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July 16, 2019

SENT VIA EMAIL TO: paula.wilson@deq.idaho.gov
Docket: 58-0102-1801
Human Health Water Quality Criteria for Arsenic

Ms. Paula Wilson
Idaho Department of Environmental Quality
1410 N. Hilton, Boise, ID 83706

Dear Ms. Wilson:

The Department of Environmental Quality (Department) has commenced a rulemaking to revise the arsenic human health water quality criteria and has an upcoming update meeting on July 23. The J.R. Simplot Company (Simplot) has participated in past meetings on this rulemaking and has retained Arcadis U.S. Inc. (Arcadis) to help provide technical information relevant to this rulemaking.

Back in August, 2018, the Idaho Association of Commerce and Industry (IACI) proposed a recommended framework for revising Idaho's human health water quality criteria.

- A. Develop additional data on arsenic water quality and paired water arsenic/fish tissue values, including samples collected in undisturbed mineralized areas of the state. These data will be helpful in developing Idaho-specific BAFs, estimates of speciation of arsenic in fish tissue and surface water, and identifying Idaho waters where use of CWA implementation tools (such as use attainability analysis) might be warranted. The sampling plan for such a study should be made available for public review and comment.
- B. Evaluate alternative approaches to assessing the toxicity of arsenic, including use of Idaho-specific data.
- C. The data gathered and alternative approaches can potentially be used for:
 - a. The development of an Idaho specific arsenic criteria that uses state specific data (such as BAF, arsenic speciation, and fish consumption rate) and an alternative toxicity assessment approach;
 - b. Developing organism only criteria for water bodies that are not designated as drinking water supply. Preliminary calculations (shown in Appendix C) derive an Idaho-specific criterion of 15 µg/L; and

- c. Identification of water bodies where criteria would be based on natural background conditions or a use attainability analysis.

To support this framework, Simplot asked Arcadis to evaluate water column and fish tissue data gathered in Montana and compare those to Idaho data. Based on this review (see attachment), there is a strong indication that inorganic arsenic concentrations in fish are independent of inorganic arsenic concentrations in water. A 15 microgram per liter ($\mu\text{g/L}$) fish consumption only criteria can be derived using an Idaho-specific BAF of 0.53 L/kg combined with the Department's standard assumptions to derive human health criteria for fish consumption only.

We hope this information is helpful to the Department in deriving an Idaho human health water quality criterion for arsenic. Please contact me at (208) 780-7365 if you have any questions.

Sincerely,



Alan L. Prouty
Vice President, Environmental & Regulatory Affairs

Attachment

C (with attachment)
Paul Anderson, Arcadis
Alex LaBeau, IACI
Lisa Macchio, EPA Region 10

J.R. Simplot Company

SUMMARY OF MONTANA ARSENIC SURFACE WATER AND FISH TISSUE DATA AND COMPARISON TO IDAHO DATA

April 2019

A large, solid orange geometric shape, resembling a stylized triangle or a section of a larger triangle, is positioned in the bottom right corner of the page. It is composed of two overlapping triangles, creating a complex, angular form that extends from the bottom edge towards the right edge and slightly upwards.

SUMMARY OF MONTANA ARSENIC SURFACE WATER AND
FISH TISSUE DATA AND COMPARISON TO IDAHO DATA

**SUMMARY OF
MONTANA ARSENIC
SURFACE WATER AND
FISH TISSUE DATA
AND COMPARISON TO
IDAHO DATA**



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Our Ref.:
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Date:
April 16, 2019

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SUMMARY OF MONTANA ARSENIC SURFACE WATER AND FISH TISSUE DATA AND COMPARISON TO IDAHO DATA

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- Figure 6 Plot of total arsenic in paired samples of surface water and fish tissue for Montana, Idaho, and both states combined (assumes concentration in non-detected samples is equal to the detection limit)

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ACRONYMS AND ABBREVIATIONS

BAF	bioaccumulation factor
IDEQ	Idaho Department of Environmental Quality
HHC	human health criteria
Montana DEQ	Montana Department of Environmental Quality
USEPA	United States Environmental Protection Agency

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1 INTRODUCTION

Based on the presentation by the Montana Department of Environmental Quality (Montana DEQ) at the 27 June 2018 rulemaking meeting regarding establishing non-anthropogenic background concentrations of arsenic in Montana Rivers, Arcadis reached out to Erik Makus of the Montana DEQ to see if paired surface water and fish tissue data were available and if such data could be shared to allow for an evaluation of arsenic bioaccumulation parallel to the one conducted using paired data from Idaho and provided to the Idaho Department of Environmental Quality (IDEQ) earlier this year (Arcadis 2018). Montana DEQ had paired data and was able to share those data. The remainder of this white paper summarizes and evaluates the paired arsenic in surface water and fish tissue data received from Montana DEQ. As described in more detail below, the data are generally consistent with paired data collected by Idaho in 2008 (IDEQ 2010) and reinforce the findings of the Arcadis (2018) evaluation. Specifically, that bioaccumulation of inorganic arsenic in fish tissue is substantially lower than assumed by the United States Environmental Protection Agency's (USEPA's) existing ambient water quality criteria, that existing Idaho (and Montana) data can be used to derive protective and practical state-wide water quality criteria applicable to waters designated for recreational use, and that when collecting fish tissue samples in the future, detection limits for inorganic arsenic in fish tissue should be as low as possible to better understand the ratio of inorganic to total arsenic in fish tissue and to develop a more representative bioaccumulation factor for inorganic arsenic in fish.

