream waste pile adjacent to Willis Gulch before merging with Russell Gulch.	15	0-6"	na	10/9/2023
Site #230	230-WGDS-SED	Sediment sample from Willis Gulch downstream of the Site #230 mine waste pile, upstream of the confluence with Russell Gulch.	15	0-6"	29'	10/9/2023
	158-MP-SO	Soil sample of the Site #158 mine waste pile, adjacent to Russell Gulch and the furthest downstream waste pile adjacent to Russell Gulch before merging with Willis Gulch.	15	0-6"	na	10/9/2023
Site #158	158-RG-SED	Sediment sample from Russell Gulch partially downstream of the Site #158 mine waste pile, immediately upstream of the sediment trap installed in the channel adjacent to Site #158, and upstream of the confluence with Willis Gulch.	15	0-6"	37.5'	10/9/2023
DS Bracket	DWS-RG-SED	Sediment sample from Russell Gulch at the lower limit of the project area, downstream of all sampled sites, the confluence with Willis Gulch, and the check dam structure and upstream of the Central City Parkway culvert.	15	0-6"	48'	10/9/2023

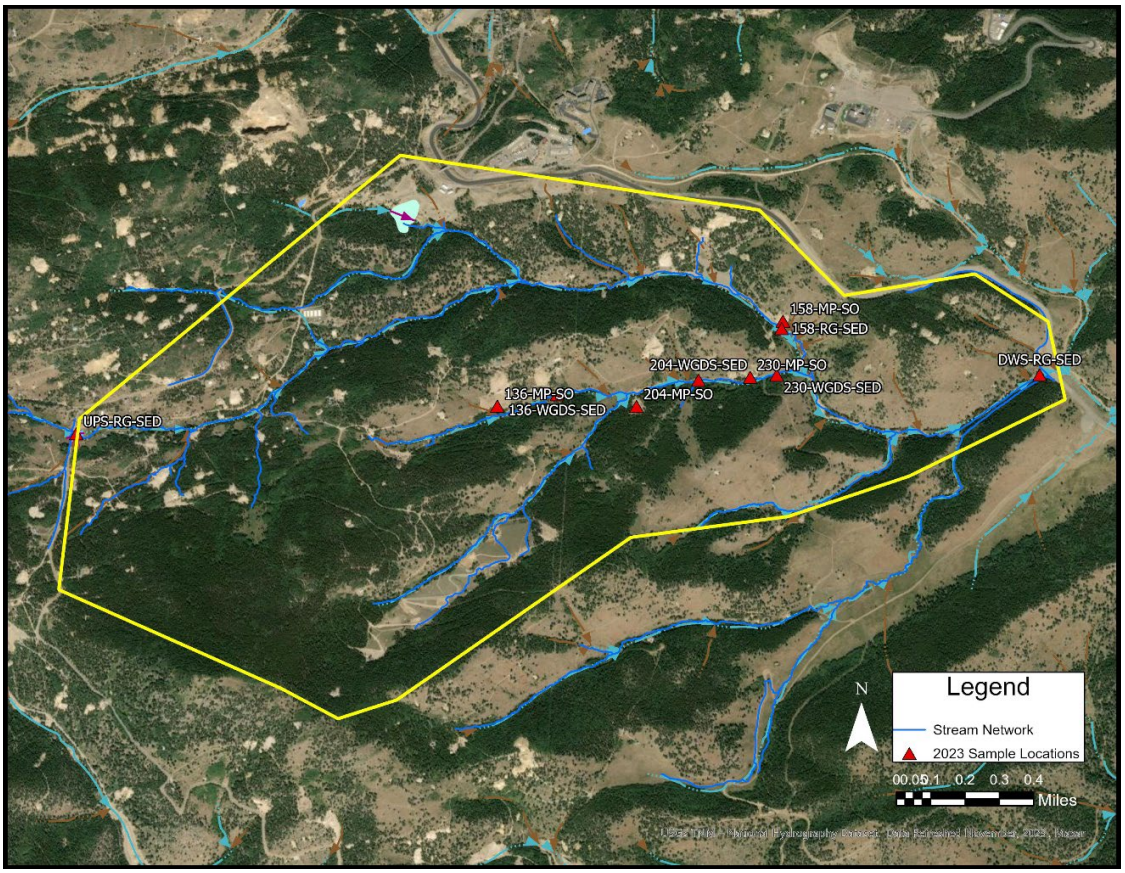


Figure 2. Overview map of the 2023 soil and sediment sample locations within Russell Gulch and Willis Gulch.

TU coordinated sampling logistics with landowners, as requested, and TU staff (personnel, schedule, equipment, access routes, and data requirements) prior to sampling. Two TU staff collected samples on October 09, 2023. One 15-point composite soil sample was collected from the toe of each waste pile (except for 204-MP-SO, which was a 16-point composite), along with an associated sediment sample from a cross section on Russell Gulch or Willis Gulch downstream of each waste pile. Two (2) sediment samples were also collected from a cross section on Russell Gulch at the upper and lower limits of the project area to bracket the drainage. The soil and sediment subsamples were collected from a surface soil depth of 0-6 inches.

In the field, TU verified that the access routes and sample sites were located within the property boundaries where access was permitted. TU obtained sample site photos and actual coordinates and recorded notes in a logbook. Once collected, the samples were labeled, stored in the lab-provided cooler on ice, sealed for return shipment with the applicable Chain of Custody forms, and shipped the following day to an accredited laboratory, ACZ Laboratories in Steamboat Springs, CO. After sampling, site photos were downloaded, labeled, and organized, and a sample overview map was created (Figure 2). The soil and sediment samples were analyzed for Total Metals, Toxicity Characteristic Leaching Procedure (TCLP), and soil characteristics (i.e., pH, organic matter, and acid-base accounting (ABA)). The analytical results were evaluated against the EPA's Soil-Based Ecological Screening Values (ESVs), the EPA's Human Health-Based Soil Contaminant Regional Screening Levels (RSLs), and the BLM's Human Health Screening Level (SL) for Chemicals in Soil and are presented in Table 2.

