Nu-West Industries, Inc.

PROPOSAL FOR SITE-SPECIFIC SELENIUM CRITERIA

Upper Blackfoot River and Georgetown Creek Watersheds

July 2017

CONTENTS

Acronyms and Abbreviations 1
1 Introduction 1
2 Definition of Sites 2
3 Resident Fish Species 2
3.1 Resident Fish in the Upper Blackfoot River Watershed 3
3.2 Resident Fish in the Georgetown Creek Watershed 4
4 Nu-West Proposed Site-Specific Criteria for Selenium 6
4.1 Summary of Approach to Developing a Fish-Tissue SSC 6
4.2 Genus Oncorhynchus 8
4.2.1 Tissue Elements for the Genus Oncorhynchus 10
4.3 Genus Salmo 11
5 Protectiveness of Site-Specific selenium Criterion 11
5.1 Family Salmonidae 12
5.1.1 Genus Salvelinus 12
5.2 Family Cyprinidae 12
5.3 Family Catostomidae 13
5.3.1 Genus Catostomus 13
5.4 Family Cottidae 14
6 Site-Specific Water-Column Selenium Concentrations 15
6.1 Georgetown Creek 18
6.2 Sites in the UBR Watershed 19
6.2.1 Sheep Creek 19
6.2.2 Angus Creek 20
6.2.2.1 No Name Creek 21
6.3 Implementation 23
7 Recommendation 24
8 References 25

TABLES

Table 1. Resident Fish Species that Occur in the Upper Blackfoot River Watershed 4

Table 2. Resident Fish Species that Occur in the Georgetown Creek Watershed 5

Table 3. IDEQ Proposed Aquatic Life Selenium Criteria (Default) and Nu-West Proposed Site-Specific Criteria.....7

Table 4. Maternal Transfer Reproductive Toxicity Studies for Oncorhynchus (from EPA 2016).....8

Table 6. Maternal Transfer Reproductive Toxicity Studies for Salvelinus (from USEPA 2016).....12

Table 7. Maternal Transfer Reproductive Toxicity Studies for Pimephales (from USEPA 2016) 13

Table 8. Maternal Transfer Reproductive Toxicity Studies for Catostomidae (from USEPA 2016).....14

Table 9. Other chronic toxicity data for the family Catostomidae (from USEPA 2016).....14

Table 10. Summary of surface water, fish tissue, site-specific bioaccumulation factors, and site-specific water-column values for Georgetown Creek……..……19

Table 11. Summary of surface water, fish tissue, site-specific bioaccumulation factors, and the site-specific water-column value for Sheep Creek…….....20

Table 12. Summary of surface water, fish tissue, site-specific bioaccumulation factors, and the site-specific water-column value for Angus Creek…….....21

Table 13. Angus Creek fish-tissue data, No Name Creek surface-water data, and the site-specific water-column value for No Name Creek……22

FIGURES

Figure 1: Upper Blackfoot River Watershed and Georgetown Creek watershed

Figure 2: Aquatic biological monitoring locations in Georgetown Creek watershed

Figure 2: Aquatic biological monitoring locations in Angus Creek and Sheep Creek sub-watersheds

APPENDICES

Appendix 1: Whole-body fish tissue and surface water selenium data collected at locations in the Georgetown Creek watershed and Upper Blackfoot River watershed

ACRONYMS AND ABBREVIATIONS

dw	dry weight
EO	egg or ovaries
GMCV	Genus Mean Chronic Value
IDAPA	Idaho Administrative Code
IDEQ	Idaho Department of Environmental Quality
IDFG	Idaho Department of Fish and Game
mg/kg dw	milligrams per kilogram dry weight
mg Se/kg EO dw	milligrams selenium per kilogram eggs or ovaries, dry weight
Nu-West	Nu-West Industries, Inc.
SMCV	Species Mean Chronic Value
SSC	site-specific criteria
UBR	Upper Blackfoot River
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
µg/L	micrograms per liter

1 INTRODUCTION

This document presents Nu-West Industries, Inc. (Nu-West) revised proposal for site-specific selenium (Se) criteria for surface waters located in two watersheds in Southeast Idaho: Upper Blackfoot River (UBR) watershed and Georgetown Creek watershed (hereafter referred to as the "Sites"). This proposal has been revised in response to input received from various stakeholders participating in the negotiated rulemaking process used by Idaho Department of Environmental Quality (IDEQ) to update its Se criterion for aquatic life.

Selenium is a naturally occurring, essential element that bioaccumulates in aquatic ecosystems. Selenium occurs in several bioavailable forms: selenate (Se^{6+}), selenite, (Se^{4+}), and organic Se compounds (e.g., seleno-L-methionine). Selenate is the primary Se species mobilized into aquatic systems from weathering and oxidation of seleniferous soils. Once Se^{6+} enters an aquatic system, it is accumulated at the base of the food chain by microbes, algae, and macrophytes, or reduced to selenite, which may then be bioconcentrated. The proportion of selenate reduced to selenite depends on site-specific conditions, such as the redox and pH of the water body. Generally, oxic flowing streams (lotic waters) tend to be dominated by Se^{6+}, while Se^{4+} dominates lentic waters (ponds and lakes), which can also have high proportions of organic Se (Ponton and Hare, 2013). Once incorporated into the base of the food chain, inorganic Se species may be further reduced to organic Se compounds that are efficiently transferred through the food chain. Diet is the predominant Se exposure pathway for aquatic consumers. At sufficiently high dietborne concentrations to fish, Se can be maternally transferred to the eggs causing mortality, deformities, and edema in larval fish (Janz et al., 2010).

In accordance with Idaho Water Quality Standards (Idaho Administrative Code, IDAPA 58.01.02 § 275) site-specific criteria (SSC) may be developed when the resident species of a water body differ in their sensitivity relative to those used to develop a water quality criterion. This is the rationale for developing the SSC for Se: the assemblage of resident fish species that occur at each Site vary in composition and differ from that used in the development of the United States Environmental Protection Agency (USEPA) 2016 Se criterion (USEPA 2016). The Recalculation Procedure (USEPA 1996; 2013) is one regulatory approach for developing a SSC that reflects a species assemblage for a given site. The SSC for Se proposed herein is a modified version of the Recalculation Procedure (USEPA 1994; 2013) in that it is based on protection of the most sensitive fish species (i.e., salmonids). This approach is intended to accurately reflect the assemblage of fish species that reside at each Site while ensuring protection of all other resident fish species.

USEPA water quality regulations at 40 CFR §131.11 (*Criteria*) allow states to develop water quality criteria based on USEPA 304(a) guidance, including 304(a) guidance modified to reflect site-specific conditions, or other scientifically defensible methods. Accordingly, under IDAPA, any person may develop SSC in accordance with the rules specified at IDAPA 58.01.02 § 275. In addition to the Recalculation Procedure, other scientifically-defensible procedures may also be applied to develop SSC per IDAPA 58.01.02 § 275, including deviations from USEPA procedures (e.g., the Recalculation Procedure) that are adequately documented and based on scientifically defensible methods (IDAPA 58.01.02 § h. ii. (5)).

Because USEPA (2016) concludes that fish are the most sensitive group of aquatic organisms to Se and because sufficient information is available to show that a tissue-based SSC based on the most sensitive

resident fish species will protect all other aquatic life, the SSC proposed for Se is specific to the most sensitive fish species that occurs at each Site. Moreover, a SSC based on the most sensitive resident species also follows Recalculation Guidance for developing SSC at sites with a limited assemblage of aquatic organisms (USEPA 1994). For these reasons, the SSC for Se included in this proposal are scientifically defensible and consistent with available regulatory guidance (see Section 4).

The core steps for developing the proposed SSC include:

a. Geographic definition of each Site (Section 2)

b. Determination of the resident fish species that occur at each Site (Section 3)

c. Recalculation of the Se criterion based on the resident fish species (Section 4)

d. An evaluation of the protectiveness of the SSC to resident fish (Section 5).

The list of resident fish species for each Site is developed from a comprehensive record of fisheries data. Salmonids (i.e., trout) in the genus *Oncorhynchus* or the genus *Salmo* are the most sensitive taxonomic group of aquatic organisms that occur at each Site. Consequently, the proposed SSC for Se are based on chronic toxicity values from USEPA (2016) for the most sensitive species in these genera. The proposed SSC for Se are expected to be protective of other resident fish species based on an evaluation of toxicity data and population information presented in this proposal.

2 DEFINITION OF SITES

According to USEPA (1994, 2013), a “Site” may be a state, region, watershed, waterbody, or segment of a waterbody. The two Sites included for the SSC in this proposal are defined at watershed scales based on existing water body units in IDAPA 58.01.02 § 150.09.

1. UBR – confluence of Lanes and Diamond Creeks to Blackfoot Reservoir (unit US-10), and all tributaries thereof; and

2. Georgetown Creek – source to mouth (unit B-22), and all tributaries thereof.

The mainstems of the Blackfoot River and Georgetown Creek are designated as *Cold Water* and *Salmonid Spawning* for the protection of aquatic life. Cold water refers to water quality appropriate for the protection and maintenance of a viable aquatic life community for cold water species. Salmonid spawning refers to waters that provide or could provide a habitat for active self-propagating populations of salmonid fishes. Tributaries of each water way are non-designated, presumed to support cold water aquatic life (IDAPA 58.01.02).

3 RESIDENT FISH SPECIES

The terms “occur at the Site” and “resident” are equivalent in the general context of recalculated SSC, and include life stages and species that:

a. Are usually present at the Site

b. Are present at the Site only seasonally due to migration

c. Are present at the Site intermittently because they periodically return to or extend their ranges into the Site

d. Were present at the Site in the past, are not currently present at the Site due to degraded conditions, but are expected to be present at the site when conditions improve

e. Are present in nearby bodies of water, are not currently present at the Site due to degraded conditions, but are expected to be present at the Site when conditions improve

(*See* IDAPA 58.01.02 § 010.85 - "Resident Species" and IDAPA 58.01.02 § 257.01 - "Recalculation Procedure")

The resident fish species occurring at each Site were determined from comprehensive survey and stocking records. The duration of survey data in conjunction with detailed stocking records provide a high degree of certainty in the list of resident species for each Site, described in the following sections.

3.1 Resident Fish in the Upper Blackfoot River Watershed

The UBR watershed supports Yellowstone cutthroat trout (*Oncorhynchus clarkii bouvieri*), rainbow trout (*O. mykiss*), brook trout (*Salvelinus fontinalis*) and various non-game species (minnows, sculpins, and suckers). A compendium of UBR fisheries data is provided in Attachment 1. In total, more than 40,000 survey results (e.g., fish counts) are available for the Blackfoot River and its tributaries between 1959 and 2016. The most comprehensive surveys are summarized below.

a. **Idaho Department of Fish and Game (IDFG) fish surveys.** The IDFG began intensive fishery evaluations and creel surveys in the UBR watershed in 1959 and have continued population and spawning surveys on the UBR and its tributaries through 2007.

b. **IDFG fish stocking records.** IDFG stocks the Blackfoot Reservoir and UBR with hatchery trout on a regular basis. Stocking records are available from 1967 to 2016. Since 1993 and 1995, only rainbow trout have been stocked in the UBR (upstream of the Reservoir) and Blackfoot Reservoir, respectively. Since 2000, only sterile rainbow trout have been stocked in the Blackfoot Reservoir and Upper Blackfoot River and beginning in 2001, all rainbow and hybrid trout sampled from the upper Blackfoot system by IDFG have been removed and anglers have been encouraged to harvest this species. These efforts are part of a management plan to avoid or minimize introgression of rainbow trout genes into the gene pool of the of native *O. clarkii bouvieri* in the Upper Blackfoot Reservoir and River (IDFG 2007).

c. **Idaho Department of Environmental Quality (IDEQ) fish surveys.** IDEQ has conducted fish surveys on nearly all tributary streams in the UBR watershed as part of the Beneficial Use Reconnaissance Program between 1993 and 2016.

d. **GEI Consultants, Inc. (GEI) and Arcadis fish surveys.** On behalf of Nu-West, GEI conducted intensive aquatic surveys on ten tributary streams in the UBR watershed between 2013 and 2015. In 2016, GEI and Arcadis continued the surveys on these tributaries. Quantitative electrofishing was conducted during late spring and early fall of each year using multi-pass techniques. All fish collected were identified to species, measured for total length, and weighed.

e. **United States Forest Service (USFS) fish surveys.** The USFS conducted fish surveys on tributaries located through the UBR between 2000 and 2002.

The list of resident species in the UBR watershed is presented in Table 1. This list is comprehensive owing to the extensive record of fisheries data available in the UBR watershed. Fish species listed in Table 1 were consistently confirmed from extensive surveys conducted by various entities. Sturgeon and centrarchids, fish that also are sensitive to Se, are not resident to the UBR watershed.

Table 1. Resident Fish Species that Occur in the Upper Blackfoot River Watershed

Family	Genus	Species	Common Name
Salmonidae	*Oncorhynchus*	*O. mykiss*	Rainbow trout
		O. clarkii bouvieri	Yellowstone cutthroat trout
	Salvelinus	*S. fontinalis*	Brook trout
Cyprinidae	*Rhinichthys*	*R. cataractae*	Longnose dace
		R. osculus	Speckled dace
		R. falcatus	Leopard dace
	Richardsonius	*R. balteatus*	Redside shiner
	Gila	*G. atraria*	Utah chub
	Couesius	*C. plumbeus*	Lake chub
	Lepidomeda	*L. copei*	N. leatherside chub
Catostomidae	*Catostomus*	*C. ardens*	Utah sucker
		C. platyrhynchus	Mountain sucker
Cottidae	*Cottus*	*C. bairdii*	Mottled sculpin
		C. beldingii	Paiute sculpin

3.2 Resident Fish in the Georgetown Creek Watershed

Brook trout and rainbow trout currently dominate the fish community in Georgetown Creek. Bonneville cutthroat trout (*O. clarkii utah*), a subspecies of cutthroat trout endemic to the Bear River drainage basin, were sampled in Georgetown Creek through the 1990s, but have not been observed in more recent surveys. However, re-establishment of Bonneville cutthroat trout in the Georgetown Creek watershed is a current management objective for IDFG (Teuscher and Capurso 2007). For these reasons, cutthroat trout are considered resident fish to Georgetown Creek in this proposal. In addition, low numbers of brown trout (*Salmo trutta)* have been collected in the lower reaches of Georgetown Creek near its confluence with Bear River.

A compendium of Georgetown Creek fisheries data is provided in Attachment 2. The most comprehensive surveys are summarized below.

a. **IDFG fish surveys.** The IDFG conducted fish surveys on Georgetown Creek and Left Hand Fork (a tributary to Georgetown Creek) in 1994, 1997, 2003, and 2007.

b. **IDFG fish stocking records.** IDFG stocks Georgetown Creek with hatchery trout during most years. According to stocking records presented by IDFG (Teuscher and Capurso 2007), rainbow trout, brook trout, and cutthroat trout were stocked in Georgetown Creek between 1913 and 2002. According to stocking records currently published by IDFG, only rainbow trout have been stocked in Georgetown Creek since 1995 (https://fishandgame.idaho.gov/ifwis/fishingplanner/). Similar to the stocking program in the Upper Blackfoot watershed, IDFG has stocked only sterile rainbow trout in Georgetown Creek to minimize introgression with native trout stocks (IDFG 2007b).

c. **IDEQ fish surveys.** IDEQ conducted fish surveys in Georgetown Creek watershed between 1997 and 2013 at four locations on Georgetown Creek and one location on Left Hand Fork.

d. **USFS fish surveys.** The USFS conducted fish surveys on Georgetown Creek and Left Hand Fork in 1994, 2000, 2001, and 2007.

e. **GEI and Arcadis fish surveys.** On behalf of Nu-West, GEI conducted fish surveys at four locations on Georgetown Creek and a location on Left Hand Fork in spring and late summer in 2015. GEI and Arcadis continued seasonal fish surveys at these locations in 2016. Quantitative electrofishing was conducted during late spring and early fall of each year using multi-pass techniques. All fish collected were identified to species, measured for total length, and weighed.

