STATE OF MARYLAND

DEPARTMENT OF THE ENVIRONMENT

CLEANUP STANDARDS FOR SOIL AND GROUNDWATER

DECEMBER 2000

INTERIM FINAL GUIDANCE

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State of Maryland

Department of the Environment

Cleanup Standards for Soil and Groundwater

1.0 INTRODUCTION

This document presents the approach and supporting documentation used to develop numeric Cleanup Standards for hazardous substances in the soil and groundwater media, and remedial action categories for the State of Maryland. The Cleanup Standards are intended to represent concentration levels at which no further remedial action would be required at a property based upon the harm posed by these substances to human health within the constraints of current knowledge (i.e., applicable only to the soil media Residential Cleanup Standard and the groundwater media Cleanup Standard). The Cleanup Standards have been developed by incorporating applicable land uses and the current or projected use of the groundwater media for potable use. Tables 1 and 2 lists the hazardous substances included in the Cleanup Standards.

The Cleanup Standards for hazardous substances in soil and groundwater media are to be considered initially as guidance. Based upon the eventual experience and success of the guidance, the Maryland Department of the Environment (hereinafter referred to as either the "MDE" or the "Department") may propose the standards for promulgation in the Code of Maryland Regulations (COMAR) at some point in the future.

Under a regulatory development process the Cleanup Standards would be developed pursuant to Maryland Environment Article 7-508, the Voluntary Cleanup Program (VCP) Act, and Environmental Article 7-208, the Controlled Hazardous Substances Act. The VCP Article requires that the Department conduct a review of the Cleanup Standards every four years once the Standards have been adopted as regulation. Should the Cleanup Standards be promulgated as regulation, the Department would institute a four year review cycle for the Standards. Any regulatory consideration will be afforded the appropriate level of public comment and participation as required by Maryland law.

2.0 PURPOSE AND APPLICABILITY

The intent of this guidance is to:

a) Provide uniform and consistent human-health based numerical Cleanup Standards for the most frequently encountered hazardous substances encountered in the soil and groundwater media at properties within the state;

b) Describe the general requirements for applicants conducting environmental assessments at properties with hazardous substances, and

c) Provide detail and specificity on the important elements of remedial actions, including the responsibilities of persons who use this guidance and the Department.

This guidance is intended to be a technical supplement for other Department programs (including the Voluntary Cleanup Program, State Superfund Program, Hazardous Waste Program, Solid Waste Program, Oil Control Program, and affected programs in the Department's Water Management Administration).

Notwithstanding the information conveyed in this document, persons must also adhere to all applicable federal and state environmental laws and regulations. Persons using this guidance should be aware that there are acceptable alternatives to this guidance for achieving compliance with regulatory requirements, including the conduct of a property specific risk assessment in accordance with the United States Environmental Protection Agency (EPA) Risk Assessment Guidance document (EPA/540/1-89/002).

3.0 DEFINITIONS

A. In this guidance, the following terms have the meanings indicated.

B. Terms defined.

(1) “Applicant” means a person who applies to participate in the Voluntary Cleanup Program, or any person that the Department determines can use this guidance.

(2) "Aquifer" means a geologic formation, group of formations, or part of a formation capable of yielding groundwater to wells or springs.

(3) "Biased Sampling" means sampling which focuses on a specific property area based upon knowledge or modeling.

(4) “Cancer risk” (CR) means the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen.

(5) "Composite Sampling" means a mixture of a mimum of two and a maximum of three grab samples to represent the average properties of the hazardous substances of concern at the extent of the area sampled.

(6) “Department” means the Maryland Department of the Environment.

(7) "Environment" means the navigable waters, the waters of the contiguous zone, ocean waters, and any other surface water, groundwater, drinking water supply, land surface or subsurface strata or ambient air within the state.

(8) "Environmental Assessment" means an Environmental Phase I and Phase II Assessment that conforms to the principles established by the American Society for Testing and Materials, or a Site Assessment that conforms to the Code of Maryland Regulations 26.14.02.03.

(9) “Exposure pathway” means the course a contaminant takes from it's source to a receptor organism.

(10) "Field Screening Technology" means analytical methods approved by the Department to determine a concentration, or range of concentrations for a particular hazardous substance; or a total concentration for a suite of genetically related hazardous substances (e.g., carcinogenic polycyclic aromatic hydrocarbons, pesticides). Field Screening Technologies

usually have lower quality assurance/quality control standards than EPA Contract Laboratory Program (CLP) requirements. As a consequence, the data generated by Field Screening Technologies cannot be used exclusively in the conduct of a human health risk assessment. For the same reasons, Field Screening Technologies cannot be used exclusively to demonstrate compliance with numerical cleanup standards.

(11) "Free Product" means a hazardous substance which occurs as an immiscible (i.e., either Dense Non-Aqueous Phase Liquid (DNAPL) or a Non Aqueous Phase Liquid (NAPL) liquid in surface water, groundwater, the vadose zone, or the ground surface.

(12) "Grab Sample" means a discrete sample that is representative of a specific location at a specific point in time.

(13) "Groundwater" means water below the land surface in the zone of saturation.

(14) "Groundwater Standard" means either the Maximum Contaminant Level (MCL) value for a chemical or the lowest value from the criteria identified in section 4.0 (C) 1 –6.

(15) “Groundwater use area” means a property located within ½ mile of a potable use well, or an area not served by a public water distribution system and reliant on groundwater for potable consumption, or an area where there is a potential for future groundwater use as a potable water supply source, or wellhead protection areas for public supply wells that have been approved by the Department.

(16) “Hazard Quotient” (HQ) means the ratio of a single chemical exposure level over a specified time period to a reference dose for that hazardous substance derived from a similar exposure period. A reference dose is EPA's preferred toxicity value for evaluating non-cancer effects from exposure to hazardous substances.

(17) "Hazardous Substance" means any substance defined as a hazardous substance under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986; or identified as a controlled hazardous substance by the Department in the Code of Maryland Regulations.

(18) “Lower explosive limit” (LEL) means the lowest concentration of gas or vapor that burns or explodes, at ambient temperatures, if an ignition source is present.

(19) “MCL” means maximum contaminant level as defined in COMAR 26.04.01.06 through 26.04.01.10.

(20) "Non-residential land use" means land that has a zoning designation by either county or local government jurisdiction that is not intended for residential land use. Typical non-residential land uses include, but are not limited to, land zoned for commercial or industrial uses.

(21) “Non-residential exposure scenario” means the set of default assumptions, as defined in this chapter (Appendix 1 - Tables 1-4) that are used to calculate a representative chemical intake for a population in a commercial setting. Exposure scenarios would typically include any setting on which commercial, industrial, manufacturing, or any other activity is

done to further either the development, manufacturing, or distribution of goods and services, intermediate and final products, including but not limited to: administration of business activities, research and development, warehousing, shipping, transport, remanufacturing, stockpiling of raw materials, storage, repair and maintenance of commercial machinery and equipment, and solid waste management.

