Water Quality Assessment for the Upper Uncompahgre Watershed:

River Watch Data Summary (2019-2021) and

Review of WQCC 2022 Regulation 93 – 303(d) List of Impaired Waters

Prepared by Arlen Huggins (UWP)

Executive Summary

This assessment of water quality in the upper Uncompahgre Watershed was produced to provide the Uncompahgre Watershed Partnership (UWP) and its stakeholders with a background of recent water quality data and provide a basis for developing the next Uncompahgre Watershed Plan and future UWP projects. The report summarizes River Watch sampling events conducted by Uncompahgre Watershed Partnership (UWP) volunteers from 2019 through 2021. It also contains the results of two major areas of analysis. In the first, River Watch data collected in the upper Uncompahgre over the 2019-2021 period by UWP and Ouray, Colorado volunteers was analyzed, with statistical results displayed in a series of box and whisker plots for all 17 sites. The second major analysis section contains a review of the Water Quality Control Commission 2022 Regulation 93 303(d) List of Impaired Waters in the upper Uncompahgre Watershed. The review emphasizes the importance of River Watch data in the development of the 2022 303(d) List and reveals how more recent River Watch data will aid in impairment evaluations in future years.

2019-2021 River Watch Events and Data

The UWP has participated in the Colorado Parks and Wildlife (CPW) River Watch Program since 2013. Previous reports summarized River Watch data through 2018. Since then, six UWP volunteers have collected water quality samples at six to eleven sites, ranging from a site on Red Mountain Creek at 10,882 ft, down to a site on Cow Creek below Ridgway Reservoir at 6,605 ft. Four new sites were established in 2021 to aid the Water Quality Control Division (WQCD) is establishing total maximum daily loads (TMDLs), and one new site below Lower Blue Lake was established to add supporting data for a U.S. Forest Service study on visitor impact. From May 2019 through December 2021 there were 103 River Watch sampling events which included 103 standard (pH, hardness, alkalinity, and temperature) samples, 95 metals samples, 16 nutrient samples and 1 macroinvertebrate sample.

River Watch Box Plot Analyses

Data from each of 17 River Watch sites, sampled from 2019-2021, were analyzed statistically using box and whisker plots which displayed the median, mean, interquartile range and spread of the complete data set for each River Watch analyte. Analytes analyzed were pH, hardness, alkalinity, dissolved Cd, Cu, Mn, Pb, Mn, and Zn, and total Ca, Mg, Fe and As. For each analyte box plots were arranged on a chart in upstream to downstream order, allowing visualization of the distribution of each site's data, as well as how these distributions changed along the length of the Uncompahgre River.

As found in previous water quality studies in the upper Uncompahgre Watershed, the current analysis of River Watch data showed that the acidity of water entering the Uncompahgre River above Ouray is due to acidic water draining into Red Mountain Creek from mine adits, exposed tailings, and waste rock surrounding the creek. pH values below the Idarado mining area ranged from 2.4 to 4.5, resulting in little or no alkalinity to buffer the acidic water in the Uncompahgre River until more alkaline water with higher pH enters the river from Canyon Creek and other tributaries. The River Watch site above Ouray had a median pH of 5, while below Ouray as alkalinity median values gradually increased from 20 mg/liter to > 100 mg/liter, pH median values increased from slightly above 7 to about 8.2 below Ridgway Reservoir.

In contrast to alkalinity, the River Watch data indicated water hardness, due mostly to the presence of magnesium and calcium, was very high in Red Mountain Creek and increased hardness in the river below the confluence. However, Canyon Creek had the greater influence, with median hardness above the confluence with the Uncompahgre being about 180 mg/liter, and below the confluence the median increased to about 350 mg/liter. Calcium concentrations produced most of the changes in hardness, and both calcium and hardness had very large ranges in concentration that were inversely dependent on streamflow.

The acidity of runoff and mine drainage into streams in the upper watershed results in harmful metals being dissolved and entering the Uncompahgre, mostly below Red Mountain Creek. Very high concentrations of dissolved metals were found in Red Mountain Creek. Box plot analyses showed these high concentrations raised dissolved metal concentrations in the Uncompahge River below the confluence. Below the Red Mountain Creek confluence dissolved metal concentrations steadily declined down to the reservoir, primarily due to dilution from creeks which had much lower concentrations of dissolved metals. For the most problematic metals (Cd, Cu, Zn and Pb), box plots indicated chronic aquatic life standards were only exceeded in Red Mountain Creek and at the Uncompahgre River site above the Ouray Hydro Dam. In addition, among the five TMDL sites, cadmium, copper, and zinc aquatic life standards were exceeded at Commodore Gulch; and cadmium and zinc aquatic life standards were exceeded at Imogene Creek.

Total metal concentrations, like iron (Fe-T), were also highest in Red Mountain Creek (median of ~12.6 mg/liter above the confluence), with box plots showing declining concentrations in the Uncompahgre River down to a site between Ouray and Ridgway where the median concentration was ~2 mg/liter. Seasonal high flows resuspend iron particles between Ridgway and Ridgway Reservoir resulting in significant broadening of Fe-T distributions. Iron particles settling out in Ridgway Reservoir resulted in the median Fe-T concentration below the reservoir being 25.3 times lower than the concentration above the reservoir. For the 2019-2021 data set, none of the River Watch sites below the Red Mountain confluence had Fe-T concentration distributions that indicated exceedance of the Fe-T standard for aquatic life. Among the River Watch TMDL sites Gray Copper Gulch had the largest median Fe-T concentration, ~2.5 mg/liter, which was approximately equal to the aquatic life standard.

Total arsenic (As-T) data were analyzed but several sites below Red Mountain Creek had few values that exceeded the method detection limit (MDL) for arsenic. As with other metals Red Mountain Creek sites had the highest As-T concentrations with values ranging as high as 35 µg/liter, and median values well above the water supply use standard of 0.02 µg/liter. Interestingly, two sites on the Uncompahgre (at Ridgway and CR24 below Ridgway) had a significant number of valid As-T data points and the box plot distributions revealed median values of 4.0 µg/liter and 5.0 µg/liter, both much greater than the water supply use standard of 0.02 µg/liter.

Review of the 2022 WQCC 303(d) List of Impaired Streams

Part of the water quality assessment completed in this report included a review of the 2022 Water Quality Control Commission (WQCC) 303(d) List of impaired streams in the upper Uncompahgre Watershed. The data used to evaluate segments came from a variety of sources in the five-year period from January 2015 through December 2019. The review documented the data used to evaluate each stream segment,

determined the portion contributed by River Watch, assessed how data collected after 2019 might have changed the assessments, and noted where additional River Watch sites could be used in future evaluations where data is currently lacking.

Seventeen stream segments in the upper Uncompahgre River Basin appear in the 2022 303(d) List. Ten of these segments are currently monitored by UWP and Ouray River Watch volunteers, but data from only six of these sites was used in the 2022 303(d) impairment assessment. Two of the six River Watch sites not used are on the lower portion of Red Mountain Creek (Segment COGUUN06b). This segment is heavily contaminated by metals coming from the Idarado mining district, but it does not appear in the 303(d) List because the WQCC has not determined if a condition of aquatic life use is attainable. The other four River Watch sites not used in the 2022 assessment were established in 2021, so were not available in the 2015-2019 data period.

Descriptions of Uncompahgre River segments where significant changes were made to the 2022 303(d) list, compared to earlier lists, are given below. For reference, Table 4 in the main body of the report provides the complete 303(d) list. One of the common reasons for retaining a non-attainment listing from an earlier 303(d) list was the lack of data to enact a change. [WQCD required 10 data points from the 2015-2019 period to change a prior listing.]

In the following descriptions dissolved metals are indicated with a "-D" and total metals with a "-T". Regarding standard attainment, a stream segment is considered impaired for a dissolved metal when the 85th percentile of the concentrations exceeds the hardness-based Table Value Standard (using the mean hardness of all data points). For total metal concentrations the median concentration is compared to a set standard, or site-specific standard in the case of Fe-T.

Segment COGUUN02_C: This segment of the Uncompahgre River extends from below Poughkeepsie Gulch to a point just above its confluence with Red Mountain Creek. Ninety-two percent of the assessment data came from one River Watch site. The segment is listed as impaired for aquatic life use due to non-attainment of standards for dissolved cadmium (Cd-D), copper (Cu-D), zinc (Zn-D), and pH. Cu-D was retained on the list despite attaining the standard in the 2015-2019 data set. River Watch data from 2019-2021 also indicated the Cu-D standard for aquatic life was attained. Dissolved lead (Pb-D) and total arsenic (As-T) were retained on the Monitoring and Evaluation (M&E) list because of insufficient data points (4) to change the listing. Dissolved manganese (Mn-D) was taken off the impaired list for water supply use.

Segment COGUUN03a_A: This segment of the Uncompahgre River extends from a point above the confluence with Red Mtn Creek to a point above the confluence with Cascade Creek in Ouray. All the assessment data came from one River Watch site above the Ouray hydro dam. The impact of Red Mountain Creek flowing into this river segment was obvious with the segment listed as impaired for non-attainment of aquatic life standards for Cd-D, Cu-D, Zn-D, and pH. Total iron (Fe-T) was removed from the impaired list for aquatic life use after attaining a new site-specific standard. Pb-D and As-T were not assessed, possibly because only a few values exceeded the Lower Reporting Limit (LRL) for both metals. However, data available since 2019 indicates the segment exceeds the Pb-D standard for aquatic life, and As-T exceeds the standard for water supply use. Total concentrations of manganese (Mn-T) and

copper (Cu-T) in the 2015-2019 and 2019-2021 data sets both exceeded agricultural use standards, but only Cu-T was added to the 303(d) list.

Segment COGUUN03a_A: This segment of the Uncompahgre River extends from a point above the confluence with Cascade Creek to a point above the confluence with Dexter Creek below Ouray. Eighty-nine percent of the assessment data came from one River Watch site. Cd-D and Cu-D both attained aquatic life standards in the 2015-2019 and 2019-2021 data sets and were removed from the 2022 303(d) list. Also, both data sets indicated non-attainment of pH for aquatic life use and pH was added to the 303(d) list. Mn-T exceeded agriculture use standards in both data sets but was not added to the 303(d) list. Fe-T was retained on the 303(d) list for aquatic life use, while the 2019-21 data set indicated a median value slightly less than the standard. Total arsenic exceeded the water supply use standard in both data sets and As-T was added to the 303(d) list.

Segment COGUUN03c_A: This segment of the Uncompahgre River extends from a point above the confluence with Dexter Creek to a point below the confluence with Dallas Creek. River Watch data accounted for about 82% of the assessment samples. It is an interesting segment in the 2022 303(d) assessment as all metals previously on the 303(d) list (Cd-D, Cu-D, Mn-D, and Fe-T) were delisted, so the segment does not appear in the 2022 list. One data point for As-T exceeded the water use standard, but this was insufficient to add it to the list. The 2019-2021 River Watch data showed standard attainment of the same metals, except for As-T, where the median exceeded the water use standard.

Segment COGUUN03e_B: This segment of the Uncompahgre River extends from below the outlet of Ridgway Reservoir to a point above Broman Canyon. One River Watch site contributed 72% of the assessment data from the 2015-2019 period. As with Segment 03c_A, all analytes on the previous 303(d) list (Cd-D, Cu-D, Fe-T, and temperature) attained standards and were delisted, so this segment also does not appear in the 2022 303(d) list. The 2019-2021 River Watch data showed standard attainment of the same metals.

Segment COGUUN09_C: This segment consists of the mainstem of Canyon Creek from its start at the confluence of Sneffels and Canyon Creeks to its confluence with the Uncompahgre River near Ouray. It is the final main tributary covered here that was evaluated for the 303(d) list using River Watch data (about 91% of the 2015-2019 data). Zn-D, the only metal on the previous 303(d) list, was delisted in 2022 based on attainment of the aquatic life standard in the 2015-2019 data set. The pH data indicated non-attainment of the minimum pH standard, but was placed on the M&E list. River Watch data from 2019-2021 agreed with the non-listing of all metals, but found pH continued to fall below the minimum pH standard for aquatic life.

Segments COGUUN10a_C and COGUUN11_G: These segments include the lower portion of Cow Creek (10a_C) and the entire length of Dallas Creek (11_G). River Watch sites were established on both creeks in 2019, but metals' data was not available for the assessment. Both segments are listed as impaired for As-T for water supply use based on WQCD data. Also, no As-T concentrations from 2019-2021 River Watch data were greater than the River Watch MDL for As-T.

River Watch data from the four new TMDL sites and the Blue Lake site were not available for the 2022 303(d) assessment but will be available for future assessments and, as noted in the summaries below,

will likely change the impairment status of some metals based on data collected, in some cases, more than 10 years ago.

Segment COGUUN06a_A: This segment is the upper portion of Red Mountain Creek from its source near Red Mountain Pass to a point above the confluence with the East Fork of Red Mtn Creek. Being above the Idarado mining area, the harmful metals in this segment are found in much lower concentrations than in Segment COGUUN06b below the mining district. Based on data from 2012-13 this segment was listed as impaired (aquatic life use) for Cu-D, Zn-D, and Ag-D, and these metals were retained in the 2022 list. Six River Watch samples from 2021 (a new TMDL site) found that Cu-D did not attain the Cu-D standard but did attain the Zn-D standard. Ag-D is not analyzed in the River Watch laboratory.

Segment COGUUN05_B: This segment contains Commodore Gulch from its source to its confluence with Red Mountain Creek. It drains an area of considerable past mining activity. No data was available in the 2015-2019 period, so its listing in 2022 was carried forward from 2018 when it was listed as impaired for aquatic life use for Zn-D, and on the M&E list for Cd-D, Cu-D, and Pb-D. River Watch data in 2021 (new TMDL site) showed that aquatic life standards were exceeded for Cd-D, Cu-D, Pb-D, and Zn-D. Mn-D also exceeded the water supply use standard.

Segment COGUUN07_A: This segment is the mainstem of Gray Copper Gulch from its source to the confluence with Red Mountain Creek just below the Idarado mining area. The 2022 303(d) list was retained from an earlier listing. There were a significant number of samples collected along the length of the gulch in 2016-2017, but most of these were not used in the 2022 assessment. Cu-D, Zn-D, Pb-D, and pH were all on the 2022 list for not meeting aquatic life use standards. River Watch data (6 samples) from one of the new 2021 TMDL sites indicated attainment of the Cu-D, Zn-D, Pb-D, and pH standards. Mn-T was also found to exceed the agriculture use standard but was not on the 2022 303(d) list. Note that most of the samples prior to 2021, where standards were exceeded, were collected in the upper part of the gulch, while the River Watch samples came from near the mouth of the gulch.

Segment COGUUN09_D: This segment consists of the entire length of Imogene Creek from its source to its confluence with Sneffels Creek (at the start of Canyon Creek). The creek has been sampled by WQCD and UWP since 2010, but only two samples were available in the 2015-2109 period, so no changes were made to the 2022 303(d) list. Cd-D and Zn-D were listed as impaired for aquatic life use, and Cu-D was on the M&E list for aquatic life use. Data from the River Watch TMDL site on Imogene Creek indicated that Cd-D, Cu-D, and Zn-D were all in non-attainment of aquatic life standards.

Segments COGUUN05_C, COGUUN05_E, and COGUUN09_B: These segments contain Governor Basin (05_C) and two sections of Sneffels Creek (05_E and 09_B), which combined with Imogene Creek become Canyon Creek. Water quality monitoring is important on these segments for assessing the impacts of past and present mining activities, and UWP remediation projects. All three segments are listed in 2022 as impaired for a variety of metals including Cd-D, Cu-D, Pb-D, and Zn-D, with insufficient data available in 2015-2019 to change any of the listings. One important change in 2022 was the delisting of macroinvertebrates in Segment -05_E when a reanalysis brought MMI scores above the aquatic life attainment threshold. Due to the importance of monitoring water quality in these segments UWP plans to add one or more River Watch sites to the Sneffels Creek segments.

Table of Contents

1. Introduction and Background

The Uncompahgre Watershed Partnership (UWP), created in 2007, has consistently been involved in water quality assessment in the Uncompahgre Watershed. The 2018 UWP Watershed Plan (UWP, 2018) provides a summary of several water quality studies conducted in the Uncompahgre Watershed by the U.S. Geological Service (USGS), the Colorado Water Quality Control Division (WQCD), UWP, and the Division of Reclamation Mining and Safety (DRMS) from 2000 through 2017. Not included in the 2018 Watershed Plan were analyses of data from the Colorado Parks and Wildlife (CPW) River Watch program, whose volunteers have collected water quality samples in the Uncompahgre Watershed since the mid-1990s. A description of River Watch is given in Section 2 of this report.

River Watch provides the bulk of the data used by the Water Quality Control Commission (WQCC) in determining if Colorado's streams are meeting standards for aquatic life, recreation, water supply, and agriculture uses. In a 2012 UWP report, Woodling (2012) assessed water quality in the Uncompahgre Watershed using a variety of data sources, including River Watch data from 2002-2008. Metals concentrations in Uncompahgre River segments in and below Red Mountain Creek were compared to water quality standards, and the list of impaired stream segments at that time. In a 2020 UWP report, Huggins (2020) extended the analyses of River Watch data through 2018, mainly showing how water quality parameters changed along the length of the river from Red Mtn Creek to a site below Ridgway Reservoir.

This report focuses on River Watch data collected in the Upper Uncompahgre Watershed from 2019 through 2021. Section 4 summarizes the data using statistical box plots for 17 River Watch sites in the Upper Uncompahgre Watershed, and Section 5 compares the 2022 303(d) list of impaired streams (evaluated using 2015-2019 data) with assessments using River Watch data analyzed since 2019.

2. Description of River Watch and UWP Involvement

***From the River Watch website**: River Watch is a statewide volunteer water quality monitoring program operated by Colorado Parks and Wildlife (CPW). Our mission is to work with voluntary stewards to monitor water quality and other indicators of watershed health and utilize this high-quality data to educate citizens and inform decision makers about the condition of Colorado's waters. This program is unique in its statewide focus and frequency of data collection.*

Since 1989 River Watch has had two primary goals: 1) Provide a hands-on real science experience, learning the value and function of Colorado's river and water ecosystems, and 2) Generate quality aquatic habitat data over space and time for use in the Clean Water Act, Colorado Parks and Wildlife, watershed, local and other decision-making processes.

River Watch is primarily funded by CPW through a mix of federal funds and Colorado Lottery funds. CPW contracts every five years with a non-profit partner to help provide professional staff to support volunteers, diversity in funding, size, and program areas. (In 2019 CPW negotiated with a new partner, River Science, which now conducts the day-to-day operations with volunteers.)

River Watch has an annual cycle that works around the school and state fiscal calendar. All volunteers are required to attend one of our four-day training events, offered in late summer or mid-fall, switching east and west slope central locations when possible.

As a baseline engagement, all groups sample and analyze all stations monthly for temperature, dissolved oxygen, alkalinity, and hardness. Also, total and dissolved metals' samples are collected monthly and analyzed at CPW laboratories for 13 metals (Al, As, Ca, Cd, Cu, Fe, K, Mg, Mn, Na, Pb, Se, and Zn). High-flow and low-flow nutrient samples (total nitrogen, ammonia, nitrate/nitrite, total

phosphorus, chloride, sulfate, and total suspended solids) are collected and analyzed at CPW laboratories. Fall macroinvertebrate samples are collected with a physical habitat assessment. Samples are sent to a certified taxonomist for identification and subsequent calculation of biotic indices that imply the health of the aquatic habitat. All data are entered into the River Watch database.

The Uncompahgre Watershed Partnership (UWP) has participated in the CPW River Watch program since 2013. However, other River Watch volunteers have collected water quality samples from the Uncompahgre and its tributaries since as early as 1999. This report focuses on UWP River Watch activities since May 2019 when a new group of UWP volunteers began collecting water quality samples at six sites

Figure 1. Google Earth image showing Ouray County River Watch sites from Cow Creek (347) at the top (north) to USGS 3586 at the bottom (south).

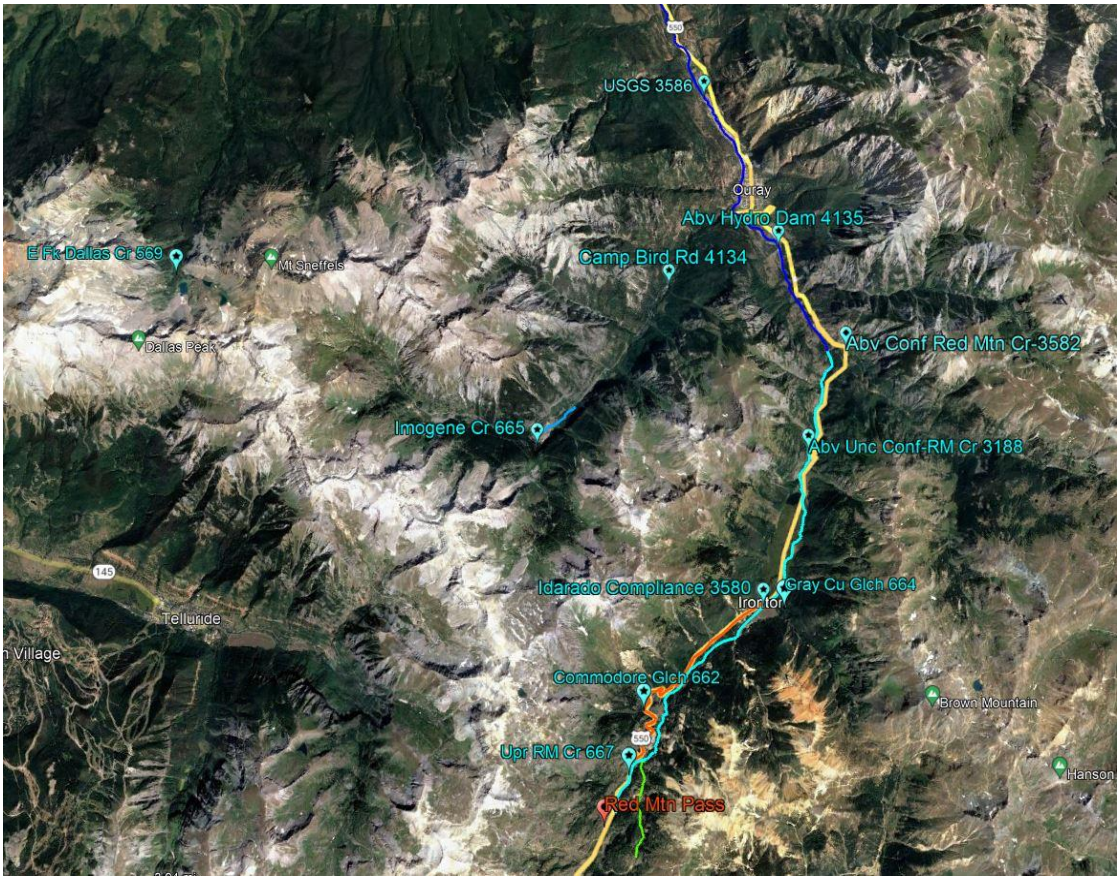

Figure 2. Google Earth image showing Ouray County River Watch sites from USGS 3586 at the top (north) to Upr RM Cr 667 at the bottom (south).

in the Uncompahgre Watershed. Beginning in the summer of 2021 UWP added four River Watch sites in the upper part of the watershed to supplement data on streams lacking sufficient data for Total Maximum Daily Load (TMDL) studies being conducted by the Colorado Water Quality Control Division (WQCD). A fifth UWP River Watch site was added below Blue Lake in cooperation with a National Forest Service visitor impact study. The locations of current UWP River Watch sites are shown on the maps in Figures 1 and 2, and site details are given in Table 1.

3. Ouray County River Watch Sampling Locations in the Uncompahgre Watershed

River Watch volunteers from Ridgway and Ouray currently sample 17 sites on the Uncompahgre River and its tributaries. The locations are shown map images in Figures 1 and 2. The site details, including the organization that samples each site, are given in Table 1. In Figure 1 the sites sampled by UWP volunteers are: Cow Cr 317, Blw Ridgway Res 393, CR24 395, Dallas Cr 336, Ridgway Town 402, and Potters Ranch 392. In Figure 2 the UWP sites are: E Fk Dallas Cr 559 (near Blue Lake), Imogene Cr 665, Gray Cu Gulch 664, Commodore Gulch 662, and Upr RM Cr (667). The remainder of the sites in Figure 2 are sampled by Ouray, Colorado, River Watch volunteers. All UWP sites are sampled monthly, year-round, except the last five UWP sites in Table 1, which are typically sampled monthly from June to October or November.

4. Summary of UWP River Watch Sampling Events and Data: 2019 – 2021

An earlier water quality report (Huggins, 2020) presented analysis results using River Watch data for the Upper Uncompahgre from 2002 through 2018. This report uses River Watch data beginning in May 2019 and ending in December 2021. There was a gap in UWP River Watch sampling from January to April 2019 when a new group of volunteers were recruited and trained. Data collection has continued through 2022, but only three months of 2022 metals' data have been archived in the River Watch database. Although data from the Ouray volunteer River Watch sites will be presented in Sections 4 and 5, only details of the sampling events for which UWP volunteers were responsible are included in Table 2.

Table 2 summarizes UWP sample collections and data availability from May 2019 through December 2021. Samples were not collected in April 2020 due to COVID restrictions imposed for volunteers by CPW. Metals and nutrient data, noted as missing in Table 2, were shipped to CPW for analysis, but have not appeared in the River Watch database. In 2022 River Watch discovered that test tubes holding samples were contaminated with aluminum. This resulted in the deletion of all aluminum data for 2019 and 2020, and for January through July in 2021. For this reason aluminum was not analyzed in Section 4.

Statistics computed from the 2019-2021 River Watch water quality data for all sampling sites in Table 1 are displayed as vertical box and whisker plots in Figures 3 through 25. Interpretation of a box and whisker plot is given in a text box in Section 4A below. Discussions in Sections 4 and 5 refer to stream segmentation, water quality standards and Table Value Standards (TVS), and the 2022 303(d) list of impaired waters. The following links to Colorado Department of Public Health and Environment (CDPHE) maps and documents provide comprehensive explanations of all these terms.

- Interactive map of Colorado stream segments: https://cdphe.maps.arcgis.com/apps/Viewer/index.html?appid=f1541d2f21834642ba1551c674fd4a79
- CDPHE (WQCD) 303(d) Listing Methodology: https://drive.google.com/file/d/1jlgq37fgFV5MpUC3HPA5misOmvhKeMrZ/view
- Water Quality Control Commission (WQCC) Regulation No. 35 Classification and numeric standards for Gunnison and Lower Dolores River Basins: https://cdphe.colorado.gov/water-quality-control-commission-regulations
- Water Quality Control Commission (WQCC) Regulation No. 31 The Basic Standards and Methodologies of Surface Water: https://cdphe.colorado.gov/water-quality-control-commission-regulations
- Water Quality Control Commission (WQCC) Regulation No. 93 Colorado's Section 303(d) List of Impaired Waters and Monitoring and Evaluation List: https://cdphe.colorado.gov/water-quality-control-commission-regulations

Table 1. River Watch sites sampled by UWP and Ouray volunteers in 2021. Locations are shown in Figures 1 and 2. First 12 sites follow the order of data plots in Sections 4A-4D. Shaded rows are referred to as TMDL sites in Sections 4A-4D.