2 OVERVIEW OF MONTANA ARSENIC DATA

Montana DEQ provided several years' worth of data on the concentration of arsenic in surface water. Montana DEQ also provided arsenic fish tissue data from 2016, the only year for which fish tissue data are available. Because paired surface water and fish tissue data are only available from the Madison River in 2016, this white paper summarizes and focuses on only the paired surface water and fish tissue data collected in 2016. Figure 1 identifies the three locations on the Madison River from which paired data are available. A single surface water sample collected in October 2016 is available from each sampling location (Table 1). Each water sample was analyzed for total arsenic but not inorganic arsenic. Total arsenic concentrations range from 0.031 to 0.089 mg/L (Table 1). Three tissue samples were collected from each of three fish species (Mountain Whitefish, Rainbow Trout, and Brown Trout) near each of the surface water sampling locations in September 2016 (Figure 1, Table 1). The fish tissue samples were analyzed for total arsenic and inorganic arsenic (Table 1) as well as several inorganic arsenic species (inorganic arsenic species are not shown in Table 1). Total arsenic was detected in 24 of 27 tissue samples at concentrations ranging from 0.25 to 2.1 mg/kg (Table 1). Inorganic arsenic was not detected in any fish tissue samples at detection limits ranging from 0.094 to 0.100 mg/kg (Table 1).

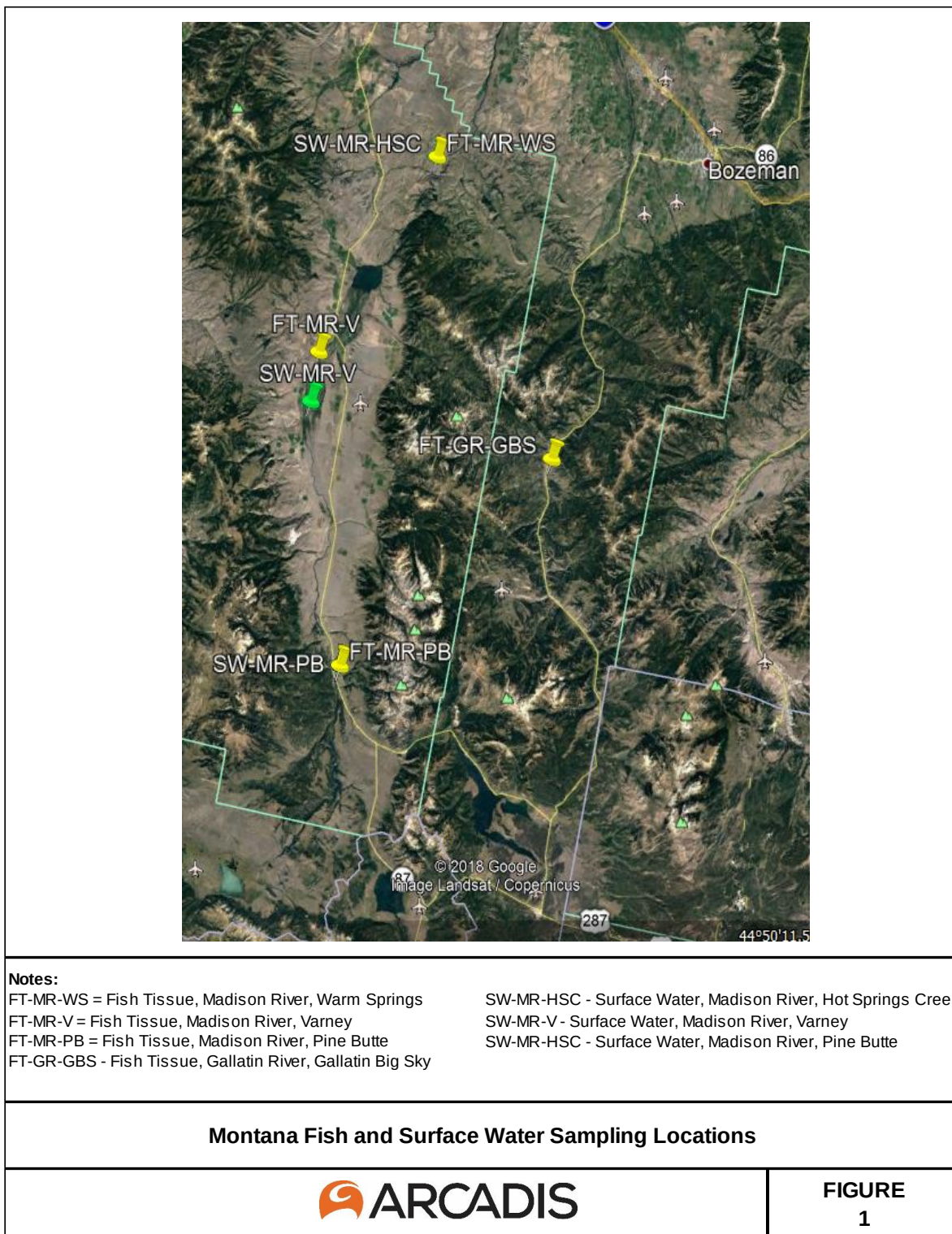
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Table 1. Montana surface water and fish tissue data.