(22) "Person" means an individual, firm, corporation, association, partnership, consortium, joint venture, commercial entity, state government agency, unit of local government, school district, conservation district, federal government agency, Indian Tribe or interstate body.

(23) "Phased Sampling" means using information obtained from a previous event to refine a subsequent sampling event.

(24) "Practical Quantitation Limit" (PQL) means the lowest amount of a chemical that can be accurately and reproducibly quantified by an analytical instrument or method. The PQL values presented are the lowest from among the most commonly required by the EPA Contract Laboratory Program (CLP) and SW-846 analytical methods.

(25) "Property" means any building, structure, installation, equipment, pipe or pipeline (including any pipe into a sewer or publicly owned treatment works) well, pit, pond lagoon, impoundment, ditch, landfill, storage container, motor vehicle, rolling stock, vessel, aircraft or any land, site or area where a hazardous substance has been generated, manufactured, refined, transported, stored, treated, handled, recycled, disposed of, released, placed or otherwise located. Where there is or has been a release or threat of release on a parcel of real estate, the entire real estate may be considered the property for the purposes of performing a remedy. A property also includes all adjacent properties where hazardous substances may have migrated since being released.

(26) "Release" means the addition, introduction, leaking, spilling, emitting, discharge "as defined in Environment Article, Titles 4 and 7", escaping, or leaching of any hazardous substance or oil into the environment.

(27) "Remedy" or "Remedial Action" means those actions consistent with a permanent remedy taken instead of, or in addition to, removal action in the event of a release or threatened release of a hazardous substance or oil into the environment, to prevent or minimize the release of hazardous substances so that the substances do not migrate or otherwise cause substantial danger to present or future public health, welfare, or the environment, and incorporates the elements of a Response Action Plan conveyed in Environmental Article Title 7, Subtitle 5, Voluntary Cleanup Program. This term includes, but is not limited to, the remedies described in CERCLA.

(28) "Residential exposure scenario" means the set of default assumptions, as defined in this chapter (Appendix 1 - Tables 1-4), that are used to calculate a representative chemical intake for a population in a residential setting. Residential use settings would typically include residential land uses, as well as land uses where there is potential for more extensive soil ingestion, such as playgrounds, recreational areas, parks, etc. Residential exposure scenario could also include agricultural land use associated with the propagation of vegetation or livestock under certain conditions. The Residential exposure scenario for the soil media is applicable from 0-15’ Below Ground Surface (BGS) or to the zone of saturation.

(29) "Residential land use" means land that has a zoning designation by either a county or local government that exclusively requires that the land shall be used as a place in which a person resides.

(30) “Risk assessment” means a scientific process used to estimate the probability of adverse effects from chemicals present at a property.

(31) "Risk Based Concentration” (RBC) means concentration levels for individual chemicals that correspond to a specific cancer risk level of 10^{-5} or an HQ of 0.1.

(32) "Secondary Drinking Water Regulation" means a non-mandatory water quality standard established by the EPA for aesthetic considerations, such as taste, odor and color.

(33) "Soil Standard – Non-Residential Cleanup Standard" means the lowest value calculated using the "non-residential exposure scenario.”

(34) "Soil Standard – Protection of Groundwater" means a value calculated for the soil media intended to be protective of groundwater quality in "groundwater use areas.”

(35) "Soil Standard – Residential Cleanup Standard – Inorganic Chemicals" means the highest value from the following options: a) a value calculated using the "Residential exposure scenario" or, b) a value determined by the Department to be the reference level for metals in soil in the State of Maryland (currently under development).

(36) "Soil Standard – Residential Cleanup Standard - Organic Compounds" means the highest value from the following options: a) a value calculated using the "Residential exposure scenario,” b) a value based on the PQL of laboratory instrumentation, or c) the soil saturation limit of a chemical.

(37) "Surface Water" means the waters of the State of Maryland, occurring on the surface of the earth.

(38) "Tentatively Identified Compound" means a non Target Analyte List organic compound detected from laboratory analysis of a sample using a Gas Chromatograph/Mass Spectrometer (GC/MS) under an approved EPA laboratory method. Tentatively Identified Compounds (TICs) are identified from reconstructed chromatograms. TICs should have a 80% spectral match, however, professional judgement is considered by the Department in the determination and identification of the TIC. A standard must be run to make a positive identification of a TIC. The analytical results are considered estimates of concentration.

(39) “Time weighted average” (TWA) means the time weighted average concentration for a hazardous substance that nearly all workers may be routinely exposed to during an 8 hour workday and 40 hour workweek without suffering adverse health effects.

(40) “Type I aquifer” means an aquifer having a transmissivity greater than 1,000 gallons/day/foot and a permeability greater than 100 gallons/day/square foot, and for natural water with a total dissolved solids concentration less than 500 milligrams/liter.

(41) "Type II aquifer" means an aquifer having either:

A) a transmissivity greater than 10,000 gallons/day/foot, a permeability greater than 100 gallons/day/square foot and natural water with a total dissolved solids concentration of between 500 and 6,000 milligrams/liter; or

B) a transmissivity between 1,000 and 10,000 gallons/day/foot, a permeability greater than 100 gallons/day/square foot and natural water with a total dissolved solids concentration of between 500 and 1,500 milligrams/liter.

4.0 DERIVATION OF STANDARDS

A. For the purpose of this guidance, the exposure pathways used to calculate the Cleanup Standards were based on residential and non-residential (commercial) scenarios (see Tables 1-4 in Appendix 1 for default assumptions).

B. The derivation of the soil standards were based on the following criteria:

1(a) RBC as calculated from two exposure pathways:

(i) ingestion;

(ii) inhalation of volatiles/fugitive dust; and

1(b) The calculation of risk based soil concentrations were based on a target hazard quotient of 0.1 and a target cancer risk of 10^{-5} for each chemical;

2) Soil standards for the protection of groundwater;

3) The soil saturation limit;

4) The PQL of laboratory instrumentation if the RBC value for a chemical is lower than the PQL; and

5) Reference levels for metals in soil.

6) TPH soil standards were calculated based solely on an ingestion exposure pathway. TPH soil RBCs were derived using equations 7 through 9 and reference dose information for hydrocarbon fractions published by the Massachusetts Department of Environmental Protection (Characterizing Risks posed by Petroleum Contaminated Sites: Implementation of MADEP VPH/EPH Approach, October 31, 1997). Gasoline Range Organics (GRO) standards were defined as the lowest RBC value calculated for the C5-C8 aliphatic, C9-C12 aliphatic, and C9-C10 aromatic fractions. Diesel Range Organics (DRO) standards were defined as the lowest RBC value calculated for the C9-C18 aliphatic, C19-C36 aliphatic, and C11-C22 aromatic fractions.

C. Groundwater Standards. The derivation of the groundwater standards were based on MCLs or Secondary Drinking Water Regulation (SDWR) standards where available. In the event that an MCL or the SDWR did not exist, the groundwater standard was based on the most conservative (lowest) value derived from the following criteria:

1) RBC as calculated from two exposure pathways:

   (i) ingestion; and

   (ii) inhalation of volatiles while showering.