Project Name	Organization	Station Name	Station No.	Water Body ID	Stream	Latitude	Longitude	Elevation (ft)
River Watch	Eric Funk	Abv Red Mtn Conf	3582	COGUUN02	Uncompahgre	37.9883	-107.6496	9,108
River Watch	Eric Funk	Idarado Compliance	3580	COGUUN06B	Red Mtn Creek	37.9382	-107.6729	9,748
River Watch	Eric Funk	Abv Uncompahgre Conf on Red Mtn Cr	3188	COGUUN06B	Red Mtn Creek	37.9677	-107.6604	9,493
River Watch	Eric Funk	Abv Hydro Dam	4135	COGUUN03A	Uncompahgre	38.0103	-107.6652	8,145
River Watch	Eric Funk	Campbird Rd (FS 853)	4134	COGUUN09	Canyon Cr	38.0022	-107.694	8,601
River Watch	Eric Funk	USGS Gauge	3586	COGUUN03B	Uncompahgre	38.0359	-107.6789	7,601
River Watch	UWP	Potters Ranch	392	COGUUN03C	Uncompahgre	38.1191	-107.7332	7,020
River Watch	UWP	Ridgway Town	402	COGUUN03C	Uncompahgre	38.1571	-107.7540	6,973
River Watch	UWP	CR24	395	COGUUN03C	Uncompahgre	38.1840	-107.7461	6,887
River Watch	UWP	CR24 blw Pleasant V Cr	336	COGUUN11	Dallas Creek	38.1722	-107.7956	7,192
River Watch	UWP	Below Ridgway Res	393	COGUUN03E	Uncompahgre	38.2442	-107.7633	6,693
River Watch	UWP	Abv Confluence Uncompahgre	347	COGUUN10A	Cow Creek	38.2523	-107.7651	6,605
River Watch	UWP	Red Mtn Cr Abv Idarado MM81	667	COGUUN06A	Red Mtn Creek	37.9083	-107.7057	10,882
River Watch	UWP	Commodore Gl @ Hwy 550	662	COGUUN05	Commodore Gl	37.9193	-107.7023	10,470
River Watch	UWP	Gray Copper G At CR20	664	COGUUN07	Gray Copper Gl	37.9377	-107.6679	9,738
River Watch	UWP	Imogene Cr Abv Canyon Cr At Camp Bird	663	COGUUN09	Imogene Creek	37.9694	-107.7274	9,888
River Watch	UWP	Below Conf. of Blue Lk and E Dallas Cr	569	COGUUN01	E. Fork Dallas Cr	38.0036	-107.8171	10,912

Table 2. Summary of UWP River Watch sampling events for 2019 through 2021. Missing samples are ones which were sent to CPW but have not been archived.

Site Name	Site No.	Year	Months	Site Samples	Standard Samples	Metals* Samples	Nutrient Samples	Macro Samples	Physical Samples	Comment
CR 24 Blw Pleasant V Cr	336	2019	05-12	8	8	8	0	0	0	
Abv Conf Uncompahgre	347	2019	05-12	8	8	7	0	0	0	Sept metals missing
Potters Ranch	392	2019	05-12	8	8	7	0	0	0	Sept metals missing
Below Ridgway Res	393	2019	05-12	8	8	7	0	0	0	Sept metals missing
CR 24	395	2019	05-12	8	8	7	0	0	0	Sept metals missing
Ridgway Town	402	2019	05-12	9	9	8	0	0	0	Sept metals missing. 1 extra sample in Dec
			Totals	49	49	44	0	0	0	* All Aluminum data deleted due to contamination.

Site Name	Site No.	Year	Months	Site Samples	Standard Samples	Metals* Samples	Nutrient Samples	Macro Samples	Physical Samples	Comment
CR 24 Blw Pleasant V Cr	336	2020	01-03, 05-12	11	10	11	2	0	1	Oct standard data missing
Abv Conf Uncompahgre	347	2020	01-03, 05-12	11	11	11	2	0	1	
Potters Ranch	392	2020	01-03, 05-12	11	11	11	2	0	1	
Below Ridgway Res	393	2020	01-03, 05-12	11	11	11	2	0	1	
CR 24	395	2020	01-03, 05-12	11	10	11	1	0	1	Feb standard data missing. June nutrient data missing.
Ridgway Town	402	2020	01-03, 05-12	11	11	11	1	0	1	June nutrient data missing
			Totals	66	64	66	10	0	6	* All Aluminum data deleted due to contamination.

Site Name	Site No.	Year	Months	Site Samples	Standard Samples	Metals* Samples	Nutrient Samples	Macro Samples	Physical Samples	Comment
CR 24 Blw Pleasant V Cr	336	2021	01-12	12	12	12	2	0	0	
Abv Conf Uncompahgre	347	2021	01-12	13	13	13	2	1	0	
Potters Ranch	392	2021	01-12	13	13	11	2	0	0	10/3, 10/31 metals missing.
Below Ridgway Res	393	2021	01-12	12	12	10	2	0	0	10/5, 11/1 metals missing.
CR 24	395	2021	01-12	12	12	10	2	0	0	10/5, 11/1 metals missing.
Ridgway Town	402	2021	01-12	13	13	11	1	0	0	10/3, 10/31 metals missing. June nutrients missing.
Below Conf. of Blue Lk and E Dallas Cr	569	2021	06-09	4	4	4	1	0	0	
Commodore Gl @ Hwy 550	662	2021	06-11	6	6	6	1	0	0	
Gray Copper G At CR20	664	2021	06-11	6	6	6	1	0	0	
Imogene Cr Abv Canyon Cr At Camp Bird	665	2021	06-11	6	6	6	1	0	0	
Red Mtn Cr Abv Idarado MM81	667	2021	06-11	6	6	6	1	0	0	
			Totals	103	103	95	16	1	0	* Jan-July Aluminum data deleted due to contamination.

A. River Watch pH Data: 2019-2021

The pH of water is a measure of its acidity and is measured on a logarithmic scale from 0 to 14. Water with a pH of 7 is neutral, with values < 7 being acidic and values > 7 being basic. River Watch monitors pH because aquatic organisms are quite sensitive to pH levels that are above or below the "normal" range of a water body. Aquatic species are adapted to a range of pH from 6.5 to 8.0. The basic standard pH range for cold water is 6.5 to 9.0, which applies to most streams in the Upper Uncompahgre that are rated for aquatic life use. Appendix B provides more detail on toxicity related to pH and metals.

Box and whisker plots show the spread and center of a data set. The spread is shown as the vertical dimension of the box, the interquartile range, plus the lengths of top and bottom whiskers. The center of the data set is the median. Bullets below describe the parts of the vertical box plots in Figures 3-25.

- The **whiskers** extend up from the top of the box to the largest data element that is less than or equal to 1.5 times the **interquartile range**, and down from the bottom of the box to the smallest data element that is larger than 1.5 times the interquartile range. If the bottom whisker extends below 0, the data minimum defines the bottom whisker.
- The **first quartile** is at the top of the bottom whisker, or bottom of the box.
- The **median** is shown as a horizontal line within the box. The **mean** is marked by an "x" within the box.
- The **third quartile** is shown at the top of the box, so the box encloses the middle of the data set between the first and third quartiles (**interquartile range**).
- For this water quality data set **outliers** are extreme, but not erroneous values, falling outside top or bottom whiskers, and plotted as small circles or dots.

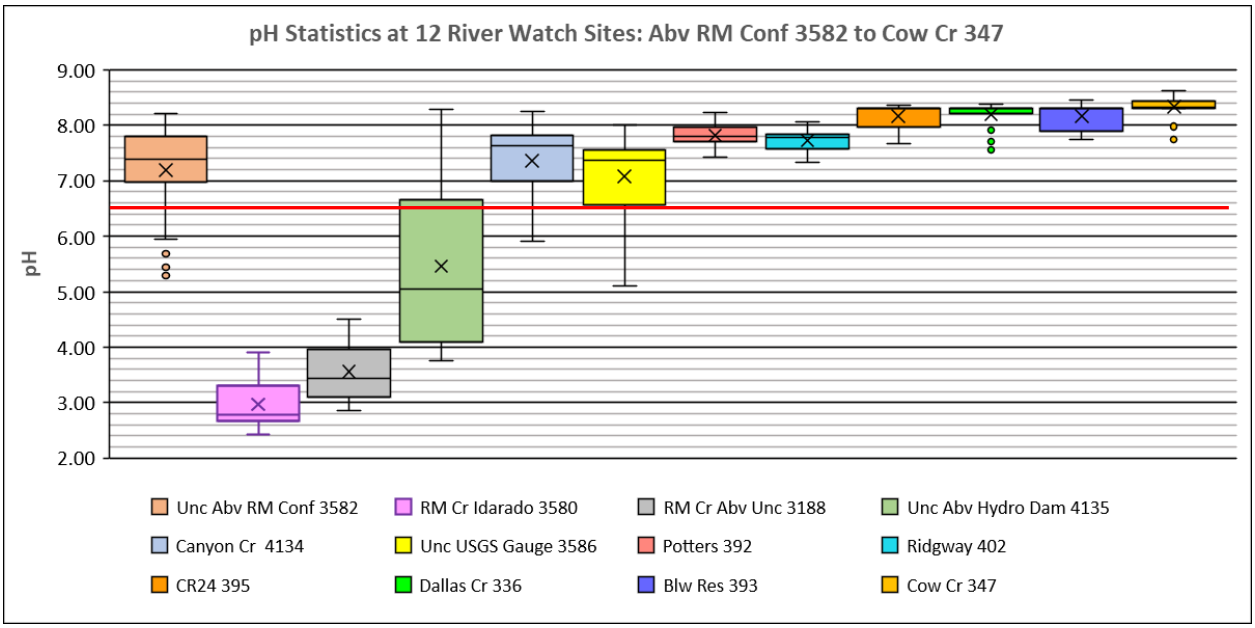

Figure 3. Box plots of pH data for River Watch sites 3582 (far left) downstream to 347 (far right). Locations are shown in Figures 1 and 2. Red line shows the minimum pH standard for aquatic life.

Statistics for River Watch pH data are shown by the box plots in Figures 3 and 4. Figure 3 shows the pH box plots for the highest site on the Uncompahgre River above Red Mtn Creek (3582) downstream to

Cow Creek (347). The impact of acid runoff from the mining district is apparent at Red Mtn Creek sites 3580 and 3188, and at the Uncompahgre River site 4135 below the confluence, where pH medians range from < 3.0 to 5.5. Low alkalinity (see Section 4B) accounts for the relatively large spread in the pH data at site 4135, immediately below the confluence, where changes in upstream acidity cannot be buffered. Non-attainment of the minimum pH standard of 6.5 is obvious at Sites 3580, 3188 and 4135. [Note that this lower segment of Red Mtn Creek, because of its overall poor water quality, is not classified for aquatic life use.] Further downstream the acidic water from Red Mtn Creek is diluted by higher pH water from streams like Canyon Creek and buffered by higher alkalinity in the Uncompahgre River below Ouray. This results in the increase in pH medians below the Hydro Dam site (4135) in Figure 3, and the continued gradual downstream increase in median pH from Potters Ranch (392) to Cow Creek (347). The box plots for the lower sites in Figure 3 also show a much-reduced spread in the pH data, also due to the buffering by higher alkalinity (less change induced by the more acidic water from upstream). Except for Site 3586, all pH values at the lower sites in Figure 4 were greater than 7.0 (basic) and about in the middle of the favorable range of pH values (6.5 to 9.0) that support aquatic life.

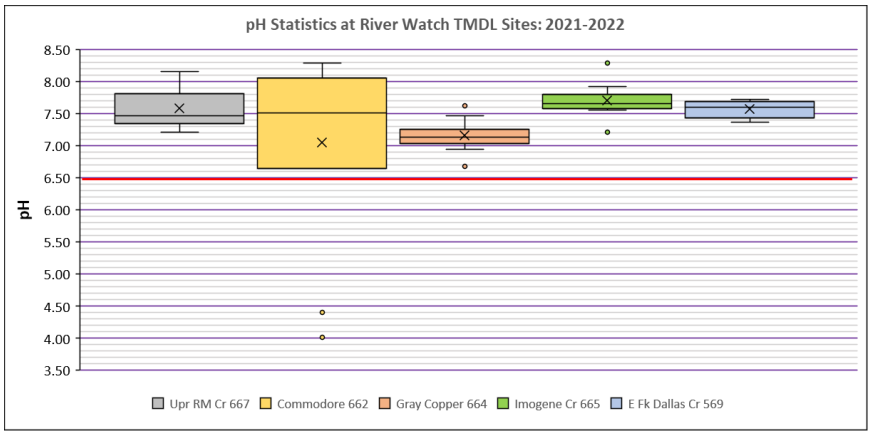

Figure 4. Box plots of pH data for the TMDL River Watch sites (667, 662, 664, 665 and 569) shown in Figure 2. Red line shows the minimum pH standard for aquatic life.

Finally, the pH box plots for River Watch TMDL sites are shown in Figure 4, with locations shown in Figure 2. Samples at these sites were collected between June and November of 2021 and 2022. Although these are high elevation sites with relatively low alkalinity, only the Commodore Gulch site (662) had two extreme values below the pH minimum standard. Both samples were collected in the fall at very low flow. The Upper Red Mtn Creek site (667) with a pH range between 7.2 and 8.2, was not impacted by acidic runoff like the lower Red Mtn Creek sites shown in Figure 3.

B. River Watch Alkalinity Data: 2019-2021

Alkalinity is the amount of carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) anions in water. It is often referred to as buffering capacity, the ability of water to resist change in pH when an acid (H^+) or base (OH^-) is added. It is measured as the concentration of calcium carbonate ($CaCO_3$) in mg/liter. Alkalinity is higher in streams flowing over limestone, which is mostly calcium carbonate, and can also be increased by irrigation runoff, or ground water pumping that interacts with surface streams. In the Uncompahgre Watershed limestone is more common in the Canyon Creek drainage and in the lower watershed below Ouray. Box plots for alkalinity data from the lower segment of Red Mountain Creek down to Cow Creek below Ridgway Reservoir are shown in Figure 5. The upstream to downstream order is the same as with the pH box plots in Figure 3. No alkalinity existed in the Red Mtn Creek sites where Figure 3 indicated pH was almost entirely less than 4.0. This acidic water reduced the alkalinity (H^+ ions exceeded OH^- ions) in

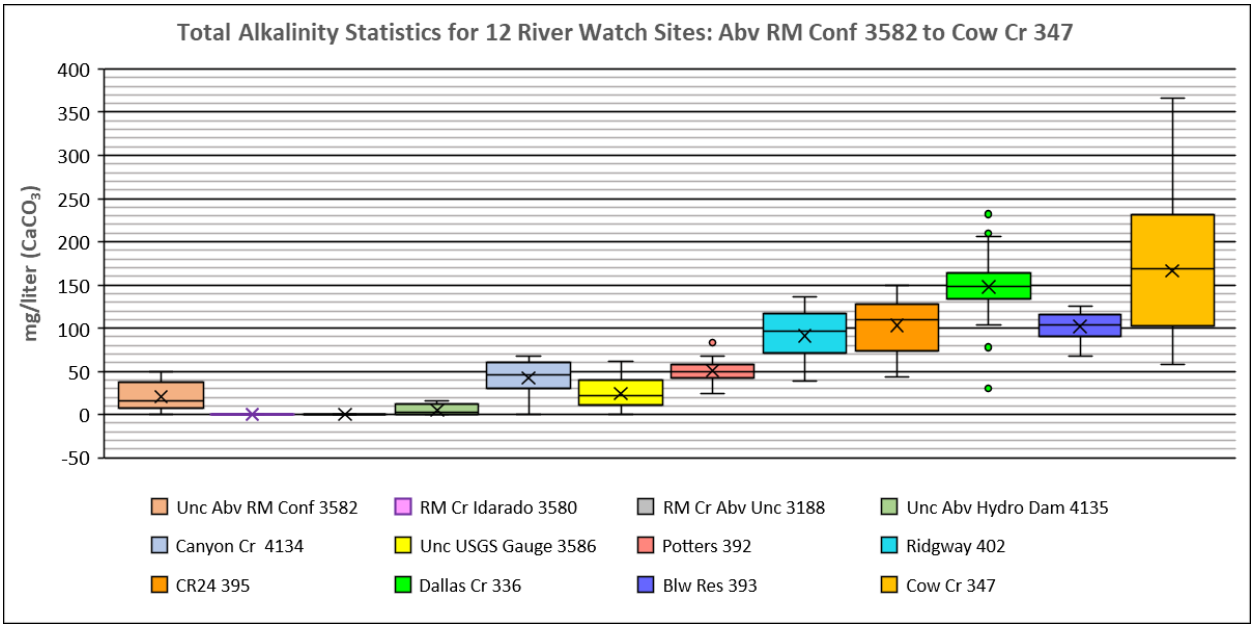

Figure 5. Box plots of alkalinity data for River Watch sites 3582 (far left) downstream to 347 (far right). Locations are shown in Figures 1 and 2. Note vertical axis starts at -50 to show sites with zero alkalinity.

the river from above the confluence, where site 3582 had a median of ~20 mg/liter, to a median of ~5 mg/liter at site 4135 below the confluence. The reduced alkalinity at site 4135 contributes to the large spread in pH data noted in Figure 3 (less buffering with fluctuations in acidic input from Red Mtn Creek).

Below Canyon Creek Figure 5 shows alkalinity in the Uncompahgre gradually increases as the streambed changes and irrigation runoff into the river increases the quantity of carbonates and bicarbonates. With less upstream input of acidic water Figure 5 shows Dallas and Cow Creeks had higher alkalinity than the river itself. The higher alkalinity in Dallas Creek (site 336) also likely increased alkalinity at Uncompahgre site 395 as significant irrigation runoff from Dallas Creek enters the Uncompahgre about two miles above site 395. Site 347 on Cow Creek had the highest median alkalinity and the largest spread in values, where maxima occurred during winter low flow and minima were observed during spring runoff.

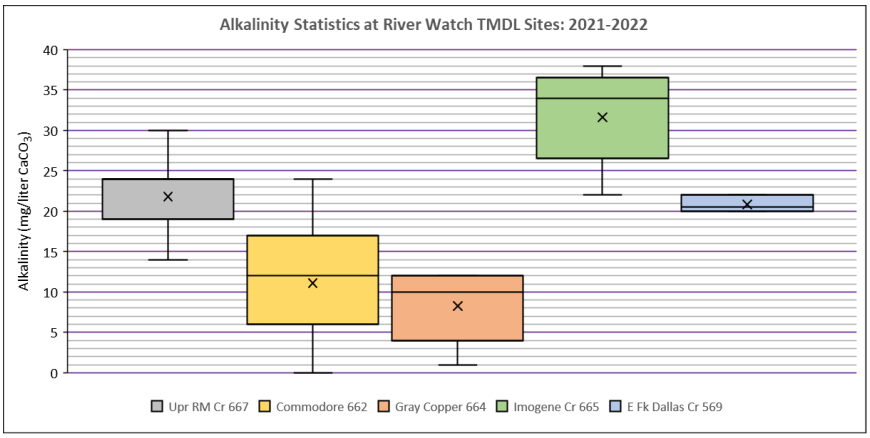

Figure 6. Box plots of alkalinity data from the TMDL River Watch sites (667, 662, 664, 665 and 569) shown in Figure 2.

Alkalinity box plots for the TMDL sites are shown in Figure 6. The vertical scale is much smaller than that used in Figure 5 making the spread in data values appear larger. In fact, the range of median values and the interquartile ranges are similar to those at Uncompahgre sites down to USGS gauge site 3586 in Figure 5. Commodore Gulch had interesting trends in alkalinity and pH; alkalinity decreased with de-

creasing flow, to zero at the lowest flow in November. The opposite trend was observed at the other TMDL sites. With zero alkalinity at Commodore Gulch in November, the pH dropped to 4.0 and produced a large spread in the pH data shown in Figure 6. Imogene Creek, which feeds into Canyon Creek, and where more limestone deposits are found, had the highest alkalinity median among the TMDL sites.

C. River Watch Hardness Data: 2019-2021

Water hardness is a measure of calcium (Ca) and magnesium (Mg) polyvalent cations (ions with a positive charge greater than +1). It has been shown that fish residing in high hardness waters can withstand higher concentrations of metals than fish residing in low hardness water with the same metals' concentrations. This positive effect is reflected in the hardness-based aquatic life Table Value Standards (TVS) for metals documented in WQCC Regulation 35. These TVS for various metals are referred to in Section 4D on River Watch metals data.

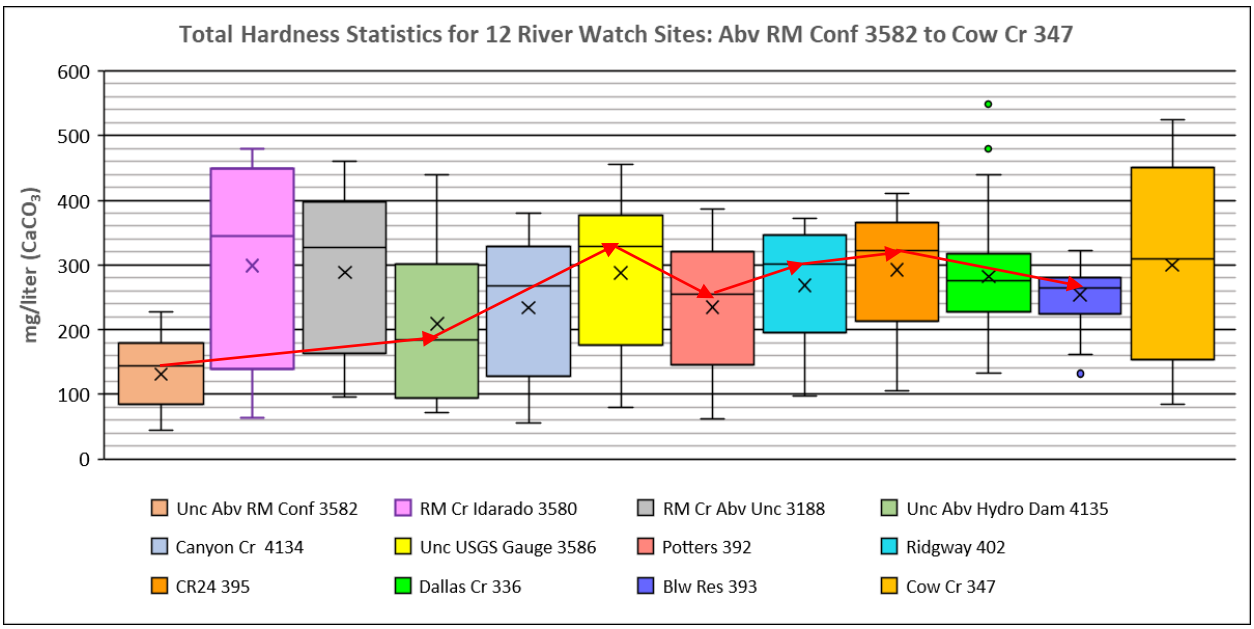

Figure 7. Box plots of total hardness data for River Watch sites 3582 (far left) downstream to 347 (far right). Locations are shown in Figures 1 and 2. Red arrows show changes in median hardness at the Uncompahgre sites.

Following the same upstream-to-downstream order as in previous figures, water hardness box plots are shown in Figure 7, and the box plots for total calcium and total magnesium are shown in Figures 8 and 9. Although the hardness values in Figure 7 were determined by a titration method, hardness in mg/liter of $CaCO_3$ can also be calculated from calcium and magnesium concentrations (as in Figures 8 and 9) using the equation: *Hardness = (2.5 x Ca) + (4.1 x Mg)*, where Ca and Mg are concentrations in mg/liter. Comparing the box plots in Figures 7, 8 and 9 it is apparent that both the magnitudes of medians and averages, and spreads in hardness data are mainly due to calcium concentrations. As with other metals, the spread in calcium concentration (and hardness) data is in large part due to seasonal streamflow changes; lower streamflow leading to higher concentration and higher streamflow leading to lower concentration. Calcium medians ranged from about 50 mg/liter at site 3582 on the Uncompahgre to about 120 mg/liter at site 3580 on Red Mtn Creek. Magnesium median concentrations ranged from

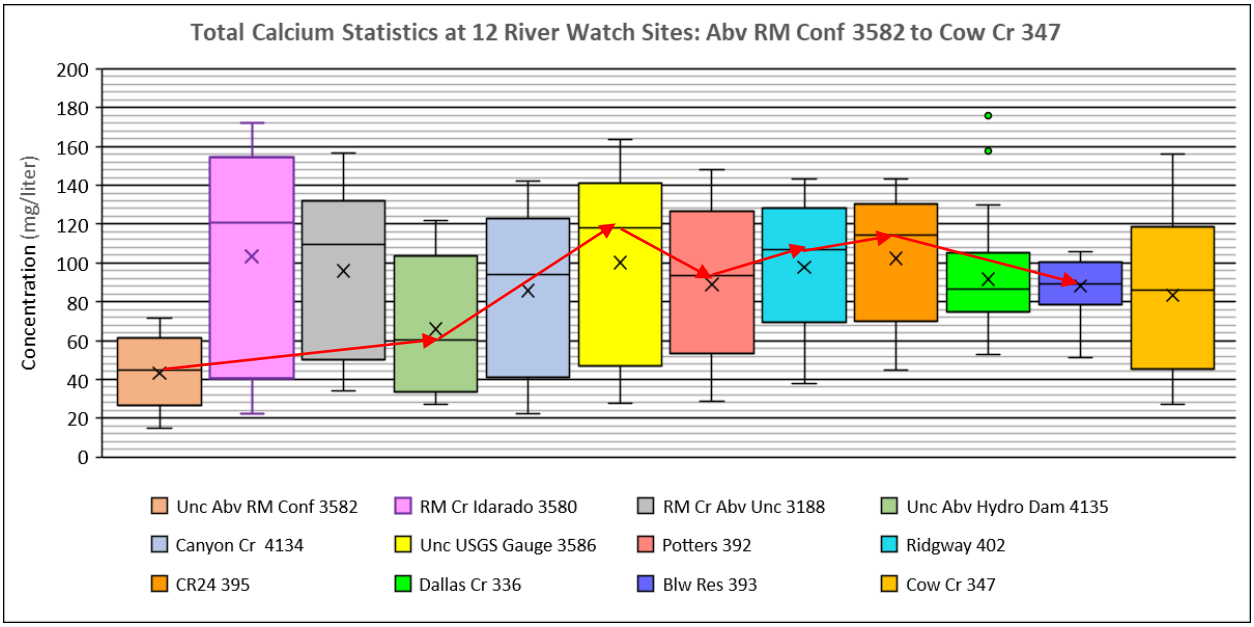

Figure 8. Box plots of total calcium (Ca) concentration data for River Watch sites 3582 (far left) downstream to 347 (far right). Locations are shown in Figures 1 and 2. Red line segments link medians at Uncompahgre River sites.

about 3-4 mg/liter at sites 3582 and 4134 to about 24.5 mg/liter at site 347 on Cow Creek. The Canyon Creek site 4134 had the smallest magnesium median while Dallas and Cow Creeks had the largest.