Fish Sample ID Number	Fish Sample Location	Fish Species	Fish Tissue - Total Arsenic (mg/kg)	Fish Tissue - Total Arsenic Lab Qualifier	Fish Tissue - Inorganic Arsenic (mg/kg)	Fish Tissue - Inorganic Arsenic Lab Qualifier	Inorganic Arsenic as a percentage of Total Arsenic (%)	Surface Water Sample Location	Surface Water - Total Arsenic (mg/l)
16364800	Varney	Mt. Whitefish	0.420		0.100	U	24	Madison River at Varney Road crossing	0.089
16364801	Varney	Mt. Whitefish	0.420		0.090	U	21		0.089
16364802	Varney	Mt. Whitefish	0.380		0.100	U	26		0.089
16364803	Varney	Rainbow Trout	1.000		0.094	U	9		0.089
16364804	Varney	Rainbow Trout	0.610		0.100	U	16		0.089
16364805	Varney	Rainbow Trout	1.700		0.100	U	6		0.089
16364806	Varney	Brown Trout	0.840		0.095	U	11		0.089
16364807	Varney	Brown Trout	0.280		0.099	U	35		0.089
16364808	Varney	Brown Trout	0.590		0.096	U	16	Madison River downstream of Hot Springs Creek and near mouth of Beartrap Canyon	0.089
16364809	Warm Springs/Norris	Mt. Whitefish	0.590		0.098	U	17		0.031
16364810	Warm Springs/Norris	Mt. Whitefish	0.280		0.100	U	36		0.031
16364811	Warm Springs/Norris	Mt. Whitefish	0.610		0.100	U	16		0.031
16364812	Warm Springs/Norris	Rainbow Trout	0.250		0.096	U	38		0.031
16364813	Warm Springs/Norris	Rainbow Trout	0.360		0.093	U	26		0.031
16364814	Warm Springs/Norris	Rainbow Trout	0.510		0.100	U	20		0.031
16364815	Warm Springs/Norris	Brown Trout	0.210	U	0.098	U	47		0.031
16364816	Warm Springs/Norris	Brown Trout	0.280		0.099	U	35		0.031
16364817	Warm Springs/Norris	Brown Trout	0.350		0.096	U	27		0.031
16404818	Gallatin Big Sky	Mt. Whitefish	0.260		0.099	U	38	No surface water data	
16404819	Gallatin Big Sky	Mt. Whitefish	0.200	U	0.092	U	46		
16404820	Gallatin Big Sky	Mt. Whitefish	0.490		0.098	U	20		
16404821	Gallatin Big Sky	Rainbow Trout	0.280		0.100	U	36		
16404822	Gallatin Big Sky	Rainbow Trout	0.620		0.099	U	16		
16404823	Gallatin Big Sky	Rainbow Trout	0.200	U	0.100	U	50		
16404824	Gallatin Big Sky	Brown Trout	0.200	U	0.095	U	48		
16404825	Gallatin Big Sky	Brown Trout	0.460		0.097	U	21		
16404826	Gallatin Big Sky	Brown Trout	0.500		0.098	U	20	Madison River at Pine Butte	0.060
16394827	Pine Butte	Mt. Whitefish	0.410		0.100	U	24		0.060
16394828	Pine Butte	Mt. Whitefish	0.340		0.100	U	29		0.060
16394829	Pine Butte	Mt. Whitefish	0.440		0.095	U	22		0.060
16394930	Pine Butte	Rainbow Trout	0.200	U	0.100	U	50		0.060
16394931	Pine Butte	Rainbow Trout	2.100		0.099	U	5		0.060
16394932	Pine Butte	Rainbow Trout	0.200	U	0.100	U	50		0.060
16394933	Pine Butte	Brown Trout	0.770		0.096	U	12		0.060
16394934	Pine Butte	Brown Trout	0.600		0.100	U	17		0.060
16394935	Pine Butte	Brown Trout	0.450		0.100	U	22		0.060

Notes: U = Analyte was not detected at or above the reported value.

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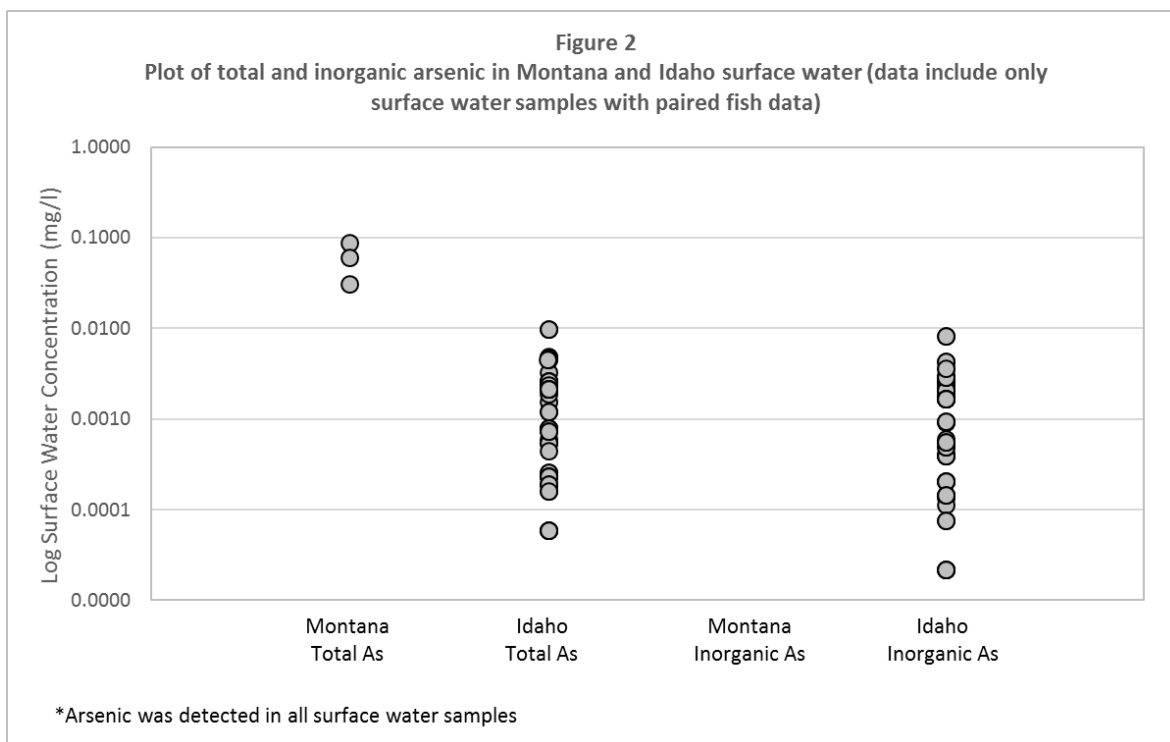