The resident list of fish species in the Georgetown Creek watershed is presented in Table 2. This list is comprehensive of species that occur in Georgetown Creek and its tributaries given the extensive record of fisheries and stocking data. Relative to the UBR watershed, the Georgetown Creek watershed comprises a smaller drainage area and thus has fewer fisheries records. The list of resident fish (i.e., salmonids) was consistently confirmed through various comprehensive surveys. From these surveys, sturgeon and centrarchids are not resident to the Georgetown Creek watershed.

Table 2. Resident Fish Species that Occur in the Georgetown Creek Watershed

Family	Genus	Species	Common Name
Salmonidae	*Oncorhynchus*	*O. mykiss*	Rainbow trout
		O. clarkii utah	Bonneville cutthroat trout
	Salvelinus	*S. fontinalis*	Brook trout
	Salmo	*S. trutta*	Brown trout

4 NU-WEST PROPOSED SITE-SPECIFIC CRITERIA FOR SELENIUM

As discussed in Section 1, and to address input received from various stakeholders including Region 10 of the EPA, Nu-West's proposed fish-tissue SSC is designed to protect the most sensitive resident fish species (i.e., salmonids) as well as other resident fish and aquatic organisms. This approach was developed after considering: the limited fish assemblages that occur at each Site (Section 2); the fish-centric nature of the USEPA (2016) Se criterion; and available regulatory guidance concerning scientifically-defensible procedures for developing SSC. The following section provides additional rationale and information on this overall approach.

4.1 Summary of Approach to Developing a Fish-Tissue SSC

USEPA nationally recommended ambient water quality criteria (AWQC) are developed to provide acceptable levels of protection to the vast majority of aquatic life. Specifically, AWQC are derived for chemicals as the 5th percentile of a genus sensitivity distribution (GSD) in order to protect 95 percent of genera (USEPA 1985). This method also was used to develop the USEPA (2016) Se AWQC. However, fish are the only taxonomic group explicitly considered in the USEPA (2016) GSD because they are the most sensitive group of aquatic organisms to Se. Specifically, the USEPA (2016) Se criterion equals the 5th percentile of tissue-based effect levels for eight genera of fish. Most of these fish genera, however, do not occur at the Sites evaluated herein and do not represent appropriate surrogates for fish species that do occur at the Sites. As described in Section 3, each Site supports a limited number of resident fish species. Critical to the approach applied herein to develop tissue-based SSC, is that toxicity data and other lines of evidence (i.e., field studies) available for non-salmonid resident fish species show they are less sensitive to Se compared to the most-sensitive resident fish (i.e., salmonids). As a result, the proposed SSC for Se is expected to protect all resident fish species. The following describes this rationale further.

The standard approach to the Recalculation Procedure is to edit the taxonomic composition of the site-specific dataset and then recalculate the criterion as the 5th percentile of the site-specific GSD (USEPA 2013). This method ensures the recalculated criterion is protective of 95% of the genera. When GSDs are developed from a limited number of genera (<20), the 5th percentile criterion will be less than the most sensitive genera tested in order to protect untested resident species. However, as discussed above, a limited species assemblage occurs at each Site included in this proposal, and available data demonstrate that other resident species are less sensitive to Se than the most sensitive species from which the proposed SSC are based. For this reason, the SSC proposed for each Site are expected to be protective of 100% of the species that occur at each Site, and therefore, a SSC derived as the 5th percentile from a GSD is not required to protect other resident species.

The UBR Site supports only four families of fish: salmonids, cyprinids, catostomids, and cottids (Section 3.1), while the Georgetown Creek Site supports only salmonids. The proposed SSC for Se for each Site is based on the most sensitive salmonid species (Section 4.2) because this value will be protective of all resident fish species. This conclusion is based on a comparison of available toxicity data presented by USEPA (2016) and others for fish species that occur in the UBR watershed. More specifically, toxicity

data for the most sensitive salmonid, relative to toxicity data for other resident fish, demonstrates the proposed SSC for Se for the UBR watershed is protective of all resident fish.

In this context, the proposed SSC should provide a similar or greater level of protection as criteria calculated from sensitivity distributions (i.e., the SSC is protective of 100 vs. 95% of genera using the 5th percentile of a GSD). As discussed in Section 1, other scientifically-defensible approaches to SSC development, or deviations from USEPA procedures, are allowed under IDAPA 58.01.02 § 275 when adequately documented and based on sound scientific rationale. In addition, IDAPA 58.01.02 § 275 also requires that other approaches used to develop SSC reflect the nature of the pollutant, beneficial uses of the water body, and the most sensitive resident species of the water body. The approach applied herein satisfies all these requirements. It is scientifically defensible because it provides sufficient protection to all resident aquatic life, is developed from robust toxicity information (see below sections), reflects the bioaccumulative and toxicological nature of Se (i.e., the proposed SSC are fish-tissue based), and is specific to the most sensitive resident species that occurs in water bodies at each Site. Moreover, the most-sensitive species approach used herein to develop the proposed SSC is further justified by USEPA (1994) guidance on the Recalculation Procedure for sites with a limited species assemblage. Specifically, for sites that support only a narrow mix of species relative to the criteria dataset, if data are available for at least one species in each family that occurs at the Site, the lowest species-specific toxicity value is used for the SSC for the site. This approach was applied to develop the proposed SSC to reflect the limited species assemblage at each Site.

Table 3 presents aquatic life water quality criteria for Se proposed by IDEQ and the SSC for Se proposed for the two sites herein by Nu-West.

Table 3. IDEQ Proposed Aquatic Life Selenium Criteria (Default) and Nu-West Proposed Site-Specific Criteria

Fish Tissue (mg/kg dw)						Water Column (µg/L)	
Egg-Ovary[1,2]		Whole Body[3,2]		Muscle[3,2]		Water Lotic[4]	
Default	**SSC**	Default	**SSC**	Default	**SSC**	Default	SSC[7,8]
15.1	**24.5[5]/21.0[6]**	8.5	**12.5**	11.3	**12.8**	3.1 (30 day)	--

Notes:
1. Egg/ovary supersedes any whole-body, muscle, or water column value when fish egg/ovary concentrations are measured.
2. Frequency: Average not to be exceeded.
3. Fish whole-body or muscle tissue supersedes water column value when both fish tissue and water concentrations are measured.
4. Exceedance of a site-specific water-column value requires fish-tissue monitoring.
5. Egg/ovary value applies to Upper Blackfoot River.
6. Egg/ovary value applies to Georgetown Creek.
7. Site-specific water column values are based on dissolved total Se in water and are derived from fish tissue values via mechanistic or bioaccumulation modeling methods in Appendix K from USEPA (2016). In streams or reaches of streams where fish are naturally absent due to low flow conditions, surface water from the fishless stream or reach and fish tissue measured downstream at the first occurrence of a continuous fish population are used for bioaccumulation modeling.
8. Fish tissue supersedes any site-specific water column value when fish are sampled downstream of the fishless stream or reach of fishless stream, at the first occurrence of a continuous fish population.

Bold Values = Nu-West proposed SSC for Se
mg/kg dw – milligrams per kilogram dry weight
SSC – site-specific criteria
µg/L – micrograms per liter

The Nu-West proposed tissue SSC in Table 3 are based on the most sensitive resident fish species at each Site. In Georgetown Creek, the egg/ovary element is the USEPA (2016) SMCV for *S. trutta*, whereas in the Upper Blackfoot River, the egg/ovary element is the USEPA (2016) SMCV for *O. mykiss.* The whole body and muscle elements for each Site are specific to *O. mykiss* because they represent the most sensitive Site-specific species at each Site for these tissue elements (i.e., *Oncorhynchus* is more sensitive than *Salmo* for these tissue elements in USEPA [2016]). The rationale for this proposed SSC is described below.

Members of the *Salmonidae* family are considered among the most sensitive to Se, along with centrarchids and sturgeon (USEPA 2016). As discussed in Section 3, however, centrarchids and sturgeon do not occur at either Site and thus are not considered resident fish species. Salmonids (cutthroat trout, rainbow trout, and brook trout) are the dominant species of resident game fish at each Site. Brown trout are considered resident fish to Georgetown creek, although they have been sampled in limited abundance (i.e., three individual brown trout were collected in one event in lower Georgetown Creek). In the general context of water quality criteria, trout at each Site are considered “critical species” given their commercial and recreational importance. Historical stocking records and current management priorities of salmonids at each Site reflect their local importance.

USEPA (2016) presents toxicity data for three salmonid genera: *Oncorhynchus*, *Salvelinus*, and *Salmo*. Based on these data, members of the *Oncorhynchus* and *Salmo* genera are clearly more sensitive to Se than fish in the genus *Salvelinus.* Consequently, Nu-West proposes SSC based on the extensive toxicity data available for the most sensitive resident species of salmonids at each Site, described below.

4.2 Genus Oncorhynchus

This section summarizes the available *Oncorhynchus* toxicity data used by USEPA (2016) to develop the *Oncorhynchus* SMCVs and GMCV. In Section 5, toxicity data are presented for other resident fish to establish the protectiveness of the proposed SSC to residents at each Site.

Table 4 presents the toxicity data from USEPA (2016) for two species within the genus *Oncorhynchus*: rainbow trout and Westslope cutthroat trout (*O. clarkii lewisi*).

Table 4. Maternal Transfer Reproductive Toxicity Studies for *Oncorhynchus* (from EPA 2016)

Genus	Species	SMCV (mg Se/kg EO dw)	GMCV (mg Se/kg EO dw)
Oncorhynchus	Rainbow Trout[1,2,3]	24.5[a]	25.3
	Cutthroat Trout[4,5]	26.2	

Notes:
[1]Holm (2002)
[2]Holm et al. (2003)
[3]Holm et al. (2005)
[4]Rudolph et al. (2008)
[5]Nautilus Environmental (2011)
[a]Nu-West proposed site-specific Se criterion for Upper Blackfoot River

A rainbow trout EC_{10} of 24.5 milligrams Se per kilogram egg/ovary, dry weight (mg Se/kg EO dw) based on edema is available from Holm (2002) and Holm et al. (2005). Over a three-year study period, eggs

were collected from spawning fish at several reference and Se-impacted streams. The eggs were fertilized with milt from wild-caught males and monitored in the laboratory until swim-up stage for percent fertilization, embryonic malformations (craniofacial, fin, and spinal malformations), edema, and mortality. In this study, edema was the most sensitive endpoint (USEPA 2016). The Species Mean Chronic Value (SMCV) for rainbow trout is 24.5 mg Se/kg EO dw and is based on the edema EC_{10} value. This is the proposed SSC for the UBR watershed because it represents the most sensitive species.

Cutthroat trout EC_{10}s are available from two studies. A cutthroat trout EC_{10} of 24.7 mg Se/kg EO dw based on alevin survival (post hatch to swim-up stage) is available from Rudolph et al. (2008). In this study, eggs from reference and Se-contaminated ponds were fertilized in the field with milt from males collected at each site and transported to the laboratory for rearing. Eggs and alevins were monitored for fertilization, hatching and mortality. After yolk absorption, all viable fry were observed for skeletal, craniofacial, and fin malformations. The most sensitive endpoint was alevin survival (e.g., the EC_{10} of 24.7 mg Se/kg EO dw).

Nautilus Environmental (2011) conducted an extensive follow-up study to Rudolph et al. (2008) and determined a cutthroat trout EC_{10} of 27.7 mg Se/kg EO dw based on larval survival at swim-up stage. Adult fish in spawning condition were collected from Se-impacted streams and ponds and from a reference lake. Fertilized eggs were reared in the laboratory until they reached swim-up stage. Skeletal, craniofacial, and fin malformations were assessed at swim-up and at 28-day post swim-up. The most sensitive endpoint was larval survival at the swim-up stage (e.g., the EC_{10} of 27.7 mg Se/kg EO dw).

USEPA (2016) used these rainbow trout and cutthroat trout EC_{10}s to calculate the *Oncorhynchus* GMCV. When multiple toxicity values are available for a single species, the SMCV equals the geometric mean of the toxicity values. Similarly, when multiple SMCVs are available for a single genus, the GMCV equals the geometric mean of SMCVs (USEPA 1985, 2016). Accordingly, the SMCV for cutthroat trout is 26.2 mg Se/kg EO dw and equals the geometric mean of 24.7 from Rudolph et al. (2008) and 27.7 mg Se/kg EO dw from Nautilus Environmental (2011). The GMCV for the genus *Oncorhynchus* is 25.3 mg Se/kg EO dw and equals the geometric mean of the rainbow trout SMCV (e.g., 24.5 mg Se/kg EO dw) and the cutthroat trout SMCV (e.g., 26.2 mg Se/kg EO dw).

The proposed SSC for Se in the UBR watershed equals the SMCV for *O. mykiss* (24.5 mg Se/kg EO dw). While the USEPA (1985) uses the GMCV as the toxicological metric in criteria calculations to avoid over-representing highly tested taxonomic groups in setting AWQC (and because species within the same genus generally have comparable sensitivity), the most sensitive species value is used herein to ensure protection to all resident fish. As discussed in USEPA (2016), there is high certainty in the *Oncorhynchus* chronic value because the three studies with *Oncorhynchus* span a narrow range of 24.5 to 27.7 mg Se/kg EO dw. In addition, this narrow range incorporates a range of sensitive reproductive endpoints for each species, and thus provides high confidence in the protectiveness of the SSC to resident fish species at both Sites.

In addition to the Se toxicity values used to calculated the *Oncorhynchus* GMCV, USEPA (2016) presents additional toxicity data for *Oncorhynchus* that are briefly summarized below.

1. Kennedy et al. (2000) conducted maternal transfer reproductive toxicity studies on wild-caught cutthroat trout at a reference and an exposed site. The chronic value for mortality and deformity in

eggs, larvae, and fry was >21.2 mg Se/kg egg dw (reported as a "greater than" value because no significant effects were observed up to the highest exposure).

2. Hardy (2005) evaluated growth, survival, deformity, and hatchability effects in Yellowstone cutthroat trout (*O. clarkii utah*) exposed to dietary Se for 124 weeks. No dose-dependent effects were observed for embryo-larval hatching or survival resulting in an unbounded NOEC of > 16.04 mg Se/kg EO dw.

Although significant dose-response relationships were not observed, the additional data support the protectiveness of the SSC proposed for the UBR watershed because Se concentrations in each study approached the *O. mykiss* SMCV and no significant effects were observed. This suggest the *O. mykiss* SMCV appropriately captures the low-end effect range for members of the genus *Oncorhynchus*.

4.2.1 Tissue Elements for the Genus *Oncorhynchus*

Toxicity endpoints in USEPA's Se criterion document are expressed as EC_{10} values on a dry weight (dw) tissue basis and comprise EO, whole-body, or muscle tissues. Because organisms in aquatic environments exposed to Se accumulate it primarily through their diets, and not directly through water, the most relevant Se toxicity studies involve extended duration dietary exposure and measurement of total Se fish tissue. Selenium in the EO of exposed adult females in pre-spawning condition and effects occurring in offspring through maternal transfer of Se produce the strongest dose-response relationships. Therefore, Se EC_{10} concentrations are commonly reported on an EO basis, as described above. The EO tissue element of the proposed SSC is specific to *O. mykiss* for the Upper Blackfoot River and to *S. trutta* for Georgetown Creek (Table 3; Section 4.2). However, the whole-body and muscle SSC values in Table 3 are specific to *O. mykiss* for each Site because these tissue values are the most sensitive of all residents at each Site.

