REVISION October 21, 2014

This informal document takes up five matters related to risk assessment that have been under study and review for several months, and are to be resolved so that derivations of EPCs and risks from individual yards can proceed, and risk communication to the community and interested agencies, including plotting of concentrations and EPCs by parcel with color-coded degrees and such, can begin. It is now imperative, in terms of site schedule, that we move forward with these activities.

The matters are:

- **Predicted Bioavailability Calculations and Influence**. A summary of the considerations and values related to bioavailability is provided below in subsequent pages.

- **Available Predicted Bioavailability Calculations for Lead**

- **Fine-grained versus Bulk Arsenic Concentrations**. A summary of this issue, considerations, and related values is provided below in subsequent pages. Also included are the statistics and evaluation showing the difference and the analysis of whether the distributions are different at the .05 and .01 power.

- **XRF-Laboratory Correlation Analysis.** Derivation and application of regressions for transforming XRF data to a lab-reporting basis.

- **Assumptions of Dermal Exposure to Soils**. A summary of this issue, a reference, and recommendation is provided.

BIOAVAILABILITY-RELATED CALCULATIONS

Intention: Base residential yard-based EPCs for soil ingestion pathway using 22% bioavailability.

The value is based on the 95th percentile of the predicted bioavailabilities as transformed from 69 IVBA results. The transform was based on the latest *site-specific* RBA/IVBA regression which includes 9 points and both mouse and swine data. Field data include sampling points from 26 actual residential yards, and 43 points on source material and other sources. Separate segregated population statistics were calculated for a residential yards-only subpopulation and for all data, as shown below. Two IVBA points taken on efflourescent salts deep in the Canyon were excluded. The strong site-specific regression adds to the defensibility of these calculations, as does the large number of points, and also having a substantial number of data from actual residential yards (point of hypothetical exposure). It is noted that at the IKHS site the predicted bioavailabilities for residential soils versus non-residential and source material soils was virtually the same (21.5% versus 22.5%). The bioavailability value is arguably well-constrained.

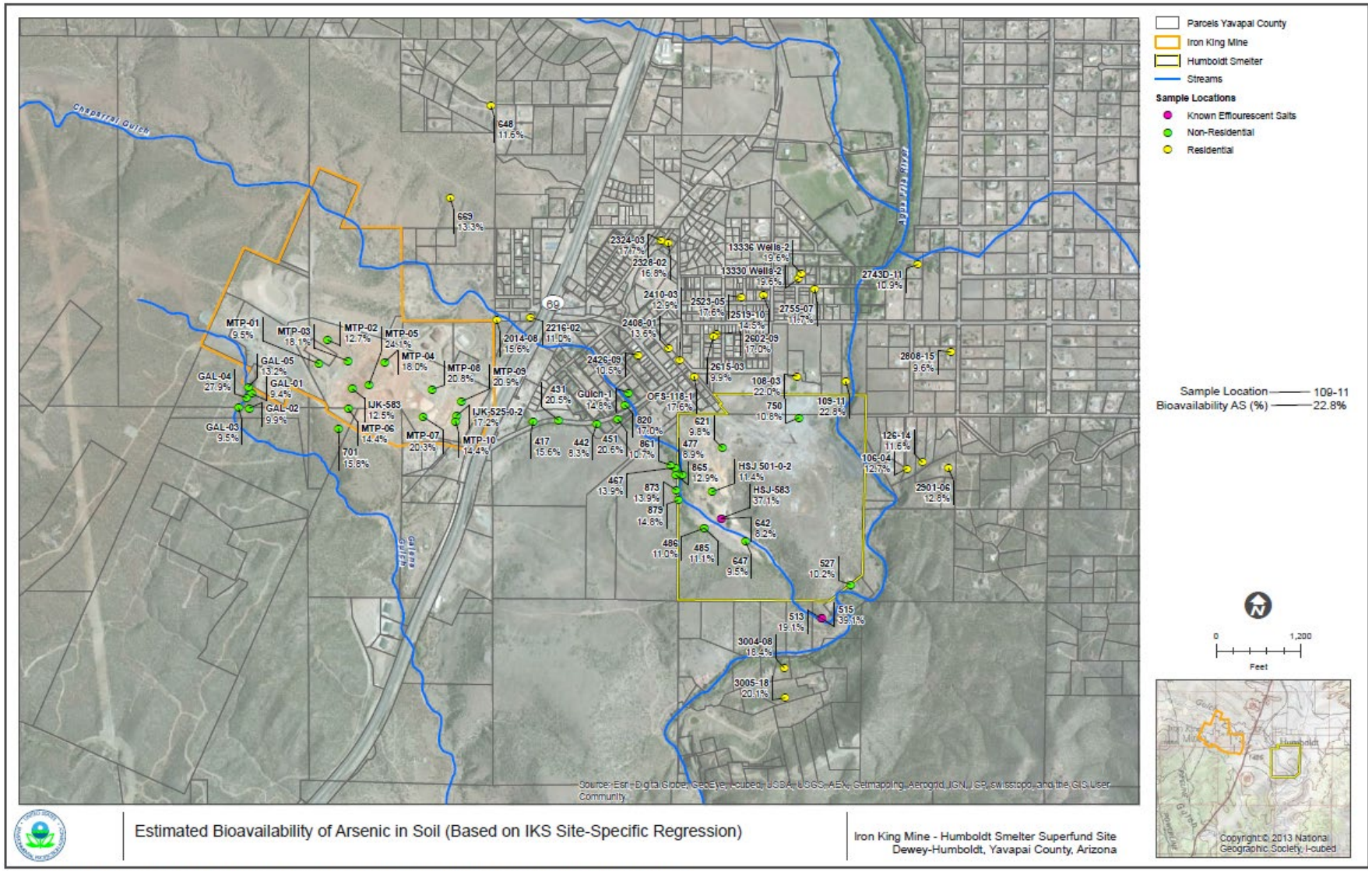
While the table shows values on a UCL as well as percentile basis, it is agreed that percentile is a better approach to this problem than is the UCL, and the proposal is to use the 95th percentile in this case.

