Total Maximum Daily Loads for Metals in the Agua Fria River, Big Bug Creek, and Lynx Creek in the Upper Agua Fria Watershed

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Abbreviated Terms

A.A.C.	Arizona Administrative Code
ADEQ	Arizona Department of Environmental Quality
Ag	Silver
AGI	Agricultural Irrigation
AGL	Agricultural Livestock
Al	Aluminum
AML	Abandoned Mine Land
As	Arsenic
Au	Gold
AWC	Aquatic and Wildlife, cold water
AWE	Aquatic and Wildlife, ephemeral
AWW	Aquatic and Wildlife, warm water
AZPDES	Arizona Pollutant Discharge Elimination System
Ba	Barium
BMP	Best Management Practice
Cd	Cadmium
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
Cu	Copper
CWA	Clean Water Act

DMR	Discharge Monitoring Report
DU	Designated Use
DWS	Domestic Water Source
EPA	Environmental Protection Agency
FBC	Full Body Contact
FC	Fish Consumption
FDC	Flow Duration Curve
Fe	Iron
GIS	Geographic Information System
Hg	Mercury
HSPF	Hydrological Simulation Program - Fortran
HUC	Hydrologic Unit Code
IR	Integrated Report
LA	Load Allocation
LBB	Lower Big Bug Creek
LDC	Load Duration Curve
MGD	Million Gallons per Day
Mn	Manganese
MOS	Margin of Safety
MRDS	Mineral Resource Data System
MS4	Municipal Separate Stormwater Sewer Systems
MSGP	Multi-Sector General Permit
Ni	Nickel
NB	Natural Background
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPS	Nonpoint source
NRCS	Natural Resources Conservation Service
NSQD	National Stormwater Quality Database
Pb	Lead
PBC	Partial Body Contact
RPI	Restoration Potential Index
RPS	Recovery Potential Screening
Se	Selenium
Si	Silicon
SSURGO	Soil Survey Geographic Database
SWAT	Soil and Water Assessment Tool
Ti	Titanium
TMDL	Total Maximum Daily Load
UB1	Unnamed tributary to Big Bug Creek
USDA	United States Department of Agriculture

USFS	United States Forest Service
USGS	United States Geological Survey
VMT	Vulnerability Mapping Tool
WASP	Water Quality Simulation Program
WBID	Waterbody Identification Number
WLA	Wasteload Allocation
WQC	Water Quality Criteria
WQS	Water Quality Standard
WWTP	Wastewater Treatment Plants
Zn	Zinc

Section 1. Introduction

Every two years, the Clean Water Act (CWA) § 305(b) and § 303(d) requires the Arizona Department of Environmental Quality (ADEQ) to assess the health of Arizona surface waters against established standards. Following U.S. Environmental Protection Agency (EPA) guidance, ADEQ combines these requirements into an Integrated Report (IR). The CWA also requires states to establish a priority ranking for impaired waters and to develop and implement a Total Maximum Daily Load (TMDL) for each §303(d)-listed impairment. Regulations at Title 40 Code of Federal Regulations (40 CFR) 130.7(c)(1) further require that "[e]ach State shall establish TMDLs for the water quality limited segments identified" in its IR.

A TMDL is the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards (WQS). It is defined as the sum of the individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources (NPSs), plus natural background (NB) levels (40 CFR §130.2). The purpose of a TMDL is to identify the pollutant load reductions needed to return a waterbody to attainment with WQS, thereby supporting the designated uses (DUs) of the waterbody. Practically speaking, a TMDL typically consists of identifying the pollutant of concern, estimating the waterbody's assimilative capacity, estimating the existing pollutant loads from sources in the watershed, determining the allowable loading from the sources and the reductions needed to meet WQS, and allocating the pollutant load among the sources.

Multiple waterbodies in the Upper Agua Fria Watershed were listed in the 2016 IR and 2022 IR or will be listed in the 2026 IR as Category 5 (impaired and requiring a TMDL) under the classifications defined in CWA § 305(b) due to exceedances of multiple metal standards. This report documents the analysis for the required TMDLs for each of these waterbodies and impaired parameters (ADEQ 2022a). Specifically, 10 waterbodies in three subwatersheds of the Upper Agua Fria Watershed—Upper Agua Fria River, Big Bug Creek, Lynx Creek—are impaired for six metals (i.e., arsenic [As], cadmium [Cd], copper [Cu], lead [Pb], selenium [Se], and zinc [Zn]), for a total of 19 parameter impairments.

This TMDL report is organized with the following sections, addressing all required components of a TMDL:

- **Problem Statement** describes the impairment(s) to be addressed by these TMDLs (Section 2);
- **Setting** presents the physical conditions in and around the Upper Agua Fria Watershed that influences pollutant loading conditions (Section 3);
- **WQS and Numeric Endpoint Targets** identifies the applicable DUs and standards that are used for data assessment and TMDL calculations (Section 4);
- **Data Evaluation** presents a review of available water quality data, including a comparison to applicable standards (Section 5);
- **Source Assessment** identifies potential sources of the pollutants of concern (Section 6);
- **Technical Approach** presents the range of possible approaches and the selected approach for TMDL development (Section 7);

- **Linkage Analysis** describes the methodology and analyses conducted to calculate the relationship between pollutant sources and receiving water conditions (Section 8);
- **TMDL Development** presents the loading capacity and allocations, the identified margin of safety (MOS), and seasonality and critical conditions (Section 9);
- **Implementation Planning** describes the regulatory and non-regulatory mechanisms by which the relevant stakeholders may achieve compliance with the TMDL allocations (Section 10); and
- **Public Participation** describes the activities undertaken to ensure adequate participation in the TMDL development process by members of the public and any significant comments on the TMDL from members of the public (Section 11).

Section 2. Problem Statement

Several segments of the Upper Agua Fria River, Big Bug Creek, and Lynx Creek within the Upper Agua Fria Watershed are listed as impaired due to the following parameters: Cd, Zn, As, Cu, Pb, and Se (ADEQ 2022a). These individual segments are known as waterbodies, and each are assigned a unique identifier. The majority of the waterbodies were first listed as impaired in 2022; however, two waterbodies in Big Bug Creek were listed in 2016 and one waterbody in Big Bug Creek will be listed in 2026 (Figure 1; Table 1). For the sake of clarity and consistency within this report, the “Upper Agua Fria River” refers to the specific section of the river that spans from its entrance into the defined project area (approximately 4.5 miles north of Dewey-Humboldt) downstream to its exit from the defined project area (approximately 7 miles south of Cordes Lakes) (Figure 1). Similarly, in this report any reference to the “Upper Agua Fria Watershed” refers to the watershed within the defined project area only. These distinctions are crucial for separating the impaired reaches, which are the focus of this TMDL, from other upstream and downstream reaches of the Agua Fria River that are not currently impaired and therefore not included in this analysis.

The approach in this report for TMDL development was selected for several reasons:

- It consolidates efforts by addressing multiple impaired waterbodies in a single TMDL report. The Upper Agua Fria Watershed contains 10 impaired waterbodies with several related parameter impairments (see Table 1) representing approximately 10% of all known waterbody impairments in the state listed in the 2024 IR
- The availability of sufficient existing data facilitated the TMDL development, thereby reducing both the cost and timespan required for completion.
- It capitalizes on the ongoing restoration efforts within the basin, fostering cross-collaboration between ADEQ, the U.S. Forest Service (USFS), and private landowners.
- The development of a TMDL will support efforts to improve water quality to the downstream receiving system of the Agua Fria River which eventually feeds into the Agua Fria National Monument and Lake Pleasant, both of which are major recreation waters for the Phoenix metro area.

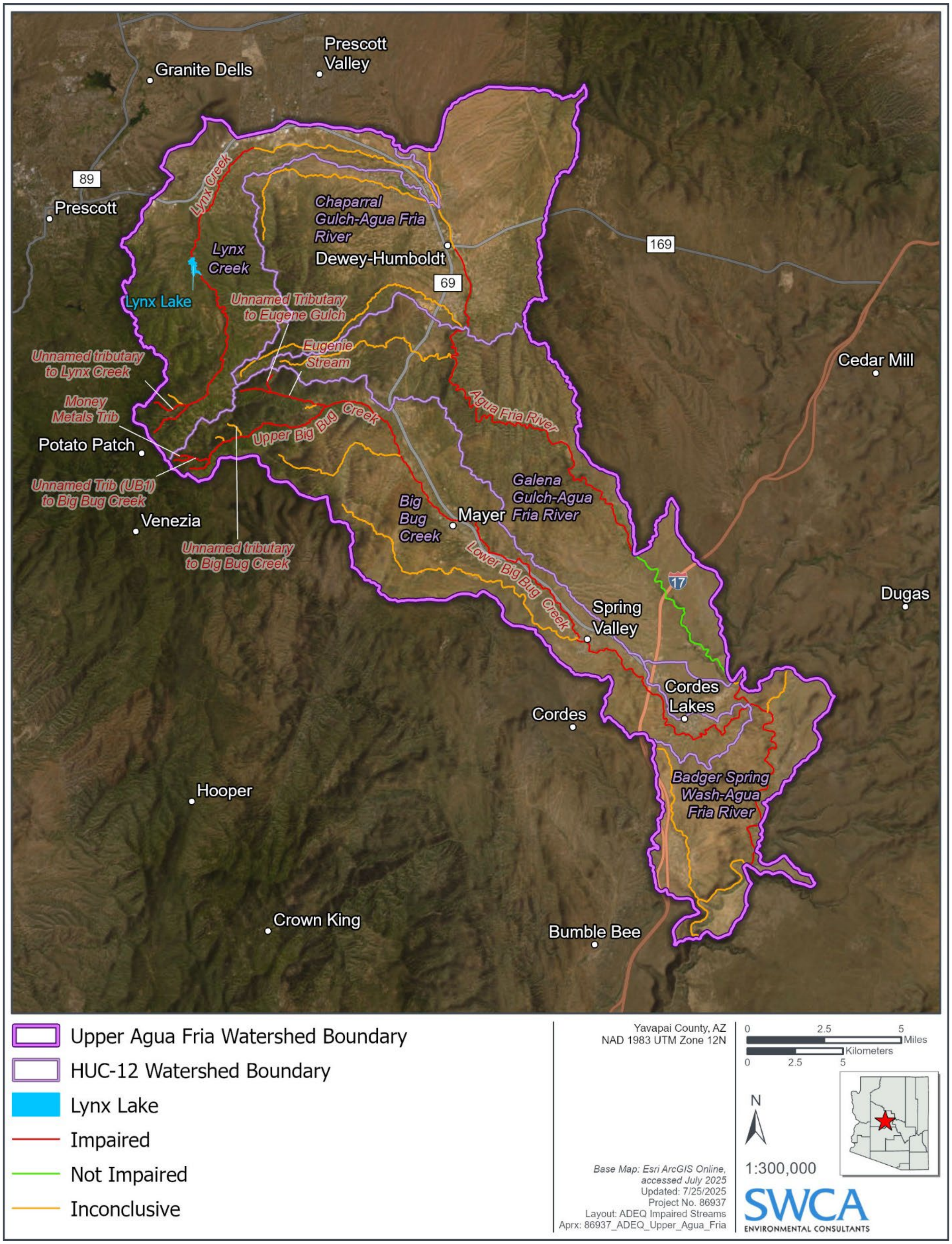

Figure 1. Impaired waterbodies in the Upper Agua Fria Watershed.

Table 1. Impaired Waterbodies, Pollutants, Uses, and Sources of Impairments.

Subwatershed	Waterbody Assessment Unit and WBID #	Pollutant	Impaired DUs	Year Listed	Pollutant Sources
Upper Agua Fria River	Agua Fria River 15070102–31B	Total Se	A&Ww* (acute and chronic)	2022	Mining, impacts from AMLs*, natural sources, agriculture, CERCLA* NPL* (Superfund sites)
		Dissolved Zn			
Big Bug Creek	Upper Big Bug Creek 15070102–034A	Dissolved Cd	A&Wc* (acute and chronic)	2022	Mining, impacts from AMLs, natural sources, agriculture
		Dissolved Zn			
	Lower Big Bug Creek 15070102–034B	Total As	AGL*, FBC*, A&Ww (acute and chronic)	2022	Mining, impacts from AMLs, natural sources, agriculture
		Cu (total and dissolved)			
		Pb (total and dissolved)			
	Unnamed tributary to Big Bug Creek 15070102–134	Dissolved Cu	A&We* (acute)	2026	Mining, impacts from AMLs, natural sources
		Dissolved Pb			
	Unnamed tributary to Big Bug Creek (UB1) 15070102–234	Dissolved Cu	A&Wc (acute and chronic)	2022	Mining, impacts from AMLs, natural sources
		Dissolved Cd			
	Unnamed tributary to Eugenie 15070102–1994	Dissolved Cu	A&We (acute)	2016	Mining, impacts from AMLs, natural sources
	Eugene Gulch 15070102–768	Dissolved Cu	A&We (acute)	2022	Mining, impacts from AMLs, natural sources, mine tailings
	Money Metals tributary 15070102–123	Dissolved Cu	A&We (acute)	2016	Mining, impacts from AMLs, natural sources
		Dissolved Zn			
Lynx Creek	Lynx Creek 15070102–033A	Dissolved Cd	A&Wc (acute and chronic)	2022	Mining, impacts from AMLs, natural sources, agriculture, CERCLA NPL (Superfund sites)
		Dissolved Zn			
		Dissolved Cu			
	Unnamed tributary to Lynx Creek 15070102–124	Dissolved Cu	A&Wc (acute and chronic)	2022	Mining, impacts from AMLs, natural sources

Notes: A&Ww = Aquatic and Wildlife warm water; A&Wc = Aquatic and Wildlife cold water; AGL = Agricultural Livestock water; FBC = Full-body contact; A&We = Aquatic and Wildlife ephemeral; AML = abandoned mine lands; CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act; NPL = National Priorities List; WBID = waterbody identification number.

Section 3. Setting

The Agua Fria Watershed is situated in central Arizona, encompassing a large portion of Yavapai County; however, it also extends into parts of Coconino and Maricopa Counties. The Agua Fria Watershed (HUC 8 - 15070102) is classified as a U.S. Geological Survey (USGS) hydrologic unit code (HUC) 8 watershed, covering approximately 1.8 million acres. The primary watercourse in the watershed, the Agua Fria River, originates northeast of Prescott, Arizona, on the north side of the Granite Dells and flows southward for approximately 120 miles. Several tributaries feed into the river, including Big Bug Creek, Lynx Creek, Eugene Gulch, and Chaparral Gulch, contributing to the watershed's overall drainage system (see Figure 1). The Agua Fria River, after leaving the TMDL project area, flows south and eventually discharges into Lake Pleasant, a major reservoir located northwest of Phoenix that serves as a critical water storage facility and recreational site.

3.1 Geology and Topography

The Upper Agua Fria Watershed varies in elevation from approximately 2,800 feet in the southern portion of the watershed to 7,900 feet in the upper reaches of Big Bug Creek. The average slope is approximately 20% with steeper slopes in the forested, mountainous portion of the watershed in the north. Geology is varied; however, early Proterozoic metavolcanic rocks are dominant throughout all three subwatersheds (Table 2; Figure 2). These metavolcanic rocks are primarily composed of metamorphosed volcanic and sedimentary sequences and host various types of mineral deposits including gold (Au), Cu, and silver (Ag) (Jaggar and Palache 1991). The presence of these mineral deposits has led to a rich history of mining in the area dating back to the 1860s and the beginning of a gold rush in the Bradshaw Mountains (Lindgren 1926).

Table 2. Percent Cover of Each Geologic Unit by Subwatershed.

Geologic Unit	Upper Agua Fria River	Big Bug Creek	Lynx Creek
Early Pleistocene to latest Pliocene surficial deposits	4%	0%	4%
Early Proterozoic granitic rocks	5%	12%	21%
Early Proterozoic metasedimentary rocks	10%	7%	8%
Early Proterozoic metavolcanic rocks	38%	46%	42%
Early Tertiary to late Cretaceous granitic rocks	5%	3%	5%
Late to Middle Miocene basaltic rocks	14%	13%	6%
Pliocene to Middle Miocene deposits	19%	10%	14%
Quaternary surficial deposits, undivided	5%	9%	0%

Source: USGS (2024c).

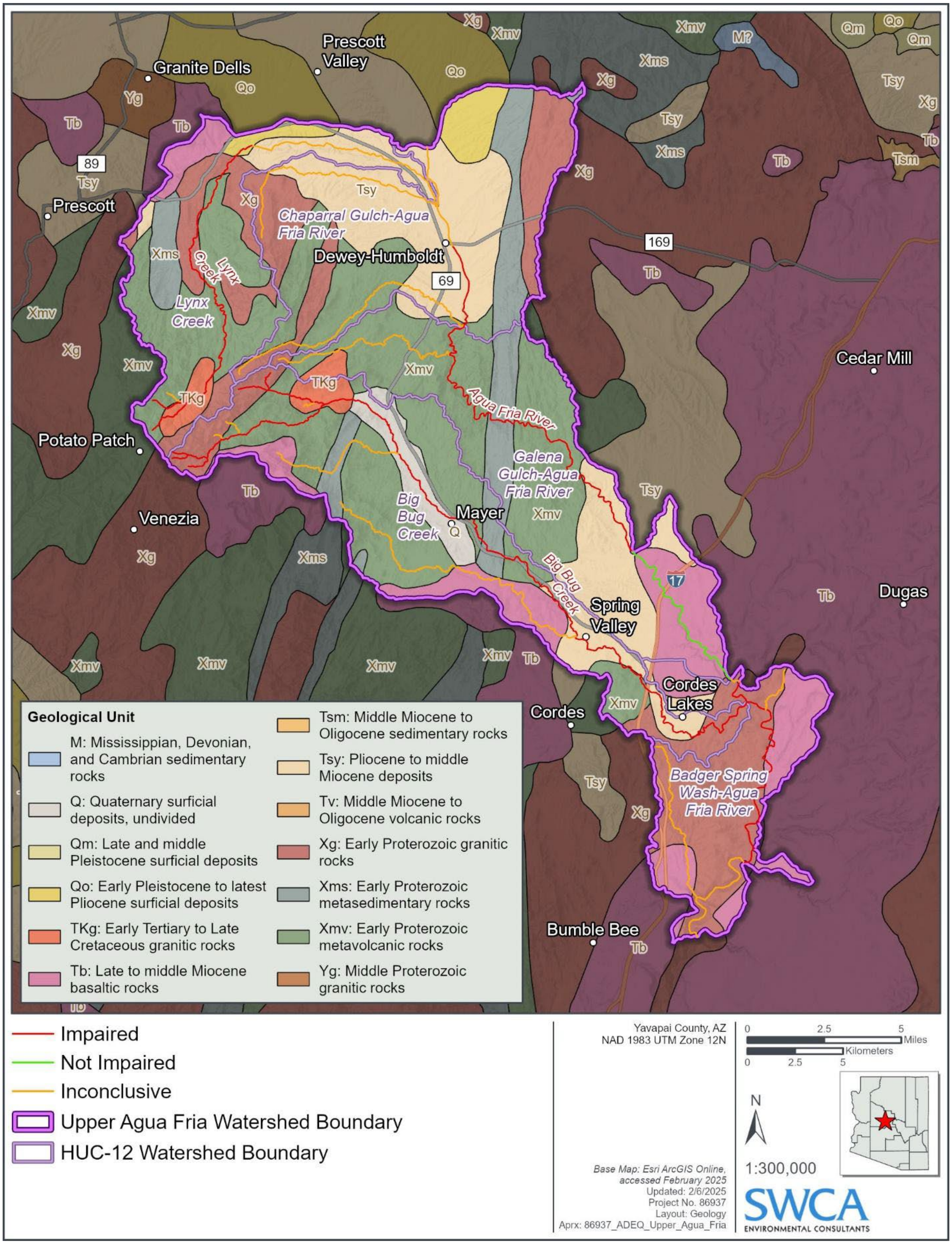

Figure 2. Geological units in the Upper Agua Fria River, Big Bug Creek, and Lynx Creek.

3.2 Climate

The closest active Western Regional Climate Center station is the Prescott, Arizona, station (026796) located north of the Upper Agua Fria Watershed at an elevation of 5,205 feet (Western Regional Climate Center 2024). The period of record for this station is May 1, 1898, to present. The data were queried for both air temperature and precipitation; the results are presented in Figures 3, 4, and 5.

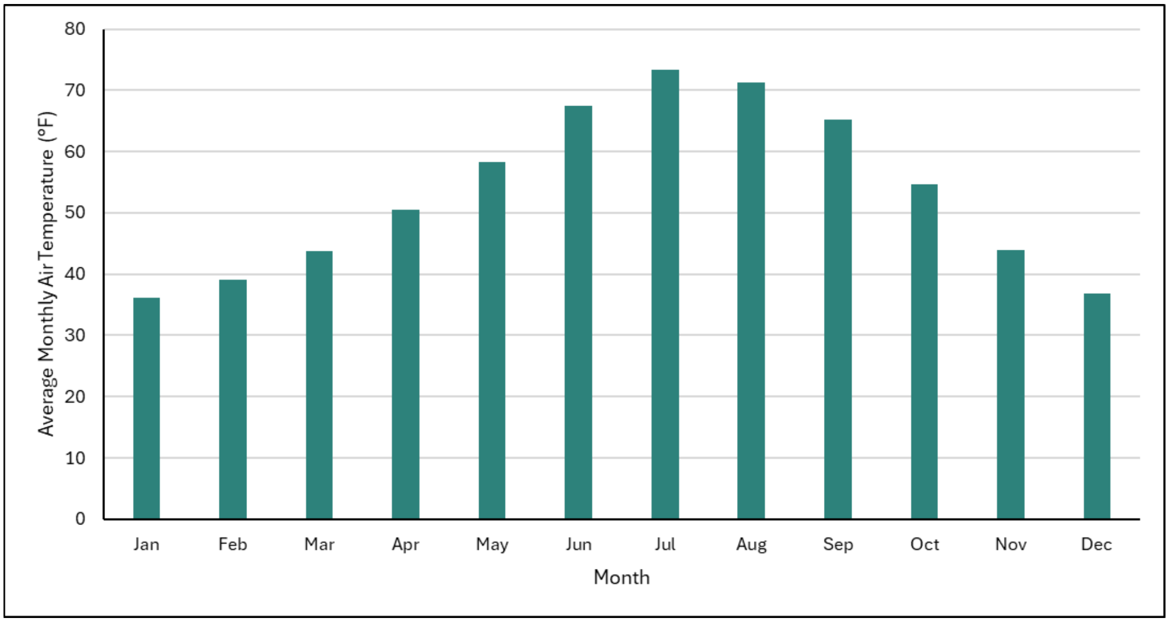

Figure 3. Monthly mean air temperature for the period of record.

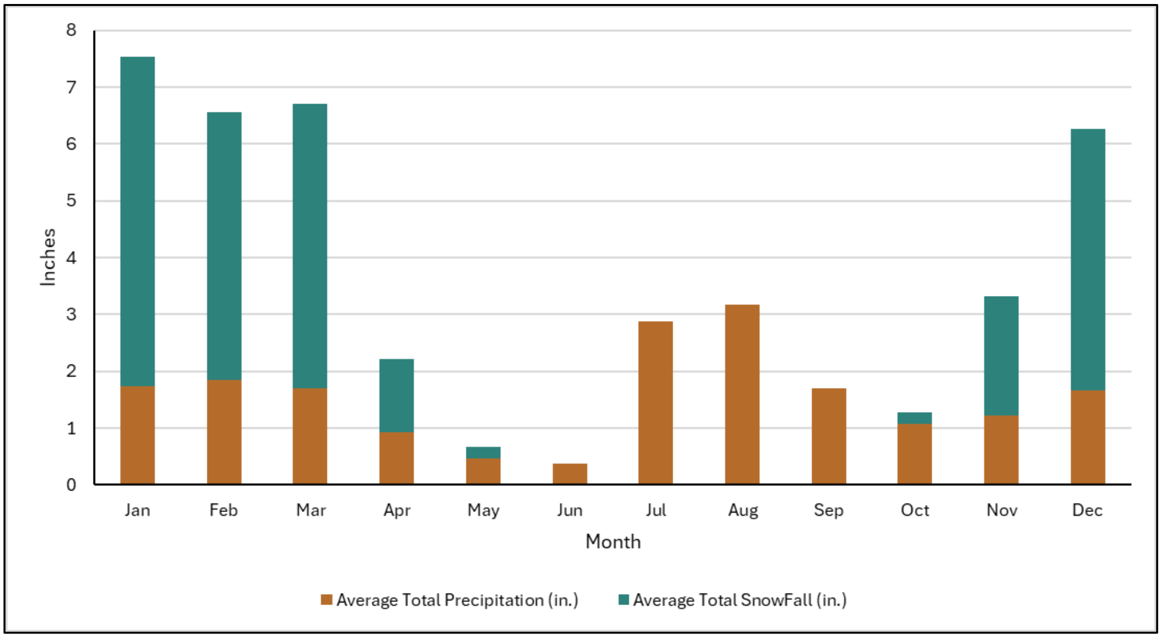

Figure 4. Mean monthly precipitation and snowfall for the period of record.

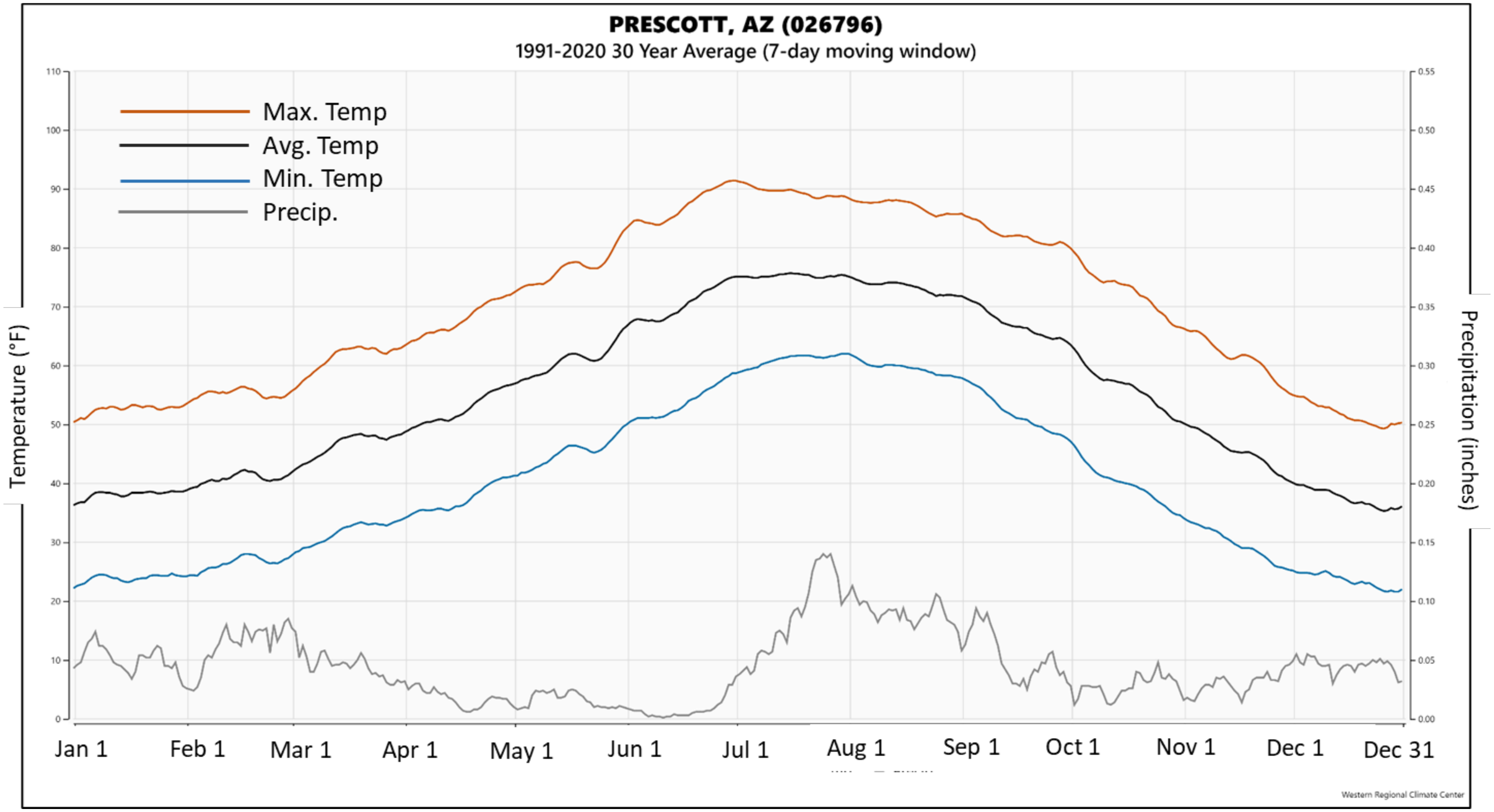

Figure 5. Precipitation and temperature trends at the Prescott, Arizona station (Western Regional Climate Center, 2024).

3.3 Land Cover

In the Upper Agua Fria Watershed, land cover across all subwatersheds is dominated by evergreen forest in the higher elevation portions of the watershed and shrub/scrub in the middle to lower elevations (Table 3; Figure 6). The minimal development in the watershed is primarily concentrated around the towns of Cordes Lakes, Spring Valley, Mayer, Humboldt, Dewey, Villages at Lynx Creek, and Eastridge.

A Superfund site, the Iron King Mine–Humboldt Smelter, is located in the town of Dewey–Humboldt (see Figure 6) and approximately 275 known mine features of various types and status (active, inactive, abandoned, etc.) are scattered throughout the Upper Agua Fria Watershed. It is likely that there are additional unknown mine features in addition to the features that have been identified. An in-depth analysis of the Superfund site and the mining types and locations is included in Section 6.

Table 3. Land Cover by Subwatershed.

Land Cover Classification	Upper Agua Fria River	Big Bug Creek	Lynx Creek
Barren land	<1%	<1%	<1%
Cultivated crops	0%	0%	0%
Developed, high intensity	<1%	<1%	1%
Developed, low intensity	1%	2%	3%
Developed, medium intensity	1%	1%	3%
Developed, open space	3%	3%	6%
Emergent herbaceous wetlands	<1%	<1%	<1%
Evergreen forest	16%	22%	63%
Hay/Pasture	<1%	0%	0%
Herbaceous	7%	21%	3%
Mixed forest	0%	0%	0%
Open water	<1%	<1%	<1%
Shrub/Scrub	71%	52%	20%
Woody wetlands	<1%	<1%	<1%

Source: USGS (2018).

Note: Shading indicates dominant land cover type.

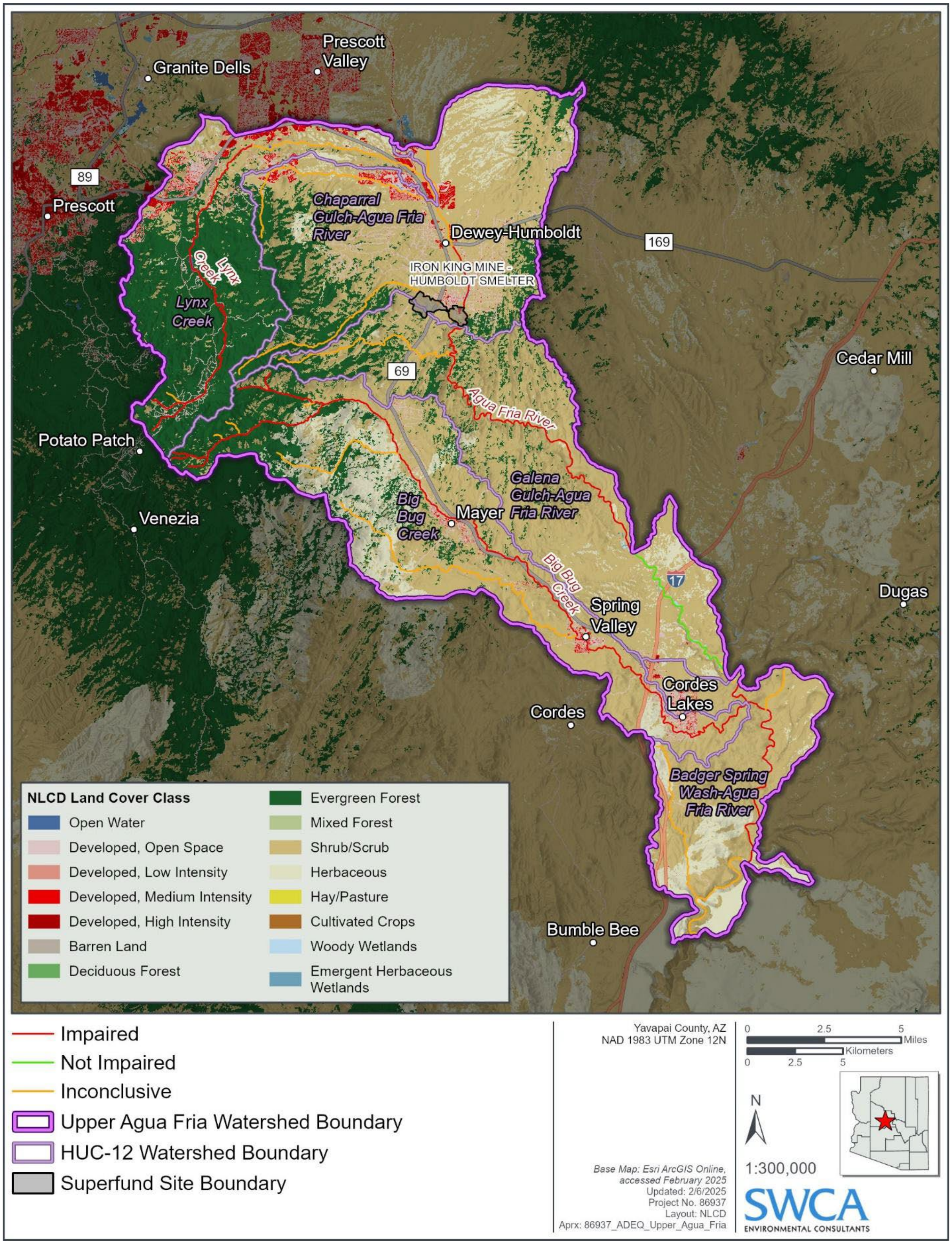

Figure 6. National land cover class in the Upper Agua Fria River, Big Bug Creek, and Lynx Creek.

3.4 Landownership

Dominant landownership class varies by waterbody with the USFS owning the majority of land in Big Bug Creek and Lynx Creek as part of Prescott National Forest (Table 4; Figure 7). In the Upper Agua Fria Watershed, private landownership dominates although state-owned lands are also prevalent. It should be noted that the Bureau of Land Management–managed Agua Fria National Monument boundary is at the confluence of Big Bug Creek and the Agua Fria River (see Figure 7).

Table 4. Landownership by Waterbody.

Landownership	Upper Agua Fria River	Big Bug Creek	Lynx Creek
USFS	12%	42%	58%
Bureau of Land Management	16%	15%	1%
State	33%	16%	4%
County	0%	<1%	0%
Private	39%	27%	37%

Source: USGS (2018).

Note: Shading indicates dominant landownership.

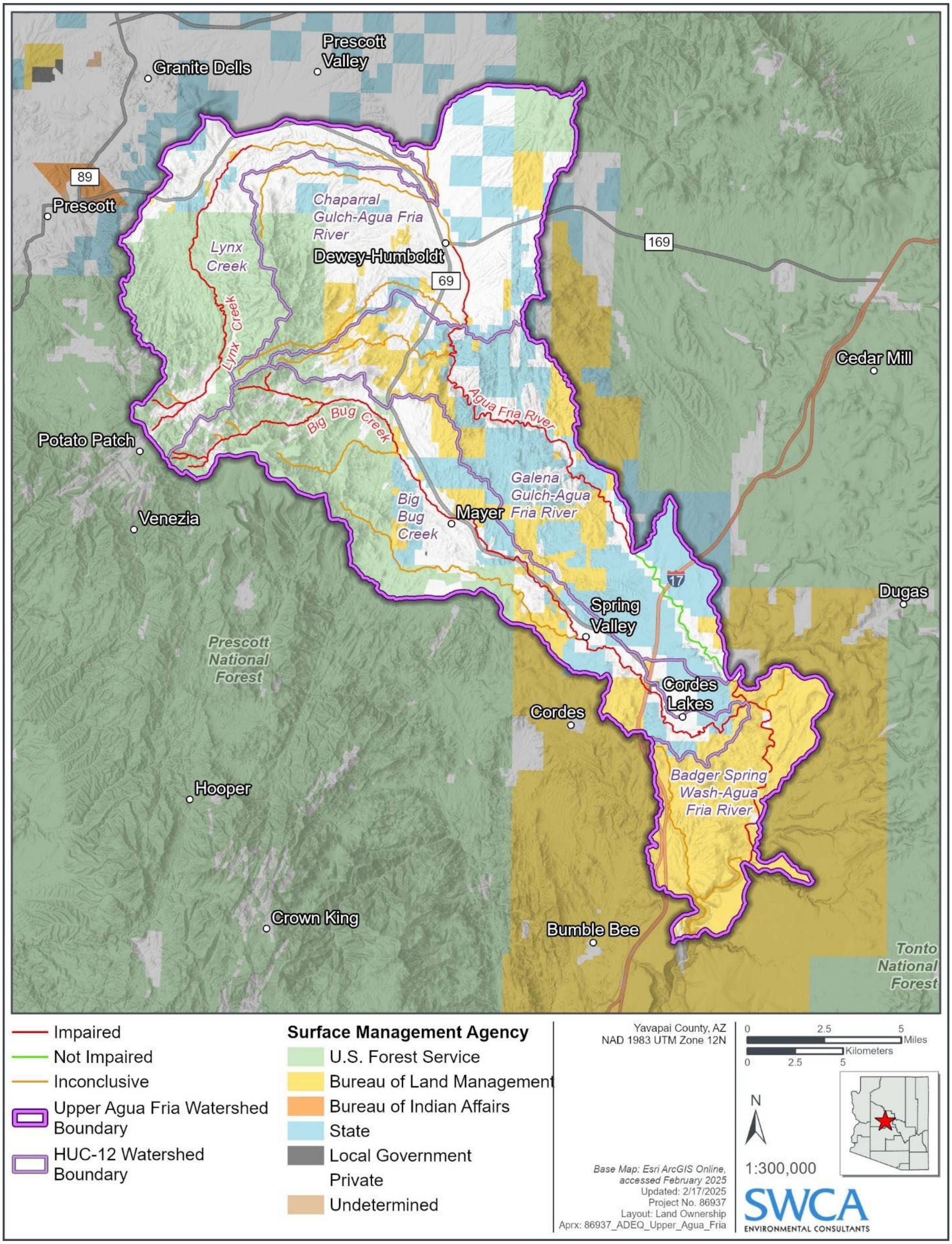

Figure 7. Landownership in the Upper Agua Fria River, Big Bug Creek, and Lynx Creek.

Section 4. Water Quality Standards and Numeric Endpoint Targets

WQS are legal standards promulgated by the State of Arizona (Title 18, Chapter 11 of the Code [A.A.C. R18-11]) which establishes DUs for waters of the state, along with rules and standard for the protection of those uses. See Section 4.1.3 for specific water quality targets. WQS are composed of three elements:

1. DUs
2. Narrative Standard and/or Numeric Water Quality Criteria (WQC), and
3. Antidegradation Policy

A numeric endpoint target identifies the specific goal or endpoint for the TMDL which signifies attainment of the waterbody's assigned DUs. The numeric target may be equivalent to a numeric WQS (if one exists), or it may represent a numeric translation of a narrative WQS. This section identifies the WQS and DU(s) applicable to the waterbody and identifies appropriate numeric endpoint targets in TMDLs for metals in the Upper Agua Fria River, Big Bug Creek, and Lynx Creek.

4.1 Water Quality Standards

In the Upper Agua Fria Watershed, waterbodies in three subwatersheds are listed as impaired due to water quality that is inconsistent with the support of applicable DUs as defined in R18-11-204.

4.1.1 Impaired Waters

ADEQ is mandated to enforce the CWA in Arizona and reports on the condition of surface waters every two years in a document known as the IR (see Section 2. Problem Statement). Rules and regulations of the CWA require states to assess the condition of surface waters, establish DUs, and develop and adopt water quality numeric standards to protect human and environmental health.

Surface waters are assessed and determined to be meeting standards (attaining) or not meeting standards (impaired), by comparing pollutant concentrations in the water to state numeric and narrative thresholds for each DU, as written in A.A.C. R18-11, Appendix B.

ADEQ assigns DUs for each assessment unit in Arizona. Assessment units are specific stream reaches delineated by ADEQ using the EPA's Reach File System, which segments streams based on influence from incoming tributaries. Over time, ADEQ has further divided these segments to accurately represent hydrologic breaks, alterations in DUs, or to highlight varying levels of impairment (ADEQ 2024). Each segment is assigned a unique WBID number. Each waterbody may contain multiple monitoring points to provide sample data that are used to determine the overall condition of the segmented reach. For more details on this assessment process, see the most recent ADEQ IR (ADEQ 2024).

For this TMDL, the three primary subwatersheds include the Upper Agua Fria River, Big Bug Creek, and Lynx Creek. Within these three subwatersheds are 10 impaired waterbodies that span four HUC 12 watersheds (Table 5; see Figure 1). The Badger Spring Wash-Agua Fria

River HUC 12 at the southern end of the Upper Agua Fria Watershed does not contain an impaired waterbody but has been included on all report maps to provide context for the receiving waters of the impaired waterbodies of the Upper Agua Fria River and Big Bug Creek.

Table 5. Subwatershed, HUC 12 Watersheds, and Impaired Waterbodies in the Upper Agua Fria Watershed.

Subwatershed	WBID #	Waterbody	Reach Length (miles)	Intercepted HUC 12 Watershed (HUC #)	Total HUC 12 Area
Upper Agua Fria River	15070102–031B	Agua Fria	17.8	Galena Gulch–Agua Fria (150701020208)	36,035 acres
				Chaparral Gulch–Agua Fria (150701020206)	37,931 acres
Big Bug Creek	15070102–034A	Upper Big Bug Creek	5.7	Big Bug Creek (150701020403)	38,342 acres
	15070102–034B	Lower Big Bug Creek	23.3		
	15070102–134	Unnamed tributary to Big Bug Creek	0.7		
	15070102–234	Unnamed tributary to Big Bug Creek (UB1)	1.3		
	15070102–1994	Unnamed tributary to Eugenie	0.7		
	15070102–768	Eugene Gulch	3.1		
	15070102–123	Money Metals tributary	0.5		
Lynx Creek	15070102–033A	Lynx Creek	12.9	Lynx Creek (150701020205)	26,694 acres
	15070102–124	Unnamed tributary to Lynx Creek	1.3		

Source: ADEQ (2022a); USGS (2021).

4.1.2 Designated Uses (DUs)

40 CFR Part 131.3(f) defines DUs as “those uses specified in the WQS regulations for each waterbody or segment whether or not they are being attained.” Arizona has established ten DUs

in A.A.C. R18-11-104 as well as narrative and numeric standard for protection of those uses. Subwatersheds and their DUs are listed in A.A.C. R18-11, Appendix B. Waterbodies not listed in A.A.C. R18-11, Appendix B, but which are a tributary to a listed waterbody, are assigned DUs according to the Tributary Rule at R18-11-105. DUs applicable to the waterbodies subject to the TMDL are listed in Table 6.

Table 6. DUs Applicable to the Upper Agua Fria River, Big Bug Creek, and Lynx Creek.

DU	Description	Subwatersheds
Agricultural Irrigation (AGI)	The use of surface water for crop irrigation.	Upper Agua Fria River Big Bug Creek
Agricultural Livestock watering (AGL)	The use of surface water as a water supply for consumption by livestock.	Upper Agua Fria River Big Bug Creek Lynx Creek
Aquatic and Wildlife (cold water) (AWC)	The use of surface water by animals, plants, or other cold-water organisms, generally occurring at an elevation greater than 5,000 feet, for habitation, growth, or propagation.	Big Bug Creek Lynx Creek
Aquatic and Wildlife (warm water) (AWW)	The use of surface water by animals, plants, or other warm water organisms, generally occurring at an elevation less than 5,000 feet, for habitation, growth, or propagation.	Upper Agua Fria River Big Bug Creek
Aquatic and Wildlife (ephemeral) (AWE)	The use of ephemeral water by animals, plants, or other organisms, excluding fish, for habitation, growth, or propagation.	Big Bug Creek
Full-body Contact (FBC)	The use of surface water for swimming or other recreational activity that causes the human body to come into direct contact with the water to the point of complete submergence. The use is such that ingestion of the water is likely and sensitive body organs, such as the eyes, ears, or nose, may be exposed to direct contact with the water.	Upper Agua Fria River Big Bug Creek Lynx Creek
Fish Consumption (FC)	The use of surface water by humans for harvesting aquatic organisms for consumption. Harvestable aquatic organisms include, but are not limited to, fish, clams, turtles, crayfish, and frogs.	Upper Agua Fria River Big Bug Creek Lynx Creek

4.1.3 Water Quality Criteria

Arizona promulgated WQS that are applicable to Cd, Zn, As, Cu, Pb, and Se in the Upper Agua Fria River, Big Bug Creek, and Lynx Creek (see A.A.C. R18-11, Appendix A). Table 7 provides a summary of the relevant WQS.

Table 7. Applicable WQS.

DU	Parameter	Standard (µg/L)
AGL	Total As	200
	Total Cu	500
	Total Pb	100
FBC	Total As	30
	Total Cu	1,300
	Total Pb	15
AWW	Dissolved As	340 (acute) 150 (chronic) (see A.A.C. R18-11: Appendix A, Table 1)
	Dissolved Cu	Hardness dependent (see A.A.C. R18-11: Appendix A, Table 5)
	Dissolved Pb	Hardness dependent (see A.A.C. R18-11: Appendix A, Table 6)
	Total Se	2 (chronic) (see A.A.C. R18-11: Appendix A, Table 1)
	Dissolved Zn	Hardness dependent (see A.A.C. R18-11: Appendix A, Table 9)
AWC	Dissolved Cd	Hardness dependent (see A.A.C. R18-11: Appendix A, Tables 2 and 3)
	Dissolved Cu	Hardness dependent (see A.A.C. R18-11: Appendix A, Table 5)
	Dissolved Zn	Hardness dependent (see A.A.C. R18-11: Appendix A, Table 9)
AWE	Dissolved Cu	Hardness dependent (see A.A.C. R18-11: Appendix A, Table 5)
	Dissolved Pb	Hardness dependent (see A.A.C. R18-11: Appendix A, Table 6)
	Dissolved Zn	Hardness dependent (see A.A.C. R18-11: Appendix A, Table 9)

Note: For methods on how to calculate hardness dependent standards, see Section 7.

4.1.4 Antidegradation Policy

The Antidegradation Policy promulgated in A.A.C. R18-11-107(B) states that

> Tier 1: The level of water quality necessary to support an existing use shall be maintained and protected. No degradation of existing water quality is permitted in a surface water where the existing water quality does not meet the applicable WQS.

Tier 1 antidegradation protection applies to surface waters listed on the State's 303(d) list, including those covered under this TMDL, for the pollutant that resulted in the listing. Based on the above provision, the Antidegradation Policy prohibits any water quality degradation which would interfere with or prevent attainment with existing DUs.

4.2 TMDL Numeric Endpoint Targets

Numeric targets are a required component of a TMDL. A numeric target is the quantitative value used to calculate the loading capacity and evaluate whether the applicable DUs are attained.

In this TMDL WQS are used as the numeric endpoints, specifically the applicable acute and chronic criteria for metals. A summary of these standards is included in Table 7.

Section 5. Data Evaluation

5.1 Data Sources

An important step in the TMDL development process is the review of existing water quality and flow monitoring data. Examination of these data assists in characterizing the impairment that the TMDL will address and provides a basis for future implementation efforts by identifying potential sources through spatial and temporal pattern analysis. This section provides a review of the available water quality, flow, and sediment data in and around the Upper Agua Fria River, Big Bug Creek, and Lynx Creek. An initial description of data sources, quality assurance, and quality control measures is provided since these procedures were similar for all three subwatersheds. What follows is an in-depth summary and evaluation of available data for each of the three subwatersheds.

5.1.1 Water Quality Data

ADEQ collects water quality data throughout the Upper Agua Fria Watershed to characterize the condition of the watershed, to assess DU attainment for CWA Section 303(d)/305(b) reporting in the IR, and to support other ADEQ program needs. Data are stored in ADEQ's online public database, the Arizona Water Quality Database, and migrated to the EPA Water Quality Portal on a weekly basis or directly uploaded to the Portal (EPA 2024). Additionally, if another entity (e.g., USGS, USFS) collects and enters data that are also entered into the EPA Water Quality Portal and meet the quality assurance required, ADEQ will include that data in the analysis.

In total, 55 monitoring locations in the Upper Agua Fria Watershed contain metals data, with collection dates ranging from November 1980 to April 2024 (Figure 8). Data will continue to be collected in the watershed beyond April 2024; however, it will not be included as a part of this TMDL analysis. An exception to this is the addition of data collected from Lynx Creek on July 23, 2024, to fill a critical data gap. Data were collected by ADEQ from three sites below Lynx Creek Lake where no data were previously available. The location of the sites is presented in Figure 8. Additionally, data were collected by ADEQ on August 13, 2024, in the Chaparral Gulch Arroyo (15070102-739), a tributary to the Upper Agua Fria. This data will be used to understand the importance of the Iron King Mine–Humboldt Smelter Superfund site as a potential source of metals to the Upper Agua Fria River.

The data summary presented below is focused primarily on the impaired waterbodies in each of the three impaired subwatersheds. Note that the Big Bug Creek waterbody consists of both upper (15070102-034A) and lower (15070102–034B) reaches both of which are listed as impaired.

Data obtained from ADEQ were reviewed, standardized, validated, and prepared for further assessment. The following list summarizes the quality control review processes of ADEQ-provided water quality data evaluated in the initial data summary:

- For the purposes of this assessment, sample results reported as “non-detect” in the EPA Water Quality Portal were represented with a value of 0.5x the reporting limit.
- Hardness data were paired with corresponding metal data to assess the exceedance of hardness dependent WQS.

Arizona has established standards for metals where toxicity is a function of hardness (A.A.C. R18-11). The WQS for metals are expressed as dissolved for acute, chronic, and ephemeral cold and warm water concentrations (see Table 7). When available, hardness data collected at the same date and time were paired with the dissolved metal data at each sampling occurrence. When corresponding hardness data were not available, the lowest hardness recorded at that site was used to be the most protective. Three sites (MGBGB025.79, MGBGB026.57, MGBGB027.31) in the dataset had no hardness data available. These sites were in the Lower Big Bug Creek impaired waterbody (15070102-034B) and were removed from the analysis. In the figures presenting dissolved metals data throughout this section, only those depicting instantaneous sampling results are compared to the hardness dependent WQC. Figures that average data by month are intended to illustrate seasonal trends only, as the criteria can only be calculated for instantaneous paired data, not averaged data.

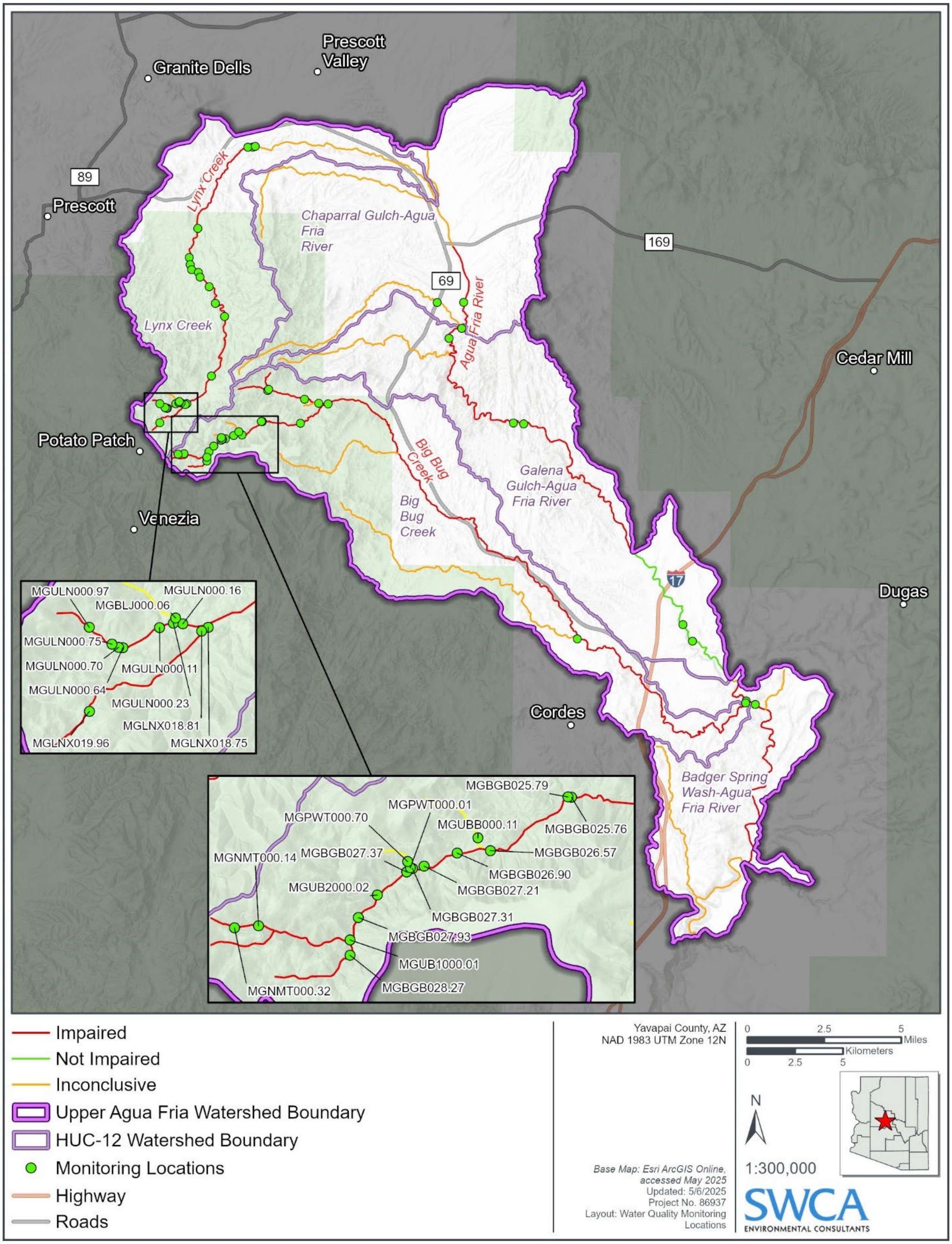

Figure 8. Water quality monitoring locations in the Upper Agua Fria Watershed.

5.1.2 Flow Data

Stream flow is an important factor in the calculation of water quality pollutant loading. Flow measurements from three different data sources were summarized to better understand the hydrologic system and fill in temporal or geographical data gaps. Flow data were obtained from the following data sources:

1. **EPA Water Quality Portal**: ADEQ monitors Arizona surface water quality to fulfill the requirements of the CWA. Flow measurements are collected at some of these monitoring locations. Monitoring data are reported to EPA and are housed in the EPA Water Quality Portal.
2. **USGS**: USGS maintains a national streamflow network of gages that are used to generate continuous streamflow information year-round (USGS 2024a). These gages provide continuous flow data at daily intervals.
3. **Yavapai County Flood Control District:** The Yavapai County Flood Control District maintains a network of stream and lake gages, some of which are located in the Upper Agua Fria Watershed. These gages collect daily discharge data.

These three flow sources cover a number of different reaches in the Upper Agua Fria Watershed (Figure 9), a detailed description of which is provided below for each impaired waterbody. The flow data were compiled, standardized, and organized into a master database to facilitate summary and analysis.

ADEQ assigns WBIDs to surface waterbodies and categorizes their flow regimes in accordance with the guidelines outlined in Arizona Revised Statute 49-201, which are detailed below:

- Perennial water means a surface water or portion of surface water that flows continuously throughout the year.
- Intermittent water means a surface water or portion of surface water that flows continuously during certain times of the year and more than in direct response to precipitation, such as when it receives water from a spring, elevated groundwater table or another surface source, such as melting snowpack.
- Ephemeral water means a surface water or portion of surface water that flows or pools only in direct response to precipitation.

As of August 2021, approximately 77% of streams in Arizona have insufficient data to determine flow regime. These waterbodies are assigned an undetermined or null flow regime in this case. ADEQ is exploring methodologies and tools to estimate flow regimes across the state to better understand flow regime of surface waters. At present, some of the WBIDs in the Upper Agua Fria Watershed remain undetermined or null, while others are assigned flow regimes (see Figure 9).

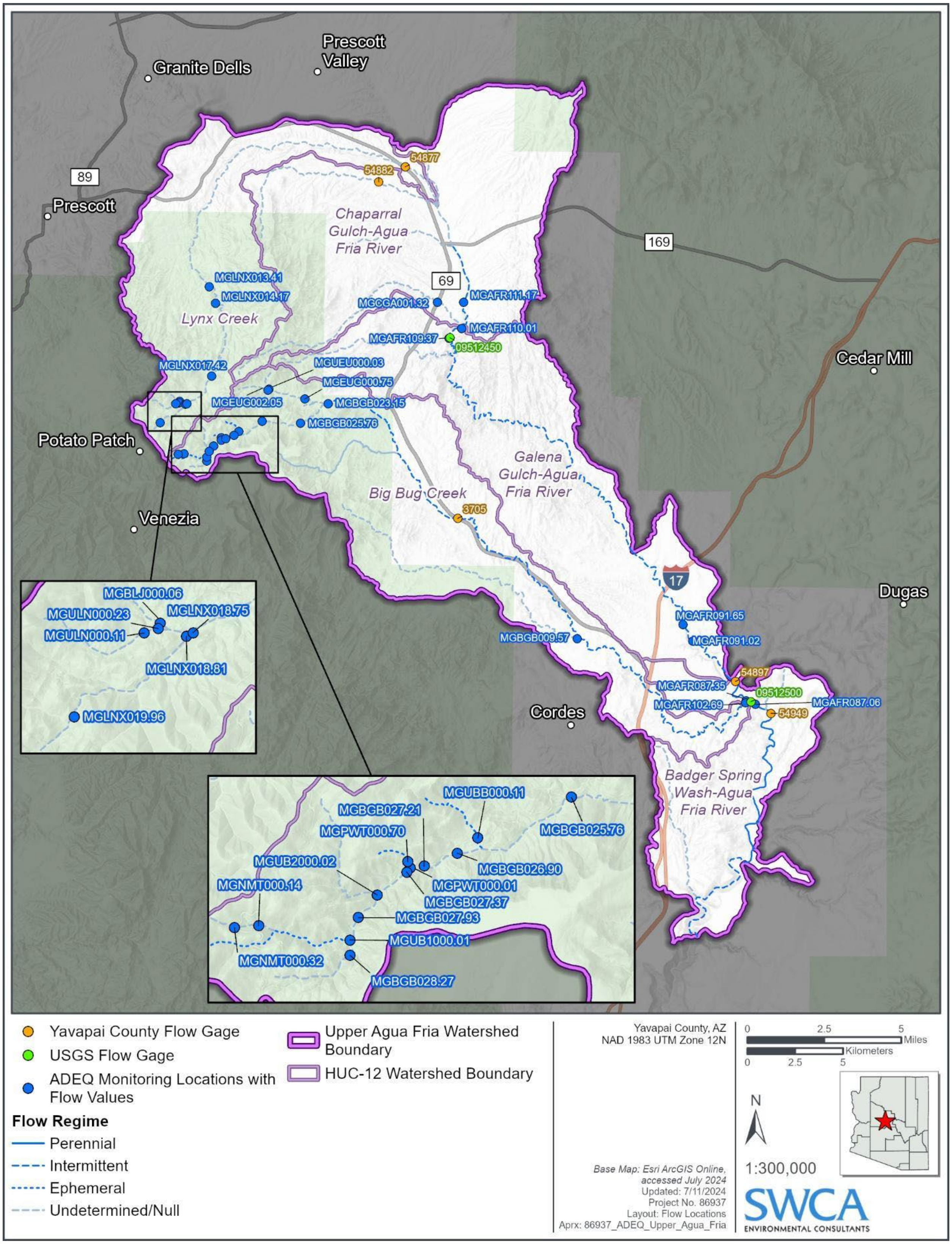

Figure 9. Flow monitoring locations in the Upper Agua Fria Watershed.

5.1.3 Sediment Data

Sediment data are limited in the Upper Agua Fria Watershed. The only data available were collected in an unimpaired reach of the Upper Agua Fria River subwatershed just below the confluence with Big Bug Creek near the MGAFR087.06 monitoring site on May 22, 1996 (Table 8). Most of the parameters measured were within the naturally occurring concentrations for soil, aside from Cu which was slightly elevated (EPA 2007a).

Table 8. Upper Agua Fria River Subwatershed Sediment Data.

Parameter	Concentration (mg/kg)	Natural Concentrations Range (mg/kg)	Latitude	Longitude	Date Collected
As	23.0	0.1–40.0	34.1855°N	112.0348°W	5/22/1996
Cd	0.5	0.01–1.0			
Cu	76.0	2.0–50.0			
Pb	31.0	15.0–40.0			
Se	1.5	0.01–2.0			
Zn	170.0	38.9–62.1			

5.2 Upper Agua Fria River Subwatershed

5.2.1 Water Quality

The Upper Agua Fria River (15070102-031B) is impaired for total Se and dissolved Zn for the chronic AWW. Dissolved Zn is also impaired for the acute AWW. There are five monitoring sites along the impaired reach with water quality data collection ranging from 1980 to 2024 (Table 9). Two monitoring sites in the middle of the 15070102-031B reach exceed the total Se standards (2 micrograms per liter [µg/L]) and the dissolved Zn standard (MGAFR109.37 and MGARF110.01) (see Figures 10–12). A detailed analysis of spatial and temporal trends is provided below for each impairment.

Table 9. Upper Agua Fria River Subwatershed Data Summary.

Subwatershed	WBID	Monitoring Site	Parameter	Year	Sample Size	Average (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Percent Exceedance
Upper Agua Fria	15070102-031B	MGAFR102.69	Total Se	2023, 2024	2	1.25	1.00	1.50	0%
			Dissolved Zn	2023, 2024	1	6.50	6.50	6.50	0%
		MGAFR103.11	Total Se	No data	0	–	–	–	–
			Dissolved Zn	1980	1	5.00	5.00	5.0	0%
		MGAFR109.37	Total Se	2002, 2003, 2018, 2019	7	0.90	2.50 E-3	3.70	14%
			Dissolved Zn	2002, 2003, 2018, 2019	7	89.30	2.50 E-2	500.00	14%
		MGARF110.01	Total Se	2008, 2009, 2014-2018	14	1.98	2.50 E-3	4.90	42%
			Dissolved Zn	2008, 2009, 2014-2018	13	87.81	2.50 E-2	490.00	8%
		MGAFR111.17	Total Se	1980, 2018, 2023, 2024	2	0.87	0.53	1.20	0%
			Dissolved Zn	1980, 2018, 2023, 2024	5	29.60	5.00	65.00	0%

Note: CD = Sampling site identification code.