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The remainder of this memorandum compares the 2016 Montana data to the 2008 Idaho data and develops estimates of bioaccumulation factors (BAFs) for arsenic based on the Montana data. To the extent the Montana data permit, the development of BAFs parallels that presented for the Idaho data in the Arcadis (2018) evaluation prepared in response to the 19 April 2018 Idaho Rulemaking meeting.

3 COMPARISON OF MONTANA AND IDAHO SURFACE WATER DATA

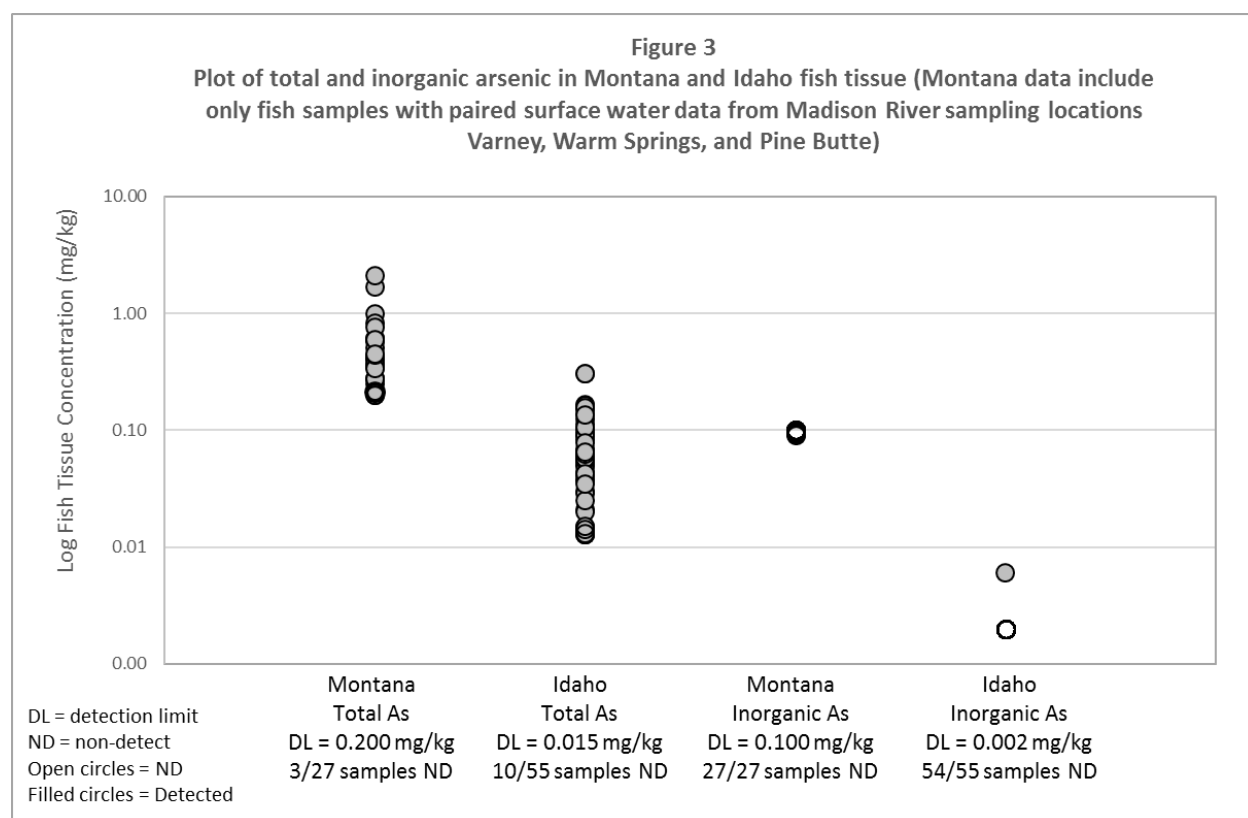
The concentration of total arsenic in the Montana surface water samples is substantially higher than in the Idaho surface water samples. The minimum concentration in Montana samples was 0.031 mg/L, about three times higher than the maximum concentration of 0.00974 mg/L detected in Idaho (Figure 2). The average total arsenic concentration in the Madison River of 0.06 mg/L is about 30 times higher than the average concentration of 0.002 mg/L in Idaho surface waters (Figure 2).



Because Montana did not speciate arsenic in surface water, inorganic arsenic concentrations in surface water between the two states cannot be compared nor can the Montana data be used to estimate that ratio of total arsenic to inorganic arsenic in surface water.

