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April 30, 2018

SENT VIA EMAIL TO: paula.wilson@deq.idaho.gov

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

Dear Ms. Wilson:

The Department of Environmental Quality (the Department) has commenced a rulemaking to revise the arsenic human health water quality criteria and has requested comments on Discussion Paper #1. The J.R. Simplot Company (Simplot) has numerous operations in Idaho (such as mining, food and fertilizer manufacturing) which may be affected by changes to Idaho's water quality criteria. Thus, Simplot has a direct interest in this rulemaking.

The toxicity threshold of inorganic arsenic in regards to human health has been debated in the scientific community for over 20 years without a clear resolution. EPA, in the National Toxics Rule, established an arsenic criteria (for fish and water consumption) of 0.018 µg/L. However, most waters in Idaho exceed that value. Arsenic is naturally occurring throughout Idaho and is commonly present in groundwater and surface waters at concentrations exceeding several parts per billion. Thus, having a water quality criterion that is less than the groundwater and drinking water standard of 10 µg/L is very problematic.

The attached report describes that the calculation of a BAF for arsenic and why the main exposure to arsenic is via drinking water and not fish consumption. Furthermore, the report discusses the difficulty of arriving at a meaningful water quality criteria for arsenic using traditional risk calculation methodologies. The naturally occurring background concentrations of arsenic in Idaho surface waters suggest that alternative approaches will need to be explored to account for this naturally occurring concentrations.

Sincerely,

Alan L. Prouty
Vice President
Environmental & Regulatory Affairs

Attachment

C:
Food NW
IACI
IMA
NAMC

J.R. Simplot Company

IDAHO ARSENIC HUMAN HEALTH CRITERIA: COMMENTS PREPARED IN RESPONSE TO THE 19 APRIL 2018 RULEMAKING MEETING

April 2018

IDAHO ARSENIC HUMAN HEALTH CRITERIA: COMMENTS PREPARED IN RESPONSE TO THE 19 APRIL 2018 RULEMAKING MEETING

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ME000366.0000

Date:

April 30, 2018

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1 INTRODUCTION

These preliminary comments are submitted in response to Idaho Department of Environmental Quality's (IDEQ's) request for comments during the 19 April 2018 arsenic human health criteria (HHC) rulemaking hearing. Given that IDEQ's request for comments was rather general, and not on a specific proposed approach or specific assumption used by a particular approach, these comments present some additional information on some of the topics discussed during the 19 April 2018 rulemaking meeting.

Specifically, the comments begin by reviewing approaches that can used to develop a bioaccumulation factor (BAF) for arsenic in waters of Idaho and demonstrate that, based on available data, an Idaho-specific BAF for inorganic arsenic is likely to be quite low (less than 1 liter water per kilogram fish (L/kg)). That finding combined with available data on the concentration of inorganic arsenic in fish tissue from Idaho indicate that potential exposures to inorganic arsenic from consumption of fish is very small compared to potential exposures from use of surface water as a potable drinking water source. In fact, the fish consumption exposures are so small compared to potential drinking water exposures, that the focus of the arsenic HHC development process should be on drinking water consumption. The comments conclude by pointing out that the approach and assumptions used by IDEQ in 2016 to update HHC for other substances will lead to an arsenic HHC that is below naturally occurring background concentrations of arsenic in virtually all waters of Idaho. This finding suggests that the approach and assumptions used in 2016 for other substances is not be appropriate for arsenic and that IDEQ will need to evaluate alternative approaches and assumptions to develop an HHC for arsenic that is protective of human health and is also pragmatic, achievable, and recognizes the naturally elevated levels of arsenic in Idaho's surface waters.

2 BAF DERIVATION BACKGROUND

The fundamental conceptual basis for establishing a BAF is that the concentration of a substance in water determines the concentration of that substance in fish. The BAF describes that relationship and allows one to predict fish concentrations from water concentration data.

Historically, BAFs are often calculated simply as the ratio of the concentration of a substance in fish to the concentration of that substance in water. Ideally, both the fish and water concentrations were collected from the same location and at the same time (i.e., are paired samples). If only a single paired sample was available, the fish to water concentration ratio from that sample was assumed to be the BAF. If more than one paired sample was available, an overall BAF was estimated by taking the average of all the BAFs calculated for each sample. That is what IDEQ did to estimate the total arsenic BAF of 143 L/kg (IDEQ 2010). However, even though a BAF can be calculated in this manner, it turns out that does not mean it is an accurate or appropriate predictor of bioaccumulation. A more representative and appropriate estimate of the BAF can be developed by plotting all of the paired data and conducting a regression analysis. The resulting regression equation represents the relationship between water and fish tissue concentration. When the regression is linear, the slope of the regression equation approximates the BAF.

