GROUNDWATER COMPARISON DATA SET AND COMPARISON CONCENTRATIONS REPORT SANTA SUSANA FIELD LABORATORY VENTURA COUNTY, CALIFORNIA *FINAL*

Prepared for:

THE BOEING COMPANY

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

U.S. DEPARTMENT OF ENERGY

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LIST OF ACRONYMS

Boeing	The Boeing Company
Cal-EPA	California Environmental Protection Agency
COPC	chemical of potential concern
CPEC	chemical of potential ecological concern
DOE	Department of Energy
DTSC	Department of Toxic Substances Control
GSU	Geological Services Unit
GRS	Groundwater Resources Consultants
H&A	Haley & Aldrich
MCL	maximum contaminant level
MWH	MWH Americas, Inc.
NASA	National Aeronautics and Space Administration
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SRAM	Standardized Risk Assessment Methodology
SSFL	Santa Susana Field Laboratory
VOC	volatile organic compound

SECTION 1

INTRODUCTION

This report presents the Groundwater Comparison Data Set and the process used to define Groundwater Comparison Concentrations for metals, fluoride, and sulfate at the Santa Susana Field Laboratory (SSFL) in Ventura County, California. This report has been prepared by MWH Americas, Inc. (MWH) for The Boeing Company (Boeing), the National Aeronautics and Space Administration (NASA), and the United States Department of Energy (DOE) to support the Resource Conservation and Recovery Act (RCRA) Corrective Action Program at the SSFL. The Groundwater Comparison Data Set and associated Groundwater Comparison Concentrations have been developed for the SSFL under the direction of the California Environmental Protection Agency (Cal-EPA) Department of Toxic Substances Control (DTSC), Geological Services Unit (GSU) Branch.

The Groundwater Comparison Data Set and Comparison Concentrations presented in this report will be used to assist in site characterization and risk assessments for the ongoing RCRA Corrective Action Program at the SSFL. For characterization purposes, the Groundwater Comparison Concentrations will be used as one factor in evaluating whether groundwater quality may have been impacted and if further characterization is needed. In both the human and ecological risk assessments, the Groundwater Comparison Data Set and Comparison Concentrations will be used in the selection of chemicals of potential concern (COPCs) or chemicals of potential ecological concern (CPECs).

This report is organized as follows:

- Section 1 introduces the Groundwater Comparison Data Set and associated Groundwater Comparison Concentrations for the SSFL;

- Section 2 describes the initial groundwater data set, and the process used to review the data and develop the final Groundwater Comparison Data Set and Comparison Concentrations;

- Section 3 provides the final Groundwater Comparison Data Set and Comparison Concentrations;

- Section 4 describes how the Groundwater Comparison Data Set and Comparison Concentrations will be used in characterization and risk assessment;

- Section 5 lists references cited in this document; and,

- Appendix A presents data tables and plots of the groundwater data set used to develop the Groundwater Comparison Concentrations, and the final Groundwater Comparison Data Set.

SECTION 2

DEVELOPMENT PROCESS

The purpose of the SSFL groundwater investigation is to determine the nature and extent of contamination. The program has focused principally on characterizing volatile organic compound (VOC) impacts related to the historical use of solvents at the SSFL. An extensive amount of work has gone into collecting data to assist in understanding and predicting the movement of contaminants in a fractured bedrock aquifer. However, other chemicals have been evaluated in the groundwater program, including metals and selected inorganic compounds. The data collected to describe the presence of metals and other inorganic compounds in groundwater has been concentrated on areas where VOC delineation was needed, although limited groundwater metals analysis has been performed on perimeter monitoring well samples. To date, a total of 390 monitoring locations have been sampled and analyzed for metals resulting in a total of approximately 18,000 analyses.

The groundwater metals data set has concentration variability, which is inherent in these naturally occurring chemicals. Complex site hydrogeology (including stratigraphic and structural variability) and evolving analytical methods over time has resulted in a data set in which the metals and inorganic concentrations in the groundwater monitoring data can vary with location and with time. In addition, due to the potential presence of metal contamination at some RFI sites there was uncertainty that the metals/inorganics data set may not represent the range of naturally occurring concentrations of these constituents (i.e. background). To address potential biases in the data set, DTSC, MWH, and Boeing evaluated the data using the procedures outlined in Section 2.2. The resulting metals data set selected for Groundwater Comparison Data Set and Comparison Concentrations represent a range of metal concentrations expected to occur naturally at the site and that are at or below the maximum background concentration.

Decisions regarding groundwater quality will be made in both the characterization and risk assessment phases of the RCRA Facility Investigation (RFI) and, if warranted, in subsequent phases of the RCRA Corrective Action Program at the SSFL. Because of the conditions described above, a Groundwater Comparison Data Set and associated Groundwater Comparison Concentrations were developed to assist decision-making in the RCRA Corrective Action Program. These tools will be used in both characterization and risk assessment to ensure that decisions are conservative and health-protective.

2.1 INITIAL REVIEW GROUNDWATER DATA SET

The final Groundwater Comparison Data Set and Comparison Concentrations were developed by evaluating SSFL groundwater data for dissolved metals and selected inorganic compounds. SSFL groundwater data include results from approximately 18,000 samples, collected from over 390 wells and piezometers. These data have been collected since the early 1980s and continued data collection is ongoing as part of the SSFL groundwater monitoring program (Haley & Aldrich [H&A], 2005). These data have been collected according to regulatory agency approved sampling and analysis work plans (Groundwater Resources Consultants [GRC], 1995a and 1995b).

For purposes of establishing the final Groundwater Comparison Data Set and Comparison Concentrations, groundwater sampling results for dissolved metals, fluoride, and sulfate collected through the 4^{th} Quarter 2004 were compiled as an "Initial Review" groundwater data set and evaluated following procedures outlined in the following sections. Following protocols in the agency-approved work plans cited above, groundwater samples for metals analysis are filtered to yield dissolved metals concentrations in groundwater. Total (unfiltered) metals concentrations were not considered because these analyses are not representative of groundwater transport conditions and, further, have been measured in only a few wells onsite.

Appendix A presents the initial comprehensive data set evaluated to establish Groundwater Comparison Concentrations for the SSFL. Information for the 25 metals, fluoride, and sulfate included in this data set is summarized in Table 2-1.

2.2 DATA EVALUATION AND REVIEW PROCESS

The Groundwater Comparison Data Set and Comparison Concentrations for the SSFL were developed using a two-component process to evaluate the data set described above. One component was a review of the entire data set for each constituent using a statistical approach. The other component was a more detailed hydrogeologic analysis of populations within the data set to establish a comparison concentration. Each of these components is described further in the following sections. DTSC, MWH and Boeing worked together in the data review and discussions were held at all stages of this process. The findings were reviewed at a series of working meetings during May, June and August 2005.

2.2.1 Data Distribution Review

The first component in the process of establishing the Groundwater Comparison Data Set and Comparison Concentrations was to develop an understanding of the data distribution for each metal. This was accomplished using several tabular and graphical methods. Tables of groundwater data for each constituent were prepared, including sample date, well number, result (concentration or analytical detection level) and laboratory qualifier. These tables are useful for viewing overall trends within the data set based on sampling date, detected versus non detected concentrations, and prevalence of metals in wells. Data tables for all constituents are included in Appendix A.

DTSC and MWH separately evaluated the groundwater data. Graphical methods included preparation of rank-order probability plots for each of the metals and selected inorganic constituents (Appendix A). The rank-order probability plots allow viewing the entire data set, provides information on data distribution, and aids in identifying different data populations.

The MWH evaluation began with the highest inflection point (a break between data populations) for each metal and the data above that point were removed from the evaluation. The population below this inflection point in the data set, i.e., the resultant data set and associated maximum concentration value, was used as a starting point for the more detailed reviews discussed below. The DTSC evaluation included a review of inflection points in the lower range of concentrations simultaneously with the detailed data review. Both evaluations were considered in the selection of the final groundwater comparison concentration data sets.

2.2.2 Detailed Data and Hydrogeologic Review

The second component in the process of developing the Groundwater Comparison Data Set and Comparison Concentrations involved a more detailed evaluation. The data set was further evaluated using time-series plots, surrounding well data, and soil data to assess whether measured concentrations in well samples represented potential impacts from site operations or represented unimpacted groundwater quality at a given location. Data quality was also considered since analytical methods have improved during the time period over which data was collected.

In this detailed review phase, selected hydrogeologic information was considered to aid in the interpretation of the groundwater data. For example, potential contaminant migration pathways were considered by evaluating groundwater flow directions and comparing results between both up-gradient and down-gradient wells. Depths to groundwater, and the relative completion details of adjacent wells and their concentrations of metals and selected inorganic compounds, were also used to assess if a selected value should be included in the final Groundwater Comparison Concentration Data Set. This review considered both discrete sampling results and entire data sets from specific wells. Sampling dates were considered because of the improvement of analytical methods over time. Data patterns, especially trends and single anomalous results, were considered in the evaluation. Finally, the presence of other chemical contamination (especially VOCs), and other metals or inorganic compounds was used in the evaluation.

Using best professional judgement, Boeing, MWH, and DTSC reviewers identified wells with sampling results considered potentially impacted or elevated. Based on this determination, all data from individual wells for a specific metal/inorganic were excluded from the final Groundwater Comparison Data Set. It should be noted that potentially impacted or elevated data was excluded from the data set to address uncertainty regarding the potential presence of contamination and to ensure that the Groundwater Comparison Concentration conservatively represented ambient conditions. Following definition of the final data set, the Groundwater Comparison Concentration for each constituent was identified as the highest concentration remaining in the final data set. For some metals with a high proportion of non detect data, detection limits achieved in the last few years were reviewed and selected as the Groundwater Comparison Concentrations.

2.2.3 Assumptions and Considerations

Many assumptions that have been made in evaluation of SSFL groundwater data to develop the Groundwater Comparison Data Set and associated Concentrations. Although the overall analysis represents a best professional judgement and weight-of-evidence approach by Boeing, MWH, and DTSC reviewers, the following assumptions and data considerations were made during the evaluation:

- Uppermost populations that deviate from linearity in rank-order probability plots were eliminated during the initial review.
- Up-gradient and down-gradient wells were assumed to provide information about potential sources of metals and selected inorganic compounds to groundwater at selected sites.
- The lateral and vertical distances of each groundwater monitoring well from SSFL site activities were considered. Wells far from site operations were more likely to be selected in the final comparison data set.

- Depth to groundwater in neighboring wells and their respective concentrations (e.g., higher concentrations at surface decreasing with depth) were considered. In some instances, shallow wells near potential sources were eliminated based on a comparison with neighboring deeper wells.

- Older groundwater monitoring data were considered to carry a lower weight in the evaluation than newer data. This was done because more recent samples typically have lower analytical detection limits.

- Two periods of groundwater metal analyses have been determined to provide anomalous data that cannot be used to characterize groundwater and establish the Groundwater Comparison Data Set and Comparison Concentrations. Specifically, data between the 4^{th} Quarter 2000 through 2^{nd} Quarter 2001, and 4^{th} Quarter 1994 have been eliminated from inclusion in the final Groundwater Comparison Data Set for selected metals/inorganics and from further consideration during characterization and risk assessment. The cause of this anomalous data is considered to be laboratory-related, and resulted in non-repeatable, elevated concentrations (i.e., spikes) from wells across the SSFL over a short period of time. Elimination of this anomalous data resulted in lower comparison values.

- The presence or absence of other potential contaminants, especially VOCs, or metals and selected inorganic compounds in a well was considered in the interpretation of data from that well. For example, some wells were eliminated from the final Groundwater Comparison Concentration Data Set because of either metal or VOC detections in those wells.

- Potential differences in metal and selected inorganic compound concentrations related to geological variability were considered part of naturally occurring conditions at the site.

- Beryllium, mercury, silver, thallium and tin results were characterized by a high proportion of elevated non detects, primarily during early sampling efforts. Based on a historical review of detection limits for these data, Groundwater Comparison Concentrations were established using recently achievable detection limits for each of these metals.

During evaluation of the data set used to develop the Groundwater Comparison Concentrations, some additional data needs were identified. As discussed with DTSC, these additional data needs will be further evaluated during the RFI and additional sampling conducted, if warranted, based on site conditions (e.g., operational history, soil concentrations, etc.). Additional data collection will be performed following protocols in DTSC-approved work plans (GRC, 1995a and 1995b), using recent laboratory methods.

Based on review to date and discussion with DTSC these data needs include:

- More recent data at selected well locations where only early sampling for metals (e.g., 1980s) was conducted;
- Additional constituents based on evaluation of RFI data needs;
- Hexavalent chromium data to supplement existing unspeciated total chromium data; and,
- Aluminum data needed to establish a groundwater comparison data set.

Additional sampling needs will be determined during evaluation and reporting of the RFI data, and discussed with DTSC during the report review process.

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SECTION 3

FINAL GROUNDWATER COMPARISON DATA SET AND COMPARISON CONCENTRATIONS

The final Groundwater Comparison Data Set and Comparison Concentrations for 25 metals, fluoride, and sulfate were established using the procedures described in Section 2. The Groundwater Comparison Concentrations for the 25 metals, fluoride, and sulfate are presented in Table 3-1.

Appendix A presents details of the final Groundwater Comparison Data Set and Comparison Concentrations for each metal and selected inorganic compounds included in this evaluation. Appendix A includes electronic copies for (1) tables of the "Initial Review Groundwater Data Set" considered during the evaluation, (2) the "Final Groundwater Comparison Data Set" determined useable for further evaluation during the RCRA Corrective Action Program at the SSFL, and (3) rank-order probability plots, prepared using the initial data set. Probability plots for the data set are also provided in hard copy format.

As described in Section 2.2.3 and below in Section 4.3, some additional data may be collected based on review findings to date. Although the established Groundwater Comparison Concentrations presented in this report are not expected to change based on the new data, the Final Groundwater Comparison Data Set may change, or new constituents may be added to the list of chemicals. If so, proposed changes to the Final Groundwater Comparison Data Set and associated Groundwater Comparison Concentrations will be documented in a revision of this document or in RFI reports, for DTSC review and approval.

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SECTION 4

USES OF THE GROUNDWATER COMPARISON DATA SET AND COMPARISON CONCENTRATIONS

The Groundwater Comparison Data Set and associated Groundwater Comparison Concentrations will be used to evaluate potential impacts to groundwater quality in the SSFL RCRA Correction Action Program. Since these comparison concentrations are considered to be at or below the maximum concentrations expected to occur naturally, concentrations below these levels will not require further evaluation for characterization or for risk assessment. Concentrations detected above these levels will undergo further evaluation in RFI reports in the context of all site data.

The Groundwater Comparison Data Set and Comparison Concentrations conservatively represent ambient conditions but were not intended to represent the full range of background concentrations. As such they will be used as a conservative threshold to make decisions regarding the need to characterize groundwater concentrations or for risk assessment as described below in Sections 4.1 and 4.2. The Groundwater Comparison Concentrations are considered to be at or below the maximum naturally occurring metals concentrations. Since any data identified as potentially impacted or elevated were removed from the initial groundwater data set, groundwater data with concentrations above the Groundwater Comparison Concentrations may have been removed that are actually naturally occurring. Therefore, concentrations above these comparison concentrations do not necessarily indicate groundwater quality has been impacted.

4.1 USES IN CHARACTERIZATION

For characterization purposes, the Groundwater Comparison Concentrations will be used as one factor in evaluating if groundwater quality may have been impacted and if further characterization is needed. This evaluation will be performed using best professional judgement in conjunction with other groundwater data (groundwater levels, time-series plots, and surrounding well data) and site data (soil data, historical site use). If the evaluation does not indicate that a constituent is a potential contaminant near an investigational area, further characterization may not be recommended even if some groundwater results are above their respective Groundwater Comparison Concentrations. Site characterization decisions with respect to Groundwater Comparison Concentrations will be described in RFI characterization reports.

4.2 USES IN RISK ASSESSMENT

For risk assessment purposes, these Groundwater Comparison Concentrations are used to select chemicals that will be included in risk assessment. This evaluation will be performed using best professional judgement, in conjunction with other groundwater data (groundwater levels, time-series plots) and other site data (soil data, historical site use) to assess potential groundwater impacts and determine if that chemical should be evaluated in the risk assessment. If the evaluation does not indicate that a constituent is a potential contaminant near an investigational unit or reporting area, then that constituent may not be selected as a COPC or CPEC in the risk assessment even if some groundwater results are above their respective Groundwater Comparison Concentrations.

A second groundwater evaluation, as described in the Standardized Risk Assessment Methodology (SRAM) Work Plan Revision 2 (MWH 2005), may also be performed. In addition to a comparison of all investigational unit groundwater data to a single Groundwater Comparison Concentration (comparison method), a Wilcoxon Rank Sum (WRS) Test may be performed comparing the investigational unit groundwater data set to the entire Final Groundwater Comparison Data Set. If the data set for any metal or inorganic chemical has a low frequency of detection, then an appropriate statistical test will be used.

The WRS Test will only be performed if it is first determined that this is an appropriate test for the groundwater data being evaluated. Criteria such as number of data in the site groundwater data set, temporal considerations, and depth of groundwater will be used to determine if the WRS Test is appropriate. The WRS Test will not be performed if it has already been determined based on a review of RFI site soil data and historical groundwater data that the metal is present due to site activities. Justification for using the WRS Test on any groundwater data sets will be provided in the RFI reports. The value of the WRS Test is that it compares all the data in two populations. This is done in recognition that an exceedance may not only be a one-time event but may also be within the statistical variability in the data. The use and application of the WRS Test is described in detail in Section 3 of the SRAM (MWH 2005).

Selection of COPCs and CPECs with respect to the Groundwater Comparison Data Set and associated Comparison Concentrations will be described in the risk assessments.

4.3 ADDITIONAL DATA COLLECTION AND DATA NEEDS

Establishment of Groundwater Comparison Concentrations does not preclude further evaluation of background. Because Groundwater Comparison Concentrations may not reflect the full range of naturally occurring metals/inorganics concentrations at the SSFL, the need may arise for establishing background concentrations for one or more constituents, based on data evaluation during RFI reporting or during the Corrective Measures Study. Background ranges would be established based on a review of the groundwater data available at that time, including any additional data obtained from locations across the facility and representative of ambient conditions.

During the evaluation described in Section 2, elevated detection limits and potentially elevated detected concentrations were observed for a number of constituents in groundwater collected early in the investigation. Potentially elevated concentrations were removed from the data set in establishing Groundwater Comparison Concentrations. Since early data represent the only samples collected from some wells, future data collected from these locations may indicate ambient constituent concentrations higher than the proposed Groundwater Comparison Concentrations.

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SECTION 5

LIST OF REFERENCES

California Department of Health Services. 2003. Maximum Contaminant Levels, September. http://www.dhs.ca.gov/ps/ddwem/chemicals/MCL/EPAandDHS.pdf

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California Office of Environmental Health Hazard Assessment (OEHHA). 2004. Public Health Goals. April 23. http://www.oehha.ca.gov/water/phg/allphgs.html

Groundwater Resources Consultants (GRC), 1995a. Sampling and Analysis Plan, Hazardous Waste Facility Post-Closure Permit PC-94/95-3-02, Area II, Santa Susana Field laboratory, Rockwell International Corporation, Rocketdyne Division, Ventura County, California. June.

Groundwater Resources Consultants (GRC), 1995b. Sampling and Analysis Plan, Hazardous Waste Facility Post-Closure Permit PC-94/95-3-03, Areas I and III, Santa Susana Field laboratory, Rockwell International Corporation, Rocketdyne Division, Ventura County, California. June.

Haley & Aldrich (H&A), 2005. Report on Annual Groundwater Monitoring, 2004, Santa Susana Field Laboratory, Ventura County, California. February.

MWH Americas, Inc. (MWH). 2005. Standardized Risk Assessment Methodology Work Plan, Revision 2, Santa Susana Field Laboratory, Ventura County, California. June.

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Table 2-1
Summary of Metals and Selected Inorganic Compounds in the SSFL Groundwater Data Set

Constituent	Sample Size (n)	Non-Detects: Number of Non Detects	Non-Detects: Range of Detection Limits (µg/L) Min	Non-Detects: Range of Detection Limits (µg/L) Max	Detects: Number of Detects	Detects: Frequency of Detection	Detects: Range of Detected Concentrations (µg/L) Min	Detects: Range of Detected Concentrations (µg/L) Max	Type of Distribution
Aluminum	1	1	47	47	0	0.0%	--	--	--
Antimony	411	318	0.02	1000	93	22.6%	0.02	6.1	Indeterminate
Arsenic	645	520	0.1	100	125	19.4%	0.12	320	Indeterminate
Barium	639	94	1	500	545	85.3%	3.9	580	Indeterminate
Beryllium	428	413	0.007	100	15	3.5%	0.01	1.8	Indeterminate
Boron	194	77	30	100	117	60.3%	20	2200	Indeterminate
Cadmium	639	565	0.015	5	74	11.6%	0.027	6.1	Indeterminate
Chromium	639	528	0.06	10	111	17.4%	0.22	88	Indeterminate
Cobalt	175	40	0.053	40	135	77.1%	0.056	180	Indeterminate
Copper	421	248	0.16	900	173	41.1%	0.19	70	Indeterminate
Fluoride	600	24	80	500	576	96.0%	70	5400	Indeterminate
Iron	431	205	2.2	500	226	52.4%	3.9	9700	Indeterminate
Lead	647	369	0.098	50	278	43.0%	0.11	120	Indeterminate
Magnesium	534	0	--	--	534	100.0%	20	270000	Indeterminate
Manganese	360	55	1	10	305	84.7%	0.13	18400	Indeterminate
Mercury	639	625	0.05	1	14	2.2%	0.069	0.8	Normal
Molybdenum	308	215	1.3	100	93	30.2%	0.44	130	Indeterminate
Nickel	412	271	0.1	50	141	34.2%	0.1	740	Indeterminate
Selenium	639	524	0.34	40	115	18.0%	0.27	80	Indeterminate
Silver	639	613	0.0006	10	26	4.1%	0.03	420	Indeterminate
Strontium	123	2	300	590	121	98.4%	178	2800	Indeterminate
Thallium	412	358	0.044	500	54	13.1%	0.009	4.7	Indeterminate
Tin	93	87	0.04	500	6	6.5%	0.2	6.5	Normal
Vanadium	168	81	0.096	500	87	51.8%	0.11	37.8	Indeterminate
Zinc	444	50	3	29	394	88.7%	2.2	19000	Indeterminate
Potassium	534	2	1200	1400	532	99.6%	600	62400	Indeterminate
Sodium	560	0	--	--	560	100.0%	24000	1840000	Indeterminate
Sulfate	575	0	--	--	575	100.0%	220	4700000	Indeterminate

Notes:
1. Distributions were tested after removing non detect data.
2. "Indeterminate" indicates that data fit neither a normal nor lognormal distribution.
3. Data summaries represented on this table reflect the 'intial review' data set used to develop the final Groundwater Comparison Concentrations.

µg/L - micrograms per liter

Table 3-1
Groundwater Comparison Concentrations for Metals and Selected Inorganic Compounds

	All Concentrations in µg/L				
Constituent	**SSFL Groundwater Comparison Concentration[a]**	**CA DHS MCLs**	**Ca DHS NLs**	**OEHHA PHGs**	**USEPA PRGs**
Antimony	2.5	6		20	15
Arsenic	7.7	50		0.004	0.05
Barium	150	1,000		2000	2,600
Beryllium	ND < 0.14	4		1	73
Boron	340		1,000		7,300
Cadmium	0.2	5		0.07	18
Chromium	14	50			55,000
Cobalt	1.9				730
Copper	4.7	1,000[b]	1,300	170	1,500
Fluoride	800	2,000		1,000	2,200
Iron	4,100	300[b]			11,000
Lead	11		15	2	
Magnesium	77,000				
Manganese	150	50[b]	500		880
Mercury	ND <0.063	2		1.2	11
Molybdenum	2.2				180
Nickel	17	100		12	730
Selenium	1.6	50			180
Silver	ND <0.17	100[b]			180
Strontium	800				22,000
Thallium	ND< 0.13	2		0.1	2.40
Tin	ND <2.4				22,000
Vanadium	2.6		50		36
Zinc	6,300	5,000[b]			11,000
Potassium	9,600				
Sodium	190,000				
Sulfate	376,000	250,000[b]			

(a) Groundwater Comparison Concentrations represent the maximum value retained in the Final Groundwater Comparison Data Set (Appendix A)

(b) Secondary MCL - Non-health based criterion (i.e. based on aesthetic, discoloration issues).

Note: A Groundwater Comparison Concentration was not established for aluminum because of insufficient data. Dissolved analysis was only conducted on one sample.

ND = Non Detect. Groundwater mercury, silver and tin results greater than values shown will undergo further evaluation.
µg/L = Micrograms per liter
Ca DHS - California Department of Health Services
MCL - Maximum Contaminant Level
NL = Notification Level
OEHHA PHG - Office of Environmental Health Hazard Assessment Public Health Goals
USEPA PRG - United States Environmental Protection Agency Preliminary Remediation Goal for tap water

Sources:
Ca DHS MCLs from http://www.dhs.ca.gov/ps/ddwem/chemicals/MCL/EPAandDHS.pdf
Ca DHS Notification Levels (NL) from DHS website - http://www.dhs.ca.gov/ps/ddwem/
OEHHA PHGs from http://www.oehha.ca.gov/water/phg/allphgs.html

APPENDIX A

GROUNDWATER COMPARISON CONCENTRATIONS DATA TABLES AND PROBABILITY PLOTS

Groundwater Comparison Data Set and Comparison Concentrations Report

Appendix A-1, Initial Review Data Set

The tables in this attachment include all available groundwater results used in the initial review of groundwater data for purposes of determining SSFL RFI Groundwater Comparison Data Set and Comparison Concentrations. Pertinent information and definitions are included below.

Data Set Includes:

1. All available groundwater samples collected through 4th quarter 2004
2. Dissolved sulfate, fluoride and metals only
3. Primary samples, Field duplicates and Split samples
4. No rejected (R) data

Data Qualifier:

U = not detected
J = Estimated value
B = For the purposes of this data set represents qualified data based on contamination in the associated Method Blank.

Well Aquifer:

NS = Near-surface groundwater
Cf = Chatsworth formation groundwater

FLUTe port #: (Flexible Liner Underground Technology)

NA = no FLUTe installed, sample collected from open borehole
P*XXX* = the numerical suffix indicates the port number of the installed FLUTe.
Composite = mixture of samples from all sampled ports of the installed FLUTe

Analytical Laboratories:

AnalTech
Assoc = Associated Laboratories
Babcock = Edward S. Babcock and Sons
BCA-Bak = BC Analytical - Bakersfield
BCA-Glen = BC Analytical - Glendale
Ceimic = Ceimic Corporation
Columbia = Columbia Analytical Services
Del Mar = Del Mar Analytical, Inc.
Del Mar Analytical = Del Mar Analytical, Inc.
E.S. Babcock = Edward S. Babcock and Sons
Eberline = Eberline Services
PacificAnal = Pacific Analytical, Inc.
UNKNOWN = Laboratory name not available
VOC Anal

Tables included in this attachment:

Table name
Aluminum - Table A-1-1
Antimony - Table A-1-2
Arsenic - Table A-1-3
Barium - Table A-1-4
Beryllium - Table A-1-5
Boron - Table A-1-6
Cadmium - Table A-1-7
Chromium - Table A-1-8
Cobalt - Table A-1-9
Copper - Table A-1-10
Fluoride - Table A-1-11
Iron - Table A-1-12
Lead - Table A-1-13
Magnesium - Table A-1-14
Manganese - Table A-1-15
Mercury - Table A-1-16
Molybdenum - Table A-1-17
Nickel - Table A-1-18
Selenium - Table A-1-19
Silver - Table A-1-20
Strontium - Table A-1-21
Thallium - Table A-1-22
Tin - Table A-1-23
Vanadium - Table A-1-24
Zinc - Table A-1-25
Potassium - Table A-1-26
Sodium - Table A-1-27
Sulfate - Table A-1-28

<u>Appendix A-2, Comparison Data Set</u>

This attachment includes tables containing data for use in characterization and risk assessment steps of the SSFL RFI. Data included in these tables are the Groundwter Comparison Data Set, which are limited to values at or below the selected groundwater Comparison Concentrations (see Appendix A-1 for complete data set). Pertinent information and definitions are included below.

Data Set Includes:

1. All available groundwater samples collected through 4th quarter 2004
2. Sulfate, Fluoride and Dissolved Metals only
3. Primary samples, Field duplicates and Split samples
4. Rejected data not included

Data Qualifier:

U = not detected
J = Estimated value
B = for the purposes of this data set represents qualified data with contamination in the associated Method Blank.

Well Aquifer:

NS = Near-surface groundwater
Cf = Chatsworth formation groundwater

FLUTe port #: (Flexible Liner Underground Technology)

NA = no FLUTe installed, sample collected from open borehole
P*XXX* = the numerical suffix indicates the port number of the installed FLUTe.
Composite = mixture of samples from all sampled ports of the installed FLUTe

Analytical Laboratories:

AnalTech
Assoc = Associated Laboratories
Babcock = Edward S. Babcock and Sons
BCA-Bak = BC Analytical - Bakersfield
BCA-Glen = BC Analytical - Glendale
Ceimic = Ceimic Corporation
Columbia = Columbia Analytical Services
Del Mar = Del Mar Analytical, Inc.
Del Mar Analytical = Del Mar Analytical, Inc.
E.S. Babcock = Edward S. Babcock and Sons
Eberline = Eberline Services
PacificAnal = Pacific Analytical, Inc.
UNKNOWN = Laboratory name not available
VOC Anal

Tables included in this Attachment:

Table name
Aluminum Not Included*
Antimony - Table A-2-2
Arsenic - Table A-2-3
Barium - Table A-2-4
Beryllium Not Included*
Boron - Table A-2-6
Cadmium - Table A-2-7
Chromium - Table A-2-8
Cobalt - Table A-2-9
Copper - Table A-2-10
Fluoride - Table A-2-11
Iron - Table A-2-12
Lead - Table A-2-13
Magnesium - Table A-2-14
Manganese - Table A-2-15
Mercury Not Included*
Molybdenum - Table A-2-17
Nickel - Table A-2-18
Selenium - Table A-2-19
Silver Not Included*
Strontium - Table A-2-21
Thallium Not Included*
Tin Not Included*
Vanadium - Table A-2-24
Zinc - Table A-2-25
Potassium - Table A-2-26
Sodium - Table A-2-27
Sulfate - Table A-2-28

* Comparison data sets not included for aluminum, beryllium, mercury, silver, thallium or tin. Groundwater concentrations above detection limits shown will undergo further evaluation.

<u>Appendix A-3, Rank-order Probability Plots</u>

This attachment includes rank-order probability plots for metals and selected inorganic constituents. The probability plot allows viewing the entire data set, provides information on data distribution, and aids in identifying different data populations. For each constituent included in this attachment, both normal and lognormal distribution plots are presented. Final Groundwater Comparison Concentrations (GWCC) are used as a reference point on each plot. Data included in these plots represent all available groundwater results used for the initial review for the Groundwater Comparison Data Set and Comparison Concentrations (see Appendix A-1 for complete data set). Pertinent information and definitions are included below.

Data Set Includes:
1. All available groundwater samples collected through 4th quarter 2004
2. Dissolved sulfate, fluoride and metals only
3. Primary samples, Field duplicates and Split samples
4. Detected values only

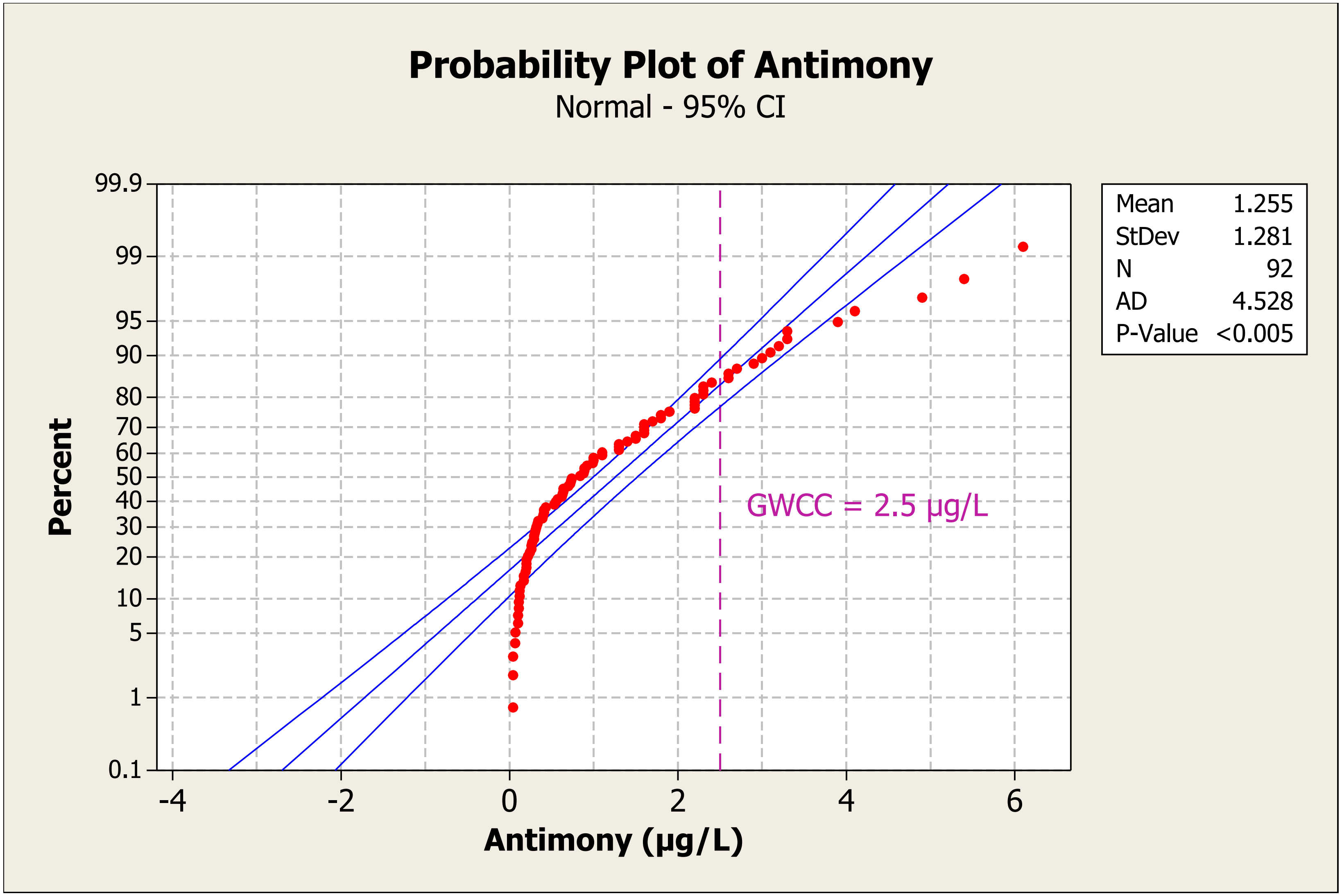
Type of Distribution Included:
1. Normal
2. Lognormal

Probability Plots included in this Attachment:

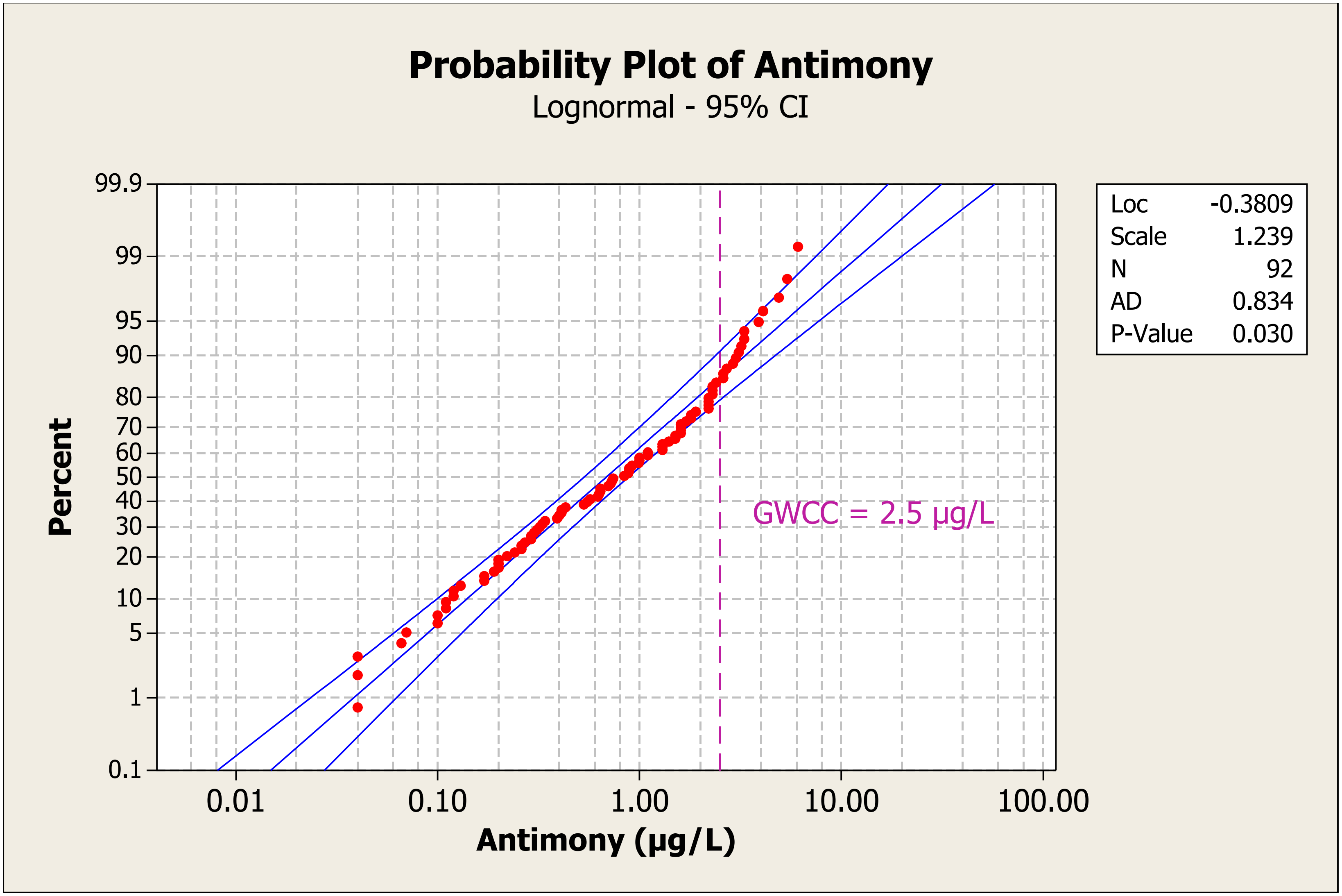
Constituent name
Aluminum Not Included*
Antimony
Arsenic
Barium
Beryllium Not Included*
Boron
Cadmium
Chromium
Cobalt
Copper
Fluoride
Iron
Lead
Magnesium
Manganese
Mercury Not Included*
Molybdenum
Nickel
Selenium
Silver Not Included*
Strontium
Thallium Not Included*
Tin Not Included*
Vanadium
Zinc
Potassium
Sodium
Sulfate

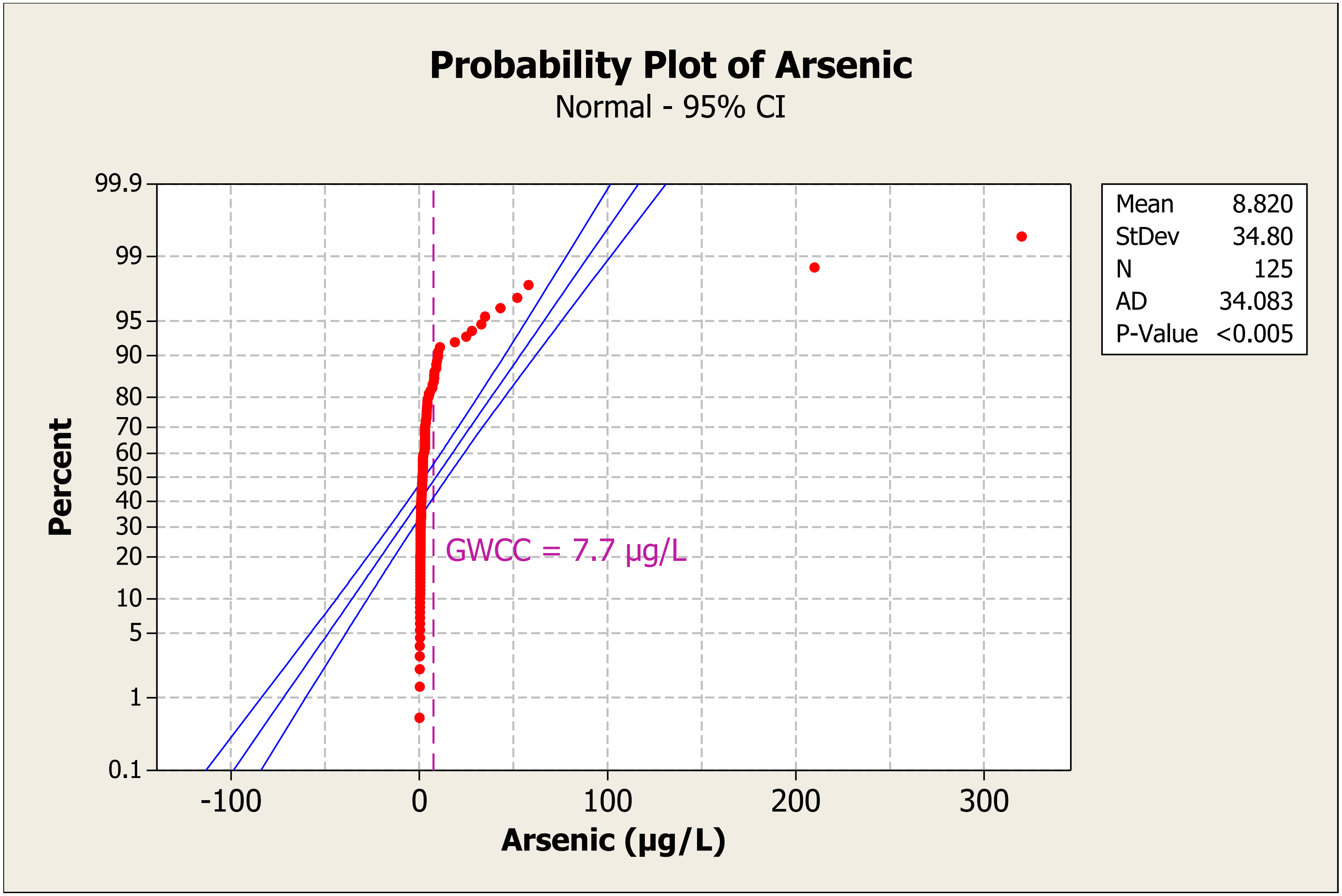
* Probability plots not included for aluminum, beryllium, mercury, silver, thallium or tin.

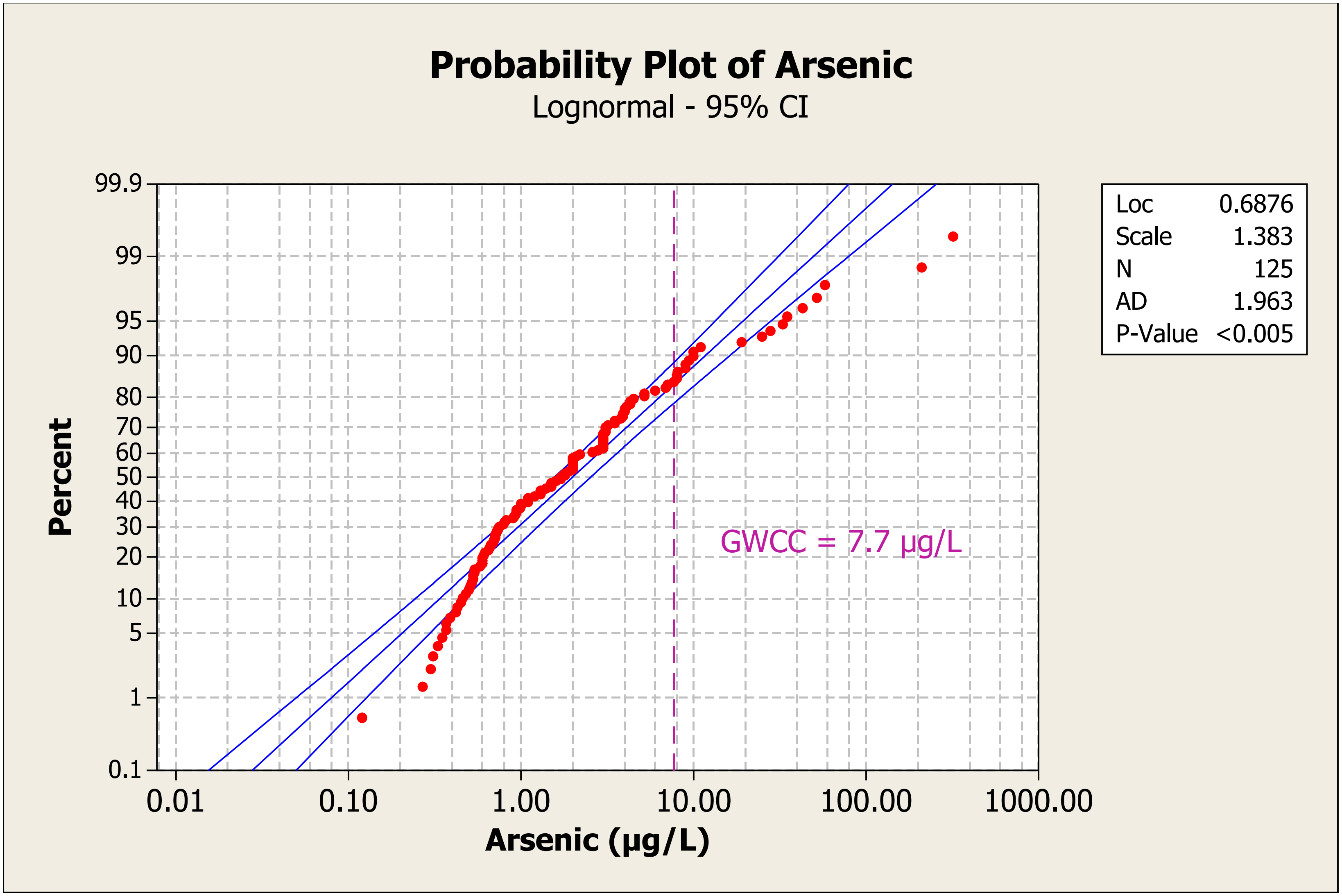
Appendix A Groundwater Comparison Concentrations Data Tables and Probability Plots not provided due to file size



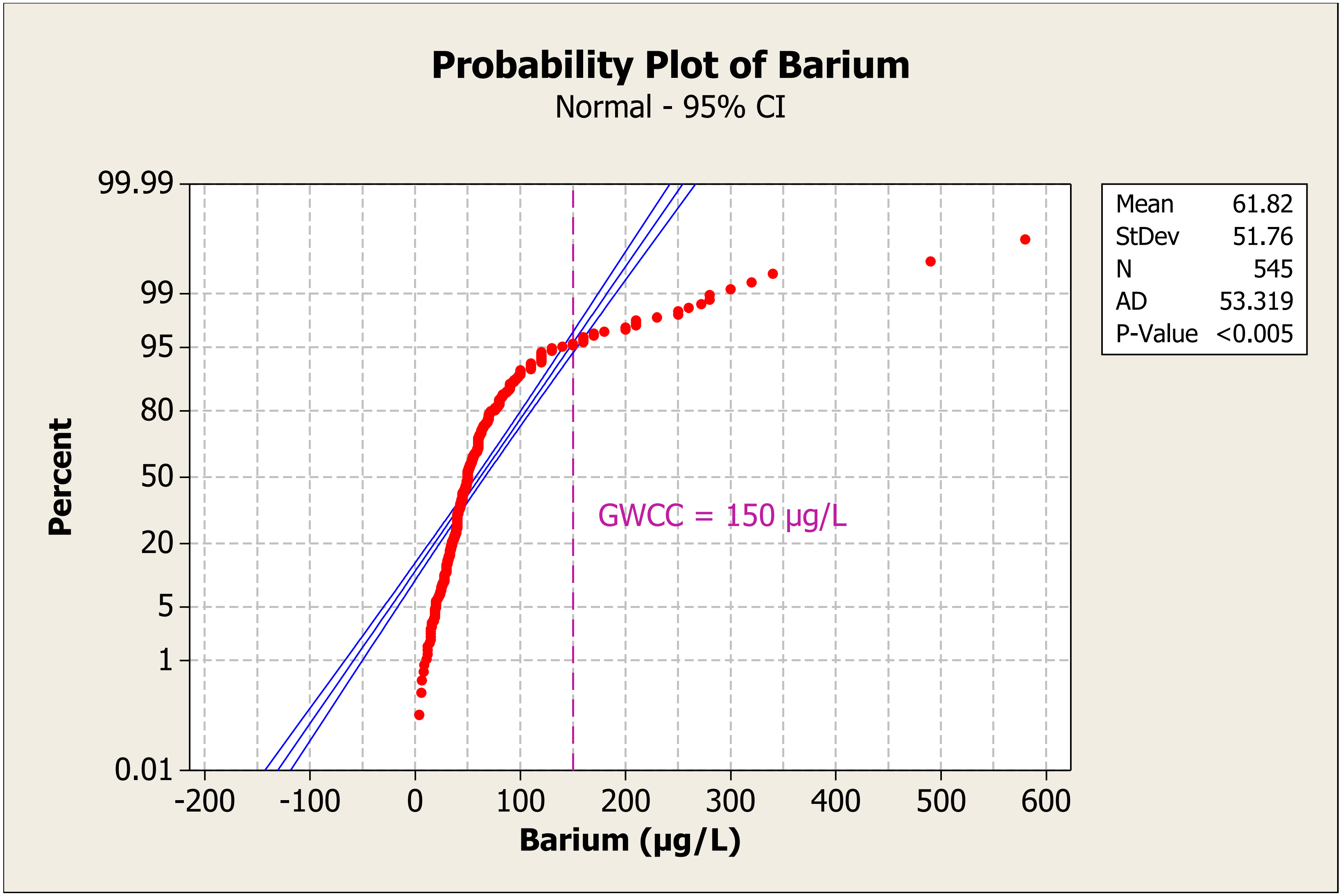
Probability Plot of Antimony
Normal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-4
-2
0
2
4
6
Antimony (µg/L)
GWCC = 2.5 µg/L
Mean 1.255
StDev 1.281
N 92
AD 4.528
P-Value <0.005


Probability Plot of Antimony
Lognormal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
0.01
0.10
1.00
10.00
100.00
Antimony (µg/L)
GWCC = 2.5 µg/L
Loc -0.3809
Scale 1.239
N 92
AD 0.834
P-Value 0.030

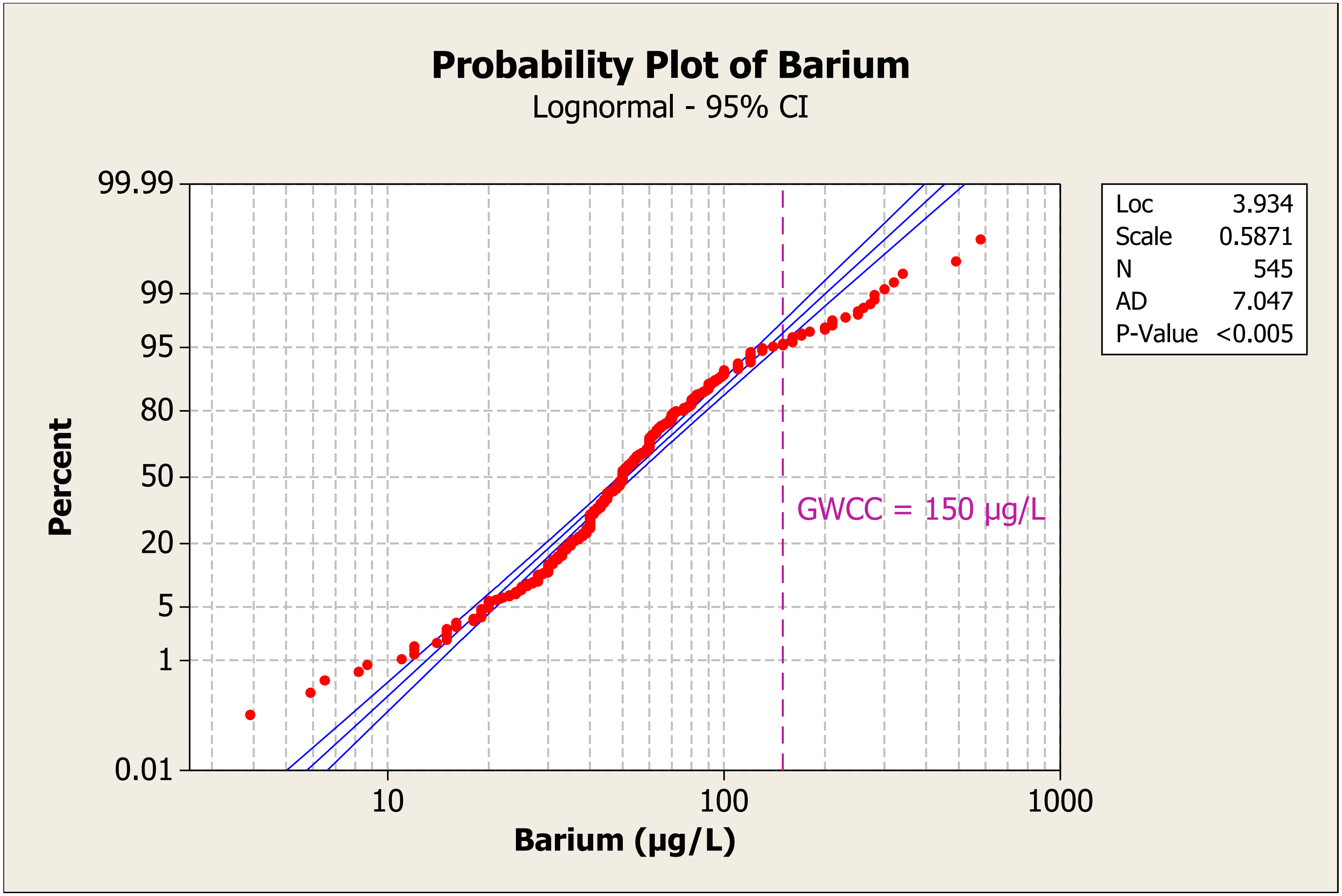

Probability Plot of Arsenic
Normal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-100
0
100
200
300
Arsenic (µg/L)
GWCC = 7.7 µg/L
Mean 8.820
StDev 34.80
N 125
AD 34.083
P-Value <0.005



Probability Plot of Arsenic
Lognormal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
0.01
0.10
1.00
10.00
100.00
1000.00
Arsenic (µg/L)
GWCC = 7.7 µg/L
Loc 0.6876
Scale 1.383
N 125
AD 1.963
P-Value <0.005

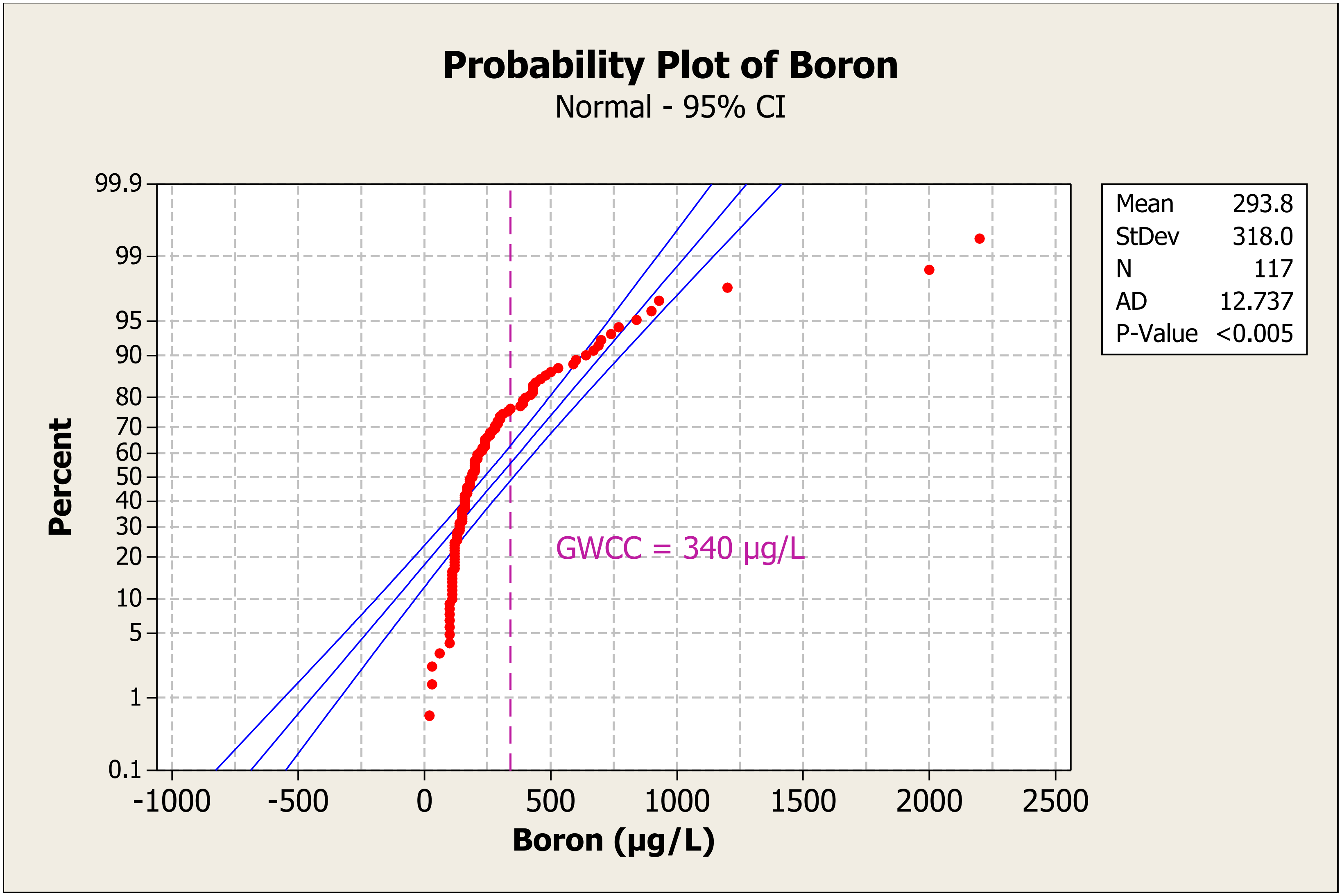


Probability Plot of Barium
Normal - 95% CI
Percent
99.99
99
95
80
50
20
5
1
0.01
-200
-100
0
100
200
300
400
500
600
Barium (µg/L)
GWCC = 150 µg/L
Mean 61.82
StDev 51.76
N 545
AD 53.319
P-Value <0.005

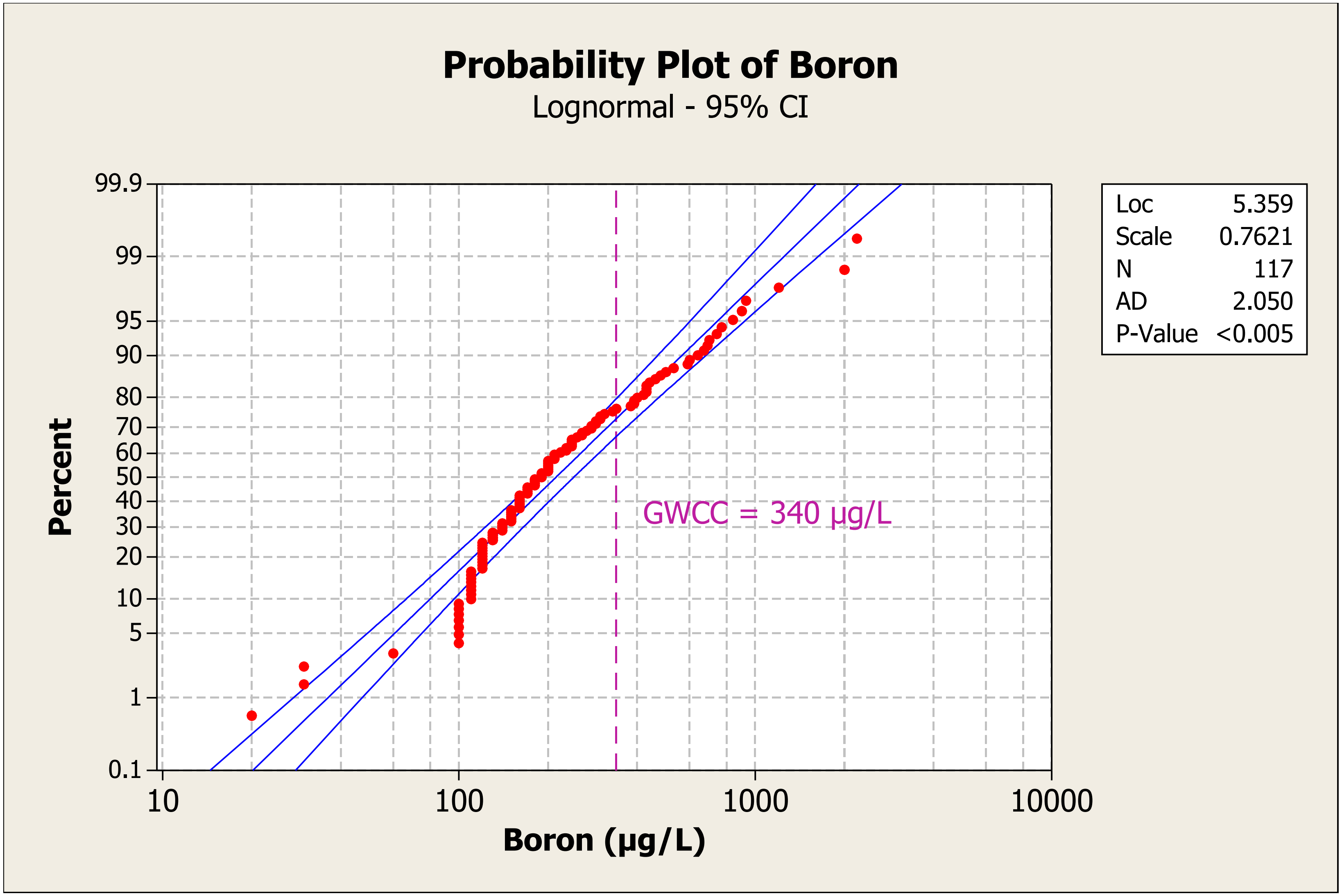


Probability Plot of Barium
Lognormal - 95% CI
Percent
99.99
99
95
80
50
20
5
1
0.01
10
100
1000
Barium (µg/L)
GWCC = 150 µg/L
Loc 3.934
Scale 0.5871
N 545
AD 7.047
P-Value <0.005

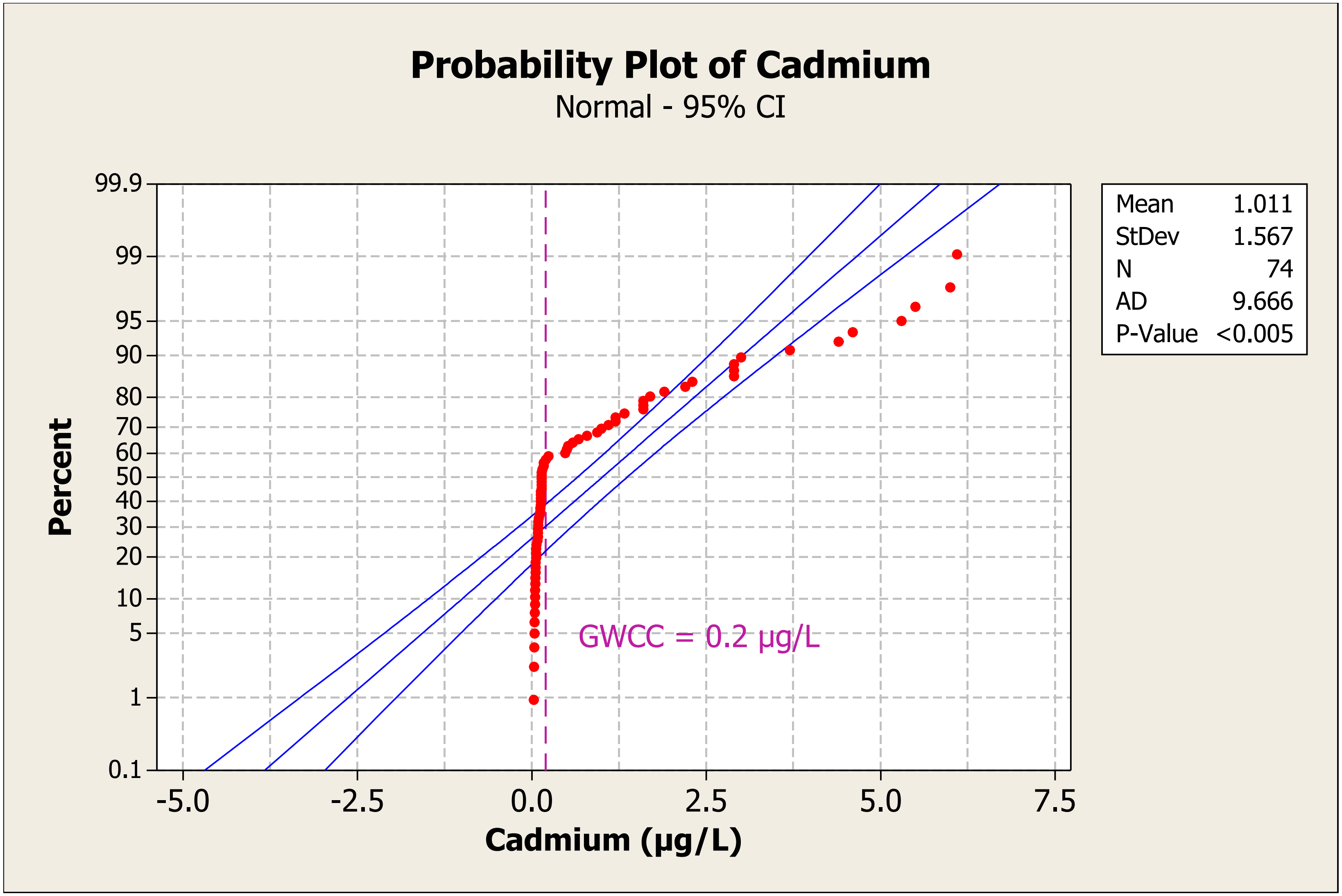
Probability plots are not included for **Beryllium**. Comparison concentrations are based on detection limits for this metal (see main text).