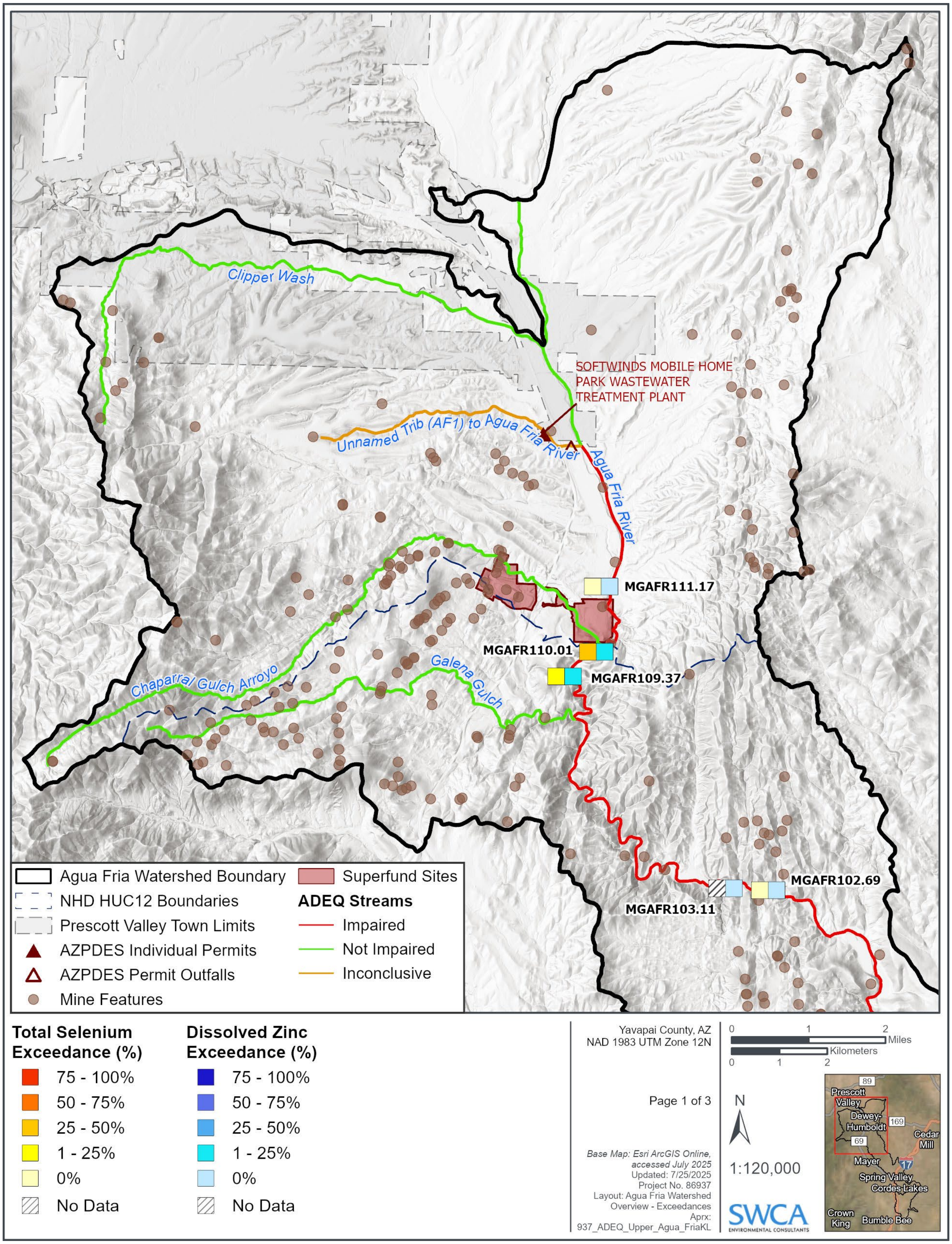

Figure 10. Pollutant sources and percent exceedances in the Upper Agua Fria River.

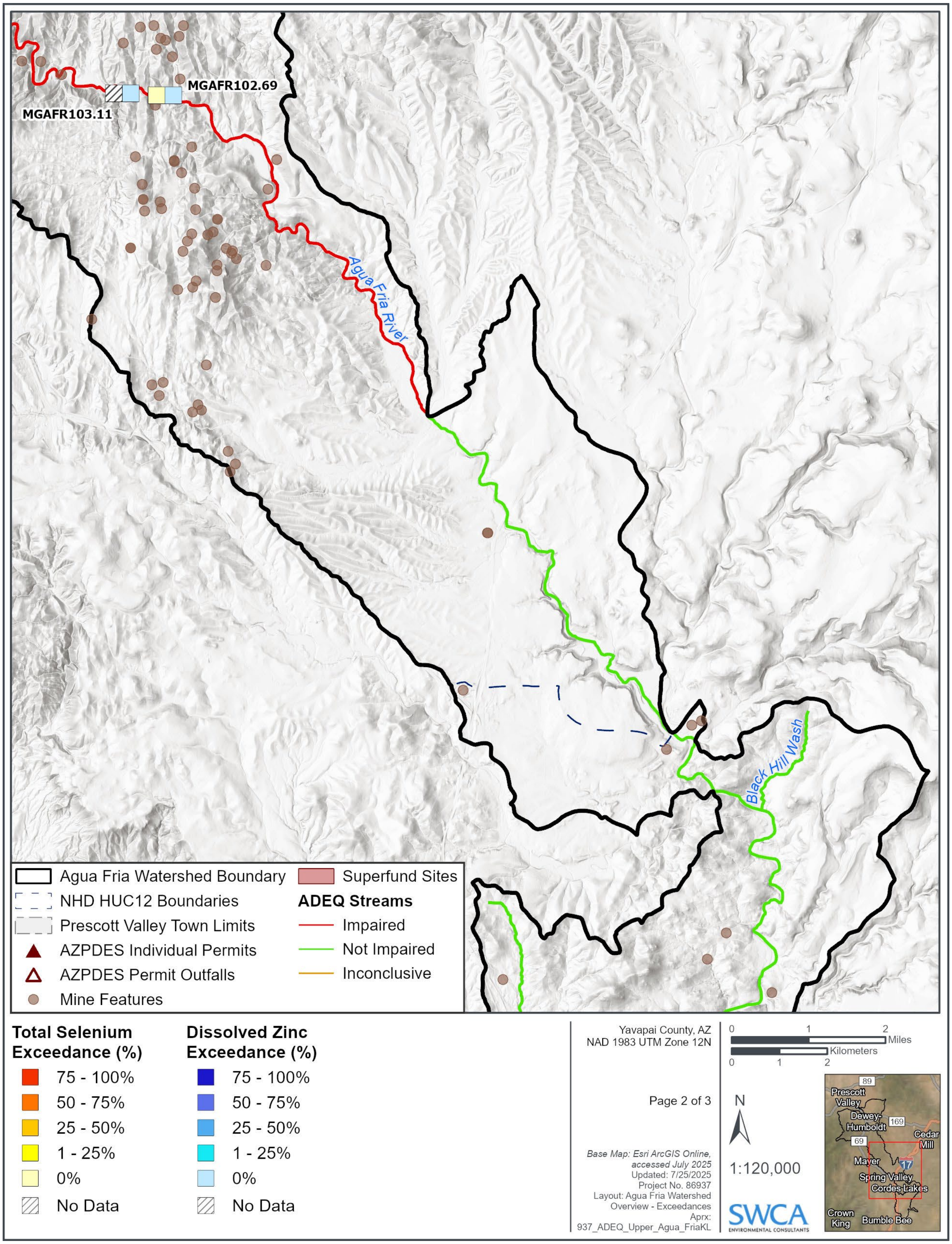

Figure 11. Pollutant sources and percent exceedances in the Upper Agua Fria River.

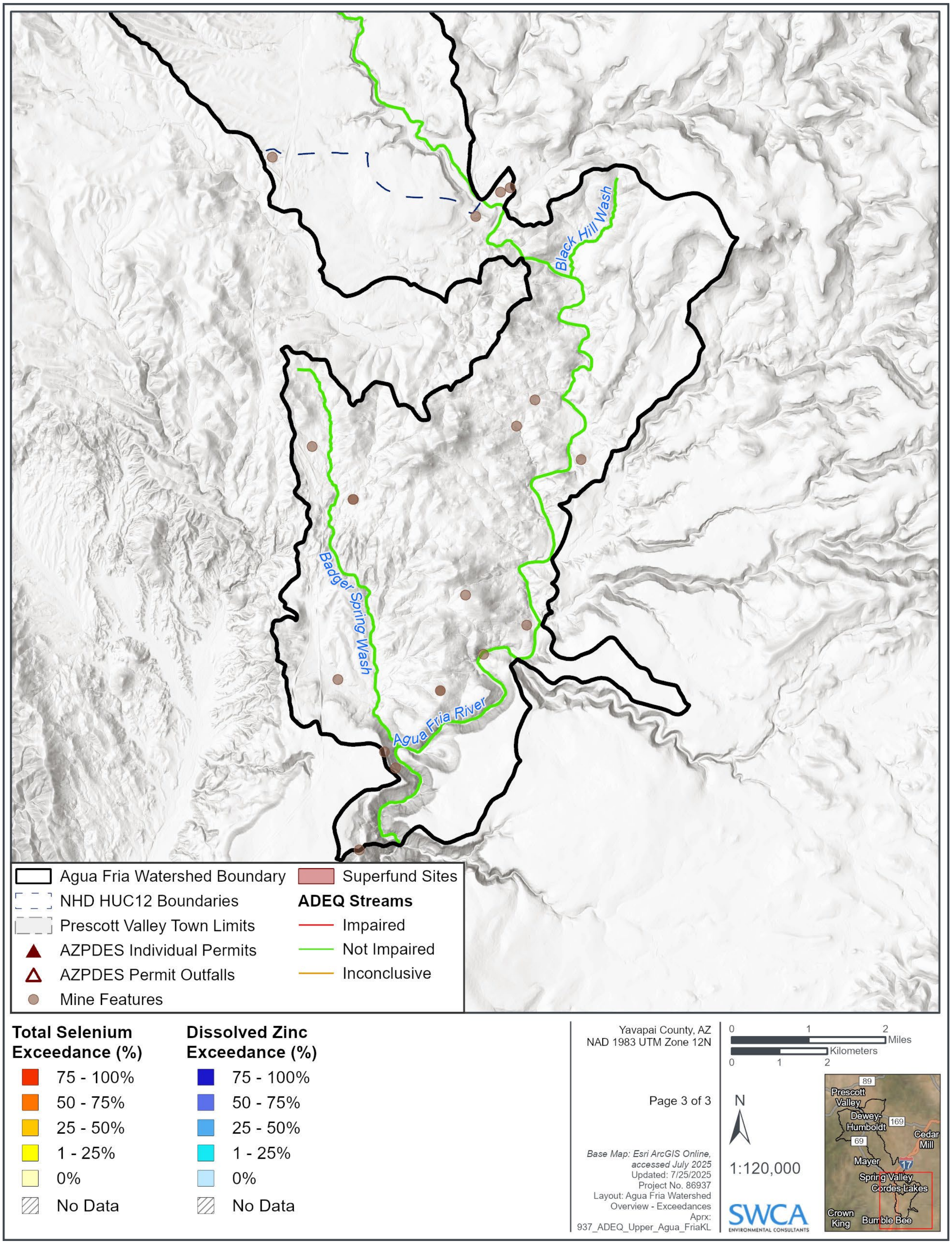

Figure 12. Pollutant sources and percent exceedances in the Upper Agua Fria River.

5.2.1.1 TOTAL SE

The highest concentrations of total Se in the Upper Agua Fria River occurred in March and April, with the most variance in March (Figure 13). No data were collected in the months of June, July, and December. Spatially, the second most upstream site (MGAFR110.01) exceeded the total Se standard 42% of the time, and the third downstream site (MGAFR109.37) exceeded 14% of the time (Figure 14). The other monitoring sites did not exceed the WQS.

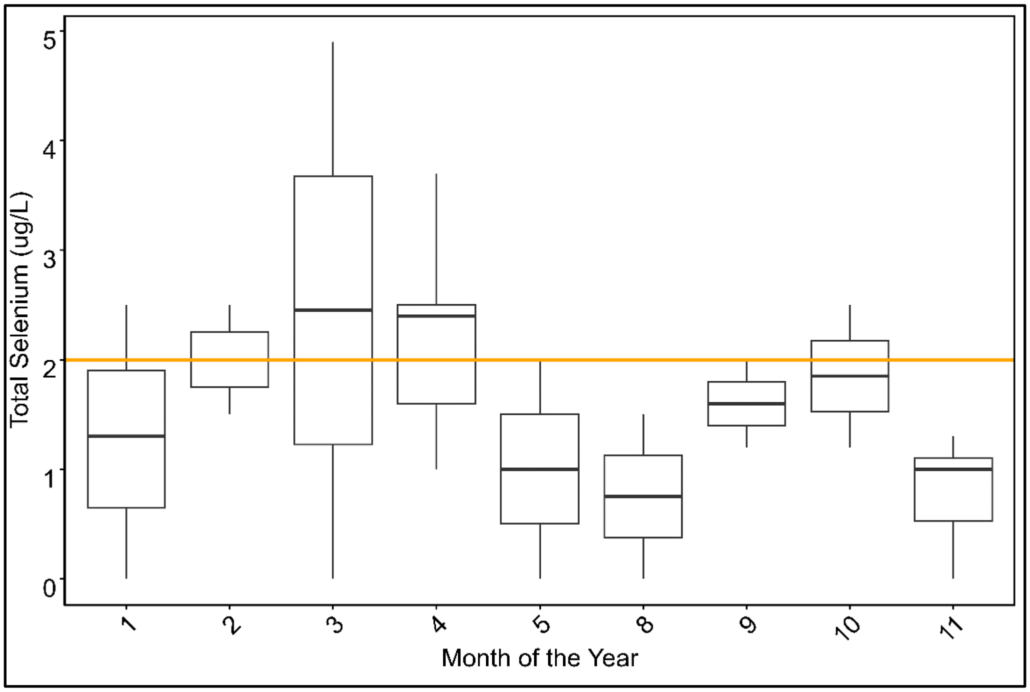

Figure 13. Concentration of total Se by month in the Upper Agua Fria River.

Notes: Monitoring locations and years of data collected were averaged for each month; orange line denotes AWW chronic criteria of 2 µg/L. The horizontal line in the middle of the box plot represents the median; the upper and lower limits of the box represent the first and third quartile.

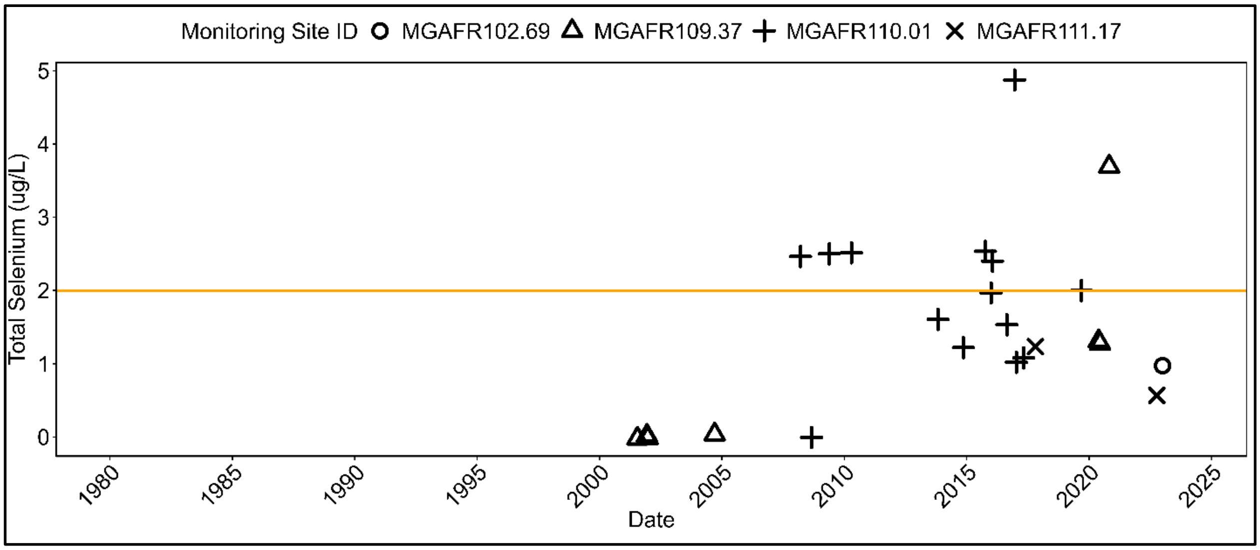

Figure 14. Total Se concentrations over time in the Upper Agua Fria River.

Note: Orange line denotes the AWW chronic criteria of 2 µg/L. Site MGAFR102.69 was created in June 2023 to replace MGAFR103.11 because MGAFR103.11 is now located on private land where an aggregate mine is operating upstream. Access to the site has not been granted such that all future data will be collected from site MGARF102.69, just downstream of site MGAFR103.11.

5.2.1.2 DISSOLVED ZN

The highest concentrations of dissolved Zn in the Upper Agua Fria River were observed in January through April, with the highest concentrations and most variance observed in April (Figure 15). Like trends observed with total Se, the second most upstream and third most downstream sites exceeded the dissolved Zn standard, 14% and 8% of the time, respectively (Figure 16). The other monitoring sites did not exceed the dissolved Zn standard.

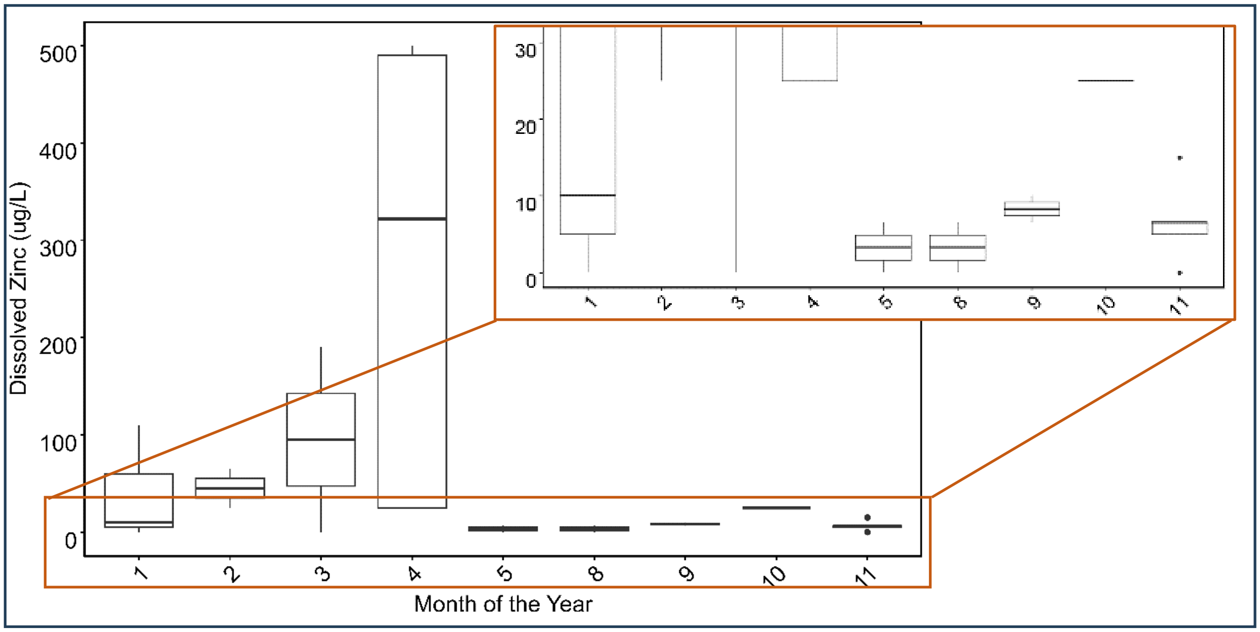

Figure 15. Concentration of dissolved Zn by month in the Upper Agua Fria River.

Notes: Monitoring locations and years of data collected were averaged for each month. The horizontal line in the middle of the box plot represents the median; the upper and lower limits of the box represent the first and third quartile. All points outside the boxplot are outliers (values beyond 1.5 times the interquartile range).

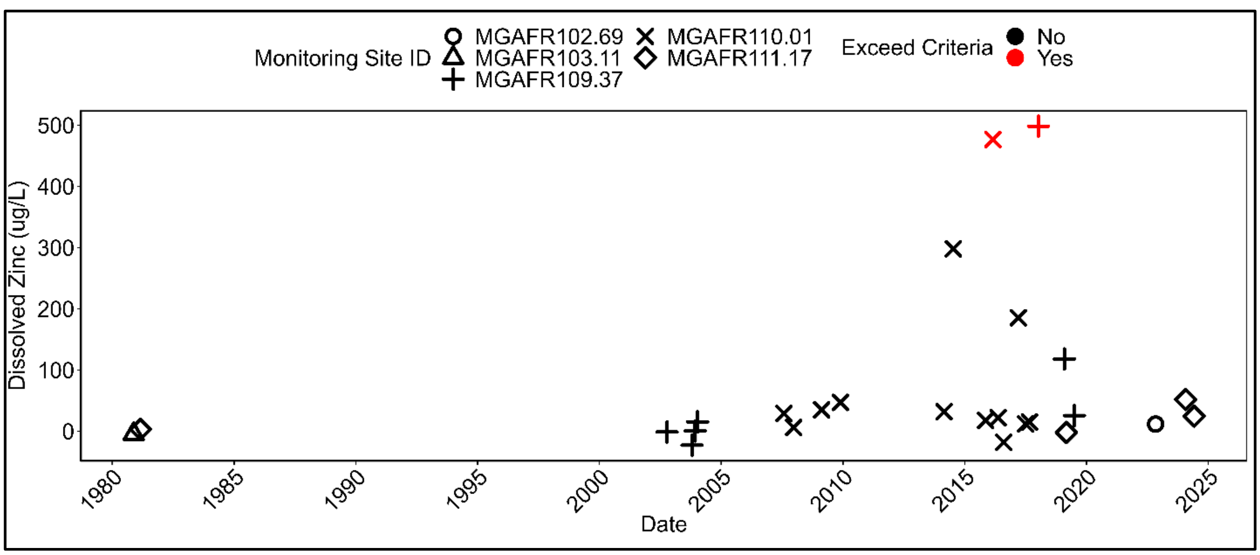

Figure 16. Dissolved Zn concentrations over time in the Upper Agua Fria River.

Notes: WQC are hardness dependent; points in red indicate exceedance.

5.2.2 Flow

ADEQ has classified the impaired reach of the Upper Agua Fria River as having an intermittent flow regime, although the reach of the river downstream of the impairment (WBID AZ15070102-

029) is classified as perennial (see Figure 1). There are four flow gages located along the Upper Agua Fria River across the entirety of the river within the Upper Agua Fria Watershed, and seven monitoring locations with recorded flow (Table 10). Flow records are available from 1980 through the present day. Of the ADEQ monitoring locations with flow data, four locations have less than 10 flow measurements, and three locations have more than 10 flow measurements.

Table 10. Summary of Flow Data Available on the Upper Agua Fria River.

Gage Operator	Gage Identifier	Period of Record	Sample Size	Impaired Reach?
USGS	09512450 - AGUA FRIA RIVER NEAR HUMBOLDT, AZ	01/08/2000–05/13/2024	8,887	Yes
USGS	09512500 - AGUA FRIA RIVER NEAR MAYER, AZ	10/01/1980–05/13/2024	8,893	No
Yavapai County	54897- Agua Fria River below Ash Creek Stage	02/05/2011–04/26/2024	4,447	No
Yavapai County	54949- Agua Fria River at Kelton Ranch Stage	01/06/2012–04/26/2024	4,026	No
ADEQ	MGAFR087.35	2011–2016	11	No
ADEQ	MGAFR111.17	2018–2024	3	Yes
ADEQ	MGAFR091.65	2018–2018	1	No
ADEQ	MGAFR110.01	2008–2018	28	Yes
ADEQ	MGAFR091.02	2019–2019	2	No
ADEQ	MGAFR087.06	1993–2020	34	No
ADEQ	MGAFR109.37	2002–2019	7	Yes

5.2.2.1 USGS GAGES

Of the two USGS gages, one is in the upper-middle portion of the impaired reach (09512450) and the other is located downstream of the impaired reach (09512500). Flow data from both gages is useful in determining flow for pollutant loading calculations.

USGS Gage 09512450 is in the impaired reach just downstream of the confluence with the Chaparral Gulch Arroyo and upstream of the confluence with Galena Gulch. Data have been collected at this gage since 2000 and is currently still in operation. USGS Gage 09512500 is located on the Upper Agua Fria River immediately downstream of the confluence with Big Bug Creek. Data have been collected at this gage since 1980, and it is currently still in operation (Figure 17). Data from these gages show that, typically, high flows occur from January to March, and the low flows occur in May and June (Figures 18–19).

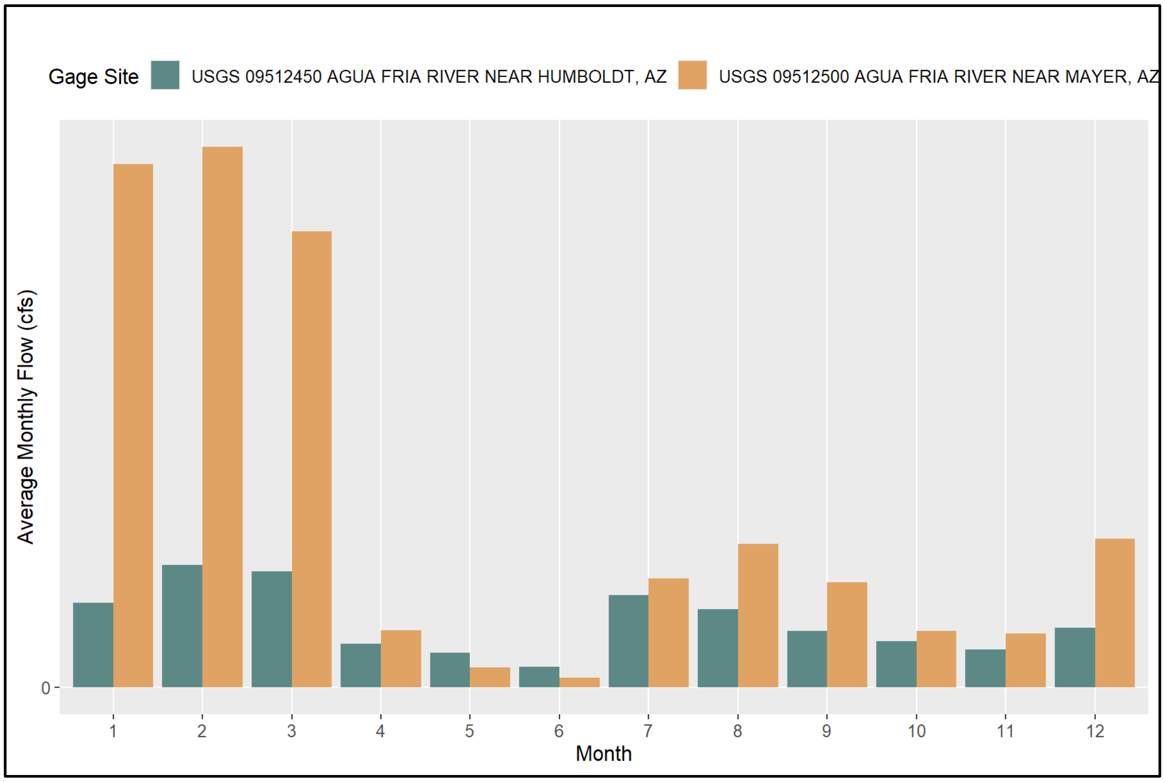

Figure 17. Monthly mean flow at USGS Gage 09512450 and USGS Gage 09512500 on the Upper Agua Fria River.

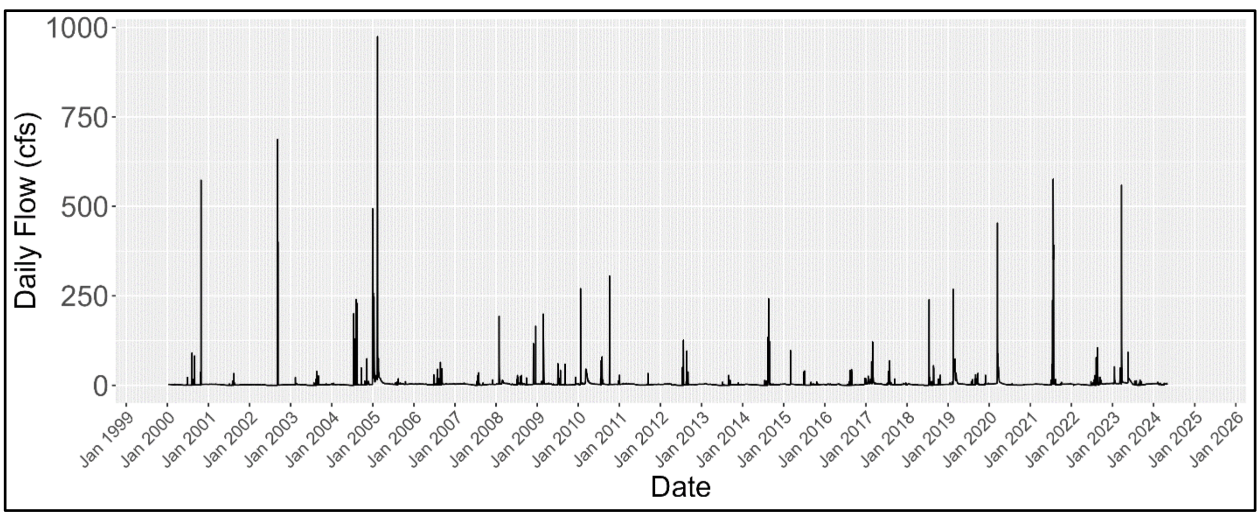

Figure 18. Flow over time at USGS Gage 09512450 on the Upper Agua Fria River.

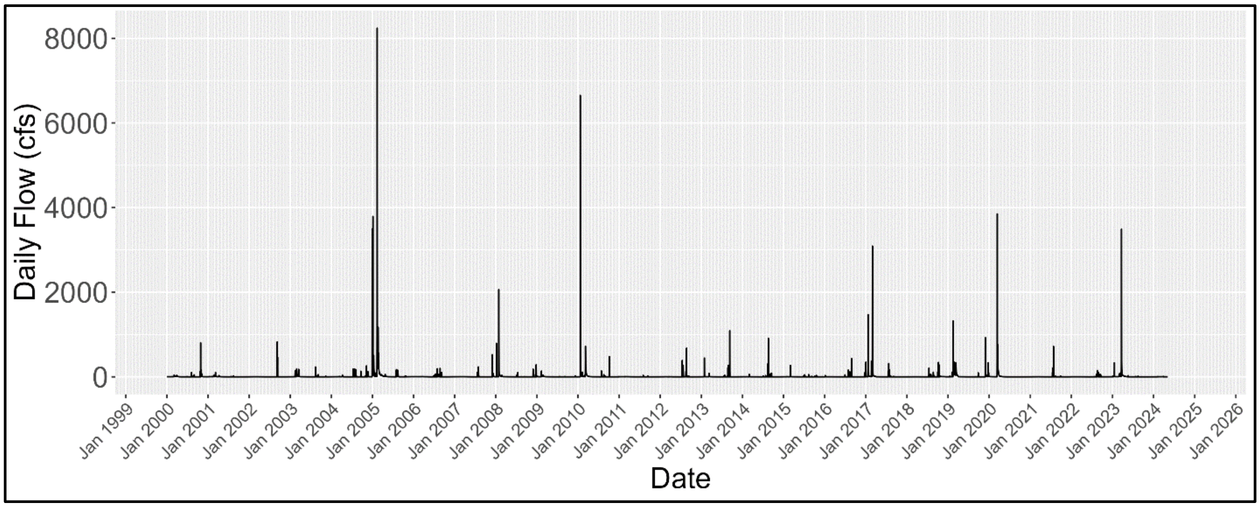

Figure 19. Flow over time at USGS Gage 09512500 on the Upper Agua Fria River.

5.2.2.2 YAVAPAI GAGES

Yavapai Gage 54897 is located on the Upper Agua Fria River downstream of the Ash Creek Stage and upstream of the confluence with Sycamore Creek. This gage has been in operation since 2011 and has over 4,000 measurements of flow on the Upper Agua Fria River. Data from this site indicate that the highest flows occur during March and July and the lowest flows occur in April, May, and June (Figure 20).

Yavapai Gage 54949 is located on the Upper Agua Fria River at Kelton Ranch Stage, just downstream of the confluence with Black Hill Wash. This gage has been in operation since 2012 and has over 4,000 measurements of flow on the Upper Agua Fria River. Data from this site indicate that the highest flows occur during March and July and the lowest flows occur in May (see Figure 20).

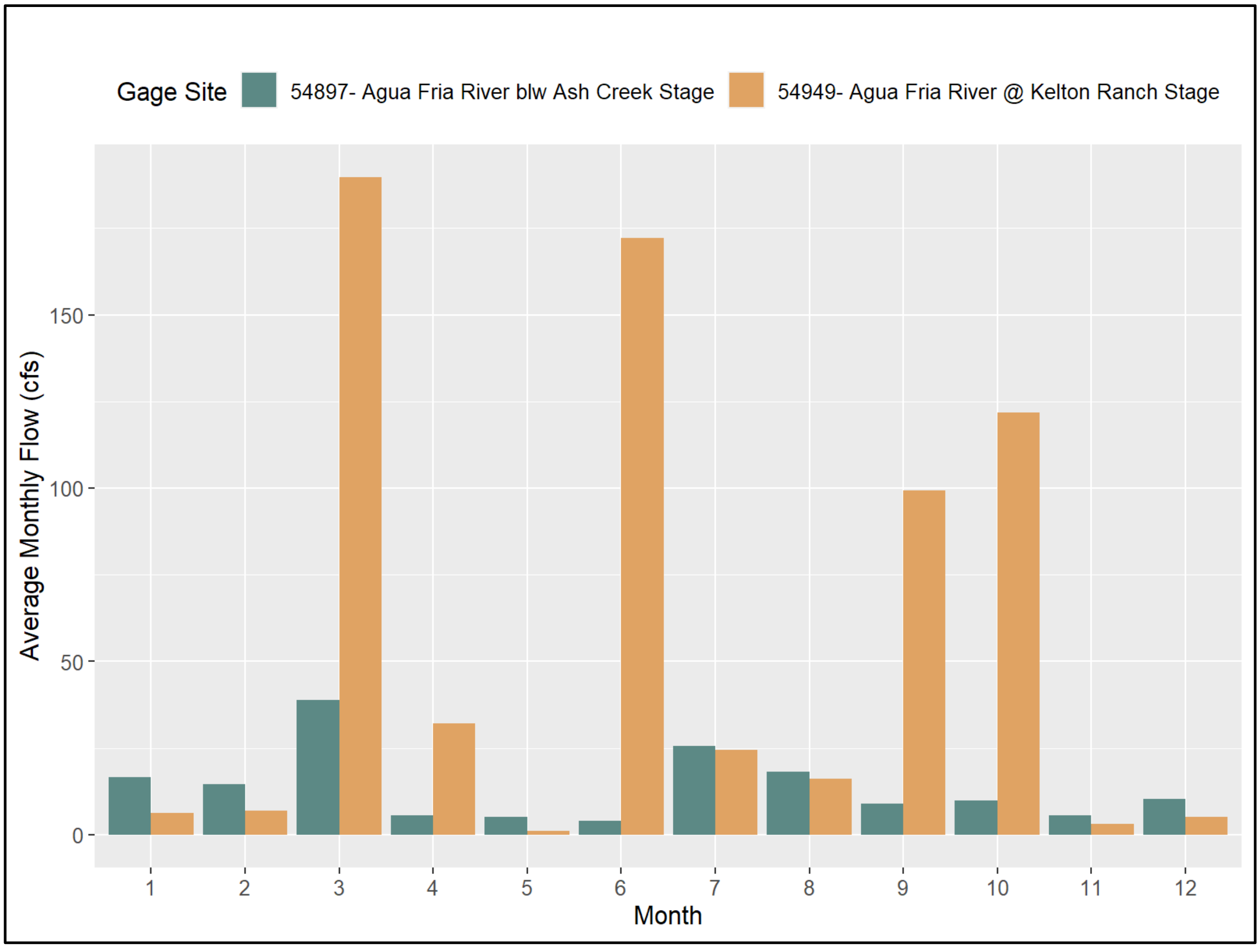

Figure 20. Average daily flow per month on Yavapai Gages 54897 and 54949 on the Upper Agua Fria River.

5.2.2.3 ADEQ MONITORING LOCATIONS

ADEQ collects water quality and flow data at monitoring locations throughout the Upper Agua Fria River. Along the entirety of the Upper Agua Fria River, there are seven monitoring sites where measurements of flow have been collected. The flow data collected at monitoring locations on the Upper Agua Fria River are summarized in Table 11.

Table 11. Flow Data Collected Along Upper Agua Fria River.

Monitoring Site	Flow Measurement Count	Minimum Flow (cfs)	Minimum Flow Month	Maximum Flow (cfs)	Maximum Flow Month	Period of Record
MGAFR087.06	34	0.17	October	27	April	1993–2020

Monitoring Site	Flow Measurement Count	Minimum Flow (cfs)	Minimum Flow Month	Maximum Flow (cfs)	Maximum Flow Month	Period of Record
MGAFR087.35	11	0.12	August	3.5	February	2011–2016
MGAFR091.02	2	0.60	January	1.81	April	2019–2019
MGAFR091.65	1	1.22	November	1.22	November	2018–2018
MGAFR109.37	7	1.10	May	4.73	April	2002–2019
MGAFR110.01	28	0.01	May	24	September	2008–2018
MGAFR111.17	3	1.20	September	5.3	February	2018–2024

Note: cfs = cubic feet per second.

5.2.3 Data Gaps

The understanding of both spatial and temporal data gaps is critical for developing an adequate approach to TMDL development. For water quality, three of the five monitoring sites in the Upper Agua Fria River had limited data (n<5), and one site had no Se data (MGAFR103.11). Ideally, data would be collected on a monthly or quarterly basis at least once per IR assessment period. In addition, higher spatial resolution of the impaired waterbody is recommended with the establishment of monitoring locations at the top and bottom of the reach and continued collection at those sites where data are already present.

For flow data, the presence of two USGS gages along the river is helpful for calculating pollutant loads; however, this impairment could also benefit from flow data collection at sites where water quality data are present. A close examination of matched pairs of flow and water quality data was conducted as a part of the technical approach.

5.3 Big Bug Creek Subwatershed

5.3.1 Water Quality

There are seven WBIDs in Big Bug Creek subwatershed (Table 12). A detailed analysis of spatial (Figures 21–23) and temporal trends is provided below for each impairment in each of the waterbodies.

Table 12. Big Bug Creek Data Summary.

									A&Ww % Exceedance		AGL % Exceedance	FBC % Exceedance
Subwatershed	WBID	Monitoring Site	Parameter	Year	Sample Size	Avg (µg/L)	Min (µg/L)	Max (µg/L)	Acute	Chronic		
Upper Big Bug Creek	15070102-034A	MGBGB02 4.41	Dissolved Cd	2018—2019	5	2.37	0.34	6.10	20%	20%		
			Dissolved Zn	2018—2019	4	223.00	13.00	650.00	50%	50%		
		MGBGB02 5.76	Dissolved Cd	2018—2019	3	2.10	1.69	2.60	0%	100%		
			Dissolved Zn	2018—2019	2	163.65	77.30	250.00	50%	50%		
		MGBGB02 5.79	Dissolved Cd	2019	3	2.57	1.72	4.00	No paired hardness data. Not included in analysis.			
			Dissolved Zn	2019	2	192.15	74.30	310.00				
		MGBGB02 6.57	Dissolved Cd	2019	3	4.41	3.23	6.48	No paired hardness data. Not included in analysis.			
			Dissolved Zn	2019	2	347.00	168.00	526.00				
		MGBGB02 6.90	Dissolved Cd	2018—2022	15	3.71	1.50	8.18	53%	100%		
			Dissolved Zn	2018—2022	12	200.11	62.00	480.00	50%	50%		

									A&Ww % Exceedance		AGL % Exceedance	FBC % Exceedance
Subwatershed	WBID	Monitoring Site	Parameter	Year	Sample Size	Avg (µg/L)	Min (µg/L)	Max (µg/L)	Acute	Chronic		
Upper Big Bug Creek	15070102-034A	MGBGB027.21	Dissolved Cd	2017—2023	11	9.58	6.00	22.00	100%	100%		
			Dissolved Zn	2017—2023	10	677.10	410.00	2,100.00	100%	100%		
		MGBGB027.31	Dissolved Cd	2019	3	7.74	3.82	9.74	No paired hardness data. Not included in analysis.			
			Dissolved Zn	2019	2	385.00	297.00	473.00	0%	0%		
		MGBGB027.37	Dissolved Cd	2017—2019	6	0.71	0.25	2.00	33%	50%		
			Dissolved Zn	2017–2019	6	34.50	17.00	50.00	50%	50%		
		MGBGB027.93	Dissolved Cd	2019	1	0.60	0.60	0.60	100%	100%		
			Dissolved Zn	2019	1	81.00	81.00	81.00	100%	100%		
		MGBGB028.27	Dissolved Cd	2010; 2019–2022	10	0.06	0.05	0.10	0%	0%		
Upper Big Bug Creek	15070102-034A	MGBGB028.27	Dissolved Zn	2010; 2019–2022	10	6.85	6.50	10.00	0%	0%		
			Total As	2010	2	7.40	2.80	12			0%	0%

									A&Ww % Exceedance		AGL % Exceedance	FBC % Exceedance
Subwatershed	WBID	Monitoring Site	Parameter	Year	Sample Size	Avg (µg/L)	Min (µg/L)	Max (µg/L)	Acute	Chronic		
Lower Big Bug Creek	15070102-034B	MGBGB009.57	Dissolved As	2010	2	3.55	3.20	3.9	0%	0%		
			Total Cu	2010	2	27.95	7.00	48.90			0%	0%
			Dissolved Cu	2010	2	7.20	4.30	10.10	0%	50%		
			Total Pb	2010	2	12.10	1.20	23.00			0%	
			Dissolved Pb	2010	2	0.85	0.40	1.30	0%	0%		
		MGBGB023.15	Total As	2013–2024	76	47.00	2.70	340.00			3%	41%
			Dissolved As	2013–2024	70	4.26	1.50	10.00	0%	0%		
			Total Cu	2013–2024	75	428.13	2.00	3,800.00			27%	9%
			Dissolved Cu	2013–2024	75	11.69	1.80	73.00	12%	25%		
Lower Big Bug Creek	15070102-034B		Total Pb	2013–2024	77	96.16	0.25	1,400.00		29% AGL 52% FBC	29%	52%
			Dissolved Pb	2013–2024	69	1.20	0.25	8.00	12%	0%		
Unnamed tributary to Big Bug Creek	15070102-134	MGUBB000.11	Dissolved Cu	2010, 2019, 2021, 2022	4	24.30	19.00	35.00	100%			

									A&Ww % Exceedance		AGL % Exceedance	FBC % Exceedance
Subwatershed	WBID	Monitoring Site	Parameter	Year	Sample Size	Avg (µg/L)	Min (µg/L)	Max (µg/L)	Acute	Chronic		
			Dissolved Pb	2010, 2019, 2021, 2022, 2024	5	185.20	150	300	100%			
Unnamed tributary to Big Bug Creek (UB1)	15070102-234	MGUB100 0.01	Dissolved Cu	2010, 2019, 2021, 2022, 2024	9	7.56	2.00	18.00	44%	44%		
			Dissolved Cd	2010, 2019, 2021, 2022, 2024	10	0.60	0.32	1.10	20%	60%		
Unnamed tributary to Eugene Gulch	15070102-1994	MGUEU00 0.03	Dissolved Cu	2013, 2014, 2022, 2023	37	234.21	54.00	374.00		100%		
Eugene Gulch	15070102-768	MGEUG00 0.21	Dissolved Cu	2023, 2018	17	122.00	5.00	830.00		29%		
Eugene Gulch	15070102-768	MGEUG00 0.75	Dissolved Cu	2010, 2018, 2019, 2022, 2023	12	28.92	5.00	61.00		83%		
		MGEUG00 2.05	Dissolved Cu	2022—2023	12	20.58	14.00	27.00		58%		

									A&Ww % Exceedance		AGL % Exceedance	FBC % Exceedance
Subwatershed	WBID	Monitoring Site	Parameter	Year	Sample Size	Avg (µg/L)	Min (µg/L)	Max (µg/L)	Acute	Chronic		
Money Metals Trib	15070102-123	MGNMT00 0.14	Dissolved Cu	2013, 2014, 2018, 2019, 2024	16	179.46	19.60	830.00		88%		
			Dissolved Zn	2013, 2014, 2018, 2019, 2024	15	3,717.86	290.00	18,000.00		86%		
Money Metals Trib	15070102-123	MGNMT00 0.32	Dissolved Cu	2014, 2019, 2024	4	8.87	5.00	18.00		25%		
			Dissolved Zn	2014, 2019, 2024	3	32.17	6.50	65.00		0%		

Note: Shaded cells indicate that there is no WQS for that parameter and associated DU.

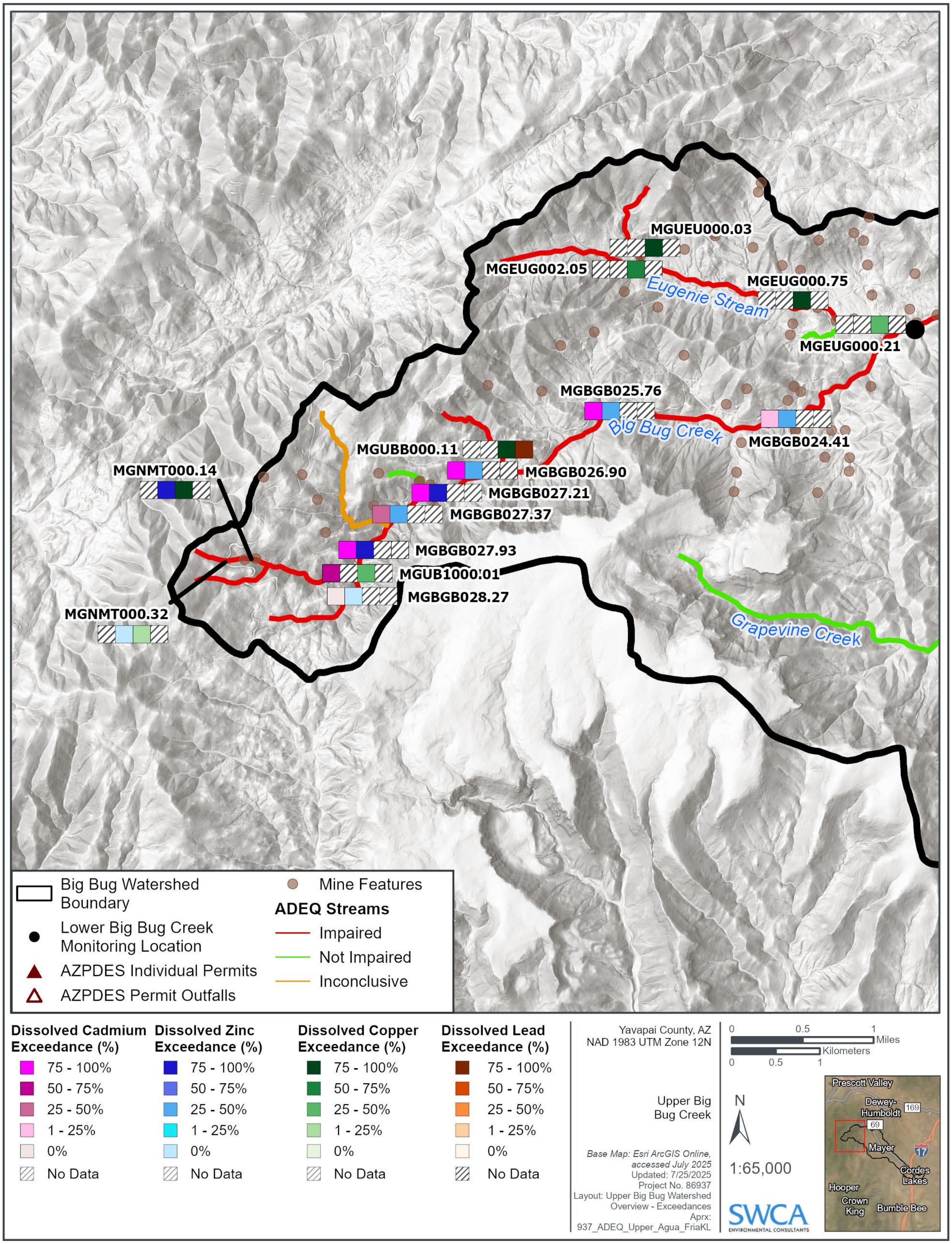

Figure 21. Pollutant sources and percent exceedance in Upper Big Bug Creek.

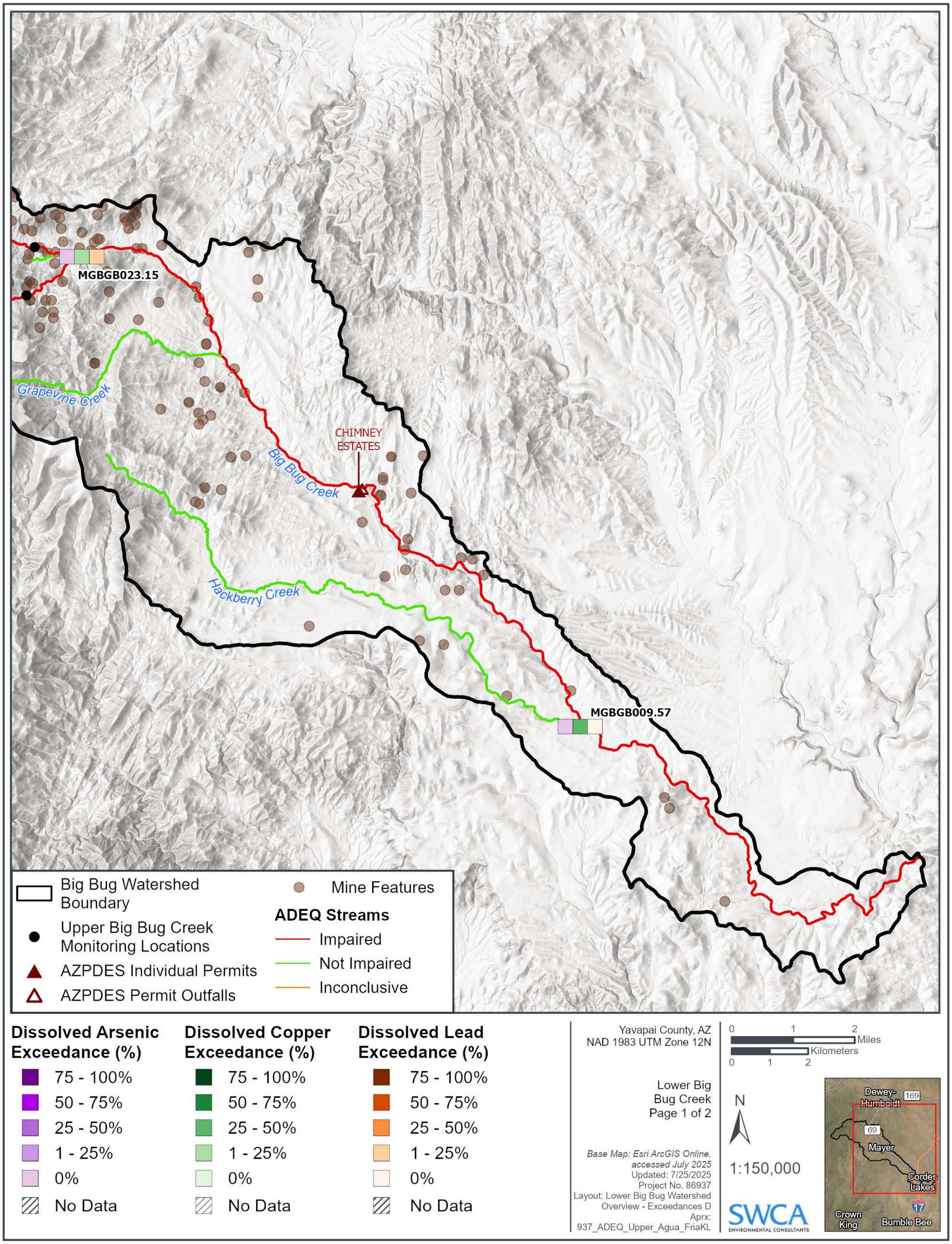

Figure 22. Pollutant sources and percent exceedance in Lower Big Bug Creek.

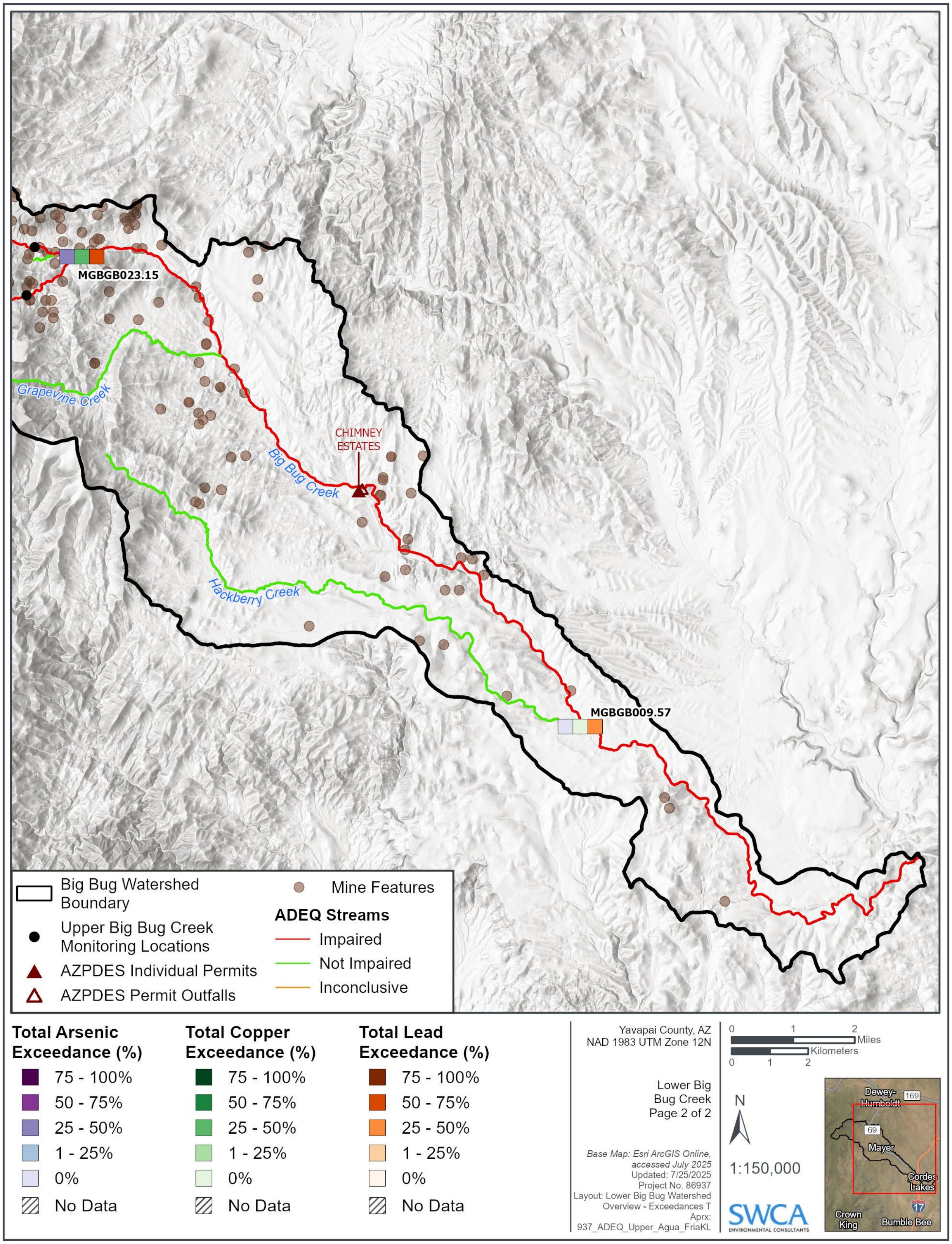

Figure 23. Pollutant sources and percent exceedance in Lower Big Bug Creek.

5.3.1.1 UPPER BIG BUG CREEK (15070102-034A)

Upper Big Bug Creek is impaired for dissolved Cd and Zn for the acute and chronic AWW. There are 10 monitoring sites along the impaired reach (1507102-034A) with water quality data ranging from 2010 to 2023 (see Table 12). Six monitoring sites exceeded the dissolved Cd and Zn standards. Three of the sites were unable to be assessed due to a lack of paired hardness data (MGBGB025.79, MGBGB026.57, MGBGB027.31).

5.3.1.1.1 Dissolved Cd

Seasonally, the dissolved concentrations of Cd in Upper Big Bug Creek varied across the months, with the lowest concentrations observed in July and August (Figure 24). Spatially, Cd concentrations exceeded the acute and chronic standards frequently, 51% and 73% of the sampled times (Figures 25–26). The most exceedances occurred in the middle of the reach (MGBGB027.21, MGBGB026.90), and no exceedances occurred at the most upstream location (MGBGB028.27) (see Figures 21–22).

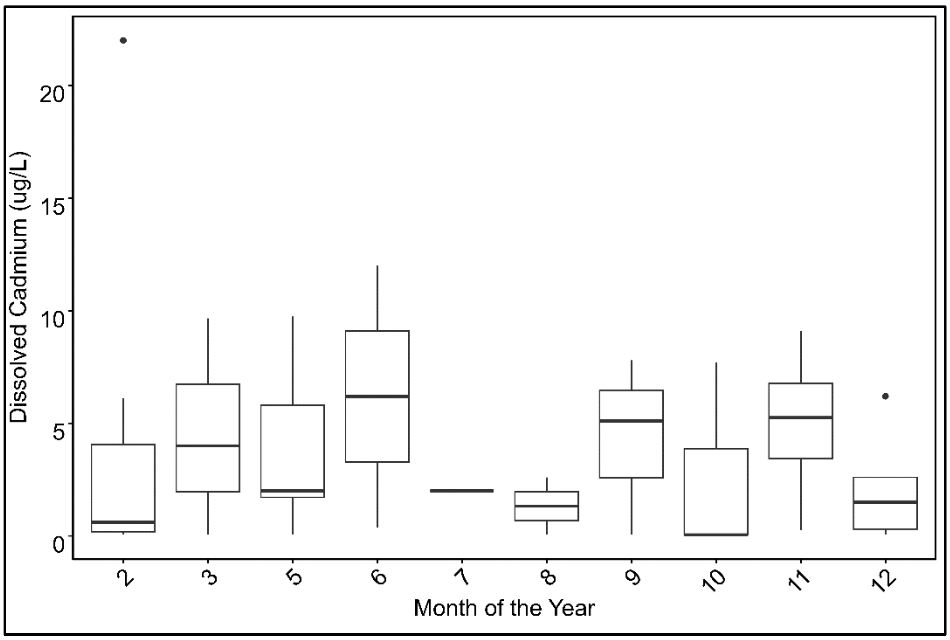

Figure 224. Concentration of dissolved Cd by month in Upper Big Bug Creek.

Notes: Monitoring locations and years of data collected were averaged for each month. The horizontal line in the middle of the box plot represents the median; the upper and lower limits of the box represent the first and third quartile. All points outside the boxplot are outliers.

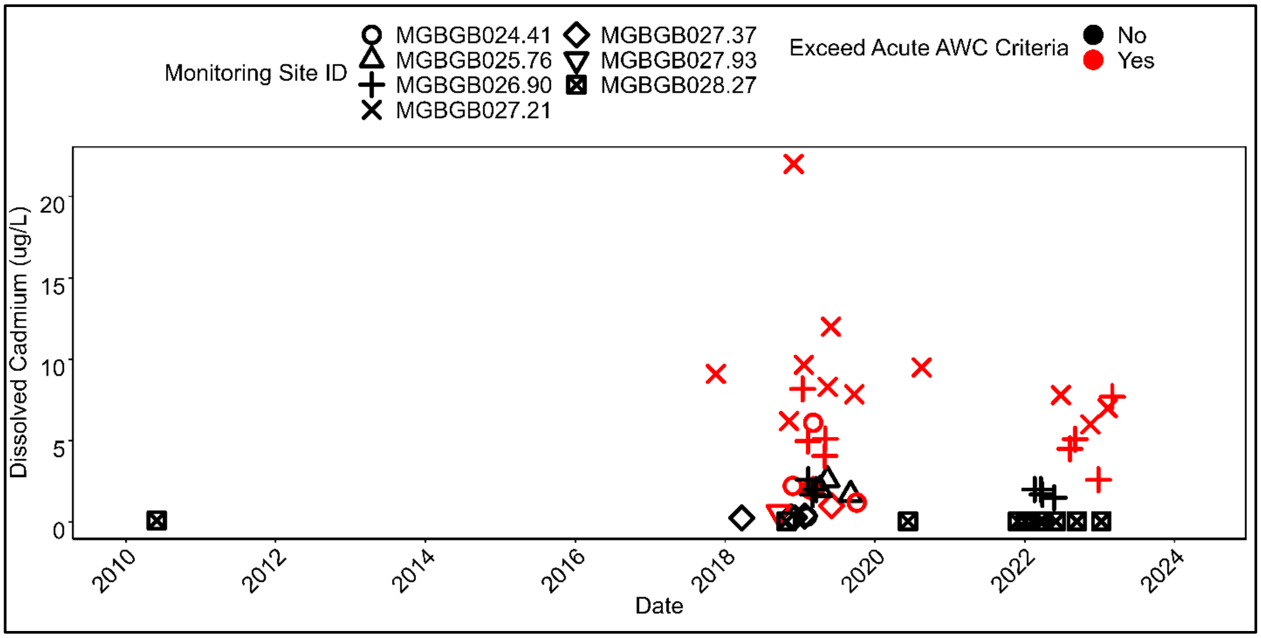

Figure 235. Instantaneous dissolved Cd concentrations over time in Upper Big Bug Creek (acute WQC).

Notes: WQC are hardness dependent; points in red indicate exceedance. No data were collected on Upper Big Bug Creek prior to 2010.

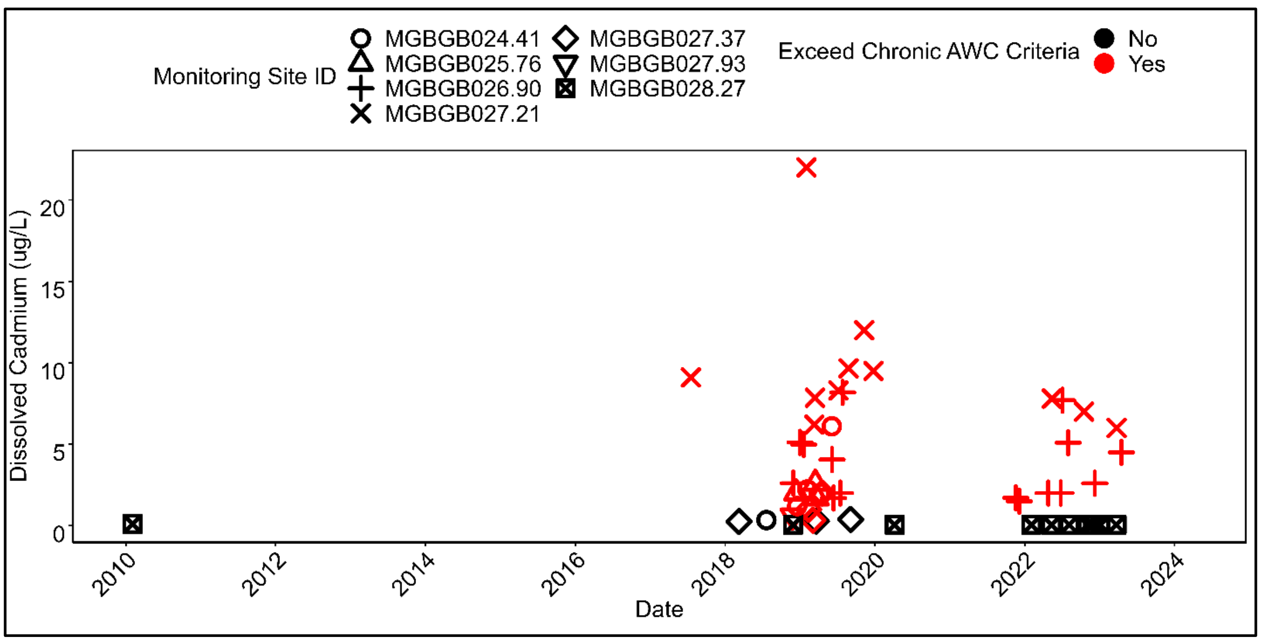

Figure 26. Dissolved Cd concentrations over time in Upper Big Bug Creek (chronic WQC).

Notes: WQC are hardness dependent; points in red indicate exceedance. No data were collected on Upper Big Bug Creek prior to 2010.

5.3.1.1.2 Dissolved Zn

Seasonally, dissolved Zn followed similar trends to dissolved Cd, with variation across months and the lowest concentration observed in July and August (Figure 27). Spatially, Zn concentrations exceeded the acute and chronic standards approximately 45% of the sampled times (Figure 28). Like Cd, most exceedances occurred in the middle of the reach (MGBGB027.21, MGBGB026.90), with no exceedances at the most upstream location (MGBGB028.27) (see Figure 28).

