San Juan River
Fish Tissue Contaminant Study

Final Report

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Executive Summary

In 2015, the plume from the Gold King Mine (GKM) waste water release flowed through tribal lands, subjecting downstream waters to high metal concentrations. Concerns remain regarding possible resuspension and remobilization of metals in sediments, and latent exposures to aquatic life or humans. The Navajo Nation Environmental Protection Agency (NNEPA) recognizes the importance of recreation in the San Juan River basin, including fishing, and the potential exposure of humans to contaminants through fish consumption. It is because of that recreational importance and the possibility of latent human exposure to metal contamination that NNEPA designed and conducted the 2017 San Juan River Fish Tissue Contaminant Study. The goal of the study was to provide a screening level assessment of metals in fish fillet tissue to help identify the prevailing human health risk associated with fish consumption subsequent to the GKM spill. This study was not designed to determine causes or locate sources of fish tissue contamination. Channel Catfish (*Ictalurus punctatus*) were selected as an indicator species based on their ecology, their sportfish status and human consumption potential, and their relative abundance in the river.

A total of 10 composite fish samples (five fish in each composite -- 50 total fish) were collected in April, 2017 and were analyzed for a suite of 25 metals. Results showed that:

- Nine of the 25 target metals were detected in at least one fillet fish tissue composite.
- Six metals (copper, magnesium, mercury, potassium, sodium, and zinc) were detected in all composites.
- Average concentrations of copper in fish fillets were similar to those from previous San Juan River fish tissue surveys (from between 1993 and 2000).
- Average levels of magnesium and zinc were lower in 2017 than in previous studies.
- Total mercury was the only frequently detected metal that was higher in the 2017 composites than in samples from previous studies.
- Mercury concentrations in Channel Catfish fillet tissue collected during 2017 were below USEPA's 0.3 mg/Kg tissue-based water quality criterion.

United States Environmental Protection Agency (USEPA) risk-based fish consumption limits are published and available for four of the target metals -- arsenic, cadmium, mercury, and selenium. The human health screening value applied for mercury was the USEPA fish tissue-based water quality criterion for methylmercury (USEPA 2006), and is the same threshold used by the states of New Mexico and Utah in their fish consumption advisory programs. All fillet results from the 2017 San Juan River collections were below the mercury criterion. Arsenic, cadmium, and selenium concentrations in fillets were all below the method reporting limits; however, the analytical methods did not enable detection down to levels that allowed consideration of all consumption categories. Because of that, it is not possible to make fish consumption recommendations based on those chemicals at this time without new (more sensitive) analytical methods and further data collection.

The 2017 fillet tissue results indicate that human health risk from recreational consumption of San Juan River fish (with respect to metal concentrations) is low. It is important to note that published USEPA consumption advice and human health benchmarks were applied here, which may not reflect the consumption patterns of selected local populations or a subsistence fishing community; however, they are appropriate (based on San Juan River Fish Tissue Study goals) for a screening level assessment of fish tissue contaminants. The results presented here provide current information on metals in San Juan River fish tissue as well as baseline data for any future studies of temporal trends.

1.0 Introduction

The Navajo Nation covers over 27,000 square miles of land in New Mexico, Arizona, and Utah, and the Navajo Nation Environmental Protection Agency is charged with the protection of human health and the environment associated with those lands. One event that triggered a need for environmental assessments and monitoring of Navajo Nation waters was the Gold King Mine (GKM) waste water spill of August 5, 2015. At that time, USEPA was conducting a study of the GKM near Silverton, Colorado to evaluate water releases from the mine and to assess the viability of additional mine remediation. During excavation activities, pressurized water began leaking, spilling about three million gallons of water into Cement Creek, a tributary of the Animas River. From the Cement Creek confluence, the Animas River flows for 126 miles and ends in Farmington, New Mexico, where it meets the San Juan River. The GKM plume flowed from the spill site, through tribal lands, and over a total distance of approximately 342 miles in a 9-day period (USEPA 2017). The NNEPA, USEPA, and many other natural resource entities have studied the GKM effects on water quality following that release.

USEPA's initial GKM spill monitoring efforts began in the fall of 2015 and continued through the fall of 2016. This monitoring effort focused on identifying changes in water quality, sediment, and biological condition since the GKM release in an effort to characterize potential impacts. USEPA began engaging with State and Tribal partners during this time to discuss expanding the monitoring to better focus on the concerns of local stakeholders in their jurisdictions. This additional monitoring effort focused on assessing the condition of sites downstream of the GKM release as compared to water quality standards and sediment risk benchmarks. USEPA posted the final metals fate and transport report for the GKM release on January 6, 2017 (*Analysis of the Transport and Fate of Metals Released from the Gold King Mine in the Animas and San Juan Rivers*; USEPA 2017).

USEPA (2017) estimated that approximately 540 tons of metals entered the Animas River over the 9-hour period of release, including aluminum, arsenic, cadmium, copper, iron, lead, manganese, mercury, and zinc. The 2017 report noted that the contamination of metals from the GKM release was transported through the Animas and San Juan River system to Lake Powell. No fish kills were reported in the rivers, and other aquatic life did not appear to show any short-term effects of the GKM plume. Water quality criteria exceedances occurred in the San Juan River as the GKM plume moved downriver. USEPA noted lead, copper, zinc and arsenic exceedances, with concentrations in the plume equal to or greater than San Juan River background concentrations. USEPA also noted that iron and aluminum made up much of the GKM plume mass, and that state and/or tribal aluminum criteria were exceeded in a number of locations in the San Juan River (although background sediment concentrations may have been a contributing factor). The USEPA (2017) report concluded that 2016 monitoring data shows that metal concentrations in water and sediment have returned to pre-event conditions in the Animas and San Juan Rivers.

The USEPA (2017) report focused primarily on water and sediment analyses, and concluded that potential human and aquatic life exposure to high metal concentrations of the plume were short-term in nature. Despite that, concerns continue regarding possible resuspension and remobilization of metals in sediments and latent exposures to aquatic life or humans in the river system. The NNEPA recognizes the importance of recreation in the San Juan River basin, including fishing, and the potential exposure of humans to contaminants through fish consumption. It is because of that recreational importance and the possibility of latent human exposure to metal contamination that NNEPA designed and conducted the 2017 San Juan River Fish Tissue Contaminant Study.

2.0 Study Design and Methods

The NNEPA San Juan River Fish Tissue Contaminant Study (hereafter referred to as the San Juan River Fish Tissue Study, or the Study) focused on assessing fish fillet tissue from the San Juan River reach downstream of the GKM release as compared to fish consumption limits based on human health benchmarks. This screening level assessment focused on prevailing human health risk associated with fish consumption subsequent to the GKM spill, and was based on monitoring current contaminant levels in fish, specifically metals relevant to the GKM spill. Additionally, the list of analytes was expanded to include metals that do not have comparative human health criteria in order to have a baseline and more expansive understanding of metals accumulated in fish tissue. The study goals were defined by NNEPA and the Navajo Nation Department of Fish and Wildlife (NNDFW), and the study design was refined and finalized in collaboration with USEPA Region 9, U.S. Fish and Wildlife Service (USFWS), and Tetra Tech. The study seeks to answer the questions:

- Which metals related to the GKM spill are bioaccumulating in fish tissue?
- What are the prevailing concentrations of metals in fish fillet tissue?
- How do these concentrations compare to human health screening values (when available)?

The study design (Tetra Tech 2017a and 2017b) identified five river locations between Farmington, New Mexico and Bluff, Utah, focusing on populated areas in the reach. The design targeted a total of 10 composite fish samples, i.e., two composites of five fish each from each of the five sampling sites (or 50 total fish). Specimen selection and compositing followed the recommendations and methods in USEPA's Fish Consumption Advisory Guidance documents (USEPA 2000a and 2000b) focusing on fishes that are commonly consumed by humans. Each of the 10 samples targeted by the study design were to consist of multiple (five) individual adult fish per composite that are similar in length (i.e., the length of the smallest specimen in the composite is at least 75% of the length of the largest individual).

Fillets from both sides of all five fish were removed (i.e., a total of 10 fillets per composite) and homogenized to prepare a composite fillet sample. Fillet tissue (rather than whole body samples) was analyzed to best represent the prevailing human health risk associated with fish consumption. Fish fillet tissue concentrations were compared to human health risk-based consumption limits for target chemicals for which those limits have been established by USEPA (USEPA 2000b). These design parameters have been applied in national-, regional-, and reach-scale studies for decades, and have been accepted by the scientific community as a valid approach to assessing human health risk (USEPA 2000a, USEPA 2000b, Stahl et al. 2009).

2.1 Field Sampling

A detailed description of the sampling design and field activities associated with the San Juan River Fish Tissue Study can be found in the *Quality Assurance Project Plan for Sample Collection Activities for the San Juan River Fish Tissue Contaminant Study (Volume 1 of 2)* (Tetra Tech 2017a) which was approved by USEPA Region 9.