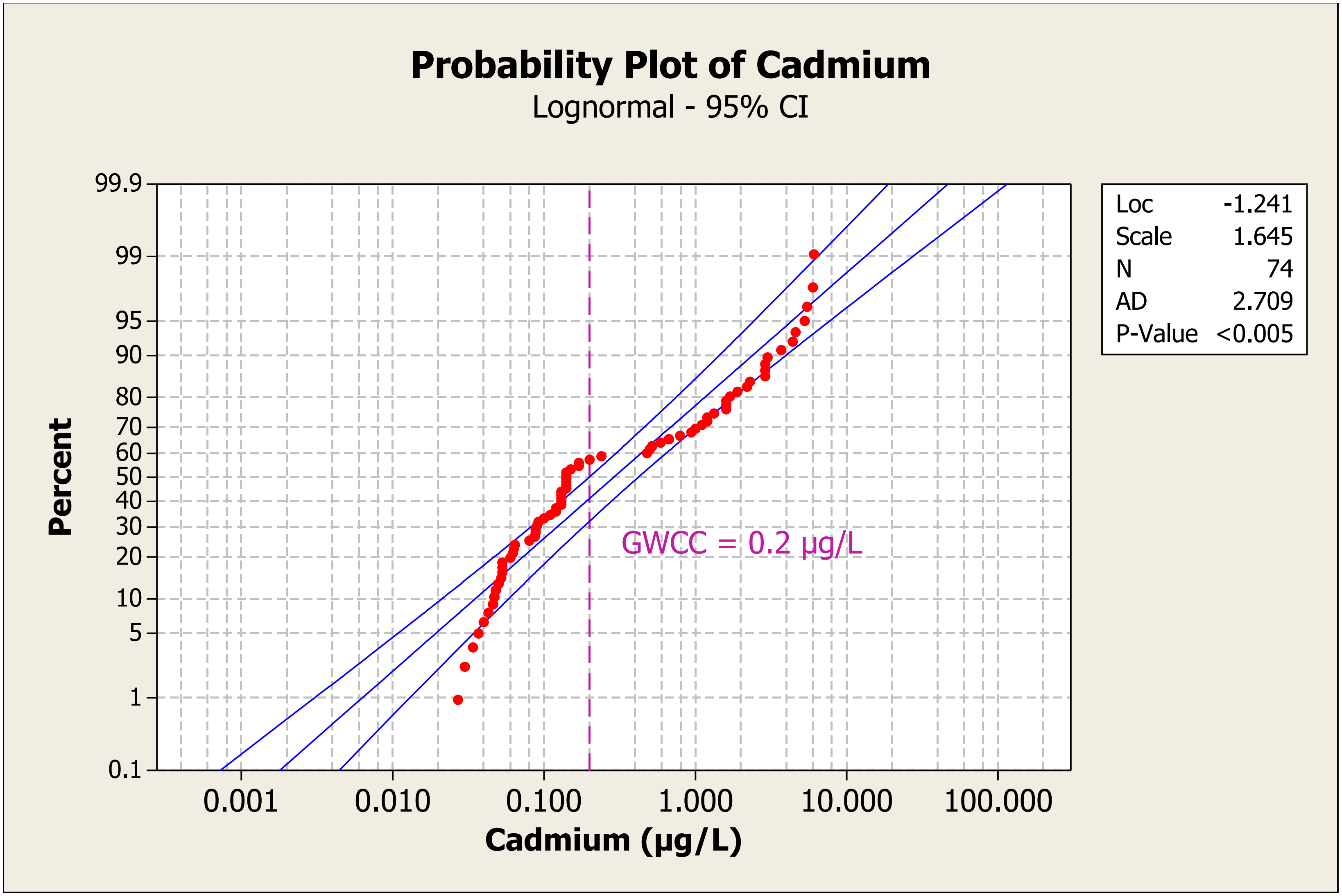
Probability Plot of Boron
Normal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-1000
-500
0
500
1000
1500
2000
2500
Boron (µg/L)
GWCC = 340 µg/L
Mean 293.8
StDev 318.0
N 117
AD 12.737
P-Value <0.005

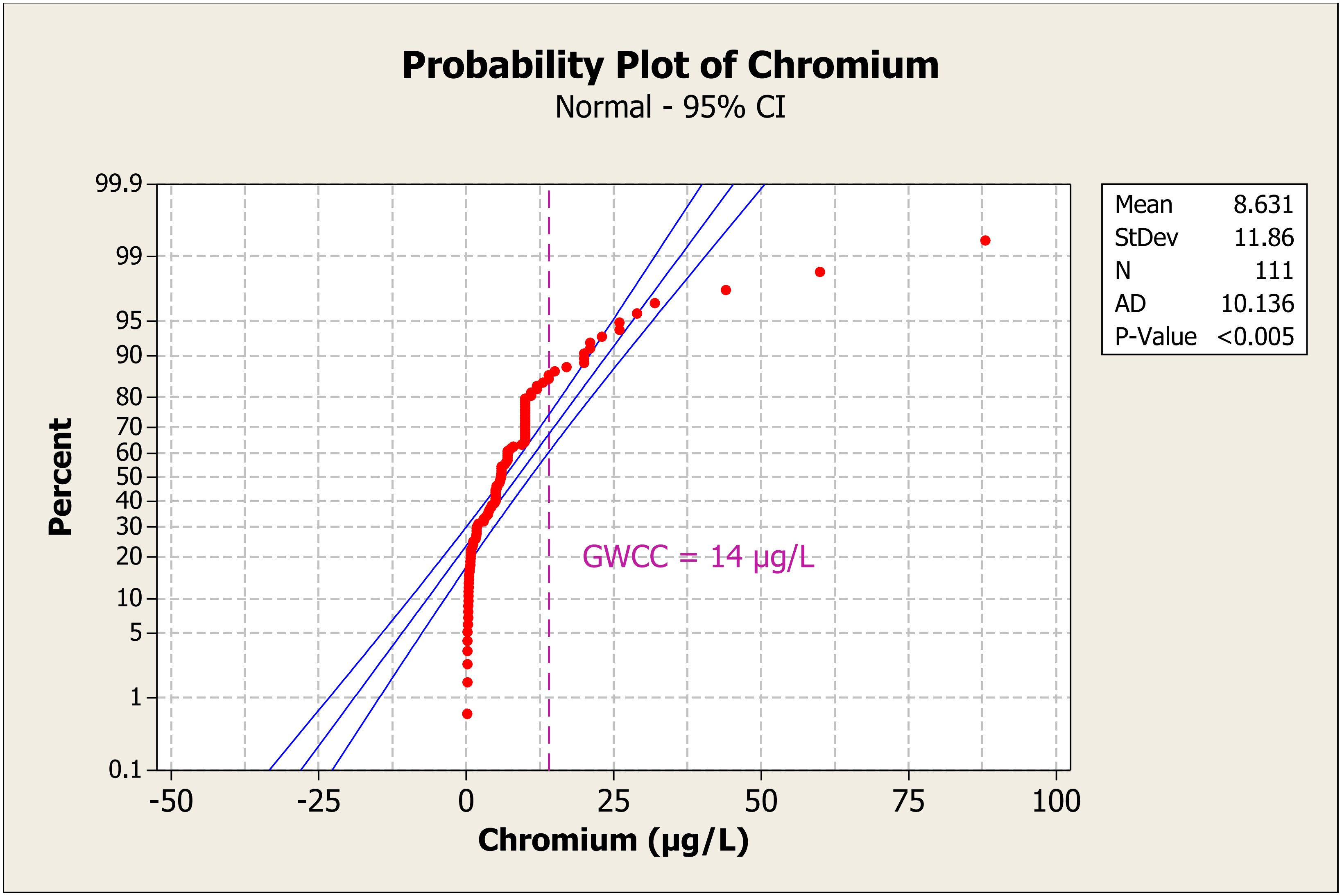


Probability Plot of Boron
Lognormal - 95% CI
Loc 5.359
Scale 0.7621
N 117
AD 2.050
P-Value <0.005
GWCC = 340 µg/L
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
10
100
1000
10000
Boron (µg/L)

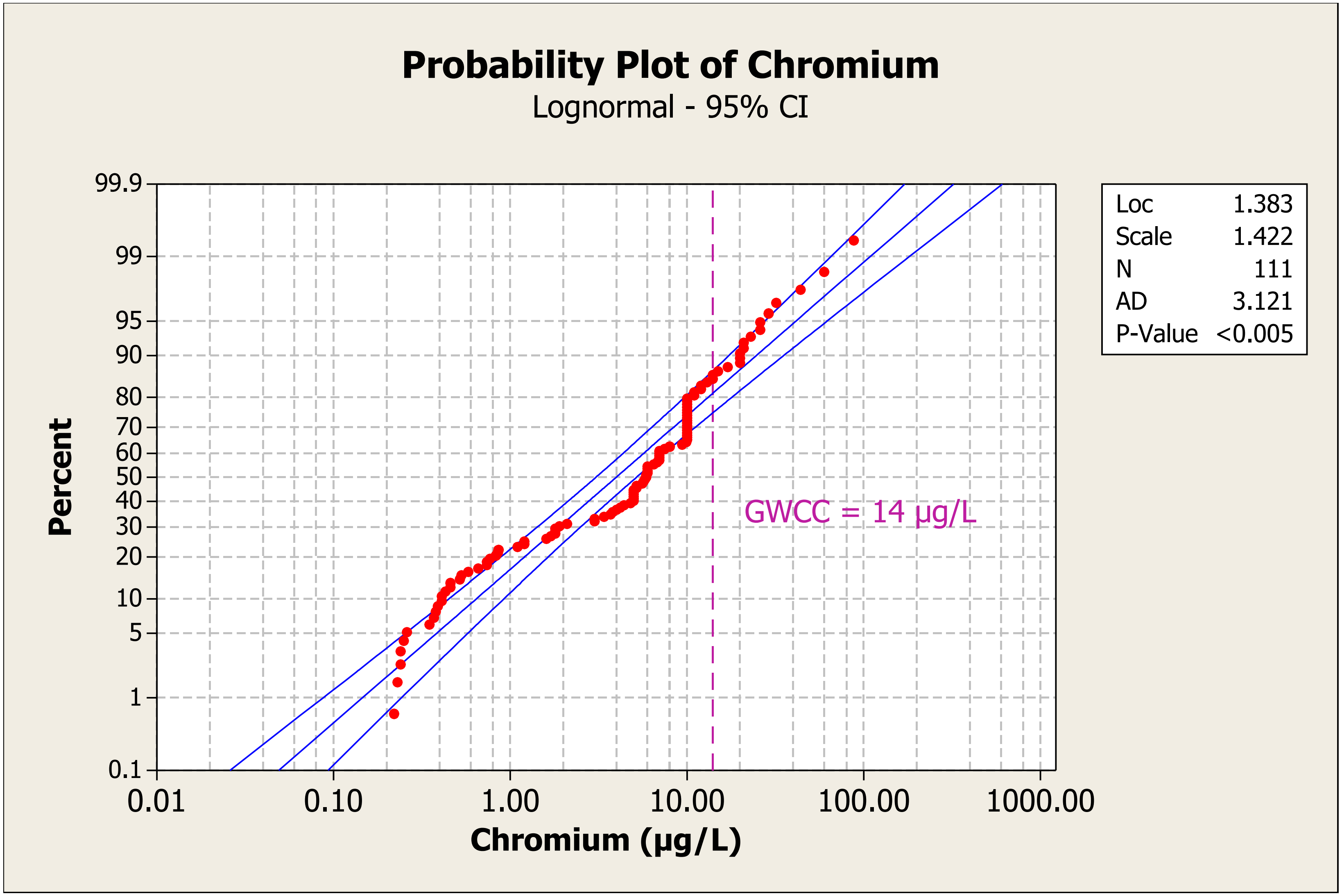


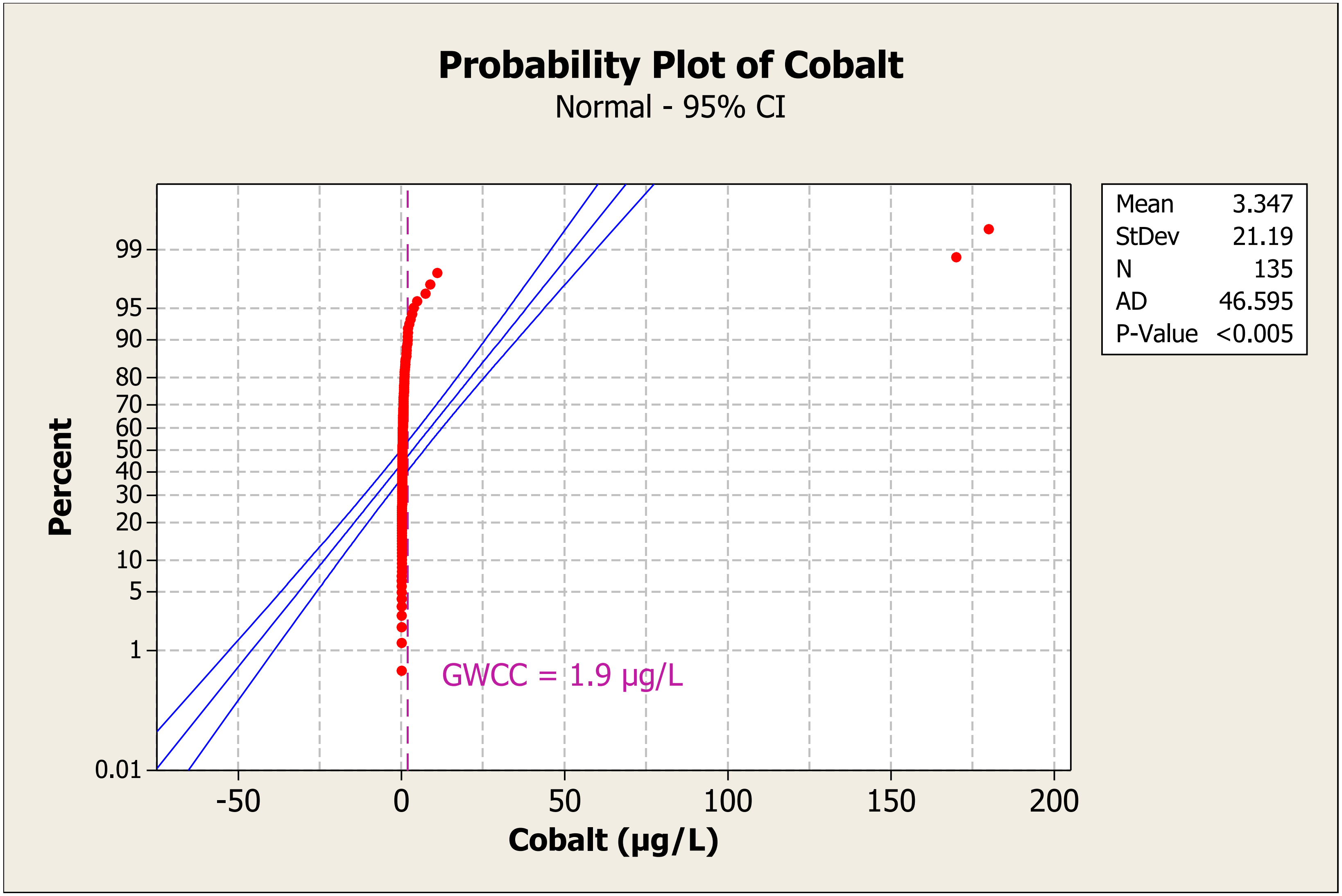
Probability Plot of Cadmium
Normal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-5.0
-2.5
0.0
2.5
5.0
7.5
Cadmium (µg/L)
GWCC = 0.2 µg/L
Mean 1.011
StDev 1.567
N 74
AD 9.666
P-Value <0.005

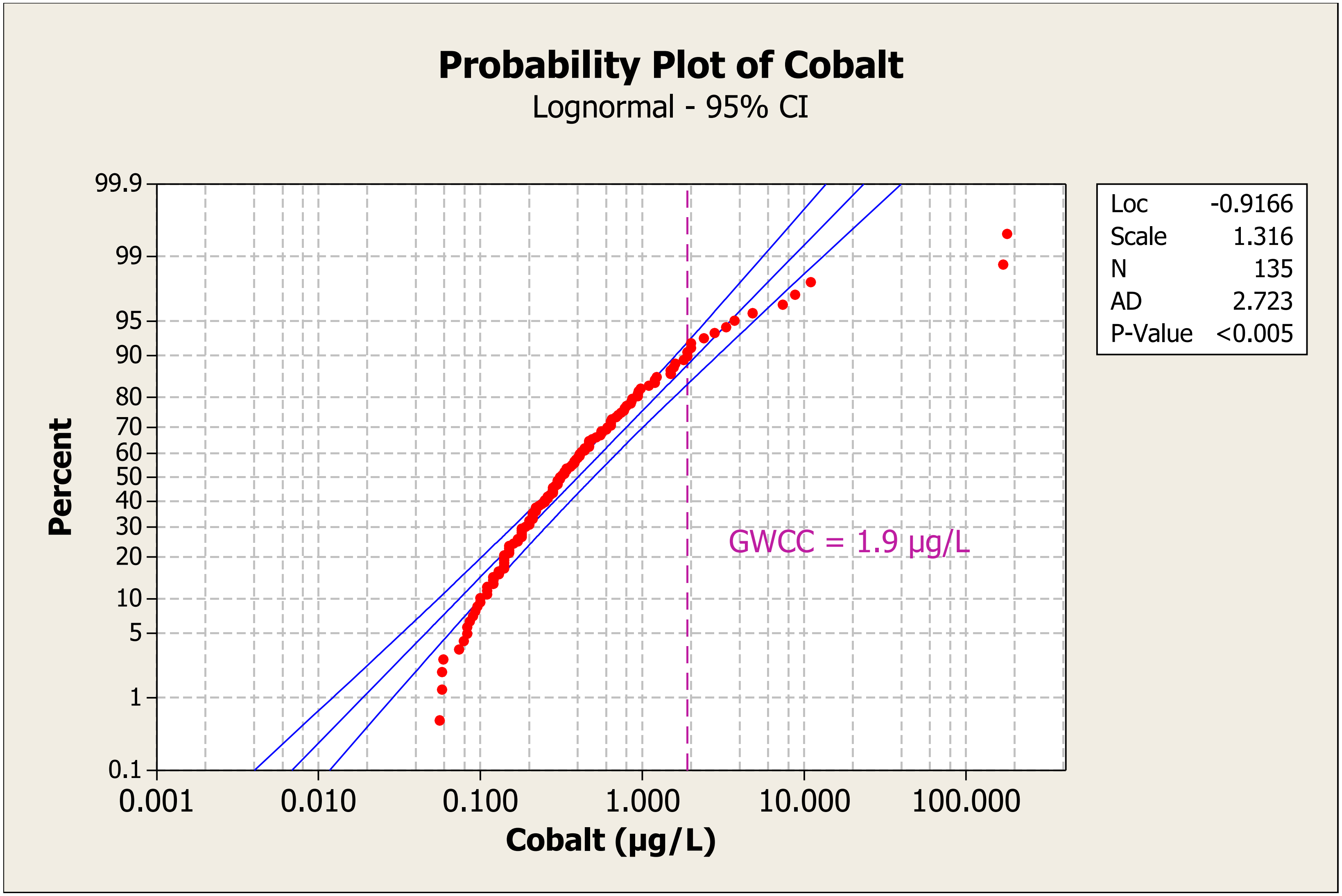

Probability Plot of Cadmium
Lognormal - 95% CI
Loc -1.241
Scale 1.645
N 74
AD 2.709
P-Value <0.005
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
GWCC = 0.2 µg/L
0.001
0.010
0.100
1.000
10.000
100.000
Cadmium (µg/L)



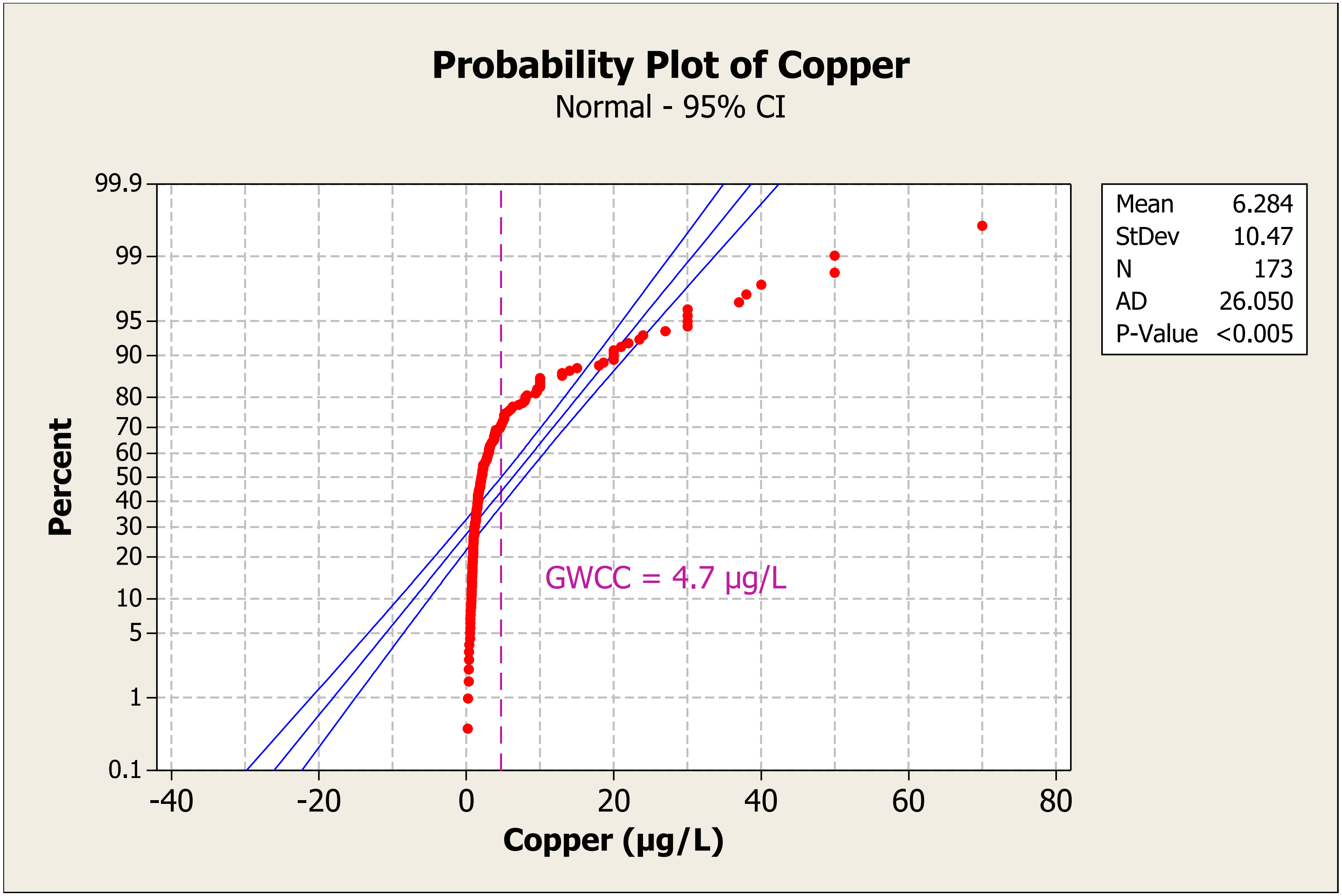
Probability Plot of Chromium
Normal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-50
-25
0
25
50
75
100
Chromium (µg/L)
GWCC = 14 µg/L
Mean 8.631
StDev 11.86
N 111
AD 10.136
P-Value <0.005


Probability Plot of Chromium
Lognormal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
0.01
0.10
1.00
10.00
100.00
1000.00
Chromium (µg/L)
GWCC = 14 µg/L
Loc 1.383
Scale 1.422
N 111
AD 3.121
P-Value <0.005

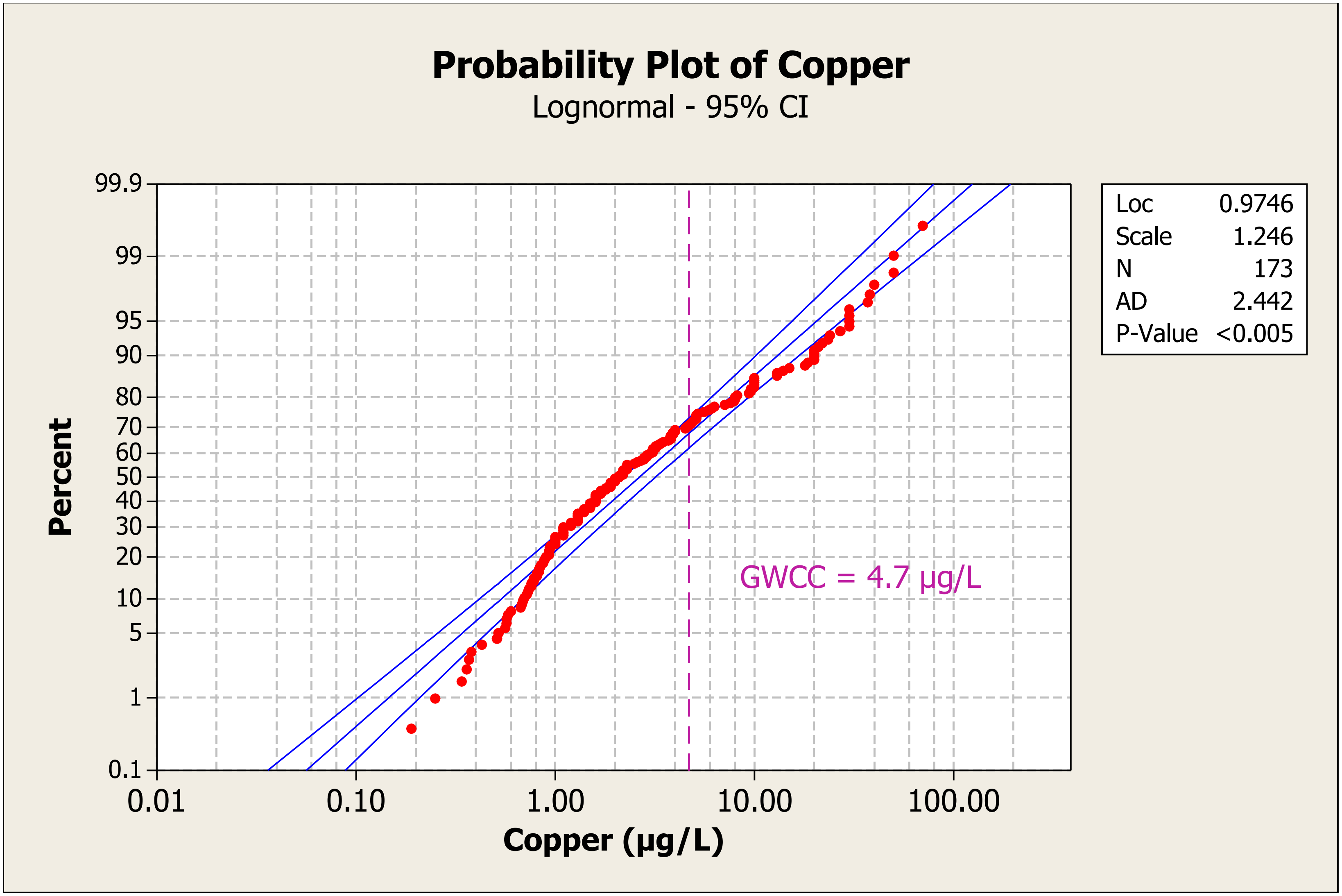

Probability Plot of Cobalt
Normal - 95% CI
Mean 3.347
StDev 21.19
N 135
AD 46.595
P-Value <0.005
Percent
99
95
90
80
70
60
50
40
30
20
10
5
1
0.01
GWCC = 1.9 µg/L
-50
0
50
100
150
200
Cobalt (µg/L)



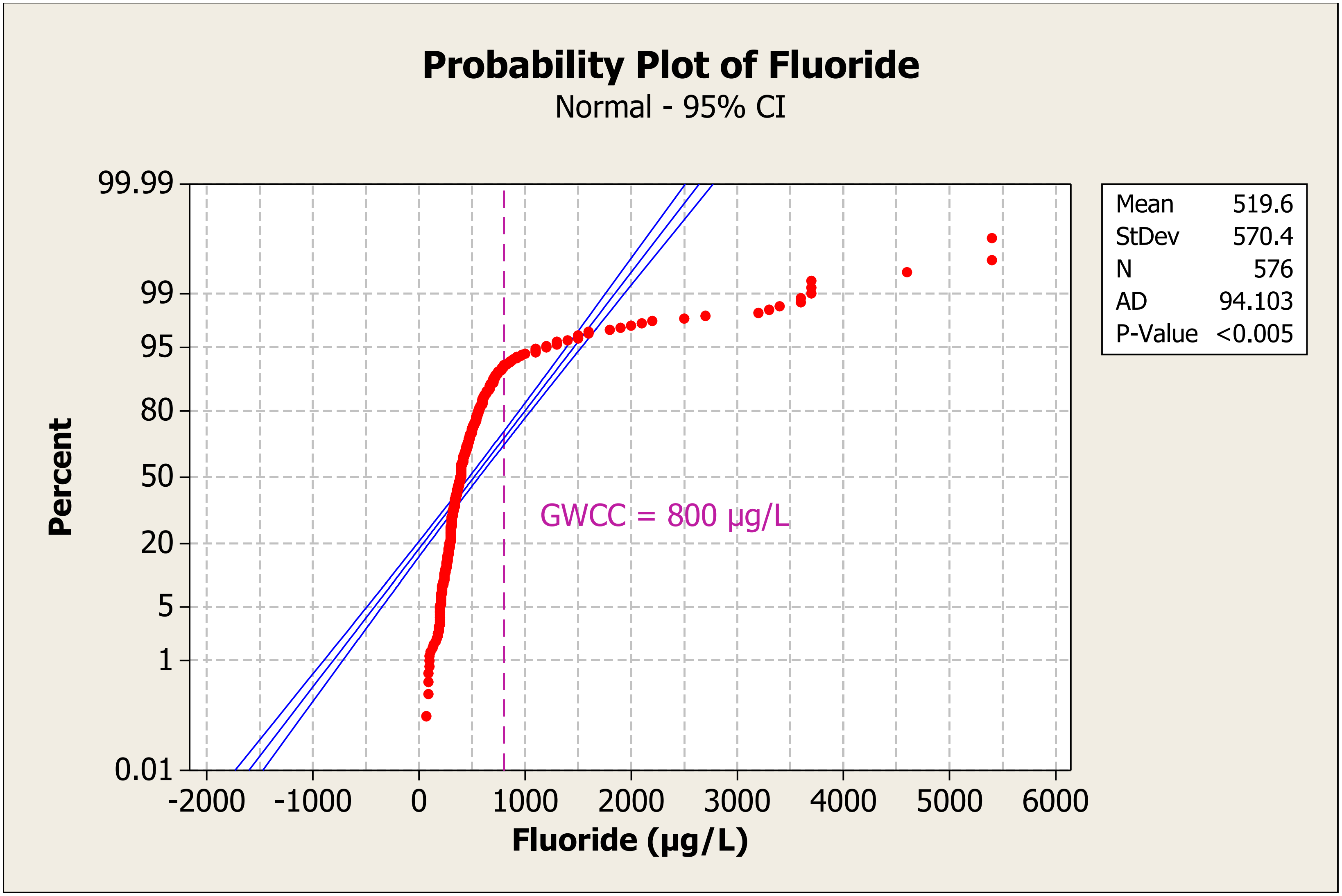
Probability Plot of Cobalt
Lognormal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
0.001
0.010
0.100
1.000
10.000
100.000
Cobalt (µg/L)
GWCC = 1.9 µg/L
Loc -0.9166
Scale 1.316
N 135
AD 2.723
P-Value <0.005

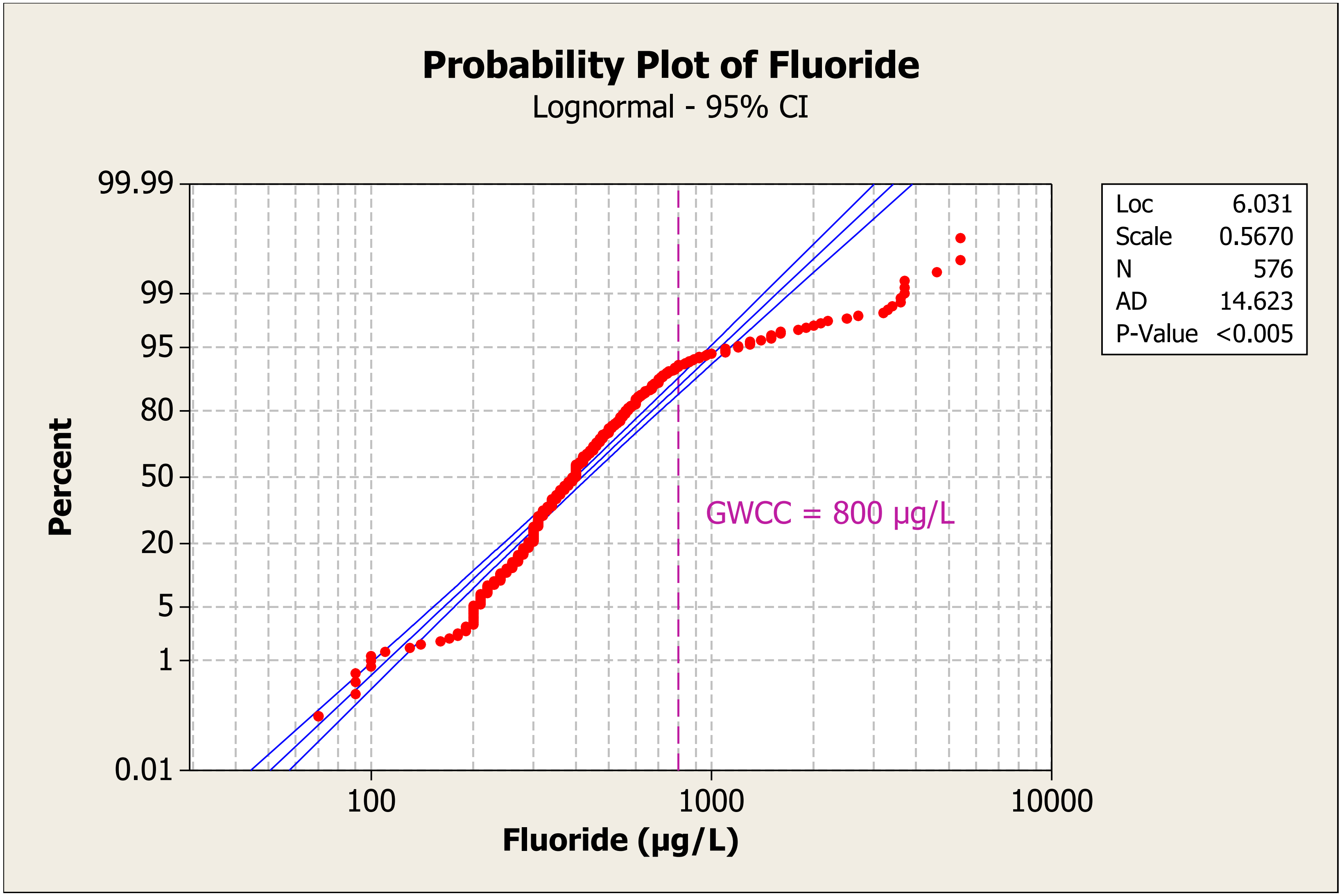


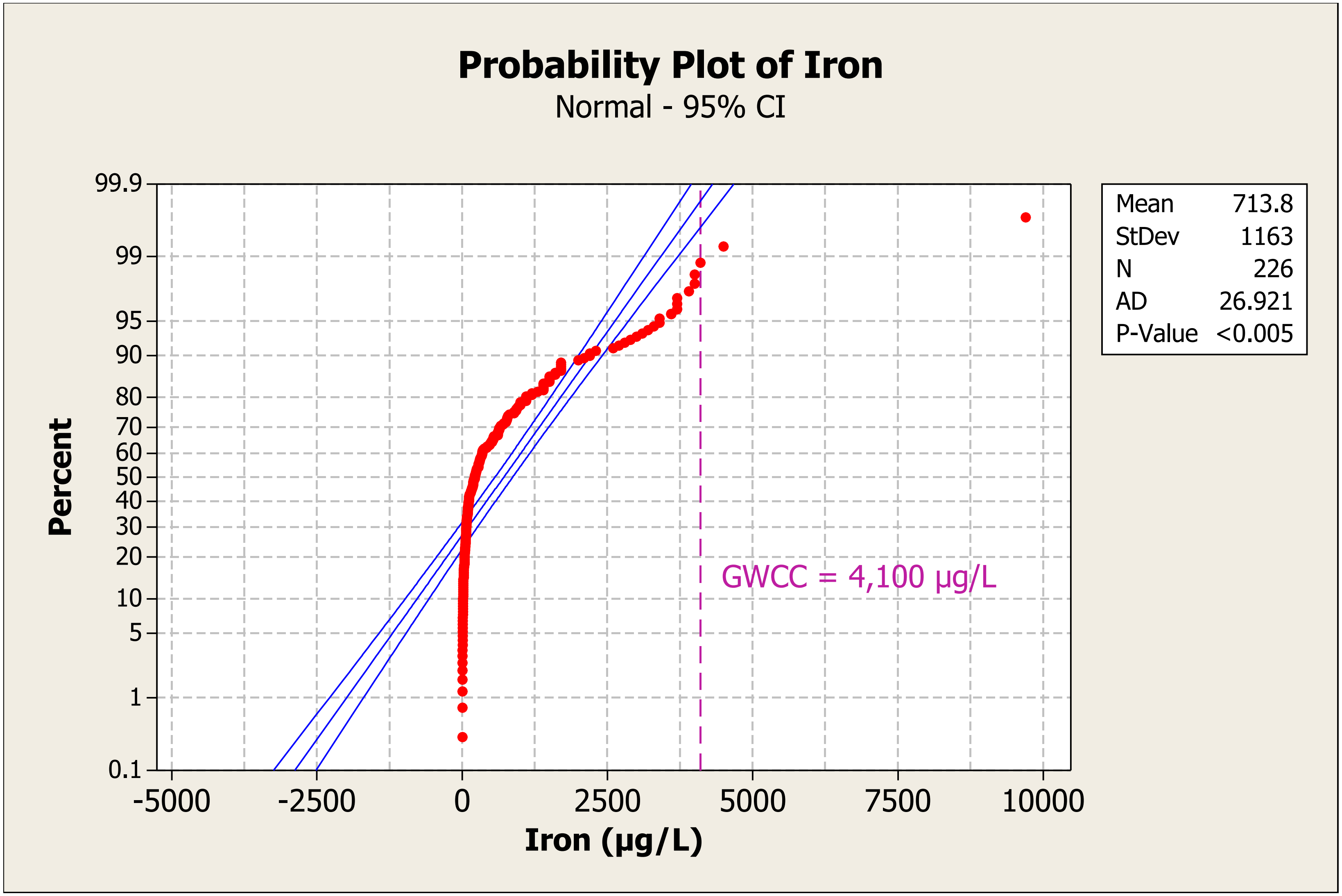
Probability Plot of Copper
Normal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-40
-20
0
20
40
60
80
Copper (µg/L)
GWCC = 4.7 µg/L
Mean 6.284
StDev 10.47
N 173
AD 26.050
P-Value <0.005



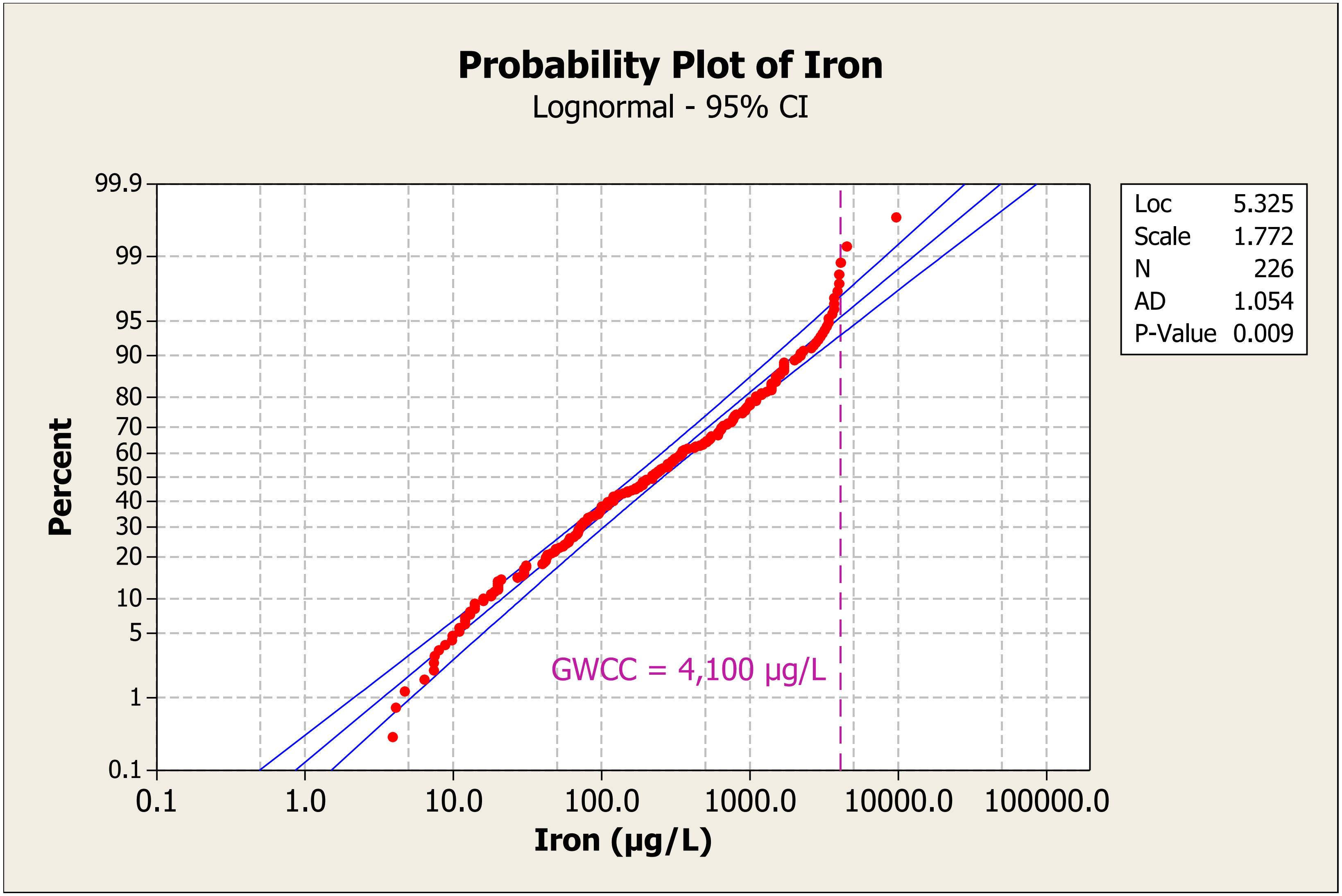
Probability Plot of Copper
Lognormal - 95% CI
Loc 0.9746
Scale 1.246
N 173
AD 2.442
P-Value <0.005
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
GWCC = 4.7 µg/L
0.01
0.10
1.00
10.00
100.00
Copper (µg/L)

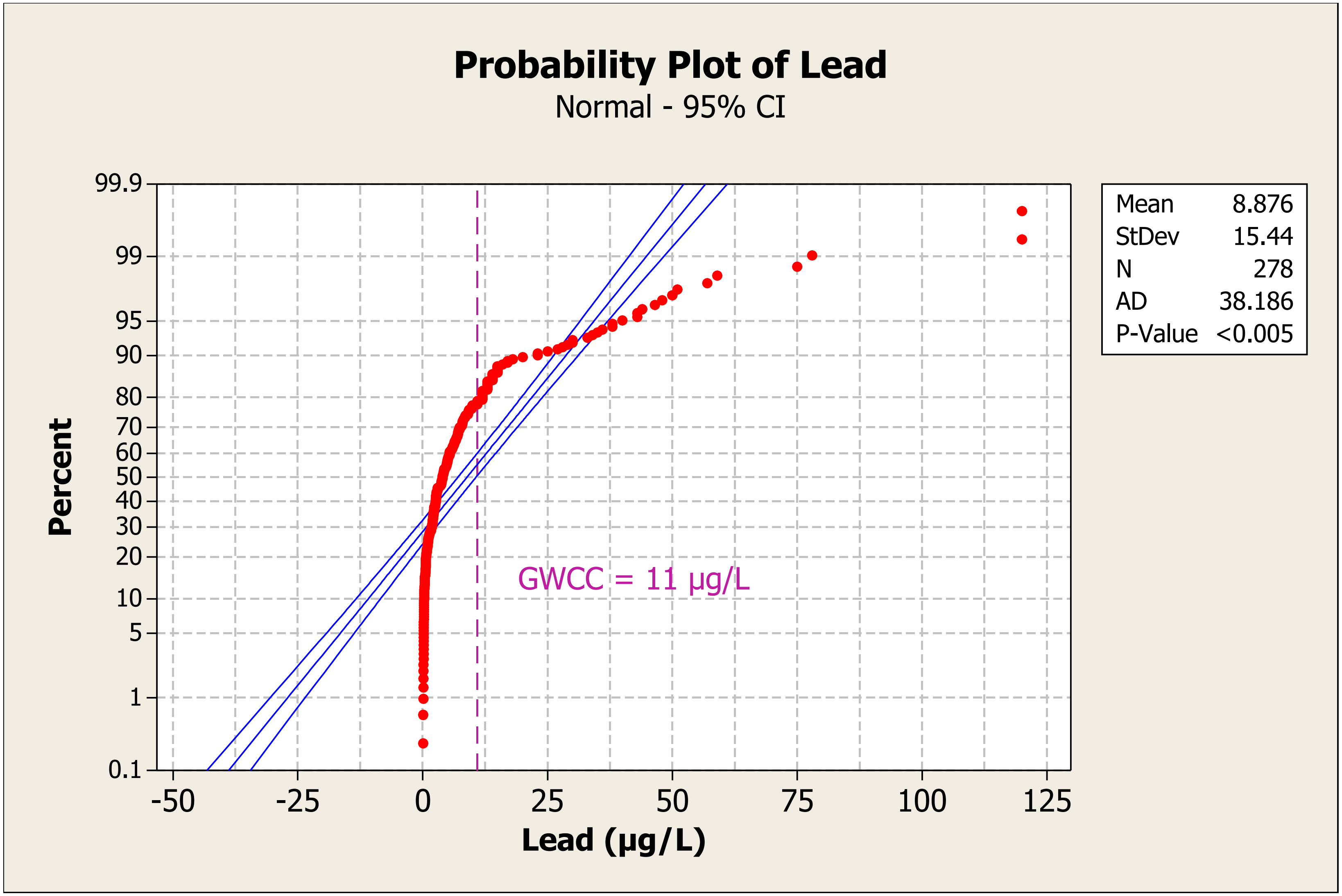

Probability Plot of Fluoride
Normal - 95% CI
99.99
99
95
80
50
20
5
1
0.01
Percent
-2000
-1000
0
1000
2000
3000
4000
5000
6000
Fluoride (µg/L)
GWCC = 800 µg/L
Mean 519.6
StDev 570.4
N 576
AD 94.103
P-Value <0.005


Probability Plot of Fluoride
Lognormal - 95% CI
Percent
99.99
99
95
80
50
20
5
1
0.01
100
1000
10000
Fluoride (µg/L)
GWCC = 800 µg/L
Loc 6.031
Scale 0.5670
N 576
AD 14.623
P-Value <0.005

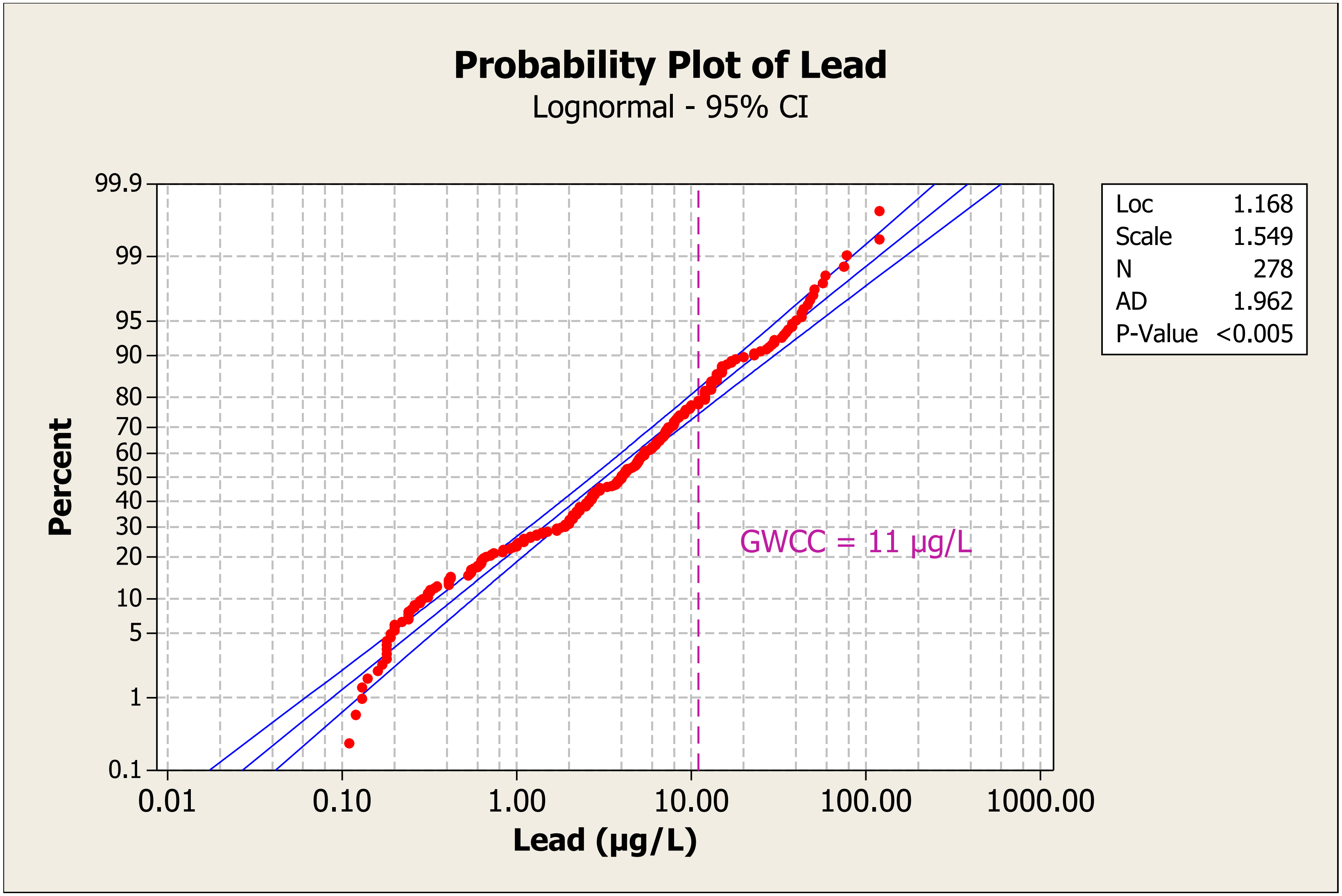


Probability Plot of Iron
Normal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-5000
-2500
0
2500
5000
7500
10000
Iron (µg/L)
GWCC = 4,100 µg/L
Mean 713.8
StDev 1163
N 226
AD 26.921
P-Value <0.005

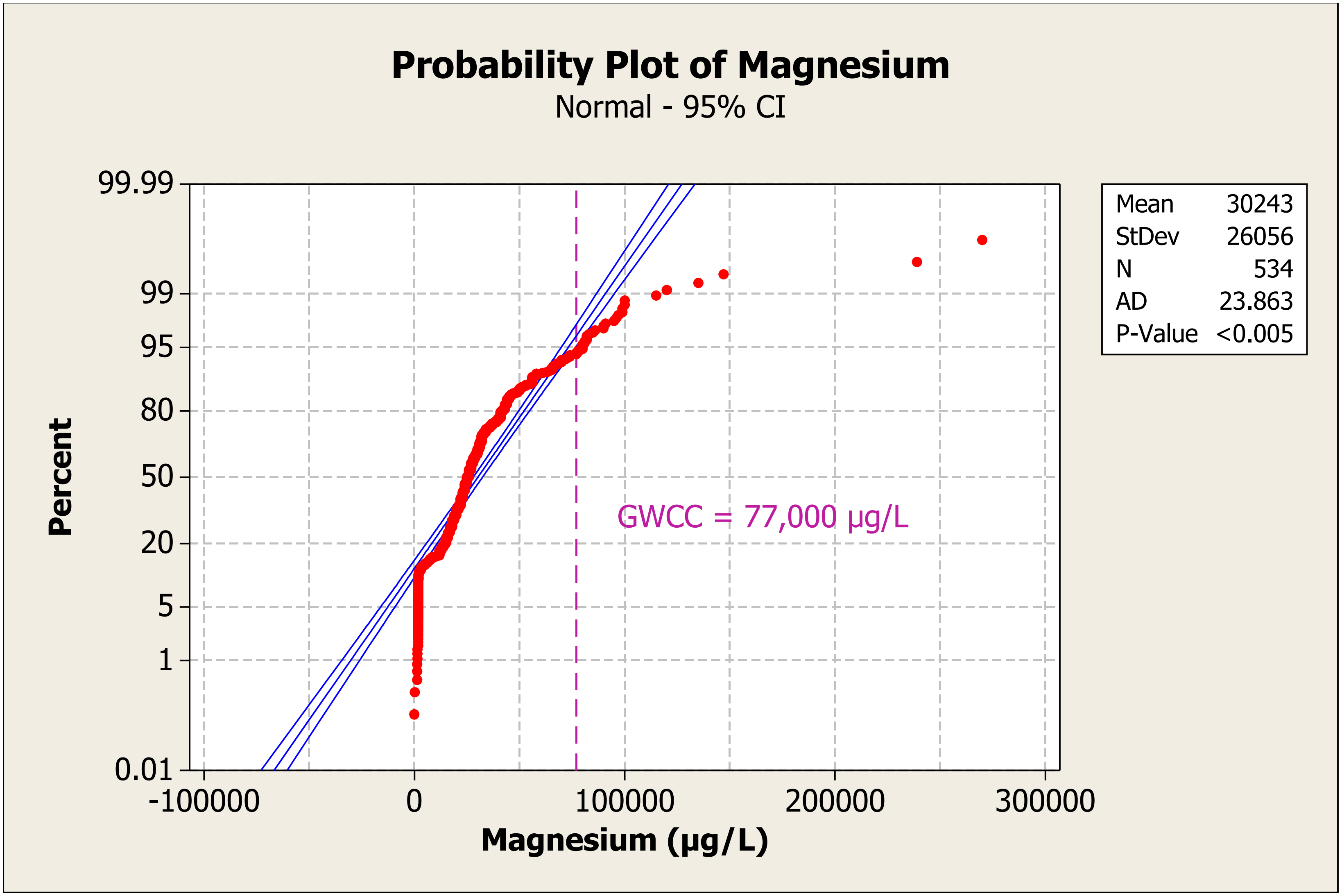

Probability Plot of Iron
Lognormal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
0.1
1.0
10.0
100.0
1000.0
10000.0
100000.0
Iron (µg/L)
GWCC = 4,100 µg/L
Loc 5.325
Scale 1.772
N 226
AD 1.054
P-Value 0.009



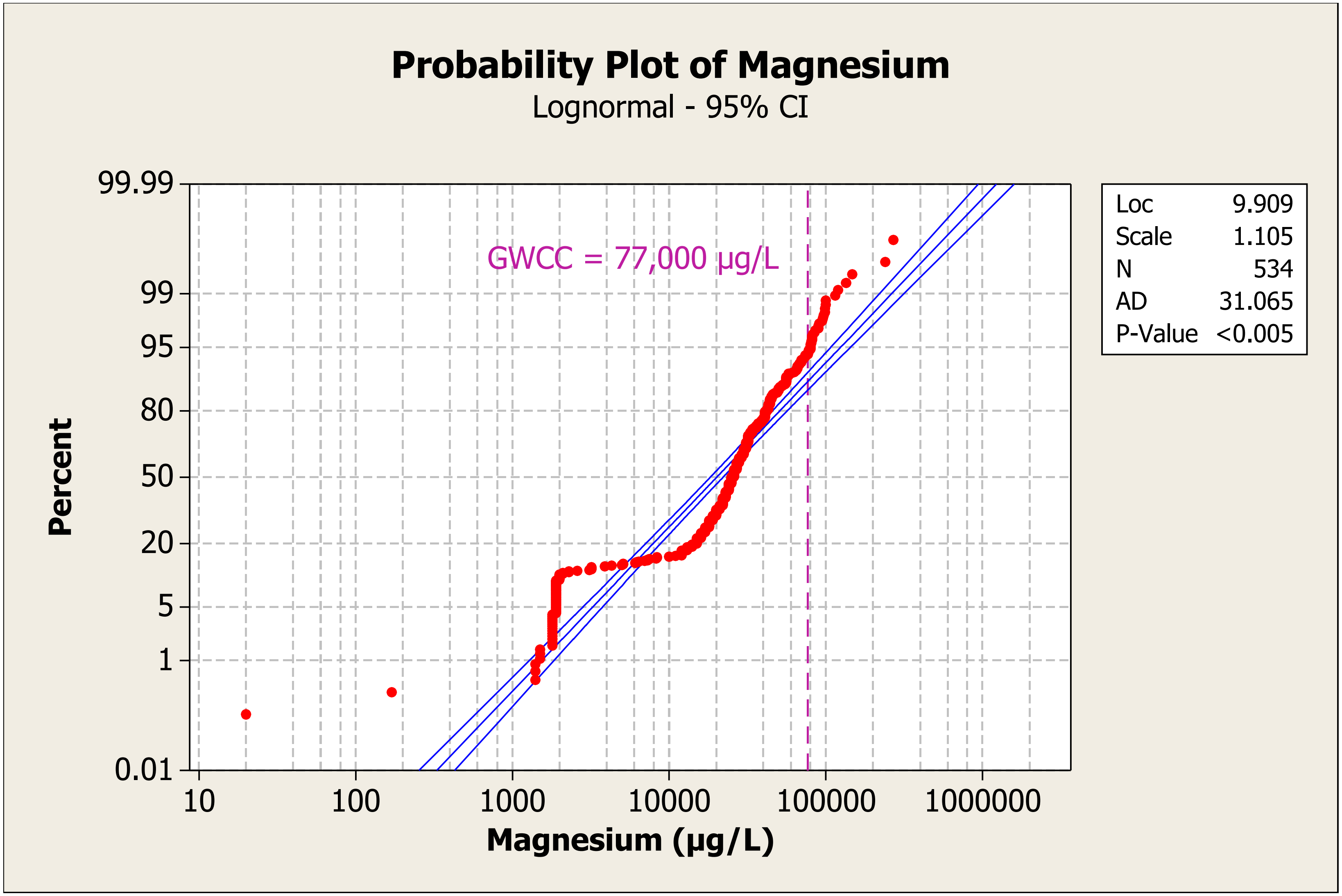
Probability Plot of Lead
Normal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-50
-25
0
25
50
75
100
125
Lead (µg/L)
GWCC = 11 µg/L
Mean 8.876
StDev 15.44
N 278
AD 38.186
P-Value <0.005



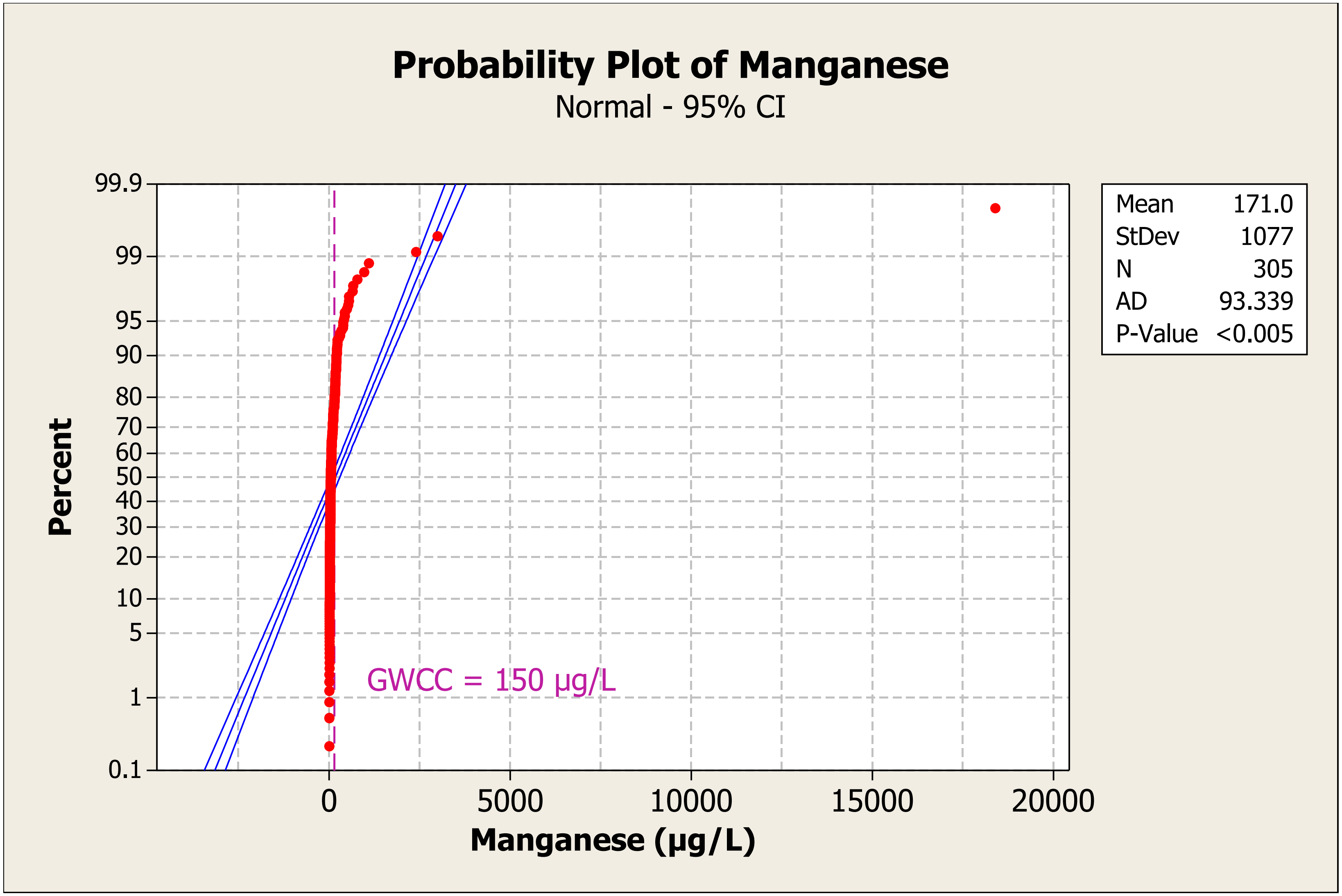
Probability Plot of Lead
Lognormal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
0.01
0.10
1.00
10.00
100.00
1000.00
Lead (µg/L)
GWCC = 11 µg/L
Loc 1.168
Scale 1.549
N 278
AD 1.962
P-Value <0.005



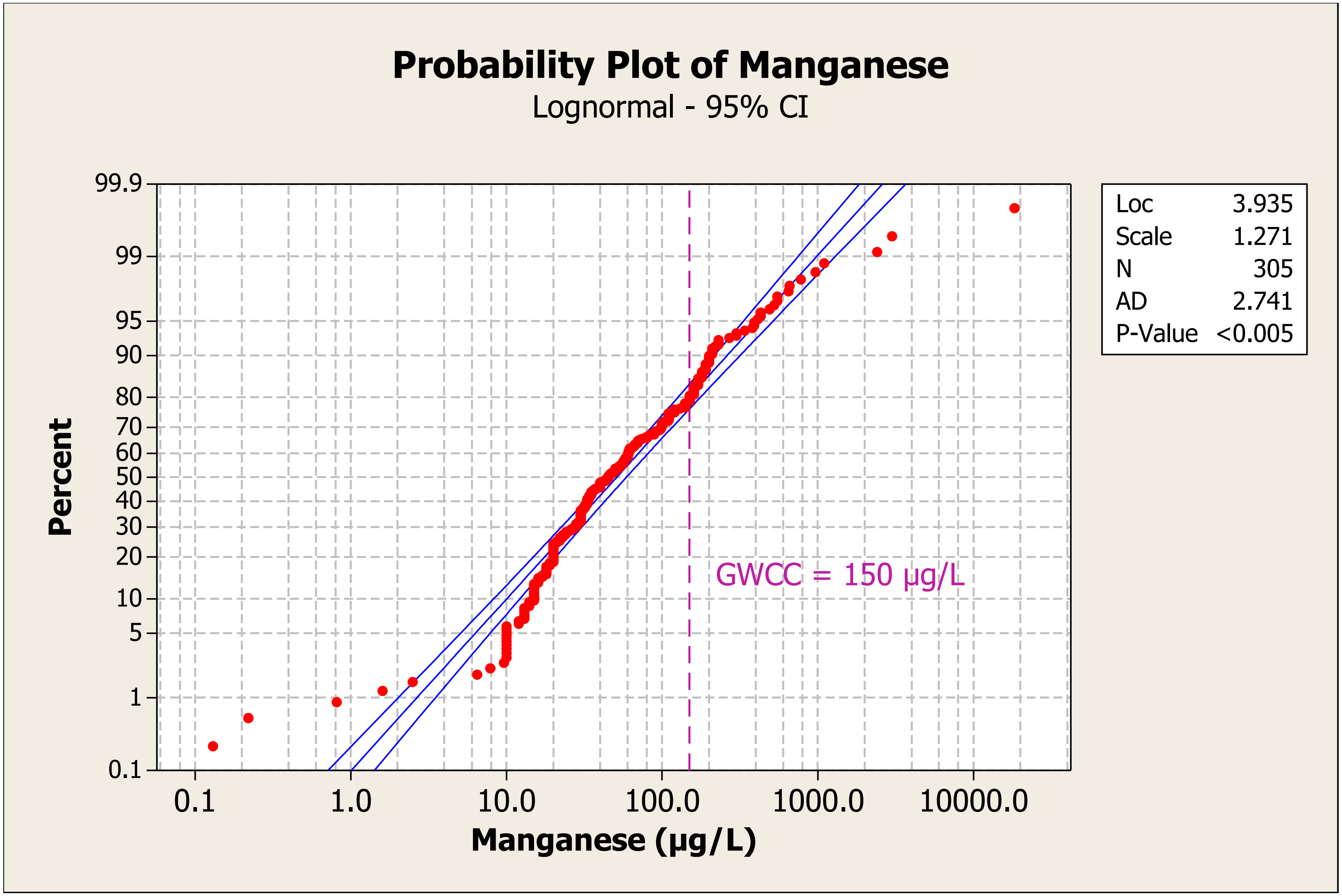
Probability Plot of Magnesium
Normal - 95% CI
Mean 30243
StDev 26056
N 534
AD 23.863
P-Value <0.005
GWCC = 77,000 µg/L
Percent
99.99
99
95
80
50
20
5
1
0.01
-100000
0
100000
200000
300000
Magnesium (µg/L)



Probability Plot of Magnesium
Lognormal - 95% CI
GWCC = 77,000 µg/L
Loc 9.909
Scale 1.105
N 534
AD 31.065
P-Value <0.005
99.99
99
95
80
50
20
5
1
0.01
Percent
10
100
1000
10000
100000
1000000
Magnesium (µg/L)

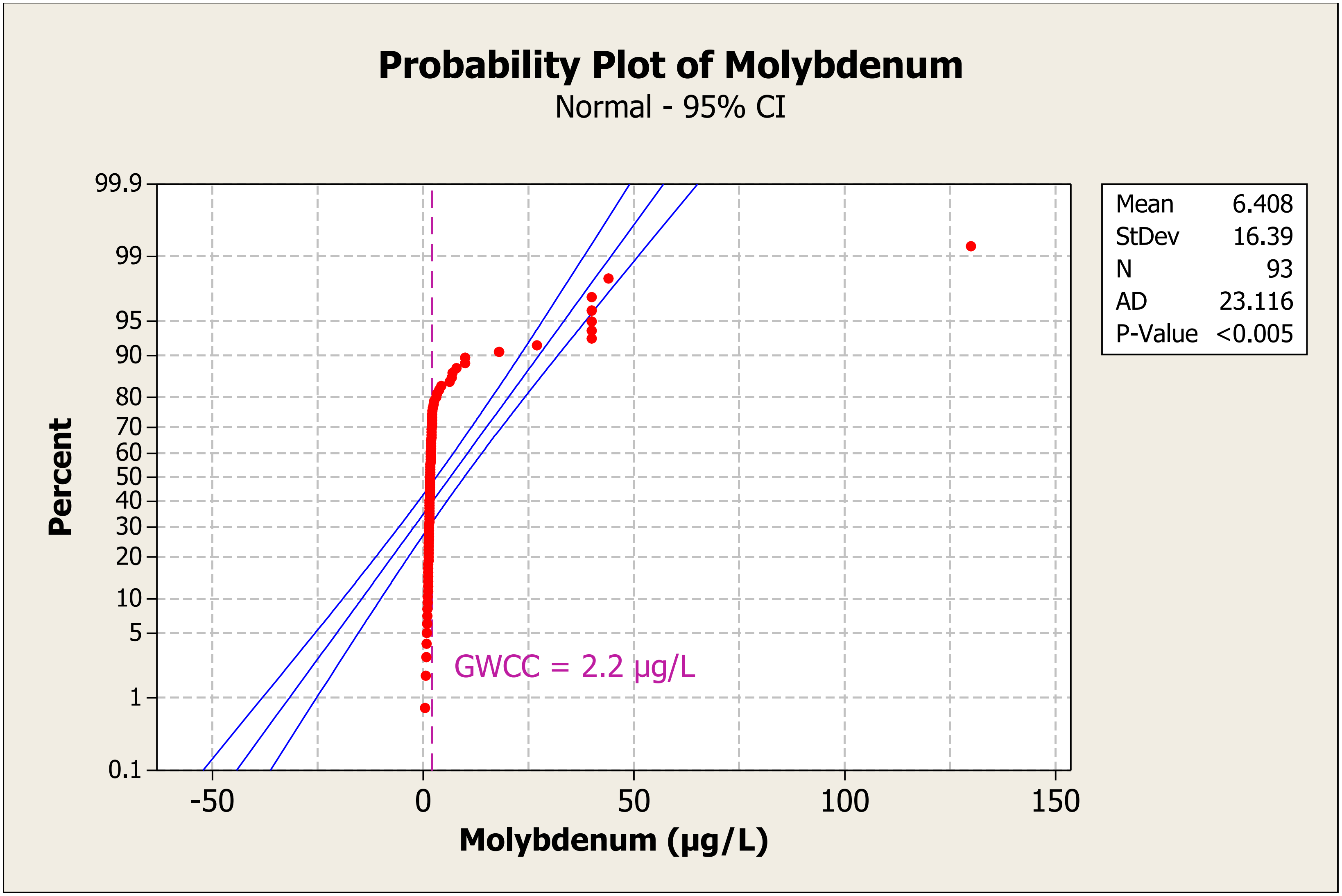


Probability Plot of Manganese
Normal - 95% CI
Mean 171.0
StDev 1077
N 305
AD 93.339
P-Value <0.005
GWCC = 150 µg/L
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
0
5000
10000
15000
20000
Manganese (µg/L)

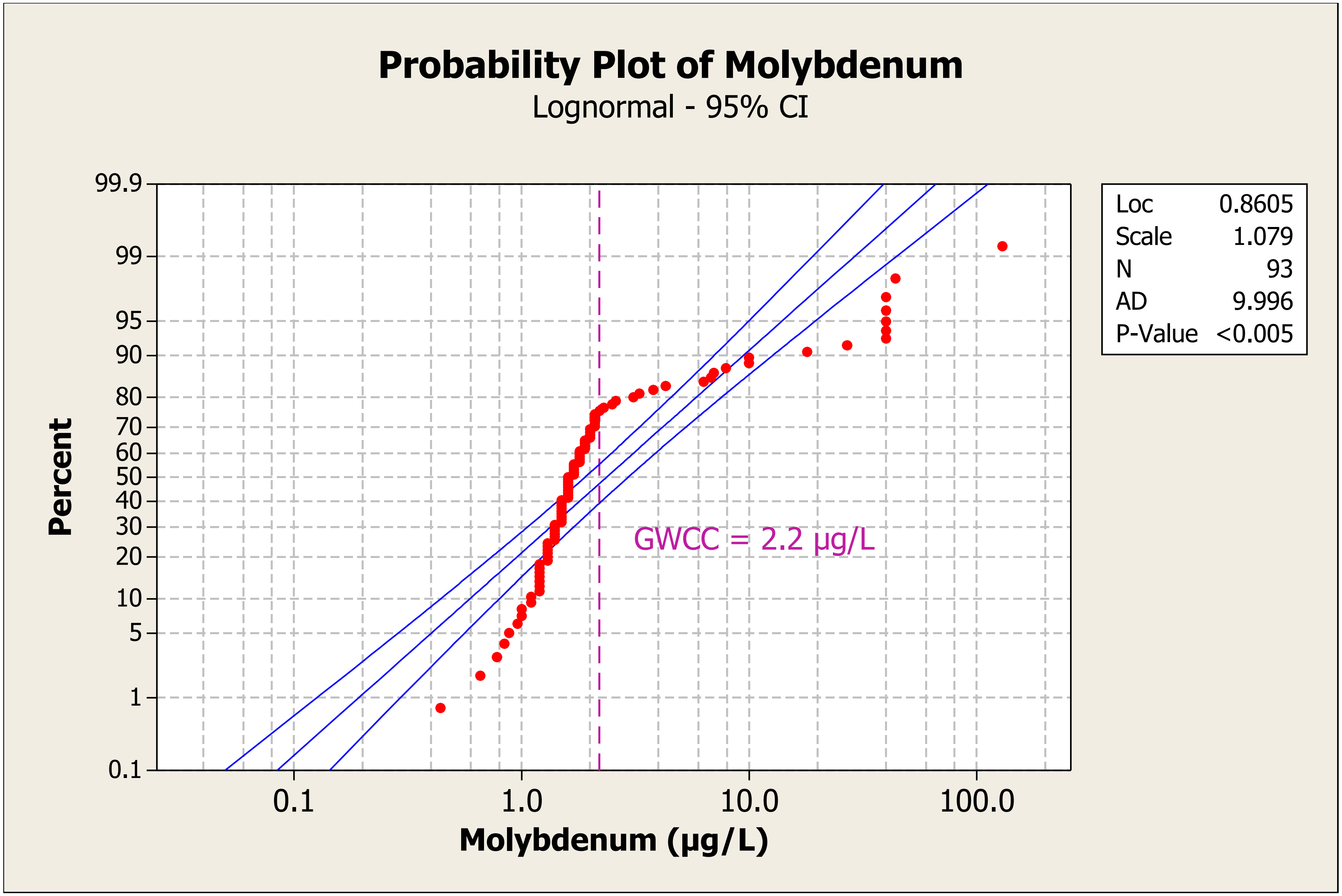


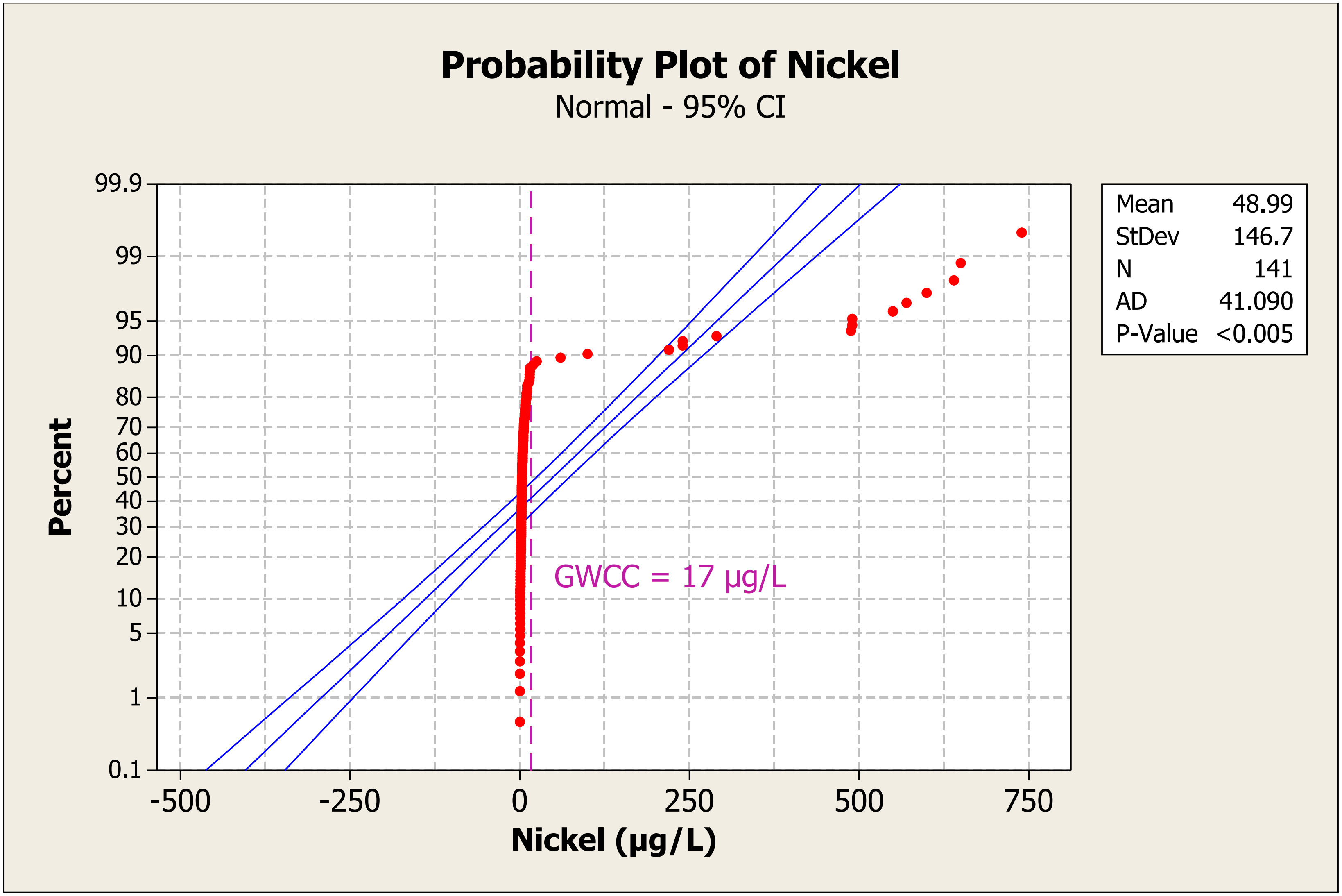
Probability Plot of Manganese
Lognormal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
0.1
1.0
10.0
100.0
1000.0
10000.0
Manganese (µg/L)
GWCC = 150 µg/L
Loc 3.935
Scale 1.271
N 305
AD 2.741
P-Value <0.005

Probability plots are not included for **mercury**. Comparison concentrations are based on detection limits for this metal (see main text).