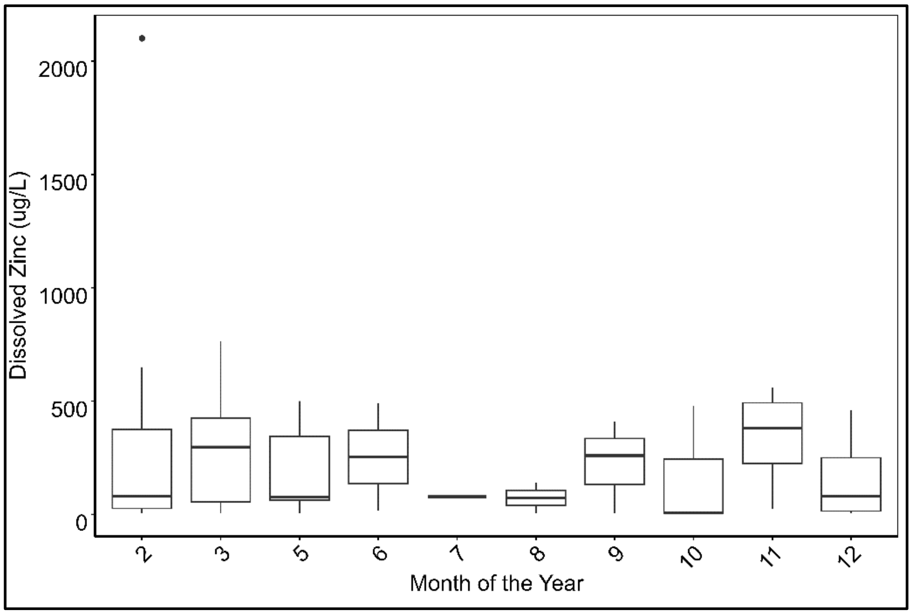

Figure 27. Concentration of dissolved Zn by month in Upper Big Bug Creek.

Notes: Monitoring locations and years of data collected were averaged for each month. The horizontal line in the middle of the box plot represents the median; the upper and lower limits of the box represent the first and third quartile. All points outside the boxplot are outliers.

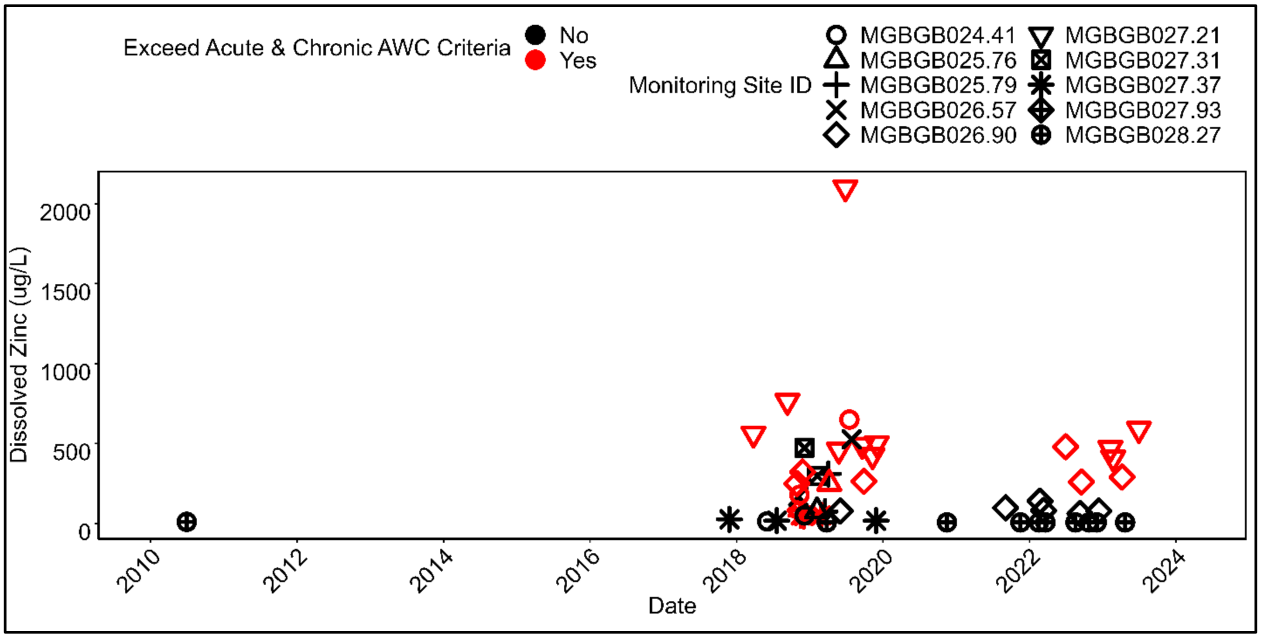

Figure 28. Instantaneous dissolved Zn concentrations over time in Upper Big Bug Creek (acute and chronic WQC).

Notes: WQC are hardness dependent; points in red indicate exceedance. No data were collected on Upper Big Bug Creek prior to 2010.

5.3.1.2 LOWER BIG BUG CREEK (15070102-034B)

Lower Big Bug Creek is impaired for total and dissolved As, Cu, and Pb for acute and chronic AWW, AGL, and FBC. There are two monitoring sites along the reach with water quality data ranging from 2010 to 2024 (see Table 12). One of the monitoring sites (MGBGB009.57) has limited data (n=2) that were collected in 2010. A detailed analysis of spatial and temporal trends is provided below for each impairment.

5.3.1.2.1 Total As

Seasonally, the highest concentrations of total As were observed in July and August (Figure 29). August was the only month that exceeded the AGL standard, no exceedances of the AGL or FBC standard occurred in the months of January, March, April, September, and December. Spatially, the most upstream monitoring site (MGBGB023.15) exceeded the FBC standard 41% of the time and the AGL 3% of the time (Figure 30). No exceedances occurred at the downstream monitoring location (MGBGB009.57). However, limited data were collected; therefore, this may not be representative of site conditions.

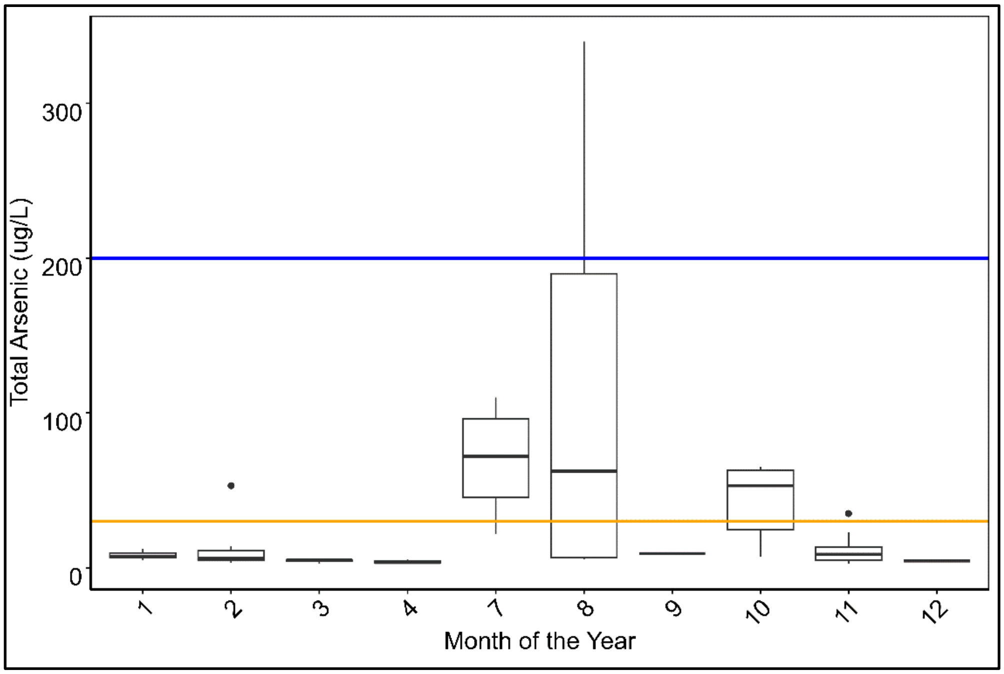

Figure 29. Concentration of total As by month in Lower Big Bug Creek.

Notes: Monitoring locations and years of data collected were averaged for each month. The orange horizontal line denotes FBC WQC (30 µg/L); blue horizontal line denotes AGL WQC (200 µg/L). The horizontal line in the middle of the box plot represents the median; the upper and lower limits of the box represent the first and third quartile. All points outside the boxplot are outliers.

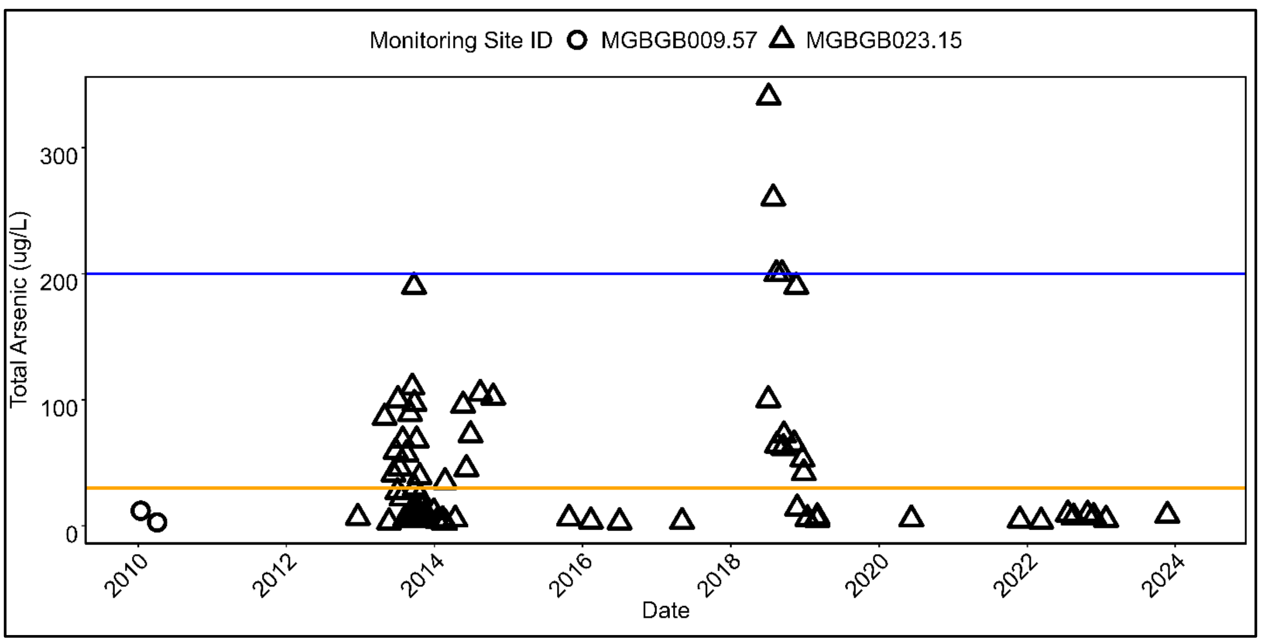

Figure 30. Instantaneous total As concentrations over time in Lower Big Bug Creek.

Notes: The orange horizontal line denotes FBC WQC (30 µg/L); blue horizontal line denotes AGL WQC (200 µg/L). No data were collected on Lower Big Bug Creek prior to 2010.

5.3.1.2.2 Dissolved As

There is no clear seasonal trend of dissolved As, however dissolved As concentrations were well below both WQS (chronic AWW = 150 µg/L; acute AWW = 340 µg/L) (Figure 31). Spatially, there were no exceedances of dissolved As at either monitoring location along the Lower Big Bug Creek waterbody (Figure 32).

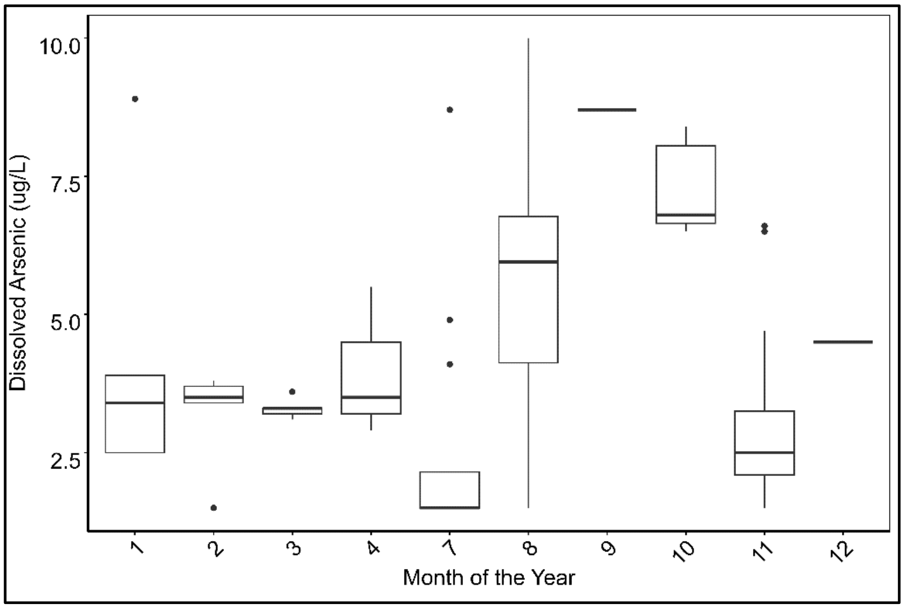

Figure 31. Concentration of dissolved As by month in Lower Big Bug Creek.

Notes: Monitoring locations and years of data collected are averaged for each month. The horizontal line in the middle of the box plot represents the median; the upper and lower limits of the box represent the first and third quartile. All points outside the boxplot are outliers. WQC are not displayed on the graph due to the low concentration of data points. Chronic AWW = 150 µg/L; Acute AWW = 340 µg/L.

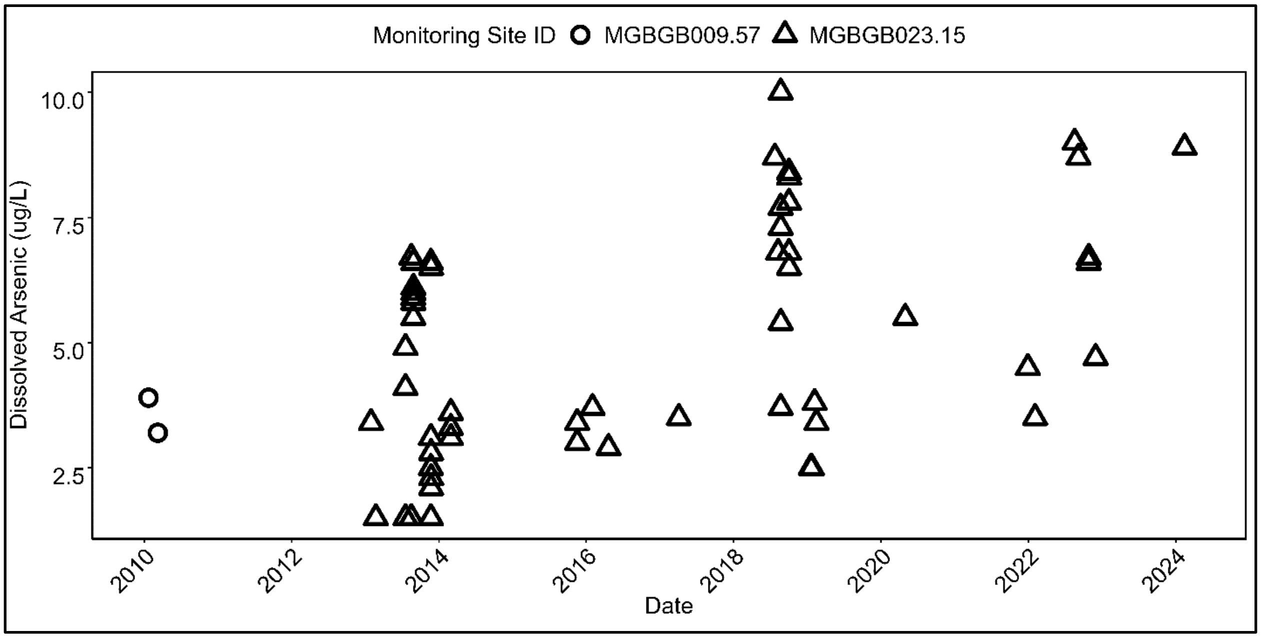

Figure 32. Instantaneous dissolved As concentrations on Lower Big Bug Creek.

Notes: WQC are not displayed on the graph due to the low concentration of data points. Chronic AWW = 150 µg/L; Acute AWW = 340 µg/L. No data were collected on Lower Big Bug Creek prior to 2010.

5.3.1.2.3 Total Cu

Seasonally, the highest concentration of total Cu was observed in July and August (Figure 33). July and August both exceeded the AGL and FBC standards, no exceedances occurred in the other months. Spatially, the most upstream monitoring site (MGBGB023.15) exceeded the FBC standard 9% of the time and the AGL 27% of the time (Figure 34). No exceedances occurred at the downstream monitoring location (MGBGB009.57). However, limited data were collected; therefore, this may not be representative of site conditions.

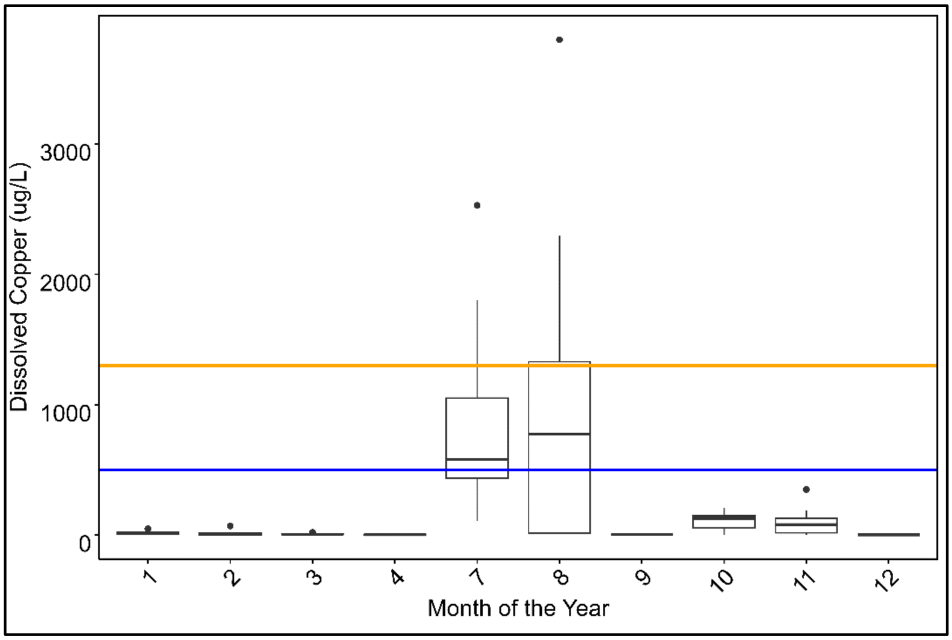

Figure 33. Concentration of total Cu by month in Lower Big Bug Creek.

Notes: Monitoring locations and years of data collected were averaged for each month. The orange horizontal line denotes FBC WQC (1,300 µg/L); blue horizontal line denotes AGL WQC (500 µg/L). The horizontal line in the middle of the box plot represents the median; the upper and lower limits of the box represent the first and third quartile. All points outside the boxplot are outliers.

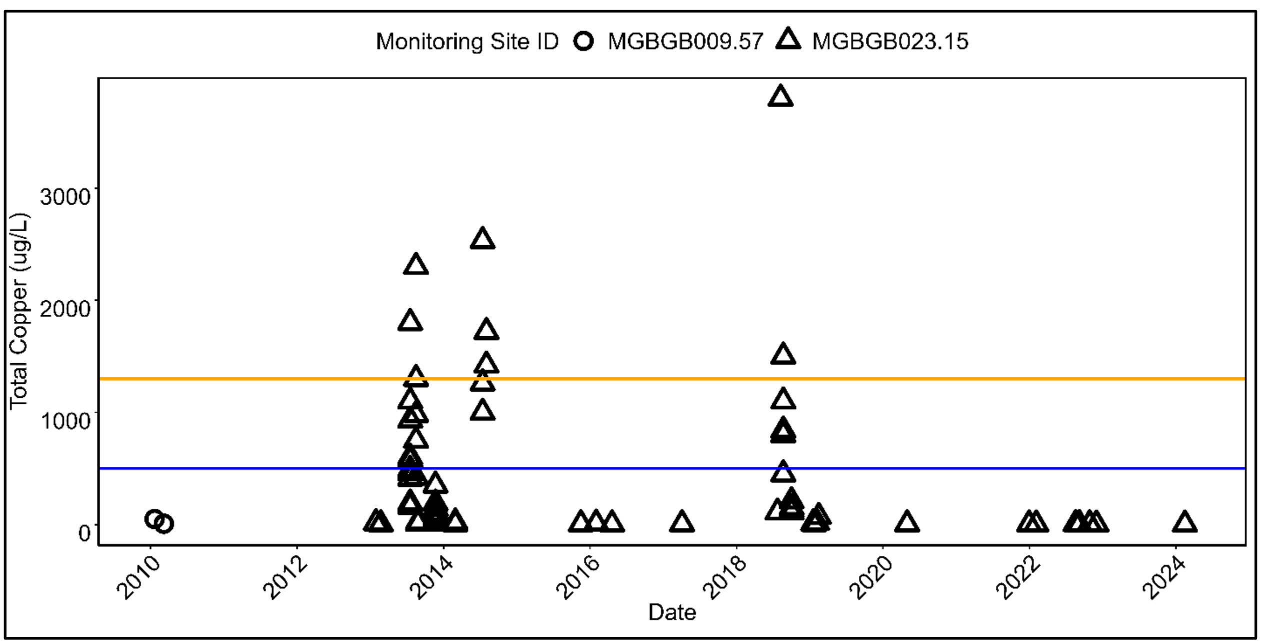

Figure 34. Instantaneous total Cu concentrations over time in Lower Big Bug Creek.

Notes: The orange horizontal line denotes FBC WQC (1,300 µg/L); blue horizontal line denotes AGL WQC (500 µg/L). No data were collected on Lower Big Bug Creek prior to 2010.

5.3.1.2.4 Dissolved Cu

There is no clear seasonal trend of dissolved Cu, however the highest concentrations observed in Lower Big Bug Creek occurred in July and November (Figure 35). Spatially, the upstream monitoring site (MGBGB023.15) exceeded the acute standard 12% of the time and the chronic standard 25% of the time (Figures 36–37). The downstream monitoring location (MGBGB009.57) exceeded the chronic standard 50% of the time but did not exceed the acute standard.

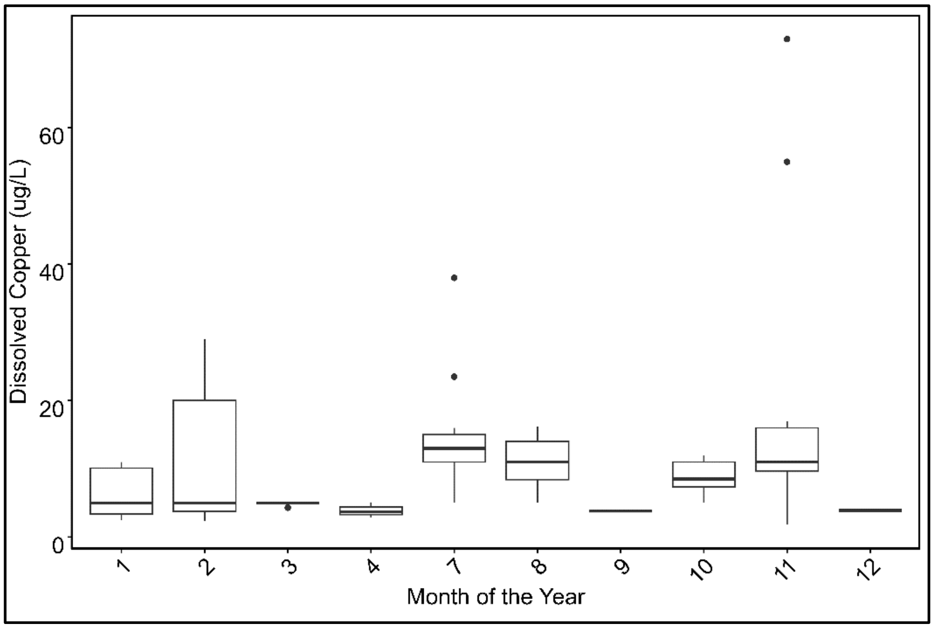

Figure 35. Concentration of dissolved Cu by month in Lower Big Bug Creek.

Notes: Monitoring locations and years of data collected were averaged for each month. The horizontal line in the middle of the box plot represents the median; the upper and lower limits of the box represent the first and third quartile. All points outside the boxplot are outliers.

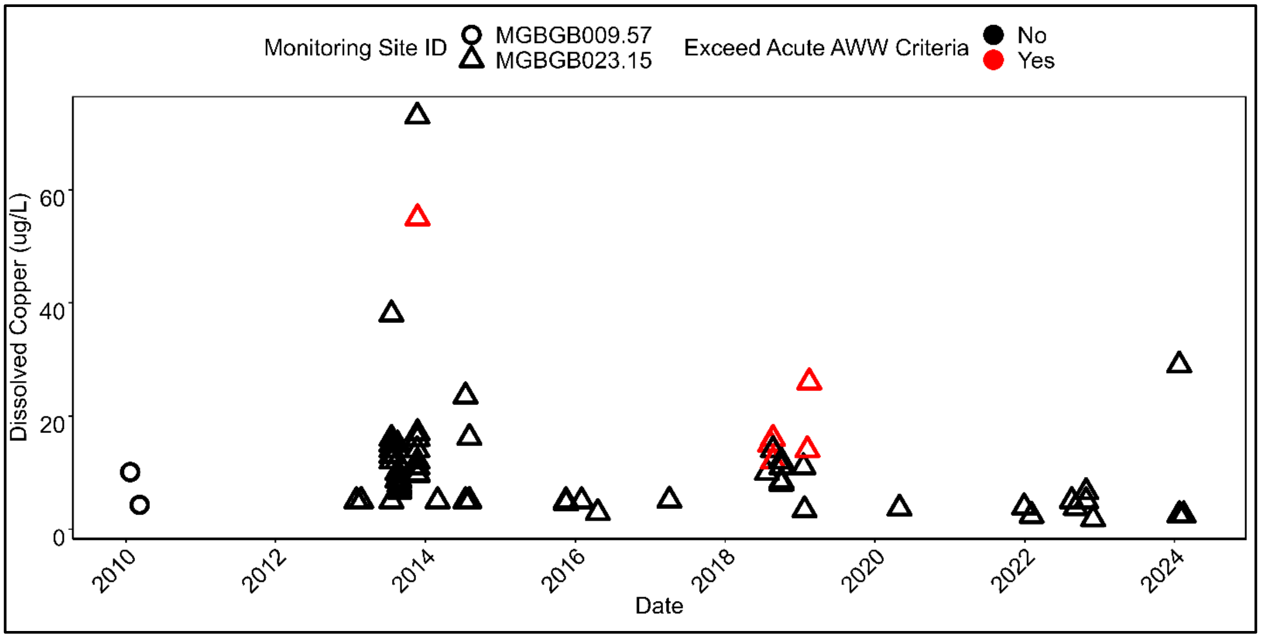

Figure 36. Instantaneous dissolved Cu concentrations over time in Lower Big Bug Creek (acute WQC).

Notes: WQC are hardness dependent; points in red indicate exceedance. No data were collected on Lower Big Bug Creek prior to 2010.

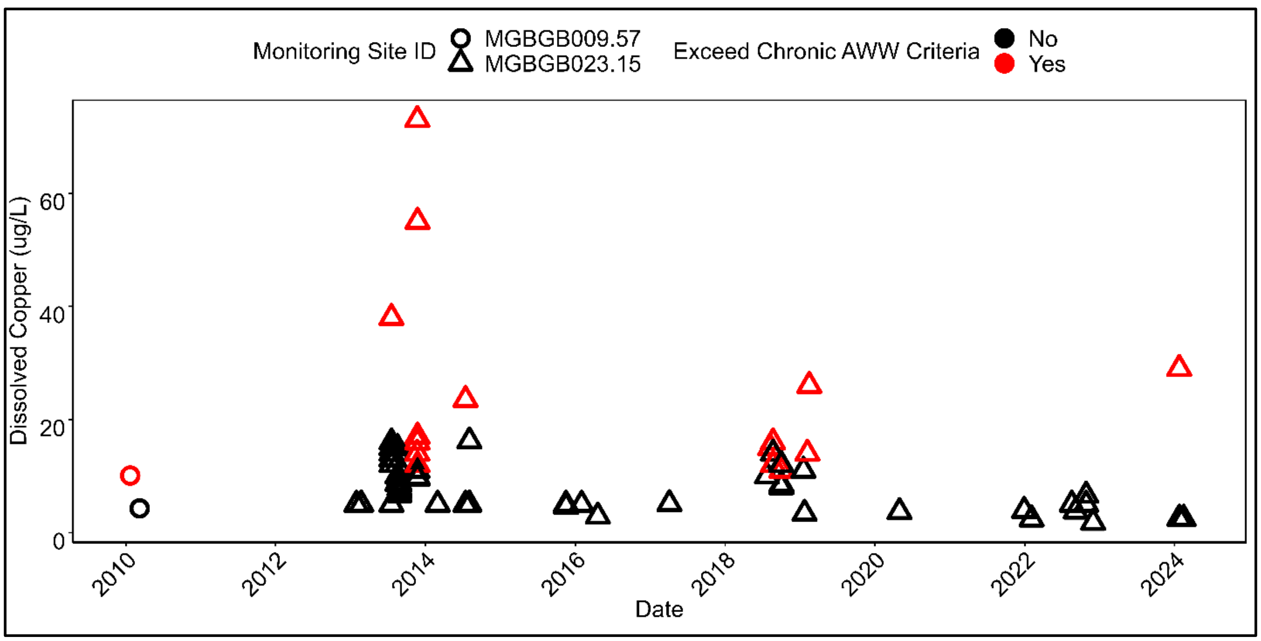

Figure 37. Instantaneous dissolved Cu concentrations over time in Lower Big Bug Creek (chronic WQC).

Notes: WQC are hardness dependent; points in red indicate exceedance. No data were collected on Lower Big Bug Creek prior to 2010.

5.3.1.2.5 Total Pb

Seasonally, the highest concentration of total Pb in Lower Big Bug Creek was observed in July and August (Figure 38). Pb concentrations exceeded the AGL and FBC standard in July and August, and the FBC standard in February, October, and November. Spatially, the most upstream monitoring site (MGBGB023.15) exceeded the FBC standard 52% of the time and the AGL 29% of the time (Figure 39). The downstream monitoring location (MGBGB009.57) exceeded the FBC 50% of the time.

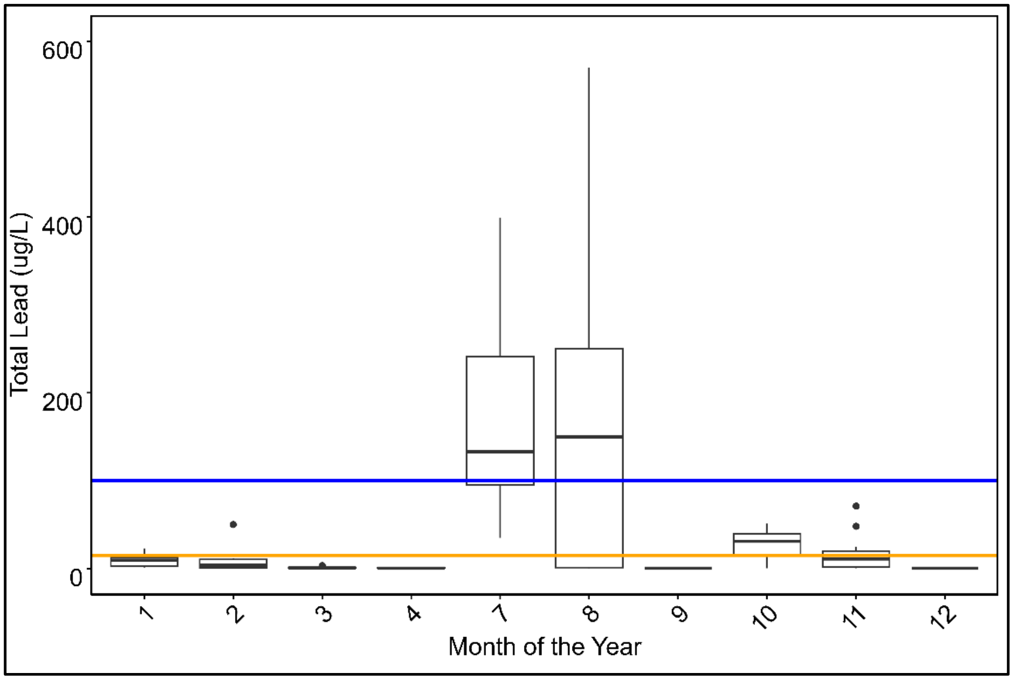

Figure 38. Concentration of total Pb by month in Lower Big Bug Creek.

Notes: Monitoring locations and years of data collected were averaged for each month. The orange horizontal line denotes FBC WQC (15 µg/L); blue horizontal line denotes AGL WQC (100 µg/L). The horizontal line in the middle of the box plot represents the median; the upper and lower limits of the box represent the first and third quartile. All points outside the boxplot are outliers. One outlier (1,400.00 µg/L) recorded in August (Month of the Year = 8) recorded at site MGBGB023.15 was removed from the graph for visual clarity.

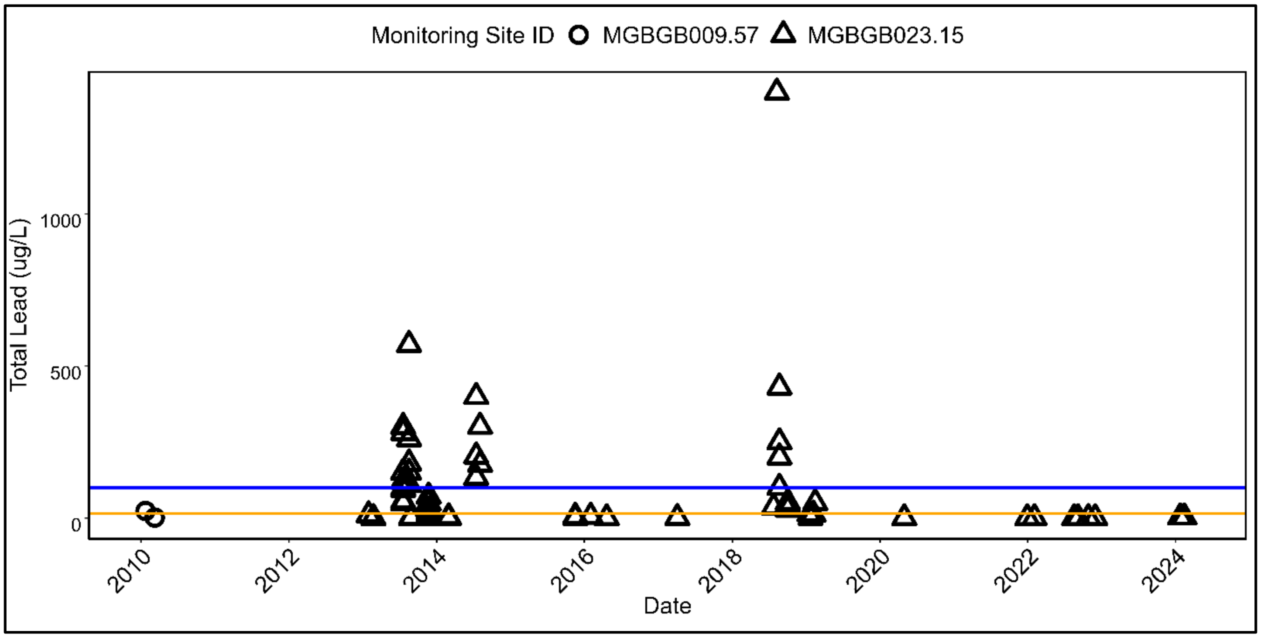

Figure 39. Instantaneous total Pb concentrations over time in Lower Big Bug Creek.

Notes: The orange horizontal line denotes FBC WQC (15 µg/L); blue horizontal line denotes AGL WQC (100 µg/L). No data were collected on Lower Big Bug Creek prior to 2010.

5.3.1.2.6 Dissolved Pb

There is no clear seasonal trend for dissolved Pb, however higher concentrations have consistently been observed in January and February (Figure 40). Spatially, there were no acute standard exceedances (Figure 41). The upstream monitoring site (MGBGB023.15) exceeded the chronic standard 12% of the time (Figure 42).

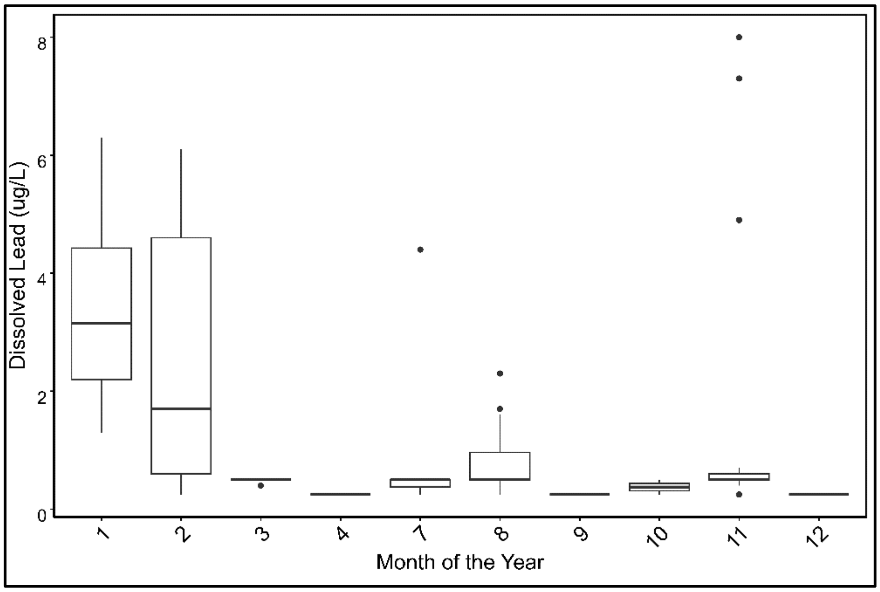

Figure 40. Concentration of dissolved Pb by month in Lower Big Bug Creek.

Notes: Monitoring locations and years of data collected were averaged for each month. The horizontal line in the middle of the box plot represents the median; the upper and lower limits of the box represent the first and third quartile. All points outside the boxplot are outliers.

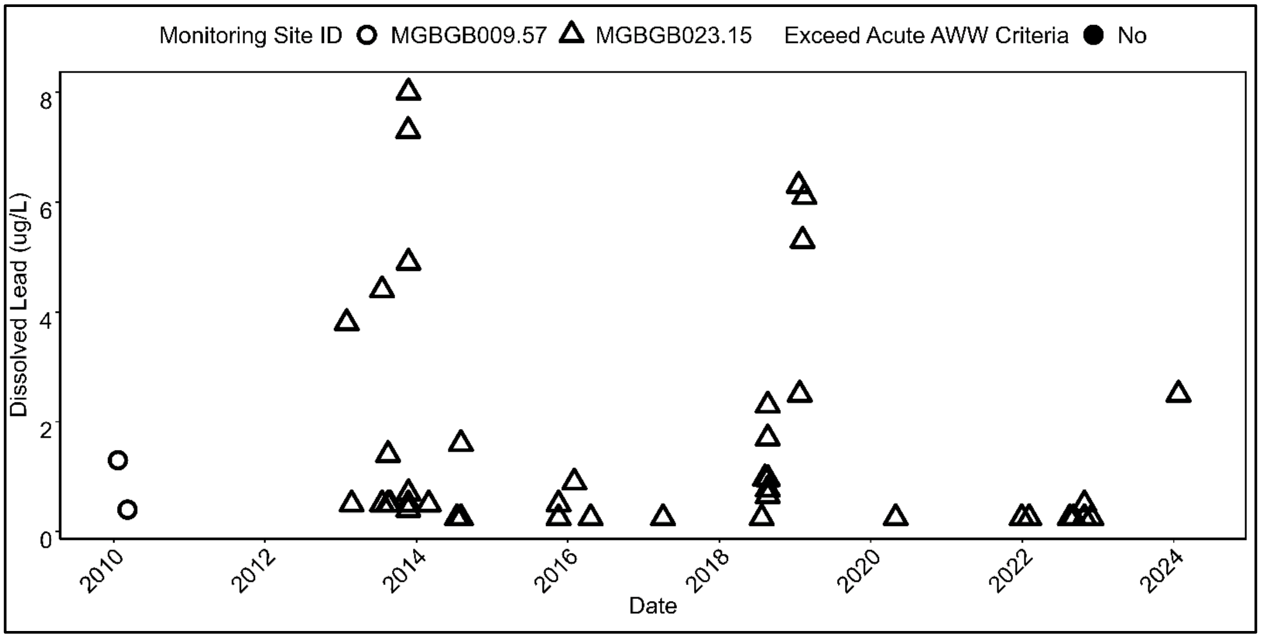

Figure 41. Instantaneous dissolved Pb concentrations over time in Lower Big Bug Creek (acute WQC).

Notes: WQC are hardness dependent; there were no exceedances detected. No data were collected on Lower Big Bug Creek prior to 2010.

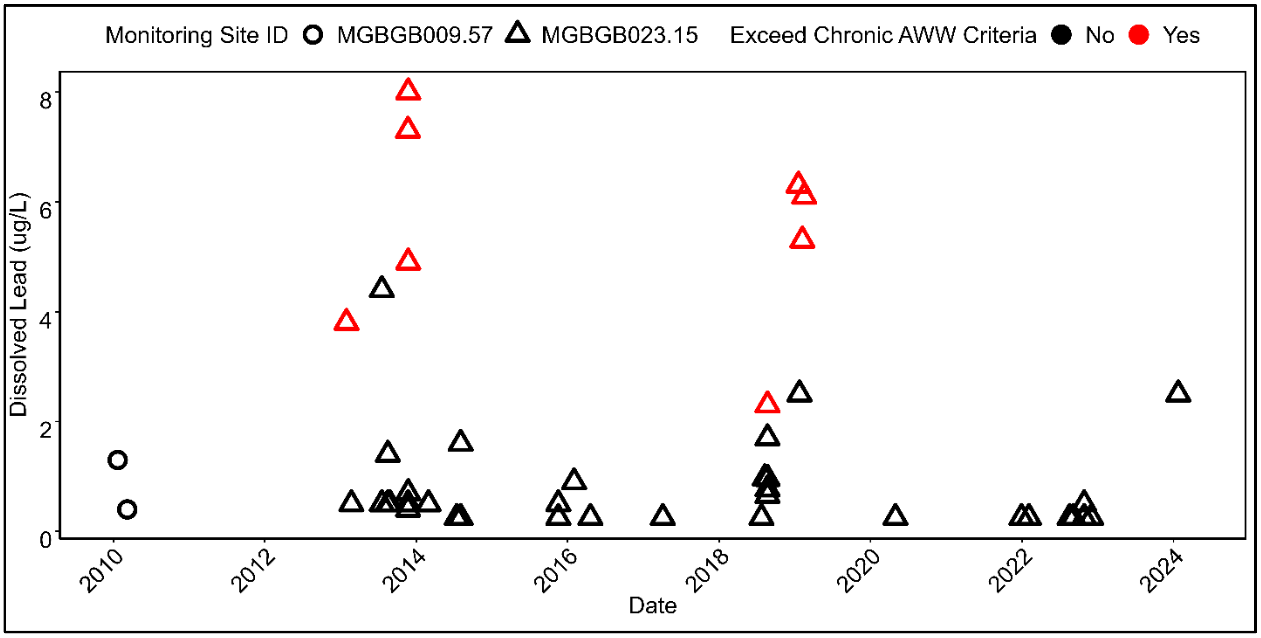

Figure 42. Instantaneous dissolved Pb concentrations over time in Lower Big Bug Creek (chronic WQC).

Notes: WQC are hardness dependent; points in red indicate exceedance. No data were collected on Lower Big Bug Creek prior to 2010.

5.3.1.3 UNNAMED TRIBUTARY TO BIG BUG CREEK (15070102-134)

The unnamed tributary to Big Bug Creek is impaired for dissolved Cu and Pb for AWE. There is one monitoring site along the reach with water quality data ranging from 2010 to 2024 (see Table 12).

5.3.1.3.1 Dissolved Cu

Seasonally, the highest concentrations of dissolved Cu were observed in January (Figure 43). Very few samples have been collected on this reach, representing only four months of the year, therefore seasonal trends are not able to be distinguished. All samples exceeded the AWE (Figure 44).

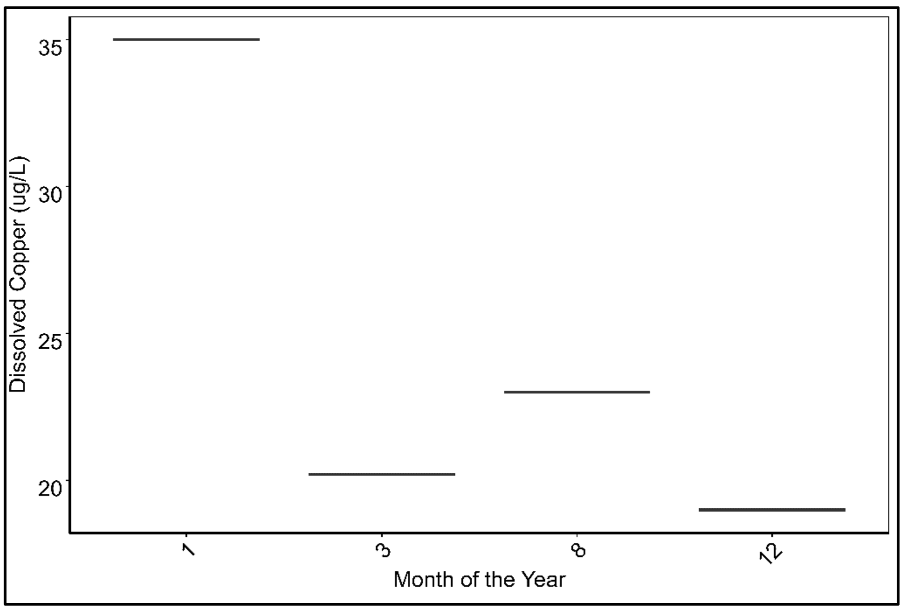

Figure 43. Concentration of dissolved Cu by month in unnamed tributary to Big Bug Creek.

Notes: Monitoring locations and years of data collected were averaged for each month. The horizontal line in the middle of the box plot represents the median; the upper and lower limits of the box represent the first and third quartile. All points outside the boxplot are outliers.

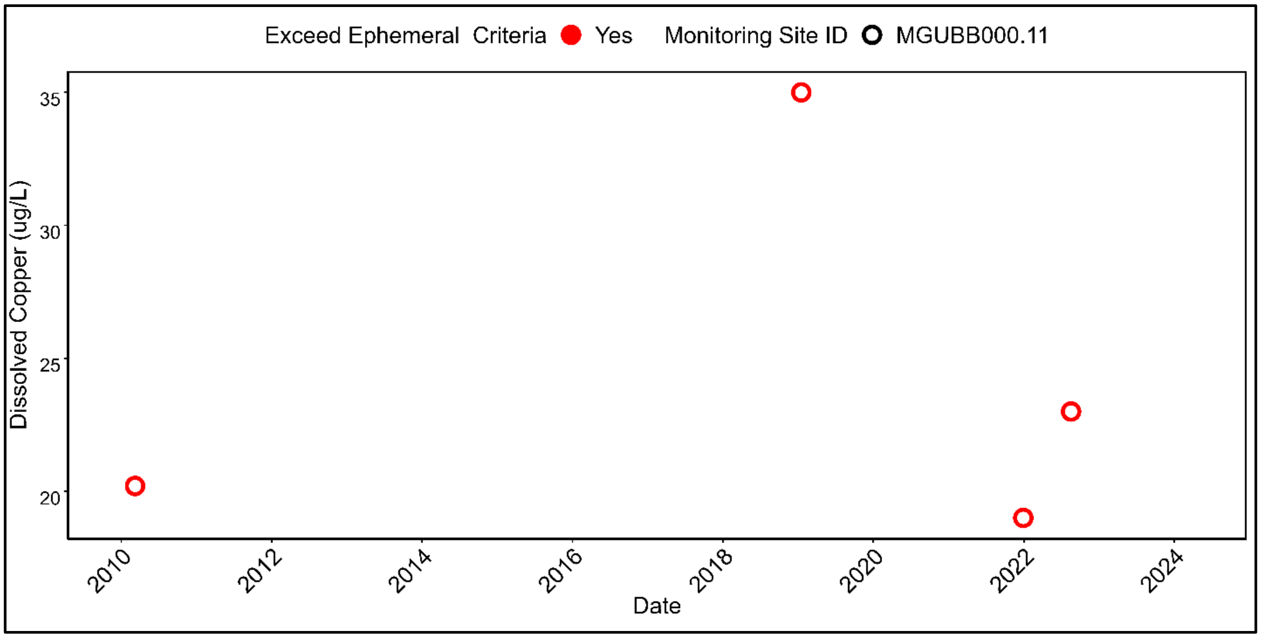

Figure 44. Instantaneous dissolved Cu concentrations over time in unnamed tributary to Big Bug Creek (acute aquatic and wildlife ephemeral WQC).

Notes: WQC are hardness dependent; points in red indicate exceedance. No data were collected on unnamed tributary to Big Bug Creek prior to 2010.

5.3.1.3.2 Dissolved Pb

Seasonally, the highest concentrations of dissolved Pb were observed in January (Figure 45). Very few samples have been collected on this reach, representing only five months of the year, therefore seasonal trends are not able to be distinguished. All samples exceeded the AWE (Figure 46).

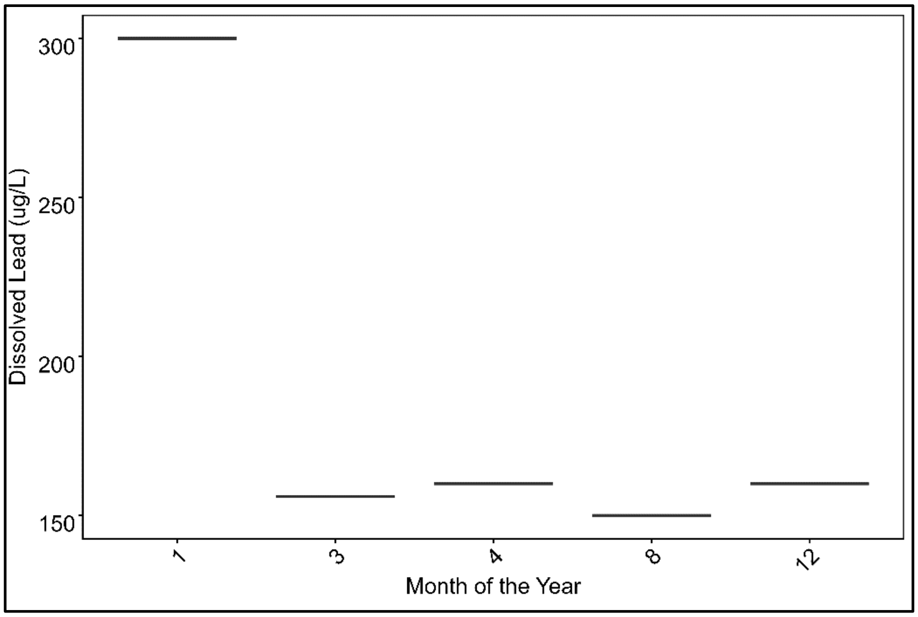

Figure 45. Concentration of dissolved Pb by month in unnamed tributary to Big Bug Creek.

Notes: Monitoring locations and years of data collected are averaged for each month. The horizontal line in the middle of the box plot represents the median; the upper and lower limits of the box represent the first and third quartile. All points outside the boxplot are outliers.

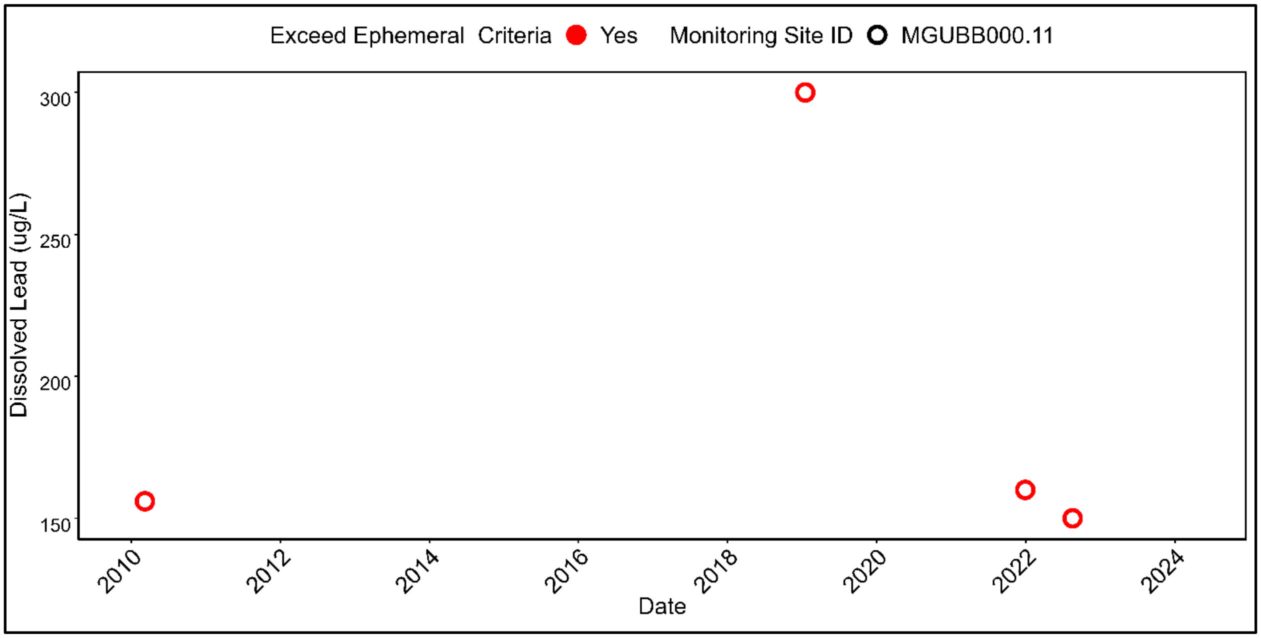

Figure 46. Instantaneous dissolved Pb concentrations over time in unnamed tributary to Big Bug Creek (acute aquatic and wildlife ephemeral WQC).

Notes: WQC are hardness dependent; points in red indicate exceedance. No data were collected on unnamed tributary to Big Bug Creek prior to 2010.

5.3.1.4 UNNAMED TRIBUTARY TO BIG BUG CREEK (UB1) (15070102-234)

The unnamed tributary to Big Bug Creek (UB1) is impaired for dissolved Cu and Cd for acute and chronic AWC. There is one monitoring site along the reach with water quality data ranging from 2010 to 2024 (see Table 12).

5.3.1.4.1 Dissolved Cu

The highest concentrations of dissolved Cu in the unnamed tributary to Big Bug Creek (UB1) were observed in January and February, with the lowest concentrations in November and December (Figure 47). Most months only have one data point (n=1) so these trends may not be representative of reach conditions. Cu concentrations exceeded the acute and chronic standard frequently, i.e., 44% of the sampled times (Figures 48–49).

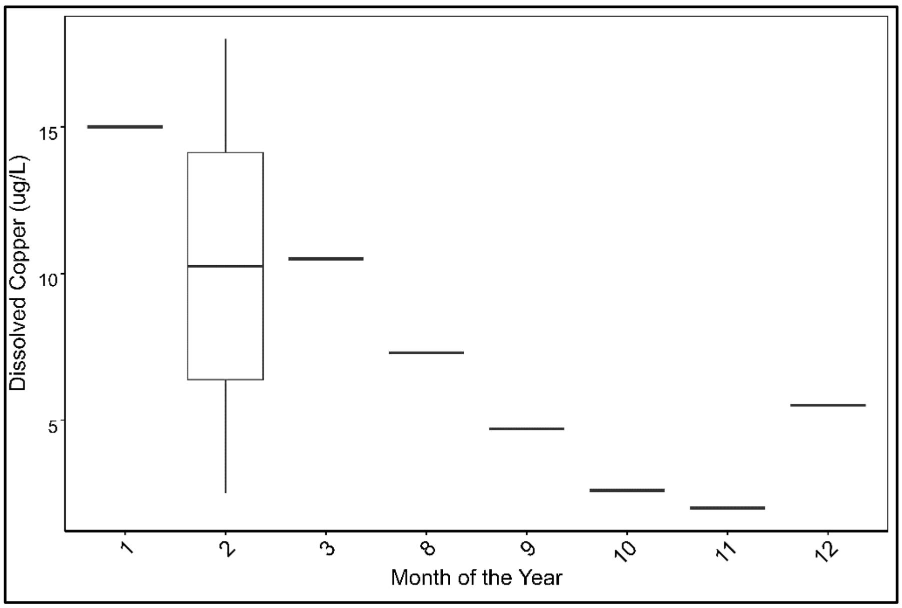

Figure 47. Concentration of dissolved Cu by month in unnamed tributary to Big Bug Creek (UB1).

Notes: Monitoring locations and years of data collected were averaged for each month. The horizontal line in the middle of the box plot represents the median; the upper and lower limits of the box represent the first and third quartile. All points outside the boxplot are outliers.

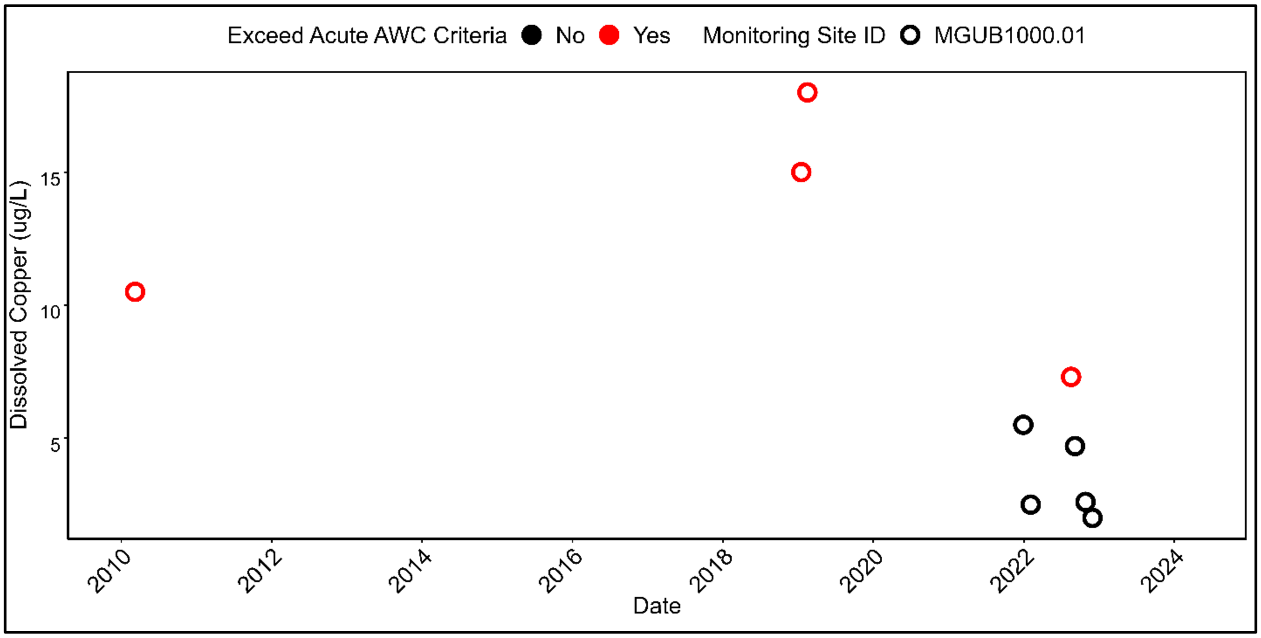

Figure 48. Instantaneous dissolved Cu concentrations over time in unnamed tributary to Big Bug Creek (UB1) (acute WQC).

Notes: WQC are hardness dependent; points in red indicate exceedance. No data were collected on unnamed tributary to Big Bug Creek (UB1) prior to 2010.

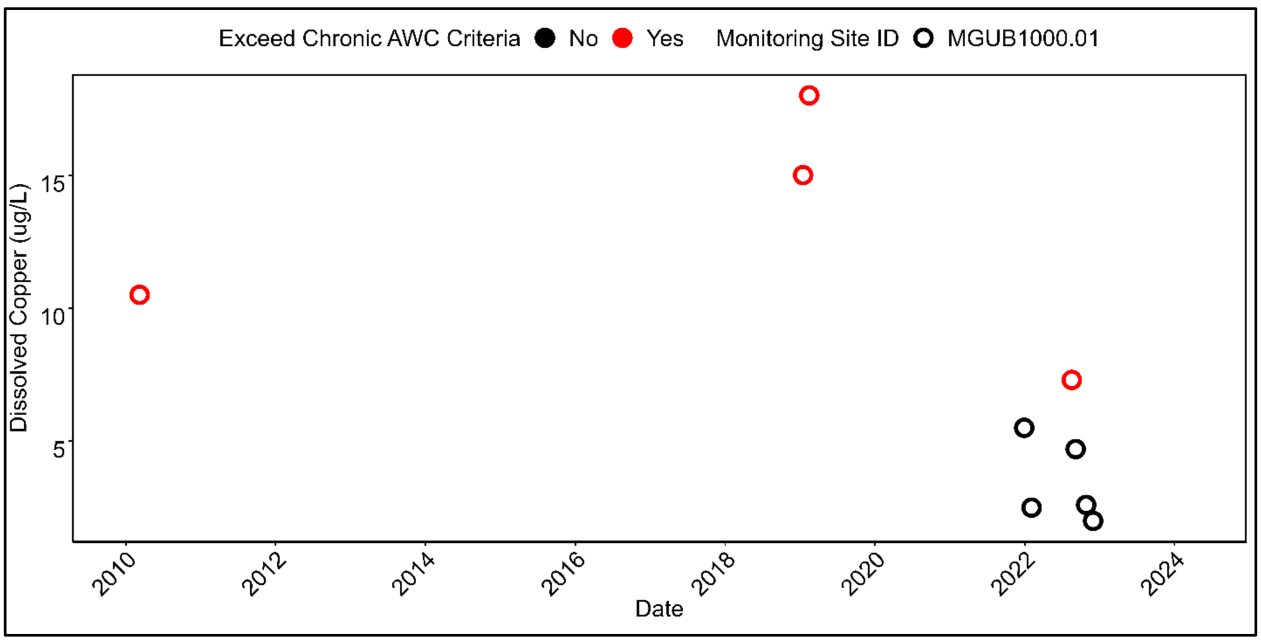

Figure 49. Instantaneous dissolved Cu concentrations over time in unnamed tributary to Big Bug Creek (UB1) (chronic WQC).

Notes: WQC are hardness dependent; points in red indicate exceedance. No data were collected on unnamed tributary to Big Bug Creek (UB1) prior to 2010.

5.3.1.4.2 Dissolved Cd

Seasonally, the highest concentrations of dissolved Cd in the unnamed tributary to Big Bug Creek were observed in February, March, and August, with the lowest concentrations observed in October through January (Figure 50). Most months only have one data point (n=1) so these trends may not be representative of actual conditions. Cd concentrations exceeded acute and chronic AWE frequently, 20% and 60% of the sampled times, respectively (Figures 51–52).

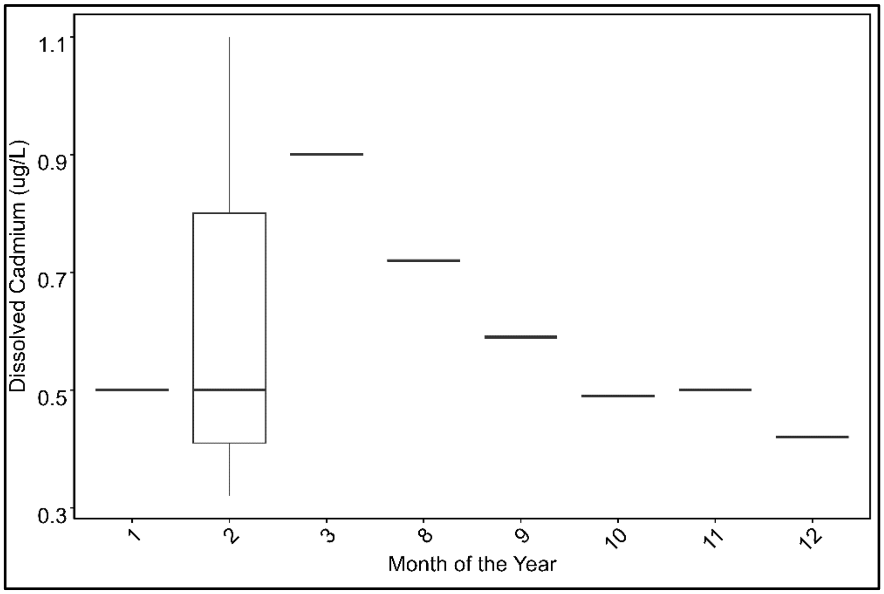

Figure 50. Concentration of dissolved Cd by month in unnamed tributary to Big Bug Creek (UB1).