The study schedule was determined based on NNDFW and USFWS expertise regarding optimal times for fish sampling in the San Juan River. The schedule accounted for preferred temperatures and flows for sampling efficiency, and avoided sampling during the spawning season of federally endangered and state protected Razorback Suckers (*Xyrauchen texanus*). The study was designed to fit these constraints while addressing study goals, and sampling was conducted by NNEPA, NNDFW, and Tetra Tech scientists during the week of 3 April 2017.

The field team was equipped with valid Scientific Collection Permits for the San Juan River study reach and an electrofishing raft appropriate for the location, sampling conditions, and targeted species. The target population for the San Juan River Fish Tissue Study was the population of fish residing in or moving through the San Juan River between Farmington, New Mexico and Bluff, Utah, that are commonly consumed by humans. The field team was tasked with collecting a composite sample of five individual fish of the same species from each sampling location. The primary target species for the San Juan River Fish Tissue Study was Channel Catfish (*Ictalurus punctatus*), a species that is abundant in the river, commonly consumed by humans, and one that may potentially accumulate high concentrations of contaminants (i.e., a bottom-dwelling species with potential close river bottom sediment contact).

Figure 1: San Juan River Channel Catfish Specimen

As fish were obtained by electrofisher in the field, they were immediately identified to species by the team's fisheries biologist. Non-target species were returned to the river. Each Channel Catfish (Figure 1) was measured to determine total body length in millimeters. When five individuals meeting the size criteria were identified (i.e., USEPA's "75% rule"), the species name, specimen lengths, and all other site and sampling information were recorded on a Field Record Form. Every attempt was made to collect the desired number and species of fish targeted for study; however, the success of the sampling effort was ultimately dependent upon the natural diversity and abundance of fish at each location and the weather/river conditions during the sampling event.

The five original sampling locations (Tetra Tech 2017a; Figure 2, below) were selected based on NNEPA, NNDFW, and USFWS expertise and recommendations to best represent populated areas of the San Juan River that are commonly fished. Location, access, and the anticipated success for fishing were considered. After field sampling commenced in April 2017, weather/river conditions and fish abundances necessitated shifting of the sampling locations to increase the likelihood of obtaining viable samples. High river levels, turbid water conditions, and an unexpected snowstorm impeded electrofishing efficiency and success. During initial sampling efforts, Channel Catfish proved to be abundant between original sites 1 and 2, but were absent downstream from site 2. Regular communication with USFWS fisheries personnel who were electrofishing the San Juan River during the same time period indicated very sparse catfish catches in the lower reaches as well.

Following discussions between NNEPA, NNDFW, and USFWS personnel in the field, the NNEPA Project Manager approved suitable replacement sites for sampling based on catch results (i.e., the noted availability of Channel Catfish). Sampling occurred in two distinct river segments: Reach U was the segment between original Site 1 and original site 2, and Reach D was just upstream of original Site 4 (Table 1 and Figure 2).

Table 1: Locations of San Juan River Fish Tissue Sampling Sites

Site	Latitude	Longitude	Description
Upstream Reach U (start)	N 36° 45’ 01.97”	W 108° 24’ 53.85”	near the Nenahnezad Chapter House
Upstream Reach U (finish)	N 36° 46’ 53.78”	W 108° 41’ 35.48”	near the Shiprock Bridge
Downstream Reach D (start)	N 37° 12' 47.81"	W 109° 11' 12.84"	near Aneth, Utah
Downstream Reach D (finish)	N 37° 15' 27.27"	W 109° 18' 4.26"	near Montezuma Creek, Utah

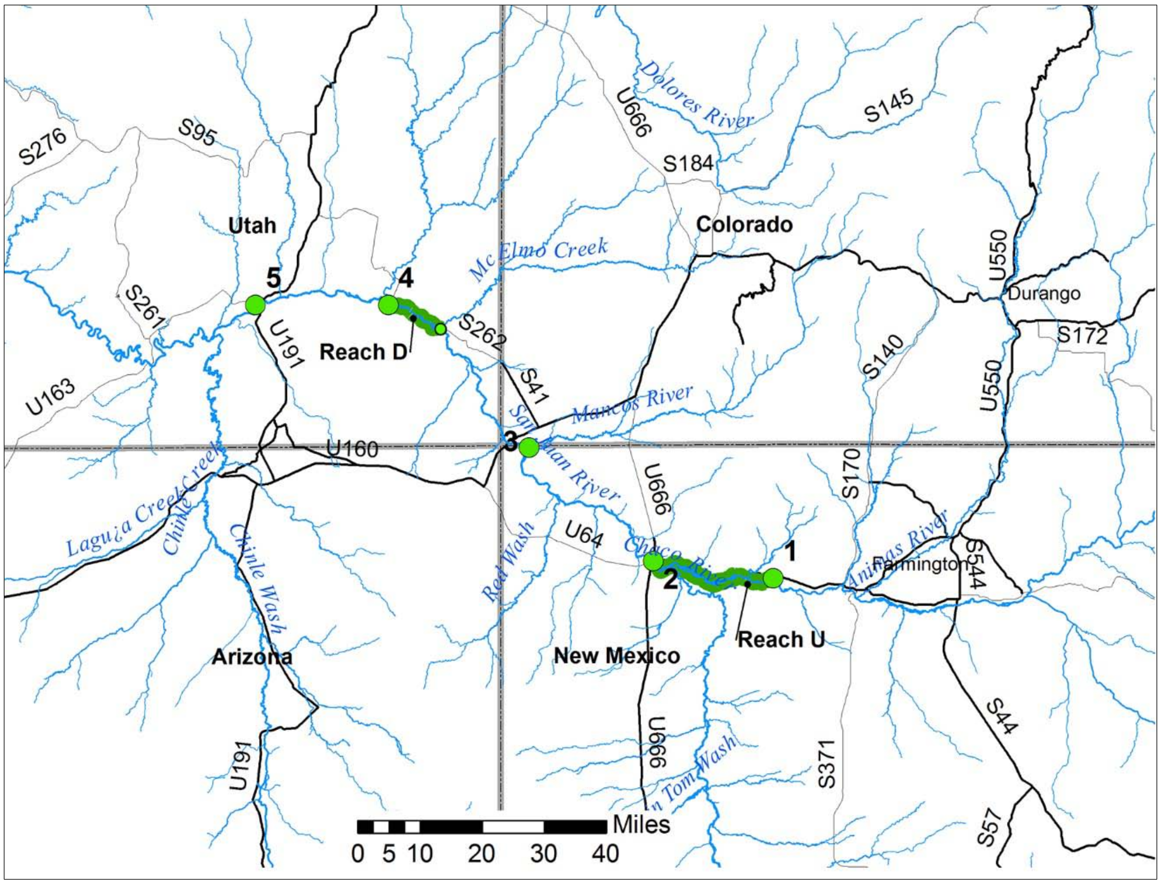

Figure 2: Map of Planned (Sites 1-5) and Final (Green Colored River Reaches) San Juan River Fish Tissue Sampling Locations

As mentioned previously, the primary target species for the San Juan River Fish Tissue Study was Channel Catfish (*Ictalurus punctatus*). The field team was successful in collecting 76 total [adult] specimens of Channel Catfish from the two river section (56 from upstream Reach U and 20 from downstream Reach D). All fish were measured to the nearest millimeter, total length, and 50 total specimens were retained to form 10 total composites. Specimens collected within each river segment were segregated into composites that conformed to USEPA’s “75% rule,” i.e., the length of the smallest specimen in the composite is at least 75% of the length of the largest individual. This ensured similar sizes (and implies similar ages or year classes) within composites. In some cases, the largest and/or smallest individuals were dropped in order to have comparable lengths within composites, within duplicate pairs, and among sampling sites. Six 5-fish composites were prepared from upstream Reach U and four 5-fish composites were retained from the downstream Reach D (age approximations below are based on information from Farokhkish 2012):

- Composite U1 – length range = 510-575 mm; average = 549 mm (approximately 6-9 years old)
- Composite U2 – length range = 543-570 mm; average = 554 mm (approximately 7-9 years old)
- Composite U3 – length range = 444-524 mm; average = 481 mm (approximately 4-8 years old)
- Composite U4 – length range = 442-519 mm; average = 477 mm (approximately 4-8 years old)
- Composite U5 – length range = 449-500 mm; average = 478 mm (approximately 4-8 years old)
- Composite U6 – length range = 436-498 mm; average = 472 mm (approximately 4-8 years old)
- Composite D1 – length range = 497-561 mm; average = 522 mm (approximately 6-9 years old)
- Composite D2 – length range = 493-550 mm; average = 516 mm (approximately 6-9 years old)
- Composite D3 – length range = 443-488 mm; average = 473 mm (approximately 4-8 years old)
- Composite D4 – length range = 438-488 mm; average = 469 mm (approximately 4-8 years old)

Fish chosen for each composite sample were wrapped, labeled, and frozen as whole specimens. All of the frozen fish were shipped under chain-of-custody by priority overnight shipping service to the Tetra Tech Biological Research Facility in Baltimore, MD.