Red arrows on Figures 8 and 9 show the upstream-to-downstream changes in hardness and calcium at the Uncompahgre River sites. The trends are similar, with the largest increase in both calcium and hardness medians occurring below Canyon Creek, between site 4135 and site 3586. The decrease in calcium below site 3586 is also reflected by a similar hardness decrease. Calcium, magnesium, and hardness medians all increase from Potters site 392 down to the reservoir, even as streamflow increases,

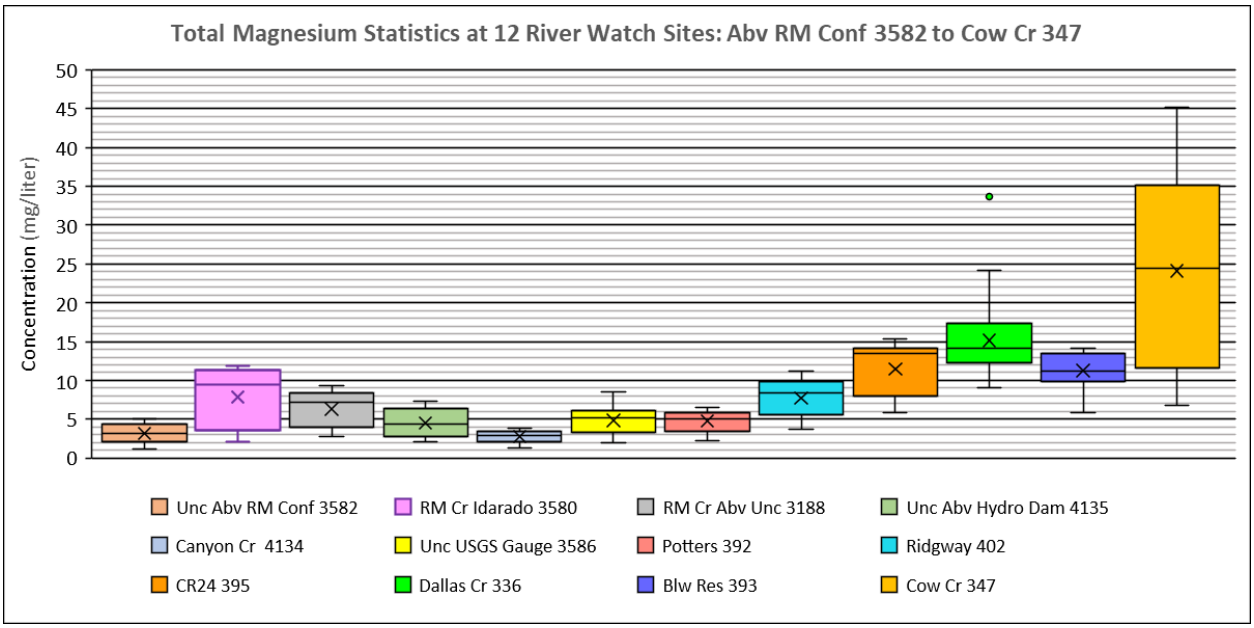

Figure 9. Box plots of total magnesium (Mg) concentration data for River Watch site 3582 (far left) downstream to site 347 (far right). Locations are shown in Figures 1 and 2.

indicating the masses of calcium and magnesium increased more than water volume increased. The medians of the three variables were all lower at site 393 below the reservoir due to dilution in the large volume of water and settling of suspended particles.

Hardness, calcium, and magnesium box plots for the five TMDL sites are shown in Figures 10, 11 and 12. Except for Gray Copper Gulch these high-altitude sites had much lower values of the three parameters than those shown at the 12 sites in Figures 7, 8 and 9. Note that site 664 is near the mouth of Gray Copper Gulch which empties into Red Mtn Creek just below site 3580 and above site 3188 (see Figure 2). The median hardness values, and median calcium and magnesium concentrations at the three sites are quite similar.

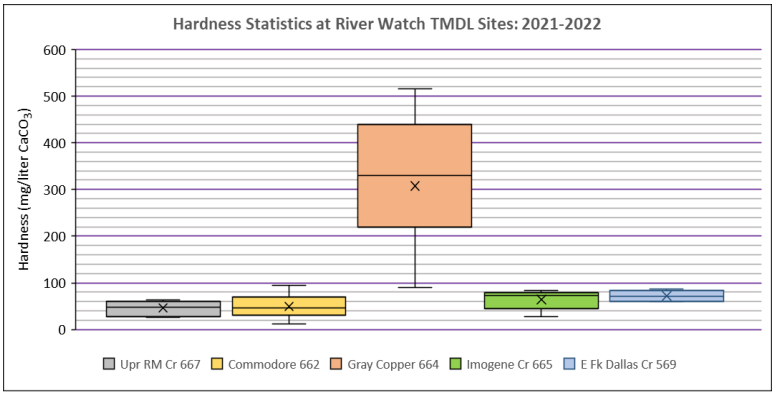

Figure 10. Box plots of hardness data from the TMDL River Watch sites (667, 662, 664, 665 and 569) shown in Figure 2.

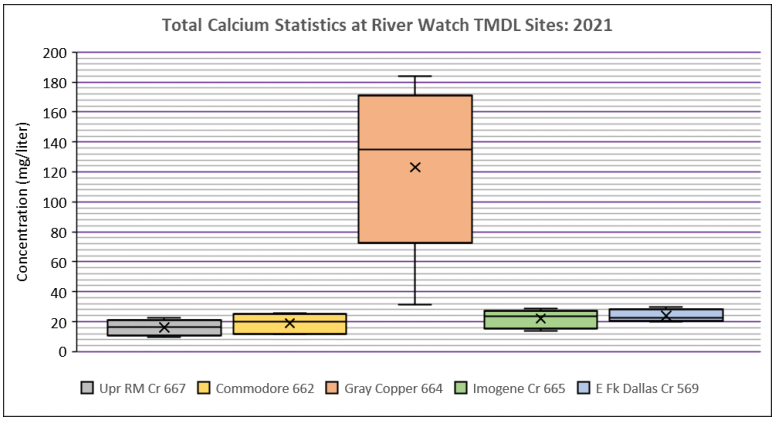

Figure 11. Box plots of total calcium data from TMDL River Watch sites (667, 662,664, 665, and 569) shown in Figure 2.

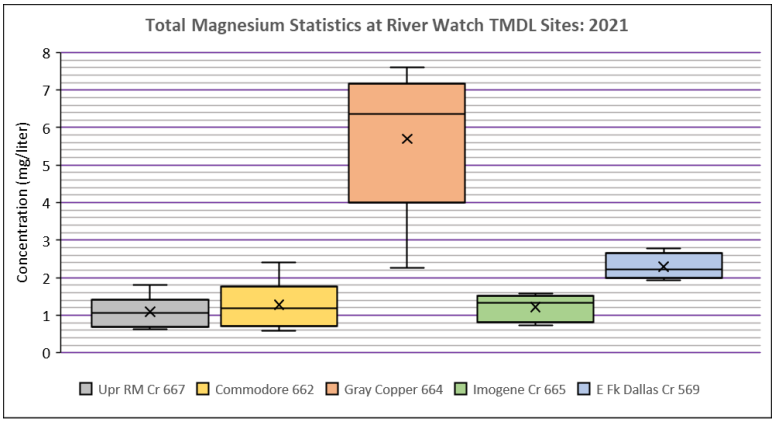

Figure 12. Box plots of total magnesium data from TMDL River Watch sites (667, 662,664, 665, and 569) shown in Figure 2.

D. River Watch Metals Data: 2019-2021

River Watch samples are analyzed for 13 different metals. Calcium and magnesium were discussed with water hardness in the previous section. Of the remaining 11 metals, only those that have led to impaired stream segments in the Uncompahgre Watershed will be discussed here. To aid in interpreting box plots in this section, and data presented in the subsequent section on impaired stream segments, Table 3 provides the River Watch Method Detection Level (MDL) and Lower Reporting Level (LRL) for each metal. For River Watch samples collected in 2019-2021, MDLs and LRLs updated in September 2020 were valid.

Dissolved Cadmium (Cd-D) Data:

Box plots of dissolved cadmium data for 12 River Watch sites are shown in Figure 13. Note that to show data that varied over three orders of magnitude the logarithms of the concentrations were used.

For reference to potential impairment, the aquatic life TVS for cadmium, computed from mean hardness values of 241 and 272 mg/liter of $CaCO_3$, are shown. The box plots indicate cadmium concentrations at Red Mtn Creek, sites 3580 and 3188, and at one site (4135) on the Uncompahgre exceeded the cadmium TVS. [*Standard exceedance is determined when the 85th percentile of concentrations is greater than the TVS.*] Section 5 below summarizes the WQCC 2022 303(d) list (WQCC Regulation #93, 2022) where further information on stream impairment is included.

Table 3. Method Detection Limit (MDL) and Lower Reporting Limit (LRL) for each River Watch variable. Note that the limits are regularly updated and that the ones shown here (yellow shading) were valid September 2020.

Indicator	Frequency	Method	Lower Reporting Limit (updated September 2020)*	Method Detection Limit (updated September 2020)*	Lower Reporting Limit (prior to September 2020)	Method Detection Limit (prior to September 2020)
Field Parameters						
pH	monthly	Meter fresh water probe	0.1 S.U.	0.1 S.U.	0.1 S.U.	0.1 S.U.
Temperature	monthly	Celsius thermometer	1.0 unit	1.0 unit	1.0 unit	1.0 unit
Dissolved Oxygen	monthly	SM 421.B	0.5 mg/L	0.5 mg/L	0.5 mg/L	0.5 mg/L
Phenol/Total Alkalinity	monthly	EPA 310.1	0.1 mg/L	0.1 mg/L	0.1 mg/L	0.1 mg/L
Total Hardness	monthly	SM 314 B	0.1 mg/L	0.1 mg/L	0.1 mg/L	0.1 mg/L
Metals (both Total and Dissolved) (µg/L)						
Aluminum	monthly	EPA 200.15 (ICP)	19.0	4.6	10	2.1
Arsenic	monthly	EPA 200.15 (ICP)	13.0	3.2	10	5.8
Calcium	monthly	EPA 200.15 (ICP)	47.0	13.0	100	18.6
Cadmium	monthly	EPA 200.15 (ICP)	0.3	0.08	0.5	0.18
Copper	monthly	EPA 200.15 (ICP)	2.4	0.6	1.0	0.5
Iron	monthly	EPA 200.15 (ICP)	57.0	14.0	10	5.2
Magnesium	monthly	EPA 200.15 (ICP)	98.0	24.0	200	91
Manganese	monthly	EPA 200.15 (ICP)	5.8	1.4	5	2.4
Lead	monthly	EPA 200.15 (ICP)	7.9	1.9	3	2.4
Potassium	monthly	EPA 200.15 (ICP)	125.0	30.0	200	100
Selenium	monthly	EPA 200.15 (ICP)	5.4	1.3	5	2.4
Sodium	monthly	EPA 200.15 (ICP)	93.0	23.0	200	100
Zinc	monthly	EPA 200.15 (ICP)	6.7	1.6	5	2.6

Figure 13 also indicates that the distributions of dissolved cadmium concentrations shifted steadily downward on the Uncompahgre River below the Red Mtn Creek confluence; site 4135 down to CR24 site 395. Cadmium was mostly not detected below Ridgway Reservoir and on Dallas and Cow Creeks

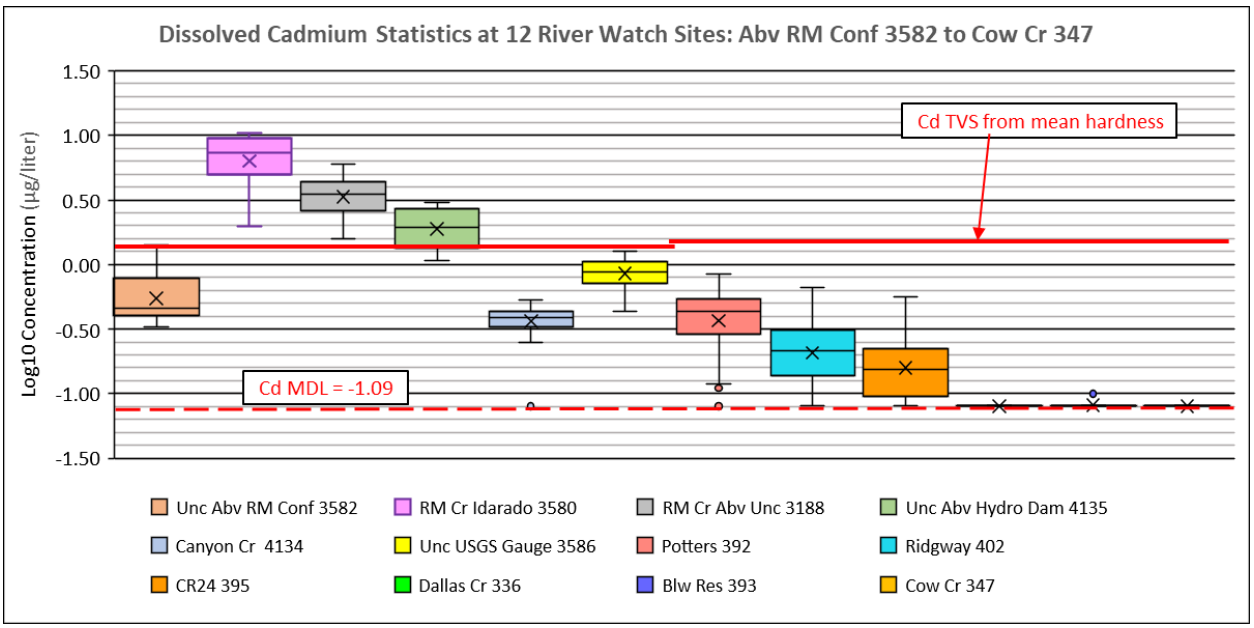

Figure 13. Box plots of dissolved cadmium (Cd) concentration data for River Watch site 3582 (far left) downstream to site 347 (far right). Locations are shown in Figures 1 and 2. Solid red lines are aquatic life TVS based on mean hardness values and the dashed red line shows the MDL for cadmium. Concentrations in log base 10.

where the median and mean concentrations are plotted at the MDL. The decrease in cadmium concentration distributions between Hydro Dam site 4235 (above Canyon Creek) and USGS site 3586 (below Canyon Creek) is mostly due to dilution by the much lower mass loading of cadmium from Canyon Creek. All cadmium concentrations on the Uncompahgre River below Canyon Creek were less than the aquatic life TVS of 1.54 µg/liter (log10 = 0.185 in Figure 13) based on a mean hardness of 272 mg/liter of $CaCO_3$.

Figure 14 shows the box plots of cadmium distributions for the River Watch TMDL sites. Table 2 indicates only 4-6 samples were available for each site in 2021. Upper Red Mtn Creek (site 667) had only one sample with a cadmium concentration above the MDL of 0.08 µg/liter (-1.09 on the log10 scale), and East Dallas Creek (site 569) had no concentrations greater than the cadmium MDL. (Note that concentrations < MDL were assigned the MDL value.) The cadmium concentrations at Commodore Gulch (site 662) and Imogene Creek (site 665) exceeded the aquatic life TVS of 0.83 µg/liter (-0.08 on the log10 scale in Figure 14).

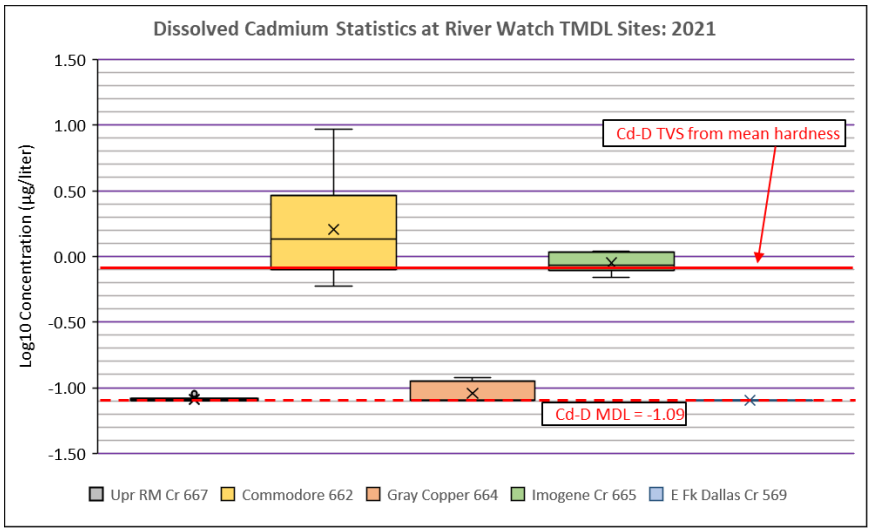

Figure 14. Box plots of dissolved cadmium (Cd-D) concentrations from TMDL River Watch sites (667, 662,664, 665, and 569) shown in Figure 2. Solid red lines are aquatic life TVS based on mean hardness values and the dashed red line shows the MDL for cadmium.

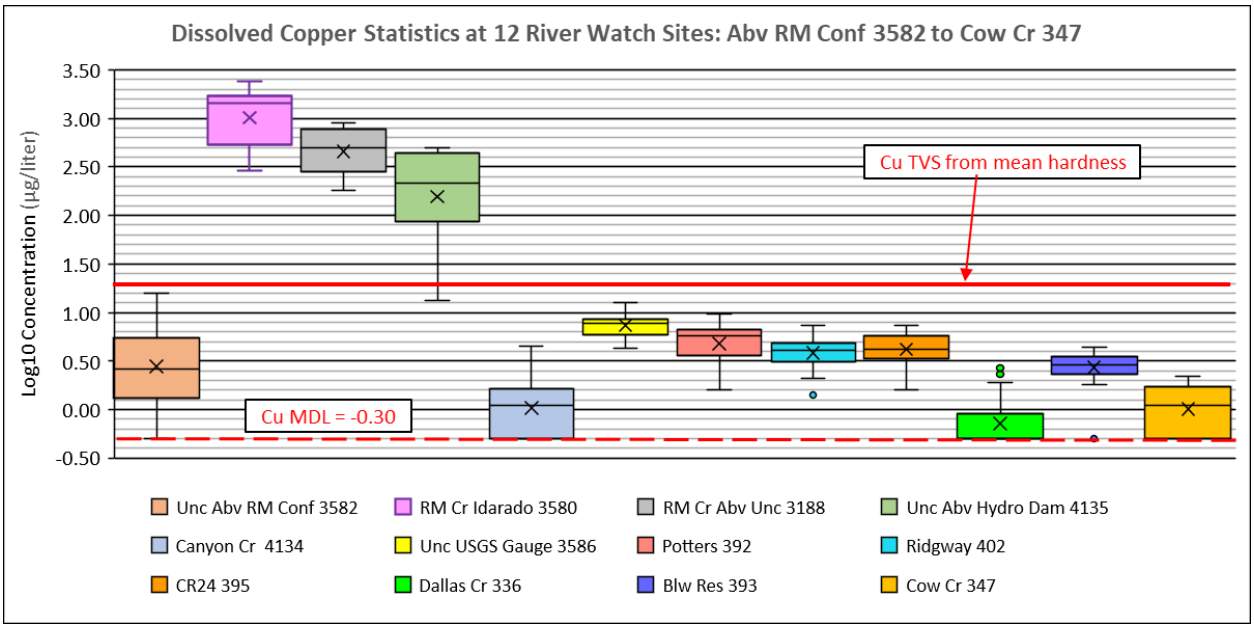

Figure 15. As in Figure 13, except showing box plots for dissolved copper (Cu). Cu MDL = 0.5 µg/liter (-0.3 on log10 scale). Cu aquatic life TVS = 21.1 µg/liter (1.30 on log10 scale).

Dissolved Copper (Cu-D) Data:

Box plots of dissolved copper concentrations at the 12 main River Watch sites are shown in Figure 15. As with cadmium, the copper distributions at Red Mtn Creek sites 3580 and 3188 and the Uncompahgre Hydro Dam site 4135 below the confluence were the only sites that exceeded the aquatic life TVS for dissolved copper. The relatively large spreads in the distributions at these three sites were due to very high concentrations during low-flow months, and much lower concentrations during spring runoff. The dilution factor by Canyon Creek for dissolved copper, evidenced by the large drop in the distributions between sites 4135 and 3586, was even greater than that for cadmium. The decrease in median concentrations between the two sites was ~200 µg/liter, an approximate decrease of 26 times. Figure 15 indicates that dissolved copper median concentrations continued to decrease from ~5.7 µg/liter at Potters Ranch site 392 to ~2.8 µg/liter below Ridgway Reservoir site 393.The spreads in the copper distributions below Canyon Creek were quite narrow, indicating much lower seasonal variability than the sites above Canyon Creek. The three creeks (Canyon, Dallas and Cow) had copper distributions much lower than distributions on the Uncompahgre River.

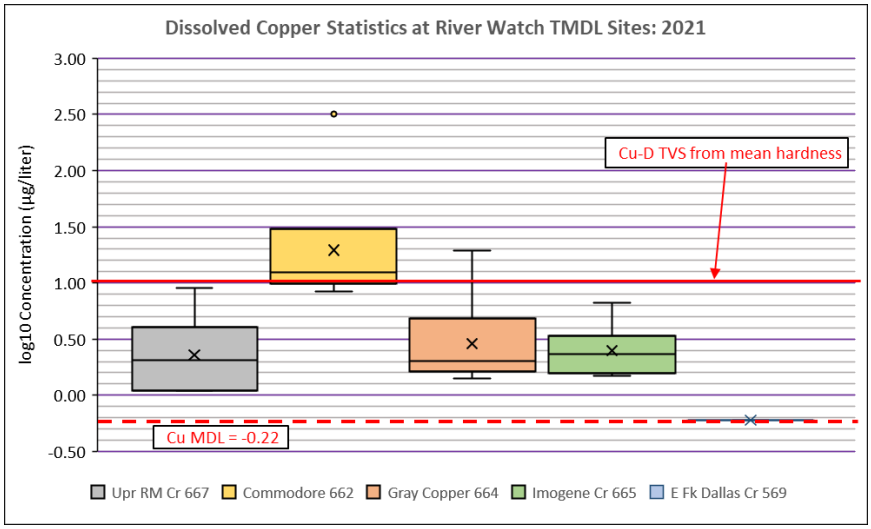

Figure 16. As in Figure 14, except for dissolved copper.

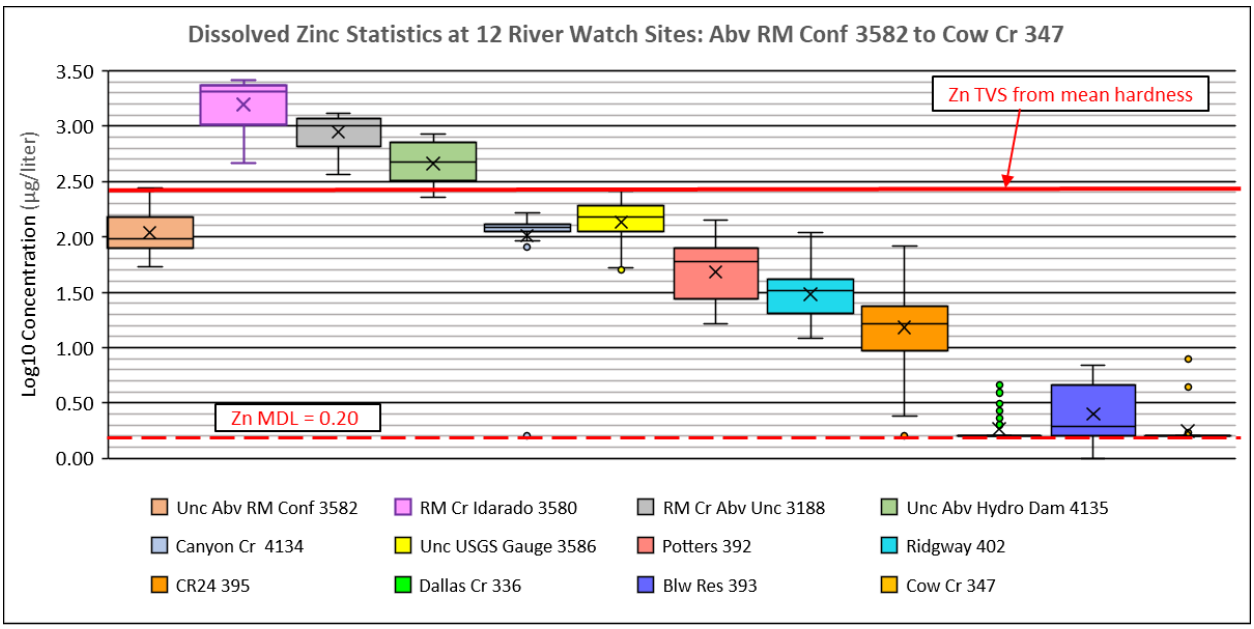

Figure 17. As in Figure 13, except showing box plots of dissolved zinc.

Box plots for dissolved copper concentrations at the River Watch TMDL sites are shown in Figure 16. The aquatic life TVS for copper was exceeded by 75% of the samples from Commodore Gulch (site 662). Note one extreme concentration of > 300 µg/liter (log10 = 2.5) is plotted as an outlier in the Commodore distribution. Concentrations at East Dallas Creek (site 569) were all less than the MDL, and the distributions of copper at sites 667, 664, and 665 were almost entirely below the TVS for copper.

Dissolved Zinc (Zn-D) Data:

Box plots for dissolved zinc measured at the 12 main River Watch sites are shown in Figure 17. The upstream-to-downstream trend in the distributions is like that noted with dissolved cadmium. The zinc distributions shifted steadily downward below Red Mtn Creek, from concentrations centered at nearly 2000 µg/liter at Idarado site 3580, to ~160 µg/liter at USGS gauge site 3586 below Ouray, to ~2 µg/liter at Below Ridgway Reservoir site 393. [*Note that on the log scale the downward trend appears to be linear, but in fact the decrease is approximately exponential when plotted on a linear scale.*] The concentrations of the dissolved metals, cadmium, copper, and zinc, all decreased below Red Mtn Creek, while calcium and magnesium in Figures 8 and 9 show concentration increases below Red Mtn Creek. This indicates there are sources of calcium and magnesium in the lower part of the watershed, while cadmium, copper, and zinc, from acidic runoff and mine drainage, come mainly from the upper watershed.

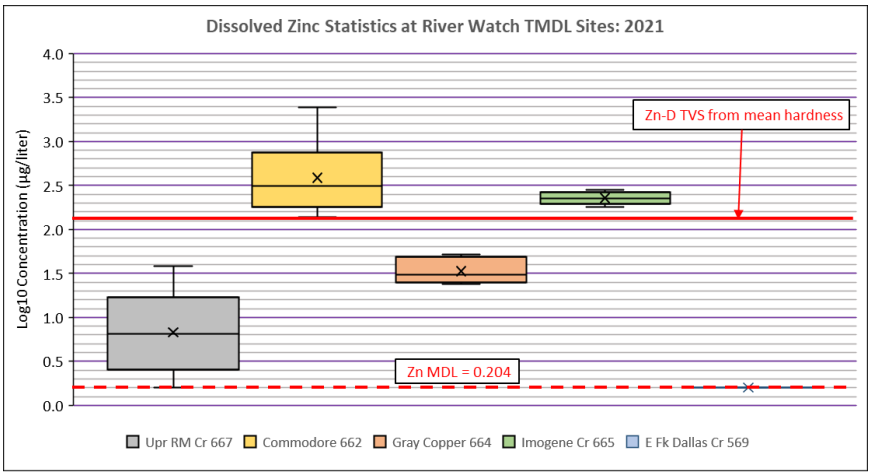

Figure 18. As in Figure 16, except showing TMDL site box plots for dissolved zinc.

Dallas Creek and Cow Creek had barely detectable zinc concentrations and only outliers are shown above the MDL line in Figure 17. Further, as with cadmium and copper only the Red Mtn Creek sites (3580 and 4135), and the site immediately below Red Mtn Creek (4135) had zinc concentrations above the zinc aquatic life standard of ~300 µg/liter (log10 = 2.48). Figure 18 displays the dissolved zinc concentration box plots for the five TMDL sites. At the Commodore Gulch site (662) and the Imogene Creek site (665) zinc distributions exceeded the aquatic life TVS for zinc. The Commodore site exceeded the TVS for cadmium, copper, and zinc. Dissolved zinc concentrations at East Dallas Creek, as with cadmium and copper, were all below the River Watch MDL for zinc.