Table 2. Summary of Total Metals (mg/kg), Screening Levels (mg/kg), and Exceedances - By Sample Location

Site Name	Sample ID	Aluminum	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Zinc
US Bracket	UPS-RG-SED	13300	13.2	6.43	23.3	82.1	26500	277	359	0.05	16.5	< 5	< 1	852
	136-MP-SO	6860	53.2	0.938	19.5	87.4	38400	184	192	0.80	9.7	< 5.1	<1.02	76.8
Site #136	136-WGDS-SED	7190	41.5	< 0.808	32.7	57.6	32400	439	345	0.24	12.1	< 5.05	1.47	123
	204-MP-SO	12700	199	11.5	35.8	269	40900	6310	418	1.39	16.9	< 5	47.5	1860
Site #204	204-WGDS-SED	6850	28.7	< 0.808	32.2	53.2	25600	199	275	0.08	13.5	< 5.05	< 1.01	106
	230-MP-SO	13800	240	1.23	46	497	33500	932	584	1.37	20.7	< 5.05	1.89	233
Site #230	230-WGDS-SED	6950	52.8	< 0.808	26.6	61	21100	297	254	0.14	11.6	< 5.05	< 1.01	87.1
	158-MP-SO	11100	171	2.55	32.5	181	34800	3700	242	1.22	15.1	< 5.05	3.82	490
Site #158	158-RG-SED	9470	57.3	< 0.808	24.3	85.5	24500	151	208	0.90	12.7	< 5.05	< 1.01	89.2
DS Bracket	DWS-RG-SED	10400	21.8	< 0.8	35.1	68.9	24900	104	355	0.13	19.9	< 5	< 1	109
Screening Level	EPA Lowest ESV [1]	--	6.8 SI	0.36 M	34 M	28 B	--	11 B	220 P	0.013 B	38 P	0.52 P	4.2 B	46 B
	EPA Residential RSL	77000	0.68	71	120000	3100	55000	400	1800	11	1500	390	390	23000
	EPA Industrial RSL	1100000	3	980	1800000	47000	820000	800	26000	46	22000	5800	5800	350000
	BLM Recreational SL	>1,000,000	30.6	1780	>1,000,000	78200	>1,000,000	800	46700	271	39000	9780	9780	587000

[1] P = Plants, SI = Soil Invetebrates, M = Mammals, B = Birds

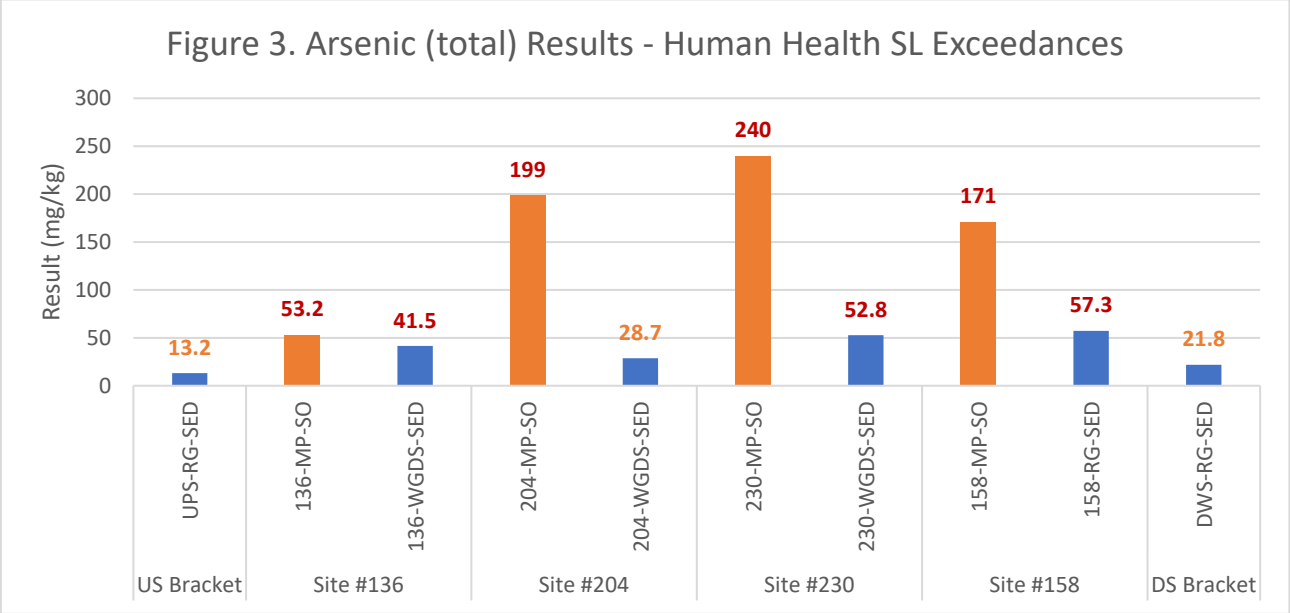
Exceeds EPA Lowest ESV

Exceeds EPA Lowest ESV & EPA Residential RSL

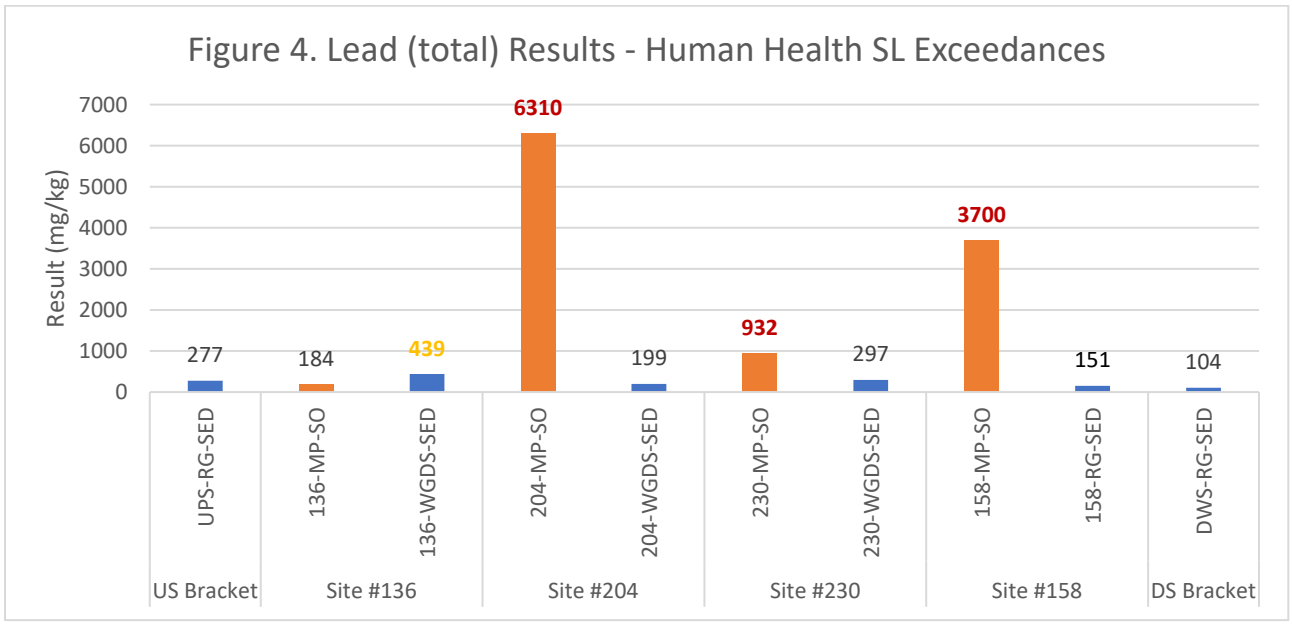
Exceeds EPA Lowest ESV, EPA Residential RSL, & EPA Industrial RSL