Figures 1a-c provide three different hypothetical example relationships between the concentration of a substance in water and fish based on five paired samples. In Figure 1a, a linear relationship exists between water and fish concentration where the fish concentration is 1/10th the water concentration across the entire range of water concentrations. In that case the BAF is 0.1 L/kg for each sample and is equal to the slope of the regression equation, which is also 0.1. Note too that the average of the fish to water ratio across all five samples is also 0.1 L/kg. In this case, a BAF of 0.1 L/kg is an accurate predictor of fish concentrations.

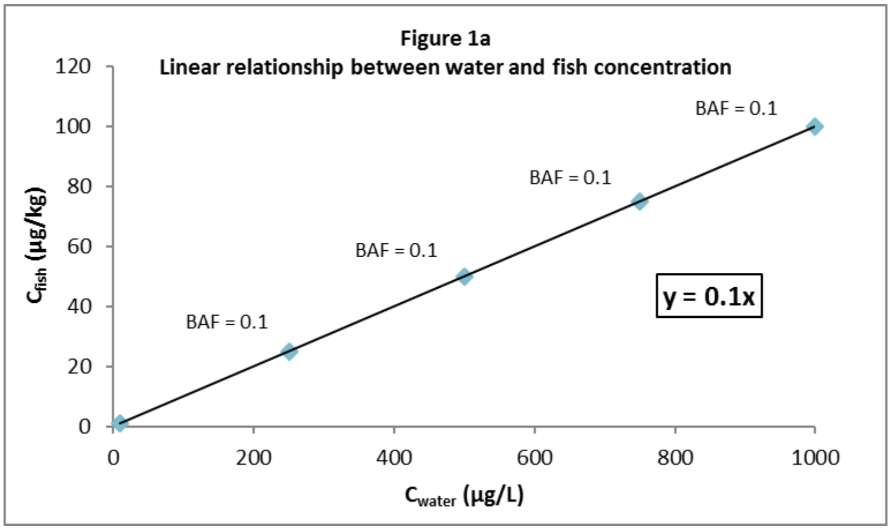


Figure 1b represents a hypothetical scenario where fish concentration is independent of water concentration. Even though water concentration varies by 1,000-fold (from 1 to 1,000 ug/l) the fish concentration remains constant at 5 ug/kg. Because there are five paired samples, a BAF can be calculated for each. Those BAFs range from 0.5 L/kg to 0.005 L/kg and have an arithmetic average BAF of 0.11 L/kg. However, that average BAF is not a good predictor of concentrations in fish. At low concentrations, for example 1 ug/L, the predicted fish concentration is 0.1 ug/kg, about 50 times lower than the measured concentration of 5 ug/kg. At high water concentrations, for example 500 ug/L, the predicted fish concentration is 55 ug/kg, about 10 times higher than the measured concentration. In this case, because fish concentration is independent of water concentration, it is not appropriate to use the average BAF from the five paired samples. The concentration in fish is constant regardless of water concentration.