2) The PQL of laboratory instrumentation if the RBC value for a chemical is lower than the PQL.

3) The calculation of risk based groundwater concentrations were based on a target hazard quotient of 0.1 and a target cancer risk of 10^{-5} for each chemical.

4) Chemical specific solubility limit.

5) Chemical specific Lower Explosive Limit (LEL) divided by the chemical specific Henry's Law constant.

6) TWA divided by the chemical specific Henry's Law constant;

RBC were calculated as per guidelines established in Risk Assessment Guidance for Superfund Volume 1 Human Health Evaluation Manual (Part A) and Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals), EPA document numbers EPA/540/1-89/002 and 9285.7-01B, respectively. RBCs for groundwater and soil were calculated using equations 1 through 20 and the default parameters as defined in Tables 1 – 4. These equations and tables are located in Appendix 1.

The methyl tert-butyl ether (MTBE) standard was set at the level defined by the Department's Oil Control Program. TPH groundwater standards were calculated based solely on an ingestion exposure pathway. TPH groundwater RBCs were derived using equations 1 through 3 and reference dose information for hydrocarbon fractions published by the Massachusetts Department of Environmental Protection (Characterizing Risks posed by Petroleum Contaminated Sites: Implementation of MADEP VPH/EPH Approach, October 31, 1997). Gasoline Range Organics (GRO) standards were defined as the lowest RBC value calculated for the C5-C8 aliphatic, C9-C12 aliphatic, and C9-C10 aromatic fractions. Diesel Range Organics (DRO) standards were defined as the lowest RBC value calculated for the C9-C18 aliphatic, C19-C36 aliphatic, and C11-C22 aromatic fractions.

D. Dermal contact exposure scenarios. Although dermal exposures were not included in the derivation of the soil and groundwater Cleanup Standards, default exposure assumptions necessary to evaluate dermal exposure to soil and groundwater are provided for informative purposes. Equations 21 through 23 are the equations for deriving RBCs for dermal contact with groundwater. Equations 24 through 26 are the equations for deriving RBCs for dermal contact with soil. Tables 5 and 6 contain default exposure assumptions for dermal exposures to groundwater and soil, respectively. These equations and tables are located in Appendix 1.

5.0 GENERAL PROVISIONS

A. Use of these standards will be at the discretion of the applicant and subject to approval by the Department. The Department may request or the applicant may choose to develop property specific Cleanup Standards using approved risk assessment techniques. The Department may deny the option to use these Cleanup Standards in situations where property conditions or expected exposures differ significantly from the assumptions used to derive the Cleanup Standards.

B. The Cleanup Standards are usually best applied at properties where there are fewer than five hazardous substances that exceed any standard for an environmental media. In general, the Cleanup Standards are based on the potential risk posed to a human receptor based upon standard EPA exposure scenarios. Other methods used to develop Cleanup Standards are described in Section 4.

Hazardous substances that are classified as non-cancer causing generally have a Cleanup Standard concentration established at Hazard Quotient of .1. This level is one order of magnitude more protective than the Department remedial action standard of a Hazard Quotient of 1. This safety factor allows for accounting of potential additive risk factors from a multiple of hazardous substances at a property.

Hazardous substances classified as cancer causing generally have a Cleanup Standard concentration established at a target cancer risk of 10^{-5}. This level is equivalent to the remedial action level established by the Department. Properties where the majority of the hazardous substances identified are considered cancer causing may not be eligible for use of the Cleanup Standards because the conditions or expected exposures differ significantly from the assumptions used to derive the Cleanup Standards.

C. The Cleanup Standards defined in this chapter were developed for the protection of human health and do not in any way imply protection of ecological receptors. At properties where adverse effects to ecological receptors may be of concern, an ecological risk assessment following methods approved by the Department will be required.

D. Chemical analyses submitted to the Department for the purposes of property characterization are to include a maximum of 30 tentatively identified compounds (TICs). The 30 reported TICs would include the highest concentrations for up to 10 Volatile Organic Compounds (VOCs) and up to 20 Semi-Volatile Organic Compounds (SVOCs). The Department may require additional sampling if the reported TICs are deemed potentially harmful to human health or the environment. The purpose of collecting additional (confirmatory) samples would be to positively identify and quantify the presence of TICs for use in a quantitative risk assessment. The basis for requiring confirmatory samples are listed below:

i) The property history suggests that the compounds were used at the property; or

ii) The estimated concentration or toxicity of the TICs would drive overall risk at the property; or

iii) The spatial distribution of the TICs indicates that they are concentrated in specific areas of the property (i.e. a contamination source area).

If the Department determines that none of the criteria listed above are met, then further evaluation of TICs will not be required. However, a qualitative discussion of all reported TICs must be included in the property specific risk assessment.

E. Reference levels for several inorganic soil constituents have been developed by the Department (see Appendix 2). The use of an reference level instead of an established soil cleanup standard will require prior approval from the Department. The use of MDE reference levels may be denied in situations where the chemical speciation of an inorganic constituent is known or believed to be in a form that may pose an unacceptable risk to current or expected users of the property.

F. **Reservation of Rights:** Notwithstanding the use of this guidance by applicants in support of environmental assessments of hazardous substances at properties, the Department reserves the right to inspect property, to collect soil or groundwater samples, and/or to determine the adequacy and validity of submitted information.

6.0 APPLICATION OF CLEANUP STANDARDS

The soil and groundwater Cleanup Standards have been designed to be applied in conjunction with a property specific environmental assessment or remedial action. The Cleanup Standards may be used by an applicant to request either a No Further Requirements determination under the VCP, or a No Further Action determination under the State Superfund program. The Cleanup Standards may also be applied to demonstrate attainment of a Remedial Action under either the VCP or State Superfund program.

6.1 Voluntary Cleanup Program

The Cleanup Standards may be applied under the VCP only after an applicant has satisfactorily completed an Environmental Phase I and Phase II Site Assessment that conforms to the principles established by the American Society for Testing and Materials, and which conforms to the environmental assessment requirements identified in Sections 7.0 – 10.0. VCP applicants who fulfill both these requirements may request a No Further Requirements determination from the Department if property hazardous substance concentrations are at or below Cleanup Standards and requirements for the applicable land use and groundwater use.

Properties that have hazardous substance concentrations in exceedance of an applicable Cleanup Standard and/or requirements (i.e., based upon the requested land use determination) must prepare a Response Action Plan (RAP) in conformance with Environmental Article 7-508. Under this condition, applicants may request a waiver from conducting the Risk Assessment component of the RAP and substitute the applicable Cleanup Standard(s) to satisfy the requirements of Environmental Article 7-508.b., Selection of Protective Criteria.

The Cleanup Standards may also be used to demonstrate attainment of a remedial action for the VCP. Applicants must comply with sections 7.0 –10.0 in order to use the Cleanup Standards for these purposes.