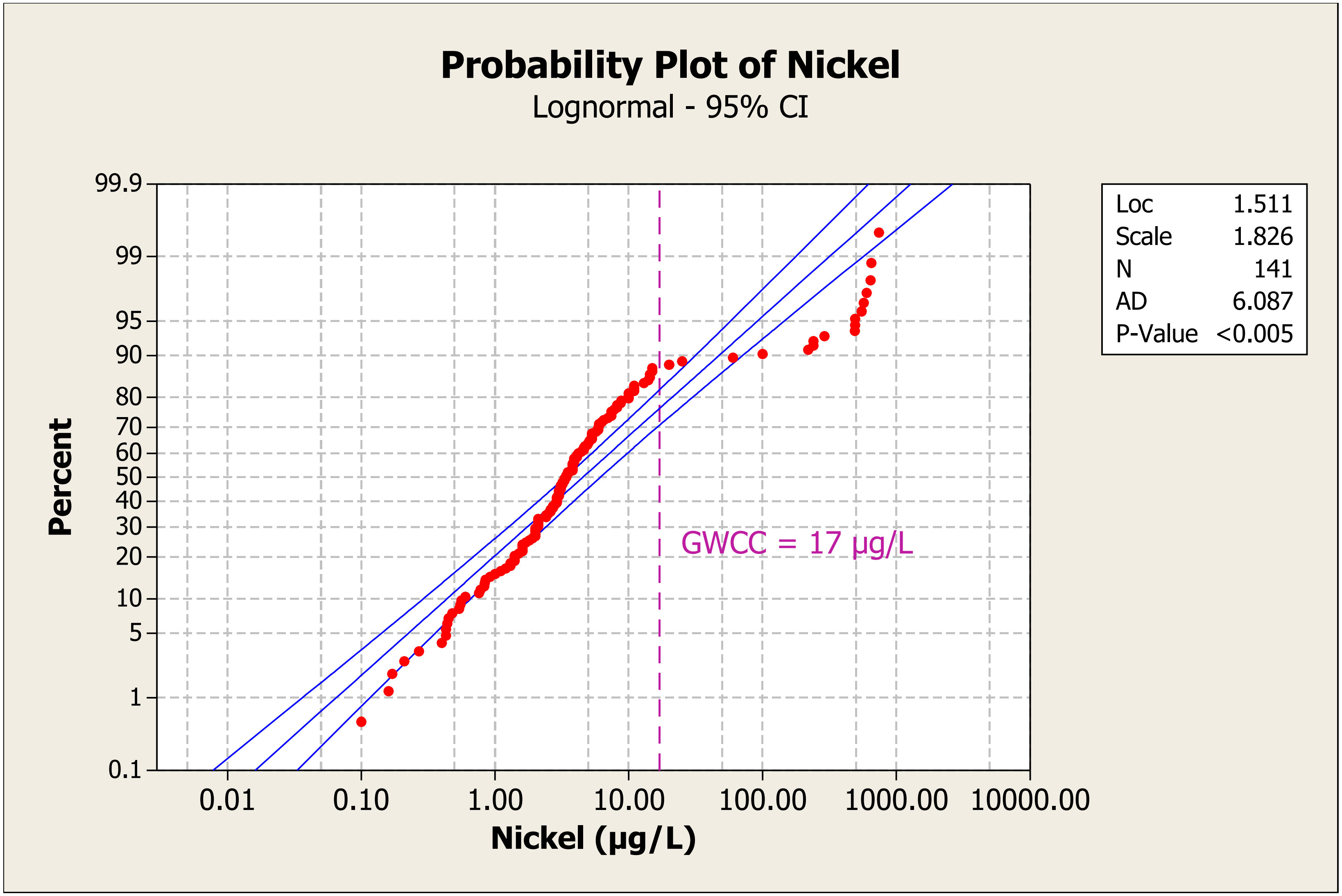


Probability Plot of Molybdenum
Normal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-50
0
50
100
150
Molybdenum (µg/L)
GWCC = 2.2 µg/L
Mean 6.408
StDev 16.39
N 93
AD 23.116
P-Value <0.005

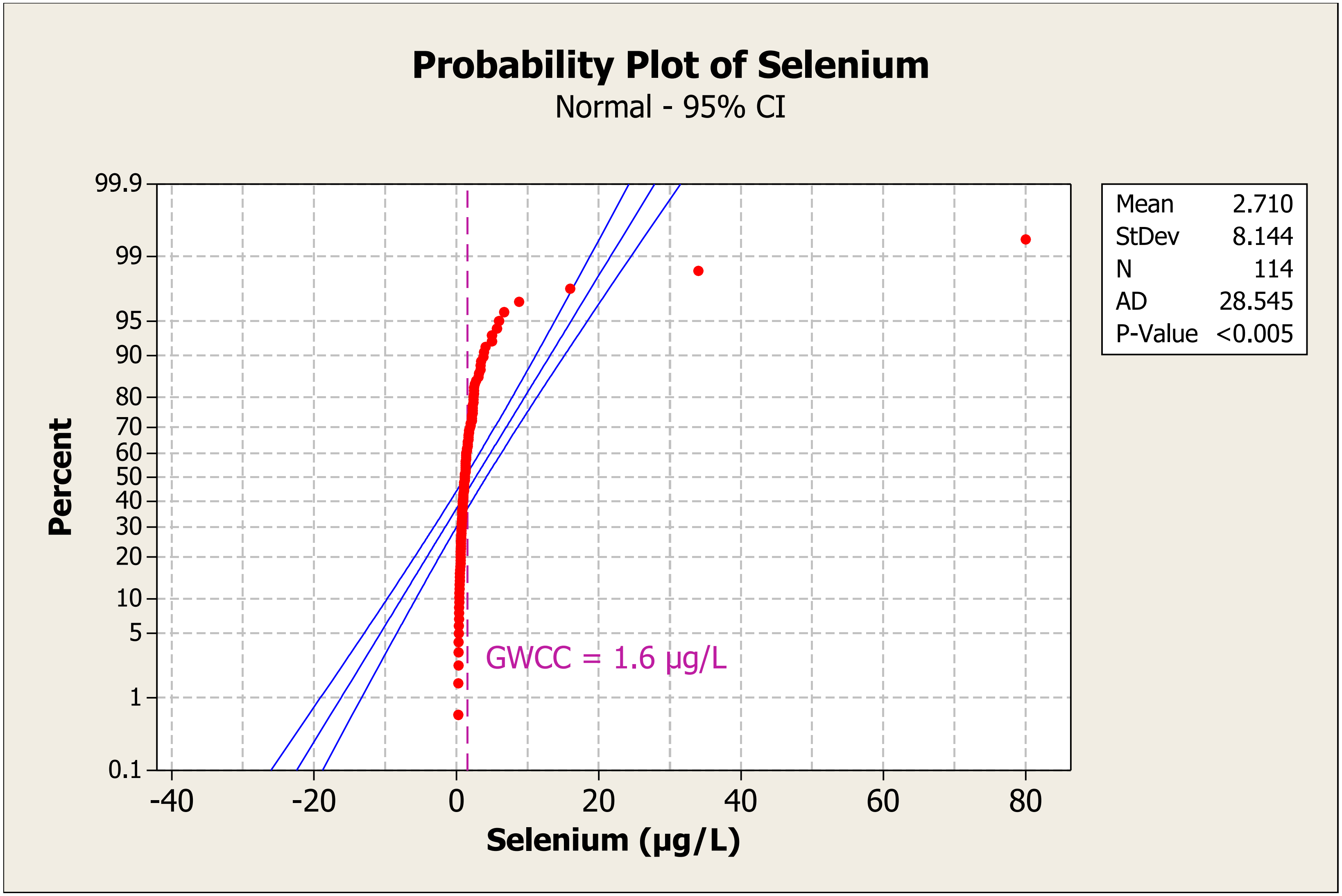

Probability Plot of Molybdenum
Lognormal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
0.1
1.0
10.0
100.0
Molybdenum (µg/L)
GWCC = 2.2 µg/L
Loc 0.8605
Scale 1.079
N 93
AD 9.996
P-Value <0.005



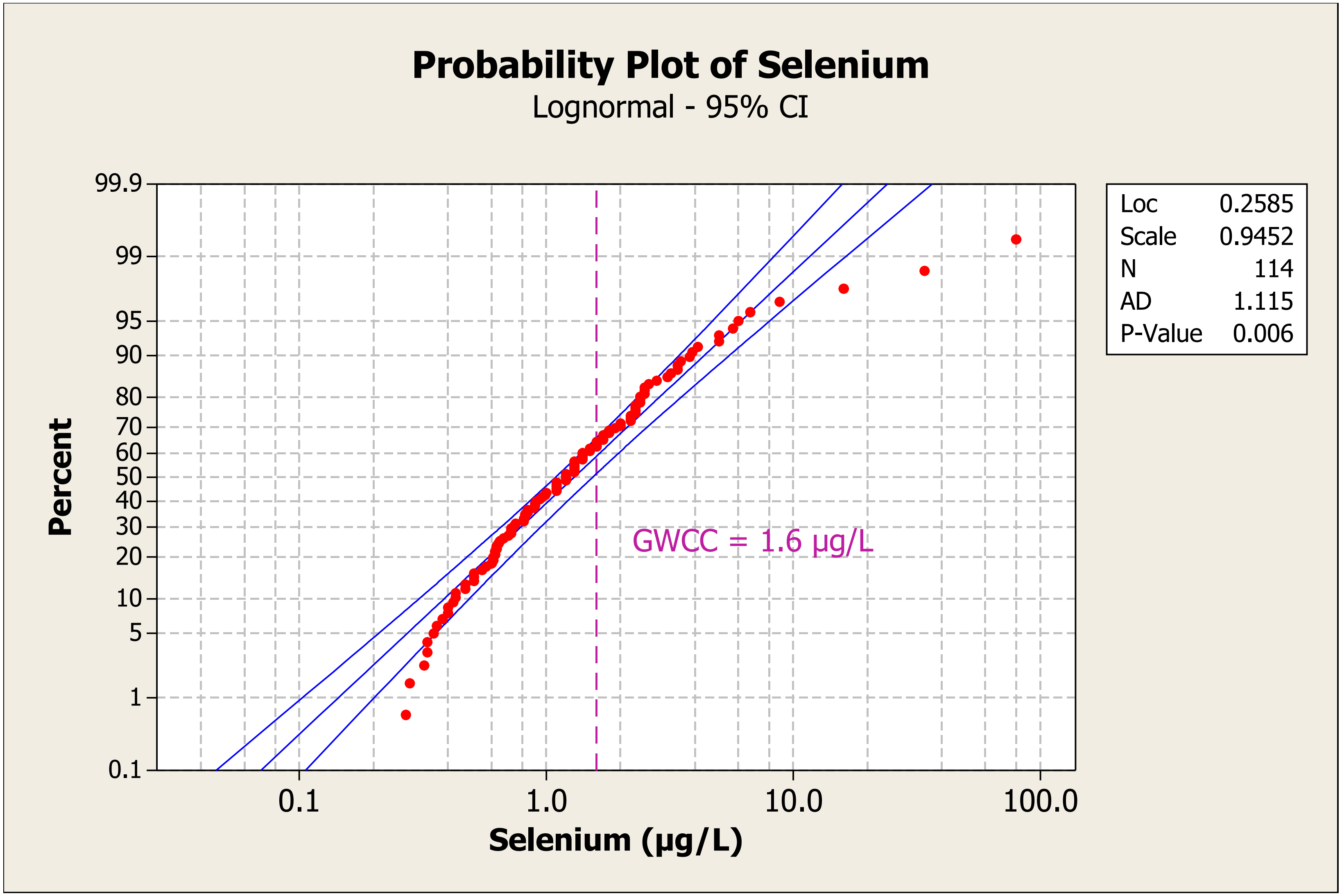
Probability Plot of Nickel
Normal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-500
-250
0
250
500
750
Nickel (µg/L)
GWCC = 17 µg/L
Mean 48.99
StDev 146.7
N 141
AD 41.090
P-Value <0.005



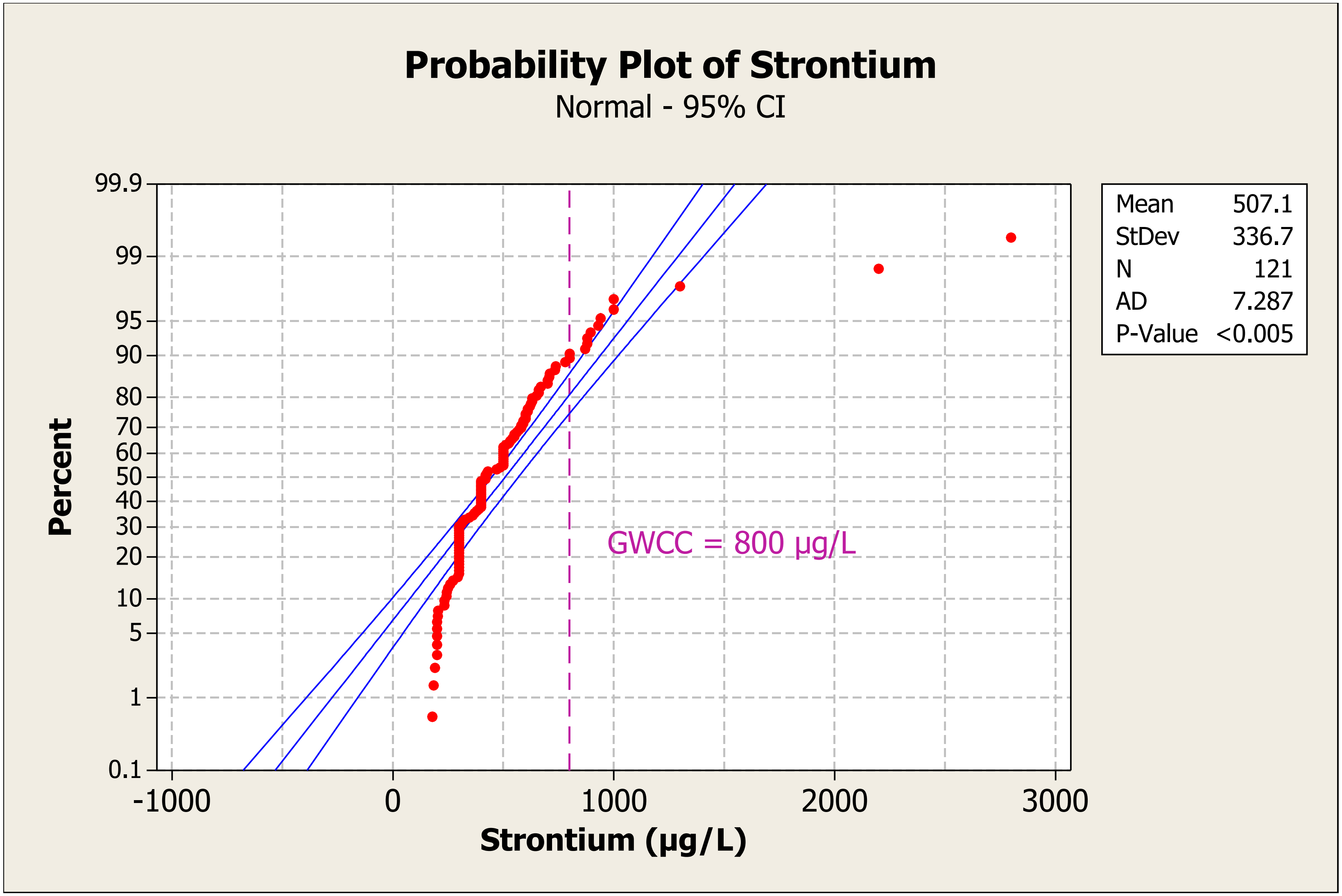
Probability Plot of Nickel
Lognormal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
0.01
0.10
1.00
10.00
100.00
1000.00
10000.00
Nickel (µg/L)
GWCC = 17 µg/L
Loc 1.511
Scale 1.826
N 141
AD 6.087
P-Value <0.005

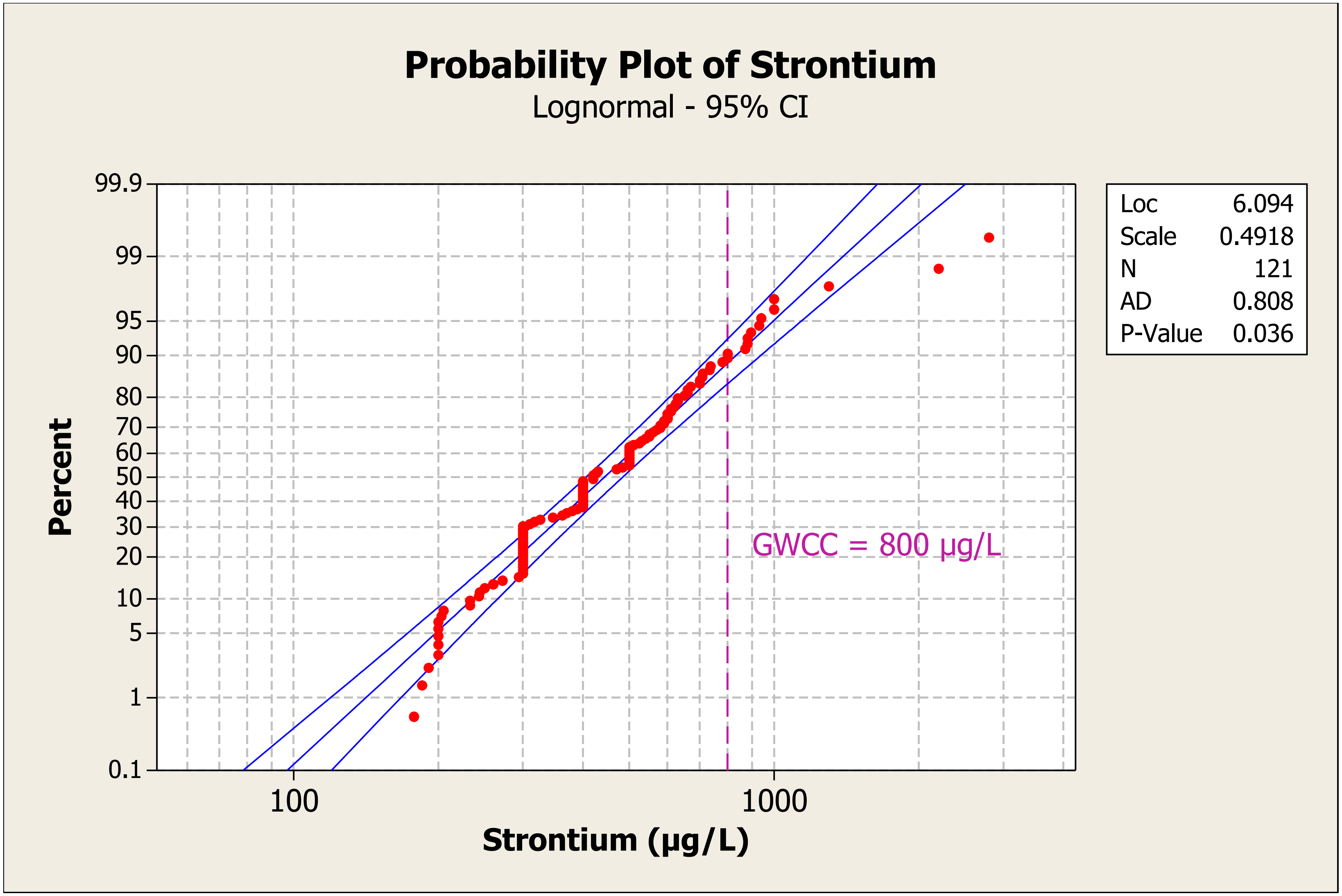


Probability Plot of Selenium
Normal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-40
-20
0
20
40
60
80
Selenium (µg/L)
GWCC = 1.6 µg/L
Mean 2.710
StDev 8.144
N 114
AD 28.545
P-Value <0.005


Probability Plot of Selenium
Lognormal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
0.1
1.0
10.0
100.0
Selenium (µg/L)
GWCC = 1.6 µg/L
Loc 0.2585
Scale 0.9452
N 114
AD 1.115
P-Value 0.006

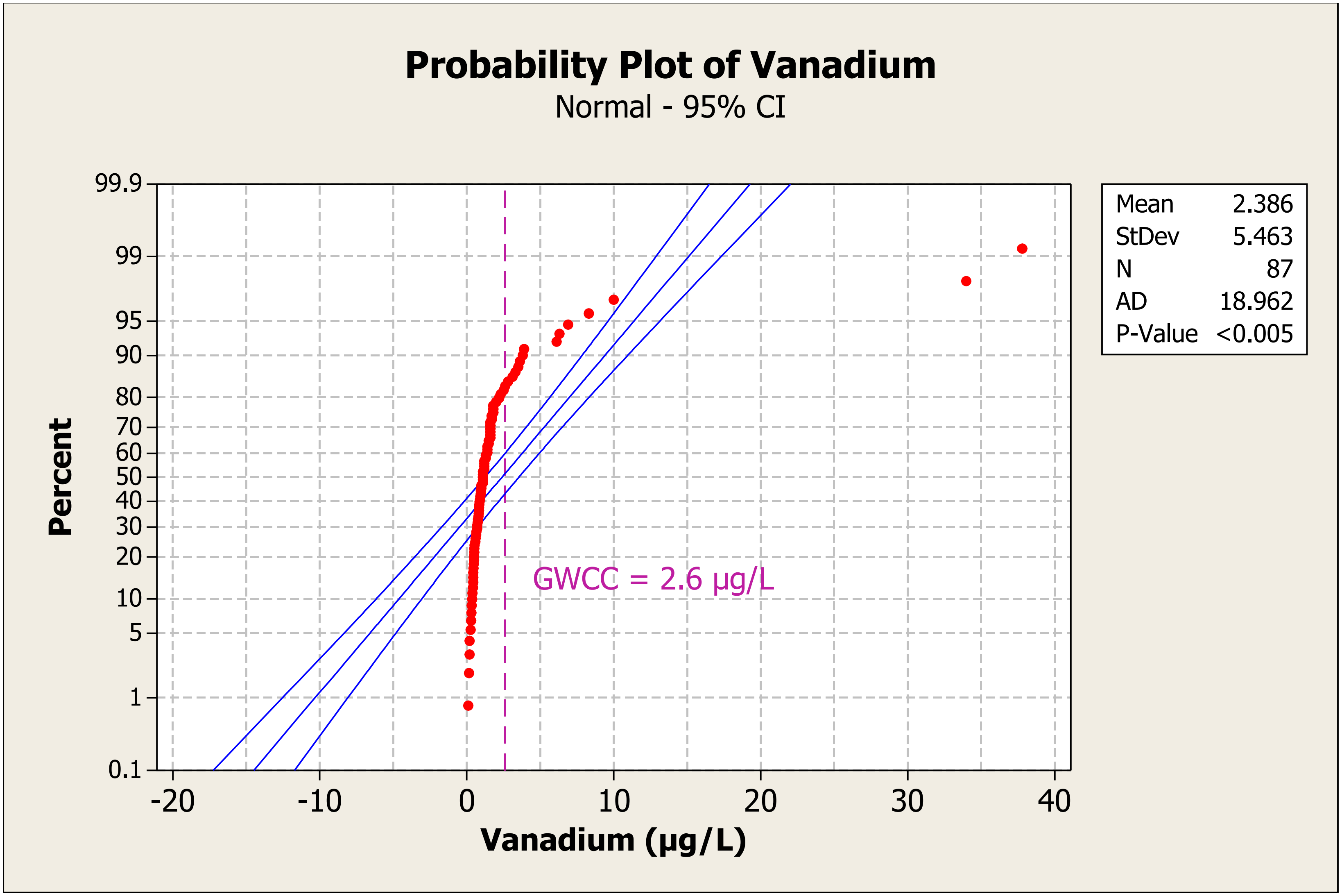
Probability plots are not included for **silver**. Comparison concentrations are based on detection limits for this metal (see main text).


Probability Plot of Strontium
Normal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-1000
0
1000
2000
3000
Strontium (µg/L)
GWCC = 800 µg/L
Mean 507.1
StDev 336.7
N 121
AD 7.287
P-Value <0.005

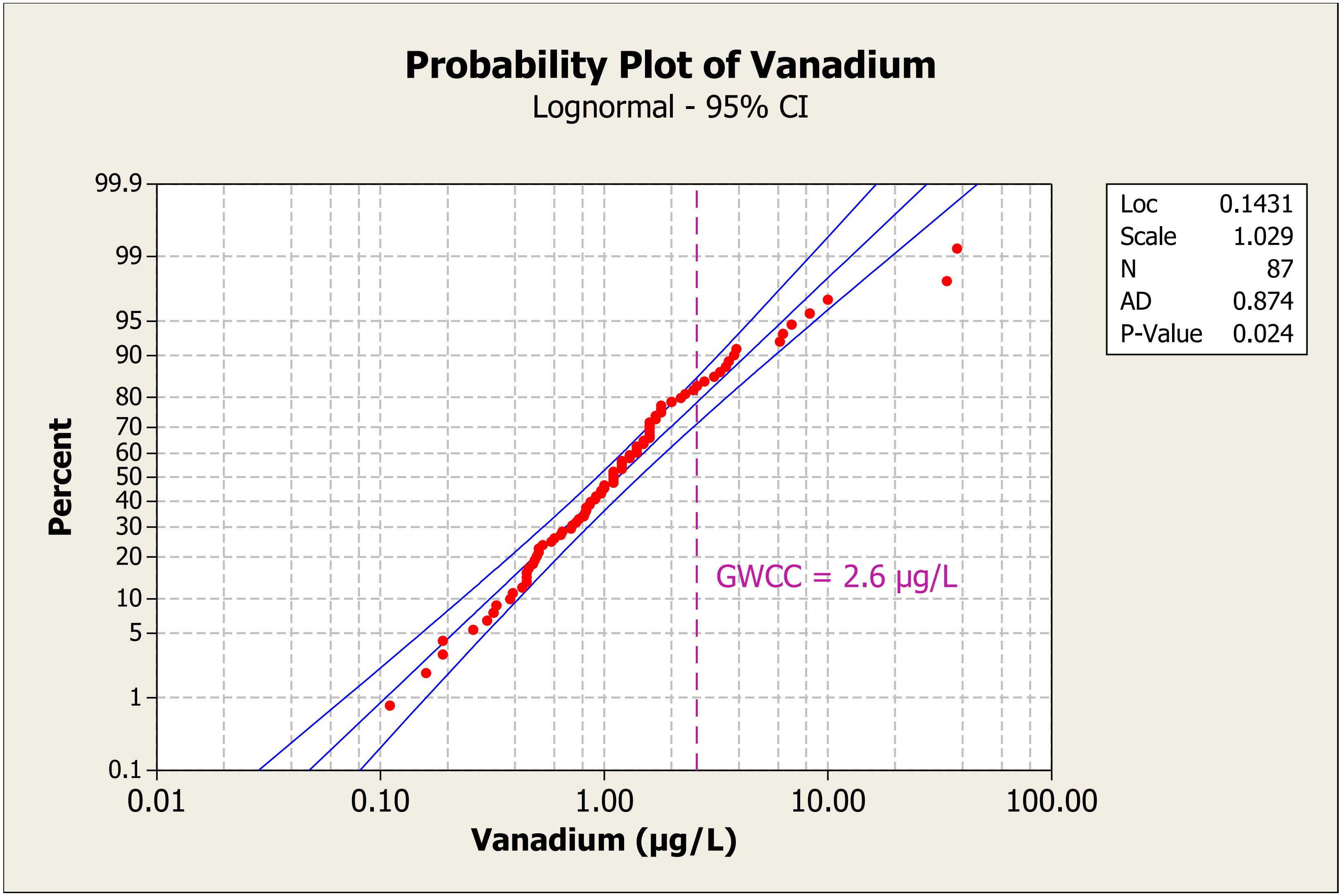

Probability Plot of Strontium
Lognormal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
100
1000
Strontium (µg/L)
GWCC = 800 µg/L
Loc 6.094
Scale 0.4918
N 121
AD 0.808
P-Value 0.036

Probability plots are not included for **Thallium**. Comparison concentrations are based on detection limits for this metal (see main text).

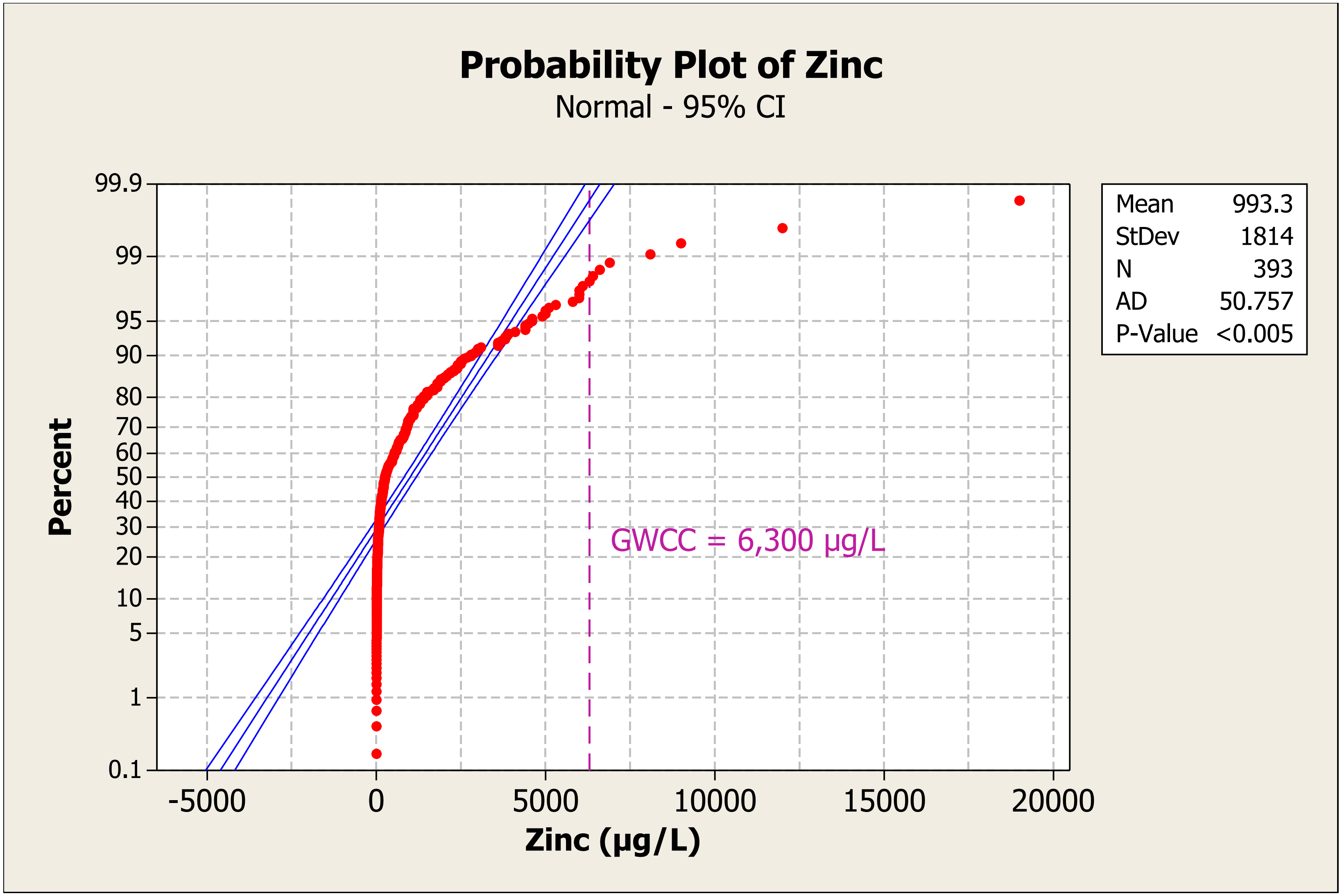
Probability plots are not included for **tin**. Comparison concentrations are based on detection limits for this metal (see main text).



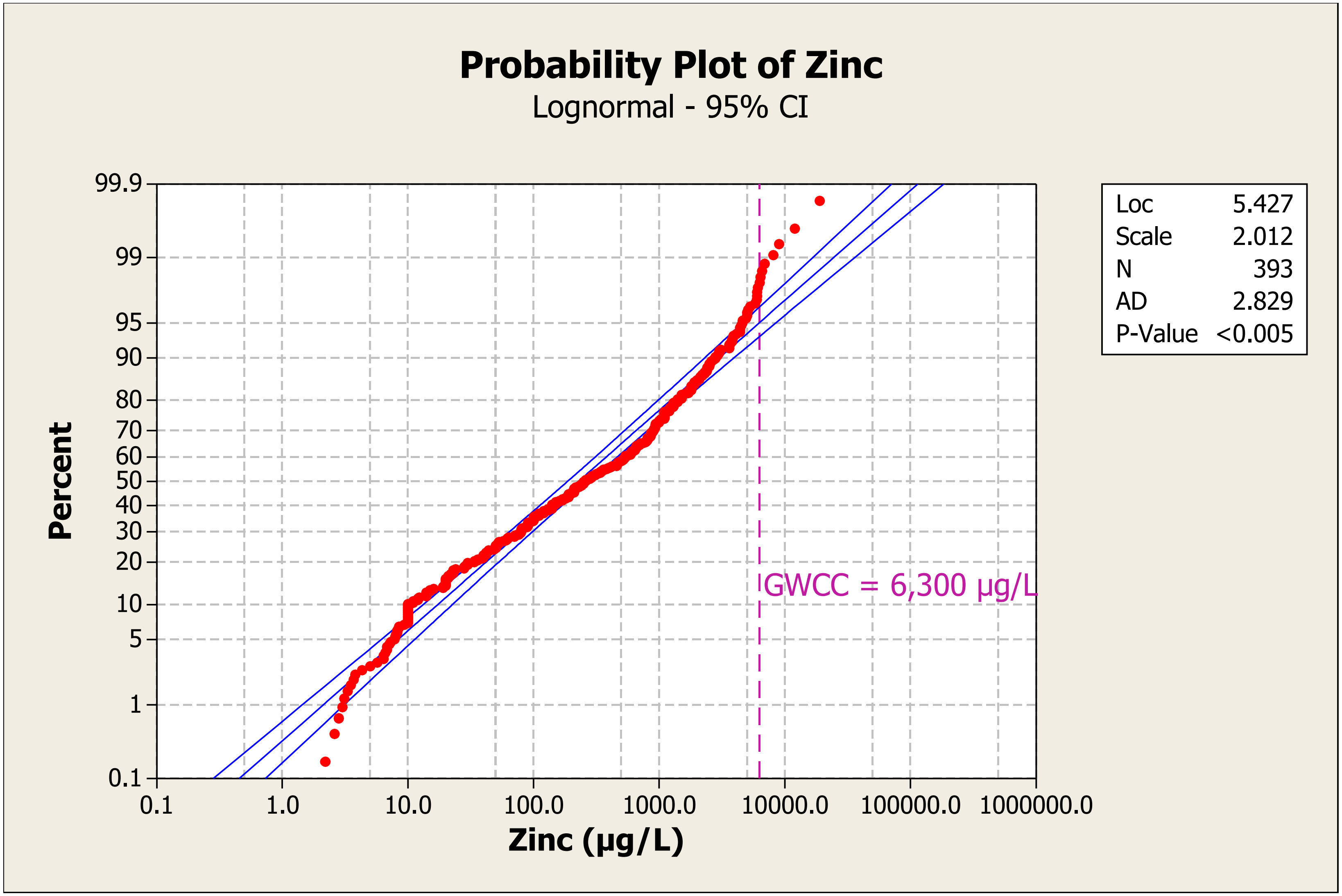
Probability Plot of Vanadium
Normal - 95% CI
Percent
Vanadium (µg/L)
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-20
-10
0
10
20
30
40
GWCC = 2.6 µg/L
Mean 2.386
StDev 5.463
N 87
AD 18.962
P-Value <0.005



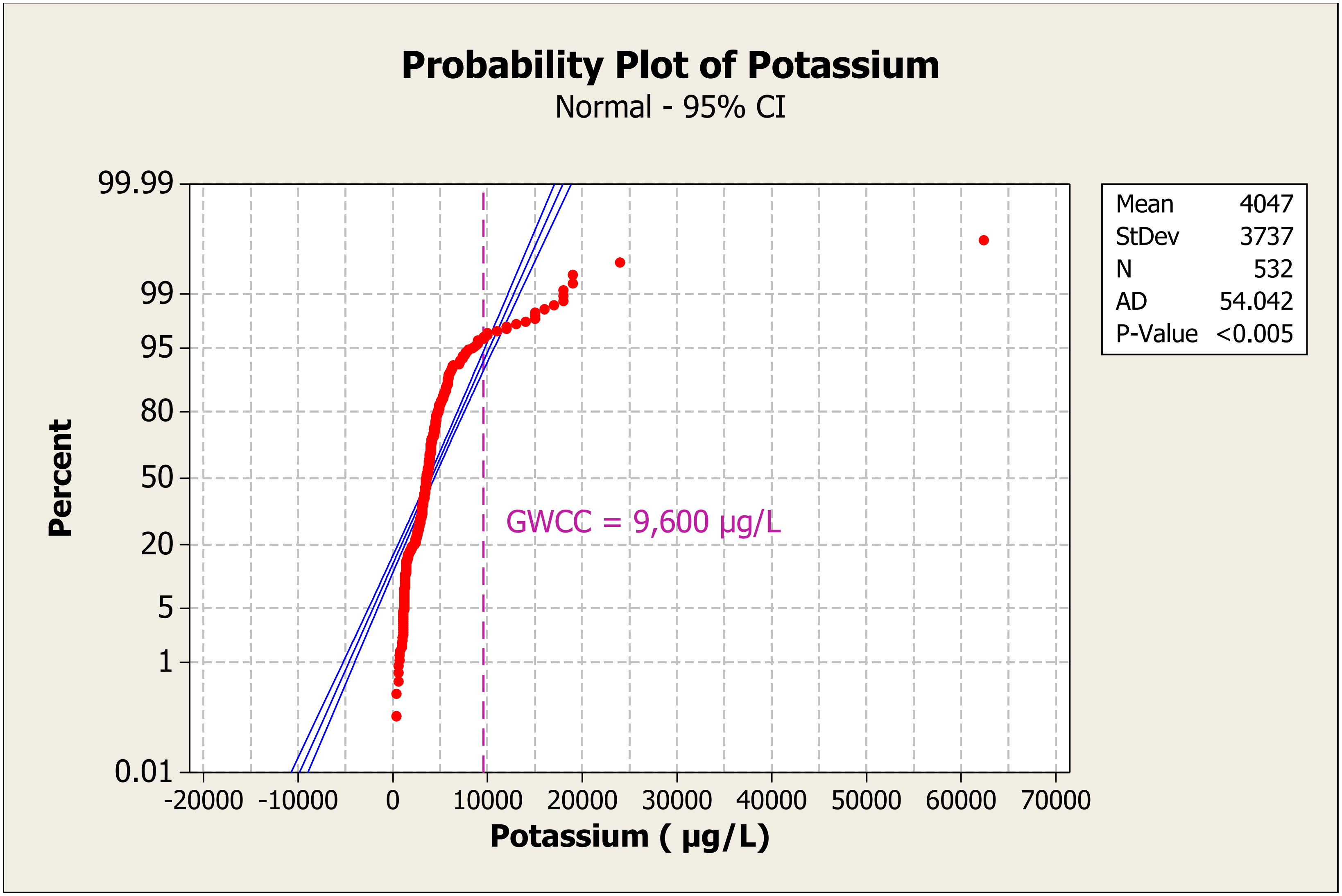
Probability Plot of Vanadium
Lognormal - 95% CI
Loc 0.1431
Scale 1.029
N 87
AD 0.874
P-Value 0.024
GWCC = 2.6 µg/L
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
0.01
0.10
1.00
10.00
100.00
Vanadium (µg/L)

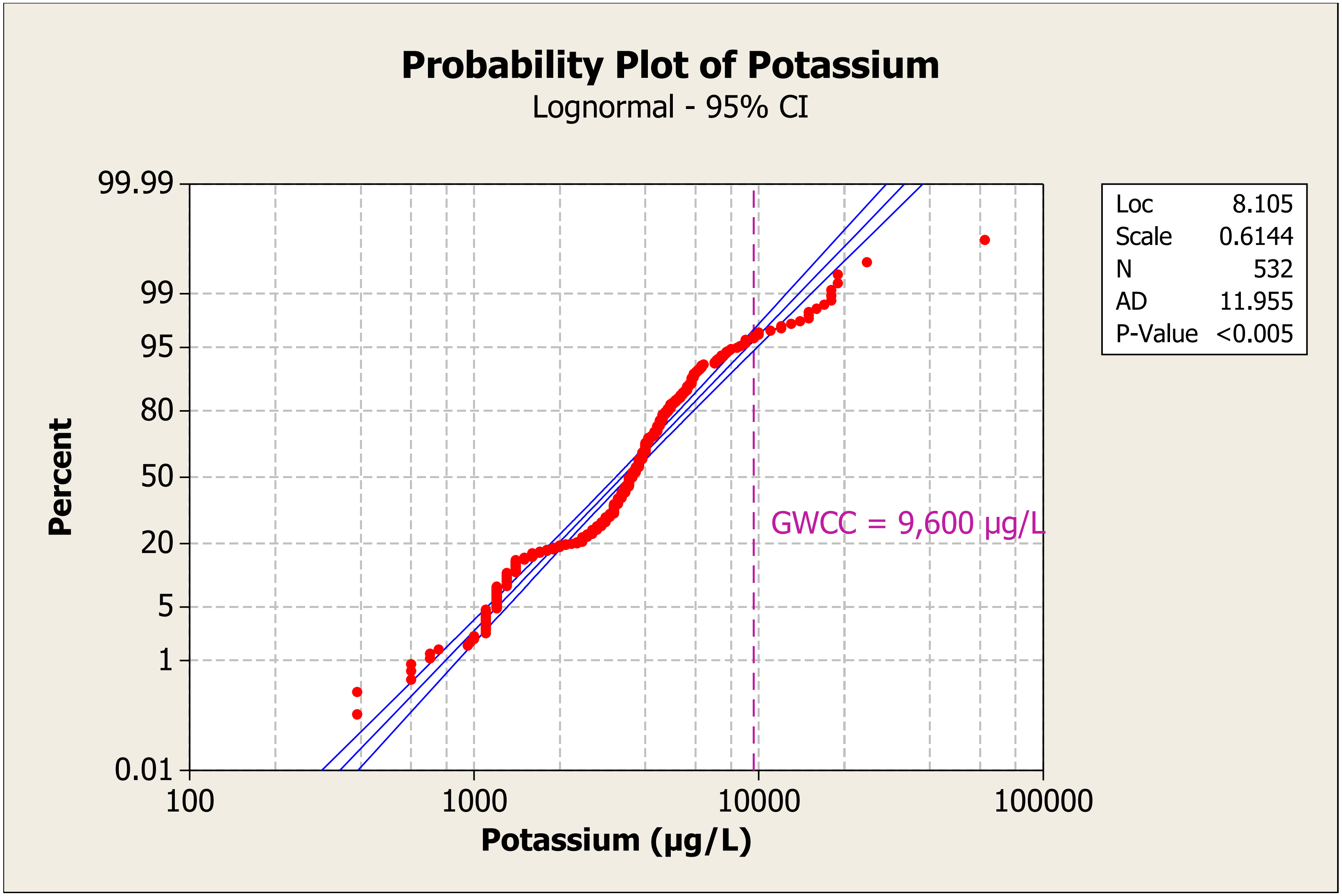


Probability Plot of Zinc
Normal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-5000
0
5000
10000
15000
20000
Zinc (µg/L)
GWCC = 6,300 µg/L
Mean 993.3
StDev 1814
N 393
AD 50.757
P-Value <0.005

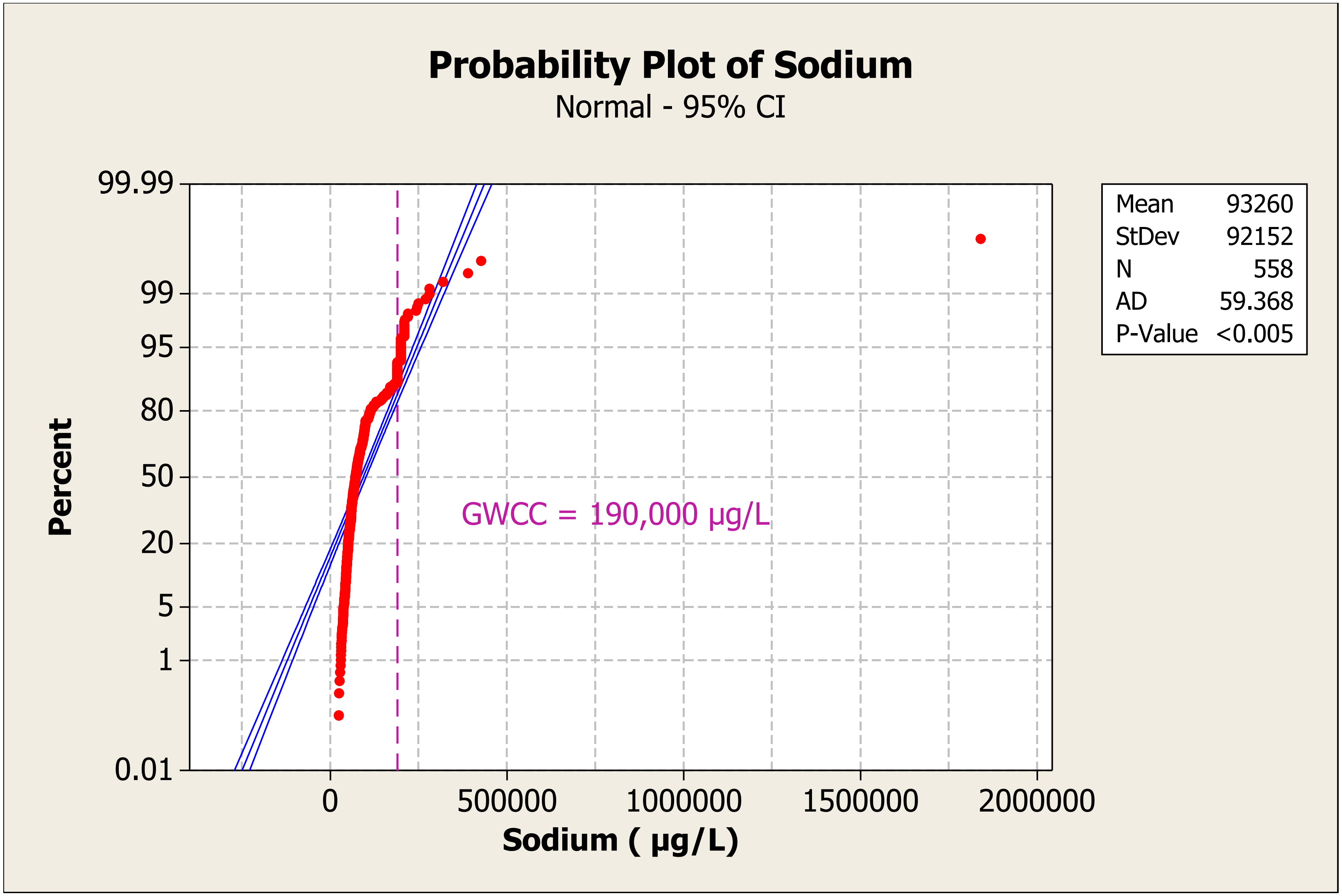


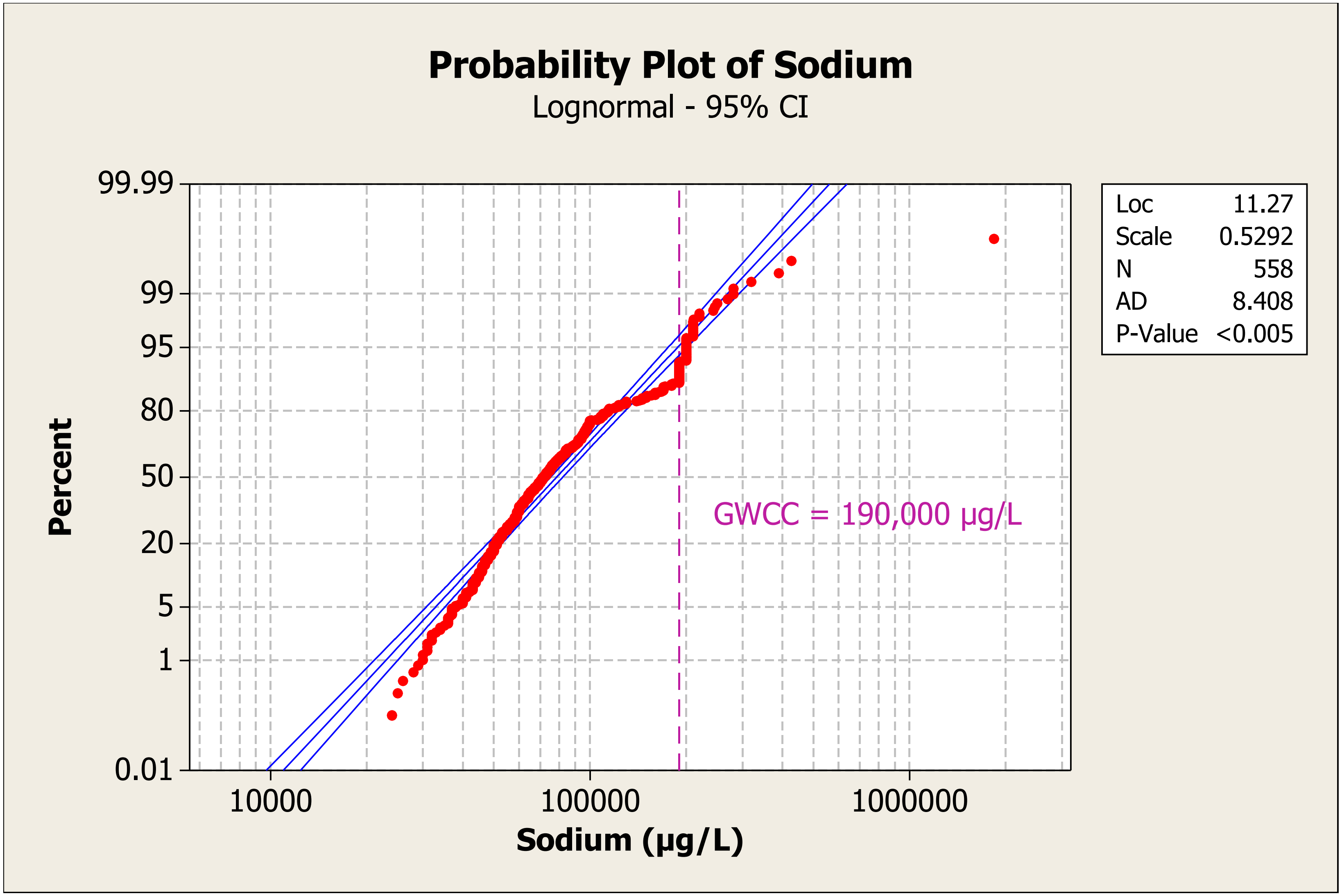
Probability Plot of Zinc
Lognormal - 95% CI
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
0.1
1.0
10.0
100.0
1000.0
10000.0
100000.0
1000000.0
Zinc (µg/L)
GWCC = 6,300 µg/L
Loc 5.427
Scale 2.012
N 393
AD 2.829
P-Value <0.005


Probability Plot of Potassium
Normal - 95% CI
Mean 4047
StDev 3737
N 532
AD 54.042
P-Value <0.005
GWCC = 9,600 µg/L
Percent
99.99
99
95
80
50
20
5
1
0.01
-20000
-10000
0
10000
20000
30000
40000
50000
60000
70000
Potassium (µg/L)

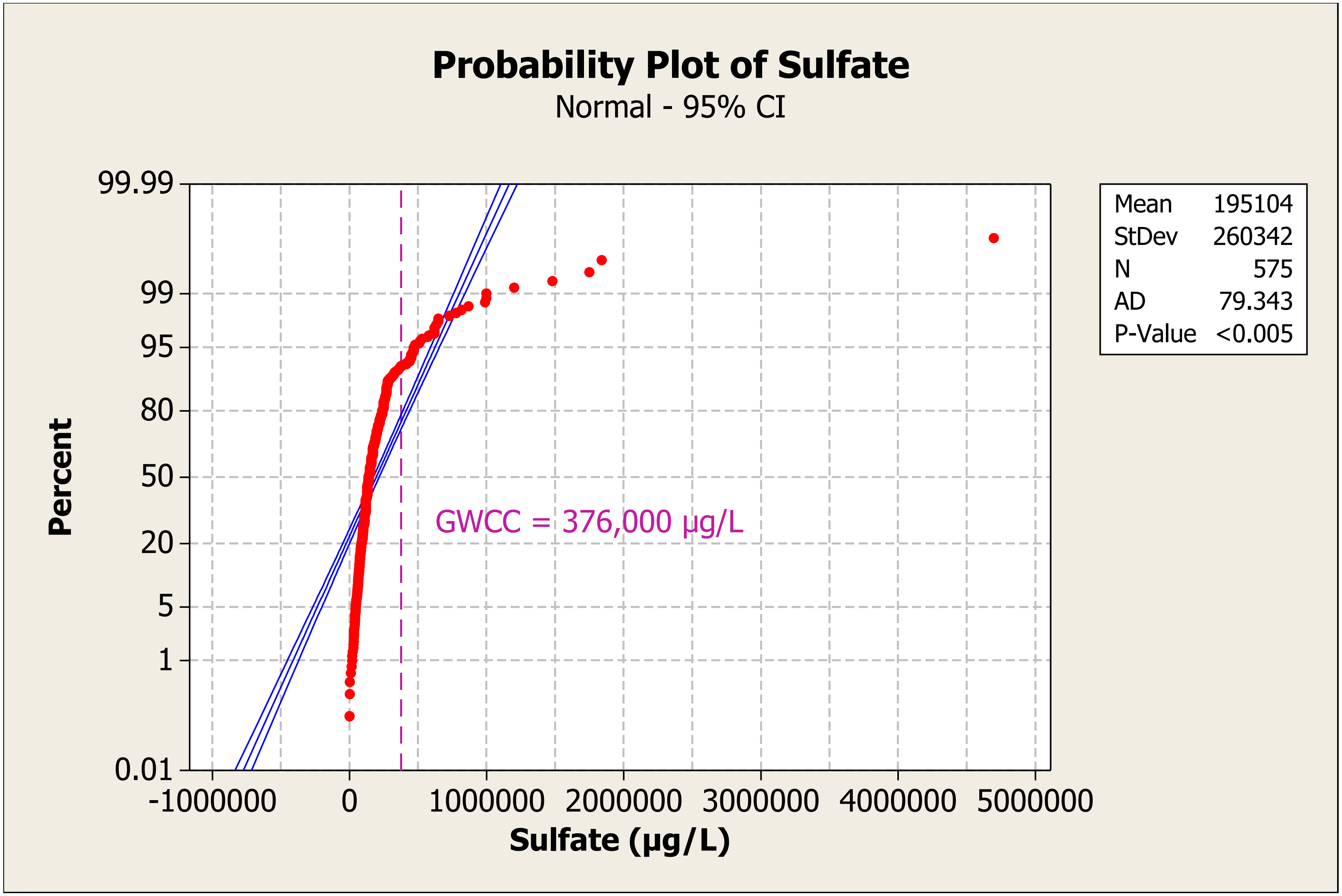


Probability Plot of Potassium
Lognormal - 95% CI
Percent
99.99
99
95
80
50
20
5
1
0.01
100
1000
10000
100000
Potassium (µg/L)
GWCC = 9,600 µg/L
Loc 8.105
Scale 0.6144
N 532
AD 11.955
P-Value <0.005

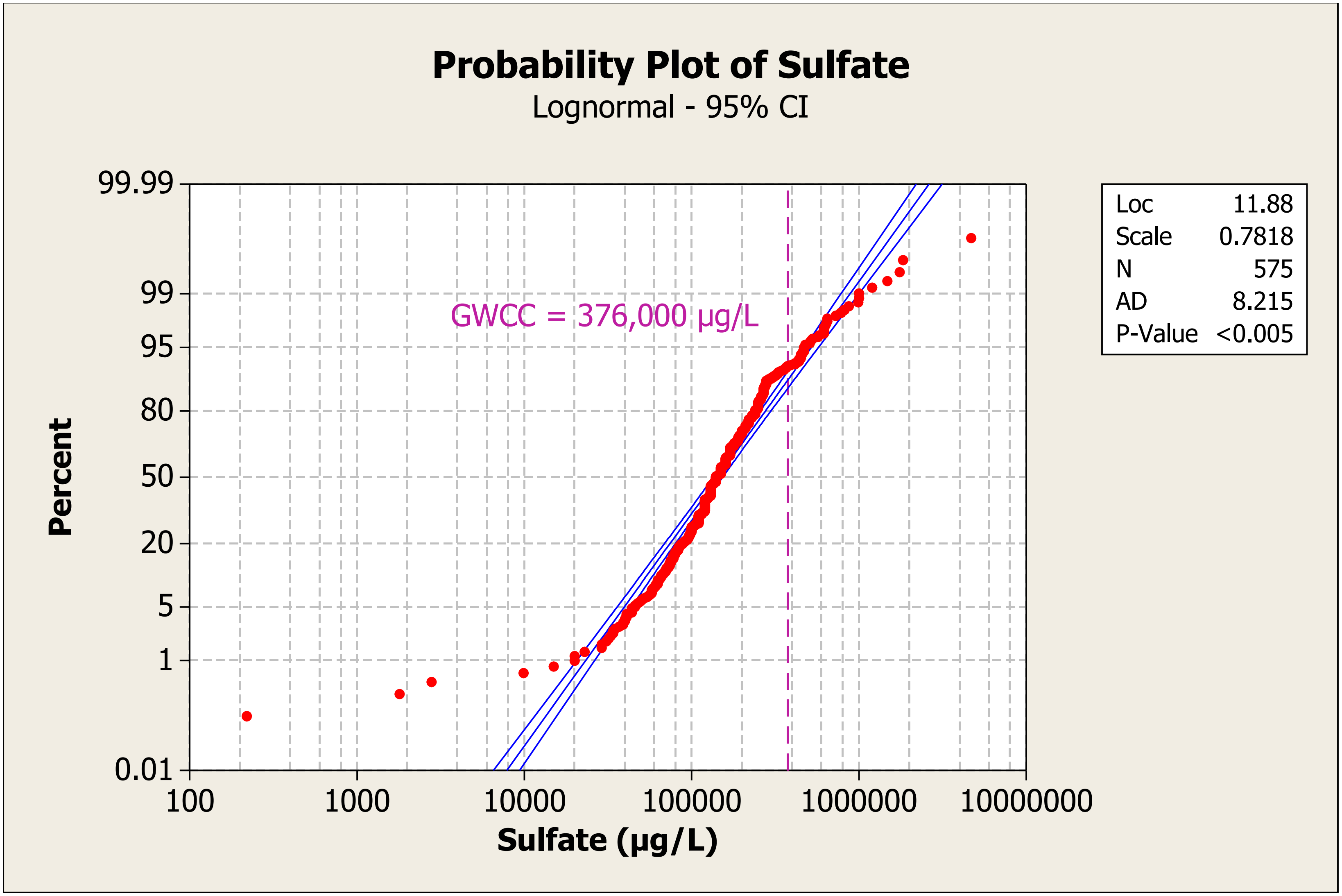

Probability Plot of Sodium
Normal - 95% CI
Percent
99.99
99
95
80
50
20
5
1
0.01
0
500000
1000000
1500000
2000000
Sodium (µg/L)
GWCC = 190,000 µg/L
Mean 93260
StDev 92152
N 558
AD 59.368
P-Value <0.005



Probability Plot of Sodium
Lognormal - 95% CI
Percent
99.99
99
95
80
50
20
5
1
0.01
10000
100000
1000000
Sodium (µg/L)
GWCC = 190,000 µg/L
Loc 11.27
Scale 0.5292
N 558
AD 8.408
P-Value <0.005



Probability Plot of Sulfate
Normal - 95% CI
99.99
99
95
80
50
20
5
1
0.01
Percent
-1000000
0
1000000
2000000
3000000
4000000
5000000
Sulfate (µg/L)
GWCC = 376,000 µg/L
Mean 195104
StDev 260342
N 575
AD 79.343
P-Value <0.005


Probability Plot of Sulfate
Lognormal - 95% CI
Percent
99.99
99
95
80
50
20
5
1
0.01
100
1000
10000
100000
1000000
10000000
Sulfate (µg/L)
GWCC = 376,000 µg/L
Loc 11.88
Scale 0.7818
N 575
AD 8.215
P-Value <0.005

APPENDIX F

SSFL PHYSICAL PARAMETERS TABLES

APPENDIX F
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SSFL PHYSICAL PARAMETERS TABLES

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1.0 Appendix F References Cited

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Soil Physical Parameter Results

Corehole	Start Depth (ft)	End Depth (ft)	Average Depth (ft)	Soil Type	Porosity (% Volume)	Reported Moisture Content (% Volume)	Calculated Air Content (% Volume)[a]	Wet bulk density (g/cc)	Dry bulk density (g/cc)	Particle Density (g/cc)	Organic Carbon (% weight)	Reference Document
AABS02S03	10	10	10	silty sand	41.3	7.2	34.1	1.64	1.56	2.66	0.17	This Document
AABS03S02	5	5	5	silty sand	44.1	12.17	31.93	1.65	1.53	2.73	0.18	This Document
AABS06S01	5	5	5	silty sand	41.4	11.82	29.58	1.69	1.58	2.69	1.4	This Document
AABS06S02	12	12	12	silty sand	40.4	11.03	29.37	1.7	1.59	2.66	0.41	This Document
ABSP-198-1	1	1	1	sand		10.2			1.6		0.13	McLaren/Hart, 1994c
ABSP-198-3-DUP3	3	3	3								0.0025	McLaren/Hart, 1994c
ABSP-198-3	3	3	3	sand		10.7			1.47		0.85	McLaren/Hart, 1994c
ABSP-198-3-BD9	3	3	3	sand		9.9			1.62		0.86	McLaren/Hart, 1994c
AFBS09S03	10	10	10	silty sand	44.9	11.08	33.82	1.58	1.47	2.66	0.37	This Document
APTF-1-30-1-1	1	1	1			16			1.76		0.0097	McLaren/Hart, 1994a
APTF-1-30-3-3	3	3	3			16			1.83		0.0099	McLaren/Hart, 1994a
APTF-1-30-3-BD6	3	3	3			23			1.63		0.0092	McLaren/Hart, 1994a
APTF-1-30-5-5	5	5	5			17			1.78		0.0091	McLaren/Hart, 1994a
APTF-1-30-D-3'	3	3	3								0.53	McLaren/Hart, 1994a
APTF-2-35-1-1	1	1	1			13			1.59		0.0028	McLaren/Hart, 1994b
APTF-2-35-1-1-BD7	1	1	1			11			1.3		0.0023	McLaren/Hart, 1994b
APTF-2-35-3-3	3	3	3			11			1.47		0.0027	McLaren/Hart, 1994b
APTF-2-35-D-1'	1	1	1								0.072	McLaren/Hart, 1994b
BCBS03S01	1	1	1	silty sand							1.73	This Document
BPBS14S01	1	1	1			6						This Document
BSBT01S01	0.33	0.33	0.33			1					0.15	MWH, 2003b
BSBT01S01	0.33	0.33	0.33			1					0.51	MWH, 2003b
BSBT01S01	0.33	0.33	0.33			1					0.078	MWH, 2003b
BSBT02S01	0.04	0.04	0.04			1		1.8762	1.67376		0.054	MWH, 2003b
BSBT02S01	0.04	0.04	0.04			1		1.5888	1.43915		0.036	MWH, 2003b
BSBT02S01	0.04	0.04	0.04			1		1.6122	1.5471		0.35	MWH, 2003b
BSBT04S01	0.33	0.33	0.33			5		1.7016	1.6218		0.53	MWH, 2003b
BSBT04S01	0.33	0.33	0.33			5					0.53	MWH, 2003b
BSBT04S01	0.33	0.33	0.33			5					0.53	MWH, 2003b
BVBS02S04	6	6	6	silty sand	36.6	19.62	16.98	1.87	1.68	2.64	0.68	This Document
CLBS06S04	10	10	10	silty sand	46.5	14.88	31.62	1.59	1.44	2.69	0.17	This Document
CLBS31S01	8	8	8	silty sand	42.7	6.22	36.48	1.61	1.55	2.7	0.15	This Document
CLBS38S02	10	10	10	silty sand	38.8	8.16	30.64	1.7	1.62	2.65	0.56	This Document
CLBS39S02	10	10	10	silty sand	37.3	9.1	28.2	1.78	1.69	2.69	0.22	This Document

Soil Physical Parameter Results

Corehole	Start Depth (ft)	End Depth (ft)	Average Depth (ft)	Soil Type	Porosity (% Volume)	Reported Moisture Content (% Volume)	Calculated Air Content (% Volume)[a]	Wet bulk density (g/cc)	Dry bulk density (g/cc)	Particle Density (g/cc)	Organic Carbon (% weight)	Reference Document
CLBS39S03	17	17	17	silty sand	27.6	3.14	24.46	1.94	1.9	2.63	0.13	This Document
CLBS40S03	17	17	17	silty sand	39.8	9.13	30.67	1.69	1.6	2.66	0.23	This Document
ECL-78-1-1-Dup	1	1	1								0.1	McLaren/Hart, 1994d
ECL-78-1-1	1	1	1	16					1.31		0.009	McLaren/Hart, 1994d
ECL-78-1-1-BD8	1	1	1	12							0.02	McLaren/Hart, 1994d
ECL-78-3-3	3	3	3	18					1.81		0.004	McLaren/Hart, 1994d
ECL-78-5-5	5	5	5	18					1.79		0.004	McLaren/Hart, 1994d
HVBS37S02	5	5	5	silty sand	37.6	10.51	27.09	1.76	1.66	2.66	0.43	This Document
ILBS01S03	9.5	9.5	9.5	silty sand	45.9	13.51	32.39	1.56	1.43	2.64	0.16	This Document
ILBS01S05	20	20	20	silty sand	40.9	7.14	33.76	1.64	1.57	2.65	0.12	This Document
ILBS01S06	29.5	29.5	29.5	silty sand	37.7	13.2	24.5	1.77	1.64	2.63	0.16	This Document
ILBS01S07	40	40	40	silty sand	35.9	21.87	14.03	1.89	1.67	2.61	0.16	This Document
ILBS02S07	25	25	25	silty sand	36.1	13.36	22.74	1.84	1.71	2.67	0.14	This Document
ILBS05S03	30	30	30	silty sand	43.9	11.14	32.76	1.58	1.46	2.61	0.11	This Document
ILBS08S01	10	10	10	silty sand	37.6	12.49	25.11	1.78	1.65	2.65	0.29	This Document
ILBS09S02	14.5	14.5	14.5	silty sand	39.5	9.29	30.21	1.69	1.6	2.64	0.2	This Document
ILBS12S04	20	20	20	silty sand	33.2	14.21	18.99	1.89	1.75	2.62	0.95	This Document
ILBS15S01	26	26	26	silty sand	40.5	12.54	27.96	1.71	1.58	2.66	0.23	This Document
ILBS30S02	9.5	9.5	9.5	silty sand	34.5	10.16	24.34	1.82	1.72	2.62	0.29	This Document
ILBS31S02	10	10	10	silty sand	39	7.27	31.73	1.66	1.59	2.61	0.35	This Document
ILBS32S02	19.5	19.5	19.5	silty sand	37.9	11.97	25.93	1.76	1.64	2.64	0.28	This Document
ILBS35S02	5	5	5	silty sand	29.1	11.91	17.19	1.98	1.86	2.63	0.3	This Document
ILBS35S03	9.5	9.5	9.5	silty sand	37.3	10.33	26.97	1.76	1.65	2.64	0.2	This Document
ILBS36S02	5.5	5.5	5.5	silty sand	34	8.96	25.04	1.85	1.76	2.66	0.35	This Document
ILBS37S01	15	15	15	silty sand	39.8	8.09	31.71	1.67	1.59	2.64	0.27	This Document
ILBS45S02	7	7	7	sandy silt								This Document
ILBS46S03	15	15	15	sandy silt								This Document
PZ002GT01	24.5	25	24.75	silty sand	30.9	10	20.9	1.94	1.84	2.66		MWH, 2003a
PZ002GT02	79.3	79.8	79.55	sand	23.6	8.8	14.8	2.12	2.03	2.66		MWH, 2003a
PZ003GT01	8.5	9	8.75	silty sand	41.7	7.1	34.6	1.61	1.54	2.64		MWH, 2003a
PZ005GT01	17.5	17.5	17.5	silty sand	35.6	19.8	15.8	1.94	1.75	2.71		MWH, 2003a
SB4.15-2-8					27.3	10.8	16.5	2.03	1.92	2.64	0.033	ICF, 1993
SB5.9-4-16					33.3	16.6	16.7	1.97	1.8	2.7	0.056	ICF, 1993
SB6.1-2-3.5					35.7	13.4	22.3	1.88	1.75	2.72	0.343	ICF, 1993

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Soil Physical Parameter Results

Corehole	Start Depth (ft)	End Depth (ft)	Average Depth (ft)	Soil Type	Porosity (% Volume)	Reported Moisture Content (% Volume)	Calculated Air Content (% Volume)[a]	Wet bulk density (g/cc)	Dry bulk density (g/cc)	Particle Density (g/cc)	Organic Carbon (% weight)	Reference Document
SB7.10-3-3.5					35.7	10.3	25.4	1.83	1.73	2.69	0.205	ICF, 1993
SBHV-3-15					34.1	13.5	20.6	1.89	1.75	2.66	0.046	ICF, 1993
SPA-1-6-1	1	1	1			11			1.6		0.024	McLaren/Hart, 1994e
SPA-1-6-3	3	3	3			9.3			1.68		0.022	McLaren/Hart, 1994e
SPA-1-6-5	5	5	5			25			1.51		0.0031	McLaren/Hart, 1994e
SPA-1-6-6	6	6	6								0.01	McLaren/Hart, 1994e
SPA-2-23-1	1	1	1			6.8			1.2		0.0019	McLaren/Hart, 1994f
SPA-2-23-5	5	5	5			0.8			1.92		0.0021	McLaren/Hart, 1994f
SPA-2-47-1	1	1	1						1.76		0.01	McLaren/Hart, 1994f
SPA-2-47-1-BD3	1	1	1						1.76			McLaren/Hart, 1994f
SPA-2-58-3	3	3	3						2.08			McLaren/Hart, 1994f
SPA-2-58-5	5	5	5						1.92			McLaren/Hart, 1994f
STL-IV-1-16-1	1	1	1			21			1.6		0.0025	McLaren/Hart, 1994g
STL-IV-1-16-1-BD4	1	1	1			22			1.6		0.0026	McLaren/Hart, 1994g
STL-IV-2-15-1	1	1	1			21		2.29	2.08		0.0079	McLaren/Hart, 1994h
STL-IV-2-15-3	3	3	3			20		2.28	2.08		0.0068	McLaren/Hart, 1994h
STL-IV-2-15-5	5	5	5			14		2.54	2.4		0.01	McLaren/Hart, 1994h

	Porosity (% Volume)	Reported Moisture Content (% Volume)	Calculated Air Content (% Volume)	Wet bulk density (g/cc)	Dry bulk density (g/cc)	Particle Density (g/cc)	Organic Carbon (% weight)	
Minimum Value	23.6	0.8	14.03	1.56	1.20	2.61	0.0019	
Maximum Value	46.5	25	36.48	2.54	2.4	2.73	1.73	
Average Value	37.4	11.0	26.1	1.8	1.7	2.7	0.2	
Standard Deviation	5.1	5.7	6.3	0.2	0.2	0.0	0.3	
Total Number of Samples with Results	39	69	39	46	70	39	75	

a - Air content (% Volume) = Porosity (% Volume) - Moisture Content (% Volume)

Notes:
1. Where soil type is not identified, no information is available.

Units:
ft = feet
g/cc = grams per cubic centimeter

Appendix F, Table F-2 (Page 1 of 7)

Bedrock Physical Parameter Results

Corehole	Start Depth (ft)	End Depth (ft)	Avg Depth (ft)	Rock Type	Modified Rock Type[a]	Porosity (% Volume)	Calculated Moisture Content (% Volume)[b]	Reported Moisture Content (% Volume)	Calculated Air Content (% Volume)[c]	Wet bulk density (g/cc)	Dry bulk density (g/cc)	Particle Density (g/cc)	Organic Carbon (% weight)	Reference Document
PZ001GT01	39.0	39.5	39.25	weathered sandstone		21.4		4.6	16.8	2.16	2.11	2.69		MWH, 2003a
PZ001GT02	57.0	57.5	57.25	shallow sandstone		15.7		4.3	11.4	2.32	2.27	2.7		MWH, 2003a
PZ003GT02	27.8	28.0	27.9	shallow sandstone		21.0		6.4	14.6	2.16	2.09	2.65		MWH, 2003a
PZ004GT01	12.6	12.8	12.7	weathered sandstone		37.8		4.5	33.3	1.72	1.67	2.69		MWH, 2003a
PZ004GT02	23.8	24.0	23.9	shallow sandstone		22.5		6.9	15.6	2.11	2.05	2.64		MWH, 2003a
PZ004GT03	27.0	27.4	27.2	shallow sandstone		18.7		4.9	13.8	2.25	2.2	2.71		MWH, 2003a
PZ005GT02	36.5	36.5	36.5	shallow sandstone		19.3		5.4	13.9	2.21	2.16	2.67		MWH, 2003a
PZ006GT01	14.0	14.5	14.25	shallow sandstone		15.6		2.1	13.5	2.26	2.24	2.65		MWH, 2003a
PZ006GT02	34.0	34.4	34.2	shallow sandstone		15.2		2.2	13	2.32	2.3	2.71		MWH, 2003a
PZ007GT01	19.4	19.7	19.55	weathered sandstone		39.7		9.5	30.2	1.69	1.6	2.65		MWH, 2003a
PZ007GT02	42.1	42.6	42.35	shallow sandstone		15.9		4.3	11.6	2.29	2.25	2.67		MWH, 2003a
PZ008GT01	37.6	38.0	37.8	shallow sandstone		20.9		5.4	15.5	2.16	2.1	2.66		MWH, 2003a
PZ008GT02	67.4	67.8	67.6	shallow sandstone		18.2		7.2	11	2.22	2.15	2.63		MWH, 2003a
PZ009GT01	19.7	20.0	19.85	weathered sandstone		23.1		5.8	17.3	2.14	2.08	2.7		MWH, 2003a
PZ009GT02	24.7	25.0	24.85	weathered sandstone		7.8		1.4	6.4	2.47	2.45	2.66		MWH, 2003a
PZ009GT03	30.7	31.0	30.85	shallow siltstone		18.0		3.9	14.1	2.28	2.24	2.73		MWH, 2003a
PZ010GT01	42.2	42.7	42.45	shallow sandstone		17.0		5.4	11.6	2.3	2.24	2.7		MWH, 2003a
PZ011GT01	34.0	34.5	34.25	shallow sandstone		18.6		4	14.6	2.21	2.17	2.67		MWH, 2003a
PZ011GT02	56.0	56.5	56.25	weathered sandstone		19.9		6.2	13.7	2.19	2.12	2.65		MWH, 2003a
PZ012GT01	18.0	18.5	18.25	weathered sandstone		21.0		0.7	20.3	2.11	2.1	2.66		MWH, 2003a
PZ012GT02	33.6	34.0	33.8	weathered sandstone		19.4		0.3	19.1	2.13	2.13	2.64		MWH, 2003a
PZ013GT01	13.0	13.6	13.3	weathered sandstone		21.4		7.4	14	2.19	2.12	2.69		MWH, 2003a
PZ013GT02	40.2	40.8	40.5	weathered sandstone		23.0		8	15	2.17	2.09	2.72		MWH, 2003a
PZ013GT03	50.0	50.6	50.3	weathered sandstone		17.2		5.8	11.4	2.26	2.2	2.66		MWH, 2003a
PZ014GT01	10.2	10.8	10.5	weathered sandstone		19.0		3.6	15.4	2.19	2.16	2.66		MWH, 2003a

Appendix F, Table F-2 (Page 2 of 7)

Bedrock Physical Parameter Results

Corehole	Start Depth (ft)	End Depth (ft)	Avg Depth (ft)	Rock Type	Modified Rock Type[a]	Porosity (% Volume)	Calculated Moisture Content (% Volume)[b]	Reported Moisture Content (% Volume)	Calculated Air Content (% Volume)[c]	Wet bulk density (g/cc)	Dry bulk density (g/cc)	Particle Density (g/cc)	Organic Carbon (% weight)	Reference Document
PZ014GT02	37.7	38.2	37.95	weathered sandstone		16.8		4.6	12.2	2.25	2.2	2.65		MWH, 2003a
PZ015GT01	19.0	19.5	19.25	weathered sandstone		19.5		5.5	14	2.2	2.15	2.67		MWH, 2003a
PZ015GT02	45.1	45.6	45.35	weathered sandstone		15.1		4.6	10.5	2.31	2.27	2.67		MWH, 2003a
PZ016GT01	12.4	12.8	12.6	weathered sandstone		16.4		5.4	11	2.29	2.24	2.68		MWH, 2003a
PZ016GT02	44.3	44.6	44.45	weathered sandstone		26.3		8.3	18	2.05	1.96	2.66		MWH, 2003a
PZ016GT03	65.0	65.5	65.25	weathered sandstone		18.5		7	11.5	2.25	2.18	2.68		MWH, 2003a
PZ017GT01	15.7	16.1	15.9	weathered sandstone		20.1		7.1	13	2.2	2.13	2.67		MWH, 2003a
PZ017GT02	44.6	45.0	44.8	weathered sandstone		18.2		6.4	11.8	2.26	2.19	2.68		MWH, 2003a
PZ018GT01	17.5	17.7	17.6	shallow siltstone		29.0		10.4	18.6	2.01	1.9	2.68		MWH, 2003a
C1	301.1	301.2	301.13	interbedded	coarse sandstone									Hurley, 2003
C1	332.1	332.3	332.21	interbedded	coarse sandstone	14.5	15		0	2.41	2.26			Hurley, 2003
C1	332.1	332.3	332.21	interbedded	coarse sandstone	13.3	15		0	2.41	2.26		0.018	Hurley, 2003
C1	301.2	301.5	301.33	interbedded	coarse sandstone	11.9	13		0	2.46	2.33			Hurley, 2003
C1	300.9	301.1	301.00	interbedded	coarse sandstone									Hurley, 2003
C1	300.4	300.9	300.67	interbedded	coarse sandstone									Hurley, 2003
C1	246.8	247.0	246.88	interbedded	banded sandstone	14.8	15		0	2.46	2.31		0.222	Hurley, 2003
C1	564.3	564.8	564.50	interbedded	siltstone						2.49			UW, 2003
C1	572.2	572.7	572.42	interbedded							2.6			UW, 2003
C1	592.8	593.0	593.25	interbedded									0.015	Hurley, 2003
C1	373.4	374.2	373.79	interbedded	coarse sandstone	10.6	11		0	2.35	2.24		0.019	Hurley, 2003
C1	572.2	572.4	572.67	interbedded	siltstone								0.39	Hurley, 2003
C1	564.3	564.5	564.75	interbedded	siltstone								0.689	Hurley, 2003
C1	408.0	408.5	408.25	interbedded	coarse sandstone	13.0	13		0.03	2.45	2.32		0.017	Hurley, 2003
C1	442.2	442.8	442.46	interbedded	coarse sandstone	12.2	13		0	2.44	2.31		0.03	Hurley, 2003
C1	592.8	593.3	593.00	interbedded		16.1	16		0.13	2.46	2.3			UW, 2003
C1	472.8	473.3	473.08	interbedded	siltstone						2.46		0.355	Hurley, 2003
C1	498.5	498.9	498.71	interbedded	siltstone	11.3	12		0	2.52	2.4		0.025	Hurley, 2003
C1	99.8	99.9	99.88	interbedded										Hurley, 2003
C1	547.7	548.1	547.88	interbedded		17.5	17		0.53	2.38	2.21		0.01	Hurley, 2003
C1	45.8	46.0	45.92	interbedded	coarse sandstone	19.3	19		0.25	2.48	2.29		0.008	Hurley, 2003
C1	525.2	525.5	525.33	interbedded	siltstone						2.51		0.399	Hurley, 2003
C1	123.3	123.7	123.46	interbedded	coarse sandstone	12.5	12		0.45	2.36	2.24		0.013	Hurley, 2003
C1	100.5	100.8	100.67	interbedded		13.9	14		0	2.45	2.31			Hurley, 2003
C2	392.5	393.0	392.75	sandstone	coarse sandstone	12.8	13		0	2.45	2.32			Hurley, 2003
C2	231.7	231.9	231.77	sandstone	siltstone	5.1	6		0	2.53	2.47		0.449	Hurley, 2003
C2	199.7	200.0	199.83	sandstone	coarse sandstone	16.3	16		0.33	2.41	2.25			Hurley, 2003
C2	99.2	99.4	99.29	sandstone		8.1	8		0.1	2.47	2.39			Hurley, 2003
C2	18.0	18.5	18.25	sandstone	medium sandstone								0.013	Hurley, 2003
C2	225.3	225.8	225.58	sandstone	coarse sandstone	14.3	14		0.31	2.41	2.27		0.009	Hurley, 2003
C2	133.0	133.4	133.21	sandstone	breccia	7.1	7		0.12	2.66	2.59		0.019	Hurley, 2003
C2	209.8	210.0	209.88	sandstone	breccia	32.6	16		16.6	2.4	2.24		0.022	Hurley, 2003

Appendix F, Table F-2 (Page 3 of 7)

Bedrock Physical Parameter Results

Corehole	Start Depth (ft)	End Depth (ft)	Avg Depth (ft)	Rock Type	Modified Rock Type[a]	Porosity (% Volume)	Calculated Moisture Content (% Volume)[b]	Reported Moisture Content (% Volume)	Calculated Air Content (% Volume)[c]	Wet bulk density (g/cc)	Dry bulk density (g/cc)	Particle Density (g/cc)	Organic Carbon (% weight)	Reference Document
C3	257.0	257.7	257.33	sandstone		12.9							0.019	Hurley, 2003
C3	242.2	242.8	242.50	sandstone		14.2							0.019	Hurley, 2003
C3	253.5	254.2	253.88	sandstone	medium sandstone	17.7							0.009	Hurley, 2003
C3	310.0	310.9	310.46	sandstone	fine sandstone	12.6							0.013	Hurley, 2003
C3	323.3	323.8	323.58	sandstone	fine sandstone	16.3	15		1.3	2.39	2.24		0.008	Hurley, 2003
C3	386.2	386.8	386.50	sandstone									0.008	Hurley, 2003
C3	296.7	297.2	296.92	sandstone		13.9							0.013	Hurley, 2003
C3	338.7	339.5	339.09	sandstone		12.1								Hurley, 2003
C3	287.2	287.9	287.54	sandstone		15.1							0.011	Hurley, 2003
C3	346.5	346.9	346.71	sandstone		17.1							0.014	Hurley, 2003
C3	388.7	389.5	389.08	sandstone		16.4							0.012	Hurley, 2003
C3	348.9	349.0	348.94	sandstone	coarse sandstone	14.4	14		0.4	2.44	2.3			Hurley, 2003
C3	426.4	427.0	426.71	sandstone	breccia	12.9							0.013	Hurley, 2003
C3	351.8	352.0	351.92	sandstone	coarse sandstone	13.8	14		0.0	2.45	2.31			Hurley, 2003
C3	437.8	438.1	437.98	sandstone	coarse sandstone	13.4	13		0.4	2.44	2.31			Hurley, 2003
C3	371.9	372.7	372.29	sandstone	medium sandstone	20.7							0.016	Hurley, 2003
C3	441.1	441.8	441.46	sandstone	coarse sandstone	14.0							0.015	Hurley, 2003
C3	444.1	444.3	444.21	sandstone	coarse sandstone	13.0	13		0.0	2.46	2.33			Hurley, 2003
C3	356.8	357.4	357.13	sandstone	coarse sandstone	13.5	14		0.0	2.43	2.29		0.014	Hurley, 2003
C3	109.8	110.0	109.88	sandstone	coarse sandstone	11.8	13		0.0	2.42	2.29			Hurley, 2003
C3	101.5	101.8	101.67	sandstone	medium sandstone	15.4	16		0.0	2.43	2.27			Hurley, 2003
C3	128.0	128.5	128.25	sandstone	coarse sandstone	5.4	13		0.0	2.21	2.08			Hurley, 2003
C3	94.0	94.2	94.08	sandstone		14.6	15		0.0	2.44	2.29			Hurley, 2003
C3	85.6	86.0	85.79	sandstone		12.6							0.013	Hurley, 2003
C3	47.3	47.8	47.58	sandstone	fine sandstone	14.5	15		0.0	2.44	2.29		0.063	Hurley, 2003
C3	34.0	34.5	34.25	sandstone	coarse sandstone	18.3	18		0.2	2.47	2.29		0.009	Hurley, 2003
C3	100.4	100.8	100.63	sandstone	coarse sandstone	15.5	16		0.0	2.38	2.22			Hurley, 2003
C3	408.3	409.0	408.67	sandstone		11.5	12		0.0	2.46	2.34		0.024	Hurley, 2003
C3	415.0	415.4	415.21	sandstone	medium sandstone	16.6							0.014	Hurley, 2003
C3	227.4	227.9	227.67	sandstone		17.0							0.012	Hurley, 2003
C3	219.2	219.7	219.44	sandstone	breccia	9.2	13		0.0	2.46	2.33		0.035	Hurley, 2003
C3	128.0	128.5	128.25	sandstone	coarse sandstone	13.9	13		0.9	2.21	2.08		0.011	Hurley, 2003
C3	196.1	197.2	196.63	sandstone	coarse sandstone	12.1							0.024	Hurley, 2003
C3	397.4	397.9	397.67	sandstone		13.9	14		0.0	2.44	2.3		0.025	Hurley, 2003
C3	186.5	187.5	187.00	sandstone	medium sandstone	14.0							0.015	Hurley, 2003
C3	176.4	176.9	176.67	sandstone	medium sandstone	14.4	15		0.0	2.41	2.26		0.009	Hurley, 2003
C3	164.2	164.6	164.38	sandstone	coarse sandstone	12.0	13		0.0	2.47	2.34		0.015	Hurley, 2003
C3	161.6	161.7	161.63	sandstone	coarse sandstone	11.5	11		0.5	2.48	2.37		0.02	Hurley, 2003
C3	206.7	207.6	207.13	sandstone	fine sandstone	11.2							0.021	Hurley, 2003
C4	360.2	360.8	360.46	sandstone	fine sandstone	8.1	16		0.0	2.35	2.19		0.026	Hurley, 2003
C4	352.8	353.7	353.21	sandstone		15.8							0.021	Hurley, 2003
C4	360.1	360.3	360.17	sandstone	fine sandstone	16.7	17		0.0	2.51	2.34			Hurley, 2003
C4	215.0	215.8	215.38	sandstone	medium sandstone	15.8	16		0.0	2.38	2.22		0.016	Hurley, 2003
C4	374.2	374.8	374.46	sandstone		14.5							0.015	Hurley, 2003
C4	385.0	385.8	385.38	sandstone	coarse sandstone	13.8	15		0.0	2.41	2.26		0.016	Hurley, 2003
C4	394.3	394.7	394.46	sandstone	banded sandstone	15.2							0.8	Hurley, 2003
C4	360.1	360.3	360.17	sandstone	fine sandstone	7.9	17		0.0	2.51	2.34			Hurley, 2003
C4	175.0	175.6	175.29	sandstone	medium sandstone	13.7	14		0.0	2.35	2.21		0.012	Hurley, 2003
C4	207.8	208.1	207.92	sandstone		14.7	15		0.0	2.36	2.21		0.034	Hurley, 2003
C4	199.4	199.5	199.48	sandstone	medium sandstone	14.4	14		0.4	2.42	2.28			Hurley, 2003