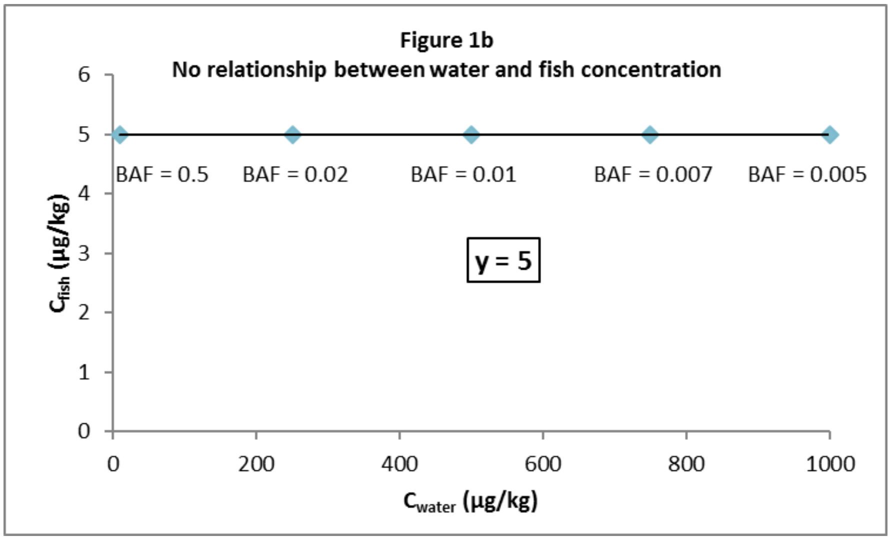
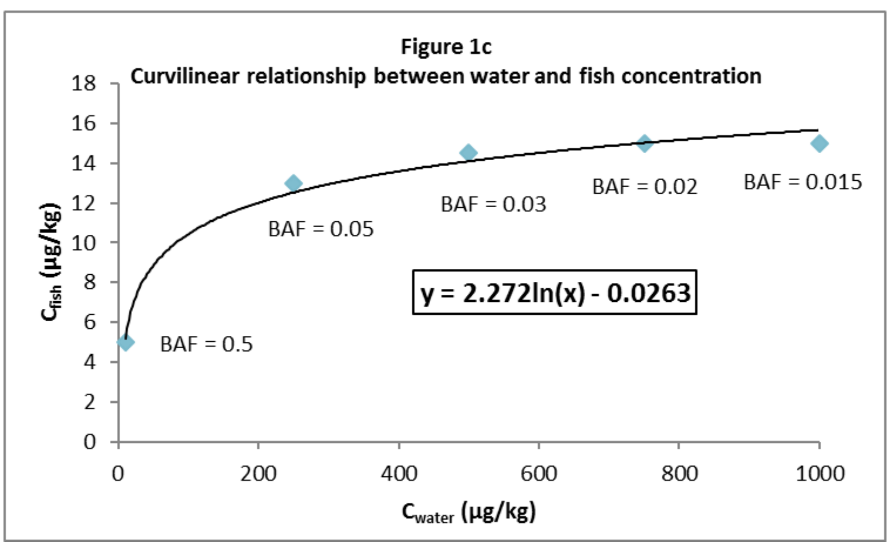


Figure 1c represents a scenario where fish concentration does depend on water concentration, but the relationship is not linear. Fish accumulate the substance at a rapid rate at low water concentrations but at a substantially lower rate at high concentrations. BAFs for the five paired samples range from 0.5 L/kg to 0.015 L/kg and have an arithmetic average BAF of 0.12 L/kg. However, that average BAF is not a good predictor of concentrations in fish. At low concentrations, for example 1 ug/L, the predicted fish concentration is 0.12 ug/kg, about 50 times lower than the measured concentration of 5 ug/kg. At intermediate and high water concentrations, for example 250 or 500 ug/L, the predicted fish concentrations are 30 and 60 ug/kg, about 2 and 4 times, respectively, higher than the measured concentration. Use of the arithmetic average BAF leads to accurate prediction of fish concentrations over a narrow range of water concentrations (between about 60 ug/L and 80 ug/L). As in the above example (Figure 1b) it is not appropriate to use the average BAF from the five paired samples. More accurate prediction over the entire range of concentrations is possible using the curvilinear regression equation shown on Figure 1c.



The key point from these three hypothetical scenarios is that all of the paired water and fish data need to be plotted to see if a relationship is apparent and, if one is, to conduct a regression analysis to quantify that relationship and determine its statistical significance. The next section of these comments presents such a preliminary evaluation of the 2008 IDEQ state-wide paired arsenic and fish data (IDEQ 2010).

3 IDAHO-SPECIFIC BAFS FOR ARSENIC

Idaho is to be commended for having the foresight to collect arsenic background data in fish and water in 2008 (IDEQ 2010). Those data are robust and provide a good overview of the concentration of arsenic (total, inorganic, and organic) in fish tissue and surface water in Idaho. IDEQ used those data to estimate not just background concentrations in water and fish but also to develop a preliminary estimate of arsenic BAFs (IDEQ 2010). Those estimates were 143 L/kg for total As and less than 11 L/kg (<11 L/kg) for inorganic arsenic.