Exceeds EPA Lowest ESV, EPA Residential RSL, EPA Industrial RSL, & BLM Recreastional SL

The Total Metals analysis included thirteen (13) metals: Aluminum, Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Nickel, Selenium, Silver, and Zinc. Two (2) of the thirteen (13) metals were identified as the primary constituents of concern (COCs) based on exceedances of human health SLs: Arsenic and Lead. All ten (10) sample sites exceeded 1+ human health SLs for Arsenic (ranging from 13.2-240 mg/kg), and four (4) sample sites exceeded 1+ human health SLs for Lead (ranging from 439-6310 mg/kg). (Figures 3 and 4) The arsenic results are 19-353x the EPA Residential RSL, 4-80x the EPA Industrial RSL, and 1.4-7.8x the BLM Recreational SL. The lead results are 1.1-15.8x the EPA Residential RSL, 1.2-7.9x the EPA Industrial RSL, and 1.2-7.9x the BLM Recreational SL. (Tables 3 and 4)



Exceeds EPA Lowest ESV, EPA Residential RSL, & EPA Industrial RSL
Exceeds EPA Lowest ESV, EPA Residential RSL, EPA Industrial RSL, & BLM Recreational SL



Exceeds EPA Lowest ESV & EPA Residential RSL
Exceeds EPA Lowest ESV, EPA Residential RSL, EPA Industrial RSL, & BLM Recreational SL

Table 3. Arsenic (total) – Human Health SL Exceedance Factors

Site Name	Sample ID	Arsenic Result (mg/kg)	EPA Residential RSL Exceedance Factor	EPA Industrial RSL Exceedance Factor	BLM Recreational SL Exceedance Factor
US Bracket	UPS-RG-SED	13.2	19	4	na
	136-MP-SO	53.2	78	18	1.7
Site #136	136-WGDS-SED	41.5	61	14	1.4
	204-MP-SO	199	293	66	6.5
Site #204	204-WGDS-SED	28.7	42	10	na
	230-MP-SO	240	353	80	7.8
Site #230	230-WGDS-SED	52.8	78	18	1.7
	158-MP-SO	171	251	57	5.6
Site #158	158-RG-SED	57.3	84	19	1.9
DS Bracket	DWS-RG-SED	21.8	32	7	na

Exceeds EPA Lowest ESV, EPA Residential RSL, & EPA Industrial RSL
Exceeds EPA Lowest ESV, EPA Residential RSL, EPA Industrial RSL, & BLM Recreastional SL

Table 4. Lead (total) – Human Health SL Exceedance Factors

Site Name	Sample ID	Lead Result (mg/kg)	EPA Residential RSL Exceedance Factor	EPA Industrial RSL Exceedance Factor	BLM Recreational SL Exceedance Factor
Site #136	136-WGDS-SED	439	1.1	na	na
Site #204	204-MP-SO	6310	15.8	7.9	7.9
Site #230	230-MP-SO	932	2.3	1.2	1.2
Site #158	158-MP-SO	3700	9.3	4.6	4.6

Exceeds EPA Lowest ESV & EPA Residential RSL
Exceeds EPA Lowest ESV, EPA Residential RSL, EPA Industrial RSL, & BLM Recreastional SL

ABA was conducted by ACZ for each sample location (i.e., acid-generating potential (AGP), acid-neutralizing potential (ANP), and acid-base potential (ABP)) and is used to determine the leachability of metals in the mine waste material. Per USGS, an ABP greater than 20 t CaCO3/Kt is generally accepted as non-acid-generating material, and an ABP less than -20 t CaCO3/Kt is generally accepted as acid-generating material. The unit of measurement for AGP, ANP, and ABP is tons of calcium carbonate per kiloton (t CaCO3/Kt).

The ABP results for the waste piles at Site #136, Site #204, and Site #158 are less than -20 t CaCO3/Kt, indicating the presence of acid-generating material (Figure 3 – red font). These values, coupled with corresponding acidic pH and sulfur content values of 2.7, 4.3, and 4.7, and 2.55%, 1.19%, and 0.74%, respectively, provide additional potential for weathering of metals and acid mine drainage (AMD) generation during precipitation events and seasonal runoff. These three (3) sites exhibited the lowest ABP values and highest Total Sulfur values of all ten (10) sites sampled. All sites exhibited acidic soil and sediment conditions, with pH ranging from 2.7 to 5.7. The ABA data will aid in assessing the in-situ treatment feasibility of utilizing neutralization material to buffer pH. (Figures 5, 6, and 7)

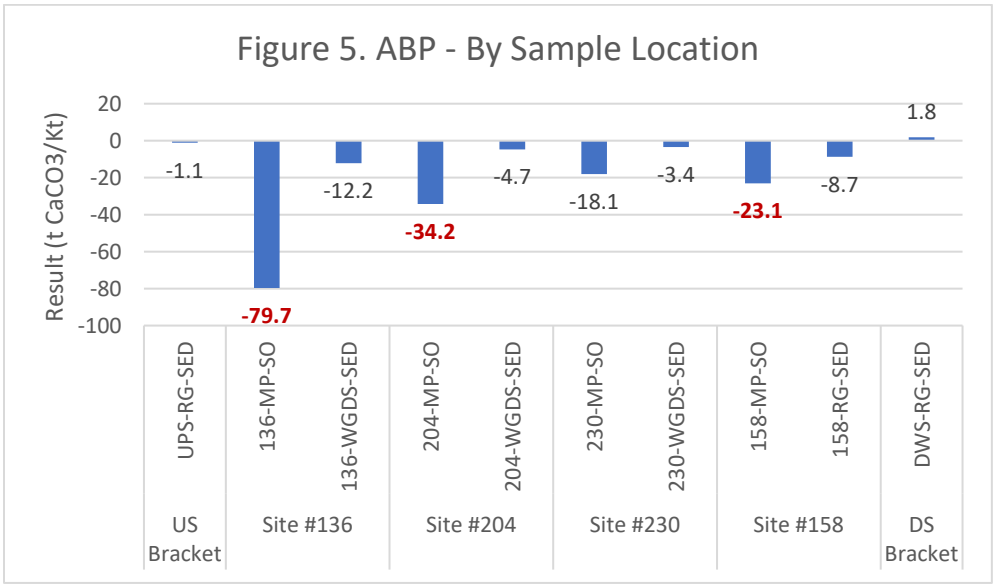


Figure 5. ABP - By Sample Location
Result (t CaCO3/Kt)
20
0
-20
-40
-60
-80
-100
-1.1
-79.7
-12.2
-34.2
-4.7
-18.1
-3.4
-23.1
-8.7
1.8
UPS-RG-SED
136-MP-SO
136-WGDS-SED
204-MP-SO
204-WGDS-SED
230-MP-SO
230-WGDS-SED
158-MP-SO
158-RG-SED
DWS-RG-SED
US Bracket
Site #136
Site #204
Site #230
Site #158
DS Bracket