VCP Applicants may also use the presumptive remedies identified in Section 11 as part of the RAP.

6.2 State Superfund Program

The Cleanup Standards are also applicable to the State Superfund program when an applicant satisfactorily completes a site assessment that conforms to:

a) the Code of Maryland Regulations (COMAR) 26.14.02.03, the Hazardous Substance Response Plan, and
b) the environmental assessment requirements conveyed in Sections 7.0 –10.0.

Applicants that satisfy these requirements may request a No Further Action from the Department provided that hazardous substance concentrations are at or below applicable land use and groundwater use Cleanup Standards and requirements. For non-residential land use properties the issuance of a No Further Action by the Department may be contingent on the placement of institutional controls such as groundwater use restrictions and deed restrictions limiting a property to non-residential uses only.

Properties that have hazardous substance concentrations in exceedance of an applicable Cleanup Standard must conduct a remedial action in conformance with COMAR 26.14.02.05-06. Applicants may request a waiver from conducting a Risk Assessment required in COMAR 26.14.02.06 , and substitute the applicable Cleanup Standard requirements.

The Cleanup Standard may also be used to demonstrate attainment of a remedial response activity as defined in COMAR 26.14.02.06. Under this condition, applicants must comply with sections 7.0 –10.0 to use the Cleanup Standards for these purposes.

Applicants may use the presumptive remedies identified in Section 11 in support of the remedial action plan for a property.

Sections 7.0 – 10.0 of the document describe minimum investigatory and remedial action requirements that must be applied in order to demonstrate attainment of a cleanup standard for the soil and/or the groundwater media. However, since most property environmental cases have unique investigatory or remedial action issues, additional actions may need to be taken to demonstrate attainment of an environmental media cleanup standard.

Figures 1 and 2 are "Decision- Tree" flow charts for the application of the groundwater and soil Cleanup Standards. These flow charts have been developed from information in Sections 7.0 – 10.0 of the Cleanup Standards document.

Additional guidance on hazardous substance environmental assessment workplan development is contained in Appendix 3.

7.0 INVESTIGATIVE REQUIREMENTS – SOIL MEDIA

To apply the Cleanup Standards at a property subject to environmental assessment for release of hazardous substance(s) to the soil media, the Department requires that surface soil (0 to 1 foot in depth) and deeper soil (1 foot in depth to a maximum of 15 feet) be sampled. The extent of soil sampling required at properties is dependent on a number of variables including: 1) the size of the property, 2) the historical use of the property, 3) the chemicals used at the property and 4) the extent of environmental studies conducted at the property. Properties that have had a Phase I Environmental Site Assessment completed in accordance with Standard E 1527-97 of the American Society for Testing and Materials (ASTM), an EPA Preliminary Assessment, or a State Site Assessment which thoroughly documents the use history of the property and types and quantities of chemicals associated with the property use, may use this information to tailor the soil sampling and chemical analysis requirements to include just chemicals known or suspected to be used, stored or manufactured at the property, either currently or in the past. If a thorough property history has not been documented, soil sampling and laboratory analysis

should include, at a minimum, priority pollutant metals, VOCs, and SVOCs, pesticides and Polychlorinated Biphenyls.

Under certain circumstances the extent of the soil media environmental assessment may be based on the results of the Phase I assessment, or equivalent property assessment. Specifically, if the assessment thoroughly documents the property history and indicates that past activities had been confined to a discrete portion of the property, the Phase II, or equivalent property assessment sampling may be concentrated in this area, and a minimal number of representative samples may be collected across the remainder of the property.

The Voluntary Cleanup Program will accept soil sample analytical results as part of an applicant's application if the samples were collected from the property within one year of submittal of the application.

At a minimum, 10 * grab samples need to be taken from a property in order to demonstrate attainment of an applicable soil Cleanup Standard. The spatial distribution and number of samples required to demonstrate attainment of an applicable Cleanup Standard is dependent on property specific conditions. Sampling workplans should adequately address the variables identified in section 7.0 (i.e., size of the property, historical use, chemical use, extent of previous environmental assessments).

For properties that are two acres in size or larger, sampling approaches that should be considered include:

a) Grid Sampling
b) Biased Sampling, or
c) Phased Sampling.

Grid Sampling should be conducted when property conditions indicate widespread and uniformly distributed release of hazardous substances. Biased Sampling is a preferred sampling approach when property conditions have been reasonably characterized, and testing is conducted to refine the conceptual site model. Phased Sampling is recommended when limited information exists regarding the presence of hazardous substances at a property. This approach may necessitate multiple sampling activities in order to demonstrate attainment of a Cleanup Standard, or may indicate that Biased or Grid Sampling should be conducted.

Composite Sampling may be used to demonstrate compliance with a cleanup standard during a remedial action. The following criteria must be adhered to when collecting composite samples:

a) The environmental assessment of a property must be considered complete by the Department,
b) The concentration of hazardous substances present a property, as defined by individual analytical results, must be within 35% (+/-) of the mean concentration of these hazardous substances,
c) A minimum of two and a maximum of three grid sample locations may be composited to represent a discrete sample location,
d) Composite sampling shall be conducted under a grid sample framework, and
e) Samples to be composited must be located adjacent to each other in the grid sample framework.

* sampling requirement based on EPA Supplemental Guidance to RAGS: Calculating the Concentration Term. This Guidance indicates that fewer than 10 samples per exposure area provides poor estimates of the mean concentration between the sample mean and the 95th percent upper confidence limit.

f) an equal volume of soil must be composited from each sample collected from the grid framework
g) each individual grid sample collected for VOC analysis from the grid framework must be preserved in methanol immersion as soon as the sample is collected. This minimizes the VOC loss resulting from blending these grid samples into the final composited sample.

The data collected from any sampling approach must be evaluated by statistical means to determine if more than one population of data exists at a property. Statistical measurements may also indicate that additional samples should be taken at the property. In the event that more than one population of data is identified at a property, attainment of an applicable Cleanup Standard must be demonstrated for each population. The Department accepts the following statistical methods to determine if more than one population data exists at a property:

a) Non-Parametric statistical methods that compare the means of two populations – Wilcoxon Rank Sum or the Quantile test as described in the EPA Guidance Document Statistical Methods for Evaluating the Attainment of Cleanup Standards for Soils and Solid Media, EPA Office of Policy, Planning and Evaluation, PB94-176831, July, 1992.

b) Parametric statistical methods for evaluation of one population of data. This evaluation would include the calculation of the mean, mode, standard deviation and upper confidence limit of a population of data. The use of this method must be appropriate for the data gathered at the property and must also be consistent with the underlying assumptions of the method being used.

Exceptions to the number of samples required to demonstrate attainment of a Soil Standard may be granted by the MDE on a property-specific basis.

The threshold established for attainment of a soil cleanup standard is when either:

a) 75% of all samples collected are equal to or less than the standard and no individual sample exceeds 10 times the standard, or

b) The 95% upper confidence limit (UCL) of the arithmetic mean is equal to or below the standard. Please refer to Figure 3 for additional guidance on calculating the 95% UCL.