4 COMPARISON OF MONTANA AND IDAHO FISH TISSUE DATA

Consistent with surface water, the concentration of total arsenic in the Idaho fish tissue samples is substantially lower than the concentration in the Montana fish tissue samples (Figure 3). The average total arsenic concentration in the Madison River fish tissue of 0.56 mg/kg is about 7.5 times higher than the average concentration of 0.074 mg/kg in Idaho fish tissue (Figure 3). The concentration of inorganic arsenic in Madison River fish tissue also appears to be higher than concentrations in Idaho fish tissue (by about 50 times) but that apparent difference is driven by differences in detection limit. All fish tissue samples from the Madison River had nondetectable levels of inorganic arsenic at a detection limit of about 0.1 mg/kg while 54 of 55 Idaho fish tissue samples were also non-detect for inorganic arsenic at a detection limit of 0.002 mg/kg (Figure 3).



As a consequence of the elevated detection limits in Madison River fish tissue, the fraction of total arsenic in fish that is inorganic in fish tissue (also referred to as the ratio of inorganic to total arsenic in fish tissue) is about five times higher than Idaho's. The ratio for Madison River fish is 0.17 while the ratio in Idaho fish is 0.038. Both of these ratios are upper bounds given that, with the exception of a single fish tissue sample in Idaho, both ratios assume inorganic arsenic concentrations in fish tissue are equal to the detection limit. If actual inorganic arsenic concentrations in fish tissue are assumed to equal one half the detection limit, the ratios would be about 0.09 and 0.02, respectively. If the concentrations of inorganic

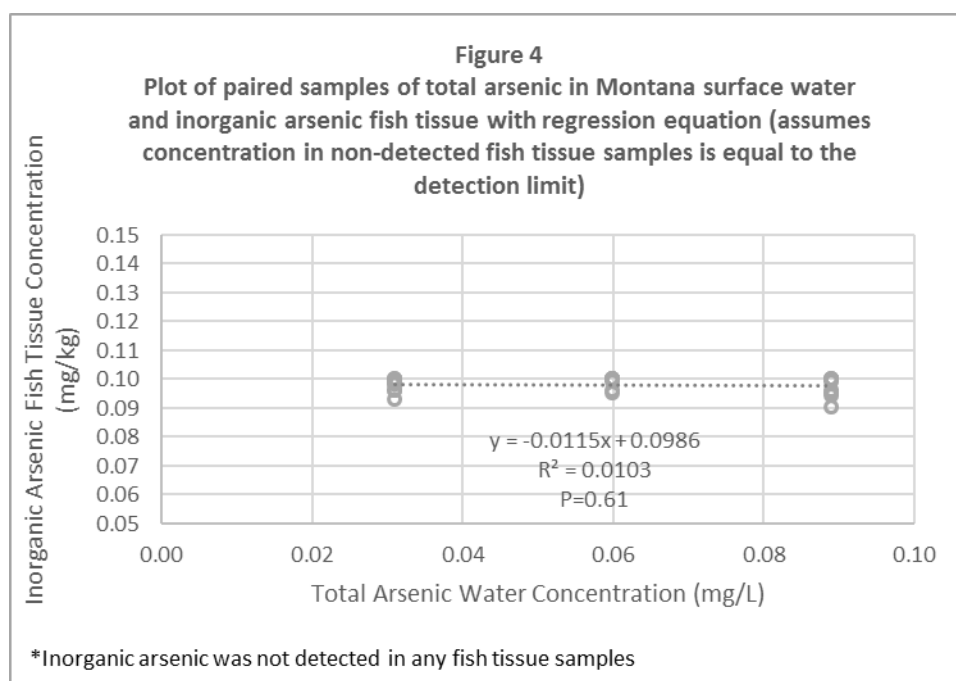
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arsenic are assumed be one tenth the detection limit, the ratios would be about 0.02 and 0.004, respectively.

The finding that inorganic arsenic is not detectable in Madison River fish reinforces the recommendation in the earlier Arcadis white paper (Arcadis 2018) arising from the Idaho fish tissue evaluation; namely, the need to refine the inorganic arsenic in fish tissue detection limit. That detection limit has a direct effect on estimated BAFs for inorganic arsenic in fish tissue. A two-fold decrease in the detection limit would decrease BAFs by two-fold, assuming inorganic arsenic concentrations in fish tissue remained nondetectable.