Notes: Monitoring locations and years of data collected were averaged for each month. The horizontal line in the middle of the box plot represents the median; the upper and lower limits of the box represent the first and third quartile. All points outside the boxplot are outliers.

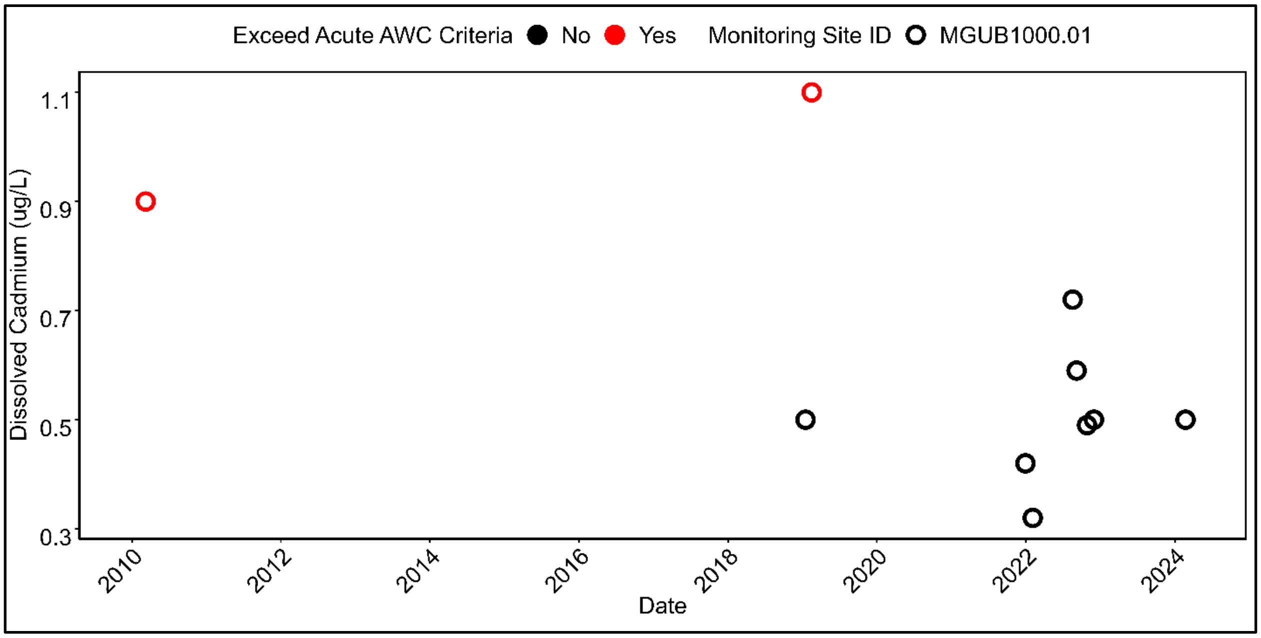

Figure 51. Instantaneous dissolved Cd concentrations over time in unnamed tributary to Big Bug Creek (UB1) (acute WQC).

Notes: WQC are hardness dependent; points in red indicate exceedance. No data were collected on unnamed tributary to Big Bug Creek (UB1) prior to 2010.

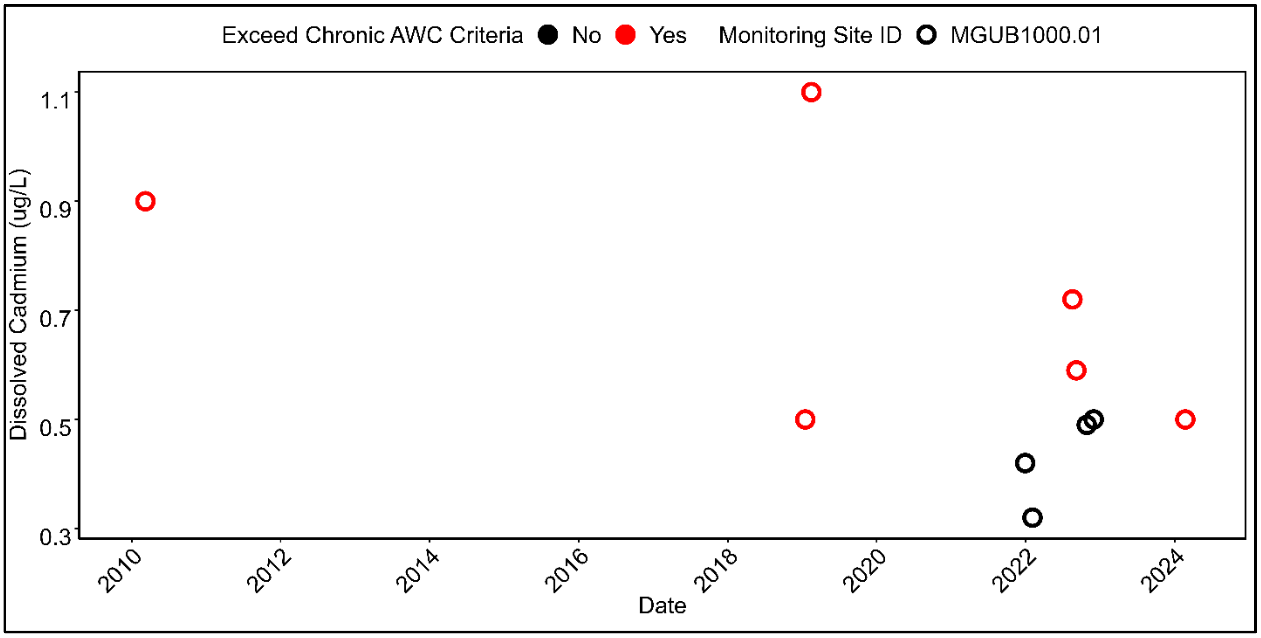

Figure 52. Instantaneous dissolved Cd concentrations over time in unnamed tributary to Big Bug Creek (UB1) (chronic WQC).

Notes: WQC are hardness dependent; points in red indicate exceedance. No data were collected on unnamed tributary to Big Bug Creek (UB1) prior to 2010.

5.3.1.5 UNNAMED TRIBUTARY TO EUGENE GULCH (15070102-1994)

The unnamed tributary to Eugene Gulch is impaired for dissolved Cu for AWE. There is one monitoring site along the reach with water quality data ranging from 2013 to 2023 (see Table 12).

5.3.1.5.1 Dissolved Cu

The concentrations of dissolved Cu varied across months (Figure 53). Many months had no data (January, February, May, June, October, and December), and a couple of months had limited data points. Therefore, seasonal trends were difficult to distinguish. Cu concentrations exceeded the acute AWE on every sampling event (Figure 54). Paired hardness concentrations at this site range from 44 to 250 milligrams per liter (mg/L), resulting in acute criteria for dissolved Cu between 5 and 37 µg/L. Exceedances are attributed to elevated dissolved Cu concentrations within this reach, with an average of 234 µg/L.

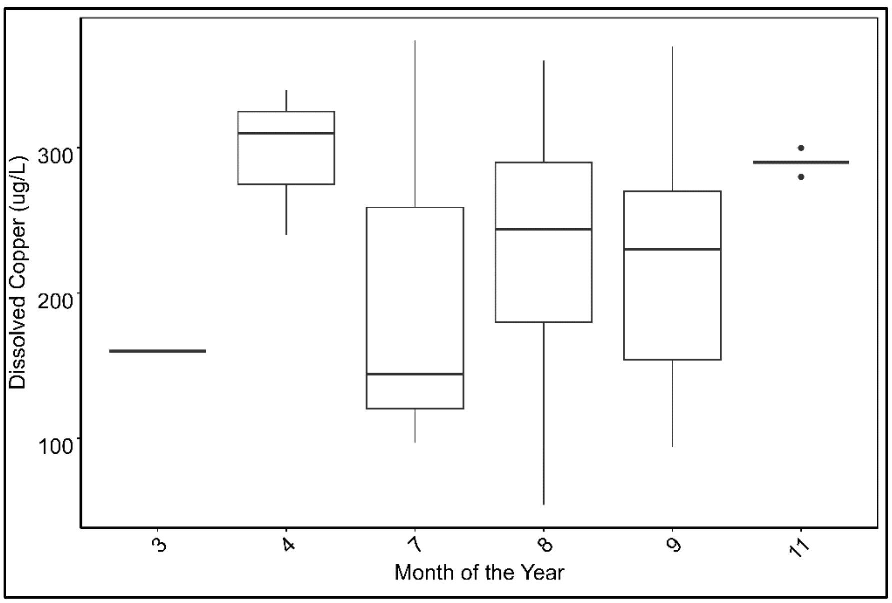

Figure 53. Concentration of dissolved Cu by month in unnamed tributary to Eugene Gulch.

Notes: Monitoring locations and years of data collected were averaged for each month. The horizontal line in the middle of the box plot represents the median; the upper and lower limits of the box represent the first and third quartile. All points outside the boxplot are outliers.

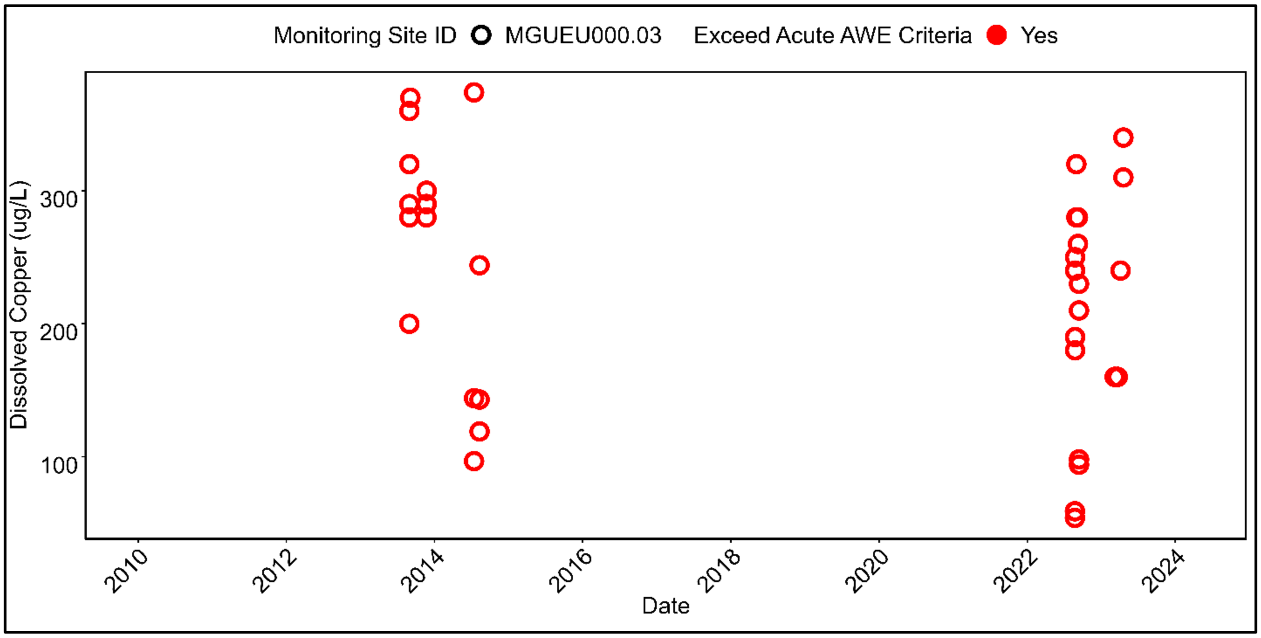

Figure 54. Instantaneous dissolved Cu concentrations over time in unnamed tributary to Eugene Gulch (acute ephemeral WQC).

Notes: WQC are hardness dependent; points in red indicate exceedance. No data were collected on Eugene Gulch prior to 2014.

5.3.1.6 EUGENE GULCH (15070102-768)

Eugene Gulch is impaired for dissolved Cu for acute AWE. There are three monitoring sites along the reach with water quality data ranging from 2010 to 2023 (see Table 12).

5.3.1.6.1 Dissolved Cu

The highest concentrations of dissolved Cu observed in Eugene Gulch were in the months of August and September (Figure 55). Overall, there was no distinct trend, and some months had no data (January, May, June, November, and December). Therefore, seasonal trends were difficult to distinguish. Spatially, Cu concentrations exceeded the acute ephemeral standard frequently, with the most exceedances, approximately 83%, occurring at the monitoring site in the middle of the reach, and the least downstream of that reach (29%) (Figure 56).

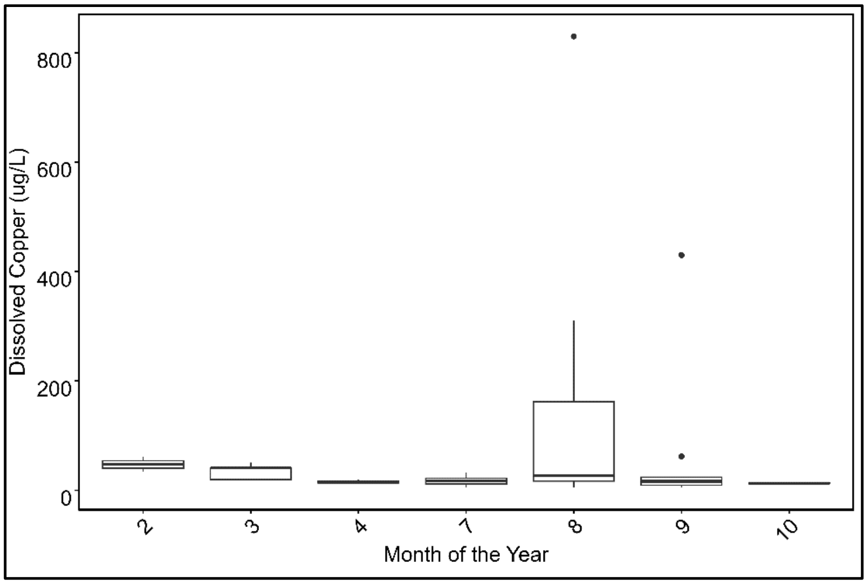

Figure 55. Concentration of dissolved Cu by month in Eugene Gulch.

Notes: Monitoring locations and years of data collected were averaged for each month. The horizontal line in the middle of the box plot represents the median; the upper and lower limits of the box represent the first and third quartile. All points outside the boxplot are outliers.

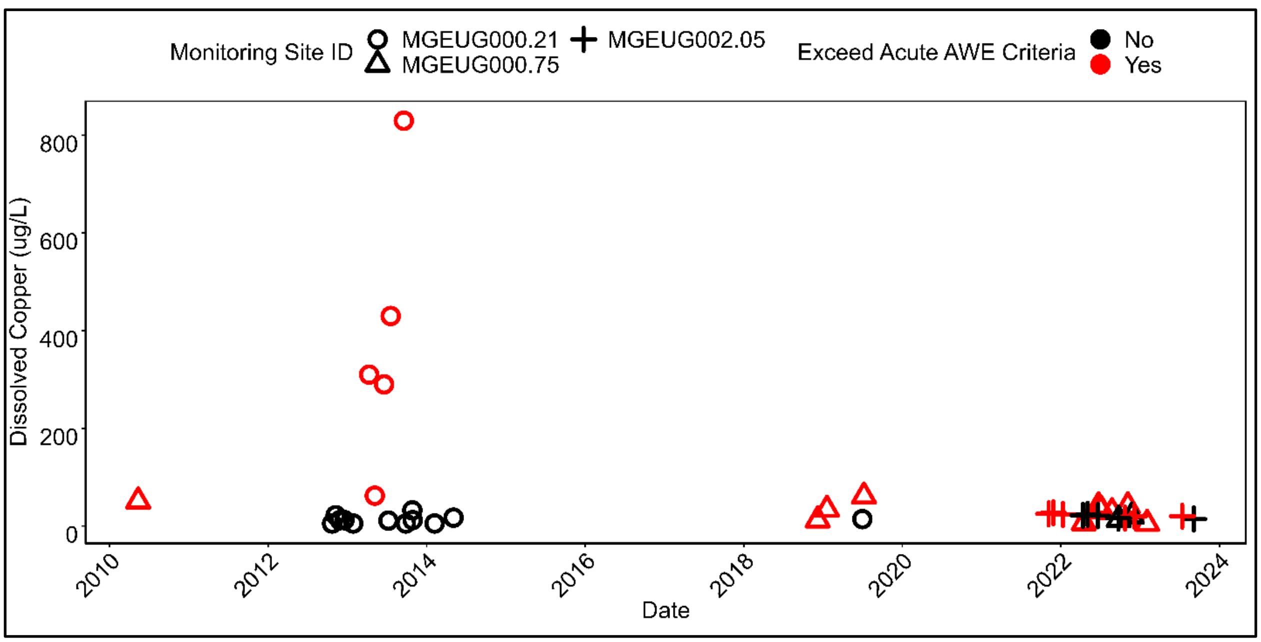

Figure 56. Instantaneous dissolved Cu concentrations over time in Eugene Gulch (acute ephemeral WQC).

Notes: WQC are hardness dependent; points in red indicate exceedance. No data were collected on Eugene Gulch prior to 2010.

5.3.1.7 MONEY METALS TRIBUTARY (15070102-123)

Money Metals tributary is impaired for dissolved Cu and Zn for acute AWE. There are two monitoring sites along the reach with water quality data ranging from 2013 to 2024 (see Table 12).

5.3.1.7.1 Dissolved Cu

The highest concentrations of dissolved Cu observed in Money Metals tributary were in the months of July and August, with lower concentrations in the winter (January through March) (Figure 57). Many months had no data (April, May, June, November, and December); therefore, seasonal trends were difficult to distinguish. Cu concentrations exceeded the acute AWE standard frequently, with the most exceedances, approximately 88%, occurring at the downstream monitoring site, with 25% of exceedances occurring upstream (Figure 58).

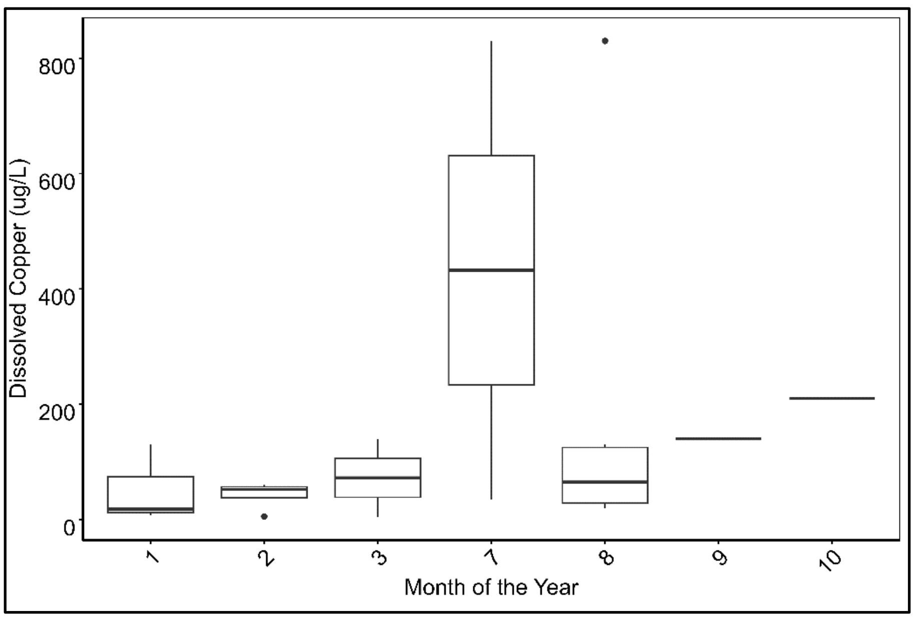

Figure 57. Concentration of dissolved Cu by month in Money Metals tributary.

Notes: Monitoring locations and years of data collected were averaged for each month. The horizontal line in the middle of the box plot represents the median; the upper and lower limits of the box represent the first and third quartile. All points outside the boxplot are outliers.

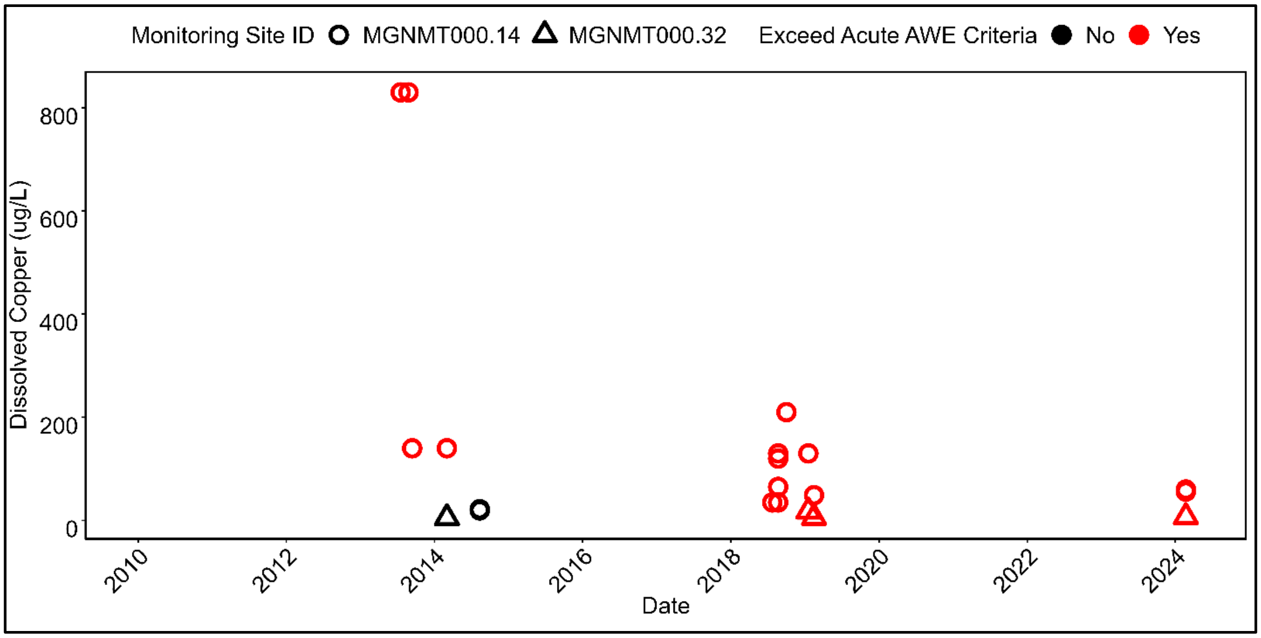

Figure 58. Instantaneous dissolved Cu concentrations over time in Money Metals tributary (acute ephemeral WQC).

Notes: WQC are hardness dependent; points in red indicate exceedance. No data were collected on Money Metals tributary prior to 2010.

5.3.1.7.2 Dissolved Zn

The highest concentrations of dissolved Zn observed in Money Metals tributary were in the months of July and August, with lower concentrations in the winter (January through March) (Figure 59). Many months had no data (April, May, June, November, and December); therefore, seasonal trends were difficult to distinguish. Spatially, Zn concentrations exceeded the acute AWE standard frequently (approximately 88% of the time) at the downstream monitoring site (MGNMT000.14). There were no exceedances occurring at the upstream site (MGNMT000.32) (Figure 60).

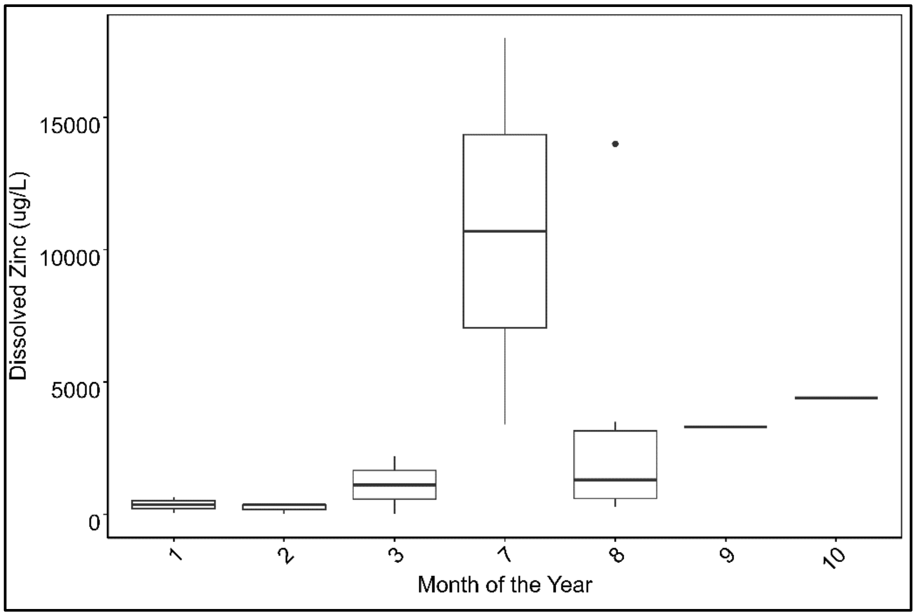

Figure 59. Concentration of dissolved Zn by month in Money Metals tributary.

Notes: Monitoring locations and years of data collected were averaged for each month. The horizontal line in the middle of the box plot represents the median; the upper and lower limits of the box represent the first and third quartile. All points outside the boxplot are outliers.

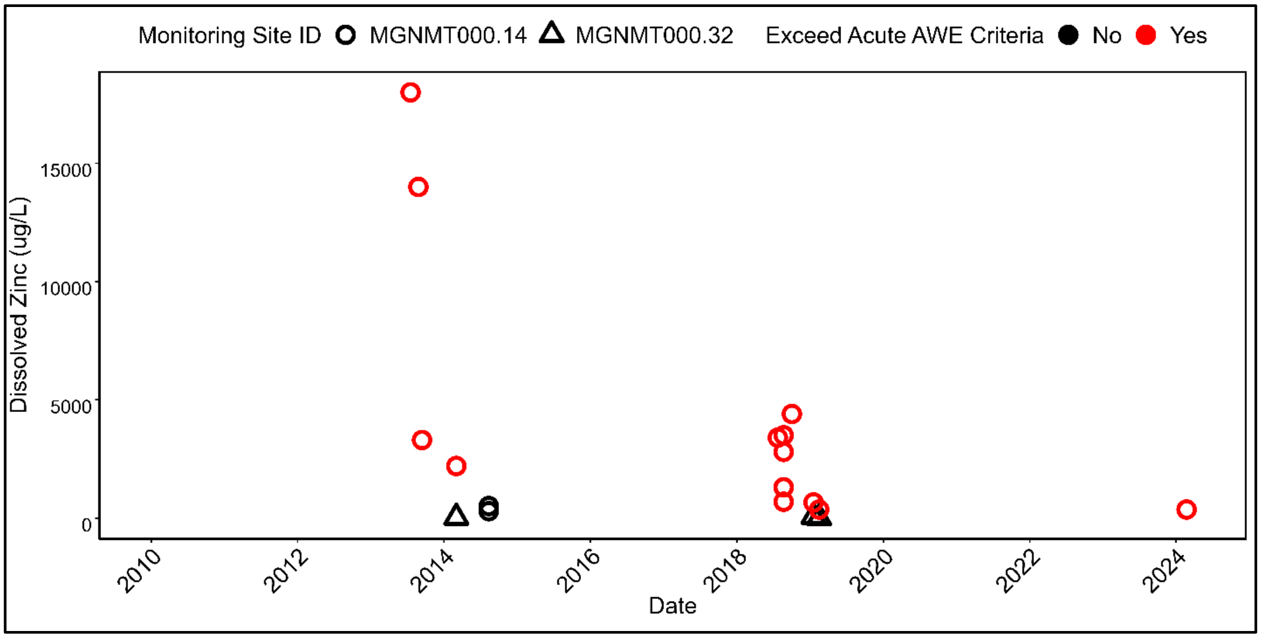

Figure 60. Instantaneous dissolved Zn concentrations over time in Money Metals tributary (acute ephemeral WQC).

Notes: WQC are hardness dependent; points in red indicate exceedance.

5.3.2 Flow

In the Upper Agua Fria Watershed, most of Big Bug Creek is classified as intermittent. There is one flow gage located along Big Bug Creek with a record of flow data collected during the period of interest (Table 13). Additionally, there are 15 ADEQ monitoring locations on Big Bug Creek with flow data that have been collected during the period of interest (Figure 9).

Table 13. Summary of Flow Data Available on Big Bug Creek.

Gage Operator	Gage Identifier	Period of Record	Sample Size
Yavapai	3705 - Big Bug Creek @ SR 69 Radar Stage	07/14/2017–04/26/2024	2,439
ADEQ	MGAFR102.69	2023–2024	2
ADEQ	MGBGB009.57	2010–2010	4
ADEQ	MGBGB023.15	2013–2024	31
ADEQ	MGBGB024.41	2018–2019	2
ADEQ	MGBGB025.76	2018–2022	2
ADEQ	MGBGB026.90	2018–2022	9
ADEQ	MGBGB027.21	2017–2020	5
ADEQ	MGBGB027.37	2017–2019	4

Gage Operator	Gage Identifier	Period of Record	Sample Size
ADEQ	MGBGB027.93	2019–2019	1
ADEQ	MGBGB028.27	2010–2022	11
ADEQ	MGUB2000.02	2019–2019	2

5.3.2.1 YAVAPAI GAGES

There is one flow gage located on Big Bug Creek, owned and operated by the Yavapai County Flood Control District (see Table 13). Gage 3705 is located near the town of Mayer downstream of the confluence with Grapevine Creek, and upstream of the confluence with Hackberry Creek. This gage has been operating since 2017 and has 2,439 measurements of flow on the Upper Agua Fria River. Data from this site indicate that the highest flows occur during July and August and the lowest flows occur in October (Figures 61–62).

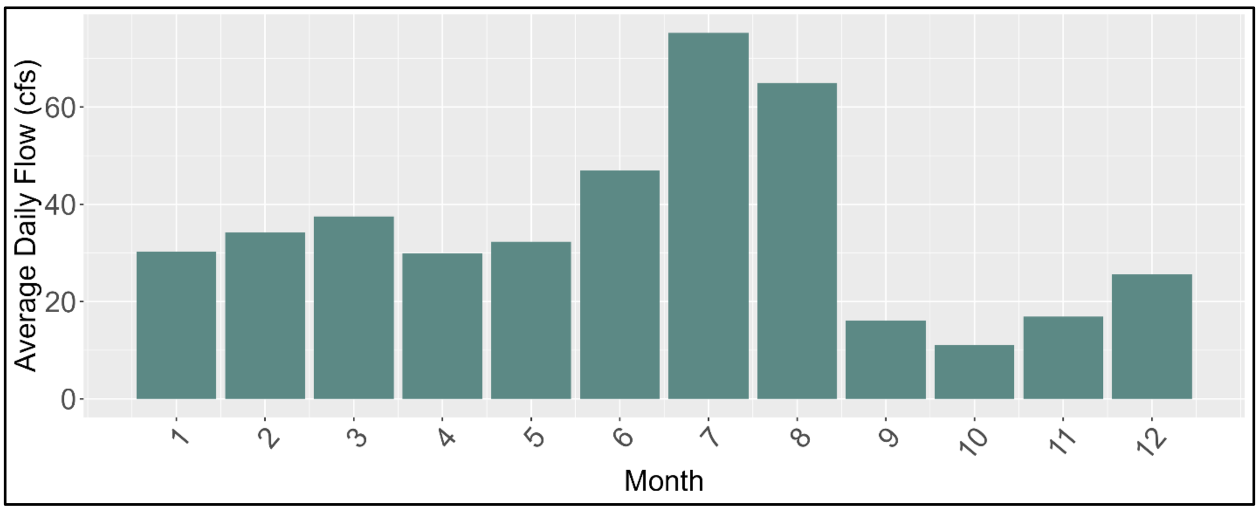

Figure 61. Average daily flow per month on Yavapai Gage 3705 - Big Bug Creek at SR 69 Radar Stage (2017–2024).

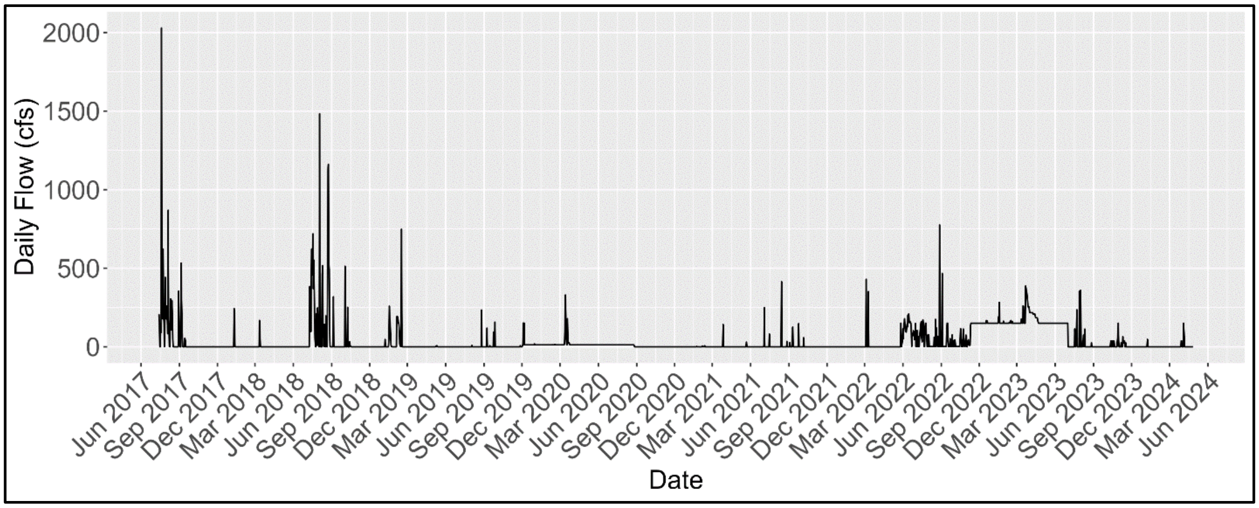

Figure 62. Average daily flow per month on Yavapai Gage 3705 - Big Bug Creek at SR 69 Radar Stage (2017–2024).

5.3.2.2 ADEQ MONITORING LOCATIONS

ADEQ collects water quality and flow data at monitoring locations throughout the Upper Agua Fria Watershed. On Big Bug Creek, there are 11 Monitoring Sites where measurements of flow have been collected. The flow data collected at monitoring locations on Big Bug Creek are summarized in Table 14.

Table 14. Summary of ADEQ Monitoring Locations Flow Data on Big Bug Creek.

Monitoring Site	Water body	Flow Measurement Count	Min Flow (cfs)	Min Flow Month	Max Flow (cfs)	Max Flow Month	Period of Record
MGBGB000.02	Big Bug Creek	2	3	November	5.10	February	2023–2024
MGBGB009.57	Big Bug Creek	4	25.8	March	65.35	January	2010–2010
MGBGB023.15	Big Bug Creek	31	0	August	21.20	February	2013–2024
MGBGB024.41	Big Bug Creek	2	0.01	December	46.29	February	2018–2019

Monitoring Site	Water body	Flow Measurement Count	Min Flow (cfs)	Min Flow Month	Max Flow (cfs)	Max Flow Month	Period of Record
MGBGB025.76	Big Bug Creek	2	0.11	December	0.37	March	2018–2022
MGBGB026.90	Big Bug Creek	9	0.09	February	0.38	August	2018–2022
MGBGB027.21	Big Bug Creek	5	0.02	June	14.70	February	2017–2020
MGBGB027.37	Big Bug Creek	4	0.01	June	14.70	February	2017–2019
MGBGB027.93	Big Bug Creek	1	5.3	February	5.30	February	2019–2019
MGBGB028.27	Big Bug Creek	11	0.008	October	4.62	February	2010–2022
MGUB2000.02	Big Bug Creek	2	7.9	January	14.97	February	2019–2019

5.3.3 Data Gaps

For water quality, six of the 20 monitoring sites in Big Bug Creek had limited data (n<5), and three sites had no hardness data (MGBGB025.79, MGBGB026.57, MGBGB027.31). Therefore, the standards could not be calculated. Ideally, data would be collected monthly at least once per IR assessment period. In addition, higher spatial resolution of the impaired waterbody is recommended with the establishment of monitoring locations at the top and bottom of the reach and continued collection at those sites where data are already present.

For flow data, the presence of one Yavapai gage along the river was helpful for calculating pollutant loads; however, this impairment could also benefit from flow data collection at sites where water quality data are present. Although there were some ADEQ monitoring locations with flow data collected, some sites only had one instance of flow data. A close examination of matched pairs of flow and water quality data was conducted as a part of the technical approach.

5.4 Lynx Creek Subwatershed

5.4.1 Water Quality

There are two impaired waterbodies in Lynx Creek (Table 15; Figure 63). A detailed analysis of spatial and temporal trends is provided below for each impairment in each waterbody.

Table 15. Lynx Creek Data Summary.

Subwatershed	WBID	Monitoring Site	Parameter	Year	Sample Size	Average (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Percent Exceedance
Lynx Creek	15070102-033A	MGLNX013.41	Dissolved Cd	1992–1993	1	0.005	0.005	0.005	0%
			Dissolved Cu	1992–1993	1	30.00	30.00	30.00	100% acute and chronic
			Dissolved Zn	1992–1993	1	43.00	43.00	43.00	0%
		MGLNX014.17	Dissolved Cd	2019	1	0.05	0.05	0.05	0%
			Dissolved Cu	2019	1	1.20	1.20	1.20	0%
			Dissolved Zn	2019	1	6.50	6.50	6.50	0%
		MGLNX017.42	Dissolved Cd	2019	2	5.25	2.30	8.20	50% acute 100% chronic
			Dissolved Cu	2019	2	26.00	23.00	29.00	50% acute 50% chronic
			Dissolved Zn	2019	2	300.00	140.00	460.00	0% acute 50% chronic
		MGLNX018.75	Dissolved Cd	2019	1	2.40	2.40	2.40	100%
			Dissolved Cu	2019	1	60.00	60.00	60.00	100%
			Dissolved Zn	2019	1	68.00	68.00	68.00	0%
		MGLNX018.81	Dissolved Cd	2010, 2016, 2017, 2019	8	12.20	2.00	40.00	75% acute 100% chronic

Subwatershed	WBID	Monitoring Site	Parameter	Year	Sample Size	Average (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Percent Exceedance
Lynx Creek	150701 02-033A	MGLNX018.81	Dissolved Cu	2010, 2016, 2017, 2019	8	33.45	11.00	75.60	25% acute 38% chronic
			Dissolved Zn	2010, 2016, 2017, 2019	8	1,292.37	79.00	3,900.00	88% acute and chronic
		MGLNX019.96	Dissolved Cd	2019	4	5.53	0.05	11.00	50% acute and chronic
			Dissolved Cu	2019	4	159.35	8.70	310.00	100% acute and chronic
			Dissolved Zn	2019	4	128.25	6.50	250.00	50% acute and chronic
		MGLNX011.05	Dissolved Cd	2024	1	ND	ND	ND	–
			Dissolved Cu	2024	1	4.2	4.2	4.2	0%
			Dissolved Zn	2024	1	ND	ND	ND	–
		MGLNX007.58	Dissolved Cd	2024	1	ND	ND	ND	–
			Dissolved Cu	2024	1	ND	ND	ND	–
			Dissolved Zn	2024	1	ND	ND	ND	–
		MGLNX007.33	Dissolved Cd	2024	1	ND	ND	ND	–
			Dissolved Cu	2024	1	1.8	1.8	1.8	0%
			Dissolved Zn	2024	1	ND	ND	ND	–
Unnamed tributary to Lynx	150701 02-124	MGULN000.11	Dissolved Cu	2001, 2019	2	308.50	32.00	585.00	50% acute 100% chronic
		MGULN000.16	Dissolved Cu	2001	1	826.00	826.00	826.00	100% acute and chronic

Subwatershed	WBID	Monitoring Site	Parameter	Year	Sample Size	Average (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Percent Exceedance
Unnamed tributary to Lynx	15070102-124	MGULN000.23	Dissolved Cu	2001, 2019	4	2,727.25	51.00	9,700.00	100% acute and chronic

Note: ND = non-detect.

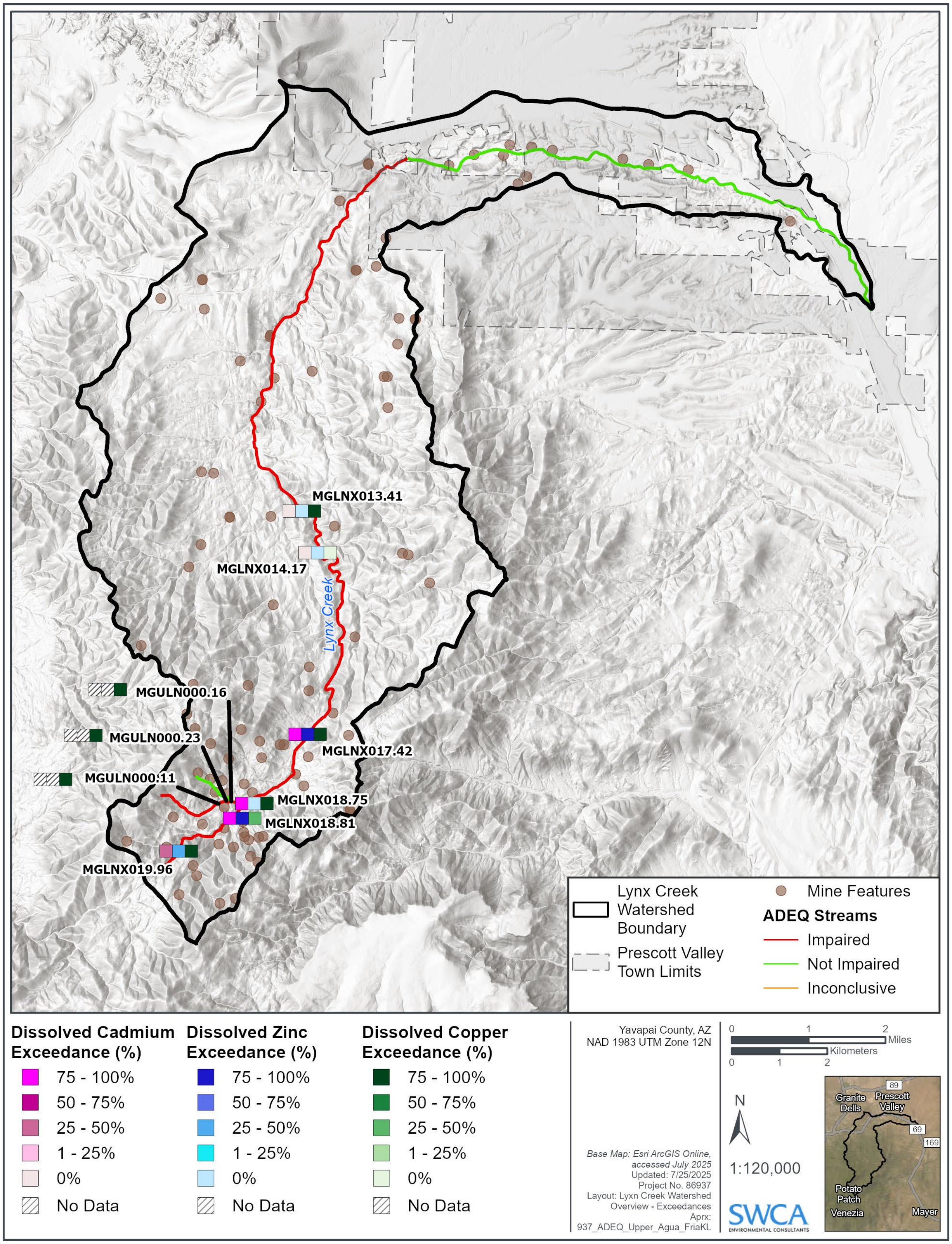

Figure 63. Pollutant sources and percent exceedance in Lynx Creek.

5.4.1.1 LYNX CREEK (15070102-033A)

Lynx Creek is impaired for dissolved Cd, Cu, and Zn for acute and chronic AWC. There are 12 monitoring sites along the reach with water quality data ranging from 1992 to 2024 (see Table 15). Five of the sites exceed the Cu standard, four of the sites exceed the Cd standard, and three of the sites exceed the Zn standard.

5.4.1.1.1 Dissolved Cd

The highest concentrations of dissolved Cd observed in Lynx Creek were in the months of April, May, and June (Figure 64). Many months had no data (February, July, September, October, and December), and many months had limited data (n=1). Therefore, seasonal trends were difficult to distinguish. Cd concentrations exceeded the acute and chronic standards frequently, 60% and 81% across all monitoring sites, respectively (Figures 65–66). Spatially, the most exceedances and highest concentrations of Cd were observed at the most upstream monitoring sites (MGLNX019.96, MGLNX018.81), and no exceedances occurred in the most downstream monitoring sites (MGLNX014.17, MGLNX013.41).

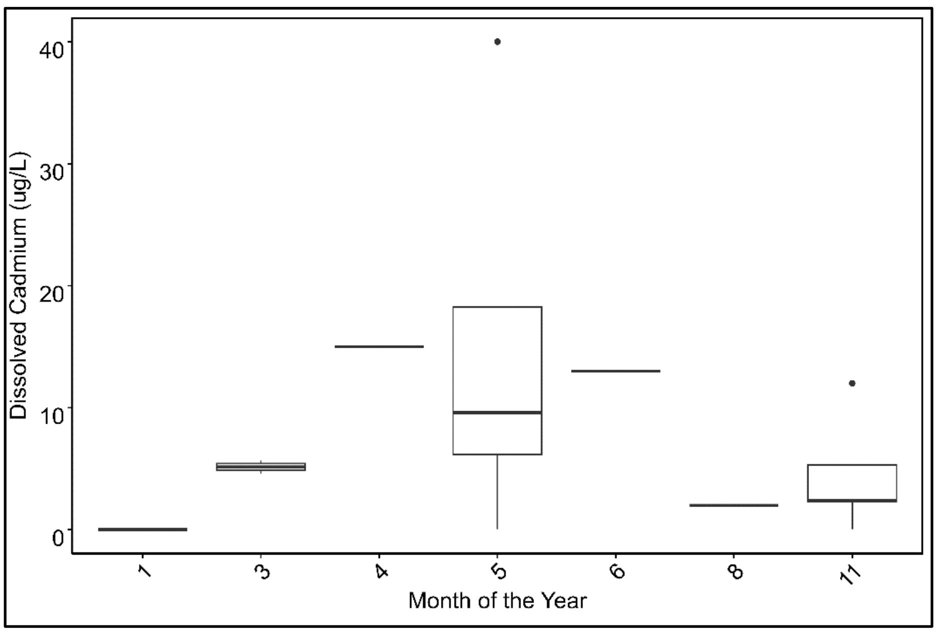

Figure 64. Concentration of dissolved Cd by month in Lynx Creek.

Notes: Monitoring locations and years of data collected were averaged for each month. The horizontal line in the middle of the box plot represents the median; the upper and lower limits of the box represent the first and third quartile. All points outside the boxplot are outliers.

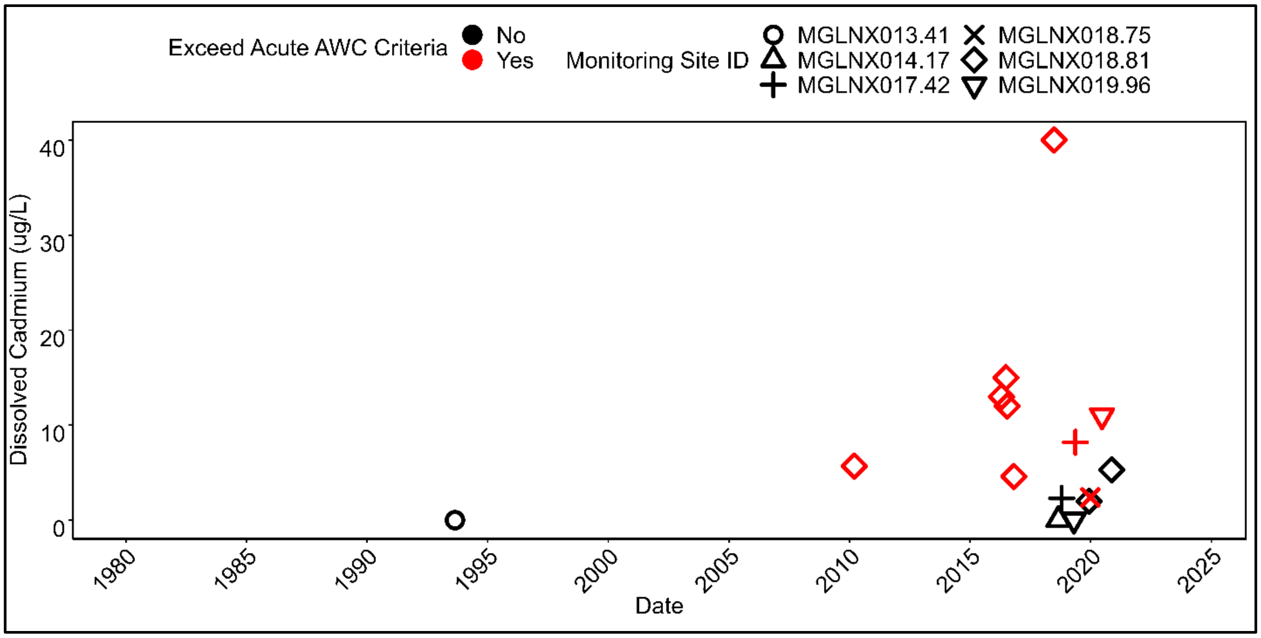

Figure 65. Instantaneous dissolved Cd concentrations over time in Lynx Creek (acute WQC).
Notes: WQC are hardness dependent; points in red indicate exceedance.

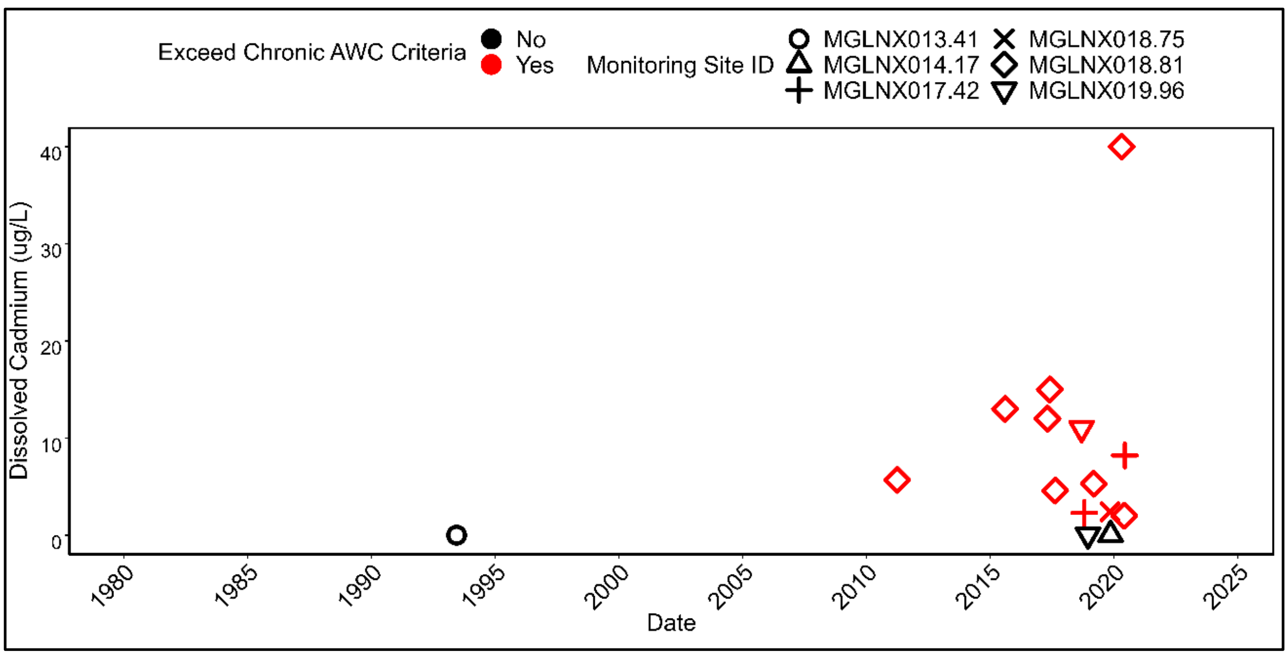

Figure 66. Instantaneous dissolved Cd concentrations over time in Lynx Creek (chronic WQC).
Notes: WQC are hardness dependent; points in red indicate exceedance.

5.4.1.1.2 Dissolved Cu

The highest concentration of dissolved Cu observed in Lynx Creek was in the month of May (Figure 67). Many months had no data (February, July, September, October, and December), and many months had limited data (n=1). Therefore, seasonal trends are difficult to distinguish. Cu concentrations exceeded the acute and chronic standard frequently, 47% and 53%, respectively, across all monitoring sites (Figures 68–69). Like Cd, the most exceedances and highest concentrations of Cd were observed at the upstream monitoring sites (MGLNX019.96, MGLNX018.81). Exceedances occurred at all monitoring sites along the reach.

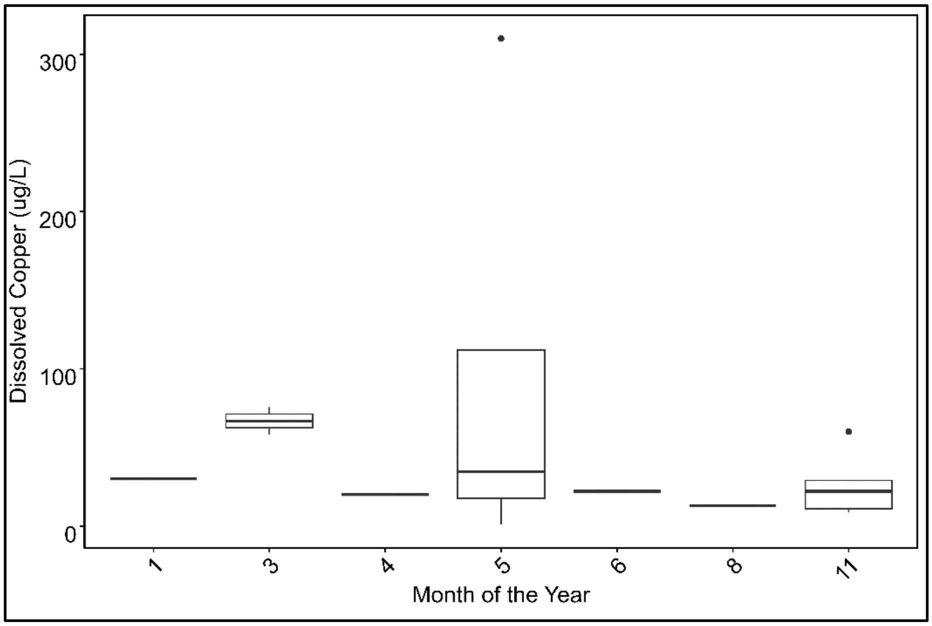

Figure 67. Concentration of dissolved Cu by month in Lynx Creek.

Notes: Monitoring locations and years of data collected were averaged for each month. The horizontal line in the middle of the box plot represents the median; the upper and lower limits of the box represent the first and third quartile. All points outside the boxplot are outliers.

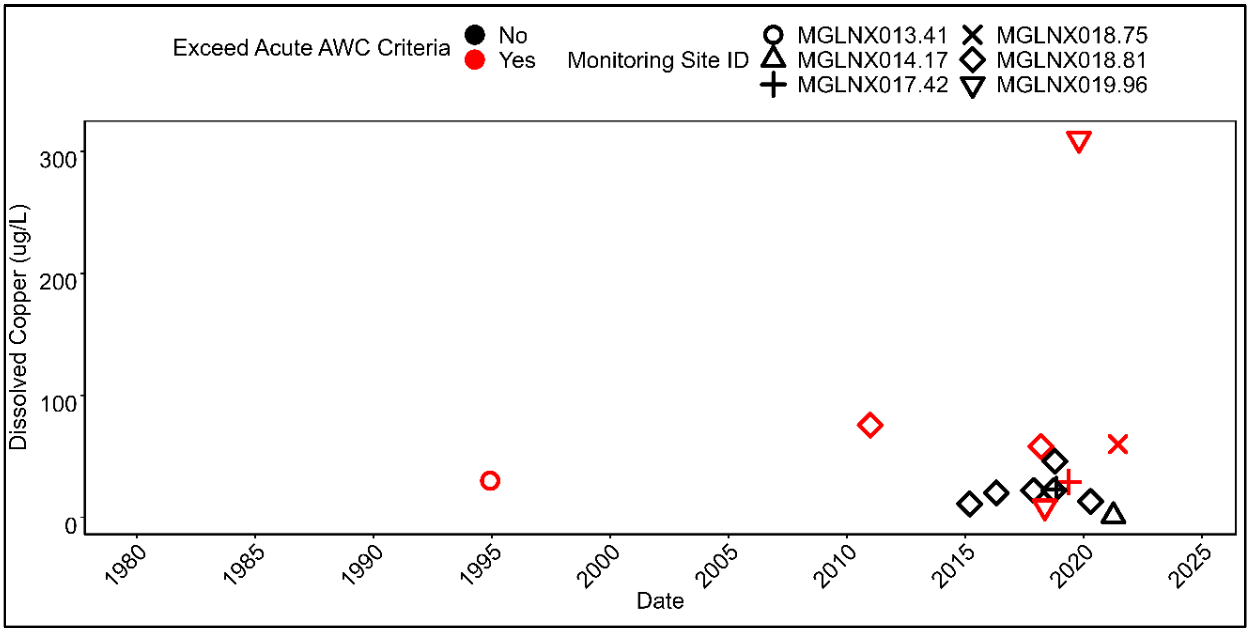

Figure 68. Instantaneous dissolved Cu concentrations over time in Lynx Creek (acute WQC).
Notes: WQC are hardness dependent; points in red indicate exceedance.

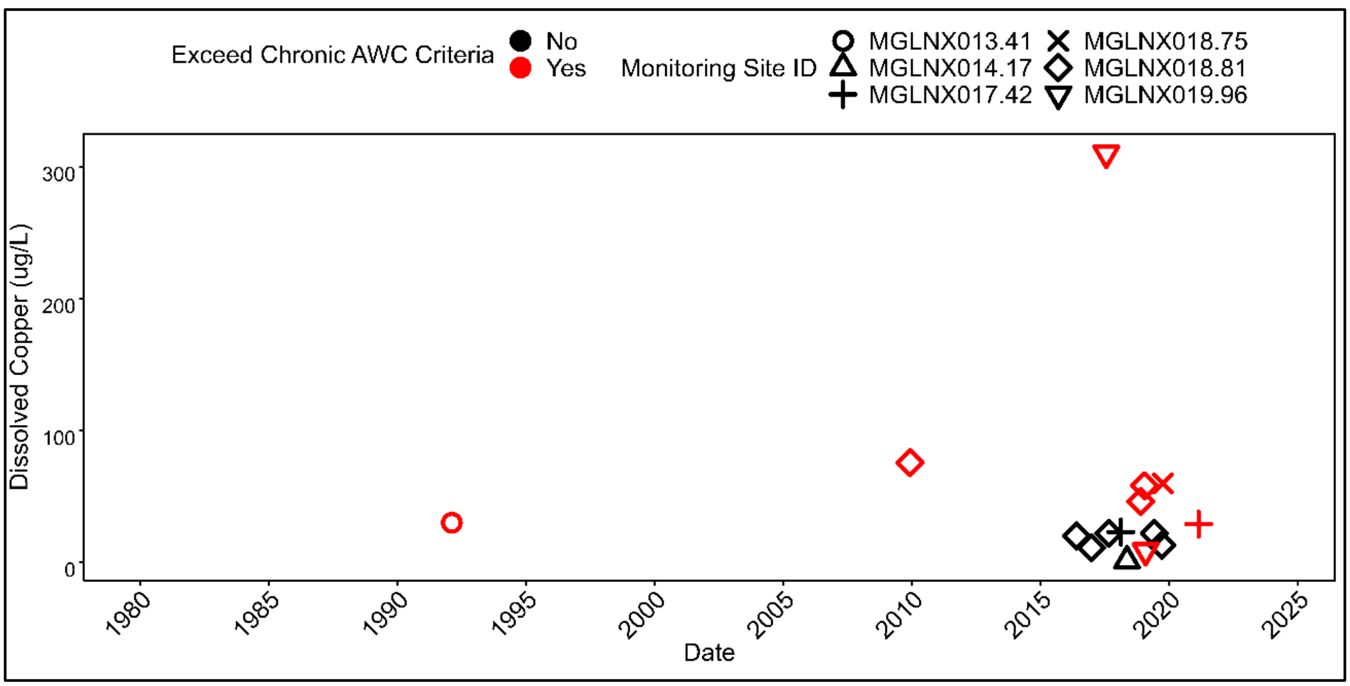

Figure 69. Instantaneous dissolved Cu concentrations over time in Lynx Creek (chronic WQC).
Notes: WQC are hardness dependent; points in red indicate exceedance.

5.4.1.1.3 Dissolved Zn

The highest concentrations of dissolved Zn observed in Lynx Creek were in the months of April, May, and June (Figure 70). Many months had no data (February, July, September, October, and December), and many months had limited data (n=1). Therefore, seasonal trends were difficult to distinguish. Zn concentrations exceeded the acute and chronic standard frequently, 60% of the time across all monitoring sites (Figure 71). Spatially, the most exceedances and highest concentrations of Cd were observed at the second most upstream monitoring site (MGLNX018.81), and no exceedances occurred in the most downstream monitoring sites (MGLNX014.17, MGLNX013.41).

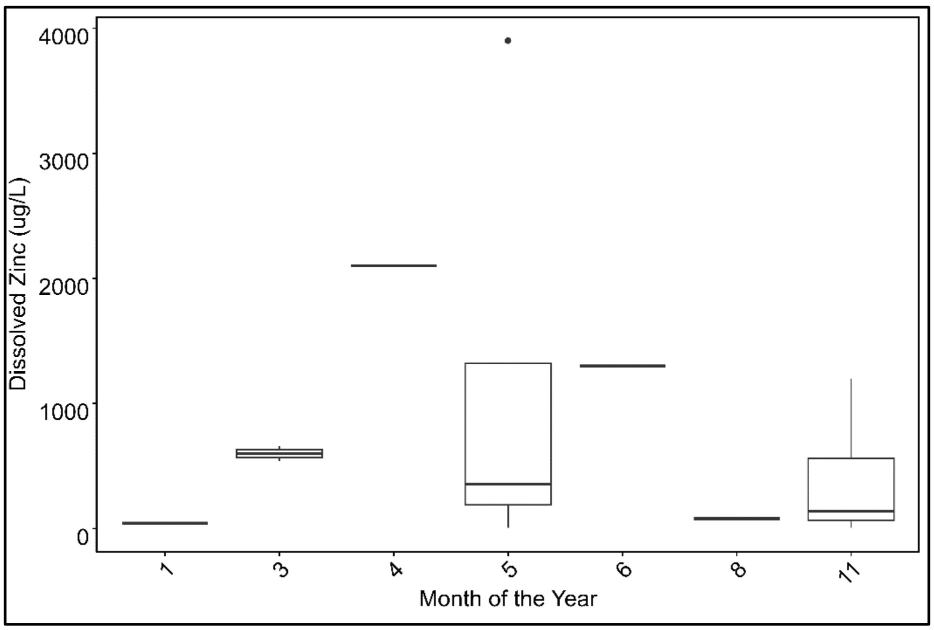

Figure 70. Concentration of dissolved Zn by month in Lynx Creek.

Notes: Monitoring locations and years of data collected were averaged for each month. The horizontal line in the middle of the box plot represents the median; the upper and lower limits of the box represent the first and third quartile. All points outside the boxplot are outliers.