Dissolved Manganese (Mn-D) Data:

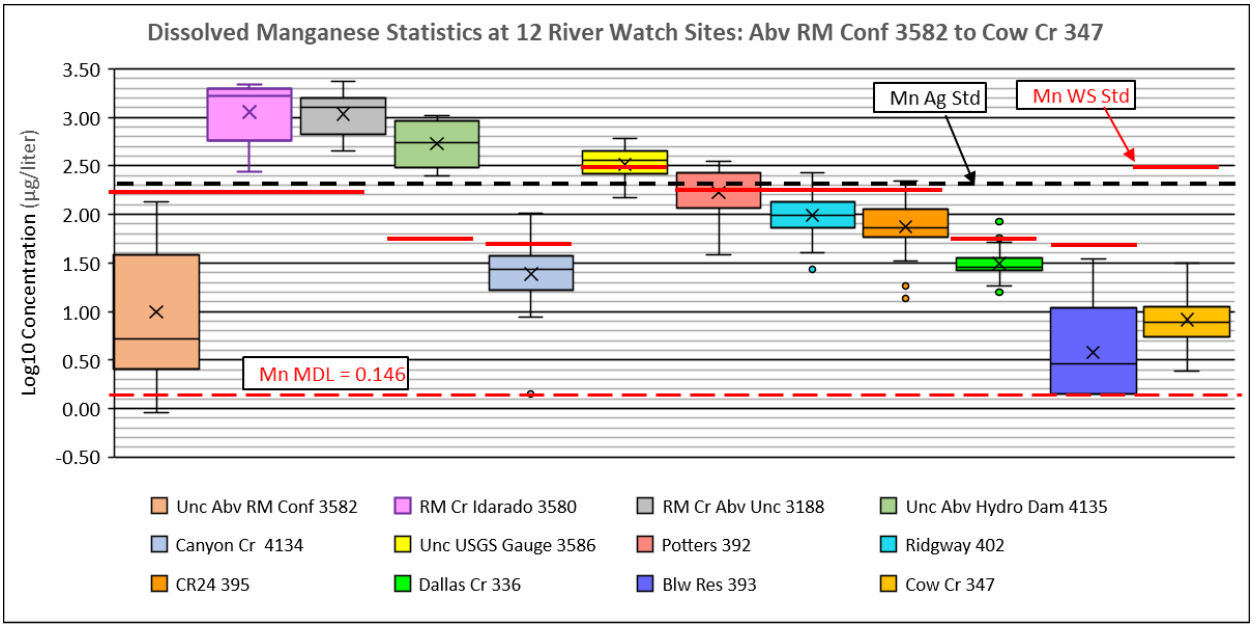

Figure 19. As in Figure 13, except showing box plots for dissolved manganese. Red line segments show the water supply (WS) use standards for different segments of the Uncompahgre Watershed. Black dashed line shows the Mn-T standard for agricultural use (200 µg/liter, log10=2.3).

Dissolved manganese data for the 12 main River Watch sites are shown by the box plots in Figure 19. Unlike the dissolved medals previously discussed, dissolved manganese (Mn-D) is generally not a threat to aquatic life in the Uncompahgre Watershed. However, on some segments of the Uncompahgre River Mn-D concentrations exceed a secondary standard for water supply use, and total manganese (Mn-T) concentrations at times exceed the standard for agricultural use. The water supply use standard values for Mn-D shown in Figure 19 are site specific and based on an earlier period of record [Determined in the 2020 WQCC 303(d) Listing Methodology]. If earlier data were not available, then a standard value of 50 µg/liter was used. For agricultural use the Mn-T standard value shown by the dashed black line on Figure 19 is 200 µg/liter (log10 = 2.3). The box plots for Mn-T are not shown, but the distributions of concentrations were not significantly different from those of Mn-D. The main differences were that Mn-T median values were slightly larger, and the spread of the Mn-T interquartile ranges were also greater at most sites. The differences did not change the comparison of Mn-D distributions with standard values shown in Figure 19.

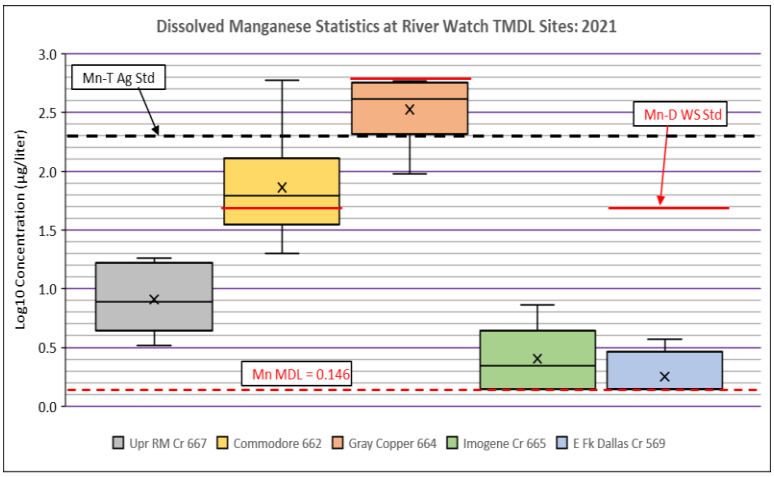

Figure 20. As in Figure 16, except showing TMDL site box plots for dissolved manganese (Mn-D), and the standards for water supply and

The Mn-D distributions followed an upstream-downstream trend that was similar to the trends of other dissolved metals shown in Figures 13, 15, and 17. Another similarity

was that the three creek sites had generally lower Mn-D concentrations than the river sites, and also smaller interquartile ranges. The Uncompahgre River site 3582 upstream of Red Mtn Creek also had a very low Mn-D median (~5 µg/liter), but a large spread in concentrations from ~1 µg/liter to ~132 µg/liter. As shown in Figure 19 the water supply standard for manganese was exceeded at the two Red Mtn Creek sites (3580 and 3188), and at three Uncompahgre River sites (4135, 3586 and 392). However, Potters Ranch site 392 is in the same river segment as sites 402 and 395, and their Mn-D concentrations, for each sampling event, would be combined into one median value, and the 74th percentile of the medians would then be compared to the water supply standard. The outcome from the 2022 303(d) list indicated this segment attained the Mn-D water supply standard. Finally, the agricultural use standard of 200 µg/liter was exceeded by the Mn-D median concentrations at two Uncompahgre River sites (4135 and 3586).

Dissolved manganese box plots for the five River Watch TMDL sites are shown in Figure 20. As in Figure 19 the water supply (red line) and agricultural use (black dashed line) standards are also shown. Note that Upper Red Mtn Creek site 667 and Imogene Creek site 665 are not listed for water supply use. Gray Copper Gulch site 664 had the distribution of Mn-D with the largest values and exceeded the agricultural use standard. Commodore Gulch site 662 exceeded the water supply standard for Mn-D (50 µg/liter), although this river segment is not on the 2022 303(d) list for water supply.

Dissolved Lead (Pb-D) Data:

Statistics for dissolved lead at the 12 main River Watch sites are displayed in Figure 21. Only three sites, RM Cr Idarado 3580, RM Cr Abv Unc 3188, and Hydro Dam site 4135 below the Red Mtn Creek confluence, had a significant number of Pb-D concentrations greater than the River Watch MDL of 2.4 µg/liter. These three Pb-D distributions indicated exceedance of the aquatic life standard, although Red Mtn Creek is currently not listed for aquatic life use. The river segment containing Hydro Dam site 4135

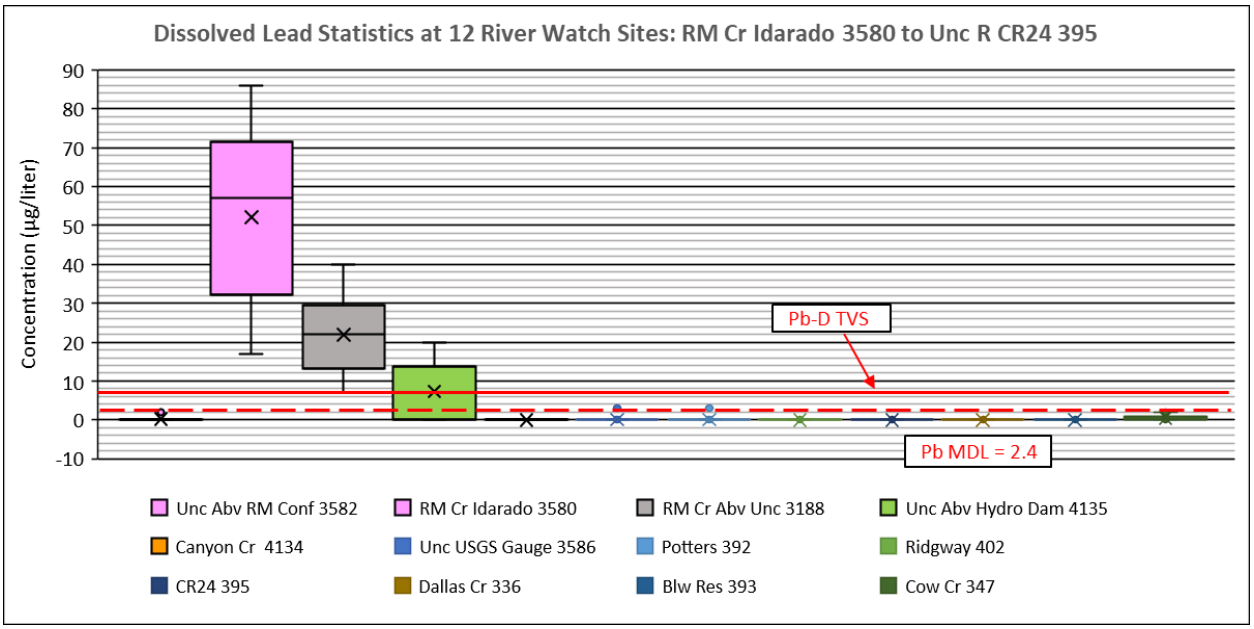

Figure 21. As in Figure 13, except showing box plots for dissolved lead (Pb-D). Concentrations that were less than the MDL of 2.4 µg/liter were plotted if given a numerical value, including zeroes.

is also not listed as impaired for Pb-D in the 2022 303(d) list. The WQCD data file (from River Watch) used for assessment of this segment contains no data for lead even though both Pb-D and Pb-T data exist in the River Watch database at values greater than the Pb-D MDL. Note that the box plots for the other nine River Watch sites in Figure 21 are centered on zero which was the value appearing in the database when a concentration was not detected, or less than the MDL. Lead data from the TMDL sites is not shown since nearly all values were less than the MDL. The Commodore Gulch site had the only two Pb-D concentrations greater than the MDL; 4 µg/liter in July 2021 and 31 µg/liter in November 2021.

Total Iron (Fe-T) Data:

Total iron (Fe-T) box plots for the 12 main River Watch sites are shown in Figure 22. The site-specific Fe-T standards for aquatic life, shown as the red line segments in Figure 22, vary from 1000 µg/liter (log10 = 3) to 7438 µg/liter (log10 = 3.87). For total metal concentrations the standard is exceeded if the median concentration is greater than the standard. See Appendix B for details of Fe-T toxicity. Figure 22 indicates that this only occurred at Potters Ranch site 392. The 2022 303(d) list shows this river segment, which includes Ridgway Town site 402 and CR24 site 395, as impaired for Fe-T with a current (2010) TMDL.

The upstream-to-downstream changes in the Fe-T distributions at the Uncompahgre River sites differ from the trend found with dissolved metals. With Fe-T the centers of the distributions tend to level off below Hydro Dam site 3586 (yellow) and the distributions broaden. In contrast, distributions of dissolved metals showed steady decreases and the spread in concentrations were relatively narrow and constant. Two UWP reports, Woodling (2012) and Huggins (2020), showed that there was a significant positive correlation between Fe-T concentration and streamflow at USGS gauge site 3586 (yellow) and CR24 site 395 (tan), and that during very high flow Fe-T concentrations often increased below site 3586 due to resuspension of particles in the streambed. The large seasonal and annual fluctuations in streamflow, and therefore Fe-T concentrations, lead to the broad distributions seen in Figure 22 box plots. The

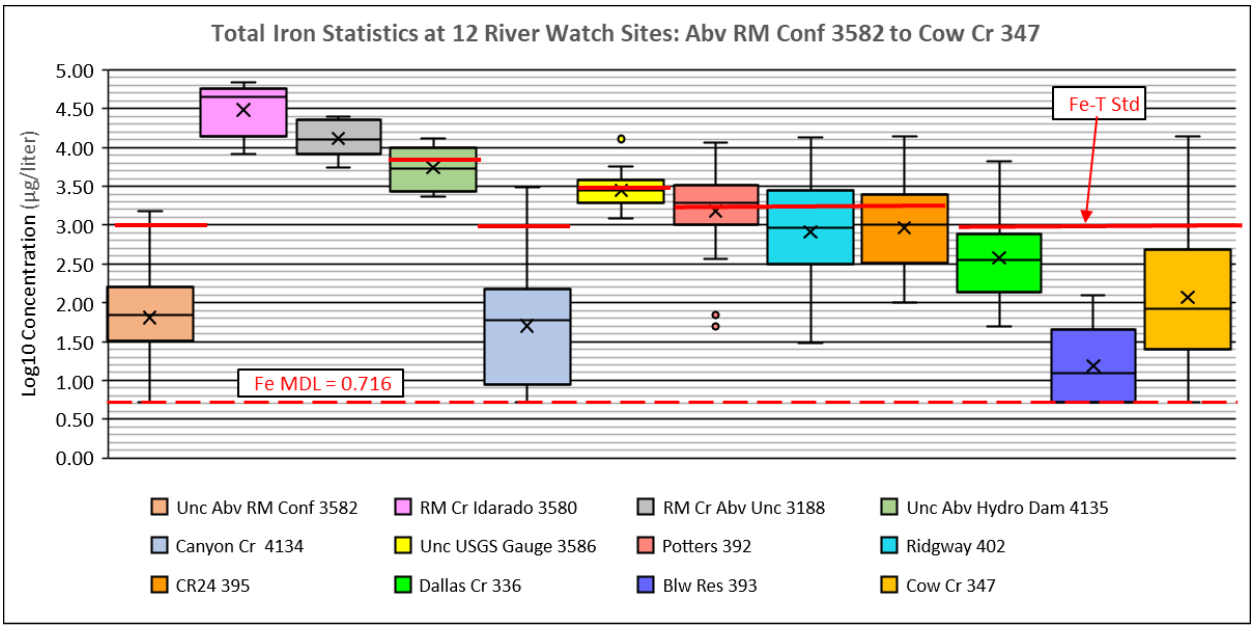

Figure 22. As in Figure 13 except showing box plots for total iron (Fe-T) concentrations. Red line segments show site-specific aquatic life use standards for different segments of the Uncompahgre River.

large drop in the entire box plot at Blw Ridgway Reservoir site 393 shows that the reservoir is a sink for total iron. Previous figures showed that the reservoir is also a sink for dissolved metals.

Figure 22 box plots show the highest altitude Uncompahgre River site 3582 (far left in Figure 22), and the three creek sites (4134, 336, and 347) had much lower median Fe-T concentrations than the main river sites, except for site 393 below the reservoir. The very broad distribution of Fe-T at the Cow Creek site (347) was due to a few very high concentrations during high flow episodes, combined with low flow periods when Fe-T was below the MDL.

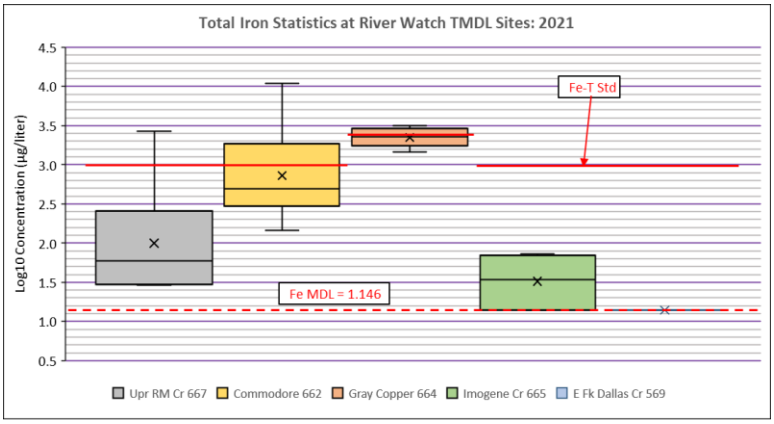

Figure 23. As in Figure 14, except showing box plots for total iron (Fe-T) at the River Watch TMDL sites.

Figure 23 displays the Fe-T concentration box plots for the River Watch TMDL sites. Recall from Table 2 that there were only 4-6 samples in the 2021 data set. Fe-T concentrations on East Dallas Creek site 569 were all below the MDL (values plotted at the MDL in Figure 23). Only Gray Copper Gulch had a median Fe-T concentration near the Fe-T aquatic life standard, and a very narrow interquartile range suggesting Fe-T concentrations were not greatly affected by seasonal flow variation. For the 2022 303(d) list, Fe-T data, which did not include the 2021 data, were insufficient to list Gray Copper Gulch as impaired, or to include it on the Monitoring and Evaluation List.

Total Arsenic (As-T) Data:

Several streams in the Uncompahge Watershed have been listed as impaired for exceeding the total arsenic (As-T) chronic standard for water supply use. The chronic As-T standard is currently very low at 0.02 µg/liter, which makes River Watch data with a range of arsenic MDLs from 3.2–5.8 µg/liter only marginally useful for assessing impairment. In fact, two streams (Dallas Creek and Cow Creek), listed as impaired for As-T, had no River Watch samples that were greater than the River Watch MDLs. [The 303(d) listing was based on WQCD data with much lower MDLs.]

Figure 24 displays As-T concentration box plots for the 12 main River Watch sites. Six of the sites had distributions dominated by concentrations below the MDL and appear with means or medians of zero. The As-T distributions at five sites (3580, 3188, 4135, 402 and 395) had a significant number of As-T concentrations greater than the MDL and exceeded the chronic As-T standard for water supply use. The two Red Mtn Creek sites (3580 and 3188) which had the highest concentrations of As-T were not assessed for impairment in the 2022 303(d) list. The Abv Hydro Dam site 4135 whose distribution of As-T concentrations is also well above the chronic standard was also not assessed for water supply use in the 2022 303(d) list. Site 3586 (yellow box plot) below Ouray, which had only one As-T value above the MDL (~25% of samples were given a numerical value, but were < MDL) was listed as impaired in 2022 based on six WQCD samples. Interestingly, neither of the two River Watch sites below Ouray (3586 and 392 in Figure 24) had more than two values greater than the As-T MDL, but the next two downstream sites,

Ridgway 402 and CR24 395 in Figure 24, had a high percentage of detectable As-T concentrations, nearly all greater than the As-T water supply standard. For the 2022 303(d) assessment, only one sample was available in the river segment containing sites 402 and 395, so no action was taken regarding As-T impairment. A box plot analysis was not completed for the five TMDL sites which had no As-T concentrations greater than the arsenic MDL.

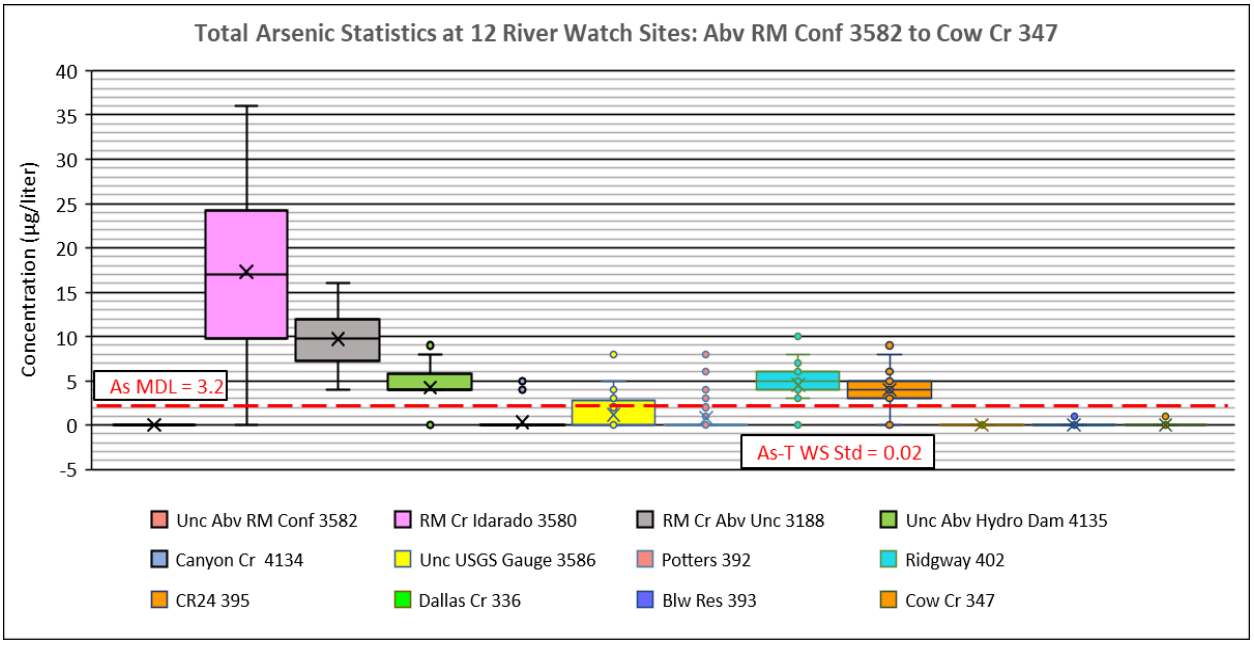

Figure 24. As in Figure 13, except showing box plots for total arsenic (As-T) at the 12 main River Watch sites. Concentrations noted as "detected", but below the River Watch MDL, were plotted if given a numerical value, including zeroes.

5. A Review of the 2022 303(d) List for Segments in the Upper Uncompahgre Watershed

Of the 17 River Watch sites listed in Table 1, 10 were used to assess impairment for the 2022 303(d) list on six different segments of the Uncompahgre River and its tributaries. The five TMDL sites added to the UWP group in 2021 were not used since the 2022 303(d) list assessment only included data from 2015 through 2019. Also, the two Red Mtn Creek sites in segment COGUUN06b were not used because the Water Quality Control Commission (WQCC) "does not believe that an impairment of the aquatic life use of segment 6b relative to a realistic expected condition for this segment has been shown". So, segment 6b is not on the current 303(d) list, but the WQCD will continue to study segment COGUUN06b regarding its attainable aquatic life use and any appropriate numeric standards.

Impaired segments of the Uncompahgre River, from Lake Como down to the segment below Ridgway Reservoir, are detailed in Table 4. The 10 segments shaded in blue are currently being monitored by River Watch. Fifteen of the segments in Table 4 are discussed in more detail in the remainder of this section. The data used by WQCD in determining the status of each segment for the 2022 303(d) list is described. The data call for the 2022 assessment was for water quality data in the period from 2015 through 2019. However, for some segments where River Watch data was used, metals data was only available for part of 2019. In these cases, and for segments that contain the new River Watch TMDL

sites, River Watch data from all of 2019 through 2021 is used to assess impairment and compare results with the 2022 303(d) list. Also, a few of the segments analyzed were delisted in 2022 but are described here to note the reasons for delisting.

Table 4. 2022 303(d) List of impaired stream segments in the Upper Uncompahgre Watershed. M&E refers to parameters being Monitored and Evaluated. (D) refers to a dissolved concentration and (T) refers to a total concentration. TMDL indicates the metal concentration exceeds standards, but a total maximum daily load (TMDL) had been established. Blue shading indicates the segment is sampled by one or more River Watch sites.

Segment	Listed Portion	Impaired Use(s)	303(d) Parameters	M&E Parameters
COGUUN02_B	Uncompahgre River: Source (Poughkeepsie Gulch) to point above Silver Creek	Aquatic Life	pH	
		Aquatic Life	Cadmium (D) - TMDL	
		Aquatic Life	Zinc (D) - TMDL	
		Aquatic Life	Copper (D) - TMDL	
		Aquatic Life		Lead (D)
		Water Supply		Arsenic (T)
		Water Supply	Manganese (D)	
		Water Supply		Cadmium (T)
COGUUN02_C	Uncompahgre River: From a point above Silver Creek to point above confluence with Red Mtn Creek	Aquatic Life		Lead (D)
		Aquatic Life	Cadmium (D) - TMDL	
		Aquatic Life	Copper (D) – TMDL	
		Aquatic Life	Zinc (D) - TMDL	
		Aquatic Life		pH
		Water Supply	Manganese (D)	
COGUUN03a_A	Uncompahgre River: From a point above confluence with Red Mtn Creek to a point above confluence with Cascade Creek	Aquatic Life	Cadmium (D) - TMDL	
		Aquatic Life	Copper (D) - TMDL	
		Aquatic Life	Zinc (D)	
		Aquatic Life	pH	
		Water Supply	Manganese (D)	
		Agriculture	Copper (T)	
COGUUN03b_A	Uncompahgre River: Point above confluence with Cascade Creek to point above confluence with Dexter Creek	Aquatic Life	Iron (T) - TMDL	
		Aquatic Life	pH	
		Water Supply	Manganese (D)	
		Water Supply	Arsenic (T)	
COGUUN03d_A	Uncompahgre River: Point below confluence with Dallas Creek to inlet of Ridgway Res	Aquatic Life	Cadmium (D) - TMDL	
		Aquatic Life	Copper (D) - TMDL	
		Aquatic Life	Iron (T) - TMDL	
COGUUN05_B	Commodore Gulch and its tributaries	Aquatic Life	Cadmium (D)	
		Aquatic Life	Copper (D)	
		Aquatic Life	Lead (D)	
		Aquatic Life	Zinc (D)	
COGUUN05_C	Governor Basin	Aquatic Life	Cadmium (D)	
		Aquatic Life	Copper (D)	
		Aquatic Life	Zinc (D)	
		Aquatic Life	Lead (D)	
		Water Supply	Manganese (D)	
		Water Supply	Lead (T)	

Segment	Listed Portion	Impaired Use(s)	303(d) Parameters	M&E Parameters
COGUUN05_D	Silver Creek	Aquatic Life	Lead (D)	
COGUUN05_E	Sneffels Creek below Governor Basin	Aquatic Life	Cadmium (D)	
		Aquatic Life	Zinc (D)	
		Aquatic Life	Macroinvertebrates	
		Aquatic Life	Lead (D)	
		Water Supply	Manganese (D)	
COGUUN06a_A	Red Mtn Creek: Source to point above confluence with E. Fork of Red Mtn Creek	Aquatic Life	Zinc (D) - TMDL	
		Aquatic Life	Silver (D)	
		Aquatic Life	Copper (D)	
COGUUN07_A	Gray Copper Gulch: Source to confluence with Red Mtn Creek	Aquatic Life	pH	
		Aquatic Life	Lead (D)	
		Aquatic Life	Copper (D)	
		Aquatic Life	Zinc (D)	
COGUUN08_A	Mineral Creek: Source to confluence with Uncompahgre River	Aquatic Life	Copper (D)	
		Aquatic Life	Zinc (D)	
		Aquatic Life	Cadmium (D)	
		Water Supply		Manganese (D)
COGUUN09_B	Sneffels Creek: From point 1.5 miles abv confluence with Imogene Cr to confluence with Imogene Cr	Aquatic Life	Lead (D)	
		Aquatic Life	Zinc (D)	
COGUUN09_C	Canyon Creek: From confluence of Imogene Cr and Sneffels Cr to the Uncompahgre River	Aquatic Life		pH
COGUUN09_D	Imogene Creek: Source to confluence with Sneffels Cr	Aquatic Life		Copper (D)
		Aquatic Life	Cadmium (D)	
		Aquatic Life	Zinc (D)	
COGUUN10a_B	Alkali Creek and its tributaries	Aquatic Life		Selenium (D)
		Aquatic Life	Iron (T)	
		Water Supply	Arsenic (T)	
COGUUN10a_C	Cow Creek: From confluence of Nate Creek to the Uncompahgre River	Water Supply	Arsenic (T)	
COGUUN11_G	Dallas Creek	Aquatic Life		Temperature
		Water Supply	Arsenic (T)	
COGUUN19_A	Ridgway Reservoir	Aquatic Life		Lead (D)
		Aquatic Life	Temperature	

Segment COGUUN02_C:

As noted in Table 4 segment 02_C on the upper Uncompahgre River extends from near the bottom of Poughkeepsie Gulch to a point immediately above the river's confluence with Red Mtn Creek. The 2022 303(d) assessment included two samples collected in 2015 by WQCD, six samples collected in 2016 by UWP and WQCD, and 41 samples collected by River Watch at site 3582 (see Figure 2). Note that not

all water quality analytes were available from all samples. River Watch metals data were only available through April of 2019.