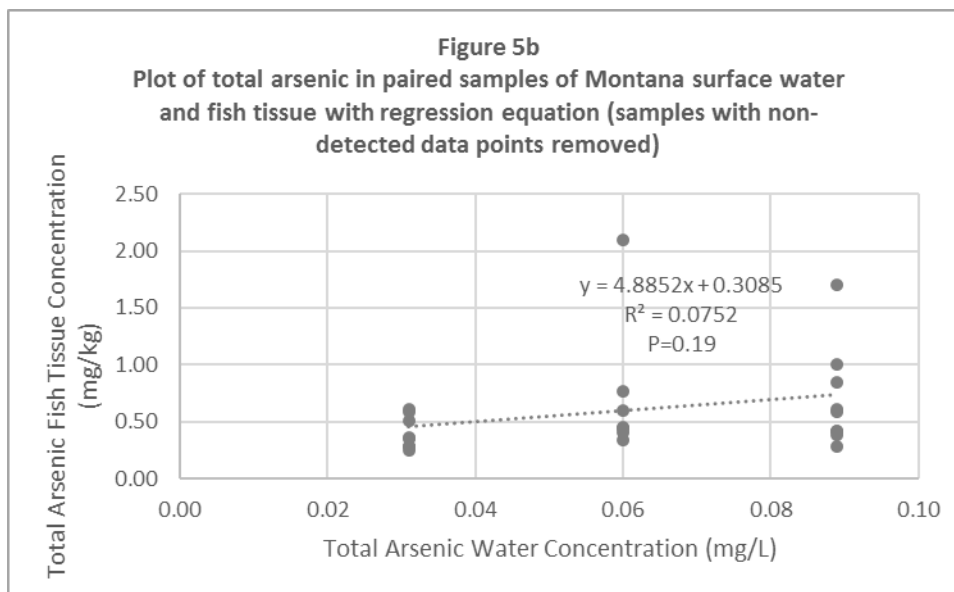
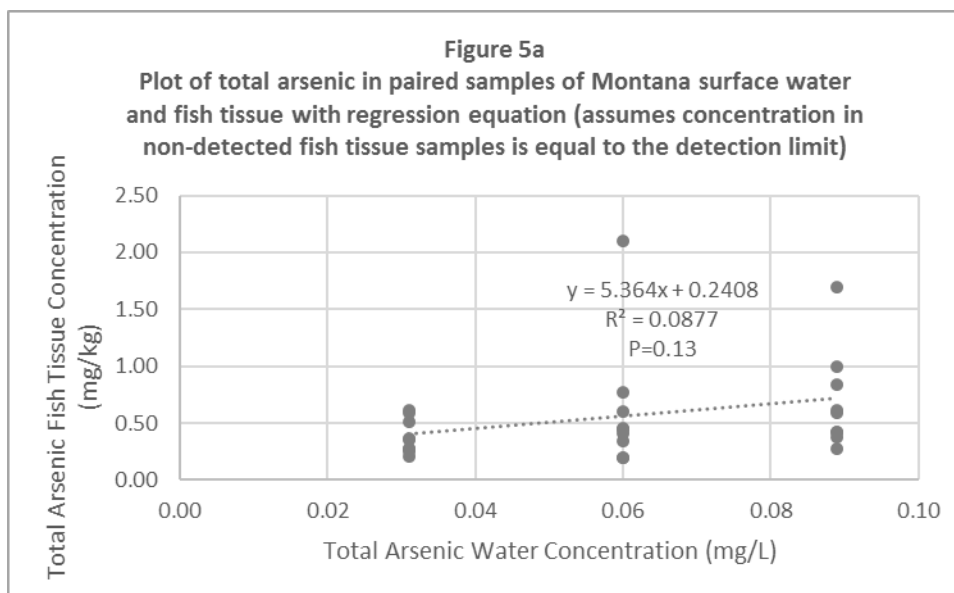
5 RELATIONSHIP BETWEEN SURFACE WATER AND FISH TISSUE CONCENTRATIONS

Even though the concentration of total arsenic in surface water ranged from 0.031 to 0.089 mg/L, the concentration of inorganic arsenic in fish tissue remained not detectable (Figure 4). Thus, given current detection limits, no relationship can be established between total arsenic in water and inorganic arsenic in fish tissue (Figure 4). This is similar to the Idaho data, except that the concentration of total arsenic in Idaho surface water was lower and the detection limit for inorganic arsenic in Idaho fish tissue was lower. Additionally, similar to the Idaho data, if the BAF of 11 L/kg developed by Idaho Department of Environmental Quality (IDEQ 2010) is applied to the Montana surface water concentrations, inorganic arsenic fish tissue concentrations are substantially overpredicted. This finding reinforces that the BAFs developed by IDEQ in 2010 are not predictive and should not be used when establishing statewide human health criteria (HHC) for arsenic.



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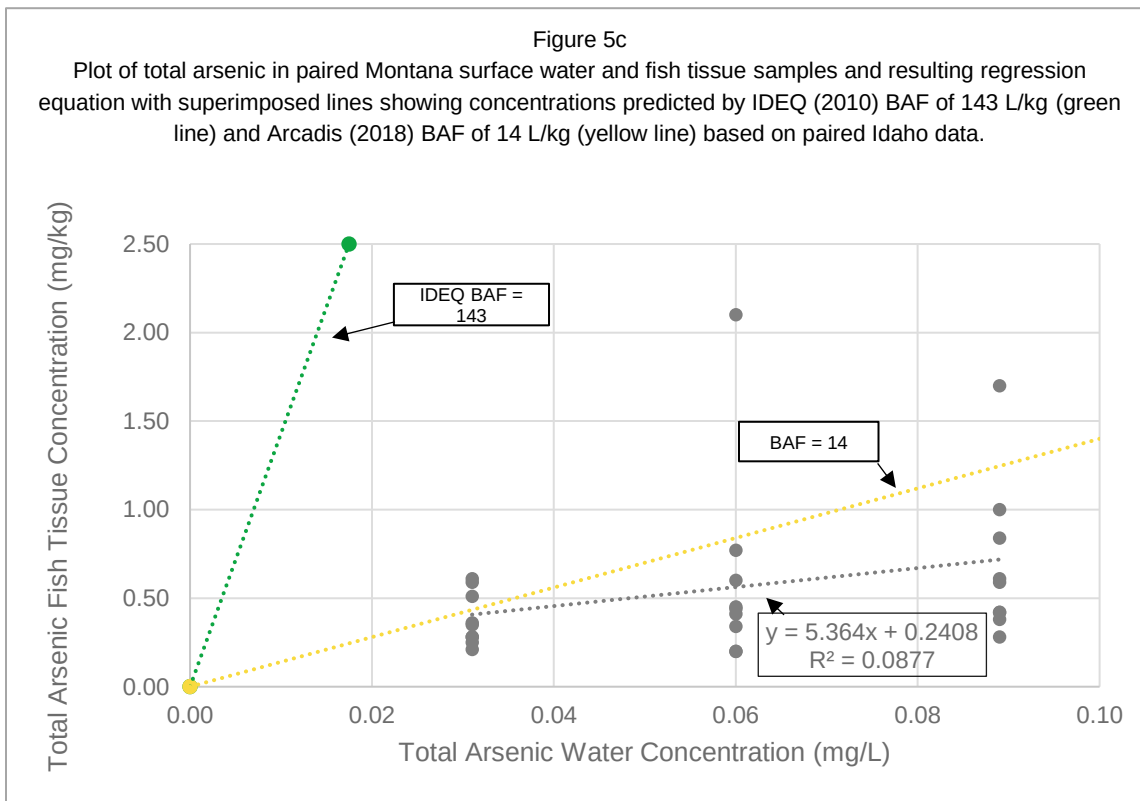
Total arsenic in fish increases linearly with increasing water concentration though the regressions are not statistically significant regardless whether non-detected samples are included in the regression (Figures 5a and 5b). The absence of a statistically significant relationship is due to the limited number of samples, limited range in water concentration (only about three-fold) and large range in fish tissue concentrations (about eight-fold).