Risk-Based Concentrations for Arsenic in Soil

Iron King Mine

% Bioavailable As IKM Regression (N=9)			
All IVBA Values (n=71)			
Risk Target	95%UCL 16.6	90th percentile 20.86	95th percentile 25.95
Arsenic RBC @ 10-6 risk (mg/kg)	1.80	1.54	1.32
Arsenic RBC @ 10-5 risk (mg/kg)	18.0	15.4	13.2
Arsenic RBC @ 10-4 risk (mg/kg)	180	154	132
Arsenic RBC @ HQ=1 (mg/kg)	297	255	218
Excluding 2 Highest IVBA Values (n=69)			
Risk Target	95%UCL 15.64	90th percentile 20.64	95th percentile 22.50
Arsenic RBC @ 10-6 risk (mg/kg)	1.87	1.55	1.46
Arsenic RBC @ 10-5 risk (mg/kg)	18.7	15.5	14.6
Arsenic RBC @ 10-4 risk (mg/kg)	187	155	146
Arsenic RBC @ HQ=1 (mg/kg)	308	257	242
Only Residential IVBA Values (n=26)			
Risk Target	95%UCL 16.36	90th percentile 19.82	95th percentile 21.53
Arsenic RBC @ 10-6 risk (mg/kg)	1.81	1.60	1.51
Arsenic RBC @ 10-5 risk (mg/kg)	18.1	16.0	15.1
Arsenic RBC @ 10-4 risk (mg/kg)	181	160	151
Arsenic RBC @ HQ=1 (mg/kg)	299	264	250

The following is a MAP of locations for IVBA Samples at Iron King. Values shown with each location is the predicated bioavailability (transformed result after site-specific regression) for that point. Points in residential yards are colored YELLOW; points in non-residential areas are colored GREEN; 2 efflourescent salt samples are colored PURPLE.



Estimated Bioavailability of Arsenic in Soil (Based on IKS Site-Specific Regression)

Iron King Mine - Humboldt Smelter Superfund Site
Dewey-Humboldt, Yavapai County, Arizona

BAO CAKEBREAD V:\USEPA_RACII\460650IRON_KING_MINE\GIS\MAPFILES\2014\BIOAVAILABILITY\BIOAVAILABILITY_IVBA-RBC_11X17.MXD TMCBROOM 7/31/2014 2:30:17 PM

The following table depicts the sample point-specific transformed IBVA (predicted bioavailability) results. This is in support of the above information. Residential soils are marked in BLUE.

