Montana Department of Environmental Quality
Remediation Division
Action Level for Arsenic in Surface Soil

1.0 Introduction

This paper provides and explains the Montana Department of Environmental Quality (DEQ) Remediation Division's generic action level of 40 milligrams/kilogram (mg/kg) for arsenic in residential surface soil. DEQ is implementing what it considers a unique approach to arsenic because arsenic occurs naturally in Montana soils at levels above both generic and Montana-specific risk-based concentrations. DEQ gathered data from 209 native soil samples collected from unimpacted soils across Montana. DEQ calculated the 95% upper confidence limit (UCL) of the mean of this data and has chosen this level of 40 mg/kg as a generic action level for arsenic in surface soil.

2.0 Data Summary and Action Level Calculation

DEQ compiled data for 209 soil samples designated as "background" or unimpacted soil. DEQ and various other entities collected the soil samples throughout the state and the general locations are shown on Figure 1 and the concentrations are listed in Attachment 1. The samples were collected from native surface soils associated with state Superfund, federal Superfund, and abandoned mine sites. The sites are located in both mineralized and non-mineralized areas of the state. Many of the samples were collected as part of initial investigations near sites for which arsenic was not determined to be a contaminant of concern. DEQ believes the data represent native arsenic concentrations in most areas of the state. The minimum concentration of arsenic found is 0.94 mg/kg and the maximum is 187 mg/kg. The average or arithmetic mean is 29 mg/kg and the 95% UCL of the mean is 40 mg/kg.

DEQ determined that the 95% UCL of 40 mg/kg represents an appropriate generic action level for arsenic because it represents native soil concentrations that can reasonably be expected for most facilities. DEQ used EPA's ProUCL Program (EPA, 2004) to calculate this UCL. Based on the evaluation performed in the ProUCL Program the data are lognormally distributed and the UCL is based on the arithmetic mean of the log-transformed data.

3.0 Risk-Based Concentrations

Typically, DEQ employs generic screening levels, such as the United States Environmental Protection Agency (EPA) Region 9 Preliminary Remediation Goals (PRGs) (EPA9, 2004) for residential soil, when making an initial determination regarding potential soil contamination at a facility. Soil concentrations that exceed the PRGs require further analysis to determine whether the facility poses an unacceptable risk to human health or the environment. EPA Region 9 calculates these PRGs conservatively without consideration of site-specific factors and bases the PRGs for carcinogens, like arsenic, on a 1×10^{-6} excess individual cancer risk. Since DEQ requires that cumulative facility risks not exceed 1×10^{-5}, the PRGs represent protective concentrations even if as many as ten carcinogens are present at a facility at the PRGs. However, the EPA Region 9 PRG for arsenic residential soil is 0.39 mg/kg (EPA9, 2004). The

data DEQ compiled indicates that arsenic concentrations in native Montana soils can range from 0.94 mg/kg to 187 mg/kg. Generally, cleanup levels are not set at concentrations below naturally occurring levels. Since the range of arsenic concentrations in native Montana soils exceeds the residential PRG, DEQ does not consider the EPA9 PRG an appropriate screening level for arsenic in Montana soils.

Because the Region 9 PRG for arsenic is not an appropriate screening level for Montana, DEQ examined the possibility of screening facilities using a risk-based arsenic concentration based on conditions specific to Montana. Montana-specific conditions include the use of a 1×10^{-5} risk level and consideration of snow cover and frozen soil during four months of year limiting exposure to soil (WRCC, 2003).

Arsenic has been shown to have both carcinogenic and non-carcinogenic effects (ATSDR, 2000; IRIS, 2005). Using EPA's risk assessment methodology (EPA, 1989), DEQ calculated a Montana-specific cancer risk-based concentration of 6 mg/kg and a Montana-specific non-cancer risk-based concentration of 32 mg/kg. Appendix A provides the bases for both the carcinogenic and the non-carcinogenic risk-based concentration calculations and Attachment 1 of the appendix is the spreadsheet DEQ used to calculate these risk-based concentrations. DEQ does not consider the cancer risk-based concentration to be an appropriate screening level because most unimpacted areas in Montana have arsenic concentrations in soils above 6 mg/kg. DEQ's selected generic action level of 40 mg/kg based on native soil concentrations of arsenic is comparable to the Montana-specific non-cancer risk-based concentration of 32 mg/kg.

4.0 Action Level Applicability

With this paper DEQ intends to provide a reasonable action level for unrestricted exposure to arsenic in surface soil. DEQ intends that this action level be used generally to determine whether remediation of arsenic is necessary at a facility unless site-specific information indicates that this action level is not appropriate. DEQ considers arsenic unique in that it is generally present in Montana soils at concentrations above the Region 9 PRG and DEQ does not intend to implement the same approach for other contaminants.

It is important to note that DEQ considers the top two feet of soil to be surface soil. The EPA Risk Assessment Guidance for Superfund (RAGS) Volume I Human Health Evaluation Manual (Part A) states, "Assessment of surface exposures will be more certain if samples are collected from the shallowest depth that can be practically obtained, rather than, for example, zero to two feet" (EPA, 1989). However, the arsenic surface soil action levels apply to the top two feet of soil to account for changes in the soil column resulting from activities like gardening, children and pets digging, resodding, bioturbation (worms, ants, moles, etc. disturbing the soil) and repairing roads or driveways. Therefore, DEQ recommends that investigators collect samples from various depths no more than 6 inches in thickness throughout the top two feet of soil in order to make decisions regarding remediation.