For each proposed site-specific tissue element presented in Table 3, values were determined based on the most sensitive resident fish using tissue conversion factors based on a taxonomic hierarchy. The proposed whole-body tissue element at each Site is 12.5 mg Se/kg WB dw and was derived by applying the *Oncorhynchus* EO-to-WB tissue conversion factor (1.96) to the *O. mykiss* SMCV of 24.5 mg/kg EO dw.

USEPA (2016) presents whole-body SMCVs of 10 and 13.3 mg/kg dw for *O. mykiss* and *O. clarkii*, respectively. The SMCV for *O. mykiss* is based on application of a muscle-to-WB conversion factor of 1.27 derived from all fish species in the USEPA (2016) dataset, while the SMCV for *O. clarkii* is based on empirical data. Thus, an empirical genus-specific EO-to-WB conversion factor is available for the genus *Oncorhynchus.*

Application of the all species muscle-to-WB CF for *O. mykiss* is inconsistent with the hierarchal processes presented in USEPA (2016). Specifically, USEPA indicates that when specific-specific CFs are not available, sequentially higher taxonomic classifications should be used to established CFs. For example, EO-to-WB CFs are not available for the redear sunfish (*Lepomis microlophus*) but are available for *L. cyanellus* and *L. macrochirus*, so USEPA applied the median CF from these two species to *L. microlophus*. Similarly, there is an EO-to-WB CF available for *O. clarkii* of 1.96. Therefore, this genus-specific CF is applied to the *O. mykiss* EO value resulting in a whole body Se threshold of 12.5 mg/kg dw. It is not clear why USEPA used the less taxonomically reliable approach of applying an all species muscle-to-WB CF to estimate the WB threshold for *O. mykiss*. Regardless, direct application of the

median *Oncorhynchus* EO-to-WB CF is more scientifically rigorous and more consistent with the methodology outlined in USEPA (2016).

The proposed muscle element (12.8 mg Se/kg dw) is the SMCV for *O. mykiss* because this is the most sensitive species-specific muscle value for each Site. USEPA (2016) calculated this value using the EO-to-muscle CF developed with empirical tissue data for *O. mykiss*.

4.3 Genus *Salmo*

This section summarizes the available toxicity data used by USEPA (2016) to develop the GMCV for *Salmo*. As discussed above, brown trout are not resident to the Upper Blackfoot River but have been collected in low numbers in lower Georgetown Creek. Table 5 presents the brown trout toxicity data from USEPA (2016).

Table 5. Maternal Transfer Reproductive Toxicity Studies for *Salmo* (from EPA 2016)

Genus	Species	SMCV (mg Se/kg EO dw)	GMCV (mg Se/kg EO dw)
Salmo	Brown Trout[1,2]	21.0[a]	21.0[a]

Notes:
[1]Formation Environmental (2011)
[2]AECOM (2012)
[a]Nu-West proposed site-specific Se criterion for Georgetown Creek

Formation (2011) collected eggs from 26 gravid females from three sampling locations near the Smoky Canyon mine site in Southeastern Idaho. Eggs were fertilized in the laboratory with milt from males collected at the same sites. Hatching success, larval malformations, and juvenile survival rates were monitored for the field-collected fish in addition to hatchery fish from two separate hatcheries. The brown trout EC_{10} of 21.0 mg Se/kg EO dw presented by USEPA (2016) is based on juvenile percent survival from hatch to swim-up using the revised count data presented by AECOM (2012).

Because the factors used by USEPA (2016) to convert EO concentrations to WB or muscle concentrations vary across species, the order of sensitivity for each tissue element also varies across species. Therefore, the most sensitive species-specific value is proposed for each tissue element, as described in Section 4.2.1. In Georgetown Creek, the WB and muscle elements are specific to *O. mykiss* (Table 3) because these values are less than the SMCV for *S. trutta* presented in USEPA (2016).

5 PROTECTIVENESS OF SITE-SPECIFIC SELENIUM CRITERION

This section describes the protectiveness of the proposed SSC to other resident fish species inhabiting each Site. Similar to the *Oncorhynchus* evaluation presented in Section 4, Se toxicity data and information on species sensitivity from USEPA (2016) are the primary source of information used to characterize the sensitivity of fish species and the protectiveness of the proposed SSC. The following

sections present toxicity data for other resident fish, to establish the protectiveness of the proposed SSC for each Site.

5.1 Family *Salmonidae*

5.1.1 Genus *Salvelinus*

Brook trout are resident species that occur at each Site. USEPA (2016) presents toxicity studies for two species in the genus *Salvelinus*: Dolly Varden (*S. malma*) and brook trout (Table 6).

Golder (2009) tested wild-caught Dolly Varden from reference and exposed sites (Table 6). Increases in larval deformity rates were associated with relatively high EO Se concentrations and the EC_{10} value presented in USEPA (2016) is 56.22 mg Se/kg EO dw.

In addition to testing rainbow trout, Holm et al. (2005) also tested wild-caught brook trout from reference and exposed sites over three years. No effects on fertilization, deformities, edema, or mortality were observed up to the maximum egg concentration of 48.7 mg Se/kg dw egg. Because an EC_{10} is available for Dolly Varden (a related species in the *Salvelinus* genus), USEPA (2016) did not use the brook trout chronic value of >48.7 mg Se/kg EO dw to calculate the *Salvelinus* GMCV (Table 6). These brook trout data indicate this species is less sensitive to Se than species in the *Oncorhynchus* or *Salmo* genera, and therefore will be protected by the proposed SSC.

Table 6. Maternal Transfer Reproductive Toxicity Studies for *Salvelinus* (from USEPA 2016)

Genus	Species	SMCV (mg Se/kg EO dw)	GMCV (mg Se/kg EO dw)
Salvelinus	Dolly Varden[1]	56.2	56.2
	Brook Trout[2]	>48.7	

Notes:
[1] Golder (2009)
[2] Holm et al. (2005)

5.2 Family *Cyprinidae*

Cyprinids (dace, chubs, and shiners) are resident fish species in the UBR watershed but they do not occur in the Georgetown Creek watershed (Tables 1 and 2). USEPA (2016) presents several sources of data to conclude cyprinids are not among the most sensitive families to Se effects. Toxicity data (EC_{10}s) were presented in USEPA (2016) for the fathead minnow (*Pimephales promelas*) from two studies.

In the Schultz and Hermanutz (1990) study, an EC_{10} could not be calculated due to high response variability among treatments. Consequently, the Schultz and Hermanutz (1990) fathead minnow chronic value (Table 7) was not used directly by USEPA (2016) to calculate the national Se criterion. However, the data from this study was considered an additional insensitive genus by USEPA that was included in the total number of taxa (i.e., genera) used to calculate the Se criteria. USEPA (2016) presents two other fathead minnow studies to support their conclusion that cyprinids are relatively insensitive to Se.

1. Fathead minnow populations persisted in Belews Lake, NC after Se contamination had eliminated most other fish species (Young et al. 2010).

2. GEI (2008) conducted maternal transfer reproductive studies with gravid adult fathead minnows collected near Denver, CO and estimated EC_{10}s for larval survival and deformities between 35 and 65 mg Se/kg WB dw (Table 7).

Table 7. Maternal Transfer Reproductive Toxicity Studies for *Pimephales* (from USEPA 2016)

Genus	Species	SMCV (mg Se/kg dw)	GMCV (mg Se/kg dw)
Pimephales	Fathead Minnow	<25.6 (EO)[1]	--
		35-65 (WB)[2]	

Notes:
[1] Schultz and Hermanutz (1990). Value not used in EPA's 5th percentile calculation due to high uncertainty; but counted towards N=15.
[2] GEI (2008)
-- Not calculated due to high uncertainty in final chronic value. However, USEPA (2016) determined that cyprinids are less sensitive than salmonids.

In addition to these fathead minnow toxicity studies, USEPA (2016) analyzed cyprinid population data from several Se-contaminated field sites. The available studies and analyses (Appendix E, USEPA [2016]) indicate that native cyprinid taxa such as chubs, shiners, and dace (the resident cyprinids in the UBR watershed) are not sensitive to Se when compared with other families of freshwater fish, including salmonids. The proposed SSC based on salmonids is therefore expected to be protective of cyprinids resident to the UBR watershed.

5.3 Family *Catostomidae*

Suckers are the only resident fish within the *Catostomidae* family that occur in the UBR watershed. They are not resident in Georgetown Creek based on available fisheries data (Section 3.2).

USEPA (2016) evaluates the sensitivity of suckers to Se based on available toxicity studies and population data from field studies, similar to their evaluation of cyprinid sensitivity.

5.3.1 Genus *Catostomus*

de Rosemond et al. (2005) evaluated reproductive effects on wild-caught white suckers (*Catostomus commersonii*) at an exposed Se site (Table 8). Although a reference site was not sampled, EO Se concentrations at the exposed site were grouped into low (8.4 to 9.4 mg Se/kg EO dw) and high (33.6 to 48.3 mg Se/kg EO dw) exposures. Embryo or larval effects were not observed up to the high Se exposure (geometric mean = 40.3 mg Se/kg EO dw).

Table 8. Maternal Transfer Reproductive Toxicity Studies for *Catostomidae* (from USEPA 2016)

Genus	Species	SMCV (mg Se/kg EO dw)	GMCV (mg Se/kg EO dw)
Catostomus	White Sucker[1]	>40.3	--

Notes:
[1]de Rosemound et al. (2005)
-- Not calculated by USEPA (2016) because no fish or eggs were collected from a reference site.

USEPA (2016) also summarizes additional toxicity studies for sucker species based on non-maternal transfer studies (Table 9).

Table 9. Other chronic toxicity data for the family *Catostomidae* (from USEPA 2016)

Genus	Species	SMCV (mg Se/kg WB dw)	GMCV (mg Se/kg WB dw)
Catostomus	Flannelmouth Sucker[1]	>10.2	--
Xyrauchen	Razorback Sucker[1]	>12.9	--
Xyrauchen	Razorback Sucker[2]	>42	

Notes:
[1]Beyers and Sodergren (2001a)
[2]Beyers and Sodergren (2001b)
-- Not calculated by USEPA (2016) because parental females not exposed; used as a line of evidence to evaluate catostomid sensitivity.

The additional Se toxicity values for sucker species are unbounded no-effect levels and provide additional information on the relative insensitivity of different species of suckers. In an evaluation of field population data, USEPA concludes suckers are more tolerant of Se compared to other fishes, including salmonids (Appendix K, USEPA 2016).

5.4 Family *Cottidae*

Sculpin in the genus *Cottus* are the only resident species in the family *Cottidae* that occur in the UBR watershed. They have not been collected in Georgetown Creek (Section 3.2).

Cottid toxicity data are not presented in USEPA (2016). However, Lo et al. (2014) evaluated the effects of dietary Se on slimy sculpin (*Cottus cognatus*) and presented the results at a Society of Environmental Toxicology and Chemistry conference (Lo et al. 2014). Field-collected sculpin were exposed to dietary Se in the laboratory for seven months and spawned for effects determination. No adverse effects were observed on hatching success, fry survival, deformities, fry length, or fry weight up to 22 mg Se/kg EO dw.

In addition to this study, available field data indicate sculpins are generally insensitive to Se. In NAMC (2008), shorthead sculpin (*C. confusus*) population densities were not significantly correlated to dietary Se or sculpin-tissue Se (up to >18 mg Se/kg whole body dw).

Local sculpin population data collected in the UBR watershed and the adjacent Salt River watershed (Formation and HabiTech, 2012) also suggest sculpins are not particularly sensitive to Se. Formation and HabiTech (2012) sampled sculpin populations across a range of reference and Se-impacted sites.

Population densities were not statistically related to surface water or sculpin-tissue Se up to >39 µg/L or >25 mg Se/kg whole-body dw, respectively.

6 SITE-SPECIFIC WATER-COLUMN SELENIUM CONCENTRATIONS

This section presents the development of site-specific Se water column values calculated in accordance with procedures described by USEPA (2016) for translating tissue criteria to estimated surface-water Se concentrations.

USEPA (2016) describes two methods for translating tissue-based criteria into equivalent site-specific water concentrations: a mechanistic bioaccumulation model and an empirical bioaccumulation factor (BAF). As described by USEPA (2016), each approach has advantages and disadvantages. The mechanistic model requires knowledge of the aquatic food web structure for the site, but does not necessarily require extensive fish-tissue sampling. In contrast, the principal disadvantage of the BAF method is the logistics and costs required to obtain sufficient empirical fish-tissue and water data. After review of each method, Nu-West selected the BAF approach to calculate site-specific water column values because site-specific fish and water data are available, and because the mechanistic model is not expected to provide more precise estimates based on site-specific characteristics and existing data (described below).

BAFs are used to relate fish-tissue Se concentrations to ambient surface-water Se concentrations, according to the following equation:

$$BAF = \frac{C_{tissue}}{C_{water}} \qquad \textit{Eq. 1}$$

Where:

BAF	=	bioaccumulation factor derived from site-specific field-collected samples of fish tissue and water (L/kg)
C_{tissue}	=	concentration of Se in fish tissue (mg Se/kg dw)
C_{water}	=	ambient concentration of dissolved Se in surface water (µg/L)

Utilizing a site-specific BAF, a site-specific Se concentration (C_{target}) in surface water, is calculated as follows:

$$C_{target} = \frac{Tissue_{criterion}}{BAF} \qquad \textit{Eq. 2}$$

Where:

C_{target}	=	site-specific Se water target (µg Se/L)
$Tissue_{criterion}$	=	site-specific Se tissue criterion (mg Se/kg dw)

BAF = bioaccumulation factor derived from site-specific field-collected samples of fish tissue and water. The BAF is calculated as the ratio of fish-tissue Se to surface water Se (L/kg)

USEPA (2016) also presents a mechanistic modeling approach to translate fish-tissue Se to a site-specific water concentration. The equation is:

$$C_{target} = \frac{Tissue_{criterion}}{TTF^{composite} \times EF} \qquad \textit{Eq. 3}$$

Where:

Ctarget = site-specific water target (µg Se/L)

$Tissue_{criterion}$ = site-specific Se tissue criterion (mg Se/kg dw)

TTFcomposite = the product of the trophic transfer factor (TTF) values of the fish species that is the target of the tissue criterion and the TTF values of all lower trophic levels in its food web (unitless)

EF = the steady state proportional bioconcentration of dissolved Se at the base of the aquatic food web (L/g). According to USEPA (2016), site-specific EF values may be derived as the ratio of the concentration of Se in particulate material (i.e., periphyton, detritus, and/or sediment) to the concentration of Se dissolved in water.