Biased sampling for the sole purpose of demonstrating attainment of the standard is not allowed.

If any sample result exceeds a soil standard by five (5) times, then the Department reserves the right to require additional delineation sampling to eliminate the possibility of a source area in close proximity to any of the threshold attainment soil samples.

At properties where an existing building(s) exceeds 25% of the property area under evaluation and testing under the building footprint(s) is not considered feasible, the Department approval with respect to demonstration of attainment of the soil standard will reflect that limited to no data was collected from this area(s). If at a later date the building is removed, the Department, pursuant to Environmental Article 7-201, may require additional environmental assessment work by persons considered responsible for the hazardous substances in this area of a property.

7.1 Exceptions to Soil Cleanup Standards

Exceptions to the application of the soils Cleanup Standards are:

a) Where it is technically impractical to reach the standard and a risk assessment demonstrates no risk is posed by the current or intended property use;

b) Where a risk assessment demonstrates no risk is posed by the current or intended property use. In this case, a restriction may need to be placed on the deed of a current use non-residential zoned property that prohibits the use of the property under a residential exposure scenario; and

c) Where the Department determines that it is technically impracticable to reach the standard and a risk assessment demonstrates that a risk is posed by the current or intended use. In this case, an appropriate containment or isolation remedy is required to prevent exposure hazard to potential receptors. In addition, a restriction may need to be placed on the deed of a current use non-residential zoned property that prohibits the use of the property under a residential exposure scenario.

8.0 USE OF FIELD SCREENING TECHNOLOGY FOR THE SOIL MEDIA

Field Screening Technology (i.e., Mobile Gas Chromatograph/Mass Spectrometer Laboratory, Immunoassay Technology and X-Ray Fluorescence equipment) for the soil media may be used in combination with a Fixed Laboratory sampling and chemical analysis program to reduce the total number of samples sent to a Fixed Laboratory for analysis in order to demonstrate attainment of a cleanup standard or to completely characterize the presence of hazardous substances at a property. Field Screening Technology may also be used to reduce/eliminate possible hazardous substances of concern from further evaluation at a property following an acceptable demonstration of positive correlation for accuracy and precision of analytical results between a Fixed Laboratory and Field Screening Technology results.

A 35% Fixed Laboratory confirmation is required for 20 or more samples tested using Field Screening Technologies. A 50% Fixed Laboratory confirmation is required for 10 – 19 samples tested using Field Screening Technologies.

8.1 Immunoassay Field Screening Technology

With respect to the use of Immunoassay Field Screening Technology or any other technology approved for use by the Department for use at properties subject to hazardous substance environmental assessment, a minimum positive correlation of 80% at sample locations tested using both the field screening technology and the fixed laboratory analytical result must be demonstrated by the applicant. This correlation is demonstrated by satisfying the following requirements:

a) The fixed laboratory data meets the quality assurance project plan requirements identified in Appendix 3,

b) The field screening technology data was produced in conformance with the manufacturers specifications, and adhered to the manufacturer's quality assurance/quality control requirements. The later information must be supplied to the Department with the data submission,

c) The field screening technology result, which is conveyed as either: 1) less than the total concentration of a contaminant suite (e.g., total polycyclic aromatic hydrocarbons, total pesticides, total Polychlorinated Biphenyls), 2) bound by concentration limits, or 3) exceeds a lower bound concentration, correlates with the fixed laboratory analytic result for the hazardous substance suite being evaluated.

A positive correlation between the Immunoassay Technology result and the fixed laboratory result is demonstrated when the total concentration of a particular suite of hazardous substances in the fixed laboratory result falls within the concentration bounds conveyed by the immunoassay result for the same sample location (e.g., a sample is analyzed by a fixed laboratory for individual Aroclor PCBs. The individual Aroclor concentrations, including Aroclor TICs are summed. This summed value is compared against the total PCB concentration value/range from the immunoassay test result. If the fixed lab result conforms with the immunoassay value/range result, then a positive correlation has been demonstrated).

Immunoassay Field Technology Screening data that has been accepted by the Department as demonstrating a positive correlation with the complementary Fixed Laboratory result may be used to represent the concentration of the contaminant of interest at the property with the lowest cleanup standard value in the analytic suite of compounds (e.g., a positive Carcinogenic Polycyclic Aromatic Hydrocarbon result using Immunoassay Technology would be used to represent the concentration of Benzo(a)Pyrene for the sample result in the application of the Cleanup Standards). Please refer to Figure 4. for further description of the application Immunoassay Technology with the Cleanup Standards.

8.2 X-Ray Fluorescence Field Screening Technology

Applicants may also use X-Ray Fluorescence (XRF) Technology to support demonstration of attainment of a cleanup standard. As with the use of the Immunoassay Technology, the same sample point from both the fixed laboratory and the XRF must have been analyzed in conformance with the QAPP requirements conveyed in Appendix 3 (i.e. for the fixed laboratory result) and in conformance with the Quality Assurance/Quality Control (QA/QC) procedures assigned by the manufacturer of the XRF. Applicants that use the XRF must supply the QA/QC procedures to the Department for review.

Since the XRF provides quantitative results for individual metal constituents, a regression analysis can be applied between the XRF and fixed laboratory data points to produce a corrected XRF data result. Corrected XRF data results may then be used by the applicant in either the conduct of a risk assessment, or as data points in the application of the Cleanup Standards. Corrected XRF data points may be used for these purposes when the regression analysis goodness of fit line between the XRF and fixed laboratory results are 90% or higher, and the data points used in the analysis represent a wide spectrum of concentration ranging from high, medium and low. Please refer to Figure 5 for further description of the application of XRF Technology with the Cleanup Standards.

9.0 HOT SPOTS/REMEDIAL ACTION REQUIREMENTS FOR THE SOIL MEDIA

Hot Spots may be identified during either a property environmental assessment or a remedial action. The following contaminant characteristics shall be considered Hot Spots:

a) Contaminant concentrations in the soil media exceeds one of the following criteria at a sampling location:

1. The EPA Removal Action Guidelines for Soil,

2. An EPA Industrial RBC value established at 1 x e-4 cancer risk or Hazard Index of 100,

3. Exceeds a traditional risk calculation of 1 x e-4 or Hazard Index of 100, or

b) Visible discoloration of soil and/or standing pools of discolored liquid that is later confirmed by laboratory analysis or field screening technology to be a hazardous substance(s), or

c) Controlled Hazardous Substances in drums, tanks, bulk storage containers, or any other container that pose an imminent threat of release as function of the poor integrity of the storage vessel, or

d) Free Product

e) Actual or potential exposure to nearby human populations, animals or the food chain from controlled hazardous substances that exceed the criteria identified in 9.a. Examples of direct exposure scenarios include but are not limited to dust generation/migration to residential areas, playgrounds, sensitive populations nearby, or

f) Threat of fire or explosion.