5.0 Site-Specific Action Levels

DEQ's generic action level may not be appropriate for all facilities. Site-specific background concentrations may exceed the generic action level of 40 mg/kg. If this is likely, DEQ encourages investigators to collect a statistically significant number of background samples to

establish a valid site-specific background concentration. Because soils are generally heterogeneous, DEQ typically requires 20 or more soil samples for statistical analyses. Because arsenic occurs in different forms in the soil, it may be appropriate to calculate site-specific risk-based concentrations based on the type of arsenic found at the facility. DEQ may require site-specific speciation or bioavailability analysis or both at facilities where this approach is proposed. If land use restrictions are appropriate for an industrial or recreational facility, DEQ may consider site-specific risk-based concentrations based on limited exposure appropriate.

6.0 Conclusion

In conclusion, DEQ has developed a generic screening level of 40 mg/kg for arsenic based on the 95% UCL of the mean for arsenic in Montana soils. This screening level can be used in making an initial determination regarding potential arsenic contamination in soil at a facility. If adequate sampling indicates that site-specific background concentrations exceed this level, site-specific cleanup levels may be appropriate. In addition, if the technical practicability or the costs of cleaning up a facility to 40 mg/kg or both warrant developing a site-specific cleanup level based on speciation or site-specific bioavailability studies DEQ may consider alternate action levels on a site-specific basis.

7.0 References

ATSDR, 2000. Toxicological Profile for Arsenic. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. September.

EPA, 1989. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part A) Interim Final. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. December. EPA/540/1-89/002.

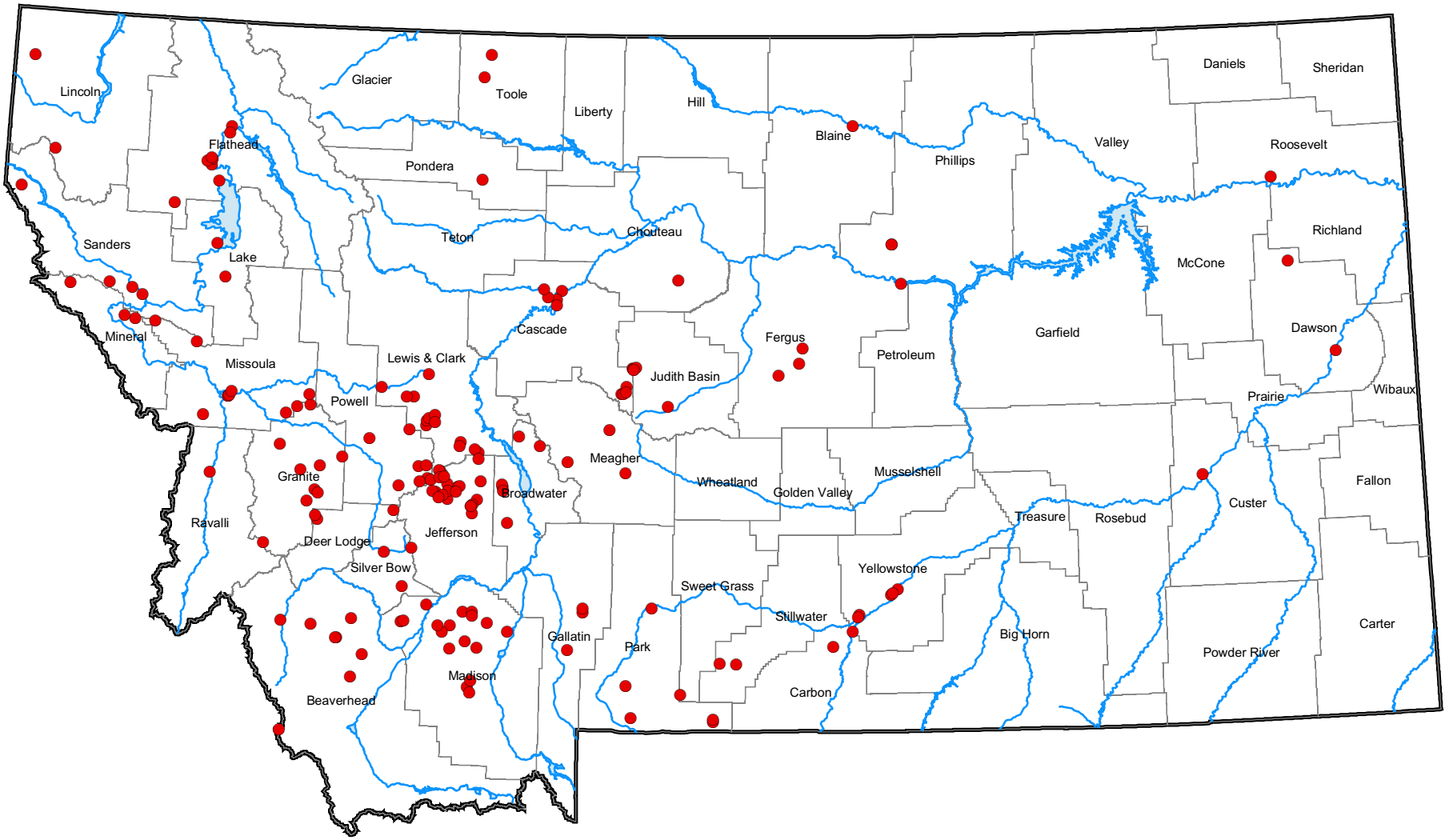
EPA9, 2004. Preliminary Remediation Goals. U.S. Environmental Protection Agency Region 9. October.

EPA, 2004. ProUCL Version 3.0. U.S. Environmental Protection Agency. April.

IRIS, 2005. Integrated Risk Information System. U.S. Environmental Protection Agency. March search: www.epa.gov/iris.

WRCC, 2003. Western Regional Climate Center. March search: www.wrcc.dri.edu.