A species-specific TTF value represents the Se concentration in the tissue of an organism relative to the Se concentration in the food it consumes (USEPA 2016). As described by USEPA (2016), site- and specifies-specific TTFs can be derived empirically by calculating the ratio from field measurements of these parameters. Application of the mechanistic model requires the user to model the food web of the targeted species, including determining the types and proportions of food organisms consumed. The $TTF^{composite}$ parameter in Eqn. 3 then equals the product of TTF values across trophic levels of the target species food-web (USEPA 2016). For example, a three-trophic level system presented in USEPA (2016) is represented in the mechanistic model according to the following equation:

$$C_{target} = \frac{Tissue_{criterion}}{TTF^{TL3} \times TTF^{TL2} \times EF} \qquad \textit{Eq.4}$$

As described below, juvenile salmonids are targeted for fish-tissue collection at these Sites in accordance with the Interagency Fish Tissue Collection Protocol developed for Southeastern Idaho streams (IDEQ 2016). While cutthroat trout diets become more diverse as they grow larger, juveniles feed primarily on invertebrates (https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_010039.pdf). Therefore,

the TTF^{TL3} term in Eqn. 4 is appropriately expressed as the ratio between salmonid tissue and invertebrates. The TTF^{TL2} term in Eqn. 4 would be expressed as the ratio between invertebrates and particulate matter (i.e., periphyton, detritus, and/or sediment). Accordingly, Eq. 4 can also be expressed as:

$$C_{target} = \frac{Tissue_{criterion}}{\frac{Fish}{Invert} \times \frac{Invert}{Particulate} \times \frac{Particulate}{Water}} \qquad Eq.5$$

In this example of a three-trophic level system, Eq.5 can then be simplified as:

$$C_{target} = \frac{Tissue_{criterion}}{\frac{Fish}{Water}} \qquad Eq.6$$

It should be noted that in this modelling scenario, Eq. 6 is equivalent to Eq. 2. As a result, site-specific water column values using the mechanistic model based on a three-trophic level system will result in the same site-specific water column value as using the BAF method. For this reason, and because empirical fish and water values are available, the BAF method is applied herein to calculate site-specific water column values.

Because Se speciation and trophic transfer potential is highly site-specific (Lemly and Smith, 1987; Brix et al., 2005; Presser and Luoma, 2010), there is a wide range of waterborne Se concentrations that could ultimately result in adverse effects to fish via dietary Se exposure. Accordingly, the applicability of ambient water quality criteria (AWQC) for Se based on waterborne concentrations is highly uncertain across sites and BAFs should be developed and applied on a site-specific basis and should not be extrapolated across large spatial scales. Thus, site-specific, field-measured BAFs were developed herein from paired measurements of fish tissue and surface water data collected at specific locations in the UBR watershed and Georgetown Creek.

Nu-West collected surface-water samples in the Spring during peak flows and again in the Fall during base-flow conditions. Fall surface-water sampling was conducted concurrent with aquatic biological monitoring in the UBR and Georgetown Creek watersheds (Sections 3.1 and 3.2). Fish samples were collected under appropriate scientific collection permits issued by IDFG and in accordance with the Interagency Fish Tissue Collection Protocol developed for Southeastern Idaho streams (IDEQ 2016). This protocol targets collection of juvenile salmonids (i.e., young-of-year) that have spent their life history in the sampled stream reach. Selection of salmonids as the target species is consistent with USEPA (2016) guidance as they are the most sensitive fish taxa in the system. Selenium tissue analysis is performed on a whole-body basis and moisture content is measured so that results are reported on a dry-weight basis.

Consistent with USEPA guidance, the fish BAFs presented for each location within the two watersheds (Section 6.1 and 6.2) were calculated based on the average peak/base flow dissolved Se concentration and the average measured co-located fish tissue concentration for each site (Eq. 1). The average peak/base flow dissolved Se concentration was determined by first taking the average concentrations during peak flow and base flow conditions, and then the average of these two values to avoid biasing the average concentration when more than one peak flow or base flow sample was available. Following the procedures outlined in Appendix K of USEPA (2016), BAFs were calculated for each site on an annual

basis and a site-specific water column values C_{target} was then calculated using Eq. 2. For each site, the average C_{target} across sampling years then provides the water column element for that site.

Importantly, average salmonid WB fish-tissue concentrations measured by Nu-West across all sampling locations and years used to develop the site-specific water column values (C_{target}) presented herein are less than proposed SSC of 11.6 mg Se/kg WB dw. Therefore, site-specific water column values presented in the following sections were developed from average dissolved peak/base flow Se (described above) paired with average WB fish-tissue concentrations that are protective of the most sensitive fish species (e.g., less than 11.6 mg Se/kg WB dw), for all locations and all years. The approach applied herein to calculate site-specific BAFs and corresponding site-specific water column values is probably overly conservative because peak-flow and base-flow Se concentrations are averaged in the BAF calculations. Consequently, peak flow concentrations are weighted equally in the BAF calculation, but these peak concentrations occur for only a short duration over the course of a year. Therefore, to correctly implement these site-specific water column values, it is necessary to utilize average results (i.e., not single values) of ambient dissolved Se for comparison to the C_{target} and specifically that those results be averaged in the same way dissolved Se concentrations were averaged to calculate site-specific BAFs.

6.1 Georgetown Creek

Nu-West conducted aquatic biological sampling in Georgetown Creek in 2015 (GEI 2016) and 2016 (Arcadis 2017). Three locations downstream of historical mining activity were sampled each year (Figure 2); however, fish were not collected at one location (BGTC-2) due to low numbers of fish observed in response to low-flow conditions. Between this reach and sample location BGTC-1, Georgetown Creek flows intermittently and typically is dry by late summer (Figure 2).

Table 10 summarizes surface-water Se and fish-tissue Se data measured at each sample location as well as the fish BAFs and site-specific water-column values (C_{target}) calculated from these data. Appendix 1 presents the raw fish-tissue data collected at these locations (i.e., individual whole-body replicates).

Site-specific water column values are proposed for two reaches of Georgetown Creek. The different values reflect differences in the hydrologic regime of Georgetown Creek and differences in Se bioaccumulation potential observed in between these reaches. During high surface-water flow conditions in spring, Georgetown Creek flows continuously to the Bear River. However, during low-flow conditions in the fall, Georgetown Creek infiltrates permeable underlying Wells Formation bedrock and ceases to flow aboveground over a distance of approximately 1.5 miles between sample locations BGTC-2 and BCGTC-1 (Figure 2). Flow then re-emerges from two springs occurring immediately upstream of location BGTC-1, where flow continues through Georgetown Creek toward the Bear River.

In addition to this hydrologic gradient, bioaccumulation potential appears to vary between these reaches as well. In particular, brook trout BAFs are significantly different between locations BGTC-1 and BGTC-3 for both 2015 and 2016 (p-value < 0.001, Mann-Whitney test). Upstream of the intermittent reach, at sample location BGTC-3, the site-specific water column value is 3.4 µg Se/L. Downstream of the intermittent reach, at sample location BGTC-1, the site-specific water column value is 7.5 µg Se/L (Table 10).

Table 10. Summary of surface water, fish tissue, site-specific bioaccumulation factors, and site-specific water-column values for Georgetown Creek.

Location	Surface Water	Whole-Body Fish Tissue				Fish Bioaccumulation Factors		C_{target}	
	Dissolved Se[1] (µg Se/L)	Brook Trout (mg Se/kg WB dw)		Rainbow Trout (mg Se/kg WB dw)		Brook Trout BAF	Rainbow Trout BAF	Brook Trout	Rainbow Trout
		N	Average	*N*	Average				
2015									
BGTC-1	4.50	10	8.95	--	--	1.99	--	6.28	--
BGTC-3	2.68	7	11.47	--	--	4.29	--	2.91	--
2016									
BGTC-1	5.80	10	9.55	10	8.47	1.65	1.46	7.59	8.56
BGTC-3	2.98	9	9.85		--	3.31	--	3.78	--
C_{target}[2]							**BGTC-1 =**	**7.5**	
							BGTC-3 =	**3.4**	

Notes:

[1] Average dissolved Se calculated from spring peak flow (e.g., average of May and early June) and late summer (September) base-flow surface water samples.

[2] Site-specific dissolved Se water-column value for reaches of Georgetown Creek. Reach-specific values were calculated to account for significantly different fish BAFs between BGTC-1 and BGTC-3 (*p*-value <0.001 for brook trout) and hydrologic differences between upper and lower Georgetown Creek.

N = Number of individual whole-body fish replicates.

C_{target} = site-specific dissolved Se water-column value (µg/L).

6.2 Sites in the UBR Watershed

Site-specific water column values are proposed herein for locations in the UBR watershed where sufficient paired fish-tissue and surface-water data are available. As described above, these site-specific values may be updated if additional fish-tissue and surface-water data are collected, consistent with USEPA (2016) guidance for updating fish BAFs with additional data collection, and following the USEPA (2016) method applied herein.

6.2.1 Sheep Creek

Nu-West conducted aquatic biological sampling in Sheep Creek in 2014 (GEI 2015), 2015 (GEI 2016), and 2016 (Arcadis 2017b). Two locations in Sheep Creek downstream of mining activities (i.e., Sheep Creek downstream of its confluence with South Fork Sheep Creek) were sampled during each year (Figure 3; Table 11).

Cutthroat trout and sculpin spp. were collected at each location during each year (2014-2016). The site-specific water column value for Sheep Creek is based on cutthroat trout BAFs because sufficient site-specific cutthroat trout tissue data are available for this sensitive species for each year and at each location. The site-specific water column value for Sheep Creek, downstream of the confluence with South Fork Sheep Creek, is 6.3 µg Se/L.

Table 11. Summary of surface water, fish tissue, site-specific bioaccumulation factors, and site-specific water-column value for Sheep Creek.

Location	Surface Water	Whole-Body Fish Tissue				Fish Bioaccumulation Factors		C_{target}
	Dissolved Se[1] (µg Se/L)	Cutthroat Trout (mg Se/kg WB dw)		Sculpin (mg Se/kg WB dw)		Cutthroat Trout BAF	Sculpin BAF	Cutthroat Trout
		N	Average	*N*	Average			
2014								
BSC-1	3.09	9	6.57	10	8.15	2.13	2.64	5.87
BSC-2	3.58	5	7.32	7	6.66	2.05	1.86	6.11
2015								
BSC-1	1.75	8	6.06	10	8.67	3.47	4.97	3.60
BSC-2	2.59	10	4.51	10	8.41	1.74	3.25	7.17
2016								
BSC-1	2.40	7	4.97	10	7.39	2.07	3.08	6.04
BSC-2	3.10	3	4.43	10	7.50	1.43	2.42	8.75
C_{target}[2] =								**6.3**

Notes:

[1] Average dissolved Se calculated from spring high flow (e.g., average of May and early June samples) and late summer (September) base-flow surface water samples.

[2] Site-specific dissolved Se water-column value for Sheep Creek (average for locations, years, cutthroat trout)

N = Number of individual whole-body fish replicates.

C_{target} = site-specific dissolved Se water-column value.

6.2.2 Angus Creek

Nu-West conducted aquatic biological sampling at four locations on Angus Creek in 2014 (GEI 2015), 2015 (GEI 2016), and 2016 (Arcadis 2017b) (Figure 3). From its headwater to mouth with the Blackfoot River, Angus Creek receives Se inputs from mining activities. Therefore, data from each sampling location are included in the calculation of a site-specific water column value for Angus Creek (Table 12).

Because cutthroat trout tissue samples were not collected in sufficient numbers at each location/year in Angus Creek, sculpin tissue data were also incorporated to calculate site-specific water column values in Angus Creek. This approach provides a conservative means to translate a salmonid-based site-specific tissue values to a water concentration because sculpin-tissue concentrations are greater than salmonid tissue concentrations when collected at the same locations and date (resulting in greater sculpin BAFs and thus lower C_{target} concentrations). This observation is also apparent for the Sheep Creek samples presented in Table 11. The site-specific water column value for Angus Creek, based on cutthroat trout and sculpin samples collected at each location, is 2.4 µg Se/L.

Table 12. Summary of surface water, fish tissue, site-specific bioaccumulation factors, and the site-specific water-column value for Angus Creek.

Location	Surface Water	Whole-Body Fish				Fish Bioaccumulation Factors		C_{target} (µg Se/L)	
	Dissolved Se[1] (µg Se/L)	Cutthroat Trout (mg Se/kg WB dw)		Sculpin (mg Se/kg WB dw)		Cutthroat Trout BAF	Sculpin BAF	Cutthroat Trout	Sculpin
		N	Average	*N*	Average				
2014									
BAC-1	0.99	3	9.20	--	--	9.29	--	1.35	--
BAC-2	2.00	--	--	10	9.32	--	4.66	--	2.68
BAC-3	1.70	3	6.47	7	6.50	3.80	3.83	3.29	3.27
BAC-4	1.78	--	--	6	6.27	--	3.53	--	3.54
2015									
BAC-1	0.68	10	7.44	--	--	10.94	--	1.14	--
BAC-2	1.17	--	--	--	--	--	--	--	--
BAC-3	0.59	--	--	10	8.24	--	14.08	--	0.89
BAC-4	0.98	--	--	10	6.43	--	6.58	--	1.90
2016									
BAC-1	1.10	3	6.30	--	--	5.72	--	2.18	--
BAC-2	2.10	5	7.98	5	8.20	3.80	3.90	3.29	3.20
BAC-3	0.93	3	4.18	10	5.86	4.52	6.33	2.76	1.97
BAC-4	1.68	--	--	6	9.04	--	5.40	--	2.32
C_{target}[2] =								**2.4**	

Notes:

[1] Average dissolved Se calculated from spring high flow (e.g., average of April and May samples) and late summer (September) base-flow surface water samples.

[2] Site-specific dissolved Se water-column value for Angus Creek (average of locations for cutthroat trout and sculpin).

N = Number of individual whole-body fish replicates.

C_{target} = site-specific dissolved Se water-column element.

6.2.2.1 No Name Creek

No Name Creek is an intermittent tributary to Angus Creek that does not support fish populations due to persistent low-flow conditions and its lack of permanent connection with Angus Creek. Appendix K of USEPA (2016) describes the following options for fishless streams:

> *"When fish are absent from a waterbody, consideration of sampling the most sensitive fish species inhabiting nearby, most proximate downstream waters may be useful in order to understand selenium bioaccumulation in such systems. Although the upper reaches of some aquatic systems may not support fish communities, the invertebrate organisms that reside there may tolerate high concentration of selenium and pose a selenium risk to predator fish if transported downstream. Users may choose to evaluate upstream waters without fish by measuring the selenium concentration in water, biotic and/or abiotic particulate material, and/or*

the tissues of invertebrate aquatic organisms that reside there. Because selenium associated with particulate material and invertebrate organisms can be transported downstream during intermittent high flows, elevated concentrations of selenium in the tissues of downstream fish could indicate upstream sources of selenium that require a more detailed evaluation of upstream conditions."

Because fish are the most sensitive taxa to Se, fish-tissue from Angus Creek provides the most direct and sensitive method for assessing compliance with the fish-tissue Se criterion. However, a site-specific water column value for No Name Creek was developed to establish dissolved Se concentrations in No Name Creek that are expected to be protective of fish in the most proximate downstream waters of Angus Creek. These values were developed by relating fish-tissue Se concentrations in Angus Creek (i.e., sample locations BAC-2 and BAC-1) to surface-water Se concentrations measured at and near the mouth of No Name Creek during intermittent spring flows (i.e., when flow from No Name Creek has the potential to reach Angus Creek). Table 13 presents the site-specific water column value developed for No Name Creek using this approach.

Table 13. Angus Creek fish-tissue data, No Name Creek surface-water data, and the site-specific water column value for No Name Creek.

Year	Angus Creek Fish[1] (mg Se/kg WB dw)	No Name Cr Water[2] (µg Se/L)	Fishless Stream Translator[3]	No Name Creek C_{target} (µg Se/L)[4]
2014	9.26	29.43	0.31	39.74
2015	7.44	19.43	0.38	32.65
2016	7.49	39.43	0.19	65.78
C_{target} (No Name Creek)				**46.1**

Notes:

[1] Average of cutthroat trout and sculpin whole-body fish tissue (mg Se/kg WB dw) from lower Angus Creek (BAC-2 and BAC-1).