The slopes of the regression equations represent the BAF that can be derived from the dataset. Comparison of the slopes of the Montana and Idaho linear regressions of total arsenic in water to total arsenic in fish indicates that the Montana slope is somewhat shallower than the slope based on the Idaho data (5.4 versus 14), indicating that the BAF based on Montana data for total arsenic (in water and fish

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tissue) is lower than the BAF based on Idaho data (Figure 5c). Additionally, as was the case with Idaho fish tissue data, the IDEQ total arsenic BAF of 143 overpredicts measured total arsenic tissue concentrations substantially (Figure 5c). Thus, comparison of all three BAFs indicates the paired Montana water and fish tissue data reinforce the linear regression-based BAF derived using paired Idaho data.

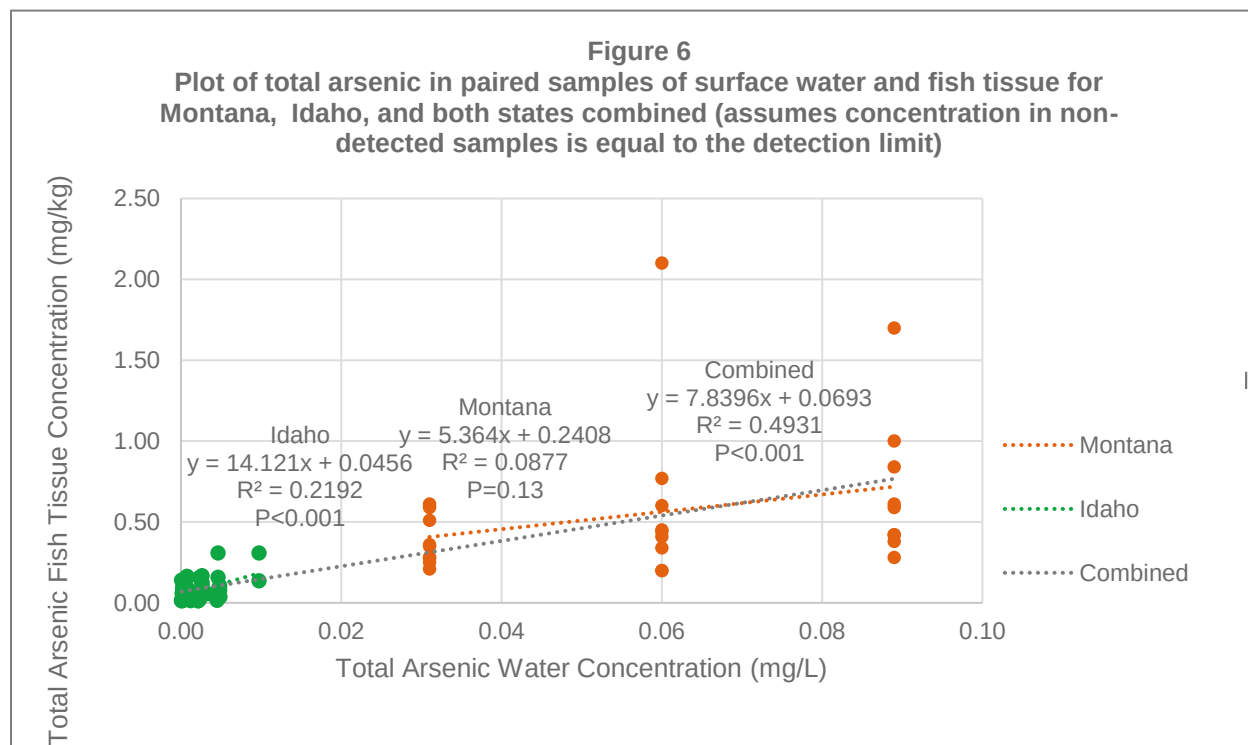


To evaluate the accumulation of arsenic over the entire range of surface water concentrations measured in Idaho and Montana, the paired data sets from both states were combined (Figure 6.) A linear regression of those data is statistically significant ($p < 0.001$) with a slope (i.e., BAF) of about half of that observed using just the Idaho data (Figure 6). That results in a total arsenic in water to total arsenic in fish BAF of 7.8 L/kg (Figure 6) compared to a BAF of 14 L/kg based on only Idaho paired data or of 5.4 L/kg based on only Montana paired data.