FIGURE 1 - NATIVE ARSENIC SAMPLE DISTRIBUTION
APRIL 2005



Attachment 1
Concentrations of Arsenic in Native Soil

April 2005

Site Name	Conc. mg/kg	Analytical Method	Source
All American Bumper and Plating	5.1	CLP SOW ILM05.3 TAL	Final Report All American Bumper and Plating Site; DEQ, 12/91
Allison Emigrant Dist	32.8	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Alps	19	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
American Dental	3.9	CLP SOW ILM02.0 TAL	Site Inspection Report for American Dental Site; DEQ, 10/93
Anaconda Aluminum Co Columbia Falls	3.8	CLP	Analytical Results Report Columbia Falls Aluminum Co; EPA FIT, 11/88
Anaconda Mineral Company Great Falls	10.8	CLP SOW ILM05.2 TAL	Final Analytical Report for the Expanded Site Investigation; EPA, 2004
Apex Virginia City Dist	6	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Argo Mine and Millsite	16	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Belle Mine	9.22	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Belle of the Castles	63	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Benbow Millsite	14.8	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Bertha Colorado Dist	187	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Big Ox Mine	25	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Big West Oil Refinery	7	SW846 - Method 6010	Preliminary Remedial Action Objectives & Preliminary Remediation Goals Big West Oil Refinery Facility; UTC, 3/05
Bitterroot Valley Sanitary Landfill	0.94	CLP SOW 3/90	Final Listing Site Inspection Report; EPA FIT, 2/91
Bitterroot Valley Sanitary Landfill	2.1	CLP SOW 3/90	Final Listing Site Inspection Report; EPA FIT, 2/91
Blackfoot Tailings	10.9	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Bluebird Colorado Dist	28	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Bon Ton	122	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Boulder Chief	23.1	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Brewery Flats	6.4	CLP SOW ILM04.0 TAL	Final Analytical Results Report Milwaukee Roundhouse Site, Lewistown, MT
Broadway Keystone Victoria	48.3	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Bullion Basin Dist	68	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Burlington Northern Fueling Facility Laurel	11	CLP SOW 7/88	Analytical Results Report; EPA, 12/92
Burlington Northern Fueling Facility Laurel	11.7	CLP SOW 7/88	Analytical Results Report; EPA, 12/92
Burlington Northern Paradise Tie Treatment	6	SW846 - Method 3050/7061	BNSF Paradise Baseline Risk Assessment, BNSF; 10/93
Burlington Northern Somers Plant	3.6	SW846 - Method 3050/7060	Remedial Investigation & Feasibility Study for Somers Tie Plant Volume I: Site Investigation; BN, 4/89
Butte Transect Data	5	SW846 - Method 3050/7060	Butte Soil Screening Study; ARCo, 1989
Butte Transect Data	80	SW846 - Method 3050/7060	Butte Soil Screening Study; ARCo, 1989
Champion Orofino Dist	24	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Charles M Russell Refuge	4.7	Lab	US Fish & Wildlife Service letter report; USF&W 3/86
Charter Oak Millsite	163	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
CHS, Inc.	1	SW846 - Method 6010	Phase I RCRA Facility Investigation; Cenex, 5/97 (pg. 34)
CHS, Inc.	13	SW846 - Method 6010	Phase I RCRA Facility Investigation; Cenex, 5/97 (pg. 34)
Clara	6	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Clark Fork River	9	CLP SOW 7/88	Stratigraphy & Chemistry of Metal-Contaminated Floodplain Sediments, Upper Clark Fork River Valley; Nimick, 3/90
Clark Fork River	95	CLP SOW 7/88	Stratigraphy & Chemistry of Metal-Contaminated Floodplain Sediments, Upper Clark Fork River Valley; Nimick, 3/90

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CMC Asbestos Bozeman	1	SW846 - Method 3050/6010/6020	Voluntary Cleanup Plan for CMC East Main Depot, Bozeman, MT, Rev. 2; City of Bozeman, 10/02
CMC Asbestos Bozeman	5.7	SW846 - Method 3050/6010/6020	Voluntary Cleanup Plan for CMC East Main Depot, Bozeman, MT, Rev. 2; City of Bozeman, 10/02
Combination Mill	76.3	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Comet Oil	1.1	SW846 - Method	Remedial Investigation Report; Mountain States Petroleum, 1995
Comet Oil	3.25	SW846 Method	Report of Analytical Results at Comet Oil; EPA FIT, 3/85
Comet Oil	7.8	SW846 - Method	Remedial Investigation Report; Mountain States Petroleum, 1995
Comet Oil Company	41	SW846 Method	Report of Analytical Results at Comet Oil; EPA FIT, 3/85
Comet Tailings	137	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Cominco - Anderson Mine Timber Shed Facility	30	SW846 - Method 6010	Letter on Former Facility Practices Background Metals Concentrations; TeckCominco, 11/03
Cominco - Brock Creek Timber Treat Facility	16.5	SW846 - Method 6010	Report of Voluntary Cleanup Activities; TeckCominco, 3/03
Compromise Mine	53.3	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Conoco Billings Refinery	7	SW846 - Method 3050/7060	Final RCRA Facility Investigation Report; Conoco, 7/97
Conoco Billings Refinery	16	SW846 - Method 3050/7060	Final RCRA Facility Investigation Report; Conoco, 7/97
Conrad Refining Company	7.2	CLP SOW 7/87	Final Report for Conrad Refining; DEQ, 6/89
Copper Cliff	3.94	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Corbin Flats	1	Acid digestion/atomic absorption	Air Quality Impact of Abandoned Mine Tailings; Pegasus, 2/85
Corbin Flats	81.2	Acid digestion/atomic absorption	Air Quality Impact of Abandoned Mine Tailings; Pegasus, 2/85
Crystal Cataract Dist	140	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Danny T Mine	4.51	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Dee Creek	44	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites Summary Report; DEQ, 3/94
Dillon Millsite	13	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Drumlummon Mine Mill & Tailings	8.22	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Dry Gulch South	25	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
East Helena	15	Lab	Comprehensive Remedial Investigation/Feasibility Study; Asarco, 3/90
East Helena	18	Lab	Comprehensive Remedial Investigation/Feasibility Study; Asarco, 3/90
Emery	91	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Emma Rochester Dist	56	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Empire Millsite	38	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Engine Rebuilders	3.4	CLP SOW ILM02.1	Expanded Site Inspection Report for the Engine Rebuilders Site; DEQ 10/93
Engine Rebuilders	8.5	CLP SOW ILM05.3 TAL	Final Report Engine Rebuilders Site; DEQ 12/91
Enterprise	88	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Ermont Mine Mill	76	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Exxon Refinery and Old Flare Site	8.8	SW846 - Method 3050/7060	Final RCRA Facility Investigation Report; Exxon, 1998
Exxon Refinery and Old Flare Site	10.6	SW846 - Method 3050/7060	Final RCRA Facility Investigation Report; Exxon, 1998
Flathead Mine	7.17	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Fort Missoula OMS #2	12.7	CLP SOW ICP TAL	Site Inspection, Fort Missoula, MT; US Army Environmental Center, 3/94
Franklin and Sam Gaty	27.1	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Free Coin Red Cloud Mill	7.8	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95