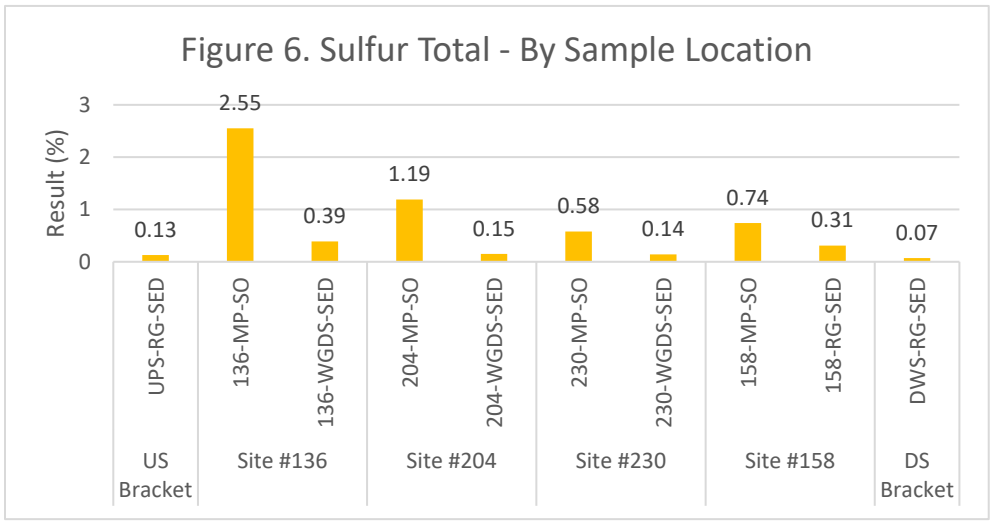


Figure 6. Sulfur Total - By Sample Location
Result (%)
3
2
1
0
0.13
2.55
0.39
1.19
0.15
0.58
0.14
0.74
0.31
0.07
UPS-RG-SED
136-MP-SO
136-WGDS-SED
204-MP-SO
204-WGDS-SED
230-MP-SO
230-WGDS-SED
158-MP-SO
158-RG-SED
DWS-RG-SED
US Bracket
Site #136
Site #204
Site #230
Site #158
DS Bracket

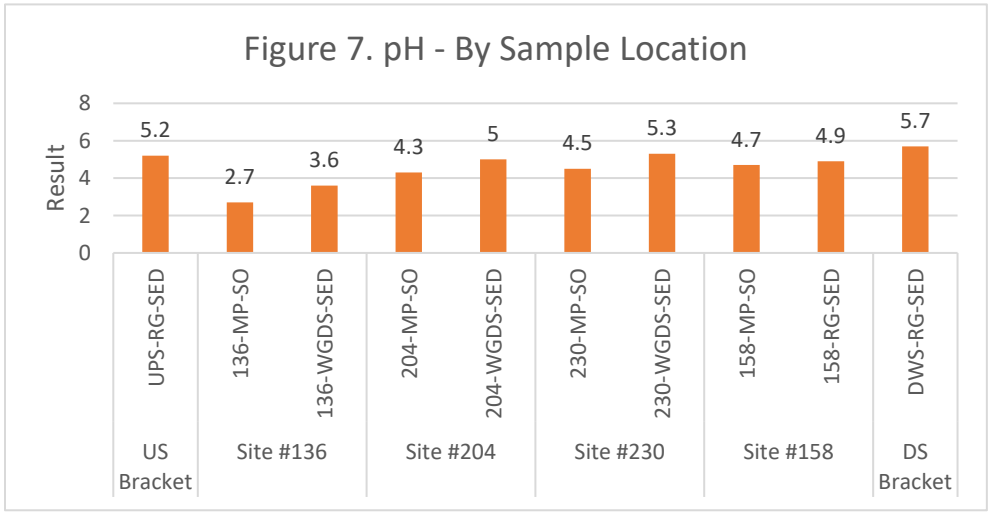


Figure 7. pH - By Sample Location
Result
8
6
4
2
0
5.2
2.7
3.6
4.3
5
4.5
5.3
4.7
4.9
5.7
UPS-RG-SED
136-MP-SO
136-WGDS-SED
204-MP-SO
204-WGDS-SED
230-MP-SO
230-WGDS-SED
158-MP-SO
158-RG-SED
DWS-RG-SED
US Bracket
Site #136
Site #204
Site #230
Site #158
DS Bracket

Site #136 (Willis Gulch)

In the 2021 Russell Gulch Sediment Study, Site #136 was ranked as a top five priority bare area based on sediment contributions to the stream channel from hillslope erosion. The site is located upstream of Site #204 and is adjacent to and near the source of Willis Gulch. Two (2) samples were collected at Site #136. One (1) composite soil sample (136-MP-SO) was collected from the toe of the waste pile, and one (1) composite sediment sample (136-WGDS-SED) was collected from a cross section on Willis Gulch downstream of the waste pile and upstream of the confluence with South Willis Gulch.

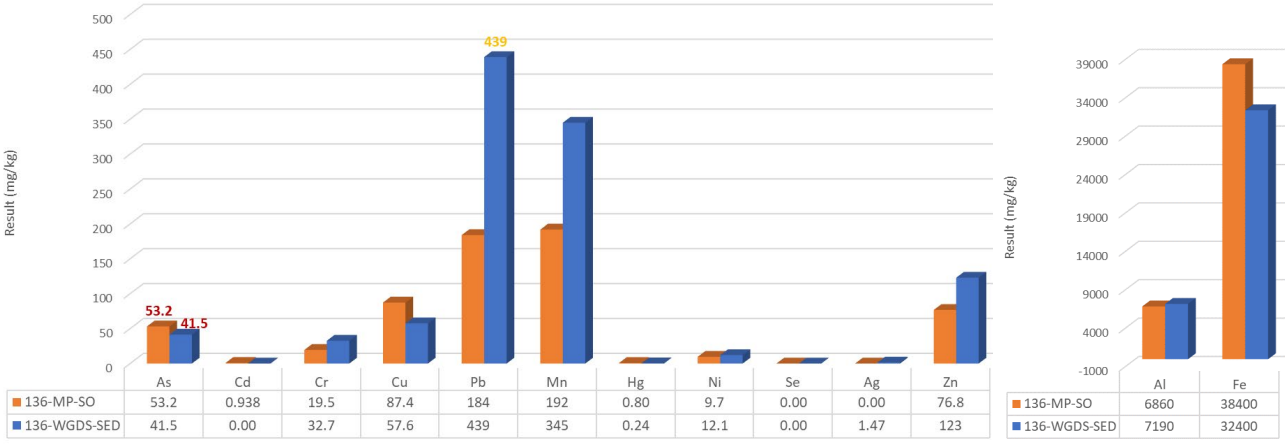
Figure 8. Site #136 - Satellite imagery of the waste pile (with numerous rills and gullies) adjacent to Willis Gulch (left) and significant gully formation along the toe of the waste pile (right).