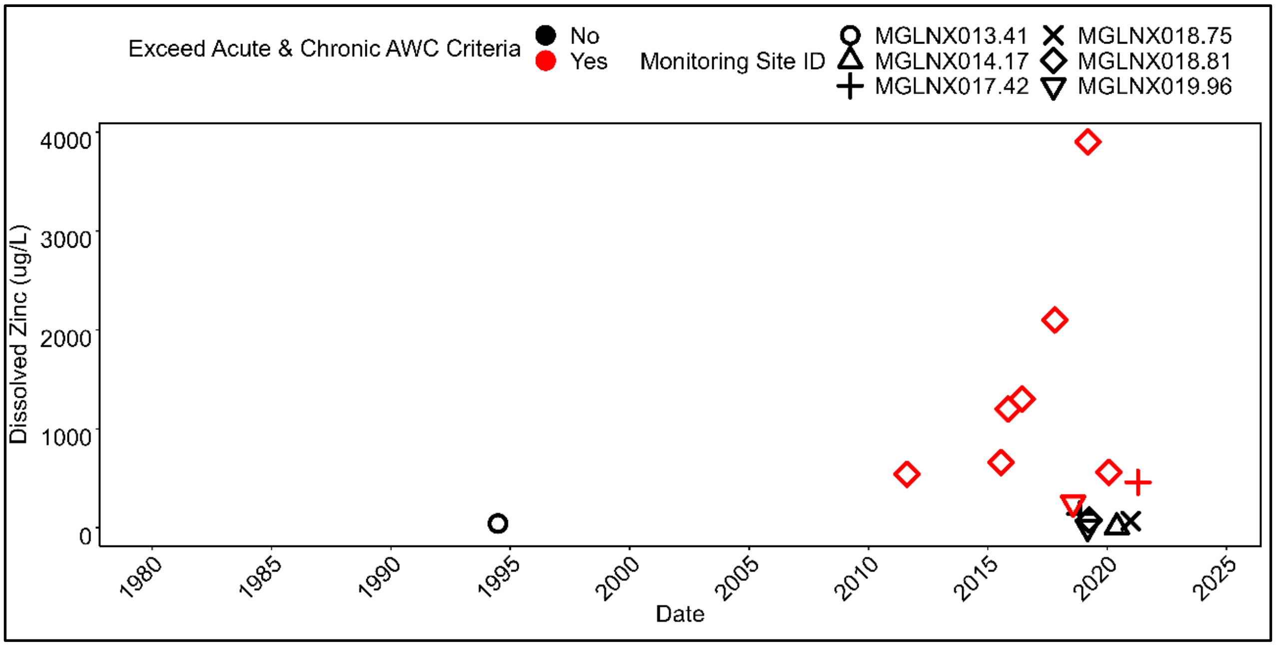

Figure 71. Instantaneous dissolved Zn concentrations over time in Lynx Creek (acute and chronic WQC).

Notes: WQC are hardness dependent; points in red indicate exceedance.

5.4.1.2 UNNAMED TRIBUTARY TO LYNX CREEK (15070102-124)

The unnamed tributary to Lynx Creek is impaired for dissolved Cu for acute and chronic AWC. There are three monitoring sites along the reach with water quality data collected in 2001 and 2019 (see Table 15). All monitoring sites along this reach exceeded the dissolved Cu standard.

5.4.1.2.1 Dissolved Cu

The highest concentrations of dissolved Cu were observed in the month of May (Figure 72). Very few samples have been collected on this reach, representing only three months of the year. Therefore, seasonal trends were not able to be distinguished. Cu concentrations exceeded the acute and chronic standard frequently, 86% and 100% of the time, respectively (Figures 73–74). In 2001, all sites had similar concentrations; however, in 2019, the middle monitoring site (MGULN000.23) had 51 times the concentration of the other sites.

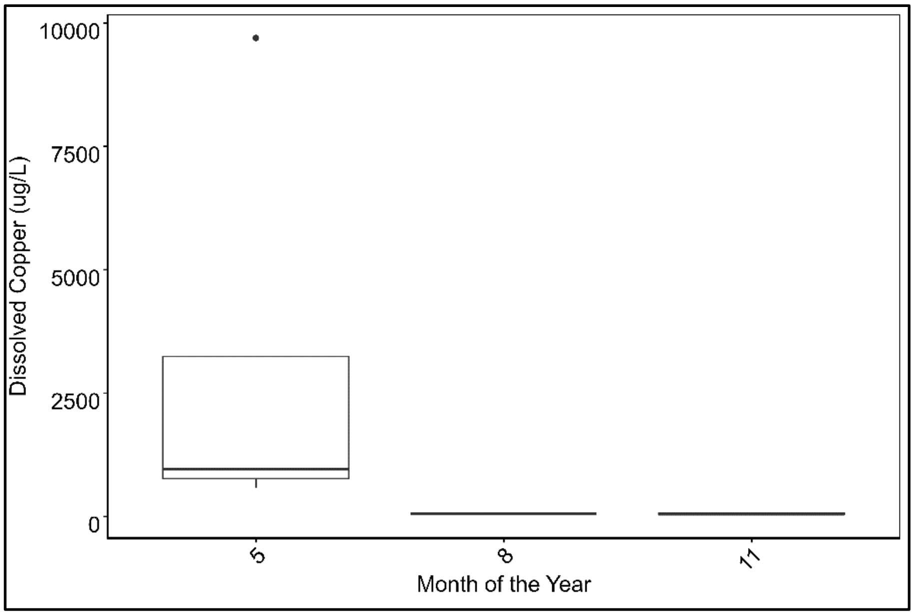

Figure 72 Concentration of dissolved Cu by month in unnamed tributary to Lynx Creek.

Notes: Monitoring locations and years of data collected were averaged for each month. The horizontal line in the middle of the box plot represents the median; the upper and lower limits of the box represent the first and third quartile. All points outside the boxplot are outliers.

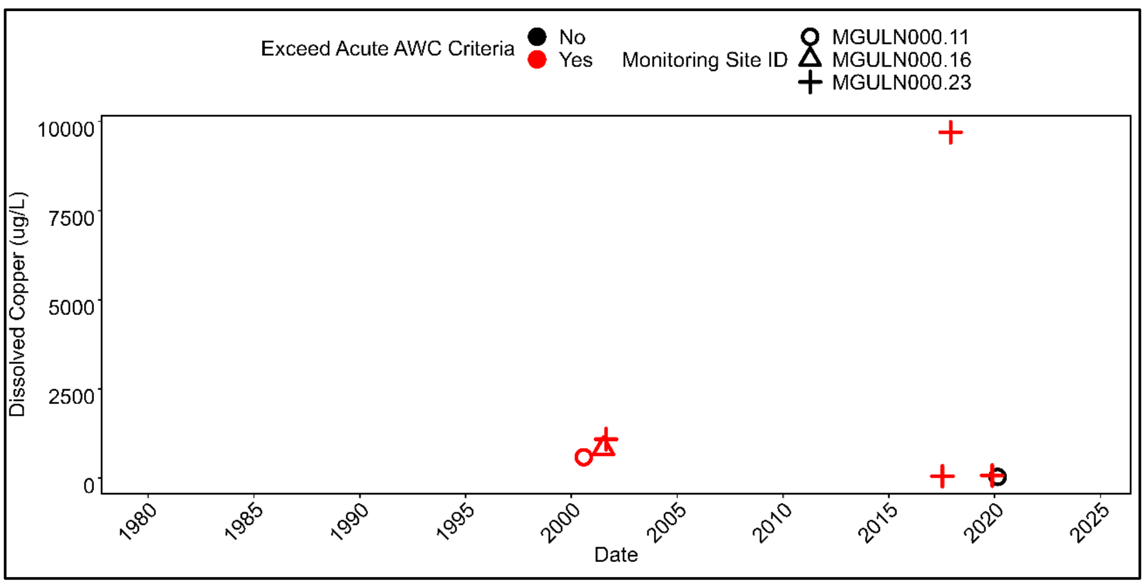

Figure 73. Instantaneous dissolved Cu concentrations over time in Lynx Creek (acute WQC).

Notes: WQC are hardness dependent; points in red indicate exceedance.

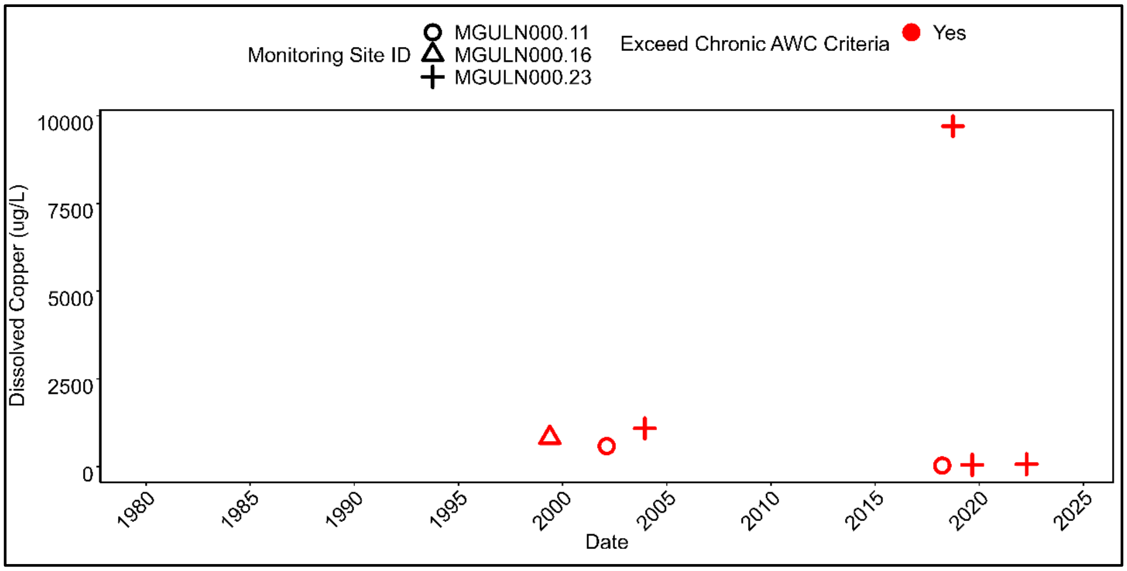

Figure 244. Instantaneous dissolved Cu concentrations over time in Lynx Creek (acute WQC).

Notes: WQC are hardness dependent; points in red indicate exceedance.

5.4.1.3 LYNX LAKE

Lynx Lake is in the middle of the impaired Lynx Creek waterbody (see Figure 1). Understanding the water and sediment quality of the lake as it relates to metals is important for better identifying the potential impact it may have on the lower portion of the Lynx Creek impairment. The lake was established by the Arizona Game and Fish Department in 1961 and is exclusively fed by water from the Lynx Creek watershed (U.S. Fish and Wildlife Service 2008). It is approximately 55 acres and activities in and around the lake include fishing, hiking, mountain biking, bird watching, swimming, gold panning, and boating (U.S. Fish and Wildlife Service 2008). DUs for the lake are FBC, Partial Body Contact (PBC), Domestic Water Source (DWS), Agricultural Irrigation (AGI), and AGL.

5.4.1.3.1 Water Quality Data

Water quality data have been collected in Lynx Lake since 1992 and as late as January 2022 and are summarized in Table 16. The lake is not currently listed as impaired.

Table 16. Lynx Lake Water Quality Data Summary.

Monitoring Location ID	Water Quality Parameter	Sample Fraction	Count	Average (mg/L)
MGLYN–A	As	Dissolved	10	0.006
		Total	11	0.007
	Cd	Dissolved	1	0.000
		Total	1	0.001

Monitoring Location ID	Water Quality Parameter	Sample Fraction	Count	Average (mg/L)
MGLYN–A	Cu	Dissolved	1	0.004
		Total	10	0.025
	Pb	Dissolved	3	0.000
		Total	11	0.003
	Se	Dissolved	0	–
		Total	1	0.000
	Zn	Dissolved	1	0.000
		Total	11	0.045
MGLYN–B	As	Dissolved	2	0.003
		Total	2	0.005
	Cd	Dissolved	0	–
		Total	0	–
	Cu	Dissolved	0	–
		Total	2	0.048
	Pb	Dissolved	0	–
		Total	2	0.006
	Se	Dissolved	0	–
		Total	0	–
	Zn	Dissolved	0	–
		Total	3	0.047
MGLYN–BR	As	Total	4	0.012
	Cd	Total	0	–
	Cu	Total	2	0.137
	Pb	Total	4	0.087
	Se	Total	0	–
	Zn	Total	4	0.117
MGLYN–C	As	Total	0	–
	Cd	Total	0	–
	Cu	Total	2	0.015
	Pb	Total	0	–
	Se	Total	0	–
	Zn	Total	0	–

5.4.2 Flow

In the Upper Agua Fria Watershed, Lynx Creek currently has an unclassified flow regime. There is one flow gage located along Lynx Creek with a record of flow data collected during the period of interest (Table 17). Additionally, there are seven total monitoring sites (6 ADEQ, 1 Yavapai County) on Lynx Creek with flow data that have been collected during the period of interest (see Figure 9).

Table 17. Summary of Flow Data Available on Lynx Creek.

Gage Operator	Gage Identifier	Period of Record	Sample Size
Yavapai	54877 - Lynx Creek Levee Stage	08/28/2001–04/26/2024	5,525
ADEQ	MGLNX013.41	1992–1993	3
ADEQ	MGLNX014.17	2019–2019	1
ADEQ	MGLNX017.42	2019–2019	2
ADEQ	MGLNX018.75	2019–2019	1
ADEQ	MGLNX018.81	2010–2019	9
ADEQ	MGLNX019.96	2019–2019	2

5.4.2.1 YAVAPAI GAGES

There is only one flow gage located on Lynx Creek, owned and operated by the Yavapai County Flood Control District (see Table 13). Gage 54877 is located near the Prescott Golf Course, just upstream of the confluence with Upper Agua Fria. This gage has been operating since 2001 and has 5,525 measurements of flow on Lynx Creek. Data from this site indicate that the highest flows occur during November and the lowest flows occur in June and August (Figures 75–76).

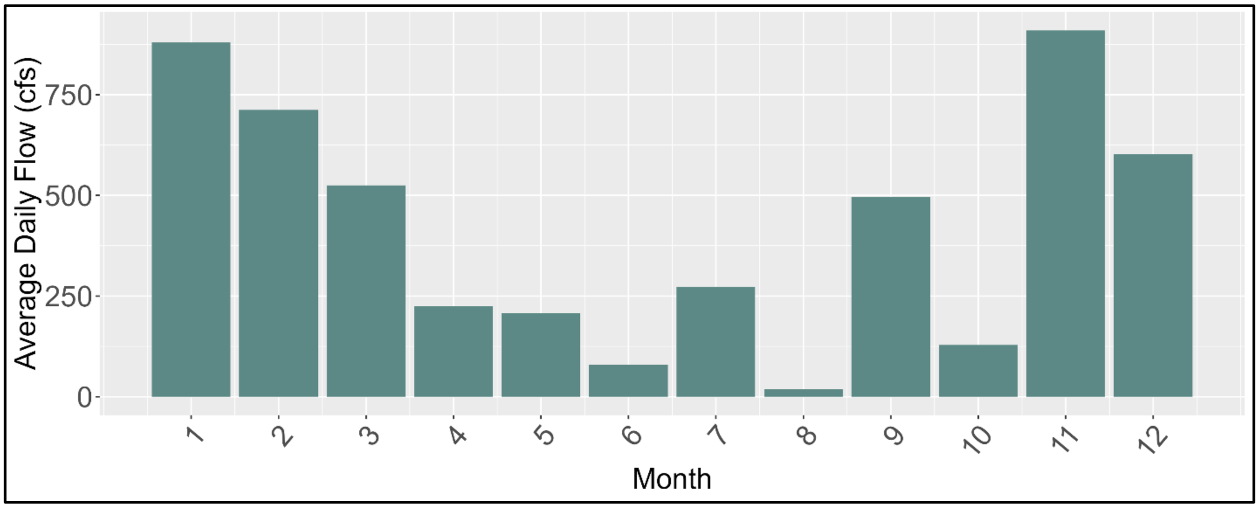

Figure 75. Average daily flow per month on Yavapai Gage 54877 - Lynx Creek Levee Stage (2001–2024).

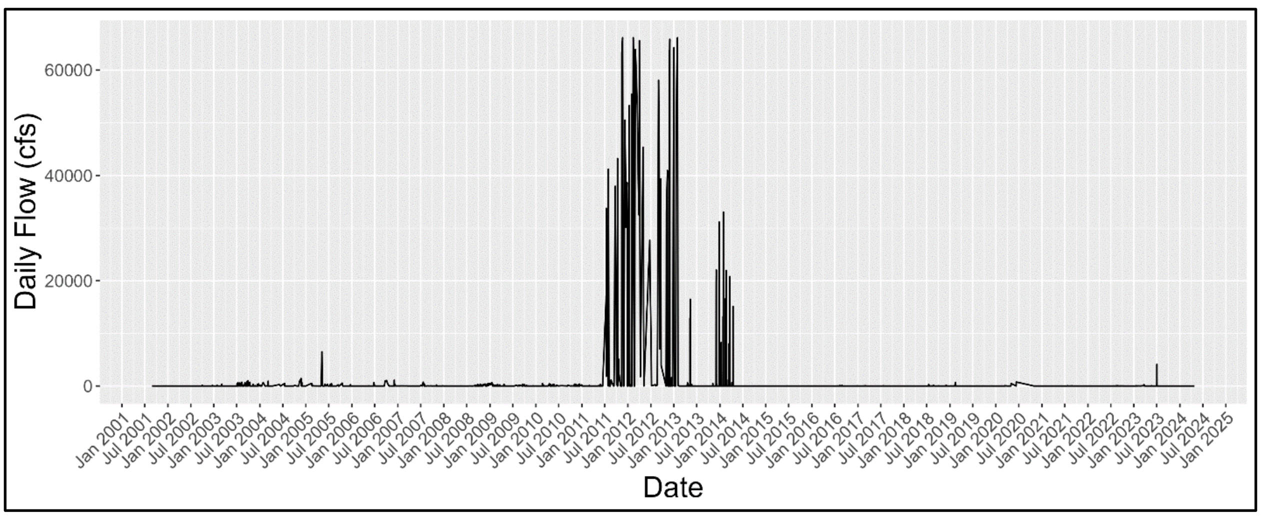

Figure 76. Average daily flow on Yavapai Gage 54877 - Lynx Creek Levee Stage (2001–2024).

5.4.2.2 ADEQ MONITORING LOCATIONS

ADEQ collects water quality and flow data at monitoring locations throughout the Upper Agua Fria Watershed. On Lynx Creek, there are seven monitoring locations where measurements of flow have been collected. The flow data collected at monitoring locations on Lynx Creek are summarized in Table 18.

Table 18. Summary of ADEQ Monitoring Locations Flow Data on Lynx Creek.

Monitoring Site	Waterbody	Flow Measurement Count	Min Flow (cfs)	Min Flow Month	Max Flow (cfs)	Max Flow Month	Period of Record
MGLNX013.41	Lynx Creek	3	0.001	November	1.66	January	1992–1993
MGLNX014.17	Lynx Creek	1	0.06	May	0.06	May	2019
MGLNX017.42	Lynx Creek	2	0.333	May	1.82	November	2019
MGLNX018.75	Lynx Creek	1	4.29	November	4.29	November	2019
MGLNX018.81	Lynx Creek	9	0.02	April	2.35	March	2010–2019
MGLNX019.96	Lynx Creek	2	0.06	May	1.71	November	2019

5.4.3 Sediment

Sediment data have been collected on Lynx Lake since 1991 and are summarized in Table 19.

Table 19. Sediment Data Summary in Lynx Lake.

Monitoring Location ID	Parameter	Sample Fraction	Unit	Count	Average
MGLYN–A	As	Total	mg/kg	1	6.1
	Cu	Total	mg/kg	1	490.0
	Pb	Total	mg/kg	1	190.0
	Nickel (Ni)	Total	mg/kg	1	12.7
	Se	Total	mg/kg	1	0.2
	Zn	Total	mg/kg	1	650
MGLYN–B	As	Total	mg/kg	1	4.7
	Cu	Total	mg/kg	1	510.0
	Pb	Total	mg/kg	1	170.0
	Ni	Total	mg/kg	1	12.1
	Zn	Total	mg/kg	1	540.0

5.4.4 Data Gaps

The only data available in the portion of Lynx Creek between Lynx Lake and Fain Lake were collected in July 2024 from three sites. While a single sampling event can be helpful for understanding general water quality in this section of the impaired reach, additional data collection on a monthly or quarterly frequency is needed to better understand the full range of water quality conditions.

In addition, there is no hardness data for Lynx Lake, making it difficult to contextualize the metals concentrations and the impact they may be having on the downstream impaired reach of Lynx Creek.

Section 6. Source Assessment

A key component of any TMDL evaluation is the assessment of known and potential sources of contamination in the watershed. Source assessment analyses are generally used to evaluate the type, magnitude, timing, and location of pollutant loading to a waterbody (EPA 1999). Source assessment methods vary widely with respect to their applicability, ease of use, and acceptability. This section presents an overview of the sources of metal pollution causing the impairments in the Upper Agua Fria Watershed as well as the mechanisms by which pollutants can reach the waterbody (fate and transport). This assessment is critical to determining and prioritizing applicable implementation efforts. See Section 7 for specifics on Source Assessment Methods.

Pollutant sources within a watershed are characterized as either point source or NPS. Point sources of pollutants are regulated under National Pollutant Discharge Elimination System (NPDES) permits and may include discharges from municipal or industrial wastewater treatment plants (WWTPs), NPDES-regulated sources of urban stormwater runoff known as Municipal Separate Stormwater Sewer Systems (MS4s), and other NPDES discharges as described below. Specifically, the State of Arizona has received authorization from EPA to operate the NPDES permit program at the state level as the Arizona Pollutant Discharge Elimination System (AZPDES). Conversely, NPSs are pollutant sources that reach the receiving water via indirect mechanisms not regulated under the NPDES program, such as historic mines, atmospheric deposition, unregulated stormwater runoff, geologic sources, or agricultural runoff.

6.1 Nonpoint Sources

NPSs, unlike point sources, are diffuse and do not originate from a single, identifiable source. These sources may be intermittent in nature and difficult to quantify. Identified NPSs that are known or thought to contribute pollutant loadings to the impaired subwatersheds are described below.

6.1.1 Legacy Mining

Historically, mining activities have been extensive throughout the Upper Agua Fria Watershed, significantly contributing to the presence of various metals in the environment. The extraction and processing of mineral deposits, including Au, Ag, Cu, Zn, and Pb, has occurred since the late 1800s in this region. These activities have left a legacy of contamination, with numerous historic mine sites and tailings piles across the watershed (Figure 77). While this area has naturally high mineral content in the soils, historic mining activities compound natural contributions in all three impaired subwatersheds. Surface runoff and erosion from these sites transport metals such as As, Cd, Cu, Pb, Se, and Zn into the waterbodies, impacting water quality and aquatic ecosystems.

Figure 77. An example of unremediated historic mining tailings piles at the Chaparral Gulch Superfund Site Area.

The bioavailability of metals refers to the proportion of total metals that are available for incorporation into biota through the process of bioaccumulation. Mining activities can significantly influence the bioavailability of metals through pH changes and the availability of oxygen. For instance, metals from mining activities may be associated with sulfide minerals, which are relatively immobile under chemically reducing conditions and thus have little impact on biota despite high metal concentrations. However, in oxidizing conditions, these sulfide minerals can release metals, increasing their bioavailability and resultant toxicity. Other factors such as soil pH, organic matter content, and the presence of carbonate minerals can also play critical roles.

In the Upper Agua Fria Watershed, a variety of resources are or were extracted through mining practices, including Cu, Au, Ag, Pb, Zn, silicon (Si), iron (Fe), manganese (Mn), titanium (Ti), and barium (Ba) Table 20; Figure 78). There are over 500 mine features in the watershed, including both active and inactive mines; however, the overwhelming majority of mines are inactive and considered historic. Many of these historic mines were not focused on extracting a single resource but instead extracted multiple types of resources. This summary is based on data from three different publicly available geographic information system (GIS) spatial layers and may not fully represent all mines within the watershed boundary. The three spatial layers are:

1. USGS: This data layer was obtained from the Prospect- and Mine-Related Features from U.S. Geological Survey 7.5- and 15-Minute Topographic Quadrangle Maps of the United States (ver. 10.0, May 2023) (USGS 2022).
2. Mines: This data layer was obtained from ADEQ's internal GIS database (ADEQ 2025a).
3. Mines: This layer was obtained from the Mineral Resource Data System (MRDS) (McFaul et al. 2000).

It should be noted that the majority of these sites have not been field verified. In addition to the features that make up each site, there may be additional sites that are unknown and will only be discovered through field verification.

Table 20. Mine Types in the Upper Agua Fria Watershed.

Historic Mine Feature Type	Upper Agua Fria Subwatershed		
	Upper Agua Fria	Big Bug	Lynx Creek
Cu	**28%**	**18%**	**13%**
Au	**29%**	**27%**	**34%**
Ag	**22%**	**14%**	**14%**
Pb	**18%**	**13%**	**13%**
Zn	**9%**	**6%**	**9%**
Iron	5%	2%	2%
Manganese	5%	1%	0%
Antimony	0	0%	1%
As	<1%	0%	1%
Sand and gravel	1%	<1%	0%
Silicon	2%	1%	0%
Marble, dimension, stone, semiprecious gemstone	<1%	<1%	0%
Tungsten, silicon, gemstone, beryllium, mica	<1%	<1%	0%
Volcanic materials	<1%	<1%	0%
Phosphate	<1%	<1%	0%
Barium	<1%	0%	0%
Clay	<1%	0%	1%
Stone, dimension	0 %	1%	0%
Unknown	41%	52%	46%
Total count	**277**	**142**	**101**

Note: Bolded values indicate the top five mined resources. Percent values do not add up to 100% due to their being multiple mines that fall under multiple mine types.

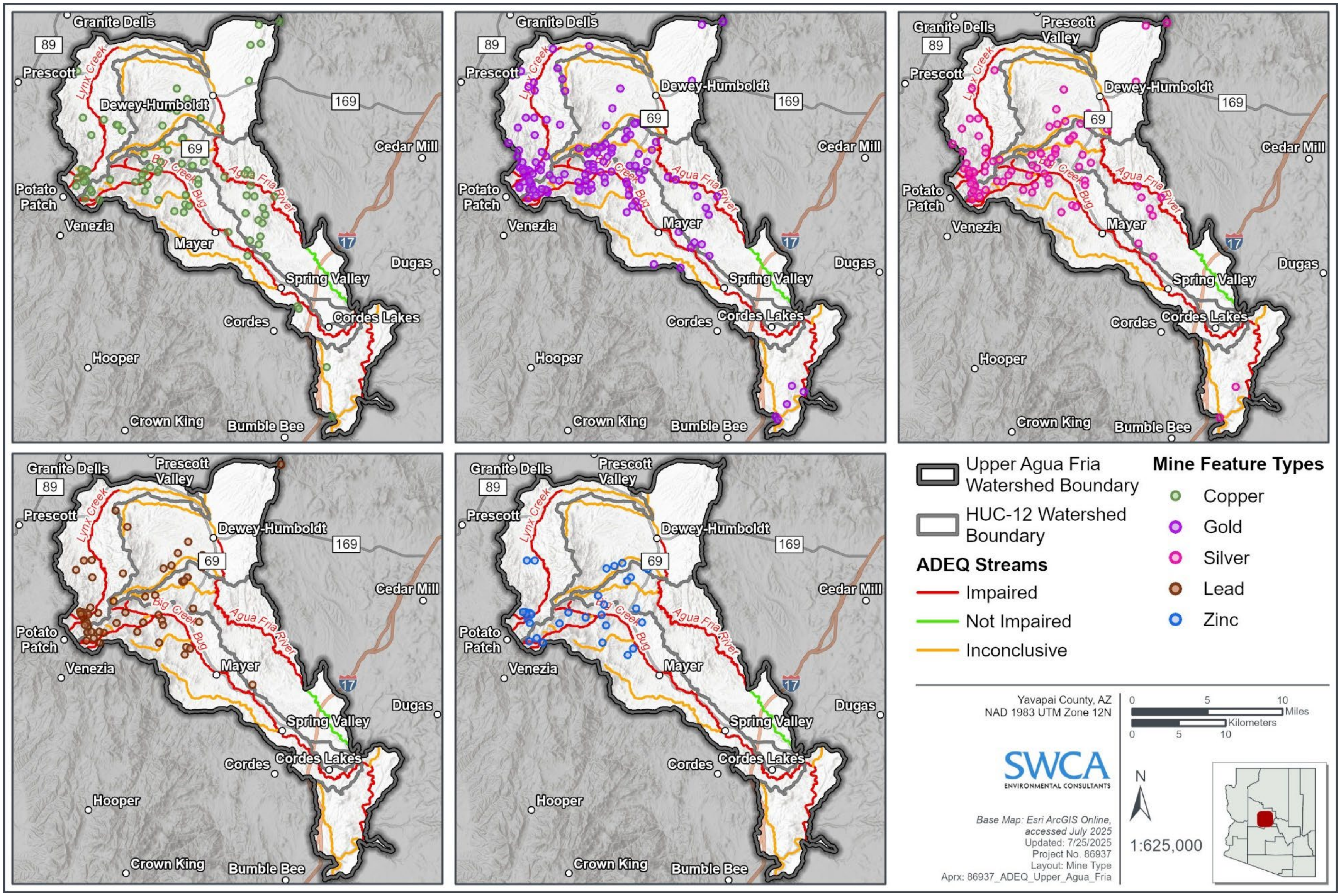

Figure 78. Distribution of historic mine features across the watershed.

Historic mine sites and areas of acid mine drainage are significant contributors to metal pollution in watersheds. Historic mines often leave behind exposed mineralized rock and tailings that can release metals into the environment. Acid mine drainage occurs when sulfide minerals in exposed rock react with water and oxygen to produce sulfuric acid, which can leach metals from the rock and carry them into surface water bodies.

The extensive history of mining coupled with underlying geology and moderately erodible soils contributes heavily to the loading of metals in each of the three subwatersheds. Additional analysis of mining patterns shows the Upper Agua Fria River subwatershed as having the highest total count of historic mines as well as the most historic mines within 1,000 feet of surface waters (Table 21; Figure 79). The density of historic mines per square mile is equitable between the three subwatersheds (approximately two per square mile); however, concentrated hot spots of historic mines are present in the Upper Agua Fria Watershed, with the densest areas being upper Lynx Creek and the areas surrounding Chaparral Gulch and Galena Gulch (Figure 80).

Table 21. Summary of Historic Mines in the Upper Agua Fria River, Big Bug Creek, and Lynx Creek Subwatersheds.

Waterbody	Total Mine Count	# of Mines < 1,000 Feet from Surface Waters
Upper Agua Fria	277	59
Big Bug Creek	142	55
Lynx Creek	101	38

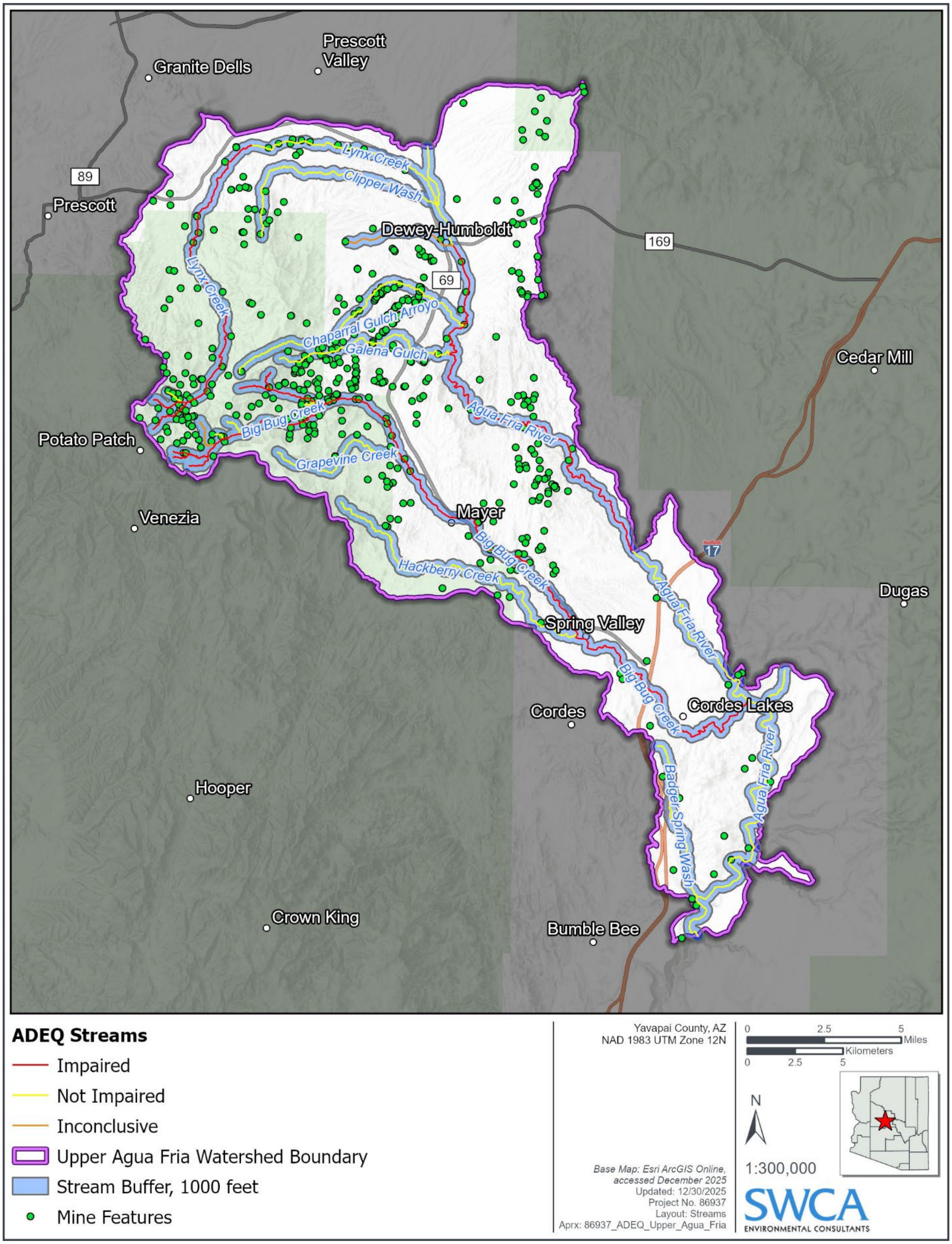

Figure 79. Mine feature proximity to surface waters in the Upper Agua Fria Watershed.

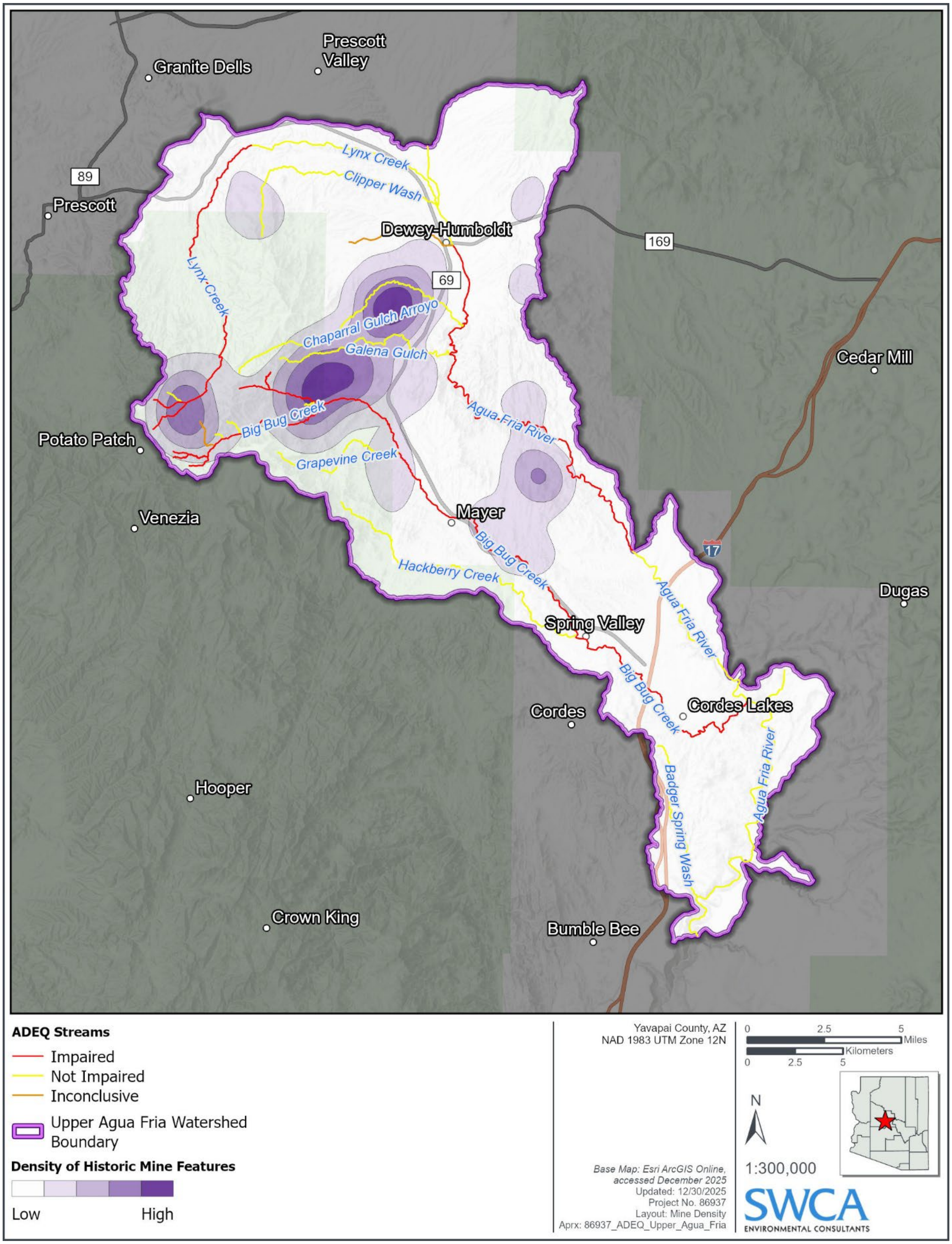

Figure 80. Historic mine feature density in the Upper Agua Fria Watershed.

6.1.2 Active Mining

Active mining in the Upper Agua Fria Watershed contributes metals to the environment through excavation, waste rock storage, and processing activities. These operations can release metals like Cu, Zn, and As into surface waters via runoff, especially during storm events. Over time, this runoff can elevate metal concentrations in streams and rivers, affecting water quality and aquatic life in the watershed.

In the Upper Agua Fria Watershed, there are eight active mines as identified in the Arizona Geological Survey 2022 Directory of Active Mines in Arizona (Garcia et al. 2022) and summarized in Table 22.

Table 22. 2022 Active Mines in the Upper Agua Fria Watershed.

Subwatershed	Active Mine Name	Commodity Type	Associated MSGPs (Y/N)
Lynx Creek	Prescott Valley Pit	Sand and Gravel	N
Upper Agua Fria	Dewey Pit FKA Hendrickson Mine	Sand and Gravel	N
	Dewey Pit	Decorative Stone	N
	Mayer Pit / Lower Bell	Decorative Stone	N
Big Bug Creek	Star Placer	Decorative Stone	Y
	Mayer Schist Quarry	Dimension Stone	Y
	Smokestack Quarry FKA Pyramid Mine	Sand and Gravel	Y
	Brown Schist Quarry	Building Stone	N

Note: MSGP = Multi-Sector General Permit

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6.1.3 Atmospheric Deposition

Atmospheric deposition can be a nonpoint source of metal pollution that is the transport of metals through the atmosphere and subsequent deposition onto land and into surface waters. Metals can be emitted into the atmosphere through various processes that include, 1) industrial activities, 2) vehicle emissions, and 3) wildfires and volcanic activity (EPA 2025a). Once airborne, these metals can settle onto surfaces through dry deposition (settling of particles) or wet deposition (associated with precipitation). The transport pathways for metals from atmospheric deposition include direct deposition onto water bodies and indirect deposition onto land, where they can be mobilized by stormwater runoff. Metals such as mercury (Hg), Pb, Cd, and As are commonly associated with atmospheric deposition. Monitoring atmospheric deposition and implementing emission control measures are essential for managing this source of metal pollution.

6.1.4 Non-regulated Stormwater

Non-regulated stormwater runoff is runoff that occurs in areas of watershed that are not covered by an MS4 permit or an industrial or construction stormwater permit. Even though this source is not regulated, it can still contribute to metal pollution in surface waters. When precipitation falls on impervious surfaces such as roads, parking lots, and rooftops, it collects pollutants, including metals, and transports them to surface water bodies. This runoff can carry metals such as Cu, Pb, and Zn from automotive fluids, brake dust, and roofing materials (EPA 2025a). Construction activities further exacerbate this issue by disturbing the soil and increasing sediment transport to water bodies. Sediments can bind with metals, facilitating their movement into streams and rivers. Best management practices (BMPs) such as silt fences, sediment basins, and vegetative buffers are essential to reduce the impact of stormwater runoff.

6.1.5 Natural Sources

Natural sources of metal pollution in surface waters include the weathering of bedrock and soil erosion from metal-rich soils. As bedrock weathers, it releases metals into the surrounding environment, which can then be transported to surface water bodies through runoff and groundwater flow. The geology of the watershed often plays an important role in determining the natural sources of metal pollution. Areas with mineral-rich bedrock, such as those containing sulfide minerals, are more likely to contribute metals like As, Cd, and Se to the watershed. Primary geologic features in the Upper Agua Fria Watershed region include Precambrian metamorphic rocks covered by Tertiary volcanic and sedimentary rocks from the Hickey Formation (CH2M Hill, Inc. 2016) that are mineral-rich and have facilitated the abundance of mining activity in the region (see Figure 2).

Soil erosion, especially from areas with high metal content, can contribute to the transport of metals during precipitation events. The Natural Resources Conservation Service (NRCS) Web Soil Survey provides detailed information on soil properties, including the K factor, which indicates the susceptibility of soil to erosion. Soils with higher K values are more prone to erosion, leading to increased transport of metals bound to soil particles into water bodies. Soils in the Upper Agua Fria Watershed range in relative erodibility from a K factor of 0.11 to 0.48 (Figure 81). The more erodible soils are located in the Galena Gulch–Agua Fria River HUC12 and the Big Bug Creek HUC12.

Se, a metalloid, is primarily found in marine-origin sandstones and shales from the Tertiary period, particularly in the arid and semi-arid western United States (Seiler et al. 1999). Weathering of Se-rich rock formations creates seleniferous soils that can release Se when exposed to water. A USGS study found that average Se concentrations in soils are 0.39 parts per million (ppm) nationwide, with reported ranges from <0.1 to 4.3 ppm. Soils in Yavapai County contain a mean of 0.2 ppm (USGS 2025) (Figure 82). Agricultural runoff primarily caused by irrigation activities in regions with Se-rich soils is the prime pathway by which Se reaches surface waters and increases levels beyond background concentrations (Seiler et al. 1999).

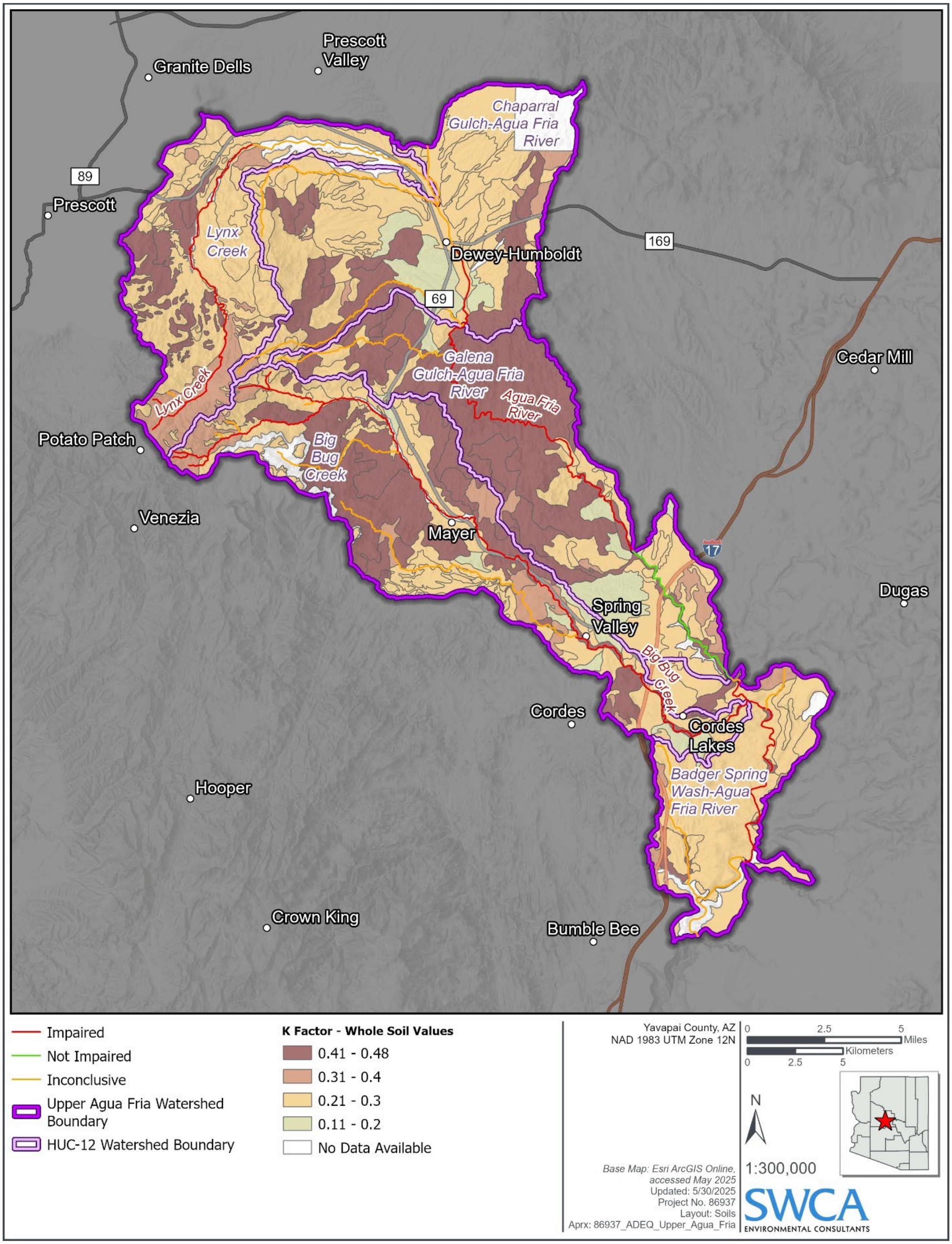

Figure 81. Soil erosion by K factor in the Upper Agua Fria Watershed.

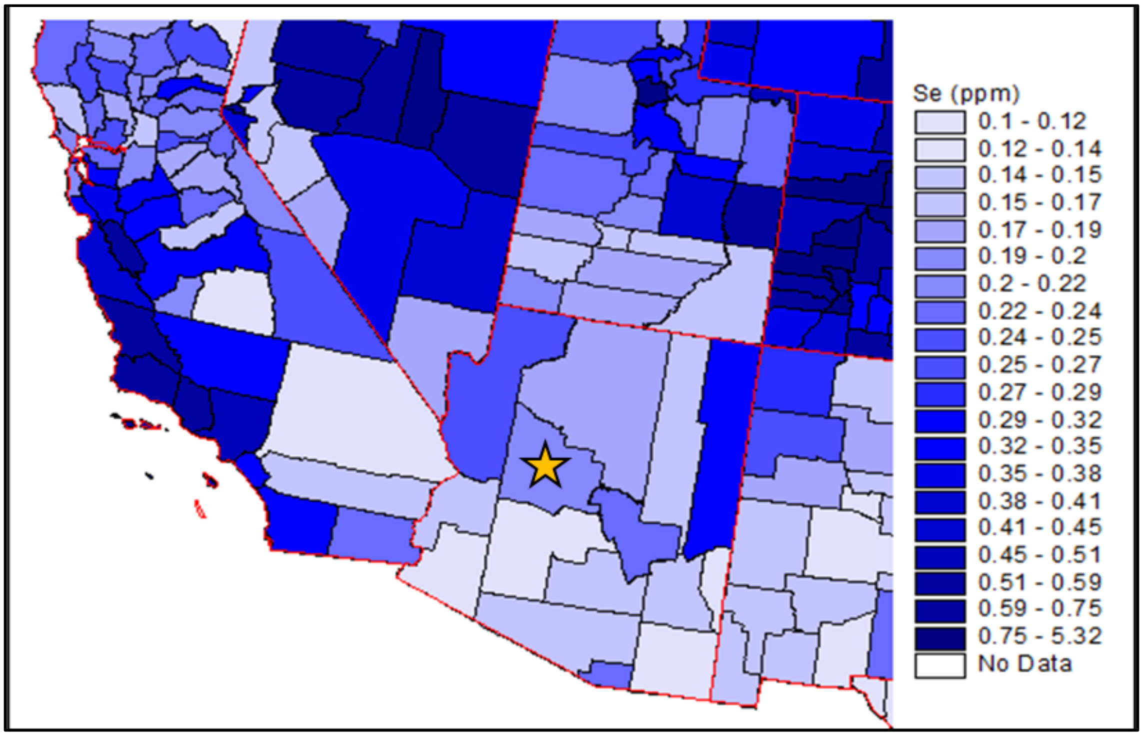

Figure 82. Se soil concentrations in the southwestern United States (as seen in USGS 2025). Yavapai County is starred.

The contribution of the NB levels of metals were assessed and calculated where data are available. Historic metals concentrations were evaluated in relation to current concentration data and the timing of active and historic mining operations as identified through the source identification process. Where data supports, the NB levels of a metal were subtracted from the current levels before the percent reduction is calculated.

6.2 Point Sources

Within the Upper Agua Fria Watershed, a number of point sources have been identified that include WWTPs, EPA Superfund sites, Phase II MS4s, and industrial stormwater discharges as described below. These point sources are regulated through several different permit types (ADEQ 2025b) and are implemented and enforced through ADEQ to regulate discharges, maintain WQS, and protect the physical, chemical, and biological integrity of Arizona's waters.

6.2.1 Wastewater Treatment Plants

WWTPs receive domestic, industrial, and commercial wastewater that often contains trace metals such as Cu, Zn, and Pb. While WWTPs are designed to reduce pollutants, they may not remove all metals, which can be discharged into nearby water bodies with the treated effluent. As a result, WWTPs can serve as a point source of metal contamination to receiving waters in a watershed.

In Arizona, WWTPs must obtain an AZPDES individual permit from ADEQ to discharge into regulated waters or if a discharge to a non-regulated water reaches a regulated water. This permit ensures compliance with WQS for the impacted regulated water(s) and must be renewed every 5 years. 40 CFR 122.45(c) requires measurement of all metals as total recoverable except hexavalent chromium (Cr VI). Therefore, dissolved metals data are unavailable for all WWTP facilities in the watershed. Additionally, depending on the facility's activities, other permits may be required—such as for biosolids land application, hazardous waste disposal, or reclaimed water reuse. In the Upper Agua Fria Watershed there are two WWTPs, as summarized in Table 23.

Table 23. WWTPs in the Upper Agua Fria Watershed.

Subwatershed	Permittee Type	Source Name	Permit Number	Receiving Water	Status	Issue Year	Expiration Year	Outfalls
Upper Agua Fria	Minor WWTP	Soft Winds Mobile Home Park WWTP	AZ0026051	Agua Fria	Active	2022	2027	1
Big Bug Creek	Minor WWTP	Chimney Estates WWTP	AZ0026999	Lower Big Bug Creek	Active	2026	2031	1

The Soft Winds Mobile Home Park WWTP is a privately-owned facility located in Dewey, Arizona. The facility is operated by Stone Castle Properties, LLC, and has a design capacity of 0.0075 million gallons per day (MGD). It serves approximately 65 residents of the mobile home park. The permit includes one outfall that discharges to an unnamed ephemeral wash, a tributary to the Upper Agua Fria River. The facility is required to conduct regular monitoring of effluent with data available since December 2012 (Table 24). The permit specifies effluent limitations and monitoring requirements for total Se and total Zn.

Table 24. Soft Winds WWTP Data Summary.

Parameter	Period of Record	WQS	Total Records	% of Values that Exceed Permit Limit	Max DMR Value in Period of Record	Date of Max Value
Se, Total	12/31/2012–12/31/2024	2 ug/L	20	15%	2.7 ug/L	12/31/2015
Zn, Total	12/31/2012–12/31/2024	225 ug/L	20	0%	210 ug/L	6/30/2020

Notes: *Effluent limit is the same as the WQS, DMR = Discharge Monitoring Report.

The Chimney Estates WWTP is a privately-owned facility located in Mayer, Arizona. The facility is operated by Residential Property Investment & Management and has a design capacity of 0.017 MGD (0.03 cfs design flow compared to 2 cfs mean flow in Lower Big Bug Creek). The permit includes one outfall that discharges to an unnamed wash that is a tributary to Lower Big Bug Creek which is impaired for total As, total Pb, total Cu, dissolved Pb, and dissolved Cu. The closest downstream monitoring location to this facility with enough data to calculate exceedances of parameters of interest is MGBGB009.57, which does have exceedances in the period of record for dissolved Cu and total Pb. However, this monitoring point is approximately 6.5 miles downstream of the Chimney Estates WWTP and exceedances are likely influenced by additional nonpoint sources. The facility is required to conduct regular monitoring of effluent for impaired parameters, total As, total Pb, and total Cu (Table 25). This facility does not monitor dissolved metals; therefore, dissolved Pb, and dissolved Cu data were not available. The facility also does not have specific water quality permit limits assigned in their permit for total As or total Pb but instead is required to report results that can be compared to the applicable WQS. A full dataset for this facility can be downloaded from the EPA Water Quality Portal (EPA 2024).

Table 25. Data Summary for the Chimney Estates WWTP.

Parameter	Period of Record	Permit Limit	WQS	Total Records	% of Values that Exceed WQS	Max DMR Value (ug/L)	Max Value Date
As, Total	12/31/2015 – 12/31/2024	NA	30 ug/L	12	0%	4.8	12/31/2022
Pb, Total	6/30/2007 – 12/31/2024	NA	15 ug/L	11	0%	1.1	12/31/2020
Cu, Total	12/31/2015 – 12/31/2024	Monthly average: 24 ug/L	500 ug/L	15	0%	13	12/31/2022

6.2.2 Municipal Separate Storm Sewer System (MS4)

Within the Upper Agua Fria Watershed, there are two permitted Phase II MS4s, Town of Prescott Valley and Yavapai County, that have a number of stormwater outfalls that transport stormwater across the watershed (Figure 83). The Town of Prescott Valley Stormwater Management Plan identifies the location of outfalls within the municipality boundaries (Town of Prescott Valley 2021). Some of these outfalls discharge into the Upper Agua Fria River or Clipper Wash, a tributary to the Upper Agua Fria River (Town of Prescott Valley 2021). These MS4s are regulated under the Arizona Phase II MS4 General Permit which requires the permit holders to implement six minimum control measures to the maximum extent practicable to protect water quality (ADEQ 2022b).

Monitoring data are not available from these entities, and there were no Arizona-specific MSGP data representative of MS4 areas. Therefore, to estimate loading, nationwide National Stormwater Quality Database (NSQD, 2015) data were used for highway or freeway primary land use. Specific outfall monitoring for both flow and water quality is recommended moving forward and are described in further detail in Section 10 Implementation Planning.

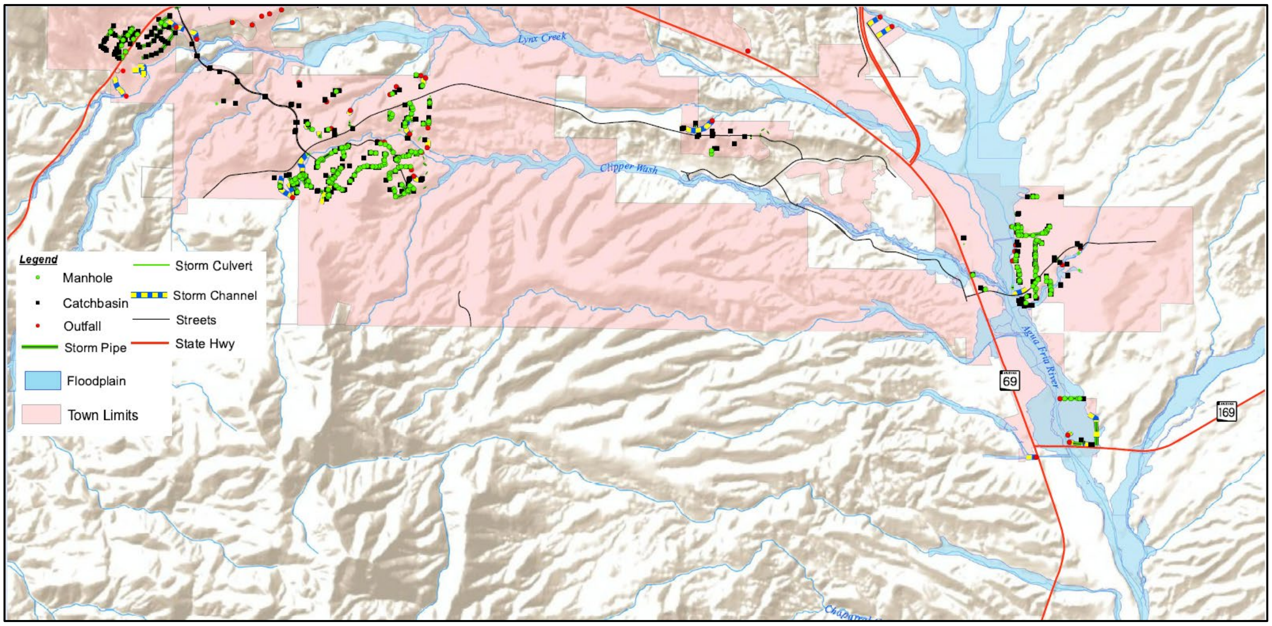

Figure 83. Stormwater outfall locations in the Town of Prescott Valley municipality.
Source: Town of Prescott Valley (2021).

6.2.3 Multi-Sector General Permit

The MSGP regulates stormwater discharges from industrial facilities, including sectors like mining, manufacturing, and scrap metal recycling. In the Upper Agua Fria Watershed, facilities covered under the MSGP can contribute metals to the environment through stormwater runoff that comes into contact with exposed materials, equipment, and waste. Without adequate controls, this runoff can carry metals into nearby streams and tributaries. Although the MSGP requires pollution prevention plans and best management practices, their effectiveness can vary, especially during heavy storms. As a result, MSGP-regulated sites remain a potential source of metal loading in the watershed.

Within the Upper Agua Fria Watershed there are 17 MSGP permittees, as summarized in Table 26. To estimate representative concentrations of metals, where the MSGP sector was not assigned in the Arizona MSGP Data, a sector was assigned or where there was more than one sector, a single sector was selected. Additionally, included in Table 26 is the paired NSQD primary land use category used to extract concentration data where applicable.

Table 26. MSGP Permittees in the Upper Agua Fria Watershed.

Subwatershed	MSGP Name	Arizona MSGP Sector	Assigned or Simplified MSGP Sector	NSQD Primary Land Use
Lynx Creek	FedEx Express PRCA	Blank	AB – Transportation Equipment, Industrial or Commercial Machinery	Industrial
	Printpack INC	X, B	B – Paper and Allied Products Manufacturing	Industrial
	Phoenix Industries Pelleting Plant	D	D – Asphalt Paving and Roofing Materials Manufactures and Lubricant manufactures	Industrial
	Prescott Valley Landfill Hauling and Transfer	L, P	L – Landfills and application sites	Industrial
	MI Metals INC and MI Windows and Doors	AA, F, Y	AA – fabricated metal products	Industrial
	UPS Prescott Valley	P	P – Land Transportation	Highway or Freeway
	Quad Cities Hauling & Transfer Station	P	P – Land Transportation	Highway or Freeway
	Superior Industries SW	AB	AB – Transportation Equipment, Industrial or Commercial Machinery	Industrial
Upper Agua Fria River	Yavapai Metal Recycling	N	N – Scrap Recycling Facilities	Industrial
	We Recycle Solar – Dewey Operations	Blank	N – Scrap Recycling Facilities	Industrial
	Former Humboldt Smelter	G	G – Metal Mining (Ore Mining and Dressing)	Industrial
Big Bug Creek	Belcher Mine	G	G – Metal Mining (Ore Mining and Dressing)	Industrial
	Red Rock Mine	G	G – Metal Mining (Ore Mining and Dressing)	Industrial
	Henrietta Mine	J, G	J – Mineral Mining and Dressing	Industrial
	Big Bug Sand and Gravel	J, AD	J – Mineral Mining and Dressing	Industrial
	Stoneworld Onyx Quarry Mayer	J	J – Mineral Mining and Dressing	Industrial
Big Bug Creek	Smokestack quarry	J	J – Mineral Mining and Dressing	Industrial

6.2.4 Iron King Mine – Humboldt Smelter Superfund Site

The Iron King Mine – Humboldt Smelter was placed on the Superfund NPL in September 2008, the same year that the EPA initiated a remedial investigation to determine the nature and extent of contamination (ADEQ 2025c). The former Iron King Mine site is located west of Highway 69 and is approximately 150 acres, with much of the property covered with mine tailings and waste rock. The facility is bounded by Chaparral Gulch to the north and Galena Gulch to the south. Ores produced from the Iron King Mine included Pb, Zn, Cu, Ag, and Au. The former Humboldt Smelter processed Cu and additional recovery of Au, Ag, Zn, and aluminum (Al). There are multiple mechanisms in which pollutants can travel from the site to waterbodies, including dust emission, infiltration, decomposition/weathering, surface runoff and erosion (EPA 2023).

Multiple soil and groundwater samples have been collected at this site to identify contamination and inform remediation efforts. Groundwater samples collected in 2019 show As levels in groundwater ranging from 0 to 700 ug/L (compared to a surface WQS of 30 ug/L for FBC) (EPA, 2019). Additionally, surface soil samples show elevated Pb concentrations in both the Humboldt Smelter and Iron King Mine property boundaries, both of which have areas that runoff into Chaparral Gulch and Galena Gulch. The Record of Decision showed that soil concentrations of site-related metals, including Pb, Cu, and Zn, decrease with increasing distance from the site, indicating that the mine tailings are likely a contributing source of metals to the impaired waterbody of the Upper Agua Fria River subwatershed (Figure 84).

Data were collected by ADEQ on August 13, 2024, in the Chaparral Gulch Arroyo (15070102-739), a tributary to the Upper Agua Fria. These concentration data used in the current loading calculations shown in Section 6.5 – Source Assessment Summary.