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Garnet Gold Mine	5.9	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Georgetown Railroad	117	CLP SOW ILM04.1	Analytical Results Report for Expanded Site Inspection; DEQ, 11/00
Geraldine Airport	11.8	SW846 - Method 200.7	Final Analytical Results Report, Geraldine, MT; DEQ, 4/91
Granite Mountain	25	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Granite Timber Co	6.2	CLP SOW 7/87	Analytical Results Report Granite Timber; EPA FIT, 11/88
Great Falls Refinery Phillips Petroleum	15	SW846 - Method 6020	RCRA Facility Investigation Report; Montana Refining Company, 10/99
Grubstake	11.4	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Haywire Mill	5	SW846 - Method 3050	Montana Department of Highways memorandum report; MDH, 1/91
Helena Regional Airport	45.6	CLP SOW 7/88	Final Report for Helena Regional Airport, Helena, MT; DEQ, 12/90
Helena Valley	6	CLP	Final Remedial Investigation Report for Mill Creek, MT; ARCo, 10/87
Highland Basin Creek Dist	40.1	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Holliday	8.68	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Homco Facility	3.9	Lab	HOMCO Phase I Audit Analytical Test Results; HOMCO, 7/91
Hummingbird/Miller	20	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Idaho Pole	1.3	SW846 - Method 200.62	Remedial Investigation Report; DEQ, 3/92
Idaho Pole	3.3	SW846 - Method 200.62	Remedial Investigation Report; DEQ, 3/92
Indian Queen	43	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Iron	95.9	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Jackson Park	17	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Jardine	20	Acid digestion/colorimetric	Interim Status Report on Development Rock Characterization; 3/00
Jardine	70	Acid digestion/colorimetric	Interim Status Report on Development Rock Characterization; 3/00
Joe Wallit Mine	8	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Joliet Weed Control District	11	SW846 - Method 200.7	Final Analytical Results Report, Joliet, MT; DEQ, 4/91
Josephine Basin Dist	84.1	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Joslyn Street Tailings	60	EPA Method 200.2	Voluntary Cleanup Action Plan for Joslyn Tailings Site, Helena, MT; BNSF 4/96
Kaiser Cement	11.3	Lab	Analytical Results Report, Kaiser Cement (Ash Grove); EPA FIT, 1/89
Kalispell City Landfill Cemetery Road	1.3	CLP SOW 7/87	Final Report for Old Kalispell City Landfill - Cemetary Road; DEQ, 6/89
Kalispell Landfill Willow Glen Road	4.4	CLP SOW 7/87	Final Report for Old Kalispell City Landfill - Willow Glen Road; DEQ, 6/89
Kleinschmidt	98.6	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Lake County Weed District	6	SW846 - Method 200.7	Final Analytical Results Report, Lake County Weed Control District; DEQ, 4/91
Lakeshore	103	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Lane/Bigler	24	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Larrys Post And Treating Co	2.6	CLP SOW 7/87	Final Report for Larry's Post & Pole, Columbia Falls, MT; DEQ, 6/89
Last Chance No 1	5.13	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Latest Out	16	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Linton	17	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Little Daisy	14.6	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Little Gem	169	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95