Table 5 presents details from the 2022 303(d) list using 2015-2019 data and compares the values with more recent River Watch data from 2019-2021. Note the data sets overlap slightly as both contain

Table 5. Columns 1-6 show details from the 2022 303(d) List for Segment COGUUN02_C using all water quality data from 2015-2019. Columns 7-9 show impairment values computed from 2019-2021 River Watch data. Column 10 indicates if the two data sets agreed. Red shading indicates non-agreement.

Uncompahgre River Basin Segment **COGUUN02_C**: Uncompahgre River from point above Silver Cr to point above confluence with Red Mtn Cr.					Uses: Aquatic Life, Water Supply, Recreation P, Agriculture				
2022 303(D) List and Assessment Data (2015-2019) WQCD and RW samples						2019-2021 RW Data: Unc Abv Red Mtn Conf (3582)			
Analyte	**Classification**	**Samples**	**Chronic TVS**	**85th %tile**	**303(D) List**	**Samples**	**Chronic TVS**	**85th %tile**	**303(D) Agreement**
Cadmium (D)	Aquatic Life	41	0.87	1.02	Yes, TMDL	26	0.88	0.96	Yes
Copper (D)	Aquatic Life	41	11.14	9.10	Yes, TMDL*	26	11.28	9.79	No
Zinc (D)	Aquatic Life	41	152.84	174.35	Yes, TMDL	26	154.92	180.73	Yes
Lead (D)	Aquatic Life	4	3.32	1.43	M&E List**	26	3.37	data < MDL	N/A*
			Std (1995-2004)	85th %tile			Std (1995-99)	85th %tile	
Manganese (D)	Water Supply	41	119.89	53.78	Delisted	26	119.89	70.50	Yes
			WS standard	50th %tile			WS standard	50th %tile	
Arsenic (T)	Water Supply	4	0.02	0.23	M&E List**	26	0.02	data < MDL	N/A*
			min std	15th %tile			min std	15th %tile	
pH min	Aquatic Life	49	6.50	5.93	Yes	28	6.50	6.05	Yes
			Chronic Std	50th %tile			Chronic Std	50th %tile	
Iron (T)	Aquatic Life	41	1000	69.00	No	26	1000	70.50	Yes
* Cu retained despite not exceeding TVS. **Pb D and As T retained on M&E due to not having sufficient new data.						* All Pb-D and As-T values < MDL.			

data from January through April of 2019. Dissolved cadmium, copper, and zinc were previously listed in Category A, meaning impaired but with a TMDL (from 2010). The three metals are retained on the 2022 list despite copper's 85th percentile value being less than the aquatic life TVS (based on mean hardness). The 2019-2021 data for copper also suggests attainment of the aquatic life TVS, so non-agreement with the 2022 impaired listing is indicated. From Table 5, dissolved lead appears to attain the aquatic life TVS, but four samples were insufficient to add it to the 303(d) list, so it was retained on the Monitoring and Evaluation (M&E) list. The assessment of manganese in water supply use was changed in 2022 from a constant value of 50 µg/liter to a standard based on an earlier period of record (1995-2004), which for this segment is 119.89 µg/liter. Therefore, manganese was delisted for 2022 and the more recent River Watch data set is in agreement. As with lead, there was insufficient data to change the listing for total arsenic in water supply use, and 2019-2021 River Watch data, with a relatively large MDL, added no new data for comparison. Finally, total iron had not been on earlier 303(d) lists and both data sets indicate that it continues to attain aquatic life standards.

Segment COGUUN03a_A:

As noted in Table 6 segment 03a_A on the Uncompahgre River extends from a point above the confluence with Red Mtn Creek to a point above the confluence with Cascade Creek in Ouray. The 2022 303(d) assessment included 24 samples collected at one River Watch site (4188 in Figure 2). This site rarely has year-round access, so most data are from April through October. The last 2022 303(d) assessment sample was in October 2018.

Table 6 presents details from the 2022 303(d) list using 2015-2019 data and compares the values with more recent River Watch data from 2019-2021. Dissolved cadmium and copper, and total iron appeared in the 2018 303(d) list as impaired with a TMDL from 2010. The 2022 assessment data in Table 6

Table 6. Columns 1-6 show details from the 2022 303(d) List for Segment COGUUN03a_A using all water quality data from 2015-2019. Columns 7-9 show impairment values computed from 2019-2021 River Watch data. Column 10 indicates if the two data sets agreed. Red shading indicates non-agreement.

Uncompahgre River Basin Segment **COGUUN03a_A**: Uncompahgre R from point abv conf with Red Mtn Cr to point above conf with Cascade Creek.					Uses: Aquatic Life, Water Supply, Recreation E, Agriculture				
2022 303(D) List and Assessment Data (2015-2019) RW data						2019-2021 RW Data: Above Hydro Dam (4135)			
Analyte	**Classification**	**Samples**	**Chronic TVS**	**85th %tile**	**303(D) List**	**Samples**	**Chronic TVS**	**85th %tile**	**303(D) Agreement**
Cadmium (D)	Aquatic Life	24	1.24	2.78	Yes, TMDL	16	1.26	2.83	Yes
Copper (D)	Aquatic Life	24	16.6	665.5	Yes, TMDL	16	16.8	470.5	Yes
Zinc (D)	Aquatic Life	24	233.7	655.2	Yes	16	236.9	774.9	Yes
Lead D)	Aquatic Life	0*			Not assessed	16	5.6	15.4	No*
			Std (1995-99)	68th %tile			Std (1995-99)	68th %tile	
Manganese (D)	Water Supply	24	588.7	882.6	Yes	16	588.7	890.9	Yes
			WS standard	50th %tile			WS standard	50th %tile	
Arsenic (T)	Water Supply	0**	0.02		Not assessed	16	0.02	4.0	No*
			Ag Standard	50th %tile			Ag Standard	50th %tile	
Copper (T)	Agriculture	24	200	352.8	Added	16	200	221.8	Yes
Manganese (T)	Agriculture	24	200	624.3	No	16	200	571.9	No
			min std	15th %tile			min std	15th %tile	
pH min	Aquatic Life	30	6.50	4.32	Yes	17	6.5	3.86	Yes
			Chronic Std	50th %tile		16	Chronic Std	50th %tile	
Iron (T)	Aquatic Life	24	7438	6910	Delisted	16	7438	5406	Yes
* Pb data in RW database, but not in 303(d) file **Only 2 of 24 values > RLR						* As-T and Pb-D not assessed in 2022 303(d) List			

show cadmium and copper continue to exceed the aquatic life TVS, but the median total iron concentration fell below the site-specific iron standard, so total iron was delisted in 2022. The Fe-T assessment based on more recent River Watch data agreed with the delisting in 2022.

The segment continued to show impairment for dissolved zinc, also in agreement with the 2019-2021 River Watch data. The 2022 303(d) assessment files show that total copper and total manganese both exceeded the chronic standard for agricultural use. Table 6 shows total copper was added to the 2022 303(d) list, but total manganese did not appear in the final listing. The assessment using 2019-2021 data indicates both copper and manganese continued to exceed the chronic agriculture use standard, however total manganese is shown be in non-agreement with the 2022 303(d) list.

Data for dissolved lead and total arsenic did not appear in the 2022 303(d) assessment files and therefore lead and arsenic were not evaluated. A review of the original River Watch data files revealed a significant number of valid data points for dissolved lead (>50% >LRL and 67% >MDL), so the reason for not evaluating lead is not obvious. The assessment in Table 6 based on 2019-2021 lead data indicates that the segment would exceed the aquatic life standard for dissolved lead. The reason for not evaluating total arsenic was obvious as only 2 of 24 values exceeded the LRL in the original River Watch file.

Segment COGUUN03b_A:

As noted in Table 7 segment 03b_A on the Uncompahgre River extends from a point above the confluence with Cascade Creek to a point above the confluence with Dexter Creek (just below the town of Ouray). The 2022 303(d) assessment included 48 samples collected at one River Watch site (USGS 3586 in Figures 1 and 2), and six samples collected at one WQCD site (WQX-10608G) in 2015 and 2016. The

final assessment sample was collected in October 2019, but the last sample with metals data was in April 2019.

Table 7 presents details from the 2022 303(d) list using 2015-2019 data and compares the values

Table 7. Columns 1-6 show details from the 2022 303(d) List for Segment COGUUN03b_A using all water quality data from 2015-2019. Columns 7-9 show impairment values computed from 2019-2021 River Watch data. Column 10 indicates if the two data sets agreed. Red shading indicates non-agreement.

Uncompahgre River Basin Segment **COGUUN03b_A**: Uncompahgre R from point abv conf with Cascade Cr to point abv conf with Dexter Cr.					Uses: Aquatic Life, Water Supply, Recreation E, Agriculture				
2022 303(D) List and Assessment Data (2015-2019) WQCD and RW data						2019-2021 RW Data: USGS Gauge (3586)			
Analyte	**Classification**	**Samples**	**Chronic TVS**	**85th %tile**	**303(D) List**	**Samples**	**Chronic TVS**	**85th %tile**	**303(D) Agreement**
Cadmium (D)	Aquatic Life	47	1.45	1.24	Delisted	28	1.6	1.12	Yes
Copper (D)	Aquatic Life	47	19.91	11.14	Delisted	28	22.08	10.6	Yes
Zinc (D)	Aquatic Life	47	283.65	173.11	No	28	316.54	201.59	Yes
			Std (1995-99)	74th %tile			Std (1995-99)	74th %tile	
Manganese (D)	Water Supply	47	413.6	448.9	Yes	28	413.6	454.35	Yes
			Ag standard	50th %tile			Ag standard	50th %tile	
Manganese (T)	Agriculture	44	200	402.5	No+	28	200	389.35	No
			WS standard	50th %tile			WS standard	50th %tile	
Arsenic (T)	Water Supply	6*	0.02	2.05	Added	8**	0.02	3.50	Yes
			min std	15th %tile			min std	15th %tile	
pH min	Aquatic Life	54	6.50	6.265	Added	31	6.5	6.126	Yes
			Chronic Std	50th %tile			Chronic Std	50th %tile	
Iron (T)	Aquatic Life	47	2971	3108	Yes,TMDL	28	2971	2832	No
*Only six WQCD samples used in assessment +Data indicate impaired, but not listed						**8 of 28 positve values with 4 > MDL			

with more recent River Watch data from 2019-2021. In 2018 dissolved cadmium and copper, and total iron, were listed as impaired with a TMDL from 2010. The 2022 assessment found that cadmium and copper aquatic life TVS were no longer exceeded and both analytes were removed from the 2022 303(d) list. The 2019-2021 River Watch data were in agreement. Total iron continued to be listed as impaired (with a TMDL) for aquatic life in 2022, however more recent River Watch data indicated the 50th percentile of total iron was slightly less than the iron standard.

In both data sets dissolved manganese was found to exceed the water supply standard that was based on data from 1995-1999. Total manganese concentration relative to agriculture use was not addressed in the 2022 303(d) assessment, even though the data in Table 7 indicated that the 50th percentile of 402.5 µg/liter was much greater than the agriculture standard of 200 µg/liter. The 2015-2019 River Watch data also implied impairment for agricultural use with a median Mn-T value of 389.35 µg/liter.

The six total arsenic samples used in the 2022 assessment exceeded the water supply standard of 0.02 µg/liter and total arsenic was added to the 2022 303(d) list. The more recent River Watch data for arsenic were in agreement with the 2022 303(d) assessment, however only 8 of 28 2015-2019 samples had positive values and only 4 of these were greater than the River Watch MDL for arsenic.

Another important addition to the 2022 303(d) list was pH. The 2015-2019 pH data indicated that the 15th percentile (6.265) was less than the minimum aquatic life standard of 6.5. A similar result was obtained using 2019-2021 River Watch data.

Segment COGUUN03c_A:

This is an interesting segment in the 2022 303(d) assessment as all metals previously listed as impaired were removed from the 2022 list. It is the segment of the Uncompahgre River from a point above

the confluence with Dexter Creek to a point below the confluence with Dallas Creek. The 2015-2019 assessment data included three River Watch sites (392, 402 and 395 in Figure 1), one WQCD site (WQX-10608C), and one USGS site (09136200). The USGS site contributed four water quality samples in 2015 and three samples in 2016. The WQCD site had only one sample in 2015. There were 165 individual samples from the three River Watch sites, but the median values of the analytes were used for assessment when the samples were collected on similar dates. This reduced the assessment values for metals

Table 8. Columns 1-6 show details from the 2022 303(d) Attainment Summary for Segment COGUUN03c_A using all water quality data from 2015-2019. Columns 7-9 show impairment values computed from 2019-2021 River Watch data. Column 10 indicates if the two data sets agreed. Red shading indicates non-agreement.

Uncompahgre River Basin Segment **COGUUN03c_A**: Uncompahgre R from point above conf with Dexter Cr to point below conf with Dallas Cr.					Uses: Aquatic Life, Water Supply, Recreation E, Agriculture				
2022 303(D) List and Assessment Data (2015-2019) WQCD Unc R Abv Cutler Cr (WQX-10608C), USGS (09146200), and RW Potters Ranch (392), Ridgway Town (402), CR24 (395)						2019-2021 RW Data: Potters Ranch (392), Ridgway Town (402), CR24 (395)			
Analyte	**Classification**	**Samples****	**Chronic TVS**	**85th %tile**	**303(D) List**	**Samples***	**Chronic TVS**	**85th %tile**	**303(D) Agreement**
Cadmium (D)	Aquatic Life	49	1.4	0.52	Delisted	87	1.51	0.53	Yes
Copper (D)	Aquatic Life	49	19.19	7.98	Delisted	87	20.67	6.58	Yes
Zinc (D)	Aquatic Life	49	272.68	46.38	No	87	295.12	67.02	Yes
			Std (1995-99)	74th %tile			Std (1995-99)	74th %tile	
Manganese (D)	Water Supply	49	180	159.53	Delisted	87	180	152.12	Yes
			WS standard	1 sample			WS standard	50th %tile	
Arsenic (T)	Water Supply	1	0.02	5.2	No*	87	0.02	4.00	No**
			min std	15th %tile			min std	15th %tile	
pH min	Aquatic Life	67	6.50	7.7	No	95	6.5	7.6	Yes
			Chronic Std	50th %tile			Chronic Std	50th %tile	
Iron (T)	Aquatic Life	49	1793	1176	Delisted	87	1793	1176	Yes
* 1 sample insufficent to change listing. **Medians used with same day multiple samples.						* All samples used rather than medians. **Samples analyzed if > MDL			

to 49, all from samples prior to 2019. An additional five River Watch samples in 2019 were analyzed for pH, hardness, and alkalinity.

Since segment 03c_A does not appear in the 2022 303(d) list, Table 8 shows details from the Standards Attainment Assessment Summary completed by WQCD in 2021. The data used for delisting dissolved cadmium and copper, and total iron for impairment for aquatic life, as well as dissolved manganese for water supply use, came from the 2021 summary. One concentration value for total arsenic exceeded the water supply standard, but this was insufficient to change the 303(d) listing. Table 8 shows that the 2019-2021 River Watch data used to evaluate impairment also found all analytes except total arsenic were in attainment. The River Watch total arsenic samples had a median concentration of 4.0 µg/liter, but all values greater than zero fell between the MDL and the LRL for arsenic, so it is not known if WQCD would consider this sufficient evidence of impairment.

Segment COGUUN03e_B:

Segment 03e_B on the Uncompahgre River extends from below the outlet of Ridgway Reservoir to a point above Broman Canyon. The 2015-2019 assessment data for the 2022 303(d) list included one USGS site (09147500) on the Uncompahgre River at Colona, and one River Watch site (393) shown in Figure 1 just below the outlet of Ridgway Reservoir. There were 21 samples from the USGS site that did

not include metals data, except for selenium. The River Watch site had 54 samples, 49 with all River Watch analytes in 2015-2018, and five samples in 2019 that did not include metals.

As with segment 03c_A, segment 03e_B had previously been listed as impaired for dissolved cadmium, dissolved copper, and total iron, due to exceeding aquatic life TVS. Each metal also had an approved TMDL from 2010. The data in Table 9 from the 2021 Standards Attainment Assessment Summary shows that cadmium, copper and iron all attained aquatic life standards, based on the 2015-2019 data,

Table 9. Columns 1-6 show details from the 2022 303(d) Attainment Summary for Segment COGUUN03c_A using all water quality data from 2015-2019. Columns 7-9 show impairment values computed from 2019-2021 River Watch data. Column 10 indicates if the two data sets agreed. Red shading indicates non-agreement.

Uncompahgre River Basin Segment **COGUUN03e_B**: Uncompahgre River from outlet of Ridgway Res to point above Broman Canyon					Uses: Aquatic Life, Water Supply, Recreation E, Agriculture				
2022 303(D) List and Assessment Data (2015-2019): USGS (09147500), RW Below Ridgway Res (393)						2019-2021 RW Data: Blw Ridgway Res (393)			
Analyte	Classification	Samples	Chronic TVS	85th %tile	303(D) List	Samples	Chronic TVS	85th %tile	303(D) Agreement
Cadmium (D)	Aquatic Life	49	1.4	0.00	Delisted	28	1.45	0.00	Yes*
Copper (D)	Aquatic Life	49	18.9	5.22	Delisted	28	19.86	3.70	Yes
Zinc (D)	Aquatic Life	49	268.1	3.92	No	28	282.77	5.00	Yes
			WS standard	85th %tile			WS standard	85th %tile	
Manganese (D)	Water Supply	49	50	14.7	No	28	50	14.03	Yes
			WS standard	50th %tile			WS standard	50th %tile	
Arsenic (T)	Water Supply	0			No	data < MDL	0.02	data < MDL	Yes*
			min std	15th %tile			min std	15th %tile	
pH min	Aquatic Life	74	6.50	7.74	No	31	6.50	7.86	Yes
			Chronic Std	50th %tile			Chronic Std	50th %tile	
Iron (T)	Aquatic Life	49	1000	41	Delisted	28	1000	13	Yes
						* All Cd-D and As-T values were < MDL.			

and were removed from the 2022 303(d) list. The assessment using 2019-2021 River Watch data agreed with the 2021 assessment.

Segment COGUUN05_B:

Segment 05_B contains Commodore Gulch from its source to its confluence with Red Mtn Creek. It was sampled by WQCD in 2012 (2 samples) and 2013 (1 sample), but had no new data in 2015-2019 for the 2022 303(d) assessment. It was identified in 2020 by the TMDL group in WQCD as needing additional data to complete a TMDL. The UWP added Commodore Gulch site 662 (see Figure 2) to its list of River Watch sites and sampled the site six times in 2021. Note that the WQCD and River Watch sampling sites were at the same location.

Table 10 shows that dissolved cadmium, copper, zinc, and lead in the 2012-2013 data set exceeded the aquatic life TVS and would have qualified for the 2018 303(d) list. However, three samples were insufficient for the 303(d) listing, so cadmium, copper and lead were put on the M&E list in 2018 and retained on this list in 2022. Dissolved zinc was added to the 2018 303(d) list because all three values exceeded the acute TVS for zinc, and this listing was also retained in 2022. Table 10 indicates that the 2021 River Watch data are in non-agreement for cadmium, copper, and lead because all would qualify for a 303(d) listing rather than the M&E list. Dissolved manganese attained the water supply standard based on 2012-2013 data, but the standard was exceeded using the River Watch data from 2021.

Table 10. Columns 1-6 show details from three WQCD samples collected in 2012-2013 for Segment COGUUN05_B. Columns 7-9 show impairment values computed from 2021 River Watch data. Column 10 indicates if the two data sets agreed. Red shading indicates non-agreement.

Uncompahgre River Basin Segment **COGUUN05_B**: Commodore Gulch					Uses: Aquatic Life, Water Supply, Recreation E, Agriculture				
2018 303(D) List and Assessment Data (2012-2013): WQCD Commodore Gulch at Hwy 550 (TMDL-RM-05)						2021 RW Data: Commodore Gulch @ Hwy 550 (662)			
Analyte	Classification	Samples	Chronic TVS	85th %tile	303(D) List	Samples	Chronic TVS	85th %tile	303(D) Agreement
Cadmium (D)	Aquatic Life	3	0.19	0.68	M&E*	6	0.46	8.88	No*
Copper (D)	Aquatic Life	3	3.62	7.95	M&E*	6	5.37	302.03	No*
Zinc (D)	Aquatic Life	3	46.25	177.00	Yes +	6	70.36	2359.64	Yes
Lead (D)	Aquatic Life	3	0.78	3.06	M&E*	6	1.30	29.65	No*
				85th %tile			WS standard	85th %tile	
Manganese (D)	Water Supply	3	50	20.7	No	6	50	566.95	No*
			WS standard	50th %tile			WS standard	50th %tile	
Arsenic (T)	Water Supply	3	.02 - 10**	0.16	No	6	.02 - 10	data < MDL	N/A
			min std	15th %tile			min std	15th %tile	
pH min	Aquatic Life	3	6.50	7.32	No	5	6.50	~ 6.8	Yes
			Chronic Std	50th %tile			Chronic Std	50th %tile	
Iron (T)	Aquatic Life	3	1000	190	No	6	1000	491.50	Yes
* Exceeded TVS, but too few samples to add to 303(d) List. **Less restrictive value is used when a standard range is specified. + 3 samples exceeded acute Zn TVS						* Cd, Cu, Zn, Pb, and Mn would qualify for the 303(d) list rather than the M&E list.			

Segment COGUUN05_C:

Governor Basin in the Sneffels-Canyon Creek watershed is designated Segment 05_C. For the 2022 303(d) assessment using 2015-2019 data there were seven WQCD and UWP water quality sites that contributed 11 samples on three days in 2015 and 2017. For all parameters analyzed, the 11 individual values were reduced to three median values for the three sample days. For aquatic life use, dissolved cadmium, copper, zinc, and lead appeared in the 2018 303(d) list, and dissolved manganese was placed on the 2018 303(d) list for water supply use. Table 11 shows that these same five parameters continued to exceed standards and were retained in the 2022 303(d) list. Total lead was added to the 2022 303(d) list due to exceeding the acute water supply standard twice in three years. There are no River Watch sites in segment 05_C, so no comparison data from 2019-2021 appear in Table 11.

Table 11. Columns 1-6 show details from the 2022 303(d) Attainment Summary for Segment COGUUN05_C using all water quality data from 2015-2019. Columns 7-9 are blank since this segment has no River Watch sites.

Uncompahgre River Basin Segment **COGUUN05_C:** Governor Basin					Uses: Aquatic Life, Water Supply, Recreation E, Agriculture				
2022 303(D) List and Assessment Data (2015-2019): WQCD (WQX-MEAS_GB-02, _GB-01), UWP (HB-04, HB-03, HB-02, GB-03)						2019-2021 Data: No RW data or other new data since 2017			
Analyte	Classification	Samples*	Chronic TVS	85th %tile	303(D) List	Samples	Chronic TVS	85th %tile	303(D) Agreement
Cadmium (D)	Aquatic Life	3	0.41	2.25	Yes**	0			
Copper (D)	Aquatic Life	3	4.68	10.89	Yes**	0			
Zinc (D)	Aquatic Life	3	60.79	542.85	Yes**	0			
Lead (D)	Aquatic Life	3	1.09	1.87	Yes	0			
			WS standard	85th %tile			WS standard	85th %tile	
Manganese (D)	Water Supply	3	50	1298	Yes	0			
			WS standard	50th %tile			WS standard	50th %tile	
Arsenic (T)	Water Supply	3	.02 - 10	5.1	No	0			
			WS standard	No. exceeded			WS standard	No. exceeded	
Lead (T)	Water Supply	3	50	2 in 3 yrs	Yes	0			
			min std	15th %tile			min std	15th %tile	
pH min	Aquatic Life	3	6.50	6.94	No	0			
*10 samples on 3 dates reduced to 3 median values. **Cd, Cu, and Zn also exceeded acute TVS.									

Segment COGUUN05_E:

Segment 05_E is a short stretch of Sneffels Creek extending from below Governor Basin down to a point about 1.5 miles above the start of Canyon Creek. It is of particular interest to the UWP which had a remediation project in this segment at Atlas Mill and a pending project in Governor Basin. The poor water quality in Governor Basin affects this segment, but harmful metal concentrations are diluted somewhat by the relatively unpolluted water coming from Sneffels Creek above Governor Basin. As with segment 05_C there are no River Watch sampling sites on segment 05_E.

Table 12. Columns 1-6 show details from the 2022 303(d) Attainment Summary for Segment COGUUN05_E using all water quality data from 2015-2019. Columns 7-9 show impairment values computed from 2012-2017 WQCD data. Column 10 indicates if the two data sets agreed. Red shading indicates non-agreement.

Uncompahgre River Basin Segment **COGUUN05_E**: Sneffels Cr below Governor Basin					Uses: Aquatic Life, Water Supply, Recreation E, Agriculture				
2022 303(D) List and Assessment Data (2015-2019): WQCD Sneffels Cr abv Atlas Mill (WQX-MEAS-SC-02), Sneffels Cr blw Atlas Mill (WQX-MEAS-SC-03)						2012-16 WQCD data: SC-02, SC-03			
Analyte	**Classification**	**Samples**	**Chronic TVS**	**85th %tile**	**303(D) List**	**Samples***	**Chronic TVS**	**85th %tile**	**303(D) Agreement**
Cadmium (D)	Aquatic Life	4	0.52	0.74	Yes	17	0.46	0.90	Yes
Copper (D)**	Aquatic Life	0	-	-	No	0**	-	-	N/A
Zinc (D)	Aquatic Life	4	81.77	168.75	Yes	18	69.72	186.00	Yes
Lead (D)	Aquatic Life	4	1.57	0.31	Yes*	15	1.29	0.81	No
			WS standard	85th %tile			WS standard	85th %tile	
Manganese (D)	Water Supply	4	50	473.75	Yes	18	50	381.50	Yes
			WS standard	50th %tile			WS standard	50th %tile	
Arsenic (T)	Water Supply	4	.02 - 10	3.55	No	18	.02 - 10	3.2	Yes
			min std	15th %tile			min std	15th %tile	
pH min	Aquatic Life	4	6.50	7.35	No	18	6.50	7.32	Yes
			WS standard	50th %tile			Chronic Std	50th %tile	
Manganese (T)	Agriculture	4	200	354.25	Yes	16	200	210.00	Yes
			MMI threshold	MMI score			MMI threshold	MMI score	
Macroinvertebrate	Aquatic Life	2++	42	35.7, 32.5	Yes	2++	48	49.2, 49.5	No
303(d) List based on data prior to 2015. * Four samples attained standard, but 10 needed to remove from list. **Cu-D was not analyzed. ++MI data from 2014						*All 2012-2016 data used for comparison with 303(d) List. **Cu-D was not analyzed. ++2014 data reanalyzed in 2018			

The 303(d) listing in column 6 of Table 12 is from 2018. There was insufficient data (4 samples) in the period from 2015 to 2019 to change the listing. All impairment designations shown in Table 12 from 2015-2019 data agreed with those in the 2018 303(d) list except dissolved lead, but it was retained due to too few samples. Columns 7-9 in Table 12 show the impairment assessment based on all data from 2012 through 2017. There is agreement with the 2022 303(d) listing except for dissolved lead where attainment was indicated using the entire data set.