All identified Hot Spots have to be addressed in accordance with a Department approved Remedial Action Plan. The Department's expectation is that treatment shall be used to remediate Hot Spot contamination, wherever practicable. Engineering controls, such as containment, may be used when the applicant has demonstrated to the satisfaction of the Department that treatment or removal is technically impracticable. Institutional Control remedial actions may be used in conjunction with treatment or containment of Hot Spots, but may not solely be used as an acceptable method to remedy Hot Spot contamination.

10.0 GROUNDWATER ASSESSMENT/REMEDIAL ACTION REQUIREMENTS

A. The groundwater Cleanup Standards are to be applied to groundwater from Type I and Type II aquifers and Groundwater Use Areas. Assessment of the groundwater media must cover the lateral and vertical extent of contamination irrespective of property ownership. The number of groundwater samples and the spatial distribution of samples taken at a property shall be determined on a property specific basis.

B. Groundwater must be remediated if any of the following conditions occurs:

1) Free product is discovered – (All Free Product/LNAPL /DNAPL must be removed).

2) The concentration of the hazardous substance(s) exceed either the target cancer risk threshold of 1e-5 or the Hazard Quotient threshold = 1 via the Inhalation Pathway Exposure Scenario (this determination would be conducted from a property specific risk calculation).

3) A drinking water well is contaminated above a Department groundwater cleanup standard, or a traditional risk assessment indicates an exceedance of a target cancer risk threshold of either 1 x e-5 or the non-carcinogenic Hazard Quotient threshold = 1 at a well head, or the Department determines that a drinking water well is at risk of becoming contaminated above a groundwater cleanup standard.

4) In a Groundwater Use Area.

The groundwater Cleanup Standards are generally applicable to groundwater when, at the interface of a surface water body, mass loading calculations indicate that exceedance of:

1) a State of Maryland Surface Water Quality Criteria will occur from the transfer of hazardous substances in groundwater across an interface with a surface water body, or
2) a groundwater cleanup standard will occur and the surface water body is either used for drinking water, or may be used for drinking water in the future.

D. Groundwater Cleanup Standards are generally applicable to groundwater from Type I and II aquifers. Exceptions to this are:

1) It is technically impractical to complete a remedial action to a groundwater cleanup standard. The standard for determining Technical Impracticability shall adhere to the EPA Guidance Documents: OSWER Directive 9234.2-25 (September 1993) - Interim Final "Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration" and OSWER Directive 9200.4-14 (January 1995) “Consistent Implementation of the FY 1993 Guidance on Technical Impracticability of Ground-Water Restoration at Superfund Sites.”

2) Where the person can demonstrate that there is no current use or projected future use of groundwater within one half mile of the property, where it can be shown that the contaminant(s) in the groundwater are at asymptotic levels but do not exceed any groundwater cleanup standard by an order of magnitude, a risk assessment demonstrates no risk is posed from the current or intended property use, and where a groundwater management zone has been implemented by the Department that restricts or prohibits the use of groundwater for the property.

3) Where hazardous substance(s) exceeds a groundwater cleanup standard; however an applicant can demonstrate that the hazardous substance(s) will not migrate off the property. Demonstration of this condition may be accomplished by the following actions:

   a) Establish a monitoring system, including perimeter sentry wells to demonstrate no off-property migration at concentrations exceeding the applicable standards.

   b) Develop a contingency remedial action plan in the event that concentrations in the perimeter wells exceed the standards.

   c) Conduct a risk assessment to demonstrate that no risk is posed by the current or intended property use.

   d) Adhere to a groundwater management zone that has been implemented by the Department that restricts or prohibits the use of groundwater for the property.

e) Secure a bond or other financial security instrument that has been approved by the Department to fund the implementation of 10.D.3.a and b.

With respect to sections 10.3.a and c. the Department shall require a minimum of two rounds of groundwater data be collected on a semi-annual basis before approving of this groundwater cleanup exception.

4) Where natural groundwater concentrations for metals exceed groundwater cleanup standards. Demonstration of this condition is required to apply this exception.

11.0 PRESUMPTIVE REMEDIAL ACTIONS FOR THE SOIL MEDIA

The Department has developed presumptive remedial actions for hazardous substances in the soils under a residential scenario and a mixed use commercial/residential scenario. Presumptive remedial actions are intended to provide the applicant with readily understood requirements in order to facilitate an expedited remedial action of the property while still being protective of public health.

11.1 Residential Use Soil Cleanup Requirement

Properties that have a residential use or have a projected future residential use are required to remedy hazardous substances in the soil to the applicable soil standard. Use of either treatment technologies or removal of hazardous substances in the soil to the applicable soil standard is required for this land use. Attainment of the soil standard must be demonstrated following the remedial action. The residential soil standard extends to a depth of 15 feet or the zone of saturation. Demonstration of attainment of the soil cleanup standard must also include evaluation of temporal variations in the depth of the zone of saturation.

Notwithstanding the soil cleanup requirements identified in this subsection, groundwater identified as being contaminated at the property in a Groundwater use area by hazardous substance release above an applicable groundwater cleanup standard or acceptable risk threshold must also be remedied to meet attainment of the groundwater cleanup standard.

11.2 Mixed Use (Commercial/Residential) Soil Cleanup Minimum Requirements

Property that has a non-residential/residential land use or has a similar projected future land use shall utilize the residential soils Cleanup Standards to evaluate risk. Hazardous substances identified at a property above the applicable soils cleanup standard must adhere to the following remedial action requirements:

a)

1) Utilize a treatment technology or perform a removal action for contaminant concentrations that exceed an EPA RBC target cancer risk threshold value of 1e-4 Cancer and/or the Hazard Quotient threshold = 10 or,

2) Remove hazardous substances that exceed the standards identified in 11.2.a.1. and place under a building foundation. Department approval of this remedial action is contingent on the applicant demonstrating that the placement of soil hazardous substances under the building footprint will not result in an unacceptable risk to a human receptor from the inhalation of contaminant vapors, and

b) Options a) 1 and 2 must also consider the Groundwater use area scenario and adhere to the Hot Spots/Remedial Action Criteria.

c) Open Space areas of the properties (i.e. not park land, but including land between buildings, etc.) with identified hazardous substance above the residential cleanup standard for soil are required to have a minimum placement of 3 feet of clean fill soil cover over a Department approved Geotextile Marker Fabric Material. This provision is applicable under an engineering control – containment remedy.

d) Areas identified for paving that have identified hazardous substances above the residential cleanup standard for soil are required to have a minimum placement of 2 feet combination of clean fill/road base and asphalt/cement over a Department approved Geotextile Marker Fabric Material. This provision is applicable under an engineering control – containment remedy.

e) With respect to the criteria identified in 11.2.c-d., the applicant will be required to have a restriction placed on the Deed that restricts excavation activities below two feet of the ground surface. This provision is applicable under an engineering control – containment remedy.

f) Underground utilities (i.e., water, sewer, gas, electric, telephone, cable, communication, and others, as appropriate) that are to be installed at the property with identified contamination above a residential cleanup standard for soil are required to over-excavate to a foot below normal placement of the utility line and a foot wider on each side of the line. A Department approved geotextile fabric must be placed in the bottom and sides of the trench and covered with a minimum of one foot of clean fill. The utility line is then placed and covered with clean fill. This provision is applicable under an engineering control – containment remedy.

g) Items c-f must also consider Contaminant Soil leaching to Groundwater Use Scenario. This provision shall only apply to Groundwater use areas.

h) Open space areas dedicated for recreation use must adhere to the Residential Cleanup Standards for soil requirements.