2.2 Sample Preparation and Analysis

The Tetra Tech Biological Research Facility in Baltimore, Maryland served as the fish sample preparation laboratory and was responsible for: filleting each valid fish sample, homogenizing the fillet tissue, preparing the required number of fish tissue aliquots for analysis and archive, shipping the fish tissue aliquots for each analysis to the analytical laboratory, and storing [frozen] archived fish tissue samples. Specific procedures for fillet tissue sample preparation activities are described in *Quality Assurance Project Plan for Sample Preparation and Analysis Activities for the San Juan River Fish Tissue Contaminant Study (Volume 2 of 2)* (Tetra Tech 2017b).

Each fish was unwrapped in the preparation laboratory, then weighed to the nearest gram, rinsed with deionized water, and placed on a clean glass cutting board. The filleting process involved removing the fillet (with belly flap [ventral muscle] attached) and skin from both sides of each fish. Fillets were composited using the “batch” method (all of the fillets from the individual specimens that make up the sample are homogenized together, regardless of each specimen’s proportion to one another) as opposed to the “individual” method (equal weights of tissue from each specimen are added together).

An electric grinder was used to prepare homogenate samples. Entire fillets (with belly flap) from both sides of each fish are homogenized, and the entire homogenized volume of all fillets from the fish sample was used to prepare the tissue sample. Tissues were mixed thoroughly until they were completely homogenized as evidenced by a fillet homogenate that consists of a fine paste of uniform color and texture. The collective weight of the homogenized tissue from each sample was recorded to the nearest gram (wet weight) after processing and sample aliquots were retained for both analysis and archive.

Homogenized fish tissue samples were analyzed by TestAmerica using Method 6020A for a suite of 24 metals and Method 7471B for mercury. Each composite sample was analyzed for: aluminum, antimony, arsenic, barium, beryllium, calcium, cadmium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, silver, sodium, strontium, thallium, vanadium, and zinc (wet weight). All of the metals except calcium, magnesium, and potassium were analyzed in USEPA's initial work after the GKM spill (USEPA 2017). The full methods with method-specific quality assurance (QA) procedures are presented in Tetra Tech 2017b. Method 6020A (Inductively Coupled Plasma-Mass Spectrometry, Revision 1) is a USEPA method with instrument detection limits generally below 0.1 µg/L. Less sensitive elements (e.g., selenium and arsenic) and desensitized major elements may be 1.0 µg/L or higher. Tissue sample results are reported based on the wet weight of the tissue sample, in milligrams per kilogram (mg/Kg). The method measures ions produced by a radio-frequency inductively coupled plasma (USEPA 1998). Method reporting limits are listed in the *Quality Assurance Project Plan for Sample Preparation and Analysis Activities for the San Juan River Fish Tissue Contaminant Study (Volume 2 of 2)* (Tetra Tech 2017b). Method 7471B (Mercury in Solid or Semisolid Waster [Manual Cold-Vapor Technique], Revision 2) is a USEPA method with a typical instrument detection limit of 0.0002 mg/L. Tissue sample results are reported based on the wet weight of the tissue sample, in milligrams per kilogram (mg/Kg). This method uses cold-vapor atomic absorption and is based on the absorption of radiation by mercury vapor (USEPA 2007a). Method reporting limits for mercury are detailed in the sample preparation and analysis Quality Assurance Project Plan (QAPP) (Tetra Tech 2017b).

During the course of the fish tissue homogenization process, aqueous equipment rinsate samples were also analyzed using Method 6020A and Method 7471B. Rinsate results were reported based on the volume of the rinsate sample, in micrograms per liter (µg/L).

3.0 Quality Assurance/Quality Control

The quality of data generated for this project was ensured through the use of trained, experienced personnel who consistently followed the standard operating procedures (SOPs), methods, and project protocols. Project staff followed all quality procedures presented in *Quality Assurance Project Plan for Sample Collection Activities for the San Juan River Fish Tissue Contaminant Study (Volume 1 of 2)* (Tetra Tech 2017a) and *Quality Assurance Project Plan for Sample Preparation and Analysis Activities for the San Juan River Fish Tissue Contaminant Study (Volume 2 of 2)* (Tetra Tech 2017b). All samples were analyzed within 28 days of homogenization (i.e., the recommended holding time for mercury) and well within the 180 day holding time for the balance of the suite of metals.

Measurement control and performance metrics are described for both sample preparation and analysis in Tetra Tech 2017b. Negative controls (blank analyses) were generated and evaluated in performance of both processing and analysis methods. The negative control for sample processing is the procedural blank (equipment rinsate) generated during homogenization operations. Analytical acceptance criteria for positive (analysis of standard reference materials or spiked control samples) and negative controls (calibration, method and instrument blanks) are described in the laboratory SOPs and the QA Manual, and are discussed in the sample preparation and analysis QAPP (Tetra Tech 2017b). In general, negative controls ideally yield no target analyte values in excess of laboratory-specific method detection limits, but, due to the ubiquitous nature of some elements in the laboratory setting, blank limits are frequently established at the reporting limit. For positive controls, spiked and control sample recoveries in a range of 75-115% are generally considered acceptable for solid matrices.

3.1 Data Review and Verification

All data entries and transmittals were reviewed for accuracy, completeness, and adherence to project QA requirements. All Sample Preparation Laboratory measurements and calculations were reviewed by the Sample Preparation Laboratory Manager prior to data submission. Laboratory results and calculations were reviewed by the Analytical Laboratory Manager who verified that the final analytical data package was complete and compliant with method and project specifics. A detailed verification, data quality, and usability assessment was performed by a Tetra Tech Quality Control chemist experienced in analytical quality assurance/quality control (QA/QC). The analytical data were reviewed for general compliance with the approved plan, for usability, and to define any apparent limitations in the data set as a result of quality control deficiencies in field or laboratory QC samples, or departures from the QA plan.

Overall, the data were found to be reliable and well documented in the laboratory reports. However, as it is inappropriate for the analytical laboratory to fully self-validate sample data, some minor changes to data qualifications are included in the analytical data tables (Appendix A) resulting from detailed comparisons of specific QC departures or deficiencies (primarily negative controls, or field and laboratory blanks) to environmental sample results. The data usability assessment was performed in accordance with the guidance established in the 2007 update to USEPA's "Pumpkin Book" -- *Solutions to Analytical Chemistry Problems with Clean Water Act Methods* (USEPA 2007b). Approved QAPP measurement goals and objectives from the QAPP (Tetra Tech 2017b) were adhered to throughout the sample analyses. Deviations from required quantitation goals are isolated to sample size, and no unnecessary dilutions were performed in advance of analysis. The example reporting limits in the approved QA plan were based on nominal sample sizes. For the most part, where detection and reporting limits deviate from those projected in the QAPP, they reflect slightly lower, rather than higher limits when adjusted for actual sample preparation masses relative to the example limits. QAPP tables for measurement sensitivity and prevailing USEPA consumption advisory guidance are provided in Section 4.2 for comparison and assessment of performance.

3.1.1 Negative Controls

Laboratory Blanks: An aqueous equipment rinsate sample was analyzed using Method 6020A for a suite of 24 metals and Method 7471B for mercury. The aqueous blank (MB 180-255541/1-A; "LAB BLK" in Table 2) prepared with field blank and rinsate samples for Inductively Coupled Plasma-Mass Spectrometry (ICP/MS) elemental analyses revealed the presence of sodium in excess of the method detection limit (MDL), but below the reporting limit (RL). The associated field QC samples were comparable to the laboratory blank, thus their values are reported with a validation flag of UJ at the observed concentration as they are not discernable from the laboratory blank (<5x the blank concentration). The same is true for tissue samples. The laboratory blanks for mercury did not reveal the presence of mercury above the laboratory MDL.

Field Blanks: Field and rinsate blanks (180-67115-12 and 180-677115-11, respectively) prepared for the analysis of ICP/MS metals both contained trace levels of aluminum, antimony, arsenic, calcium, and the previously mentioned sodium. Results for the two field QC samples are comparable overall as seen in Table 2, with the exception of aluminum which was higher in the blank than in the rinsate sample. Of the trace level contaminants observed, only arsenic has an established USEPA fish consumption limit, and none of the measured sample concentrations for arsenic exceeded ½ of the RL.

Table 2: Negative Controls: Equivalence and Qualification Limits

Element	Lab Blank	QUAL	RINSATE (µg/L)	QUAL	Field Blank (µg/L)	QUAL	MAX Tiss Eq† (mg/Kg)	UJ (<5x BLK)	J <10x BLK
Aluminum			18	J	27	J	2.7	13.5	27
Antimony			0.5	J	0.54	J	0.054	0.27	0.54
Arsenic			0.4	J	0.41	J	0.041	0.205	0.41
Calcium	15	J (T)	110	J	91	J	15	75	150
Chromium			0.39	J			0.039	0.195	0.39
Sodium	383	J (Aq)	440	UJ	360	UJ	44	220	440
Strontium	0.0546	J (T)					0.0546	0.273	0.546
Zinc			2.9	J			0.29	1.45	2.9

Note: Lab blanks were prepared for both aqueous (Aq) and tissue (T) digestions. Only positive results are presented in their units, microgram per liter (µg/L) and milligram per kilogram (mg/Kg), respectively).

†Conversion factors from aqueous to tissue equivalence reflect adjustment from 100mL sample size to 1g, and conversion of ppb to ppm units or µg/L *1000 (units) / 100 (sample size), or, simply aqueous ppb *0.1 = tissue equivalent in mg/Kg.