Also, Table 12 shows Sneffels Creek was originally designated as impaired for aquatic life use for macroinvertebrates based on two MMI scores from 2014 which did not meet the impairment threshold of 42. A recent reanalysis of the MMIs by WQCD using a new MMI tool produced the results shown in columns 8 and 9 of Table 12. The reanalysis shows the segment as now attaining the MI aquatic life standard and has been removed from the 303(d) list.

Segment COGUUN09_B:

Segment 09_B is the segment of Sneffels Creek immediately below segment 05_E and extends from a point 1.5 miles above its confluence with Imogene Creek down to the confluence with Imogene Creek. For the 2015-2019 assessment period there were four sites sampled by WQCD and UWP that contribut-

ed eight individual samples. Median values were used on two dates with multiple samples, reducing the data points used for assessment to six. The 2022 303(d) listings shown in column 6 of Table 13 were retained from 2018, except for macroinvertebrates which were delisted in 2022. There are no River Watch sites on segment 09_B and no new data is available since 2019. The comparison data in columns 7-9 of Table 13 are from the five years (2010-2014) preceding the 2022 303(d) assessment period.

Table 13. Columns 1-5 show details from the 2022 303(d) Attainment Summary for Segment COGUUN09_B using all water quality data from 2015-2019. Column 6 is the 2022 303(d) listing retained from 2018. Columns 7-9 show impairment values computed from 2010-2014 WQCD and UWP data. Column 10 indicates if the two data sets agreed. Red shading indicates non-agreement.

Uncompahgre River Basin Segment **COGUUN09_B**: Sneffels Cr from a point 1.5 miles above conf with Imogene Cr to conf with Imogene Cr					Uses: Aquatic Life, Recreation E, Agriculture, (no Water Supply)				
2022 303(D) List and Assessment Data (2015-2019): WQCD Sneffels Cr abv Canyon Cr @ Camp Brd (WQX-MEAS-SC-04), Sneffels Cr abv Imogene Pass Brdg (WQX-MEAS-SC-06), Sneffels Cr near mouth (WQX-10695), UWP Silver Basin @ Old Imogene Pass Rd (SB-01)						2010-14 WQCD, UWP data: SC-04, SC-06, 10695			
Analyte	**Classification**	**Samples**	**Chronic TVS**	**85th %tile**	**303(D) List**	**Samples***	**Chronic TVS**	**85th %tile**	**303(D) Agreement**
Cadmium (D)	Aquatic Life	6	0.49	0.48	Yes*	9	0.48	0.73	No
Copper (D)	Aquatic Life	6	5.79	0.1	No	0**	-	-	N/A
Zinc (D)	Aquatic Life	6	76.12	137.75	Yes*	12	73.07	153.50	Yes
Lead (D)	Aquatic Life	6	1.44	0.66	Yes*	8	1.37	4.43	No
			min std	15th %tile			min std	15th %tile	
pH min	Aquatic Life	6	6.50	7.35	No	12	6.50	6.74	Yes
			MMI threshold	MMI scores			MMI threshold	MMI score	
Macroinvertebrate	Aquatic Life	2	48	50.9, 61.1	No**	1++	42	25.00	No
* Retained from 2018 303(d) list since 10 samples needed to change listing. **Removed from list based on new samples.						*2010-2014 data used for comparison with 303(d) List. **Cu-D was not analyzed. ++ One sample from the 2018 assessment			

Table 13 column 6 shows dissolved cadmium, zinc, and lead were listed as impaired in the 2022 303(d) list (retained from 2018). The data from 2010-2014 in Table 13 indicate none of the three metals attained the aquatic life TVS. The 2015-2019 data indicated dissolved cadmium and lead attained the aquatic life use TVS, but were retained on the 2022 303(d) list because 10 samples were needed to change the listing. The non-attainment of the aquatic life TVS for dissolved zinc was indicated in both data sets. The single macroinvertebrate sample from the 2010-2014 period did not attain the MMI impairment threshold and appeared on the 2018 303(d) list. Two samples from the 2015-2019 period exceeded the MMI threshold and segment 09_B was delisted for 2022.

Segment COGUUN09_D:

Segment 09_D consists of the entire length of Imogene Creek from its source to its confluence with Sneffels Creek (at the start of Canyon Creek). It has been sampled by WQCD and UWP since 2010. Prior to the 2022 303(d) assessment segment 09_D was in non-attainment of the aquatic life chronic TVS for dissolved cadmium and zinc, and on the M&E list for dissolved copper. Within the 2015-2019 data assessment period for the 2022 303(d) list three sites (see Table 14) were sampled by WQCD on two dates in 2016. The three sample values from each date were converted to a median, resulting in only two values for each analyte in the assessment. River Watch site Imogene Cr abv Canyon Cr @ Camp Bird (665) was established in 2021 and sampled 11 times in 2021 and 2022 (Table 2). Data for total and dissolved metals is available from 2021 and is used in comparison with the 2022 303(d) listing in Table 14.

Table 14 indicates that the impairment assessment using data from 2016 (columns 4 and 5) is similar to the assessment using the 2021 River Watch data (columns 8 and 9). The one non-agreement in column 10 was for dissolved copper, which indicated non-attainment in 2021.

Table 14. Columns 1-6 show details from two WQCD samples (medians of three values) collected in 2016 for Segment COGUUN09_D. Columns 7-9 show impairment values computed from 2021 River Watch data. Column 10 indicates if the two data sets agreed. Red shading indicates non-agreement.

Uncompahgre River Basin Segment **COGUUN09_D**: Imogene Cr from its source to its confluence with Sneffels Cr.					Uses: Aquatic Life, Recreation P, Agriculture, (No Water Supply)				
2022 303(D) List and Assessment Data (2015-2019): WQCD sites Imogene Cr abv Canyon Cr at Camp Bird (WQX-MEAS-IC-05), Imogene Cr abv Richmond Cr WQX-MEAS-IC-03), Imogene Cr blw Camp Bird No. 3 (WQX-MEAS-IC-02)						2021 RW data: Imogene Cr abv Canyon Cr at Campbird (665); same as WQCD site IC-05.			
Analyte	Classification	Samples	Chronic TVS	85th %tile	303(D) List	Samples	Chronic TVS	85th %tile	303(D) Agreement
Cadmium (D)	Aquatic Life	2	0.50	1.14	Yes	6	0.51	1.09	Yes
Copper (D)	Aquatic Life	2	5.95	3.64	M&E*	6	5.99	6.50	No*
Zinc (D)	Aquatic Life	2	78.46	268.00	Yes	6	79.04	279.75	Yes
Manganese (D)	Aquatic Life	2	1406.77	7.40	No	6	1410.53	7.12	Yes
			Chronic Std	50th %tile			Chronic Std	50th %tile	
Iron (T)	Aquatic Life	2	1000	81.5	No	6	1000	35.5	Yes
			min std	15th %tile			min std	15th %tile	
pH min	Aquatic Life	2	6.50	7.41	No	6	6.50	7.23	Yes
*Two samples showed attainment, but did not have required 10 samples to remove from M&E list.						* Qaulifies for 303(d) rather than M&E List			

Segment COGUUN09_C:

Segment 09_C consists of the mainstem of Canyon Creek from its start at the confluence of Sneffels and Canyon Creeks to its confluence with the Uncompahgre River near Ouray. There is one River Watch

Table 15. Columns 1-6 show details from the 2022 303(d) Attainment Summary for Segment COGUUN09_C using all water quality data from 2015-2019. Columns 7-9 show impairment values computed from 2019-21 River Watch data. Column 10 indicates if the two data sets agreed. Red shading indicates non-agreement.

Uncompahgre River Basin Segment **COGUUN09_C**: Canyon Cr from its inception at confluence of Imogene Cr and Sneffels Cr to confluence with Uncompahgre River					Uses: Aquatic Life, Recreation P, Agriculture, (no Water Supply)				
2022 303(D) List and Assessment Data (2015-2019): WQCD sites Canyon Cr blw Camp Bird (WQX-10690), Canyon Cr blw Sneffels and Imogene conf (WQX-CC-01), Canyon Cr at FR 853 (WQX-10690A); RW site Canyon Cr Camp Bird RD FW 853 (4134)						2019-21 RW data: Campbird Rd FS 853 (4134)			
Analyte	**Classification**	**Samples**	**Chronic TVS**	**85th %tile**	**303(D) List**	**Samples**	**Chronic TVS**	**85th %tile**	**303(D) Agreement**
Cadmium (D)	Aquatic Life	46	1.32	0.54	No	26	1.34	0.49	Yes
Copper (D)	Aquatic Life	46	17.90	3.25	No	26	18.15	2.70	Yes
Zinc (D)	Aquatic Life	46	253.64	120.40	Delisted**	26	257.01	135.84	Yes
Manganese (D)	Aquatic Life	46	2152.06	41.96	No	26	2172.53	66.34	Yes
			Chronic Std	50th %tile			Chronic Std	50th %tile	
Iron (T)	Aquatic Life	46	1000	104	No	26	1000	48.5	Yes
			min std	15th %tile			min std	15th %tile	
pH min	Aquatic Life	46	6.50	6.04	M&E*	28	6.50	6.239	No*
*Recommended for 303(d), but changed to M&E in final assessment. **Recommended for 303(d) for non-attainment of acute std, but not listed.						* Qaulifies for 303(d) rather than M&E List			

site, Campbird Rd FS853 (4134), about two miles above the Uncompahgre confluence (see Figure 2) that provided more than 90% of the 57 water quality samples collected during the 2015-2019 303(d) assessment period. Metals data were available from River Watch samples through April 2019. Three WQCD sites were sampled four times in the five-year period, three times in 2015 and once in 2019.

Dissolved zinc was on the previous 303(d) list for non-attainment of the aquatic life standard for zinc. Table 15 indicates that dissolved zinc was removed from the 2022 303(d) list despite having two samples in three years that exceeded the acute TVS for dissolved zinc. Table 15 also indicates that the 15th percentile of pH values was less than the minimum pH standard for aquatic life, but pH was added to the M&E list rather than the 303(d) list for 2022. The comparison of 2015-2019 assessment values with those based on 2019-2021 River Watch data in Table 15 shows agreement with all parameters except pH, which showed non-attainment in both assessment periods.

Segment COGUUN06a_A:

Segment 06a_A is the upper portion of Red Mtn Creek from its source near Red Mtn Pass to a point above the confluence with the East Fork of Red Mtn Creek. A portion of the creek's water comes from a diversion originating in San Juan County on the south side of the pass. The segment was added to the 303(d) list in 2012 and has been retained on the list through 2022, since only a limited number of samples became available after the 2012 listing. River Watch site Red Mtn Cr Abv Idarado MM81 (667) was added to segment 06a_A in 2021 and results from six 2021 samples are used in the assessment comparison in Table 16.

Table 16. Columns 1-6 show details from three WQCD samples collected in 2012-2013 for Segment COGUUN06a_A. Columns 7-9 show impairment values computed from 2021 River Watch data. Column 10 indicates if the two data sets agreed. Red shading indicates non-agreement.

Uncompahgre River Basin Segment **COGUUN06a_A**: Red Mtn Cr from source to just above confluence with E Fork Red Mtn Cr					Uses: Aquatic Life, Recreation N, Agriculture (no Water Supply)				
2022 303(D) List and Assessment Data (2012-2013): WQCD sites Red Mtn Cr abv Waste Rock (RM-03), Red Mtn Cr abv Idarado MM81 (RM-02), Red Mtn Cr culvert (RM-01)						2021 RW Data: Red Mtn Cr Abv Idarado MM81 (667), same as WQCD site RM-01			
Analyte	**Classification**	**Samples***	**Chronic TVS**	**85th %tile**	**303(D) List**	**Samples**	**Chronic TVS**	**85th %tile**	**303(D) Agreement**
Cadmium (D)	Aquatic Life	3	0.17	0.14	No	6	0.39	0.09	Yes
Copper (D)	Aquatic Life	3	3.08	0.00	Yes*	6	4.44	8.71	Yes
Zinc (D)	Aquatic Life	3	38.91	71.00	Yes, TMDL	6	57.44	36.74	No
Lead (D)	Aquatic Life	3	0.63	0.00	No	6	1.02	0.00	Yes**
Silver (D)	Aquatic Life	3	0.037	0.00	Yes*	0*	-	-	-
			min std	15th %tile			min std	15th %tile	
pH min	Aquatic Life	3	6.50	6.282	No	6	6.50	7.22	Yes
*Cu and Ag listed in 2012. Later data indicate attainment, but 10 samples needed to delist.						*RW does not analyze for Ag. **RW MDL for Pb-D is 2.4.			

Table 16 shows the 303(d) assessment using data from 2012-2013 since no new data were available in 2015-2019. After bias removal the three sample values in Table 16 were selected from four individual samples on three separate dates. In Table 16 dissolved copper and silver show attainment of the aquatic life TVS, but are retained on the 2022 303(d) list since 10 samples are needed to delist. Using the 2021 River Watch data, columns 8 and 9 in Table 16 show dissolved copper exceeded the aquatic life TVS. In contrast dissolved zinc is shown to be in non-attainment for aquatic life use using 2012-2013 data, but in attainment using the six 2021 River Watch samples. The original 2012 303(d) list did not contain pH and

the 2022 list was not changed based on the three values in Table 16 that did not attain the minimum pH standard for aquatic life. However, the 15th percentile for pH from 2021 River Watch data was 7.22, considerably higher than the minimum standard.

Segment COGUUN07_A:

Segment 07_A is the mainstem of Gray Copper Gulch from its source to the confluence with Red Mountain Creek just below the Idarado mining area. WQCD and UWP have sampled the stream since 2012. The 2022 303(d) list was retained from the one established in 2012, since only one data point was available for the 2022 assessment. This was the median of two samples collected in July of 2016. However, when the national water quality data portal (https://www.waterqualitydata.us/) was searched, eight additional samples collected by UWP in July and September of 2017 were found. River Watch site Gray Copper Gulch at CR20 (664) was added to Gray Copper Gulch in 2021. The location shown in Figure 2 is the same as UWP site GC-05. Table 17 shows assessment values for segment 07_A based on all data from 2016 and 2017, rather than just the single sample from 2016. Data from site 664 in 2021 was used in the Table 17 assessment comparison in columns 7–10.

Table 17. Columns 1-6 show details from 10 WQCD and UWP samples collected in 2016-2017 for Segment COGUUN07_A. [Note that samples collected on the same day were not combined into median values.] Columns 7-9 show impairment values computed from 2021 River Watch data. Column 10 indicates if the two data sets agreed. Red shading indicates non-agreement.

Uncompahgre River Basin Segment **COGUUN07_A**: Gray Copper Gulch from source to confluence with Red Mtn Cr.					Uses: Aquatic Life, Water Supply, Recreation P, Agriculture				
2022 303(D) List and Assessment Data (2015-2019): UWP/WQCD sites Gray Cu Gulch GC-01, GC-02, GC Abv SM, GC Blw SM, Vrn-Adt-01, GC-05						2021 RW Data: Gray Copper Gulch @CR20 (664), same as UWP site GC-05			
Analyte	**Classification**	**Samples***	**Chronic TVS**	**85th %tile**	**303(D) List****	**Samples**	**Chronic TVS**	**85th %tile**	**303(D) Agreement**
Cadmium (D)	Aquatic Life	10	0.95	0.37	No	6	1.85	0.12	Yes
Copper (D)	Aquatic Life	10	12.30	238.50	Yes	6	26.14	18.68	No
Zinc (D)	Aquatic Life	10	169.91	84.00	Yes	6	378.98	51.51	No
Lead (D)	Aquatic Life	8	3.76	72.15	Yes	6	9.55	0.00	No
			Chronic Std	50th %tile			Chronic Std	50th %tile	
Iron (T)	Aquatic Life	10	2338	3550.00	No	6	2338	2295	Yes
			WS Std	85th %tile			WS Std	85th %tile	
Manganese (D)	Water Supply	10	620.50	523.48	No	6	620.50	580.95	Yes
			Ag Std	50th %tile			Ag Std	50th %tile	
Manganese (T)	Agriculture	10	200.00	118.00	No	6	200.00	431.55	No
			min std	15th %tile			min std	15th %tile	
pH min	Aquatic Life	3	6.50	6.90	Yes	6	6.50	6.69	No
*All samples from 2016-2017, only 1 2016 sample in 2022 assessment data file. **2022 list is the same as 2012 list.						All six samples from site 664 near mouth of Gray Cu Gulch			

Table 17 indicates that dissolved copper, zinc and lead were retained on the 2022 303(d) list for exceeding aquatic life TVS, but that the 2016-2017 data indicate dissolved zinc attained the aquatic life TVS. The 2021 River Watch data (columns 8 and 9) indicate that dissolved copper, zinc and lead all attained the aquatic life TVS and were in non-agreement with the 2022 303(d) list. The main difference between the 2016-17 data set and the 2021 data set is that the former contained samples along the length of Gray Copper Gulch, while the latter contained only samples near the bottom of the gulch. Appendix A contains a detailed report on Gray Copper Gulch water quality data, where distinct differences in water quality between the upper and lower sections of the gulch are noted.

Table 17 shows total iron was not on the 2022 303(d) list but the 10 data points from 2016-17 indicate that the aquatic life site-specific standard was exceeded. The 2021 River Watch data for total iron show the opposite with the 50th percentile being slightly less than the aquatic life standard. Dissolved manganese did not appear on the 303(d) list for water supply, and both data sets show attainment for water supply use. Total manganese was also not on the 303(d) list for agriculture use. The 2016-17 data agreed with this non-listing but the 2021 River Watch data showed that the agriculture standard was exceeded.

Water samples from 2012-2013 indicated that segment 07_A was impaired for pH (15th percentile was less than the minimum standard for aquatic life) and pH was placed on the 303(d) list. The three samples in Table 17 from 2016-17 indicated attainment, as did the six River Watch samples from 2021. Appendix A indicates that most of the lower non-attaining pH values from 2012-13 came from the higher altitude sites in segment 07_A where dissolved copper and zinc also frequently exceeded their aquatic life TVS. Results in Appendix A also indicate higher pH values in all data sets were generally observed on the lower portion of the gulch.

Segment COGUUN10a_C:

Segment 10a_C is an approximately seven-mile section of Cow Creek from the confluence with Nate Creek down to the confluence with the Uncompahgre River. For the 2015-2019 303(d) assessment period one WQCD site (WQX-10669C) and one River Watch site (Cow Cr Abv Conf Uncompahgre – 347) provided water quality data. River Watch site 347 was established in May 2019 and had seven sampling events, but metals data had not been processed by the end of 2019, so the only metals data for the 2022 303(d) assessment came from two WQCD samples.

Table 18. Columns 1-6 show details from the 2022 303(d) Attainment Summary for Segment COGUUN10a_C using all water quality data from 2015-2019. Columns 7-9 show impairment values computed from 2019-21 River Watch data and 2014-15 WQCD data. Column 10 indicates if the two data sets agreed. Red shading indicates non-agreement.

Uncompahgre River Basin Segment **COGUUN10a_C**: Cow Creek from the confluence with Nate Cr to the Uncompahgre River					Uses: Aquatic Life, Water Supply, Recreation P, Agriculture				
2022 303(D) List and Assessment Data (2015-2019): WQCD site Cow Cr at Hwy 550 (WQX-10669C); RW site Abv Conf Uncompahgre (347)						2019-21 RW data: Abv Uncompahgre Conf (347) + 2014-2015 WQCD data (6 samples)			
Analyte	**Classification**	**Samples**	**Chronic TVS**	**85th %tile**	**303(D) List**	**Samples**	**Chronic TVS**	**85th %tile**	**303(D) Agreement**
			WS standard	50th %tile			WS standard	50th %tile	
Arsenic (T)	Water Supply	2	0.02	0.96	Yes*	6*	0.02	0.58	Yes
			min std	15th %tile			min std	15th %tile	
pH min	Aquatic Life	2	6.50	7.96	No	31	6.50	8.3	Yes
			max std	85th %tile			max std	85th %tile	
pH max	Aquatic Life	2	9.00	8.36	No	23	9.00	8.48	Yes
*On 303(d) List based on data prior to 2015. Retained as two recent samples also exceeded standard.						* All WQCD samples > MDL in 2014 and 2015. No RW samples had As-T > MDL.			

Prior to 2022 segment 10a_C was on the 303(d) list due to total arsenic exceeding the water supply standard. Table 18 indicates that the 50th percentile of total arsenic concentration for the two WQCD samples also exceeded the water supply standard, so total arsenic was retained on the 2022 303(d) list. Columns 7-9 in Table 18, using WQCD data from 2014-15, also indicated the total arsenic standard for water supply was exceeded.

Segment COGUUN11_G:

Segment 11_G is the entirety of Dallas Creek from its source to the confluence with the Uncompahgre River just above Ridgway Reservoir. As with Cow Creek, a River Watch site (Dallas Cr CR24 blw Pleasant V Cr – 336) was established in May 2019. Seven water quality samples were collected at site 336 in the 2015-2019 303(d) assessment period, but metals data had not been analyzed before the evaluation was completed. Two WQCD samples from site WQX-10644 provided the only new data for the 2022 303(d) assessment.

Prior to 2022 segment 11_G was on the 303(d) list for exceeding the water supply standard for total arsenic. It is also on the M&E list for not attaining the aquatic life standard for temperature. Table 19 indicates that the 50th percentile of total arsenic concentration for the two WQCD samples also exceeded the water supply standard, so total arsenic was retained on the 2022 303(d) list. Columns 7-9 in Table 19, using WQCD data (3 samples) from 2019-20, also indicated the total arsenic standard for water supply was exceeded.

The M&E temperature listing (not shown in Table 19) was based on two measurements from 2012 and 2013 which indicated the aquatic life winter season temperature standard was exceeded. The distributions of stream temperatures measured at Dallas Creek River Watch site 336 in 2019-2021 are shown in Figure 25 (June – Sept) and Figure 26 (Oct – May). The Daily Maximum (DM) temperature standard for aquatic life is shown in each figure. None of the 33 discrete temperature measurements from the two seasons represented in Figures 25 and 26 exceeded the DMs for summer or winter. This suggests the temperature standards on Dallas Creek are being attained, however WQCD is installing a continuously recording temperature sensor near the USGS stream gauge site on Dallas Creek to gather a more comprehensive record to assess the aquatic life temperature standards (DM and MWAT – Maximum Weekly Average Temperature).

Table 19. Columns 1-6 show details from the 2022 303(d) Attainment Summary for Segment COGUUN11_G using all water quality data from 2015-2019. Columns 7-9 show impairment values computed from 2019-21 River Watch data and 2019-20 WQCD data. Column 10 indicates if the two data sets agreed. Red shading indicates non-agreement.

Uncompahgre River Basin Segment **COGUUN11_G**: Mainstem of Dallas Cr					Uses: Aquatic Life, Water Supply, Recreation P, Agriculture				
2022 303(D) List and Assessment Data (2015-2019): WQCD site Dallas Cr blw Conf with Pleasant Valley Cr (WQX-10664)						2019-21 RW data: Blw Conf Pleasant V Cr (336) + 2019-20 WQCD data (3 samples)			
Analyte	**Classification**	**Samples***	**Chronic TVS**	**85th %tile**	**303(D) List**	**Samples**	**Chronic TVS**	**85th %tile**	**303(D) Agreement**
			WS standard	50th %tile			WS standard	50th %tile	
Arsenic (T)	Water Supply	2	0.02	0.92	Yes**	3*	0.02	1.01	Yes
			min std	15th %tile			min std	15th %tile	
pH min	Aquatic Life	2	6.50	7.96	No	28	6.50	7.97	Yes
			max std	85th %tile			max std	85th %tile	
pH max	Aquatic Life	2	9.00	8.36	No	28	9.00	8.33	Yes
*2019 River Watch data had not been archived, so only 2 samples available from WQCD. ** Retained on 303(d) since both samples exceeded WS standard.						* All WQCD samples > MDL in 2019 and 2020. No RW samples had As-T > MDL.			

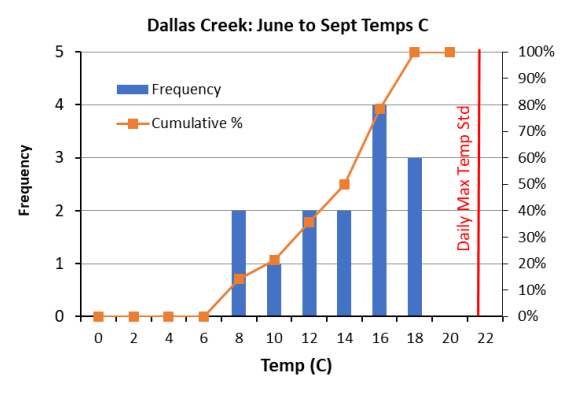

Figure 25. Histogram of stream temperatures measured at Dallas Creek River Watch site 336 in June through September 2019-2021. Daily maximum temperature standard for aquatic life shown by red line.

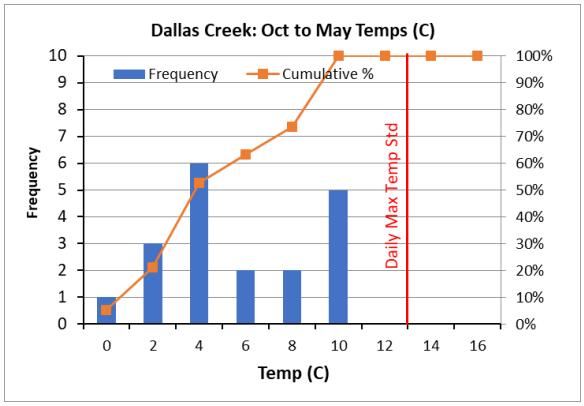

Figure 26. Histogram of stream temperatures measure at Dallas Creek River Watch site 336 in October through May 2019-2021. Daily maximum temperature standard for aquatic life shown by red line.

6. Summary and Significant Results

UWP River Watch volunteers successfully completed sampling at 11 River Watch sites between May 2019 and December 2021. Sampling locations and details of sampling events were given in Sections 2 and 3. There were 103 sampling events at 11 sites that included 103 standard samples consisting of pH, alkalinity, hardness, and temperature measurements. Ninety-five metals samples, unfiltered and filtered, were analyzed for 13 metals at a CPW laboratory and archived in the River Watch database. In addition, 16 nutrient samples and one macroinvertebrate sample were collected, analyzed, and archived. Of the 11 sites, five were new sites added in 2021 to the upper Uncompahgre watershed to aid the WQCD with TMDL studies. By the next 303(d) list evaluation there should also be enough samples in these five stream segments to update their impairment status.

Section 4 presented results of statistical analyses of all 2019-2021 River Watch data collected at 17 sites in the upper Uncompahgre watershed. Site locations shown in Figures 1 and 2 ranged from one near Red Mtn Pass down to a site just below Ridgway Reservoir. Data from each site were represented by box and whisker plots which displayed the median, mean, interquartile range and spread of the complete data set for each River Watch analyte. For each analyte, box plots were arranged on a chart in upstream to downstream order, allowing visualization of the distribution of each site's data, as well as how these distributions changed along the length of the Uncompahgre River.

Some specific results from Section 4 are as follows:

<u>pH and alkalinity results</u>

- Very acidic water with pH values ranging from 2.4 to 4.5 were found at lower Red Mtn Creek sites. The higher pH values have been observed below Idarado in spring months when higher flow with pH > 7 comes from upper Red Mtn Creek (Figure 4).
- A large spread in pH data (4.1 – 6.6 interquartile range) was noted at the Uncompahgre River site 4135 below Red Mtn Creek (Figure 3) due to very low alkalinity. Note that this acidic water is what runs through the Ouray Hydro Plant.
- Increasing alkalinity and greater buffering at River Watch sites below Ouray led to narrow spreads in pH distributions (Figure 3), with nearly all pH values greater than 7.