Figure 2a presents the 54 state-wide paired fish and surface water data for inorganic arsenic collected by IDEQ in 2008. With the exception of a single sample, the inorganic arsenic concentration in all fish was not detected at a detection limit of 0.002 mg/kg. This plot is very similar the hypothetical scenario presented in Figure 1b. The measured concentrations in fish (almost all of which are not detected) are identical regardless of whether the inorganic arsenic concentration in water is low (0.02 ug/L in the Selway River) or more than 200 times higher (8.2 ug/L in the Snake River). Given the available data at the current detection limit, a relationship between measured concentrations of inorganic arsenic in fish and Idaho surface water cannot be established using a regression approach.

As with the hypothetical example shown in Figure 1b, a BAF can be calculated for each of the 54 paired samples and an arithmetic mean BAF of <11 L/kg for inorganic arsenic can be estimated, but as with the hypothetical example, inorganic arsenic concentrations below the detection limit will be predicted at low concentrations and concentrations above the detection limit will be predicted at intermediate and higher water concentrations. For example, at a water concentration of 0.00002 mg/L of inorganic arsenic, the predicted concentration of inorganic arsenic in fish is 0.00022 mg/kg, about 10 times lower than the detection limit (Figure 2b). At a water concentration of 0.002 mg/L of inorganic arsenic, the predicted concentration of inorganic arsenic in fish is 0.022 mg/kg, or approximately 10 times above the detection limit (Figure 2b). The magnitude of overprediction continues to increase with increasing water concentration (Figure 2b). It is worth noting that a predicted concentration below the detection limit is consistent with the finding of no detected inorganic arsenic concentrations in virtually all fish. However, predicted inorganic concentrations above 0.002 mg/kg in fish tissue (the detection limit) are inconsistent with IDEQ's 2008 data (Figure 2b) and confirm that the arithmetic mean BAF of 11 L/kg is not appropriate to use to predict inorganic arsenic concentrations in fish in Idaho surface waters. That BAF will over predict fish tissue concentrations in surface water having more than approximately 0.00018 mg/L (0.18 ug/L) of inorganic arsenic; an inorganic arsenic concentration exceeded by approximately 90% of Idaho surface waters tested to date by IDEQ (IDEQ 2010).

Figure 2a
Plot of inorganic arsenic in paired samples of Idaho surface water and fish tissue

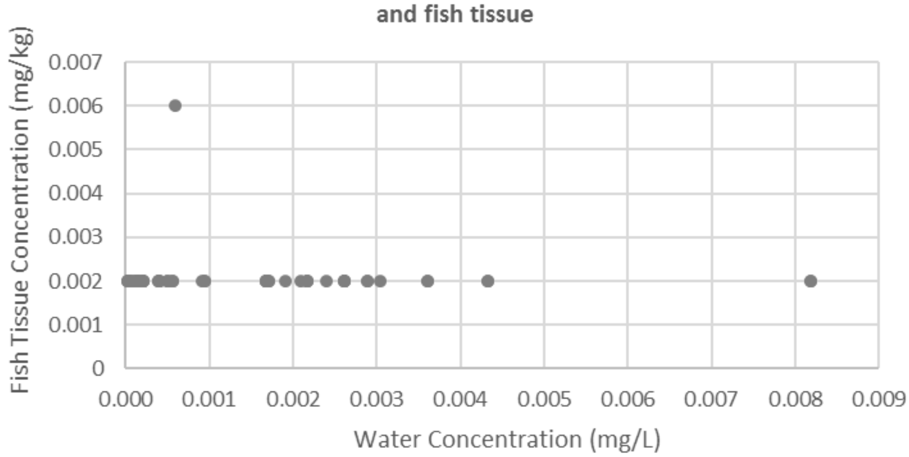
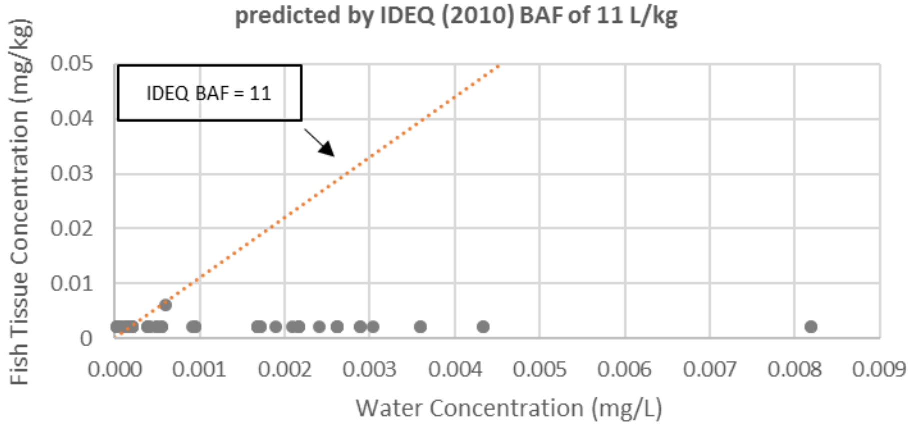