QUAL = data qualifiers

BLK = blank

J flags indicate an estimated value, when the mass spectral data indicate the presence of an analyte that's is greater than zero but below the reporting limit.

U flags indicate that the compound was analyzed but not detected. An estimated detection limit is calculated based on signal to noise ratio.

Aluminum was observed in only one field sample (Downstream Composite 1) at levels less than the tissue equivalent for the blank, thus it has been qualified UJ in its assessment.

Antimony was observed at levels just above the MDL, but below the RL in five samples (Upstream 2, Upstream 3, Upstream 6, Downstream 1, and Downstream 2), but was not discernable from the associated field blanks (<5x the blank concentration). These values were qualified as UJ in the usability assessment at the levels observed in analysis.

Arsenic was observed at levels close to, but above the laboratory MDL and below the RL in samples Upstream 1-6, Downstream 1, Downstream 3, and Downstream 4. However, as none of the measured tissue concentrations were discernable from field blank values, all have been qualified UJ at the observed concentration. As stated previously, none of the measured concentration would translate to a recommended consumption limit of less than 16 meals per month.

Calcium was observed in all tissue samples at levels in excess of 5 times the associated blank values. As such all values except that for sample Downstream 1 have been reported with a J qualifier indicating it is an estimated (potential maximum) concentration between 5 and 10 times the associated blanks. Sample Downstream 1 revealed a calcium concentration greater than 10 times the highest blank concentration at 130 mg/Kg. Therefore, the calcium concentration for that sample is presented without additional qualification.

Chromium was observed between the MDL and RL in the rinsate blank and one tissue sample (Downstream 2). The positive results for that sample was just above the tissue equivalent blank value, therefore it is qualified UJ as undiscernible from the associated blank.

Sodium was observed in all laboratory and field blanks. However, all samples exceeded 10 times the tissue equivalent for the associated blanks, therefore no qualification was necessary.

Zinc was observed in only the rinsate blank, however it was at a concentration of less than 10 times the associated samples, and therefore no data qualification was made for zinc values.

3.1.2 Positive Controls

Laboratory Control Samples which were prepared and analyzed with the samples revealed no recoveries outside of laboratory limits. The matrix spike and matrix spike duplicate (MS/MSD) for ICP/MS analyses were prepared using Upstream Composite 2, and the MSD fraction yielded a 71% recovery, just below the lower acceptance criteria of 75%; however, precision for the two spiked samples was well within limits, the recovery was not so low as to suggest a significant bias, and all sample values were qualified as estimates as they were already reported between the MDL and RL. No further qualifications were attached based on this result.

4.0 Results

The goal of the San Juan River Fish Tissue Study was to provide a screening level assessment to help identify the prevailing human health risk associated with fish consumption subsequent to the GKM spill. To address the study objectives, metal concentrations in fish fillet samples were compared to risk-based consumption limits established by USEPA (USEPA 2000b and USEPA 2006). Application of human health thresholds identifies tissue concentrations that are above (or below) a level protective of human health. USEPA risk-based consumption limits are published for four of the metals targeted for study, i.e., arsenic, cadmium, mercury, and selenium. The screening value applied for mercury was the USEPA fish tissue-based water quality criterion for methylmercury (USEPA 2006). Freshwater fish contamination studies have shown that methylmercury can account for (on average) more than 90% of the mercury concentration in predator fish tissue. USEPA (2000a) and USEPA (2006) recommended monitoring for total mercury (as adopted for the San Juan River Fish Tissue Study) rather than methylmercury in fish contaminant screening studies, applying the conservative assumption that all mercury is present in fish tissue as methylmercury. Additionally, the list of target analytes included metals that do not have comparative human health criteria in order to establish a baseline and gain a more expansive understanding of metals accumulated in San Juan River fish tissue.

4.1 Analytic Approach

Analytical method selection was based on direct comparison to method applications from previous USEPA San Juan River studies. The methods selected (Method 6020A for a suite of 24 metals and Method 7471B for mercury) are well-documented and widely accessible in commercial laboratories nationally. For the purposes of this data collection, it is acknowledged that method RLs may not always compare favorably to some of the fish tissue consumption limits. Thus, direct comparison of reported limits or estimated concentrations to human health screening values were undertaken carefully. Samples with no evidence of target elements were reported as not detected (ND) considering the laboratory RL. An undetected sample result may appear to suggest a higher concentration than a trace level value observed between the laboratory-derived MDL and RL. The MDL is an empirically determined quantitation limit with a 99% confidence that the value is not zero. Reporting a detection when there is no substance present is known as a “false positive.” The USEPA MDL is designed to control against false positives at the 99-percent confidence level. Reporting the detection of a substance at the MDL concentration in a blank sample or a sample that does not contain the analyte should be rare (less than or equal to 1 percent).

The fish fillet tissue samples were analyzed for the suite of metals listed in Table 3. Human health thresholds were applied to identify tissue concentrations above a level protective of human health. The fish tissue metal concentrations were compared to existing USEPA risk-based fish consumption limits (USEPA 2000b). Tables 4 through 6 present the risk-based consumption limits for three of those metals, i.e., arsenic, cadmium, and selenium. The screening value applied for mercury was the USEPA fish tissue-based water quality criterion for methylmercury (USEPA 2006).

Table 3: San Juan River Fish Tissue Study Target Analytes (using USEPA Methods 6020A and 7471B)[1]

Analyte	Included in 2017 USEPA GKM Report[2]?	USEPA Risk-based Consumption Limit?	Evaluation Benchmarks	RL[3] (mg/Kg)	MDL (mg/Kg)
Aluminum	Yes			3.00	1.82
Antimony	Yes			0.200	0.0325
Arsenic	Yes	Yes	See Table 4	0.100	0.0203
Barium	Yes			1.00	0.0474
Beryllium	Yes			0.100	0.0243
Calcium				50.0	8.03
Cadmium	Yes	Yes	See Table 5	0.100	0.0105
Chromium	Yes			0.200	0.0816
Cobalt	Yes			0.0500	0.00820
Copper	Yes			0.200	0.122
Iron	Yes			5.00	3.68
Lead	Yes			0.100	0.0481
Magnesium				50.0	3.33
Manganese	Yes			0.500	0.174
Mercury	Yes	Yes	0.3 mg/Kg fish tissue based Water Quality Criterion (USEPA 2006a)	0.0330	0.00739
Molybdenum	Yes			0.500	0.0784
Nickel	Yes			0.100	0.0294
Potassium				50.0	5.35
Selenium	Yes	Yes	See Table 6	0.500	0.122
Silver	Yes			0.100	0.0133
Sodium	Yes			50.0	21.1
Strontium	Yes			0.500	0.0344
Thallium	Yes			0.100	0.00390
Vanadium	Yes			0.100	0.0565
Zinc	Yes			0.500	0.288

[1]Tetra Tech 2017b
[2]USEPA 2017
[3]Example projected reporting limits from the Tetra Tech 2017b QAPP based on nominal sample sizes

Table 4: Monthly Fish Consumption Limits for Carcinogenic and Noncarcinogenic Health Endpoints – Arsenic (inorganic) (USEPA 2000b)

Risk Based Consumption Limit[a]	Noncancer Health Endpoints[b]	Cancer Health Endpoints[c]
Fish Meals/Month	Concentrations *(mg/Kg, wet weight)*	Concentrations *(mg/Kg, wet weight)*
Unrestricted (>16)	0 - 0.088	0 - 0.002
16	>0.088 - 0.18	>0.002 - 0.0039
12	>0.18 - 0.23	>0.0039 - 0.0052
8	>0.23 - 0.35	>0.0052 - 0.0078
4	>0.35 - 0.7	>0.0078 - 0.016
3	>0.7 - 0.94	>0.016 - 0.021
2	>0.94 - 1.4	>0.021 - 0.031
1	>1.4 - 2.8	>0.031 - 0.063
0.5	>2.8 - 5.6	>0.063 - 0.13
None (<0.5)	>5.6	>0.13

[a] The assumed meal size is 8 oz (0.227 kg) for the general population and an adult body weight of 70 kg.
[b] Chronic, systemic effects.
[c] Cancer values represent tissue concentrations at a 1 in 100,000 risk level.

Table 5: Monthly Fish Consumption Limits for Noncarcinogenic Health Endpoint – Cadmium (USEPA 2000b)

Risk Based Consumption Limit[a]	Noncancer Health Endpoints[b]
Fish Meals/Month	Fish Tissue Concentrations *(mg/Kg, wet weight)*
Unrestricted (>16)	0 - 0.088
16	>0.088 - 0.18
12	>0.18 - 0.23
8	>0.23 - 0.35
4	>0.35 - 0.7
3	>0.7 - 0.94
2	>0.94 - 1.4
1	>1.4 - 2.8
0.5	>2.8 - 5.6
None (<0.5)	>5.6

[a] The assumed meal size is 8 oz (0.227 kg) for the general population and an adult body weight of 70 kg.
[b] Chronic, systemic effects.