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Livingston	19	CLP	Final Remedial Investigation Report for Mill Creek, MT; ARCo, 10/87
Livingston	146	CLP	Final Remedial Investigation Report for Mill Creek, MT; ARCo, 10/87
Lohof Gravel Pit	7.1	CLP	Analytical Results Report Lohof Gravel, Billings, MT; EPA FIT, 2/86
Lost Cabin Mine	14	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Lower Glengarry	8.61	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Lower River Road	6.3	CLP SOW ILM04.1	Final Sampling and Analytical Results Report - Lower River Road Site; DEQ, 11/02
Lower River Road	8.8	CLP SOW ILM04.1	Final Sampling and Analytical Results Report - Lower River Road Site; DEQ, 11/02
Mammoth South Boulder Dist	28	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Martin Wisdom Dist	5.08	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Mary Emmee	143	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Maud S	19	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Microbial Biotechnology Inc	5	SW846 - Method 3050	Preliminary Assessment Narrative Report, Microbial Biotechnology Inc.; EPA, 3/94
Middle Fork Warm Springs	32.1	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Miles City Airport	4.7	SW846 - Method 200.7	Final Analytical Results Report, Miles City, MT; DEQ, 4/91
Mill Creek Woodman Dist/Ward Lode	5.04	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Mission Wye	10	SW846 - Method 3050/7060	Mission Wye, MT Remedial Investigation - Phase I Report; BN, 1992 (rev)
Missoula Sawmill	5	SW846 - Method 3050	Sampling and Analytical Results, Missoula, MT; MCHHD, 2/00
Missouri	10	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Monarch Elliston Dist	22.6	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Montana Prince	11	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Montro Gold	4.44	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Morning Glory Cataract Dist	15	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Morse & Kennedy	5	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Mouat Mine	4.27	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites Summary Report; DEQ, 3/94
Nancy Lee Mine AML	7.89	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Nellie Grant	10	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
North American Oil Refinery	1.5	SW846 - Method 6010/7000	Final Report for North American Refinery, Kalispell, MT; DEQ, 6/89
Norwegian	10.6	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites Summary Report; DEQ, 3/94
NW SE Section 26 Sheridan Dist	26	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Ohio Keating	6.11	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Old Agency Landfill	6.2	Lab	Final Site Inspection Report Old Agency Landfill Site; EPA FIT, 3/91
Old Elkhorn	12.3	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Old Poplar Landfill	12.6	CLP SOW 7/87	Final Site Inspection Report Old Poplar Landfill Site, Poplar, MT; EPA FIT, 4/91
Ontario Millsite	88	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Pacific	12.8	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Park Mine	44	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Peerless Jenny	18.9	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Philipsburg	11	CLP	Final Remedial Investigation Report for Mill Creek, MT; ARCo, 10/87

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Philipsburg	13	CLP	Final Remedial Investigation Report for Mill Creek, MT; ARCo, 10/87
Piegan Gloster Mill	33.3	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Poor Man/Yager/Daisy	16.3	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Prester John	131	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Red Mountain 13	103	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Red Water	87	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Reliance Refining Company	4.1	CLP SOW 7/87	Final Report for Kalispell Pole & Timber/Reliance Refining; DEQ, 6/89
Rhodia, Inc.	18	CLP SOW ICP-AES (ILMO5.2)	Expanded Site Investigation, Final Analytical Report; EPA, 4/04 (pg. 5)
Rhodia, Inc.	94.9	CLP SOW ICP-AES (ILMO5.2)	Expanded Site Investigation, Final Analytical Report; EPA, 4/04 (pg. 5)
Richey Airport	6	SW846 - Method 200.7	Final Analytical Results Report, Richey, MT; DEQ, 4/91
Ripple Mines	9.62	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Salteste Consolidate	4.52	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Sannes Farm	6	SW846 - Method 3050/7060	Sannes Farm Preliminary Assessment Report; DEQ, 8/93
Sannes Farm	7.2	CLP SOW ILM03.0	Final Site Inspection Report - Sannes Farm Site, Silesia, MT; DEQ, 9/95
SE SW Section 10 Stemple Dist	21.3	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Silver Bow 1999 borrow area	10	SW846 - Method 6010B	SA1 Supplemental Borrow Area Investigation; DEQ, 2/99
Silver Bow 1999 borrow area	140	SW846 - Method 6010B	SA1 Supplemental Borrow Area Investigation; DEQ, 2/99
Silver Bow 2001 borrow area	20	SW846 - Method 6010B	SA1 Borrow Area Investigation Results; DEQ, 9/01
Silver Bow 2002 borrow area	4	SW846 - Method 6020	Borrow Area Results; DEQ, 1/02
Silver Bow 2002 borrow area	26	SW846 - Method 6020	Borrow Area Results; DEQ, 1/02
Silver Bow 2003 borrow area 1	10	SW846 - Method 200.7 CLP-M	SA2 Draft Borrow Source Investigation; DEQ, 9/03
Silver Bow 2003 borrow area 1	18	SW846 - Method 200.7 CLP-M	SA2 Draft Borrow Source Investigation; DEQ, 9/03
Silver Bow 2003 borrow area 2	10	SW846 - Method 200.7 CLP-M	SA2 Draft Borrow Source Investigation; DEQ, 9/03
Silver Bow 2003 borrow area 2	25	SW846 - Method 200.7 CLP-M	SA2 Draft Borrow Source Investigation; DEQ, 9/03
Silver Bow 2003 borrow area 3	10	SW846 - Method 200.7 CLP-M	SA2 Draft Borrow Source Investigation; DEQ, 9/03
Silver Bow 2003 borrow area 3	23	SW846 - Method 200.7 CLP-M	SA2 Draft Borrow Source Investigation; DEQ, 9/03
Silver Dyke Adit	10.5	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Silver Lake Millsite	64	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Snowshoe Libby Dist	54.2	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Sourdough	76.1	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Strawberry Pony Dist	20.1	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
SW NE Section 10 Smith River Dist	18	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Swansea Tailings Mine	19.5	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Tacoma	29.8	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Tail Holt	31.8	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Texaco Sunburst Works Refinery	10	SW846 - Method 3050/6010	Remedial Investigation, Texaco, Inc. Sunburst Works Refinerty Site, Sunburst, MT; Texaco, 11/90
Third Term	20	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Thistle I	19	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95