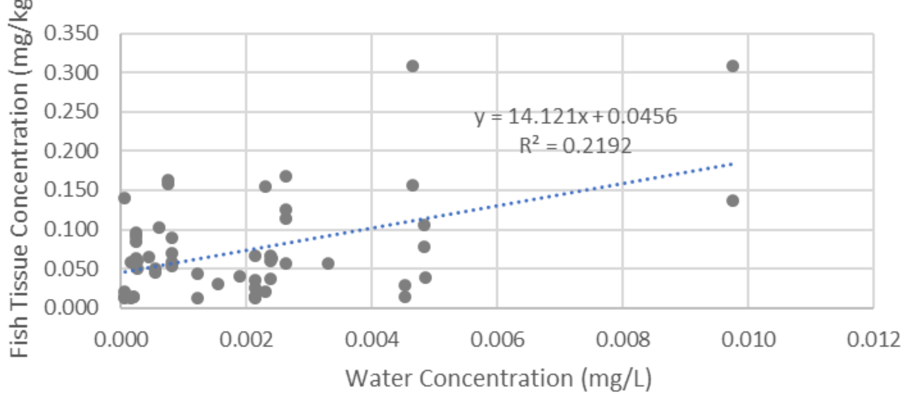
Figure 2b
Plot of inorganic arsenic in paired samples of Idaho surface water and fish tissue with superimposed line showing concentrations predicted by IDEQ (2010) BAF of 11 L/kg



It should be noted as well that the arithmetic mean BAF of 11 L/kg (or any of the individual BAFs developed based on non-detected concentrations of inorganic arsenic in fish) are upper bound estimates of the BAF. The actual BAF will be lower because the true fish concentration is below the current detection limit. For example, at a water concentration of 0.001 mg/L inorganic arsenic, a paired fish tissue sample at the current detection limit of 0.002 mg/kg results in an upper bound BAF of 2 L/kg. If the actual concentration in fish turned out to be 0.001 mg/kg, equal to one half the detection limit, the BAF would be 1 L/kg. If the actual concentration in fish turned out to be 0.0001 mg/kg, the BAF would be 0.1 L/kg. Thus, not only is use of the inorganic arsenic arithmetic mean BAF of 11 L/kg inappropriate to predict fish tissue concentrations, but for most waters of Idaho such predictions will be upper bounds. Actual concentrations would be expected to be lower.

IDEQ did find detectable concentrations of total arsenic in all surface water samples and most fish tissue samples. Those data can be used to develop an estimate of the BAF for total and inorganic arsenic in Idaho surface waters. Figure 3a presents the 54 state-wide paired fish and surface water data for total arsenic collected by IDEQ in 2008 and the equation that results from conducting a linear regression analysis using those data. The regression is statistically significant (p=0.0003) and indicates that water concentration explains about 22% of the variation observed in fish concentration (R2=0.22). Ten of the sampling locations had non-detectable concentrations of total arsenic in fish (total arsenic was detected in all surface water samples). When the data are plotted excluding the locations with non-detected levels of total arsenic in fish, the regression remains statistically significant (p=0.001) and continues to explain approximately 22% of the variation observed in fish concentrations (Figure 3b). Both regression equations have slopes of approximately 14 (Figures 3a,b) which represents the state-wide BAF for total arsenic of approximately 14 L/kg.

Figure 3a
Plot of total arsenic in paired samples of Idaho surface water and fish tissue with regression equation (assumes concentration in non-detected fish tissue samples is equal to the detection limit)



The linear regression based BAF of 14 L/kg is a better predictor of total arsenic concentration in fish tissue that the arithmetic average BAF of 143 L/kg. Use of the latter results in predicted total arsenic concentrations in fish tissue that are substantially higher than the highest total arsenic concentrations measured in fish. For example, at a water concentration of 0.002 mg/L the highest measured concentration of total arsenic in fish tissue was about 0.15 mg/kg and most concentrations were less than 0.1 mg/kg. The predicted concentration using the arithmetic average BAF is 0.29 mg/kg, or about two times higher than the highest measured concentration (Figure 4). At the highest water concentration (0.009 mg/L) the predicted fish tissue concentration is 1.3 mg/kg, or about four times higher than the highest measured concentration (Figure 4). Thus, like the inorganic arsenic arithmetic mean BAF of 11 L/kg, the total arsenic mean BAF of 143 L/kg is inappropriate to use to predict total arsenic concentrations in Idaho fish. The regression-based BAF of 14 L/kg is a better predictor of total arsenic concentrations in fish than the arithmetic mean BAF.