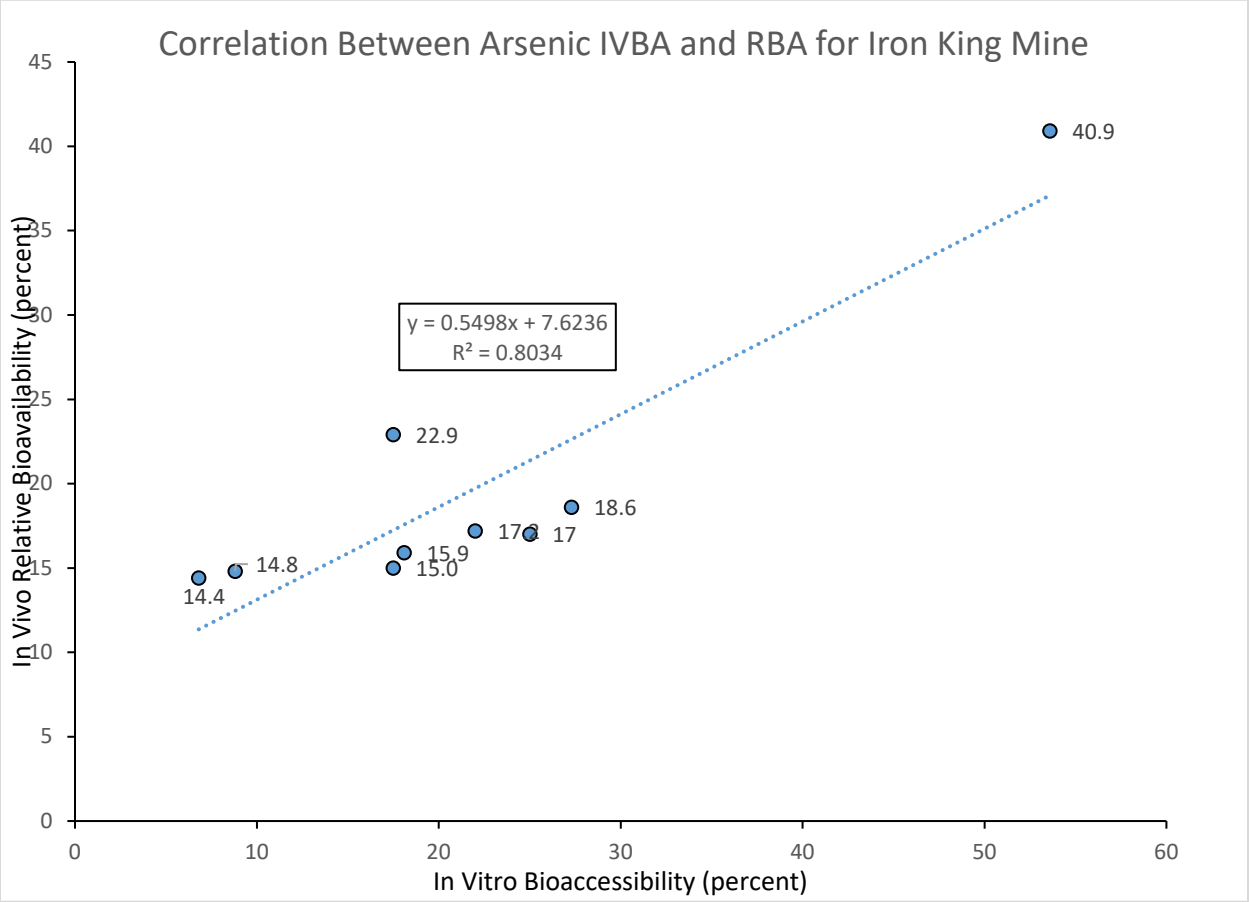
Bioavailability of Arsenic in Soil

Iron King Mine

Sample Location	Date	% Bioavailable As IKM Regression (N=9)		
		All Samples	Minus Effluorescent Salt Samples	Residential Only
648	5/3/2013	11.6	11.6	11.6
669	5/1/2013	13.3	13.3	13.3
106-04	2/26/2014	12.7	12.7	12.7
108-03	2/24/2014	22.0	22.0	22.0
109-11	2/19/2014	22.8	22.8	22.8
126-14	2/27/2014	11.6	11.6	11.6
13330WellsSt	7/11/2013	19.6	19.6	19.6
13336WellsSt	7/12/2013	19.6	19.6	19.6
2014-08	1/31/2014	15.6	15.6	15.6
2216-02	3/5/2014	11.0	11.0	11.0
2324-03	2/5/2014	17.7	17.7	17.7
2328-02	2/5/2014	16.8	16.8	16.8
2408-01	3/10/2014	13.6	13.6	13.6
2410-03	3/10/2014	12.9	12.9	12.9
2426-09	2/5/2014	10.5	10.5	10.5
2519-10	3/10/2014	14.5	14.5	14.5
2523-05	2/19/2014	17.6	17.6	17.6
2602-09	2/13/2014	17.0	17.0	17.0
2615-03	2/20/2014	9.9	9.9	9.9
2743D-11	2/24/2014	10.9	10.9	10.9
2755-07	2/22/2014	11.7	11.7	11.7
2808-15	2/21/2014	9.6	9.6	9.6
2901-06	2/26/2014	12.8	12.8	12.8
3004-08	3/3/2014	18.4	18.4	18.4
3005-18	3/4/2014	20.1	20.1	20.1
OSF-118-1	9/18/2008	17.6	17.6	17.6
417	4/30/2013	15.6	15.6	
431	4/30/2013	20.5	20.5	
442	4/30/2013	8.3	8.3	
451	4/30/2013	20.6	20.6	
467	4/30/2013	13.9	13.9	
477	4/30/2013	8.9	8.9	
485	4/30/2013	11.1	11.1	
486	4/30/2013	11.0	11.0	
513	4/29/2013	19.1	19.1	

527	4/29/2013	10.2	10.2
621	4/30/2013	9.8	9.8
642	5/1/2013	8.2	8.2
647	5/2/2013	9.5	9.5
701	5/2/2013	15.8	15.8
750	5/4/2013	10.8	10.8
753	5/5/2013	27.8	27.8
820	5/1/2013	17.0	17.0
861	5/1/2013	10.7	10.7
865	5/1/2013	12.9	12.9
873	5/1/2013	13.9	13.9
879	5/1/2013	14.8	14.8
978	5/6/2013	8.2	8.2
979	4/29/2013	9.3	9.3
980	4/30/2013	15.2	15.2
GAL-01	2/28/2014	9.4	9.4
GAL-02	2/28/2014	9.9	9.9
GAL-03	2/28/2014	9.5	9.5
GAL-04 (FD)	2/28/2014	27.9	27.9
GAL-05	2/28/2014	13.2	13.2
GulchYard	7/13/2013	14.8	14.8
HSJ 501-0-2	9/4/2008	11.4	11.4
IJK-525-0-2	8/20/2008	17.2	17.2
IJK-583	5/2/2009	12.5	12.5
MTP-01	2/27/2014	9.5	9.5
MTP-02	2/27/2014	12.7	12.7
MTP-03	2/27/2014	18.1	18.1
MTP-04	2/27/2014	18.0	18.0
MTP-05	2/27/2014	24.1	24.1
MTP-06	2/27/2014	14.4	14.4
MTP-07	2/27/2014	20.3	20.3
MTP-08	2/27/2014	20.8	20.8
MTP-09	2/27/2014	20.9	20.9
MTP-10	2/27/2014	14.4	14.4
515	4/29/2013	39.1	
HSJ-583	5/2/2009	37.1	