Attachment 1
Concentrations of Arsenic in Native Soil

Thumper Mica	8.47	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites Summary Report; DEQ, 3/94
Tiger Hughesville Dist	5.1	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Townsend	3	CLP	Final Remedial Investigation Report for Mill Creek, MT; ARCo, 10/87
Townsend	6	CLP	Final Remedial Investigation Report for Mill Creek, MT; ARCo, 10/87
True Blue	45	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Trumley Heap Leach	21.3	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Uncle Sam	20	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Upper Blackfoot Mining Complex	8.4	CLP SOW ILM02.1 TAL	Final Site Inspection Report Upper Blackfoot Mining Complex Site, Lewis & Clark County, MT; DEQ, 2/94
Upper Blackfoot Mining Complex	27.2	CLP SOW ILM02.1 TAL	Final Site Inspection Report Upper Blackfoot Mining Complex Site, Lewis & Clark County, MT; DEQ, 2/94
Victory Evening Star	71	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Vortex	14.1	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites Summary Report; DEQ, 3/94
Vosburg Mine	85	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Western By Products	10	Lab	Analytical Results for Western By-Products, Great Falls, MT; EPA FIT, 1/85
Wickes Smelter	11	CLP SOW ILM02.1 TAL	Reclamation Investigation, Wickes Smelter; DEQ, 5/96
Wickes Smelter	63	XRF Spectrase 9000	Reclamation Investigation, Wickes Smelter; DEQ, 5/96
Wickes Smelter - Comet Creek borrow area	5	SW846 - Method 6010B	Borrow soil data for Construction Report; DEQ, due 5/05
Wickes Smelter - Comet Creek borrow area	26	SW846 - Method 6010B	Borrow soil data for Construction Report; DEQ, due 5/05
Wild Cat	51.1	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Wright Lode	29	CLP SOW ILM05.3 TAL	Abandoned Hardrock Mine Priority Sites 1995 Summary Report; DEQ, 4/95
Yale Oil of South Dakota	3.6	CLP SOW ILM05.2 TAL	Analytical Results Report for Yale Oil of South Dakota, Billings, MT; EPA FIT, 11/89
95% UCL (ProUCL - 4/12/05)	40		
Maximum	187		
Minimum	0.94		
Geometric Mean	15		
Arithmetic Mean	29		
Standard Deviation	37		

Appendix A – Risk-Based Concentrations

The following sections and attached spreadsheets provide discussion of the specific methods and analysis DEQ used to calculate Montana-specific residential risk-based concentrations to compare with native soil concentrations.

1.0 Standard Default Factors

Several parameters used in the calculation are standard default values that could be used in calculating any residential risk-based concentration. These factors are described in this section.

1.1 Carcinogenic Averaging Time

The averaging time included in the calculation of a carcinogenic risk-based concentration is based on the average human life expectancy of 75 years provided in the EPA Exposure Factors Handbook (EFH) Volume I – General Factors (EPA, 1997). The life expectancy in years is multiplied by 365 days to derive the averaging time of 27,375 days as indicated in RAGS Volume I (EPA, 1989).

1.2 Conversion Factor

A standard conversion factor of 0.000001 is used to convert milligrams (mg) of soil ingested to kilograms (kg) of soil since the contaminant concentration is provided as milligrams of contaminant per kilogram of soil (EPA, 1989).

1.3 Childhood Exposure Factors for Non-carcinogenic Exposure

Because children have a lower body weight and a higher soil ingestion rate than adults, they may be more sensitive to non-carcinogenic effects than adults. Therefore, DEQ bases non-carcinogenic risk-based concentrations on childhood exposure, rather than lifetime exposure. DEQ used EPA recommended childhood exposure factors. DEQ applies the childhood exposure parameters over the course of the first 6 years of life with an average body weight of 15 kg. The body weight estimate is an average of the weights for children within each year of age. For non-carcinogens, the exposure duration of 6 years is multiplied by 365 days for an averaging time of 2,190 days (EPA, 1989). EPA recommends these general exposure factors in the EFH (EPA, 1997 and EPA, 2002a).

The childhood ingestion rate of 200 mg/day represents a conservative estimate of the mean (EPA, 1997 and EPA, 2002a). This rate does not take into account pica behavior (the repeated eating of non-nutritive substances) associated with soil ingestion because this type of behavior is very uncommon (EPA, 1997) and, if a child with this type of behavior resides at a facility with arsenic contamination, intervention and medical assistance should occur on an individual basis. There may be no levels of arsenic in soil that are protective of a child who displays consistent pica behavior; however, most children do not display pica behavior on a daily basis for long periods of time.

DEQ used a childhood inhalation rate of 7.8 cubic meters (m^3)/day based on a time-weighted average of the recommended long-term inhalation rates for children within each year of age (EPA, 1997 and EPA, 2002a). The child skin surface area of 2,800 square centimeters (cm^2) includes bare head, hands, forearms, lower legs, and feet (EPA, 2004b). The child adherence

factor of 0.2 mg/cm^2-day is a weighted average (based on exposure to head, hands, forearms, lower legs, and feet) for daycare children playing indoors and outdoors (EPA, 2004b).

2.0 Adjusted Factors for Carcinogenic Exposure

DEQ has adjusted the following factors to account for the climate in Montana and to account for long-term, time-weighted average (6 years as a child and 24 years as an adult) exposures. While these adjusted factors are not defaults, they are not specific to arsenic and may be used in calculating risk-based concentrations for other contaminants.

2.1 Particulate Emission Factor

DEQ calculated a particulate emission factor (PEF) using the equation and table found in the EPA Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (EPA, 2002b). The PEF of 3.17E+08 m^3/kg is based on the meteorologic conditions of Zone IV and the climatologic value corresponding to Salt Lake City. These climatic conditions are similar to those found in Montana.

2.2 Exposure Frequency

In order to determine an appropriate residential soil exposure frequency that includes consideration of snow cover and frozen soil, DEQ analyzed the monthly average climate data the Western Regional Climate Center (WRCC) compiled over an extended period of time (some data have been compiled since 1882). The WRCC data indicates that an average snow cover of two inches or greater or average temperatures of 32° Fahrenheit or less or both occur throughout Montana for at least four months per year (WRCC, 2003). Therefore, DEQ chose 240 days per year as the exposure frequency for exposure to residential soil.