Appendix F, Table F-2 (Page 4 of 7)

Bedrock Physical Parameter Results

Corehole	Start Depth (ft)	End Depth (ft)	Avg Depth (ft)	Rock Type	Modified Rock Type[a]	Porosity (% Volume)	Calculated Moisture Content (% Volume)[b]	Reported Moisture Content (% Volume)	Calculated Air Content (% Volume)[c]	Wet bulk density (g/cc)	Dry bulk density (g/cc)	Particle Density (g/cc)	Organic Carbon (% weight)	Reference Document
C4	196.7	197.3	196.96	sandstone		14.3							0.006	Hurley, 2003
C4	237.8	238.3	238.08	sandstone	siltstone	14.1							0.623	Hurley, 2003
C4	257.2	258.1	257.63	sandstone	coarse sandstone	13.3	13		0.3	2.42	2.29		0.011	Hurley, 2003
C4	99.8	100.0	99.88	sandstone	coarse sandstone	12.8	13		0.0	2.46	2.33			Hurley, 2003
C4	123.4	123.9	123.67	sandstone	medium sandstone	16.4	17		0.0	2.33	2.16		0.008	Hurley, 2003
C4	188.4	189.0	188.71	sandstone	fine sandstone	18.0	19		0.0	2.34	2.15		0.023	Hurley, 2003
C4	333.4	333.9	333.67	sandstone	siltstone	6.9	7		0.0	2.43	2.36			Hurley, 2003
C4	335.5	335.7	335.58	sandstone	banded sandstone	11.9	12		0.0	2.42	2.3			Hurley, 2003
C4	335.5	335.7	335.58	sandstone	banded sandstone	4.8	5		0.0	2.38	2.33		0.855	Hurley, 2003
C4	335.0	335.3	335.13	sandstone	banded sandstone	6.6	7		0.0	2.53	2.46			Hurley, 2003
C4	225.6	226.1	225.83	sandstone		12.3							0.024	Hurley, 2003
C4	247.4	247.8	247.63	sandstone	coarse sandstone	9.6							0.028	Hurley, 2003
C4	333.4	333.9	333.67	sandstone	siltstone	11.8	5		6.8	2.42	2.37		0.129	Hurley, 2003
C4	298.2	298.8	298.46	sandstone	medium sandstone	12.4	12		0.4	2.45	2.33			Hurley, 2003
C4	298.2	298.8	298.46	sandstone	medium sandstone	14.0	14		0.0	2.46	2.32		0.024	Hurley, 2003
C4	276.3	276.8	276.54	sandstone	coarse sandstone	15.1	15		0.1	2.38	2.23		0.017	Hurley, 2003
C4	265.7	266.3	265.96	sandstone		13.9							0.03	Hurley, 2003
C4	341.8	342.3	342.08	sandstone	fine sandstone	16.8	18		0.0	2.38	2.2		0.019	Hurley, 2003
C4	70.4	71.4	70.92	sandstone	siltstone	14.7	14		0.7	2.45	2.31		1.057	Hurley, 2003
C4	95.6	96.0	95.79	sandstone	fine sandstone	14.6							0.01	Hurley, 2003
C4	62.8	62.9	62.83	sandstone	siltstone	20.4							1.382	Hurley, 2003
C4	27.9	28.2	28.04	sandstone		17.8	19		0.0	2.26	2.07		0.006	Hurley, 2003
C4	38.5	39.3	38.92	sandstone		16.0							0.016	Hurley, 2003
C4	51.3	51.9	51.63	sandstone		15.9	16		0.0	2.39	2.23		0.021	Hurley, 2003
C4	62.8	62.9	62.83	sandstone	siltstone	20.4							0.609	Hurley, 2003
C4	63.7	63.9	63.79	sandstone	siltstone	2.6	3		0.0	2.52	2.49		0.571	Hurley, 2003
C4	137.0	137.9	137.46	sandstone	medium sandstone	12.4	17		0.0	2.36	2.19		0.017	Hurley, 2003
C4	168.2	168.8	168.46	sandstone	coarse sandstone	16.1	16		0.1	2.38	2.22			Hurley, 2003
C4	80.6	81.2	80.88	sandstone	medium sandstone	17.0	17		0.0	2.35	2.18		0.012	Hurley, 2003
C4	125.0	126.2	125.58	sandstone	fine sandstone	17.2	18		0.0	2.37	2.19		0.027	Hurley, 2003
C4	142.3	142.8	142.54	sandstone	banded sandstone	16.4	18		0.0	2.4	2.22		0.99	Hurley, 2003
C4	168.2	168.8	168.46	sandstone	medium sandstone	15.1	15		0.1	2.37	2.22		0.023	Hurley, 2003
C4	156.0	156.8	156.38	sandstone	banded sandstone	13.3							0.452	Hurley, 2003
C4	170.5	170.8	170.60	sandstone	hard sandstone	1.0	1		0.0	2.63	2.62		0.022	Hurley, 2003
C5	119.3	119.7	119.50	sandstone	siltstone	2.6	3		0.0	2.46	2.43		0.492	Hurley, 2003
C5	165.2	165.9	165.54	sandstone	coarse sandstone	13.4	14		0.0	2.46	2.32		0.019	Hurley, 2003
C5	156.5	157.3	156.92	sandstone	coarse sandstone	10.4	11		0.0	2.49	2.38		0.029	Hurley, 2003
C5	133.6	134.4	134.00	sandstone	siltstone	2.3	3		0.0	2.48	2.45		0.259	Hurley, 2003
C5	93.9	94.6	94.25	sandstone	siltstone	6.2	6		0.2	2.45	2.39		0.207	Hurley, 2003
C5	84.2	85.0	84.58	sandstone	coarse sandstone	14.0	14		0.0	2.47	2.33			UW, 2003
C5	73.2	74.1	73.63	sandstone	hard sandstone	4.1	4		0.1	2.48	2.44		0.013	Hurley, 2003
C5	62.5	63.3	62.88	sandstone	coarse sandstone	7.3	7		0.3	2.4	2.33		0.028	Hurley, 2003
C5	146.7	147.2	146.92	sandstone	banded sandstone	14.1	14		0.1	2.48	2.34		0.403	Hurley, 2003
C5	16.7	17.3	16.96	sandstone									0.014	Hurley, 2003
C6	239.5	240.0	239.75	sandstone	hard sandstone	3.6	3		0.6	2.66	2.63		0.005	Hurley, 2003
C6	223.7	224.5	224.08	sandstone	hard sandstone	0.6	0		0.6	2.65	2.65		0.008	Hurley, 2003
C6	213.0	213.7	213.33	sandstone	medium sandstone	14.2	14		0.2	2.41	2.27		0.021	Hurley, 2003
C6	263.3	263.9	263.58	sandstone	coarse sandstone	13.2	13		0.2	2.42	2.29		0.03	Hurley, 2003
C6	263.3	263.9	263.58	sandstone	coarse sandstone	13.6	13		0.6	2.42	2.29			Hurley, 2003
C6	249.3	249.8	249.58	sandstone	coarse sandstone	15.6	14		1.6	2.42	2.28		0.01	Hurley, 2003

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Bedrock Physical Parameter Results

Corehole	Start Depth (ft)	End Depth (ft)	Avg Depth (ft)	Rock Type	Modified Rock Type[a]	Porosity (% Volume)	Calculated Moisture Content (% Volume)[b]	Reported Moisture Content (% Volume)	Calculated Air Content (% Volume)[c]	Wet bulk density (g/cc)	Dry bulk density (g/cc)	Particle Density (g/cc)	Organic Carbon (% weight)	Reference Document
C6	271.0	271.3	271.13	sandstone		9.4	10		0.0	2.43	2.33		0.033	Hurley, 2003
C6	293.0	293.4	293.21	sandstone	banded sandstone	20.2							4.045	Hurley, 2003
C6	301.2	302.1	301.63	sandstone	hard sandstone	14.1							0.008	Hurley, 2003
C6	204.9	205.8	205.33	sandstone	coarse sandstone	11.3	12		0.0	2.47	2.35		0.018	Hurley, 2003
C6	61.0	61.5	61.25	sandstone		11.9							0.019	Hurley, 2003
C6	356.7	357.2	356.92	sandstone	fine sandstone	13.0							0.03	Hurley, 2003
C6	336.3	337.3	336.79	sandstone	breccia	10.1							0.014	Hurley, 2003
C6	310.3	310.9	310.58	sandstone		10.6							0.03	Hurley, 2003
C6	280.8	281.3	281.08	sandstone	coarse sandstone	9.8	10		0.0	2.5	2.4		0.019	Hurley, 2003
C6	109.0	109.7	109.33	sandstone	medium sandstone	11.2							0.019	Hurley, 2003
C6	13.5	14.3	13.92	sandstone	medium sandstone	13.1	14		0.0	2.45	2.31		0.014	Hurley, 2003
C6	21.8	22.5	22.17	sandstone		14.5							0.021	Hurley, 2003
C6	365.6	366.3	365.92	sandstone	fine sandstone	7.7	7		0.7	2.19	2.12		0.264	Hurley, 2003
C6	48.8	49.4	49.13	sandstone		10.7							0.054	Hurley, 2003
C6	81.4	82.0	81.71	sandstone	coarse sandstone	4.9	11		0.0	2.52	2.41		0.017	Hurley, 2003
C6	99.7	100.0	99.83	sandstone	hard sandstone	7.0							0.007	Hurley, 2003
C6	193.7	194.4	194.04	sandstone		15.1							0.019	Hurley, 2003
C6	118.5	119.1	118.79	sandstone	medium sandstone	17.5							0.104	Hurley, 2003
C6	128.5	129.0	128.75	sandstone	coarse sandstone	3.2	4		0.0	2.58	2.54		0.021	Hurley, 2003
C6	142.4	142.8	142.63	sandstone	medium sandstone	12.8	13		0.0	2.44	2.31		0.023	Hurley, 2003
C6	150.7	151.0	150.83	sandstone	banded sandstone	16.5							0.211	Hurley, 2003
C6	161.5	162.3	161.88	sandstone	coarse sandstone	13.6	14		0.0	2.43	2.29		0.018	Hurley, 2003
C6	174.2	175.0	174.58	sandstone		12.3	15		0.0	2.39	2.24		0.024	Hurley, 2003
C6	71.3	72.0	71.67	sandstone		11.6							0.024	Hurley, 2003
C6	426.3	427.1	426.71	sandstone	breccia	10.5	11		0.0	2.49	2.38		0.017	Hurley, 2003
C6	508.6	509.2	508.88	sandstone	banded sandstone	14.3	14		0.3	2.42	2.28		0.292	Hurley, 2003
C6	376.4	377.2	376.79	sandstone	medium sandstone	13.1							0.018	Hurley, 2003
C6	495.3	495.6	495.42	sandstone		11.3	14		0.0	2.41	2.27		0.017	Hurley, 2003
C6	486.4	486.8	486.63	sandstone	siltstone	11.7							0.349	Hurley, 2003
C6	475.5	476.1	475.79	sandstone	coarse sandstone	12.3							0.009	Hurley, 2003
C6	466.3	466.8	466.50	sandstone	medium sandstone	12.5							0.013	Hurley, 2003
C6	456.4	457.3	456.83	sandstone	coarse sandstone	12.5	13		0.0	2.46	2.33		0.017	Hurley, 2003
C6	517.8	518.3	518.00	sandstone	banded sandstone	10.2	10		0.2	2.48	2.38		0.451	Hurley, 2003
C6	426.3	427.1	426.71	sandstone	breccia									Hurley, 2003
C6	417.4	417.9	417.67	sandstone		16.1							0.018	Hurley, 2003
C6	409.7	410.5	410.08	sandstone	breccia	15.6							0.015	Hurley, 2003
C6	396.8	397.7	397.21	sandstone	breccia	6.7							0.018	Hurley, 2003
C6	396.8	397.7	397.21	sandstone	breccia	14.6							0.018	Hurley, 2003
C6	387.6	388.3	387.92	sandstone	hard sandstone	4.0	4		0.0	2.52	2.48		0.013	Hurley, 2003
C6	435.2	435.8	435.46	sandstone	coarse sandstone	13.6							0.012	Hurley, 2003
C7	383.3	384.1	383.71	sandstone	coarse sandstone	7.3	10		0.0	2.51	2.41		0.035	Hurley, 2003
C7	237.7	238.0	237.83	sandstone	breccia								0.017	Hurley, 2003
C7	254.3	255.0	254.63	sandstone	hard sandstone	4.7	4		0.7	2.39	2.35		0.016	Hurley, 2003
C7	265.6	266.3	265.96	sandstone	medium sandstone	18.6	17		1.6	2.44	2.27		0.024	Hurley, 2003
C7	400.3	400.8	400.54	sandstone	siltstone	4.7	4		0.7	2.46	2.42		0.332	Hurley, 2003
C7	412.2	412.8	412.50	sandstone	banded sandstone								0.265	Hurley, 2003
C7	334.3	334.8	334.50	sandstone	medium sandstone								0.04	Hurley, 2003
C7	341.2	342.1	341.63	sandstone	medium sandstone	10.4	10		0.4	2.49	2.39			UW, 2003
C7	354.8	355.0	354.88	sandstone	banded sandstone	11.2	11		0.1	2.49	2.38		1.582	Hurley, 2003
C7	360.3	360.8	360.54	sandstone	medium sandstone	12.7	12		0.7	2.48	2.36		0.022	Hurley, 2003

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Bedrock Physical Parameter Results

Corehole	Start Depth (ft)	End Depth (ft)	Avg Depth (ft)	Rock Type	Modified Rock Type[a]	Porosity (% Volume)	Calculated Moisture Content (% Volume)[b]	Reported Moisture Content (% Volume)	Calculated Air Content (% Volume)[c]	Wet bulk density (g/cc)	Dry bulk density (g/cc)	Particle Density (g/cc)	Organic Carbon (% weight)	Reference Document
C7	392.2	392.7	392.42	sandstone	coarse sandstone	12.0	13		0.0	2.49	2.36		0.034	Hurley, 2003
C7	229.6	229.8	229.67	sandstone	breccia								0.016	Hurley, 2003
C7	165.9	166.7	166.29	sandstone	coarse sandstone	12.9	13		0.0	2.46	2.33		0.02	Hurley, 2003
C7	35.4	35.9	35.67	sandstone	fine sandstone	16.9	17		0.0	2.41	2.24		0.015	Hurley, 2003
C7	80.0	80.8	80.38	sandstone	coarse sandstone	10.6	14		0.0	2.47	2.33		0.018	Hurley, 2003
C7	114.4	115.0	114.71	sandstone	coarse sandstone	12.1	12		0.1	2.48	2.36		0.019	Hurley, 2003
C7	130.9	131.5	131.21	sandstone	coarse sandstone	12.0	13		0.0	2.44	2.31		0.023	Hurley, 2003
C7	156.9	157.8	157.38	sandstone	medium sandstone	14.4	14		0.4	2.45	2.31		0.02	Hurley, 2003
C7	185.5	186.0	185.75	sandstone	fine sandstone	16.7	17		0.0	2.44	2.27		0.03	Hurley, 2003
C7	199.3	199.9	199.63	sandstone	medium sandstone	15.4	16		0.0	2.43	2.27		0.019	Hurley, 2003
C7	207.9	208.7	208.29	sandstone	medium sandstone	11.9	12		0.0	2.5	2.38		0.037	Hurley, 2003
C7	146.1	147.5	146.79	sandstone	coarse sandstone	13.5	12		1.5	2.48	2.36		0.036	Hurley, 2003
C8	369.2	369.8	369.50	sandstone	coarse sandstone	14.4	14		0.4	2.47	2.33		0.012	UW, 2003
C8	356.3	356.8	356.54	sandstone	coarse sandstone	16.3	16		0.3	3.07	2.91		0.013	UW, 2003
C8	338.1	338.6	338.33	sandstone	coarse sandstone	13.5	14		0.0	2.45	2.31		0.0165	UW, 2003
C8	322.7	323.5	323.08	sandstone		10.9	11		0.0	2.07	1.96		0.016	UW, 2003
C8	216.8	217.4	217.08	sandstone		15.7	15		0.7	2.44	2.29			UW, 2003
C8	228.8	229.5	229.13	sandstone	coarse sandstone	13.5	14		0.0	2.46	2.32			UW, 2003
C8	32.3	33.1	32.71	sandstone	coarse sandstone	14.6	15		0.0	2.42	2.27		0.008	UW, 2003
C8	60.0	61.0	60.50	sandstone	coarse sandstone	17.3	18		0.0	2.39	2.21		0.0125	UW, 2003
C8	83.5	84.1	83.79	sandstone		13.1	13		0.1	2.48	2.35		0.015	UW, 2003
C8	104.9	105.8	105.33	sandstone		13.4	13		0.4	2.48	2.35			UW, 2003
C8	122.1	122.8	122.42	sandstone	fine sandstone	14.1	14		0.1	2.45	2.31			UW, 2003
C8	388.3	388.5	388.38	sandstone							2.44		0.354	UW, 2003
C8	144.8	144.8	144.79	sandstone	siltstone						2.34			UW, 2003
C8	167.4	168.0	167.71	sandstone		13.9	14		0.0	2.45	2.31		0.012	UW, 2003
C8	167.4	168.0	167.71	sandstone									0.0165	UW, 2003
C8	176.6	177.3	176.92	sandstone		13.3	14		0.0	2.45	2.31			UW, 2003
C8	199.6	199.9	199.75	sandstone	siltstone						2.4			UW, 2003
C8	322.7	323.5	323.08	sandstone	coarse sandstone								0.016	UW, 2003
C8	398.5	398.8	398.67	sandstone							2.41		0.274	UW, 2003
C8	83.5	84.1	83.79	sandstone									0.0165	UW, 2003
C8	286.8	287.4	287.08	sandstone	coarse sandstone	16.1	16		0.1	2.43	2.27		0.0153	UW, 2003
C8	265.6	266.1	265.83	sandstone							2.41		0.279	UW, 2003
C8	247.3	247.8	247.54	sandstone		15.9	16		0.0	2.78	2.62		0.0125	UW, 2003
C8	77.0	77.7	77.33	sandstone		12.0	12		0.0	2.5	2.38		0.0165	UW, 2003
C8	297.0	297.7	297.33	sandstone	coarse sandstone	14.2	14		0.2	2.47	2.33		0.012	UW, 2003
RD-45	272.5	274.0	273.25	sandstone	medium sandstone	11.9					2.328	2.68	0.05	Golder, 1997
RD-45	209.0	210.0	209.50	sandstone	medium sandstone	10.3					2.336	2.67	0.1	Golder, 1997
RD-45	114.0	115.0	114.50	sandstone	fine sandstone	9.4					2.37	2.69	0.14	Golder, 1997
RD-45	207.0	208.0	207.50	sandstone		13.9								GRC, 1992
RD-45	115.0	116.0	115.50	sandstone	fine sandstone	12.4								GRC, 1992
RD-46B	292.4	292.7	292.54	sandstone		15.4	15		0.4	2.32	2.17			Sterling, 1999
RD-46B	281.8	282.1	281.92	sandstone		1.0	1.8		0.0	2.65	2.632			Sterling, 1999
RD-46B	24.0	24.2	24.08	sandstone		21.0	11.2		9.8	2.18	2.068			Sterling, 1999
RD-46B	358.3	358.6	358.42	sandstone		15.0	10.2		4.8	2.35	2.248			Sterling, 1999
RD-46B	49.8	50.2	50.00	sandstone		13.2	20.7		0.0	2.27	2.063			Sterling, 1999
RD-46B	245.0	245.3	245.17	sandstone		2.9	2.9		0.0	2.62	2.591			Sterling, 1999
RD-46B	210.2	210.5	210.33	sandstone		12.2	13.2		0.0	2.46	2.328			Sterling, 1999
RD-46B	177.8	178.2	178.00	sandstone		13.6	12.4		1.2	2.42	2.296			Sterling, 1999

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Bedrock Physical Parameter Results

Corehole	Start Depth (ft)	End Depth (ft)	Avg Depth (ft)	Rock Type	Modified Rock Type[a]	Porosity (% Volume)	Calculated Moisture Content (% Volume)[b]	Reported Moisture Content (% Volume)	Calculated Air Content (% Volume)[c]	Wet bulk density (g/cc)	Dry bulk density (g/cc)	Particle Density (g/cc)	Organic Carbon (% weight)	Reference Document
RD-46B	140.4	140.8	140.63	sandstone		13.5	11.8		1.7	2.38	2.262			Sterling, 1999
RD-46B	139.4	139.8	139.63	sandstone		1.8	1.7		0.1	1.81	1.793			Sterling, 1999
RD-46B	105.2	105.5	105.33	sandstone		15.2	11.4		3.8	2.4	2.286			Sterling, 1999
RD-46B	70.0	70.4	70.21	sandstone		11.9	9.3		2.6	2.33	2.237			Sterling, 1999
RD-49	40.3	41.0	40.70	interbedded	siltstone	7.2					2.54	2.72	0.39	Golder, 1997
RD-49	68.5	70.0	69.25	interbedded	coarse sandstone	8.7					2.409	2.7	0.15	Golder, 1997
RD-49	62.5	64.0	63.40	interbedded	medium sandstone	10.4					2.313	2.67	0.02	Golder, 1997
RD-49	70.0	71.0	70.50	interbedded		11.8								GRC, 1992
RD-54C	28.0	29.1	28.51	sandstone		12.7					2.328	2.69	0.13	Golder, 1997
RD-55	26.5	28.0	27.25	interbedded	siltstone	10.6					2.333		1.22	Golder, 1997
RD-55	46.0	47.0	46.50	interbedded	siltstone	11.4					2.392	2.7	0.7	Golder, 1997
RD-55	76.4	78.0	77.13	interbedded	medium sandstone	16.8					2.22	2.64	0.07	Golder, 1997
RD-55	90.0	91.1	90.51	interbedded	coarse sandstone	10.5					2.341	2.7	0.15	Golder, 1997
RD-55	46.0	47.0	46.50	interbedded	fine sandstone	12.1								GRC, 1992
RD-55	89.0	90.0	89.50	interbedded	breccia	16.0								GRC, 1992
RD-55	28.0	29.0	28.50	interbedded	fine sandstone	13.6								GRC, 1992
Minimum Value						0.55	0.00	0.30	0	1.69	1.6	2.63	0.005	
Maximum Value						39.7	20.7	10.4	33.3	3.07	2.91	2.73	4.045	
Average Value						13.7	12.5	5.3	3.1	2.4	2.3	2.7	0.1	
Standard Deviation						5.1	4.2	2.3	6.2	0.2	0.1	0.0	0.4	
Total Number of Samples with Results						255	150	34	184	184	204	44	188	

a - Modified rock type identifies the subcategory of a particualar rock type that the corehole is associated with.
Where no modified rock type is identified, no information is available.
b - Moisture content (% Volume) = (Wet bulk density (g/cc) - Dry bulk density (g/cc)) × 1 cc water/1g water
c - Air content (% Volume) = Porosity (% Volume) - Moisture Content (% Volume)

Units:
ft = feet
g/cc = grams per cubic centimeter

APPENDIX G

VAPOR MIGRATION MODELING METHODOLOGY

APPENDIX G

VAPOR MIGRATION MODELING METHODOLOGY
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Attachment No.

LIST OF ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
CFOU	Chatsworth Formation Operable Unit
CSM	Conceptual site model
DTSC	California Department of Toxic Substances Control
ISC3	Industrial Source Complex model
SRAM	Standardized Risk Assessment Methodology
SSFL	Santa Susana Field Laboratory
Surficial OU	Surficial Media Operable Unit
USEPA	U.S. Environmental Protection Agency
VOCs	Volatile organic compounds

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G.1 INTRODUCTION

G.1.1 Background

The objective of this appendix is to supplement the Santa Susana Field Laboratory (SSFL) Standardized Risk Assessment Methodology (SRAM) with a detailed description of the methodologies for modeling the migration of volatile organic compounds (VOCs) from the subsurface into indoor and outdoor air. The methods described in this appendix are intended to provide a consistent approach that can be used in the human health and ecological risk assessment of the potential migration of VOCs by estimating exposure point concentrations in indoor and outdoor air at investigational units at the SSFL. Although each investigational unit is unique, many have similar potential contaminants, exposure pathways, and receptors. In addition, many of the investigational units share similar physical characteristics such as type of geology and depth to groundwater. As such, a consistent technical approach for all units at the SSFL is proposed in the risk assessment process for vapor migration. The vapor migration methodology will be applied to each investigational unit to determine the potential human and ecological risks due to exposures to volatile chemicals present in various media at the Surficial Media Operable Unit (Surficial OU) and Chatsworth Formation Operable Unit (CFOU). As such, Sections 6 and 10 of the main text of the SSFL SRAM contains the details of how the vapor migration evaluation will be incorporated into the cumulative multi-media multi-exposure pathway risk assessment of potential SSFL receptors. In general, the modeling described in this appendix describes how exposure point concentrations are estimated from environmental matrix concentrations. SRAM Sections 6, 8, and 9 describe how these exposure point concentrations are used to estimate receptor exposure.

This appendix presents mathematical equations used to model VOC migration into outdoor and indoor air from soil and groundwater concentrations. The evaluation of the migration of VOCs into outdoor air relies on a model that predicts soil vapor surface-flux from all subsurface sources that is combined with atmospheric dispersion models to predict outdoor air quality. A single model is used to predict indoor air concentrations from all subsurface sources.

The vapor migration models are based on scientifically-accepted equations that predict chemical behavior in the subsurface. The uncertainty associated with the application of these models to specific conditions at SSFL will be reduced to acceptable levels through a DTSC-approved field validation study as described in Section G.2.3.3.

G.1.2 Approach for Evaluating Vapor Migration

The characterization of contamination at SSFL investigational units includes the sampling and analysis of groundwater, surface water, bedrock, soil, sediment, and soil vapor. Concentrations in soil, sediment, and bedrock (collectively termed as bulk soil media) concentrations, groundwater, and soil vapor can all be used as inputs into vapor migration models for predicting indoor and outdoor air quality. The following approach will be used for modeling vapor migration at SSFL for the purposes of estimating both indoor and outdoor air quality:

- Soil vapor concentrations are the preferred input into the vapor migration models and will be collected from investigational units near VOC source areas where technically feasible, e.g., where access and soil thickness are adequate.
- A field validation study for the vapor migration models presented in this appendix will be performed at representative locations onsite to verify the models are performing adequately. If the field validation study shows that the models predict conservative vapor concentrations, then vapor modeling will be used in situations described below.
- Where contaminated groundwater has migrated from source areas, groundwater concentrations will be used as the input into the field-validated vapor models in down-gradient areas. Any existing (and any additional soil gas data collected in this situation as part of the field validation study) will also be used as an input to the vapor migration models. Any indoor or outdoor air concentrations and risks estimated based on groundwater concentrations will be noted in the risk assessment text.
- When soil vapor samples cannot be collected at an investigational unit near VOC source areas, bulk soil media concentrations will be used as inputs to the vapor migration models. Any indoor or outdoor air concentrations and risks estimated based on bulk soil media concentrations will be noted in the risk assessment text.
- When soil vapor samples cannot be collected and multiple sources of VOC are present (e.g., both soil and groundwater contain VOCs), then risks from all sources will be calculated.
- Shallow saturated zones (i.e., near-surface groundwater) essentially eliminate the migration of VOCs from sources below those zones. At those locations vapor from deeper groundwater will not be considered as input into the vapor flux model.

G.1.3 Sources of VOCs

The Surficial OU and CFOU have been locally impacted by chlorinated solvents from surficial spills and subsequent infiltration. These contaminants may then migrate to areas away from the source. VOCs in the subsurface may volatilize to outdoor and indoor air and result in complete exposure pathways. Figures 1 and 2 depict a generalized conceptual site model (CSM) for human and ecological receptors, respectively. The figures identify exposure pathways for vapor migration at the SSFL. This appendix describes the methods for estimating VOC concentrations in outdoor and indoor air as a result of subsurface vapor migration from the following media:

- CFOU groundwater,
- CFOU unweathered bedrock,
- Surficial OU weathered bedrock,
- Surficial OU soil, and
- Surficial OU shallow groundwater.

Investigational units at SSFL have one or more of these contaminated media. For the purposes of evaluating vapor migration, the following situations will be considered:

1. *"VOC Source Areas" - Investigational units where VOC sources are present in Surficial OU soils, and VOCs are also present in underlying media (i.e.., Surficial OU groundwater, Surficial OU weathered bedrock, CFOU groundwater and/or CFOU unweathered bedrock)* – Soil vapor concentrations represent vapor impacts from all sources below the sample point and will be used as a vapor migration model input. In addition, separate vapor migration calculations will be made to evaluate the contribution of each media to outdoor and indoor air quality for the risk assessment.

   The use of soil gas data for vapor migration model input is preferred and will be used when obtainable. If soil gas data cannot be obtained due to technical or feasibility limitations (e.g., low permeability soils, distance to known sources, insufficient soil thickness), bulk soil data or bulk bedrock data will be used to conduct the risk assessment for the vadose zone impacts.

   For cases where Surficial OU groundwater is present[1] above the CFOU, modeling will be conducted using the Surficial OU groundwater concentrations. Modeling considering CFOU groundwater and/or CFOU bedrock concentrations will not be conducted, because vapor flux through shallow groundwater is not considered significant. If there is no Surficial OU

[1] This would not apply if the Surficial OU groundwater is not continuous over the CFOU impacts or if the presence of Surficial OU groundwater is transient.

groundwater present above the CFOU media, vapor migration calculations will be made to evaluate the contribution of CFOU groundwater using groundwater concentrations as the model input.

2. *"Distal Areas" - Investigational units where no VOC sources are present in Surficial OU soils, but where VOCs are present in underlying media (i.e., Surficial OU or CFOU groundwater and/or bedrock)* – In these cases, no soil VOC sources or impacts are expected. If soil vapor samples have not been collected and field validation and site conditions clearly indicate that soil vapor sampling would not contribute meaningfully to remedial decisions, groundwater concentrations will be used as inputs to the field-validated vapor migration model. For example, this approach will be acceptable if field validation studies demonstrate that it will provide a more conservative estimation of risk. If soil vapor samples are also available separate vapor migration calculations using concentrations from both media will be conducted. The risk assessment will describe the choice of exposure point concentration and the modeling results used to determine that concentration.

   For cases where Surficial OU groundwater is present[2] above the CFOU, modeling will be conducted using the Surficial OU groundwater concentrations. Modeling using CFOU groundwater and/or CFOU bedrock concentrations will not be conducted, because vapor flux through shallow groundwater is not considered significant.

Vapor modeling is used to estimate VOC migration from measured soil vapor and groundwater concentrations. As described above, in certain situations bulk soil media concentrations and groundwater concentrations will be used as inputs into the field-validated vapor migration model. Sampling and analysis of indoor or outdoor air samples is not typically recommended for risk characterization because of the numerous samples (above identified sources, downwind from sources, and upwind, background samples) required and the inherent variability in this type of sample. In contrast, using investigational unit-specific characterization data coupled with SSFL-calibrated fate and transport models is an excellent way for calculating exposure point concentrations for use in risk assessment.

As described below, the steady-state vapor flux model is used to evaluate vapor migration to outdoor air and the Johnson and Ettinger (1991) model is used to assess vapor intrusion to indoor

[2] This would not apply if the Surficial OU groundwater is not continuous over the CFOU impacts or if the presence of Surficial OU groundwater is transient.

air. This use of these models is consistent with the most recent U.S. Environmental Protection Agency (USEPA, 2002) and California Department of Toxic Substances Control (DTSC, 2005) guidance. These models assume volatile compounds migrate to the surface from groundwater or a source in the vadose zone. Where VOC sources exist in both vadose zone and groundwater and soil gas data cannot be obtained due to technical or feasibility limitations (e.g., low permeability soils, distance to known sources), separate calculations of contribution of the media (groundwater and soil matrix data) to outdoor and indoor air concentration are made in order to assess the significance of the vapor migration pathways for each of the media. However, the calculated risks from each medium should not simply be summed, as the observed concentrations may reflect the effect of a single initial source (the chemical concentration in one medium may be the source of contamination of other). Therefore, when multiple sources of VOCs are present, separate risks will be presented for modeled exposure concentrations from each VOC source, but will not be summed. The potential uncertainty of risk from using solely bulk soil or groundwater data will be addressed in the investigational unit-specific assessment uncertainty sections. Investigational units where the uncertainty in vapor migration estimates are large enough to affect risk-based decisions regarding site cleanup may be candidate sites for further characterization (e.g., soil vapor and/or flux measurements). Uncertainty in risk estimates due to the use of soil matrix data will be identified in the risk assessment.

G.2 OUTDOOR AIR

Outdoor air concentrations of volatile compounds from the subsurface will be estimated using a steady-state vapor flux model combined with an outdoor air dispersion model. These two models are discussed separately below.

G.2.1 Vapor Flux Model

The vapor flux model is a steady-state model that simulates vapor flux through the gaseous and aqueous phases of the subsurface to the ground surface. Similar to the Jury vapor flux model (Jury et al. 1983, 1990), the model accounts for upward diffusive flux as well as downward advective flux due to recharge. Unlike the Jury model, the model is a steady-state model and does not account for changes in concentration over time. The equations presented here are based on basic transport principals, including diffusion by Fick's Law and advective transport by Darcy's Law, and represent a refined approach to estimate flux which accounts for the potential transport of vapors through fractures and matrix in the bedrock in addition to the vadose zone soils. The potential for migration through bedrock fractures is not specifically addressed in the Jury model or similarly based models used by USEPA (1996 and 2002b) and American Society for Testing and Materials (ASTM, 2000), but these models can be used provided the effective diffusivity through the bedrock is appropriately determined to account for the fractures.

The model simulates 1-D vapor flux in a homogenous subsurface extending from the source to the ground surface. VOCs diffuse upward in response to a concentration gradient from a constant concentration source. It is assumed that the VOC concentrations in the aqueous and gaseous phases are in equilibrium. Recharge is assumed to be steady state and advective mass flux of VOCs occurs only in the aqueous phase and that flux is in the downward direction. In contrast, diffusive mass flux of VOCs is directed upward, so advective and diffusive fluxes occur in the opposite direction under this scenario.

G.2.1.1 Diffusive Flux

The diffusive mass transport is described by Fick's 1st Law:

$$F_d = -D_{eff} \times \frac{dC_v}{dZ} \tag{1}$$

where

$$D_{eff} = D_{eff,v} + \frac{1}{H'} D_{eff,w} \tag{2}$$

where

F_d	=	mass flux due to diffusion (μg/m^2-s)
D_{eff}	=	overall effective diffusion coefficient (m^2/s)
$D_{eff,\,v}$	=	effective diffusion coefficient in the soil vapor phase (m^2/s)
$D_{eff,\,w}$	=	effective diffusion coefficient in the soil water phase (m^2/s)
C_v	=	sub-surface vapor concentration (μg/m^3-vapor)
Z	=	vertical coordinate measured position upward from the source (*e.g.* elevation) (m)
H'	=	Dimensionless Henry's Law coefficient (m^3-water/m^3-vapor)

G.2.1.2 Liquid Phase Advective Flux

The advective flux in the soil moisture phase is given by the following equation:

$$F_{adv} = (q \times C_w) = \left(q \times \frac{C_v}{H'}\right) \quad (3)$$

where

F_{adv} = mass advective flux in the aqueous phase (µg/m^2-s)
C_w = sub-surface aqueous phase concentration (µg/m^3-water)
q = Darcy flux of the aqueous phase (m/s)

The seepage (Darcy) velocity of water through the vadose zone is the negative of the average steady recharge rate, where

$$q = -R \quad (4)$$

R = average steady recharge rate (m/s)

The seepage velocity is negative since flow is downward and the vertical coordinate has been defined as positive upward. Thus Equation 3 becomes

$$F_{adv} = -\left(R \times \frac{C_v}{H'}\right) \quad (5)$$

G.2.1.3 Total Flux

The total flux due to aqueous and gaseous transport is obtained by adding Equations 1 and 5 yielding the following equation.

$$F = -\left[D_{eff} \times \frac{dC_v}{dZ}\right] - \left(R \times \frac{C_v}{H'}\right) \quad (6)$$

where

F = total mass flux (µg/m^2-s)

Equation 6 can be integrated between two points of known concentration under the conditions of steady recharge (R) and homogenous subsurface properties to obtain a solution for F:

$$F = \frac{R}{H'} \times \frac{C_1 - \left[C_2 \times \exp\left(\frac{R \times L}{D_{eff} \times H'} \right) \right]}{\exp\left(\frac{R \times L}{D_{eff} \times H'} \right) - 1} \qquad (7)$$

where

C_1	=	sub-surface vapor concentration at the bottom of a subsurface layer (µg/m^3-vapor)
C_2	=	sub-surface vapor concentration at the top of a subsurface layer (µg/m^3-vapor)
L	=	thickness of the subsurface layer (m)

For scenarios with a single homogenous subsurface layer between the source and the ground surface and a VOC concentration of zero at the ground surface, Equation 7 simplifies to:

$$F = \frac{C_{source} R / H'}{\exp\left(\frac{R \times L}{D_{eff} \times H'} \right) - 1} \qquad (8)$$

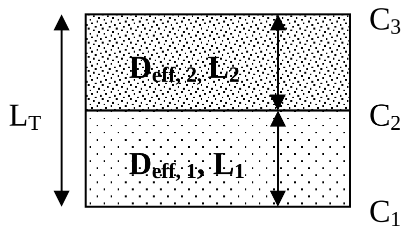
where

C_{source}	=	sub-surface source vapor concentration (µg/m^3-vapor)

Derivation of Equations 7 and 8 are provided in Attachment 1. It should be noted that D_{eff} and R are not independent and care should be taken in any sensitivity analyses.

G.2.1.4 Effect of Varying Subsurface Conditions on Contaminant Flux

The flux calculated by Equation 7 assumes uniform soil properties. For investigational units with multiple soil and/or bedrock layers, such as investigational units with multiple soil covers and/or bedrock layers, the overall flux is determined by evaluating the flux in each layer. Conservation of mass requires that the flux across each later be equal provided that there is no loss (e.g., biodegradation or generation of chemicals). For example, consider the scenario for estimating flux across two adjacent layers as depicted in the following diagram:



For this scenario, the following equations are used:

$$F_1 = \frac{R}{H'} \times \frac{C_1 - \left[C_2 \times \exp\left(\frac{R \times L_1}{D_{eff,1} \times H'} \right) \right]}{\exp\left(\frac{R \times L_1}{D_{eff,1} \times H'} \right) - 1} \qquad (9a)$$

$$F_2 = \frac{R}{H'} \times \frac{C_2 - \left[C_3 \times \exp\left(\frac{R \times L_2}{D_{eff,2} \times H'} \right) \right]}{\exp\left(\frac{R \times L_2}{D_{eff,2} \times H'} \right) - 1} \qquad (9b)$$

where

F_1	=	total mass flux through layer 1 (µg/m^2-s)
F_2	=	total mass flux through layer 2 (µg/m^2-s)
$D_{eff,1}$	=	overall effective diffusion coefficient layer 1 (m^2/s)
$D_{eff,2}$	=	overall effective diffusion coefficient layer 2 (m^2/s)
C_1	=	sub-surface vapor concentration at the bottom of a layer 1(µg/m^3-vapor)
C_2	=	sub-surface vapor concentration at the top of a layer 1 and at the bottom of layer 2 (µg/m^3-vapor)
C_3	=	sub-surface vapor concentration at the top of a layer 2 (µg/m^3-vapor)
L_1	=	thickness of layer 1 (m)
L_2	=	thickness of layer 2 (m)

The vapor flux is determined by setting F_1=F_2 and solving for the concentration C_2 at the interface between the layers. Then C_2 is re-substituted into either equation 9a or 9b to obtain the vapor flux. The solution results in calculating the vapor flux using equation 7 using a total effective diffusion coefficient across the thickness of all soil layers:

$$F = \frac{R}{H'} \times \frac{C_1 - \left[C_3 \times \exp\left(\frac{R \times L_T}{H' \times D^T{}_{eff}} \right) \right]}{\exp\left(\frac{R \times L_T}{H' \times D^T{}_{eff}} \right) - 1} \tag{9c}$$

where

D^T_{eff} = overall effective diffusion coefficient (m^2/s);
L_T = the total combined thickness of all layers (m);

The total effective diffusion coefficient is the harmonic average of the diffusion coefficients through each layer and is described by:

$$D^T_{eff} = L_T \Big/ \sum \frac{L_i}{D_{eff,i}} \tag{9d}$$

where

$D_{eff,\,i}$ = effective diffusion coefficient through layer i (m^2/s); and
L_i = the thickness of layer, i.

G.2.1.5 Calculation of Effective Diffusion Coefficients

In Equation 2, the effective diffusion coefficient is calculated from the water and vapor phase diffusion coefficients. The effective diffusion coefficient for the water phase is calculated with the assumption that the bedrock fractures are completely air filled and consequently do not contribute to the effective diffusion coefficient. The effective diffusion coefficient for the water phase is determined by:

$$D_{eff,w} = \theta_w \times \tau_w \times D_w \tag{10}$$

where

θ_w = volumetric water content of the matrix (m^3-water/m^3-soil)
τ_w = tortuosity of the aqueous phase (dimensionless)
D_w = molecular diffusion coefficient in water (m^2/s)

Millington and Quirk (1961) provide an empirical relationship for the aqueous phase tortuosity factor and Equation 10 may be re-written as:

$$D_{eff,w} = \theta_w \left(\frac{\theta_w^{7/3}}{n^2} \right) \times D_w \qquad (11)$$

where

n = matrix porosity (m^3-void space/m^3-soil)

The diffusion coefficient for the vapor phase assumes that VOCs will diffuse through air-filled fractures and partially saturated matrix. For reference, fracture porosity refers to the space associated solely with bedrock fractures and assumed to be completely air filled. Also, matrix porosity refers to spaces in soil or bedrock that can be filled with air and/or water and does not include space associated with fractures. The fractures are assumed to be smooth channels with a tortuosity of unity. The equation for effective diffusion coefficient in air that accounts for both the fractures and matrix is

$$D_{eff,v} = \left(\phi_f \times D_a\right) + \left[\left(\theta_v\right) \times \tau_v \times D_a\right] \qquad (12)$$

where

ϕ_f = fracture porosity (m^3-fractures/m^3-soil)
n = matrix porosity (m^3-void space/m^3-soil)
θ_v = volumetric air content of the matrix (m^3-vapor/m^3-soil)
τ_v = tortuosity of the vapor phase (dimensionless)
D_a = molecular diffusion coefficient in air (m^2/s)

Using the Millington and Quirk (1961) expression for the vapor phase tortuosity factor Equation 12 may be re-written as:

$$D_{eff,v} = \left[\phi_f + \theta_v \left(\frac{\theta_v^{7/3}}{n^2} \right) \right] \times D_a \qquad (13)$$

Combining Equations 11, 13 and 2 the effective diffusion (D_{eff}) coefficient is described by:

$$D_{eff} = \left[\theta_w \left(\frac{\theta_w^{7/3}}{n^2} \right) \times \frac{D_w}{H'} \right] + \left\{ \left[\phi_f + \theta_v \left(\frac{\theta_v^{7/3}}{n^2} \right) \right] \times D_a \right\} \qquad (14)$$

Equation 14 is used in Equation 7 to estimate vapor mass flux from the sub-surface including transport through bedrock fractures as well as through bedrock matrix. For use in non-fractured media, the percent fracture porosity term is set to zero.

G.2.2 Air Dispersion Modeling

Two air dispersion models are presented in this appendix that may be used to predict the air concentrations of VOCs for risk assessments at SSFL. The first model is the USEPA Q/C simplified air dispersion model that will be used to predict the air concentrations at the source area. The second model is the Industrial Source Complex 3 (ISC3) model that may be used to predict air concentrations down wind of the source area. The ISC3 model allows for more site-specific considerations in the modeling but also requires an additional level of resources to run. The ISC3 model will be used when results of the Q/C dispersion model estimates risks to either onsite or offsite receptors that exceed acceptable criteria. Further discussion of each model is provided below.

G.2.2.1 USEPA Q/C Dispersion Model

USEPA Soil Screening Guidance (1996 and 2002b) presents the Q/C dispersion factor that relates an estimated flux-rate to an outdoor air concentrations directly over the source area by the following equation.

$$C_{outdoor} = \frac{F \times CF_1 \times CF_2}{Q/C} \qquad (15)$$

where:

$C_{outdoor}$ = outdoor air concentration (μg/m^3)
F = total mass flux as calculated from Equation 7 (μg/ m^2 sec)
Q/C = dispersion factor (g/m^2 sec per kg/m^3)
CF_1 = conversion factor (1×10^{-6} g/μg)
CF_2 = conversion factor (1×10^{9} μg/kg)

USEPA developed default parameters to estimate default region specific Q/C factors. USEPA developed Q/C parameters using the ISC3 air dispersion model. The Q/C factor can be estimated using the following equation.

$$Q/C = A \times \exp\left[\frac{(\ln A_{site} - B)^2}{C}\right] \qquad (16)$$

where

A_{site} = *Areal extent of site or subsurface source (acres)*
A = *11.9110, USEPA (2002b) default for Los Angeles, CA*
B = *18.4385, USEPA (2002b) default for Los Angeles, CA*
C = *209.7845, USEPA (2002b) default for Los Angeles, CA*

Other screening models besides the USEPA Q/C model, such as SCREEN3, were considered for providing conservative estimates of onsite air concentrations. A comparison between the Q/C and SCREEN3 model is presented in Attachment 2. The results of the comparison indicate that the Q/C is consistently more conservative than the SCREEN3 model. As such the Q/C model was selected for use.

G.2.2.2 ISC3

The Q/C dispersion model terms assume that the receptor is located directly over the source area. It is anticipated that the use of the Q/C model will be sufficient for most investigational units. The use of the more detailed ISC3 model will be limited to those investigational units where onsite air concentrations exceed an unacceptable risk level and subsequently the downwind air concentrations could also exceed a risk level. In such situations further air dispersion modeling will be done to estimate down wind air concentrations.

An additional model that may be used includes the ISC3 model (USEPA, 1995). The ISC3 is a steady-state Gaussian plume model which can be used to assess pollutant concentrations from a wide variety of sources associated with an industrial complex. This model can account for the following: settling and dry deposition of particles; downwash; area sources; plume rise as a function of downwind distance; separation of point sources; and limited investigational unit-specific terrain adjustment. The use of the ISC3 model requires additional investigational unit-specific inputs describing aerial extent of sub-surface sources; separation of point sources; and terrain adjustments. The investigational unit-specific parameter value inputs required to operate the ISC3 models and their justification will be described in the investigational unit-specific risk assessments. Site data will be used where available and appropriate. Table G-1 lists dispersion air parameters needed to conduct ISC3 modeling and values from input parameter data collected to date. Receptor locations and grid points will depend on the location of the investigational unit, potential locations of down wind receptors and the SSFL property boundary. For each site, a sufficient number of down wind receptor locations will be included to evaluate sensitive receptor locations.

G.2.3 Input Assumptions

The vapor migration modeling to outdoor air relies upon source concentrations as well as soil and chemical characteristics that describe effective diffusion coefficients.

G.2.3.1 Source Concentrations

These models have been developed using soil vapor concentrations for source concentrations. As such, for investigational units with measured soil vapor VOC concentrations, the measured vapor concentrations can be used directly as inputs in the outdoor air models outlined in Section 2. Soil vapor data collected less than 3 feet deep will not be used.

In certain situations as discussed in Section G.1.2, bulk soil concentrations and groundwater concentrations will be used as inputs into the field-validated vapor migration model (see Section G.2.3.3). In these cases, the uncertainties resulting from an investigational unit modeling approach that depends on hypothetical equilibrium partitioning relationships between water, soil and/or bedrock matrix, and soil gas will be addressed in the investigational unit assessment uncertainty sections to assist in the interpretation of the results. This allows the greatest use of the data currently available in the investigational unit risk assessments.

In cases where the gaseous phase is in contact with the groundwater, soil vapor concentrations can be estimated from measured groundwater concentrations using the Henry's Law relationship as shown in the following equation:

$$C_{source} = C_{groundwater} \times H' \tag{17}$$

where

C_{source}	=	vapor concentration in the gaseous (air) phase (µg/m^3-vapor)
$C_{groundwater}$	=	aqueous concentration (µg/m^3-water); where ug/m^3 = µg/L x 1000 L/m^3
H'	=	Henry's Law coefficient (m^3-water/m^3-vapor)

For investigational units where soil vapor data are not available, bulk soil measurements of VOCs maybe used to estimate a soil vapor concentration that can be used in the outdoor air models outlined in Section 2 using the following 3-phase equilibrium equation:

$$C_{source} = C_{soil} \frac{H'\rho_{soil}}{\left(H'\theta_a + \theta_w + \rho_{soil} f_{oc} k_{oc}\right)} \tag{18}$$

where

C_{source} = vapor concentration in the gaseous (air) phase (µg/m^3-vapor)
C_{soil} = bulk soil concentration (µg/kg-soil);
H' = Henry's Law coefficient (m^3-water/m^3-vapor)
f_{oc} = soil fraction organic carbon content (kg-organic carbon/kg-soil)
k_{oc} = chemical specific organic carbon-water partitioning coefficient (m^3/ kg-soil) m^3/kg = cm^3/g x 10^{-6} m^3/cm^3 x 10^3 g/kg
θ_w = water-filled porosity (m^3-water/m^3-soil)
θ_a = air-filled porosity (m^3-vapor/m^3-soil)
ρ_{soil} = soil dry bulk density (kg/cm^3); kg/m^3 = g/cm^3 x 10^{-3} kg/g x 10^6 m^3/cm^3

For investigational units where surface flux measurements are conducted, the measured fluxes will be used as a direct input into the air dispersion models described in Section G.2.2 if the flux chamber data are determined to be adequate for risk assessment purposes based on the field validation studies discussed further in section G.2.3.3. Risk estimates from modeled fluxes may be presented along with risk estimates from measured flux data, for particular investigational units. In addition, measured flux data will be used to understand the performance of the vapor migration model by comparing measured vapor flux to modeled flux. Thus, the measured vapor flux will also be useful for validating these vapor migration models for use at SSFL is discussed further in Section G.2.3.3.

Input concentrations for the models will be representative of both average (central tendency) and RME (maximum) site conditions. The characteristics of the investigational unit and the exposure area will be considered in making these input concentrations estimates. Average and RME estimates of exposure point concentrations, based on model input parameters, will be combined with other exposure parameters (described in SRAM Section 6) to develop appropriate average and RME risk estimates for the risk assessments.

G.2.3.2 Effective Diffusion Coefficients

The overall effective diffusion coefficient is calculated as described above in Equation 14. The site-specific soil characterization inputs are listed in Table G-2. Inputs related to chemical-specific physical properties of VOCs (e.g., Henry's law constant, solubility, and soil adsorption) are listed in Table G-3 and are obtained from USEPA (2002a). Inputs for chemicals that are not listed in Table G-3 will be obtained from literature sources or may be approximated (e.g., Lyman et al. 1983). Chemical properties needed for investigational unit risk assessments that are not presented in Table G-3 will be appropriately documented in the investigational unit risk assessments.

G.2.3.3 Field Validation of Vapor Migration Model

The validation of this model for use at the SSFL will be accomplished by characterizing select representative portions of investigational units for vapor migration and air dispersion. A limited number of locations at the SSFL will be selected to represent the various types of conditions that exist and are relevant to the potential vapor migration and air dispersion of VOCs. The results of model validation at an area with representative site characteristics will be sufficient for model validation at investigational units with similar characteristics. Some of the site characteristics that will be considered for further characterization include those described in Section G.1.2 where there is VOC contamination in soil, VOC contamination in CFOU groundwater, VOC contamination in weathered/unweathered bedrock, and varying thickness of soil cover. Other site characteristic groupings may be considered.

A work plan for vapor flux and ambient air sampling at one of the investigational units at SSFL, the Former Liquid Oxygen (LOX) site, has already been proposed and approved by DTSC (MWH 2005). However, the LOX vapor sampling only represents a part of the effort required for field validation of the vapor migration models. Therefore, an additional work plan that describes the entire scope of the field validation study will be submitted for DTSC approval. This field validation study work plan will include how data collected from the LOX site will be used for validation of the models.

The scope of the vapor migration model field validation study will include collection of measured soil gas and vapor flux data in the situations described in Section G.1.3, including source and distal areas. As part of the field validation work, colocated samples will be collected from bulk soil and groundwater media where present in addition to measurement of soil vapor. Air dispersion modeling will be field-validated by the collection of ambient air samples at and downwind of a VOC source area. The results of SSFL field validation/model calibration efforts will be applied to SSFL investigational units with similar characteristics. The submittal of field validation data will also include a quantitative sensitivity and uncertainty analysis of the models. In addition to supporting model validation efforts, the results of the sensitivity and uncertainty analyses will be used to establish appropriate model input parameters (average and RME), in particular soil/bedrock physical properties, that can be applied at other investigational units. As such, the methods and parameters presented in this appendix to estimate outdoor concentrations may be modified based on the results of model validations and calibrations from the field validation data. At a minimum, the soil/bedrock physical properties presented in this appendix to estimate outdoor concentrations will be updated based on the results of model validations and calibrations from the field validation data. The results of the field validation study will be submitted in a report for DTSC approval. As necessary, the field validation study report will also include modifications or supplements to this appendix for DTSC review and approval.

G.3 INDOOR AIR

G.3.1 Vapor Migration from Subsurface Source to Indoor Air

The potential human exposures via indoor vapor inhalation of VOCs originating in subsurface soil or groundwater are calculated using the model of Johnson and Ettinger (1991). The Johnson and Ettinger model calculates an attenuation factor that relates a soil vapor concentrations from a subsurface source to indoor air. Three transport mechanisms are considered:

- Diffusion through vadose zone soils (as described in Section 2.1 previously for the vapor flux model);
- Convection into the building due to the negative pressure differential between the subsurface and building; and
- Mixing of vapors within a building resulting from building ventilation.

The Johnson and Ettinger (1991) model requires input parameter values to characterize the vadose zone and building characteristics. Investigational unit-specific inputs include depth to volatile source and soil characteristics (porosity, moisture content, fraction organic carbon, hydraulic conductivity). Investigational unit-specific bedrock and soil model input parameter values to be used in the analyses are listed in Table G-3. Where investigational unit-specific data are not available for building parameters to serve as inputs into the Johnson and Ettinger model, available default parameters listed in DTSC (2005) are used as shown in Table G-3.

The attenuation factor, α, calculated by the Johnson and Ettinger (1991) model represents the ratio of concentrations of a volatile compound in indoor air to the soil vapor concentration.

$$\alpha = \frac{C_{building}}{C_{source}} \tag{19}$$

where

$C_{building}$	=	indoor air vapor concentration (µg/m^3-air)
C_{source}	=	sub-surface source vapor concentration (µg/m^3-vapor)

$$\alpha = \left[\left(\frac{D_{eff} \times A_B}{Q_{building} \times L_T}\right) \times \exp\left(\frac{Q_{soil} \times L_{crack}}{D^{crack} \times A_{crack}}\right)\right] \Big/$$

$$\left\{\exp\left(\frac{Q_{soil} \times L_{crack}}{D^{crack} \times A_{crack}}\right) + \left(\frac{D_{eff} \times A_B}{Q_{building} \times L_T}\right) + \left(\frac{D_{eff} \times A_B}{Q_{soil} \times L_T}\right)\left[\exp\left(\frac{Q_{soil} \times L_{crack}}{D^{crack} \times A_{crack}}\right) - 1\right]\right\} \tag{20}$$

where

D_{eff}	=	Total overall effective diffusion coefficient (m^2/s)
A_B	=	Area of the enclosed space below grade (m^2)
$Q_{building}$	=	Building ventilation rate (m^3/s)
L_T	=	Source-building separation (m)
Q_{soil}	=	Volumetric flow rate of soil gas into the enclosed space (m^3/s)
L_{crack}	=	Enclosed space foundation or slab thickness (m)
A_{crack}	=	Area of total cracks (m^2)
D_{crack}	=	Effective diffusion coefficient through the cracks (m^2/s) (assumed equivalent to effective diffusion coefficient of the soil layer in contact with the floor).

investigational units with multiple soil and/or bedrock layers, such as investigational units with multiple soil covers and/or bedrock layers, the overall migration into indoor air is determined by evaluating Equation 20 using the overall effective diffusion coefficient. The overall effective diffusion coefficient is the harmonic average of the diffusion coefficients through each layer and is described by:

$$D_{eff}^{T} = L_T \Big/ \sum \frac{L_i}{D_{eff,i}} \qquad (21)$$

where

D^T_{eff} = overall effective diffusion coefficient (m^2/s);
L_T = the total diffusive distance (m);
$D_{eff,\,i}$ = effective diffusion coefficient through layer i (m^2/s); and
L_i = the thickness of layer, i (m).

G.3.2 Input Assumptions

The vapor migration modeling to indoor air relies upon inputs that describe building characteristics, soil and chemical characteristics that describe effective diffusion coefficients, and source concentrations.

G.3.2.1 Building Characteristics

Where existing buildings occur at investigational units and vapor migration into indoor air is a potential concern, available and appropriate building specific parameters will be used. For modeling into future potential structures, USEPA (2002a) and DTSC (2005) default parameters will be used and are listed in Table G-4.

G.3.2.2 Effective Diffusion Coefficients

The overall effective diffusion coefficient is calculated as described above in Equation 14. The methods for addressing fractured bedrock and layered media are also applicable to the vapor intrusion calculations. The site-specific soil characterization inputs are listed in Table G-4. Inputs related to chemical-specific physical properties of VOCs (e.g., Henry's law constant, solubility, and soil adsorption) are listed in Table G-3 and are obtained from USEPA (2002a). Inputs for chemicals that are not listed in Table G-3 will be obtained from literature sources or may be approximated (e.g., Lyman et al. 1983). Chemical properties needed for investigational unit risk assessments that are not presented in Table G-3 will be appropriately documented in the investigational unit risk assessments.

G.3.2.3 Source Concentrations

As with the vapor flux model, the Johnson and Ettinger model is directly applicable to measured soil vapor concentrations and the indoor air concentration would be calculated as:

$$C_{building} = \alpha \times C_{source} \tag{22}$$

Soil vapor data collected less than 3 feet deep will not be used. To calculate the indoor air concentration from a groundwater or soil source concentration, the partitioning relationship in Equations 17 and 18 will used to predict source soil vapor concentrations from groundwater and soil source concentrations, respectively.

The use of soil vapor data for model input is preferred. In certain situations as discussed in Section G.1.2, bulk soil media concentrations and groundwater concentrations will be used as inputs into the field-validated vapor migration model (see Section G.2.3.3). In these cases, the uncertainties resulting from an investigational unit modeling approach that depends on hypothetical equilibrium partitioning relationships between water, soil and/or bedrock matrix, and soil gas will be addressed in the I nvestigational unit assessment uncertainty sections to assist in the interpretation of the results. This allows the greatest use of the data currently available in the investigational unit risk assessments.

Input concentrations for the models will be representative of both average (central tendency) and RME (maximum) site conditions. The characteristics of the investigational unit and the exposure area will be considered in making these input concentrations estimates. Average and RME estimates of exposure point concentrations, based on model input parameters, will be combined with other exposure parameters (described in SRAM Section 6) to develop appropriate average and RME risk estimates.

G.4 SUMMARY

The methodology described in this appendix provides a consistent approach for the assessment risk associated with the potential migration of VOCs into indoor and outdoor air at the investigational units at the SSFL. A modeling strategy with a preferred basis of soil vapor concentrations has been presented. The methodology will be applied to each investigational unit to determine the potential human and ecological risks due to exposures to chemicals present in various media. The suitability of the models, use of soil and/or groundwater sources, or other inputs parameters will be assessed through a field validation study. Appropriate average and RME estimates of exposure point concentrations of VOC in air will be developed using these models. Sections 6 and 10 of the main text of the SRAM will contain the details of how the evaluation of vapor migration will be incorporated into the cumulative multi-media multi-exposure pathway risk assessment of potential SSFL receptors. The methodology can be applied to assess vapor migration from VOC sources in both Surficial OU and CFOU.

G.5 REFERENCES

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APPENDIX G

TABLES

Table G-1 (1 of 1)

Parameters Used in ISC3 Modeling

Inputs	Value	Units
Source Inputs		
Source Coordinates	Site-specific	m
Mass Emission Flux	Site-specific[a]	$\mu g/m^2$-sec
Area Source Length	Site-specific	m
Area Source Width	Site-specific	m
Area Source Angle Relative to North that the Source is Facing	Site-specific	degrees
Area Source Release Height	Site-specific	m
Receptor Inputs		
Receptor Coordinates	Site-specific	m
Meteorological Inputs (hourly data for one year) [b]		
Wind Speed	Site-specific	m/s
Wind Direction	Site-specific	degree from North
Ambient Temperature	Site-specific	K
Stability Class (1-6)	Site-specific	unitless
Rural and Urban Mixing Height	Site-specific	m

[a] - Mass emission flux inputs may be from either actual flux measurements or outputs from the vapor flux model (See Section G.2.1). For investigational units where both modeled and measured flux inputs are available, the ISC3 dispersion modeling may be conducted using both modeled and measured fluxes (See Sections G.2.3.1 and G.2.3.3).

[b] - The best available data that is representative of investigational unit-specific conditions.

Table G-2 (1 of 1)

Parameter Values Used in Steady-State Flux Model for Vapor Migration to Outdoor Air

Parameter	Value	Units	Source
Soil bulk density (Qb)	a	kg/m^3	Site-specific
Water recharge (R)	1.00E-09	m/sec	Site-specific based on median groundwater recharge rate of 1.2 inches per year. MWH (2003a)
Organic carbon content of soil (foc)	a	fraction	Site-specific
Volumetric soil water content (θw)	a	m^3/m^3	Site-specific
Volumetric soil air content (θa)	a	m^3/m^3	Site-specific
Soil porosity (ns)	a	m^3/m^3	Site-specific
Volumetric unweathered bedrock water content (θw,ubr)	a	m^3/m^3	Site-specific
Volumetric unweathered bedrock air content (θa,ubr)	a	m^3/m^3	Site-specific
Unweathered bedrock porosity (nubr)	a	m^3/m^3	Site-specific
Unweathered bedrock fractures (ϕubr)	a	m^3/m^3	Site-specific
Volumetric weathered bedrock water content (θw,wbr)	a	m^3/m^3	Site-specific
Volumetric weathered bedrock air content (θa,wbr)	a	m^3/m^3	Site-specific
Weathered bedrock porosity (nwbr)	a	m^3/m^3	Site-specific
Weathered bedrock fractures (ϕwbr)	a	m^3/m^3	Site-specific
Depth to top of contaminated zone (L)	a	m	Site-specific

[a] The parameters presented in this table will be developed using the data presented in Appendix F or additional data obtained during field validation studies.

Table G-3 (1 of 2)

Chemical Property Values Used in Vapor Migration Models(a)

Chemical	Organic carbon partition coefficient, Koc (cm^3/g)	Diffusivity in air, Da (cm^2/s)	Diffusivity in water, Dw (cm^2/s)	Henry's law constant H' (unitless)	Henry's law constant H ($atm\text{-}m^3/mol$)
1,1,1-Trichloroethane	1.10E+02	7.80E-02	8.80E-06	7.03E-01	1.72E-02
1,1,2,2-Tetrachloroethane	9.33E+01	7.10E-02	7.90E-06	1.41E-02	3.44E-04
1,1,2-Trichloro-1,2,2-trifluoroethane	1.11E+04	7.80E-02	8.20E-06	1.97E+01	4.80E-01
1,1,2-Trichloroethane	5.01E+01	7.80E-02	8.80E-06	3.73E-02	9.11E-04
1,1-Dichloroethane	3.16E+01	7.42E-02	1.05E-05	2.30E-01	5.61E-03
1,1-Dichloroethene	5.89E+01	9.00E-02	1.04E-05	1.07E+00	2.60E-02
1,2,3-Trichloropropane	2.20E+01	7.10E-02	7.90E-06	1.67E-02	4.08E-04
1,2,4-Trichlorobenzene	1.78E+03	3.00E-02	8.23E-06	5.81E-02	1.42E-03
1,2,4-Trimethylbenzene	1.35E+03	6.06E-02	7.92E-06	2.52E-01	6.14E-03
1,2-Dibromoethane	2.50E+01	2.17E-02	1.19E-05	3.04E-02	7.41E-04
1,2-Dichlorobenzene	6.17E+02	6.90E-02	7.90E-06	7.77E-02	1.90E-03
1,2-Dichloroethane	1.74E+01	1.04E-01	9.90E-06	4.00E-02	9.77E-04
1,2-Dichloropropane	4.37E+01	7.82E-02	8.73E-06	1.15E-01	2.79E-03
1,3,5-Trimethylbenzene	1.35E+03	6.02E-02	8.67E-06	2.41E-01	5.87E-03
1,3-Dichlorobenzene	1.98E+03	6.92E-02	7.86E-06	1.27E-01	3.09E-03
1,4-Dichlorobenzene	6.17E+02	6.90E-02	7.90E-06	9.82E-02	2.39E-03
2-Butanone	2.30E+00	8.08E-02	9.80E-06	2.29E-03	5.58E-05
Acetone	5.75E-01	1.24E-01	1.14E-05	1.59E-03	3.87E-05
Acrolein	2.76E+00	1.05E-01	1.22E-05	4.99E-03	1.22E-04
Acrylonitrile	5.90E+00	1.22E-01	1.34E-05	4.21E-03	1.03E-04
Benzene	5.89E+01	8.80E-02	9.80E-06	2.27E-01	5.54E-03
Bromodichloromethane	5.50E+01	2.98E-02	1.06E-05	6.54E-02	1.60E-03
Bromoform	8.71E+01	1.49E-02	1.03E-05	2.41E-02	5.88E-04
Bromomethane	1.05E+01	7.28E-02	1.21E-05	2.55E-01	6.22E-03
Carbon disulfide	4.57E+01	1.04E-01	1.00E-05	1.24E+00	3.02E-02
Carbon tetrachloride	1.74E+02	7.80E-02	8.80E-06	1.24E+00	3.03E-02
Chlorobenzene	2.19E+02	7.30E-02	8.70E-06	1.51E-01	3.69E-03
Chloroethane	4.40E+00	2.71E-01	1.15E-05	3.61E-01	8.80E-03
Chloroform	3.98E+01	1.04E-01	1.00E-05	1.50E-01	3.66E-03
Chloromethane	2.12E+00	1.26E-01	6.50E-06	3.61E-01	8.80E-03
cis-1,2-Dichloroethene	3.55E+01	7.36E-02	1.13E-05	1.67E-01	4.07E-03
Dibromochloromethane	6.31E+01	1.96E-02	1.05E-05	3.20E-02	7.81E-04
Dibromomethane	1.26E+01	4.30E-02	8.44E-06	3.52E-02	8.59E-04
Dichlorodifluoromethane	4.57E+02	6.65E-02	9.92E-06	1.40E+01	3.42E-01
Ethylbenzene	3.63E+02	7.50E-02	7.80E-06	3.22E-01	7.86E-03
Isopropylbenzene	4.89E+02	6.50E-02	7.10E-06	4.74E+01	1.16E+00
m,p-Xylene	3.89E+02	7.69E-02	8.44E-06	3.13E-01	7.64E-03
m,p-Xylene	4.07E+02	7.00E-02	7.80E-06	3.00E-01	7.32E-03
Methyl tert-butyl ether	7.26E+00	1.02E-01	1.05E-05	2.56E-02	6.23E-04
Methylene chloride	1.17E+01	1.01E-01	1.17E-05	8.96E-02	2.18E-03
n-Butylbenzene	1.11E+03	5.70E-02	8.12E-06	5.38E-01	1.31E-02
n-Propylbenzene	5.62E+02	6.01E-02	7.83E-06	4.37E-01	1.07E-02
o-Xylene	3.63E+02	8.70E-02	1.00E-05	2.12E-01	5.18E-03
sec-Butylbenzene	9.66E+02	5.70E-02	8.12E-06	5.68E-01	1.39E-02
Styrene	7.76E+02	7.10E-02	8.00E-06	1.12E-01	2.74E-03

Table G-3 (2 of 2)

Chemical Property Values Used in Vapor Migration Models(a)

Chemical	Organic carbon partition coefficient, Koc (cm^3/g)	Diffusivity in air, Da (cm^2/s)	Diffusivity in water, Dw (cm^2/s)	Henry's law constant H' (unitless)	Henry's law constant H ($atm\text{-}m^3/mol$)
tert-Butylbenzene	7.71E+02	5.65E-02	8.02E-06	4.87E-01	1.19E-02
Tetrachloroethene	1.55E+02	7.20E-02	8.20E-06	7.53E-01	1.84E-02
Toluene	1.82E+02	8.70E-02	8.60E-06	2.72E-01	6.62E-03
trans-1,2-Dichloroethene	5.25E+01	7.07E-02	1.19E-05	3.84E-01	9.36E-03
trans-1,3-Dichloropropene	4.57E+01	6.26E-02	1.00E-05	7.24E-01	1.77E-02
Trichloroethene	1.66E+02	7.90E-02	9.10E-06	4.21E-01	1.03E-02
Trichlorofluoromethane	4.97E+02	8.70E-02	9.70E-06	3.97E+00	9.68E-02
Vinyl acetate	5.25E+00	8.50E-02	9.20E-06	2.09E-02	5.10E-04
Vinyl chloride	1.86E+01	1.06E-01	1.23E-05	1.10E+00	2.69E-02

[a] The parameters presented in this table are from USEPA's User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings (USEPA 2003)

Table G-4 (1 of 1)

Parameter Values Used in Model for Vapor Migration to Indoor Air

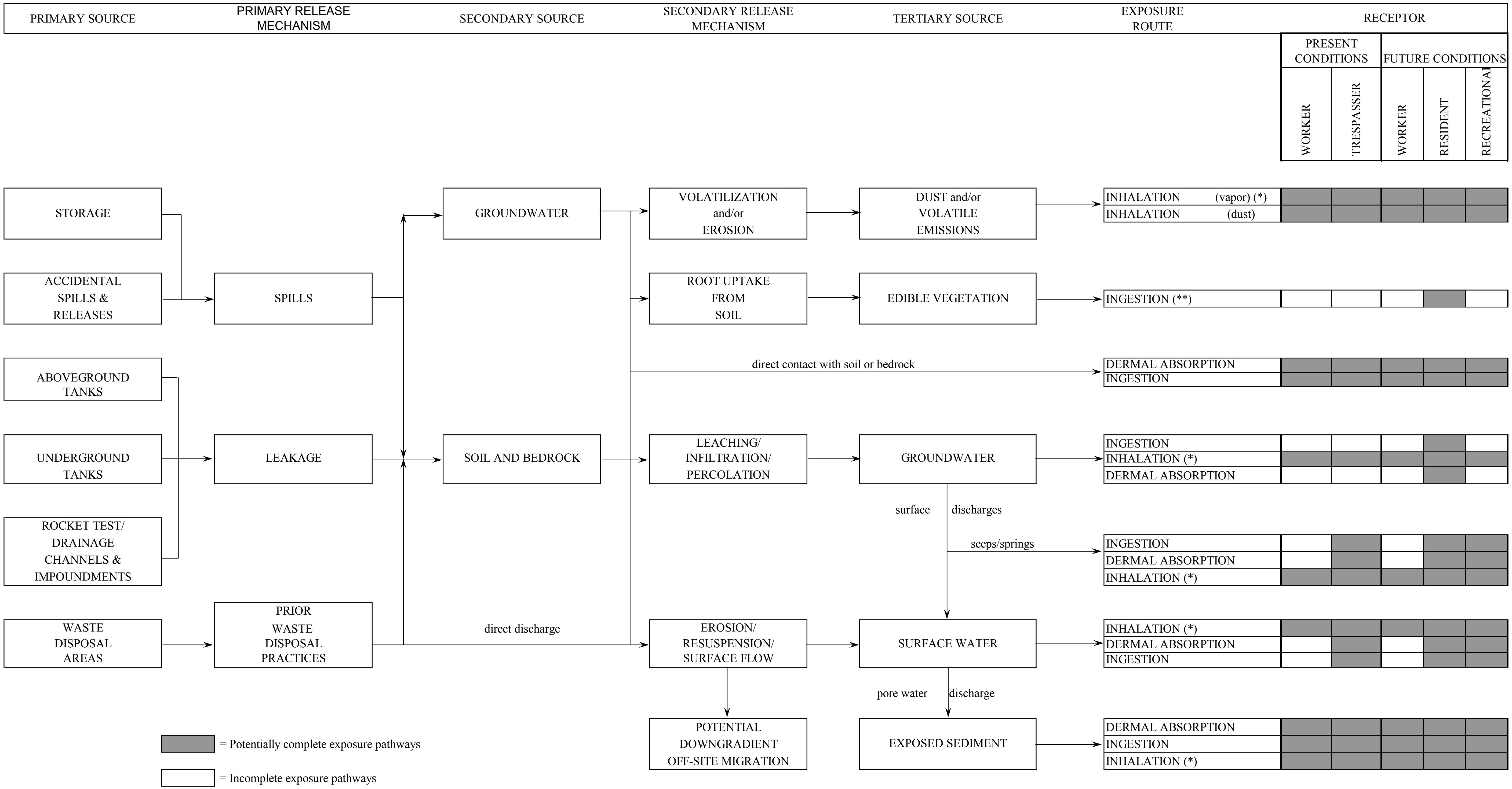
Parameter	Units	Value	Source
Average soil Temperature (Ts)	^{o}C	18	Region-specific, estimated from graph presented in USEPA (2003)
Depth below grade to bottom of enclosed space floor (Lf)	cm	15	USEPA (2002a)
Depth below grade to top of contamination (Lt)	cm	Site-specific	Site-specific
Depth below grade to bottom of contamination (Lb)	cm	Site-specific	Site-specific
Thickness of soil stratum A (h A)	cm	Site-specific	Site-specific
Thickness of weathered bedrock stratum B (h B)	cm	Site-specific	Site-specific
Thickness of unweathered bedrock stratum C (h C)	cm	Site-specific	Site-specific
Soil bulk density (Qb)	g/cm^3	a	Site-specific
Volumetric soil water content (θw)	cm^3/cm^3	a	Site-specific
Volumetric soil air content (θa)	cm^3/cm^3	a	Site-specific
Soil porosity (ns)	cm^3/cm^3	a	Site-specific
Volumetric unweathered bedrock water content (θw,ubr)	cm^3/cm^3	a	Site-specific
Volumetric unweathered bedrock air content (θa,ubr)	cm^3/cm^3	a	Site-specific
Unweathered bedrock porosity (nubr)	cm^3/cm^3	a	Site-specific
Unweathered bedrock fractures (ϕubr)	cm^3/cm^3	a	Site-specific
Volumetric weathered bedrock water content (θw,wbr)	cm^3/cm^3	a	Site-specific
Volumetric weathered bedrock air content (θa,wbr)	cm^3/cm^3	a	Site-specific
Weathered bedrock porosity (nwbr)	cm^3/cm^3	a	Site-specific
Weathered bedrock fractures (ϕwbr)	cm^3/cm^3	a	Site-specific
Soil gas advection rate (Qsoil)	L/min	5	USEPA (2002a)[b]
Enclosed space floor thickness (L crack)	cm	15	USEPA (2002a)
Soil building pressure differential (ΔP)	$(g/cm\text{-}s^2)$	40	USEPA (2002a)
Enclosed space floor length - Residential (LB)	cm	1000	USEPA (2002a)
Enclosed space floor width - Residential (WB)	cm	1000	USEPA (2002a)
Enclosed space height - Residential (HB)	cm	244	USEPA (2002a)
Enclosed space floor length - Commercial (LB)	cm	3048	Site-specific - based on 10,000 ft^2 commercial building.
Enclosed space floor width - Commercial (WB)	cm	3048	Site-specific - based on 10,000 ft^2 commercial building.
Enclosed space height - Commercial (HB)	cm	366	Site-specific - based single story building with 12 foot ceilings.
Crack-to-total area ratio	unitless	0.00038	USEPA (2002a)
Indoor air exchange rate - Residential (ER)	(1/hour)	0.5	DTSC (2005) default value.
Indoor air exchange rate - Commercial (ER)	(1/hour)	1	DTSC (2005) default value.