[2] Average of spring surface water data from lower No Name Creek near the confluence with Angus Creek.

[3] Fishless Stream Translator = Angus Creek fish tissue (mg Se/kg WB dw) / No Name Creek surface water (µg Se/L).

[4] Site-specific water column value for No Name Creek to protect most proximate downstream fish populations.

The hierarchy of criterion elements, including application of water-column values (in fish-bearing and fishless streams), is presented in Table 3. In particular, fish tissue measurements take precedence over any site-specific water column values when fish are sampled downstream of the fishless stream, at the first occurrence of a continuous fish population. The rationale for this hierarchy follows the current scientific understanding of Se effects to aquatic life, with fish being the most sensitive taxonomic group. In addition, the approach described herein for monitoring streams that are fishless due to natural low-flow conditions is in-line with USEPA (2016) options described above for such waters; specifically, targeting fish inhabiting nearby, most proximate waters while also measuring waterborne Se concentrations in the fishless stream. This fishless stream translator presented in Table 13 relates the surface water Se concentration from No Name Creek (fishless stream) to fish-tissue Se from most proximate fish populations in Angus Creek (fish populations occur immediately downstream of No Name Creek). This

approach is conceptually similar to a dilution factor approach, but incorporates fish tissue because it is the most sensitive and reliable measure of potential Se effects. In this approach, fish are collected immediately downstream of No Name Creek, which provides a means of assessing the protectiveness of No Name Creek on most proximate fish populations.

6.3 Implementation

An important aspect of the proposed SSC is implementation. USEPA (2016) provides guidance on some components of implementing a multi-element (water, tissue) criterion for Se but guidance is lacking in other areas. Important in compliance monitoring for Se is balancing the need to minimize the uncertainty in ensuring compliance through fish-tissue sampling with the impact of this sampling on important biological resources. To address this issue, Nu-West proposes that routine compliance monitoring be undertaken by first measuring Se in water and comparing measured concentrations to the SSC water column values derived herein. While the water element is the least accurate component of the criterion, measuring it makes no biological impact on the streams and is the most logistically feasible.

As described above, the site-specific water-column values are derived based on BAFs that use the average fish-tissue Se concentration measured in the Fall and the average of peak and base-flow dissolved Se concentration. Similarly, the site-specific water-column value for No Name Creek is derived based on a Fishless Stream Translator that uses the average fish-tissue Se concentration measured in the Fall and the average peak-flow dissolved Se concentration. Thus, it is important that future surface-water monitoring be based on this same metric to ensure comparability with the development of the site-specific water column values. Therefore, Nu-West proposes that the average peak/base flow dissolved Se concentration be used to compare with the site-specific water column values presented herein for streams with fish present and average peak-flow Se for No Name Creek. If surface-water sampling results in an exceedance of a site-specific water column value, this indicates the potential for an exceedance of the overall SSC, but requires confirmation through tissue sampling. Consequently, exceedance of a water value would require a fish sampling program.

If a surface-water value is exceeded, a fish sampling program would be implemented at the next timeframe that falls within the window of recommended fish-tissue sampling per the Southeastern Idaho Fish Tissue Protocol (IDEQ 2016) (flow and fish presence permitting). For example, the average peak/base-flow dissolved Se concentration can be determined by surface-water sampling conducted during spring high-flow conditions (typically late April through May) and summer base-flow conditions (typically occurring by mid-July). Therefore, by mid-August, the average of peak/base-flow dissolved Se can be calculated to decide whether fish-sampling in the fall is required to assess compliance with the site-specific fish-tissue criterion.

If average fish-tissue Se concentrations remain below the SSC tissue elements presented in Table 3, then it will be concluded that the site is in compliance with the SSC. Surface-water Se and fish-tissue Se collected during compliance sampling will be used to update the site-specific BAF to reflect this new information and site-specific water column values may be re-calculated accordingly.

Lastly, the enforcement of the state-wide Se criterion applicable in waters downstream of either Site, will ensure the protection of the proposed SSC to those downstream waters. That enforcement could

encompass appropriate actions in upstream waters as specified in the IDAPA, including potentially those required by Section 303(d) of the Clean Water Act, if required to protect beneficial uses (includes resident fish species) in the downstream waters.

7 RECOMMENDATION

Nu-West proposes SSC for Se (Table 3) for application to the two “Sites” described in Section 2. The proposed SSC for Se are developed from USEPA’s (2016) Se criterion, are specific to the most sensitive resident fish species, and are protective of other resident fish taxa. The proposed SSC consist of an EO element (25.3 mg Se/kg EO dw for Upper Blackfoot River and 21.0 mg Se/kg EO dw for Georgetown Creek), a whole-body element (12.5 mg Se/kg whole-body dw), and a muscle element (12.8 mg Se/kg muscle dw). Site-specific water column values are recommended in order to determine whether fish-tissue sampling is required to assess compliance with the fish-tissue SSC. The recommended water column values values are 7.5 µg Se/L for lower Georgetown Creek (downstream of intermittent reach), 3.4 µg Se/L for upper Georgetown Creek (upstream of intermittent reach), 6.3 µg Se/L for Sheep Creek, 2.4 µg Se/L for Angus Creek, and 46.1 µg Se/L for No Name Creek. These site-specific water column values are implemented based on the average ambient surface-water Se measured during peak flow and base flow (i.e., the same manner in which they were developed).

The proposed SSC values are applicable to each Site according to the well-documented resident fishes that occur at each Site (Section 3). A SSC established from the most sensitive resident follows USEPA guidance for Sites containing few resident families. In agreement with USEPA (2016) recommendations, this proposal expresses the SSC for Se as a single criterion composed of multiple elements in a manner that explicitly affirms the primacy of the whole-body or muscle element over the water-column element, and the EO element over the other elements. The hierarchy of each element corresponds directly to the level of certainty associated with each element. For example, the water column element has the highest uncertainty and is applied last. In contrast, the tissue elements override water column values because they provide a more direct measure of exposure and effects.

Adoption into IDAPA of the SSC for Se at the two Sites could occur at 58.01.02 § 275.02 to reflect water quality criteria for specific waters, consistent with the current structure of the administrative code, or other sections of IDAPA 58.01.02 following IDEQ recommendations.

8 REFERENCES

Arcadis. 2017. Draft 2016 data summary report. Georgetown Canyon Mine Site. Bear Lake and Caribou Counties, Idaho. February 20, 2017.

Arcadis. 2017b. Draft 2016 aquatic biomonitoring data summary report. South and Central Rasmussen Ridge Area. Caribou County, Idaho.

AECOM. 2012. Reproductive success study with brown trout (Salmo trutta). Data quality assurance report. Final. December 2012.

Beyers, D.W. and Sodergren, C. 2001a. Evaluation of interspecific sensitivity to selenium exposure: Larval razorback sucker versus flannelmouth sucker. Larval Fish Laboratory. Department of Fishery and Wildlife Biology, Colorado State University, Fort Collins, CO.

Beyers, D.W. and Sodergren, C. 2001a. Evaluation of interspecific sensitivity to selenium exposure: Larval razorback sucker versus flannelmouth sucker. Larval Fish Laboratory. Department of Fishery and Wildlife Biology, Colorado State University, Fort Collins, CO.

Beyers, D.W. and Sodergren, C. 2001b. Assessment of exposure of larval razorback sucker to selenium in natural waters and evaluation of laboratory-based predictions. Larval Fish Laboratory. Department of Fishery and Wildlife Biology, Colorado State University, Fort Collins, CO.

Brix, K.V., Toll, J.E., Tear, L.M., DeForest, D.K., Adams, W.J., 2005. Setting site-specific water quality standards using tissue residue criteria and bioaccumulation data. Part 2. Calculating site-specific selenium water quality standards for protecting fish and birds. Environ. Toxicol. Chem. 24, 231-237.

de Rosemond, K. Liber and A. Rosaasen. 2005. Relationship between embryo selenium concentration and early life stage development in white sucker. Bull. Environ. Contamin. Toxicol. 74: 1134-1142.

Formation (2011). Brown trout laboratory reproduction studies conducted in support of development of a site-specific selenium criterion. Prepared for J.R. Simplot Company by Formation Environmental. Revised October 2011.

Formation and HabiTech, Inc. 2012. Technical Support Document: Proposed Site-Specific Selenium Criterion, Sage and Crow Creeks, Idaho. Prepared for J.R. Simplot Company.

GEI Consultants. 2008. Maternal transfer of selenium in fathead minnows, with modeling of ovary tissue to whole body concentrations. Project 062790. Chadwick Ecological Division, Littleton, CO.

GEI Consultants. 2015. Aquatic biological sampling data summary report for South and Central Rasmussen Ridge Area Streams, 2014. Caribou County, Idaho.

GEI Consultants. 2016. Aquatic biological sampling data summary report for Georgetown Canyon Mine Area Streams, 2015. Bear Lake and Caribou Counties, Idaho.

GEI Consultants. 2016b. Aquatic biological sampling data summary report for South and Central Rasmussen Ridge Area Streams, 2015. Caribou County, Idaho.

Golder Associates. 2009. Development of a site-specific selenium toxicity threshold for Dolly Varden Char. Report Number 04-1421-101/2000. Report to Northgate Minerals Corporation, Smithers, British Columbia.

Hardy, R.W. 2005. Effects of dietary selenium on cutthroat trout (*Oncorhynchus clarkii*) growth and reproductive performance. Report for Montgomery Watson Harza. December 14.

Holm, J. 2002. Sublethal effects of selenium on rainbow trout (*Oncorhynchus mykiss*) and brook trout (*Salvelinus fontinalis*). Masters Thesis. Department of Zoology, University of Manitoba, Winnipeg, MB.

Holm, J., V.P. Palace, K. Wautier, R.E. Evans, C.L. Baron, C. Podemski, P. Siwik and G. Sterling. 2003. An assessment of the development and survival of rainbow trout (*Oncorhynchus mykiss*) and brook trout (*Salvelinus fontinalis*) exposed to elevated selenium in an area of active coal mining. Proceedings of the 26th Annual Larval Fish Conference 2003, Bergen, Norway.

Holm, J., V.P. Palace, P. Siwik, G. Sterling, R. Evans, C. Baron, J. Werner and K. Wautier. 2005. Developmental effects of bioaccumulated selenium in eggs and larvae of two salmonid species. Environ. Toxicol. Chem. 24: 2373-2381.

Idaho Department of Environmental Quality. 2016. Interagency Fish Tissue Collection Protocol for Southeastern Idaho streams .

Idaho Department of Fish and Game. 2007. Management Plan for the Conservation of Yellowstone Cutthroat Trout in Idaho. April 2007.

Idaho Department of Fish and Game. 2007b. Management Plan for the Conservation of Bonneville Cutthroat Trout in Idaho. November 2007.

Janz, D.M., DeForest, D.K., Brooks, M.L., Chapman, P.M., Gilron, G., Hoff, D., Hopkins, W.A., McIntyre, D.O., Mebane, C.A., Palace, V.P., Skorupa, J.P., Wayland, M., 2010. Selenium toxicity to aquatic organisms, in: P.M. Chapman, W.J. Adams, M.L. Brooks, C.G. Delos, S.N. Luoma, W.A. Maher, H.M. Ohlendorf, T.S. Presser, D.P. Shaw (Eds.), Ecological Assessment of Selenium in the Aquatic Environment. CRC Press, Boca Raton, Florida, pp. 141-232.

Kennedy, C.J., L.E. McDonald, R. Loveridge and M.M. Strosher. 2000. The effect of bioaccumulated selenium on mortalities and deformities in the eggs, larvae, and fry of a wild population of cutthroat trout (*Oncorhynchus clarkii lewisi*). Arch. Environ. Contam. Toxicol. 39: 46-52.

Lemly, A.D., Smith, G.J., 1987. Aquatic Cycling of Selenium: Implications for Fish and Wildlife, Leaflet 12. United States Department of the Interior, Fish and Wildlife Service, 10.

Lo, B., V. Marlatt, J. Baker, J. Elphick, A. Debruyn, M. Patterson, B. Leighton, C. Kennedy and H. Baily. 2014. Effect of dietary selenium on adult Slimy Sculpin (Cottus cognatus) and their offspring. Society of Environmental Toxicology and Chemistry, 35th Annual North America Conference 2014, Vancouver, British Columbia, Canada.

Nautilus Environmental. 2011. Evaluation of the Effects of Selenium on Early Life Stage Development of Westslope Cutthroat Trout from the Elk Valley, BC. Report to Elk Valley Selenium Task Force, November 24, 2011.

Presser, T.S., Luoma, S.N., 2010. A methodology for ecosystem-scale modeling of selenium. Integr. Environ. Assess. Manag. 6, 685-710.

Ponton, D.E., Hare, L., 2013. Relating selenium concentrations in a planktivore to selenium speciation in lakewater. Environ. Poll. 176, 254-260.

Rudolph, B.L., I. Andreller and C.J. Kennedy. 2008. Reproductive success, early life stage development, and survival of Westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) exposed to elevated selenium in an area of active coal mining. Environ. Sci. Technol. 42: 3109-3114.

Schultz, R. and R. Hermanutz. 1990. Transfer of toxic concentrations of selenium from parent to progeny in the fathead minnow (*Pimephales promelas*). Bull. Environ. Contam. Toxicol. 45: 568-573.

Teuscher, D. and J. Capurso. 2007. Management Plan for Conservation of Bonneville Cutthroat Trout in Idaho. Idaho Department of Fish and Game. IDFG 07-48.

USEPA. 1985. Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses. PB85-227049. Office of Research and Development.

USEPA. 1994. Interim Guidance on Determination and Use of Water-Effect Ratios for Metals. EPA-823-B-94-001. Office of Water. Office of Science and Technology. February.

USEPA. 2013. Revised Deletion Process for the Site-Specific Recalculation Procedure for Aquatic Life Criteria. EPA-823-R-13-001. Office of Water. April.

USEPA. 2016. Aquatic Life Ambient Water Quality Criterion for Selenium – Freshwater 2016. EPA 822-R-16-006. Office of Water. Office of Science and Technology Washington, D.C. June.

Young, T.F., K. Finley, W. Adams, J. Besser, W.A. Hopkins, D. Jolley, E. McNaughton, T.S. Presser, D.P. Shaw, and J. Unrine. 2010. Appendix A. Selected case studies of ecosystem contamination by selenium. in: Chapman P.M., W.J. Adams, M.L. Brooks, C.G. Delos, S.N. Luoma, W.A. Maher, H.M. Ohlendorf, T.S. Presser, D.P. Shaw (eds). Ecological Assessment of Selenium in the Aquatic Environment. SETAC Press, Pensacola, FL, USA.

Arcadis U.S., Inc.