As described in the earlier Arcadis report (Arcadis 2018) the total arsenic in water to total arsenic in fish BAFs can be adjusted by the fraction of total arsenic in fish that is comprised of inorganic arsenic to develop BAFs that predict the concentration of inorganic arsenic in fish based of the total concentration of arsenic in surface water. The fraction based on Idaho paired surface water and tissue data is 0.038. The fraction of total arsenic in fish tissue that is assumed to be inorganic arsenic based on paired Montana data is 0.17. The fraction based on combined Idaho and Montana data is 0.09. When the respective total arsenic in surface water to total arsenic in fish BAFs are adjusted by these fractions, the BAFs to predict the inorganic arsenic concentration in fish tissue from total arsenic in surface water become 0.53 L/kg based on just the Idaho paired data, 0.91 L/kg based on just the Montana paired data, and 0.71 L/kg based on the combined Idaho and Montana data. As described above, and previously in Arcadis (2018),

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all of these are upper bound BAFs because inorganic arsenic was detected in only one of 90 fish tissue samples but the BAFs assume that inorganic arsenic was present at the detection limit. Had one half the detection limit been assumed as typical for non-detected concentrations, the BAFs would be two-fold lower (i.e., 0.27, 0.46, and 0.36, respectively). In fact, the actual BAFs could be substantially lower than just two-fold. We don't know how much lower, though given the virtually universal lack of detectable concentrations of inorganic arsenic in fish tissue in both Idaho and Montana fish, actual BAFs are likely to be substantially lower.



6 IDAHO-SPECIFIC FISH CONSUMPTION ONLY HHC

As described in Arcadis (2018) the BAF of 0.53 L/kg can be combined with IDEQ's standard assumptions to derive an HHC for fish consumption only. Those assumptions include consumption of 66.5 grams of Idaho fish by a person weighing 80 kilograms, for every day of the year, for every year of his or her entire lifetime, and an allowable risk of 1×10^{-5} . Using those assumptions and the current cancer slope factor for arsenic of $1.5 \text{ (mg/kg-day)}^{-1}$ results in a fish consumption only HHC of 15 ug/L for total arsenic. Based on the data collected by IDEQ in 2008 (IDEQ 2010), virtually all of the surface waters sampled by IDEQ in 2008, with the exception of the Bruneau River have naturally occurring background concentrations of total arsenic lower than a fish consumption only HHC of 15 ug/L. If a BAF that assumes inorganic arsenic concentrations in fish tissue are equal to one half the detection limit is used to derive the fish consumption only HHC (i.e., a BAF of 0.27 L/Kg), the HHC becomes 30 ug/L. All surface waters sampled by Idaho in 2008 would meet such an HHC. Based on information presented by IDEQ during the 23 May 2018 Rulemaking meeting, such an HHC would be applicable to about "96,490 stream miles in Idaho

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designated (or presumed) for Recreation Uses (fish only criteria)", or about 80 percent of the stream miles in Idaho Summary and Recommendations

The paired surface water and fish tissue data collected by Montana are generally consistent with those collected by IDEQ in 2008. The Montana data reinforce the utility and protectiveness of the BAFs derived based on a linear regression of paired Idaho data (Arcadis 2018) and also reinforce that the IDEQ (2010) BAFs (e.g., 143 L/kg for total arsenic in fish tissue and 11 L/kg for inorganic arsenic in fish tissue) greatly overpredict measured concentrations of either total or inorganic arsenic in fish tissue and should not be used to derive statewide HHC. A key limitation of the Montana data is elevated detection limits for inorganic arsenic in fish tissue. Because of those elevated detection limits, the Montana data cannot be used to refine a key uncertainty associated with the Idaho data; that being the actual concentration of inorganic arsenic fish tissue samples and the fraction of total arsenic in fish tissue that is comprised of inorganic arsenic. Those elevated detection limits do, however, reinforce the need for IDEQ to refine to the extent possible and practical the detection limits for inorganic arsenic in any future fish tissue sampling effort.

Finally, and as described previously (Arcadis 2018), the data collected so far can be used to establish an organism only arsenic HHC. An analysis of the data collected by the Department shows that an Idaho-specific BAF for inorganic arsenic is low. That finding is reinforced by the Montana data. Looking at paired Idaho data, there is a strong indication that inorganic arsenic concentrations in fish are independent of inorganic arsenic concentrations in water. A 15 ug/L fish consumption only criteria can be derived using an Idaho-specific BAF of 0.53 L/kg combined with the Department's standard assumptions to derive human health criteria for fish consumption only. Those assumptions include consumption of 66.5 grams of Idaho fish by a person weighing 80 kilograms, for every day of the year, for every year of his or her entire lifetime, and an allowable risk of 1×10^{-5} . Using those assumptions and the current cancer slope factor for arsenic of $1.5 \text{ (mg/kg-day)}^{-1}$ results in a fish consumption only criteria of 15 ug/L for total arsenic. A criterion of 15 ug/L is protective of human health, and achievable for the vast majority of Idaho's waters.

7 REFERENCES

Arcadis 2018. Idaho Arsenic Human Health Criteria: Comments Prepared in Response to the 19 April 2018 Rulemaking Meeting. Arcadis, Chelmsford, MA. April.

IDEQ. 2010. Arsenic, Mercury, and Selenium in Fish Tissue and Water from Idaho's Major Rivers: A Statewide Assessment. Prepared by Don A. Essig. March

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A decorative graphic consisting of three thin orange lines. One line is horizontal, extending across the width of the page. Two other lines are diagonal, starting from the bottom left and extending towards the top right, intersecting the horizontal line.