[a] The parameters presented in this table will be developed using the data presented in Appendix F or additional data obtained during field validation studies.

[b] The default soil gas advection rate of 5 liters per minute assumes a default residential building dimensions. The default soil gas advection ratewill be proportionally increased for future building size, if future building sizes are considered likely exceed the building dimension defaults.

APPENDIX G

FIGURES



Notes:

(*) Exposure limited to volatile compounds as defined in the text; residential and worker receptors include both indoor and outdoor air exposure to volatiles; nonresidental and nonworker receptors include only outdoor air exposure. For residents, inhalation of volatiles from shallow groundwater includes pathways associated with both domestic use and migration to indoor air, whereas, nonresidential exposure includes only migration to indoor and outdoor air for workers and only outdoor air for recreators. Exposure to fugitive dust is limited to non-volatile organic compounds.

(**) Exposure limited to bioaccumulatable compounds as described in the text.

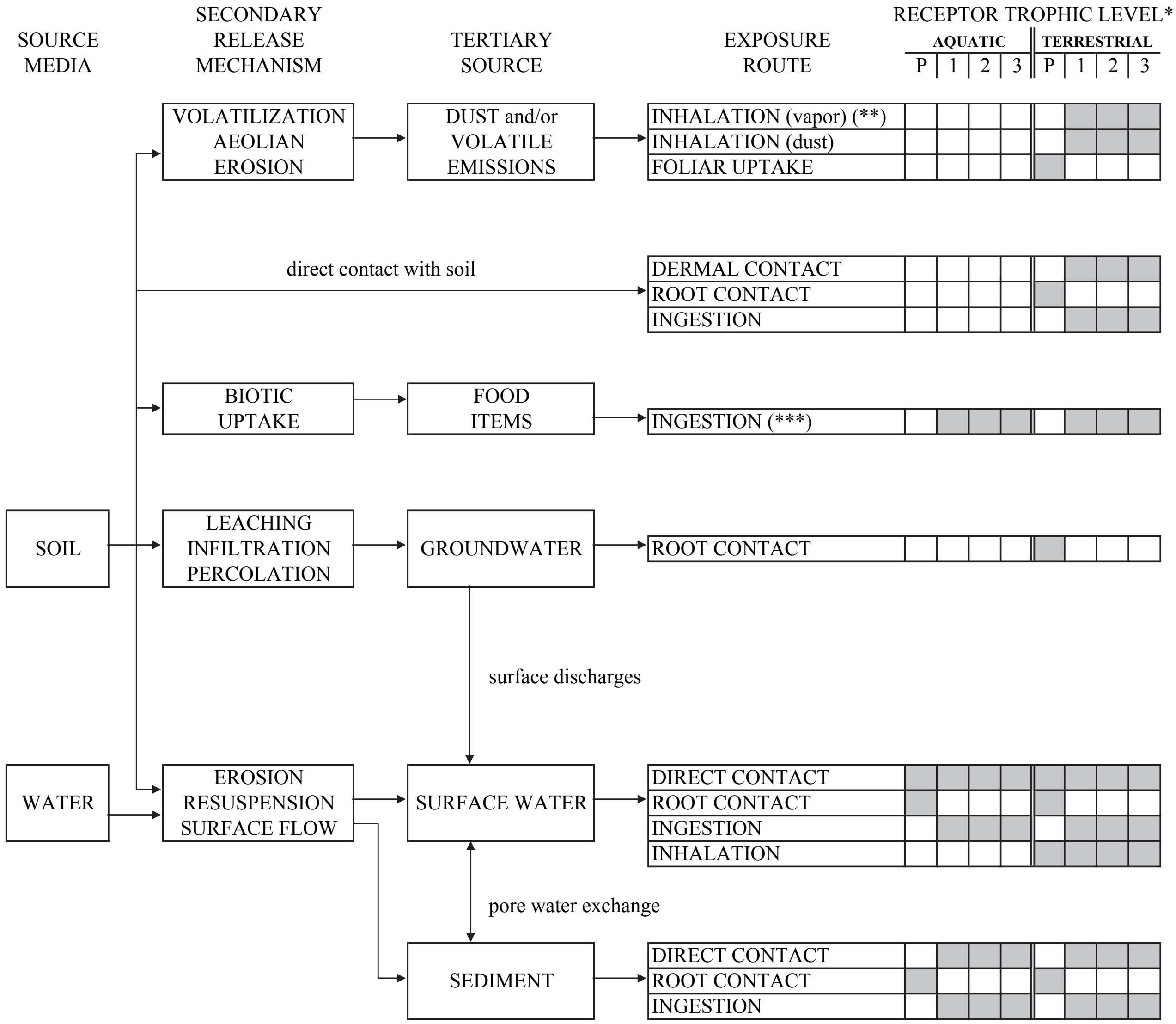
MWH

Santa Susana Field Laboratory (SSFL)
Generalized Conceptual Site Model of Human Exposures

FIGURE
G-1

Project/Boeing SSFL RA/MWH_SRAM2005-Rev2/Figure G-1.ai

06/07/05



Notes:
(*) Trophic Level: P= Primary producers (e.g., plants); 1=1st consumer (e.g., invertebrates); 2=2nd consumer (e.g., wading birds); 3=3rd consumer (e.g., fish-eating birds)
(**) Exposures limited to volatile compounds as defined in the text.
(***) Exposures limited to bioaccumulatable compounds as described in the text.

APPENDIX G

ATTACHMENT G-1

VAPOR MIGRATION MODEL EQUATION DERIVATION

APPENDIX G
ATTACHMENT G-1

VAPOR MIGRATION MODEL EQUATION DERIVATION

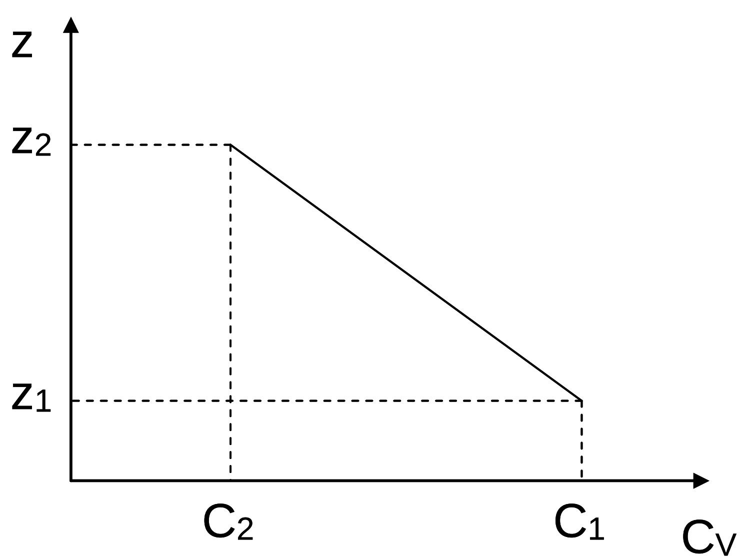
Differential Flux Equation:

$$F = -D_{eff}\frac{dC_v}{dz} - R\frac{C_v}{H} \tag{1}$$

$$F + R\frac{C_v}{H} = -D_{eff}\frac{dC_v}{dz} \tag{2}$$

$$dz = -D_{eff}\frac{dC_v}{F + R\frac{C_v}{H}} \tag{3}$$

Boundary Conditions: $$\begin{cases} z = z_1 \Rightarrow C_v = C_1 \\ z = z_2 \Rightarrow C_v = C_2 \end{cases} \tag{4}$$



Integrating Equation (3)[1] and applying boundary conditions (4) yields:

$$\int_{z1}^{z2} dz = -D_{eff} \cdot \int_{C1}^{C2} \frac{dC_v}{F + R\dfrac{C_v}{H}} \tag{5}$$

$$z\Big]_{z1}^{z2} = -D_{eff} \cdot \left[\frac{H}{R}\ln\left(F + \frac{R}{H}C_v\right)\right]_{C1}^{C2} \tag{6}$$

$$z_2 - z_1 = -D_{eff} \cdot \left[\frac{H}{R}\ln\left(F + \frac{R}{H}C_2\right)\right] + D_{eff} \cdot \left[\frac{H}{R}\ln\left(F + \frac{R}{H}C_1\right)\right] \tag{7}$$

$$z_2 - z_1 = D_{eff}\frac{H}{R}\ln\left(\frac{F + \dfrac{R}{H}C_1}{F + \dfrac{R}{H}C_2}\right) \tag{8}$$

Let $L = z_2 - z_1$. Replacing L into Equation (8) and rearranging it yields:

$$\frac{L \cdot R}{D_{eff} \cdot H} = \ln\left(\frac{F + \dfrac{R}{H}C_1}{F + \dfrac{R}{H}C_2}\right) \tag{9}$$

$$\exp\left(\frac{L \cdot R}{D_{eff} \cdot H}\right) = \frac{F + \dfrac{R}{H}C_1}{F + \dfrac{R}{H}C_2} \tag{10}$$

---

[1] From CRC Standard Math Tables 27th Ed. Integral #27 page 238: $\int \frac{dx}{a+bx} = \frac{1}{b}\ln(a+bx)$

$$\exp\left(\frac{L \cdot R}{D_{eff} \cdot H}\right) \cdot \left(F + \frac{R}{H} C_2\right) = F + \frac{R}{H} C_1 \tag{11}$$

$$F \exp\left(\frac{L \cdot R}{D_{eff} \cdot H}\right) + \frac{R \cdot C_2}{H} \exp\left(\frac{L \cdot R}{D_{eff} \cdot H}\right) = F + \frac{R \cdot C_1}{H} \tag{12}$$

$$\frac{R \cdot C_2}{H} \exp\left(\frac{L \cdot R}{D_{eff} \cdot H}\right) - \frac{R \cdot C_1}{H} = F - F \exp\left(\frac{L \cdot R}{D_{eff} \cdot H}\right) \tag{13}$$

$$\frac{R}{H}\left(C_2 \cdot \exp\left(\frac{L \cdot R}{D_{eff} \cdot H}\right) - C_1\right) = F \cdot \left(1 - \exp\left(\frac{L \cdot R}{D_{eff} \cdot H}\right)\right) \tag{14}$$

$$F = \frac{\frac{R}{H}\left(C_2 \cdot \exp\left(\frac{L \cdot R}{D_{eff} \cdot H}\right) - C_1\right)}{\left(1 - \exp\left(\frac{L \cdot R}{D_{eff} \cdot H}\right)\right)} \tag{15}$$

Multiplying the numerator and denominator of Equation (15) by (-1) yields the equivalent of Equation 7 presented in the Appendix G text:

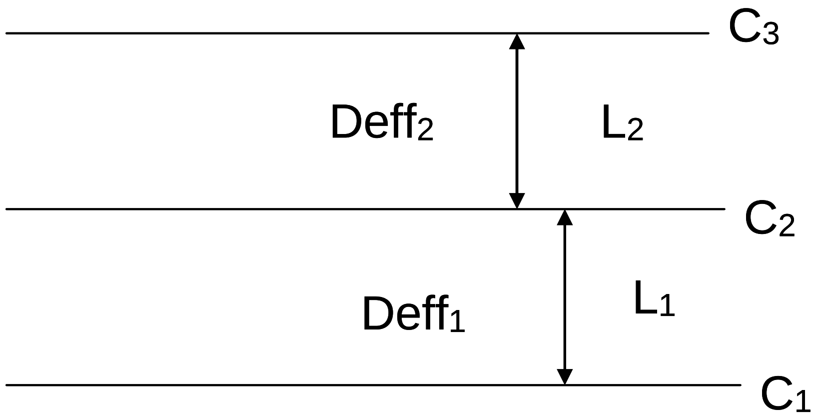
$$F = \frac{R}{H} \frac{\left(C_1 - C_2 \cdot \exp\left(\frac{L \cdot R}{D_{eff} \cdot H}\right)\right)}{\left(\exp\left(\frac{L \cdot R}{D_{eff} \cdot H}\right) - 1\right)} \tag{16}$$

Solving equation (16) for C_2=0 yields the equivalent of Equation 8 presented in the Appendix G text:

$$F = \frac{C_1 R/H}{\left(\exp\left(\frac{L \cdot R}{D_{eff} \cdot H}\right) - 1\right)} \tag{17}$$

Effect of Varying Subsurface Conditions:

Let:



$$F_1 = \frac{R}{H}\frac{\left(C_1 - C_2 \cdot \exp\left(\frac{L_1 \cdot R}{D_{eff\,1} \cdot H}\right)\right)}{\left(\exp\left(\frac{L_1 \cdot R}{D_{eff\,1} \cdot H}\right) - 1\right)} \quad (18)$$

$$F_2 = \frac{R}{H}\frac{\left(C_2 - C_3 \cdot \exp\left(\frac{L_2 \cdot R}{D_{eff\,2} \cdot H}\right)\right)}{\left(\exp\left(\frac{L_2 \cdot R}{D_{eff\,2} \cdot H}\right) - 1\right)} \quad (19)$$

Let:

$$\gamma_1 = \frac{L_1 \cdot R}{D_{eff\,1} \cdot H} \quad (20)$$

$$\gamma_2 = \frac{L_2 \cdot R}{D_{eff\,2} \cdot H} \quad (21)$$

Replacing Equations (20) and (21) into Equations (18) and (19) respectively yields:

$$F_1 = \frac{R}{H}\frac{\left(C_1 - C_2 \cdot e^{\gamma_1}\right)}{\left(e^{\gamma_1} - 1\right)} \quad (22)$$

$$F_2 = \frac{R}{H}\frac{\left(C_2 - C_3 \cdot e^{\gamma_2}\right)}{\left(e^{\gamma_2} - 1\right)} \quad (23)$$

To satisfy the principle of conservation of mass:

$$F_1 = F_2 \tag{24}$$

$$\frac{R}{H}\frac{\left(C_1 - C_2 \cdot e^{\gamma_1}\right)}{\left(e^{\gamma_1} - 1\right)} = \frac{R}{H}\frac{\left(C_2 - C_3 \cdot e^{\gamma_2}\right)}{\left(e^{\gamma_2} - 1\right)} \tag{25}$$

$$\left(C_1 - C_2 \cdot e^{\gamma_1}\right)\left(e^{\gamma_2} - 1\right) = \left(C_2 - C_3 \cdot e^{\gamma_2}\right)\left(e^{\gamma_1} - 1\right) \tag{26}$$

$$C_1 \cdot e^{\gamma_2} - C_2 \cdot e^{\gamma_1+\gamma_2} - C_1 + C_2 \cdot e^{\gamma_1} = C_2 \cdot e^{\gamma_1} - C_3 \cdot e^{\gamma_1+\gamma_2} - C_2 + C_3 \cdot e^{\gamma_2} \tag{27}$$

$$C_2 \cdot (1 - \cdot e^{\gamma_2+\gamma_1}) = C_1 \cdot (1 - e^{\gamma_2}) + C_3 \cdot e^{\gamma_2} \cdot (1 - e^{\gamma_1}) \tag{28}$$

$$C_2 = \frac{C_1 \cdot (1 - e^{\gamma_2}) + C_3 \cdot e^{\gamma_2} \cdot (1 - e^{\gamma_1})}{(1 - e^{\gamma_2+\gamma_1})} \tag{29}$$

$$F_1 = \frac{R}{H}\frac{\left(C_1 - C_2 \cdot e^{\gamma_1}\right)}{\left(e^{\gamma_1} - 1\right)} \tag{30}$$

$$F_1 = \frac{R}{H}\left(\frac{C_1}{\left(e^{\gamma_1} - 1\right)} - \frac{C_1 \cdot (1 - e^{\gamma_2}) + C_3 \cdot e^{\gamma_2} \cdot (1 - e^{\gamma_1})}{(1 - e^{\gamma_2+\gamma_1})}\frac{e^{\gamma_1}}{\left(e^{\gamma_1} - 1\right)}\right) \tag{31}$$

$$F_1 = \frac{R}{H}\left(\frac{C_1}{\left(e^{\gamma_1} - 1\right)} - \frac{e^{\gamma_1}}{\left(e^{\gamma_1} - 1\right)}\frac{C_1 \cdot (1 - e^{\gamma_2})}{(1 - e^{\gamma_2+\gamma_1})} + \frac{e^{\gamma_1}}{\left(e^{\gamma_1} - 1\right)}\frac{C_3 \cdot e^{\gamma_2} \cdot (e^{\gamma_1} - 1)}{(1 - e^{\gamma_2+\gamma_1})}\right) \tag{32}$$

$$F_1 = \frac{R}{H}\left(\frac{C_1 - C_1 \cdot e^{\gamma_2+\gamma_1} - e^{\gamma_1}C_1 + C_1 \cdot e^{\gamma_1+\gamma_2}}{\left(e^{\gamma_1} - 1\right)\left(1 - e^{\gamma_2+\gamma_1}\right)} + \frac{C_3 \cdot e^{\gamma_1+\gamma_2}}{\left(1 - e^{\gamma_2+\gamma_1}\right)}\right) \tag{33}$$

$$F_1 = \frac{R}{H}\left(\frac{C_1 \cdot \left(1 - e^{\gamma_1}\right)}{\left(e^{\gamma_1} - 1\right)\left(1 - e^{\gamma_2+\gamma_1}\right)} + \frac{C_3 \cdot e^{\gamma_1+\gamma_2}}{\left(1 - e^{\gamma_2+\gamma_1}\right)}\right) \tag{34}$$

$$F_1 = \frac{R}{H}\left(\frac{-C_1}{\left(1 - e^{\gamma_2+\gamma_1}\right)} + \frac{C_3 \cdot e^{\gamma_1+\gamma_2}}{\left(1 - e^{\gamma_2+\gamma_1}\right)}\right) \tag{35}$$

$$F_1 = \frac{R}{H}\left(\frac{C_1 - C_3 \cdot e^{\gamma_1+\gamma_2}}{e^{\gamma_1+\gamma_2} - 1}\right) \tag{36}$$

Replacing the definition of γ_1 and γ_2, Equations (20) and (21), into Equation (36) yields:

$$F_1 = \frac{R}{H}\left(\frac{C_1 - C_3 \cdot e^{\left(\frac{L1 \cdot R}{Deff1 \cdot H} + \frac{L2 \cdot R}{Deff2 \cdot H}\right)}}{e^{\left(\frac{L1 \cdot R}{Deff1 \cdot H} + \frac{L2 \cdot R}{Deff2 \cdot H}\right)} - 1}\right) \tag{37}$$

$$F_1 = \frac{R}{H}\left(\frac{C_1 - C_3 \cdot e^{\left(\frac{R}{H}\left(\frac{L1}{Deff1} + \frac{L2}{Deff2}\right)\right)}}{e^{\left(\frac{R}{H}\left(\frac{L1}{Deff1} + \frac{L2}{Deff2}\right)\right)} - 1}\right) \tag{38}$$

General Form:

$$F = \frac{R}{H}\left[\frac{C_1 - C_n \exp\left(\frac{R}{H}\sum\frac{L_i}{D_{eff,i}}\right)}{\exp\left(\frac{R}{H}\sum\frac{L_i}{D_{eff,i}}\right) - 1}\right] \tag{39}$$

$$D_{eff,T} = \frac{L_T}{\sum\frac{L_i}{D_{eff,i}}} \tag{40}$$

$$\sum\frac{L_i}{D_{eff,i}} = \frac{L_T}{D_{eff,T}} \tag{41}$$

$$F = \frac{R}{H}\left[\frac{C_1 - C_n \exp\left(\frac{R}{H}\frac{L_T}{D_{eff,T}}\right)}{\exp\left(\frac{R}{H}\frac{L_T}{D_{eff,T}}\right) - 1}\right] \tag{42}$$

Equation 42 is the equivalent of Equation 9c presented in the Appendix G text.

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APPENDIX G

ATTACHMENT G-2

Q/C AND SCREEN3 MODEL COMPARISONS

APPENDIX G
ATTACHMENT G-2

Q/C and SCREEN3 Model Comparisons

Comparison Scenarios

This attachment to Appendix G presents a comparison of the Q/C dispersion factor[1] and the SCREEN3 model for providing estimates of onsite air concentrations from subsurface vapor flux. The estimated annual average outdoor air concentration were calculated using these two dispersion models assuming a unit flux (1 μg/m2/s) and various source sizes (0.5 acres to 30 acres). For this evaluation the sources were assumed to be square. The Q/C model parameter inputs for Los Angeles were used in the Q/C modeling. The SCREEN3 modeling was evaluated using the rural setting, flat terrain, ground level emissions release, and the default meteorological settings. The SCREEN3 evaluation results in the maximum 1-hour concentration given these default conservative settings. In order to compare the SCREEN3 results to the Q/C model results the maximum 1-hour concentration outputs from SCREEN3 were converted to annual concentration using a conversion factor of 0.1[2]. Conversion factors ranging from 0.06 to 0.1 have been reported, although these factors are commonly applied at distances removed from the source. Even at near source locations the 1-hour maximum concentration will likely over-estimate of the annual average, as the 1-hour maximum concentration is reflective of a stable, low wind speed condition which is not reflective of the varied meteorological conditions that exist throughout the year.

Results

Table 1 presents the SCREEN3 modeling results. Table 2 presents the Q/C modeling results. Table 3 presents the model comparison results. The results of the comparison indicate that within the range of site size, the Q/C is consistently more conservative than the SCREEN3 model.

[1] USEPA. 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. Office of Solid Waste and Emergency Response, Washington, DC. OSWER 9355.4-24. December.
[2] The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments, Appendix H. California EPA, Office of Environmental Health Hazard Assessment. August 2003.

Table 1. SCREEN3 Model Results

SCREEN3 - MODEL					
Area		SQRT(area)	Max. 1-hour Concentration	Annual Average Concentration	Distance to Max.
(acres)	(m^2)	(m)	(µg/m3)	(µg/m^3)[a]	(m)
0.5	2025	45.00	1.30E+01	1.30E+00	87
1	4050	63.64	1.93E+01	1.93E+00	95
2	8100	90.00	2.67E+01	2.67E+00	109
5	20250	142.30	3.91E+01	3.91E+00	140
10	40500	201.25	5.07E+01	5.07E+00	178
30	121500	348.57	7.26E+01	7.26E+00	277

[a] Max 1-hour concentration output from SCREEN3 was converted to annual concentration using a conversion factor of 0.1 (The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments, Appendix H. California EPA, Office of Environmental Health Hazard Assessment. August 2003.)

Table 2. Q/C Model Results

SSG (Q/C)		
Site: Los Angeles	A	11.9110
	B	18.4385
	C	209.7845
Area (acres)	Q/C (g/m2/s)/(kg/m^3)	Annual Average Conc. (µg/m^3)
0.5	68.1836	1.47E+01
1	60.2239	1.66E+01
2	53.4376	1.87E+01
5	45.9476	2.18E+01
10	41.2059	2.43E+01
30	34.9995	2.86E+01

Table 3. Model Comparison Results

Source Size (acres)	SCREEN3 Annual Average Conc. (μg/m^3)	SSG Q/C Annual Average Conc. (μg/m^3)	Percent Difference of SCREEN3 Result Relative to SSG Q/C Result
0.5	1.30E+00	1.47E+01	-91.1
1	1.93E+00	1.66E+01	-88.4
2	2.67E+00	1.87E+01	-85.8
5	3.91E+00	2.18E+01	-82.0
10	5.07E+00	2.43E+01	-79.1
30	7.26E+00	2.86E+01	-74.6

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APPENDIX H

EXAMPLE HUMAN HEALTH RISK SUMMARY TABLES

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EXAMPLE HUMAN HEALTH RISK SUMMARY TABLES

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Appendix H Table H-1 (1 of 1)

Occurrence, Distribution, and Selection of Chemicals of Potential Concern

Chemical	Minimum[a] Concentration	Minimum Qualifier	Maximum[a] Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Greater Than Background[b] (Yes/No)	Greater Than 5% Detects (Yes/No)	COPC Flag (Yes/No)	Rational for Contaminant Deletion

(a) Minimum/Maximum Detected Concentration
(b) Applies to metals and dioxins/furans only.

Appendix H Table H-2 (1 of 1)

Selection of Exposure Pathways

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway

Appendix H Table H-3 (1 of 1)

Values Used for Daily Intake Calculations

Exposure Route	Parameter Code[a]	Parameter Definition	Units	CTE Value	RME Value

(a) An identifying abbreviation used for each parameter (e.g., IR = ingestion rate).

Appendix H Table H-4 (1 of 1)

Medium-Specific Exposure Point Concentration Summary

Chemical of Potential Concern	Units	CTE EPC	Method of Calculation	RME EPC	Method of Calculation

Appendix H Table H-5 (1 of 1)

Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure

Chemical of Potential Concern	Ingestion Intake (Non Cancer)	Ingestion Intake (Non-Cancer) Units	Dermal Absorption (Non-Cancer)	Dermal Absorption (Non-Cancer) Units	Oral Reference Dose	Oral Reference Dose Units	Ingestion Hazard Quotient	Dermal Hazard Quotient	Inhalation Intake	Inhalation Intake (Non-Cancer) Units	Reference Concentration	Reference Concentration Units	Inhalation Hazard Quotient	Hazard Index

Total Hazard Index Across All Exposure Routes/Pathways:

Appendix H Table H-6 (1 of 1)

Calculation of Cancer Risks
Reasonable Maximum Exposure

Chemical of Potential Concern	Ingestion Intake (Cancer)	Ingestion Intake (Cancer) Units	Dermal Absorption (Cancer)	Dermal Absorption (Cancer) Units	Oral Cancer Slope Factor	Oral Cancer Slope Factor Units	Ingestion Risk	Dermal Risk	Inhalation Intake	Inhalation Intake (Cancer) Units	Inhalation Cancer Slope Factor	Inhalation Cancer Slope Factor Units	Inhalation Cancer Risk	Cancer Risk

Total Risk Across All Exposure Routes/Pathways:

Appendix H Table H-7 (1 of 1)

Risk Summary

Medium	Exposure Medium	Exposure Point	Cancer Risk					Hazard Index				
			Ingestion	Dermal	Inhalation	Total	COPC Contributing Majority of Risk	Ingestion	Dermal	Inhalation	Total	COPC Contributing Majority of Risk

APPENDIX I

BIOLOGICAL CONDITIONS REPORT

Addendum to the Biological Conditions Report Santa Susana Field Laboratory Ventura County, California

Prepared for

The Boeing Company

National Aeronautics and Space Administration

and

U.S. Department of Energy

Prepared by

MWH Americas, Inc.
Pasadena, California

and

AMEC Earth & Environmental, Inc.
San Rafael, California

July 2003 / September 2005

This addendum to the Biological Conditions Report (BCR) was prepared for the Santa Susana Field Laboratory (SSFL) in April 2000, and revised in June 2003 and in March 2005, based on additional information gathered since the biological surveys were completed for the original report (Ogden 1998). As stated in the BCR, the original scope of work only included focused surveys on specific RCRA Facility Investigation (RFI) sites and vegetation mapping for the remainder of the SSFL. No protocol surveys were completed due to time and seasonal constraints on the original surveys. This addendum addresses additional information regarding federally listed endangered species and sensitive plant and wildlife species possibly present at the SSFL. The vegetation map was updated in March 2005 based on the results of numerous additional surveys conducted by AMEC, MWH, and Padre between 2000 and 2004. The maps from the original April 1998 Biological Conditions Report are not reproduced in this appendix.

<u>Additional Plant Species</u>

Braunton's milk vetch (*Astragalus brauntonii*) is a perennial herb that is ranked by the California Native Plant Society (CNPS) as extremely rare. Braunton's milk vetch occurs in a variety of plant communities, including chaparral, valley grassland, coastal sage scrub, and closed-cone pine forest. A distinguishing feature of habitats with this plant species is the presence of carbonate substrate in disturbed habitats (CNPS Inventory 1994). Braunton's milk vetch has been identified at nine locations in Ventura County. It was observed during 1999 south of the Former Sodium Disposal Facility at the western edge of the property. It may occur at other locations at the SSFL, and future focused surveys will be completed at investigational units where potential actions will occur.

Plummer's mariposa lily (*Calochortus plummerii*) is a slender-branched perennial that is considered rare, threatened, or endangered in California and elsewhere by the CNPS (i.e., classified as CNPS List 1B). Plummer's mariposa lily occurs in the Santa Monica Mountains in chaparral habitats with granitic and alluvial soils. This plant has been identified at two locations along the Happy Valley drainage: (1) about five feet from the streambed near the terminus of Happy Valley drainage at the SSFL property line and (2) on the slopes adjacent to the drainage at the stream division (MWH 2003a).

Another sensitive plant species, thought to be extinct, has been found in the vicinity of, but not at the SSFL. The San Fernando Valley spineflower (*Chorizanthe parryi* var. *fernandina*) is a Category 1 candidate for listing by the U.S. Fish and Wildlife Service and is currently petitioned for listing at the state level. Habitat for this low, spring-blooming (April to June) annual is thin soils over rock outcroppings below 762 meters (2500 feet) elevation, usually in association with coastal sage scrub. This species was identified in the past in San Diego County, but recent evidence indicates that these occurrences were incorrectly identified. The CNPS lists the occurrence of this species as greatly limited and considers this California endemic highly sensitive and endangered throughout a part of its range.

In addition to these two plant species, two federally listed threatened species of *Dudleya* may potentially occur onsite, as well as two other endangered plants: Lyon's pentachaeta (*Pentachaeta lyonii*) and California orcutt grass (*Orcuttia californica*). These species were not listed in Table 3-1 of the original report. Additional surveys for all of these potentially occurring plant species will be completed in suitable habitats at investigational units where potential actions will occur.

<u>Additional Wildlife Species</u>

The coast horned lizard (*Phrynosoma coronatum blainvillei*) is classified as a Species of Special Concern by the California Department of Fish and Game. This diurnal lizard occurs in a variety of habitats in southern California and feeds primarily on insects (Zeiner et al. 1988). At SSFL, the coast horned lizard has been observed at the Area II Landfill (MWH 2003b).

A number of sensitive wildlife species were considered as potentially occurring at the SSFL (See Tables 3-2 through 3-5*)*. Federally listed endangered species that could potentially occur at the SSFL but were not listed in these tables include the least Bell's vireo (*Vireo bellii pusillus*), southwestern willow flycatcher (*Empidonax trailii extimus*), arroyo southwestern toad (*Bufo microscaphus californicus*), Quino checkerspot butterfly (*Euphydryas editha quino*), and San Diego fairy shrimp (*Branchinecta sandiegoensis*). These species require protocol surveys at certain times of the year. Protocol surveys were not completed during the original surveys, and habitat for these species is limited at the SSFL. The southern rubber boa (*Charina bottae umbratica*) and southern Pacific rattlesnake (*Crotalis viridis helleri*) are other species of concern in California that may also potentially occur in habitats at the SSFL. Additional surveys will be completed in suitable habitats for sensitive species that may occur at investigational units where potential actions will occur.

BCR Addendum References

MWH. 2003a. Biological Assessment for the Happy Valley Perchlorate Interim Measures Project.

MWH. 2003b. Area I and Area II Landfills Investigation Work Plan - Work Plan Addendum Amendment, SWMU 4.2 and SWMU 5.1, Santa Susana Field Laboratory, Ventura County, California.

Zeiner, D.C., W.F. Laudenslayer, K.E. Mayer, and M. White (eds). 1988. *California's Wildlife. Vol. 1. Amphibians and Reptiles.* California Statewide Wildlife Habitat Relationships System. California State Department of Fish and Game.

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Biological Conditions Report
Santa Susana Field Laboratory
Ventura County, California

Prepared for

Boeing North American,
Rocketdyne Propulsion and Power

and

National Aeronautics and Space Administration

and

U.S. Department of Energy
Energy Technology Engineering Center Division

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April 1998
Project No. 313150002

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SECTION 1
INTRODUCTION

This Biological Conditions Report was prepared as part of the Standardized Risk Assessment Methodology (SRAM) being developed for risk assessments conducted at the Santa Susana Field Laboratory (SSFL) (Figures 1-1 and 1-2). The SSFL is jointly owned by Boeing North American, Inc. and the National Aeronautics and Space Administration (NASA), and it is operated by the Rocketdyne Division (Rocketdyne) of Boeing. A small portion of the SSFL owned by Boeing is leased to the U.S. Department of Energy (DOE). The SSFL is divided into four administrative areas (Areas I, II, III, and IV) and has a 2,000-foot-wide undeveloped area along its southern margin. The SRAM is being developed in support of a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) at the SSFL. A RCRA Facility Assessment (RFA) was conducted in 1990 for U.S. Environmental Protection Agency (USEPA) and identified 122 Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs) within the four administrative areas of the SSFL (ICF 1993a-c). Selected SWMUs and AOCs were identified as requiring further investigation and have been grouped into 39 RFI sites (Figure 1-3). Information regarding materials used and wastes generated, and other environmental programs at the SSFL are summarized elsewhere (Ogden 1996). The Biological Conditions Report summarizes the results of field surveys conducted at the SSFL from 1995-1997, including the presence and distribution of vegetation communities, wildlife species detected, and locations of sensitive plant and animal species at the 39 RFI sites. Field surveys focused primarily on the RFI sites; however, the entire SSFL was surveyed during the 1995–1997 site visits. The information presented in this report will be utilized in developing ecological risk assessments conducted at the SSFL and any additional environmental documentation for actions conducted at the SSFL.

Figure 1-1

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Figure 1-2

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Figure 1-3

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SECTION 2
BIOLOGICAL SURVEY METHODS

2.1 VEGETATION SURVEYS

The SSFL was surveyed several times during the period from June 12, 1995 to February 6, 1997. Detailed surveys of each of the 36 RFI sites were conducted, while vegetation surveys of the open space and large areas between sites were performed using both field mapping and aerial photograph interpretation. The following is a list of the dates when botanical and vegetation surveys were performed at the SSFL:

Survey Periods

June 12-15, 1995	July 29-31, 1996
July 5, 1995	January 14-15, 1997
March 11-15, 1996	February 6, 1997
May 6-8, 1996	

All plant communities were visited and mapped, and all plant species were identified and recorded. Nomenclature for plant species conforms to Munz (1974), while vegetation communities and habitat types follow Holland (1986).

2.2 WILDLIFE SURVEYS

Wildlife surveys were conducted several times during the period from July 5, 1995 through February 6, 1997. The following is a list of the dates when wildlife surveys were performed at the SSFL:

Survey Periods

July 5-7, 1995	May 6-8, 1996
October 23-27, 1995	July 29-31, 1996
December 11-15, 1995	January 14-15, 1997
March 11-15, 1996	February 6, 1997

All habitats were visited, but no trapping or quantitative surveys were performed. All animal species observed were identified and recorded. Nomenclature for birds, mammals, reptiles, and amphibians conforms to Laudenslayer et al. (1991) and for fish to the American Fisheries Society (AFS 1991).

SECTION 3
EXISTING CONDITIONS OF SSFL

3.1 PHYSICAL SETTING

The SSFL is located 29 miles northwest of downtown Los Angeles, California, in the southeast corner of Ventura County (Figure 1-1). The SSFL occupies approximately 2,700 acres of hilly terrain, with approximately 700 feet of topographic relief near the crest of the Simi Hills. The Simi Hills are bordered on the east by the San Fernando Valley and to the north by the Simi Valley. Most of the land adjacent to the site property is undeveloped and mountainous. About 73 percent of the area within a 5-mile radius of the site is undeveloped. Figure 1-2 shows the general geographic location, property lines, and topography of the facility.

The facility is divided into four administrative areas (Areas I, II, III, and IV) and an open space (Figure 1-3). The areas are owned and operated as follows (SAIC 1991):

- Area I (U.S. Environmental Protection Agency [USEPA] ID Number CAD 093365435) consists of 713 acres located in the northeast portion of the facility. Rocketdyne operates the entire area. Rocketdyne owns 671 acres, and the remaining 42 acres are owned by the National Aeronautics and Space Administration (NASA). The 42-acre NASA property in Area I was formerly owned by the U.S. Air Force.

- Area II (USEPA ID Number CAD 1800090010) consists of 410 acres located in the north-central portion of the site. Area II is owned by NASA and operated by Rocketdyne.

- Area III (USEPA ID Number CAD 093365435) consists of 114 acres and is owned and operated by Rocketdyne.

- Area IV (USEPA ID Number CAD 000629972 and CA 3890090001) consists of 290 acres located in the northwest section of the site. Rocketdyne owns and operates the entire area. A portion of Area IV (90 acres, which houses the Energy Technology Engineering Center [ETEC], a division of the Department of Energy [DOE]), is leased by the DOE and operated by Rocketdyne under an option to buy contract with the DOE. Five National Pollutant Discharge Elimination System (NPDES) discharge points and drainage channels are located in Area IV.

- The open space consists of 1,200 acres of undeveloped land along the southern boundary of the facility. This naturally vegetated area is owned by Rocketdyne. Industrial activities have never been conducted in this area. Two NPDES discharge points and drainage channels are located in the open space.

3.2 CLIMATE

The climate in the vicinity of the SSFL is classified as Mediterranean subtropical, with mean temperatures ranging from 50°F in the winter to 70°F in the summer. Precipitation on the property averages approximately 18 inches per year, based on meteorological data obtained from the weather station located at the SSFL (ICF 1993a-c).

3.3 SOILS

The soils at the SSFL consist primarily of Quaternary alluvium and the Chatsworth Formation (ICF 1993a-c). Quaternary alluvium is composed of unconsolidated sand, silt, and clay eroded primarily from the surrounding Chatsworth Formation. Depth of the alluvium ranges from a few feet to approximately 40 feet. The Chatsworth Formation is a very thick unit of sandstone bedrock, reaching up to 6,000 feet in thickness within the vicinity of the SSFL. This soil type forms the many sandstone cliffs and lenses that comprise the rock outcrop habitat located throughout the property.

3.4 SURFACE WATER HYDROLOGY

The majority of Areas I, II, III and IV and the open space drain offsite to the south and southwest, and the northern portion of Areas I, II, III, and IV drain to the north (Edelman 1991). Surface water also accumulates in several man-made ponds located throughout the facility, the largest of which is the Silvernale Reservoir (SWMU 6.8) located on the west side of the property. Figure 3-1 (map pocket) shows the known surface water drainages and impoundments on the SSFL (these features are designated as drainages and open water habitat in Figure 3-1). The surface water holding ponds also collect runoff from site-related activities, and recycled water is also pumped into Silvernale Reservoir. The pond associated with the Building 56 Landfill (SWMU 7.1) site is man-made and reportedly the result of digging into the water table while attempting to construct the foundation of the building (Ueshiro 1995).

3.5 GROUND-WATER HYDROLOGY

Ground water is associated with the two geological formations that occur onsite. Shallow ground water is associated with the Quaternary alluvium layer and generally occurs within canyons and drainages on the facility. Deep ground water is associated with the Chatsworth Formation and is the dominant ground-water system on the property.

The amount of ground water associated with these systems varies with seasonal precipitation. Depth of the shallow ground water ranged from approximately ground surface to 39.3 feet below ground surface (bgs) during 1994 (GRC 1995). The shallow ground-water flow essentially follows the natural topography.

The deep ground water associated with the Chatsworth Formation has been pumped for use at the facility since the 1950's and has affected the depth of the local water table (ICF 1993a-c). The depth of ground water in the Chatsworth Formation ranged from near ground surface to 619.1 feet bgs during 1994 (GRC 1995). A ground-water divide occurs in Area IV, where ground water on the northwest half of Area IV flows to the northwest, and ground water southeast of the divide flows to the east-southeast. Ground-water contours also indicate that ground water in the southwest portion of Area III flows to the southwest. Historic pumping and operation of ground-water extraction and treatment systems since 1987 had created a cone of depression in the ground water in the center of the SSFL. Additional ground-water divides have been identified north and south of the cone of depression.

3.6 BIOLOGICAL FEATURES

Information on vegetation and wildlife was obtained through field reconnaissance surveys conducted in June, July, October, and December 1995, in March and May 1996, and in January and February 1997. The focus of the surveys was to provide information on the biological communities found at the SSFL facility and to identify sensitive biological resources present at the various sites at the SSFL.

3.6.1 Vegetation Communities and Habitat Types

Within the SSFL and open space, 16 different habitat types occur: freshwater marsh, open water, unvegetated drainage channels, coast live oak woodland, southern coast live oak riparian forest, southern willow scrub, mulefat scrub, baccharis scrub, Venturan coastal sage scrub, chaparral, native grassland, nonnative grassland, ruderal, rock outcrop, eucalyptus woodland, and developed. The 16 habitat types and their site-specific characteristics are discussed in the following sections. Rock outcrop occurs throughout the site and may be found within any of the habitat types. Figure 3-1 presents a vegetation map for the SSFL. Plant species observed onsite are presented in Appendix A.

Freshwater Marsh

Freshwater marsh habitat onsite is dominated by perennial, emergent monocots typically 4.2 to 6.5 feet tall. Freshwater marsh occurs in areas that are permanently flooded by standing freshwater. This habitat is characterized by a complex of cattails (*Typha* sp.), bulrush (*Scirpus* sp.), and toad rush (*Juncus bufonius*).

Open Water and Unvegetated Drainage Channels

Open water consists of ponded water with no emergent vegetation. Unvegetated drainages show obvious signs of channeling, have discernible banks and high water marks and show evidence of scouring. The majority of unvegetated drainage channel habitat occurs in the open space in Bell Canyon and can also be found sporadically across the SSFL.

Southern Coast Live Oak Riparian Forest

This habitat represents an open to locally dense evergreen community dominated by coast live oak, with arroyo willow (*Salix lasiolepis*) occurring to a lesser extent. This community type appears to be richer in herbs and poorer in understory shrubs than other riparian communities (Holland 1986). Southern coast live oak riparian forest is associated with bottomlands and outer floodplains along larger streams and occurs on fine-grained, rich alluvium (Holland 1986). At the SSFL facility, shrub species in this association include poison oak (*Toxicodendron diversilobum*) and broom baccharis (*Baccharis sarothroides*).

Southern Willow Scrub

Southern willow scrub is a riparian habitat consisting of dense, broad-leafed, winter-deciduous thickets. This habitat is dominated by willows (*Salix* sp.), with cottonwood (*Populus fremontii*) and sycamore (*Platanus racemosa*) scattered throughout. The dense canopy typically inhibits the development of an understory.

Mulefat Scrub

This habitat on the facility is represented by a herbaceous riparian community dominated by mulefat (*Baccharis salicifolia*) (Holland 1986). This early succession community is maintained by frequent flood disturbance. In the absence of disturbance, most stands could become cottonwood- or sycamore-dominated riparian forests or woodlands. Mulefat scrub is scattered throughout the SSFL.

Coast Live Oak Woodland

Coast live oak woodland typically occurs on north-facing slopes or in shaded ravines, and intergrades with coastal sage scrub or chaparral on drier sites. This habitat is dominated by coast live oak (*Quercus agrifolia*), which is evergreen and reaches a height of 30 to 80 feet. The shrub layer is poorly developed but includes white-flowered currant (*Ribes indecorum*) and Santa Susana tarplant (*Hemizonia minthornii*). The understory is continuous and dominated by nonnative weedy species. Coast live oak woodland occurs throughout the open space and on a majority of the SSFL.

Venturan Coastal Sage Scrub

This habitat is found from the coastal region south of Point Conception to northern Baja California, extending east to the vicinity of the Cajon and San Gorgonio Passes. Typical stands are fairly dense, with bare ground occurring between shrubs, and occur on dry, rocky slopes, usually below 9,800 feet. The coastal sage scrub habitat at the SSFL facility is dominated by California sagebrush (*Artemisia californica*), black sage (*Salvia mellifera*), and laurel sumac (*Malosma laurina*). Venturan coastal sage scrub occurs mainly on the northwest corner of the open space and throughout the SSFL.

Chaparral

Chaparral is composed of broad-leafed sclerophyllous shrubs that grow about 5 to 10 feet tall and form dense, often nearly impenetrable stands. The plants of this association are typically deep rooted. There is usually little or no understory except in openings; considerable leaf litter accumulates, however. This habitat occurs on dry, rocky, often steep north-facing slopes with little soil. Characteristic shrub species include chamise (*Adenostoma fasciculatum*), sugarbush (*Rhus ovata*), and black sage. Chaparral occurs throughout the open space and the SSFL.

Baccharis Scrub

Baccharis scrub is most often found in recently disturbed areas, such as along roadsides, and is characterized by nearly monotypic stands of coyote bush (*Baccharis pilularis* ssp. *consanguinea*). Other associated species include California sagebrush (*Artemisia californica*), deerweed (*Lotus scoparius*), and weedy, nonnative herbs such as tocalote (*Centaurea melitensis*) and black mustard (*Brassica nigra*).

Native Grassland

Native grassland is characterized by a dense herbaceous cover of perennial, tussock-forming grass species, such as foothill stipa (*Stipa lepida*). Native and introduced annuals occur between the bunchgrasses, often exceeding them in cover (Holland 1986). This association generally occurs on fine-textured clay soils that are moist or wet in winter, but very dry in the summer. In addition to *Stipa*, other species present include blue-eyed grass (*Sisyrinchium bellum*), lilac mariposa (*Calochortus splendens*), and soap plant (*Chlorogalum pomeridianum*). At the SSFL, native grassland occurs primarily as small isolated patches within a matrix of nonnative grassland.

Nonnative Grassland

This habitat is a dense to sparse cover of annual grasses often associated with numerous species of showy-flowered, native annual forbs, especially in years of high rainfall. This association occurs on fine-textured, usually clay soils, which are moist or even waterlogged during the winter rainy season and very dry during the summer and fall. Characteristic species on the facility include slender wild oat (*Avena barbata*), soft chess

(*Bromus mollis*), and red brome (*Bromus rubens*). Nonnative grassland occurs throughout the SSFL.

Ruderal Habitat

Ruderal habitat is comprised of many introduced species that can withstand frequent disturbance and/or has been disturbed by human activities. Many of the species in this community are similar to those found in nonnative grasslands; however, ruderal habitats also have a greater percentage of nongrass species and only sparse coverage of the area. Ruderal habitat on the facility is dominated by deerweed, black mustard, and tocalote. Ruderal habitat is widespread on the northern half of the SSFL.

Rock Outcrop

This habitat consists of rock formations where there is only a minor component, typically less than 15 percent ground cover, of vegetation within the area. Rock outcrop habitat can be important to birds of prey for roosting and nesting, while mammals may create dens in the caves formed by the rocks, and reptiles may potentially live in the cracks of boulders. This habitat occurs throughout the SSFL.

Eucalyptus Woodland

Eucalyptus woodland is often represented by a monotypic stand of eucalyptus trees (*Eucalyptus* sp.) with very little understory. These nonnative trees are usually planted for aesthetic reasons, wind breaks, or as shade trees. One large stand of eucalyptus woodland occurs north of the Instrument and Equipment Laboratories (SWMUs 4.3, 4.4, and AOCs).

Developed

Developed areas are associated with many of the sites. An area is considered developed when buildings, paved roads, or other structures are present with only a minimal amount of vegetation. Small areas of lawn and ornamental bushes are often planted in developed habitats. Although this vegetation does support some wildlife species, the habitat is considered very low quality and is primarily used by introduced, common urban species.

3.6.2 Wildlife

Sixty-nine bird species were detected during surveys of the sites at the SSFL facility. The most frequently observed bird species include scrub jay (*Aphelocoma coerulescens*), yellow-rumped warbler (*Dendroica coronata*), turkey vulture (*Cathartes aura*), red-shouldered hawk (*Buteo lineatus elegans*), northern flicker (*Colaptes auratus*), California quail (*Callipepla californica*), and red-winged blackbird (*Agelaius phoeniceus*). A complete list of bird species observed during surveys of the facility is presented in Appendix C. An additional 19 bird species have been documented by SSFL personnel since 1983 and are presented in Appendix D.

Thirteen mammal species were detected on the property, including mule deer (*Odocoileus hemionus*), bobcat (*Felis rufus*), and San Diego black-tailed jackrabbit (*Lepus californica bennettii*). Ten reptile species, including western whiptail (*Cnemidophorus tigris multiscutatus*) and side-blotched lizard (*Uta stansburiana*), were observed on the facility. Three amphibian species, California slender salamander (*Batrachoseps attenuatus*), Pacific tree frog (*Hyla regilla*), and California toad (*Bufo boreas haliophilus*), were also detected. Two species of fish were observed in the ponds located on the SSFL property. Catfish (probably bullhead, *Ameirus* sp.) and goldfish (*Carassius auratus*) were observed. The catfish and goldfish were introduced to these ponds and are probably a source of food for piscivorous (fish-eating) bird species, such as the great blue heron. A complete list of the fish, amphibians, reptiles, and mammals detected at the SSFL facility is presented in Appendix E.

3.6.3 Sensitive Plants

Plant species are designated as sensitive because of their overall rarity, status, unique habitat requirements, and/or restricted distribution (USFWS 1990). In general, it is a combination of these factors that leads to a sensitivity designation. Sensitivity, as it is used herein, does not refer to an increased response to contaminant effects but refers to plant species listed by the USFWS and CDFG. In addition, the CDFG uses the California Native Plant Society (CNPS) listing to determine candidate species for threatened or endangered status. Two sensitive plant species were observed at the SSFL facility. Santa Susana tarplant is located throughout the facility, and southern California black walnut is primarily located in the Burro Flats area and the west end of the SSFL, with solitary individuals sparsely distributed across the SSFL. The locations of these sensitive plants are shown in Figure 3-2. The sensitive plant species data described in the following sections are summarized in Table 3-1.

The Santa Susana tarplant is listed as rare by the State of California. This shrub typically grows from 2 to 3.5 feet in height on sandstone outcrops. Originally reported from the Santa Susana Pass area, the range of the Santa Susana tarplant is now known to include Castro Peak, Charmlee Park, the vicinity of the Chatsworth Reservoir, and the southwest slope of Calabasas Peak. The primary threat to this sensitive plant species is the continued encroachment of development into its habitat. Botanical surveys conducted for this project located Santa Susana tarplant throughout the SSFL.

Southern California black walnut (*Juglans californica* var. *californica*) is a List 4 CNPS sensitive species (Skinner and Pavlik 1994). List 4 species are defined as those plants that are of limited distribution and whose known populations need to be watched. This deciduous tree typically grows from 15 to 30 feet in height on slopes or canyons from 165 to 3,000 feet elevation. The southern California black walnut is known from the transverse mountain ranges in Ventura and Los Angeles Counties, including the Santa Monica, San Gabriel, and San Bernardino Mountains, and ranges as far south as San Diego County. The principal threat to this sensitive species is urbanization. A population of 23 southern California black walnut trees were located across the Burro Flats area. Four black walnut trees occur adjacent to the ESADA Storage Area (SWMU 7.9). Single California black walnut trees also occur at the Instrument and Equipment Laboratories (SWMUs 4.3, 4.4, and AOC) and in the open space.

3.6.4 Sensitive Wildlife

Fifteen wildlife species were detected on the SSFL property that are considered sensitive by the USFWS or CDFG, or are important indicators of wildlife corridor functions. Locations where sensitive wildlife species were either observed or sign (i.e., tracts, scat) was detected at the facility are shown in Figure 3-2. The following sensitive wildlife species data are summarized in Tables 3-2 through 3-5.

Reptiles

The two-striped garter snake (*Thamnophis hammondi*) is considered a "special animal" by the CDFG. Special animals are defined as biologically rare, very restricted in distribution, or declining throughout their range; as populations in California that are threatened with extirpation; or as species that are closely associated with a habitat that is declining in the state (in this case, aquatic and riparian habitats). The two-striped garter snake is locally common in aquatic habitats from coastal central California to northwestern Baja California. It prefers rocky streams with protected pools, cattle ponds, marshes, vernal pools, and other shallow bodies of water lacking large aquatic predators (Stebbins 1966). Prey includes invertebrates, frogs, tadpoles, and small fish. The two-striped garter snake is active during the day and at dusk, from early spring to late fall. Individuals were observed in or adjacent to aquatic areas on the SSFL.

Birds

The great blue heron (*Ardea herodias herodias*) is considered a “special animal” by the CDFG. This species is the most widespread of all North American herons (Terres 1980) and is found throughout most of California (Zeiner et al. 1990a). The great blue heron commonly occurs throughout the year as a nonbreeder in open water and is less common along rivers, in croplands, pastures, and foothill ponds (Zeiner et al. 1990a). Nearly 75 percent of its diet is fish (Cogswell 1977), and it also eats small rodents, amphibians, snakes, lizards, insects, crustaceans, and small birds (Zeiner et al. 1990a). This species is considered sensitive at nesting colonies because human disturbance and human activity at a colony may cause nest desertion. This species was observed in or adjacent to aquatic areas on the SSFL. There is a moderate potential for this species to nest in any of the secluded tall trees or snags located at the SSFL facility.

Loggerhead shrike (*Lanius ludovicianus*) is considered a "species of special concern" by the CDFG. This is a fairly common breeding species in southern California. It utilizes a variety of habitats, occurring wherever bushes or trees are scattered on open ground. Loggerhead shrike was observed in nonnative grassland habitat. This species is a yearlong resident in southern California and likely nests at the SSFL.

The southern California rufous-crowned sparrow (*Aimophila ruficeps canescens*) is a CDFG “species of special concern.” This species is a resident in Ventura County, preferring grassy or rocky slopes with open scrub at elevations from sea level to 2,000 feet. It forages and nests on the ground, usually near vegetative cover, and maintains year-round territories. This species prefers coastal sage scrub habitats, and its numbers have been reduced greatly by urban development. Rufous-crowned sparrows were observed at the SSFL.

<u>Birds of Prey</u>

Birds of prey (raptors) as a group are considered sensitive because of loss of foraging areas, their vulnerability to human disturbance, their low population densities, and their position at the top of the food chain. Several species were observed flying over the facility and presumably forage there. Impacts to nesting raptors are covered under specific CDFG permits for take of nesting raptors.

The sharp-shinned hawk (*Accipiter striatus velox*) is considered a “species of special concern” by the CDFG and is distributed throughout North America, Central America, and South America. In California, it is a fairly common migrant and winter resident, although its breeding distribution is poorly documented (Zeiner et al. 1990a). The San Jacinto Mountains north of San Diego County are the documented southern breeding range of this species. During winter, it occupies a variety of habitats and requires a certain amount of dense vegetative cover, but this can be localized and scattered through relatively open country. The sharp-shinned hawk often darts out from a perch to capture unsuspecting avian prey and also hunts in low gliding flights (Zeiner et al. 1990a). One individual of this species was observed flying over the Expendable Launch Vehicle (ELV) Final Assembly Building 206 (SWMU 5.2) during surveys of the property; additionally, SSFL personnel have documented a sighting of this species in the vicinity of the STL-IV Area (SWMU 6.5) in June 1987.

The Cooper's hawk (*Accipiter cooperii*) is considered a "species of special concern" by the CDFG and nests primarily in oak woodlands but occasionally in willows or eucalyptus. This species breeds from late March through June and nests primarily in oak woodlands and occasionally in willows or eucalyptus. Outside of the breeding season, it disperses widely from southern Canada to northern Mexico. It has declined as a breeding species in California primarily because of destruction of oak and riparian woodland. A male and female Cooper's hawk were observed roosting in the oak woodland habitat in the open space and are likely to nest there.

The red-shouldered hawk (*Buteo lineatus elegans*) is common in southern California, occurring in wooded areas on the coastal plain. This species does not have any sensitivity status at the federal level, although the state regulates the removal of any active nesting locations. The red-shouldered hawk, a carnivore at the top of the food web, is an important indicator of wildlife habitat quality. It readily adapts to wooded urban settings such as parks, rural residential areas, and wooded business parks. Breeding season for these tree-nesting hawks is midwinter through midspring. A single, recently fledged red-shouldered hawk was observed perched on top of a tall test stand at the STL-IV Area (SWMU 6.5), suggesting that nesting occurs on the SSFL property.

The red-tailed hawk (*Buteo jamaicencis*) is probably the most common hawk in urban fringe areas. Similar to the red-shouldered hawk, removal of this species' nest are regulated by the state. In addition, as a carnivore at the top of the food web, the red-tailed hawk is an important indicator of wildlife habitat quality. Several red-tailed hawks were observed flying over the SSFL property.

The turkey vulture (*Cathartes aura*) is considered a declining species in the region, having been eliminated from all coastal sites where it formerly nested. This raptor species is considered sensitive by the CDFG at nesting locations. This species is a fairly common spring and fall migrant in southern California, an uncommon to locally common winter visitor, and a rare to uncommon summer resident. Several turkey vultures were observed roosting on several rock ledges and circling over all portions of the SSFL facility. Based on these observations, there is a moderate potential that they nest onsite, and the species presumably forages throughout the property.

The great horned owl (*Bubo virginianus*) is a fairly common species, occurring in woodlands and forests, often adjacent to open hunting areas. It can also be found foraging and nesting in urban fringe areas. This species does not have any sensitivity status at the state and federal levels other than the regulations covering impacts to raptor nests. The great horned owl is a carnivore at the top of the food chain, and as such it is an important indicator of wildlife habitat quality. Two great horned owls were observed roosting at the top of a power pole northeast of Building 901 at the west end of the Bowl Area and Building 901 Leach Field (SWMU 4.15 and AOC), and were observed nesting adjacent to the Bowl Area.

Mammals

The bobcat (*Felis rufus*) is considered a “harvest species” by the CDFG. A "harvest species" is a CDFG wildlife management term defined as a commercially valuable fur-bearing or trophy animal whose population size or distribution may be influenced by trapping and hunting pressure, as well as habitat loss, and whose relative abundance within a region is a good indicator of the diversity of the ecosystem. The bobcat’s position at the top of the food chain makes it an important indicator of the wildlife habitat quality and wildlife corridor functions. Home range studies conducted by Zezulak and Schwab (1980) in Riverside County indicated home ranges of 1.8 to 20.7 square miles (1,152 to 13,248 acres) with a mean of 10.3 square miles (6,592 acres). Bobcats are, for the most part, nocturnal and require cover and den sites such as rock caves, hollow logs, or very dense brush. Prey includes rabbits, rodents, birds, and occasionally deer. Bobcats also require access to a water source. Bobcat and their sign (e.g., scat and tracks) have been observed throughout the SSFL and open space.

The mule deer (*Odocoileus hemionus*) is considered a “harvest species” by the CDFG. In California, mule deer occur throughout the state with the exception of the San Joaquin Valley and some southeastern desert areas. Locally, mule deer inhabit a variety of habitats, including riparian and oak woodlands, coniferous forest, coastal sage scrub, and chaparral. Suitable habitat is a mosaic of vegetation, providing clearings interspersed with dense brush or tree thickets. Brushy areas and thickets are important for escape cover and thermal regulation. Deer also require a permanent source of water. Mule deer browse and graze, preferring tender new growth of various shrubs such as ceanothus, mountain mahogany, and bitterbrush. Forbs and grasses are important in spring, and mule deer feed heavily on acorns when available, primarily in autumn. They also dig out subterranean mushrooms and commonly frequent salt or mineral licks.

Local populations of mule deer are dispersed and seldom form herds. The usual groups consist of a doe with her fawn or a doe with twin fawns and a pair of yearlings. Bucks usually are solitary. Mule deer establish home ranges to which they restrict their movements. Natural predators of deer include mountain lions, coyotes, and bobcats. Deer populations can decline in response to fragmentation, degradation, or destruction of habitat. Movement corridors may be instrumental in maintaining population continuity and allowing the dispersal of juveniles. Several individuals and sign (i.e., tracks, scat) were observed throughout the SSFL.

The San Diego black-tailed jackrabbit (*Lepus californica bennettii*) is considered a "species of special concern" by the CDFG. This species is found from the coast to the western slope of the coastal mountains up to 6,000 feet. It inhabits open land but requires some shrubs for cover. Typical habitats include early stages of chaparral, open coastal sage scrub, and grasslands near the edges of brush. Grasses and forbs are the rabbit's preferred foods. Chew and Chew (1970) reported a diet of 65 percent shrub browse and 35 percent herbage. Breeding occurs throughout the year, and young are born under shrubs with no special nest structure. Home ranges averaging 45 acres have been recorded in California (Lechleitner 1958). One San Diego black-tailed jackrabbit was observed at the STL-IV Area (SWMU 6.5), and another was observed north of the FSDF (SWMU 7.3).

Species Potentially Occurring at the SSFL

A number of other sensitive wildlife species are either known from the area or have the potential to occur at the facility. Species that are considered to have a high potential to occur at the facility are described in the following paragraphs. These species are known from the surrounding area, and suitable habitats are available at the SSFL. Species that are considered to have a low to moderate potential to occur at the facility are described in Appendix E. The potential for these species to occur is typically low to moderate if the study area is at the edge of the known species range or if adequate amounts of suitable habitat are lacking at the SSFL.

Reptiles

The San Diego horned lizard (*Phrynosoma coronatum blainvillei*) is considered a "species of special concern" by the State of California. This subspecies is endemic to extreme southwestern California, occurring from sea level to elevations of over 8,000 feet, and frequents a variety of habitats from sage scrub and chaparral to coniferous and broadleaf woodlands (Stebbins 1966). It is most often found on sandy or friable soils with open scrub. Habitat requirements include open areas for sunning, bushes for cover, and fine loose soil for rapid burial. Harvester ants are the primary food item of the horned lizard and indicate the potential for the lizard to occur in an area. This taxon is primarily active in late spring (April through May) and early summer (June through July) after which individuals typically estivate. Threats to this species include urban development, conversion of habitat to agriculture, and collection of individuals for the pet trade (SDHS 1980). Although no San Diego horned lizards were detected at the facility, suitable habitat and prey items for this subspecies occur at the facility, and the San Diego horned lizard is known to occur within the Santa Susana Mountains. There is a high to moderate probability that the San Diego horned lizard occurs onsite in low numbers.

The coastal rosy boa (*Lichanura trivirgata roseofusca*) is considered a fully protected species by the CDFG. This boa is widely but sparsely distributed throughout desert and chaparral habitats in southern California, ranging from western Los Angeles County to eastern San Bernardino County (Zeiner et al. 1988). It occurs in dry rocky brushlands and arid habitats, usually near intermittent streams, but does not require permanent water. It is secretive and chiefly nocturnal and best surveyed for at night. It is declining as a result of habitat alteration and collection for the pet trade. Habitat requirements include vegetation or rock outcrops for shelter and small mammals or birds for prey. There is a high probability that this species occurs at the facility.

The coast patch-nosed snake (*Salvadora hexalepis virgultea*) is considered a “species of special concern” by the CDFG. The distribution of the coast patch-nosed snake includes the coastal slope of southern California and northern Baja California (Stebbins 1966). The species is found in a variety of habitats from sea level to 7,000 feet, including coastal sage scrub, chaparral, riparian, grasslands, and agricultural fields (Zeiner et al. 1988). Its activity patterns are diurnal and it is active most of the year in southern California. It prefers open habitats with friable or sandy soils and enough cover to escape predation. Burrowing rodents are a preferred food source. This uncommon snake is threatened by intensive agricultural practices and urbanization of its habitat. There is a high probability that the coast patch-nosed snake occurs at the SSFL facility.

Birds

The golden eagle (*Aquila chrysaetos canadensis*) enjoys full federal protection under the Bald Eagle Act and is considered a "species of special concern" by the CDFG. Golden eagles are distributed throughout North America, Eurasia, and North Africa (Johnsgard 1990). Golden eagles occur as breeding residents in the western half of the United States and formerly nested in the northeast (Terres 1980; Johnsgard 1990). This species is an uncommon resident throughout California (Zeiner et al. 1990a). Golden eagles forage in grassy and open shrubby habitats and nest primarily on cliffs, with secondary use of large trees (e.g., oaks and sycamores). Breeding pairs may occupy territories of several square miles, within which they may often use several nest sites, shifting nest sites from year to year. This species has declined regionally because of loss of foraging and nesting habitat to urban and agricultural development, illegal shooting, incidental poisoning of prey species (e.g., ground squirrels and prairie dogs), egg collecting, power line electrocution, and human disturbance at the nest (Snow 1973; Johnsgard 1990; Scott 1985). Facility personnel at the STL-IV Area (SWMU 6.5) documented a golden eagle sighting in November 1989.

Mammals

The ringtail cat (*Bassariscus astutus*) has been given fully protected status by the CDFG. The ringtail cat was previously classified with raccoons in the Procyonidae family but are now placed in their own family, the Bassaricadae. This nocturnal species is seldom observed but is normally associated with steep rocky slopes adjacent to streams. It is also associated with caves and abandoned mines. Home ranges of this species have been estimated at 100 to 1,200 acres (Grinnel et al. 1937). Ringtails require rocky areas not more than 0.6 mile from water. Rocketdyne personnel have reported observation of this species in the Instrument and Equipment Laboratories area in December 1996.

The mountain lion (*Felis concolor*) is considered a “harvest species” by the CDFG, and there is presently a moratorium on mountain lion hunting. Mountain lions typically occur in remote, hilly, or mountainous areas. They require open water sources, such as streams or rock pools, large foraging areas, and rocky shelters or caves for denning. The home range of mountain lions can cover areas as large as 25 to 96 square miles (16,000 to 61,440 acres) for males and 3 to 12 square miles (1,920 to 7,680 acres) for females, with a typical minimum home range of 15 square miles (9,600 acres) per individual (Russell 1978; Hornocker 1970). Mountain lions are chiefly nocturnal but may also be active during the day if undisturbed. This cat is active year-round and may travel up to 25 miles per night in search of food. Prey includes mule deer (up to 60 to 80 percent of diet), rabbits, rodents, coyotes, snakes, and occasionally livestock. Because of its large home range size, this species is susceptible to increased human pressures. No mountain lions were detected at the facility during project surveys, although SSFL personnel have reported sightings. There is a high potential for mountain lions to occur onsite.

The American badger (*Taxidea taxus jeffersoni*) is considered a “species of special concern” and “harvest species” by the CDFG. It is an uncommon resident of level, open areas in grasslands, agricultural areas, and open shrub habitats. It digs large burrows in dry, friable soils and feeds mainly on fossorial mammals: ground squirrels, gophers, rats, mice, etc. Badgers are primarily active during the day but may become more nocturnal when in proximity to humans. The home range of badgers has been measured at 1,327 to 1,549 acres for males and 338 to 751 acres for females in Utah (Lindzey 1978), and 400 to 600 acres in Idaho (Messick and Hornocker 1981). Mating occurs in late summer or early fall, and two to three young are born 183 to 265 days later in March or April (Long 1973). Badgers are known to live at least 11 to 15 years (Messick and Hornocker 1981). Threats to badgers include urban and agricultural development of habitat and possibly excessive trapping and persistent poisons in prey in some areas (Zeiner et al. 1990b). The American badger has been reported by SSFL personnel to have occurred historically onsite; due to its large home range size, it is very difficult to observe. There is a high probability that the American badger occurs at the SSFL facility.

The San Diego desert woodrat (*Neotoma lepida intermedia*) is a “species of special concern” in the state of California. Like other woodrats, it constructs large middens, usually of small twigs, cactus pads, and other plant material. Middens are often constructed under patches of prickly pear or cholla (*Opuntia* spp.), in rock outcrops, or under low trees. Although the middens are easily detectable and several were observed on the SSFL property, trapping is usually necessary to distinguish between the middens of the dusky-footed woodrat (*Neotoma fuscipes*) and those of the desert woodrat. The primary threat to this species is urbanization and habitat degradation. There is a high probability that the San Diego desert woodrat occurs at the SSFL facility.

3.6.5 Habitat Quality

The wildlife and vegetative habitats at the SSFL facility are generally considered to be of high quality. Habitat quality is positively influenced by the availability of several sources of water at the site, relative size of the open space on the property, biological and physical diversity, and connections to larger areas of open space.

Water can play an important role in determining the habitat quality of a site. Areas that have a readily available source of water typically support those vegetative habitats that in turn are able to support a wide variety of wildlife species. Sources of water at the facility include areas of open water such as Silvernale Reservoir and several ponds, perennial springs, and streams scattered across the facility. These permanent sources of water are high quality resources that may attract wildlife from adjacent open space areas.

The undeveloped areas within the SSFL facility, both in the open space and the natural areas surrounding the developed site areas, consists of a large area of diverse habitats. This diversity is reflected in a wide variety of floral and faunal species occurring at the site. The habitat and species diversity associated with the SSFL property, the physical attributes of the facility, and its geographic location makes the area a potentially important route for effective movement from floral and faunal source units (large habitat areas from which species can migrate to repopulate or maintain current populations in more restricted areas). According to recent studies of wildlife movement within the Santa Susana Mountains, the open space associated with the site may play an important role as a habitat linkage between the Santa Susana Mountains, the Simi Hills, and possibly the San Gabriel Mountains (Edelman 1991; Envicom 1993).

3.6.6 Trophic Relationships

Trophic relationships refer to the interaction of one organism with another on a predator/prey basis; this relationship is often shown as a food web or chain. Positions within the web may include:

- Primary producer – a photosynthetic plant
- Herbivore or primary consumer – the first animal which feeds on a plant
- Secondary consumer – an animal feeding on an herbivore
- Tertiary consumer – an animal feeding on a secondary consumer

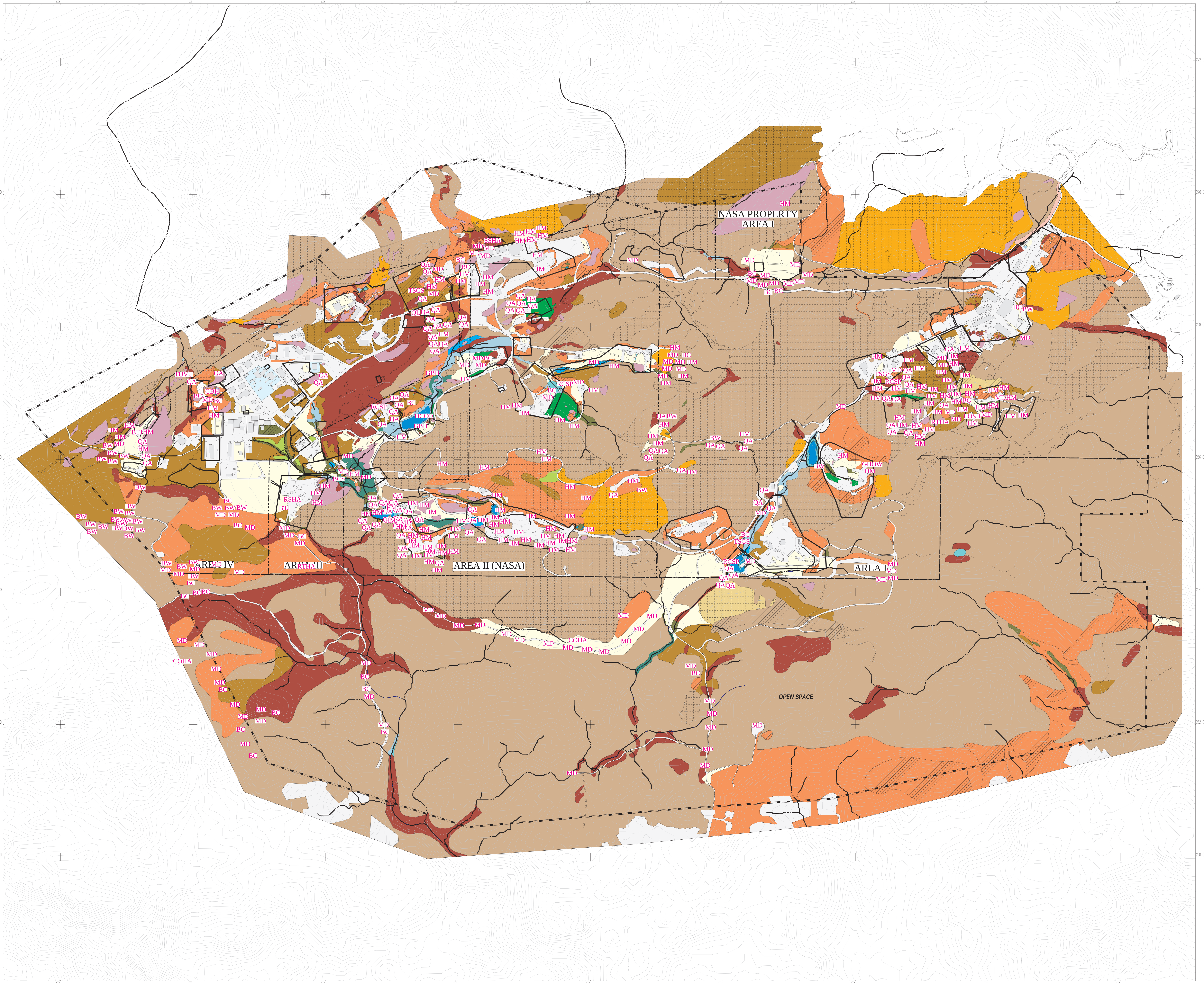
Trophic relationships are useful for determining the flow of energy and matter within an ecosystem and for modeling potential chemical exposure through the food web. The food web model developed for the SSFL illustrates trophic relationships among species found on the SSFL (Figure 3-3).

In the trophic model developed for the SSFL, aquatic and terrestrial plants are identified as primary producers. That is, they rely on solar energy and nutrients in the soil, sediment, and/or water for growth and reproduction. Mammals, reptiles, amphibians, fish, birds, and invertebrates are considered herbivores if they eat plants. Some of these animals, such as birds or fish, are also considered secondary consumers; birds and fish may eat portions of a plant as well as consume species such as invertebrates. Tertiary consumers include carnivorous species such as bobcats, raptors, snakes, toads, and fish.

A complete food chain for the SSFL may include plants, rabbits that eat the plants, and bobcats that eat the rabbits. Another example is that of a piscivorous bird that feeds on fish, which feeds on other fish, invertebrates, and plant matter.

Vegetation Map with Sensitive Species

Santa Susana Field Laboratory



- VENTURAN COASTAL SAGE SCRUB
- VENTURAN COASTAL SAGE SCRUB/CHAPARRAL
- BACCHARIS SCRUB
- CHAPARRAL
- CHAPARRAL/COAST LIVE OAK WOODLAND
- NONNATIVE GRASSLAND
- NATIVE GRASSLAND
- COAST LIVE OAK RIPARIAN FOREST
- COAST LIVE OAK WOODLAND
- FRESHWATER MARSH
- MULEFAT SCRUB
- SOUTHERN WILLOW SCRUB/MULEFAT SCRUB
- SOUTHERN WILLOW SCRUB
- OPEN WATER
- RUDERAL HABITAT
- ROCK OUTCROP
- DEVELOPED
- DISTURBED VEGETATION OVERLAY
- VEGETATION WITH ROCK OUTCROPS OVERLAY
- Drainages

Legend

Sensitive Wildlife

MD	MULE DEER
BC	BOBCAT
TUVU	TURKEY VULTURE
RSHA	RED-SHOULDERED HAWK
BTJ	S.D. BLACK-TAILED JACKRABBIT
RTHA	RED-TAILED HAWK
GBH	GREAT BLUE HERON
GHOW	GREAT HORNED OWL
SSHA	SHARP-SHINNED HAWK
RCSP	RUFOUS-CROWNED SPARROW
DCCO	DOUBLE-CRESTED CORMORANT
TSGS	TWO-STRIPED GARTER SNAKE
COHA	COOPER'S HAWK
LOSH	LOGGERHEAD SHRIKE

Sensitive Plants

HM	SANTA SUSANA MOUNTAIN TARPLANT
BW	SOUTHERN CAL. BLACK WALNUT
QA	VALLEY OAK
QL	COAST LIVE OAK

MAP NOTES:
1. AMEC Earth and Environmental. 2003. Standardized Risk Assessment Methodology Workplan, Surficial Operable Unit, Revision 1, Santa Susana Field Laboratory, Ventura County California. (Biological Conditions Report, Appendix C.) In preparation.
2. Map coordinates in Stateplane, NAD 27, Zone V.
3. Species locations not necessarily to scale.