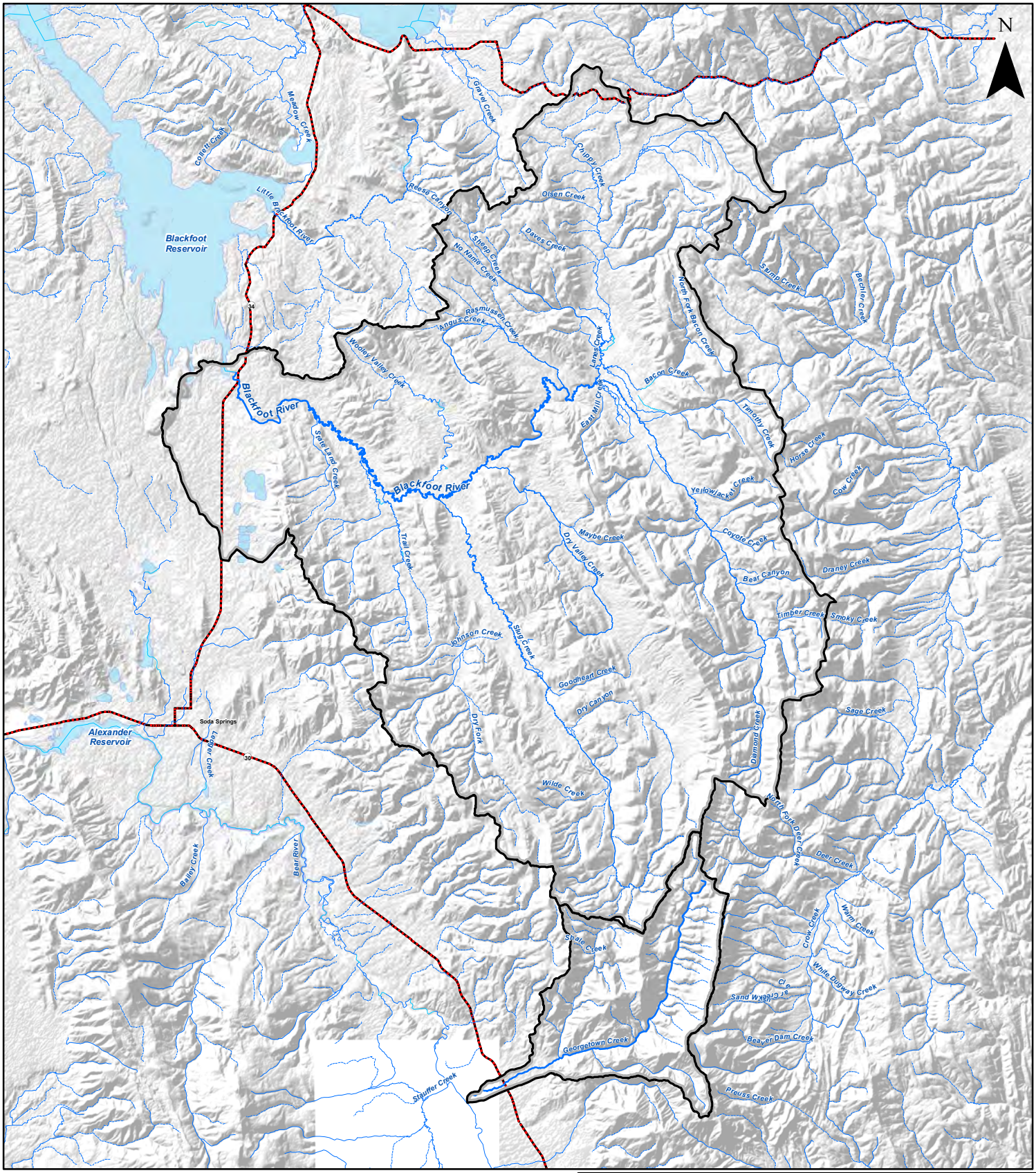
630 Plaza Drive

Highlands Ranch, Colorado 80129

Tel 720 386 1648

Fax 720 344 3535

www.arcadis.com



Nu-West Industries, Inc. / Nu-West Mining, Inc.
Bear Lake and Caribou Counties, Idaho
Proposal for Site-Specific Selenium Criteria

Upper Blackfoot River Watershed and Georgetown Creek Watershed

4 2 0 4 Miles

1 inch = 24,000 feet

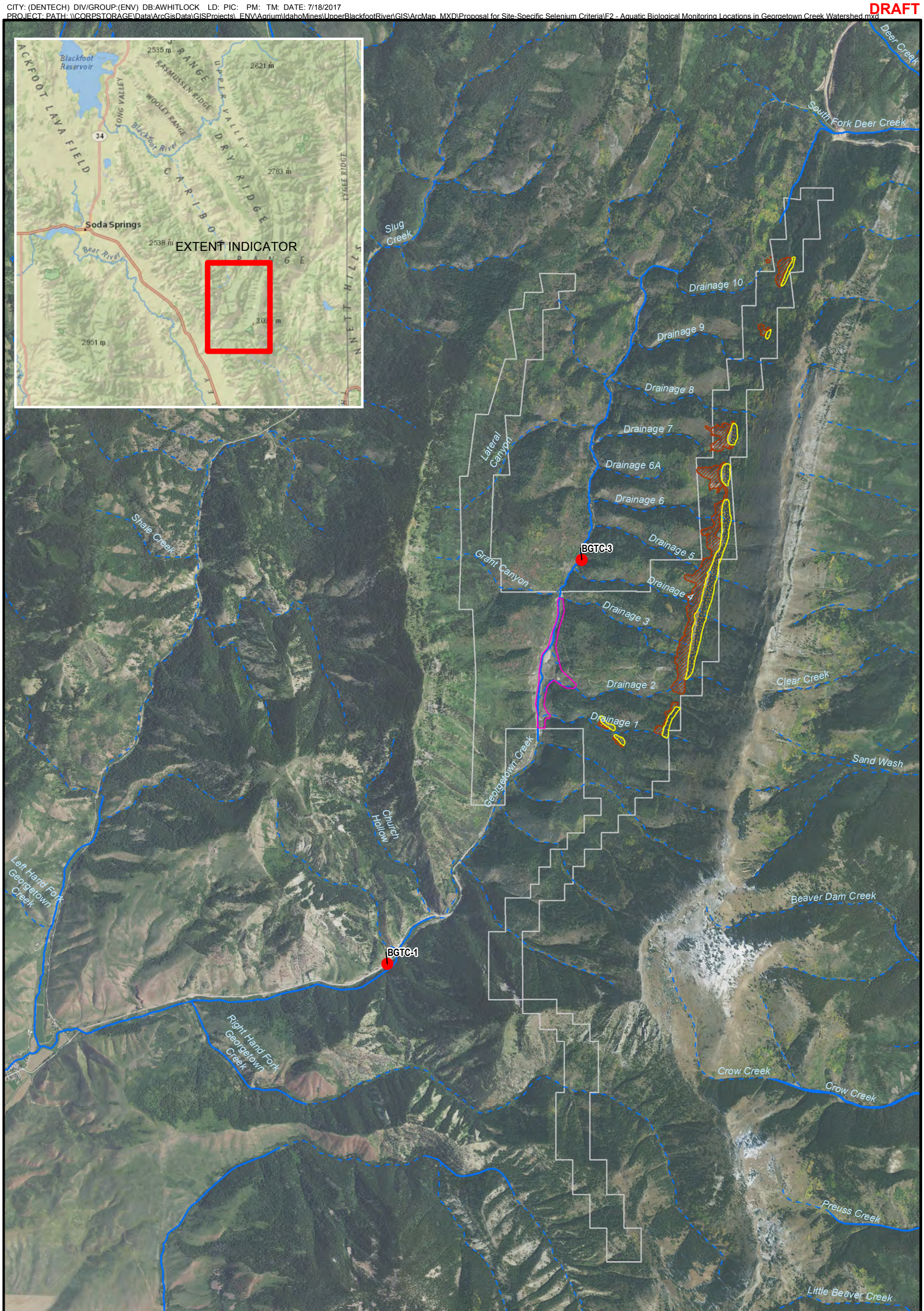
ARCADIS Design & Consultancy for natural and built assets

FIGURE 1

CITY: (DENTECH) DIV/GROUP:(ENV) DB:AWHITLOCK LD: PIC: PM: TM: DATE: 7/17/2017
PROJECT: PATH: \\CORPSTORAGE\Data\ArcGisData\GISProjects_ENV\Agrium\IdahoMines\UpperBlackfootRiver\GIS\ArcMap_MXD\Proposal for Site-Specific Selenium Criteria\F1 - Upper Blackfoot River Watershed and Georgetown Creek Watershed.mxd

CITY: (DENTECH) DIV/GROUP:(ENV) DB:AWHITLOCK LD: PIC: PM: TM: DATE: 7/18/2017
PROJECT: PATH: \\CORPSTORAGE\Data\ArcGisData\GISProjects_ENV\Agrium\IdahoMines\UpperBlackfootRiver\GIS\ArcMap_MXD\Proposal for Site-Specific Selenium Criteria\F2 - Aquatic Biological Monitoring Locations in Georgetown Creek Watershed.mxd

DRAFT



Legend

- Area owned by Nu-West Mining, Inc.
- Approximate Mining Pit Area
- Overburden Storage Area (Refinement survey conducted September 2014)
- Industrial Complex Area
- Perennial Stream
- Intermittent Stream
- Sampling Locations

N

0 3,500 7,000
SCALE IN FEET

Nu-West Mining, Inc. / Nu-West Mining, Inc.
Bear Lake and Caribou Counties, Idaho
Proposal for Site Specific Selenium Criteria

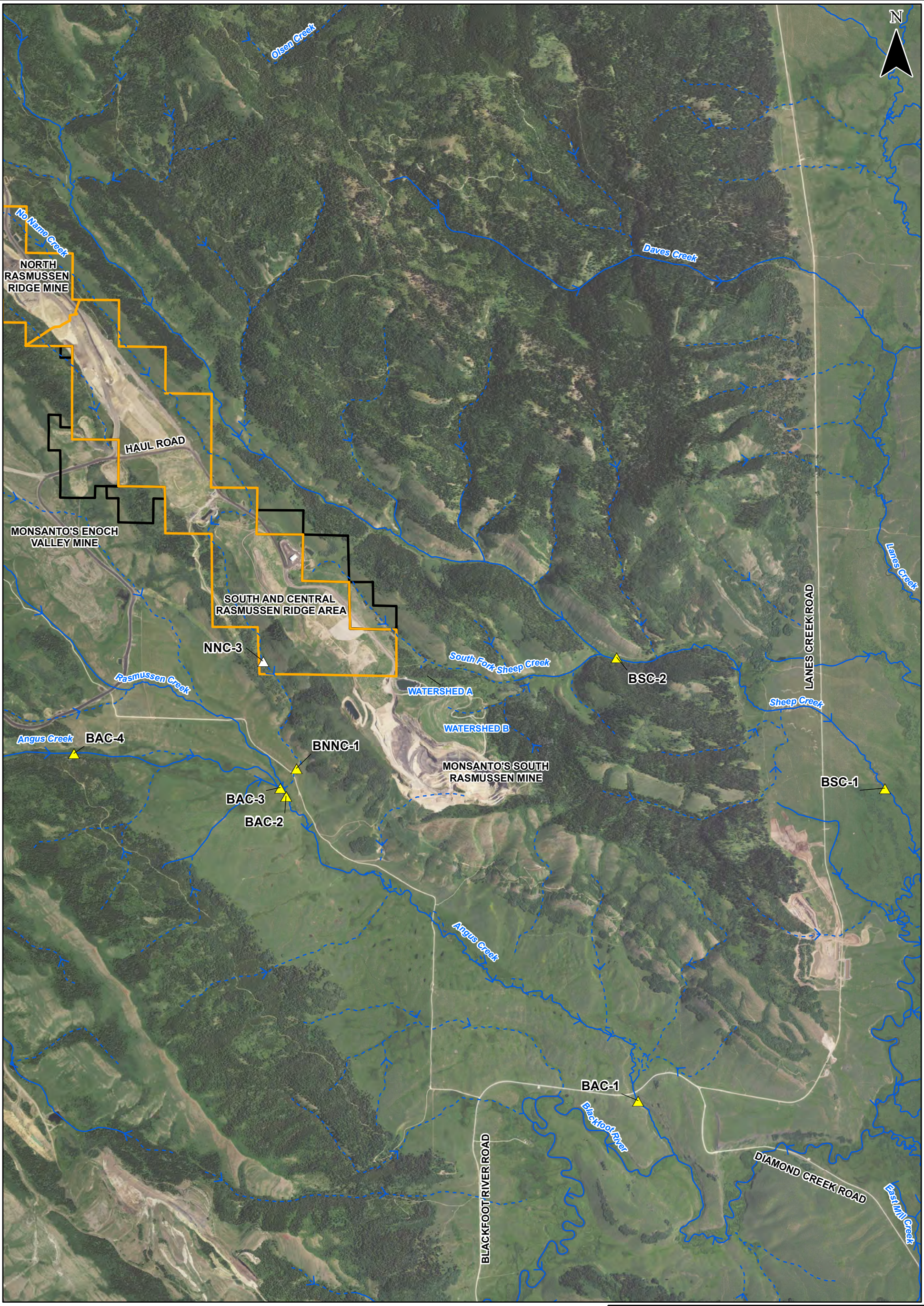
AQUATIC BIOLOGICAL MONITORING LOCATIONS IN GEORGETOWN CREEK WATERSHED

ARCADIS Design & Consultancy for natural and built assets

FIGURE
2

Aerial Layer Credit: NAIP, 2015

CITY: (DENTECH) DIV/GROUP:(ENV) DB:AWHITLOCK LD: PIC: PM: TM: DATE: 7/18/2017
PROJECT: PATH: \\CORPSTORAGE\Data\ArcGisData\GISProjects_ENV\Agrium\IdahoMines\UpperBlackfootRiver\GIS\ArcMap_MXD\Proposal for Site-Specific Selenium Criteria\F3 - Aquatic Biological Monitoring Locations in Angus Creek and Sheep Creek Sub-Watersheds.mxd



Legend:

- Stream Monitoring and Stream Biomonitoring Location
- Surface Water Monitoring Location
- Perennial Stream
- Intermittent Stream
- Lease Boundary
- Special Use Permit

0 2,600 5,200
SCALE IN FEET

Source: 2015 NAIP Imagery

Nu-West Industries, Inc. / Nu-West Mining, Inc.
Bear Creek and Caribou Counties, Idaho
Proposal for Site-Specific Selenium Criteria

Aquatic Biological Monitoring Locations in Angus Creek and Sheep Creek Sub-Watersheds

ARCADIS Design & Consultancy for natural and built assets

FIGURE
3

Appendix 1. Whole-body fish tissue and surface water selenium data collected at locations in the Georgetown Creek watershed and Upper Blackfoot River watershed used to calculate site-specific water column trigger values.