The waste pile (136-MP-SO) arsenic level was 78x the EPA Residential RSL, 18x the EPA Industrial RSL, and 1.7x the BLM Recreational SL. The Willis Gulch (136-WGDS-SED) arsenic level was 61x the EPA Residential RSL, 14x the EPA Industrial RSL, and 1.4x the BLM Recreational SL, and the lead level was 1.1x the EPA Residential RSL. *Overall, arsenic exceeded all three human health SLs at both sites, and lead exceeded one human health SL at the Willis Gulch site (Figure 9).*

Seven (7) of the twelve (12) metals detected *increased* in concentration in the Willis Gulch sample compared to the waste pile sample, which may indicate (for those specific analytes) mobilization of material from the waste pile to Willis Gulch, variable concentrations of metals across the waste pile, or inputs from other sediment sources to Willis Gulch that have higher concentrations of metals. Five (5) of the twelve (12) metals detected *decreased* in concentration in the Willis Gulch sample compared to the waste pile sample, which may indicate (for those specific analytes) variable concentrations of metals across the waste pile or dilution from other sediment sources to Willis Gulch that are either unimpacted or have

lower concentrations of metals. Some aspen stands and pine trees may facilitate sediment attenuation and erosion reduction. *Regardless, arsenic exceeded all three human health SLs, and lead exceeded one human health SL in Willis Gulch.*

Figure 9. Site #136 – Total Metals



	As	Cd	Cr	Cu	Pb	Mn	Hg	Ni	Se	Ag	Zn
136-MP-SO	53.2	0.938	19.5	87.4	184	192	0.80	9.7	0.00	0.00	76.8
136-WGDS-SED	41.5	0.00	32.7	57.6	439	345	0.24	12.1	0.00	1.47	123

	Al	Fe
136-MP-SO	6860	38400
136-WGDS-SED	7190	32400

Exceeds EPA Lowest ESV & EPA Residential RSL

Exceeds EPA Lowest ESV, EPA Residential RSL, EPA Industrial RSL, & BLM Recreational SL

Figure 10. Site #136 - Rill erosion and gully erosion along the toe of the waste pile, looking upslope from left to right.

Figure 11. Site #136 - Channelized and incised section of Willis Gulch ~ 450 feet downstream of waste pile (left) and gully erosion of mine waste adjacent to Willis Gulch ~ 400 feet downstream of waste pile (right).

Figure 12. Site #136 - Willis Gulch sediment sample (136-WGDS-SED) location downstream of the waste pile, looking upstream (left) and downstream (right).

Site #204 (Willis Gulch)

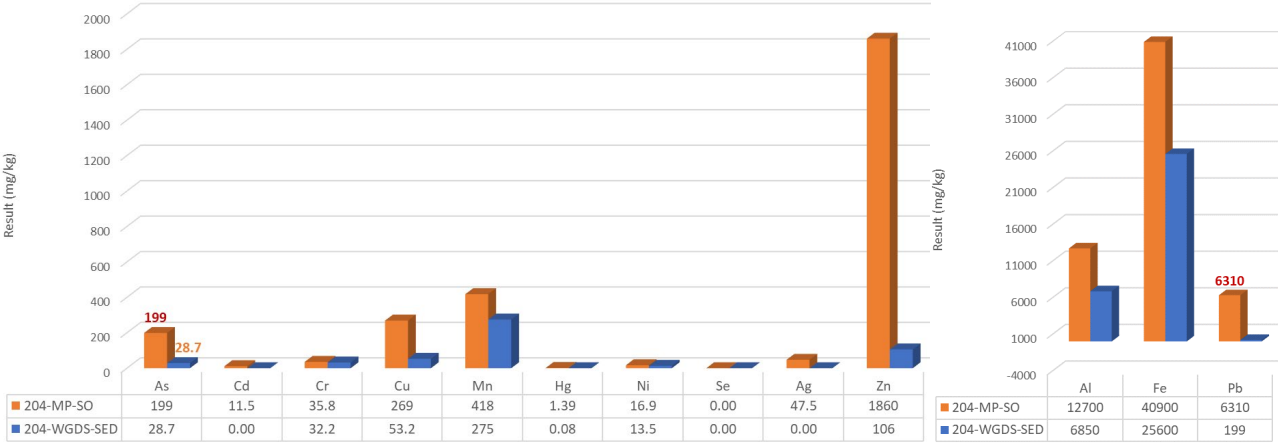
In the 2021 Russell Gulch Sediment Study, Site #204 was ranked as a top five priority bare area based on sediment contributions to the stream channel from hillslope erosion. The site is downstream of Site #136, upstream of Site #230, and adjacent to South Willis Gulch and Willis Gulch, with connectivity to Willis Gulch immediately below the confluence with South Willis Gulch. Two (2) samples were collected at Site #204. One (1) composite soil sample (204-MP-SO) was collected from the toe of the waste pile, and one (1) composite sediment sample (204-WGDS-SED) was collected from a cross section on Willis Gulch downstream of the waste pile and the confluence with South Willis Gulch.

Figure 13. Satellite imagery of the Site #204 waste pile (with numerous rills and gullies) adjacent to Willis Gulch and the South Willis Gulch confluence.