2.3 Age-Adjusted Factors

Because contact rates may be different for children and adults, a time-weighted average approach is used to calculate lifetime exposure that begins with childhood and occurs over the course of 30 years, which is the reasonable maximum period of time an individual may be expected to live in a particular residence. Childhood exposure parameters are applied to the first 6 years of exposure with adult exposure parameters applied to the remaining 24 years of exposure. DEQ calculated the arsenic residential soil risk-based concentration based on exposure during the first 30 years of life using age-adjusted factors. Attachment 2 of this appendix provides the spreadsheet used to calculate age-adjusted factors and the parameters involved in the calculation are discussed in the following sections. The general approach is taken from the EPA Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (EPA, 2002b) and the EPA Region 9 PRGs (EPA9, 2004).

2.3.1 Soil Ingestion Factor

The soil ingestion factor of 114 mg-year/kg-day is based on a childhood ingestion rate and body weight and an adult ingestion rate and body weight. The childhood parameters used are those described above in Section 1.3. The adult parameters used are 100 mg/day over the course of the remaining 24 years that make up the first 30 years of life with an average body weight of 70 kg. EPA recommends an adult soil ingestion rate of 100 mg/day for residential scenarios in the EFH (EPA, 1997). According to the data included in the EFH (EPA, 1997) 70 kg remains a conservative estimate of the mean body weight

for adults that does not require adjustment of the dose-response relationship used to derive the arsenic cancer slope factor.

2.3.2 Air Inhalation Factor

The air inhalation factor of 8 m^3-year/kg-day is based on a childhood inhalation rate and body weight and an adult inhalation rate and body weight. The body weights are the same as those used for soil ingestion. DEQ used the childhood inhalation rate mentioned previously of 7.8 m^3/day based on a time-weighted average of the recommended long-term inhalation rates for children within each year of age (EPA, 1997 and EPA, 2002a). DEQ used an adult inhalation rate of 15.2 m^3/day based on the recommended long-term inhalation rates for males 19 to 65 years of age. The inhalation rate for males was chosen over that for females because it is higher and therefore more conservative.

2.3.3 Dermal Factor

The dermal factor of 361 mg-year/kg-day is based on skin surface areas, adherence and body weights for both children and adults. The body weights are the same as those used for soil ingestion and inhalation. The adult skin surface area available for dermal exposure of 5,700 cm^2 includes bare head, hands, forearms, and lower legs (EPA, 2004b). As stated previously, the child skin surface area of 2,800 cm^2 also includes bare feet (EPA, 2004b). The adult adherence factor of 0.07 mg/cm^2-day is a weighted average (based on exposure to hands, face, forearms, and lower legs) for residential adult gardeners (EPA, 2004b). The child adherence factor of 0.2 mg/cm^2-day is a weighted average (based on exposure to hands, face, forearms, lower legs, and feet) for daycare children playing indoors and outdoors (EPA, 2004b).

3.0 Arsenic Toxicity and Absorption Factors

EPA classifies arsenic as Class A, a known human carcinogen (Integrated Risk Information System (IRIS), 2005). Arsenic is also known to cause noncarcinogenic effects in humans (IRIS, 2005). Based on sufficient evidence from human data, exposure to arsenic through inhalation has been observed to cause increased lung cancer mortality. In addition, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic (IRIS, 2005). Skin lesions are considered the most sensitive noncarcinogenic endpoint followed by an increased incidence of blackfoot disease (IRIS, 2005). Typically, noncarcinogenic effects are observed at arsenic concentrations that are higher than those found to be protective of carcinogenic risks associated with chronic residential exposure (IRIS, 2005; Agency for Toxic Substances and Disease Registry (ATSDR), 2000).

The July 29, 2004 issue of *Inside EPA* indicates that an EPA workgroup will soon advise EPA to adopt a stricter estimate of the risks posed by arsenic (EPA, 2004a). This would result in a tightening of the arsenic slope factor listed in IRIS and stricter standards for drinking water and, potentially, action levels for other media. If the slope factor listed in IRIS is increased and the information indicates that the increased slope factor applies to arsenic in soils, DEQ may re-evaluate its residential soil arsenic action level.

3.1 Slope Factors
DEQ obtained oral and inhalation slope factors of 1.5 and 15.0 kg-day/mg, respectively, from IRIS in March 2005 (IRIS, 2005).

3.2 Reference Doses
DEQ obtained the oral reference dose of 0.0003mg/kg-day from IRIS in March 2005 (IRIS, 2005). Since no inhalation reference concentration was available on IRIS in March 2005, DEQ used the oral reference dose for the inhalation pathway.

3.3 Oral Absorption
Risks from ingestion of arsenic in soil are difficult to assess because arsenic exists in many geochemical forms (e.g., oxides, sulfides) and physical forms (e.g., flue dust, slag, tailings, waste ore, pesticides) (National Center for Environmental Research (NCER), 2000). Some forms of arsenic are poorly soluble in water or more tightly bound with other soil constituents, making them less easily absorbed through the gastrointestinal tract. Arsenic bioavailability has been found to be dependent on the mineral form of arsenic, the encapsulating matrix, and site-specific environmental conditions. Low arsenic bioavailability has been observed in mine site soils, which is probably due to the high proportion of poorly soluble arsenosulfides (Juhasz, *et. al.*, 2003). Calcinated material, a poorly soluble encapsulating matrix, has been observed to cause reduced arsenic bioavailability (NCER, 2000). Arsenic speciation and site-specific conditions such as grain size, residence time in soil, and soil pH have also been shown to influence bioavailability (Juhasz, *et. al.*, 2003). Both acidic and alkaline conditions have been shown to increase bioavailability (Juhasz, *et. al.*, 2003). Study results of soil arsenic bioavailability show a correlation between the amount of soil fed to the study animal and the calculated bioavailability (Washington Office of Environmental Health Assessment Services (EHAS), 1999). The more soil fed to the study animal the less bioavailable the soil arsenic appeared (EHAS, 1999).