N

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FIGURE
3-1

Figure 3-2

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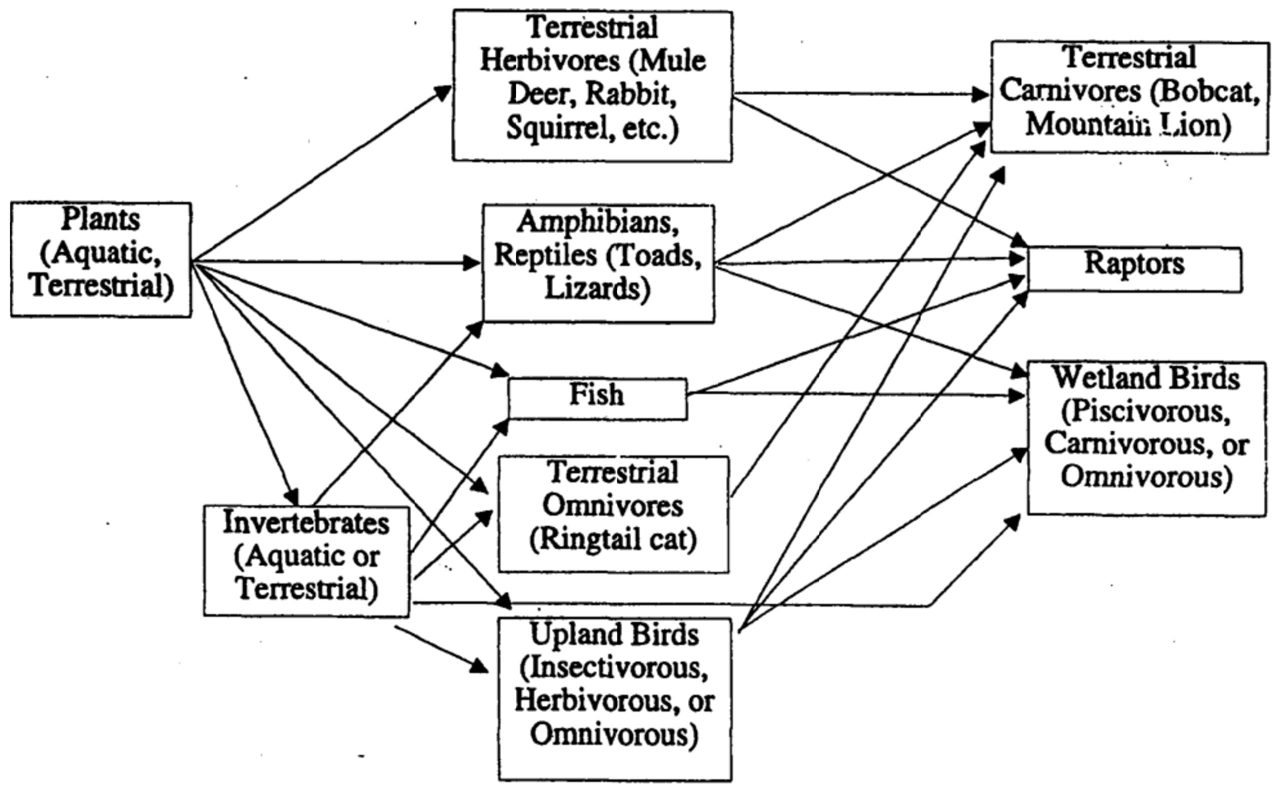

OGDEN

Trophic Model for the Rocketdyne Santa Susana Field Laboratory Facility

FIGURE 3-3

Table 3-1

SENSITIVE PLANT SPECIES OBSERVED OR POTENTIALLY OCCURRING AT THE SSFL FACILITY

Species Name	State Status	Federal Status	Likelihood of Occurrence*
Santa Susana tarplant (*Hemizonia minthornii*)	Rare	--	Observed throughout the SSFL primarily on rock outcrops.
Southern California black walnut (*Juglans californica* var. *californica*)	Candidate (CNPS List 4)	--	Observed 23 trees in the vicinity of Burro Flats and west of the STL-IV Area (SWMU 6.5). Four individuals adjacent to the ESADA Storage Area (SWMU 7.9), and individual trees observed across the SSFL.
Braunton's milkvetch (*Astragalus brauntonii*)	Candidate (CNPS List 1B)	Endangered	Not observed. Suitable habitat present onsite but low potential to occur. Known from fewer than ten extant occurrences, none of which are at or adjacent to the SSFL.
Plummer's mariposa lily (*Calochortus plummerae*)	Candidate (CNPS List 1B)	--	Not observed. Low potential to occur in chaparral habitat onsite. Less common at higher elevations. Has been reported in area of the SSFL but not on or immediately adjacent to the SSFL.
San Fernando Valley spineflower (*Chorizanthe parryi* var. *fernandina*)	Candidate (CNPS List 1A)	Candidate	Not observed. Extremely low potential to occur onsite. Presumed to be extinct.
Santa Monica Mountains dudleya (*Dudleya cymosa* ssp. *ovatifolia*)	Candidate (CNPS List 1B)	Threatened	Not observed. Low potential to occur onsite. Known from fewer than ten occurrences, none of which are at or adjacent to the SSFL.
Many-stemmed dudleya (*Dudleya multicaulis*)	Candidate (CNPS List 1B)	--	Not observed. Low potential to occur in the coastal sage scrub and chaparral habitats onsite. Not reported to occur at or adjacent to the SSFL.

*Likelihood of occurrence is based on known species range and the presence and quality of suitable habitat.

Table 3-2

SENSITIVE REPTILE SPECIES OBSERVED OR POTENTIALLY OCCURRING AT THE SSFL FACILITY

Species Name	State Status	Federal Status	Likelihood of Occurrence*
San Diego horned lizard (*Phrynosoma coronatum blainvillei*)	Species of Special Concern	--	Not observed. High potential to occur in appropriate habitat at the SSFL. Known to occur within the Santa Susana Mountains.
Silvery legless lizard (*Anniella pulchra pulchra*)	Species of Special Concern	--	Not observed. Moderate potential to occur in appropriate habitat (chaparral and coastal scrub) at the SSFL.
Coastal rosy boa (*Lichanura trivirgata roseofusca*)	Protected	--	Not observed. High potential to occur in appropriate habitat (rocky chaparral-covered hillsides and canyons) at the SSFL.
Coast patch-nosed snake (*Salvadora hexalepis virgultea*)	Species of Special Concern	--	Not observed. High potential to occur in appropriate habitat (coastal chaparral) at the SSFL. Widely distributed throughout California.
Two-striped garter snake (*Thamnophis hammondi*)	Special Animal	--	Observed at the Old Conservation Yard (SWMU 7.4), the LETF (SWMU 4.12), the Bravo Area (SWMUs 5.13, 5.14, and 5.15), and at the Perimeter Pond (SWMU 4.17). Expected to occur throughout appropriate habitat at the SSFL.
San Diego mountain king snake (*Lampropeltis zonata pulchra*)	Protected	--	Not observed. Low to moderate potential to occur in the rock outcrop habitat at the SSFL. May be at edge of range.

*Likelihood of occurrence is based on known species range and the presence and quality of suitable habitat.

Table 3-3

SENSITIVE AMPHIBIAN SPECIES POTENTIALLY OCCURRING AT THE SSFL FACILITY

Species Name	State Status	Federal Status	Likelihood of Occurrence*
Western spadefoot toad (*Scaphiopus hammondi*)	Species of Special Concern	--	Not observed. Low to moderate potential to occur at the SSFL. Occurs primarily in native grasslands at lower elevations. Few small patches of native grassland occurs at the SSFL and may not be sufficient to support toad populations.
Southwestern pond turtle (*Clemmys marmorata pallida*)	Species of Special Concern (under review for Protected status)	--	Not observed. Low to moderate potential to occur in the aquatic habitat at the SSFL.
California red-legged frog (*Rana aurora draytoni*)	Species of Special Concern	Threatened	Not observed. Low potential to occur in the aquatic habitat at the SSFL. Uncommon throughout southern California.

*Likelihood of occurrence is based on known species range and the presence and quality of suitable habitat.

Table 3-4

SENSITIVE BIRD SPECIES OBSERVED OR POTENTIALLY OCCURRING AT THE SSFL FACILITY

Species Name	State Status	Federal Status	Likelihood of Occurrence*
Double-crested cormorant (*Phalacrocorax auritus*)	Species of Special Concern	--	Observed on Silvernale Reservoir. There is only a low to moderate probability that this species nests onsite.
Great blue heron (*Ardea herodias herodias*)	Special Animal	--	Observed in freshwater marsh and aquatic habitat at the Silvernale Reservoir adjacent to the SPA (Area II AOC), the Building 56 Landfill (SWMU 7.1), the Bowl Area and Building 901 Leach Field (SWMU 4.15 and AOC), and the CTL-III area (SWMU 4.7). Moderate potential to nest in the large trees at the SSFL.
California gnatcatcher (*Polioptila californica*)	Species of Special Concern	Threatened	Not observed. Low potential to occur in the sage scrub habitat onsite. May be at edge of known range. Focused surveys did not detect gnatcatchers.
Southern California rufous-crowned sparrow (*Aimophila ruficeps canescens*)	Species of Special Concern	--	Observed north of the ECL area (SWMU 6.1, 6.3 and AOC), and between the Alfa Area (SWMUs 5.9, 5.10, and 5.11) and the SPA (Area II AOC).
Loggerhead shrike (*Lanius ludovicianus*)	Species of Special Concern	--	Observed south of the Happy Valley Site (Area II AOC). This species probably nests at the SSFL.
Sharp-shinned hawk (*Accipiter striatus velox*)	Species of Special Concern	--	Observed flying over the ELV Final Assembly Building 206 (SWMU 5.2). Historically documented at the SSFL by Rocketdyne personnel.

Table 3-4

SENSITIVE BIRD SPECIES OBSERVED OR POTENTIALLY OCCURRING AT THE SSFL FACILITY

Species Name	State Status	Federal Status	Likelihood of Occurrence*
Red-shouldered hawk (*Buteo lineatus elegans*) [1]	--	--	Observed evidence of nesting at the SSFL in the vicinity of the STL-IV area.
Red-tailed hawk (*Buteo jamaicencis*) [1]	--	--	Observed roosting in the vicinity of Happy Valley (Area I AOC), and flying over the CTL-III Area (SWMU 4.7), the SPA (Area II AOC), and the Building 56 Landfill (SWMU 7.1).
Turkey vulture (*Cathartes aura*) [1]	--	--	Observed roosting and flying over the entire SSFL and are expected to forage on the property.
Great horned owl (*Bubo virginianus*) [1]	--	--	Observed two owls roosting at the Bowl Area and Building 901 Leach Field (SWMU 4.15 and AOC).
Cooper's hawk (*Accipiter cooperii*)	Species of Special Concern	--	Observed a male and female roosting in the buffer zone. This species has a high probability of nesting onsite.
Golden eagle (*Aquila chrysaetos canadensis*)	Species of Special Concern	Protected	Not observed during biological surveys; however, this species has been historically documented by Rocketdyne personnel.

[1] Although no official status is given for these raptors, raptor nests are protected to varying degrees by separate state regulations. Additionally, raptors are considered important to the ecosystem due to their position at the top of the food chain.

* Likelihood of occurrence is based on known species range and the presence and quality of suitable habitat.

Table 3-5

SENSITIVE MAMMAL SPECIES OBSERVED OR POTENTIALLY OCCURRING AT THE SSFL FACILITY

Species Name	State Status	Federal Status	Likelihood of Occurrence*
Bobcat (*Felis rufus*)	Harvest Species	--	Observed bobcat sign, including scat and tracks, throughout the Buffer Zone and at all the RFI sites except the Bowl Area and Building 901 Leach Field (SWMU 4.15 and AOC). One bobcat was observed foraging in the scrub habitat west of the Perimeter Pond (SWMU 4.17).
Mule deer (*Odocoileus hemionus*)	Harvest Species	--	Observed mule deer or sign, including scat and tracks, throughout the Buffer Zone and at all the RFI sites except the Bowl Area and Building 901 Leach Field (SWMU 4.15 and AOC), the RIHL (SWMU 7.7), and the Former Coal Gasification PDU (SWMU 7.10).
San Diego black-tailed jackrabbit (*Lepus californica bennettii*)	Species of Special Concern	--	Observed one individual at the STL-IV area (SWMU 6.5) and another at the FSDF (SWMU 7.3).
Los Angeles little pocket mouse (*Perognathus longimembris brevinasus*)	Species of Special Concern	(Under review for Endangered or Threatened status)	Not observed. Low to moderate potential to occur in appropriate habitat at the SSFL. A live-trapping study would need to be performed to determine if this subspecies is present at the SSFL.

Table 3-5

SENSITIVE MAMMAL SPECIES OBSERVED OR POTENTIALLY OCCURRING AT THE SSFL FACILITY

Species Name	State Status	Federal Status	Likelihood of Occurrence*
Ringtail (*Bassariscus astutus*)	Protected	--	Reported from Instrument and Equipment Laboratories area in December 1996. Moderate to high potential to occur elsewhere at the SSFL in areas of rock outcrops.
Mountain lion (*Felis concolor*)	Harvest Species	--	Not observed. High potential to occur at the SSFL. Known to occur in the area.
American badger (*Taxidea taxus jeffersoni*)	Species of Special Concern, Harvest Species	--	Not observed. High potential to occur at the SSFL. Known to occur in the area.
San Diego desert woodrat (*Neotoma lepida intermedia*)	Species of Special Concern	--	Not observed during biological surveys; however, this species has been historically documented by SSFL personnel.

*Likelihood of occurrence is based on known species range and the presence and quality of suitable habitat.

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APPENDIX J

LARGE HOME RANGE SPECIES EXPOSURE

APPENDIX J
LARGE HOME RANGE SPECIES EXPOSURE
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APPENDIX J

LARGE HOME RANGE SPECIES EXPOSURE

J.1 INTRODUCTION

To complete the Phase I predictive ecological risk assessment for large home range representative species, it is necessary to evaluate their relative exposure across a number of investigational units and across the facility as a whole. This discussion outlines the proposed method for examining the risk to large home range species across the Santa Susana Field Laboratory (SSFL).

There are four representative species at the SSFL with home ranges that are larger than the size of any of the investigational units: bobcat, red-tailed hawk, mule deer, and great blue heron. The remainder of the representative species (e.g., plants, aquatic invertebrates, deer mouse, and thrush) are expected to occupy only one investigational unit. The bobcat, red-tailed hawk, and great blue heron eat a variety of prey species and, therefore, require larger home ranges for foraging. The typical range of home range sizes and diet for these representative species are listed below.

Representative Species	Home Range Size	Diet
Bobcat	1.8 to 20.7 square miles (Zezulak and Schwab 1980)	Mostly rabbits and rodents (75%) with some deer, birds, reptiles, amphibians, invertebrates, and vegetation (Zeiner et al. 1990a)
Red-tailed Hawk	0.3 to 3.8 square miles (Zeiner et al. 1990b)	Small mammals (68%), small birds (17.5%), reptiles and amphibians (7%), and invertebrates (3.2%) (Sherrod 1978)
Mule Deer	0.20 to 1.19 sq. mi. for does (Taber and Dasmann 1958) 0.15 to 3.2 sq. mi. for bucks (Chapman and Feldhammer 1992)	Vegetation (100%)
Great Blue Heron	1.8 to10 miles from nest (Zeiner et al. 1990b, USEPA 1993)	Fish (75%); also small rodents, amphibians, snakes, lizards, insects, crustaceans, and small birds (USEPA 1993, Zeiner et al. 1990b)

There are a variety of developed land and wildlife habitats across the SSFL. The amount of foraging habitat available at each investigational unit will determine the relative proportion of exposure to the large home range species. Based on the types of prey species that the bobcat, great blue heron, and red-tailed hawk forage on and the types of habitats that occur at the SSFL, the most frequently used habitats of these three species are listed below.

Representative Species	Foraging Habitats	Reference
Bobcat	Native and nonnative grasslands, Venturan coastal sage scrub, chaparral, coast live oak woodlands, rock outcrops, coast live oak riparian forest, and southern cottonwood willow riparian forest	Zeiner et al. 1990a
Red-tailed Hawk	Native and nonnative grasslands, Venturan coastal sage scrub, rock outcrops, and ruderal habitat	Zeiner et al. 1990b
Great Blue Heron	Open water, freshwater marsh, undifferentiated wetlands, waters of the U.S., native and nonnative grasslands	Zeiner et al. 1990b

Native and nonnative grasslands are the primary habitats of rodents and all three of the large home range species include rodents in their diets; therefore, they would be expected to forage in these habitats. Bobcats generally use the cover of scrub, rock outcrops, and trees to stalk and capture prey in the open (Zeiner et al. 1990a). Bobcats are not considered to use dense habitat types like Baccharis scrub, or some of the wetland habitats that do not afford adequate cover. Red-tailed hawks forage over open grasslands and fields, over rock outcrops, and in the more open Venturan coastal sage scrub as opposed to the dense chaparral (Zeiner et al. 1990b). Although hawks use woodlands and riparian habitats for perching or nesting, they generally do not forage in these habitats. The great blue heron is expected to spend the majority of its foraging time in and around the edges of the ponds and marsh, but not in the woodlands (Zeiner et al. 1990b). The herons also may forage in the grasslands on rodents, reptiles, and amphibians.

To calculate the exposure for those species foraging at multiple investigational units, the following assumptions were made:

- To provide a simplified and conservative estimate of risk, the bobcat and red-tailed hawk are assumed to feed exclusively on deer mice. Great blue heron is assumed to ingest a combination of fish, aquatic invertebrates, and deer mice. Great blue heron will not be considered a representative species if aquatic habitat is not present at an investigational unit.

- Large home range species may forage off the SSFL; however, for purposes of this risk assessment, the SSFL is assumed to represent 100 percent of the species home range.

- The chemical concentration calculated for each media (e.g., soil, water, and tissue) evaluated at an investigational unit is assumed to represent chemical concentrations in each of the habitats identified at an investigational unit.

- The fraction of time a large home range species will spend foraging at each investigational unit (i.e., the area use factor) is dependent on the amount of foraging habitat present at an investigational unit.

- Large home range species may spend time off the SSFL; however, for purposes of this risk assessment, each large home range species is assumed to spend 100 percent of their time on the SSFL.

J.2 THREE-STEP PROCESS

The calculation of a representative species exposure and risk at each investigational unit and for the facility as a whole will be an iterative process, progressing from very conservative assumptions to less conservative assumptions. The first and most conservative iteration (Step 1) assumes the large home range species occupies a single investigational unit for 100 percent of its foraging time. The second iteration (Step 2) assumes the large home range species only forages within appropriate habitats encompassing all investigational units (i.e., combined investigational unit risk). The last iteration (Step 3) assumes the large home range species forages in appropriate habitats across the entire facility (as defined by the SSFL property line) and any off-site contaminated areas. Specific steps to calculate risks to large home range species following this iterative process are described below.

J.2.1 Step 1. Calculation of Individual Investigational Unit Risk

Step 1a. Select investigational units for evaluation. Using information provided in the Biological Conditions Report (Appendix I) and methodology described in this SRAM (Sections 9 through 12), select investigational units for evaluation based on (1) appropriate foraging habitat for the large home range species of concern, and (2) the presence of a complete exposure pathway in air, groundwater, soil, sediment, or surface water, of that habitat. Each investigational unit will be evaluated, provided each contains appropriate habitat for the large home range species of concern.

Step 1b. Calculate large home range species exposure at each investigational unit assuming that they forage 100 percent of the time (assume area use factor = 1) at that investigational unit. This step will provide a conservative method for assessing risk presented by a particular investigational unit.

Step 1c. Calculate the hazard quotient (HQ) based on the methodology described in Step 1b above and in Section 12.1.3 of the SRAM. The relative exposure at each investigational unit will be divided by the TRV to calculate the HQ. If any chemicals of potential environmental concern (CPECs) have similar toxic effects (e.g., polyaromatic hydrocarbons [PAHs]), the HQs will be added together to calculate a hazard index (HI). If the individual investigational unit HQ or HI is less than 1, then a decision identifying no risk to large home range species at 100 percent usage can be made for a site; however, the site will still be evaluated as part of the incremental risk to large home range species. The HQ and/or HI values will be used to rank each investigational unit for potential ecological risk. Proceed to Step 2.

J.2.2 Step 2. Calculation of Reporting Area Risk

Step 2a. Calculate exposure of large home range species at all investigational units with appropriate foraging habitat within a Reporting Area. Relative exposure at each investigational unit within a Reporting Area will be calculated with a species-specific adjusted area use factor based on the percent of foraging habitat provided by each investigational unit divided by the total foraging habitat provided by all investigational units within a Reporting Area.

Step 2b. Calculate the HQ based on methodology previously discussed.

Step 2c. Add chemical-specific HQs for each investigational unit to calculate a "total HQ" for the large home range species. If any CPECs have similar toxic effects (e.g., PAHs), the HQs will be added together to calculate a HI. If the combined investigational unit HQ and/or HI is less than 1, then no additional iterations would be necessary. If the "total HQ" and/or HI is greater than 1, further investigation is necessary. The total HQ or HI values will be used to rank each investigational unit for potential ecological risk and to identify potential contamination "hot spots." Proceed to Step 3.

J.2.3 Step 3. Calculation of SSFL-Wide Risk

Step 3a. Identify and quantify acreage of appropriate habitat for large home range species that is not associated with investigational units, but encompasses the entire facility.

Step 3b. Calculate facility-wide exposure assuming the large home range species evaluated in Step 2 also forage in habitats that are not part of investigational units (i.e., exposed across the entire facility, not just contaminated sites). Relative exposure at an investigational unit will be calculated with an adjusted area use factor based on the percent of foraging habitat on each investigational unit and foraging habitat outside the investigational units divided by the total foraging habitat on all investigational units. Because this step incorporates all appropriate habitats available at the SSFL, and not just habitats occurring at a given investigational unit, background concentrations of metals and dioxins will be included in the exposure calculations.

Step 3c. Calculate the HQ and/or HI based on previously described methodology. The resulting HQs will be added for each investigational unit and the areas outside investigational units at the SSFL to calculate a facilitywide total HQ for the large home range species. If any CPECs have similar toxic effects (e.g., PAHs), the HQs will be added together to calculate an HI. This HQ and/or HI can be used to support risk management decisions.

The results of this iterative, large home range species risk assessment will be used to facilitate the risk decision and management processes; as described in Section 12 of the SRAM.

J.3 EXAMPLE LARGE HOME RANGE SPECIES EXPOSURE AND RISK CALCULATIONS (STEPS 1 THROUGH 3)

An example using artificial acreages and the types of habitats on the SSFL for a subset of the investigational units and an artificial chemical data set for the red-tailed hawk is provided in Table 1a. Equations and assumptions used to calculate exposure to the red-tailed hawk are provided below. This example assumes that five investigational units occur at the SSFL with appropriate red-tailed hawk habitat.

Reference Species: Red-tailed Hawk
Home Range: SSFL
Types of Foraging Habitats: Venturan coastal sage scrub, native grassland, nonnative grassland, rock outcrops, and ruderal habitat

The exposure dosage of the red-tailed hawk will be calculated as identified in Section 10 of the SRAM and shown below:

$$D_{rt} = \{(C_d \times R_{rt} \times F_{rtd})/W_{rt}\} \times \Psi_{rt} \times \Theta_{rt} \quad (1)$$

$$R_{rt} = 0.0582 \times W_{rt}^{0.651} \quad (2)$$

$$EPV = D_{rt} \tag{3}$$

$$C_d = C_s \; x \; BSAF \tag{4}$$

where:

D_r	=	daily dosage to red-tailed hawk from prey, mg/kg-day
C_d	=	chemical concentration in deer mouse either measured directly or by equation 4, mg/kg
C_s	=	chemical concentration in soil, mg/kg
BSAF	=	bioaccumulation factors measured at selected sites or estimated from the literature (if necessary) and applied across the SSFL, unitless
R_{rt}	=	food intake rate for red-tailed hawk, 0.066 kg/d
F_{rtd}	=	fraction of deer mouse in red-tailed hawk diet, 1.0 unitless
W_{rt}	=	mean weight of adult red-tailed hawk, 1.2 kg (Dunning 1993)
Ψ_{rt}	=	fraction of year spent at SSFL, unitless
Θ_{rt}	=	fraction of time on SSFL spent in exposure unit, unitless
EPV	=	exposure point value for the red-tailed hawk, mg/kg-day

Table 1a. CHEMICALS OF POTENTIAL ENVIRONMENTAL CONCERN DETECTED IN SOIL SAMPLES AT EACH INVESTIGATIONAL UNIT (ARTIFICIAL DATA)

	95 percent UCL of the Mean Soil Concentration (mg/kg)				
CPECs	Invest. Unit 1	Invest. Unit 2	Invest. Unit 3	Invest. Unit 4	Invest. Unit 5
Lead	500.0	5.0	30.0	15.0	10.0
Zinc	400.0	60.0	40.0	300.0	320.0
PCB	NA	28.0	6.0	NA	1.0
TPH-diesel	2,000.0	2,500.0	500.0	5,000.0	500.0

NA = not sampled or analyzed

Step 1a. The exposure point values (EPVs) are calculated assuming that the red-tailed hawk uses the entire investigational unit, area use factor = 1 (Table 1b). For this example it was assumed that the biota sediment/soil accumulation factor (BSAF) for each chemical in deer mice is 2.

Table 1b. EXPOSURE POINT VALUES CALCULATED WITH AN AREA USE FACTOR OF 1

	EPVs (mg/kg-day)					
CPECs	Invest. Unit 1	Invest. Unit 2	Invest. Unit 3	Invest. Unit 4	Invest. Unit 5	Reference Dose mg/kg-day
Lead	27.12	0.27	1.63	0.81	0.54	0.014[a]
Zinc	21.69	3.25	2.17	16.27	17.36	14.50[b]
PCB	NA	1.52	0.33	NA	0.05	0.09[c]
TPH-diesel	108.47	135.59	27.12	271.18	27.12	50.0[d]

NA = not sampled or analyzed
[a] No observable adverse effect level (NOAEL) for Japanese quail for relatively soluble lead in acetate form (EFA West 1998).
[b] NOAEL for white leghorn chickens (Sample et al. 1996).
[c] NOAEL for Aroclor 1254 for chickens (EFA West 1998).
[d] NOAEL for mouse multiplied by 0.1 to calculate a NOAEL for red-tailed hawk (ATSDR 1993).

Step 1b. An HQ is calculated for each investigational unit. (Table 1c). Based on this calculation, the majority of chemicals on the sites pose a risk (HQ>1). Zinc and diesel do not pose a risk to red-tailed hawks at investigational unit 3 and zinc does not pose a risk at investigational unit 2 (Table 1c). No PCBs were analyzed in investigational units 1 and 4; therefore, there are no HQs. With the conservative area use factor of 1, CPECs pose a risk to red-tailed hawks. The organic CPECs do not have similar toxic effects; therefore, no HIs will be calculated. The HQs for lead and zinc will be summed to calculate an HI for metals at the investigational unit. Based on the total HQ, all contaminants pose a risk to red-tailed hawks.

Table 1c. HAZARD QUOTIENTS FOR RED-TAILED HAWK ASSUMING AREA USE FACTOR OF 1

	HQs					
CPECs	Invest. Unit 1	Invest. Unit 2	Invest. Unit 3	Invest. Unit 4	Invest. Unit 5	Sum HQ
Lead	1,937.1	19.3	116.4	57.6	38.6	2,169
Zinc	1.5	0.22	0.15	1.12	1.2	4.19
PCB	0	16.9	3.67	0	0.56	21.13
TPH-diesel	2.17	2.71	0.54	5.42	1.54	11.84

Step 2a. To determine the combined risk for the red-tailed hawk from feeding across all five investigational units at the facility, the EPV is recalculated using a revised area use factor based on the amount of hawk habitat at each investigational unit divided by the hawk habitat at all the investigational units (see Table 2a):

Table 2a. ACREAGE OF HABITAT TYPES USED BY RED-TAILED HAWKS AT FIVE INVESTIGATIONAL UNITS

Habitats	Invest. Unit 1	Invest. Unit 2	Invest. Unit 3	Invest. Unit 4	Invest. Unit 5	Total Acreage for All Investigational Units at SSFL	Acreage not in an Invest. Unit	Total Acreage for Entire SSFL
Venturan CSS	1.2	1.2	0.3	2.7	2.1	7.5	92.5	100.0
Native Grassland	0	0	0	0	0	0	2.0	2.0
Nonnative Grassland	0.74	0.46	0.56	1.16	0	2.9	22.1	25.0
Rock Outcrops	0.5	1.7	0.2	0	2.4	4.8	70.2	75.0
Ruderal	1.0	0.1	0.2	3.4	1.7	6.3	187.7	200.0
Total Hawk Habitat	3.4	3.4	1.3	7.3	6.1	21.5	380.5	402.0
Fraction Hawk Habitat per investigational unit (refined area use factor by investigational unit)	0.16	0.16	0.06	0.34	0.28	1.00		

CSS = Coastal sage scrub

The revised EPC (EPV_R) for combined investigational unit risk analysis equals the original EPV times the fraction of hawk habitat per investigational unit divided by the sum of hawk habitat for all investigational units (see Table 2b).

Table 2b. REVISED EXPOSURE POINT VALUES CALCULATED WITH AN AREA USE FACTOR BASED ON HAWK FORAGING HABITAT AT EACH INVESTIGATIONAL UNIT

CPECs	EPV_Rs for Evaluating Combined Unit Risks (mg/kg-day)					
	Invest. Unit 1	Invest. Unit 2	Invest. Unit 3	Invest. Unit 4	Invest. Unit 5	Reference Dose mg/kg-day
Lead	4.34	0.04	0.1	0.28	0.15	0.014[a]
Zinc	3.47	0.52	0.13	5.53	4.86	14.50[b]
PCB	0.0	0.24	0.02	0.0	0.02	0.09[c]
TPH-diesel	17.36	21.69	1.63	92.20	7.59	50.0[d]

a,b,c,d = See Table 1b

Step 2b. The HQs for each investigational unit are recalculated based on the EPV_R. The HQs are totaled to estimate the combined investigational unit total HQ for hawks (Table 2c). If the HQs are less then 1, then no further action is recommended. However, the chemical-specific

HQ-totals for hawk exposure across all investigational units are greater than 1; therefore, proceed to Step 3.

Table 2c. HAZARD QUOTIENTS FOR EACH INVESTIGATIONAL UNIT AND THE COMBINED INVESTIGATIONAL UNIT HAZARD QUOTIENT FOR RED-TAILED HAWKS

	HQs					
CPECs	Invest. Unit 1	Invest. Unit 2	Invest. Unit 3	Invest. Unit 4	Invest. Unit 5	Sum HQ
Lead	310	2.86	7.14	20	10.7	350.7
Zinc	0.24	0.04	0.01	0.38	0.34	2.0
PCB	0.0	2.67	0.22	0.0	0.22	3.11
TPH-diesel	0.35	0.43	0.03	1.84	0.15	2.81

Step 3a. To more realistically estimate risk, hawk exposure will be recalculated using a revised area use factor based on the amount of hawk habitat at each investigational unit divided by the hawk habitat across the entire SSFL (see Table 3a). Background concentrations in soil will be multiplied by the site-specific BSAF for mice to identify the exposure concentrations of chemicals outside the investigational units in order to calculate a combined investigational unit exposure.

Table 3a. FRACTION OF RED-TAILED HAWK HABITAT PROVIDED BY EACH INVESTIGATIONAL UNIT COMPARED TO THE ENTIRE SSFL

Habitats	Invest. Unit 1	Invest. Unit 2	Invest. Unit 3	Invest. Unit 4	Invest. Unit 5	Habitat Not in Invest. Units	Total SSFL
Total Hawk Habitat (acres)	3.4	3.4	1.3	7.3	6.1	380.5	402
Fraction (%) Hawk Habitat on SSFL	0.008	0.009	0.003	0.02	0.02	0.95	

A revised EPC (EPV_R) for the facilitywide risk analysis will equal the original EPV times the fraction of hawk habitat per investigational unit divided by the sum of hawk habitat for the entire SSFL facility (see Table 3b).

Table 3b. REVISED EXPOSURE POINT VALUES CALCULATED WITH A REFINED AREA USE FACTOR BASED ON FRACTION OF HAWK HABITAT AT EACH INVESTIGATIONAL UNIT DIVIDED BY THE TOTAL HAWK HABITAT AT THE SSFL

	EPV_Rs for Evaluating Facilitywide Risks (mg/kg-day)						
CPECs	Invest. Unit 1	Invest. Unit 2	Invest. Unit 3	Invest. Unit 4	Invest. Unit 5	Land outside Invest. Units	Reference Dose mg/kg-day
Lead	0.22	0.002	0.005	0.01	0.008	2.0	0.014[a]
Zinc	0.17	0.03	0.007	0.29	0.26	10.0	14.50[b]
PCB	0.0	0.01	0.001	0.0	0.008	0.0	0.09[c]
TPH-diesel	0.09	1.15	0.08	4.88	0.41	0.5	50.0[d]

a,b,c,d = See Table 1b

Table 3c. HAZARD QUOTIENTS FOR EACH INVESTIGATIONAL UNIT AND FOR THE SSFL USING AN AREA USE FACTOR FOR THE RED-TAILED HAWK BASED ON HABITAT AT EACH INVESTIGATIONAL UNIT DIVIDED BY FRACTION OF HAWK HABITAT AT THE SSFL

	HQs						
CPECs	Invest. Unit 1	Invest. Unit 2	Invest. Unit 3	Invest. Unit 4	Invest. Unit 5	Land outside Invest. Units	Sum HQs
Lead	15.7	0.14	0.36	0.71	0.57	142.86	160.34
Zinc	0.01	0.002	0.004	0.02	0.02	0.0007	0.06
PCB	0.0	0.11	0.01	0.0	0.09	0.0	0.21
TPH-diesel	0.02	0.02	0.002	0.1	0.01	0.0	0.15

Step 3b. The HQs and/or HIs for each investigational unit are recalculated based on the facilitywide EPV_R. The HQs are totaled to estimate the facilitywide HQ-total for hawks (Table 3c). If the HQs are less then 1, then no further action is recommended. However, if the chemical-specific HQ totals for hawk exposure across the SSFL are greater than 1, the risk to large home range species will be further evaluated using risk management criteria.

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APPENDIX K

BIOACCUMULATION FACTORS CALCULATIONS

APPENDIX K
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BIOACCUMULATION FACTOR CALCULATIONS

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APPENDIX K

ATTACHMENT K-1

SSFL AQUATIC BIOACCUMULATION FACTOR SELECTION

Appendix K, Attachment K-1 (1 of 2)

SSFL Aquatic Bioaccumulation Factor Selection

	Aquatic Vertebrate							Aquatic Invertebrate							Aquatic Plant						
Chemical	Sample Number	Average BAF[a]	BAF SD[a]	Maximum BAF	Selected BAF (approx. 75th%)[b]	Alternate expression of 75th %[c]	Greater BAF[d]	Sample Number	Average BAF[a]	BAF SD[a]	Maximum BAF	Selected BAF (approx. 75th%)[b]	Alternate expression of 75th %[c]	Greater BAF[d]	Sample Number	Average BAF[a]	BAF SD[a]	Maximum BAF	Selected BAF (approx. 75th%)[b]	Alternate expression of 75th %[c]	Greater BAF[d]
1,2,3,4,6,7,8-HpCDD	4	0.023	0.015	0.044	0.025	0.039	0.039	4	0.076	0.060	0.166	0.054	0.136	0.136	4	0.020	0.008	0.028	0.025	0.028	0.028
1,2,3,4,6,7,8-HpCDF	1	0.043	NA	0.043	0.043	NA	0.043	4	0.077	0.042	0.138	0.073	0.119	0.119	4	0.027	0.010	0.038	0.034	0.037	0.037
1,2,3,4,7,8,9-HpCDF								1	0.073	NA	0.073	0.073	NA	0.073							
1,2,3,4,7,8-HxCDD	4	0.206	0.110	0.369	0.169	0.316	0.316	3	0.235	0.124	0.364	0.226	0.359	0.359							
1,2,3,4,7,8-HxCDF	2	0.127	NA	0.138	0.127	NA	0.127	4	0.279	0.137	0.481	0.243	0.416	0.416							
1,2,3,6,7,8-HxCDD	4	0.292	0.215	0.614	0.211	0.508	0.508	4	0.237	0.128	0.421	0.225	0.365	0.365							
1,2,3,6,7,8-HxCDF	3	0.437	0.045	0.487	0.420	0.481	0.481	4	0.263	0.098	0.401	0.246	0.361	0.361							
1,2,3,7,8,9-HxCDD	4	0.111	0.071	0.216	0.085	0.182	0.182	3	0.194	0.084	0.285	0.175	0.278	0.278							
1,2,3,7,8,9-HxCDF																					
1,2,3,7,8-PeCDD	4	0.845	0.528	1.629	0.682	1.373	1.373	4	0.417	0.158	0.646	0.397	0.575	0.575							
1,2,3,7,8-PeCDF	4	0.610	0.306	1.049	0.558	0.916	0.916	4	0.633	0.378	1.159	0.653	1.011	1.011							
2,3,4,6,7,8-HxCDF	2	0.110	NA	0.121	0.110	NA	0.110	4	0.157	0.064	0.246	0.156	0.221	0.221							
2,3,4,7,8-PeCDF	4	1.155	0.446	1.711	1.267	1.601	1.601	4	0.493	0.201	0.744	0.568	0.695	0.695							
2,3,7,8-TCDD	4	1.709	0.788	2.861	1.497	2.497	2.497	4	0.652	0.170	0.840	0.750	0.823	0.823							
2,3,7,8-TCDF	4	0.744	0.370	1.234	0.821	1.114	1.114	4	1.652	0.892	2.662	2.134	2.544	2.544	1	0.071	NA	0.071	0.071	NA	0.071
Acenaphthene																					
Aluminum	4	0.010	0.007	0.020	0.010	0.018	0.018	4	0.023	0.005	0.028	0.025	0.025	0.025	4	0.094	0.068	0.193	0.079	0.163	0.163
Anthracene																					
Antimony	2	1.794	NA	1.965	1.794	NA	1.794	1	0.258	NA	0.258	0.258	NA	0.258	1	0.539	NA	0.539	0.539	NA	0.539
Arsenic								4	0.224	0.083	0.335	0.222	0.307	0.307	2	0.353	NA	0.360	0.353	NA	0.353
Barium	4	0.075	0.026	0.112	0.070	0.101	0.101	4	1.056	0.323	1.491	1.057	1.379	1.379	4	0.254	0.103	0.375	0.295	0.358	0.358
Benzo(a)anthracene								1	1.103	NA	1.103	1.103	NA	1.103							
Benzo(a)pyrene								1	0.560	NA	0.560	0.560	NA	0.560							
Benzo(b)fluoranthene								1	1.357	NA	1.357	1.357	NA	1.357							
Benzo(e)pyrene																					
Benzo(g,h,i)perylene								1	0.640	NA	0.640	0.640	NA	0.640							
Benzo(k)fluoranthene								2	0.794	NA	1.300	0.794	NA	0.794							
Beryllium								3	0.163	0.023	0.188	0.157	0.186	0.186	1	0.328	NA	0.328	0.328	NA	0.328
Boron								2	0.427	NA	0.525	0.427	NA	0.427	2	1.753	NA	2.191	1.753	NA	1.753
Cadmium																					
Chromium	4	0.171	0.104	0.286	0.226	0.274	0.274	4	0.325	0.116	0.426	0.397	0.397	0.397	4	0.440	0.331	0.930	0.338	0.771	0.771
Chrysene								2	1.068	NA	1.833	1.068	NA	1.068							
Cobalt	1	0.030	NA	0.030	0.030	NA	0.030	4	0.072	0.024	0.091	0.090	0.090	0.090	4	0.138	0.087	0.247	0.169	0.225	0.225
Copper	4	0.103	0.016	0.117	0.115	0.115	0.115	4	2.355	0.720	3.303	2.358	3.075	3.075	3	0.214	0.083	0.310	0.168	0.297	0.297
Dibenz(a,h)anthracene								1	3.158	NA	3.158	3.158	NA	3.158							
Fluoranthene	1	0.089	NA	0.089	0.089	NA	0.089	2	0.834	NA	1.458	0.834	NA	0.834							
Fluorene																					
Indeno(1,2,3-cd)pyrene								1	0.632	NA	0.632	0.632	NA	0.632							
Iron	4	0.013	0.008	0.023	0.013	0.020	0.020	4	0.024	0.005	0.029	0.026	0.026	0.026	4	0.120	0.093	0.258	0.096	0.213	0.213
Lead																					
Magnesium	4	0.232	0.039	0.263	0.255	0.255	0.255	4	0.455	0.078	0.566	0.445	0.533	0.533	4	0.470	0.156	0.593	0.528	0.528	0.528
Manganese	4	0.049	0.035	0.101	0.036	0.084	0.084	4	0.731	0.265	0.990	0.865	0.865	0.865	4	0.580	0.391	0.972	0.861	0.971	0.971
Mercury	4	0.855	0.326	1.270	0.846	1.181	1.181	4	0.244	0.057	0.322	0.248	0.301	0.301	1	0.366	NA	0.366	0.366	NA	0.366
Molybdenum	2	0.756	NA	1.092	0.756	NA	0.756														
Naphthalene	1	5.769	NA	5.769	5.769	NA	5.769														
Nickel	4	0.104	0.059	0.164	0.141	0.163	0.163	4	0.259	0.105	0.342	0.342	0.342	0.342	4	0.335	0.249	0.690	0.318	0.584	0.584
OCDD	4	0.012	0.007	0.020	0.017	0.017	0.017	4	0.083	0.091	0.218	0.049	0.174	0.174	4	0.019	0.008	0.028	0.023	0.027	0.027
OCDF	4	0.014	0.007	0.020	0.018	0.018	0.018	4	0.031	0.009	0.043	0.033	0.040	0.040	4	0.024	0.010	0.034	0.032	0.032	0.032
PCB-105	4	118.425	147.284	324.500	124.118	265.709	265.709	4	10.566	12.505	28.647	8.167	23.071	23.071	3	1.011	0.884	1.673	1.353	1.438	1.438
PCB-114	4	130.112	149.762	328.214	163.333	279.874	279.874	4	15.294	18.176	41.500	12.429	33.470	33.470							
PCB-118	4	145.034	175.205	385.915	162.963	320.239	320.239	4	12.674	13.906	32.222	12.014	26.580	26.580	4	0.693	0.789	1.549	1.179	1.483	1.483
PCB-123	4	168.089	196.729	432.813	201.818	364.817	364.817	4	19.311	21.010	48.273	20.417	40.322	40.322							
PCB-126	4	52.748	62.317	140.769	51.813	115.065	115.065	4	7.364	7.599	17.938	6.992	14.963	14.963							
PCB-128	4	122.362	142.027	308.462	157.742	264.389	264.389	4	1.735	1.301	3.184	2.065	3.036	3.036	2	1.403	NA	1.758	1.403	NA	1.403
PCB-138	4	160.109	186.517	408.636	197.692	346.626	346.626	4	9.757	11.167	25.846	7.418	20.925	20.925	4	0.672	0.774	1.536	1.115	1.446	1.446
PCB-153	4	203.836	221.277	471.642	298.592	425.114	425.114	4	13.247	14.452	33.803	11.030	27.699	27.699	4	0.671	0.747	1.385	1.245	1.245	1.245
PCB-156	4	168.684	200.608	439.091	202.308	369.292	369.292	4	13.118	15.839	35.692	12.091	28.958	28.958	1	1.645	NA	1.645	1.645	NA	1.645
PCB-157	4	126.074	158.697	350.185	126.286	284.772	284.772	4	12.264	12.794	29.429	14.037	25.058	25.058							
PCB-167	4	176.217	206.656	450.000	221.429	382.873	382.873	4	16.433	17.339	39.643	19.082	33.772	33.772							
PCB-170	4	233.887	280.501	610.000	285.833	514.388	514.388	4	8.620	8.719	20.333	9.600	17.339	17.339							
PCB-18	2	5.792	NA	10.273	5.792	NA	5.792	2	0.775	NA	1.527	0.775	NA	0.775	2	0.652	NA	1.195	0.652	NA	0.652
PCB-180	4	211.994	232.153	491.364	314.286	444.147	444.147	4	11.003	11.915	27.893	9.455	22.919	22.919	2	1.289	NA	1.568	1.289	NA	1.289
PCB-187	4	245.275	282.047	611.486	322.222	527.322	527.322	4	15.202	15.249	35.657	16.892	30.450	30.450							
PCB-189	2	15.329	NA	26.633	15.329	NA	15.329	2	3.212	NA	6.194	3.212	NA	3.212							
PCB-195	4	190.458	222.298	478.000	253.529	412.756	412.756	4	5.968	5.683	13.353	7.040	11.651	11.651							
PCB-206	4	117.788	122.264	251.000	191.765	240.052	240.052	4	1.805	1.949	4.588	1.312	3.755	3.755							
PCB-209	4	49.036	50.875	102.727	82.188	99.910	99.910														
PCB-28	2	8.113	NA	13.844	8.113	NA	8.113	2	1.899	NA	3.500	1.899	NA	1.899	1	0.088	NA	0.088	0.088	NA	0.088
PCB-44	4	52.810	62.690	139.063	58.889	115.500	115.500	4	3.004	3.898	8.722	2.006	6.902	6.902	4	1.203	1.284	2.439	2.181	2.181	2.181

Appendix K, Attachment K-1 (2 of 2)

SSFL Aquatic Bioaccumulation Factor Selection

	Aquatic Vertebrate							Aquatic Invertebrate							Aquatic Plant						
Chemical	Sample Number	Average BAF[a]	BAF SD[a]	Maximum BAF	Selected BAF (approx. 75th%)[b]	Alternate expression of 75th %[c]	Greater BAF[d]	Sample Number	Average BAF[a]	BAF SD[a]	Maximum BAF	Selected BAF (approx. 75th%)[b]	Alternate expression of 75th %[c]	Greater BAF[d]	Sample Number	Average BAF[a]	BAF SD[a]	Maximum BAF	Selected BAF (approx. 75th%)[b]	Alternate expression of 75th %[c]	Greater BAF[d]
PCB-52	4	78.234	88.760	198.710	90.313	166.994	166.994	4	7.977	9.826	22.344	4.839	17.804	17.804	4	1.073	1.151	2.213	1.913	1.913	1.913
PCB-66	3	73.858	105.637	195.385	22.190	179.495	179.495	4	8.601	9.869	22.885	5.769	18.469	18.469	4	0.860	0.921	1.808	1.488	1.780	1.780
PCB-77	4	9.057	10.123	22.464	11.200	19.180	19.180	4	5.273	6.047	13.875	4.768	11.320	11.320							
PCB-8	2	5.867	NA	11.250	5.867	NA	5.867														
PCB-81	4	60.326	68.367	154.615	66.077	128.692	128.692	2	1.806	NA	3.515	1.806	NA	1.806							
PCB-90/101	4	100.424	111.626	250.455	119.091	212.049	212.049	4	8.080	9.110	21.182	6.048	17.191	17.191	4	0.607	0.671	1.236	1.136	1.136	1.136
Phenanthrene	2	0.261	NA	0.276	0.261	NA	0.261	3	0.721	0.820	1.667	0.279	1.541	1.541							
Pyrene								2	0.591	NA	1.000	0.591	NA	0.591							
Selenium	4	3.045	1.505	4.824	3.280	4.551	4.551	4	2.598	1.033	3.862	2.945	3.631	3.631	2	2.242	NA	2.532	2.242	NA	2.242
Silver								4	0.697	0.303	1.142	0.636	1.000	1.000							
Thallium								3	0.217	0.074	0.296	0.207	0.291	0.291	2	0.351	NA	0.522	0.351	NA	0.351
Vanadium	4	0.013	0.008	0.024	0.011	0.021	0.021	4	0.029	0.009	0.035	0.035	0.035	0.035	4	0.166	0.118	0.303	0.226	0.284	0.284
Zinc	4	0.297	0.108	0.440	0.309	0.405	0.405	4	0.491	0.165	0.658	0.554	0.657	0.657	4	0.212	0.068	0.304	0.212	0.280	0.280

NA = not applicable

(a) Arithmetic average and Standard Deviation (SD) calculated from BAF samples when Sample Number (N) $\geq$ 3.

(b) Selected BAF (approx. 75th%)- Specific BAFs were calculated for all samples collected. BAF selection based on rank and sample number; N=4, 2nd highest BAF value, N=3 middle BAF value, N=2 the average BAF value and N=1 is the only calculated BAF.

(c) When N = 3 or 4, the average + 1 standard deviation (SD) is an approximation of the 75th percentile BAF.
If the average + SD > maximum measured BAF and N=4, the 2nd from the highest BAF value was reported.
If the average + SD > maximum measured BAF and N=3 the greater of two distribution based approximations, using the following equations, is reported.
1. [(maximum BAF - minimum BAF) x (42/67) + minimum BAF] or 2. [(maximum BAF - middle BAF) x (9/34) + middle BAF]

(d) The greater of the two BAF values which apprioximate the 75th percentile used for the Applied Daily Dose calculation.

APPENDIX K

ATTACHMENT K-2

SSFL TERRESTRIAL BIOACCUMULATION FACTOR SELECTION

Appendix K, Attachment K-2 (1 of 2)

SSFL Terrestrial Bioaccumulation Factor Selection

	Terrestrial Vertebrate							Terrestrial Invertebrate							Terrestrial Plant						
Chemical	Sample Number	Average BAF[a]	BAF SD[a]	Maximum BAF	Selected BAF (approx. 75th%)[b]	Alternate expression of 75th %[c]	Greater BAF[d]	Sample Number	Average BAF[a]	BAF SD[a]	Maximum BAF	Selected BAF (approx. 75th%)[b]	Alternate expression of 75th %[c]	Greater BAF[d]	Sample Number	Average BAF[a]	BAF SD[a]	Maximum BAF	Selected BAF (approx. 75th%)[b]	Alternate expression of 75th %[c]	Greater BAF[d]
1,2,3,4,6,7,8-HpCDD	4	0.142	0.147	0.348	0.147	0.289	0.289	4	0.351	0.192	0.587	0.420	0.543	0.543	4	0.189	0.136	0.340	0.261	0.325	0.325
1,2,3,4,6,7,8-HpCDF	3	0.310	0.218	0.441	0.430	0.433	0.433	3	0.298	0.242	0.577	0.172	0.540	0.540	3	0.202	0.065	0.261	0.212	0.225	0.225
1,2,3,4,7,8,9-HpCDF																					
1,2,3,4,7,8-HxCDD	1	0.238	NA	0.238	0.238	NA	0.238	2	0.780	NA	0.880	0.780	NA	0.780							
1,2,3,4,7,8-HxCDF	1	0.081	NA	0.081	0.081	NA	0.081	1	0.653	NA	0.653	0.653	NA	0.653							
1,2,3,6,7,8-HxCDD	1	0.215	NA	0.215	0.215	NA	0.215	3	0.689	0.175	0.827	0.748	0.769	0.769	1	0.163	NA	0.163	0.163	NA	0.163
1,2,3,6,7,8-HxCDF	1	0.654	NA	0.654	0.654	NA	0.654	1	0.259	NA	0.259	0.259	NA	0.259							
1,2,3,7,8,9-HxCDD	1	0.179	NA	0.179	0.179	NA	0.179	3	0.678	0.256	0.955	0.630	0.934	0.934							
1,2,3,7,8,9-HxCDF																					
1,2,3,7,8-PeCDD								2	0.878	NA	1.073	0.878	NA	0.878							
1,2,3,7,8-PeCDF								2	0.426	NA	0.458	0.426	NA	0.426							
2,3,4,6,7,8-HxCDF	1	0.536	NA	0.536	0.536	NA	0.536	1	0.559	NA	0.559	0.559	NA	0.559							
2,3,4,7,8-PeCDF	1	0.442	NA	0.442	0.442	NA	0.442	2	0.514	NA	0.711	0.514	NA	0.514							
2,3,7,8-TCDD																					
2,3,7,8-TCDF	1	0.187	NA	0.187	0.187	NA	0.187	4	0.609	0.409	1.160	0.594	1.017	1.017							
Acenaphthene								1	2.407	NA	2.407	2.407	NA	2.407							
Aluminum	4	0.071	0.050	0.127	0.097	0.121	0.121	4	0.270	0.138	0.394	0.370	0.370	0.370	4	0.580	0.223	0.769	0.742	0.742	0.742
Anthracene								1	2.818	NA	2.818	2.818	NA	2.818							
Antimony	2	0.584	NA	0.731	0.584	NA	0.584	4	3.705	4.090	9.814	2.099	7.794	7.794	4	4.187	1.178	5.545	4.626	5.365	5.365
Arsenic								3	0.402	0.242	0.637	0.415	0.474	0.474	3	0.706	0.122	0.784	0.770	0.773	0.773
Barium	4	0.314	0.044	0.365	0.332	0.358	0.358	4	1.746	1.055	2.976	2.274	2.801	2.801	4	0.912	0.229	1.110	1.004	1.004	1.004
Benzo(a)anthracene	1	16.106	NA	16.106	16.106	NA	16.106	1	1.894	NA	1.894	1.894	NA	1.894	1	5.238	NA	5.238	5.238	NA	5.238
Benzo(a)pyrene	1	5.938	NA	5.938	5.938	NA	5.938	1	1.000	NA	1.000	1.000	NA	1.000							
Benzo(b)fluoranthene	1	5.250	NA	5.250	5.250	NA	5.250	1	2.043	NA	2.043	2.043	NA	2.043							
Benzo(e)pyrene								1	1.087	NA	1.087	1.087	NA	1.087							
Benzo(g,h,i)perylene	1	4.521	NA	4.521	4.521	NA	4.521	1	0.531	NA	0.531	0.531	NA	0.531							
Benzo(k)fluoranthene	1	7.813	NA	7.813	7.813	NA	7.813	1	0.893	NA	0.893	0.893	NA	0.893							
Beryllium								3	0.240	0.163	0.403	0.240	0.283	0.283	4	0.523	0.186	0.643	0.606	0.606	0.606
Boron	1	11.511	NA	11.511	11.511	NA	11.511	1	4.644	NA	4.644	4.644	NA	4.644	1	7.395	NA	7.395	7.395	NA	7.395
Cadmium								3	9.223	10.463	20.987	5.724	19.686	19.686	3	5.994	4.810	11.544	3.412	10.804	10.804
Chromium	4	0.109	0.036	0.155	0.120	0.145	0.145	4	1.608	1.075	2.631	2.431	2.431	2.431	4	6.529	2.917	10.203	7.314	9.446	9.446
Chrysene	1	6.380	NA	6.380	6.380	NA	6.380	1	1.864	NA	1.864	1.864	NA	1.864	3	1.365	1.418	2.889	1.124	2.784	2.784
Cobalt	4	0.156	0.098	0.290	0.156	0.253	0.253	3	0.186	0.084	0.266	0.194	0.213	0.213	4	0.486	0.223	0.681	0.665	0.665	0.665
Copper	4	0.650	0.105	0.800	0.644	0.755	0.755	4	8.879	5.843	17.300	7.921	14.721	14.721	4	1.709	0.300	1.992	1.878	1.878	1.878
Dibenz(a,h)anthracene	1	16.477	NA	16.477	16.477	NA	16.4773														
Fluoranthene	1	2.344	NA	2.344	2.344	NA	2.344	2	0.905	NA	1.545	0.905	NA	0.905	3	1.318	1.526	3.030	0.824	2.844	2.844
Fluorene								1	3.939	NA	3.939	3.939	NA	3.939							
Indeno(1,2,3-cd)pyrene	1	7.212	NA	7.212	7.212	NA	7.212	1	0.857	NA	0.857	0.857	NA	0.857							
Iron	4	0.062	0.042	0.118	0.068	0.104	0.104	4	0.285	0.169	0.466	0.373	0.454	0.454	4	0.514	0.177	0.677	0.627	0.627	0.627
Lead								2	0.243	NA	0.378	0.243	NA	0.243	4	1.211	0.929	2.598	0.869	2.140	2.140
Magnesium	4	0.644	0.162	0.796	0.748	0.748	0.748	4	0.837	0.353	1.312	0.883	1.191	1.191	4	1.058	0.123	1.187	1.137	1.181	1.181
Manganese	4	0.100	0.051	0.167	0.112	0.151	0.151	4	0.458	0.287	0.738	0.657	0.657	0.657	4	0.805	0.194	0.994	0.850	0.850	0.850
Mercury								3	1.451	1.833	3.561	0.542	3.285	3.285	2	0.816		1.413	0.816	NA	0.816
Molybdenum	4	1.606	1.304	3.535	1.252	2.910	2.910	4	2.883	3.031	7.198	2.711	5.913	5.913	4	7.304	6.276	16.315	6.837	13.579	13.579
Naphthalene																					
Nickel	4	0.093	0.030	0.133	0.094	0.123	0.123	4	1.374	0.949	2.273	2.100	2.100	2.100	4	5.337	2.364	8.619	5.478	7.701	7.701
OCDD	4	0.097	0.117	0.272	0.049	0.214	0.214	4	0.256	0.215	0.569	0.203	0.472	0.472	4	0.154	0.098	0.237	0.234	0.234	0.234
OCDF	3	0.434	0.505	1.005	0.253	0.939	0.939	3	0.231	0.272	0.544	0.103	0.504	0.504	4	0.234	0.099	0.349	0.284	0.333	0.333
PCB-105	4	1.319	1.381	3.030	1.841	2.700	2.700	4	7.467	5.126	12.500	10.364	10.364	10.364	4	2.304	1.199	3.356	3.303	3.303	3.303
PCB-114	3	3.182	3.406	6.829	2.634	6.588	6.588	4	14.086	12.527	30.903	14.691	26.613	26.613	2	3.684	NA	4.346	3.684	NA	3.684
PCB-118	4	1.610	1.593	3.163	2.799	2.799	2.799	4	8.767	5.788	14.444	11.470	11.470	11.470	4	2.272	1.257	3.509	3.152	3.152	3.152
PCB-123	2	3.381	NA	3.454	3.381	NA	3.381	4	6.629	5.958	12.632	10.828	12.587	12.587	2	3.419	NA	3.516	3.419	NA	3.419
PCB-126	2	1.850	NA	2.051	1.850	NA	1.850	4	4.421	2.770	6.768	5.325	5.325	5.325	2	2.226	NA	2.464	2.226	NA	2.226
PCB-128	4	1.466	1.503	2.979	2.537	2.969	2.969	4	3.169	2.052	5.548	3.807	5.221	5.221	4	1.588	1.039	2.830	2.010	2.627	2.627
PCB-138	4	1.379	1.319	2.578	2.458	2.458	2.458	4	3.750	2.369	6.313	4.467	6.119	6.119	4	1.754	1.101	3.000	2.331	2.855	2.855
PCB-153	4	2.411	2.387	4.750	4.180	4.180	4.180	4	5.229	3.231	8.150	7.067	7.067	7.067	4	1.914	1.171	3.178	2.600	3.085	3.085
PCB-156	4	1.883	2.054	4.438	2.656	3.937	3.937	4	4.290	2.633	6.653	5.800	5.800	5.800	4	1.601	0.892	2.560	2.160	2.493	2.493
PCB-157	4	9.542	17.031	35.029	2.676	26.573	26.573	4	3.693	2.179	5.930	4.594	5.872	5.872	4	1.628	1.002	2.871	1.977	2.630	2.630
PCB-167	4	2.683	2.803	5.325	4.886	4.886	4.886	4	4.243	2.527	6.451	5.880	5.880	5.880	4	1.701	1.069	2.946	2.183	2.771	2.771
PCB-170	4	2.271	2.356	4.442	4.173	4.173	4.173	4	2.574	1.665	4.457	3.250	4.239	4.239	4	1.173	0.739	2.059	1.414	1.913	1.913
PCB-18	1	0.065	NA	0.065	0.065	NA	0.065	1	0.142	NA	0.142	0.142	NA	0.142							
PCB-180	4	2.068	2.083	4.484	3.113	4.150	4.150	4	2.455	1.525	3.778	3.587	3.587	3.587	4	1.219	0.864	2.375	1.274	2.082	2.082
PCB-187	4	0.729	0.516	1.270	1.003	1.245	1.245	4	4.885	3.060	8.052	6.419	7.945	7.945	4	1.572	1.184	3.194	1.521	2.755	2.755
PCB-189	3	3.732	3.302	7.102	3.590	7.033	7.033	4	1.857	1.062	2.591	2.386	2.386	2.386	2	2.164	NA	2.568	2.164	NA	2.164
PCB-195	3	1.932	1.423	3.490	1.607	3.355	3.355	4	1.274	0.645	1.929	1.669	1.918	1.918	1	1.021	NA	1.021	1.021	NA	1.021
PCB-206	3	1.387	0.832	2.038	1.673	1.770	1.770	3	0.527	0.450	0.993	0.492	0.977	0.977	1	0.794	NA	0.794	0.794	NA	0.794
PCB-209	3	1.256	1.173	2.540	0.988	2.429	2.429	3	0.991	0.780	1.586	1.278	1.360	1.360	1	2.443	NA	2.443	2.443	NA	2.443
PCB-28								1	1.680	NA	1.680	1.680	NA	1.680	1	7.963	NA	7.963	7.963	NA	7.963
PCB-44								4	3.289	3.991	9.118	2.203	7.280	7.280	4	2.690	1.297	4.441	2.588	3.987	3.987
PCB-52								4	5.671	5.790	13.670	5.720	11.461	11.461	4	2.921	1.522	4.920	3.079	4.442	4.442
PCB-66	4	0.744	0.596	1.349	1.097	1.340	1.340	4	6.276	4.456	10.941	8.356	10.731	10.731	4	2.276	1.250	3.756	2.869	3.526	3.526
PCB-77	1	0.768	NA	0.768	0.768	NA	0.768	4	3.650	2.586	7.000	3.552	6.237	6.237	3	1.936	1.094	2.833	2.258	2.411	2.411

Appendix K, Attachment K-2 (2 of 2)

SSFL Terrestrial Bioaccumulation Factor Selection

	Terrestrial Vertebrate							Terrestrial Invertebrate							Terrestrial Plant						
Chemical	Sample Number	Average BAF[a]	BAF SD[a]	Maximum BAF	Selected BAF (approx. 75th%)[b]	Alternate expression of 75th %[c]	Greater BAF[d]	Sample Number	Average BAF[a]	BAF SD[a]	Maximum BAF	Selected BAF (approx. 75th%)[b]	Alternate expression of 75th %[c]	Greater BAF[d]	Sample Number	Average BAF[a]	BAF SD[a]	Maximum BAF	Selected BAF (approx. 75th%)[b]	Alternate expression of 75th %[c]	Greater BAF[d]
PCB-8	1	0.372	NA	0.372	0.372	NA	0.372	1	0.217	NA	0.217	0.217	NA	0.217							
PCB-81								4	4.216	2.904	6.949	5.981	5.981	5.981	2	3.000	NA	3.322	3.000	NA	3.000
PCB-90/101	4	0.117	0.107	0.232	0.183	0.224	0.224	4	4.943	3.256	7.937	6.188	6.188	6.188	4	2.405	1.211	3.750	3.103	3.616	3.616
Phenanthrene	1	3.356	NA	3.356	3.356	NA	3.356	2	1.845	NA	2.653	1.845	NA	1.845	4	3.350	3.841	8.889	2.889	7.191	7.191
Pyrene	1	3.622	NA	3.622	3.622	NA	3.622	2	2.917	NA	4.750	2.917	NA	2.917	3	0.932	0.974	1.985	0.750	1.906	1.906
Selenium	2	5.817	NA	5.951	5.817	NA	5.817	1	1.842	NA	1.842	1.842	NA	1.842							
Silver								3	6.209	0.422	6.683	6.071	6.631	6.631	2	1.688	NA	2.055	1.688	NA	1.688
Thallium								3	0.615	0.472	1.101	0.586	1.087	1.087	4	0.374	0.138	0.565	0.360	0.511	0.511
Vanadium	4	0.101	0.067	0.182	0.126	0.168	0.168	4	0.235	0.117	0.329	0.324	0.324	0.324	4	0.498	0.192	0.696	0.612	0.690	0.690
Zinc	4	2.271	1.204	4.019	2.106	3.475	3.475	4	1.980	1.145	3.264	2.233	3.125	3.125	4	1.294	0.331	1.766	1.232	1.625	1.625

NA = not applicable
(a) Arithmetic average and Standard Deviation (SD) calculated from BAF samples when Sample Number (N) $\geq$ 3.
(b) Selected BAF (approx. 75th%)- Specific BAFs were calculated for all samples collected. BAF selection based on rank and sample number; N=4, 2nd highest BAF value, N=3 middle BAF value, N=2 the average BAF value and N=1 is the only calculated BAF.
(c) When N = 3 or 4, the average + 1 standard deviation (SD) is an approximation of the 75th percentile BAF.
If the average + SD > maximum measured BAF and N=4, the 2nd from the highest BAF value was reported.
If the average + SD > maximum measured BAF and N=3 the greater of two distribution based approximations, using the following equation, is reported.
1. [(maximum BAF - minimum BAF) x (42/67) + minimum BAF] or 2. [(maximum BAF - middle BAF) x (9/34) + middle BAF]
(d) The greater of the two BAF values which approximate the 75th percentile used for the Applied Daily Dose calculation.

APPENDIX K

ATTACHMENT K-3

DATA USED IN AQUATIC INVERTEBRATE BIOACCUMULATION FACTOR SELECTION

Appendix K, Attachment K-3 (1 of 4)

Data Used in Aquatic Invertebrate Bioaccumulation Factor Selection

CHEMICAL	TISSUE TYPE	TISSUE SAMPLE ID	TISSUE CONCENTRATION (WET WEIGHT)	UNITS	TISSUE VALIDATION QUALIFIER	TISSUE DETECTION LIMIT	SEDIMENT SAMPLE ID	SEDIMENT TYPE	SEDIMENT CONCENTRATION (DRY WEIGHT)	SEDIMENT VALIDATION QUALIFIER	SEDIMENT DETECTION LIMIT
1,2,3,4,6,7,8-HpCDD	AI	R2AI04S01	47.7	pg/g			R2FS04S01	FS	287		
1,2,3,4,6,7,8-HpCDD	AI	R2AI03S01	39.3	pg/g			R2FS03S01	FS	734		
1,2,3,4,6,7,8-HpCDD	AI	R2AI01S01	34.7	pg/g			R2FS01	FS	790		
1,2,3,4,6,7,8-HpCDD	AI	R2AI02S01	39	pg/g			R2FS02S01	FS	957		
1,2,3,4,6,7,8-HpCDF	AI	R2AI04S01	5.38	pg/g			R2FS04S01	FS	39.1		
1,2,3,4,6,7,8-HpCDF	AI	R2AI03S01	7.26	pg/g			R2FS03S01	FS	99.6		
1,2,3,4,6,7,8-HpCDF	AI	R2AI02S01	5.88	pg/g			R2FS02S01	FS	117		
1,2,3,4,6,7,8-HpCDF	AI	R2AI01S01	5.05	pg/g			R2FS01	FS	107.1		
1,2,3,4,7,8,9-HpCDF	AI	R2AI03S01	0.8	pg/g	J		R2FS03S01	FS	10.9		
1,2,3,4,7,8-HxCDD	AI	R2AI04S01	1.43	pg/g	J		R2FS04S01	FS	3.93		
1,2,3,4,7,8-HxCDD	AI	R2AI03S01	1.81	pg/g	J		R2FS03S01	FS	8.02		
1,2,3,4,7,8-HxCDD	AI	R2AI02S01	1.32	pg/g	J		R2FS02S01	FS	11.3		
1,2,3,4,7,8-HxCDF	AI	R2AI04S01	1.15	pg/g	J		R2FS04S01	FS	2.39	J	
1,2,3,4,7,8-HxCDF	AI	R2AI01S01	1.13	pg/g	J		R2FS01	FS	4.645		
1,2,3,4,7,8-HxCDF	AI	R2AI03S01	0.98	pg/g	J		R2FS03S01	FS	4.63		
1,2,3,4,7,8-HxCDF	AI	R2AI02S01	0.96	pg/g	J		R2FS02S01	FS	5.33		
1,2,3,6,7,8-HxCDD	AI	R2AI04S01	6.36	pg/g			R2FS04S01	FS	15.1		
1,2,3,6,7,8-HxCDD	AI	R2AI03S01	7.17	pg/g			R2FS03S01	FS	31.9		
1,2,3,6,7,8-HxCDD	AI	R2AI02S01	6.89	pg/g			R2FS02S01	FS	42.3		
1,2,3,6,7,8-HxCDD	AI	R2AI01S01	5.28	pg/g			R2FS01	FS	37.95		
1,2,3,6,7,8-HxCDF	AI	R2AI04S01	0.85	pg/g	J		R2FS04S01	FS	2.12	J	
1,2,3,6,7,8-HxCDF	AI	R2AI03S01	0.96	pg/g	J		R2FS03S01	FS	3.9		
1,2,3,6,7,8-HxCDF	AI	R2AI01S01	0.92	pg/g	J		R2FS01	FS	3.925		
1,2,3,6,7,8-HxCDF	AI	R2AI02S01	0.77	pg/g	J		R2FS02S01	FS	4.5		
1,2,3,7,8,9-HxCDD	AI	R2AI04S01	2.36	pg/g	J		R2FS04S01	FS	8.27		
1,2,3,7,8,9-HxCDD	AI	R2AI03S01	3.24	pg/g	J		R2FS03S01	FS	18.5		
1,2,3,7,8,9-HxCDD	AI	R2AI02S01	2.81	pg/g	J		R2FS02S01	FS	23.4		
1,2,3,7,8-PeCDD	AI	R2AI04S01	1.55	pg/g	J		R2FS04S01	FS	2.4	J	
1,2,3,7,8-PeCDD	AI	R2AI03S01	1.76	pg/g	J		R2FS03S01	FS	4.43		
1,2,3,7,8-PeCDD	AI	R2AI01S01	1.83	pg/g	J		R2FS01	FS	5.7		
1,2,3,7,8-PeCDD	AI	R2AI02S01	1.79	pg/g	J		R2FS02S01	FS	5.92		
1,2,3,7,8-PeCDF	AI	R2AI04S01	2.84	pg/g	J		R2FS04S01	FS	2.45	J	
1,2,3,7,8-PeCDF	AI	R2AI01S01	2.4	pg/g	J		R2FS01	FS	3.675		
1,2,3,7,8-PeCDF	AI	R2AI02S01	1.65	pg/g	J		R2FS02S01	FS	4.28		
1,2,3,7,8-PeCDF	AI	R2AI03S01	1.83	pg/g	J		R2FS03S01	FS	5.5		
2,3,4,6,7,8-HxCDF	AI	R2AI04S01	0.7	pg/g	J		R2FS04S01	FS	2.85		
2,3,4,6,7,8-HxCDF	AI	R2AI03S01	0.87	pg/g	J		R2FS03S01	FS	5.59		
2,3,4,6,7,8-HxCDF	AI	R2AI01S01	0.74	pg/g	J		R2FS01	FS	5.69		
2,3,4,6,7,8-HxCDF	AI	R2AI02S01	0.63	pg/g	J		R2FS02S01	FS	6.45		
2,3,4,7,8-PeCDF	AI	R2AI04S01	2.5	pg/g	J		R2FS04S01	FS	3.36		
2,3,4,7,8-PeCDF	AI	R2AI01S01	2.13	pg/g	J		R2FS01	FS	3.75		
2,3,4,7,8-PeCDF	AI	R2AI02S01	1.5	pg/g	J		R2FS02S01	FS	4.46		
2,3,4,7,8-PeCDF	AI	R2AI03S01	1.78	pg/g	J		R2FS03S01	FS	5.48		
2,3,7,8-TCDD	AI	R2AI01S01	0.62	pg/g	J		R2FS01	FS	0.7385		
2,3,7,8-TCDD	AI	R2AI04S01	0.27	pg/g	J		R2FS04S01	FS	0.36	J	
2,3,7,8-TCDD	AI	R2AI03S01	0.32	pg/g	J		R2FS03S01	FS	0.59		
2,3,7,8-TCDD	AI	R2AI02S01	0.38	pg/g	J		R2FS02S01	FS	0.795		
2,3,7,8-TCDF	AI	R2AI04S01	15.6	pg/g			R2FS04S01	FS	5.86		
2,3,7,8-TCDF	AI	R2AI01S01	16.1	pg/g			R2FS01	FS	7.545		
2,3,7,8-TCDF	AI	R2AI02S01	9.72	pg/g			R2FS02S01	FS	9.66		
2,3,7,8-TCDF	AI	R2AI03S01	10.7	pg/g			R2FS03S01	FS	13.3		
Aluminum	AI	R2AI01S01	611.724	MG/KG			R2FS01	FS	22184.56085	J	90
Aluminum	AI	R2AI03S01	733.7219	MG/KG			R2FS03S01	FS	28800	J	90
Aluminum	AI	R2AI02S01	643.0556	MG/KG			R2FS02S01	FS	26600	J	90
Aluminum	AI	R2AI04S01	271.7474	MG/KG			R2FS04S01	FS	16790.1739	J	
Antimony	AI	R2AI03S01	0.4649	MG/KG			R2FS03S01	FS	1.8	J	0.2
Arsenic	AI	R2AI01S01	2.0612	MG/KG			R2FS01	FS	6.14655	J	
Arsenic	AI	R2AI03S01	1.4848	MG/KG			R2FS03S01	FS	6.7		
Arsenic	AI	R2AI02S01	1.3892	MG/KG			R2FS02S01	FS	6.8		
Arsenic	AI	R2AI04S01	0.728	MG/KG			R2FS04S01	FS	5.3536	J	
Barium	AI	R2AI04S01	162.0387	MG/KG			R2FS04S01	FS	108.6766		
Barium	AI	R2AI01S01	146.074	MG/KG			R2FS01	FS	138.14025	J	
Barium	AI	R2AI02S01	152.1925	MG/KG			R2FS02S01	FS	159	J	
Barium	AI	R2AI03S01	131.5285	MG/KG			R2FS03S01	FS	183	J	

Appendix K, Attachment K-3 (2 of 4)

Data Used in Aquatic Invertebrate Bioaccumulation Factor Selection

CHEMICAL	TISSUE TYPE	TISSUE SAMPLE ID	TISSUE CONCENTRATION (WET WEIGHT)	UNITS	TISSUE VALIDATION QUALIFIER	TISSUE DETECTION LIMIT	SEDIMENT SAMPLE ID	SEDIMENT TYPE	SEDIMENT CONCENTRATION (DRY WEIGHT)	SEDIMENT VALIDATION QUALIFIER	SEDIMENT DETECTION LIMIT
Benzo(a)anthracene	AI	R2AI04S01	8.6	UG/KG	J		R2FS04S01	FS	7.8	J	
Benzo(a)pyrene	AI	R2AI04S01	8.4	UG/KG	J		R2FS04S01	FS	15	J	
Benzo(b)fluoranthene	AI	R2AI04S01	19	UG/KG	J		R2FS04S01	FS	14		
Benzo(g,h,i)perylene	AI	R2AI04S01	16	UG/KG			R2FS04S01	FS	25		
Benzo(k)fluoranthene	AI	R2AI04S01	13	UG/KG	J		R2FS04S01	FS	10		
Benzo(k)fluoranthene	AI	R2AI01S01	9.8	UG/KG	J		R2FS01	FS	34	J	
Beryllium	AI	R2AI01S01	0.1633	MG/KG			R2FS01	FS	0.8668		
Beryllium	AI	R2AI02S01	0.1729	MG/KG			R2FS02S01	FS	1.1		
Beryllium	AI	R2AI03S01	0.1715	MG/KG			R2FS03S01	FS	1.2		
Boron	AI	R2AI04S01	3.5669	MG/KG			R2FS04S01	FS	6.7929		
Boron	AI	R2AI01S01	3.0976	MG/KG			R2FS01S01	FS	9.4378		
Chromium	AI	R2AI02S01	18.2738	MG/KG			R2FS02S01	FS	42.9	J	
Chromium	AI	R2AI03S01	17.8541	MG/KG			R2FS03S01	FS	45	J	
Chromium	AI	R2AI01S01	10.7463	MG/KG			R2FS01	FS	34.41185	J	
Chromium	AI	R2AI04S01	4.2425	MG/KG			R2FS04S01	FS	25.5232	J	
Chrysene	AI	R2AI04S01	22	UG/KG	J		R2FS04S01	FS	12		
Chrysene	AI	R2AI01S01	13	UG/KG	J		R2FS01	FS	43	J	
Cobalt	AI	R2AI03S01	1.3406	MG/KG			R2FS03S01	FS	14.8	J	
Cobalt	AI	R2AI02S01	1.228	MG/KG			R2FS02S01	FS	13.7	J	
Cobalt	AI	R2AI01S01	0.8049	MG/KG			R2FS01	FS	11.9866	J	
Cobalt	AI	R2AI04S01	0.4108	MG/KG			R2FS04S01	FS	10.3522	J	
Copper	AI	R2AI01S01	110.7506	MG/KG			R2FS01	FS	33.5309	J	2
Copper	AI	R2AI02S01	95.7326	MG/KG			R2FS02S01	FS	40.6	J	2
Copper	AI	R2AI04S01	68.1492	MG/KG			R2FS04S01	FS	31.0081		
Copper	AI	R2AI03S01	80.681	MG/KG			R2FS03S01	FS	51.7	J	2
Dibenz(a,h)anthracene	AI	R2AI04S01	12	UG/KG	J		R2FS04S01	FS	3.8	J	
Fluoranthene	AI	R2AI04S01	35	UG/KG			R2FS04S01	FS	24		
Fluoranthene	AI	R2AI01S01	22	UG/KG			R2FS01	FS	104.5	J	
Indeno(1,2,3-cd)pyrene	AI	R2AI04S01	12	UG/KG	J		R2FS04S01	FS	19		
Iron	AI	R2AI01S01	883.409	MG/KG			R2FS01	FS	30667.42815	J	
Iron	AI	R2AI03S01	1059.1303	MG/KG			R2FS03S01	FS	40600	J	
Iron	AI	R2AI02S01	903.8934	MG/KG			R2FS02S01	FS	37296.0373	J	
Iron	AI	R2AI04S01	403.5741	MG/KG			R2FS04S01	FS	24579.881	J	
Magnesium	AI	R2AI04S01	3294.4665	MG/KG			R2FS04S01	FS	5820.3991		
Magnesium	AI	R2AI01S01	3186.2427	MG/KG			R2FS01	FS	7164.66	J	
Magnesium	AI	R2AI02S01	3581.7333	MG/KG			R2FS02S01	FS	8490	J	
Magnesium	AI	R2AI03S01	3604.5709	MG/KG			R2FS03S01	FS	9330	J	
Manganese	AI	R2AI02S01	441.3493	MG/KG			R2FS02S01	FS	446	J	
Manganese	AI	R2AI01S01	351.936	MG/KG			R2FS01	FS	407.03665	J	
Manganese	AI	R2AI03S01	461.6152	MG/KG			R2FS03S01	FS	668	J	
Manganese	AI	R2AI04S01	164.523	MG/KG			R2FS04S01	FS	434.2689	J	
Mercury	AI	R2AI03S01	0.0967	MG/KG			R2FS03S01	FS	0.3005		
Mercury	AI	R2AI02S01	0.1026	MG/KG			R2FS02S01	FS	0.4134		
Mercury	AI	R2AI01S01	0.0694	MG/KG			R2FS01	FS	0.3288	J	
Mercury	AI	R2AI04S01	0.0367	MG/KG			R2FS04S01	FS	0.1898	J	
Nickel	AI	R2AI02S01	8.3853	MG/KG			R2FS02S01	FS	24.5		
Nickel	AI	R2AI03S01	8.812	MG/KG			R2FS03S01	FS	25.8		
Nickel	AI	R2AI01S01	5.0054	MG/KG			R2FS01	FS	21.56585	J	
Nickel	AI	R2AI04S01	2.1677	MG/KG			R2FS04S01	FS	17.8162	J	
OCDD	AI	R2AI04S01	688	pg/g			R2FS04S01	FS	3150		
OCDD	AI	R2AI01S01	480	pg/g			R2FS01	FS	9850	J	
OCDD	AI	R2AI03S01	303	pg/g			R2FS03S01	FS	8430	J	
OCDD	AI	R2AI02S01	344	pg/g			R2FS02S01	FS	12400	J	
OCDF	AI	R2AI04S01	4.31	pg/g	J		R2FS04S01	FS	101		
OCDF	AI	R2AI03S01	8.13	pg/g			R2FS03S01	FS	250		
OCDF	AI	R2AI02S01	8.75	pg/g			R2FS02S01	FS	314		
OCDF	AI	R2AI01S01	5.62	pg/g	J		R2FS01	FS	273		
PCB-105	AI	SNAI02S01	9.74	ng/g		0.109999999	SNFS02S01	FS	0.34		
PCB-105	AI	SNAI03S01	2.45	ng/g		0.029999999	SNFS03S01	FS	0.3		