Stream	Location	Sample Date	Species	Whole-Body Fish (mg Se/kg WB dw)	Annual Average Dissolved Se (µg/L)	Fish Whole-Body BAF
Georgetown Creek						
Georgetown Creek	BGTC-1	9/19/2015	BRK	6.5	4.50	1.44
Georgetown Creek	BGTC-1	9/19/2015	BRK	12.3	4.50	2.73
Georgetown Creek	BGTC-1	9/19/2015	BRK	11.4	4.50	2.53
Georgetown Creek	BGTC-1	9/20/2015	BRK	7.9	4.50	1.76
Georgetown Creek	BGTC-1	9/20/2015	BRK	9	4.50	2.00
Georgetown Creek	BGTC-1	9/20/2015	BRK	8.7	4.50	1.93
Georgetown Creek	BGTC-1	9/20/2015	BRK	9.3	4.50	2.07
Georgetown Creek	BGTC-1	9/20/2015	BRK	8.8	4.50	1.96
Georgetown Creek	BGTC-1	9/20/2015	BRK	6.9	4.50	1.53
Georgetown Creek	BGTC-1	9/20/2015	BRK	8.7	4.50	1.93
Georgetown Creek	BGTC-1	9/18/2016	BRK	7.16	5.8	1.23
Georgetown Creek	BGTC-1	9/18/2016	BRK	10.2	5.8	1.76
Georgetown Creek	BGTC-1	9/18/2016	BRK	9.59	5.8	1.65
Georgetown Creek	BGTC-1	9/18/2016	BRK	9.28	5.8	1.60
Georgetown Creek	BGTC-1	9/18/2016	BRK	7.91	5.8	1.36
Georgetown Creek	BGTC-1	9/18/2016	BRK	10.3	5.8	1.78
Georgetown Creek	BGTC-1	9/18/2016	BRK	8.2	5.8	1.41
Georgetown Creek	BGTC-1	9/18/2016	BRK	8.43	5.8	1.45
Georgetown Creek	BGTC-1	9/18/2016	BRK	14	5.8	2.41
Georgetown Creek	BGTC-1	9/18/2016	BRK	10.4	5.8	1.79
Georgetown Creek	BGTC-1	9/18/2016	RBT	7.64	5.8	1.32
Georgetown Creek	BGTC-1	9/18/2016	RBT	10.8	5.8	1.86
Georgetown Creek	BGTC-1	9/18/2016	RBT	8.8	5.8	1.52
Georgetown Creek	BGTC-1	9/18/2016	RBT	8.48	5.8	1.46
Georgetown Creek	BGTC-1	9/18/2016	RBT	7.25	5.8	1.25
Georgetown Creek	BGTC-1	9/18/2016	RBT	8.84	5.8	1.52
Georgetown Creek	BGTC-1	9/18/2016	RBT	6.42	5.8	1.11
Georgetown Creek	BGTC-1	9/18/2016	RBT	8.32	5.8	1.43
Georgetown Creek	BGTC-1	9/18/2016	RBT	10.7	5.8	1.84
Georgetown Creek	BGTC-1	9/18/2016	RBT	7.47	5.8	1.29
Georgetown Creek	BGTC-3	9/19/2015	BRK	7.9	2.68	2.95
Georgetown Creek	BGTC-3	9/19/2015	BRK	7	2.68	2.62
Georgetown Creek	BGTC-3	9/19/2015	BRK	11.5	2.68	4.30
Georgetown Creek	BGTC-3	9/19/2015	BRK	14.3	2.68	5.35
Georgetown Creek	BGTC-3	9/19/2015	BRK	10.7	2.68	4.00
Georgetown Creek	BGTC-3	9/19/2015	BRK	15.6	2.68	5.83
Georgetown Creek	BGTC-3	9/19/2015	BRK	13.3	2.68	4.97
Georgetown Creek	BGTC-3	9/18/2016	BRK	11.3	2.98	3.80
Georgetown Creek	BGTC-3	9/18/2016	BRK	10.1	2.98	3.39
Georgetown Creek	BGTC-3	9/18/2016	BRK	9.26	2.98	3.11
Georgetown Creek	BGTC-3	9/18/2016	BRK	10.5	2.98	3.53
Georgetown Creek	BGTC-3	9/18/2016	BRK	8.98	2.98	3.02
Georgetown Creek	BGTC-3	9/18/2016	BRK	10.1	2.98	3.39
Georgetown Creek	BGTC-3	9/18/2016	BRK	9.16	2.98	3.08
Georgetown Creek	BGTC-3	9/18/2016	BRK	9.3	2.98	3.13
Georgetown Creek	BGTC-3	9/18/2016	BRK	9.92	2.98	3.33
Angus Creek						
Angus	BAC-1	9/11/2014	CUT	7.91	0.99	7.99
Angus	BAC-1	9/11/2014	CUT	8.78	0.99	8.87
Angus	BAC-1	9/11/2014	CUT	10.9	0.99	11.01
Angus	BAC-1	9/20/2015	CUT	7.11	0.68	10.46
Angus	BAC-1	9/20/2015	CUT	3.8	0.68	5.59
Angus	BAC-1	9/20/2015	CUT	5.48	0.68	8.06
Angus	BAC-1	9/20/2015	CUT	4.8	0.68	7.06
Angus	BAC-1	9/20/2015	CUT	7.98	0.68	11.74
Angus	BAC-1	9/20/2015	CUT	5.67	0.68	8.34
Angus	BAC-1	9/20/2015	CUT	16.74	0.68	24.62
Angus	BAC-1	9/20/2015	CUT	7.75	0.68	11.40
Angus	BAC-1	9/20/2015	CUT	7.47	0.68	10.99
Angus	BAC-1	9/20/2015	CUT	7.61	0.68	11.19
Angus	BAC-1	9/13/2016	CUT	6.16	1.1	5.60
Angus	BAC-1	9/13/2016	CUT	5.88	1.1	5.35
Angus	BAC-1	9/13/2016	CUT	6.85	1.1	6.23
Angus	BAC-2	9/9/2014	SCU	9.2	2.0	4.60
Angus	BAC-2	9/9/2014	SCU	9.4	2.0	4.70
Angus	BAC-2	9/9/2014	SCU	9.1	2.0	4.55
Angus	BAC-2	9/9/2014	SCU	8.6	2.0	4.30
Angus	BAC-2	9/9/2014	SCU	10.3	2.0	5.15
Angus	BAC-2	9/9/2014	SCU	8.7	2.0	4.35
Angus	BAC-2	9/9/2014	SCU	8.9	2.0	4.45
Angus	BAC-2	9/9/2014	SCU	9.5	2.0	4.75
Angus	BAC-2	9/9/2014	SCU	9.9	2.0	4.95
Angus	BAC-2	9/9/2014	SCU	9.6	2.0	4.80
Angus	BAC-2	9/14/2016	CUT	7.08	2.1	3.37
Angus	BAC-2	9/14/2016	CUT	10.30	2.1	4.90
Angus	BAC-2	9/14/2016	CUT	8.01	2.1	3.81
Angus	BAC-2	9/14/2016	CUT	7.2	2.1	3.43
Angus	BAC-2	9/14/2016	CUT	7.33	2.1	3.49
Angus	BAC-2	9/14/2016	SCU	7.6	2.1	3.62
Angus	BAC-2	9/14/2016	SCU	8.46	2.1	4.03
Angus	BAC-2	9/14/2016	SCU	8.4	2.1	4.00

Appendix 1. Whole-body fish tissue and surface water selenium data collected at locations in the Georgetown Creek watershed and Upper Blackfoot River watershed used to calculate site-specific water column trigger values.

Stream	Location	Sample Date	Species	Whole-Body Fish (mg Se/kg WB dw)	Annual Average Dissolved Se (µg/L)	Fish Whole-Body BAF
Georgetown Creek						
Angus	BAC-2	9/14/2016	SCU	9.17	2.1	4.37
Angus	BAC-2	9/14/2016	SCU	7.36	2.1	3.50
Angus	BAC-3	9/10/2014	CUT	7.4	1.7	4.35
Angus	BAC-3	9/10/2014	CUT	6	1.7	3.53
Angus	BAC-3	9/10/2014	CUT	6	1.7	3.53
Angus	BAC-3	9/10/2014	SCU	7.5	1.7	4.41
Angus	BAC-3	9/10/2014	SCU	9.8	1.7	5.76
Angus	BAC-3	9/10/2014	SCU	5.28	1.7	3.11
Angus	BAC-3	9/10/2014	SCU	6.2	1.7	3.65
Angus	BAC-3	9/10/2014	SCU	5.24	1.7	3.08
Angus	BAC-3	9/10/2014	SCU	6.5	1.7	3.82
Angus	BAC-3	9/10/2014	SCU	5	1.7	2.94
Angus	BAC-3	9/18/2015	SCU	6.34	0.59	10.84
Angus	BAC-3	9/18/2015	SCU	10.8	0.59	18.46
Angus	BAC-3	9/18/2015	SCU	9.33	0.59	15.95
Angus	BAC-3	9/18/2015	SCU	5.2	0.59	8.89
Angus	BAC-3	9/18/2015	SCU	5.82	0.59	9.95
Angus	BAC-3	9/18/2015	SCU	4.15	0.59	7.09
Angus	BAC-3	9/18/2015	SCU	10.44	0.59	17.85
Angus	BAC-3	9/18/2015	SCU	9.2	0.59	15.73
Angus	BAC-3	9/18/2015	SCU	13.33	0.59	22.79
Angus	BAC-3	9/18/2015	SCU	7.78	0.59	13.30
Angus	BAC-3	9/14/2016	CUT	4.52	0.93	4.89
Angus	BAC-3	9/14/2016	CUT	4.16	0.93	4.50
Angus	BAC-3	9/14/2016	CUT	3.87	0.93	4.18
Angus	BAC-3	9/14/2016	SCU	8.67	0.93	9.37
Angus	BAC-3	9/14/2016	SCU	4.5	0.93	4.86
Angus	BAC-3	9/14/2016	SCU	5.97	0.93	6.45
Angus	BAC-3	9/14/2016	SCU	7.42	0.93	8.02
Angus	BAC-3	9/14/2016	SCU	4.21	0.93	4.55
Angus	BAC-3	9/14/2016	SCU	7.19	0.93	7.77
Angus	BAC-3	9/14/2016	SCU	6.19	0.93	6.69
Angus	BAC-3	9/14/2016	SCU	4.78	0.93	5.17
Angus	BAC-3	9/14/2016	SCU	6.02	0.93	6.51
Angus	BAC-3	9/14/2016	SCU	3.63	0.93	3.92
Angus	BAC-4	9/10/2014	SCU	6	1.8	3.38
Angus	BAC-4	9/10/2014	SCU	6.2	1.8	3.49
Angus	BAC-4	9/10/2014	SCU	6.6	1.8	3.72
Angus	BAC-4	9/10/2014	SCU	5.9	1.8	3.32
Angus	BAC-4	9/10/2014	SCU	6.5	1.8	3.66
Angus	BAC-4	9/10/2014	SCU	6.4	1.8	3.61
Angus	BAC-4	9/18/2015	SCU	7.31	1.0	7.48
Angus	BAC-4	9/18/2015	SCU	5.66	1.0	5.79
Angus	BAC-4	9/18/2015	SCU	7.27	1.0	7.44
Angus	BAC-4	9/18/2015	SCU	7.14	1.0	7.30
Angus	BAC-4	9/18/2015	SCU	6.22	1.0	6.36
Angus	BAC-4	9/18/2015	SCU	7.1	1.0	7.26
Angus	BAC-4	9/18/2015	SCU	5.38	1.0	5.50
Angus	BAC-4	9/18/2015	SCU	3.85	1.0	3.94
Angus	BAC-4	9/18/2015	SCU	8.03	1.0	8.21
Angus	BAC-4	9/18/2015	SCU	6.33	1.0	6.48
Angus	BAC-4	9/14/2016	SCU	8.16	1.2	6.62
Angus	BAC-4	9/14/2016	SCU	8.34	1.2	6.76
Angus	BAC-4	9/14/2016	SCU	9.55	1.2	7.74
Angus	BAC-4	9/14/2016	SCU	8.68	1.2	7.04
Angus	BAC-4	9/14/2016	SCU	10.6	1.2	8.59
Angus	BAC-4	9/14/2016	SCU	8.91	1.2	7.22
Sheep Creek						
Sheep	BSC-1	9/11/2014	CUT	6.1	3.09	1.98
Sheep	BSC-1	9/11/2014	CUT	5.5	3.09	1.78
Sheep	BSC-1	9/11/2014	CUT	4.6	3.09	1.49
Sheep	BSC-1	9/11/2014	CUT	5.8	3.09	1.88
Sheep	BSC-1	9/11/2014	CUT	8	3.09	2.59
Sheep	BSC-1	9/11/2014	CUT	8.3	3.09	2.69
Sheep	BSC-1	9/11/2014	CUT	8.8	3.09	2.85
Sheep	BSC-1	9/11/2014	CUT	7	3.09	2.27
Sheep	BSC-1	9/11/2014	CUT	5	3.09	1.62
Sheep	BSC-1	9/11/2014	SCU	9.5	3.09	3.08
Sheep	BSC-1	9/11/2014	SCU	8.6	3.09	2.79
Sheep	BSC-1	9/11/2014	SCU	6.4	3.09	2.07
Sheep	BSC-1	9/11/2014	SCU	8.4	3.09	2.72
Sheep	BSC-1	9/11/2014	SCU	8.1	3.09	2.63
Sheep	BSC-1	9/11/2014	SCU	7.4	3.09	2.40
Sheep	BSC-1	9/11/2014	SCU	8.2	3.09	2.66
Sheep	BSC-1	9/11/2014	SCU	8.6	3.09	2.79
Sheep	BSC-1	9/11/2014	SCU	8.6	3.09	2.79
Sheep	BSC-1	9/11/2014	SCU	7.7	3.09	2.50
Sheep	BSC-1	9/16/2015	CUT	6.43	1.75	3.68
Sheep	BSC-1	9/16/2015	CUT	5.5	1.75	3.15
Sheep	BSC-1	9/16/2015	CUT	5.62	1.75	3.22
Sheep	BSC-1	9/16/2015	CUT	4.69	1.75	2.69

Appendix 1. Whole-body fish tissue and surface water selenium data collected at locations in the Georgetown Creek watershed and Upper Blackfoot River watershed used to calculate site-specific water column trigger values.