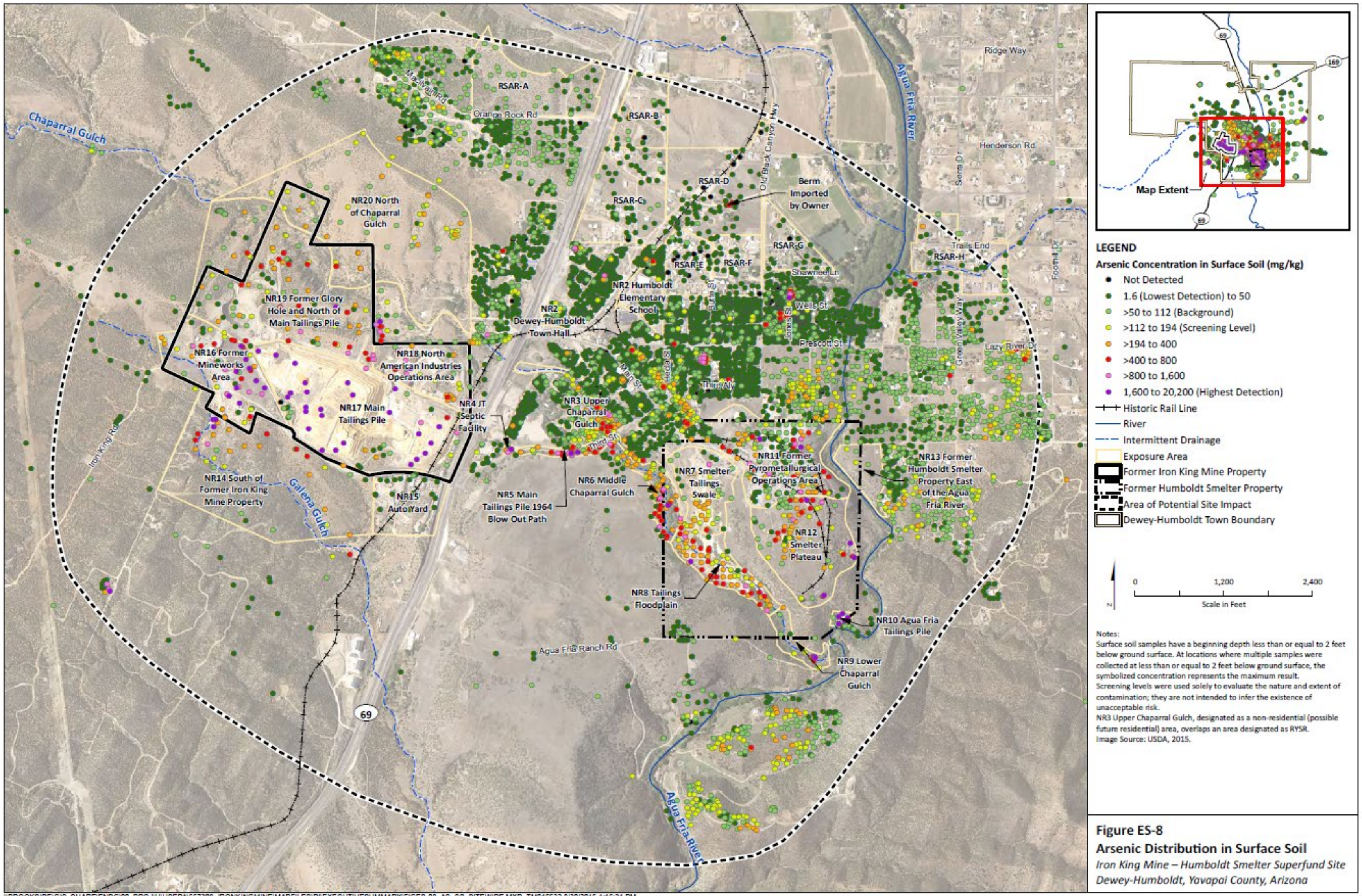

Figure 84. As distribution in surface soil (EPA 2023).

6.2.5 Poland Walker Tunnel

The Poland Walker Tunnel is part of the historic Poland Mine complex, a former gold mining and milling site located in Yavapai County, Arizona, spanning both USFS land and private property. The privately owned western portion of the site, which includes the tunnel itself, contains a large waste rock pile and a historic second mill site, while the eastern section on USFS-administered land holds remnants of the first mill site and smaller waste rock and tailings areas. The waste rock pile associated with the tunnel, much of which is on private land, has spilled onto USFS land, raising environmental concerns. These waste materials, potentially rich in metals such as As, Pb, and Zn, pose a risk of leaching into the surrounding environment, especially during storm events. An unnamed drainage, with little evidence of any sustained flow outside of storm events, cuts through the site and connects to downstream water systems, creating a pathway for metal transport into Big Bug Creek and eventually the Upper Agua Fria River Subwatershed.

The Poland Walker Tunnel is located at an existing ADEQ monitoring site (Monitoring Site MGPWT000.01) where there are some site-specific data, as summarized in Table 27. Average dissolved Cd concentrations (0.12 ug/L) are skewed by one observation (1.90 ug/L) that is above the pollutant target concentration on Upper Big Bug Creek (0.4 ug/L Chronic TMDL Target). Similar to dissolved Cd, the average dissolved Zn concentration (10.1 ug/L) is skewed by one observation (190 ug/L) that is above the pollutant target concentration on Upper Big Bug Creek (56.2 ug/L).

Table 27. Poland Walker Tunnel Water Quality Data Summary.

Parameter	Observations	Minimum Value	Maximum Value	Average	Standard Deviation	% Exceedance
Dissolved Cd (ug/L)	32	8.9 E-3	1.90	0.12	0.33	3%
Dissolved Zn (ug/L)	32	0.35	190	10.10	33.3	3%

6.3 Source Assessment Summary

Understanding the sources of pollution is an important component of TMDL development. This allows for targeted implementation and evaluation of management options that will achieve the desired source load reductions (Section 10). Table 28 provides a summary of the sources identified for the Upper Agua Fria Watershed by subwatershed.

Table 28. Source Summary Table.

	Upper Agua Fria Subwatershed	Big Bug Creek Subwatershed	Lynx Creek Subwatershed
Impaired reaches	Upper Agua Fria River	Upper Big Bug Creek Lower Big Bug Creek Unnamed tributary to Big Bug Creek	Lynx Creek Tributary to Lynx Creek

	Upper Agua Fria Subwatershed	Big Bug Creek Subwatershed	Lynx Creek Subwatershed
		Unnamed tributary to Big Bug Creek (UB1) Unnamed tributary to Eugene Gulch Eugene Gulch Money Metal Tributary	
Impaired parameters	Total Se Dissolved Zn	Total As Total Pb Total Cu Dissolved Cu Dissolved Pb Dissolved Zn	Dissolved Cu Dissolved Cd Dissolved Zn
Legacy mining	277 mine sites 59 mines <1,000 feet from surface waters	142 mine sites 55 mines <1,000 feet from surface waters	101 mine sites 38 mines <1,000 feet from surface waters
Active mining sites	Dewey Pit Mayer Pit/Lower Bell	Star Placer Mayer Schist Quarry Smokestack Quarry aka Pyramid Mine Brown Schist Quarry	Prescott Valley Pit Sand and Gravel Mine
Dominant mine type (% mines in watershed)	Au: 29% Cu: 28% Ag: 22% Pb: 18% Zn: 9% Iron: 5% Manganese: 5%	Au: 27% Cu: 18% Ag: 14% Pb: 13% Zn: 6% Iron: 2%	Au: 34% Ag: 14% Cu: 13% Pb: 13% Zn: 9% Iron: 2%
WWTPs	Soft Winds Mobile Home Park WWTP (AZ0026051)	Chimney Estates WWTP (AZ0026999)	
MS4s	Town of Prescott MS4		Town of Prescott MS4
MSGP	Yavapai Metal Recycling We Recycle Solar – Dewey Operations Former Humboldt Smelter	Belcher Mine Red Rock Mine Henrietta Mine Big Bug Sand and Gravel Stoneworld Onyx Quarry Mayer Smokestack quarry	FedEx Express PRCA Printpack INC Phoenix Industries Pelleting Plant Prescott Valley Landfill MI Metals INC and MI Windows and Doors UPS Prescott Valley Quad Cities Hauling and Transfer Station

	Upper Agua Fria Subwatershed	Big Bug Creek Subwatershed	Lynx Creek Subwatershed
			Superior Industries SW
Other Point Sources	Iron King Mine – Humboldt Smelter Superfund Site	Poland Walker Tunnel	

6.3.1 Load Distributions

For reaches where data were sufficient to calculate loads (see Section 7 for Technical Approaches), load distributions of point sources and NPSs were summarized and are included in Table 29 and 30 and Figures 85 and 86 in the following sections. Lynx Creek did not have enough data to provide a full source summary.

6.3.1.1 UPPER AGUA FRIA RIVER

Current loading of point sources and NPSs in the Upper Agua Fria River Subwatershed are summarized in Table 29 and Figure 85. For details on MOS see Section 7.

Table 29. Current Loading Source Assessment Summary for Upper Agua Fria River.

		Current Load (g/day)	
		Total Se	Dissolved Zn
Point Sources	Soft Winds Mobile Home Park WWTP	0.06	6.39
	We Recycle Solar Dewey Operations (MSGP)	0.0027	1.44
	Yavapai Metal Recycling (MSGP)	0.0029	1.54
	MS4s (Yavapai County)	2.39	47.73
	Iron King – Humboldt Smelter (EPA Superfund site)	0.54	284.76
	Point source total	**2.99**	**341.86**
Nonpoint Sources	Active mining	0.57	302.02
	Legacy mining	5.93	583.30
	NPS total	**14.50**	**2130.63**

Note: g/day = grams per day

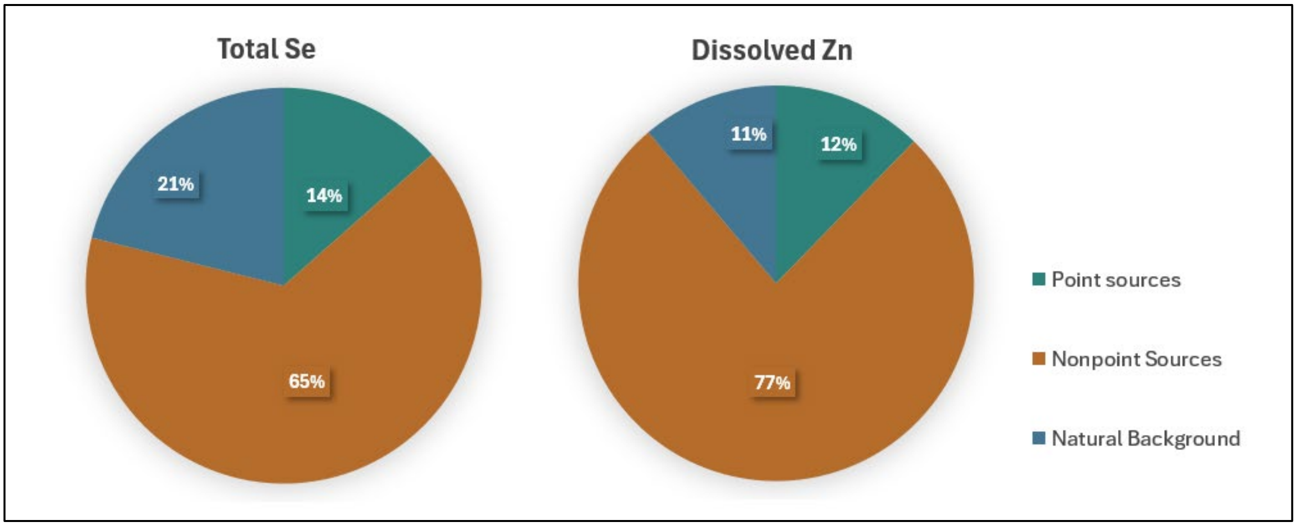

Figure 85. Source summary for Upper Agua Fria River.
See section 7.2.4 for more information on natural background concentrations

6.3.1.2 LOWER BIG BUG CREEK

Current loading of point sources and NPSs in Big Bug Creek are summarized in Table 30 and Figure 84.

Table 30. Current Loading Source Assessment Summary for Lower Big Bug Creek.

		Current Load (g/day)			
Source Type	Source Name	Total As	Total Pb	Total Cu	Dissolved Cu
Point Sources	Chimney Estates WWTP	1.25	0.62	1.00	0.53
	Big Bug Sand and Gravel	0.52	7.13	4.27	4.10
	Henrietta Mine	0.30	4.13	2.47	2.37
	Smokestack Quarry	0.26	3.50	2.10	2.01
	Stoneworld Onyx Quarry Mayer	0.30	4.10	2.46	2.36
	Point Source Totals	**2.63**	**19.48**	**12.30**	**11.38**
Nonpoint Sources	Active mining	0.08	1.05	0.63	0.60
	Legacy mining	39.34	84.99	1,352.06	48.75
	Nonpoint Source Subtotal	**39.4**	**86**	**1,353**	**49**

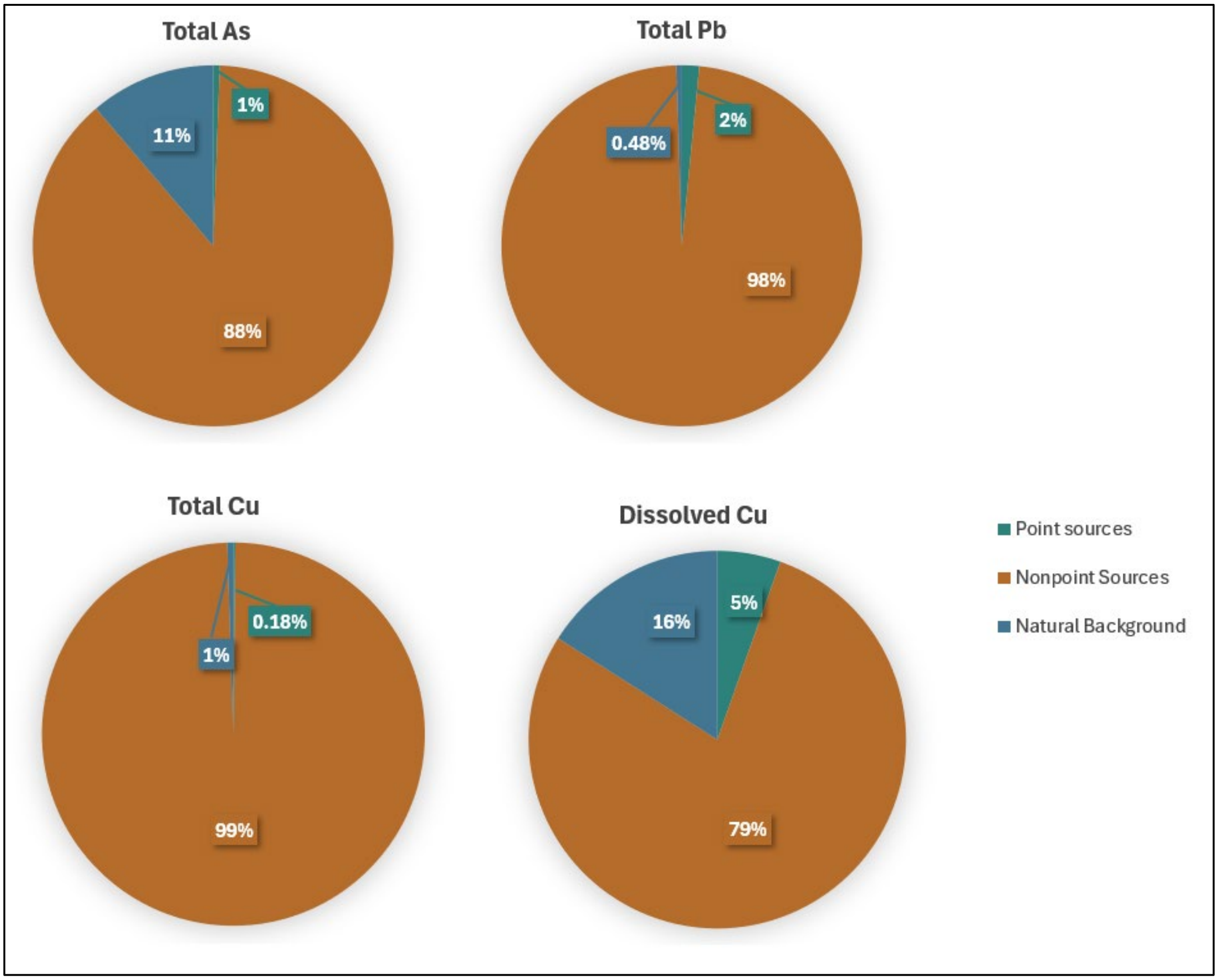

Figure 86. Source summary for Lower Big Bug Creek.
See section 7.2.4 for more information on natural background concentrations

Section 7. TMDL Technical Approach

A TMDL is equal to the amount of a pollutant that can be assimilated by a waterbody while still meeting WQS and protecting designating uses (i.e., loading capacity). This loading capacity is allocated among identified sources as WLA from point sources, LA from nonpoint sources, NB conditions, plus an MOS. It is defined by the following equation:

$$TMDL = WLA + LA + NB + MOS$$

7.1 Technical Approaches Considered

There are multiple approaches for developing TMDLs, including flow-based methods like load duration curves (LDCs), concentration-based assessments, and complex watershed modeling using tools such as Hydrological Simulation Program – Fortran (HSPF) or Soil and Water Assessment Tool (SWAT). The selection of an approach depends on factors such as data availability, watershed complexity, pollutant sources, and the level of detail needed to support management decisions. The following sections describe the different approaches considered in this TMDL analysis.

7.1.1 LDCs

LDCs were explored as a method to assess pollutant loads under varying flow conditions. LDCs are graphical tools that relate streamflow to pollutant concentrations or loads by plotting observed data against flow duration percentiles to identify when exceedances occur. While this approach can be useful for interpreting pollutant loading patterns across different hydrologic conditions, its application can be limited due to sparse flow data and a lack of paired water quality measurements needed to confidently construct the curves.

7.1.2 Concentration-Based TMDLs

Concentration-based TMDLs were also considered as an alternative approach. This method sets target pollutant concentrations, often based on WQC, rather than calculating loads, and compares them directly to observed instream concentrations to assess impairment. This approach reduces reliance on streamflow estimates but can be constrained by the frequency and spatial coverage of water quality sampling, which can hinder the ability to characterize typical conditions or capture variability across seasons and hydrologic events.

7.1.3 Combined Modeling

A complex modeling scenario was explored that would couple a watershed model (e.g. HSPF) with an in-stream model (e.g., Water Quality Simulation Program or WASP) to estimate loading. While this type of scenario can be useful for TMDL completion, obstacles to application can be hindered by limited availability of both water quality and flow data, the TMDL Numeric Endpoints being the same as the WQC, and little to no available source loading data. Because metals have numeric WQS (acute and chronic) that can be used directly in the TMDL analysis, there is no need to translate TMDL endpoints to WQS. Also, additions and updates to the modeling results may be needed in the future. This complex modeling does not lend itself well to TMDL updates because the model would have to be recalibrated and revalidated with any new inputs.

7.1.4 USGS StreamStats

The USGS StreamStats tool could also be utilized as a method to generate additional flow data if there is a scarcity of flow data, which can be the greatest limitation in terms of calculating loads. This tool is an online application that provides hydrologic and geomorphic data for streams and rivers in the U.S. where users can select a specific location on a map to obtain information such as streamflow statistics, watershed characteristics, and flood risk assessments (USGS 2024b). USGS StreamStats models were explored for the Upper Agua Fria Watershed; however, the only reports that are available in the state are for bankfull, flood, and peak flow statistics. Other potentially more useful reports such as annual flow, baseflow, and flow percentiles are not available for Arizona, therefore the StreamStats tool was not a viable option for estimating flow for this TMDL.

7.2 Selected Approaches

After evaluation and consideration of various technical approaches, the use of both LDCs and a concentration-based approach were determined to be best suited to address metal impairments in the Upper Agua Fria Watershed. The selected approach by impaired reach is presented in Table 31. Key water quality and flow locations to be used in the calculations for both LDCs and the concentration-based approach are presented in Figure 87. For reaches with at least three paired data points for flow and water quality, the LDC was used. If there was insufficient flow data and paired data points, the concentration-based approach was selected.

The LDC and concentration-based approaches were selected for the following reasons:

- metals pollutants have numeric WQS (acute and chronic) that can be used directly in the TMDL analysis;
- the selected approaches make the best use of available water quality data;
- these approaches allow for additions and updates to the TMDLs with minimal effort;
- data availability limits the feasibility of complex modeling; and
- the USGS StreamStats approach does not provide flow estimates for the flow regimes in which water quality data are available in Arizona.

Table 31. TMDL Development Approach by Impaired Waterbody.

Subwatershed	Impaired Waterbody	WBID	TMDL Approach
Upper Agua Fria River	Upper Agua Fria River	15070102-031B	LDC
Big Bug Creek	Upper Big Bug Creek	15070102-034A	Concentration-based
	Lower Big Bug Creek (LBB)	15070102-034B	LDC
	Unnamed tributary to Big Bug Creek	15070102-134	Concentration-based
	Unnamed tributary to Big Bug Creek (UB1)	15070102-234	Concentration-based
	Unnamed tributary to Eugene Gulch	15070102-1994	Concentration-based
	Eugene Gulch	15070102-768	Concentration-based
	Money Metal Tributary	15070102-123	Concentration-based
Lynx Creek	Lynx Creek	15070102-033A	Concentration-based
	Unnamed tributary to Lynx Creek	15070102-124	Concentration-based

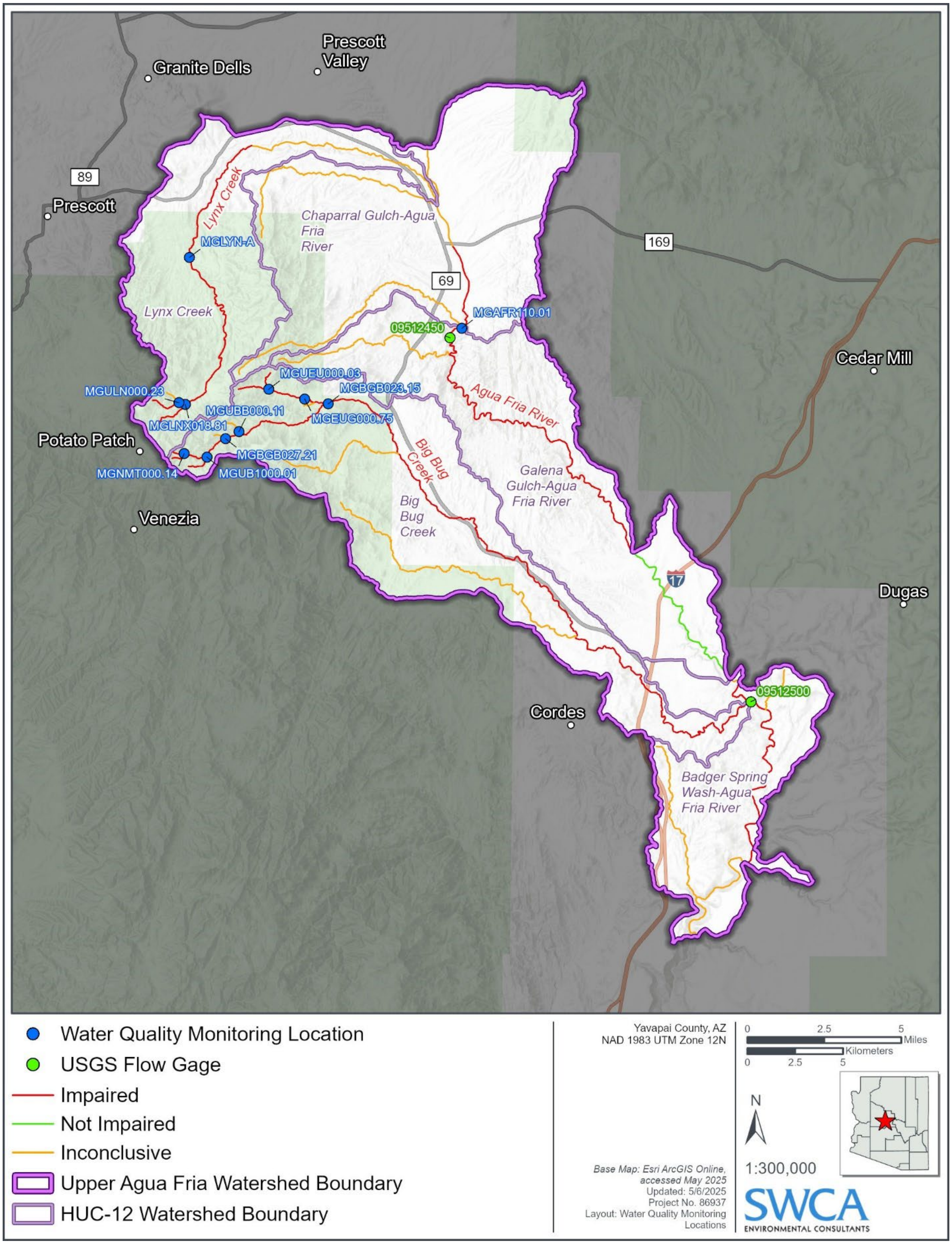

Figure 257. Water quality and flow locations to be used in TMDL calculations.

7.2.1 LDCs

The first selected approach to address impairments in the Upper Agua Fria Watershed is to employ the use of LDCs. LDCs are generally calculated for the target site to compare existing water quality conditions with those required to meet WQS (EPA 2007b). LDCs are a tried and tested method for addressing impairments that allows for characterizing water quality concentrations across different flow regimes (EPA 2007b). They identify allowable and existing loads, can provide insight into critical conditions, and are well-suited for analyses of periodic monitoring data collected by grab samples because the method can help differentiate between various types of sources. LDCs will be used to calculate a TMDL for the following waterbodies:

- Agua Fria River (15070102-031B)
- Lower Big Bug Creek (15070102-034B)

The LDC calculation consists of the following steps:

1. Flow data are used to generate a flow frequency table ranking all the observed flows from the highest observed flow to the lowest. The ranked flows are plotted to create a flow duration curve (FDC).
2. The FDC is translated into an LDC by multiplying each flow by the appropriate WQS and a conversion factor. This curve represents the loading capacity (or TMDL) for each observation. For parameters that are hardness dependent, use of the minimum, 10th percentile, 25th percentile, and median of the observed hardness values were explored for calculation of the WQS. Use of the 25th percentile was selected as it is protective of water quality while still providing flexibility in calculating percent reductions.
3. Each instream sample value is converted to a daily load by multiplying the observed concentration by the corresponding observed flow and a conversion factor.
4. The difference between the observed load and loading capacity for each flow regime quantifies the necessary load reductions as follows:

Load Reduction (%) = (current load – loading capacity)/current load) x 100).

Both observed loads and loading capacities for conditions ranging from high flow to low flow are then plotted. Loads plotted above the LDC represent exceedances of the loading capacity. Loads plotted below the curve represent allowable daily loads and are in attainment of WQS. Loads that plot above the allowable load curve in the 1–10% flow ranges (rare high-flow conditions) represent hydrologic conditions of flooding or peak storm and spring runoff flows. Loads plotting above the curve between the 10% to 40% (wet) and 40% to 60% (mid-range) flow ranges likely reflect other precipitation-driven or spring melt contributions. Those plotting above the curve in the 60% to 90% flow ranges are indicative of constant discharge sources or base flow. Loads that plot above the curve in greater than 90% of all recorded flows reflect hydrologic conditions of drought and low flow.

An underlying premise of the LDC approach is the correlation of water quality impairments to flow conditions. The LDC alone does not consider specific fate and transport mechanisms, which can vary depending on watershed or pollutant characteristics. The LDC approach helps identify the issues surrounding the impairment and roughly differentiates among sources. For example, when a stream is dominated by point source loading under drier conditions, the loads calculated from observed instream data will form a linear cluster in the drier conditions of the

LDC. If the linear cluster plots are above the LDC under these flow conditions, then point source loading is likely causing the impairment.

7.2.2 Concentration-Based TMDL

The remaining impairments in the Big Bug Creek and Lynx Creek waterbody do not have enough paired flow and water quality data to support development of an LDC. Specifically, those impaired waterbodies are:

- Upper Big Bug Creek (15070102-034A)
- Unnamed tributary to Big Bug Creek (15070102-134)
- Unnamed tributary to Big Bug Creek (UB1) (15070102-234)
- Unnamed tributary to Eugene Gulch (15070102-1994)
- Eugene Gulch (15070102-768)
- Money Metals tributary (15070102-123)
- Lynx Creek (15070102-033A)
- Unnamed tributary to Lynx Creek (15070102-124)

Additionally, the count of measured flow values is too low to develop regressions with any of the continuous flow gages in the watershed, and the necessary USGS StreamStats outputs are not available in the state of Arizona. In light of these limitations, the approach to developing TMDLs for these waterbodies will rely primarily on a concentration-based approach. A concentration-based approach utilizes the water quality numeric standard as the TMDL target and eliminates reliance on dilution and other instream processes to meet the TMDL. It assumes that if all sources are at or below the WQS, then the receiving water will attain WQS. This process will be developed as follows:

1. Identify the key monitoring location for each waterbody based on data availability, percent exceedance of the WQS, and location within the impaired waterbody.
2. Calculate the appropriate WQS for each impairment. Use of the 25th percentile of hardness concentration was selected as it is protective of water quality while still providing flexibility in calculating percent reductions.
3. Calculate the percent reduction needed in parameter concentration at key monitoring locations to achieve the TMDL target as follows:

   Percent reduction = ((observed concentration – WQS)/observed concentration) x 100.

   Understanding percent reductions through the lens of concentration (instead of load) eliminates the uncertainty in the calculation that would be introduced by including flows and associated loads.
4. In cases where a key monitoring location is upstream of a downstream site that is impaired, additional future monitoring and analysis will be recommended to refine the percent reduction at the upstream site and ensure that it is protective of downstream waters.

7.2.3 Source Assessment

In the Upper Agua Fria Watershed, there are sources that do not have site-specific data but are likely a contributor of pollutants to the watershed. To accurately understand the contribution of pollutants from sources in the Upper Agua Fria Watershed that did not have comprehensive site-specific datasets, representative concentrations were estimated using either Arizona Discharge Monitoring Report (DMR) data or NSQD data, and where appropriate, runoff estimates were made using the Curve Number method. Methods of analysis are described in the following sections. Actual values for each source are included in the Source Assessment Summary (Section 6.3).

7.2.3.1 REPRESENTATIVE CONCENTRATION DATA

Representative concentrations for water quality parameters of interest were obtained from either site-specific data, the Arizona statewide DMRs, or from the NSQD. For sources where site-specific DMR data was unavailable, statewide DMR data were summarized, and if statewide DMR data were unavailable, NSQD was utilized. Details on specific methods are outlined below.

Arizona Statewide DMR Data

DMR data are records submitted by permitted facilities that detail the quantity and quality of pollutants discharged into surface waters, as required by environmental regulatory agencies. Statewide Arizona MSGP data were utilized to estimate loading from MSGP sites that did not have monitoring data. The statewide MSGP data were summarized by sector and water quality parameters, and only parameters with more than two data records were summarized. The relevant MSGP sectors are summarized in Table 26.

National Stormwater Quality Database Data

NSQD data consist of stormwater runoff quality measurements collected from various land uses across the United States to support analysis of pollutant concentrations and inform stormwater management practices (NSQD 2015). To support loading estimates in the Upper Agua Fria Watershed, NSQD data were summarized by primary land use and state. NSQD primary land use categories are Commercial, Highway or Freeway, Industrial, Institutional, Open Space, and Recreational.

In instances where a primary land use category did not have summary data for the state of Arizona, data from Colorado and Texas was summarized. These states were selected because they were the only other southwestern states in the national database. If there were no data for Colorado or Texas, nationwide data were summarized.

Dissolved Metals

Concentration data on dissolved metals were limited in both the statewide DMR and the NSQD. In the absence of dissolved metal concentrations, conversion factors, as summarized in Table 33, for dissolved metals were used to estimate dissolved concentrations from total concentration values (EPA 1996).

Table 32. Conversion Factors for Dissolved Metals.

Metal	Conversion Factors	
	Acute	Chronic
As	1.000	1.000
Cd*	0.944	0.909
Chromium (III)	0.316	0.860
Chromium (VI)	0.982	0.962
Cu	0.960	0.960
Pb*	0.791	0.791
Hg	0.850	NA
Ni	0.998	0.997
Ag	0.850	NA
Zn	0.85	0.986

*Conversion factors for Cd and Pb are hardness dependent. These values are calculated with a hardness of 100 mg/L as calcium carbonate ($CaCO_3$).

PRECIPITATION AND RUNOFF ESTIMATES

Due to the limited amount of flow data available in this watershed, runoff was estimated using the rainfall-runoff Curve Number method developed by the U.S. Department of Agriculture (USDA 2021). Curve Numbers are unitless representations of the portion of runoff expected for an area based on unique soil/land use combinations. Curve numbers range from a low of 1 to a high of 100. Higher curve numbers indicate more runoff during a storm event and are influenced by slow draining soils and impervious cover.

The Curve Number method was used to calculate runoff (Q) using the NRCS runoff equation and Curve Numbers were obtained from the USDA Soil Survey Geographic Database (SSURGO) soils data.

$$Q = \frac{(P - Ia)^2}{(P - Ia) + S}$$

Where:

Q = Runoff (in)

P = Rainfall (in)

Ia = initial abstraction (in)

S = potential maximum retention after runoff begins (in)

Rainfall (P) was estimated using data from the nearest National Oceanic and Atmospheric Administration National Center for Environmental Information Weather Site (Prescott - US1AZYV0001). Storms with at least 0.5 inches of precipitation within 24 hours were classified as storm events, and their precipitation totals were summed annually from 2015 to 2025. This 0.5-inch threshold is the on-site retention guidance for Arizona as stated in the State Post Construction Stormwater Standards (EPA 2016).

Q was converted to a volume of runoff in liters using the following equation:

$$Runoff\ Volume\ (L) = Q\ \times Drainage\ Area\ (acres) \times \frac{1\ ft}{12\ in} \times \frac{43{,}560\ ft^2}{acre} \times \frac{28{,}316\ L}{ft^3}$$

Where:

Drainage Area = acreage of the parcel boundary that the source of interest is located in

7.2.4 Natural Background

The contribution of NB levels of metals was assessed and calculated where data was available. Historic metals concentrations were evaluated in relation to current concentration data and the timing of active and historic mining operations as identified through the source identification process. Where data support, the NB levels of a metal were subtracted from the current levels before the percent reduction was calculated.

7.2.4.1 UPPER AGUA FRIA RIVER SUBWATERSHED

The NB for dissolved Zn and total Se was calculated using data available at monitoring location MGAFR111.17, just upstream of the inflow of Chaparral Gulch (n = 3) (see Figure 9). This appears to be the most upstream monitoring location with the least human disturbance in the contributing watershed. An average load of 311.16 g/day of dissolved Zn was calculated which represents 18% of the TMDL. An average load of 4.68 g/day of total Se was calculated that represents 30% of the TMDL.

7.2.4.2 BIG BUG CREEK SUBWATERSHED

Limited As, Cu, and Pb data were available in the watershed beyond the data collected at the impaired monitoring locations; therefore, literature values were used to represent background concentrations for these parameters. The concentration of 10 ug/L was selected based on a comprehensive study that assessed surface and groundwater As concentrations across the state of Arizona (Jones et al. 2020).

For total As, the NB load was calculated using a concentration of 10 ug/L times (Jones et al. 2020) the average flow of all observed sample points (n = 30) for a value of 49.77 g/day, 49% of the TMDL.

For total Cu, the NB load was calculated using a concentration of 7 ug/L times the average flow of all observed sample points (n = 30) for a value of 34.84 g/day, 2% of the TMDL. The background concentration of 7 ug/L was selected based on a single data point collected at a downstream monitoring location on Lower Big Bug Creek in 2010 (MGBGB009.57). Cu concentrations are known to vary from 0.2 to 30 ug/L in freshwater systems (Bowen 1985) indicating that a value of 7 ug/L as an NB is reasonable. No data exist for dissolved Cu at MGBGB009.57; therefore, 60% of the total Cu concentration was assumed to be dissolved resulting in a concentration value of 4.2 ug/L. The NB load for dissolved Cu is 20.91 g/day or 20% of the TMDL.

For total Pb, the NB load was calculated using a concentration of 1.2 ug/L times the average flow of all observed sample points (n = 30) for a value of 5.97 g/day, 5% of the TMDL. The background concentration of 1.2 ug/L was selected based on based on a single data point collected at a downstream monitoring location on Lower Big Bug Creek in 2010 (MGBGB009.57).

7.2.4.3 LYNX CREEK SUBWATERSHED

NB was not calculated for these impairments as there are no data or literature review studies to support the presence of a NB concentration in these waters for these parameters.

7.2.5 Waterbody Specific Approaches

7.3.1 UPPER AGUA FRIA

For the impaired reach of the Upper Agua Fria River, the total Se and dissolved Zn impairments was elucidated using the LDC method. For both the total Se and dissolved Zn impairments, water quality data from site MGARF110.01 and flow data from the USGS Gage 9512450 were used to calculate loads (see Figure 9). Site MGAFR110.01 was selected due to the greatest number of observed water quality concentrations for both Se and Zn. The site also exhibits exceedances of the WQS for both parameters. While the USGS gage is approximately 0.5 mile downstream of site MGAFR110.01, it was selected as the best available option for flow given its continuous record of data and proximity to the water quality sampling location. The WQS for dissolved Zn is hardness dependent, therefore the calculated value based on the 25th percentile of observed hardness values was selected as the standard to use to calculate the loading capacity. Table 34 presents a summary of the relevant information for each parameter to develop the TMDL.

Table 33. Data to be Used in TMDL Calculations for Each Impairment in Agua Fria River.

Impairment Parameter	Key Monitoring Location	Flow Location	WQS to Calculate LDCs (ug/L)	Sample Size	Percent Exceedance
Total Se	MGAFR110.01	USGS Gage 9512450	AWW Chronic = 2	14	42%
Dissolved Zn	MGAFR110.01	USGS Gage 9512450	AWW Acute & Chronic = 246*	13	8%

Note: Dissolved Zn standard was calculated based on the 25th percentile of observed total hardness values of 240 mg/L.

To ensure that the study period (i.e., the time frame of water quality data collection for site MGARF110.01) covers a representative range of historic flows, average annual flows recorded at USGS Gage 9512450 from 2000 to 2024 were compared to flows measured during the period of study of 2008 to 2018 (Figure 88). As shown in Figure 88, flows during the period of study are represented by all three hydrologic regimes identified over the timespan of the USGS gage. That is, some of the highest and lowest flows on record are represented during the period of study.

The average daily USGS flows were used to create an FDC that are used to calculate loading capacity and understand the relationship to observed loads for both total Se and dissolved Zn (Figure 89). Load reductions and percent reductions needed were calculated for each of the five flow regimes.

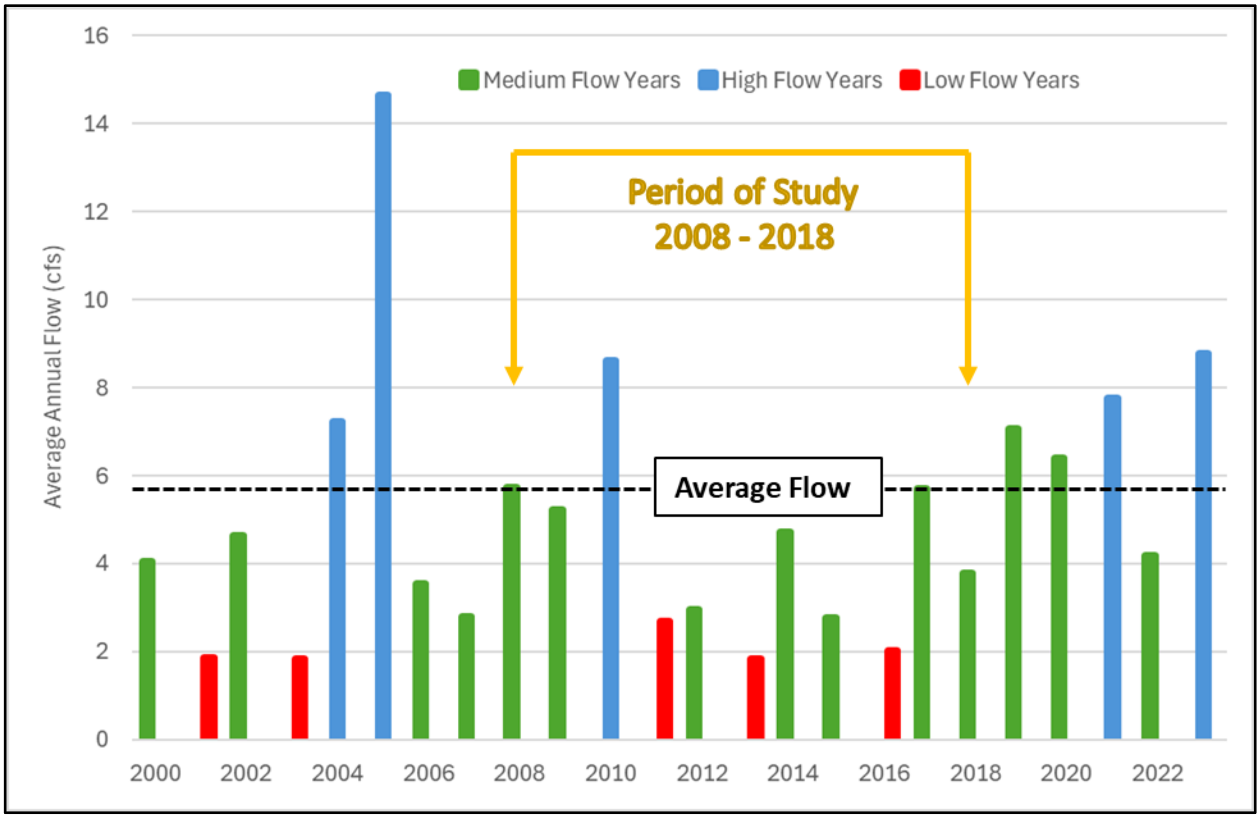

Figure 88. Period of study as compared to the entire flow record for USGS Gage 9512450.

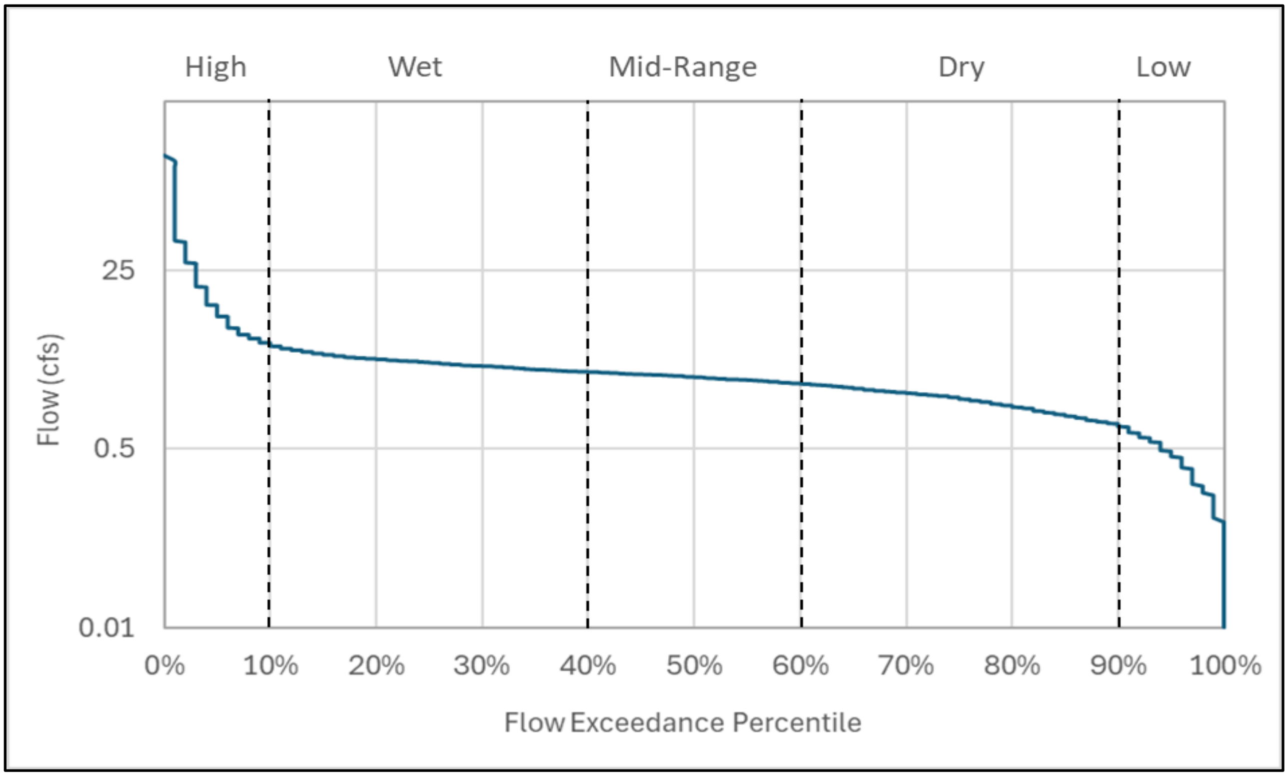

Figure 89. FDC for USGS Gage 9512450 using data from 2008 to 2018.

7.2.5.1 BIG BUG CREEK SUBWATERSHED

A varied approach will be employed for understanding and calculating pollutant loads, percent reductions, and TMDLs for each impaired waterbody in the Big Bug Creek subwatershed. A description of each approach by impaired waterbody is presented below.

Lower Big Bug Creek (LBB)

Given the availability of flow and water quality data, an LDC will be developed for the Lower Big Bug Creek (LBB) impairments. The most data-rich site for all parameters (i.e., As, Cu, Pb) with exceedances is site MGBGB023.15 at the top of the impaired waterbody just below the confluence with the Eugene Gulch tributary (see Figure 9). This site also has 20 flow measurements, although additional flow values are needed to ensure all water quality observations have a paired flow. A regression was generated using observed flow values from site MGBGB023.15 and USGS Gage 9512500 (n = 20, R^2 = 0.89, y = 0.0261x + 0.1722) to develop flow values for water quality observations with no measured flow data (n = 12). Table 35 presents a summary of the relevant information for each parameter to develop the TMDL.

Table 34. Data to be Used in TMDL Calculations for Each Impairment for Big Bug Creek.

Impairment Parameter	Flow Location	WQS to Calculate LDCs (ug/L)	Sample Size	Percent Exceedance
Total As	MGBGB023.15 USGS 9512500	AGL = 200 FBC = 30	30	AGL = 3% FBC = 41%
Total Cu	MGBGB023.15 USGS 9512500	AGL = 500 FBC = 1300	30	AGL = 27% FBC = 9%
Dissolved Cu*	MGBGB023.15 USGS 9512500	AWW Acute = 19.7* AWW Chronic = 12.7*	30	AWW Acute = 12% AWW Chronic =25%
Total Pb	MGBGB023.15 USGS 9512500	AGL = 100 FBC = 15	30	AGL = 29% FBC = 52%
Dissolved Pb*	MGBGB023.15 USGS 9512500	AWW Acute = 100.1* AWW Chronic = 3.9*	29	AWW Acute = 0% AWW Chronic = 12%

Note: Dissolved Cu and Pb standard were calculated based on the 25th percentile of observed total hardness values of 150 mg/L.

Other Impaired Waterbodies in Big Bug Creek Subwatershed

The approach for the remaining impaired waterbodies in the Big Bug Creek subwatershed will be concentration-based and follow the process described above. All relevant information for each impaired waterbody to successfully execute this approach is presented in Table 36.

Table 35. Data to be Used in TMDL Development for Each Impairment in Big Bug Creek Watershed.

Impaired Waterbody	Impairment Parameter	Key Monitoring Location	Data Observ ations	Paired Flows	WQS (ug/L)	% Exceedance	Downstream Reach
Eugene Gulch	Dissolved Cu	MGEUG0 00.75	10	7	AWE = 4.1[*]	AWE = 83%	Lower Big Bug Creek
Unnamed tributary to Eugene Gulch	Dissolved Cu	MGUEU0 00.03	15	5	AWE = 18.6[†]	AWE = 100%	Eugene Gulch
Upper Big Bug Creek	Dissolved Cd	MGBGB0 27.21	10	5	AWC Acute = 0.8[‡] AWC Chronic = 0.4[‡]	AWC Acute = 100% AWC Chronic = 100%	Lower Big Bug Creek
	Dissolved Zn	MGBGB0 27.21	10	5	AWC Acute = 56.2[3] AWC Chronic = 56.2[3]	AWC Acute = 100% AWC Chronic = 100%	
Unnamed tributary to Upper Big Bug Creek	Dissolved Cu	MGUBB0 00.11	4	4	AWE = 5.3[§]	AWE = 100%	Upper Big Bug Creek
	Dissolved Pb	MGUBB0 00.11	5	5	AWE = 24.1[§]	AWE = 100%	
Unnamed tributary to Upper Big Bug Creek (UB1)	Dissolved Cu	MGUB100 0.01	9	9	AWC Acute = 4.1[¶] AWC Chronic = 3.0[¶]	AWC Acute = 44% AWC Chronic = 44%	Upper Big Bug Creek
	Dissolved Cd	MGUB100 0.01	10	10	AWC Acute = 0.5[¶] AWC Chronic = 0.3[¶]	AWC Acute = 20% AWC Chronic = 60%	
Money Metals tributary	Dissolved Cu	MGNMT0 00.14	11	8	AWE = 4.9[#]	AWE = 88%	Yes – Unnamed tributary to Upper Big Bug Creek (UB1)
	Dissolved Zn	MGNMT0 00.14	11	8	AWE = 272.3[#]	AWE = 86%	

[*] Dissolved Cu standard was calculated based on the 25th percentile of observed total hardness values of 16 mg/L.

[†] Dissolved Cu standard was calculated based on the 25th percentile of observed total hardness values of 79 mg/L.

[‡] Dissolved Cd and Zn standard were calculated based on the 25th percentile of observed total hardness values of 42 mg/L.

§ Dissolved Cu and Pb standard were calculated based on the 25th percentile of observed total hardness values of 21 mg/L.

¶ Dissolved Cu and Cd standard were calculated based on the 25th percentile of observed total hardness values of 28 mg/L.

Dissolved Cu and Zn standard were calculated based on the 25th percentile of observed total hardness values of 19 mg/L.

7.2.6 LYNX CREEK SUBWATERSHED

The approach for the two impaired waterbodies in the Lynx Creek subwatershed will be concentration-based and follow the process described above in section 7.2.2. All relevant information for each impaired waterbody to successfully execute this approach is presented in Table 37. Further evaluation of the Lynx Creek Lake data at site MGLYN–A was conducted to determine if exceedances occur in the lake at the site closest to the outlet. No hardness data were available for the lake, so the maximum hardness value of 160 mg/L for the closest Lynx Creek site, MGLNX011.05, was used to calculate appropriate standard for dissolved Cu, Cd, and Zn. Based on these estimated standards, no exceedances of the three metals occurred in the lake. Additionally, data collected in August 2024 in the creek below Lynx Lake does not indicate any exceedances. Additional data collection is warranted in the portion of Lynx Creek below the lake to determine whether the impairment remains downstream of the lake.

Table 36. Data to be Used in TMDL Calculations for Each Impairment in Lynx Creek Watershed.

Impaired Waterbody	Impairment Parameter	Key Monitoring Location	Data Observations	Paired Flows	WQS (ug/L)	Percent Exceedance of the WQC	Contribution to Downstream Impairment?
Unnamed tributary to Lynx Creek	Dissolved Cu	MGULN000.23	4	3	AWC Acute = 31* AWC Chronic = 19*	AWC Acute = 100% AWC Chronic = 100%	Yes – Lynx Creek
Lynx Creek	Dissolved Cd	MGLNX018.81	8	8	AWC Acute = 6.5† AWC Chronic = 2†	AWC Acute = 75% AWC Chronic = 100%	No – although the creek does discharge into Lynx Lake identified as Category 3 (inconclusive)
	Dissolved Zn	MGLNX018.81	8	8	AWC Acute = 379† AWC Chronic = 379†	AWC Acute = 88% AWC Chronic = 88%	

Impaired Waterbody	Impairment Parameter	Key Monitoring Location	Data Observations	Paired Flows	WQS (ug/L)	Percent Exceedance of the WQC	Contribution to Downstream Impairment?
	Dissolved Cu	MGLNX01 8.81	8	8	AWC Acute = 50† AWC Chronic = 29†	AWC Acute = 25% AWC Chronic = 38%	

*Dissolved Cu standard was calculated based on the 25th percentile of observed total hardness values of 243 mg/L.

†Dissolved Cd, Zn, and Cu standard were based on the 25th percentile of observed total hardness values of 400 mg/L.

7.3 Margin of Safety

The MOS is a required component of a TMDL that accounts for uncertainty in the relationship between the modeled pollutant loads and the quality of the receiving waterbody (EPA 2007b). The MOS can be implicit through the use of conservative assumptions and values for calculations, or explicit as a certain percentage of the loading capacity. For all TMDL calculations in the Upper Agua Fria Watershed, both an explicit and implicit MOS are utilized. The explicit MOS is calculated as 10% of the TMDL. The use of an explicit MOS is warranted to account for data variability that is not captured in the low sample counts for each impairment. The MOS also relies on conservative assumptions in the analysis including use of the 25th percentile of hardness for calculating allowable loads (TMDL) and no assimilation is assumed between sources and receiving reaches and unless otherwise noted, percent reductions for both LDCs and concentration-based TMDLs were calculated using the average of exceedances only (versus the average across flow regimes) to ensure that recommended percent reduction is high enough to resolve the impairment.

The MOS used for each subwatershed is summarized in Table 38.

Table 37. Margin of Safety Description.

Subwatershed	MOS Description
Upper Agua Fria River	The MOS is explicitly defined as 10% of the loading capacity for a value of 1.57 g/day for total Se. The use of an explicit MOS is warranted to account for unknown variability in the data due to the small sample counts (n = 14).
	The MOS is explicitly defined as 10% of the loading capacity for a value of 170.93 g/day for dissolved Zn. The use of an explicit MOS is warranted to account for unknown variability in the data due to the small sample count (n = 13).

Subwatershed	MOS Description
Big Bug Creek—Lower Big Bug Reach	The MOS for each impairment is explicitly defined as 10% of the loading capacity. The use of an explicit MOS is warranted to account for uncertainty in estimating TMDL components due to lack of data for both the TMDL calculation and NB estimation.
Big Bug Creek—all other reaches	The implicit MOS relies on conservative assumptions in the analysis including use of the 25th percentile of hardness for calculating allowable loads (TMDL) and no assimilation is assumed between sources and receiving reaches. An explicit MOS was not calculated because the use of the relevant WQS as the TMDL target is a much more conservative approach than calculating an explicit MOS and readily accounts for any uncertainty.
Lynx Creek	The implicit MOS relies on conservative assumptions in the analysis including use of the 25th percentile of hardness for calculating allowable loads (TMDL) and no assimilation is assumed between sources and receiving reaches. An explicit MOS was not calculated because the use of the relevant WQS as the TMDL target is a much more conservative approach than calculating an explicit MOS and readily accounts for any uncertainty.

Section 8. Linkage Analysis

The purpose of the linkage analysis is to establish the connections or linkages between the loadings to waterbodies (i.e., the causes of impairment) and the water quality response within the receiving waters. This section describes the approach used to characterize waterbody response to pollutant loadings from the watershed.

8.1 Metals

Understanding the fate and transport of metals in the watershed is crucial for assessing and improving water quality as it relates to human health impacts and the ecological health of streams. Metals, both naturally occurring and anthropogenic, can be introduced into watershed systems through various pathways, including historic and active mine discharges, non-regulated stormwater runoff, atmospheric deposition, and underlying geologic formations coupled with erosion. Once discharged into aquatic systems, metals can undergo complex physical, chemical, and biological processes that influence their distribution, concentration, and potential toxicity. Understanding these processes is critical for predicting the movement and fate of metals, which can have significant implications for ecosystem health, human safety, and regulatory compliance.

Certain geographic regions naturally contain high metal concentrations, and where land disturbance accelerates erosion, metals can enter air, water, and soil, eventually reaching aquatic ecosystems. Metals enter surface waters from both point sources and NPSs where deposited metals can infiltrate groundwater or be washed into streams during storms. Naturally metal-rich areas and sites with legacy contamination, such as historic mining lands, can also become pollution sources when land cover is altered thus increasing erosion and runoff. Once in water, metal bioavailability and toxicity depend on environmental factors like pH, temperature, redox potential, and microbial activity where free metal ions are the most toxic, often disrupting regulation in aquatic organisms, leading to system dysfunction and/or mortality (EPA 2025a). Acid mine drainage can further impair ecosystems by lowering pH and depositing metal hydroxides that suppress aquatic habitats. Figure 90 illustrates possible pathways through which both point sources and NPSs contribute metals to surface waters and the transformations that could occur with downstream transport.

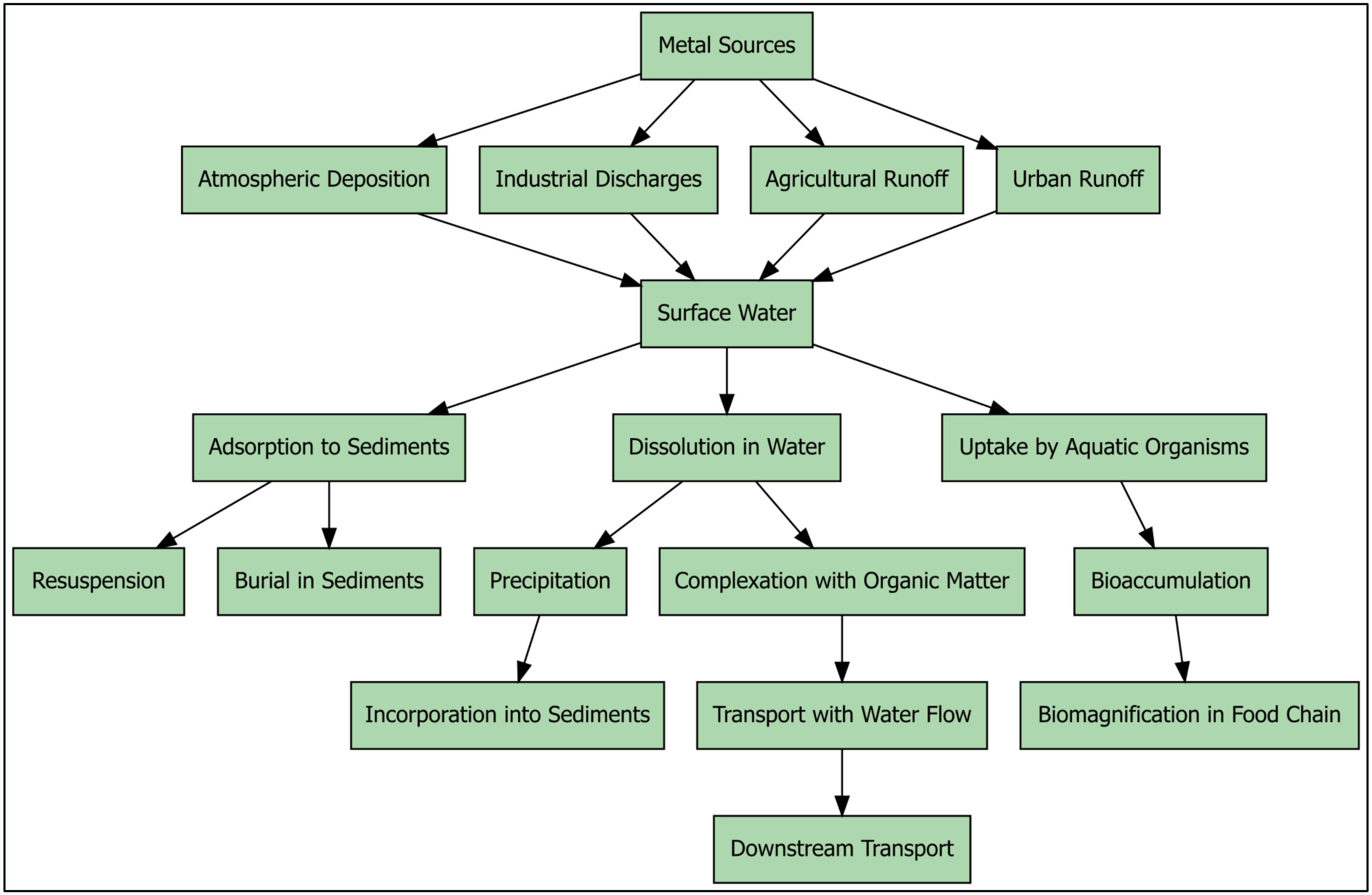

Figure 90. General transport of metals in surface water systems (Adapted from EPA 2025a).

As discussed in Section 2, several waterbodies in the Upper Agua Fria River, Big Bug Creek, and Lynx Creek subwatersheds within the larger Upper Agua Fria Watershed are listed as impaired due to the following parameters: Cd, Zn, As, Cu, Pb, and Se. With the exception of Se, these parameters are all metals that tend to behave similarly in aquatic environments. Several factors influence metal mobilization and toxicity, but generally speaking, metals are more toxic and mobile when the factors outlined below are present (Zhou 2023). A summary of metals as they relate to fate, transport, toxicity, and sources is provided in Table 39. Since Se is considered to be a nonmetal, a separate description is provided in Section 6.1 and Section 8.2.

- **Elevated salt concentrations**: increased salinity contributes to a desorption of metals from solid materials.
- **Change in redox conditions**: when the amount of oxygen in water decreases it changes the oxidation state of a metal to a reduced state where it can become more soluble and mobile.
- **Low pH:** a lower pH increases the solubility of metals making them more readily available and potentially more toxic.
- **Biochemical process**: when heavy metals adsorb onto particulate organic matter or sediment, they can be remobilized into the water by microbial processes such as biodegradation.
- **Water hardness**: when an aquatic environment exhibits a low hardness, there is less competition for binding sites, effectively increasing the bioavailability and toxicity of metals to aquatic organisms. In hardness-rich waters, metals bind to calcium and magnesium ions present in the water column as well as to ions bound to the gills of organisms therefore decreasing bioavailability and toxicity.

Table 38. Characteristics and Transport Summary for As, Pb, Cd, Cu, and Zn.

Metal	Chemical Forms	Factors influencing Fate, Transport, and Toxicity	Primary Sources
As	**Arsenite (As(III)):** reducing conditions. More toxic due to higher solubility and ability to readily enter cells. **Arsenate (As(V)):** oxidizing conditions (more typical in surface water).	**Adsorption:** arsenate readily binds to iron oxides **pH influence:** higher pH generally Pbs to increased adsorption. **Microbial activity:** microorganisms can play a role in As transformation by facilitating oxidation or reduction between arsenate and arsenate, impacting its mobility. **Redox conditions:** As species change depending on redox conditions. As(V) in oxidizing conditions, and As(III) in reducing conditions. As(III) is more toxic.	**Surface water runoff:** industrial, mining, and agricultural areas where As-containing materials or geology are present. **Geology**: types of rocks and mineral present in the area greatly influence the amount of As released into water.
Cd	**Cd(II):** divalent cation that is the primary form of Cd in water.	**Solubility**: highly soluble in water. **Adsorption**: readily binds to clay minerals, iron and manganese oxide present in sediments, effectively immobilizing it. **pH influence**: higher pH level increases Cd adsorption to sediments, lower pH enhances mobility. **Organic matter interaction**: dissolved organic matter can form complexes with Cd, increasing its mobility in water. **Redox condition**: Low oxygen (reducing conditions) mobilizes Cd by dissolving previously adsorbed forms.	**Surface water runoff**: urban, industrial, mining, and agricultural areas where Cd-containing materials or geology are present. **Groundwater leaching**: from contaminated soil into groundwater. **Atmospheric deposition:** Airborne particles can settle into water bodies through precipitation.
Cu	**Cu(I):** lower oxidation state and is considered more reactive and toxic. **Cu(II):** higher oxidation state, requires further reduction to become toxic.	**Solubility**: highly soluble in water **Adsorption**: readily binds to various organic and inorganic particles, effectively immobilizing it **pH influence**: higher pH level increase Cu adsorption to sediments, lower pH enhances its mobility. **Organic matter interaction:** Higher organic matter in water can increase Cu binding and reduce its bioavailability. **Redox condition**: The oxidation state of Cu and the redox conditions in the waterbody significantly affect its speciation Cu(I) or Cu(II) and mobility. Cu(II) is generally more mobile in water.	**Surface water runoff**: urban, industrial, mining, and agricultural areas where Cu-containing materials or geology are present. **Corrosion of Cu pipes**: Leaching of Cu from plumbing systems with Cu pipes.

Metal	Chemical Forms	Factors influencing Fate, Transport, and Toxicity	Primary Sources
Pb	**Pb carbonate ($PbCO_3$):** Primary form in water**.**	**Solubility**: low solubility in water. Does not dissolve in water readily due to a protective oxide layer on its surface. Even in the form of Pb carbonate, solubility in water is low. **Adsorption**: readily binds to organic matter and clay particles, effectively immobilizing it. **Water chemistry**: Presence of carbonates, silicates, and other minerals can form precipitates with Pb, reducing its solubility. **pH influence**: higher pH level increase Pb adsorption to sediments, lower pH enhances its mobility and solubility. **Organic Matter interaction:** Higher organic matter in water can increase Pb binding and reduce its bioavailability. **Redox Condition**: High level of oxygen can promote oxidation of Pb, leading to increased solubility.	**Surface water runoff**: Urban, industrial, mining, and agricultural areas where Pb-containing materials or geology are present. **Corrosion of Pb pipes**: Leaching of Pb from plumbing systems with Pb pipes.
Zn	**Zn chloride (ZnCl2):** highly soluble, often found in treated water. **Zn carbonate (ZnCO3):** present in natural waters with carbonate-rich rocks. **Zn sulfide (ZnS):** in natural waters with high sulfide concentrations. **Zn oxide (ZnO):** present in suspended particles in water.	**Solubility**: most Zn compounds are highly soluble in water. **Adsorption**: readily binds to various organic and inorganic particles, effectively immobilizing it. **pH influence**: Zn higher pH level increase zine adsorption to sediments, lower pH enhances its mobility **Organic Matter interaction:** Higher organic matter in water can increase Zn binding and reduce its bioavailability. **Redox Condition**: Low oxygen can potentially facilitate more soluble Zn speciation.	**Geology**: types of rocks and minerals present in the area can greatly influence the amount of Zn released into water. **Surface water runoff:** industrial, mining, and agricultural areas where Zn-containing materials or geology are present.