	= residential
	= non-residential
	= known effluorescent salts
	Shaded values reported at detection limit



Site Specific Regression for IKHS

Available Lead Bioavailability Calculations

Estimates of Bioavailability of Lead in Soil

Iron King Mine

Sample	% Bioavailable Drexler & Brattin Regression
417	0.12
431	13.53
442	0.24
451	9.80
467	0.03
477	1.21
485	0.12
486	0.25
513	0.77
527	0.02
621	15.35
642	3.39
647	1.73
701	3.05
750	45.47
753	0.43
820	0.13
861	0.37
865	0.14
873	0.30
879	0.08
978	1.93
979	15.61
980	0.46
GAL-01	2.97
GAL-02	22.41
GAL-03	21.69
GAL-04 FD	1.98
GAL-05	3.44
GulchYard	2.34
MTP-01	0.74
MTP-02	61.43
MTP-03	13.66
MTP-04	0.90
MTP-05	1.95

All data	
95%UCL	
90%ile	45.1
95%ile	58.7

Residential only	
95%UCL	
90%ile	57.6
95%ile	63.9

Non-residential only	
95%UCL	
90%ile	15.6
95%ile	22.4

MTP-06	1.80
MTP-07	1.06
MTP-08	1.61
MTP-09	0.85
MTP-10	3.45
515	0.77
648	5.83
669	12.47
106-04	25.06
108-03	31.90
109-11	53.42
126-14	31.10
13330WellsSt	7.41
13336WellsSt	8.50
2014-08	5.53
2216-02	47.63
2324-03	30.44
2328-02	33.74
2408-01	7.18
2410-03	7.00
2426-09	35.09
2519-10	44.81
2523-05	30.70
2602-09	70.21
2615-03	15.89
2743D-11	27.70
2755-07	41.29
2808-15	27.78
2901-06	34.46
3004-08	64.81
3005-18	60.46

	= residential
	= non-residential
	= known effluorescent salts
	Shaded values reported at detection limit

Fine-grained (Sieved) vs. Bulk Concentration Comparisons

One of the strengths of the IKHS field program is the very large number of samples – now over 5000, in residential yards, allowing not only for a very-well refined background analysis but also for yard-specific analysis at many hundreds of properties. In the arid environment at the IKHS site, correlative studies have shown good association between laboratory and XRF data, and regressions have been developed to express XRF data to a lab-consistent basis. (In reality, XRF and lab measure two slightly different things, and so a direct match between the two is not to be expected, nor is lab data always necessarily "more true" or "accurate").

Sieving XRF data in the field prior to analysis by XRF would not have been practical and would have greatly limited the number of samples that could have been collected. XRF results were therefore on a bulk soil basis (stones, colloids, sticks, and these kinds of things *were* removed, clays crushed, and the sample homogenized prior to XRF analysis – also, each sample was shot twice by XRF to verify and to allow for an assessment of the variability in the analysis).

Children in particular may place fingers in the mouth after the child has made contact with soils, and the finer fraction of the soil may adhere better to the fingers than does the coarser fraction. The question has been raised, therefore, if the concentration of arsenic in the finer fraction may be significantly higher in the finer grained soils than that found in the bulk (fine and coarse together) soils, thereby imparting a higher risk to the fines for the soil ingestion pathway.

To examine this question for IKHS, we took advantage of the 29 samples collected for IVBA analysis from actual residential yards (out of 71 total samples collected for IVBA). Specifically, the IVBA lab protocol calls for sieving the sample prior to engaging the ingestion process. The concentration of metals in the sample *after* sieving but *before* ingestion must be recorded in the protocol, because this is then used to determine what percentage of the original mass of metals is recovered after ingestion.

The IVBA results themselves are irrelevant to the present question, but the sieved concentrations measured intermediate to the IVBA analyses could be compared to the bulk concentrations detected in the same samples to provide an evaluation of how the sieved concentrations may vary with the bulk concentrations in the same samples. XRF bulk analyses were transformed using the appropriate lab-consistent regression before doing this analysis. For this analysis, N = 22 residential yard soil samples.

The results can be summarized as follows:

1) Numerically, the sieved results for arsenic are on average are 17% higher than unsieved results. However, the variance is high; the standard deviation constitutes about 24-27 percent of the mean. Average sieved/unsieved ratios were the same for total, residential only, and non-residential only results.

2) 33 percent of the sieved/unsieved ratios for arsenic are *less than* or equal to 1.0.

3) Sieved results for lead on average are 18% (all results) and 23% (residential only) higher than unsieved results. The variance is also relatively high; the standard deviation constitutes about 29 percent (all results) and 33 percent (residential only) of the mean.

4) 40 percent of the sieved/unsieved ratios for lead are *less than* or equal to 1.0.