Table 6: Monthly Fish Consumption Limits for Noncarcinogenic Health Endpoint – Selenium (USEPA 2000b)

Risk Based Consumption Limit[a]	Noncancer Health Endpoints[b]
Fish Meals/Month	**Fish Tissue Concentrations, *(mg/Kg, wet weight)***
Unrestricted (>16)	0 - 0.029
16	>0.029 - 0.059
12	>0.059 - 0.078
8	>0.078 - 0.12
4	>0.12 - 0.23
3	>0.23 - 0.31
2	>0.31 - 0.47
1	>0.47 - 0.94
0.5	>0.94 - 1.9
None (<0.5)	>1.9

[a] The assumed meal size is 8 oz (0.227 kg) for the general population and an adult body weight of 70 kg.
[b] Chronic, systemic effects.

4.2 Analytical Results

Results for all fish tissue samples collected from the Upstream Reach and the Downstream Reach are presented in Appendix A Tables A1 and A2, respectively. Most of the target metals were not detected (i.e., were below the RL) and reported as ND (Tables A1 and A2). Nine of the target metals were detected in at least one fillet fish tissue composite: copper (in all 10 samples), iron (in 5 samples), magnesium (in all samples), manganese (in 1 sample), mercury (in all samples), nickel (in 4 samples), potassium (in all samples), sodium (in all samples), and zinc (in all samples).

Intra-station variability in metal concentrations was relatively low and may reflect the size similarities between composite samples. The average length of fish in the Upstream Reach composites only differed by 82 mm (approximately 3 inches) and average lengths of Downstream composites only differed by 53 mm (approximately 2 inches). The highest intra-station variability (i.e., differences in station composite results, J flag results included) was observed at the Upstream Reach, with nickel showing a 77 percent relative standard deviation (% RSD) over the 6 composites, followed by manganese at 41% RSD, and antimony and thallium at 29% RSD. All of the remaining elements had % RSD values of less than 20 percent. Variability among composites from the Downstream Reach did not exceed the maximum of 34% RSD for antimony and no other elements in excess of 28% (observed for both strontium and zinc).

Box-and-whisker plots of the analytical results were prepared for metals that were found in all 10 fish fillet composites (i.e., 100% positive detections, no J flags). Minimum, maximum, median, 25th percentile, and 75th percentile values are shown in the plots in Appendix B. Inter-station comparisons for copper, magnesium, mercury, potassium, sodium, and zinc show that the range of concentrations were typically wider for the Downstream Reach (with the exception of copper which showed a wider range of values in the Upstream Reach). The box-and-whisker plots showed no interquartile range (i.e., 25th percentile to 75th percentile) separation when comparing the Upstream to Downstream Reach results for each of the six frequently detected metals, which implies no notable difference in metal concentrations in fish between the reaches.

As mentioned in Section 4.1, USEPA risk-based fish consumption limits (USEPA 2000b and USEPA 2006) are available for four of the target metals -- arsenic, cadmium, mercury, and selenium – with the screening value for mercury based the USEPA fish tissue-based water quality criterion for methylmercury. San Juan River arsenic, cadmium, and selenium results were below the levels of detection (Tables A1 and A2); therefore, mercury is the only target metal with detection concentrations that can be assessed using human health protection benchmarks. For arsenic, cadmium, and selenium, the analytical methods did not allow detection down to levels that allowed consideration of all consumption categories (see Tables 4 and 5). Because of that, it is not possible to make fish consumption recommendations based on those chemicals at this time without new (more sensitive) analytical methods and further data collection.

Mercury was detected in all San Juan River fish tissue samples. Concentrations ranged from 0.095 to 0.19 mg/Kg (wet weight); therefore, all results were below the 0.3 mg/Kg fish tissue based water quality criterion for methylmercury (Figure 3) even when applying the conservative assumption that all mercury was present in fish tissue as methylmercury (See Section 4.0).

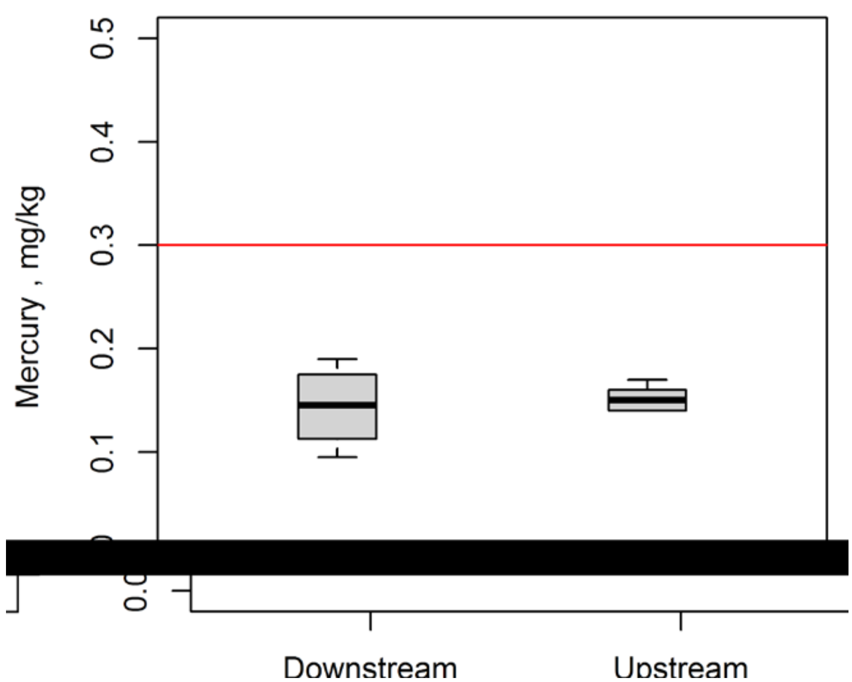

Figure 3: San Juan River fillet fish tissue mercury concentrations compared to USEPA's fish tissue based water quality criterion.

Many studies have shown that mercury concentrations in fish, particularly predators or top carnivores, increase with age (and therefore with increasing length/weight), which demonstrates the influence of increased duration of exposure on mercury accumulation in fish tissue (USEPA 2010a). Lusk et al. (2005) found that methylmercury concentrations in catfish collected from Navajo Nation lakes in 2004 were significantly correlated with average length (r^2=0.87) and average weight (r^2=0.88). Channel Catfish targeted for the San Juan River Fish Tissue Study were larger, adult specimens that would typically be harvested and consumed by anglers. Fish sizes within composites followed USEPA's "75% rule" so intra-composite lengths were similar, by design. Inter-composite lengths were similar as well (see Section 2.1) to allow comparisons between composites and sampling locations. Therefore, the study did not include the objective to assess mercury and fish size relationships. Mercury fish tissue concentrations proved to be similar between composites with a tight range of between 0.095 and 0.19 mg/Kg. Despite this, size and concentration comparisons showed a positive (albeit weak) relationship of increasing mercury with increasing fish size (r^2=0.09) (Figure 4).

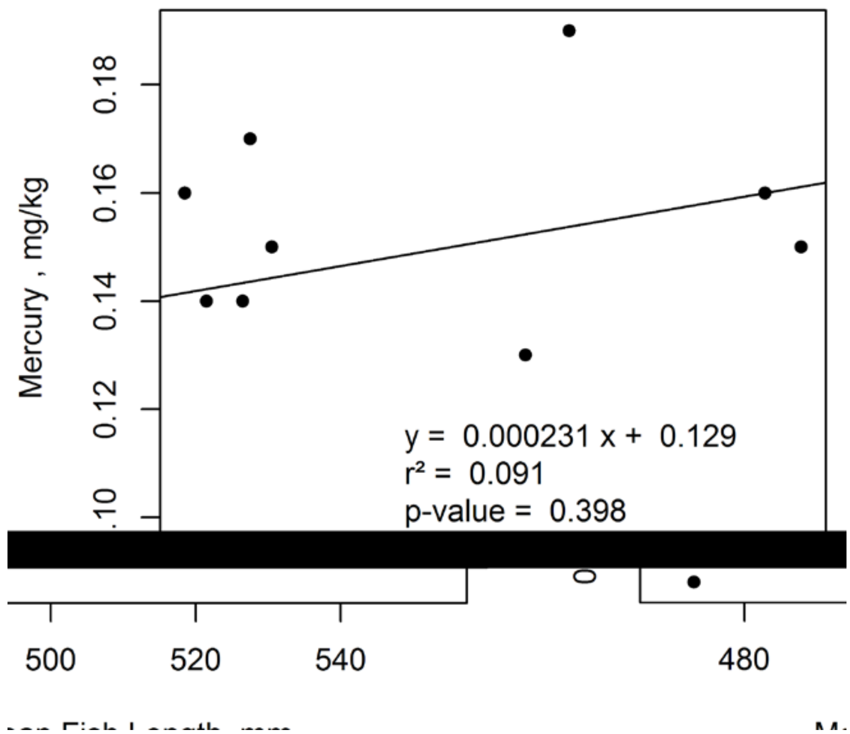

Figure 4: A comparison of fish length and mercury concentrations in San Juan River fish fillets.