The waste pile (204-MP-SO) arsenic level was 293x the EPA Residential RSL, 66x the EPA Industrial RSL, and 6.5x the BLM Recreational SL, and the lead level was 15.8x the EPA Residential RSL, 7.9x the EPA Industrial RSL, and 7.9x the BLM Recreational SL. The waste pile at this site exhibited the 2nd highest arsenic concentration (199 mg/kg) and the highest lead concentration (6310 mg/kg) across all the sites sampled. The Willis Gulch (204-WGDS-SED) arsenic level was 42x the EPA Residential RSL and 10x the EPA Industrial RSL. *Overall, arsenic exceeded all three human health SLs at the waste pile site and two human health SLs at the Willis Gulch site, and lead exceeded all three human health SLs at the waste pile site (Figure 14).*

All twelve (12) of the metals detected *decreased* in concentration in the Willis Gulch sample compared to the waste pile sample, which may indicate limited mobilization of material from the waste pile to Willis Gulch, variable concentrations of metals across the waste pile, or dilution from other sediment sources to Willis Gulch that are either unimpacted or have lower concentrations of metals. Trees at the site (30-60' buffer zone) and previous restoration work (i.e., remnants of riprap stabilization along the base of the waste pile) are likely facilitating sediment attenuation and erosion reduction. However, it is apparent that sediment has breached the restoration feature and is migrating to the stream through a narrow, open area in the trees at the base of the waste pile. *Regardless, arsenic exceeded two human health SLs in Willis Gulch.*

Figure 14. Site #204 – Total Metals



	As	Cd	Cr	Cu	Mn	Hg	Ni	Se	Ag	Zn
204-MP-SO	199	11.5	35.8	269	418	1.39	16.9	0.00	47.5	1860
204-WGDS-SED	28.7	0.00	32.2	53.2	275	0.08	13.5	0.00	0.00	106

	Al	Fe	Pb
204-MP-SO	12700	40900	6310
204-WGDS-SED	6850	25600	199

Exceeds EPA Lowest ESV, EPA Residential RSL, & EPA Industrial RSL

Exceeds EPA Lowest ESV, EPA Residential RSL, EPA Industrial RSL, & BLM Recreational SL

Figure 15. Site #204 - Looking south across Willis Gulch at the waste pile, with a view of the connectivity to Willis Gulch through the trees (left) and the northwest-facing slope of the waste pile (right).

Figure 16. Site #204 – Looking southwest from the top of the waste pile (left) and the toe of the waste pile where sediment has breached a previously installed erosion control feature (right).

Figure 17. Site #204 - Looking upslope from Willis Gulch at the waste pile (left); note the sediment migration downslope below the previously installed erosion control structure. Looking downslope from the top of the waste pile (right); note the primary gully down the face of the waste pile, with connectivity to Willis Gulch.

Figure 18. Site #204 - Willis Gulch sediment sample (204-WGDS-SED) location downstream of the waste pile, looking upstream (left) and downstream (right).

Site #230 (Willis Gulch)

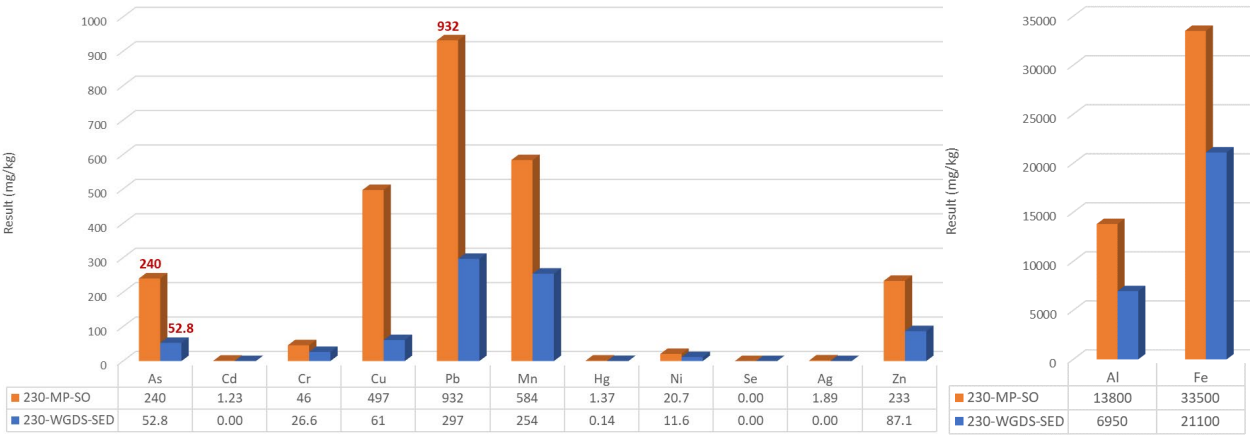
In the 2021 Russell Gulch Sediment Study, Site #230 was ranked as a top five priority bare area based on sediment contributions to the stream channel from hillslope erosion. The site is located downstream of Site #204, adjacent to Willis Gulch, and is the furthest downstream waste pile adjacent to Willis Gulch before merging with Russell Gulch. Two (2) samples were collected at Site #230. One (1) composite soil sample (230-MP-SO) was collected from the toe of the waste pile, targeting areas with connectivity to Willis Gulch, and one (1) composite sediment sample (230-WGDS-SED) was collected from a cross section on Willis Gulch downstream of the waste pile and upstream of the confluence with Russell Gulch.

Figure 19. Satellite imagery of the Site #230 waste pile (with numerous rills and gullies visible at the eastern portion) adjacent to Willis Gulch, ~ 700 feet upstream of the confluence with Russell Gulch.

The waste pile (230-MP-SO) arsenic level was 353x the EPA Residential RSL, 80x the EPA Industrial RSL, and 7.8x the BLM Recreational SL, and the lead level was 2.3x the EPA Residential RSL, 1.2x the EPA Industrial RSL, and 1.2x the BLM Recreational SL. The waste pile at this site exhibited the highest arsenic concentration (240 mg/kg) and the 3rd highest lead concentration (932 mg/kg) across all the sites sampled. The Willis Gulch (230-WGDS-SED) arsenic level was 78x the EPA Residential RSL, 18x the EPA Industrial RSL, and 1.7x the BLM Recreational SL. *Overall, arsenic exceeded all three human health SLs at both sites, and lead exceeded all three human health SLs at the waste pile site (Figure 20).*

All twelve (12) of the metals detected *decreased* in concentration in the Willis Gulch sample compared to the waste pile sample, which may indicate limited mobilization of material from the waste pile to Willis Gulch, variable concentrations of metals across the waste pile, or dilution from other sediment sources to Willis Gulch that are either unimpacted or have lower concentrations. Some trees at the site and previous restoration work (i.e., riprap stabilization along the base of the waste pile) are likely facilitating sediment attenuation and erosion reduction. *Regardless, arsenic exceeded all three human health SLs in Willis Gulch.*

Figure 20. Site #230 – Total Metals



Exceeds EPA Lowest ESV, EPA Residential RSL, EPA Industrial RSL, & BLM Recreational SL

Figure 21. Site #230 – Steep slopes with Willis Gulch at the base, rill erosion and gully erosion, and an old mining structure.