5) Statistical comparisons using EPA's ProUCL statistical tool indicate that the sieved and unsieved data sets cannot be statistically distinguished (using 3 separate statistical tests) at either p=0.05 or p=0.01 for both arsenic and lead, when considering the total data sets.

The results indicate a significant variability in the fine/bulk concentration ratio and the *populations are not statistically different at either p=.05 or p=.01*. See accompanying tables and evaluations.

Effect of Sieving on Arsenic and Lead Concentrations

Iron King

Mine

Sample	Sample Date	Total Unsieved As mg/kg	Total Sieved As mg/kg	As Ratio Sieved/Unsieved	Total Unsieved Pb mg/kg	Total Sieved Pb mg/kg	Pb Ratio Sieved/Unsieved	Residential Sample
669	5/1/2013	223	305	1.37	147	184	1.25	X
106-04	2/26/2014	225	250	1.11	18	21	1.17	X
108-03	2/24/2014	264	420	1.59	567	770	1.36	X
109-11	2/19/2014	181	170	0.94	220	230	1.04	X
126-14	2/27/2014	188	180	0.96	17	22	1.33	X
2014-08	1/31/2014	207	310	1.50	205	300	1.47	X
2216-02	3/5/2014	156	280	1.79	281	350	1.25	X
2324-03	2/5/2014	236	230	0.97	170	170	1.00	X
2328-02	2/5/2014	569	780	1.37	411	520	1.26	X
2408-01	3/10/2014	169	220	1.30	739	840	1.14	X
2410-03	3/10/2014	279	290	1.04	2,420	2,000	0.83	X
2426-09	2/5/2014	387	340	0.88	30	65	2.14	X
2519-10	3/10/2014	137	160	1.17	21	47	2.19	X
2523-05	2/19/2014	154	170	1.10	189	220	1.16	X
2602-09	2/13/2014	380	140	0.37	19,076	15,000	0.79	X
2615-03	2/20/2014	802	1,200	1.50	19	16	0.86	X
2743D-11	2/24/2014	542	650	1.20	16	10	0.60	X
2755-07	2/22/2014	142	150	1.06	29	34	1.18	X
2808-15	2/21/2014	369	410	1.11	9	18	1.92	X
2901-06	2/26/2014	166	160	0.96	15	14	0.92	X
3004-08	3/3/2014	167	260	1.56	546	650	1.19	X
3005-18	3/4/2014	254	230	0.90	488	450	0.92	X
417	4/30/2013	2,420	2,550	1.05	3,270	3,760	1.15	
431	4/30/2013	273	447	1.64	375	572	1.53	
442	4/30/2013	3,840	2,990	0.78	5,740	5,390	0.94	
451	4/30/2013	603	585	0.97	823	704	0.86	
467	4/30/2013	1,350	1,480	1.10	2,850	2,860	1.00	
477	4/30/2013	3,720	3,580	0.96	3,060	2,960	0.97	

485	4/30/2013	4,080	4,180	1.02	3,740	4,290	1.15	
486	4/30/2013	1,710	1,750	1.02	4,100	3,820	0.93	
513	4/29/2013	838	888	1.06	249	220	0.88	
515	4/29/2013	4,340	3,960	0.91	226	220	0.97	
527	4/29/2013	4,920	6,730	1.37	6,290	9,490	1.51	
621	4/30/2013	174	310	1.78	102	125	1.23	
701	5/2/2013	591	841	1.42	363	490	1.35	
820	5/1/2013	726	660	0.91	1,290	1,110	0.86	
861	5/1/2013	330	497	1.51	478	723	1.51	
865	5/1/2013	494	649	1.31	860	1,030	1.20	
873	5/1/2013	530	680	1.28	760	894	1.18	
879	5/1/2013	896	892	1.00	1,910	1,630	0.85	

SD = Standard Deviation
% RSD = Percent relative Standard deviation

Total Average	1.17	**Total Average**	1.18
Total SD	0.29	**Total SD**	0.34
%RSD	25.1	**%RSD**	29.1
Res Average	1.17	**Res Average**	1.23
Res SD	0.31	**Res SD**	0.41
%RSD	26.6	**%RSD**	33.3
Non-Res Average	1.17	**Non-Res Average**	1.11
Non-Res SD	0.28	**Non-Res SD**	0.23
%RSD	23.7	**%RSD**	21.0