Figure 3b
Plot of total arsenic in paired samples of Idaho surface water and fish tissue with regression equation (non-detected fish tissue samples not included)

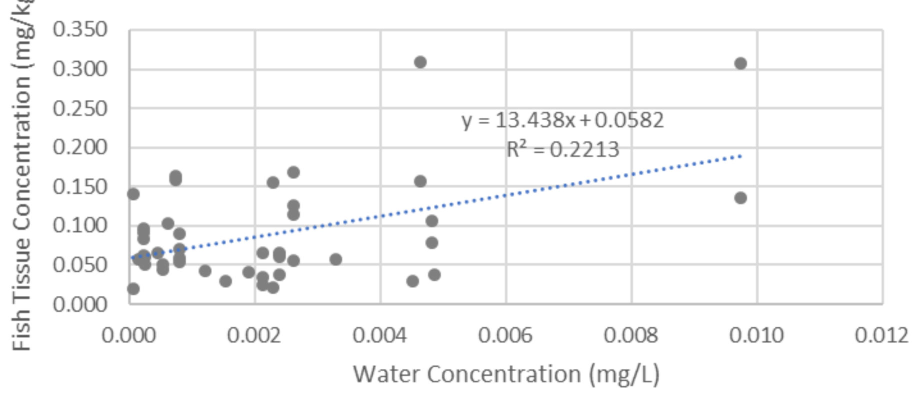
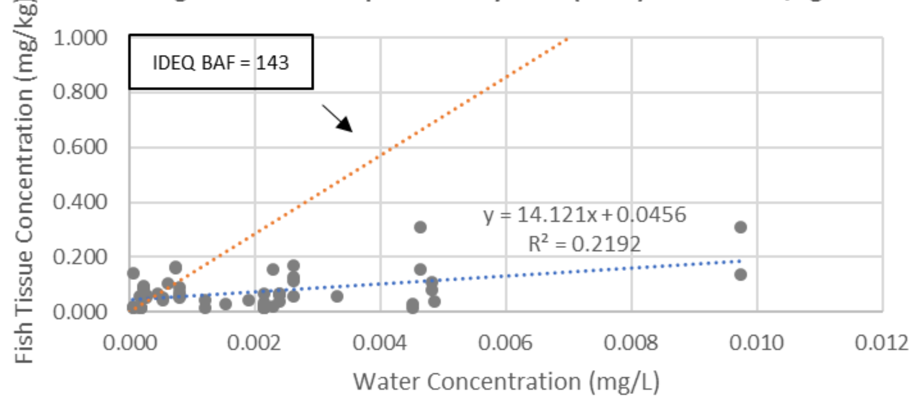


Figure 4
Plot of total arsenic in paired samples of Idaho surface water and fish tissue with regression equation with superimposed line showing concentrations predicted by IDEQ (2010) BAF of 143 L/kg



The paired total and inorganic arsenic tissue data collected by IDEQ in 2008 can be used to convert the regression based total arsenic BAF of 14 L/kg into a BAF that can be used to predict concentrations of inorganic arsenic in fish tissue from concentrations of total arsenic in surface water. IDEQ (2010) reports that less than 3.8% of the arsenic present in Idaho fish tissue is inorganic arsenic. That would mean that less than 3.8% of predicted total arsenic in fish tissue using the total arsenic BAF of 14 L/kg is inorganic arsenic. Combining the total arsenic BAF of 14 L/kg with the inorganic to total arsenic percentage in fish tissue of 3.8% results in a total arsenic in surface water to inorganic arsenic in fish tissue BAF of 0.53 L/kg (14 L/kg x 0.038). The actual total to inorganic arsenic BAF is lower because the estimate of 3.8% of inorganic arsenic in fish tissue is an upper bound. Given the above, the BAF of 0.53 L/kg is the best available, but still a conservative, estimate to predict inorganic arsenic concentrations in fish tissue.