- Alkalinity at Red Mtn Creek sites 3580 and 3188, and the Uncompahgre site 4135 below the confluence (Figure 5) is practically nonexistent and provides no buffering capacity for acidic water from Red Mtn Creek.
- Alkalinity gradually increases below Canyon Creek (Figure 5) due mostly to changing geology; mainly the presence of limestone both in the streambed and subsurface sedimentary rock. There was a larger spread in alkalinity data below Ridgway (Figure 5) where seasonal changes in flow from Dallas Creek, which had higher alkalinity than the river, might account for this.

<u>Calcium, magnesium, and hardness results</u>

- The magnitude and spread in hardness values, and the upstream-to-downstream trend in hardness was mostly due to the concentrations of calcium (Figures 7 and 8).
- The large spread in hardness and calcium data is due to the inverse relationship between these analytes and streamflow. At the CR24 River Watch site, Figure 27 shows hardness varied from ~420 mg/liter ($CaCO_3$) at 40 cfs to ~125 mg/liter ($CaCO_3$) at 900 cfs.

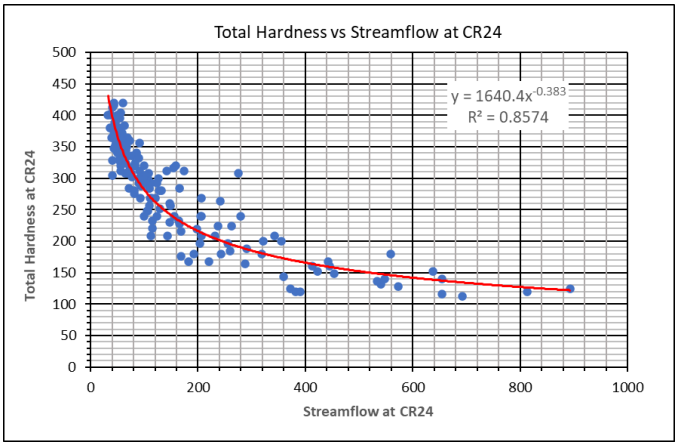

Figure 27. Scatter plot of total hardness vs streamflow at River Watch CR24 395 site. Power fit equation and R-squared value are shown.

- Magnesium concentrations (Figure 9) along the Uncompahgre were low with narrow distributions (less dependence on streamflow) from above Red Mtn Creek down to Potters Ranch above Ridgway. Below Potters Ranch the median Mg concentrations increased about three-fold between Potters Ranch and Ridgway Reservoir (Figure 9).
- Among the TMDL sites the distributions of hardness, calcium and magnesium were uniquely different at Gray Copper Gulch which had much larger medians, means and data spreads, compared to the other four sites (Figure 10).

<u>Dissolved metal results</u>

- Box plots of Cd-D, Cu-D, and Zn-D concentrations (Figures 13, 15, and 17) followed a similar upstream-to-downstream trend, from Uncompahgre site 3582 above Red Mtn Creek to site 393 below Ridgway Reservoir. On the Uncompahgre, box plot distributions of the three metals shifted sharply upward below the confluence with Red Mtn Creek, then dropped steadily downward as water from creeks like Canyon Creek entered the river with much lower concentrations of the metals. Although dilution likely caused most of the decrease in dissolved concentrations, chemical reactions with the positive metal ions, and sedimentation of the resulting particles, could also have contributed to the decrease along the length of the river.

- Of the 12 main River Watch sites (Figures 13, 15, and 17) analyzed, only the two Red Mtn Creek sites (3580 and 3188) and the first Uncompahgre site (4235) below the confluence had box plot distributions that indicated exceedance of the aquatic life TVS for Cd-D, Cu-D, and Zn-D.
- At the five TMDL sites (Figures 14, 16, and 18) Cd-D, Cu-D, and Zn-D were not detectable at the East Fork Dallas Creek site 667 below Blue Lake, while the Cd-D and Zn-D distributions exceeded aquatic life TVS at Commodore Gulch site 662 and Imogene Creek site 665. The Cu-D aquatic life TVS was also exceeded at Commodore Gulch. None of the three metals' TVS were exceeded at the Upper Red Mtn Creek site or at the mouth of Gray Copper Gulch (site 664).
- For the 12 main River Watch sites, Mn-D box plots (Figure 19) followed the trend displayed by other dissolved metals, with distributions decreasing steadily below Red Mtn Creek. The median Mn-D concentration at the Red Mtn Creek Idarado site 3580 was about 600 times larger than the Mn-D median below Ridgway Reservoir site 393. The Mn-D box plots at Canyon, Dallas and Cow Creeks fell below the Uncompahgre River plots, except at the site above Red Mtn Creek (3582) and the site below Ridgway Reservoir (393). Five sites from Red Mtn Creek to Potters Ranch had box plot distributions that showed exceedance of site-specific water supply use standards.
- Of the five TMDL sites, three sites (Upper Red Mtn Creek-667, Imogene Creek-665, and E Dallas Creek-569) had Mn-D box plots (Figure 20) that fell below those for the main river sites. The Mn-D distributions at Commodore Gulch site 662 and Gray Copper Gulch site 664 were in the range of the box plots on the lower sections of the Uncompahgre River. The Commodore Gulch Mn-D box plot indicated exceedance of the water supply use standard, and the Gray Copper Gulch box plot indicated exceedance of the agricultural use standard.
- Dissolved lead (Pb-D) was only routinely detected at concentrations above the MDL at Red Mtn Creek sites 3580 and 3188, and Uncompahgre site 4235 just below the confluence. Median concentrations and data spreads both decreased markedly upstream-to-downstream. The distributions all indicated exceedance of the aquatic life TVS for Pb-D.

<u>Total metal results</u>

- Only Fe-T and As-T concentrations were examined. Red Mtn Creek was the obvious source of iron with the median Fe-T concentration at Idarado site 3580 (Figure 23) being greater than 50,000 µg/liter. Moving downstream, from Idarado to USGS site 3586, box plot medians dropped by more than an order of magnitude. Below Ouray medians dropped gradually, but box plot ranges broadened markedly down to Ridgway Reservoir due to the large seasonal differences in flow and some increases in Fe-T below Ouray during very high flow periods. Sedimentation of Fe-T in Ridgway Reservoir accounts for the large drop (~25 times) in the box plot medians from above to below the reservoir. At TMDL sites (Figure 24), Gray Copper Gulch site 664 had the highest median Fe-T concentration and a very narrow data range, suggesting a lack of dependence on streamflow.
- As with most other analyzed metals, As-T was detected in significant concentrations at and just below Red Mtn Creek (Figure 25), where box plots distributions were much greater than

the water supply standard. Interestingly, As-T was also found at detectable concentrations above the water supply standard on the Uncompahgre at Ridgway site 402 and CR24 site 395, although this segment is not on the 303(d) list. However, Cow Creek and Dallas Creek where As-T is on the 2022 303(d) list for water supply had no samples with detectable As-T.

The 2022 WQCC 303(d) list of impaired Colorado stream segments in the Uncompahgre Basin was reviewed in Section 5. The 303(d) list was compiled based on assessment of water quality data collected from 1 January 2015 through 31 December 2019. The impairment status of numerous segments was retained from earlier listings due to the lack of sufficient new data to change the listing. Table 4 provided details of the 303(d) list for 19 Uncompahgre Basin stream segments, from the top of the basin down to the segment below Ridgway Reservoir. River Watch data was available for the 303(d) assessment in 10 of the 19 segments, and generally contributed 80-90% of all the available data for those 10 segments. However, due to the time needed to analyze and archive River Watch data, most River Watch sites had metals data available only through the first few months of 2019. Also, data from the TMDL sites added in 2021 contributed data to five different Uncompahgre Basin stream segments, but these data were not available for the 2022 303(d) assessment. An interactive map showing the impairment status of Colorado stream segments is available at the following CDPHE web site: https://cdphe.maps.arcgis.com/apps/Viewer/index.html?appid=f1541d2f21834642ba1551c674fd4a79 .

With more recent River Watch data available since 2019, Section 5 compared the 2022 303(d) list with evaluations of impairment based on River Watch data from 2019 through 2021. Tables 5-19 provided the details of these comparisons for 15 different stream segments. A summary of the segments is presented here. This includes listings that might have changed based on the more recent River Watch data.

Segment COGUUN02_C - Uncompahgre River segment from near the bottom of Poughkeepsie Gulch to a point just above the confluence with Red Mtn Creek: This segment was on the 303(d) list for Cd-D, Cu-D, and Zn-D (aquatic life use) with a TMDL in place, and on the M&E list for Pb-D. Listings were retained in 2022 despite Cu-D and Pb-D attaining TVS in the 2015-2019 data. Cu-D also attained TVS in the 2019-2021 River Watch data. Mn-D was delisted for water supply use in 2022 when a new site-specific standard was applied, and recent River Watch data also showed attainment. As-T was added to the 2022 M&E list for water supply. No recent River Watch data was compared since all values were > the As-T MDL.

Segment COGUUN03a_A - Uncompahgre River segment from a point above the confluence with Red Mtn Creek to a point above the confluence with Cascade Creek in Ouray: Impairment for aquatic life use was retained for Cd-D, Cu-D, and Zn-D, with 2019-2021 River Watch data in agreement. Pb-D was not assessed for the 2022 303(d) list, but 2019-2021 River Watch data indicated the aquatic life TVS was exceeded. Mn-T is not on the 303(d) list for agricultural use, but both data sets indicate that the standard was exceeded. As-T (water supply) and pH (aquatic life) were added to the 2022 303(d) list and 2019-2021 River Watch data also showed these standards were exceeded. Fe-T is on the 303(d) list for aquatic life, but 2019-2021 River Watch data indicated Fe-T was slightly below the standard.

Segment COGUUN03c_A - Uncompahgre River segment from a point above the confluence with Dexter Creek to a point below the confluence with Dallas Creek: *All previously listed metals; Cd-D and Cu-D (aquatic life), Mn-D (water supply), and Fe-T (aquatic life) were delisted in 2022.* The evaluation based on

more recent River Watch data also showed attainment of the various standards. As-T was not listed for water supply use due to insufficient data. River Watch data where As-T values were > MDL indicated the segment could be impaired for water supply.

Segment COGUUN03e_B - Uncompahgre River segment from below the outlet of Ridgway Reservoir to a point above Broman Canyon: *Cd-D, Cu-D and Fe-T all attained aquatic life standards and were delisted in 2022.* The 2019-2021 River Watch data also showed these metals attained aquatic life standards.

Segment COGUUN05_B - Commodore Gulch from its source to its confluence with Red Mtn Creek: This segment had no data from 2015-2019. Based on 2012-2013 data it was on the M&E list for Cd-D, Cu-D, and Pb-D, and the 303(d) list for Zn-D, all for aquatic life use. The newly acquired River Watch data from 2021 indicated all four metals exceeded aquatic life standards. Mn-D was not of the 303(d) list for water supply, but the 2021 River Watch data indicates that this standard was also exceeded.

Segment COGUUN05_C - Governor Basin stream from its source to its confluence with Sneffels Creek: This segment is on the 2022 303(d) list for exceeding aquatic life standards for Cd-D, Cu-D, Zn-D and Pb-D. It also exceeds the water supply use standard for Mn-D (chronic) and Pb-T (acute). There is no River Watch data for this segment.

Segment COGUUN05_E - a short stretch of Sneffels Creek extending from below Governor Basin down to a point about 1.5 miles above the start of Canyon Creek: No River Watch data exists for this segment. Prior to 2022 this segment was on the 303(d) list for exceeding aquatic life TVS for Cd-D, Zn-D, and Pb-D. It also exceeded the water supply use standard for Mn-D, and the agriculture use standard for Mn-T. These listings were retained in the 2022 303(d) list due to insufficient data from 2015-2019. The segment was taken off the 303(d) list for macroinvertebrates after 2014 MMI scores were revised upward.
Segment COGUUN09_B - segment of Sneffels Creek immediately below segment 05_E and extends from a point 1.5 miles above its confluence with Imogene Creek down to the confluence with Imogene Creek: Prior to 2022 this segment was on the 303(d) list for exceeding aquatic life TVS for Cd-D, Zn-D, and Pb-D. The listings were retained in 2022 due to lack of sufficient data from 2015-2019. The segment was delisted for macroinvertebrates after two new macroinvertebrate scores exceeded the attainment MMI index. No River Watch data exists for comparison, but this site would be a good addition to the River Watch network serviced by UWP.

Segment COGUUN09_D - Imogene Creek from its source to its confluence with Sneffels Creek (at the start of Canyon Creek): Prior to 2022 this segment was on the 303(d) list for exceeding aquatic life TVS for Cd-D and Zn-D, and on the M&E list for Cu-D (aquatic life). These listings were retained in 2022 due to insufficient data from 2015-2019. Six River Watch samples from 2021 indicated that aquatic life TVS for Cd-D, Cu-D, and Zn-D were all exceeded.

Segment COGUUN09_C - Canyon Creek from its start at the confluence of Sneffels and Canyon Creeks to its confluence with the Uncompahgre River near Ouray: Based on data from 2015-2019 this segment was delisted for Zn-D in aquatic life use, while pH was added to the aquatic life 2022 M&E list. Twenty-six River Watch samples from 2019-2021 indicated Zn-D attained the aquatic life TVS, but pH was in non-attainment of the minimum pH aquatic life standard.

Segment COGUUN06a_A - upper portion of Red Mtn Creek from its source near Red Mtn Pass to a point above the confluence with the East Fork of Red Mtn Creek: A lack of new data since 2012 has kept this segment on the 2022 303(d) list for Cu-D, Zn-D, and Ag-D in aquatic life use. Six samples from the new River Watch site showed non-attainment of the aquatic life TVS for Cu-D, but attainment of the TVS for Zn-D. River Watch data does not include analysis of Ag-D.

Segment COGUUN07_A - Gray Copper Gulch from its source to the confluence with Red Mountain Creek just below the Idarado mining area: This segment is on the 2022 303(d) list for exceeding the aquatic life TVS for Cu-D, Zn-D, and Pb-D; and for pH being in non-attainment of the minimum pH standard for aquatic life. Data from 2015-2019 included samples taken along the length of the gulch. Six River Watch samples collected in 2021 from near the mouth of the gulch showed that Cu-D, Zn-D, and Pb-D attained the aquatic life TVS, and also that the pH minimum standard was attained. The agriculture use standard for Mn-T was not on the 2022 303(d) list, but River Watch data indicated that the standard was exceeded.

Segment COGUUN10a_C - an approximately seven-mile section of Cow Creek from the confluence with Nate Creek down to the confluence with the Uncompahgre River: Cow Creek was retained on the 303(d) list in 2022 for continued exceedance of the water supply standard for As-T. The River Watch MDL for As-T was not reached in 2019-2021 data, so a comparison was not possible.

Segment COGUUN11_G - Dallas Creek from its source to the confluence with the Uncompahgre River just above Ridgway Reservoir: Dallas Creek was retained on the 2022 303(d) list for exceeding the water supply standard for total arsenic. It is also on the M&E list for not attaining the aquatic life standard for temperature. River Watch data from 2019-2021 indicated that the aquatic life standard for temperature was attained using discrete samples. No River Watch samples had As-T concentrations greater than the MDL.

References and Data Sources

CDPHE, WQCC, 2021: Regulation No. 31-The Basic Standards and Methodologies for Surface Water, 261 pp.

CDPHE, WQCC, 2022: Regulation No. 35-Classifications and Numeric Standards for Gunnison and Lower Dolores River Basins, 238pp.

CDPHE, WQCC, 2022: Regulation #93-Colorado's Section 303(d) List of Impaired Waters and Monitoring and Evaluation List, 277pp.

Huggins, A., 2020: Water Quality Assessment from Data Collected at River Watch Sites in the Uncompahgre Basin, 29pp.

River Watch data https://coloradoriverwatch.org/

UWP, Alpine Environmental Consultants, 2018: Upper Uncompahgre Watershed Water Quality Report: 2016 and 2017, 89pp.

UWP, 2018: Uncompahgre Watershed Plan 2018, 152pp, http://www.uncompahgrewatershed.org/

Water quality data https://www.waterqualitydata.us/portal/

Woodling, John, 2012: Uncompahgre River Water Quality Report 2012, 159pp, http://www.uncompahgrewatershed.org/

APPENDIX A: Review of Water Quality Measurements from Gray Copper Gulch

The map in Figure 1 shows the location of Gray Copper Gulch in the San Juan Mountains of southwest Colorado. The stream running through the gulch generally flows year-round and enters Red Mountain Creek just below the Idarado mining area. Water quality data have been collected in the past by the Water Quality Control Division (WQCD) and the Uncompahgre Watershed Partnership (UWP) at sites GC-01a, GC-01, Vrn-adt-1, GC-02, GC-03, GC-Abv SM, GC-Blw SM and GC-05, and currently by Colorado Parks and Wildlife's River Watch program at site RW 664 (same as GC-05). Sites GC-01 and GC-02 were located above and below the Vernon Mine, shown by the yellow shaded area in Figure 1. Site Vrn-

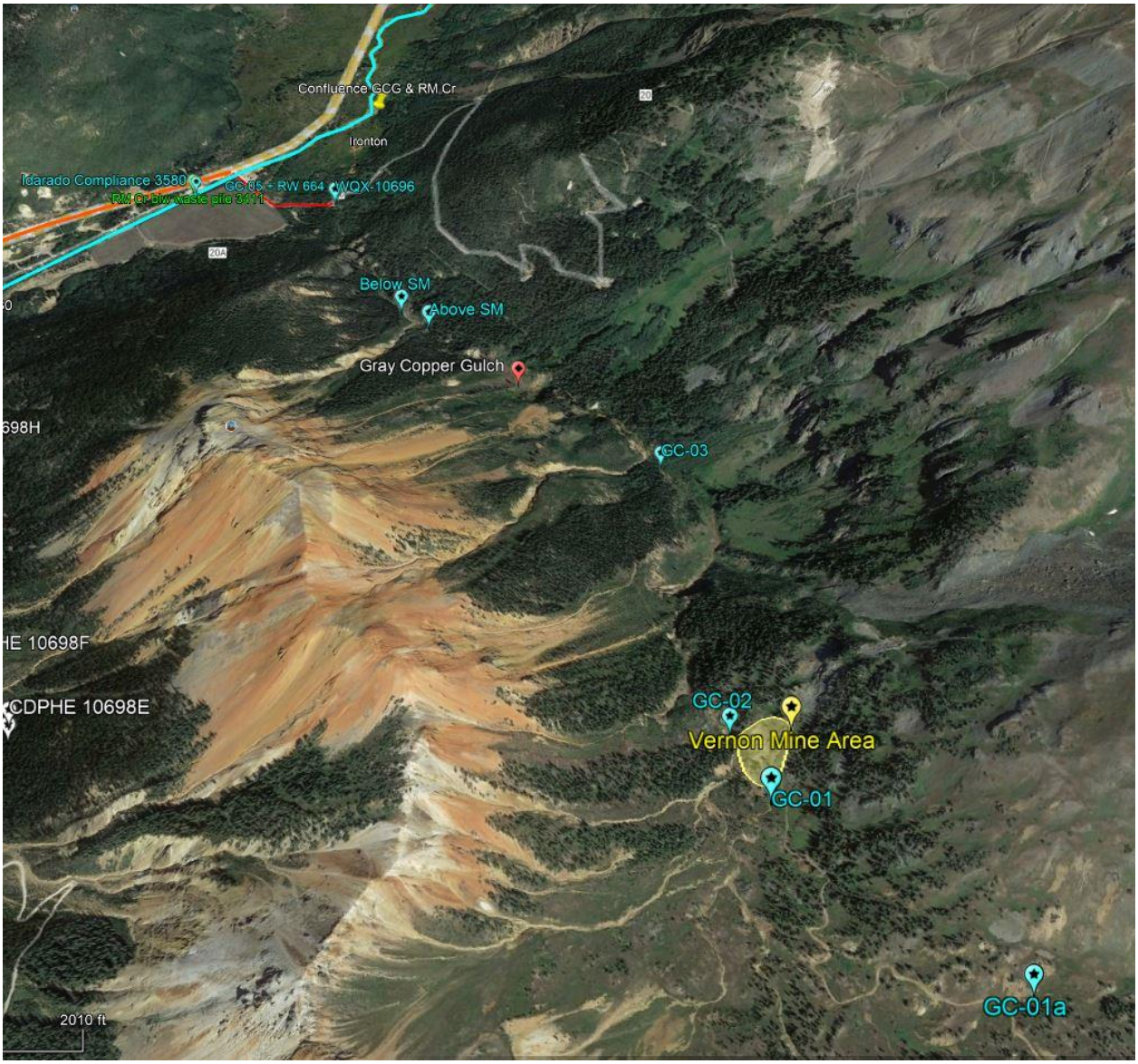

Figure 4. Google Map image showing Gray Copper Gulch and water quality sampling sites noted in the text and Table 1. Red Mountain No. 1 is the orange-colored mountain on the southwest side of the Gulch. The confluence of Gray Copper Gulch with Red Mountain Creek (blue line) is shown by the yellow pin at the upper left of the image.

adt-1 was at the Vernon Mine adit (not shown in Figure 1), and presumably water from the adit entered Gray Copper Gulch between GC-01 and GC-02. Sites GC-Abv SM and GC-Blw SM were located above and below where the Silver Mtn Mine adit drains into the gulch. Acid drainage from mines, runoff from Red Mtn No. 1, drainage from mine waste, and groundwater bring a variety of metals into Gray Copper Gulch.

Table 1 shows the dates when water quality data have been collected in Gray Copper Gulch, and the sites that were sampled on each date. Some of the data have been analyzed and discussed in earlier reports, most recently in the UWP 2016-2017 Water Quality Report (UWP, Alpine Environmental Consultants, 2018). Two of the main findings from 2016 and 2017 were that the Silver Mtn Mine and Vernon Mine adits were not having significant impacts on metal loading in Gray Copper Gulch. A more detailed review of the water quality parameters is provided below.

Table 1. WQ sampling periods and sites for Gray Copper Gulch.

Date	Flow	Water Quality Sites	Comments
May 2012	High	GC-01, GC-02, GC-03, GC-05	Collected by WQCD
Sept 2012	Low	GC-01, GC-02, GC-03, GC-05	Collected by WQCD
Jun 2013	High	GC-01a, GC-01, GC-02, GC-05	Collected by WQCD
July 2016	High	GC-Abv SM, GC-Blw SM	Collected by WQCD, UWP
July 2017	High	GC-01, Vrn-adt-1, GC-02, GC-05	Collected by WQCD, UWP
Sep 2017	Low	GC-01, Vrn-adt-1, GC-02, GC-05	Collected by WQCD, UWP
Jun, July 2021	High	RW-665	Collected by River Watch
Aug, Sep, Oct, Nov 2021	Low	RW-665	Collected by River Watch

Gray Copper Gulch is classified for the following uses: Aquatic Life Cold 2, Water Supply, Recreation P, and Agriculture. Based on the water quality data from 2012 and 2013, Gray Copper Gulch was placed on the Water Quality Control Commission 303(d) List for pH, dissolved zinc, dissolved lead, and dissolved copper, all for exceeding aquatic life standards. For the 2022 303(d) List only one water quality value (the median of two samples) for each parameter was available in the 2015-2019 assessment period. The single value was insufficient to change the impairment status based on the earlier data. [*Recently it was found that the data from 2017 was not used to assess impairment for 2022. Whether the 2017 data would have affected the listing is uncertain.*] River Watch data from 2021 and 2022 will contribute a significant number of samples (at least 11) to the next assessment period.

Figures 2 – 8 are a series of bar graphs showing data for pH, Cu-D, Pb-D, and Zn-D that appear in the 303(d) List, plus Fe-T, Mn-D, and As-T, which the data suggest might exceed standards for aquatic life and water supply. The graphs show data for the dates shown in Table 1. A "D" refers to a dissolved metal concentration, and "T" refers to a total metal concentration. Data for other parameters are available, but these are the ones most frequently found to pollute streams in the Uncompahgre Watershed. Figure 2 shows pH values for all samples. Six of the ten pH values that did not meet the minimum pH standard of 6.5 for aquatic life came from the two sites above (GC-01) and below (GC-02) the Vernon Mine. Of the nine pH measurements taken at the lowest site (GC-05 or RW 664), only one did not meet the minimum pH standard. Measurable alkalinity was only observed at sites at and below GC-03, possibly accounting for the increase in pH at the mouth of the gulch.

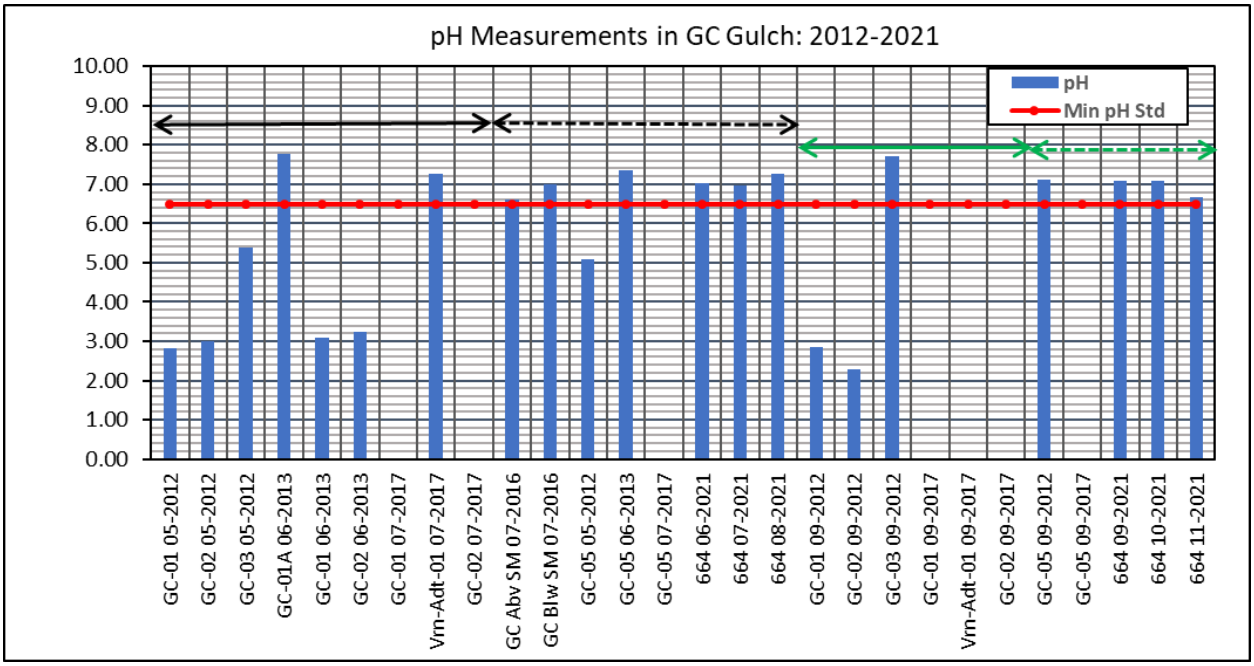

Figure 2. pH values (blue bars) from water quality samples collected in Gray Copper Gulch. The aquatic life minimum pH standard is shown by the red line. X-axis labels show site numbers and dates (mm-yyyy) for the samples. The Vrn-Adt-01 measurements were made directly from the Vernon Mine Adit, not from the gulch itself. Black arrows enclose periods of higher flow, solid line for the higher elevation sites and dashed line for the lower sites. See map in Figure 1. Green arrows enclose periods of lower flow, solid line for the higher elevation sites and dashed line for the lower sites; lowest being GC-05/RW-664 near the mouth of the gulch.