ANALYSIS

POPULATIONS OF SEIVED AND UNSEIVED DATA: ARE THEY STATISTICALLY DIFFERENT

Summary of Population Comparison Results

			Null Hypothesis: Sieved <= Unsieved		
			t-Test		**Wilcoxon-Mann-Whitney**
			Student t (Pooled)	**Welch-Satterthwaite**	
Alpha = 0.05					
All Data Sieved As mg/kg	- vs-	All Data Unsieved As mg/kg	Student t (Pooled) Test: Do Not Reject H0, Conclude Sieved <= Unsieved	Welch-Satterthwaite Test: Do Not Reject H0, Conclude Sieved <= Unsieved	Do Not Reject H0, Conclude Sieved <= Unsieved
All Data Sieved Pb mg/kg	- vs-	All Data Unsieved Pb mg/kg	Student t (Pooled) Test: Do Not Reject H0, Conclude Sieved <= Unsieved	Welch-Satterthwaite Test: Do Not Reject H0, Conclude Sieved <= Unsieved	Do Not Reject H0, Conclude Sieved <= Unsieved
Alpha = 0.01					
All Data Sieved As mg/kg	- vs-	All Data Unsieved As mg/kg	Student t (Pooled) Test: Do Not Reject H0, Conclude Sieved <= Unsieved	Welch-Satterthwaite Test: Do Not Reject H0, Conclude Sieved <= Unsieved	Do Not Reject H0, Conclude Sieved <= Unsieved
All Data Sieved Pb mg/kg	- vs-	All Data Unsieved Pb mg/kg	Student t (Pooled) Test: Do Not Reject H0, Conclude Sieved <= Unsieved	Welch-Satterthwaite Test: Do Not Reject H0, Conclude Sieved <= Unsieved	Do Not Reject H0, Conclude Sieved <= Unsieved

Backup Calculations Seived/Unseived Statistical Difference: ARSENIC – p = 0.5

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	########
From File	IKM_As&Pb_Sieved vs. Unsieved_ProUCL_09_12_14.xls
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference (S)	0
Selected Null Hypothesis	Sample 1 Mean <= Sample 2 Mean (Form 1)
Alternative Hypothesis	Sample 1 Mean > the Sample 2 Mean

Sample 1 Data: Total Sieved
As mg/kg
Sample 2 Data: Total Unsieved As mg/kg

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	40	40
Number of Distinct Observations	36	40
Minimum	140	136.5
Maximum	6730	4920
Mean	1024	950.8
Median	433.5	374.4
SD	1416	1326
SE of Mean	223.9	209.6

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 - Mean of Sample 2 <= 0

	t-Test	Critical

Method	DF	Value	t (0.05)	P-Value
Pooled (Equal Variance)	78	0.24	1.665	0.406
Welch-Satterthwaite (Unequal Variance)	77.7	0.24	1.665	0.406

Pooled SD 1371.756

Conclusion with Alpha = 0.050

Student t (Pooled) Test: Do Not Reject H0, Conclude Sample 1 <= Sample 2

Welch-Satterthwaite Test: Do Not Reject H0, Conclude Sample 1 <= Sample 2

Test of Equality of Variances

Variance of Sample 1	2005983
Variance of Sample 2	1757446

Numerator DF	Denominator DF	F-Test Value	P-Value
39	39	1.141	0.682

Conclusion with Alpha = 0.05

Two variances appear to be equal

Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Uncensor Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	########
From File	IKM_As&Pb_Sieved vs. Unsieved_ProUCL_09_12_14.xls
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	0
Selected Null Hypothesis	Sample 1 Mean/Median <= Sample 2 Mean/Median (Form 1)
Alternative Hypothesis	Sample 1 Mean/Median > Sample 2 Mean/Median

Sample 1 Data: Total Sieved

As mg/kg
Sample 2 Data: Total Unsieved As mg/kg

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	40	40
Number of Distinct Observations	36	40
Minimum	140	136.5
Maximum	6730	4920
Mean	1024	950.8
Median	433.5	374.4
SD	1416	1326
SE of Mean	223.9	209.6

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 <= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	1696
Standardized WMW U-Stat	0.727
Mean (U)	800
SD(U) - Adj ties	103.9
Approximate U-Stat Critical Value (0.05)	1.645
P-Value (Adjusted for Ties)	0.234

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Sample 1 <= Sample 2
P-Value >= alpha (0.05)

Backup Calculations Seived/Unseived Statistical Difference: LEAD – p=0.05

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	9/12/2014 11:32
From File	IKM_As&Pb_Sieved vs. Unsieved_ProUCL_09_12_14.xls
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference (S)	0
Selected Null Hypothesis	Sample 1 Mean <= Sample 2 Mean (Form 1)
Alternative Hypothesis	Sample 1 Mean > the Sample 2 Mean

Sample 1 Data: Total Sieved
Pb mg/kg
Sample 2 Data: Total Unsieved Pb mg/kg

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	40	40
Number of Distinct Observations	38	40
Minimum	9.5	9.383
Maximum	15000	19076
Mean	1555	1553
Median	505	393
SD	2889	3260
SE of Mean	456.7	515.5

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 - Mean of Sample 2 <= 0

	t-Test	Critical

Method	DF	Value	t (0.05)	P-Value
Pooled (Equal Variance)	78	0.004	1.665	0.499
Welch-Satterthwaite (Unequal Variance)	76.9	0.004	1.665	0.499

Pooled SD 3080.060

Conclusion with Alpha = 0.050

Student t (Pooled) Test: Do Not Reject H0, Conclude Sample 1 <= Sample 2

Welch-Satterthwaite Test: Do Not Reject H0, Conclude Sample 1 <= Sample 2

Test of Equality of Variances

Variance of Sample 1	8344512
Variance of Sample 2	10629029

Numerator DF	Denominator DF	F-Test Value	P-Value
39	39	1.274	0.453

Conclusion with Alpha = 0.05

Two variances appear to be equal

Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Uncensor Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	9/12/2014 11:32
From File	IKM_As&Pb_Sieved vs. Unsieved_ProUCL_09_12_14.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference	0
Selected Null Hypothesis	Sample 1 Mean/Median <= Sample 2 Mean/Median (Form 1)
Alternative Hypothesis	Sample 1 Mean/Median > Sample 2 Mean/Median