4 IDAHO-SPECIFIC FISH CONSUMPTION ONLY HHC

The BAF of 0.53 L/kg can be combined with IDEQ's standard assumptions to derive 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 $1x10^{-5}$. Using those assumptions and the current cancer slope factor for arsenic of 1.5 $(mg/kg\text{-}day)^{-1}$ results in a fish consumption only human health criterion of 15 ug/L for total arsenic. Based on the data collected by IDEQ in 2008 (IDEQ 2010), all surface waters 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.

5 POTENTIAL RISK ASSOCIATED WITH CONSUMPTION OF IDAHO FISH

Further evidence of a minimal contribution of fish consumption to any potential risk associated with inorganic arsenic in Idaho surface waters is provided by combining the 2008 IDEQ fish tissue results with the above mentioned standard assumptions IDEQ used to derive the 2016 HHC (i.e., a fish consumption rate of 66.5 grams per person per day, 80 kilogram bodyweight, cancer slope factor of 1.5 $(mg/kg\text{-}day)^{-1}$). Assuming the concentration of inorganic arsenic in Idaho fish is equal to one half the detection limit used by Idaho in its 2008 fish tissue analysis (i.e., 0.001 mg/kg), results in a potential excess lifetime cancer risk of $1x10^{-6}$. That is ten times lower than the allowable risk level used by Idaho to set the 2016 HHC and is at the low end of USEPA's range of allowable risk. Moreover, any actual risks would be lower because actual concentrations are likely to be lower, given that 53 of 54 fish tissue samples had non-detected inorganic arsenic concentrations.

6 IDAHO-SPECIFIC HHC INCLUDING WATER CONSUMPTION

The low potential exposures and risks associated with consumption of fish contrast with potential exposures from use of surface water as a drinking water source. Using the 2016 IDEQ standard assumptions for drinking water (2.4 liters per person per day) combined with the standard assumptions about fish consumption and the above BAF results in a fish consumption and drinking water ingestion HHC of 0.22 ug/L assuming all arsenic in surface water consumed as potable water is inorganic arsenic. IDEQ (2010) reported that on average, 73% of the total arsenic in surface water was in an inorganic form. Incorporating that percentage in the derivation results in a HHC of 0.3 ug/L. If fish consumption is excluded from the derivation (i.e., the criteria are for water consumption only) the criteria remain at 0.22 ug/L and 0.3 ug/L, respectively. Thus, including or excluding the fish consumption pathway has no meaningful effect on the resulting criteria.

7 IMPLICATIONS OF RELATIVE FISH CONSUMPTION AND DRINKING WATER EXPOSURES

The above evaluations indicate that fish consumption exposures make a negligible contribution to the exposure to inorganic arsenic in Idaho surface water. Virtually all of the potential exposure is associated with the assumption that surface water is used as a potable drinking water supply and that the water is consumed absent any treatment that would reduce the naturally present inorganic arsenic concentration. Combined with the absence of a strong relationship between inorganic arsenic concentrations in surface and fish suggests that potential risks associated with fish consumption can be excluded from the derivation of HHC, and further, that such exclusion will not adversely affect public health.

The evaluations also indicate that current concentrations of arsenic in virtually all Idaho surface waters measured to date exceed a human health criterion that includes potential exposures via drinking water consumption where those potential exposures are estimated using the assumptions and approach Idaho used in 2016 to update its HHC. (See Table A-1 in Appendix A.) It is notable that the exposure assumptions used to derive HHC protective of drinking water exposures (e.g., drinking water consumption rate, bodyweight) are generally accepted and are unlikely to undergo much Idaho-specific modification. The HHC derivation assumption most amenable to modification, and which Idaho has the flexibility to modify, is the allowable lifetime cancer risk level. However, even increasing allowable risk to 1×10^{-4}, equal to the same level used by Oregon for its arsenic human health criterion and approved by USEPA (IDEQ 2018), results in a potential criterion of 3 ug/L (assuming 73% of total arsenic in surface water is inorganic). Data collected to date by IDEQ (2010) suggest that naturally occurring total arsenic concentrations in approximately 30% of Idaho surface waters exceed such a criterion. (See Table A-1 in Appendix A.) The frequent exceedance of naturally occurring background raises important questions about the practicality of such a criterion and whether the typical approach and assumptions used by IDEQ and USEPA to derive HHC are appropriate and applicable to arsenic in Idaho surface waters. The naturally occurring background concentrations of arsenic in Idaho surface waters suggest that alternative approaches will need to be explored that account for the naturally occurring background concentrations.