5.0 Discussion

The goal of this study was to provide a screening level assessment of metals in fish to help identify the prevailing human health risk associated with fish consumption subsequent to the GKM spill. This study was not designed to determine causes or locate sources of fish tissue contamination. Results present current [2017] levels of metals in San Juan River fish, with Channel Catfish selected as an indicator species based on their ecology (e.g., feeding habits and close association with river sediments), their sportfish status and human consumption potential, and their relative abundance in the river.

Nine of the 25 target metals were detected in at least one fillet tissue composite. Six metals (copper, magnesium, mercury, potassium, sodium, and zinc) were detected in all composites collected during the 2017 sampling event. Lusk et al. (2005) summarized (geometric mean) fillet concentrations of metals in multiple San Juan River fish species reported by multiple researchers from 1993 to 2000. That summary can be used for a cursory temporal comparison with the 2017 results for four of the six frequently-detected metals (i.e., potassium and sodium were not included in Lusk et al. 2005). Average concentrations of copper in fish fillets were comparable between those summarized by Lusk et al. (2005) (0.37 mg/Kg) and the current study (0.35 mg/Kg). Average levels of magnesium and zinc were lower in the 2017 samples than those from previous samplings (237 compared to 287, and 4.5 compared to 7.4 mg/Kg, respectively). Total mercury was the only frequently detected metal that was higher in the 2017 composites (0.15 mg/Kg) than in the samples summarized by Lusk et al. (2005) (0.08 mg/Kg).

The USEPA (2017) GKM report noted that water quality criteria exceedances for the designated use “fish consumption” occur frequently in the San Juan River as a result of arsenic and mercury levels, and that those exceedances occurred before (historically), during, and after the GKM release (post-plume in 2015 and 2016). The report concluded that there is no indication that fish consumption exceedances changed after the GKM release. Results from the 2017 San Juan River Fish Tissue Study showed that mercury concentrations in all Channel Catfish fillet samples were below USEPA’s fish tissue-based water quality criterion.

The 2017 ND results for arsenic, cadmium, and selenium cannot be interpreted as supporting unrestricted San Juan River Channel Catfish consumption. The RLs for arsenic, cadmium, and selenium (using Method 6020A) did not enable detection down to levels that allowed consideration of all consumption categories. Because of that, it is not possible to make fish consumption recommendations based on those chemicals at this time. Lower detection levels (e.g., for arsenic and selenium) would require additional data collection and emerging (and more costly) analytical methods such as ICP/MS with a hydride generation system to increase sensitivity.

The 2017 fillet tissue results indicate that human health risk from recreational consumption of San Juan River fish [with respect to metal concentrations] is low. It is important to note that published USEPA consumption advice and human health benchmarks were applied here, which may not reflect the consumption patterns of selected local populations or a subsistence fishing community; however, they are appropriate (based on San Juan River Fish Tissue Study goals) for a screening level assessment of metals in fish. Fish for the 2017 study were collected in spring; therefore, information on seasonal fluctuations or trends would require additional (e.g., fall) sampling. The results presented here provide current [2017] information on metals in San Juan River fish tissue as well as baseline data for any future studies of temporal trends.

6.0 Literature Cited

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APPENDIX A

Analytical Results

Table A1: San Juan River Upstream Reach fillet tissue concentrations (mg/Kg, wet weight)

		Sample ID	Upstream Composite 1			Upstream Composite 2			Upstream Composite 3			Upstream Composite 4		
		Lab ID	180-67115-2			180-67115-3			180-67115-8			180-67115-9		
		Collect Date, Time	6/5/2017 14:10			6/5/2017 13:30			6/6/2017 17:00			6/6/2017 13:30		
		Analysis 1	6/29/2017 4:41			6/29/2017 4:46			6/29/2017 5:19			6/29/2017 5:40		
		Analysis2 (Hg)	6/22/2017 19:02			6/22/2017 18:56			6/22/2017 19:12			6/22/2017 19:14		
		Receipt Date	6/8/2017 9:00			6/8/2017 9:00			6/8/2017 9:00			6/8/2017 9:00		
		Preparation 1	6/22/2017 10:55			6/22/2017 10:55			6/22/2017 10:55			6/22/2017 10:55		
		Preparation 2 (Hg)	6/22/2017 18:12			6/22/2017 18:12			6/22/2017 18:12			6/22/2017 18:12		
CAS	**Analyte**	**Units**	**VALUE**	**RL**	**MDL**	**VALUE**	**RL**	**MDL**	**VALUE**	**RL**	**MDL**	**VALUE**	**RL**	**MDL**
7429-90-5	Aluminum	mg/Kg	ND	2.9	1.8	ND	3.2	1.9	ND	3.2	2	ND	3.1	1.9
7440-36-0	Antimony	mg/Kg	ND	0.19	0.032	ND	0.21	0.034	ND	0.22	0.035	ND	0.21	0.034
7440-38-2	Arsenic	mg/Kg	ND	0.097	0.02	ND	0.11	0.021	ND	0.11	0.022	ND	0.1	0.021
7440-39-3	Barium	mg/Kg	ND	0.97	0.046	ND	1.1	0.05	ND	1.1	0.051	ND	1	0.049
7440-41-7	Beryllium	mg/Kg	ND	0.097	0.024	ND	0.11	0.026	ND	0.11	0.026	ND	0.1	0.025
7440-43-9	Cadmium	mg/Kg	ND	0.097	0.01	ND	0.11	0.011	ND	0.11	0.011	ND	0.1	0.011
7440-70-2	Calcium	mg/Kg	ND	49	7.8	ND	53	8.5	ND	54	8.6	ND	52	8.3
7440-47-3	Chromium	mg/Kg	ND	0.19	0.079	ND	0.21	0.086	ND	0.22	0.088	ND	0.21	0.084
7440-48-4	Cobalt	mg/Kg	ND	0.049	0.008	ND	0.053	0.0086	ND	0.054	0.0088	ND	0.052	0.0085
7440-50-8	Copper	mg/Kg	0.25	0.19	0.12	0.32	0.21	0.13	0.44	0.22	0.13	0.36	0.21	0.13
7439-89-6	Iron	mg/Kg	ND	4.9	3.6	5.3	5.3	3.9	ND	5.4	4	ND	5.2	3.8
7439-92-1	Lead	mg/Kg	ND	0.097	0.047	ND	0.11	0.051	ND	0.11	0.052	ND	0.1	0.05
7439-95-4	Magnesium	mg/Kg	220	49	3.2	230	53	3.5	230	54	3.6	230	52	3.4
7439-96-5	Manganese	mg/Kg	ND	0.49	0.17	ND	0.53	0.18	ND	0.54	0.19	ND	0.52	0.18
7439-98-7	Molybdenum	mg/Kg	ND	0.49	0.076	ND	0.53	0.083	ND	0.54	0.084	ND	0.52	0.081
7440-02-0	Nickel	mg/Kg	ND	0.097	0.029	ND	0.11	0.031	0.12	0.11	0.032	0.052	0.1	0.03
7440-09-7	Potassium	mg/Kg	3600	49	5.2	3600	53	5.6	3800	54	5.8	3800	52	5.5
7782-49-2	Selenium	mg/Kg	ND	0.49	0.12	ND	0.53	0.13	ND	0.54	0.13	ND	0.52	0.13
7440-22-4	Silver	mg/Kg	ND	0.097	0.013	ND	0.11	0.014	ND	0.11	0.014	ND	0.1	0.014
7440-23-5	Sodium	mg/Kg	620	49	20	580	53	22	660	54	23	640	52	22
7440-24-6	Strontium	mg/Kg	ND	0.49	0.033	ND	0.53	0.036	ND	0.54	0.037	ND	0.52	0.035
7440-28-0	Thallium	mg/Kg	ND	0.097	0.0038	ND	0.11	0.0041	ND	0.11	0.0042	ND	0.1	0.004
7440-62-2	Vanadium	mg/Kg	ND	0.097	0.055	ND	0.11	0.059	ND	0.11	0.061	ND	0.1	0.058
7440-66-6	Zinc	mg/Kg	4.3	0.49	0.28	4.5	0.53	0.3	4.3	0.54	0.31	4.6	0.52	0.3
7439-97-6	Mercury	mg/Kg	0.16	0.034	0.0076	0.15	3	1.8	0.15	0.031	0.0069	0.14	0.034	0.0075

Note: RL = Reporting Limit; MDL = Method Detection Limit; ND = Not Detected

Table A1: San Juan River Upstream Reach fillet tissue concentrations (mg/Kg, wet weight) (continued)