Source: EPA (2025a).

8.2 Selenium

As a metalloid, Se sources as well as fate and transport pathways are markedly different than the metals presented in Table 39. Se is a vital trace element for human health but has a low toxicity threshold for both humans and wildlife. As a metalloid, it shares chemical properties with sulfur and often occurs alongside it in nature; however, Se is far less abundant, making up less than one part per million of Earth's major rock types (Hem 1985).

Section 9. TMDL Development

A TMDL is defined as the sum of the WLAs for point sources, plus the sum of the LAs for nonpoint and NB sources, plus a MOS. This loading budget, with an appropriate MOS, will result in a pattern of loading that the waterbody can process with its available assimilative loading capacity (i.e., TMDL) without exceeding WQS, as shown in the following equation:

$$TMDL = \sum WLA + \sum LA + MOS + NB$$

Where,

$\sum WLA$ = *Sum of all individual point source WLAs*

$\sum LA$ = *Sum of all nonpoint source LAs*

MOS = Margin of safety

NB = Natural background

The TMDLs documented in this section address metals impairments in three subwatersheds, Upper Agua Fria River, Big Bug Creek, and Lynx Creek, using two approaches, LDCs and concentration-based approach (see Section 7 for a detailed description of approaches).

The use of both an LDC and concentration-based approach were employed for understanding and calculating pollutant loads, percent reductions, and TMDLs for impaired waterbodies. For concentration-based TMDLs, the TMDL equals the WQS. A daily load expression was not calculated for concentration-based TMDLs due to small sample sizes as described in Appendix B of the EPA’s Options for Expressing Daily Loads in TMDLs (EPA 2007c). Unless otherwise noted, percent reductions for both LDCs and concentration-based TMDLs were calculated using the average of exceedances only (versus the average across flow regimes) to ensure that recommended percent reduction is high enough to resolve the impairment.

9.1 Upper Agua Fria River Subwatershed

9.1.1 Upper Agua Fria River TMDL Analysis

LDCs were developed for both total Se (Figure 91) and dissolved Zn (Figure 92) in the Upper Agua Fria River following the approach outlined in Section 7.3.1. For both impairments, water quality data from site MGARF110.01 and flow data from the USGS Gage 9512450 were used to calculate loads. The TMDL was calculated as the current flow multiplied by the appropriate WQS. The current pollutant load was calculated by taking the average of only those samples that exceeded the WQS. This approach ensures that the calculated percent reduction (see equation below) will result in a reduced pollutant load that resolves the impairment.

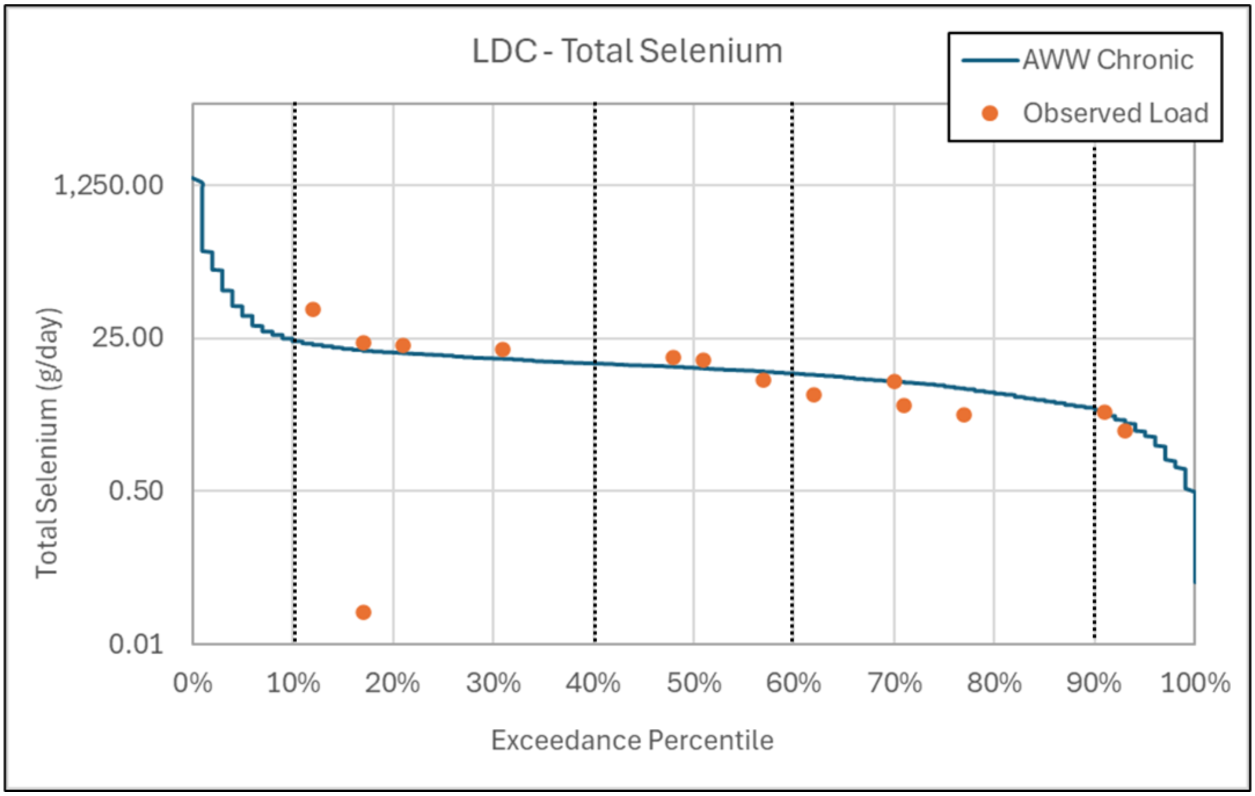

Figure 91. LDC for total Se in the Upper Agua Fria River.

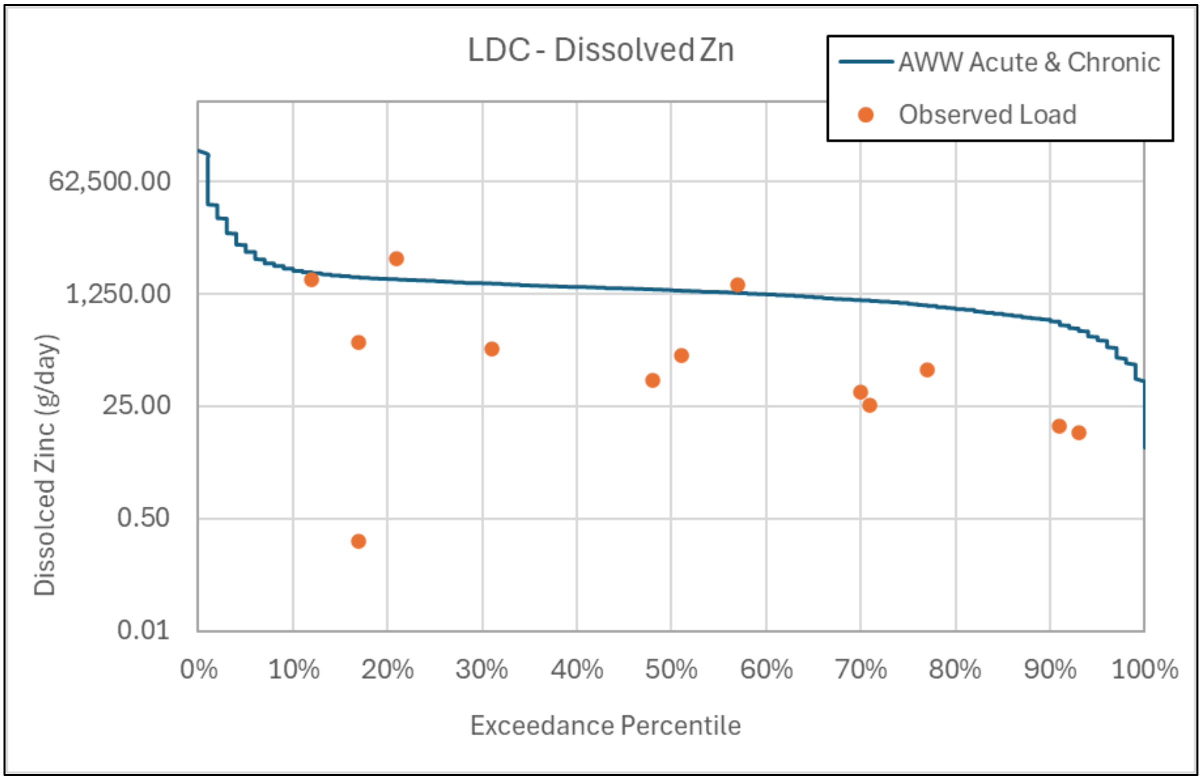

Figure 92. LDC for dissolved Zn in the Upper Agua Fria River.

Current loads from point sources, nonpoint sources, and NB sources were calculated using the methods outlined in Section 6 (Table 40). The TMDL analysis includes a 10% explicit MOS. Current point source loads are assumed to remain constant into the future with no load reductions taken in the TMDL analysis. NB loads were calculated using data available at monitoring location MGAFR111.17, just upstream of the inflow of Chaparral Gulch (see Figure 9 and Section 7.4). The necessary load reductions will be achieved through nonpoint source reductions calculated after accounting for the MOS, point source, and NB loads.

Table 39. TMDL Summary for Upper Agua Fria River.

Parameter	Source	Current Load (g/day)	TMDL (g/day)	Percent Load Reduction (%)
Total Se	Point sources	2.99	2.99	0%
	Nonpoint Sources	14.50	6.50	55%
	Natural Background	4.68	4.68	0%
	Margin of Safety	1.57	1.57	0%
	Total	**23.75**	**15.75**	**34%**
Dissolved Zn	Point sources	341.86	341.86	0%

Parameter	Source	Current Load (g/day)	TMDL (g/day)	Percent Load Reduction (%)
	Nonpoint Sources	2,130.63	885.32	58%
	Natural Background	311.16	311.16	0%
	Margin of Safety	170.93	170.93	0%
	Total	**2,954.58**	**1,709.27**	**42%**

9.1.2 Wasteload and Load Allocations

WLAs for all point sources in the watershed are equivalent to current calculated loads. As described in Section 6, there is one active point source upstream of the impairment, the Soft Winds Mobile Home Park WWTP (Permit # AZ0026051) (see Table 23). The dissolved Zn WLA for the facility was calculated using the design flow of 0.0075 MGD and the WQS identified in the permit as 225 ug/L (calculated based on the average hardness of the effluent of 216 mg/L) for a dissolved Zn WLA of 6.39 g/day, <1% of the TMDL. The total Se WLA for the facility was calculated using the design flow of 0.0075 MGD and the WQS identified in the permit as 2 ug/L for a WLA of 0.06 g/day, <1% of the TMDL.

In addition, there are three MSGP sites and one MS4. Together, WLAs for point sources represent 19% and 20% of the total TMDL load for total Se and dissolved Zn, respectively (Table 41).

The LA for NPSs is composed of loads from active unpermitted mine features calculated using the methods outlined in Section 6 and legacy mines (which pre-date modern mining regulation, are not active mines, and have no current responsible party) after accounting for the WLAs, NB, and MOS (see equation below).

$$\textit{Load Allocation} = \textit{TMDL} - \textit{WLA} - \textit{NB} - \textit{MOS}$$

Based on this analysis, NPSs need to be reduced by 55% for total Se and 58% for dissolved Zn.

Table 40. Wasteload Allocation and Load Allocation Summary for Upper Agua Fria River.

Allocation	Source	Total Se (g/day)	Dissolved Zn (g/day)
WLAs	WWTP	0.06	6.39
	We Recycle Solar Dewey Operations (MSGP)	0.0027	1.44
	Yavapai Metal Recycling (MSGP)	0.0029	1.54
	MS4s (Yavapai County)	2.39	47.73

Allocation	Source	Total Se (g/day)	Dissolved Zn (g/day)
WLAs	Iron King (EPA Superfund site)	0.54	284.76
	WLA subtotal	**2.99**	**341.86**
NPS LAs	Active mining	0.57	302.02
	Legacy mining	5.93	583.30
	LA subtotal	**6.50**	**885.32**
Natural background		4.68	311.16
MOS (10%)		1.57	170.93
Total - TMDL		**15.75**	**1,709.3**

9.2 Big Bug Creek Subwatershed - Lower Big Bug Creek

9.2.1 TMDL Analysis

LDCs were developed for total As (Figure 93), total Pb (Figure 94), total Cu (Figure 95), and dissolved Cu (Figure 96) in the Lower Big Bug Creek following the approach outlined in Section 7. For all impairments, water quality data from site MGBGB023.15 and flow data modeled from USGS Gage 9512500 were used to calculate loads (see Section 7.3.2). The observed pollutant load and the loading capacity were calculated by taking the average of only those samples that exceeded the WQS. This approach ensures that the calculated percent reduction will result in a reduced pollutant load that resolves the impairment.

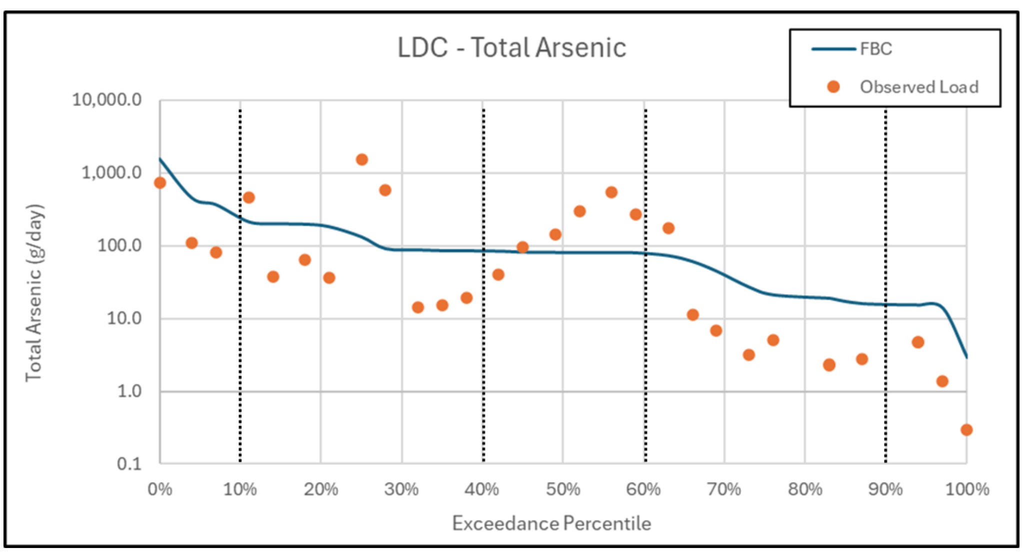

Figure 93. LDC for total As in Lower Big Bug Creek.

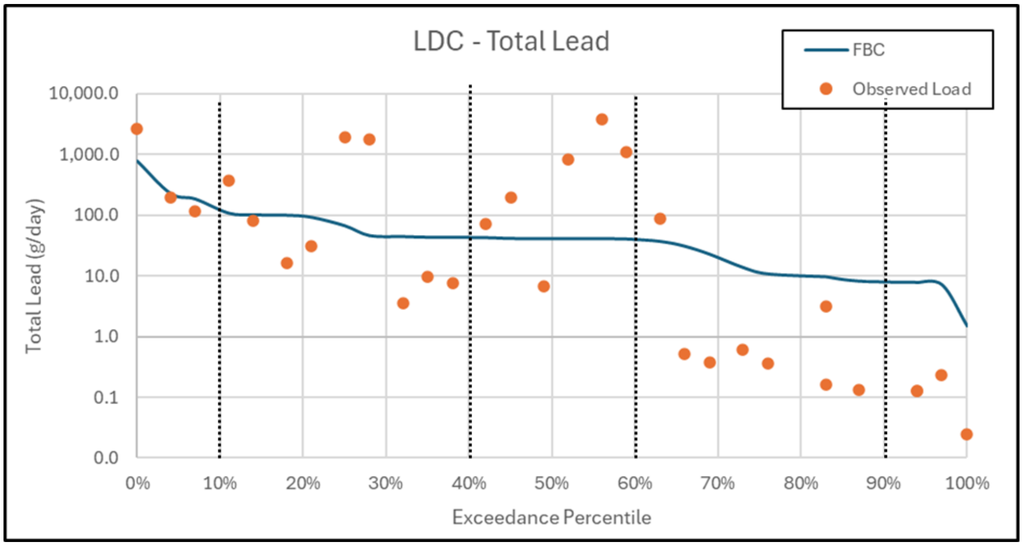

Figure 94. LDC for total Pb in Lower Big Bug Creek.

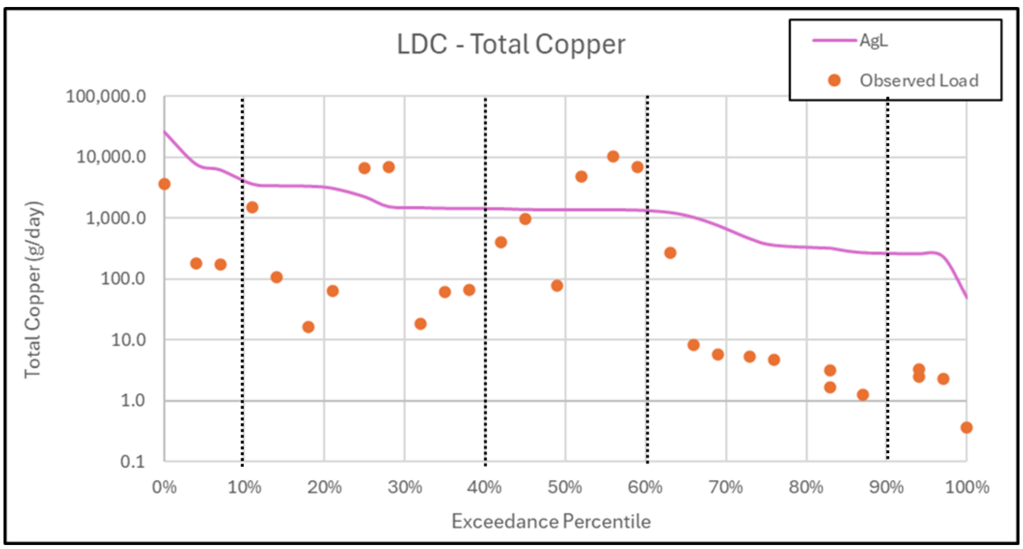

Figure 95. LDC for total Cu in Lower Big Bug Creek.

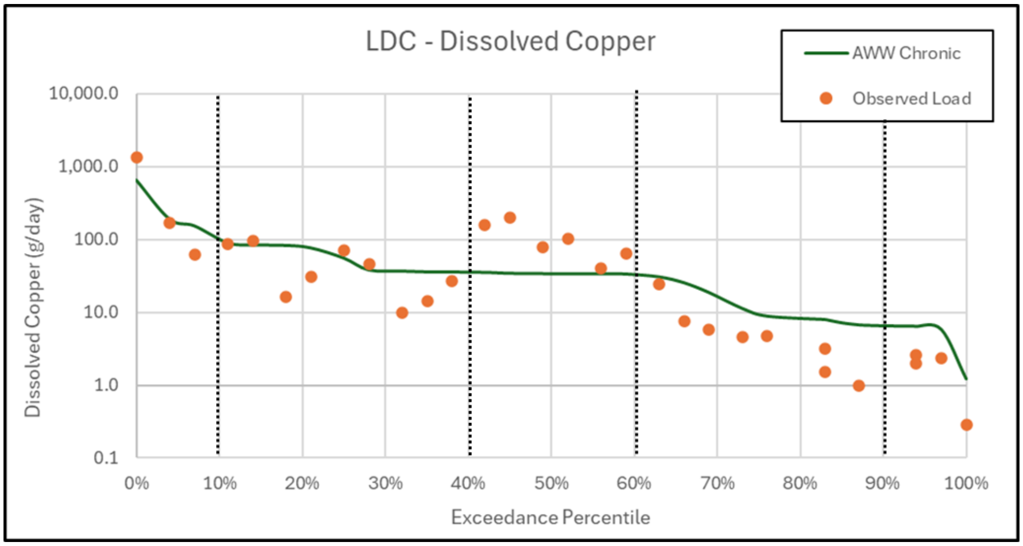

Figure 96. LDC for dissolved Cu in Lower Big Bug Creek.

Following the approach outlined in Section 7, current loads from point sources, nonpoint sources, and NB sources were calculated and are summarized in Table 41.

Table 41. TMDL Summary for Lower Big Bug Creek.

Parameter	Source	Current Load (g/day)	TMDL (g/day)	Percent Load Reduction (%)
Total As	Total	452.95	102.02	77%
	Point sources	2.63	2.63	0%
	Nonpoint Sources	390.34	40.80	90%
	Natural background	49.77	49.77	0%
	Margin of safety	10.20	10.20	0%
Total Pb	Total	1,260.89	123.88	90%
	Point sources	19.48	19.48	0%
	Nonpoint sources	1,223.05	104.89	91%
	Natural background	5.97	5.97	0%
	Margin of safety	12.39	12.39	0%
Total Cu	Total	7,108.64	1,555.36	78%
	Point sources	12.30	12.30	0%
	Nonpoint sources	6,905.97	1,363.99	80%

Parameter	Source	Current Load (g/day)	TMDL (g/day)	Percent Load Reduction (%)
Total Cu	Natural background	34.84	34.84	0%
	Margin of safety	155.54	155.54	0%
Dissolved Cu	Total	219.83	104.64	52%
	Point sources	11.38	11.38	0%
	Nonpoint sources	164.54	60.20	63%
	Natural background	33.45	33.45	0%
	Margin of safety	10.46	10.46	0%

9.2.2 Wasteload and Load Allocations

As described in Section 6, there is one active point source that discharges to the impaired waterbody, the Chimney Estates WWTP (permit # AZ0026999). The WLA for the facility was calculated using the design flow of 0.017 MGD and the most protective WQS or permit limit (if specified in the permit). In addition, there are six MSGP sites. Together, WLAs for point sources represent 3%, 16%, 1% and 11% of the total TMDL load for total As, total Pb, total Cu, and dissolved Cu respectively (Table 43).

The LA for NPSs is comprised of loads from active unpermitted mine features calculated using the methods outlined in Section 6 and legacy unpermitted mines after accounting for the WLAs, NB, and MOS (see equation below).

Load Allocation = TMDL – WLA – NB – MOS

Based on this analysis, NPSs need to be reduced by 90% for total As 91% for total Pb, 80% for total Cu, and 63% for dissolved Cu.

Table 42. Wasteload Allocation and Load Allocation Summary for Lower Big Bug Creek.

Allocation Table					
		Total As (g/day)	Total Pb (g/day)	Total Cu (g/day)	Dissolved Cu (g/day)
WLAs	WWTP	1.25	0.62	1	0.53
	Big Bug Sand and Gravel	0.52	7.13	4.27	4.10
	Henrietta Mine	0.30	4.13	2.47	2.37
	Smokestack Quarry	0.26	3.50	2.10	2.01

Allocation Table					
		Total As (g/day)	Total Pb (g/day)	Total Cu (g/day)	Dissolved Cu (g/day)
	Stoneworld Onyx Quarry Mayer	0.30	4.10	2.46	2.36
	WLA subtotal	**2.63**	**19.48**	**12.30**	**11.38**
NPS LAs	Active mining	0.08	1.05	0.63	0.60
	Brown Schist Quarry	0.08	1.05	0.63	0.60
	Legacy mining	39.34	84.99	1,352.06	48.75
	LA subtotal	**39.42**	**86.04**	**1,352.68**	**49.35**
Natural background		49.77	6	35	33
MOS (10%)		10.20	12	156	10
Total - TMDL		**102.0**	**123.9**	**1,555.4**	**104.6**

9.3 Big Bug Creek Subwatershed – Upper Big Bug Creek

9.3.1 TMDL Analysis

The TMDLs for Upper Big Bug Creek address the acute and chronic AWW impairment due to dissolved Cd (Table 44) and Zn (Table 45). Dissolved Cd and Zn concentrations need to be reduced by over 90%.

Table 43. Percentage Reduction for Upper Big Bug Creek Dissolved Cd Impairment.

Key Monitoring Location	Dissolved Cd Observations	Flow Observations	TMDL Target (ug/L)	DU Impairment	Average Dissolved Cd (ug/L)	% Reduction Needed
MGBGB027.21	10	5	0.8	AWC Acute	9.8	92%
			0.4	AWC Chronic	9.8	96%

Table 44. Percentage Reduction for Upper Big Bug Creek Dissolved Zn Impairment

Key Monitoring Location	Dissolved Zn Observations	Flow Observations	TMDL Target (ug/L)	DU Impairment	Average Dissolved Zn (ug/L)	% Reduction Needed
MGBGB027.21	10	5	56.2	AWC Acute	677.1	92%
			56.2	AWC Chronic	677.1	92%

9.3.2 Seasonality and Critical Conditions

Cd and Zn concentration appears to increase with increasing flow, however there are limited data points at higher flows to confirm that this is a consistent trend (Figures 97–98).

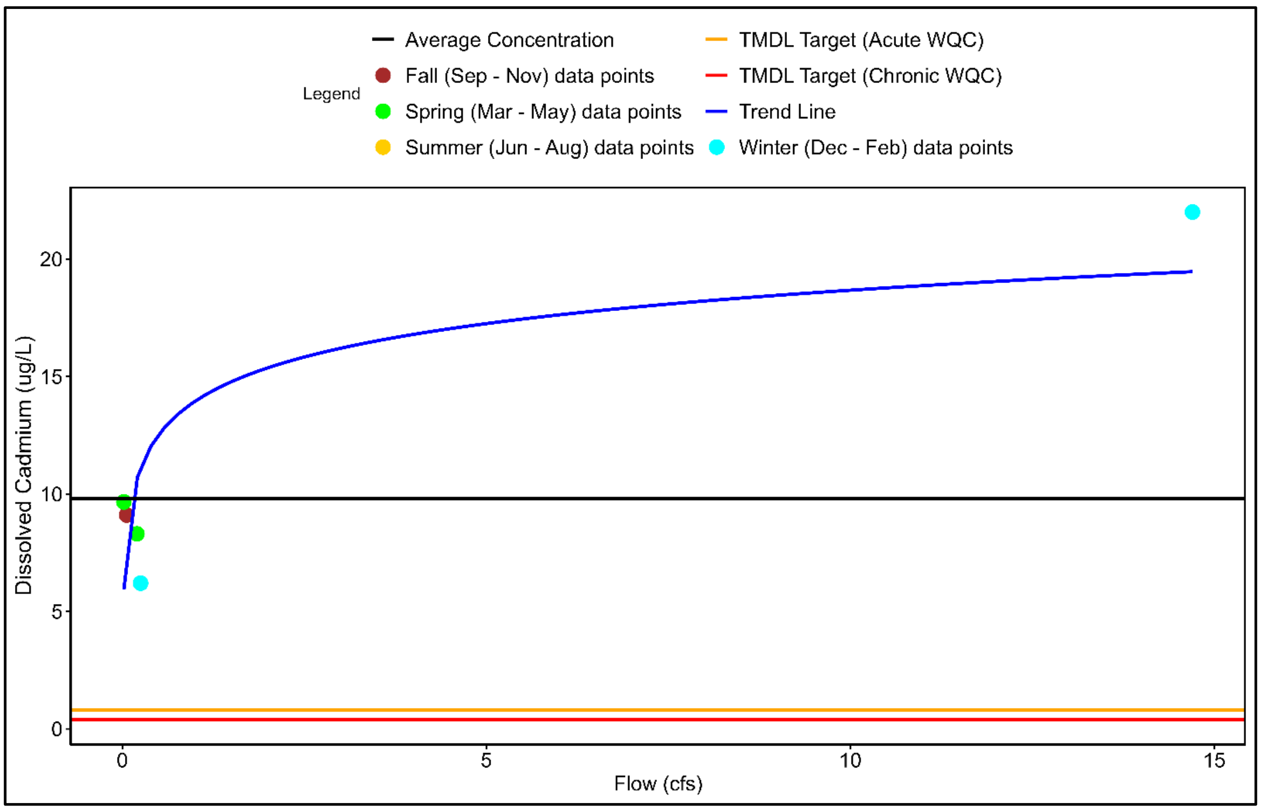

Figure 97. Relationship between flow and dissolved Cd in Upper Big Bug Creek.
Note: There are no paired flow and dissolved Cd data in the summer season.

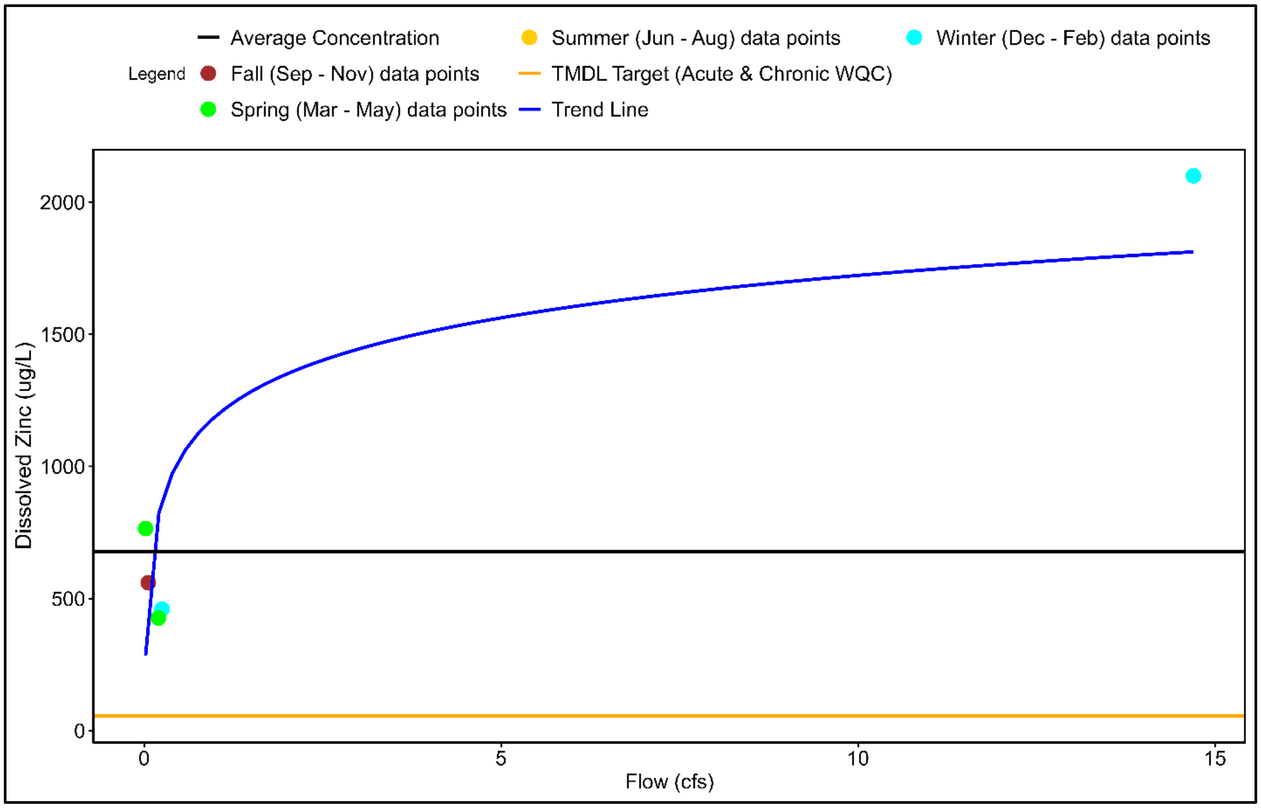

Figure 98. Relationship between flow and dissolved Zn in Upper Big Bug Creek.
Note: There are no paired flow and dissolved Zn data in the summer season.

9.4 Big Bug Creek Subwatershed – Unnamed Tributary to Big Bug Creek

9.4.1 TMDL Analysis

The TMDLs for the unnamed tributary to Big Bug Creek address the AWE impairment due to dissolved Cu (Table 46) and Pb (Table 47). Dissolved Cd and Zn concentrations need to be reduced by over 75%.

Table 45. Percentage Reduction for the Unnamed Tributary to Upper Big Bug Creek Dissolved Cu Impairment.

Key Monitoring Location	Dissolved Cu Observations	Flow Observations	TMDL Target (ug/L)	DU Impairment	Average Dissolved Cu (ug/L)	% Reduction Needed
MGUBB000.11	4	5	5.3	AWE	24.3	78%

Table 46. Percentage reduction for the Unnamed Tributary to Upper Big Bug Creek Dissolved Pb Impairment.

Key Monitoring Location	Dissolved Pb Observations	Flow Observations	TMDL Target (ug/L)	DU Impairment	Average Dissolved Pb (ug/L)	% Reduction Needed
MGUBB000.11	5	5	24.1	AWE	185.2	87%

9.4.2 Seasonality and Critical Conditions

Dissolved Cu and dissolved Pb concentrations appear to increase with increasing flow, however there are limited data points to determine consistent trends (Figures 99–100).

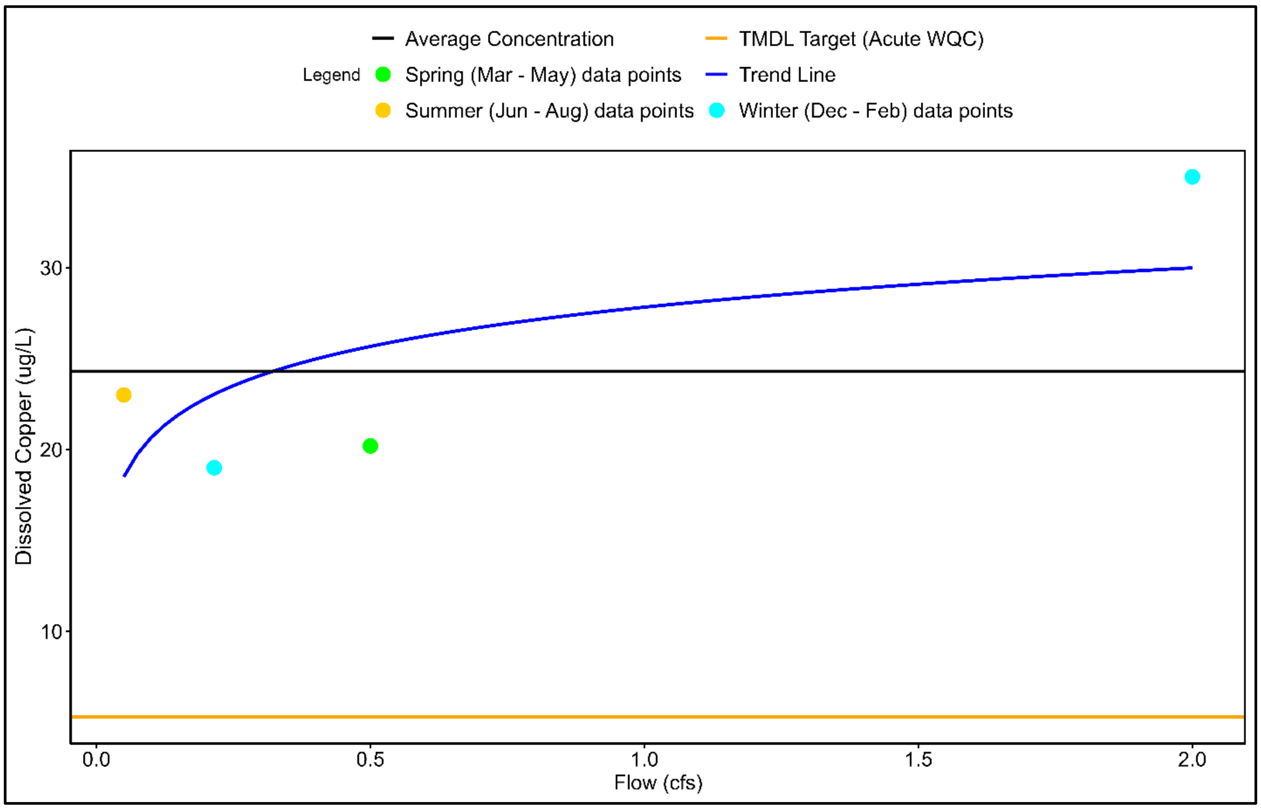

Figure 99. Relationship between flow and dissolved Cu in unnamed tributary to Upper Big Bug Creek.

Note: There are no flow or dissolved Cu data in the fall season.

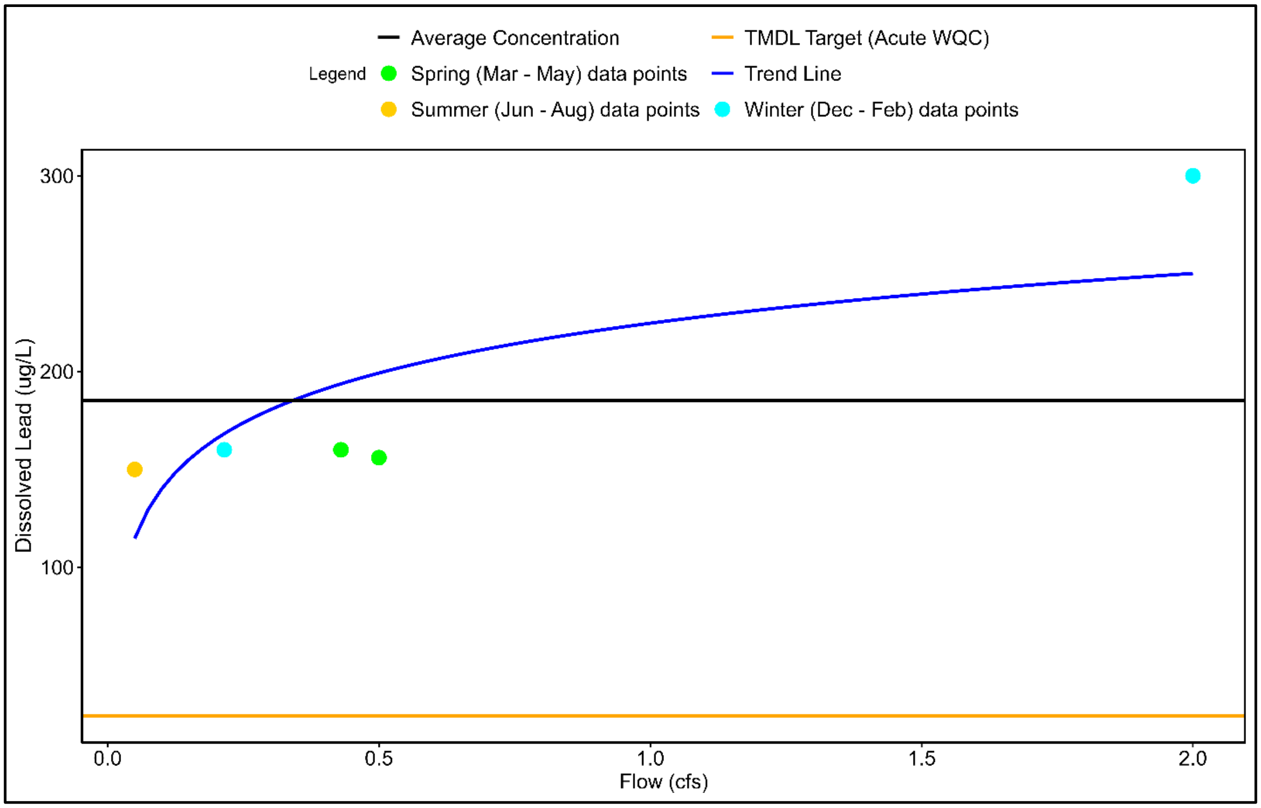

Figure 100. Relationship between flow and dissolved Pb in unnamed tributary to Upper Big Bug Creek.

Note: There are no flow or dissolved Cu data in the fall season.

9.5 Big Bug Creek Subwatershed – Unnamed Tributary to Big Bug Creek (UB1)

9.5.1 TMDL Analysis

The TMDLs for the unnamed tributary to Big Bug Creek (UB1) address the acute and chronic AWC impairment due to dissolved Cu (Table 48) and Cd (Table 49).

Table 47. Percentage Reduction for the Unnamed Tributary to Upper Big Bug Creek (UB1) Dissolved Cu Impairment

Key Monitoring Location	Dissolved Cu Observations	Flow Observations	TMDL Target (ug/L)	DU Impairment	Average Dissolved Cu (ug/L)	% Reduction Needed
MGUB1000.01	9	11	4.1	AWC Acute	7.6	46%
			3	AWC Chronic	10.2	70%

Table 48. Percentage Reduction for the Unnamed Tributary to Upper Big Bug Creek (UB1) Dissolved Cd Impairment

Key Monitoring Location	Dissolved Cd Observations	Flow Observations	TMDL Target (ug/L)	DU Impairment	Average Dissolved Cd (ug/L)	% Reduction Needed
MGUB1000.01	10	11	0.5	AWC Acute	0.7	27%
			0.3	AWC Chronic	0.6	50%

9.5.2 Seasonality and Critical Conditions

Dissolved Cu and Cd concentration appears to increase with increasing flow, however there are limited data points at higher flows to confirm that this is a consistent trend (Figures 101–102).

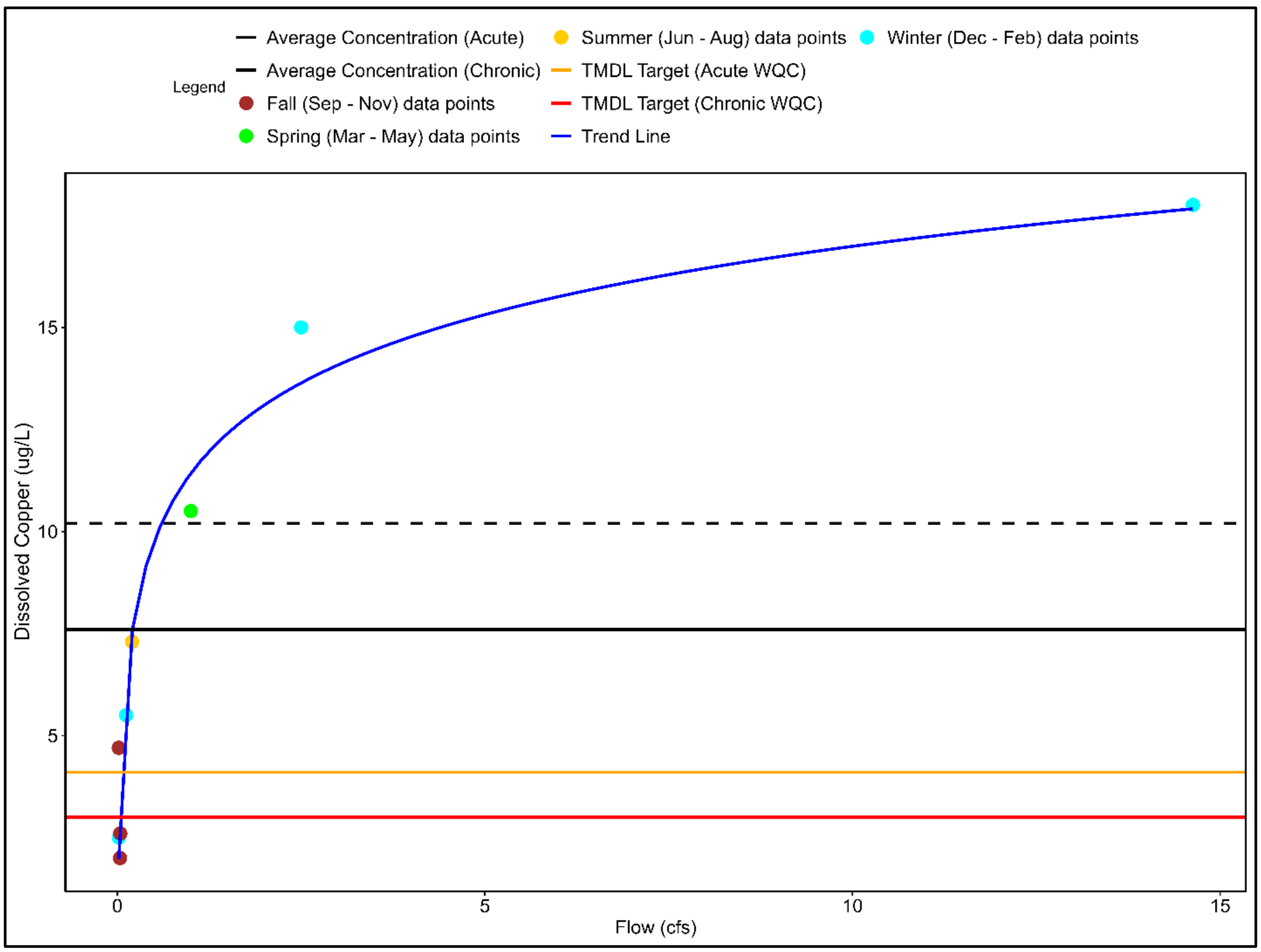

Figure 101. Relationship between flow and dissolved Cu in unnamed tributary to Upper Big Bug Creek (UB1).

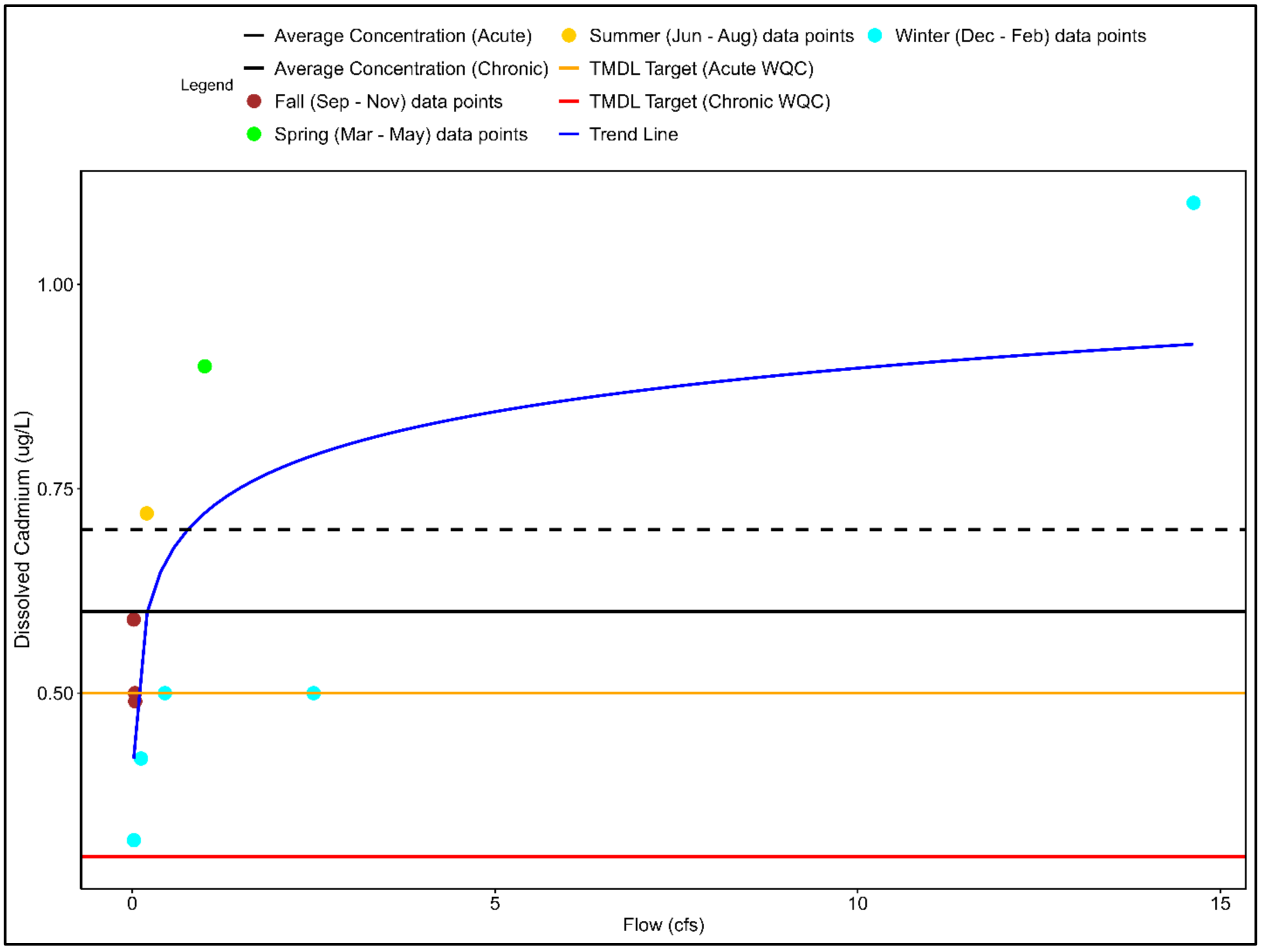

Figure 102. Relationship between flow and dissolved Cd in unnamed tributary to Upper Big Bug (UB1).

9.6 Big Bug Creek Subwatershed - Eugene Gulch

9.6.1 TMDL Analysis

The TMDL for Eugene Gulch addresses the AWE impairment due to dissolved Cu (Table 50).

Table 49. Percentage Reduction for the Eugene Gulch Dissolved Cu Impairment.

Key Monitoring Location	Dissolved Cu Observations	Flow Observations	TMDL Target (ug/L)	DU Impairment	Average Dissolved Cu (ug/L)	% Reduction Needed
MGEUG000.75	10	7	4.1	AWE	31.3	87%

9.6.2 Seasonality and Critical Conditions

Cu concentration appears to increase with flow (Figure 103). However, there are no paired flow and dissolved Cu data in the fall or summer seasons, so additional data are needed to confirm this observation.

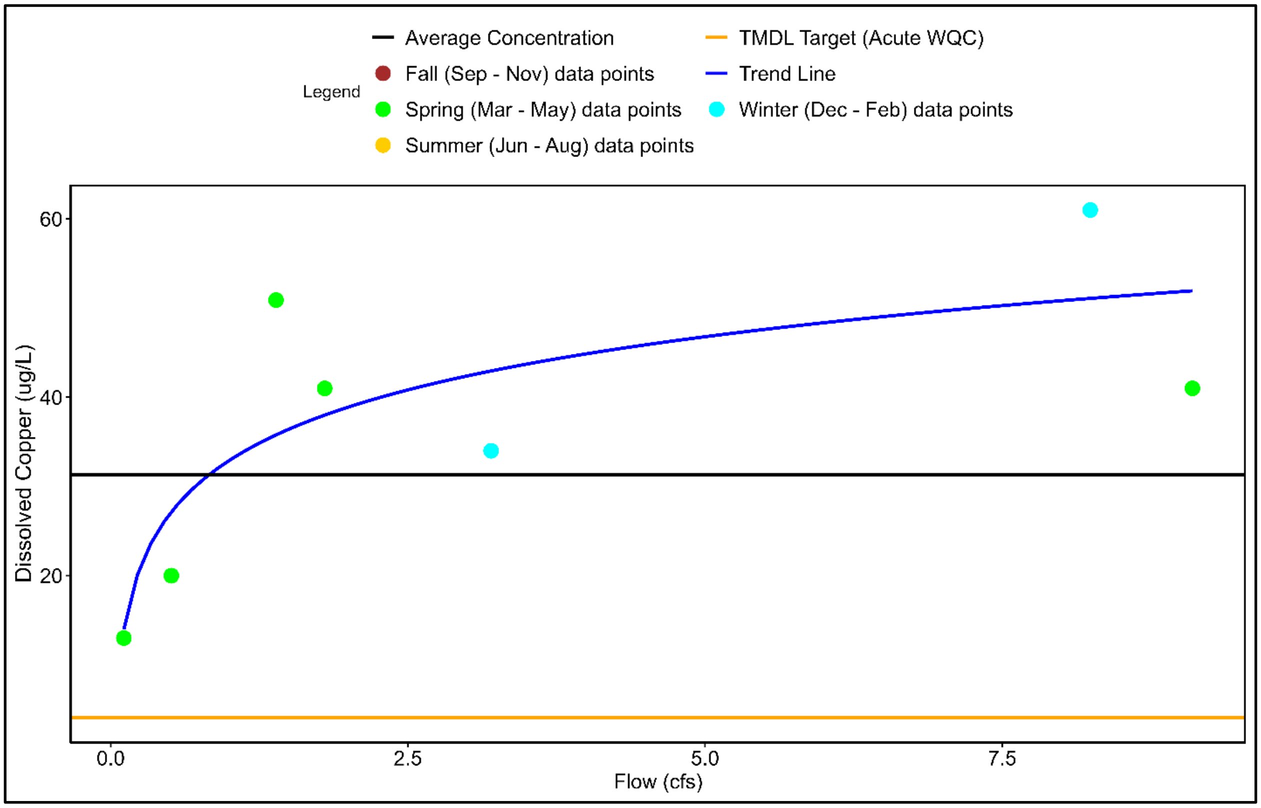

Figure 103. Relationship between flow and dissolved Cu in Eugene Gulch.
Note: There are no paired flow and dissolved Cu data in the Fall or Summer seasons.

9.7 Big Bug Creek Subwatershed – Unnamed Tributary to Eugene Gulch

9.7.1 TMDL Analysis

The TMDL for the unnamed tributary to Eugene Gulch addresses the AWE impairment due to dissolved Cu (Table 51). Dissolved Cu concentrations need to be reduced by over 90%.

Table 50. Percentage Reduction for the Unnamed Tributary to Eugene Gulch Dissolved Cu Impairment/

Key Monitoring Location	Dissolved Cu Observations	Flow Observations	TMDL Target (ug/L)	DU Impairment	Average Dissolved Cu (ug/L)	% Reduction Needed
MGEUU000.03	15	7	18.2	AWE	265.1	93%

9.7.2 Seasonality and Critical Conditions

Cu concentration appears to decrease with increasing flow; however, there are limited data points at higher flows to confirm that this is a consistent trend (Figure 104).

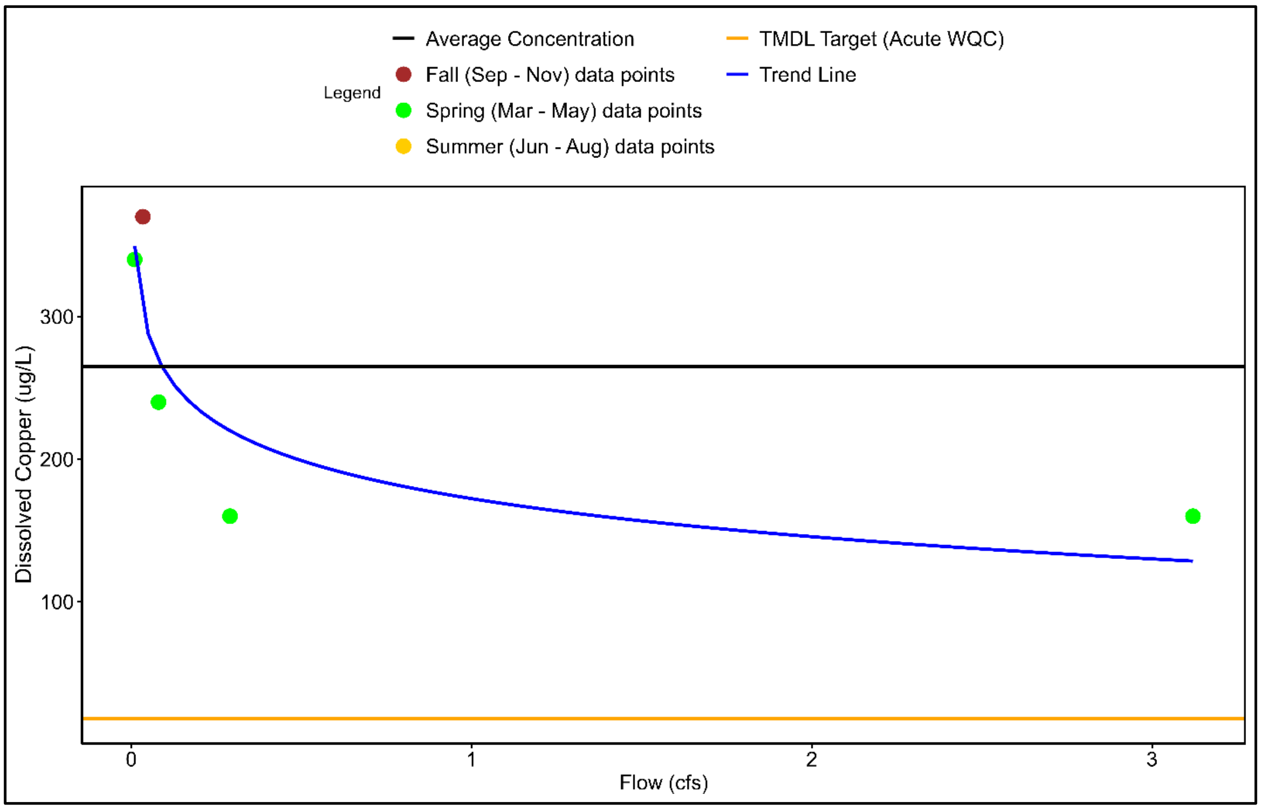

Figure 104. Relationship between flow and dissolved Cu in unnamed tributary to Eugene Gulch.

Note: There are no paired flow and dissolved Cu data in the summer season, and there are no data in the winter season.

9.8 Big Bug Creek Subwatershed – Money Metals Tributary

9.8.1 TMDL Analysis

The TMDL for the Money Metals tributary addresses the AWE impairment due to dissolved Cu (Table 52) and Zn (Table 53). Dissolved Cu and dissolved Zn concentrations need to be reduced by over 90%.

Table 51. Percentage Reduction for the Money Metals Tributary Dissolved Cu Impairment.

Key Monitoring Location	Dissolved Cu Observations	Flow Observations	TMDL Target (ug/L)	DU Impairment	Average Dissolved Cu (ug/L)	% Reduction Needed
MGNMT000.14	11	8	4.9	AWE	234.2	98%

Table 52. Percentage Reduction for the Money Metals Tributary Dissolved Zn Impairment.

Key Monitoring Location	Dissolved Zn Observations	Flow Observations	TMDL Target (ug/L)	DU Impairment	Average Dissolved Zn (ug/L)	% Reduction Needed
MGNMT000.14	11	8	272.3	AWE	4,608	94%

9.8.2 Seasonality and Critical Conditions

Dissolved Cu concentrations vary and do not seem to be directly correlated to flow; however, the highest concentrations of Cu are observed at low flows (Figure 105). Dissolved Zn concentration appears to decrease with increasing flow; however, Zn concentrations are variable in low flow conditions (Figure 106).

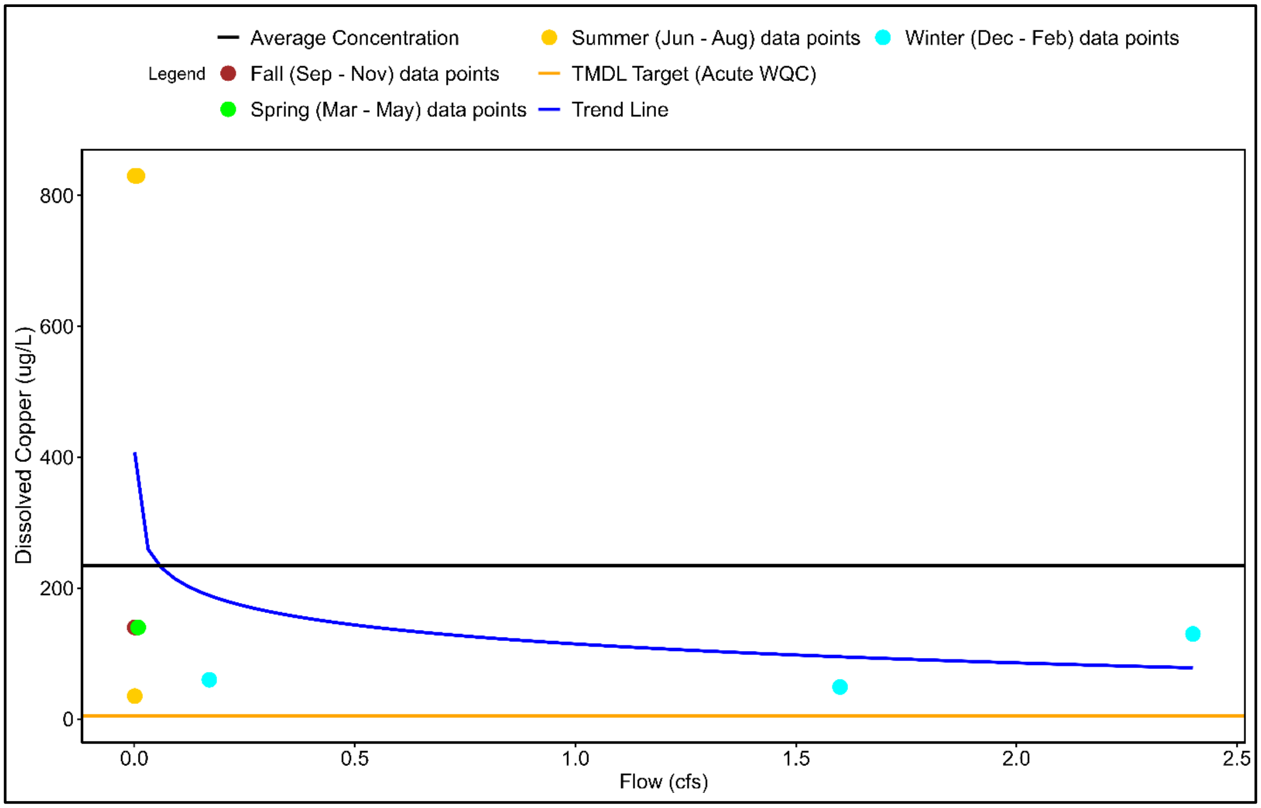

Figure 105. Relationship between flow and dissolved Cu in Money Metals tributary.

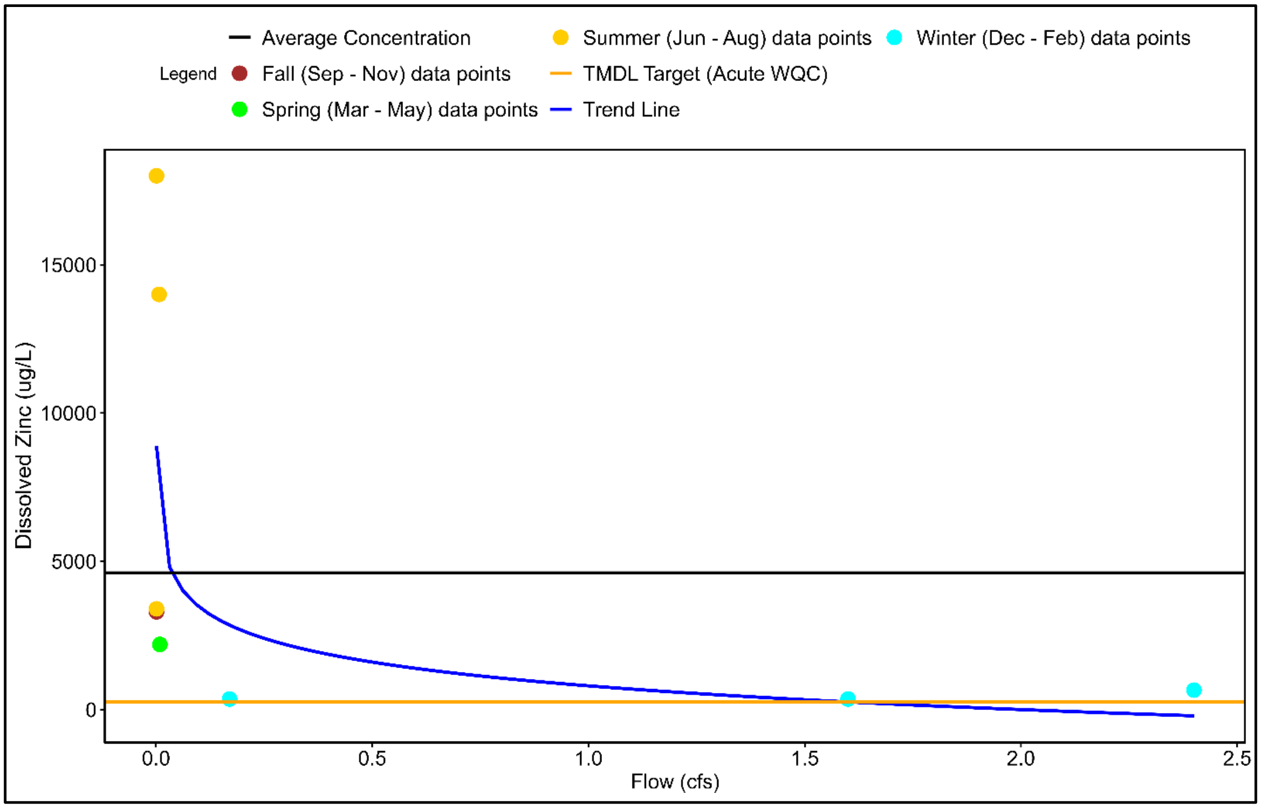

Figure 106. Relationship between flow and dissolved Zn in Money Metals tributary.