8 REFERENCES

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 2010

IDEQ. 2018. Rulemaking Docket 58-0102-1801 Arsenic Human Health Criteria Discussion Paper #1. April 2018.

APPENDIX A

Summary of Total Arsenic Concentrations in Idaho Surface Waters Exceeding Two Hypothetical Alternative Human Health Criteria of 0.3 ug/L and 3.0 ug/L

Table 1 - Summary of Total Arsenic Concentrations in Idaho Surface Waters[1] Exceeding Two Hypothetical Alternative Human Health Criteria of 0.3 µg/L and 3.0 µg/L[2]

Sample ID	Site Name	Sample Date	Total Arsenic in Water (µg/L)
051	Bruneau River	8/14/2008	17.00
047	Snake River #2	8/19/2008	9.74
13313000	Johnson Creek @ YP	9/2/2008	4.92
085	Portneuf River	7/20/2008	4.86
095	Snake River #3	8/20/2008	4.83
083	Snake River #1	8/18/2008	4.64
030	Coeur d'Alene R #1	8/2/2008	4.52
13305000	Lemhi Nr Lemhi	9/10/2008	4.05
13056500	Henry's Fk Nr Rexburg	9/9/2008	3.55
13302005	Pahsimeroi @ Ellis	9/11/2008	3.52
017	Bear River	8/13/2008	3.30
13185000	Boise R @ Twn Spr	9/5/2008	3.23
094	Lemhi River	9/3/2008	2.82
077	Henry's Fork	7/17/2008	2.40
040	Salmon R #1	9/9/2008	2.39
028	Salmon R #2	9/10/2008	2.29
063	Payette River	8/21/2008	2.25
13206000	Boise R @ Glenwood	9/4/2008	2.22
061	Camas Creek	7/16/2008	2.15
097	SF Snake	7/18/2008	2.14
012	Salmon R #3	9/29/2008	1.90
005	Blackfoot	7/19/2008	1.54
091	Big Wood River #2	7/10/2008	1.21
044	Pahsimeroi	9/5/2008	1.03
011	Big Wood River	7/9/2008	0.80
037	Blackfoot River #2	8/12/2008	0.80
084	SF Salmon	8/27/2008	0.78
099	Payette River #2	8/25/2008	0.74
027	NF Big Lost	7/15/2008	0.61
054	Coeur d'Alene R #3	8/1/2008	0.59
050	Priest River	7/30/2008	0.54
038	Coeur d'Alene R #2	7/31/2008	0.53
068	Camas Creek #2	9/4/2008	0.45
031	Weiser River	8/26/2008	0.33
055	NF Payette	8/28/2008	0.26
087	SF Payette	9/2/2008	0.24
086	Saint Joe River	8/3/2008	0.24
026	NF Clearwater R	9/16/2008	0.19
074	Lochsa River	9/17/2008	0.16
088	Selway River	9/18/2008	0.06

Notes:

[1]Total arsenic concentrations in Idaho surface waters reported in "Table E-1. Water Sample Results by Site" of *Arsenic, Mercury, and Selenium in Fish Tissue and Water from Idaho's Major Rivers: A Statewide Assessment. Prepared by Don A. Essig. March 2010.*

[2]The alternative hypothetical human health criterion of 0.3 µg/L is derived using the standard equation to derive human health criteria (see *IDEQ Rulemaking Docket 58-0102-1801 Arsenic Human Health Criteria Discussion Paper #1. April 2018*) and assumes a person weighs 80 kilograms, drinks 2.4 liters of water per day, eats 66.5 grams of fish per day, that arsenic has a cancer slope factor of 1.5 $(mg/kg\text{-}day)^{-1}$ and the acceptable excess lifetime cancer risk level is 1×10^{-5} (one in one hundred thousand). The alternative hypothetical human health criterion of 3 µg/L is derived using the same approach and assumptions except the acceptable excess lifetime cancer risk level is 1×10^{-4} (one in ten thousand).

unshaded - samples with total arsenic concentrations less than or equal to 0.3 µg/L
yellow shaded - samples with total arsenic concentrations greater than 0.3 µg/L and less than or equal to 3.0 µg/L
red shaded - samples with total arsenic concentrations greater than 3.0 µg/L

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