Stream	Location	Sample Date	Species	Whole-Body Fish (mg Se/kg WB dw)	Annual Average Dissolved Se (µg/L)	Fish Whole-Body BAF
Georgetown Creek						
Sheep	BSC-1	9/16/2015	CUT	6.73	1.75	3.86
Sheep	BSC-1	9/16/2015	CUT	6.57	1.75	3.77
Sheep	BSC-1	9/16/2015	CUT	10.43	1.75	5.98
Sheep	BSC-1	9/16/2015	CUT	2.47	1.75	1.42
Sheep	BSC-1	9/16/2015	SCU	10.04	1.75	5.75
Sheep	BSC-1	9/16/2015	SCU	10.24	1.75	5.87
Sheep	BSC-1	9/16/2015	SCU	8.86	1.75	5.08
Sheep	BSC-1	9/16/2015	SCU	8.26	1.75	4.73
Sheep	BSC-1	9/16/2015	SCU	6.25	1.75	3.58
Sheep	BSC-1	9/16/2015	SCU	7.31	1.75	4.19
Sheep	BSC-1	9/16/2015	SCU	9.61	1.75	5.51
Sheep	BSC-1	9/16/2015	SCU	11.26	1.75	6.45
Sheep	BSC-1	9/16/2015	SCU	8	1.75	4.58
Sheep	BSC-1	9/16/2015	SCU	6.91	1.75	3.96
Sheep	BSC-1	9/13/2016	CUT	5.16	2.40	2.15
Sheep	BSC-1	9/13/2016	CUT	4.64	2.40	1.93
Sheep	BSC-1	9/13/2016	CUT	4.77	2.40	1.99
Sheep	BSC-1	9/13/2016	CUT	4.28	2.40	1.78
Sheep	BSC-1	9/13/2016	CUT	4.83	2.40	2.01
Sheep	BSC-1	9/13/2016	CUT	6.53	2.40	2.72
Sheep	BSC-1	9/13/2016	CUT	4.56	2.40	1.90
Sheep	BSC-1	9/13/2016	SCU	6.71	2.40	2.80
Sheep	BSC-1	9/13/2016	SCU	7.99	2.40	3.33
Sheep	BSC-1	9/13/2016	SCU	7.04	2.40	2.93
Sheep	BSC-1	9/13/2016	SCU	8.11	2.40	3.38
Sheep	BSC-1	9/13/2016	SCU	7.84	2.40	3.27
Sheep	BSC-1	9/13/2016	SCU	6.51	2.40	2.71
Sheep	BSC-1	9/13/2016	SCU	6.8	2.40	2.83
Sheep	BSC-1	9/13/2016	SCU	7.72	2.40	3.22
Sheep	BSC-1	9/13/2016	SCU	7.79	2.40	3.25
Sheep	BSC-1	9/13/2016	SCU	7.43	2.40	3.10
Sheep	BSC-2	9/9/2014	CUT	9.7	3.58	2.71
Sheep	BSC-2	9/9/2014	CUT	6.1	3.58	1.71
Sheep	BSC-2	9/9/2014	CUT	5.8	3.58	1.62
Sheep	BSC-2	9/9/2014	CUT	9.8	3.58	2.74
Sheep	BSC-2	9/9/2014	CUT	5.19	3.58	1.45
Sheep	BSC-2	9/9/2014	SCU	4.7	3.58	1.31
Sheep	BSC-2	9/9/2014	SCU	4.6	3.58	1.29
Sheep	BSC-2	9/9/2014	SCU	7.2	3.58	2.01
Sheep	BSC-2	9/9/2014	SCU	6.2	3.58	1.73
Sheep	BSC-2	9/9/2014	SCU	8.4	3.58	2.35
Sheep	BSC-2	9/9/2014	SCU	9.5	3.58	2.66
Sheep	BSC-2	9/9/2014	SCU	6	3.58	1.68
Sheep	BSC-2	9/15/2015	CUT	6.13	2.59	2.37
Sheep	BSC-2	9/15/2015	CUT	4.66	2.59	1.80
Sheep	BSC-2	9/15/2015	CUT	3.47	2.59	1.34
Sheep	BSC-2	9/15/2015	CUT	4.29	2.59	1.66
Sheep	BSC-2	9/15/2015	CUT	6.07	2.59	2.35
Sheep	BSC-2	9/15/2015	CUT	4.63	2.59	1.79
Sheep	BSC-2	9/15/2015	CUT	4.68	2.59	1.81
Sheep	BSC-2	9/15/2015	CUT	3.91	2.59	1.51
Sheep	BSC-2	9/15/2015	CUT	3.51	2.59	1.36
Sheep	BSC-2	9/15/2015	CUT	3.7	2.59	1.43
Sheep	BSC-2	9/15/2015	SCU	7.23	2.59	2.80
Sheep	BSC-2	9/15/2015	SCU	11.71	2.59	4.53
Sheep	BSC-2	9/15/2015	SCU	8.22	2.59	3.18
Sheep	BSC-2	9/15/2015	SCU	6.61	2.59	2.56
Sheep	BSC-2	9/15/2015	SCU	7.72	2.59	2.99
Sheep	BSC-2	9/15/2015	SCU	7.59	2.59	2.94
Sheep	BSC-2	9/15/2015	SCU	7.69	2.59	2.97
Sheep	BSC-2	9/15/2015	SCU	9.95	2.59	3.85
Sheep	BSC-2	9/15/2015	SCU	6.92	2.59	2.68
Sheep	BSC-2	9/15/2015	SCU	10.46	2.59	4.05
Sheep	BSC-2	9/13/2016	CUT	3.72	3.10	1.20
Sheep	BSC-2	9/13/2016	CUT	5.52	3.10	1.78
Sheep	BSC-2	9/13/2016	CUT	4.04	3.10	1.30
Sheep	BSC-2	9/13/2016	SCU	5.64	3.10	1.82
Sheep	BSC-2	9/13/2016	SCU	8.02	3.10	2.59
Sheep	BSC-2	9/13/2016	SCU	8	3.10	2.58
Sheep	BSC-2	9/13/2016	SCU	6.55	3.10	2.11
Sheep	BSC-2	9/13/2016	SCU	7.25	3.10	2.34
Sheep	BSC-2	9/13/2016	SCU	11.8	3.10	3.81
Sheep	BSC-2	9/13/2016	SCU	6.71	3.10	2.16
Sheep	BSC-2	9/13/2016	SCU	7.71	3.10	2.49
Sheep	BSC-2	9/13/2016	SCU	6.24	3.10	2.01
Sheep	BSC-2	9/13/2016	SCU	7.1	3.10	2.29

Notes:

BRK = Brook Trout

RBT = Rainbow Trout

CUT = Cutthroat Trout

SCU = Sculpin

Appendix 1. Whole-body fish tissue and surface water selenium data collected at locations in the Georgetown Creek watershed and Upper Blackfoot River watershed used to calculate site-specific water column trigger values.

Stream	Location	Sample Date	Species	Whole-Body Fish (mg Se/kg WB dw)	Annual Average Dissolved Se (µg/L)	Fish Whole-Body BAF
Georgetown Creek						

Attachment 1. Compendium of Fish Surveys in the Upper Blackfoot River Watershed

Surveys	Dates	Data Source	Streams	Total Fish Count	Fish Species
Idaho Department of Fish and Game - Fish Srveys[1]	1959 - 1961	Culpin (1963)	Blackfoot River and tributaries: Angus Creek, Bacon Creek, Chippy Creek, Diamond Creek, Lanes Creek, Sheep Creek, Timothy Creek	1,467	Yellowstone cutthroat trout
	1970-1971	Heimer (1972)	Diamond Creek, Angus Creek, Lanes Creek, Sheep Creek, Spring Creek, Timothy Creek, Trail Creek, Slug Creek	624	Blackfoot reservoir: chubs and suckers. Tributaries: Yellowstone cutthroat trout
	1978-1981	Thurow (1980, 1981)	Blackfoot Reservoir and Blackfoot River	1,611	Yellowstone cutthroat trout, hatchery and wild rainbow trout
	1960-1980	Thurow (1981)	Blackfoot River	7,670	Cutthroat trout
	1981	Thurow (1980, 1981)	Diamond Creek, Sheep Creek, Spring Creek, Bacon Creek, Browns Canyon Creek, Diamond Creek, Kendall Creek, Lanes Creek, Sheep Creek, Slug Creek Spring Creek, Timothy Creek, Trail Creek	5,049	Brook trout, Yellowstone cutthroat trout
	1981	Mariah (1981)	Timber Creek, Diamond Creek, Slug Creek, Trail Creek	1,299	Brook trout, cutthroat trout, longnose dace, speckled dace, Paiute sculpin, Utah chub
	1978-1986	Schill and Heimer (1988); Heimer (1987)	Spring Creek, Timothy Creek, Bacon Creek, Browns Canyon Creek, Sheep Creek	1,728 Spawners; 1,513 Redds	Yellowstone cutthroat trout
	1987	Schill and Heimer (1988)	Diamond Creek	183	Trout > 90 mm
	1999-2001	Meyer and Lamansky (2002)	Angus Creek, Bacon Creek, Bear Canyon Creek, Browns Canyon Creek,Chippy Creek, Cold Spring Creek, Coyote Creek, Diamond Creek, Dry Canyon Creek, Kendal Creek, Lanes Creek, Maybe Creek, Sheep Creek, Slug Creek, Stewart Canyon, Timber Creek, Trail Creek	1,699	Brook trout, hybrid trout, rainbow trout, Yellowstone cutthroat trout, mottled sculpin, Paiute sculpin, longnose dace, speckled dace, leatherside chub, Utah chub, mountain sucker, Utah sucker, redside shiner
	2001	Maxim (2001)	Middle Sheep Creek	190	Cutthroat trout, mottled sculpin
	2001-2007	Teuscher (2009)	Blackfoot River	8,752	Yellowstone cutthroat trout
Idaho Department of Fish and Game - stock records	1967-2016	IDFG (2017)	Blackfoot River	36,052,232	Coho salmon (pre-1977), cutthroat trout, rainbow trout, hybrid (rainbow x cutthroat)
Beneficial Use Reconnaissance Program Data	1993 - 2016	IDEQ (2017)	Blackfoot River and tributaries: Angus Creek, Bacon Creek, Browns Canyon, Chicken Creek, Chippy Creek, Corrailsen Creek, Corral Creek, Coyote Creek, Daves Creek, Diamond Creek, Dry Valley Creek, Johnson Creek, Kendall Canyon Creek, Lanes Creek, Little Blackfoot River, Mill Canyon, Olsen Creek, Sheep Creek, Slug Creek, Spring Creek, State Land Creek, Timothy Creek, Trail Creek.Timothy Creek,	1,744	Utah sucker, mountain sucker, mottled sculpin, Paiute sculpin, lake chub, cutthroat trout, rainbow trout, brook trout, mountain whitefish, longnose dace, leopard dace, speckled dace, redside shiner

Attachment 1. Compendium of Fish Surveys in the Upper Blackfoot River Watershed

US Forest Service Surveys[1]	2000-2002	USFS (2009); Formation (2011)	Angus Creek, Bacon Creek, Bear Canyon Creek, Browns Canyon Creek, Cabin Creek, Campbell Creek, Corrailsen Creek, Coyote Creek, Daves Creek, Diamond Creek, Goodheart Creek, Hornet Creek, Johnson Creek, Kendall Creek, Lander Creek, Lanes Creek, Mill Creek, Mill Canyon Creek, Olsen Creek, S. Stewart Canyon Creek, Timber Creek, Trail Creek, Yellow Jacket Creek	Not Reported	Cutthroat trout, rainbow trout, brook trout, speckled dace, longnose dace, redside shiner, sculpin spp., sucker spp.
GEI and Arcadis	2013-2016	GEI (2014, 2015, 2016a,b); Arcadis (2017)	Angus Creek, Bear Canyon Creek, Coyote Creek, Sheep Creek, South Fork Sheep Creek, Slug Creek, South Fork Timber Creek.	6,623	Brook trout, cutthroat trout, sculpin spp., mountain sucker, Utah sucker, longnose dace, speckled dace, redside shiner

Notes:

[1]Survey data requested from Agencies

Acronyms and Abbreviations:

IDFG = Idaho Department of Fish and Game
IDEQ = Idaho Departmetn of Environmental Quality
USFS = United States Forest Service

References:

Arcadis. 2017a. Draft 2016 Aquatic Biomonitoring Data Summary Report. South and Central Rasmussen Ridge Area. Caribou County, Idaho.

Arcadis. 2017b. Draft 2016 Aquatic Biomonitoring Data Summary Report for Champ Mine Area Streams. Caribou County, Idaho.

Cuplin, Paul. 1963. Blackfoot River Fishery Investigation. F 38-R, May 1, 1959 to April 30, 1961. Federal Aid to Fish Restoration Job Completion Report. State of Idaho Fish and GameDepartment. December, 1963.

Formation. 2011. Data Summary Report - Upper Blackfoot River Watershed. Preliminary Draft. Prepared for: J.R. Simplot Company. August.

GEI. 2014. Aquatic Biological Sampling Data Report for No Name Creek and South Rasmussen Drainage, 2013. Caribou County, Idaho.

GEI. 2015. Aquatic Biological Sampling Data Report for South and Central Rasmussen Ridge Area Streams, 2014. Caribou County, Idaho.

GEI. 2016a. Aquatic Biological Sampling Data Summary Report for Champ Mine Area Streams, 2015, Caribou County, Idaho.

GEI. 2016b. Aquatic Biological Sampling Data Summary Report for South and Central RasmussenRidge Area Streams, 2015, Caribou County, Idaho.

Heimer, J.T. 1972. Blackfoot Fisheries Inventory, Idaho Fish and Game Department, Vol 29,Article 11, April 1972.

Heimer, J., D. Schill, M. Harenda, and T. Ratzlaff 1987. Federal Aid in Fish Restoration, JobPerformance Report, Regional Fisheries Management Investigations, Project F-71-R-11, IDFG, December 1987.

Idaho Department of Fish and Game. 2017. Blackfoot Basin. Historical Stocking Records. https://fishandgame.idaho.gov/ifwis/fishingplanner/stocking/?search=blackfoot.

Idaho Department of Environmental Quality. 2017. BURP Data Viewer. http://www2.deq.idaho.gov/water/BurpViewer/BurpSite/

Mariah Associates. 1992. Aquatic Monitoring Program for Rhone-Poulenc's Wooley ValleyOperation, Caribou County, Idaho. Final Report to Rhone-Poulenc Basic Chemicals Company, Montpelier, Idaho.

Maxim Technologies, Inc. (Maxim). 2001. Baseline Data Collection Aquatic Resources, NorthRasmussen Ridge Mines, Caribou County, Idaho. Prepared for Agrium-CPO. May 2001.

Meyer, K.A., Lamansky, J.A. Jr., Schill, D.J., Zaroban, D.W. 2013. Nongame Fish Species Distribution and Habitat Associations in the Snake River Basin of Southern Idaho. Western North American Naturalist. 73(1) 20-34.

Schill, D. and J. Heimer, 1988. Federal Aid in Fish Restoration, Job Performance Report,Regional Fisheries Management Investigations, Project F-71-R-12, Vol 074, Article 06, November 1988.

Teuscher, D., 2009. Fishery Management Annual Report, Southeast Region, 2007, IDFG 09-118, May 2009.

Thurow, R., 1980. Federal Aid to Fish and Wildlife Restoration, Subproject IV: River & StreamInvestigations, Study IV: Blackfoot River Fisheries Investigations, Project F-73-R-1, IDFG, January 1980.

Thurow, R., 1981. Federal Aid to Fish and Wildlife Restoration, Job Completion Report,Subproject IV: River and Stream Investigations, Study IV: Blackfoot River Fisheries Investigations Jobs I-V. Idaho Department of Fish and Game Project F-73-R-3.

Attachment 2. Compendium of Fish Surveys in the Georgetown Creek Watershed

Surveys	Dates	Data Source	Streams	Total Fish Count	Fish Species
Idaho Department of Fish and Game - Surveys[1]	1994, 1997, 2003, 2007	Teuscher and Capurso (2007)	Left Hand Fork, Georgetown Creek	Not Reported	Brook trout, cutthroat trout, cutthroat/rainbow hybrids, rainbow trout.
Idaho Department of Fish and Game - Stocking Records	1968-2011	IDFG (2017)	Left Hand Fork, Georgetown Creek	81,923	Brook trout, cutthroat trout, rainbow trout.
Idaho Department of Environmental Quality Surveys	1997, 2012, 2013	IDEQ (2017)	Left Hand Fork, Georgetown Creek	58	Brook trout, cutthroat trout, rainbow trout, brown trout.
US Forest Service Surveys[1]	1994	Cowley (1994)	Georgetown Creek	Upper: 9 Lower: Not Reported	Brook trout, cutthroat trout, cutthroat/rainbow hybrids, rainbow trout.
	2000, 2001, 2007	USFS (2003); Teuscher and Capurso (2007)	Left Hand Fork, Georgetown Creek	Not Reported	Brook trout, cutthroat/rainbow hybrids, rainbow trout.
GEI and Arcadis	2015-2016	GEI (2016); Arcadis (2017)	Left Hand Fork, Georgetown Creek	661	Brook trout, Cutthroat trout, Cutthroat/Rainbow hybrids, Rainbow trout.

Notes:

[1]Survey data requested from Agencies

Acronyms and Abbreviations:

IDFG = Idaho Department of Fish and Game
IDEQ = Idaho Departmetn of Environmental Quality
USFS = United States Forest Service

References:

Arcadis. 2017. Draft 2016 Aquatic Biomonitoring Data Summary Report for Georgetown Canyon Mine Area Streams. Georgetown Canyon Mine Site. Bear Lake and Caribou Counties, Idaho. February.

Cowley, P.K. 1994. Fish Surveys of the Caribou National Forest. Uinta and Wasatch-Cache National Forest.

GEI. 2016. Final Aquatic Biological Sampling Data Summary Report for Georgetown Canyon Mine Area Streams, 2015. Bear Lake and Caribou Counties, Idaho. September.

Idaho Department of Fish and Game. 2017. Historical Stocking Records. https://fishandgame.idaho.gov/ifwis/fishingplanner/stocking/.

[1]Survey data requested from Agencies

U.S. Forest Service Caribou-Targhee National Forest. 2003. U.S. Department of Agriculture. Georgetown Ecosystem Analysis at the Watershed Scale. May.

IDEQ = Idaho Department of Environmental Quality