		Sample ID	**Upstream Composite 5**			**Upstream Composite 6**		
		Lab ID	180-67115-1			180-67115-5		
		Collect Date, Time	6/5/2017 15:30			6/5/2017 14:10		
		Analysis 1	6/29/2017 4:11			6/29/2017 4:41		
		Analysis2 (Hg)	6/22/2017 18:49			6/22/2017 19:02		
		Receipt Date	6/8/2017 9:00			6/8/2017 9:00		
		Preparation 1	6/22/2017 10:55			6/22/2017 10:55		
		Preparation 2 (Hg)	6/22/2017 18:12			6/22/2017 18:12		
CAS	**Analyte**	**Units**	**VALUE**	**RL**	**MDL**	**VALUE**	**RL**	**MDL**
7429-90-5	Aluminum	mg/Kg	ND	2.9	1.8	ND	3.1	1.9
7440-36-0	Antimony	mg/Kg	ND	0.2	0.032	ND	0.21	0.034
7440-38-2	Arsenic	mg/Kg	ND	0.098	0.02	ND	0.1	0.021
7440-39-3	Barium	mg/Kg	ND	0.98	0.046	ND	1	0.049
7440-41-7	Beryllium	mg/Kg	ND	0.098	0.024	ND	0.1	0.025
7440-43-9	Cadmium	mg/Kg	ND	0.098	0.01	ND	0.1	0.011
7440-70-2	Calcium	mg/Kg	ND	49	7.9	ND	52	8.4
7440-47-3	Chromium	mg/Kg	ND	0.2	0.08	ND	0.21	0.085
7440-48-4	Cobalt	mg/Kg	ND	0.049	0.008	ND	0.052	0.0085
7440-50-8	Copper	mg/Kg	0.41	0.2	0.12	0.31	0.21	0.13
7439-89-6	Iron	mg/Kg	ND	4.9	3.6	5.6	5.2	3.8
7439-92-1	Lead	mg/Kg	ND	0.098	0.047	ND	0.1	0.05
7439-95-4	Magnesium	mg/Kg	230	49	3.3	230	52	3.5
7439-96-5	Manganese	mg/Kg	ND	0.49	0.17	0.58	0.52	0.18
7439-98-7	Molybdenum	mg/Kg	ND	0.49	0.077	ND	0.52	0.082
7440-02-0	Nickel	mg/Kg	0.088	0.098	0.029	0.28	0.1	0.031
7440-09-7	Potassium	mg/Kg	3600	49	5.2	3700	52	5.6
7782-49-2	Selenium	mg/Kg	ND	0.49	0.12	ND	0.52	0.13
7440-22-4	Silver	mg/Kg	ND	0.098	0.013	ND	0.1	0.014
7440-23-5	Sodium	mg/Kg	610	49	21	700	52	22
7440-24-6	Strontium	mg/Kg	ND	0.49	0.034	ND	0.52	0.036
7440-28-0	Thallium	mg/Kg	ND	0.098	0.0038	ND	0.1	0.0041
7440-62-2	Vanadium	mg/Kg	ND	0.098	0.055	ND	0.1	0.059
7440-66-6	Zinc	mg/Kg	5.1	0.49	0.28	4.7	0.52	0.3
7439-97-6	Mercury	mg/Kg	0.17	0.034	0.0075	0.14	0.037	0.0082

Note: RL = Reporting Limit; MDL = Method Detection Limit; ND = Not Detected

Table A2: San Juan River Downstream Reach fillet tissue concentrations (mg/kg, wet weight)

		Sample ID	Downstream Composite 1			Downstream Composite 2			Downstream Composite 3			Downstream Composite 4		
		Lab ID	180-67115-4			180-67115-6			180-67115-7			180-67115-10		
		Collect Date, Time	6/5/2017 16:15			6/6/2017 9:30			6/6/2017 11:30			6/6/2017 15:00		
		Analysis 1	6/29/2017 4:37			6/29/2017 5:09			6/29/2017 5:14			6/29/2017 5:45		
		Analysis2 (Hg)	6/22/2017 19:00			6/22/2017 19:04			6/22/2017 19:10			6/22/2017 19:16		
		Receipt Date	6/8/2017 9:00			6/8/2017 9:00			6/8/2017 9:00			6/8/2017 9:00		
		Preparation 1	6/22/2017 10:55			6/22/2017 10:55			6/22/2017 10:55			6/22/2017 10:55		
		Preparation 2 (Hg)	6/22/2017 18:12			6/22/2017 18:12			6/6/2017 11:30			6/22/2017 18:12		
CAS	**Analyte**	**Units**	**VALUE**	**RL**	**MDL**	**VALUE**	**RL**	**MDL**	**VALUE**	**RL**	**MDL**	**VALUE**	**RL**	**MDL**
7429-90-5	Aluminum	mg/Kg	ND	3	1.8	ND	3	1.8	ND	3	1.8	ND	3.2	1.9
7440-36-0	Antimony	mg/Kg	ND	0.2	0.032	ND	0.2	0.033	ND	0.2	0.032	ND	0.21	0.035
7440-38-2	Arsenic	mg/Kg	ND	0.099	0.02	ND	0.1	0.02	ND	0.099	0.02	ND	0.11	0.022
7440-39-3	Barium	mg/Kg	ND	0.99	0.047	ND	1	0.047	ND	0.99	0.047	ND	1.1	0.05
7440-41-7	Beryllium	mg/Kg	ND	0.099	0.024	ND	0.1	0.024	ND	0.099	0.024	ND	0.11	0.026
7440-43-9	Cadmium	mg/Kg	ND	0.099	0.01	ND	0.1	0.011	ND	0.099	0.01	ND	0.11	0.011
7440-70-2	Calcium	mg/Kg	ND	50	7.9	ND	50	8	ND	50	7.9	ND	53	8.5
7440-47-3	Chromium	mg/Kg	ND	0.2	0.081	ND	0.2	0.082	ND	0.2	0.081	ND	0.21	0.087
7440-48-4	Cobalt	mg/Kg	ND	0.05	0.0081	ND	0.05	0.0082	ND	0.05	0.0081	ND	0.053	0.0087
7440-50-8	Copper	mg/Kg	0.39	0.2	0.12	0.31	0.2	0.12	0.37	0.2	0.12	0.38	0.21	0.13
7439-89-6	Iron	mg/Kg	7.4	5	3.6	6.2	5	3.7	4.3	5	3.6	ND	5.3	3.9
7439-92-1	Lead	mg/Kg	ND	0.099	0.048	ND	0.1	0.048	ND	0.099	0.048	ND	0.11	0.051
7439-95-4	Magnesium	mg/Kg	310	50	3.3	220	50	3.3	220	50	3.3	250	53	3.5
7439-96-5	Manganese	mg/Kg	ND	0.5	0.17	ND	0.5	0.17	ND	0.5	0.17	ND	0.53	0.19
7439-98-7	Molybdenum	mg/Kg	ND	0.5	0.078	ND	0.5	0.078	ND	0.5	0.078	ND	0.53	0.083
7440-02-0	Nickel	mg/Kg	ND	0.099	0.029	ND	0.1	0.029	ND	0.099	0.029	ND	0.11	0.031
7440-09-7	Potassium	mg/Kg	5000	50	5.3	3600	50	5.4	3800	50	5.3	3800	53	5.7
7782-49-2	Selenium	mg/Kg	ND	0.5	0.12	ND	0.5	0.12	ND	0.5	0.12	ND	0.53	0.13
7440-22-4	Silver	mg/Kg	ND	0.099	0.013	ND	0.1	0.013	ND	0.099	0.013	ND	0.11	0.014
7440-23-5	Sodium	mg/Kg	890	50	21	560	50	21	590	50	21	590	53	22
7440-24-6	Strontium	mg/Kg	ND	0.5	0.034	ND	0.5	0.034	ND	0.5	0.034	ND	0.53	0.037
7440-28-0	Thallium	mg/Kg	ND	0.099	0.0039	ND	0.1	0.0039	ND	0.099	0.0039	ND	0.11	0.0041
7440-62-2	Vanadium	mg/Kg	ND	0.099	0.056	ND	0.1	0.057	ND	0.099	0.056	ND	0.11	0.06
7440-66-6	Zinc	mg/Kg	5.7	0.5	0.29	4.5	0.5	0.29	4.2	0.5	0.29	4	0.53	0.31
7439-97-6	Mercury	mg/Kg	0.19	0.033	0.0074	0.13	0.035	0.0078	0.095	0.034	0.0075	0.16	0.036	0.0081

Note: RL = Reporting Limit; MDL = Method Detection Limit; ND = Not Detected

APPENDIX B

Box-and-whisker Plots of Detected Metals

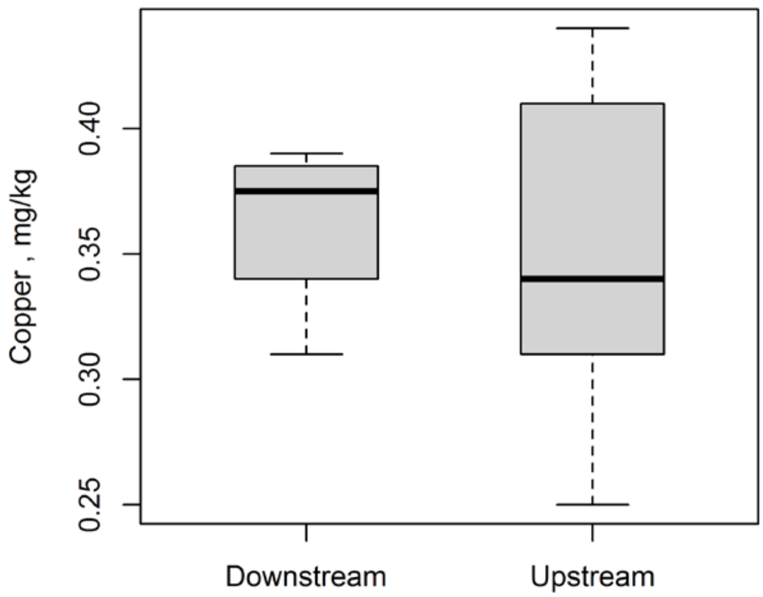

Figure B1: San Juan River fillet fish tissue copper concentrations (minimum, maximum, median, and interquartile range) in mg/kg, wet weight.