Appendix K, Attachment K-3 (3 of 4)

Data Used in Aquatic Invertebrate Bioaccumulation Factor Selection

CHEMICAL	TISSUE TYPE	TISSUE SAMPLE ID	TISSUE CONCENTRATION (WET WEIGHT)	UNITS	TISSUE VALIDATION QUALIFIER	TISSUE DETECTION LIMIT	SEDIMENT SAMPLE ID	SEDIMENT TYPE	SEDIMENT CONCENTRATION (DRY WEIGHT)	SEDIMENT VALIDATION QUALIFIER	SEDIMENT DETECTION LIMIT
PCB-105	AI	SNAI01S01	21.3	ng/g		0.189999998	SNFS01	FS	4		
PCB-105	AI	SNAI04S01	5.16	ng/g		0.029999999	SNFS04S01	FS	41		
PCB-114	AI	SNAI02S01	0.498	ng/g		0.109999999	SNFS02S01	FS	0.012	J	
PCB-114	AI	SNAI03S01	0.174	ng/g		0.029999999	SNFS03S01	FS	0.014	J	
PCB-114	AI	SNAI01S01	1.06	ng/g		0.189999998	SNFS01	FS	0.15		
PCB-114	AI	SNAI04S01	0.251	ng/g		0.029999999	SNFS04S01	FS	1.4		
PCB-118	AI	SNAI02S01	26.1	ng/g		0.109999999	SNFS02S01	FS	0.81		
PCB-118	AI	SNAI03S01	8.53	ng/g		0.029999999	SNFS03S01	FS	0.71		
PCB-118	AI	SNAI01S01	56	ng/g		0.189999998	SNFS01	FS	8.85		
PCB-118	AI	SNAI04S01	12.8	ng/g		0.029999999	SNFS04S01	FS	96		
PCB-123	AI	SNAI02S01	0.531	ng/g		0.109999999	SNFS02S01	FS	0.011	J	
PCB-123	AI	SNAI03S01	0.196	ng/g		0.029999999	SNFS03S01	FS	0.0096	J	
PCB-123	AI	SNAI01S01	1.12	ng/g		0.189999998	SNFS01	FS	0.135		
PCB-123	AI	SNAI04S01	0.256	ng/g		0.029999999	SNFS04S01	FS	0.99		
PCB-126	AI	SNAI02S01	0.287	ng/g		0.109999999	SNFS02S01	FS	0.016	J	
PCB-126	AI	SNAI03S01	0.0909	ng/g		0.029999999	SNFS03S01	FS	0.013	J	
PCB-126	AI	SNAI01S01	0.508	ng/g		0.189999998	SNFS01	FS	0.115		
PCB-126	AI	SNAI04S01	0.166	ng/g		0.029999999	SNFS04S01	FS	1.5		
PCB-128	AI	SNAI02S01	0.987	ng/g		0.109999999	SNFS02S01	FS	0.31		
PCB-128	AI	SNAI03S01	0.537	ng/g		0.029999999	SNFS03S01	FS	0.26		
PCB-128	AI	SNAI01S01	6.43	ng/g		0.189999998	SNFS01	FS	3.9		
PCB-128	AI	SNAI04S01	1.45	ng/g		0.029999999	SNFS04S01	FS	33		
PCB-138	AI	SNAI02S01	33.6	ng/g		0.109999999	SNFS02S01	FS	1.3		
PCB-138	AI	SNAI03S01	8.16	ng/g		0.029999999	SNFS03S01	FS	1.1		
PCB-138	AI	SNAI01S01	84.7	ng/g		0.189999998	SNFS01	FS	15		
PCB-138	AI	SNAI04S01	15.4	ng/g		0.029999999	SNFS04S01	FS	130		
PCB-153	AI	SNAI02S01	24	ng/g		0.109999999	SNFS02S01	FS	0.71		
PCB-153	AI	SNAI03S01	7.39	ng/g		0.029999999	SNFS03S01	FS	0.67		
PCB-153	AI	SNAI01S01	63.3	ng/g		0.189999998	SNFS01	FS	7.9		
PCB-153	AI	SNAI04S01	10.2	ng/g		0.029999999	SNFS04S01	FS	72		
PCB-156	AI	SNAI02S01	4.64	ng/g		0.109999999	SNFS02S01	FS	0.13		
PCB-156	AI	SNAI03S01	1.33	ng/g		0.029999999	SNFS03S01	FS	0.11		
PCB-156	AI	SNAI01S01	6.85	ng/g		0.189999998	SNFS01	FS	1.5		
PCB-156	AI	SNAI04S01	1.76	ng/g		0.029999999	SNFS04S01	FS	14.3		
PCB-157	AI	SNAI02S01	1.03	ng/g		0.109999999	SNFS02S01	FS	0.035	J	
PCB-157	AI	SNAI03S01	0.379	ng/g		0.029999999	SNFS03S01	FS	0.027	J	
PCB-157	AI	SNAI01S01	2.04	ng/g		0.189999998	SNFS01	FS	0.375		
PCB-157	AI	SNAI04S01	0.455	ng/g		0.029999999	SNFS04S01	FS	3		
PCB-167	AI	SNAI02S01	2.22	ng/g		0.109999999	SNFS02S01	FS	0.056		
PCB-167	AI	SNAI03S01	0.935	ng/g		0.029999999	SNFS03S01	FS	0.049		
PCB-167	AI	SNAI01S01	4.7	ng/g		0.189999998	SNFS01	FS	0.69		
PCB-167	AI	SNAI04S01	1.14	ng/g		0.029999999	SNFS04S01	FS	5.8		
PCB-170	AI	SNAI02S01	2.44	ng/g		0.109999999	SNFS02S01	FS	0.12		
PCB-170	AI	SNAI03S01	0.864	ng/g		0.029999999	SNFS03S01	FS	0.09		
PCB-170	AI	SNAI01S01	6.43	ng/g		0.189999998	SNFS01	FS	1.45		
PCB-170	AI	SNAI04S01	1.22	ng/g		0.029999999	SNFS04S01	FS	11		
PCB-18	AI	SNAI01S01	0.336	ng/g		0.189999998	SNFS01S01	FS	0.22		
PCB-18	AI	SNAI04S01	0.0546	ng/g		0.029999999	SNFS04S01	FS	2.5		
PCB-180	AI	SNAI02S01	7.81	ng/g		0.109999999	SNFS02S01	FS	0.28		
PCB-180	AI	SNAI03S01	2.08	ng/g		0.029999999	SNFS03S01	FS	0.22		
PCB-180	AI	SNAI01S01	19.3	ng/g		0.189999998	SNFS01	FS	2.95		
PCB-180	AI	SNAI04S01	2.72	ng/g		0.029999999	SNFS04S01	FS	22		
PCB-187	AI	SNAI02S01	3.53	ng/g		0.109999999	SNFS02S01	FS	0.099		
PCB-187	AI	SNAI03S01	1.25	ng/g		0.029999999	SNFS03S01	FS	0.074		
PCB-187	AI	SNAI01S01	8.88	ng/g		0.189999998	SNFS01	FS	1.1		
PCB-187	AI	SNAI04S01	1.39	ng/g		0.029999999	SNFS04S01	FS	7.5		
PCB-189	AI	SNAI01S01	0.607	ng/g		0.189999998	SNFS01	FS	0.098		
PCB-189	AI	SNAI04S01	0.177	ng/g		0.029999999	SNFS04S01	FS	0.77		
PCB-195	AI	SNAI02S01	0.227	ng/g		0.109999999	SNFS02S01	FS	0.017	J	
PCB-195	AI	SNAI03S01	0.0704	ng/g		0.029999999	SNFS03S01	FS	0.01	J	
PCB-195	AI	SNAI01S01	0.627	ng/g		0.189999998	SNFS01	FS	0.185		
PCB-195	AI	SNAI04S01	0.0906	ng/g		0.029999999	SNFS04S01	FS	1		
PCB-206	AI	SNAI02S01	0.39	ng/g		0.109999999	SNFS02S01	FS	0.085		
PCB-206	AI	SNAI03S01	0.0656	ng/g		0.029999999	SNFS03S01	FS	0.05		

Appendix K, Attachment K-3 (4 of 4)

Data Used in Aquatic Invertebrate Bioaccumulation Factor Selection

CHEMICAL	TISSUE TYPE	TISSUE SAMPLE ID	TISSUE CONCENTRATION (WET WEIGHT)	UNITS	TISSUE VALIDATION QUALIFIER	TISSUE DETECTION LIMIT	SEDIMENT SAMPLE ID	SEDIMENT TYPE	SEDIMENT CONCENTRATION (DRY WEIGHT)	SEDIMENT VALIDATION QUALIFIER	SEDIMENT DETECTION LIMIT
PCB-206	AI	SNAI01S01	0.754	ng/g		0.189999998	SNFS01	FS	0.585		
PCB-206	AI	SNAI04S01	0.136	ng/g		0.029999999	SNFS04S01	FS	4.3		
PCB-28	AI	SNAI01S01	1.12	ng/g		0.189999998	SNFS01	FS	0.32		
PCB-28	AI	SNAI04S01	0.807	ng/g		0.029999999	SNFS04S01	FS	2.7		
PCB-44	AI	SNAI02S01	1.57	ng/g		0.109999999	SNFS02S01	FS	0.18		
PCB-44	AI	SNAI03S01	0.321	ng/g		0.029999999	SNFS03S01	FS	0.16		
PCB-44	AI	SNAI01S01	2.07	ng/g		0.189999998	SNFS01	FS	1.65		
PCB-44	AI	SNAI04S01	0.764	ng/g		0.029999999	SNFS04S01	FS	23		
PCB-52	AI	SNAI02S01	7.15	ng/g		0.109999999	SNFS02S01	FS	0.32		
PCB-52	AI	SNAI03S01	1.5	ng/g		0.029999999	SNFS03S01	FS	0.31		
PCB-52	AI	SNAI01S01	13.7	ng/g		0.189999998	SNFS01	FS	2.95		
PCB-52	AI	SNAI04S01	3.5	ng/g		0.029999999	SNFS04S01	FS	42		
PCB-66	AI	SNAI02S01	5.95	ng/g		0.109999999	SNFS02S01	FS	0.26		
PCB-66	AI	SNAI03S01	1.5	ng/g		0.029999999	SNFS03S01	FS	0.26		
PCB-66	AI	SNAI01S01	11.7	ng/g		0.189999998	SNFS01	FS	2.1		
PCB-66	AI	SNAI04S01	3.37	ng/g		0.029999999	SNFS04S01	FS	19		
PCB-77	AI	SNAI02S01	1.11	ng/g		0.109999999	SNFS02S01	FS	0.08		
PCB-77	AI	SNAI03S01	0.329	ng/g		0.029999999	SNFS03S01	FS	0.069		
PCB-77	AI	SNAI01S01	1.43	ng/g		0.189999998	SNFS01	FS	0.6		
PCB-77	AI	SNAI04S01	0.628	ng/g		0.029999999	SNFS04S01	FS	9.4		
PCB-81	AI	SNAI03S01	0.0457	ng/g		0.029999999	SNFS03S01	FS	0.013	J	
PCB-81	AI	SNAI04S01	0.0942	ng/g		0.029999999	SNFS04S01	FS	0.98		
PCB-90/101	AI	SNAI02S01	23.3	ng/g		0.230000004	SNFS02S01	FS	1.1		
PCB-90/101	AI	SNAI01S01	63.5	ng/g		0.389999986	SNFS01	FS	10.5		
PCB-90/101	AI	SNAI03S01	5.49	ng/g		0.059999999	SNFS03S01	FS	1.1		
PCB-90/101	AI	SNAI04S01	12.1	ng/g		0.059999999	SNFS04S01	FS	120		
Phenanthrene	AI	R2AI04S01	20	UG/KG			R2FS04S01	FS	12		
Phenanthrene	AI	R2AI01S01	17	UG/KG	J		R2FS01	FS	61	J	
Phenanthrene	AI	R2AI02S01	7.4	UG/KG	J		R2FS02S01	FS	34		
Pyrene	AI	R2AI04S01	25	UG/KG			R2FS04S01	FS	25	J	
Pyrene	AI	R2AI01S01	18	UG/KG	J		R2FS01	FS	98.5	J	
Selenium	AI	R2AI04S01	1.4866	MG/KG	J		R2FS04S01	FS	0.3849	J	
Selenium	AI	R2AI01S01	1.3692	MG/KG	J		R2FS01	FS	0.465	J	0.1
Selenium	AI	R2AI02S01	1.5086	MG/KG	J		R2FS02S01	FS	0.72		0.1
Selenium	AI	R2AI03S01	1.4886	MG/KG	J		R2FS03S01	FS	1		0.1
Silver	AI	R2AI01S01	4.151	MG/KG			R2FS01	FS	3.63625		
Silver	AI	R2AI02S01	2.9877	MG/KG			R2FS02S01	FS	4.7		
Silver	AI	R2AI03S01	2.0653	MG/KG			R2FS03S01	FS	4		
Silver	AI	R2AI04S01	0.9336	MG/KG			R2FS04S01	FS	1.8905		
Thallium	AI	R2AI01S01	1.1425	MG/KG			R2FS01	FS	3.86325		
Thallium	AI	R2AI02S01	1.0553	MG/KG			R2FS02S01	FS	5.1		
Thallium	AI	R2AI03S01	0.9326	MG/KG			R2FS03S01	FS	6.3		
Vanadium	AI	R2AI01S01	1.891	MG/KG			R2FS01	FS	54.3846	J	
Vanadium	AI	R2AI03S01	2.2103	MG/KG			R2FS03S01	FS	63.6	J	
Vanadium	AI	R2AI02S01	1.9556	MG/KG			R2FS02S01	FS	63.8	J	
Vanadium	AI	R2AI04S01	0.639	MG/KG			R2FS04S01	FS	38.7394	J	
Zinc	AI	R2AI01S01	222.1501	MG/KG	J		R2FS01	FS	337.74315	J	
Zinc	AI	R2AI04S01	145.931	MG/KG	J		R2FS04S01	FS	263.6441	J	
Zinc	AI	R2AI02S01	194.4929	MG/KG	J		R2FS02S01	FS	399	J	
Zinc	AI	R2AI03S01	107.6003	MG/KG	J		R2FS03S01	FS	403	J	

APPENDIX K

ATTACHMENT K-4

DATA USED IN AQUATIC PLANT BIOACCUMULATION FACTOR SELECTION

Appendix K, Attachment K-4 (1 of 2)

Data Used in Aquatic Plant Bioaccumulation Factor Selection

CHEMICAL	TISSUE TYPE	TISSUE SAMPLE ID	TISSUE CONCENTRATION (WET WEIGHT)	UNITS	TISSUE VALIDATION QUALIFIER	TISSUE DETECTION LIMIT	SEDIMENT SAMPLE ID	SEDIMENT TYPE	SEDIMENT CONCENTRATION (DRY WEIGHT)	SEDIMENT VALIDATION QUALIFIER	SEDIMENT DETECTION LIMIT
1,2,3,4,6,7,8-HpCDD	AP	R2AP01S01	22.3	pg/g			R2FS01	FS	790		
1,2,3,4,6,7,8-HpCDD	AP	R2AP04S01	7.15	pg/g	J		R2FS04S01	FS	287		
1,2,3,4,6,7,8-HpCDD	AP	R2AP02S01	13.2	pg/g	J		R2FS02S01	FS	957		
1,2,3,4,6,7,8-HpCDD	AP	R2AP03S01	8.36	pg/g	J		R2FS03S01	FS	734		
1,2,3,4,6,7,8-HpCDF	AP	R2AP04S01	1.47	pg/g	J		R2FS04S01	FS	39.1		
1,2,3,4,6,7,8-HpCDF	AP	R2AP01S01	3.61	pg/g	J		R2FS01	FS	107.1		
1,2,3,4,6,7,8-HpCDF	AP	R2AP02S01	2.38	pg/g	J		R2FS02S01	FS	117		
1,2,3,4,6,7,8-HpCDF	AP	R2AP03S01	1.61	pg/g	J		R2FS03S01	FS	99.6		
2,3,7,8-TCDF	AP	R2AP03S01	0.94	pg/g	J		R2FS03S01	FS	13.3		
Aluminum	AP	R2AP01S01	4290.2488	MG/KG			R2FS01	FS	22184.56085	J	90
Aluminum	AP	R2AP02S01	2102.5253	MG/KG			R2FS02S01	FS	26600	J	90
Aluminum	AP	R2AP04S01	1119.1406	MG/KG			R2FS04S01	FS	16790.1739	J	
Aluminum	AP	R2AP03S01	1077.9852	MG/KG			R2FS03S01	FS	28800	J	90
Antimony	AP	R2AP03S01	0.9708	MG/KG			R2FS03S01	FS	1.8	J	0.2
Arsenic	AP	R2AP01S01	2.2151	MG/KG			R2FS01	FS	6.14655	J	
Arsenic	AP	R2AP02S01	2.3442	MG/KG			R2FS02S01	FS	6.8		
Barium	AP	R2AP01S01	51.7424	MG/KG			R2FS01	FS	138.14025	J	
Barium	AP	R2AP02S01	46.9592	MG/KG			R2FS02S01	FS	159	J	
Barium	AP	R2AP04S01	23.0078	MG/KG			R2FS04S01	FS	108.6766		
Barium	AP	R2AP03S01	24.9295	MG/KG			R2FS03S01	FS	183	J	
Beryllium	AP	R2AP01S01	0.284	MG/KG			R2FS01	FS	0.8668		
Boron	AP	R2AP04S01	14.8848	MG/KG			R2FS04S01	FS	6.7929		
Boron	AP	R2AP01S01	12.4066	MG/KG			R2FS01S01	FS	9.4378		
Chromium	AP	R2AP01S01	32.0011	MG/KG			R2FS01	FS	34.41185	J	
Chromium	AP	R2AP02S01	14.5181	MG/KG			R2FS02S01	FS	42.9	J	
Chromium	AP	R2AP03S01	12.6424	MG/KG			R2FS03S01	FS	45	J	
Chromium	AP	R2AP04S01	5.375	MG/KG			R2FS04S01	FS	25.5232	J	
Cobalt	AP	R2AP01S01	2.9612	MG/KG			R2FS01	FS	11.9866	J	
Cobalt	AP	R2AP02S01	2.3097	MG/KG			R2FS02S01	FS	13.7	J	
Cobalt	AP	R2AP03S01	1.1952	MG/KG			R2FS03S01	FS	14.8	J	
Cobalt	AP	R2AP04S01	0.5947	MG/KG			R2FS04S01	FS	10.3522	J	
Copper	AP	R2AP01S01	10.3826	MG/KG			R2FS01	FS	33.5309	J	2
Copper	AP	R2AP04S01	5.2129	MG/KG			R2FS04S01	FS	31.0081		
Copper	AP	R2AP03S01	8.4823	MG/KG			R2FS03S01	FS	51.7	J	2
Iron	AP	R2AP01S01	7897.8805	MG/KG			R2FS01	FS	30667.42815	J	
Iron	AP	R2AP02S01	3589.3313	MG/KG			R2FS02S01	FS	37296.0373	J	
Iron	AP	R2AP03S01	2572.8683	MG/KG			R2FS03S01	FS	40600	J	
Iron	AP	R2AP04S01	1519.3359	MG/KG			R2FS04S01	FS	24579.881	J	
Magnesium	AP	R2AP02S01	5034.049	MG/KG			R2FS02S01	FS	8490	J	
Magnesium	AP	R2AP04S01	3074.2188	MG/KG			R2FS04S01	FS	5820.3991		
Magnesium	AP	R2AP01S01	3713.4373	MG/KG			R2FS01	FS	7164.66	J	
Magnesium	AP	R2AP03S01	2248.7624	MG/KG			R2FS03S01	FS	9330	J	
Manganese	AP	R2AP02S01	433.4153	MG/KG			R2FS02S01	FS	446	J	
Manganese	AP	R2AP01S01	350.5239	MG/KG			R2FS01	FS	407.03665	J	
Manganese	AP	R2AP03S01	163.7401	MG/KG			R2FS03S01	FS	668	J	
Manganese	AP	R2AP04S01	105.1562	MG/KG			R2FS04S01	FS	434.2689	J	
Mercury	AP	R2AP01S01	0.1205	MG/KG			R2FS01	FS	0.3288	J	
Nickel	AP	R2AP01S01	14.8776	MG/KG			R2FS01	FS	21.56585	J	
Nickel	AP	R2AP02S01	7.784	MG/KG			R2FS02S01	FS	24.5		
Nickel	AP	R2AP03S01	5.2345	MG/KG			R2FS03S01	FS	25.8		
Nickel	AP	R2AP04S01	2.2852	MG/KG			R2FS04S01	FS	17.8162	J	
OCDD	AP	R2AP01S01	274	pg/g			R2FS01	FS	9850	J	
OCDD	AP	R2AP04S01	73.3	pg/g			R2FS04S01	FS	3150		
OCDD	AP	R2AP02S01	170	pg/g			R2FS02S01	FS	12400	J	
OCDD	AP	R2AP03S01	85.4	pg/g			R2FS03S01	FS	8430	J	
OCDF	AP	R2AP01S01	9.35	pg/g	J		R2FS01	FS	273		
OCDF	AP	R2AP04S01	3.21	pg/g	J		R2FS04S01	FS	101		
OCDF	AP	R2AP02S01	5.66	pg/g	J		R2FS02S01	FS	314		
OCDF	AP	R2AP03S01	3.37	pg/g	J		R2FS03S01	FS	250		
PCB-105	AP	SNAP03S01	0.502	ng/g		0.170000002	SNFS03S01	FS	0.3		
PCB-105	AP	SNAP02S01	0.46	ng/g		0.180000007	SNFS02S01	FS	0.34		
PCB-105	AP	SNAP04S01	0.275	ng/g		0.209999993	SNFS04S01	FS	41		

Appendix K, Attachment K-4 (2 of 2)

Data Used in Aquatic Plant Bioaccumulation Factor Selection

CHEMICAL	TISSUE TYPE	TISSUE SAMPLE ID	TISSUE CONCENTRATION (WET WEIGHT)	UNITS	TISSUE VALIDATION QUALIFIER	TISSUE DETECTION LIMIT	SEDIMENT SAMPLE ID	SEDIMENT TYPE	SEDIMENT CONCENTRATION (DRY WEIGHT)	SEDIMENT VALIDATION QUALIFIER	SEDIMENT DETECTION LIMIT
PCB-118	AP	SNAP03S01	1.1	ng/g		0.170000002	SNFS03S01	FS	0.71		
PCB-118	AP	SNAP02S01	0.955	ng/g		0.180000007	SNFS02S01	FS	0.81		
PCB-118	AP	SNAP01S01	0.339	ng/g		0.219999999	SNFS01	FS	8.85		
PCB-118	AP	SNAP04S01	0.652	ng/g		0.209999993	SNFS04S01	FS	96		
PCB-128	AP	SNAP03S01	0.457	ng/g		0.170000002	SNFS03S01	FS	0.26		
PCB-128	AP	SNAP02S01	0.325	ng/g		0.180000007	SNFS02S01	FS	0.31		
PCB-138	AP	SNAP03S01	1.69	ng/g		0.170000002	SNFS03S01	FS	1.1		
PCB-138	AP	SNAP02S01	1.45	ng/g		0.180000007	SNFS02S01	FS	1.3		
PCB-138	AP	SNAP01S01	0.453	ng/g		0.219999999	SNFS01	FS	15		
PCB-138	AP	SNAP04S01	0.935	ng/g		0.209999993	SNFS04S01	FS	130		
PCB-153	AP	SNAP03S01	0.928	ng/g		0.170000002	SNFS03S01	FS	0.67		
PCB-153	AP	SNAP02S01	0.884	ng/g		0.180000007	SNFS02S01	FS	0.71		
PCB-153	AP	SNAP01S01	0.341	ng/g		0.219999999	SNFS01	FS	7.9		
PCB-153	AP	SNAP04S01	0.628	ng/g		0.209999993	SNFS04S01	FS	72		
PCB-156	AP	SNAP03S01	0.181	ng/g		0.170000002	SNFS03S01	FS	0.11		
PCB-18	AP	SNAP01S01	0.263	ng/g		0.219999999	SNFS01S01	FS	0.22		
PCB-18	AP	SNAP04S01	0.269	ng/g		0.209999993	SNFS04S01	FS	2.5		
PCB-180	AP	SNAP03S01	0.345	ng/g		0.170000002	SNFS03S01	FS	0.22		
PCB-180	AP	SNAP02S01	0.283	ng/g		0.180000007	SNFS02S01	FS	0.28		
PCB-28	AP	SNAP04S01	0.238	ng/g		0.209999993	SNFS04S01	FS	2.7		
PCB-44	AP	SNAP02S01	0.439	ng/g		0.180000007	SNFS02S01	FS	0.18		
PCB-44	AP	SNAP03S01	0.349	ng/g		0.170000002	SNFS03S01	FS	0.16		
PCB-44	AP	SNAP01S01	0.292	ng/g		0.219999999	SNFS01	FS	1.65		
PCB-44	AP	SNAP04S01	0.337	ng/g		0.209999993	SNFS04S01	FS	23		
PCB-52	AP	SNAP02S01	0.708	ng/g		0.180000007	SNFS02S01	FS	0.32		
PCB-52	AP	SNAP03S01	0.593	ng/g		0.170000002	SNFS03S01	FS	0.31		
PCB-52	AP	SNAP01S01	0.456	ng/g		0.219999999	SNFS01	FS	2.95		
PCB-52	AP	SNAP04S01	0.536	ng/g		0.209999993	SNFS04S01	FS	42		
PCB-66	AP	SNAP02S01	0.47	ng/g		0.180000007	SNFS02S01	FS	0.26		
PCB-66	AP	SNAP03S01	0.387	ng/g		0.170000002	SNFS03S01	FS	0.26		
PCB-66	AP	SNAP01S01	0.26	ng/g		0.219999999	SNFS01	FS	2.1		
PCB-66	AP	SNAP04S01	0.351	ng/g		0.209999993	SNFS04S01	FS	19		
PCB-90/101	AP	SNAP02S01	1.36	ng/g		0.370000005	SNFS02S01	FS	1.1		
PCB-90/101	AP	SNAP03S01	1.25	ng/g		0.340000004	SNFS03S01	FS	1.1		
PCB-90/101	AP	SNAP01S01	0.489	ng/g		0.439999998	SNFS01	FS	10.5		
PCB-90/101	AP	SNAP04S01	0.918	ng/g		0.430000007	SNFS04S01	FS	120		
Selenium	AP	R2AP01S01	1.1772	MG/KG	J		R2FS01	FS	0.465	J	0.1
Selenium	AP	R2AP04S01	0.7512	MG/KG	J		R2FS04S01	FS	0.3849	J	
Thallium	AP	R2AP01S01	2.0147	MG/KG			R2FS01	FS	3.86325		
Thallium	AP	R2AP02S01	0.9236	MG/KG			R2FS02S01	FS	5.1		
Vanadium	AP	R2AP02S01	19.3181	MG/KG			R2FS02S01	FS	63.8	J	
Vanadium	AP	R2AP01S01	12.2837	MG/KG			R2FS01	FS	54.3846	J	
Vanadium	AP	R2AP04S01	2.9258	MG/KG			R2FS04S01	FS	38.7394	J	
Vanadium	AP	R2AP03S01	3.8471	MG/KG			R2FS03S01	FS	63.6	J	
Zinc	AP	R2AP01S01	102.5974	MG/KG	J		R2FS01	FS	337.74315	J	
Zinc	AP	R2AP02S01	84.6969	MG/KG	J		R2FS02S01	FS	399	J	
Zinc	AP	R2AP04S01	49.7656	MG/KG	J		R2FS04S01	FS	263.6441	J	
Zinc	AP	R2AP03S01	57.1403	MG/KG	J		R2FS03S01	FS	403	J	

APPENDIX K

ATTACHMENT K-5

DATA USED IN FISH BIOACCUMULATION FACTOR SELECTION

Appendix K, Attachment K-5 (1 of 4)

Data Used in Fish Bioaccumulation Factor Selection

CHEMICAL	TISSUE TYPE	TISSUE SAMPLE ID	TISSUE CONCENTRATION (WET WEIGHT)	UNITS	TISSUE VALIDATION QUALIFIER	TISSUE DETECTION LIMIT	SEDIMENT SAMPLE ID	SEDIMENT TYPE	SEDIMENT CONCENTRATION (DRY WEIGHT)	SEDIMENT VALIDATION QUALIFIER	SEDIMENT DETECTION LIMIT
1,2,3,4,6,7,8-HpCDD	FI	R2FI04S01	12.6	pg/g			R2FS04S01	FS	287		
1,2,3,4,6,7,8-HpCDD	FI	R2FI01S01	20.1	pg/g			R2FS01	FS	790		
1,2,3,4,6,7,8-HpCDD	FI	R2FI03	10.465	pg/g			R2FS03S01	FS	734		
1,2,3,4,6,7,8-HpCDD	FI	R2FI02S01	8.56	pg/g			R2FS02S01	FS	957		
1,2,3,4,6,7,8-HpCDF	FI	R2FI03	4.29	pg/g	J		R2FS03S01	FS	99.6		
1,2,3,4,7,8-HxCDD	FI	R2FI04S01	1.45	pg/g	J		R2FS04S01	FS	3.93		
1,2,3,4,7,8-HxCDD	FI	R2FI01S01	1.7	pg/g	J		R2FS01	FS	10.07		
1,2,3,4,7,8-HxCDD	FI	R2FI02S01	1.73	pg/g	J		R2FS02S01	FS	11.3		
1,2,3,4,7,8-HxCDD	FI	R2FI03	1.055	pg/g	J		R2FS03S01	FS	8.02		
1,2,3,4,7,8-HxCDF	FI	R2FI01S01	0.64	pg/g	J		R2FS01	FS	4.645		
1,2,3,4,7,8-HxCDF	FI	R2FI02S01	0.62	pg/g	J		R2FS02S01	FS	5.33		
1,2,3,6,7,8-HxCDD	FI	R2FI04S01	9.27	pg/g			R2FS04S01	FS	15.1		
1,2,3,6,7,8-HxCDD	FI	R2FI01S01	8.02	pg/g			R2FS01	FS	37.95		
1,2,3,6,7,8-HxCDD	FI	R2FI02S01	7.67	pg/g			R2FS02S01	FS	42.3		
1,2,3,6,7,8-HxCDD	FI	R2FI03	5.18	pg/g	J		R2FS03S01	FS	31.9		
1,2,3,6,7,8-HxCDF	FI	R2FI03	1.9	pg/g	J		R2FS03S01	FS	3.9		
1,2,3,6,7,8-HxCDF	FI	R2FI02S01	1.89	pg/g	J		R2FS02S01	FS	4.5		
1,2,3,6,7,8-HxCDF	FI	R2FI01S01	1.58	pg/g	J		R2FS01	FS	3.925		
1,2,3,7,8,9-HxCDD	FI	R2FI04S01	1.79	pg/g	J		R2FS04S01	FS	8.27		
1,2,3,7,8,9-HxCDD	FI	R2FI01S01	1.8	pg/g	J		R2FS01	FS	21.15		
1,2,3,7,8,9-HxCDD	FI	R2FI03	1.31	pg/g	J		R2FS03S01	FS	18.5		
1,2,3,7,8,9-HxCDD	FI	R2FI02S01	1.65	pg/g	J		R2FS02S01	FS	23.4		
1,2,3,7,8-PeCDD	FI	R2FI04S01	3.91	pg/g	J		R2FS04S01	FS	2.4	J	
1,2,3,7,8-PeCDD	FI	R2FI01S01	3.89	pg/g	J		R2FS01	FS	5.7		
1,2,3,7,8-PeCDD	FI	R2FI03	2.525	pg/g	J		R2FS03S01	FS	4.43		
1,2,3,7,8-PeCDD	FI	R2FI02S01	2.95	pg/g	J		R2FS02S01	FS	5.92		
1,2,3,7,8-PeCDF	FI	R2FI04S01	2.57	pg/g	J		R2FS04S01	FS	2.45	J	
1,2,3,7,8-PeCDF	FI	R2FI01S01	2.05	pg/g	J		R2FS01	FS	3.675		
1,2,3,7,8-PeCDF	FI	R2FI02S01	2.1	pg/g	J		R2FS02S01	FS	4.28		
1,2,3,7,8-PeCDF	FI	R2FI03	1.885	pg/g	J		R2FS03S01	FS	5.5		
2,3,4,6,7,8-HxCDF	FI	R2FI01S01	0.69	pg/g	J		R2FS01	FS	5.69		
2,3,4,6,7,8-HxCDF	FI	R2FI02S01	0.64	pg/g	J		R2FS02S01	FS	6.45		
2,3,4,7,8-PeCDF	FI	R2FI04S01	5.75	pg/g			R2FS04S01	FS	3.36		
2,3,4,7,8-PeCDF	FI	R2FI02S01	5.65	pg/g			R2FS02S01	FS	4.46		
2,3,4,7,8-PeCDF	FI	R2FI01S01	3.68	pg/g	J		R2FS01	FS	3.75		
2,3,4,7,8-PeCDF	FI	R2FI03	3.62	pg/g	J		R2FS03S01	FS	5.48		
2,3,7,8-TCDD	FI	R2FI04S01	1.03	pg/g	J		R2FS04S01	FS	0.36	J	
2,3,7,8-TCDD	FI	R2FI02S01	1.19	pg/g			R2FS02S01	FS	0.795		
2,3,7,8-TCDD	FI	R2FI01S01	1.03	pg/g	J		R2FS01	FS	0.7385		
2,3,7,8-TCDD	FI	R2FI03	0.64	pg/g	J		R2FS03S01	FS	0.59		
2,3,7,8-TCDF	FI	R2FI01S01	9.31	pg/g			R2FS01	FS	7.545		
2,3,7,8-TCDF	FI	R2FI04S01	4.81	pg/g			R2FS04S01	FS	5.86		
2,3,7,8-TCDF	FI	R2FI02S01	4.86	pg/g			R2FS02S01	FS	9.66		
2,3,7,8-TCDF	FI	R2FI03	5.535	pg/g			R2FS03S01	FS	13.3		
Aluminum	FI	R2FI01S01	436.2155	MG/KG			R2FS01	FS	22184.56085	J	90
Aluminum	FI	R2FI03	298.88465	MG/KG			R2FS03S01	FS	28800	J	90
Aluminum	FI	R2FI04S01	145.3744	MG/KG			R2FS04S01	FS	16790.1739	J	
Aluminum	FI	R2FI02S01	44.5379	MG/KG			R2FS02S01	FS	26600	J	90
Antimony	FI	R2FI03	3.5371	MG/KG			R2FS03S01	FS	1.8	J	0.2
Antimony	FI	R2FI04S01	2.3038	MG/KG			R2FS04S01	FS	1.4189	J	
Barium	FI	R2FI01S01	15.4855	MG/KG			R2FS01	FS	138.14025	J	
Barium	FI	R2FI04S01	7.604	MG/KG			R2FS04S01	FS	108.6766		
Barium	FI	R2FI02S01	10.2848	MG/KG			R2FS02S01	FS	159	J	
Barium	FI	R2FI03	9.6364	MG/KG			R2FS03S01	FS	183	J	
Chromium	FI	R2FI04S01	7.3036	MG/KG			R2FS04S01	FS	25.5232	J	
Chromium	FI	R2FI01S01	7.7765	MG/KG			R2FS01	FS	34.41185	J	
Chromium	FI	R2FI03	4.88815	MG/KG			R2FS03S01	FS	45	J	
Chromium	FI	R2FI02S01	2.6293	MG/KG			R2FS02S01	FS	42.9	J	
Cobalt	FI	R2FI01S01	0.3576	MG/KG			R2FS01	FS	11.9866	J	
Copper	FI	R2FI01S01	3.9282	MG/KG			R2FS01	FS	33.5309	J	2
Copper	FI	R2FI04S01	3.576	MG/KG			R2FS04S01	FS	31.0081		
Copper	FI	R2FI02S01	3.7607	MG/KG			R2FS02S01	FS	40.6	J	2
Copper	FI	R2FI03	4.41855	MG/KG			R2FS03S01	FS	51.7	J	2

Appendix K, Attachment K-5 (2 of 4)

Data Used in Fish Bioaccumulation Factor Selection

CHEMICAL	TISSUE TYPE	TISSUE SAMPLE ID	TISSUE CONCENTRATION (WET WEIGHT)	UNITS	TISSUE VALIDATION QUALIFIER	TISSUE DETECTIO N LIMIT	SEDIMENT SAMPLE ID	SEDIMENT TYPE	SEDIMENT CONCENTRATION (DRY WEIGHT)	SEDIMENT VALIDATION QUALIFIER	SEDIMENT DETECTION LIMIT
Fluoranthene	FI	R2FI01S01	9.3	UG/KG	J		R2FS01	FS	104.5	J	
Iron	FI	R2FI01S01	699.869	MG/KG			R2FS01	FS	30667.42815	J	
Iron	FI	R2FI04S01	309.4069	MG/KG			R2FS04S01	FS	24579.881	J	
Iron	FI	R2FI03	443.8494	MG/KG			R2FS03S01	FS	40600	J	
Iron	FI	R2FI02S01	162.0981	MG/KG			R2FS02S01	FS	37296.0373	J	
Magnesium	FI	R2FI01S01	1882.2157	MG/KG			R2FS01	FS	7164.66	J	
Magnesium	FI	R2FI04S01	1481.681	MG/KG			R2FS04S01	FS	5820.3991		
Magnesium	FI	R2FI02S01	1972.0073	MG/KG			R2FS02S01	FS	8490	J	
Magnesium	FI	R2FI03	1649.55335	MG/KG			R2FS03S01	FS	9330	J	
Manganese	FI	R2FI01S01	41.288	MG/KG			R2FS01	FS	407.03665	J	
Manganese	FI	R2FI04S01	15.4454	MG/KG			R2FS04S01	FS	434.2689	J	
Manganese	FI	R2FI02S01	13.292	MG/KG			R2FS02S01	FS	446	J	
Manganese	FI	R2FI03	18.51875	MG/KG			R2FS03S01	FS	668	J	
Mercury	FI	R2FI04S01	0.241	MG/KG			R2FS04S01	FS	0.1898	J	
Mercury	FI	R2FI03	0.25425	MG/KG			R2FS03S01	FS	0.3005		
Mercury	FI	R2FI01S01	0.2735	MG/KG			R2FS01	FS	0.3288	J	
Mercury	FI	R2FI02S01	0.195	MG/KG			R2FS02S01	FS	0.4134		
Molybdenum	FI	R2FI03	0.7318	MG/KG			R2FS03S01	FS	0.67		
Molybdenum	FI	R2FI04S01	0.2766	MG/KG			R2FS04S01	FS	0.6574		
Naphthalene	FI	R2FI01S01	15	UG/KG	J		R2FS01	FS	2.6	J	
Nickel	FI	R2FI04S01	2.9195	MG/KG			R2FS04S01	FS	17.8162	J	
Nickel	FI	R2FI01S01	3.049	MG/KG			R2FS01	FS	21.56585	J	
Nickel	FI	R2FI03	1.949	MG/KG			R2FS03S01	FS	25.8		
Nickel	FI	R2FI02S01	0.9006	MG/KG			R2FS02S01	FS	24.5		
OCDD	FI	R2FI04S01	62.3	pg/g			R2FS04S01	FS	3150		
OCDD	FI	R2FI01S01	165	pg/g			R2FS01	FS	9850	J	
OCDD	FI	R2FI03	85.15	pg/g			R2FS03S01	FS	8430	J	
OCDD	FI	R2FI02S01	38.4	pg/g			R2FS02S01	FS	12400	J	
OCDF	FI	R2FI04S01	2.03	pg/g	J		R2FS04S01	FS	101		
OCDF	FI	R2FI01S01	4.8	pg/g	J		R2FS01	FS	273		
OCDF	FI	R2FI03	3.125	pg/g	J		R2FS03S01	FS	250		
OCDF	FI	R2FI02S01	1.36	pg/g	J		R2FS02S01	FS	314		
PCB-105	FI	SNFI03	97.35	ng/g		0.105	SNFS03S01	FS	0.3		
PCB-105	FI	SNFI02S01	42.2	ng/g		0.11	SNFS02S01	FS	0.34		
PCB-105	FI	SNFI01S01	85.5	ng/g		0.08	SNFS01	FS	4		
PCB-105	FI	SNFI04S01	152	ng/g		0.12	SNFS04S01	FS	41		
PCB-114	FI	SNFI03	4.595	ng/g		0.105	SNFS03S01	FS	0.014	J	
PCB-114	FI	SNFI02S01	1.96	ng/g		0.11	SNFS02S01	FS	0.012	J	
PCB-114	FI	SNFI01S01	3.6	ng/g		0.08	SNFS01	FS	0.15		
PCB-114	FI	SNFI04S01	6.86	ng/g		0.12	SNFS04S01	FS	1.4		
PCB-118	FI	SNFI03	274	ng/g		0.105	SNFS03S01	FS	0.71		
PCB-118	FI	SNFI02S01	132	ng/g		0.11	SNFS02S01	FS	0.81		
PCB-118	FI	SNFI01S01	238	ng/g		0.08	SNFS01	FS	8.85		
PCB-118	FI	SNFI04S01	419	ng/g		0.12	SNFS04S01	FS	96		
PCB-123	FI	SNFI03	4.155	ng/g		0.105	SNFS03S01	FS	0.0096	J	
PCB-123	FI	SNFI02S01	2.22	ng/g		0.11	SNFS02S01	FS	0.011	J	
PCB-123	FI	SNFI01S01	4.34	ng/g		0.08	SNFS01	FS	0.135		
PCB-123	FI	SNFI04S01	5.52	ng/g		0.12	SNFS04S01	FS	0.99		
PCB-126	FI	SNFI03	1.83	ng/g		0.105	SNFS03S01	FS	0.013	J	
PCB-126	FI	SNFI02S01	0.829	ng/g		0.11	SNFS02S01	FS	0.016	J	
PCB-126	FI	SNFI01S01	1.91	ng/g		0.08	SNFS01	FS	0.115		
PCB-126	FI	SNFI04S01	2.7	ng/g		0.12	SNFS04S01	FS	1.5		
PCB-128	FI	SNFI03	80.2	ng/g		0.105	SNFS03S01	FS	0.26		
PCB-128	FI	SNFI02S01	48.9	ng/g		0.11	SNFS02S01	FS	0.31		
PCB-128	FI	SNFI01S01	73.4	ng/g		0.08	SNFS01	FS	3.9		
PCB-128	FI	SNFI04S01	146	ng/g		0.12	SNFS04S01	FS	33		
PCB-138	FI	SNFI03	449.5	ng/g		0.105	SNFS03S01	FS	1.1		
PCB-138	FI	SNFI02S01	257	ng/g		0.11	SNFS02S01	FS	1.3		
PCB-138	FI	SNFI01S01	426	ng/g		0.08	SNFS01	FS	15		
PCB-138	FI	SNFI04S01	742	ng/g		0.12	SNFS04S01	FS	130		
PCB-153	FI	SNFI03	316	ng/g		0.105	SNFS03S01	FS	0.67		
PCB-153	FI	SNFI02S01	212	ng/g		0.11	SNFS02S01	FS	0.71		
PCB-153	FI	SNFI01S01	299	ng/g		0.08	SNFS01	FS	7.9		

Data Used in Fish Bioaccumulation Factor Selection

CHEMICAL	TISSUE TYPE	TISSUE SAMPLE ID	TISSUE CONCENTRATION (WET WEIGHT)	UNITS	TISSUE VALIDATION QUALIFIER	TISSUE DETECTIO N LIMIT	SEDIMENT SAMPLE ID	SEDIMENT TYPE	SEDIMENT CONCENTRATION (DRY WEIGHT)	SEDIMENT VALIDATION QUALIFIER	SEDIMENT DETECTION LIMIT
PCB-153	FI	SNFI04S01	523	ng/g		0.12	SNFS04S01	FS	72		
PCB-156	FI	SNFI03	48.3	ng/g		0.105	SNFS03S01	FS	0.11		
PCB-156	FI	SNFI02S01	26.3	ng/g		0.11	SNFS02S01	FS	0.13		
PCB-156	FI	SNFI01S01	42.2	ng/g		0.08	SNFS01	FS	1.5		
PCB-156	FI	SNFI04S01	74.4	ng/g		0.12	SNFS04S01	FS	14.3		
PCB-157	FI	SNFI03	9.455	ng/g		0.105	SNFS03S01	FS	0.027	J	
PCB-157	FI	SNFI02S01	4.42	ng/g		0.11	SNFS02S01	FS	0.035	J	
PCB-157	FI	SNFI01S01	8.66	ng/g		0.08	SNFS01	FS	0.375		
PCB-157	FI	SNFI04S01	14.2	ng/g		0.12	SNFS04S01	FS	3		
PCB-167	FI	SNFI03	22.05	ng/g		0.105	SNFS03S01	FS	0.049		
PCB-167	FI	SNFI02S01	12.4	ng/g		0.11	SNFS02S01	FS	0.056		
PCB-167	FI	SNFI01S01	19.1	ng/g		0.08	SNFS01	FS	0.69		
PCB-167	FI	SNFI04S01	33.4	ng/g		0.12	SNFS04S01	FS	5.8		
PCB-170	FI	SNFI03	54.9	ng/g		0.105	SNFS03S01	FS	0.09		
PCB-170	FI	SNFI02S01	34.3	ng/g		0.11	SNFS02S01	FS	0.12		
PCB-170	FI	SNFI01S01	45.5	ng/g		0.08	SNFS01	FS	1.45		
PCB-170	FI	SNFI04S01	91.7	ng/g		0.12	SNFS04S01	FS	11		
PCB-18	FI	SNFI01S01	2.26	ng/g		0.08	SNFS01S01	FS	0.22		
PCB-18	FI	SNFI04S01	3.28	ng/g		0.12	SNFS04S01	FS	2.5		
PCB-180	FI	SNFI03	108.1	ng/g		0.105	SNFS03S01	FS	0.22		
PCB-180	FI	SNFI02S01	88	ng/g		0.11	SNFS02S01	FS	0.28		
PCB-180	FI	SNFI01S01	101	ng/g		0.08	SNFS01	FS	2.95		
PCB-180	FI	SNFI04S01	178	ng/g		0.12	SNFS04S01	FS	22		
PCB-187	FI	SNFI03	45.25	ng/g		0.105	SNFS03S01	FS	0.074		
PCB-187	FI	SNFI02S01	31.9	ng/g		0.11	SNFS02S01	FS	0.099		
PCB-187	FI	SNFI01S01	42.1	ng/g		0.08	SNFS01	FS	1.1		
PCB-187	FI	SNFI04S01	68.4	ng/g		0.12	SNFS04S01	FS	7.5		
PCB-189	FI	SNFI01S01	2.61	ng/g		0.08	SNFS01	FS	0.098		
PCB-189	FI	SNFI04S01	3.1	ng/g		0.12	SNFS04S01	FS	0.77		
PCB-195	FI	SNFI03S01	4.78	ng/g		0.09	SNFS03S01	FS	0.01	J	
PCB-195	FI	SNFI02S01	4.31	ng/g		0.11	SNFS02S01	FS	0.017	J	
PCB-195	FI	SNFI01S01	4.27	ng/g		0.08	SNFS01	FS	0.185		
PCB-195	FI	SNFI04S01	7.22	ng/g		0.12	SNFS04S01	FS	1		
PCB-206	FI	SNFI03	12.55	ng/g		0.105	SNFS03S01	FS	0.05		
PCB-206	FI	SNFI02S01	16.3	ng/g		0.11	SNFS02S01	FS	0.085		
PCB-206	FI	SNFI01S01	13.6	ng/g		0.08	SNFS01	FS	0.585		
PCB-206	FI	SNFI04S01	22.1	ng/g		0.12	SNFS04S01	FS	4.3		
PCB-209	FI	SNFI02S01	2.26	ng/g		0.11	SNFS02S01	FS	0.022	J	
PCB-209	FI	SNFI03	1.315	ng/g		0.105	SNFS03S01	FS	0.016	J	
PCB-209	FI	SNFI01S01	1.33	ng/g		0.08	SNFS01	FS	0.165		
PCB-209	FI	SNFI04S01	2.47	ng/g		0.12	SNFS04S01	FS	0.78		
PCB-28	FI	SNFI01S01	4.43	ng/g		0.08	SNFS01	FS	0.32		
PCB-28	FI	SNFI04S01	6.43	ng/g		0.12	SNFS04S01	FS	2.7		
PCB-44	FI	SNFI03	22.25	ng/g		0.105	SNFS03S01	FS	0.16		
PCB-44	FI	SNFI02S01	10.6	ng/g		0.11	SNFS02S01	FS	0.18		
PCB-44	FI	SNFI01S01	19.3	ng/g		0.08	SNFS01	FS	1.65		
PCB-44	FI	SNFI04S01	36.6	ng/g		0.12	SNFS04S01	FS	23		
PCB-52	FI	SNFI03	61.6	ng/g		0.105	SNFS03S01	FS	0.31		
PCB-52	FI	SNFI02S01	28.9	ng/g		0.11	SNFS02S01	FS	0.32		
PCB-52	FI	SNFI01S01	64	ng/g		0.08	SNFS01	FS	2.95		
PCB-52	FI	SNFI04S01	93.2	ng/g		0.12	SNFS04S01	FS	42		
PCB-66	FI	SNFI03	50.8	ng/g		0.105	SNFS03S01	FS	0.26		
PCB-66	FI	SNFI01S01	46.6	ng/g		0.08	SNFS01	FS	2.1		
PCB-66	FI	SNFI04S01	76	ng/g		0.12	SNFS04S01	FS	19		
PCB-77	FI	SNFI03	1.55	ng/g		0.105	SNFS03S01	FS	0.069		
PCB-77	FI	SNFI02S01	0.896	ng/g		0.11	SNFS02S01	FS	0.08		
PCB-77	FI	SNFI01S01	1.4	ng/g		0.08	SNFS01	FS	0.6		
PCB-77	FI	SNFI04S01	2.18	ng/g		0.12	SNFS04S01	FS	9.4		
PCB-8	FI	SNFI03	0.135	ng/g		0.105	SNFS03S01	FS	0.012	J	
PCB-8	FI	SNFI04S01	0.155	ng/g		0.12	SNFS04S01	FS	0.32		
PCB-81	FI	SNFI03	2.01	ng/g		0.105	SNFS03S01	FS	0.013	J	
PCB-81	FI	SNFI02S01	0.859	ng/g		0.11	SNFS02S01	FS	0.013	J	
PCB-81	FI	SNFI01S01	1.7	ng/g		0.08	SNFS01	FS	0.099		

Appendix K, Attachment K-5 (4 of 4)

Data Used in Fish Bioaccumulation Factor Selection

CHEMICAL	TISSUE TYPE	TISSUE SAMPLE ID	TISSUE CONCENTRATION (WET WEIGHT)	UNITS	TISSUE VALIDATION QUALIFIER	TISSUE DETECTIO N LIMIT	SEDIMENT SAMPLE ID	SEDIMENT TYPE	SEDIMENT CONCENTRATION (DRY WEIGHT)	SEDIMENT VALIDATION QUALIFIER	SEDIMENT DETECTION LIMIT
PCB-81	FI	SNFI04S01	3.37	ng/g		0.12	SNFS04S01	FS	0.98		
PCB-90/101	FI	SNFI03	275.5	ng/g		0.215	SNFS03S01	FS	1.1		
PCB-90/101	FI	SNFI02S01	131	ng/g		0.23	SNFS02S01	FS	1.1		
PCB-90/101	FI	SNFI01S01	296	ng/g		0.16	SNFS01	FS	10.5		
PCB-90/101	FI	SNFI04S01	475	ng/g		0.23999999	SNFS04S01	FS	120		
Phenanthrene	FI	R2FI02S01	9.4	UG/KG	J		R2FS02S01	FS	34		
Phenanthrene	FI	R2FI01S01	15	UG/KG	J		R2FS01	FS	61	J	
Selenium	FI	R2FI04S01	1.8568	MG/KG	J		R2FS04S01	FS	0.3849	J	
Selenium	FI	R2FI01S01	1.525	MG/KG	J		R2FS01	FS	0.465	J	0.1
Selenium	FI	R2FI02S01	2.1028	MG/KG	J		R2FS02S01	FS	0.72		0.1
Selenium	FI	R2FI03	1.1577	MG/KG	J		R2FS03S01	FS	1		0.1
Vanadium	FI	R2FI01S01	1.3265	MG/KG			R2FS01	FS	54.3846	J	
Vanadium	FI	R2FI04S01	0.4094	MG/KG			R2FS04S01	FS	38.7394	J	
Vanadium	FI	R2FI03	0.6418	MG/KG			R2FS03S01	FS	63.6	J	
Vanadium	FI	R2FI02S01	0.498	MG/KG			R2FS02S01	FS	63.8	J	
Zinc	FI	R2FI01S01	148.5098	MG/KG	J		R2FS01	FS	337.74315	J	
Zinc	FI	R2FI04S01	81.5473	MG/KG			R2FS04S01	FS	263.6441	J	
Zinc	FI	R2FI02S01	101.8423	MG/KG	J		R2FS02S01	FS	399	J	
Zinc	FI	R2FI03	74.39345	MG/KG			R2FS03S01	FS	403	J	

APPENDIX K

ATTACHMENT K-6

DATA USED IN TERRESTRIAL VERTEBRATE BIOACCUMULATION FACTOR SELECTION

Appendix K, Attachment K-6 (1 of 3)

Data Used in Terrestrial Vertebrate Bioaccumulation Factor Selection

CHEMICAL	TISSUE TYPE	TISSUE SAMPLE ID	TISSUE CONCENTRATION (WET WEIGHT)	UNITS	TISSUE VALIDATION QUALIFIER	TISSUE DETECTION LIMIT	SOIL SAMPLE ID	SOIL TYPE	SOIL CONCENTRATION (DRY WEIGHT)	SOIL VALIDATION QUALIFIER	SOIL DETECTION LIMIT	PERCENT MOISTURE	BAF Rank
1,2,3,4,6,7,8-HpCDD	MO	CLMO04S01	1.83	pg/g			CLSS04	SS	16.45			0.68	1
1,2,3,4,6,7,8-HpCDD	MO	CLMO06S01	4.56	pg/g			CLSS06S01	SS	97.1			0.68	2
1,2,3,4,6,7,8-HpCDD	MO	CLMO07S01	0.49	pg/g	J		CLSS07S01	SS	41.4			0.68	3
1,2,3,4,6,7,8-HpCDD	MO	CLMO05S01	1.08	pg/g			CLSS05S01	SS	96.6			0.68	4
1,2,3,4,6,7,8-HpCDF	MO	CLMO04S01	0.73	pg/g	J		CLSS04	SS	5.17			0.68	1
1,2,3,4,6,7,8-HpCDF	MO	CLMO06S01	1.14	pg/g			CLSS06S01	SS	8.29			0.68	2
1,2,3,4,6,7,8-HpCDF	MO	CLMO05S01	0.29	pg/g	J		CLSS05S01	SS	15.7			0.68	3
1,2,3,4,7,8-HxCDD	MO	CLMO06S01	0.105	pg/g	J		CLSS06S01	SS	1.38	J		0.68	
1,2,3,4,7,8-HxCDF	MO	CLMO04S01	0.34	pg/g	J		CLSS04	SS	1.335	J		0.68	
1,2,3,6,7,8-HxCDD	MO	CLMO06S01	0.292	pg/g	J		CLSS06S01	SS	4.24			0.68	
1,2,3,6,7,8-HxCDF	MO	CLMO04S01	0.2	pg/g	J		CLSS04	SS	0.955	J		0.68	
1,2,3,7,8,9-HxCDD	MO	CLMO06S01	0.14	pg/g	J		CLSS06S01	SS	2.45	J		0.68	
2,3,4,6,7,8-HxCDF	MO	CLMO04S01	0.12	pg/g	J		CLSS04	SS	0.7	J		0.68	
2,3,4,7,8-PeCDF	MO	CLMO04S01	0.22	pg/g	J		CLSS04	SS	1.555	J		0.68	
2,3,7,8-TCDF	MO	CLMO04S01	0.14	pg/g	J		CLSS04	SS	2.345			0.68	
Aluminum	MO	BVMO07S01	356.2963	MG/KG			BVSS07	SS	8792.5669	J		0.68	1
Aluminum	MO	BVMO08S01	196.9794	MG/KG			BVSS08S01	SS	6350	J	90	0.68	2
Aluminum	MO	BVMO06S01	130.9174	MG/KG			BVSS06S01	SS	9300	J	90	0.68	3
Aluminum	MO	BVMO05S01	39.1943	MG/KG			BVSS05S01	SS	7370	J	90	0.68	4
Antimony	MO	BVMO06S01	0.1451	MG/KG			BVSS06S01	SS	0.62	J	0.2	0.68	
Antimony	MO	BVMO07S01	0.1739	MG/KG			BVSS07	SS	1.2443	J		0.68	
Barium	MO	BVMO07S01	6.3407	MG/KG			BVSS07	SS	54.32885			0.68	1
Barium	MO	BVMO05S01	4.6351	MG/KG			BVSS05S01	SS	43.6	J		0.68	2
Barium	MO	BVMO08S01	4.1648	MG/KG			BVSS08S01	SS	44.2	J		0.68	3
Barium	MO	BVMO06S01	4.6789	MG/KG			BVSS06S01	SS	55.2	J		0.68	4
Benzo(a)anthracene	MO	CLMO05S01	6.7	UG/KG	J		CLSS05S01	SS	1.3	J		0.68	
Benzo(a)pyrene	MO	CLMO05S01	3.8	UG/KG	J		CLSS05S01	SS	2	J		0.68	
Benzo(b)fluoranthene	MO	CLMO05S01	4.2	UG/KG	J		CLSS05S01	SS	2.5			0.68	
Benzo(g,h,i)perylene	MO	CLMO05S01	6.8	UG/KG			CLSS05S01	SS	4.7			0.68	
Benzo(k)fluoranthene	MO	CLMO05S01	5	UG/KG	J		CLSS05S01	SS	2	J		0.68	
Boron	MO	BVMO07S01	5.2914	MG/KG			BVSS07	SS	1.4365			0.68	
Chromium	MO	BVMO07S01	0.756	MG/KG			BVSS07	SS	15.21855	J		0.68	1
Chromium	MO	BVMO05S01	0.4692	MG/KG			BVSS05S01	SS	12.2	J		0.68	2
Chromium	MO	BVMO08S01	0.5867	MG/KG			BVSS08S01	SS	21.5	J		0.68	3
Chromium	MO	BVMO06S01	0.3479	MG/KG			BVSS06S01	SS	14.2	J		0.68	4
Chrysene	MO	CLMO05S01	4.9	UG/KG	J		CLSS05S01	SS	2.4			0.68	
Cobalt	MO	BVMO07S01	0.5235	MG/KG			BVSS07	SS	5.644	J		0.68	
Cobalt	MO	BVMO08S01	0.2346	MG/KG			BVSS08S01	SS	4.7	J		0.68	
Cobalt	MO	BVMO06S01	0.1944	MG/KG			BVSS06S01	SS	5.2	J		0.68	
Cobalt	MO	BVMO05S01	0.087	MG/KG			BVSS05S01	SS	4.5	J		0.68	
Copper	MO	BVMO05S01	2.3301	MG/KG			BVSS05S01	SS	9.1	J	2	0.68	1
Copper	MO	BVMO06S01	1.8553	MG/KG			BVSS06S01	SS	9	J	2	0.68	2
Copper	MO	BVMO07S01	2.5951	MG/KG			BVSS07	SS	13.7714			0.68	3
Copper	MO	BVMO08S01	3.6201	MG/KG			BVSS08S01	SS	19.9	J	2	0.68	4
Dibenz(a,h)anthracene	MO	CLMO05S01	5.8	UG/KG	J		CLSS05S01	SS	1.1	J		0.68	
Fluoranthene	MO	CLMO05S01	3.6	UG/KG	J		CLSS05S01	SS	4.8			0.68	
Indeno(1,2,3-cd)pyrene	MO	CLMO05S01	6	UG/KG			CLSS05S01	SS	2.6			0.68	
Iron	MO	BVMO07S01	624.9383	MG/KG			BVSS07	SS	16583.18595	J		0.68	1
Iron	MO	BVMO08S01	373.6842	MG/KG			BVSS08S01	SS	17288.8158	J		0.68	2
Iron	MO	BVMO06S01	234.1743	MG/KG			BVSS06S01	SS	17534.6113	J		0.68	3
Iron	MO	BVMO05S01	98.3649	MG/KG			BVSS05S01	SS	15027.2345	J		0.68	4
Magnesium	MO	BVMO05S01	688.1517	MG/KG			BVSS05S01	SS	2700	J		0.68	1
Magnesium	MO	BVMO08S01	636.3844	MG/KG			BVSS08S01	SS	2660	J		0.68	2
Magnesium	MO	BVMO07S01	650.6173	MG/KG			BVSS07	SS	3423.9578			0.68	3

Appendix K, Attachment K-6 (2 of 3)

Data Used in Terrestrial Vertebrate Bioaccumulation Factor Selection

CHEMICAL	TISSUE TYPE	TISSUE SAMPLE ID	TISSUE CONCENTRATION (WET WEIGHT)	UNITS	TISSUE VALIDATION QUALIFIER	TISSUE DETECTION LIMIT	SOIL SAMPLE ID	SOIL TYPE	SOIL CONCENTRATION (DRY WEIGHT)	SOIL VALIDATION QUALIFIER	SOIL DETECTION LIMIT	PERCENT MOISTURE	BAF Rank
Magnesium	MO	BVMO06S01	485.7798	MG/KG			BVSS06S01	SS	3470	J		0.68	4
Manganese	MO	BVMO07S01	9.0568	MG/KG	J		BVSS07	SS	169.49945	J		0.68	1
Manganese	MO	BVMO08S01	6.7757	MG/KG	J		BVSS08S01	SS	189	J		0.68	2
Manganese	MO	BVMO05S01	2.8673	MG/KG	J		BVSS05S01	SS	137	J		0.68	3
Manganese	MO	BVMO06S01	4.0367	MG/KG	J		BVSS06S01	SS	223	J		0.68	4
Molybdenum	MO	BVMO06S01	0.1923	MG/KG			BVSS06S01	SS	0.17			0.68	1
Molybdenum	MO	BVMO05S01	0.2483	MG/KG			BVSS05S01	SS	0.62			0.68	2
Molybdenum	MO	BVMO07S01	0.2405	MG/KG			BVSS07	SS	0.8219			0.68	3
Molybdenum	MO	BVMO08S01	0.3009	MG/KG			BVSS08S01	SS	1.3			0.68	4
Nickel	MO	BVMO07S01	0.4005	MG/KG			BVSS07	SS	9.39915	J		0.68	1
Nickel	MO	BVMO05S01	0.1887	MG/KG			BVSS05S01	SS	6.3			0.68	2
Nickel	MO	BVMO08S01	0.3297	MG/KG			BVSS08S01	SS	12.6			0.68	3
Nickel	MO	BVMO06S01	0.1503	MG/KG			BVSS06S01	SS	7.4			0.68	4
OCDD	MO	CLMO04S01	18.3	pg/g			CLSS04	SS	210.5			0.68	1
OCDD	MO	CLMO06S01	14.3	pg/g			CLSS06S01	SS	904			0.68	2
OCDD	MO	CLMO05S01	11	pg/g			CLSS05S01	SS	1000			0.68	3
OCDD	MO	CLMO07S01	4.6	pg/g			CLSS07S01	SS	455			0.68	4
OCDF	MO	CLMO06S01	6.56	pg/g			CLSS06S01	SS	20.4			0.68	1
OCDF	MO	CLMO04S01	0.87	pg/g	J		CLSS04	SS	10.75			0.68	2
OCDF	MO	CLMO05S01	1.09	pg/g	J		CLSS05S01	SS	74.7			0.68	3
PCB-105	MO	BVMO05S01	3.2	ng/g		0.01	BVSS05S01	SS	3.3			0.68	1
PCB-105	MO	BVMO06S01	0.766	ng/g		0.02	BVSS06S01	SS	1.3			0.68	2
PCB-105	MO	BVMO07S01	0.187	ng/g		0.02	BVSS07	SS	1.8			0.68	3
PCB-105	MO	BVMO08S01	0.65	ng/g		0.02	BVSS08S01	SS	25			0.68	4
PCB-114	MO	BVMO05S01	0.177	ng/g		0.01	BVSS05S01	SS	0.081			0.68	1
PCB-114	MO	BVMO06S01	0.0236	ng/g		0.02	BVSS06S01	SS	0.028	J		0.68	2
PCB-114	MO	BVMO08S01	0.0243	ng/g		0.02	BVSS08S01	SS	0.91			0.68	3
PCB-118	MO	BVMO05S01	6.68	ng/g		0.01	BVSS05S01	SS	6.6			0.68	1
PCB-118	MO	BVMO06S01	2.06	ng/g		0.02	BVSS06S01	SS	2.3			0.68	2
PCB-118	MO	BVMO07S01	0.415	ng/g		0.02	BVSS07	SS	3.6			0.68	3
PCB-118	MO	BVMO08S01	2.16	ng/g		0.02	BVSS08S01	SS	57			0.68	4
PCB-123	MO	BVMO05S01	0.105	ng/g		0.01	BVSS05S01	SS	0.095			0.68	
PCB-123	MO	BVMO06S01	0.0307	ng/g		0.02	BVSS06S01	SS	0.029	J		0.68	
PCB-126	MO	BVMO05S01	0.0364	ng/g		0.01	BVSS05S01	SS	0.069			0.68	
PCB-126	MO	BVMO08S01	0.21	ng/g		0.02	BVSS08S01	SS	0.32			0.68	
PCB-128	MO	BVMO06S01	1.43	ng/g		0.02	BVSS06S01	SS	1.5			0.68	1
PCB-128	MO	BVMO05S01	3.41	ng/g		0.01	BVSS05S01	SS	4.2			0.68	2
PCB-128	MO	BVMO08S01	1.11	ng/g		0.02	BVSS08S01	SS	20			0.68	3
PCB-128	MO	BVMO07S01	0.357	ng/g		0.02	BVSS07	SS	6.45			0.68	4
PCB-138	MO	BVMO05S01	13.2	ng/g		0.01	BVSS05S01	SS	16			0.68	1
PCB-138	MO	BVMO06S01	4.72	ng/g		0.02	BVSS06S01	SS	6			0.68	2
PCB-138	MO	BVMO08S01	8.77	ng/g		0.02	BVSS08S01	SS	84			0.68	3
PCB-138	MO	BVMO07S01	1.02	ng/g		0.02	BVSS07	SS	21			0.68	4
PCB-153	MO	BVMO06S01	4.56	ng/g		0.02	BVSS06S01	SS	3			0.68	1
PCB-153	MO	BVMO05S01	10.7	ng/g		0.01	BVSS05S01	SS	8			0.68	2
PCB-153	MO	BVMO08S01	7.61	ng/g		0.02	BVSS08S01	SS	45			0.68	3
PCB-153	MO	BVMO07S01	0.593	ng/g		0.02	BVSS07	SS	10			0.68	4
PCB-156	MO	BVMO05S01	2.13	ng/g		0.01	BVSS05S01	SS	1.5			0.68	1
PCB-156	MO	BVMO06S01	0.527	ng/g		0.02	BVSS06S01	SS	0.62			0.68	2
PCB-156	MO	BVMO08S01	0.812	ng/g		0.02	BVSS08S01	SS	10			0.68	3
PCB-156	MO	BVMO07S01	0.0682	ng/g		0.02	BVSS07	SS	1.15			0.68	4
PCB-157	MO	BVMO05S01	4.82	ng/g		0.01	BVSS05S01	SS	0.43			0.68	1
PCB-157	MO	BVMO06S01	0.137	ng/g		0.02	BVSS06S01	SS	0.16			0.68	2
PCB-157	MO	BVMO08S01	0.212	ng/g		0.02	BVSS08S01	SS	2.1			0.68	3
PCB-157	MO	BVMO07S01	0.0265	ng/g		0.02	BVSS07	SS	0.56			0.68	4
PCB-167	MO	BVMO06S01	0.426	ng/g		0.02	BVSS06S01	SS	0.25			0.68	1
PCB-167	MO	BVMO05S01	1.11	ng/g		0.01	BVSS05S01	SS	0.71			0.68	2
PCB-167	MO	BVMO08S01	0.349	ng/g		0.02	BVSS08S01	SS	3.7			0.68	3
PCB-167	MO	BVMO07S01	0.0695	ng/g		0.02	BVSS07	SS	0.965			0.68	4
PCB-170	MO	BVMO05S01	1.99	ng/g		0.01	BVSS05S01	SS	1.4			0.68	1
PCB-170	MO	BVMO06S01	0.641	ng/g		0.02	BVSS06S01	SS	0.48			0.68	2
PCB-170	MO	BVMO08S01	0.769	ng/g		0.02	BVSS08S01	SS	6.8			0.68	3
PCB-170	MO	BVMO07S01	0.0918	ng/g		0.02	BVSS07	SS	2.5			0.68	4

Appendix K, Attachment K-6 (3 of 3)

Data Used in Terrestrial Vertebrate Bioaccumulation Factor Selection

CHEMICAL	TISSUE TYPE	TISSUE SAMPLE ID	TISSUE CONCENTRATION (WET WEIGHT)	UNITS	TISSUE VALIDATION QUALIFIER	TISSUE DETECTION LIMIT	SOIL SAMPLE ID	SOIL TYPE	SOIL CONCENTRATION (DRY WEIGHT)	SOIL VALIDATION QUALIFIER	SOIL DETECTION LIMIT	PERCENT MOISTURE	BAF Rank
PCB-18	MO	BVMO08S01	0.023	ng/g		0.02	BVSS08S01	SS	1.1			0.68	
PCB-180	MO	BVMO06S01	1.32	ng/g		0.02	BVSS06S01	SS	0.92			0.68	1
PCB-180	MO	BVMO05S01	2.69	ng/g		0.01	BVSS05S01	SS	2.7			0.68	2
PCB-180	MO	BVMO08S01	2.09	ng/g		0.02	BVSS08S01	SS	12			0.68	3
PCB-180	MO	BVMO07S01	0.204	ng/g		0.02	BVSS07	SS	4.95			0.68	4
PCB-187	MO	BVMO05S01	0.39	ng/g		0.01	BVSS05S01	SS	0.96			0.68	1
PCB-187	MO	BVMO06S01	0.0995	ng/g		0.02	BVSS06S01	SS	0.31			0.68	2
PCB-187	MO	BVMO08S01	0.628	ng/g		0.02	BVSS08S01	SS	3.6			0.68	3
PCB-187	MO	BVMO07S01	0.0614	ng/g		0.02	BVSS07	SS	1.95			0.68	4
PCB-189	MO	BVMO05S01	0.2	ng/g		0.01	BVSS05S01	SS	0.088			0.68	1
PCB-189	MO	BVMO06S01	0.0425	ng/g		0.02	BVSS06S01	SS	0.037	J		0.68	2
PCB-189	MO	BVMO08S01	0.0596	ng/g		0.02	BVSS08S01	SS	0.37			0.68	3
PCB-195	MO	BVMO06S01	0.0603	ng/g		0.02	BVSS06S01	SS	0.054			0.68	1
PCB-195	MO	BVMO05S01	0.072	ng/g		0.01	BVSS05S01	SS	0.14			0.68	2
PCB-195	MO	BVMO08S01	0.121	ng/g		0.02	BVSS08S01	SS	0.54			0.68	3
PCB-206	MO	BVMO06S01	0.0978	ng/g		0.02	BVSS06S01	SS	0.15			0.68	1
PCB-206	MO	BVMO05S01	0.166	ng/g		0.01	BVSS05S01	SS	0.31			0.68	2
PCB-206	MO	BVMO08S01	0.144	ng/g		0.02	BVSS08S01	SS	1			0.68	3
PCB-209	MO	BVMO06S01	0.0382	ng/g		0.02	BVSS06S01	SS	0.047	J		0.68	1
PCB-209	MO	BVMO05S01	0.0275	ng/g		0.01	BVSS05S01	SS	0.087			0.68	2
PCB-209	MO	BVMO08S01	0.047	ng/g		0.02	BVSS08S01	SS	0.61			0.68	3
PCB-66	MO	BVMO06S01	0.0993	ng/g		0.02	BVSS06S01	SS	0.23			0.68	1
PCB-66	MO	BVMO05S01	0.158	ng/g		0.01	BVSS05S01	SS	0.45			0.68	2
PCB-66	MO	BVMO07S01	0.0686	ng/g		0.02	BVSS07	SS	0.425			0.68	3
PCB-66	MO	BVMO08S01	0.0487	ng/g		0.02	BVSS08S01	SS	6.1			0.68	4
PCB-77	MO	BVMO06S01	0.0241	ng/g		0.02	BVSS06S01	SS	0.098			0.68	
PCB-8	MO	BVMO08S01	0.0214	ng/g		0.02	BVSS08S01	SS	0.18			0.68	
PCB-90/101	MO	BVMO07S01	0.352	ng/g		0.039999999	BVSS07	SS	4.75			0.68	1
PCB-90/101	MO	BVMO06S01	0.135	ng/g		0.039999999	BVSS06S01	SS	2.3			0.68	2
PCB-90/101	MO	BVMO05S01	0.0849	ng/g		0.029999999	BVSS05S01	SS	8			0.68	3
PCB-90/101	MO	BVMO08S01	0.478	ng/g		0.039999999	BVSS08S01	SS	78			0.68	4
Phenanthrene	MO	CLMO05S01	2.9	UG/KG	J		CLSS05S01	SS	2.7			0.68	
Pyrene	MO	CLMO05S01	5.1	UG/KG			CLSS05S01	SS	4.4	J		0.68	
Selenium	MO	BVMO05S01	0.2666	MG/KG			BVSS05S01	SS	0.14		0.1	0.68	
Selenium	MO	BVMO08S01	0.3455	MG/KG			BVSS08S01	SS	0.19		0.1	0.68	
Vanadium	MO	BVMO07S01	1.4035	MG/KG			BVSS07	SS	24.0803	J		0.68	1
Vanadium	MO	BVMO08S01	0.7064	MG/KG			BVSS08S01	SS	17.5	J		0.68	2
Vanadium	MO	BVMO06S01	0.4789	MG/KG			BVSS06S01	SS	23.7	J		0.68	3
Vanadium	MO	BVMO05S01	0.193	MG/KG			BVSS05S01	SS	18.8	J		0.68	4
Zinc	MO	BVMO05S01	71.1137	MG/KG			BVSS05S01	SS	55.3	J		0.68	1
Zinc	MO	BVMO06S01	37.133	MG/KG			BVSS06S01	SS	55.1	J		0.68	2
Zinc	MO	BVMO08S01	73.6156	MG/KG			BVSS08S01	SS	146	J		0.68	3
Zinc	MO	BVMO07S01	36.4691	MG/KG			BVSS07	SS	82.33795	J		0.68	4