12. REFERENCES

The following references were used in the development of this Guidance document:

a. USEPA. Exposure Factors Handbook, Volume I, General Factors. August 1997. EPA/600/P-95/002Fa.

b. USEPA. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A). December 1989. EPA/540/1-89/002.

c. USEPA, Human Health Evaluation Manual, Supplemental Guidance: “Standard Default Exposure Factors.” March 1991. OSWER Directive 9285.6-03.

d. USEPA, Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals). December 1991. Publication 9285.7-01B.

e. USEPA, Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals). December 1991. Publication 9285.7-01B.

f. USEPA, Dermal Exposure Assessment: Principles and Applications. Interim Report, January 1992. EPA/600/8-91/011B.

g. USEPA, Soil Screening Guidance: Technical Background Document. May 1996 (EPA/540/R-95/128) and Soil Screening Guidance: User's Guide, April 1996 (EPA/650/R-96/018).

h. USEPA's Soil Screening Guidance (EPA/650/R-96/018)

i. Kissel, J. C.; Richter, K. Y., Fensky, R. A. 1996. "Field measurement of dermal soil loading attributable to various activities: Implications for exposure assessment." Risk Analysis. 15:115-125.

j. USEPA Region III Risk-Based Concentration Table Technical Background Information. October 1999.

k. USEPA, Supplemental Guidance to the RAGS: Calculating the Concentration Term. May 1992. Publication 9285.7-081

l. USEPA, Data Quality Objectives for Remedial Response Activities, March 1987. Publication EPA/540/G-87/003.

m. American Society for Testing and Materials (ASTM), Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process, Designation E 1527 –97, 1997.

n. USEPA, Hazard Evaluation Handbook – A Guide to Removal Actions, Fourth Edition, EPA 903/B-97-006, 1997.

o. USEPA, Statistical Methods for Evaluating the Attainment of Cleanup Standards for Soils and Solid Media, EPA Office of Policy, Planning and Evaluation, PB94-176831, July, 1992

p. USEPA, OSWER Directive 9234.2-25 (September 1993) - Interim Final Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration

q. USEPA, OSWER Directive 9200.4-14 (January 1995) Consistent Implementation of the FY 1993 Guidance on Technical Impracticability of Ground-Water Restoration at Superfund Sites

TABLE 1 – GENERIC NUMERIC CLEANUP STANDARDS FOR GROUNDWATER AND SOIL

	Groundwater Standards	**Soil Standards**		
	Type I and II aquifers	***Residential Clean-up Standard***	***Non-Residential Clean-up Standard***	***Standard for the Protection of Groundwater*** [a]
Analyte	***(mg/L)***	***(mg/kg)***	***(mg/kg)***	***(mg/kg)***
VOCs				
Acetone	1.6E-01	7.8E+02	2.1E+03	3.1E-01
Benzene	5.0E-03	7.7E-01	3.2E+00	1.7E-02
Bromodichloromethane	1.0E-01	9.3E+01	2.8E+02	3.2E-01
Bromoform	1.0E-01	1.6E+02	4.1E+02	3.8E-01
Bromomethane	2.2E-03	4.3E-01	1.8E+00	5.3E-03
2-Butanone	9.4E-01	4.7E+03	1.2E+04	--
Carbon Disulfide	8.3E-02	4.0E+01	1.7E+02	3.3E-01
Carbon Tetrachloride	5.0E-03	2.0E-01	8.2E-01	3.3E-02
Chlorobenzene	1.0E-01	1.8E+01	7.4E+01	6.5E-01
Chloroethane	1.6E-02	2.0E+03	6.1E+03	--
Chloroform	1.0E-01	3.8E-02	1.6E-01	2.9E-01
Chloromethane	1.1E-02	4.4E+02	1.4E+03	--
Dibromochloromethane	1.0E-01	6.8E+01	2.1E+02	3.3E-01
Dibromochloropropane	2.0E-04	4.1E+00	1.3E+01	--
1,2-Dibromoethane	5.0E-05	6.8E-02	2.1E-01	--
1,1-Dichloroethane	1.6E-01	5.6E+01	2.4E+02	4.4E-01
1,2-Dichloroethane	5.0E-03	9.1E-01	3.8E+00	1.2E-02
1,1-Dichloroethene	7.0E-03	4.4E-01	2.4E+00	2.9E-02
cis-1,2-Dichloroethene	7.0E-02	7.8E+01	2.1E+02	2.0E-01
trans-1,2-Dichloroethene	1.0E-01	1.6E+02	4.1E+02	3.4E-01
1,2-Dichloroethene (total)	1.4E-02	7.0E+01	1.9E+02	--
1,2-Dichloropropane	5.0E-03	6.8E-01	2.8E+00	1.5E-02
cis-1,3-Dichloropropene	7.3E-03	5.7E+01	1.8E+02	--
trans-1,3-Dichloropropene	7.3E-03	5.7E+01	1.8E+02	--
Ethylbenzene	7.0E-01	2.6E+02	4.0E+02	6.7E+00
2-Hexanone	2.7E-02	3.1E+02	8.3E+02	--
Isopropylbenzene	1.6E-01	7.8E+02	2.1E+03	--
4-Methyl-2-pentanone	1.3E-01	6.3E+02	1.7E+03	--
Methylene Chloride	5.0E-03	8.2E+01	4.4E+02	1.2E-02
Methyl tert-butyl ether	2.0E-02[c]	6.5E+02	2.7E+03	6.1E-02
Styrene	1.0E-01	6.4E+02	1.5E+03	1.8E+00
Tetrachloroethene	5.0E-03	5.9E+01	2.1E+02	2.9E-02
1,1,2,2-Tetrachloroethane	3.7E-03	3.8E+00	2.1E+01	1.4E-02
Toluene	1.0E+00	7.5E+01	3.2E+02	5.9E+00
1,1,1-Trichloroethane	2.0E-01	2.3E+02	9.7E+02	9.6E-01
1,1,2-Trichloroethane	5.0E-03	6.3E+00	3.4E+01	1.5E-02
Trichloroethene	5.0E-03	2.9E+01	1.2E+02	2.8E-02
Vinyl Chloride	2.0E-03	1.9E+00	1.0E+01	6.7E-03
Xylenes	1.0E+01	4.3E+02	4.3E+02	1.0E+02