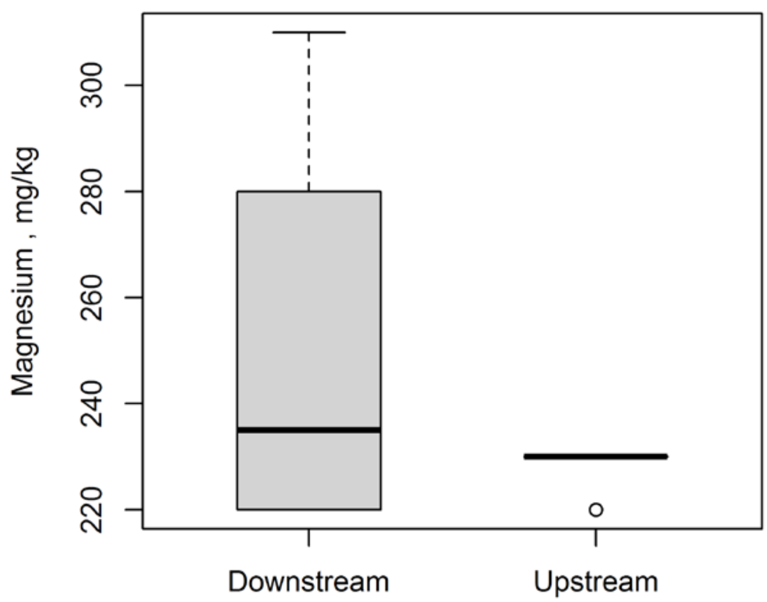

Figure B2: San Juan River fillet fish tissue magnesium concentrations (minimum, maximum, median, and interquartile range) in mg/kg, wet weight.

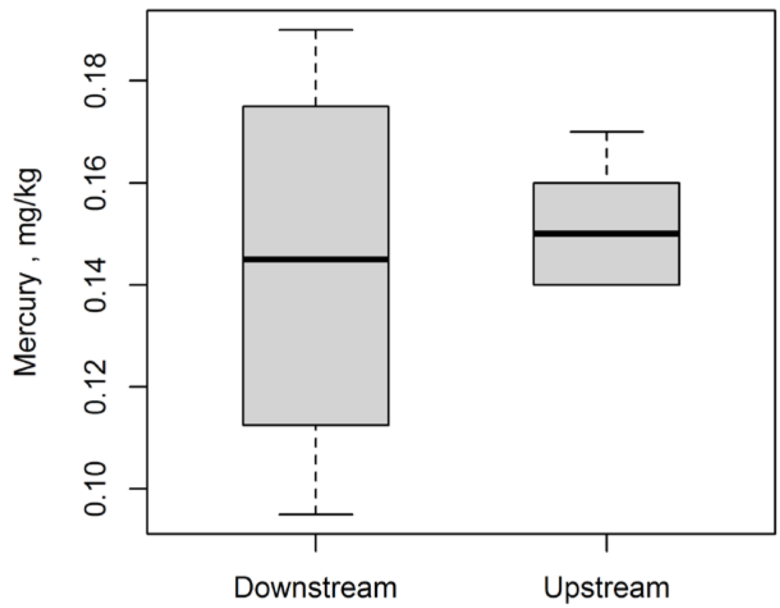

Figure B3: San Juan River fillet fish tissue mercury concentrations (minimum, maximum, median, and interquartile range) in mg/kg, wet weight.

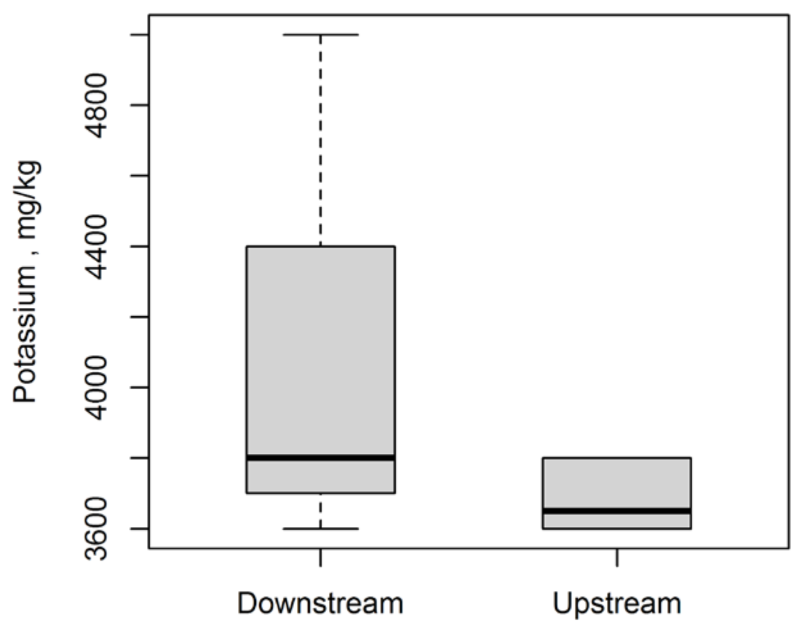

Figure B4: San Juan River fillet fish tissue potassium concentrations (minimum, maximum, median, and interquartile range) in mg/kg, wet weight.

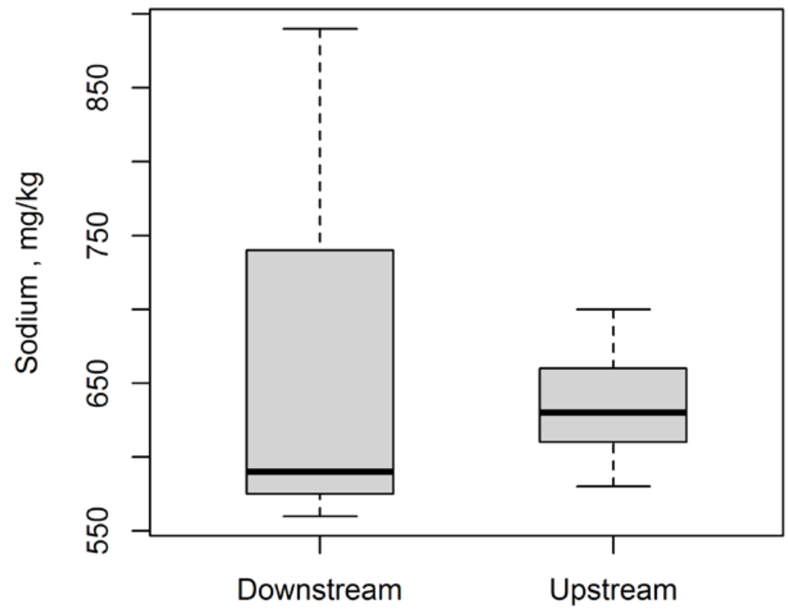

Figure B5: San Juan River fillet fish tissue sodium concentrations (minimum, maximum, median, and interquartile range) in mg/kg, wet weight.

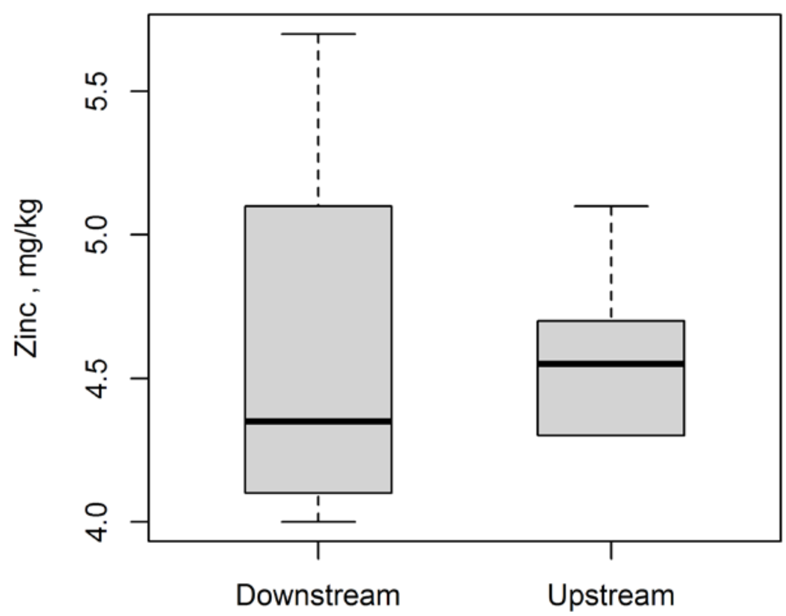

Figure B6: San Juan River fillet fish tissue zinc concentrations (minimum, maximum, median, and interquartile range) in mg/kg, wet weight.