APPENDIX K

ATTACHMENT K-7

DATA USED IN TERRESTRIAL INVERTEBRATE BIOACCUMULATION FACTOR SELECTION

Data Used in Terrestrial Invertebrate Bioaccumulation Factor Selection

CHEMICAL	TISSUE TYPE	TISSUE SAMPLE ID	TISSUE CONCENTRATION (WET WEIGHT)	UNITS	TISSUE VALIDATION QUALIFIER	TISSUE DETECTION LIMIT	SOIL SAMPLE ID	SOIL TYPE	SOIL CONCENTRATION (DRY WEIGHT)	SOIL VALIDATION QUALIFIER	SOIL DETECTION LIMIT	BAF Rank
1,2,3,4,6,7,8-HpCDD	TI	CLTI07S01	24.3	pg/g			CLSS07S01	SS	41.4			1
1,2,3,4,6,7,8-HpCDD	TI	CLTI06S01	40.8	pg/g			CLSS06S01	SS	97.1			2
1,2,3,4,6,7,8-HpCDD	TI	CLTI05S01	23	pg/g			CLSS05S01	SS	96.6			3
1,2,3,4,6,7,8-HpCDD	TI	CLTI04S01	2.59	pg/g			CLSS04	SS	16.45			4
1,2,3,4,6,7,8-HpCDF	TI	CLTI07S01	3.89	pg/g			CLSS07S01	SS	6.74			1
1,2,3,4,6,7,8-HpCDF	TI	CLTI06S01	1.43	pg/g	J		CLSS06S01	SS	8.29			2
1,2,3,4,6,7,8-HpCDF	TI	CLTI05S01	2.27	pg/g			CLSS05S01	SS	15.7			3
1,2,3,4,7,8-HxCDD	TI	CLTI05S01	0.7	pg/g	J		CLSS05S01	SS	1.03	J		
1,2,3,4,7,8-HxCDD	TI	CLTI07S01	0.73	pg/g	J		CLSS07S01	SS	0.83	J		
1,2,3,4,7,8-HxCDF	TI	CLTI07S01	0.49	pg/g	J		CLSS07S01	SS	0.75	J		
1,2,3,6,7,8-HxCDD	TI	CLTI07S01	2.44	pg/g			CLSS07S01	SS	2.95			1
1,2,3,6,7,8-HxCDD	TI	CLTI06S01	3.17	pg/g	J		CLSS06S01	SS	4.24			2
1,2,3,6,7,8-HxCDD	TI	CLTI05S01	1.99	pg/g			CLSS05S01	SS	4.04			3
1,2,3,6,7,8-HxCDF	TI	CLTI07S01	0.38	pg/g	J		CLSS07S01	SS	1.47	J		
1,2,3,7,8,9-HxCDD	TI	CLTI06S01	2.34	pg/g	J		CLSS06S01	SS	2.45	J		1
1,2,3,7,8,9-HxCDD	TI	CLTI07S01	1.09	pg/g	J		CLSS07S01	SS	1.73	J		2
1,2,3,7,8,9-HxCDD	TI	CLTI05S01	0.93	pg/g	J		CLSS05S01	SS	2.07	J		3
1,2,3,7,8-PeCDD	TI	CLTI05S01	0.43	pg/g	J		CLSS05S01	SS	0.63	J		
1,2,3,7,8-PeCDD	TI	CLTI07S01	0.59	pg/g	J		CLSS07S01	SS	0.55	J		
1,2,3,7,8-PeCDF	TI	CLTI05S01	0.13	pg/g	J		CLSS05S01	SS	0.33	J		
1,2,3,7,8-PeCDF	TI	CLTI07S01	0.22	pg/g	J		CLSS07S01	SS	0.48	J		
2,3,4,6,7,8-HxCDF	TI	CLTI07S01	0.35	pg/g	J		CLSS07S01	SS	0.626	J		
2,3,4,7,8-PeCDF	TI	CLTI05S01	0.2	pg/g	J		CLSS05S01	SS	0.63	J		
2,3,4,7,8-PeCDF	TI	CLTI07S01	0.44	pg/g	J		CLSS07S01	SS	0.619	J		
2,3,7,8-TCDF	TI	CLTI06S01	0.94	pg/g	J		CLSS06S01	SS	0.81			1
2,3,7,8-TCDF	TI	CLTI07S01	0.41	pg/g	J		CLSS07S01	SS	0.69			2
2,3,7,8-TCDF	TI	CLTI05S01	0.36	pg/g	J		CLSS05S01	SS	0.72			3
2,3,7,8-TCDF	TI	CLTI04S01	0.421	pg/g		0	CLSS04	SS	2.345			4
Acenaphthene	TI	CLTI06S01	13	UG/KG	J		CLSS06S01	SS	5.4	J		
Aluminum	TI	BVTI07S01	3466.6221	MG/KG			BVSS07	SS	8792.5669	J		1
Aluminum	TI	BVTI05S01	2728.8288	MG/KG			BVSS05S01	SS	7370	J	90	2
Aluminum	TI	BVTI06S01	1996.7576	MG/KG			BVSS06S01	SS	9300	J	90	3
Aluminum	TI	BVTI08S01	643.3884	MG/KG			BVSS08S01	SS	6350	J	90	4
Anthracene	TI	CLTI06S01	31	UG/KG			CLSS06S01	SS	11			
Antimony	TI	BVTI05S01	5.9865	MG/KG			BVSS05S01	SS	0.61	J	0.2	1
Antimony	TI	BVTI06S01	1.3011	MG/KG			BVSS06S01	SS	0.62	J	0.2	2
Antimony	TI	BVTI07S01	2.1256	MG/KG			BVSS07	SS	1.2443	J		3
Antimony	TI	BVTI08S01	0.9343	MG/KG			BVSS08S01	SS	0.78	J	0.2	4
Arsenic	TI	BVTI07S01	2.2118	MG/KG			BVSS07	SS	3.4736	J		1
Arsenic	TI	BVTI06S01	1.5366	MG/KG			BVSS06S01	SS	3.7			2
Arsenic	TI	BVTI08S01	0.4607	MG/KG			BVSS08S01	SS	3			3
Barium	TI	BVTI07S01	161.7032	MG/KG			BVSS07	SS	54.32885			1
Barium	TI	BVTI05S01	99.1441	MG/KG			BVSS05S01	SS	43.6	J		2
Barium	TI	BVTI06S01	48.8723	MG/KG			BVSS06S01	SS	55.2	J		3
Barium	TI	BVTI08S01	37.4504	MG/KG			BVSS08S01	SS	44.2	J		4
Benzo(a)anthracene	TI	CLTI06S01	89	UG/KG	J		CLSS06S01	SS	47	J		
Benzo(a)pyrene	TI	CLTI06S01	60	UG/KG	J	15	CLSS06S01	SS	60	J		
Benzo(b)fluoranthene	TI	CLTI06S01	94	UG/KG	J	15	CLSS06S01	SS	46			
Benzo(e)pyrene	TI	CLTI06S01	50	UG/KG	J	15	CLSS06S01	SS	46	J		
Benzo(g,h,i)perylene	TI	CLTI06S01	34	UG/KG		15	CLSS06S01	SS	64			
Benzo(k)fluoranthene	TI	CLTI06S01	50	UG/KG		15	CLSS06S01	SS	56			
Beryllium	TI	BVTI07S01	0.1308	MG/KG			BVSS07	SS	0.3245			1
Beryllium	TI	BVTI06S01	0.1081	MG/KG			BVSS06S01	SS	0.45			2

Data Used in Terrestrial Invertebrate Bioaccumulation Factor Selection

CHEMICAL	TISSUE TYPE	TISSUE SAMPLE ID	TISSUE CONCENTRATION (WET WEIGHT)	UNITS	TISSUE VALIDATION QUALIFIER	TISSUE DETECTION LIMIT	SOIL SAMPLE ID	SOIL TYPE	SOIL CONCENTRATION (DRY WEIGHT)	SOIL VALIDATION QUALIFIER	SOIL DETECTION LIMIT	BAF Rank
Beryllium	TI	BVTI08S01	0.0254	MG/KG			BVSS08S01	SS	0.33			3
Boron	TI	BVTI07S01	6.6714	MG/KG			BVSS07	SS	1.4365			
Cadmium	TI	BVTI05S01	9.2342	MG/KG			BVSS05S01	SS	0.44			1
Cadmium	TI	BVTI07S01	6.7492	MG/KG			BVSS07	SS	1.1791	J		2
Cadmium	TI	BVTI08S01	3.1579	MG/KG			BVSS08S01	SS	3.3			3
Chromium	TI	BVTI06S01	37.3546	MG/KG			BVSS06S01	SS	14.2	J		1
Chromium	TI	BVTI05S01	29.6577	MG/KG			BVSS05S01	SS	12.2	J		2
Chromium	TI	BVTI07S01	12.6819	MG/KG			BVSS07	SS	15.21855	J		3
Chromium	TI	BVTI08S01	11.5579	MG/KG			BVSS08S01	SS	21.5	J		4
Chrysene	TI	CLTI06S01	110	UG/KG	J		CLSS06S01	SS	59			
Cobalt	TI	BVTI07S01	1.5024	MG/KG			BVSS07	SS	5.644	J		1
Cobalt	TI	BVTI06S01	1.0086	MG/KG			BVSS06S01	SS	5.2	J		2
Cobalt	TI	BVTI08S01	0.4661	MG/KG			BVSS08S01	SS	4.7	J		3
Copper	TI	BVTI05S01	157.4324	MG/KG			BVSS05S01	SS	9.1	J	2	1
Copper	TI	BVTI07S01	109.0848	MG/KG			BVSS07	SS	13.7714			2
Copper	TI	BVTI06S01	56.7937	MG/KG			BVSS06S01	SS	9	J	2	3
Copper	TI	BVTI08S01	79.2562	MG/KG			BVSS08S01	SS	19.9	J	2	4
Fluoranthene	TI	CLTI06S01	170	UG/KG			CLSS06S01	SS	110			
Fluoranthene	TI	CLTI07S01	4.5	UG/KG	J		CLSS07S01	SS	17			
Fluorene	TI	CLTI06S01	13	UG/KG	J		CLSS06S01	SS	3.3	J		
Indeno(1,2,3-cd)pyrene	TI	CLTI06S01	42	UG/KG		15	CLSS06S01	SS	49			
Iron	TI	BVTI07S01	7728.7937	MG/KG			BVSS07	SS	16583.18595	J		1
Iron	TI	BVTI05S01	5608.1081	MG/KG			BVSS05S01	SS	15027.2345	J		2
Iron	TI	BVTI06S01	3806.255	MG/KG			BVSS06S01	SS	17534.6113	J		3
Iron	TI	BVTI08S01	1427.2727	MG/KG			BVSS08S01	SS	17288.8158	J		4
Lead	TI	BVTI07S01	7.6426	MG/KG			BVSS07	SS	20.2189	J		
Lead	TI	BVTI08S01	2.512	MG/KG			BVSS08S01	SS	23.1	J	0.9	
Magnesium	TI	BVTI05S01	3542.3423	MG/KG			BVSS05S01	SS	2700	J		1
Magnesium	TI	BVTI07S01	3022.4193	MG/KG			BVSS07	SS	3423.9578			2
Magnesium	TI	BVTI06S01	2267.1305	MG/KG			BVSS06S01	SS	3470	J		3
Magnesium	TI	BVTI08S01	1331.405	MG/KG			BVSS08S01	SS	2660	J		4
Manganese	TI	BVTI07S01	125.0627	MG/KG			BVSS07	SS	169.49945	J		1
Manganese	TI	BVTI05S01	90	MG/KG			BVSS05S01	SS	137	J		2
Manganese	TI	BVTI06S01	68.0293	MG/KG			BVSS06S01	SS	223	J		3
Manganese	TI	BVTI08S01	25.219	MG/KG			BVSS08S01	SS	189	J		4
Mercury	TI	BVTI07S01	0.0739	MG/KG			BVSS07	SS	0.02075	J		1
Mercury	TI	BVTI08S01	0.0574	MG/KG			BVSS08S01	SS	0.106			2
Mercury	TI	BVTI06S01	0.0516	MG/KG			BVSS06S01	SS	0.2057			3
Molybdenum	TI	BVTI06S01	1.2236	MG/KG			BVSS06S01	SS	0.17			1
Molybdenum	TI	BVTI05S01	1.6811	MG/KG			BVSS05S01	SS	0.62			2
Molybdenum	TI	BVTI07S01	0.9963	MG/KG			BVSS07	SS	0.8219			3
Molybdenum	TI	BVTI08S01	0.5322	MG/KG			BVSS08S01	SS	1.3			4
Nickel	TI	BVTI06S01	16.8175	MG/KG			BVSS06S01	SS	7.4			1
Nickel	TI	BVTI05S01	13.2297	MG/KG			BVSS05S01	SS	6.3			2
Nickel	TI	BVTI07S01	6.6957	MG/KG			BVSS07	SS	9.39915	J		3
Nickel	TI	BVTI08S01	5.1612	MG/KG			BVSS08S01	SS	12.6			4
OCDD	TI	CLTI07S01	259	pg/g			CLSS07S01	SS	455			1
OCDD	TI	CLTI05S01	203	pg/g			CLSS05S01	SS	1000			2
OCDD	TI	CLTI06S01	157	pg/g			CLSS06S01	SS	904			3
OCDD	TI	CLTI04S01	16.6	pg/g			CLSS04	SS	210.5			4
OCDF	TI	CLTI07S01	6.8	pg/g			CLSS07S01	SS	12.5			1
OCDF	TI	CLTI06S01	2.1	pg/g	J		CLSS06S01	SS	20.4			2
OCDF	TI	CLTI05S01	3.53	pg/g			CLSS05S01	SS	74.7			3
PCB-105	TI	BVTI07S01	22.5	ng/g			BVSS07	SS	1.8			1
PCB-105	TI	BVTI05S01	34.2	ng/g			BVSS05S01	SS	3.3			2
PCB-105	TI	BVTI06S01	7.95	ng/g			BVSS06S01	SS	1.3			3
PCB-105	TI	BVTI08S01	22.2	ng/g			BVSS08S01	SS	25			4

Data Used in Terrestrial Invertebrate Bioaccumulation Factor Selection

CHEMICAL	TISSUE TYPE	TISSUE SAMPLE ID	TISSUE CONCENTRATION (WET WEIGHT)	UNITS	TISSUE VALIDATION QUALIFIER	TISSUE DETECTION LIMIT	SOIL SAMPLE ID	SOIL TYPE	SOIL CONCENTRATION (DRY WEIGHT)	SOIL VALIDATION QUALIFIER	SOIL DETECTION LIMIT	BAF Rank
PCB-114	TI	BVTI07S01	0.958	ng/g			BVSS07	SS	0.031	J		1
PCB-114	TI	BVTI05S01	1.19	ng/g			BVSS05S01	SS	0.081			2
PCB-114	TI	BVTI06S01	0.269	ng/g			BVSS06S01	SS	0.028	J		3
PCB-114	TI	BVTI08S01	1.04	ng/g			BVSS08S01	SS	0.91			4
PCB-118	TI	BVTI07S01	52	ng/g			BVSS07	SS	3.6			1
PCB-118	TI	BVTI05S01	75.7	ng/g			BVSS05S01	SS	6.6			2
PCB-118	TI	BVTI06S01	18.8	ng/g			BVSS06S01	SS	2.3			3
PCB-118	TI	BVTI08S01	55.9	ng/g			BVSS08S01	SS	57			4
PCB-123	TI	BVTI05S01	1.2	ng/g			BVSS05S01	SS	0.095			1
PCB-123	TI	BVTI06S01	0.314	ng/g			BVSS06S01	SS	0.029	J		2
PCB-123	TI	BVTI07S01	0.609	ng/g			BVSS07	SS	0.2815			3
PCB-123	TI	BVTI08S01	0.58	ng/g			BVSS08S01	SS	0.65			4
PCB-126	TI	BVTI05S01	0.467	ng/g			BVSS05S01	SS	0.069			1
PCB-126	TI	BVTI07S01	0.41	ng/g			BVSS07	SS	0.077			2
PCB-126	TI	BVTI06S01	0.197	ng/g			BVSS06S01	SS	0.038	J		3
PCB-126	TI	BVTI08S01	0.13	ng/g			BVSS08S01	SS	0.32			4
PCB-128	TI	BVTI05S01	23.3	ng/g			BVSS05S01	SS	4.2			1
PCB-128	TI	BVTI06S01	5.71	ng/g			BVSS06S01	SS	1.5			2
PCB-128	TI	BVTI07S01	17.2	ng/g			BVSS07	SS	6.45			3
PCB-128	TI	BVTI08S01	13.1	ng/g			BVSS08S01	SS	20			4
PCB-138	TI	BVTI05S01	101	ng/g			BVSS05S01	SS	16			1
PCB-138	TI	BVTI06S01	26.8	ng/g			BVSS06S01	SS	6			2
PCB-138	TI	BVTI07S01	75.4	ng/g			BVSS07	SS	21			3
PCB-138	TI	BVTI08S01	53	ng/g			BVSS08S01	SS	84			4
PCB-153	TI	BVTI05S01	65.2	ng/g			BVSS05S01	SS	8			1
PCB-153	TI	BVTI06S01	21.2	ng/g			BVSS06S01	SS	3			2
PCB-153	TI	BVTI07S01	48.6	ng/g			BVSS07	SS	10			3
PCB-153	TI	BVTI08S01	37.8	ng/g			BVSS08S01	SS	45			4
PCB-156	TI	BVTI05S01	9.98	ng/g			BVSS05S01	SS	1.5			1
PCB-156	TI	BVTI07S01	6.67	ng/g			BVSS07	SS	1.15			2
PCB-156	TI	BVTI06S01	2.48	ng/g			BVSS06S01	SS	0.62			3
PCB-156	TI	BVTI08S01	7.05	ng/g			BVSS08S01	SS	10			4
PCB-157	TI	BVTI05S01	2.55	ng/g			BVSS05S01	SS	0.43			1
PCB-157	TI	BVTI06S01	0.735	ng/g			BVSS06S01	SS	0.16			2
PCB-157	TI	BVTI07S01	1.93	ng/g			BVSS07	SS	0.56			3
PCB-157	TI	BVTI08S01	1.68	ng/g			BVSS08S01	SS	2.1			4
PCB-167	TI	BVTI05S01	4.58	ng/g			BVSS05S01	SS	0.71			1
PCB-167	TI	BVTI06S01	1.47	ng/g			BVSS06S01	SS	0.25			2
PCB-167	TI	BVTI07S01	3.64	ng/g			BVSS07	SS	0.965			3
PCB-167	TI	BVTI08S01	3.22	ng/g			BVSS08S01	SS	3.7			4
PCB-170	TI	BVTI05S01	6.24	ng/g			BVSS05S01	SS	1.4			1
PCB-170	TI	BVTI06S01	1.56	ng/g			BVSS06S01	SS	0.48			2
PCB-170	TI	BVTI07S01	5.04	ng/g			BVSS07	SS	2.5			3
PCB-170	TI	BVTI08S01	3.9	ng/g			BVSS08S01	SS	6.8			4
PCB-18	TI	BVTI08S01	0.156	ng/g			BVSS08S01	SS	1.1			
PCB-180	TI	BVTI05S01	10.2	ng/g			BVSS05S01	SS	2.7			1
PCB-180	TI	BVTI06S01	3.3	ng/g			BVSS06S01	SS	0.92			2
PCB-180	TI	BVTI07S01	9.45	ng/g			BVSS07	SS	4.95			3
PCB-180	TI	BVTI08S01	6.55	ng/g			BVSS08S01	SS	12			4
PCB-187	TI	BVTI05S01	7.73	ng/g			BVSS05S01	SS	0.96			1
PCB-187	TI	BVTI06S01	1.99	ng/g			BVSS06S01	SS	0.31			2
PCB-187	TI	BVTI07S01	7.92	ng/g			BVSS07	SS	1.95			3
PCB-187	TI	BVTI08S01	3.63	ng/g			BVSS08S01	SS	3.6			4
PCB-189	TI	BVTI05S01	0.228	ng/g			BVSS05S01	SS	0.088			1
PCB-189	TI	BVTI06S01	0.0883	ng/g			BVSS06S01	SS	0.037	J		2
PCB-189	TI	BVTI07S01	0.314	ng/g			BVSS07	SS	0.145			3
PCB-189	TI	BVTI08S01	0.106	ng/g			BVSS08S01	SS	0.37			4
PCB-195	TI	BVTI05S01	0.27	ng/g			BVSS05S01	SS	0.14			1
PCB-195	TI	BVTI06S01	0.0901	ng/g			BVSS06S01	SS	0.054			2
PCB-195	TI	BVTI07S01	0.31	ng/g			BVSS07	SS	0.315			3
PCB-195	TI	BVTI08S01	0.277	ng/g			BVSS08S01	SS	0.54			4

Appendix K, Attachment K-7 (4 of 4)

Data Used in Terrestrial Invertebrate Bioaccumulation Factor Selection

CHEMICAL	TISSUE TYPE	TISSUE SAMPLE ID	TISSUE CONCENTRATION (WET WEIGHT)	UNITS	TISSUE VALIDATION QUALIFIER	TISSUE DETECTION LIMIT	SOIL SAMPLE ID	SOIL TYPE	SOIL CONCENTRATION (DRY WEIGHT)	SOIL VALIDATION QUALIFIER	SOIL DETECTION LIMIT	BAF Rank
PCB-206	TI	BVTI06S01	0.149	ng/g			BVSS06S01	SS	0.15			1
PCB-206	TI	BVTI07S01	0.246	ng/g			BVSS07	SS	0.5			2
PCB-206	TI	BVTI08S01	0.096	ng/g			BVSS08S01	SS	1			3
PCB-209	TI	BVTI05S01	0.138	ng/g			BVSS05S01	SS	0.087			1
PCB-209	TI	BVTI07S01	0.147	ng/g			BVSS07	SS	0.115			2
PCB-209	TI	BVTI08S01	0.0662	ng/g			BVSS08S01	SS	0.61			3
PCB-28	TI	BVTI08S01	0.907	ng/g			BVSS08S01	SS	0.54			
PCB-44	TI	BVTI07S01	1.55	ng/g			BVSS07	SS	0.17			1
PCB-44	TI	BVTI05S01	0.749	ng/g			BVSS05S01	SS	0.34			2
PCB-44	TI	BVTI06S01	0.262	ng/g			BVSS06S01	SS	0.15			3
PCB-44	TI	BVTI08S01	1.05	ng/g			BVSS08S01	SS	12			4
PCB-52	TI	BVTI07S01	7.04	ng/g			BVSS07	SS	0.515			1
PCB-52	TI	BVTI05S01	5.72	ng/g			BVSS05S01	SS	1			2
PCB-52	TI	BVTI06S01	1.3	ng/g			BVSS06S01	SS	0.42			3
PCB-52	TI	BVTI08S01	5.54	ng/g			BVSS08S01	SS	28			4
PCB-66	TI	BVTI07S01	4.65	ng/g			BVSS07	SS	0.425			1
PCB-66	TI	BVTI05S01	3.76	ng/g			BVSS05S01	SS	0.45			2
PCB-66	TI	BVTI06S01	1.2	ng/g			BVSS06S01	SS	0.23			3
PCB-66	TI	BVTI08S01	3.59	ng/g			BVSS08S01	SS	6.1			4
PCB-77	TI	BVTI05S01	1.26	ng/g			BVSS05S01	SS	0.18			1
PCB-77	TI	BVTI07S01	1.03	ng/g			BVSS07	SS	0.29			2
PCB-77	TI	BVTI06S01	0.329	ng/g			BVSS06S01	SS	0.098			3
PCB-77	TI	BVTI08S01	0.83	ng/g			BVSS08S01	SS	1.2			4
PCB-8	TI	BVTI08S01	0.0391	ng/g			BVSS08S01	SS	0.18			
PCB-81	TI	BVTI05S01	0.41	ng/g			BVSS05S01	SS	0.059			1
PCB-81	TI	BVTI07S01	0.308	ng/g			BVSS07	SS	0.0515			2
PCB-81	TI	BVTI06S01	0.0801	ng/g			BVSS06S01	SS	0.023	J		3
PCB-81	TI	BVTI08S01	0.28	ng/g			BVSS08S01	SS	0.62			4
PCB-90/101	TI	BVTI07S01	37.7	ng/g			BVSS07	SS	4.75			1
PCB-90/101	TI	BVTI05S01	49.5	ng/g			BVSS05S01	SS	8			2
PCB-90/101	TI	BVTI06S01	12.2	ng/g			BVSS06S01	SS	2.3			3
PCB-90/101	TI	BVTI08S01	26.7	ng/g			BVSS08S01	SS	78			4
Phenanthrene	TI	CLTI05S01	2.8	UG/KG	J		CLSS05S01	SS	2.7			
Phenanthrene	TI	CLTI06S01	130	UG/KG			CLSS06S01	SS	49			
Pyrene	TI	CLTI06S01	130	UG/KG			CLSS06S01	SS	120	J		
Pyrene	TI	CLTI07S01	76	UG/KG			CLSS07S01	SS	16			
Selenium	TI	BVTI08S01	0.35	MG/KG	J		BVSS08S01	SS	0.19		0.1	
Silver	TI	BVTI08S01	0.7351	MG/KG			BVSS08S01	SS	0.11			1
Silver	TI	BVTI06S01	0.5464	MG/KG			BVSS06S01	SS	0.09			2
Silver	TI	BVTI07S01	1.131	MG/KG			BVSS07	SS	0.19255			3
Thallium	TI	BVTI05S01	2.2014	MG/KG			BVSS05S01	SS	2			1
Thallium	TI	BVTI07S01	0.98	MG/KG			BVSS07	SS	1.67295			2
Thallium	TI	BVTI06S01	0.3639	MG/KG			BVSS06S01	SS	2.3			3
Vanadium	TI	BVTI07S01	7.9271	MG/KG			BVSS07	SS	24.0803	J		1
Vanadium	TI	BVTI05S01	6.0901	MG/KG			BVSS05S01	SS	18.8	J		2
Vanadium	TI	BVTI06S01	4.7923	MG/KG			BVSS06S01	SS	23.7	J		3
Vanadium	TI	BVTI08S01	1.4529	MG/KG			BVSS08S01	SS	17.5	J		4
Zinc	TI	BVTI05S01	180.4955	MG/KG			BVSS05S01	SS	55.3	J		1
Zinc	TI	BVTI07S01	183.8715	MG/KG			BVSS07	SS	82.33795	J		2
Zinc	TI	BVTI06S01	106.5074	MG/KG			BVSS06S01	SS	55.1	J		3
Zinc	TI	BVTI08S01	71.7355	MG/KG			BVSS08S01	SS	146	J		4

APPENDIX K

ATTACHMENT K-8

DATA USED IN TERRESTRIAL PLANT BIOACCUMULATION FACTOR SELECTION

Appendix K, Attachment K-8 (1 of 3)

Data Used in Terrestrial Plant Bioaccumulation Factor Selection

CHEMICAL	TISSUE TYPE	TISSUE SAMPLE ID	TISSUE CONCENTRATION (WET WEIGHT)	UNITS	TISSUE VALIDATION QUALIFIER	TISSUE DETECTION LIMIT	SOIL SAMPLE ID	SOIL TYPE	SOIL CONCENTRATION (DRY WEIGHT)	SOIL VALIDATION QUALIFIER	SOIL DETECTION LIMIT	BAF Rank
1,2,3,4,6,7,8-HpCDD	TP	CLTP04S01	5.6	pg/g			CLSS04	SS	16.45			1
1,2,3,4,6,7,8-HpCDD	TP	CLTP07S01	10.8	pg/g			CLSS07S01	SS	41.4			2
1,2,3,4,6,7,8-HpCDD	TP	CLTP05S01	10.7	pg/g			CLSS05S01	SS	96.6			3
1,2,3,4,6,7,8-HpCDD	TP	CLTP06S01	4.21	pg/g			CLSS06S01	SS	97.1			4
1,2,3,4,6,7,8-HpCDF	TP	CLTP07S01	1.76	pg/g	J		CLSS07S01	SS	6.74			1
1,2,3,4,6,7,8-HpCDF	TP	CLTP05S01	3.33	pg/g	J		CLSS05S01	SS	15.7			2
1,2,3,4,6,7,8-HpCDF	TP	CLTP06S01	1.09	pg/g	J		CLSS06S01	SS	8.29			3
1,2,3,6,7,8-HxCDD	TP	CLTP05S01	0.66	pg/g	J		CLSS05S01	SS	4.04			
Aluminum	TP	BVTP06S01	7151.5293	MG/KG			BVSS06S01	SS	9300	J	90	1
Aluminum	TP	BVTP08S01	4714.4439	MG/KG			BVSS08S01	SS	6350	J	90	2
Aluminum	TP	BVTP07S01	4519.0747	MG/KG			BVSS07	SS	8793	J		3
Aluminum	TP	BVTP05S01	2160.7606	MG/KG			BVSS05S01	SS	7370	J	90	4
Antimony	TP	BVTP05S01	3.3823	MG/KG			BVSS05S01	SS	0.61	J	0.2	1
Antimony	TP	BVTP06S01	2.868	MG/KG			BVSS06S01	SS	0.62	J	0.2	2
Antimony	TP	BVTP08S01	2.9594	MG/KG			BVSS08S01	SS	0.78	J	0.2	3
Antimony	TP	BVTP07S01	3.4619	MG/KG			BVSS07	SS	1.24	J		4
Arsenic	TP	BVTP08S01	2.3509	MG/KG			BVSS08S01	SS	3			1
Arsenic	TP	BVTP06S01	2.8473	MG/KG			BVSS06S01	SS	3.7			2
Arsenic	TP	BVTP07S01	1.9663	MG/KG			BVSS07	SS	3.5	J		3
Barium	TP	BVTP07S01	60.3084	MG/KG			BVSS07	SS	54			1
Barium	TP	BVTP06S01	55.4262	MG/KG			BVSS06S01	SS	55.2	J		2
Barium	TP	BVTP08S01	42.1136	MG/KG			BVSS08S01	SS	44.2	J		3
Barium	TP	BVTP05S01	25.4201	MG/KG			BVSS05S01	SS	43.6	J		4
Benzo(a)anthracene	TP	CLTP04S01	11	UG/KG	J		CLSS04S01	SS	2.1	J		
Beryllium	TP	BVTP06S01	0.2895	MG/KG			BVSS06S01	SS	0.45			1
Beryllium	TP	BVTP07S01	0.1966	MG/KG			BVSS07	SS	0.3245			2
Beryllium	TP	BVTP08S01	0.1965	MG/KG			BVSS08S01	SS	0.33			3
Beryllium	TP	BVTP05S01	0.086	MG/KG			BVSS05S01	SS	0.35			4
Boron	TP	BVTP07S01	10.623	MG/KG			BVSS07	SS	1.4			
Cadmium	TP	BVTP05S01	5.0792	MG/KG			BVSS05S01	SS	0.44			1
Cadmium	TP	BVTP07S01	4.0229	MG/KG			BVSS07	SS	1.2	J		2
Cadmium	TP	BVTP08S01	9.9921	MG/KG			BVSS08S01	SS	3.3			3
Chromium	TP	BVTP06S01	144.8832	MG/KG			BVSS06S01	SS	14.2	J		1
Chromium	TP	BVTP07S01	111.3028	MG/KG			BVSS07	SS	15.21855	J		2
Chromium	TP	BVTP08S01	110.8474	MG/KG			BVSS08S01	SS	21.5	J		3
Chromium	TP	BVTP05S01	42.0052	MG/KG			BVSS05S01	SS	12.2	J		4
Chrysene	TP	CLTP04S01	13	UG/KG	J		CLSS04	SS	4.5	J		1
Chrysene	TP	CLTP07S01	10	UG/KG	J		CLSS07S01	SS	8.9			2
Chrysene	TP	CLTP06S01	4.9	UG/KG	J		CLSS06S01	SS	59			3
Cobalt	TP	BVTP06S01	3.5425	MG/KG			BVSS06S01	SS	5.2	J		1
Cobalt	TP	BVTP08S01	3.125	MG/KG			BVSS08S01	SS	4.7	J		2
Cobalt	TP	BVTP07S01	2.0586	MG/KG			BVSS07	SS	5.644	J		3
Cobalt	TP	BVTP05S01	1.0487	MG/KG			BVSS05S01	SS	4.5	J		4
Copper	TP	BVTP06S01	17.9238	MG/KG			BVSS06S01	SS	9	J	2	1
Copper	TP	BVTP05S01	17.094	MG/KG			BVSS05S01	SS	9.1	J	2	2
Copper	TP	BVTP08S01	32.9484	MG/KG			BVSS08S01	SS	19.9	J	2	3
Copper	TP	BVTP07S01	18.0398	MG/KG			BVSS07	SS	13.7714			4
Fluoranthene	TP	CLTP04S01	20	UG/KG	J		CLSS04	SS	6.6	J		1
Fluoranthene	TP	CLTP07S01	14	UG/KG	J		CLSS07S01	SS	17			2
Fluoranthene	TP	CLTP06S01	11	UG/KG			CLSS06S01	SS	110			3
Iron	TP	BVTP06S01	11871.2509	MG/KG			BVSS06S01	SS	17535	J		1
Iron	TP	BVTP08S01	10831.6195	MG/KG			BVSS08S01	SS	17289	J		2
Iron	TP	BVTP07S01	7739.4481	MG/KG			BVSS07	SS	16583	J		3
Iron	TP	BVTP05S01	4269.6629	MG/KG			BVSS05S01	SS	15027	J		4
Lead	TP	BVTP08S01	60.0221	MG/KG			BVSS08S01	SS	23.1	J	0.9	1
Lead	TP	BVTP06S01	8.1678	MG/KG			BVSS06S01	SS	9.4	J	0.9	2
Lead	TP	BVTP07S01	14.2959	MG/KG			BVSS07	SS	20.2	J		3
Lead	TP	BVTP05S01	8.1475	MG/KG			BVSS05S01	SS	12.2	J	0.9	4
Magnesium	TP	BVTP06S01	4118.9643	MG/KG			BVSS06S01	SS	3470	J		1
Magnesium	TP	BVTP08S01	3023.7832	MG/KG			BVSS08S01	SS	2660	J		2
Magnesium	TP	BVTP07S01	3321.8344	MG/KG			BVSS07	SS	3424			3
Magnesium	TP	BVTP05S01	2527.6097	MG/KG			BVSS05S01	SS	2700	J		4

Appendix K, Attachment K-8 (2 of 3)

Data Used in Terrestrial Plant Bioaccumulation Factor Selection

CHEMICAL	TISSUE TYPE	TISSUE SAMPLE ID	TISSUE CONCENTRATION (WET WEIGHT)	UNITS	TISSUE VALIDATION QUALIFIER	TISSUE DETECTION LIMIT	SOIL SAMPLE ID	SOIL TYPE	SOIL CONCENTRATION (DRY WEIGHT)	SOIL VALIDATION QUALIFIER	SOIL DETECTION LIMIT	BAF Rank
Manganese	TP	BVTP06S01	221.6866	MG/KG			BVSS06S01	SS	223	J		1
Manganese	TP	BVTP08S01	160.7341	MG/KG			BVSS08S01	SS	189	J		2
Manganese	TP	BVTP07S01	142.8571	MG/KG			BVSS07	SS	169	J		3
Manganese	TP	BVTP05S01	73.0625	MG/KG			BVSS05S01	SS	137	J		4
Mercury	TP	BVTP06S01	0.0452	MG/KG			BVSS06S01	SS	0.2057			
Mercury	TP	BVTP08S01	0.1498	MG/KG			BVSS08S01	SS	0.106			
Molybdenum	TP	BVTP06S01	2.7736	MG/KG			BVSS06S01	SS	0.17			1
Molybdenum	TP	BVTP05S01	4.2389	MG/KG			BVSS05S01	SS	0.62			2
Molybdenum	TP	BVTP07S01	2.7597	MG/KG			BVSS07	SS	0.8219			3
Molybdenum	TP	BVTP08S01	3.5163	MG/KG			BVSS08S01	SS	1.3			4
Nickel	TP	BVTP06S01	63.781	MG/KG			BVSS06S01	SS	7.4			1
Nickel	TP	BVTP07S01	51.4915	MG/KG			BVSS07	SS	9.39915	J		2
Nickel	TP	BVTP08S01	48.6526	MG/KG			BVSS08S01	SS	12.6			3
Nickel	TP	BVTP05S01	21.3579	MG/KG			BVSS05S01	SS	6.3			4
OCDD	TP	CLTP07S01	108	pg/g			CLSS07S01	SS	455			1
OCDD	TP	CLTP04S01	49.3	pg/g			CLSS04	SS	210.5			2
OCDD	TP	CLTP05S01	100	pg/g			CLSS05S01	SS	1000			3
OCDD	TP	CLTP06S01	39.2	pg/g			CLSS06S01	SS	904			4
OCDF	TP	CLTP04S01	3.75	pg/g	J		CLSS04	SS	10.75			1
OCDF	TP	CLTP07S01	3.55	pg/g	J		CLSS07S01	SS	12.5			2
OCDF	TP	CLTP06S01	3.26	pg/g	J		CLSS06S01	SS	20.4			3
OCDF	TP	CLTP05S01	10.8	pg/g			CLSS05S01	SS	74.7			4
PCB-105	TP	BVTP08S01	83.9	ng/g			BVSS08S01	SS	25			1
PCB-105	TP	BVTP05S01	10.9	ng/g			BVSS05S01	SS	3.3			2
PCB-105	TP	BVTP07S01	2.72	ng/g			BVSS07	SS	1.8			3
PCB-105	TP	BVTP06S01	1.36	ng/g			BVSS06S01	SS	1.3			4
PCB-114	TP	BVTP05S01	0.352	ng/g			BVSS05S01	SS	0.081			
PCB-114	TP	BVTP08S01	2.75	ng/g			BVSS08S01	SS	0.91			
PCB-118	TP	BVTP08S01	200	ng/g			BVSS08S01	SS	57			1
PCB-118	TP	BVTP05S01	20.8	ng/g			BVSS05S01	SS	6.6			2
PCB-118	TP	BVTP07S01	5.52	ng/g			BVSS07	SS	3.6			3
PCB-118	TP	BVTP06S01	2.06	ng/g			BVSS06S01	SS	2.3			4
PCB-123	TP	BVTP05S01	0.334	ng/g			BVSS05S01	SS	0.095			
PCB-123	TP	BVTP08S01	2.16	ng/g			BVSS08S01	SS	0.65			
PCB-126	TP	BVTP05S01	0.17	ng/g			BVSS05S01	SS	0.069			
PCB-126	TP	BVTP08S01	0.636	ng/g			BVSS08S01	SS	0.32			
PCB-128	TP	BVTP08S01	56.6	ng/g			BVSS08S01	SS	20			1
PCB-128	TP	BVTP05S01	8.44	ng/g			BVSS05S01	SS	4.2			2
PCB-128	TP	BVTP06S01	1.52	ng/g			BVSS06S01	SS	1.5			3
PCB-128	TP	BVTP07S01	3.22	ng/g			BVSS07	SS	6.45			4
PCB-138	TP	BVTP08S01	252	ng/g			BVSS08S01	SS	84			1
PCB-138	TP	BVTP05S01	37.3	ng/g			BVSS05S01	SS	16			2
PCB-138	TP	BVTP06S01	6.31	ng/g			BVSS06S01	SS	6			3
PCB-138	TP	BVTP07S01	13.3	ng/g			BVSS07	SS	21			4
PCB-153	TP	BVTP08S01	143	ng/g			BVSS08S01	SS	45			1
PCB-153	TP	BVTP05S01	20.8	ng/g			BVSS05S01	SS	8			2
PCB-153	TP	BVTP06S01	3.63	ng/g			BVSS06S01	SS	3			3
PCB-153	TP	BVTP07S01	6.7	ng/g			BVSS07	SS	10			4
PCB-156	TP	BVTP08S01	25.6	ng/g			BVSS08S01	SS	10			1
PCB-156	TP	BVTP05S01	3.24	ng/g			BVSS05S01	SS	1.5			2
PCB-156	TP	BVTP06S01	0.532	ng/g			BVSS06S01	SS	0.62			3
PCB-156	TP	BVTP07S01	0.95	ng/g			BVSS07	SS	1.15			4
PCB-157	TP	BVTP08S01	6.03	ng/g			BVSS08S01	SS	2.1			1
PCB-157	TP	BVTP05S01	0.85	ng/g			BVSS05S01	SS	0.43			2
PCB-157	TP	BVTP06S01	0.165	ng/g			BVSS06S01	SS	0.16			3
PCB-157	TP	BVTP07S01	0.355	ng/g			BVSS07	SS	0.56			4
PCB-167	TP	BVTP08S01	10.9	ng/g			BVSS08S01	SS	3.7			1
PCB-167	TP	BVTP05S01	1.55	ng/g			BVSS05S01	SS	0.71			2
PCB-167	TP	BVTP06S01	0.28	ng/g			BVSS06S01	SS	0.25			3
PCB-167	TP	BVTP07S01	0.537	ng/g			BVSS07	SS	0.965			4
PCB-170	TP	BVTP08S01	14	ng/g			BVSS08S01	SS	6.8			1
PCB-170	TP	BVTP05S01	1.98	ng/g			BVSS05S01	SS	1.4			2
PCB-170	TP	BVTP06S01	0.43	ng/g			BVSS06S01	SS	0.48			3
PCB-170	TP	BVTP07S01	0.812	ng/g			BVSS07	SS	2.5			4

Appendix K, Attachment K-8 (3 of 3)

Data Used in Terrestrial Plant Bioaccumulation Factor Selection

CHEMICAL	TISSUE TYPE	TISSUE SAMPLE ID	TISSUE CONCENTRATION (WET WEIGHT)	UNITS	TISSUE VALIDATION QUALIFIER	TISSUE DETECTION LIMIT	SOIL SAMPLE ID	SOIL TYPE	SOIL CONCENTRATION (DRY WEIGHT)	SOIL VALIDATION QUALIFIER	SOIL DETECTION LIMIT	BAF Rank
PCB-180	TP	BVTP08S01	28.5	ng/g			BVSS08S01	SS	12			1
PCB-180	TP	BVTP05S01	3.44	ng/g			BVSS05S01	SS	2.7			2
PCB-180	TP	BVTP06S01	0.826	ng/g			BVSS06S01	SS	0.92			3
PCB-180	TP	BVTP07S01	1.62	ng/g			BVSS07	SS	4.95			4
PCB-187	TP	BVTP08S01	11.5	ng/g			BVSS08S01	SS	3.6			1
PCB-187	TP	BVTP05S01	1.46	ng/g			BVSS05S01	SS	0.96			2
PCB-187	TP	BVTP06S01	0.37	ng/g			BVSS06S01	SS	0.31			3
PCB-187	TP	BVTP07S01	0.738	ng/g			BVSS07	SS	1.95			4
PCB-189	TP	BVTP05S01	0.155	ng/g			BVSS05S01	SS	0.088			
PCB-189	TP	BVTP08S01	0.95	ng/g			BVSS08S01	SS	0.37			
PCB-195	TP	BVTP05S01	0.143	ng/g			BVSS05S01	SS	0.14			
PCB-206	TP	BVTP05S01	0.246	ng/g			BVSS05S01	SS	0.31			
PCB-209	TP	BVTP08S01	1.49	ng/g			BVSS08S01	SS	0.61			
PCB-28	TP	BVTP08S01	4.3	ng/g			BVSS08S01	SS	0.54			
PCB-44	TP	BVTP05S01	1.51	ng/g			BVSS05S01	SS	0.34			1
PCB-44	TP	BVTP07S01	0.44	ng/g			BVSS07	SS	0.17			2
PCB-44	TP	BVTP08S01	29	ng/g			BVSS08S01	SS	12			3
PCB-44	TP	BVTP06S01	0.197	ng/g			BVSS06S01	SS	0.15			4
PCB-52	TP	BVTP05S01	4.92	ng/g			BVSS05S01	SS	1			1
PCB-52	TP	BVTP08S01	86.2	ng/g			BVSS08S01	SS	28			2
PCB-52	TP	BVTP07S01	1.23	ng/g			BVSS07	SS	0.515			3
PCB-52	TP	BVTP06S01	0.544	ng/g			BVSS06S01	SS	0.42			4
PCB-66	TP	BVTP05S01	1.69	ng/g			BVSS05S01	SS	0.45			1
PCB-66	TP	BVTP08S01	17.5	ng/g			BVSS08S01	SS	6.1			2
PCB-66	TP	BVTP07S01	0.54	ng/g			BVSS07	SS	0.425			3
PCB-66	TP	BVTP06S01	0.278	ng/g			BVSS06S01	SS	0.23			4
PCB-77	TP	BVTP05S01	0.51	ng/g			BVSS05S01	SS	0.18			1
PCB-77	TP	BVTP08S01	2.71	ng/g			BVSS08S01	SS	1.2			2
PCB-77	TP	BVTP07S01	0.208	ng/g			BVSS07	SS	0.29			3
PCB-81	TP	BVTP05S01	0.196	ng/g			BVSS05S01	SS	0.059			
PCB-81	TP	BVTP08S01	1.66	ng/g			BVSS08S01	SS	0.62			
PCB-90/101	TP	BVTP05S01	30	ng/g			BVSS05S01	SS	8			1
PCB-90/101	TP	BVTP08S01	242	ng/g			BVSS08S01	SS	78			2
PCB-90/101	TP	BVTP07S01	7.01	ng/g			BVSS07	SS	4.75			3
PCB-90/101	TP	BVTP06S01	2.97	ng/g			BVSS06S01	SS	2.3			4
Phenanthrene	TP	CLTP04S01	24	UG/KG			CLSS04	SS	2.7	J		1
Phenanthrene	TP	CLTP05S01	7.8	UG/KG	J		CLSS05S01	SS	2.7			2
Phenanthrene	TP	CLTP07S01	9.2	UG/KG	J		CLSS07S01	SS	7.1			3
Phenanthrene	TP	CLTP06S01	16	UG/KG			CLSS06S01	SS	49			4
Pyrene	TP	CLTP04S01	13	UG/KG	J		CLSS04	SS	6.55	J		1
Pyrene	TP	CLTP07S01	12	UG/KG	J		CLSS07S01	SS	16			2
Pyrene	TP	CLTP06S01	7.5	UG/KG	J		CLSS06S01	SS	120	J		3
Silver	TP	BVTP07S01	0.2545	MG/KG			BVSS07	SS	0.19255			
Silver	TP	BVTP08S01	0.226	MG/KG			BVSS08S01	SS	0.11			
Thallium	TP	BVTP06S01	1.3	MG/KG			BVSS06S01	SS	2.3			1
Thallium	TP	BVTP08S01	0.7567	MG/KG			BVSS08S01	SS	2.1			2
Thallium	TP	BVTP07S01	0.55	MG/KG			BVSS07	SS	1.67295			3
Thallium	TP	BVTP05S01	0.48	MG/KG			BVSS05S01	SS	2			4
Vanadium	TP	BVTP06S01	16.5028	MG/KG			BVSS06S01	SS	23.7	J		1
Vanadium	TP	BVTP08S01	10.7156	MG/KG			BVSS08S01	SS	17.5	J		2
Vanadium	TP	BVTP07S01	9.8762	MG/KG			BVSS07	SS	24.0803	J		3
Vanadium	TP	BVTP05S01	5.157	MG/KG			BVSS05S01	SS	18.8	J		4
Zinc	TP	BVTP05S01	97.6664	MG/KG			BVSS05S01	SS	55.3	J		1
Zinc	TP	BVTP06S01	67.9	MG/KG			BVSS06S01	SS	55.1	J		2
Zinc	TP	BVTP08S01	172.652	MG/KG			BVSS08S01	SS	146	J		3
Zinc	TP	BVTP07S01	81.7979	MG/KG			BVSS07	SS	82.33795	J		4

APPENDIX K

ATTACHMENT K-9

DATA USED TO DEVELOP A SOIL-TO-PLANT BIOTA ACCUMULATION FACTOR FOR PERCHLORATE

APPENDIX K, ATTACHMENT K-9

DATA USED TO DEVELOP A SOIL-TO-PLANT BIOTA ACCUMULATION FACTOR FOR PERCHLORATE

INTRODUCTION

Perchlorate (ClO_4^-)[1] has been detected in soils at a few sites at Boeing's Santa Susana Field Laboratory (SSFL). To support effective decision-making, both human health and ecological risk assessments for sites at the SSFL will evaluate potential risks due to exposures to perchlorate in soil. Given recent investigation findings that suggest perchlorate is capable of accumulating in certain plant species (Susarla *et al.* 1999a, Susarla *et al.* 1999b, Susarla *et al.* 1999c, Susarla *et al.* 2000, Smith *et al.* 2001, Ellington *et al.* 2001, Nzengung 1998, Nzengung 2002, Nzengung and Wang 2000, Schnoor *et al.* 2002, van Aken and Schnoor 2002, Sundberg, *et al.* 2003, Tan 2003), exposure scenarios of interest include the ingestion of perchlorate that may bioaccumulate into (a) vegetation (possible exposures to herbivorous wildlife) and (b) hypothetical produce/crops grown in gardens (possible exposures to potential future residents). The soil-to-plant biota accumulation factor (BAF)[2] is a key parameter commonly used to estimate potential exposures due to the ingestion of perchlorate that may accumulate in terrestrial plants which may then be consumed by either human or ecological receptors of concern.

This technical memorandum is intended to support discussions with regulatory agencies regarding the development of an appropriate soil-to-plant BAF for perchlorate that can be applied in performing baseline risk assessments for sites at the SSFL. To this end, provided herein is an overview of available pertinent scientific studies and identification of an appropriate study from which a perchlorate soil-to-plant BAF can be derived. Accordingly, the technical information in this memorandum is presented as follows:

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1 Perchlorate is an oxidizing agent that has been used in solid propellants for rockets and missiles and as ignitable sources for fireworks, road flares, air bag inflators, and matches (Urbansky 1998, Smith *et al.* 2001). In addition, perchlorates have been detected in laboratory waste by-products of perchloric acid. Perchlorate also occurs naturally in nitrate-rich mineral deposits used in fertilizers.

2 A chemical-specific soil-to-plant BAF is used to estimate exposures to perchlorate due to the ingestion of plants by humans and herbivorous wildlife. Specifically, the soil-to-plant BAF is used to determine the concentration of perchlorate in plant tissues according to the following equation:

$C_{plant} = C_{soil} \cdot BAF$ … where C_{plant} is the concentration in plant tissues and C_{soil} is the concentration in soils.

- Identification and acquisition of relevant scientific literature;
- Overview of relevant scientific literature;
- Identification of the preferred study to derive a soil-to-plant BAF for perchlorate; and
- Proposed soil-to-plant BAF for perchlorate.

Dr. Andrew Jackson of Texas Tech University, a recognized expert who has conducted numerous studies on the uptake of perchlorate into plants, was contacted and provided information to develop this memorandum.

IDENTIFICATION AND ACQUISITION OF RELEVANT SCIENTIFIC LITERATURE

Existing available studies published in the peer-reviewed literature were used to derive a soil-to-plant BAF for perchlorate. However, it should be noted that many of studies were designed with other specific objectives in mind (*i.e.*, not specifically designed to develop a soil-to-plant BAF) and, thus are considered to provide "found data" (*i.e.*, opportunistically found data that may be used to develop a soil-to-plant BAF). Only studies that transparently documented the study design, including reporting all of the following information, were considered relevant for this technical memorandum:

- Plant species and plant part (*e.g.*, leaf, stem) tested;
- Exposure media (*e.g.*, soil, irrigation water);
- Exposure duration;
- Measured media concentration;
- Measured plant concentration;
- Sample size; and
- Full citation or full citation of source.

A list of all the studies of the uptake and retention of perchlorate in plants that were reviewed for this technical memorandum is provided in Table 1. As shown, a relatively large number of papers related to the topic of perchlorate uptake by plants exists in the published literature. Whereas the majority of these studies describe the bioaccumulation of perchlorate into plants from irrigation water, only a few studies provide the necessary data (*i.e.*, measured concentrations of perchlorate in co-located soil and plant tissue samples) required for determining a soil-to-plant BAF. Use of irrigation water studies to derive a soil-to-plant BAF without the essential soil and plant concentration data requires several assumptions to perform the necessary conversion and, therefore, adds an indeterminate level of uncertainty (Dr. Jackson 2004, pers. comm.). Accordingly, more specific criteria used to select among the germane bioaccumulation studies are the following:

- Direct measurements of perchlorate in soils are preferred over measurements in water (*e.g.*, irrigation water, groundwater, hydroponic studies);
- Studies using terrestrial plants were preferred over studies using aquatic plants;
- Plant and soil samples must have been collected from the same approximate locations—*i.e.*, co-located soil and plant tissue samples;
- Measured concentrations of perchlorate in leaf tissue was preferred over concentrations of perchlorate in other plant parts[3]—use of leaf data are considered to provide the most conservative data for calculation of plant BAFs (Dr. Jackson 2004, pers. comm.);
- A continuous source of perchlorate provided/administered to the plant is preferred over a non-continuous source; and
- Field studies are preferred over laboratory/greenhouse studies.

OVERVIEW OF RELEVANT SCIENTIFIC LITERATURE

Based on recent laboratory and field studies, perchlorate has been found to readily bioaccumulate into a number of foodcrops from water (*e.g.*, lettuce, cucumbers, and soybeans) (Susarla *et al*, 1999c and Yu *et al.* 2004). Studies of commercial produce and products available in grocery

[3] Studies have found that much higher concentrations (as much as 7- to 100-fold) of perchlorate were detected in the leaves as compared to other parts of the plant (*e.g.*, stems, roots, seeds) (Susarla *et al.* 1999a, Susarla *et al.* 1999b, Susarla *et al.* 1999c, Susarla *et al.* 2000, Smith *et al.* 2001, Ellington *et al.* 2001, Nzengung 1998, Nzengung 2002, Nzengung and Wang 2000, Schnoor *et al.* 2002, van Aken and Schnoor 2002, Sundberg, *et al.* 2003, Tan 2003).

stores have detected perchlorate in lettuce, mustard greens, milk, and tobacco products (Danelski and Beeman 2003[4]; Sharp and Lunder 2003; Kirk *et al.* 2003; and Ellington *et al.* 2001).

However, only a few of these studies are suitable for determining a soil-to-plant BAF—many of the studies examined the bioaccumulation of perchlorate from irrigation water and did not measure perchlorate levels in the soil.

Studies Investigating the Bioaccumulation of Perchlorate From Water

The peer-reviewed literature is dominated by studies that have examined the uptake and retention of perchlorate into plants from water (*e.g.*, irrigation water, groundwater, hydroponic studies). Seventeen (17) studies of this type were identified. Plants examined include willows, bullrushes, cucumbers, soybeans, lettuce, and parrot feather among others (Table 1).

In general, these studies have found that plants readily bioaccumulate perchlorate from water. In fact, some of these plants are sometimes used to "phyto"-remediate perchlorate-tainted groundwater (AFCEE 2002). These studies often focus on transformation products that are produced as the plant takes up perchlorate. Some studies have found that plants have the potential to reduce perchlorate into chlorate, chloride, and chlorite (Bacchus *et al.* 1999, Susarla *et al.* 1999a, Susarla *et al.* 1999b, Susarla *et al.* 2000, Nzengung 1998, Nzengung *et al.* 1999a, Nzengung *et al.* 1999b, Nzengung 2002, Nzengung and Wang 2000, Schnoor *et al.* 2002, van Aken and Schnoor 2002).

Because the use of irrigation water studies to derive a soil-to-plant BAF requires assumptions that add an indeterminate level of uncertainty (Dr. Jackson 2004, pers. comm.), these studies are not used to derive a soil-to-plant BAF for perchlorate. This conclusion is consistent with the recommendation of Dr. Jackson (2004, pers. comm.). However, these studies are useful for providing a perspective for selecting soil studies. For example, studies examining bioaccumulation from water suggest that much of the perchlorate appears to be sequestered in the leaves of plants compared to other plant parts (Susarla *et al.* 1999a, Susarla *et al.* 1999b, Susarla *et al.* 1999c, Susarla *et al.* 2000, Nzengung 1998, Nzengung 2002, Nzengung and Wang 2000, Schnoor *et al.* 2002, van Aken and Schnoor 2002, Sundberg, *et al.* 2003, Tan 2003).

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4 Danelski and Beeman 2003 and Sharp and Lunder 2003 are not peer-reviewed studies. Consequently, they do not meet the criteria as relevant scientific literature and the studies are not included in Table 1.

Studies Investigating the Bioaccumulation of Perchlorate From Soil

Three (3) pertinent studies were selected as appropriate for deriving a soil-to-plant BAF; a study of perchlorate bioaccumulation in tobacco plants (Ellington *et al.* 2001), a study of perchlorate bioaccumulation in cucumber, lettuce and soybean leaves (Yu *et al.* 2004), and a study perchlorate in water, soil, vegetation and rodents in the Las Vegas Wash (Smith *et al.* 2004).

Brief Summary of Ellington *et al.* (2001). The Ellington *et al.* study (2001) intended to determine if perchlorate could be taken up into tobacco grown on soil amended with Chilean saltpeter, a naturally occurring source of perchlorate. Another study objective was to characterize the persistence of perchlorate in the tobacco plant over time and through a series of industrial processes. The Ellington *et al.* study (2001) was a field study with tobacco growing over a full season in amended soil. The tobacco was collected at the end of the season and 8 samples of tobacco lamina (*i.e.,* leaf without the midrib) analyzed. Perchlorate was detected in all leaf samples collected. Results of the study can be found in Table 2. The leaf and soil concentrations presented in Table 2 are based on the mean of measured concentrations in soil and tobacco lamina presented in the Ellington *et al*. (2001) paper[5].

The amendment process or frequency of amendment is not described in this study. However, the soil was collected several months after the tobacco was collected and measures were taken to ensure that plant material was not included in the soil samples. If this delay in sampling and analyzing the soil had any effects on the resulting soil-to-plant BAF, it would likely result in an overestimate of a soil-to-plant BAF. The perchlorate concentration is unlikely to have increased in the soils without further soil amendments; however, rain or irrigation water may have transported some of the remaining perchlorate away from the root zone. Thus, following the delay, the measured concentrations of perchlorate in the co-located soils would be lower (than if the soil samples were collected at the time of harvest), resulting in a greater estimate of the soil-to-plant BAF.

Brief Summary of Yu *et al.* (2004). Yu *et al.* (2004) studied the uptake of perchlorate into cucumber, soybean, and lettuce grown in sand (50 or 100 g soils) under laboratory conditions. The cucumber plants were watered with varying nutrient solutions of Hydrosol[6] and water to

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[5] Mean concentrations were obtained directly from Table 1 of the Ellington *et al*. (2001) paper.

[6] Hydrosol is a diluted solution of Peter's All-Purpose Plant Food (20-20-20) (Yu *et al.* 2004). As reported in Yu *et al.* (2004), Peter's Plant Food main components include nitrate, phosphate, magnesium, iron, copper, manganese, zinc, and molybdenum.

determine if nutrients affected the uptake of perchlorate—lettuce and soybean plants were watered with a 100% Hydrosol solution. Depending on the study, plants were exposed over a 4-, 6-, or 8-week period and all studies were performed in the laboratory. For the 4- and 6-week studies, the plants were given a single dose of perchlorate via solution to achieve a desired sand concentration. In the one 8-week study, cucumbers were watered with a 100% Hydrosol solution and the sand was dosed with perchlorate at Week 0 (the start of the study) and at Week 4. Samples of sand and plants (leaves and roots) were collected on a weekly or biweekly basis. Plant sample size ranged from 1 to 5 samples per analysis.

All plants accumulated perchlorate from soils—for cucumber and lettuce, concentrations of perchlorate in soils decreased to nondetectable amounts. For all plants tested, perchlorate was largely sequestered in above ground tissues (primarily leaves) compared to below ground tissues (primarily roots) and perchlorate concentrations in leaf tissue often showed a high degree of variability: both between plants within a treatment and from week to week—up to an order of magnitude in the case of the lettuce study. The authors also conclude that study results suggest that perchlorate exudation, transformation, or transpiration from leaves occurs. Please note that Table 2[7] presents the mean sand concentration at the beginning of the study and the mean leaf tissue burden at the end of the study or when the sand concentration went to non-detectable levels (*i.e.*, negligible perchlorate available for uptake), whichever comes first.

Brief Summary of Smith *et al.* (2004). Smith *et al.* (2004) investigated the correlation between water, vegetation, and soil perchlorate concentrations and rodent exposure in a perchlorate-contaminated area. Traps were set in three designated areas along the Las Vegas Wash. Water, soil, and vegetation samples were collected within 0.25 meters of the traps. The vegetation collected was not identified by species, but rather categorized by type (*e.g.* aquatic grass, leaf litter, or terrestrial broadleaf). Seeds and secondary stems associated with the plant samples were not removed prior to analysis. The authors found that the perchlorate concentrations measured in rodent livers and kidneys were correlated to soil perchlorate concentrations but were not correlated with vegetation concentrations. Based on these findings, the authors concluded that soil contamination is the best predictor of exposure in field rodents. Terrestrial broadleaf vegetation was found to have the highest plant tissue concentrations of perchlorate of all the vegetation type categories studied, and, as such, provides the most conservative estimate of a BAF. This study presented the plant data in terms of wet-weight, but the percent moisture

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7 Please note that the cucumber study that resulted in the greatest perchlorate accumulation into the leaves is presented in Table 2. Mean concentrations were obtained directly from Table 1 of the Yu *et al*. (2004) paper.

content of the vegetation was not presented. Since soil concentrations at the SSFL are reported in dry weight, a soil-to-plant BAF based on dry weight terms is required. Given the lack of the percent moisture of vegetation, using data from this study would require an assumption to convert wet weight to dry weight that would introduce an indeterminate level of uncertainty.

THE PREFERRED STUDY

The Ellington *et al.* (2001) study is selected as the preferred study for deriving a perchlorate BAF. This field study meets all of the criteria stated above. In addition, the plants in the study received a continuous source of perchlorate for a relatively long exposure time. This study also has a sufficiently large sample size to account for statistical variation among the data set. A matrix of all the reviewed studies summarizing aspects of the study based on the key features identified above is provided in Figure 1.

Study Provides Continuous Source of Perchlorate to Plants

The Ellington *et al.* study (2001) was performed using Chilean saltpeter (a known naturally occurring source of perchlorate) amended soil. The soil provided a continuous source of perchlorate, while in the Yu *et al.* (2004) study the laboratory sand was dosed only once with perchlorate for all but one scenario resulting in varying rates of perchlorate uptake. The single scenario where the sand was dosed a second time at 4 weeks, caused a spike in leaf tissue concentrations, but the final concentration at 8 weeks was below the leaf tissue concentration at 4 weeks. Additionally, in the Yu *et al*. (2004) study, the leaf tissue concentrations varied greatly from individual to individual within a treatment group[8] and from week to week, with the extreme being lettuce with an order of magnitude change in concentration measured from Week 4 (753 ppm) to Week 5 (20 ppm). Neither an increasing or decreasing trend in the weekly or bi-weekly results could be discerned. The Smith *et al.* (2004) study was performed in what the authors call "an area highly contaminated with perchlorate". It is assumed that the plants were also provided a continuous source of perchlorate.

Use of Data for Leaves

Both the Ellington *et al.* (2001) study and the Yu *et al.* (2004) study analyzed the leaves of the plants. Although the Smith *et al.* (2004) study primarily analyzed leaves, any seeds or secondary stems associated with the vegetation were not removed prior to analysis. Several studies

[8] Based on standard deviations provided in Table 1 of Yu *et al*. (2004).

observed that the highest concentration of perchlorate in the plant is found in the leaves (Susarla *et al.* 1999a, Susarla *et al.* 1999b, Susarla *et al.* 1999c, Susarla *et al.* 2000, Smith *et al.* 2001, Ellington *et al.* 2001, Nzengung 1998, Nzengung 2002, Nzengung and Wang 2000, Schnoor *et al.* 2002, van Aken and Schnoor 2002, Sundberg, *et al.* 2003, Tan 2003). Dr. Jackson (2004, pers. comm.) noted that if the weight of other parts of the plant (*e.g.*, seeds, fruit, stem) is added to the weight of the leafy portions, the BAF for the whole plant is likely to decrease. Thus, to ensure a conservative estimate, where possible, only data for leaves were considered in deriving the BAF for perchlorate (see Table 2).

Recommendations of Dr. Jackson (Texas Tech University)

Dr. Andrew Jackson of Texas Tech University is a recognized expert who, along with his colleagues at Texas Tech University, has conducted numerous studies on the uptake of perchlorate into plants. In fact, Dr. Jackson recently gave a presentation on the uptake of perchlorate into plants at the American Chemical Society's (ACS) 2004 annual meeting.

Dr. Jackson (2004, pers. comm.), a co-author of the Yu *et al.* (2004) study, recommended that the Ellington *et al.* study (2001)—not the Yu *et al.* (2004) study—be used to derive a soil-to-plant perchlorate BAF. His chief reasons are as follows:

- Study meets all of the minimum reporting requirements for peer-reviewed literature for this technical memorandum including providing the name of the plants tested, sample size, exposure duration, measured plant and source concentrations, and a full citation.
- Study provides data on co-located plant and soil samples.
- Study has a continuous source of perchlorate and a long exposure time (*i.e.*, full growing season).
- Study measured perchlorate concentrations in leaves, where much of the perchlorate is sequestered in plants (leading to conservative estimates of bioaccumulation).

In addition, Dr. Jackson (2004, pers. comm.) has gone back and calculated the pore water concentration for the data in the Yu *et al.* study (2004) as well as other unpublished data and derived uptake factors in the range of 300-fold.

PROPOSED SOIL-TO-PLANT BIOTA ACCUMULATION FACTOR

Perchlorate has been detected in soils at a few sites at the SSFL facility. As previously mentioned, exposure scenarios of interest include the ingestion of perchlorate that may bioaccumulate into (a) vegetation at the facility (possible exposures to herbivorous wildlife) and (b) hypothetical produce/crops grown in future gardens at the facility (possible exposures to potential future residents). To evaluate these exposure scenarios using existing data, a soil-to-plant BAF for perchlorate is required.

The Ellington *et al.* study (2001) reports a mean leaf concentration of 96 mg/kg [dry weight] and a mean soil concentration of 0.3 mg/kg [dry weight]. Accordingly, the proposed soil-to-plant BAF for perchlorate is calculated by dividing the leaf concentration by the soil concentration:

$$\text{Soil-to-Plant BAF} = 96 \text{ mg/kg [dw]}/0.34 \text{ mg/kg [dw]} = 282$$

Dr. Jackson's calculations corroborate this proposed BAF. The Boeing Company proposes to use this soil-to-plant BAF in screening and, if needed, baseline assessments of potential human health and ecological risks.

EPILOG

On 02 February 2005, the Boeing Company submitted this technical memorandum and three articles from the peer-reviewed literature (Ellington *et al.* 2001, Yu *et al.* 2004, Smith *et al.* (2004) to the Department of Toxic Substances Control (DTSC). On 28 February 2005, representatives of the Boeing Company and DTSC held a teleconference to discuss the technical memorandum and to reach agreement on an acceptable soil-to-plant BAF for perchlorate. During the teleconference, DTSC agreed to the proposed soil-to-plant BAF of 282 for use in screening. This agreement was documented in a memorandum from Mr. Michael Anderson (DTSC/HERD) to Mr. Gerard Abrams (DTSC) (DTSC 2005).

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Table 1. Plants Tested for Perchlorate Uptake

Plant	Media	Results	Reference
Lettuce	Water	Found in leaves	Susarla *et al.* 1999a
	Water/Soil conc. reported[1]		Yu *et al.* 2004
Tobacco	Soil	Found in leaves, midrib, cured chewing tobacco, and cigarettes	Ellington *et al.* 2001
	Water		Sundberg *et al.* 2003
Cucumber	Water/Soil conc. reported[1]	Found in leaves (cucumber not tested)	Yu *et al.* 2004
Soybean	Water/Soil conc. reported[1]	Detected in leaves[2]	Yu *et al.* 2004
Parrot Feather (*Myriophyllum aquaticum*)	Water	Detected and transformed into chloride	Susarla *et al.* 1999b
	Water		Susarla *et al.* 1999c
	Water		Nzengung 1998
	Water		Nzengung *et al.* 1999a
	Water		Nzengung 2002
Eucalyptus trees	Water	Uptake of perchlorate and transformation of up to 40% to chloride	Nzengung 1998
	Water		Nzengung *et al.* 1999a
	Water		Nzengung *et al.* 1999b
	Water		Nzengung and Wang 1999
	Water		Nzengung 2002
Willow trees	Water	Uptake of perchlorate and transformation to chloride	Nzengung 1998
	Water		Nzengung *et al.* 1999a
	Water		Nzengung *et al.* 1999b
	Water		Nzengung and Wang 1999
	Water		Nzengung 2002
	Water		Tan 2003
	Water		MWH 2004

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Table 1. Plants Tested for Perchlorate Uptake

Plant	Media	Results	Reference
Eastern cottonwood (poplar)	Water	Uptake of perchlorate and transformation to chlorite, chlorate, and chloride	Nzengung 1998
	Water		Nzengung *et al.* 1999a
	Water		Nzengung and Wang 1999
	Water		Nzengung 2002
	Water		Schnoor *et al.* 2002
	Water		Van Aken and Schnoor 2002
Spinach (minced)	Water	Uptake of perchlorate and transformation to chloride	Nzengung 1998
	Water		Nzengung *et al.* 1999a
	Water		Nzengung 2002
French tarragon (minced)	Water	Uptake of perchlorate and transformation to chloride	Nzengung 1998
	Water		Nzengung *et al.* 1999a
	Water		Nzengung 2002
Peat Moss	Water	Perchlorate sorbs to peat moss very quickly	Nzengung 2002
Tarragon	Water	Uptake of perchlorate inconclusive	Bacchus *et al.* 1999
Sweet gum	Water	Uptake of perchlorate and presence of metabolites chlorate, chlorite, and chloride	Susarla *et al.* 2000
Black willow	Water	Uptake of perchlorate and presence of metabolites chlorate, chlorite, and chloride	Susarla *et al.* 2000
Pickleweed	Water	Uptake of perchlorate and presence of metabolites chlorate, chlorite, and chloride	Susarla *et al.* 2000
	Water		Bacchus *et al.* 1999

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Table 1. Plants Tested for Perchlorate Uptake

Plant	Media	Results	Reference
Smartweed	Water	Uptake of perchlorate and presence of metabolites chlorate, and chlorite	Susarla *et al.* 2000
	Water		Bacchus *et al.* 1999
	Water	Detected in samples from the Bosque and Leon Watershed	Tan 2003
	Water		MWH 2004
Fragrant White water-lily	Water	Uptake of perchlorate and presence of metabolites chlorate, chlorite, and chloride	Susarla *et al.* 2000
	Water		Bacchus *et al.* 1999
Duckmeat	Water	Perchlorate uptake not found	Susarla *et al.* 2000
	Water		Bacchus *et al.* 1999
Blue-hyssop	Water	Uptake of perchlorate	Bacchus *et al.* 1999
Perennial glasswort	Water	Uptake of perchlorate	Bacchus *et al.* 1999
Waterweed	Water	Perchlorate uptake not found	Bacchus *et al.* 1999
Watercress	Water	Uptake of perchlorate	Tan 2003
	Water		MWH 2004
Ash	Water	Uptake of perchlorate	Tan 2003
	Water		MWH 2004
Chinaberry	Water	Uptake of perchlorate	Tan 2003
	Water		MWH 2004
Elm	Water	Uptake of perchlorate	Tan 2003
	Water		MWH 2004
Mulberry	Water	Uptake of perchlorate	Tan 2003
	Water		MWH 2004
Hackberry	Water	Uptake of perchlorate	Tan 2003
	Water		MWH 2004

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Table 1. Plants Tested for Perchlorate Uptake

Plant	Media	Results	Reference
Bullrush	Water/ Sediment	Collected from Longhorn Army Ammunition Plant. Detected in roots and plant.	Smith *et al.* 2001
	Water	Detected in samples collected upstream of Lake Las Vegas, in the Las Vegas Delta Area, and at the Longhorn Army Ammunition Plant.	Parsons 2001
Crabgrass	Soil	Collected from Longhorn Army Ammunition Plant. Detected in seeds and blades.	Smith *et al.* 2001
Cupgrass	Soil	Collected from Longhorn Army Ammunition Plant. Detected in blades.	Smith *et al.* 2001
Goldenrod	Soil	Collected from Longhorn Army Ammunition Plant. Detected in seeds, leaves, stems and roots.	Smith *et al.* 2001
Salt cedar	Water	Detected in samples collected upstream of Lake Las Vegas.	Urbansky *et al.* 2000
	Water/Soil		Parsons 2001
Algae	Water	Collected from the Las Vegas Wash, upstream of Lake Las Vegas, and in the Indian Head Area. Detected perchlorate in sample.	Parsons 2001
	Water	Collected from the Lake Belton, Texas.	MWH 2004
Bermuda grass	Water/Soil	Detected in samples collected upstream of Lake Las Vegas.	Parsons 2001
	Water		Nzengung 2002
Phragmites	Water	Detected in samples collected upstream of Lake	Parsons 2001

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Table 1. Plants Tested for Perchlorate Uptake

Plant	Media	Results	Reference
		Las Vegas.	
Grass (family *Poaceae*)	Water/Soil	Detected in samples collected from the Las Vegas Delta Area.	Parsons 2001
Sago (*Potamogeton pectinatus)*	Water/Soil	Detected in samples collected in Yuma, Arizona	Parsons 2001
Alfalfa	Water/Soil	Detected in samples collected in Yuma, Arizona	Parsons 2001
Arrowweed	Water/Soil	Detected in samples collected in Yuma, Arizona	Parsons 2001
Honey mesquite	Water/Soil	Detected in samples (bean and unidentified) collected in Yuma, Arizona	Parsons 2001
Quail bush	Water/Soil	Detected in samples collected in Yuma, Arizona	Parsons 2001
Johnson grass	Water/Soil	Detected in samples collected from the Alleghany Ballistics Laboratory	Parsons 2001
Saltbush	Water/Soil	Detected in samples collected from the Holloman Air Force Base.	Parsons 2001
Water pepper	Water	Detected in samples collected from the Indian Head Area	Parsons 2001
Hydrilla	Water	Detected in samples collected from the Indian Head Area	Parsons 2001
Lizard's tail (*Saururus cernuus*)	Water/Soil	Detected in samples collected from the Indian Head Area	Parsons 2001
Loblolly pine needles	Water/Soil	Detected in samples collected from the Longhorn	Parsons 2001

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Table 1. Plants Tested for Perchlorate Uptake

Plant	Media	Results	Reference
		Army Ammunition Plant	
Sedge	Water/Soil	Detected in samples collected from the Longhorn Army Ammunition Plant	Parsons 2001

1 – In the Yu *et al.* 2004 study, perchlorate-contaminated water was applied to sand to achieve a specific sand concentration.

2 – The researchers did not report that they also tested the bean and pod of the soybean. Perchlorate was detected in the pod but not the bean (Jackson 2004, pers. comm.).

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Table 2. Plant Uptake Studies

Plant	Type of Study	Study Duration	Perchlorate Concentration (mg/kg-DW)		Soil-to-Plant BAF	Reference	Selection/ Rationale
			Soil	Leaf			
Tobacco leaf	Field, Loamy sand	Season	0.34	96	282	Ellington *et al.* 2001	Selected. 1. Plants exposed throughout growing season. 2. Conducted under field conditions. 3. Continuous source of perchlorate in soils. 4. BAF based on leaves, providing the greatest estimate of the BAF.
Lettuce leaf	Lab-sand; 100% Hydrosol	6 weeks	0.069	20.8	301	Yu *et al.* 2004	Not selected, at the recommendation of Dr. Jackson. 1. Plants exposed for 4 to 8 weeks. 2. Conducted under laboratory conditions. 3. Values are based on a single spiking of lab sand—*i.e.*, plants were not exposed to a continuous source concentration. 4. Different plant uptake factors can be calculated due to the variability in the data. 5. BAF based on leaves, providing the greatest estimate of the BAF.
Cucumber leaf	Lab-sand; 25% Hydrosol /75% water	4 weeks	0.108	219	2029	Yu *et al.* 2004	
Soybean leaf	Lab-sand; 100% Hydrosol	4 weeks	0.128	14.5	113	Yu *et al.* 2004	

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Table 2. Plant Uptake Studies

Plant	Type of Study	Study Duration	Perchlorate Concentration (mg/kg-DW)		Soil-to-Plant BAF	Reference	Selection/ Rationale
			Soil	Leaf			
Terrestrial Broadleaf	Field	--	24.7	No DW concen. reported	--	Smith *et al.* 2004	Not selected. The study reported plant concentrations in wet weight, but did not report the percent moisture content of the vegetation. Use of this study would require an assumption that would result in an indeterminate level of uncertainty.

Source:

- Ellington et al (2001) – Mean soil and tobacco lamina concentrations (from Table 1 of Ellington et al.).
- Yu et al. (2004) – Initial sand concentration and leaf tissue burden at the end of the study or when the sand concentration goes to non-detect, whichever occurs first (from Table 1 of Yu et al.).

Figure 1. Summary Matrix for Perchlorate Bioaccumulation Studies

Study	Study Design				Media		Plant		Plant Part						Suitable for Deriving Soil-to-Plant BAF?
	field	lab	co-loc	contin	soil	water	terr	aquat	whole	leaf	stem	root	seed	other	
Bacchus *et al.* (1999)		■				■	■	■	■						No
✓ Ellington *et al.* (2001)	■		■	■	■		■			■					**Yes**
MWH (2004)	■		■	■		■	■		■	■					No
Nzengung (1998)		■	■	■		■	■			■	■	■			No
Nzengung (2002)		■	■	■		■	■			■	■	■			No
Nzengung and Wang (2000)		■	■	■		■	■	■		■	■	■			No
Nzengung *et al.* (1999a)		■				■	■			■	■	■			No
Nzengung *et al.* (1999b)		■				■	■			■	■	■			No
Parsons (2001)	■			■	■	■	■	■	■						No, lacks co-located soil and plant samples
Schnoor *et al.* (2002)		■	■			■	■			■	■	■			No
Smith *et al.* (2001)	■			■	■	■	■	■	■	■	■	■	■		No, lacks co-located soil and plant samples
Smith *et al*. (2004)	■		■	■	■	■	■	■		■					Yes, but requires wet-to-dry weight conversion assumption
Sundberg et al (2003)		■	■			■	■			■	■	■			No
Susarla *et al.* (1999a)		■				■		■		■	■	■			No
Susarla *et al.* (1999b)		■	■			■		■		■	■	■			No
Susarla *et al.* (1999c)		■				■	■			■	■	■			No
Susarla *et al.* (2000)		■	■			■	■	■		■	■	■			No
Tan (2003)	■		■			■	■	■	■	■				■	No
Urbansky *et al.* (2000)	■			■		■	■			■	■				No
Van Aken and Schnoor (2002)		■				■	■			■	■	■			No
Yu *et al.* (2004)		■	■		■	■	■			■		■			Yes, but requires assumptions regarding equilibrium

Notes:
■ = Yes
□ = No
✓ = selected study

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