Figure 3 shows dissolved copper (Cu-D) concentrations and Table 2 provides a comparison of water quality parameter medians. During both high-flow and low-flow periods, Cu-D concentrations at the higher sites generally exceeded those at the lower sites. Also, from Table 2 Cu-D median concentrations at all sites were much higher during high-flow than low-flow. This suggests the higher concentrations are related to the snowmelt and runoff period. The high flow to low flow difference was not as obvious at the higher sites where GC-02 below the Vernon Mine had the highest concentrations of all the samples (>300 µg/liter) in Septembers of 2012 and 2017. GC-02 also had the highest Cu-D concentration for each of the dates sampled. Further, for every pair of GC-01 and GC-02 samples, the Cu-D concentration below the Vernon Mine was always greater than the concentration above the mine. Data from 2017, which included samples from the Vernon Mine adit, showed that metal loads from the adit were insufficient to account for the increase in concentration, or load, from GC-01 to GC-02. From all Cu-D data, the 85th percentile of Cu-D concentrations was 140 µg/liter, well above the chronic standard of 14.1 µg/liter based on mean hardness. This agrees with the 2022 303(d) listing of impairment for aquatic life, which was only based on 2012-13 data. However, 2021 data from the lowest site shows only one of six samples exceeded the chronic TVS for Cd-D. This could affect the assessment in the next 303(d) listing. (Note that the much higher TVS at the lower sites were due to higher hardness values; in Table 2, medians of 74 mg/liter $CaCO_3$ at the higher sites, and 380 mg/liter $CaCO_3$ at the lower sites.)

Table 2. Median values of water quality parameters in Gray Copper Gulch from data shown in Figures 2-8. Metal concentrations are in µg/liter and hardness is in mg/liter of $CaCO_3$. The largest median hardness and metal concentration in each flow regime are shaded light blue. The smallest median pH is shaded light blue.

		pH	Hardness	As-T	Cd-D	Cu-D	Fe-T	Pb-D	Mn-D	Zn-D
High Flow Medians	High Sites	3.24	10.0	0.96	0.11	52.50	3500.0	2.5	31.0	20.0
	Low Sites	6.98	210.0	0.54	0.11	11.55	2700.0	0.3	267.3	40.0
	All Sites	6.60	75.0	0.80	0.11	37.50	3010.0	2.1	62.0	25.0
Low Flow Medians	High Sites	2.85	17.0	1.81	0.08	50.00	1430.0	13.0	118.0	46.0
	Low Sites	7.09	415.0	0.00	0.00	2.00	2857.5	0.0	570.6	49.8
	All Sites	7.09	356.0	0.19	0.08	3.00	2696.0	0.1	322.9	49.8

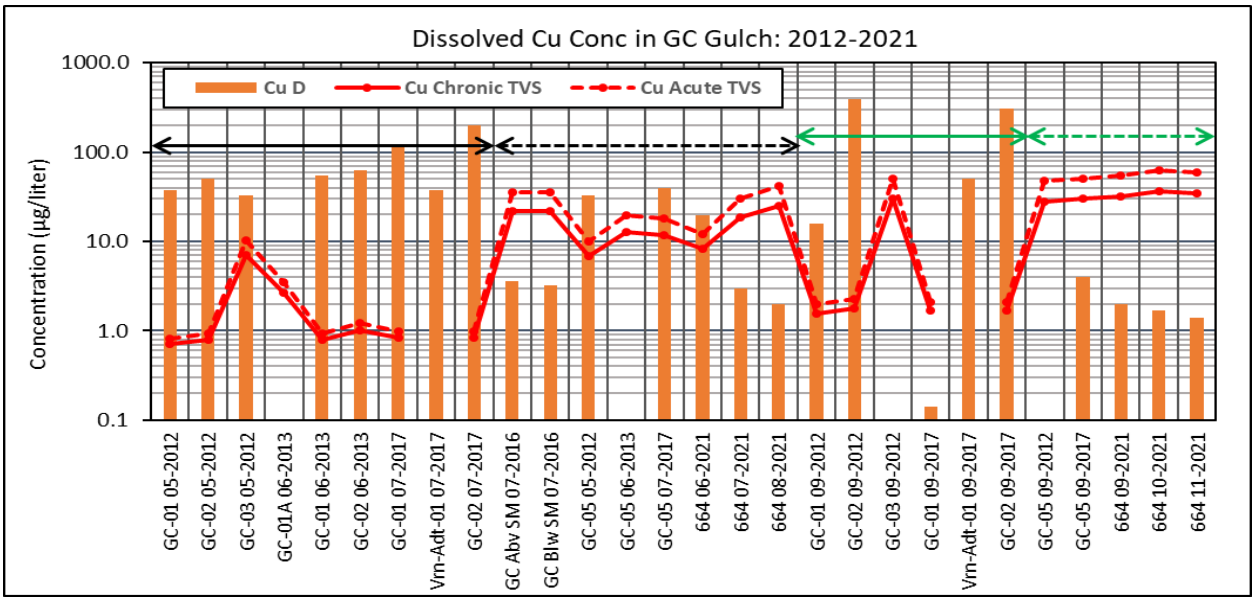

Figure 3. As in Figure 2 except showing Cu-D concentrations (tan bars) and the hardness-based chronic and acute Table Value Standards (TVS) for aquatic life (red solid and dashed lines).

Dissolved lead (Pb-D) concentrations are shown in Figure 4. Concentrations that exceeded the aquatic life chronic TVS came mainly from the sites above and below Vernon Mine (GC-01 and GC-02). Table 1 shows the low-flow median as 13.0 µg/liter and the high-flow median as 2.5 µg/liter. Note that the two concentrations from the Vernon mine adit (Vrn-adit-01 in Figure 4) were much lower than concentrations above and below the adit, and well below the aquatic life TVS. The Pb-D data from 2017, not used in the 2022 303(d) assessment, indicated that four of eight samples exceeded the Pb-D TVS. Using all Pb-D data in Figure 4, the 85th percentile of Pb-D concentrations was 11.1 µg/liter, well above the chronic TVS of 4.5 µg/liter based on mean hardness. This agrees with the 2022 303(d) listing of impairment for aquatic life, which was only based on 2012-13 data. However, as with Cu-D, the 2021 Pb-D data from the lowest site (RW-664) indicates the chronic TVS for Pb-D was not exceeded near the mouth of the gulch.

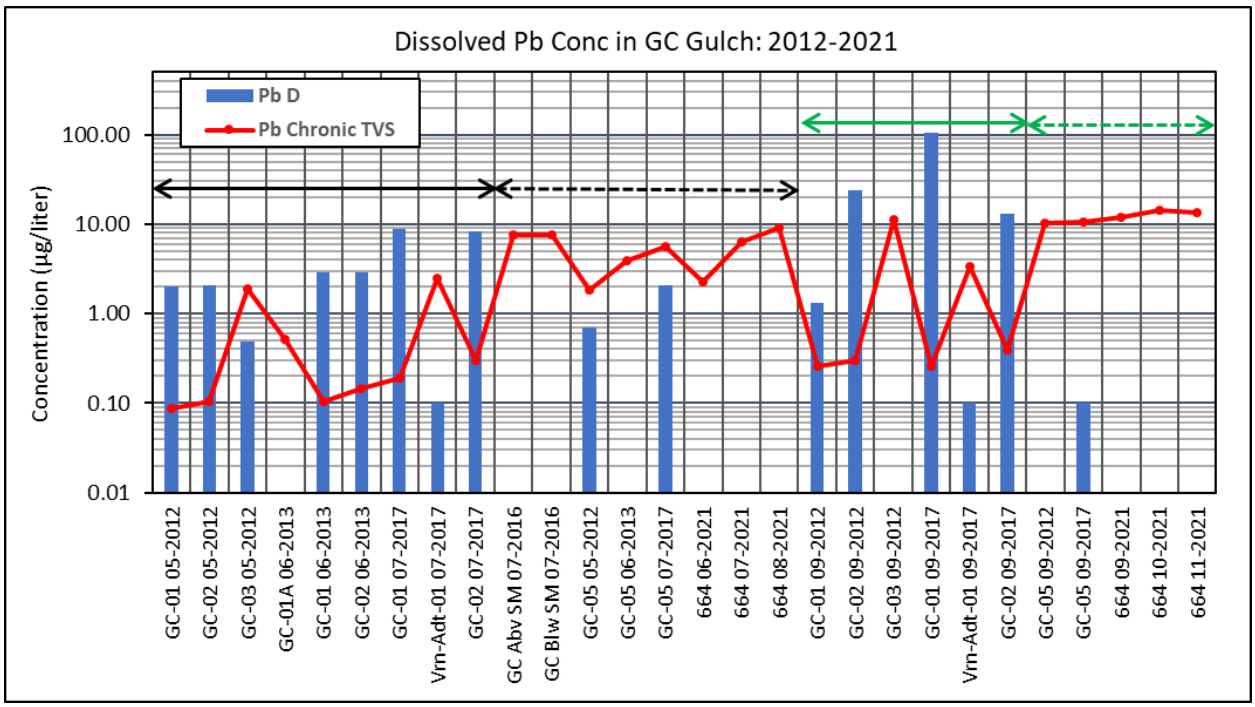

Figure 4. As in Figure 3 except showing Pb-D concentrations (blue bars) and the hardness-based chronic table value standards (TVS) for aquatic life (red line). All 2021 site 664 concentrations are blank due to being below the MDL of 2.4 µg/liter.

Dissolved zinc (Zn-D) concentrations are shown in Figure 5. Unlike Cu-D, the Zn-D concentrations tended to be higher at the lower elevation sites particularly at high flow where the median concentrations from Table 1 were 20 µg/liter at the high sites and 40 µg/liter at the low sites. However, due to the lower hardness values at the higher sites, Figure 5 shows the chronic TVS for Zn-D was more frequently exceeded at the higher sites. Nine of 15 (60%) higher site Zn-D concentrations exceeded the chronic TVS at both high flow and low flow. This contrasts with the lower sites where none of the 13 Zn-D concentrations exceeded the chronic TVS at high flow and low flow. Although Zn-D appears in the 2022 303-D List, when all the data in Figure 5 are considered the 85th percentile concentration is 69.4 µg/liter compared to the hardness-based chronic TVS of 119.4 µg/liter. This would indicate attainment of the Zn-D standard.

Total iron (Fe-T) concentrations are shown in Figure 6. Comparing the higher sites at high flow and low flow, Figure 6 indicates that Fe-T concentrations at high flow are generally greater than low flow concentrations. Also, the high flow median in Table 2 is 3,500 µg/liter, compared to the low-flow median of 1,400 µg/liter. GC-01 and GC-02 had the highest Fe-T concentrations, both at high flow and low flow, contributing 8 of the 15 higher-site measurements that exceeded the site-specific aquatic life standard of 2,338 µg/liter.

At low-flow, Figure 6 shows that lower site Fe-T concentrations were generally larger than the higher site concentrations, with Table 2 indicating that the lower site median concentration of 2,857 µg/liter was twice as great as the higher site median of 1,430 µg/liter. In addition, all lower site concentrations at low flow exceeded the Fe-T aquatic life standard. Using all the Fe-T data from Figure 6, about 61% of the concentrations exceeded the aquatic life standard, as did the 50th percentile concentration of

2,857 µg/liter. These indicators would qualify Gray Copper Gulch as impaired for Fe-T, even though it is not on the 2022 303(d) List for Fe-T.

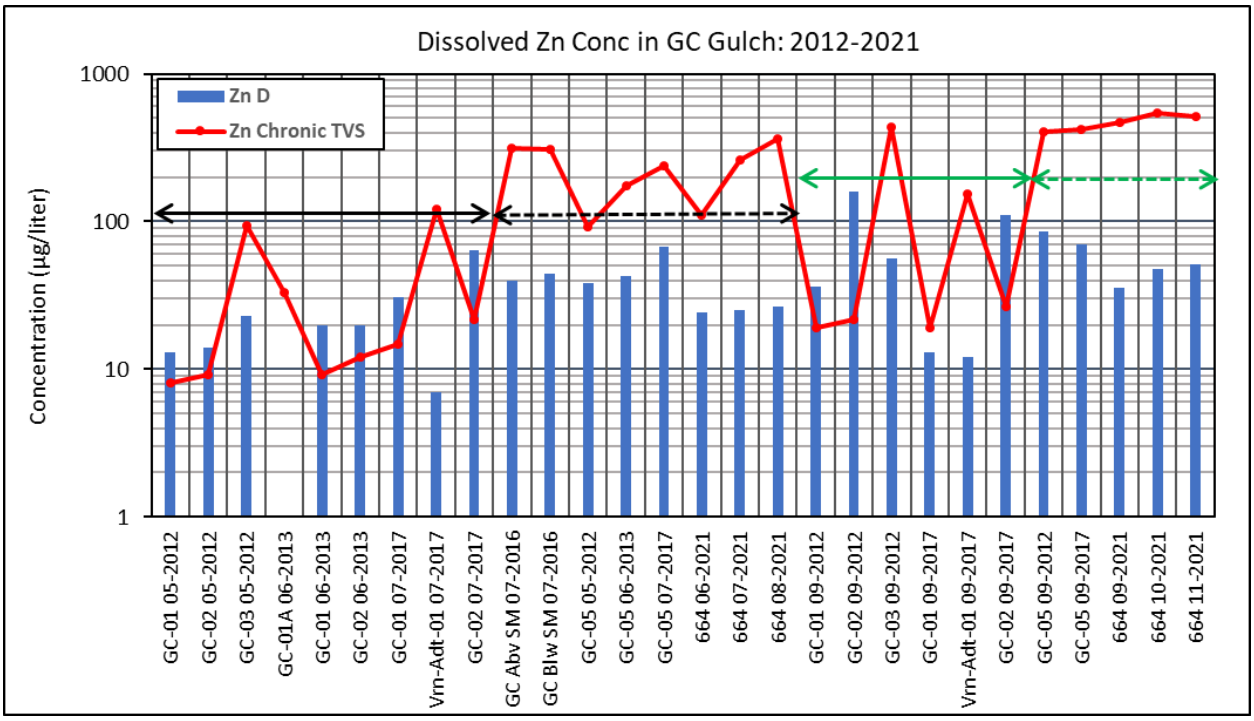

Figure 5. As in Figure 4, except showing dissolved zinc (Zn-D) concentrations (blue bars) and hardness-based chronic Table Value Standards (TVS) for aquatic life (red line).

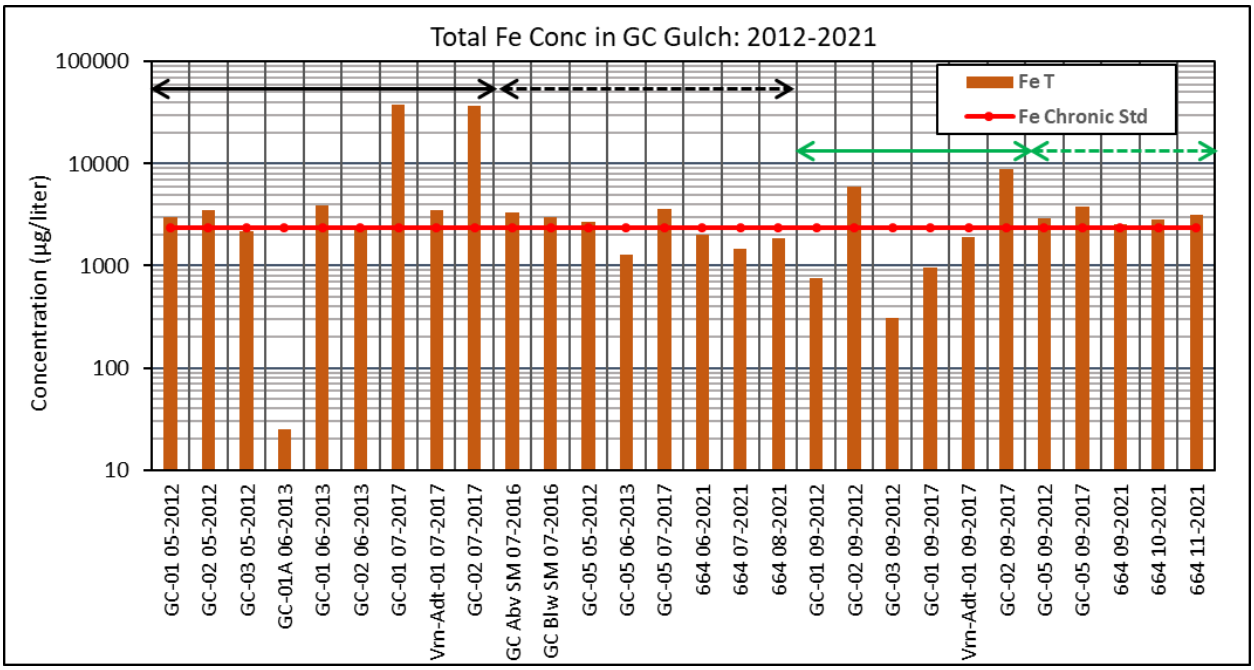

Figure 6. As in Figure 5, except showing total iron (Fe-T) concentrations (brown bars) and the site specific chronic aquatic life standard of 2338 µg/liter for Fe-T (red line).

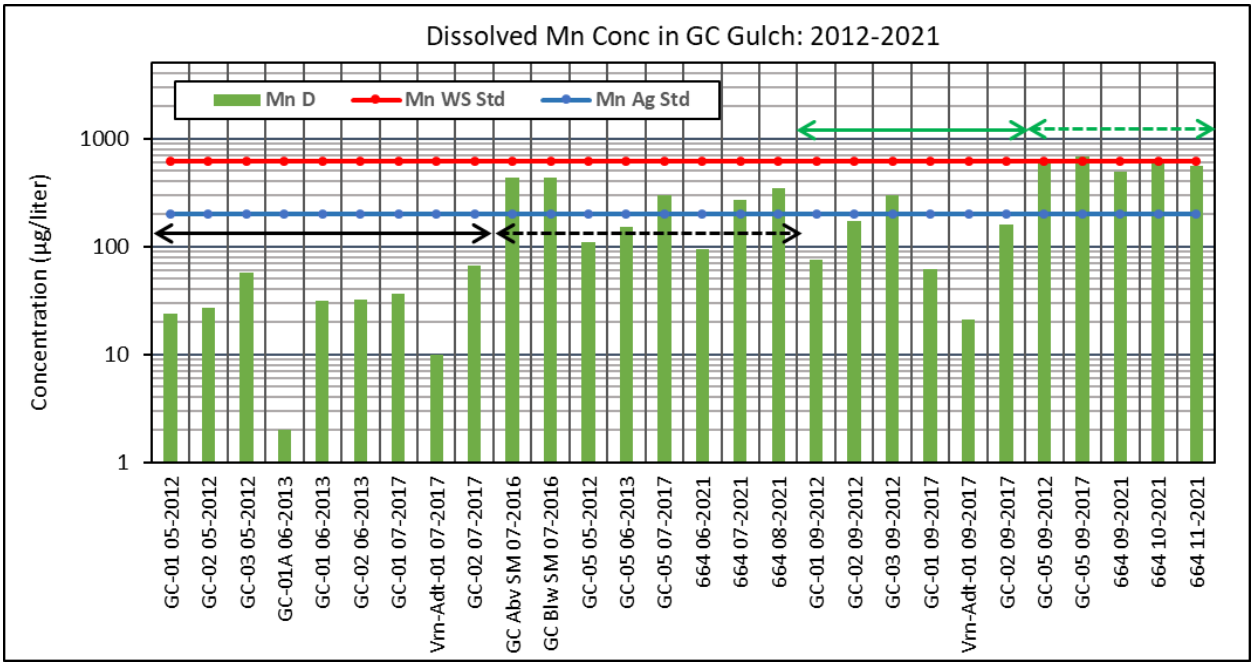

Figure 7. As in Figure 6, except showing dissolved manganese (Mn-D) concentrations (green bars), the Water Supply standard for Mn-D (red line), and the Agriculture standard for Mn-T (blue line). Note that Mn-D concentrations are shown, but Mn-T values were nearly the same and would not change the comparison with the Agriculture standard.

Figure 7, showing dissolved manganese (Mn-D) concentrations, clearly shows that Mn-D had higher concentrations at the lower sites during both high flow and low flow. From Table 2, at high flow the median Mn-D concentration for higher sites was 31.0 µg/liter, compared to the lower site median of 267.3 µg/liter. At low flow the median Mn-D concentration for higher sites was 118.0, compared to the lower site median of 570.6 µg/liter. Two water quality standards for manganese are shown in Figure 7, one a secondary standard for Water Supply (620.5 µg/liter), and the other a standard for Agriculture Use (200 µg/liter of Mn-T). Only one lower site sample at low flow exceeded the Water Supply standard, but 11 samples at low flow exceeded the Agriculture Use standard. (Note that Mn-T concentrations are similar to but slightly higher than Mn-D concentrations in Figure 7.) The 50th percentile Mn-T concentration for all sites was 135.8 µg/liter, which would indicate attainment of the Agriculture Use standard. However, if only lower sites are considered the 50th percentiles at high and low flow (Table 2) are higher than the Agriculture Use standard. Manganese is not on the 2022 303(d) List but is likely to be considered in the next assessment when data from lower sites in 2021 and 2022 will be available.

Several tributaries of the Uncompahgre River are on the 2022 303(d) List for exceeding the Water Supply standard for total arsenic (As-T). Figure 8 shows As-T concentrations in Gray Copper Gulch. Data are missing from site 664 because the River Watch Method Detection Limit (MDL) for As-T in 2021 was 5.8 µg/liter, much higher than the As-T concentrations encountered in 2021. The MDL for most other samples collected by WQCD or UWP varied from 0.3 – 1.0 µg/liter. Due to the concentrations less than MDL from lower sites, a comparison of concentrations between high and low sites will not be attempted. Arsenic impairment for this stream segment is based on concentrations exceeding the upper

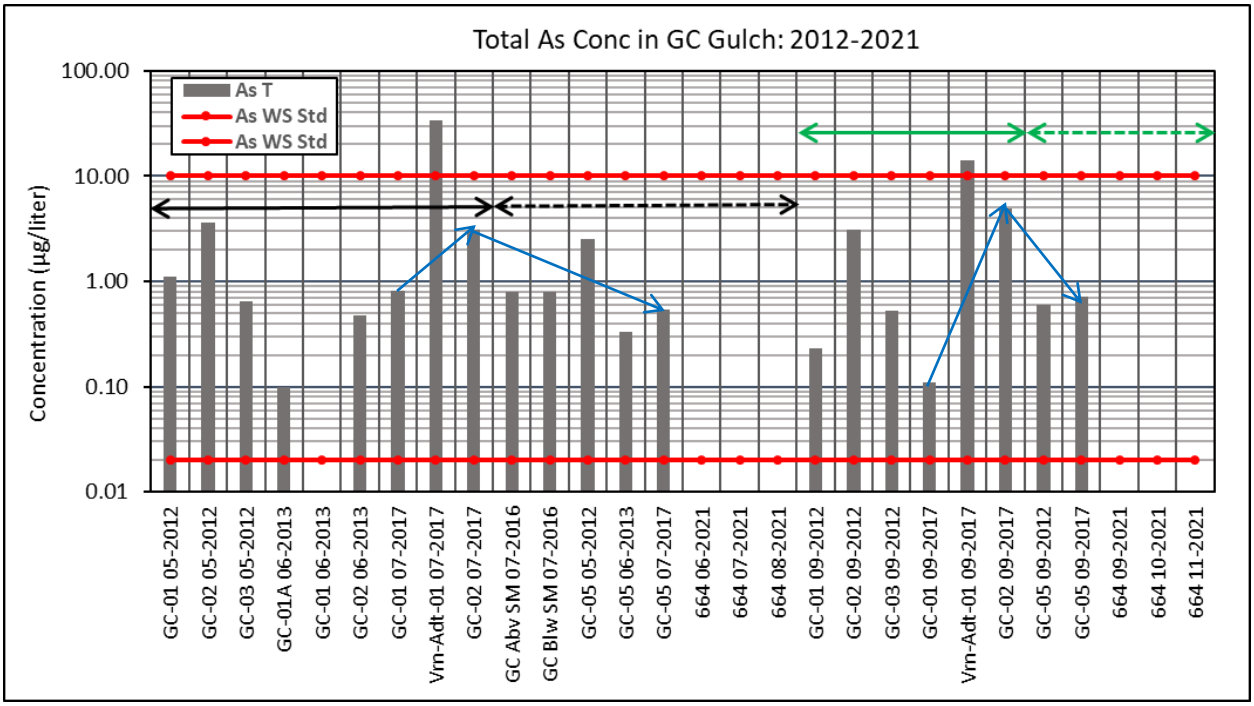

Figure 8. As in Figure 6, except showing total arsenic (As-T) concentrations (gray bars) and the Water Supply standard for As-T (red lines). In the WQCD 303(d) Listing Methodology for 2022 the As-T Water Supply standard is given as a concentration range from 0.02 to 10 µg/liter.

value of the Water Supply standard range (10 µg/liter). Figure 8 shows that only two As-T concentrations exceeded 10 µg/liter, and both came from the Vernon Mine adit, in July and September of 2017. The blue arrows in Figure 8 show the upstream to downstream changes in As-T in July and September 2017. Looking at all As-T data from GC-01 and GC-02, the As-T concentration at GC-02 was always significantly greater than the As-T concentration at GC-01. However, as with other metals, the As-T loads from the adit were shown to be insufficient to cause the increase in As-T concentrations. The arsenic causing the increase in concentration between GC-01 and GC-02 must therefore be coming from other sources.

APPENDIX B: Aquatic Toxicity

Metal toxicity

The toxicity of a given metal concentration changes based on water quality components including hardness and the species involved. Some of the toxicity data generated in laboratory studies throughout the world helps explain toxicity of metals in the metal regime of the Uncompahgre River. From Garia et al (2021), *"Heavy metals mainly enter the fish body through gills, body surface and digestive tract during ingestion of metal accumulated food materials. Cadmium, chromium, nickel, arsenic, copper, mercury, lead and zinc are the most common heavy metal pollutants that cause severe toxicity in fish. Development of* oxidative stress *is the fundamental molecular mechanism of metal toxicity. The stress weakens the immune system, causes tissue and organ damage, growth defect and reduces reproductive ability."*

Undissolved iron particles have both direct and indirect toxic effects on aquatic life. The direct effect is due to particles adhering to the gills of fish and impairing breathing, while the indirect effect is due to fine iron particles covering streambeds and making them unsuitable for spawning and limiting the development of healthy macroinvertebrate populations.

The toxicity of a specific metal differs for various life stages of aquatic organisms. In general fish species tend to be most sensitive to metal toxicity as newly hatched larvae and fry. Fish are insensitive to metal pollution in the egg stage and comparatively less sensitive at older life stages.

Hardness and Alkalinity

Cadmium, copper, lead and zinc toxicity to aquatic life is mitigated by hardness: the higher the hardness, the less toxic a given concentration of a metal. This mitigation occurs in part because calcium and magnesium (the principal components of hardness) compete with metals such as copper for uptake across gill membranes in fish. Additionally, most metals form carbonate/bicarbonate complexes that reduce metal toxicity as alkalinity increases. Alkalinity usually increases as hardness increases.

Acidity, pH

The pH of a stream affects what can live in it. All animals and plants are adapted to a certain pH range, but most prefer 6.5-8.0. An increase or decrease in pH outside the normal range of a water body will cause problems and possibly death of the aquatic organism (depending on its sensitivity). The following table shows how pH can affect the various life stages of brown trout.

River Parameter pH Values for Brown Trout Life Cycle.

	Egg	Fry	Juvenile	Adult
Tolerant pH	5.0-9.5	5.0-9.5	5.0-9.5	5.0-9.5
Optimal pH	6.8-7.8	6.8-7.8	6.8-7.8	6.8-7.8

References

River Watch, 2021: Colorado River Watch Water Quality Sampling Manual, Version 7.21, 347pp, https://coloradoriverwatch.org/.

Garia, P. et al, 2021: Effect of Heavy Metals on Fishes: Toxicity and Bioaccumulation, J. Clinical Toxicology, 10 pp.