9.9 Lynx Creek Subwatershed – Unnamed Tributary to Lynx Creek

9.9.1 TMDL Analysis

The TMDL for the unnamed tributary to Lynx Creek addresses the acute and chronic AWC impairment due to dissolved Cu (Table 54). Dissolved Cu concentrations need to be reduced by almost 100%.

Table 53. Percentage Reduction for the Unnamed Tributary to Lynx Creek Dissolved Cu Impairment.

Key Monitoring Location	Dissolved Cu Observations	Flow Observations	TMDL Target (ug/L)	DU Impairment	Average Dissolved Cu (ug/L)	% Reduction Needed
MGULN000.23	4	3	31	Acute	2,727.3	99%
			19	Chronic	2,727.3	99%

9.9.2 Seasonality and Critical Conditions

Cu concentrations vary and do not appear to be directly correlated to flow; additional data are needed to decipher trends (Figure 107).

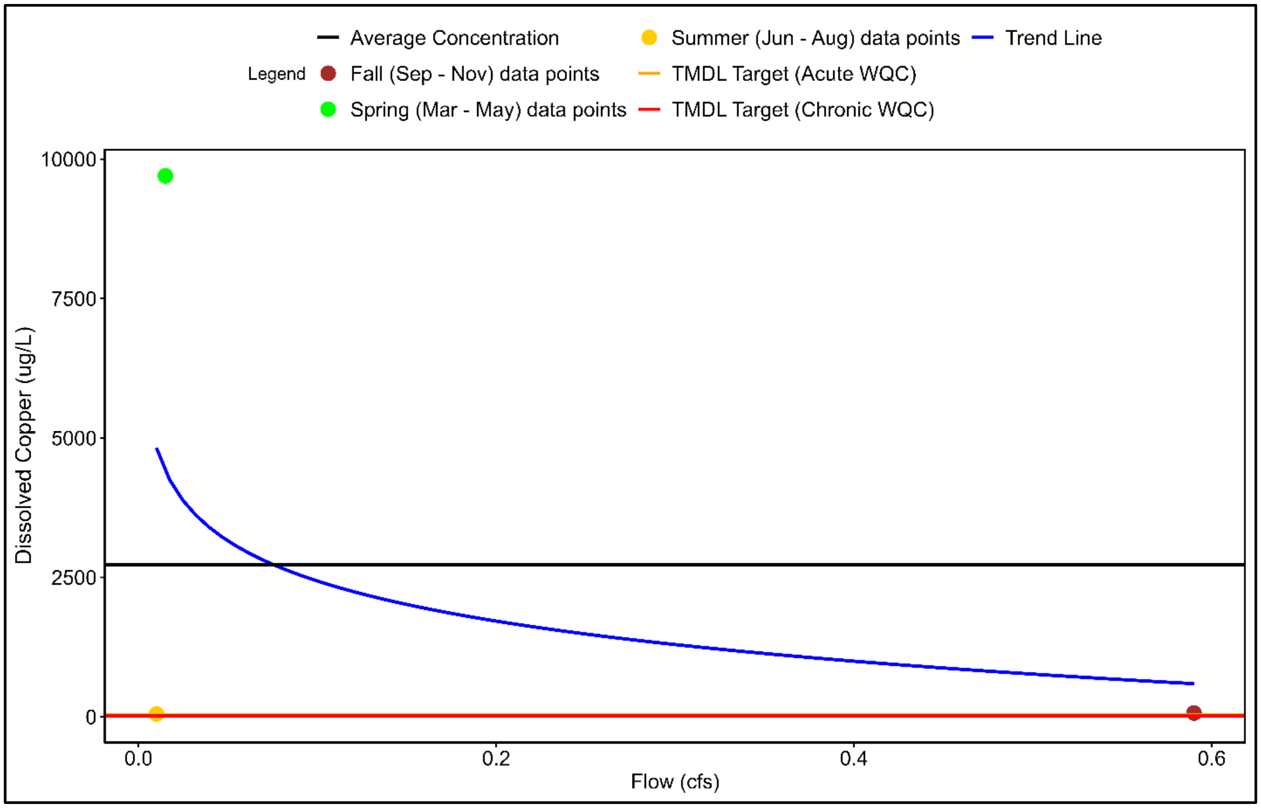

Figure 107. Relationship between flow and dissolved Cu in unnamed tributary to Lynx Creek. Note: There are no flow or dissolved Cu data in the winter season.

9.10 Lynx Creek Subwatershed – Lynx Creek

9.10.1 TMDL Analysis

The TMDLs for Lynx Creek address the acute and chronic AWC impairment due to dissolved Cu (Table 55), dissolved Cd (Table 56), and dissolved Zn (Table 57).

Table 54. Percentage Reduction for Lynx Creek Dissolved Cu Impairment.

Key Monitoring Location	Dissolved Cu Observations	Flow Observations	TMDL Target (ug/L)	DU Impairment	Average Dissolved Cu (ug/L)	% Reduction Needed
MGLNX018.81	8	8	50	AWC Acute	59.9	16%
			29	AWC Chronic	59.9	52%

Table 55. Percentage Reduction for Lynx Creek Dissolved Cd Impairment.

Key Monitoring Location	Dissolved Cd Observations	Flow Observations	TMDL Target (ug/L)	DU Impairment	Average Dissolved Cd (ug/L)	% Reduction Needed
MGLNX018.81	8	8	6.5	AWC Acute	20	68%
			2	AWC Chronic	12.2	84%

Table 56. Percentage Reduction for Lynx Creek Dissolved Zn Impairment.

Key Monitoring Location	Dissolved Zn Observations	Flow Observations	TMDL Target (ug/L)	DU Impairment	Average Dissolved Zn (ug/L)	% Reduction Needed
MGLNX018.81	8	8	379	AWC Acute	1,465.7	74%
			379	AWC Chronic	1,465.7	74%

9.10.2 Seasonality and Critical Conditions

Dissolved Cu concentration varies and does not seem to be directly correlated to flow (Figure 108), while dissolved Cd and dissolved Zn concentrations appear to decrease with increasing flow (Figures 109–110)

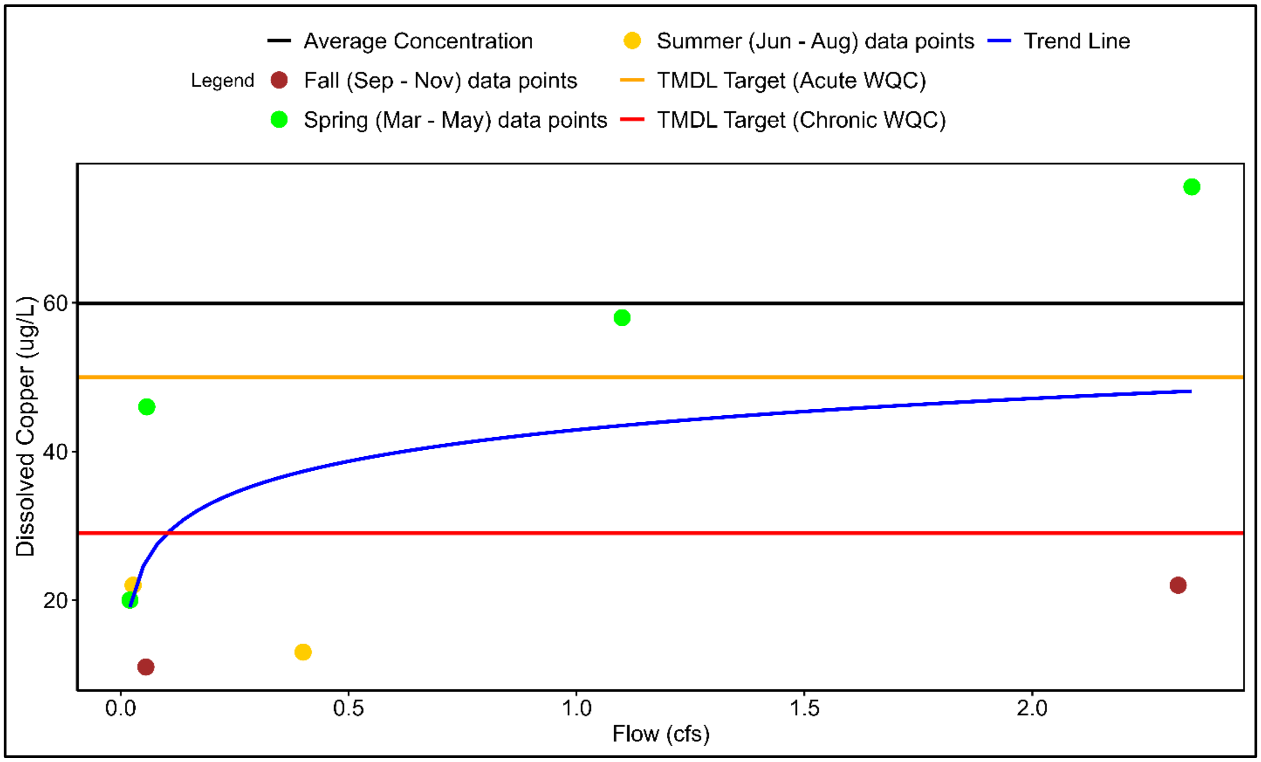

Figure 108. Relationship between flow and dissolved Cu in Lynx Creek.

Note: There are no flow or dissolved Cu data in the Winter season.

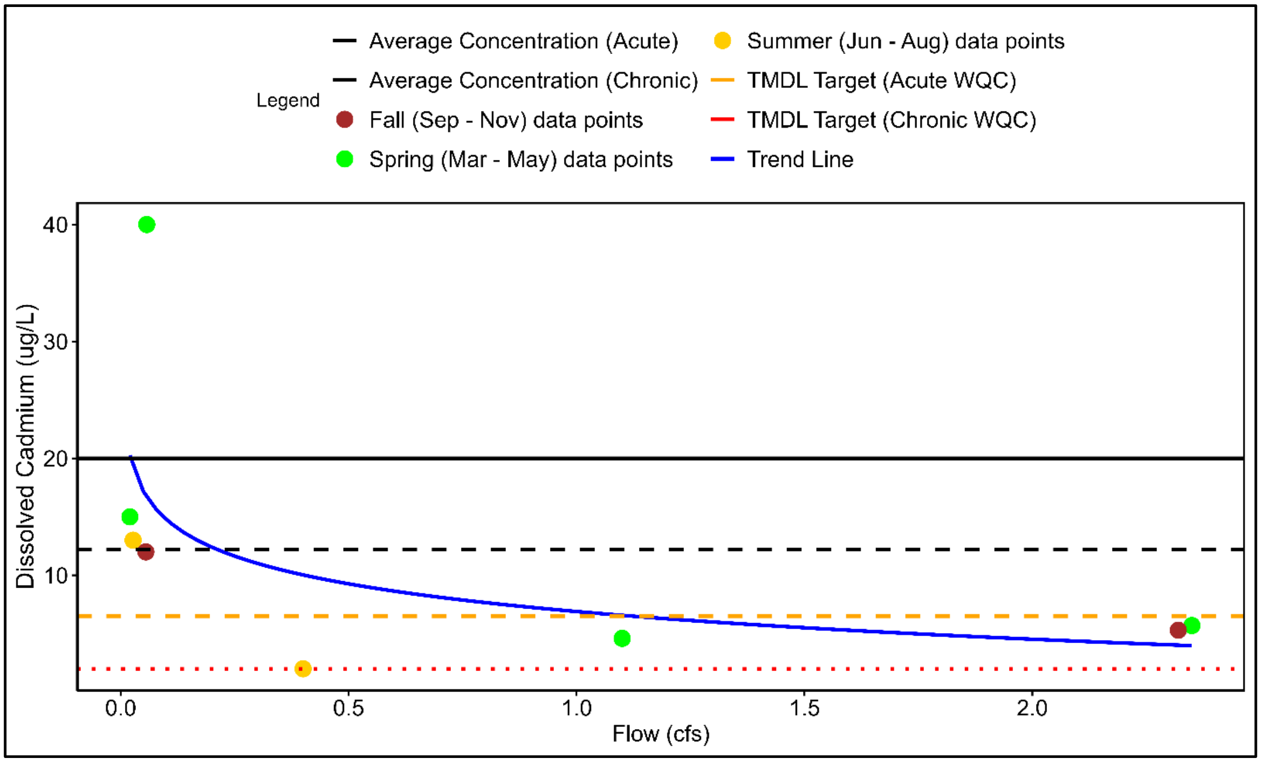

Figure 109. Relationship between flow and dissolved Cd in Lynx Creek.

Note: There are no flow or dissolved Cu data in the winter season.

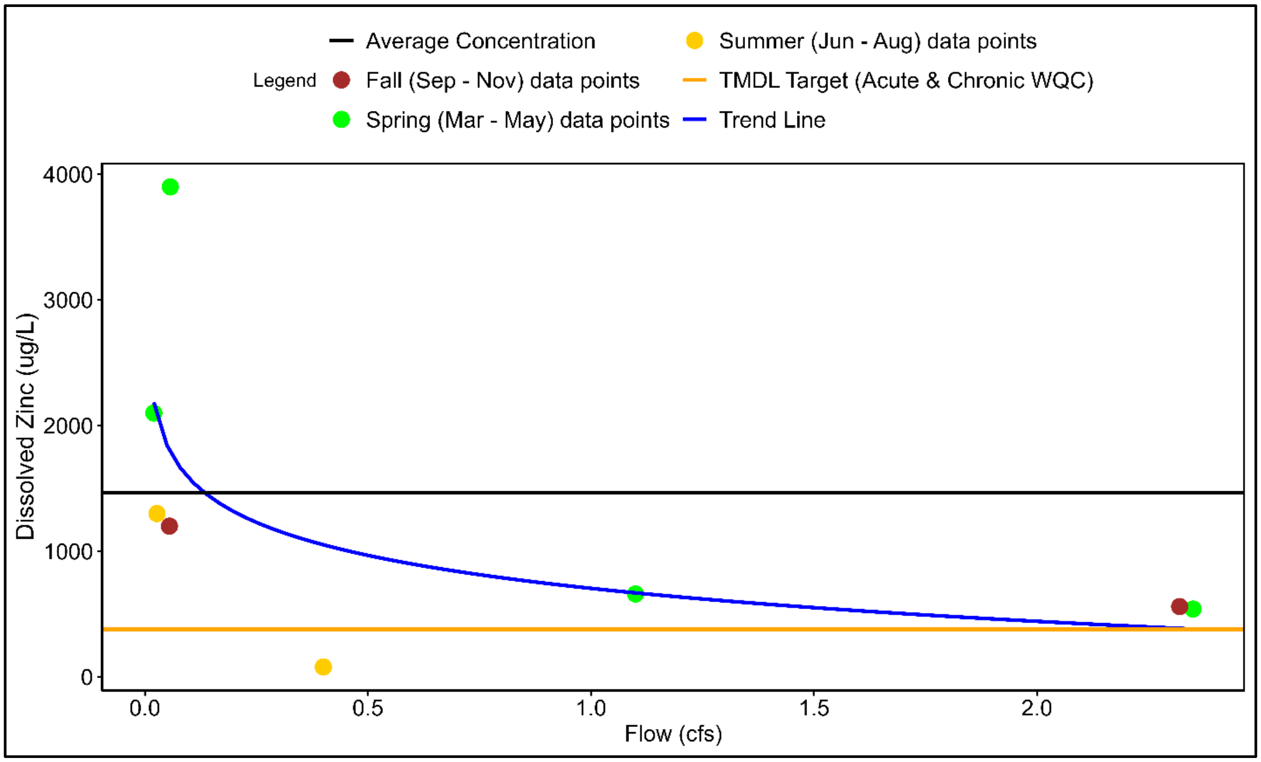

Figure 110. Relationship between flow and dissolved Zn in Lynx Creek.

Note: There are no flow or dissolved Cu data in the winter season.

9.11 TMDL Summary

Table 57 and Figures 111 through 117 summarize the percent reductions needed for each of the 10 impaired waterbodies in the Upper Agua Fria Watershed. Also presented are the TMDL targets based on the most protective DU and the associated TMDL components.

Table 57. TMDL Summary for Impaired Waterbodies in the Upper Agua Fria Watershed.

Impaired Waterbody	Key Monitoring Location	Approach	Impaired Parameter	DU Impairment	Current Load / Concentration	TMDL Target	Overall % Reduction Needed
Upper Agua Fria River	MGARF110.01	LDC	Dissolved Zn	AWW Acute and Chronic	2,954.58 g/day	1,709.27 g/day	42
			Total Se	AWW Chronic	23.75 g/day	15.75 g/day	34
Lower Big Bug Creek	MGBGB023.15	LDC	Dissolved Cu	AWW Acute and Chronic	219.83 g/day	104.64 g/day	52
			Total Cu	AGL	7,108.64 g/day	1,555.36 g/day	78
			Total As	FBC	452.95 g/day	102.02 g/day	77
			Total Pb	AGL and FBC	1,260.89 g/day	123.88 g/day	90
Eugene Gulch	MGEUG000.75	Concentration -based	Dissolved Cu	AWE Acute	31.30 ug/L	4.10 ug/L	87
Unnamed tributary to Eugene Gulch	MGEUU000.03	Concentration -based	Dissolved Cu	AWE Acute	265.10 ug/L	18.20 ug/L	93
Upper Big Bug Creek	MGBGB027.21	Concentration -based	Dissolved Cd	AWC Acute and Chronic	9.80 ug/L	0.40 ug/L	96
			Dissolved Zn	AWC Acute and Chronic	677.10 ug/L	56.20 ug/L	92
Unnamed tributary to Big Bug Creek	MGUBB000.11	Concentration -based	Dissolved Cu	AWE Acute	24.30 ug/L	5.30 ug/L	78
			Dissolved Pb	AWE Acute	185.20 ug/L	24.10 ug/L	87
Unnamed tributary to Big Bug Creek (UB1)	MGUB1000.01	Concentration -based	Dissolved Cu	AWC Acute and Chronic	10.20 ug/L	3.00 ug/L	70
			Dissolved Cd	AWC Chronic	0.60 ug/L	0.30 ug/L	50
	MGNMT000.14		Dissolved Cu	AWE Acute	234.20 ug/L	4.90 ug/L	98

Impaired Waterbody	Key Monitoring Location	Approach	Impaired Parameter	DU Impairment	Current Load / Concentration	TMDL Target	Overall % Reduction Needed
Money Metals tributary		Concentration -based	Dissolved Zn	AWE Acute	4,608.00 ug/L	272.30 ug/L	94
Unnamed tributary to Lynx Creek	MGULN000.23	Concentration -based	Dissolved Cu	AWC Acute and Chronic	2,727.30 ug/L	19.00 ug/L	99
Lynx Creek	MGLNX018.81	Concentration -based	Dissolved Cu	AWC Acute and Chronic	59.90 ug/L	29.00 ug/L	52
			Dissolved Cd	AWC Acute and Chronic	12.20 ug/L	2.00 ug/L	84
			Dissolved Zn	AWC Acute and Chronic	1,465.70 ug/L	379.00 ug/L	74

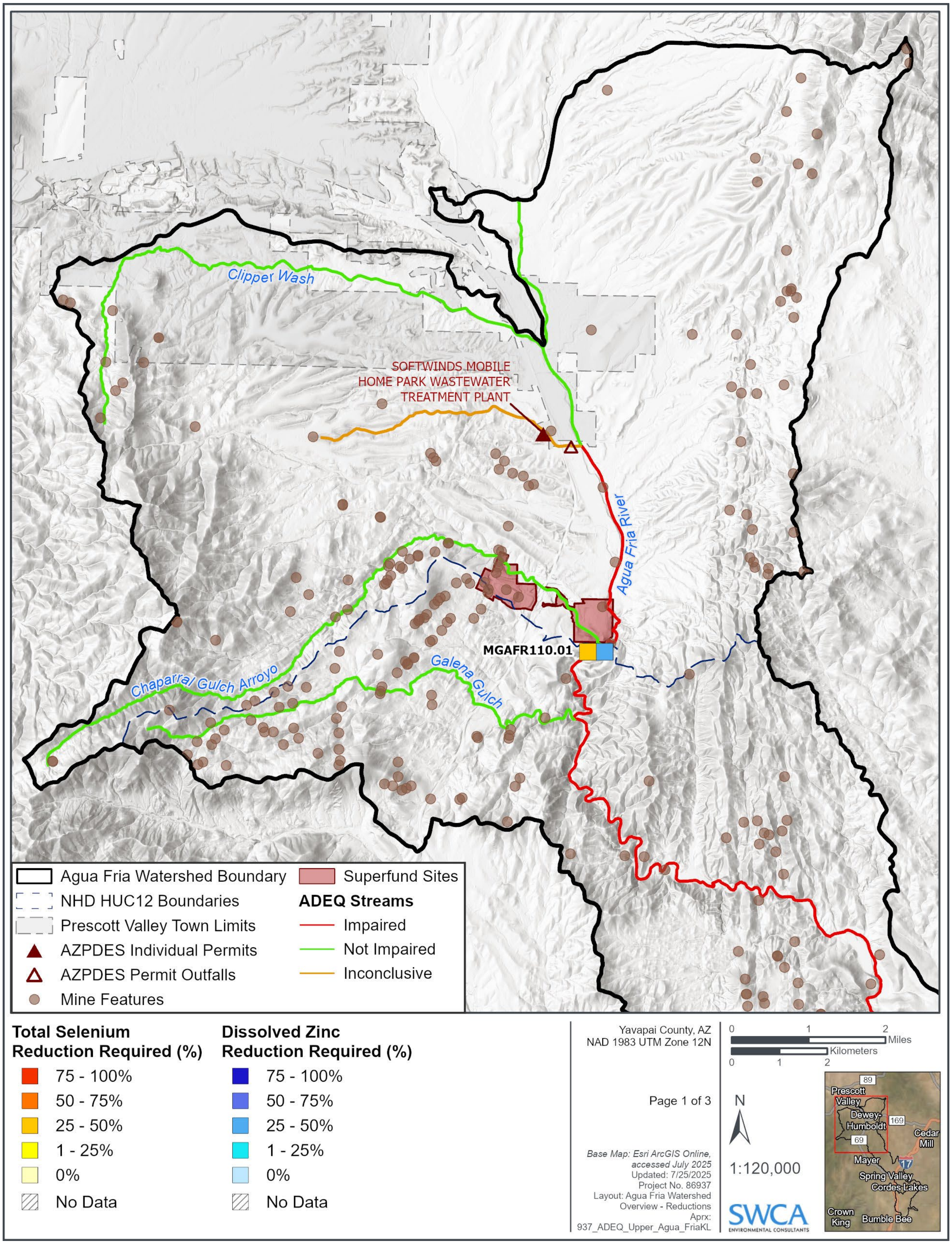

Figure 111. Percentage reduction needed in Upper Agua Fria River Subwatershed.

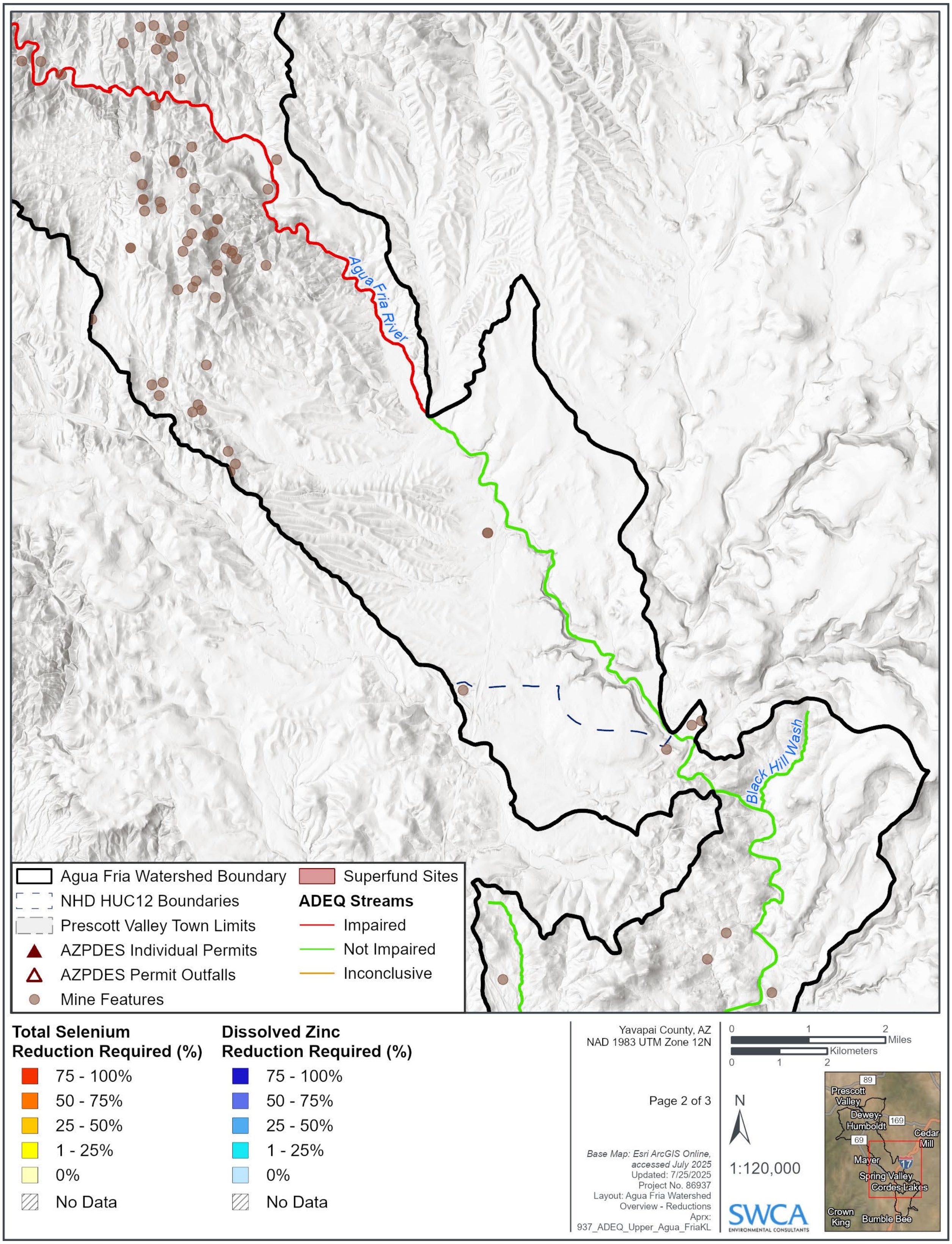

Figure 112. Percentage reduction needed in Upper Agua Fria River Subwatershed.

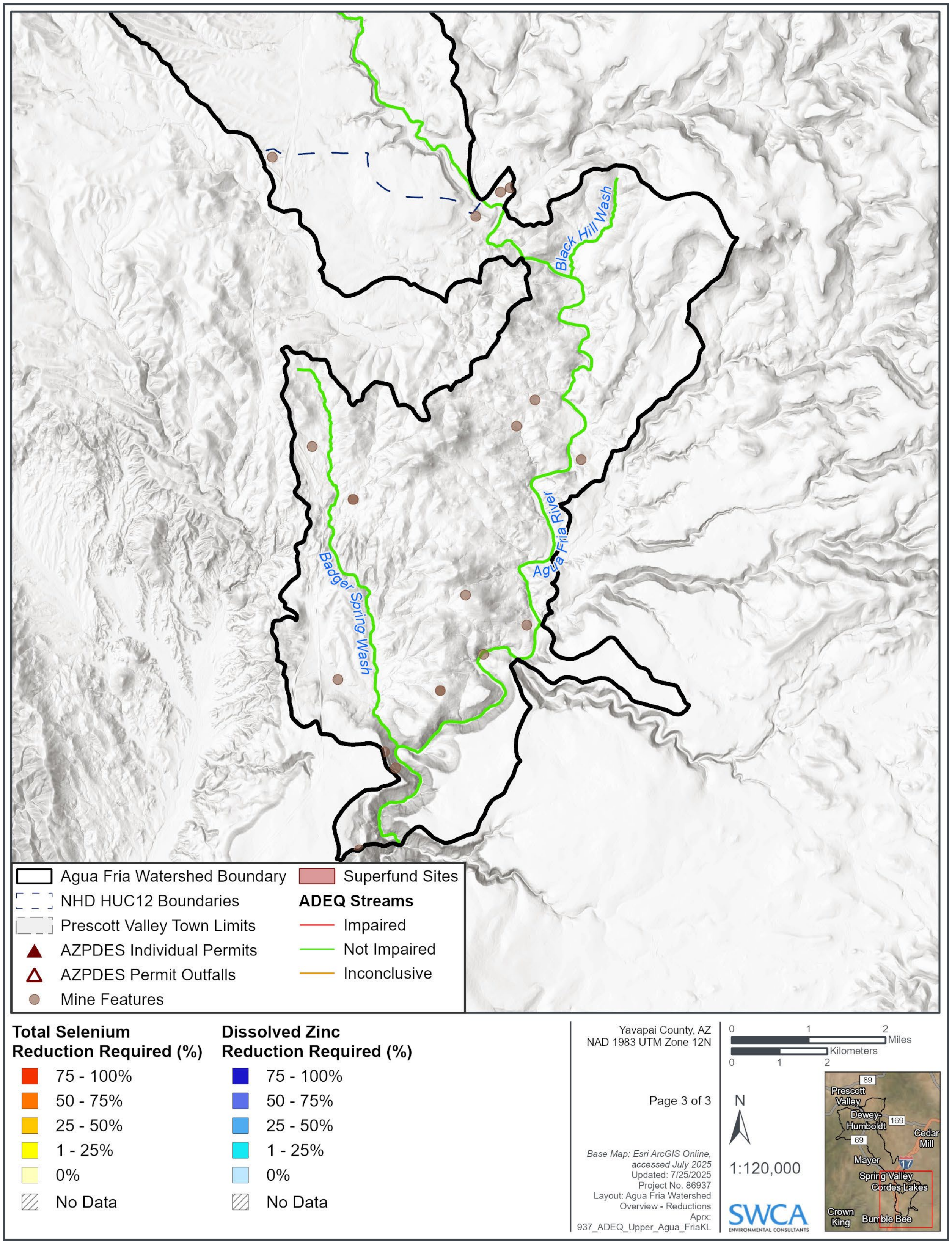

Figure 113. Percentage reduction needed in Upper Agua Fria River Subwatershed.

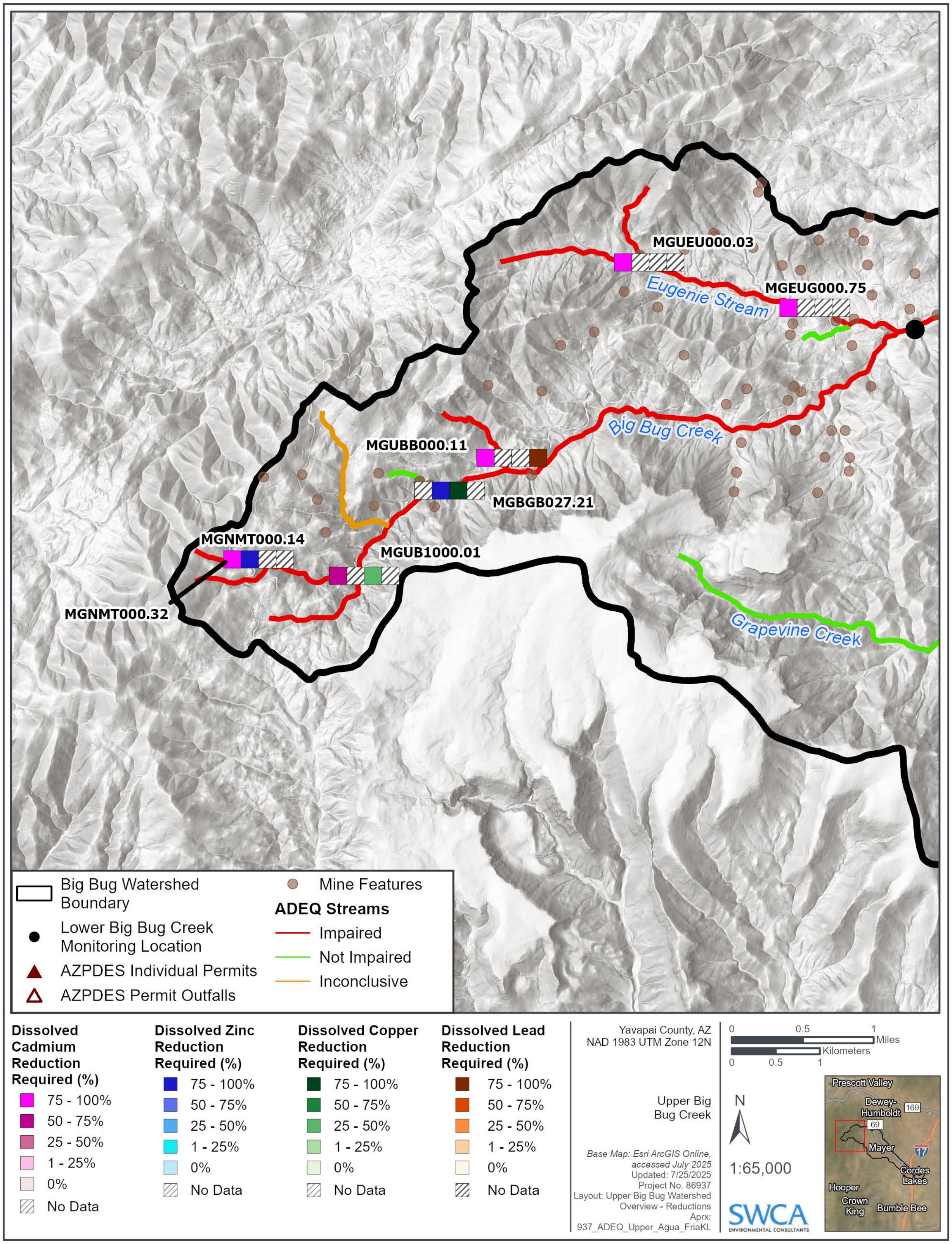

Figure 114. Percentage reduction needed in Big Bug Creek Subwatershed.

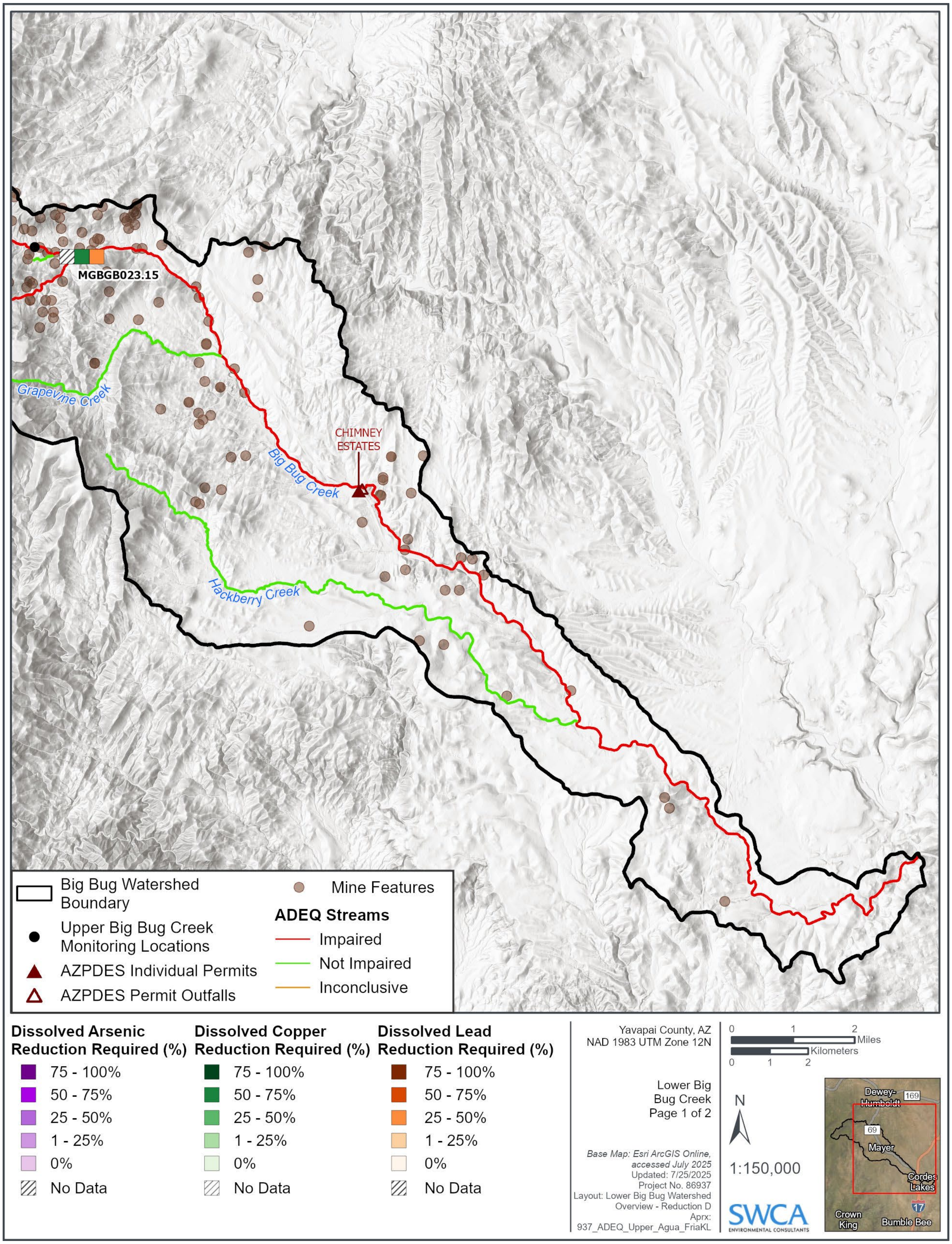

Figure 115. Percentage reduction needed in Big Bug Creek Subwatershed.

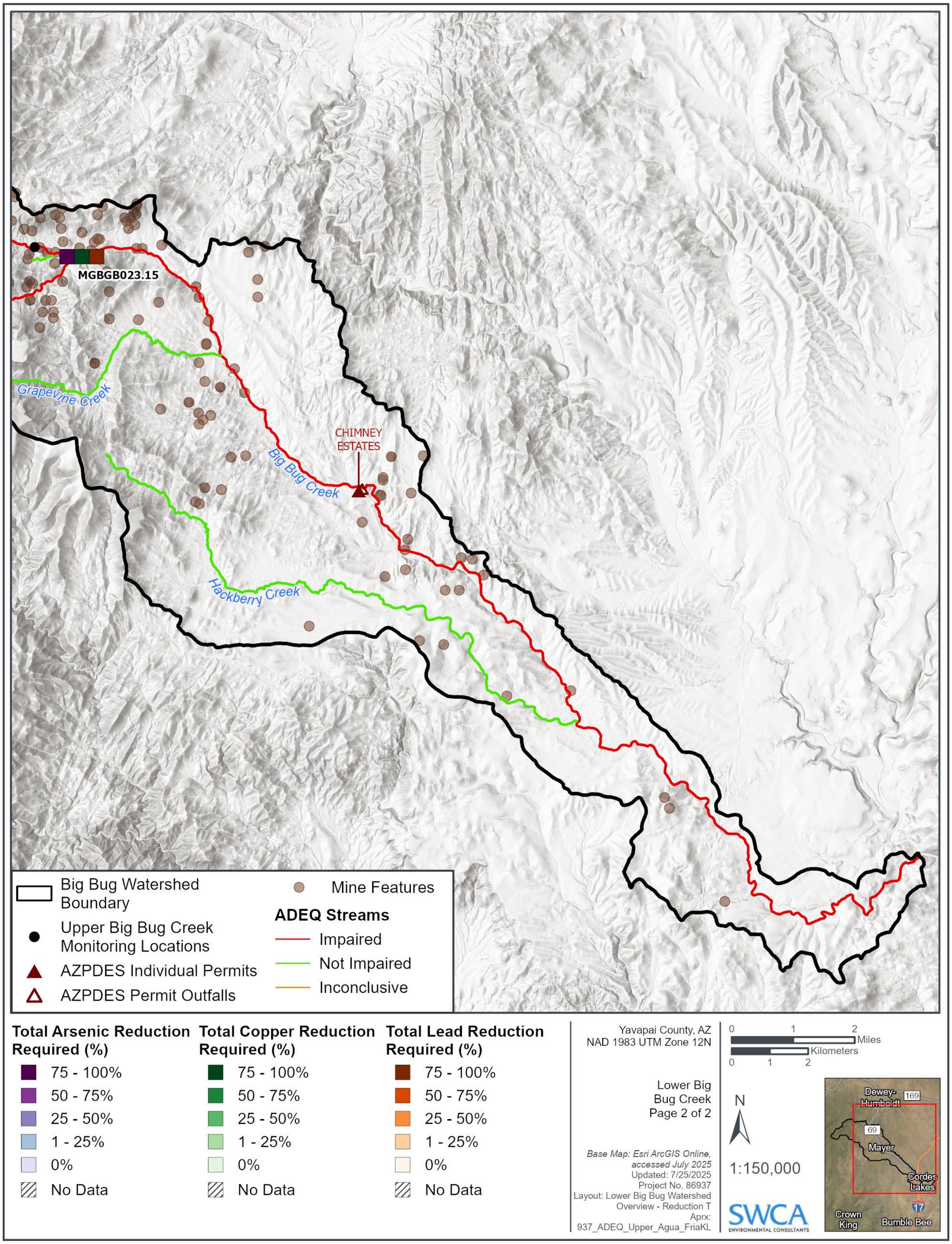

Figure 266. Percentage reduction needed in Big Bug Creek Subwatershed.

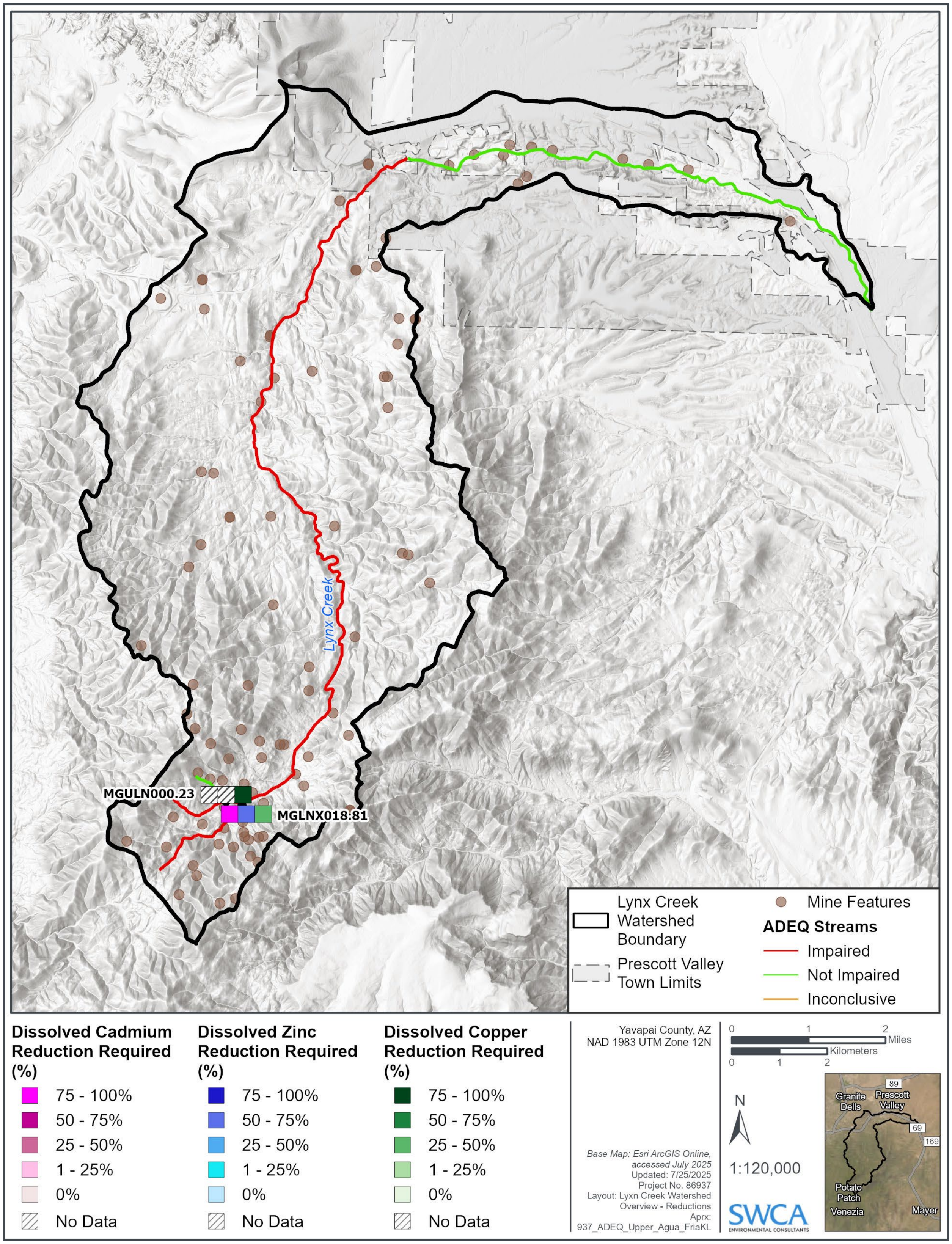

Figure 117. Percentage reduction needed in Lynx Creek Subwatershed.

Section 10. Implementation Planning

The allocations (WLAs and LAs) described in this TMDL report are designed to return the targeted impaired waterbodies to attainment with their DUs under Arizona's WQSs. Per A.R.S. § 49-234(G), TMDLs must include an implementation plan that outlines the methods of achieving the stated load reductions. The following section identifies implementation actions that will further efforts to attain the requirements of the TMDL and associated allocations.

10.1 Point Sources

Point sources in the Upper Agua Fria Watershed are regulated through AZPDES permits to maintain WQS. ADEQ will incorporate the WLAs assigned to each permittee during their respective permit renewals, if deemed necessary, per the provisions of A.A.C. R18-9-B906 and R18-9-A905. Establishing new or expanded point source discharges must comply with A.A.C. R18-11-107 and any applicable antidegradation rules to ensure no further impairment of the watershed. Within the project area, there are a number of permitted sources, though Table 58 specifically only lists the ten facilities or sites that received calculated WLAs for the metal pollutants of concern for this TMDL.

Table 58. AZPDES Permittees and Permit Renewal Cycles.

<table>
<tr><th>Permittee Name</th><th>AZPDES ID/Permit Type</th><th>Current Permit Effective Date</th><th>Next Permit Renewal</th></tr>
<tr><td>Soft Winds Mobile Home Park WWTP</td><td>AZ0026051</td><td>07/14/2022</td><td>01/14/2027</td></tr>
<tr><td>Chimney Estates WWTP</td><td>AZ0026999</td><td>01/30/2026</td><td>01/29/2031</td></tr>
<tr><td>Yavapai County</td><td>Phase II MS4</td><td>09/30/2021</td><td>In Progress</td></tr>
<tr><td>We Recycle Solar — Dewey Operations</td><td>MSGP (Sector N—Scrap Recycling)</td><td rowspan="6">01/16/2025</td><td rowspan="6">01/2029</td></tr>
<tr><td>Yavapai Metal Recycling</td><td>MSGP (Sector N—Scrap Recycling)</td></tr>
<tr><td>Big Bug Sand and Gravel</td><td>MSGP (Sector J, AD—Mineral Mining)</td></tr>
<tr><td>Henrietta Mine</td><td>MSGP (Sector J, G—Mineral Mining)</td></tr>
<tr><td>Smokestack Quarry</td><td>MSGP (Sector J—Mineral Mining)</td></tr>
<tr><td>Stoneworld Onyx Quarry Mayer</td><td>MSGP (Sector J—Mineral Mining)</td></tr>
<tr><td>Iron King Mine — Humboldt Smelter</td><td>EPA Superfund Site</td><td>N/A</td><td>N/A</td></tr>
</table>

Permittee Name	AZPDES ID/Permit Type	Current Permit Effective Date	Next Permit Renewal

Note: "General Permit Cycle" indicates that the facility's discharges are regulated under a statewide AZPDES general permit — such as MSGP, or MS4. Unlike individual permits that have facility-specific effective and expiration dates, general permits are issued and renewed by ADEQ for a set statewide cycle (typically every five years). Individuals obtain and maintain coverage under the overarching active permit during that timeframe.

Note: The Iron King Mine — Humboldt Smelter is listed as "N/A" because it is a legacy EPA Superfund site undergoing remediation under CERCLA, rather than an actively operating facility with an AZPDES discharge permit. However, site-specific activities may require agency coordination with EPA to ensure adherence to the TMDL.

10.1.1 Point Source Monitoring Plan

To track compliance, facilities and sites must monitor their effluent for pollutants of concern (Table 59).

Table 59. AZPDES Permittees Locations and Monitoring Frequency.

Permittee Name	Monitoring Site	Frequency
Soft Winds Mobile Home Park WWTP	Outfall 001	1x/6 months
Chimney Estates WWTP	Outfall 001	1x/year (2027–2029)
Yavapai County	Stormwater Outfalls	Per General Permit
We Recycle Solar — Dewey Operations	Stormwater Outfalls	Per General Permit
Yavapai Metal Recycling	Stormwater Outfalls	Per General Permit
Big Bug Sand and Gravel	Stormwater Outfalls	Per General Permit
Henrietta Mine	Stormwater Outfalls	Per General Permit
Smokestack Quarry	Stormwater Outfalls	Per General Permit
Stoneworld Onyx Quarry Mayer	Stormwater Outfalls	Per General Permit

Permittee Name	Monitoring Site	Frequency
Iron King Mine — Humboldt Smelter	Superfund Runoff	EPA Directed

The Soft Winds Mobile Home Park WWTP discharges from Outfall 001 to an unnamed ephemeral wash that is a tributary to the Agua Fria River. To track compliance, the facility is required to monitor specific metals of concern—total Se and total Zn—once every six months using an 8-hour composite sample. The permittee is required to submit DMRs electronically via the myDEQ portal. Soft Winds WWTP will need to continue to monitor its discharge per the terms of its permit to ensure they are meeting their assigned WLAs.

The Chimney Estates WWTP discharges from Outfall 001 to an unnamed wash that is a tributary to Big Bug Creek. To align with this TMDL, the facility's monitoring requirements focus on the pollutants of concern, specifically requiring 8-hour composite samples for total As, total Cu, and total Pb once per year during 2027, 2028, and 2029. The permittee is required to submit DMRs electronically via the myDEQ portal. Chimney Estates WWTP will need to continue monitoring its discharge per the terms of its permit to ensure they are meeting their assigned WLAs.

The Phase II MS4, Yavapai County, has several stormwater outfalls that discharge into the Upper Agua Fria River and its tributaries. This MS4 is regulated under the Arizona Phase II MS4 General Permit, which requires the county to implement six minimum control measures to the maximum extent practicable. Currently, specific local water quality monitoring data are not available from this entity, and national database estimates were used for TMDL calculations. Moving forward, specific outfall monitoring for both flow and water quality is recommended to track its assigned WLAs.

To ensure that stormwater runoff does not carry exposed metals and waste into local waterways, facilities covered under the MSGP—such as We Recycle Solar, Yavapai Metal Recycling, Big Bug Sand and Gravel, Henrietta Mine, Smokestack Quarry, and Stoneworld Onyx Quarry—are required under ADEQ's AZPDES permitting authority to adhere to strict pollution prevention plans and deploy BMPs. As the primary control mechanism for meeting the WLAs assigned in this TMDL, these facilities must conduct ongoing stormwater monitoring in accordance with their permits to verify their protective measures are effective.

10.1.2 Superfund Coordination: Iron King Mine — Humboldt Smelter

While typical point sources in this watershed are managed through standard AZPDES permits, the Iron King Mine and Humboldt Smelter Superfund site requires a different implementation approach. The superfund site warrants detailed discussion because it represents one of the most significant contributors of metal loading—specifically As, Pb, Cu, and Zn—to Chaparral Gulch, Galena Gulch, and the Upper Agua Fria River.

Operating from the late 1800s until 1968, the former mine and smelter occupy over 300 acres of land along State Route 69 and were officially placed on the EPA's National Priorities List in September 2008. Early testing and remediation actions began that same year, with EPA notably conducting residential yard cleanups in 2012 and 2017 to address immediate exposure risks in the community. In October 2023, ADEQ concurred with EPA's Record of Decision, which selected a containment strategy focused on excavating and consolidating mine wastes and contaminated soils into two on-site repositories—one located on the existing mine tailings pile west of Highway 69, and a second on the former smelter property east of the highway. The selected remedy also includes the continued excavation and removal of impacted soils from residential yards, which will be placed into one of the two repositories.

To prepare for the construction of these repositories, the EPA has scheduled Remedial Design field work, which started in March 2026. This field work will utilize heavy equipment in both residential and non-residential areas to drill borings, conduct geophysical surveys, and dig test pits. The primary goals of this Remedial Design fieldwork are to measure the depth of the contamination, gather characteristics of the waste to assist with the final repository design, and test local materials for use as backfill and cover for the repositories.

Tracking the progress of the selected remedy will be critical for measuring future metal load reductions in the watershed. Because remediation efforts are being led by the EPA in direct coordination with ADEQ, this TMDL's implementation strategy relies on this ongoing coordination to track these cleanup milestones.

10.2 Nonpoint Sources

Per A.R.S. § 49-234(G), “Any reductions in loadings from nonpoint sources shall be achieved voluntarily.” The proposed actions in this section and their associated schedules are provided for internal management and public information purposes. This plan should not be construed as a rule or regulation.

10.2.1 General BMPs for the Project Area

NPS pollution is a significant contributor to elevated metal concentrations in the Upper Agua Fria Watershed. The primary nonpoint sources include legacy mining, active unpermitted mining features, atmospheric deposition, non-regulated stormwater, and natural geologic sources.

The deployment of BMPs—encompassing both structural methodologies and non-structural strategies—is essential to address these environmental concerns. A number of potential BMPs to curtail metals pollution and monitor load reductions across the watershed are listed in Table 60. Because much of the watershed area is under private ownership, it is essential to involve landowners, local communities, and industry partners when identifying project areas and deploying solutions.

Table 60. Structural and Non-Structural BMPs.

BMP	Expected Results
Cap and cover mine-impacted soils throughout the Upper Agua Fria Watershed.	Reduce infiltration of rain and snowmelt into mine waste, minimize erosion, and reduce the runoff of metals into surface waters.
Revegetate mine-impacted sites throughout the Upper Agua Fria Watershed, prioritizing areas closest to surface waters.	Reduce erosion and wind transport of soils containing metals and decrease migration of metals through plant uptake and soil stabilization.
Removal of mining materials.	Replace contaminated soils with clean soils to reduce the quantity of metals being transported in runoff or by wind.
Complete stormwater BMPs and retrofits for runoff, focusing on roads within 100 feet of streams or areas where discharge is directly to a waterbody. Specific treatments could include road stabilization, settling basins, depression areas, stormwater runoff collection areas, and vegetation buffers.	Reduce stormwater runoff and associated pollutant transport from roads near surface waters.
Install limestone channels to raise pH and neutralize acid from mine drainage at abandoned mines features.	Raise the pH and neutralize acid from mine drainage.
When financially possible, add biochar when vegetating legacy mining areas.	Reduce the availability and mobility of metals in soil and water and improve soil health to support revegetation.
Restore existing or install synthetic wetlands for passive treatment of acid mine drainage.	Raise the pH and neutralize acid from mine drainage, adsorption of metals to wetland sediments and vegetation.
Expand existing monitoring throughout the watershed to include paired flow and metals data, specifically capturing different hydraulic events (i.e., spring runoff and storm events).	Record annual loads of metals throughout the watershed.
Develop a monitoring program to collect samples from legacy mining areas during storm runoff.	Identify and quantify the contribution of legacy mine sites to the metals loading in surface water during storm events.
Develop MS4 implementation guidance based on the LAs from this TMDL.	Provide guidance for MS4 permittees on how to monitor and track MS4 loading.

10.2.2 Remediation Efforts in the Project Area

Several legacy mine remediation efforts have been successfully completed within the project area, establishing a precedent for future initiatives. Table 61 summarizes completed and in-progress remediation efforts.

Table 61. Completed and Ongoing Remediation Activities.

Responsible Parties	Remediation Activity	Year Completed
USFS	Blue John Mine: mine shaft and adit were closed, and tailings and waste rock were excavated and placed into a fenced, on-site repository capped with biosolids and native plants to stop the release of metals.	2006
EPA	Sheldon Mine: Capping and stabilization of historical tailings piles, and channelization of upper Lynx Creek headwaters to divert clean water around waste rock.	2013
ADEQ, USFS	Eugene Mine: remediation of former gold mine and mill site to reduce heavy metal impacts to the Big Bug Creek Watershed, with site characterization and runoff sampling continuing.	2022
ADEQ, USFS	Poland Walker Tunnel Mine Remediation: Capping, stabilization, and drainage controls of legacy waste rock and tailings to eliminate active discharge into Big Bug Creek.	2021 (ongoing monitoring)
ADEQ	Money Metals Mine Remediation: Installation of stormwater diversional channel around legacy waste rock piles, capping of tailings, and adit closure to mitigate metal loading into Big Bug Creek.	Ongoing
EPA, ADEQ	Iron King Mine & Humboldt Smelter Superfund Site: Multi-phase cleanup of over 300 acres of heavily polluted soils involving soil testing, removal of mine tailing piles, and residential yard cleanups.	Ongoing
Cosanti Foundation, ADEQ, Natural Channel Design	Utilized BMPs for erosion control of Agua Fria River to mitigate bank scour and downcutting, paired with community stream stabilization workshops.	2010
Town of Prescott Valley	Lower Lynx Creek Stormwater Capture: Installation of bank stabilization and sediment retention infrastructure upstream of Fain Lake to trap legacy mine waste before it reaches the mainstem.	Ongoing

Responsible Parties	Remediation Activity	Year Completed
USFS, BLM, ADEQ	Galena Gulch / Humboldt Mining District Mitigation: Localized adit closures and minor waste rock capping on public land parcels to reduce heavy metal leaching into the mainstem Agua Fria River.	2004 (now part of Superfund site)
USDA NRCS, Private Landowners	Big Bug Creek Riparian Fencing and Well Placement: Rotational grazing management and riparian exclusion fencing along Big Bug Creek. Uses alternative upland solar wells to prevent livestock from eroding banks and kicking up metal-heavy sediments.	Ongoing
BLM	Agua Fria National Monument Watershed Protection: Broad-scale erosion control, road decommissioning, and check-dam installations to catch sediment coming from upstream impaired reaches before it travels further south.	Ongoing

10.3 Future Actions and Monitoring

10.3.1 Sampling

Ongoing monitoring within the watershed plays a crucial role in assessing the success of implementation activities, addressing information gaps, and measuring progress toward long-term watershed objectives. However, rather than establishing a rigid sampling schedule at this time, sampling will be conducted, as deemed necessary, to obtain data for ADEQ to meet the Clean Water Act Sections 305(b) and 303(d) and to evaluate the effectiveness of TMDL-related project implementation in the waterbody.

10.3.2 5-Year TMDL Review and Update Schedule

In accordance with A.R.S. § 49-234, ADEQ will review this TMDL at least once every five years to determine if attainment of applicable surface WQSs have been achieved. This evaluation will determine if the implemented point source controls and voluntary nonpoint source BMPs are successfully reducing metal concentrations (including As, Cd, Cu, Pb, Se, and Zn) in the Upper Agua Fria River, Big Bug Creek, Lynx Creek, and their tributaries, or if additional steps should be taken to modify the implementation plan and expedite progress toward restoring these waters. Additionally, because natural mineralization significantly contributes to baseline metal loading, ADEQ will evaluate whether site-specific water quality standards or natural background adjustments are appropriate pursuant to A.A.C. R18-11-119 as additional monitoring data are collected.

10.3.3 Implementation Timeline

Implementation of this TMDL relies on a collaborative, community-led framework that leverages the strengths, resources, and local expertise of non-governmental organizations, watershed groups, and local partners. Rather than establishing a strict, legally binding timeline with specific start and end dates, the strategy establishes a phased 5-year adaptive horizon designed to support third-party initiatives, voluntary landowner practices, and externally funded restoration projects. Because reductions from nonpoint sources are voluntary, actual completion dates and the execution of these actions may vary significantly, as they are entirely subject to landowner willingness, available funding, and agency capacity. ADEQ's role focuses on facilitating access to CWA § 319 funding, providing technical assistance, and tracking progress, while evaluating watershed response during the schedule 5-year review to determine if modifications to this implementation plan are appropriate.

Section 11. Public Participation

The development of the TMDL would not have been possible without the participation of the public and the engagement of local interest groups, including representatives from:

- Prescott National Forest
- Bureau of Land Management
- Yavapai County Flood Control District
- Town of Prescott Valley
- City of Prescott
- Upper Agua Fria Watershed Partnership
- Prescott Valley Wastewater Treatment Plant
- Dewey-Humboldt Community Environmental Board

The following is a summary of public meetings held within the watershed and major topics of discussion:

- **Initial Stakeholder Engagement:** Starting in April 2024, we held initial stakeholder meetings to present TMDL background information, discuss impairments of interest, and establish desired levels of engagement. All participating groups expressed interest in receiving regular updates and providing feedback throughout the Upper Agua Fria TMDL project.

- **Project Updates:** Provided regular TMDL status updates to stakeholders via email every 30-45 days (April 2024 – June 2026).

- **National Training Workshop on Water Quality Data, Assessment, and Plans:** In June 2025, Clay Mansfield, Associate Environmental Science Specialist, presented ADEQ's stakeholder engagement efforts for Arizona's Upper Agua Fria TMDL project during a breakout session at an annual national virtual conference hosted by the Environmental Law Institute (ELI).

- **Upper Agua Fria Watershed Partnership:** Clay Mansfield presented at virtual meetings for the Upper Agua Fria Watershed Partnership (UAFWP) in July 2024 (project background and introduction) and February 2026 (results summary).

- **Informal Comment Period**

- **Public Comment Period**

- **Public Meeting No. 1:** The first public meeting was held at <LOCATION> on <DATE>. Information was presented on the TMDL development process, the nature of local waterbody impairments, and preliminary findings. Significant topics of conversation raised by meeting attendees included: <LIST TOPICS RAISED IN MEETING>.
- **Public Meeting No. <X>:** The first public meeting was held at <LOCATION> on <DATE>. Information was presented on the TMDL development process, the nature of local waterbody impairments, and preliminary findings. Significant topics of conversation raised by meeting attendees included: <LIST TOPICS RAISED IN MEETING>.

The draft TMDL was published on ADEQ's website on <DATE> for <X> days, and a public notice of publication was prominently placed in <LIST PUBLICATIONS>. During the public notice period, <NUMBER OF COMMENT> public comments were received. The following section summarizes the contents of the public comments and provides responses from ADEQ.

Comment No. 1: <SUMMARIZE COMMENT>

ADEQ Response No. 1: <SUMMARIZE ADEQ'S RESPONSE TO THE COMMENT, INCLUDING ANY CHANGES MADE TO THE DRAFT TMDL AS A CONSEQUENCE.>

Comment No. <X>: <SUMMARIZE COMMENT>

ADEQ Response No. <X>: <SUMMARIZE ADEQ'S RESPONSE TO THE COMMENT, INCLUDING ANY CHANGES MADE TO THE DRAFT TMDL AS A CONSEQUENCE.>

Section 12. Administrative Transparency and Generative AI Disclosure

In accordance with Arizona State Generative AI Policy (P2000), ADEQ utilized the State's governed instance of Google Gemini and NotebookLM during the internal review and finalization of this report. These tools were used by ADEQ staff for supplemental drafting, editorial revising, and the conceptualization of strategic visuals. All generative AI interactions were conducted within a secure, non-training environment where data is not utilized to improve public models. All underlying scientific analysis and data interpretation were performed independently by SWCA Environmental Consultants and verified by ADEQ, who maintain full accountability for the accuracy and regulatory compliance of this report.

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