Sample 1 Data: Total Sieved

Pb mg/kg

Sample 2 Data: Total Unsieved Pb mg/kg

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	40	40
Number of Distinct Observations	38	40
Minimum	9.5	9.383
Maximum	15000	19076
Mean	1555	1553
Median	505	393
SD	2889	3260
SE of Mean	456.7	515.5

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 <= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	1658
Standardized WMW U-Stat	0.361
Mean (U)	800
SD(U) - Adj ties	103.9
Approximate U-Stat Critical Value (0.01)	2.326
P-Value (Adjusted for Ties)	0.359

Conclusion with Alpha = 0.01

Do Not Reject H0, Conclude Sample 1 <= Sample 2

P-Value >= alpha (0.01)

Backup Calculations Seived/Unseived Statistical Difference: ARSENIC = p-0.01

-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	########
From File	IKM_As&Pb_Sieved vs. Unsieved_ProUCL_09_12_14.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0
Selected Null Hypothesis	Sample 1 Mean <= Sample 2 Mean (Form 1)
Alternative Hypothesis	Sample 1 Mean > the Sample 2 Mean

Sample 1 Data: Total Sieved
As mg/kg
Sample 2 Data: Total Unsieved As mg/kg

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	40	40
Number of Distinct Observations	36	40
Minimum	140	136.5
Maximum	6730	4920
Mean	1024	950.8
Median	433.5	374.4
SD	1416	1326
SE of Mean	223.9	209.6

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 - Mean of Sample 2 <= 0

Method	DF	t-Test Value	Critical t (0.01)	P-Value
Pooled (Equal Variance)	78	0.24	2.375	0.406
Welch-Satterthwaite (Unequal Variance)	77.7	0.24	2.375	0.406

Pooled SD 1371.756

Conclusion with Alpha = 0.010

Student t (Pooled) Test: Do Not Reject H0, Conclude Sample 1 <= Sample 2

Welch-Satterthwaite Test: Do Not Reject H0, Conclude Sample 1 <= Sample 2

Test of Equality of Variances

Variance of Sample 1	2005983
Variance of Sample 2	1757446

Numerator DF	Denominator DF	F-Test Value	P-Value
39	39	1.141	0.682

Conclusion with Alpha = 0.01

Two variances appear to be equal

Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Uncensor Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	########
From File	IKM_As&Pb_Sieved vs. Unsieved_ProUCL_09_12_14.xls
Full Precision	OFF
Confidence Coefficient	99%

Substantial Difference	0
Selected Null Hypothesis	Sample 1 Mean/Median <= Sample 2 Mean/Median (Form 1)
Alternative Hypothesis	Sample 1 Mean/Median > Sample 2 Mean/Median

Sample 1 Data: Total Sieved
As mg/kg
Sample 2 Data: Total Unsieved As mg/kg

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	40	40
Number of Distinct Observations	36	40
Minimum	140	136.5
Maximum	6730	4920
Mean	1024	950.8
Median	433.5	374.4
SD	1416	1326
SE of Mean	223.9	209.6

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 <= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	1696
Standardized WMW U-Stat	0.727
Mean (U)	800
SD(U) - Adj ties	103.9
Approximate U-Stat Critical Value (0.01)	2.326
P-Value (Adjusted for Ties)	0.234

Conclusion with Alpha = 0.01

Do Not Reject H0, Conclude Sample 1 <= Sample 2

P-Value >= alpha (0.01)

Backup Calculations Seived/Unseived Statistical Difference: LEAD p = 0.01

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	########
From File	IKM_As&Pb_Sieved vs. Unsieved_ProUCL_09_12_14.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0
Selected Null Hypothesis	Sample 1 Mean <= Sample 2 Mean (Form 1)
Alternative Hypothesis	Sample 1 Mean > the Sample 2 Mean

Sample 1 Data: Total Sieved Pb mg/kg

Sample 2 Data: Total Unsieved Pb mg/kg

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	40	40
Number of Distinct Observations	38	40
Minimum	9.5	9.383
Maximum	15000	19076
Mean	1555	1553

Median	505	393
SD	2889	3260
SE of Mean	456.7	515.5

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 - Mean of Sample 2 <= 0

Method	DF	t-Test Value	Critical t (0.01)	P-Value
Pooled (Equal Variance)	78	0.004	2.375	0.499
Welch-Satterthwaite (Unequal Variance)	76.9	0.004	2.376	0.499

Pooled SD 3080.060

Conclusion with Alpha = 0.010

Student t (Pooled) Test: Do Not Reject H0, Conclude Sample 1 <= Sample 2

Welch-Satterthwaite Test: Do Not Reject H0, Conclude Sample 1 <= Sample 2

Test of Equality of Variances

Variance of Sample 1	8344512
Variance of Sample 2	10629029

Numerator DF	Denominator DF	F-Test Value	P-Value
39	39	1.274	0.453

Conclusion with Alpha = 0.01

Two variances appear to be equal

Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Uncensor Full Data Sets without NDs

User Selected Options

Date/Time of Computation	########
From File	IKM_As&Pb_Sieved vs. Unsieved_ProUCL_09_12_14.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference	0
Selected Null Hypothesis	Sample 1 Mean/Median <= Sample 2 Mean/Median (Form 1)
Alternative Hypothesis	Sample 1 Mean/Median > Sample 2 Mean/Median