Figure 22. Site #230 – Rill erosion with a previously constructed berm that appears to be capturing runoff and limiting sediment transport to Willis Gulch (left) and the base of the waste pile where sediment flows directly into Willis Gulch (right).

Figure 23. Site #230 - Willis Gulch sediment sample (230-WGDS-SED) location downstream of the waste pile, looking upstream (left) and downstream (right).

Site #158 (Russell Gulch)

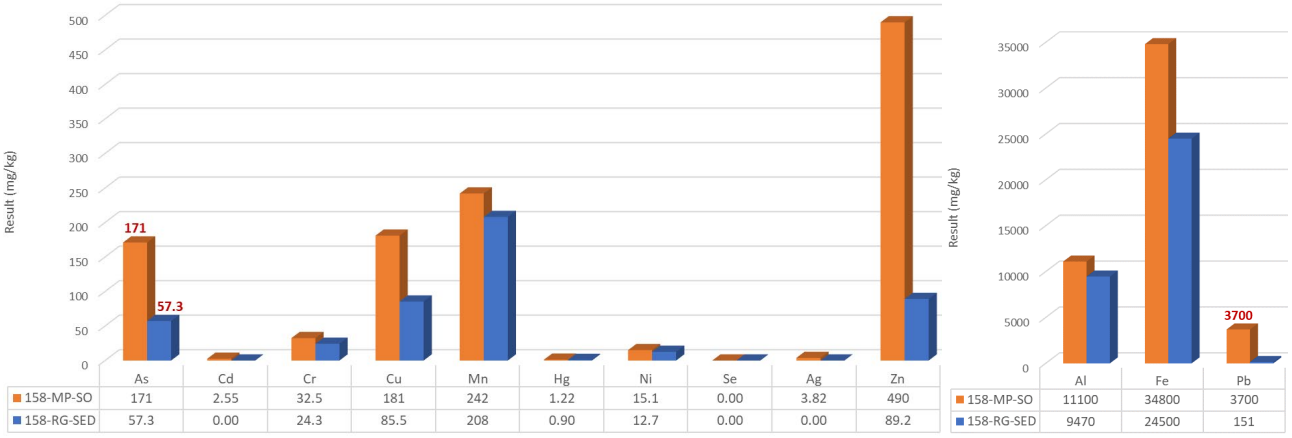
In the 2021 Russell Gulch Sediment Study, Site #158 was ranked as a top five priority bare area based on sediment contributions to the stream channel from hillslope erosion. The site is adjacent to Russell Gulch and is the furthest downstream waste pile adjacent to Russell Gulch before merging with Willis Gulch. Two (2) samples were collected at Site #158. One (1) composite soil sample (158-MP-SO) was collected from the toe of the waste pile, targeting areas with connectivity to Russell Gulch, and one (1) composite sediment sample (158-RG-SED) was collected from a cross section on Russell Gulch partially downstream of the waste pile (i.e., immediately upstream of the sediment trap installed in the channel adjacent to Site #158) and upstream of the confluence with Willis Gulch. The primary connectivity to the stream occurs at the southeast side of the waste pile, where sediment is being transported downslope via gully erosion. Where the sediment was sampled, there appears to be minimal connectivity with the waste pile due to sediment attenuation and erosion control achieved by the riprap toe stabilization installed along the base of the waste pile. TU chose the sediment sample location based on the significant sediment accumulation at the sediment trap, which could represent sediment transported downstream from numerous other AML sites adjacent to Russell Gulch upstream of Site #158.

The waste pile (158-MP-SO) arsenic level was 251x the EPA Residential RSL, 57x the EPA Industrial RSL, and 5.6x the BLM Recreational SL, and the lead level was 9.3x the EPA Residential RSL, 4.6x the EPA Industrial RSL, and 4.6x the BLM Recreational SL. The waste pile at this site exhibited the 3rd highest arsenic concentration (171 mg/kg) and the 2nd highest lead concentration (3700 mg/kg) across all the sites sampled. The Russell Gulch (158-RG-SED) arsenic level was 84x the EPA Residential RSL, 19x the EPA Industrial RSL, and 1.9x the BLM Recreational SL. *Overall, arsenic exceeded all three human health SLs at both sites, and lead exceeded all three human health SLs at the waste pile site (Figure 25).*

Figure 24. Satellite imagery of the Site #158 waste pile (with numerous rills and gullies) adjacent to Russell Gulch.

All twelve (12) of the metals detected *decreased* in concentration in the Russell Gulch sample compared to the waste pile sample, which may indicate limited mobilization of material from the waste pile to Russell Gulch, variable concentrations of metals across the waste pile, or dilution from other sediment sources to Russell Gulch that are either unimpacted or have lower concentrations of metals. Previous restoration work (i.e., riprap stabilization along the base of the waste pile) is likely facilitating sediment attenuation and erosion reduction. *Regardless, arsenic exceeded all three human health SLs in Russell Gulch.*

Figure 25. Site #158 – Total Metals



	As	Cd	Cr	Cu	Mn	Hg	Ni	Se	Ag	Zn
158-MP-SO	171	2.55	32.5	181	242	1.22	15.1	0.00	3.82	490
158-RG-SED	57.3	0.00	24.3	85.5	208	0.90	12.7	0.00	0.00	89.2

	Al	Fe	Pb
158-MP-SO	11100	34800	3700
158-RG-SED	9470	24500	151

Exceeds EPA Lowest ESV, EPA Residential RSL, EPA Industrial RSL, & BLM Recreational SL

Figure 26. Site #158 – The base of the southeast portion of the waste pile where sediment flows directly into Russell Gulch (left) and the origination point of that sediment from the top of the waste pile where there's significant gully erosion (right).

Figure 27. Site #158 – The southeast corner of the previous riprap stabilization work (left) and a downslope view of the southwest-facing slope of the waste pile with Russell Gulch and a historic mine structure at the base (right).

Figure 28. Site #158 – Russell Gulch sediment sample (158-RG-SED) location, partially downstream of the waste pile, looking upstream (left) and downstream, where the in-channel sediment trap is located (right).

Upstream Bracket & Downstream Bracket (Russell Gulch)

Two (2) sediment samples were collected to bracket the Russell Gulch drainage upstream of the sampled waste piles, ideally where no historic mining impacts exist, and downstream of the sampled waste piles, where cumulative impacts from impaired sediment transport and deposition are likely concentrated. Both sites are located on Russell Gulch, with the upstream site at the upper limit of the project area and source of Russell Gulch and the downstream site at the lower limit of the project area, downstream of the confluence with Willis Gulch and upstream of the Central City Parkway culvert. One (1) composite sediment sample (UPS-RG-SED) was collected at the upstream site, and one (1) composite sediment (DWS-RG-SED) sample was collected at the downstream site.