DEQ evaluated several references concerning the issue of oral absorption of arsenic in soils. These references are listed separately in Section 5.1 of this appendix. Based on a compilation of all these references relative arsenic bioavailability in soils has been shown to vary from 8.3% to 100%. Because of this extreme variability, DEQ has chosen to use 100% oral absorption in developing its risk-based concentration. This concentration would be appropriate in the absence of any site-specific bioavailability information, which might include speciation, arsenic source information (e.g., mining wastes, smelting wastes, pesticides), or a site-specific bioavailability study. DEQ may determine that a site-specific arsenic risk-based concentration may be appropriate for facilities with adequate site-specific information. This detailed information must be provided to DEQ if a site-specific arsenic soil risk-based concentration will be developed.

3.4 Dermal Absorption
The dermal absorption fraction of 0.03 is from EPA RAGS Volume I Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) – Final (EPA, 2004b). The value is based on a study Wester, *et. al*. conducted in 1992 and published

in 1993 that the EPA has frequently cited. The study found that arsenic was poorly absorbed through the skin.

4.0 Risk Level and Noncarcinogenic Effects

The acceptable risk range provided in the Federal National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (EPA, 1990) is 1×10^{-6} to 1×10^{-4}. DEQ uses a target risk level of 1.0×10^{-5} when calculating risk-based action levels. In addition, action levels for noncarcinogenic substances are calculated to be protective of children as the most sensitive population based on their lower body weight and higher incidental soil ingestion rate. The more conservative action levels that are protective of children are also protective of adults with higher body weights and lower incidental soil ingestion rates. Even though adult inhalation rates, skin surface areas, and adherence rates are higher than those of children, incidental soil ingestion is the primary driver of risks from exposure to arsenic and other substances in soils. Basing noncarcinogenic action levels on childhood exposure provides an additional level of conservatism to ensure that a facility is protective of this sensitive population.

4.1 Target Cancer Risk

The arsenic residential soil risk-based concentration of 6 mg/kg is based on a target cancer risk of 1.0×10^{-5}. This target risk is within the range specified in the NCP and is the same as the cumulative cancer risk DEQ allows at other state Superfund facilities. However, because this risk-based concentration is below the native soil concentration of arsenic found at most facilities in Montana, DEQ has developed a generic action level of 40 mg/kg based on native soil concentrations.

4.2 Noncarcinogenic Effects

DEQ has calculated a noncarcinogenic residential soil risk-based concentration of 32 mg/kg for arsenic based on childhood exposure to residential soil. This concentration is comparable to DEQ's generic action level of 40 mg/kg based on native soil concentrations.

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Soil Ingestion Factor (EPA, December 1991)

IFSadj = EDc*IRSc/BWc + (EDtot-EDc)*IRSa/BWa

Parameters	Values
IFSadj (Age-adjusted soil ingestion factor - mg*yr/kg*day: EPA, December 2002)	114
EDc (Child exposure duration - yr; EPA, December 1991)	6
IRSc (Child soil ingestion rate - mg/day; EPA, September 2002)	200
BWc (Child body weight - kg; EPA, September 2002)	15
EDtot (Total exposure duration - yr; EPA, December 1991)	30
IRSa (Adult soil ingestion rate - mg/day; EPA, August 1997)	100
BWa (Adult body weight - kg; EPA, August 1997)	70

Air Inhalation Factor

IFAadj = EDc*IRAc/BWc + (EDtot-EDc)*IRAa/BWa

Parameters	Values
IFAadj (Age-adjusted inhalation factor - m^3*yr/kg*day: EPA9, October 2002)	8
EDc (Child exposure duration - yr; EPA, December 1991)	6
IRAc (Child inhalation rate - m^3/day; EPA, September 2002)	7.8
BWc (Child body weight - kg; EPA, September 2002)	15
EDtot (Total exposure duration - yr; EPA, December 1991)	30
IRAa (Adult inhalation rate - m^3/day; EPA, August 1997)	15.2
BWa (Adult body weight - kg; EPA, August 1997)	70

Dermal Factor

DFadj = EDc*DFc/BWc + (EDtot-EDc)*DFa/BWa

Parameters	Values
DFadj (Age-adjusted dermal factor - mg*yr/kg*day: EPA, December 2002)	361
EDc (Child exposure duration - yr; EPA, December 1991)	6
DFc (Child dermal factor - mg/day; EPA, July 2004)	560
BWc (Child body weight - kg; EPA, August 1997)	15
EDtot (Total exposure duration - yr; EPA, December 1991)	30
DFa (Adult dermal factor - mg/day; EPA, July 2004)	399
BWa (Adult body weight - kg; EPA, August 1997)	70

Dermal Factor Adult (Residential Adult Gardener Mean Adherence)

DFa = SAa*Afa

Parameters	Values
DFa (Adult dermal factor - mg/day; EPA, July 2004)	399
SAa (Adult head, hands, forearms, lower legs surface area - cm^2; EPA, July 2004)	5700
AFa (Adult weighted adherence factor - mg/cm^2*day; EPA, July 2004)	0.07

Dermal Factor Child (Daycare Child Mean Adherence)

DFc = Sac*Afc

Parameters	Values
DFc (Child dermal factor - mg/day; EPA, July 2004)	560
SAc (Child head, hands, forearms, lower legs, feet surface area - cm^2; EPA, July 2004)	2800
AFc (Child weighted adherence factor - mg/cm^2*day; EPA, July 2004)	0.2