Sample 1 Data: Total Sieved
Pb mg/kg
Sample 2 Data: Total Unsieved Pb mg/kg

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	40	40
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Sample 1 Rank Sum W-Stat	1658
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Mean (U)	800

SD(U) - Adj ties	103.9
Approximate U-Stat Critical Value (0.01)	2.326
P-Value (Adjusted for Ties)	0.359

Conclusion with Alpha = 0.01

Do Not Reject H0, Conclude Sample 1 <= Sample 2

P-Value >= alpha (0.01)

XRF / Laboratory Correlation Analysis

XRay Fluorescence Spectroscopy (XRF) sampling in the field has proven to be an effective means of characterizing yard soil concentrations in the xeric environment of the IKHS site. Because some data collected are laboratory data and some data are XRF, it has become important to be able to report XRF data on a laboratory-equivalent basis. In most cases, this is achieved by deriving a regression and "transforming" the XRF data according to the regression. Each surface soil sample bag was analyzed by the XRF twice. This approach allows for characterization of the variability of the method at this specific site, as well as to phase out some of the heterogeneity which might appear in the XRF data.

It is important to note that laboratory analysis and XRF analysis are methods that differ and neither one is necessarily more "correct." The laboratory sample involves a chemical digestion of an aliquot of soil from a sample. The XRF is a direct measurement from a small point of homogenized soil directly in front of the emission window of the XRF device. It is expected that there would be some difference between the two methods. The corroboration is therefore an approach to put all samples on a similar reporting basis, rather than to "correct" the XRF data.

The following shows the analysis of the lab/XRF corroboration analysis.

Adjustment Equation Statistics

			Correlation Coefficients	
Constituent	Intercept	Regression Coefficient	Pearson	Spearman
Arsenic	0.102	0.975	0.928	0.902
Iron	-0.291	1.053	0.916	0.872
Lead	-0.614	1.241	0.925	0.908
Manganese	-0.019	0.978	0.915	0.823
Zinc	0.294	0.869	0.933	0.919
Copper *	0.802	0.368	0.499	0.439
Chromium *	0.478	0.632	0.296	0.261

* The correlation for copper and chromium is not sufficiently strong to offer reliable adjustment of XRF results.

Dermal Exposure Pathway

In general, dermal absorption of metals adsorbed to soils would be expected to be low. A question has been raised as to whether maintaining a dermal pathway is appropriate in this case. In particular, the arsenic found at IKHS is from sulfide minerals and of the arsenopyrite form (which is of the 3+ oxidation state). This arsenic is strongly held in the mineral matrix and thereby very unlikely to pass through the skin barrier. The bioavailability by the ingestion pathway has been shown to be 22%, suggesting that even in the gut in a more aqueous environment the passage over the thinner membranes of the intestine is low.

Attached below is an excerpt from a memo from EPA Region 8 for a similar mining site indicating, due to actual studies and site characteristics, that the dermal exposure route specifically for yard soils *in this type of situation* should be eliminated (assumed to be negligible). It would appear that the characteristics of IKHS would support the same conclusions.

The table below shows the potential impact that the dermal exposure pathway has.

Route Contribution to Total Risk

	Ingestion	Dermal	Inhalation	Total	10-4 RBC		
Default	86.7%	13.2%	0.1%	100.0%	67.0		
Site-specific w/dermal	71.0%	28.9%	0.1%	100.0%	146.2	118.3%	% higher than Default
Site-specific wo/dermal	99.8%	0.0%	0.2%	100.0%	205.6	40.6%	% higher than w/dermal

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 8

1595 Wynkoop Street
DENVER, CO 80202-1129
Phone 800-227-8917
http://www.epa.gov/region08

April 5, 2012

MEMORANDUM

SUBJECT: Comments on Focused Remedial Investigation

Crystal Mine OU 5, Jefferson County Montana

FROM: Susan Griffin, PhD, DABT
Senior Toxicologist

TO: Kristine Edwards
Remedial Project Manager

--EXCERPTED TEXT ONLY—

Section 5.4.2.2 Calculation of Intake for COPCs

In section 5.4.2.2 equations are provided for assessing dermal exposure to inorganics in soil. Even though information is limited on the rate and extent of dermal absorption of metals in soil across the skin, most scientists consider that this pathway is likely to be minor in comparison to the amount of exposure that occurs by the oral route. This view is based on the recognition that most metals tend to bind to soils, reducing the likelihood that they would dissociate from the soil and cross the skin, and ionic species such as metals have a relatively low tendency to cross the skin even when contact does occur. For example, studies by Lowney (2005) have shown that dermal absorption of arsenic from Colorado and New York soils was negligible. Due to the lack of evidence supporting dermal absorption of lead from soil, neither EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model or Adult Lead Methodology (ALM) even include a dermal exposure pathway. Based on this, and recognizing that current methods and data are very limited for attempting to quantify dermal absorption of chemicals from soil, dermal contact with soil and sediment is not evaluated quantitatively in Region 8, I would suggest that the risk assessment acknowledge that dermal exposure is a complete, but insignificant pathway, and address this qualitatively instead of quantitatively.