The upstream Russell Gulch (UPS-RG-SED) arsenic level was 19x the EPA Residential RSL and 4x the EPA Industrial RSL. The downstream Russell Gulch (DWS-RG-SED) arsenic level was 32x the EPA Residential RSL and 7x the EPA Industrial RSL. *Overall, arsenic exceeded two human health SLs at both sites (Figure 29).*

Four (4) of the eleven (11) metals detected *increased* in concentration in Russell Gulch downstream compared to Russell Gulch upstream, which may indicate (for those specific analytes) mobilization and downstream transport of impaired sediment from the numerous AML sites adjacent to Willis Gulch and Russell Gulch upstream, as well as variable concentrations of metals across those sites. Seven (7) of the eleven (11) metals detected *decreased* in concentration in Russell Gulch downstream compared to Russell Gulch upstream, which may indicate (for those specific analytes) variable concentrations of metals across the numerous AML sites upstream, dilution from sediment sources to Russell Gulch that are either unimpacted or have lower concentrations of metals, or that the Russell Gulch upstream site was more characteristic of a waste pile rather than natural background conditions. The Russell Gulch upstream site was intended to serve as an unimpacted reference point for the drainage. However, sampling was not possible on the west side of the culvert at Virginia Canyon Road, where the soil appeared to be unimpacted. Instead, sampling occurred on the east side of the culvert where the 0-6 inch soil subsamples appeared to be mine-impacted material. Suppose a true background sample had been collected and showed lower concentrations of metals. In that case, it's possible that all analytes at the Russell Gulch downstream site would have increased in concentration compared to the Russell Gulch upstream site.

A check dam structure on Russell Gulch below the confluence with Willis Gulch captures a significant amount of sediment. However, elevated concentrations of metals at the Russell Gulch downstream site may indicate that sediment breaches the check dam or other AML sites upslope of Russell Gulch between the check dam and Russell Gulch downstream site are contributing impaired sediment to the stream channel. *Regardless, arsenic exceeded two human health SLs in Russell Gulch.*

Figure 29. Upstream & Downstream Bracket – Total Metals

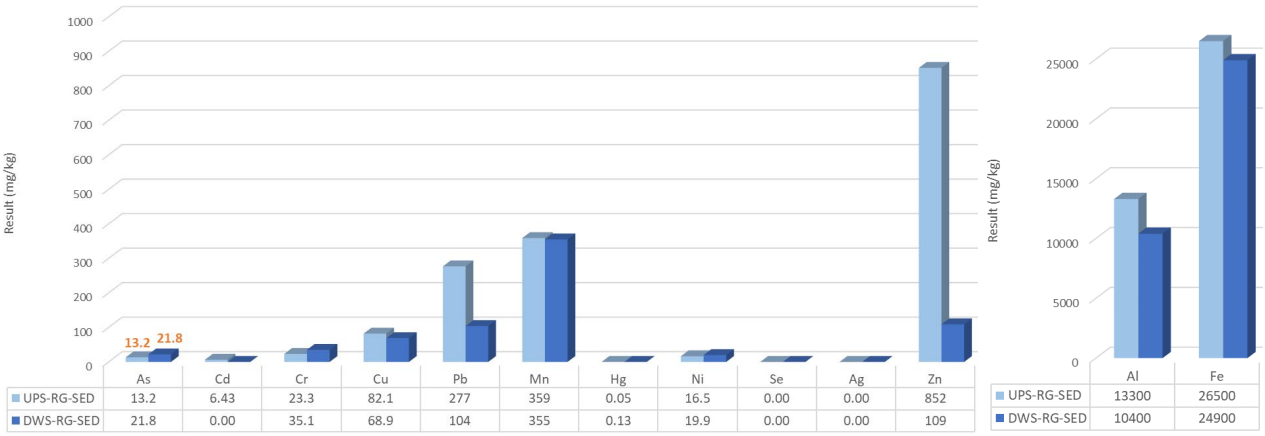


Figure 30. Brackets – Upstream Russell Gulch sediment sample (UPS-RG-SED) cross section, looking downstream (left) and looking upstream at the Russell Gulch drainage from the Central City Parkway (right).

Figure 31. Brackets – Downstream Russell Gulch sediment sample (DWS-RG-SED) cross section, looking upstream (left) and looking downstream towards the Central City Parkway culvert (right).

Accomplishments & Next Steps

TU completed the primary grant objective to collect samples for AML site characterization in the Russell Gulch drainage. In 2024, TU will communicate findings to applicable stakeholders and further assess the feasibility of potential AML reclamation work in Russell Gulch and Willis Gulch. The analytical results will support the evaluation, prioritization, and planning for watershed restoration and provide the foundation for collaboration with landowners and project partners, including progressing through the CERCLA process with an EPA on-scene coordinator (OSC). Future reclamation and restoration activity would aim to restore environmental conditions (e.g., water quality, stream function, and aquatic, riparian, and terrestrial habitat) and reduce human and ecological receptor exposure pathways to elevated concentrations of metals in the Russell Gulch drainage and downstream on the North Fork of Clear Creek by addressing the mobilization of metals and mine-impacted sediment to receiving waters. TU appreciates the support and partnership provided through UCCWA's grant program and looks forward to continuing collaborative, science-based efforts in the Clear Creek Watershed that improve and protect our state waters and the ecological services they provide to our communities and coldwater fisheries.

Budget & Funding Leverage

The project budget (reimbursement and match) totaled $9,772.69. The grant match requirement of $2,256.64 was fulfilled and exceeded by ~ 10%, totaling $2,490.40 (100% private). The cost for the laboratory analysis totaled $6,485.40 ($3995.00 to UCCWA and $2,490.40 to SODBRG as match), the Tailwater Limited consult totaled $67.50, other supplies totaled $207.84 (e.g., sample shipment, sample bags, trowel, and scoops), and travel totaled $70.32. The UCCWA funds provided the opportunity to leverage private funds, which accounted for ~ 25% of the total project budget.

TROUT UNLIMITED INC.			
Grant Tasks	**Funding Sources**		
	UCCWA	Soderberg	**TOTAL**
Task 1 - Project Management	$2,057.82		$2,057.82
Task 2 - Surface Soil & Water Sampling	$4,340.66	$2,490.40	$6,831.06
Indirect	$883.81		$883.81
TOTAL – All Project Funding	$7,282.29	$2,490.40	$9,772.69

Note: A 13.84% NICRA rate for TU was applied to all project funds.

Match Requirement	$ 2,256.64
Cash/In-Kind Match (Private)	$ 2,490.40
Total Match %	110.36%

Funding Breakdown (% of Total Budget)	
UCCWA	74.52%
Private	25.48%