	Groundwater Standards	Soil Standards		
	Type I and II aquifers	***Residential Clean-up Standard***	***Non-Residential Clean-up Standard***	***Standard for the Protection of Groundwater [a]***
Analyte	***(mg/L)***	***(mg/kg)***	***(mg/kg)***	***(mg/kg)***
SVOCs				
Acenaphthene	9.4E-02	1.8E+02	1.8E+02	1.3E+01
Acenaphthylene	9.4E-02	4.7E+02	1.2E+03	--
Anthracene	4.3E-02	6.1E+00	6.1E+00	2.0E+01
Benz[a]anthracene	5.0E-03	7.9E+00	2.2E+01	4.0E+01
Benzo[a]pyrene	2.0E-04	7.9E-01	2.4E+00	4.1E+00
Benzo[b]fluoranthene	5.0E-03	7.9E+00	1.1E+01	1.2E+02
Benzo[g,h,i]perylene	2.6E-04	2.3E+02	6.2E+02	--
Benzo[k]fluoranthene	5.0E-03	5.9E+00	5.9E+00	1.2E+02
bis(2-Chloroethyl)ether	5.0E-03	1.6E+00	8.9E+00	1.2E-02
bis(2-Ethylhexyl)phthalate	6.0E-03	1.6E+02	4.1E+02	1.8E+03
Carbazole	3.7E-02	1.5E+02	1.5E+02	2.5E+00
4-Chloroaniline	6.3E-03	3.1E+01	8.3E+01	2.1E-02
2-Chloronaphthalene	1.3E-01	6.3E+02	1.7E+03	--
2-Chlorophenol	7.8E-03	3.9E+01	1.0E+02	--
Chrysene	5.0E-03	3.8E+00	3.8E+00	4.0E+01
Dibenz[a,h]anthracene	5.0E-03	7.9E-01	2.4E+00	3.8E+02
Dibenzofuran	6.3E-03	3.1E+01	8.3E+01	--
1,2-Dichlorobenzene	6.0E-01	6.0E+02	6.0E+02	8.6E+00
1,3-Dichlorobenzene	1.4E-03	7.0E+00	1.9E+01	--
1,4-Dichlorobenzene	7.5E-02	3.2E+01	1.7E+02	1.1E+00
3,3-Dichlorobenzidine	2.0E-02	1.3E+01	1.4E+01	3.3E-01
2,4-Dichlorophenol	5.0E-03	2.3E+01	6.2E+01	--
Diethylphthalate	1.3E+00	2.0E+03	2.0E+03	9.7E+00
2,4-Dimethylphenol	3.1E-02	1.6E+02	4.1E+02	1.9E-01
Dimethylphthalate	1.6E+01	7.8E+04	2.1E+05	--
Di-n-butylphthalate	1.6E-01	7.8E+02	2.1E+03	1.1E+02
4,6-Dinitro-2-methylphenol	1.6E-04	7.8E-01	2.1E+00	--
2,4-Dinitrophenol	5.0E-03	1.6E+01	4.1E+01	--
2,4-Dinitrotoluene	5.0E-03	1.6E+01	4.1E+01	2.0E-02
2,6-Dinitrotoluene	1.6E-03	7.8E+00	2.1E+01	5.3E-03
Di-n-octylphthalate	2.0E-02	1.6E+02	4.1E+02	3.7E+04
Fluoranthene	6.3E-02	3.1E+02	8.3E+02	1.3E+04
Fluorene	6.3E-02	1.6E+02	1.6E+02	1.7E+01
Hexachlorobutadiene	2.3E-04	1.6E+00	4.1E+00	2.4E-01
Hexachlorocyclopentadiene	5.0E-02	4.7E-01	2.0E+00	2.0E+02
Hexachloroethane	2.0E-03	7.8E+00	2.1E+01	7.5E-02

	Groundwater Standards	Soil Standards		
	Type I and II aquifers	***Residential Clean-up Standard***	***Non-Residential Clean-up Standard***	***Standard for the Protection of Groundwater [a]***
Analyte	***(mg/L)***	***(mg/kg)***	***(mg/kg)***	***(mg/kg)***
Indeno[1,2,3-c,d]pyrene	5.0E-03	4.6E-01	4.6E-01	3.5E+02
Isophorone	3.1E-01	1.6E+03	4.1E+03	9.2E-01
2-Methylnaphthalene	3.1E-02	1.6E+02	4.1E+02	--
2-Methylphenol	7.8E-02	3.9E+02	1.0E+03	3.0E-01
4-Methylphenol	7.8E-03	3.9E+01	1.0E+02	--
Naphthalene	1.8E-02	8.4E+00	3.5E+01	7.4E-01
2-Nitroaniline	1.1E-03	--	--	--
4-Nitroaniline	1.1E-03	--	--	--
Nitrobenzene	5.0E-03	3.9E+00	1.0E+01	1.6E-02
2-Nitrophenol	1.3E-02	6.3E+01	1.7E+02	--
4-Nitrophenol	1.3E-02	6.3E+01	1.7E+02	--
N-Nitrosodiphenylamine	1.5E-01	2.8E+02	2.8E+02	4.1E+00
N-Nitroso-di-n-propylamine	5.0E-03	8.2E-01	2.5E+00	1.2E-02
2,2-Oxybis(1-Chloropropane)	1.0E-02	8.2E+01	2.5E+02	--
Pentachlorophenol	1.0E-03	4.8E+01	1.5E+02	--
Phenanthrene	4.7E-01	2.3E+03	6.2E+03	--
Phenol	9.4E-01	4.7E+03	1.2E+04	2.4E+00
Pyrene	4.7E-02	2.3E+02	6.2E+02	9.9E+01
1,2,4-Trichlorobenzene	7.0E-02	7.8E+01	2.1E+02	2.6E+00
2,4,5-Trichlorophenol	1.6E-01	7.8E+02	2.1E+03	--
2,4,6-Trichlorophenol	6.6E-02	2.8E+02	1.5E+03	--
Pesticides/PCBs				
Aldrin	4.3E-05	2.3E-01	6.2E-01	2.1E+00
Atrazine	3.0E-03	2.6E+01	8.0E+01	--
a-BHC	1.2E-04	9.1E-01	2.8E+00	3.1E-03
b-BHC	4.1E-04	1.8E+00	1.8E+00	1.1E-02
d-BHC	4.7E-04	2.3E+00	6.2E+00	--
g-BHC (Lindane)	2.0E-04	2.3E+00	6.2E+00	4.7E-03
a-Chlordane	2.0E-03	3.9E+00	1.0E+01	4.8E+00
g-Chlordane	2.0E-03	3.9E+00	1.0E+01	4.8E+00
4,4'-DDD	3.0E-03	2.4E+01	7.3E+01	6.1E+01
4,4'-DDE	2.1E-03	1.7E+01	5.2E+01	1.9E+02
4,4'-DDT	7.8E-04	3.9E+00	1.0E+01	4.1E+01
Dieldrin	4.6E-05	3.6E-01	1.0E+00	2.0E-02

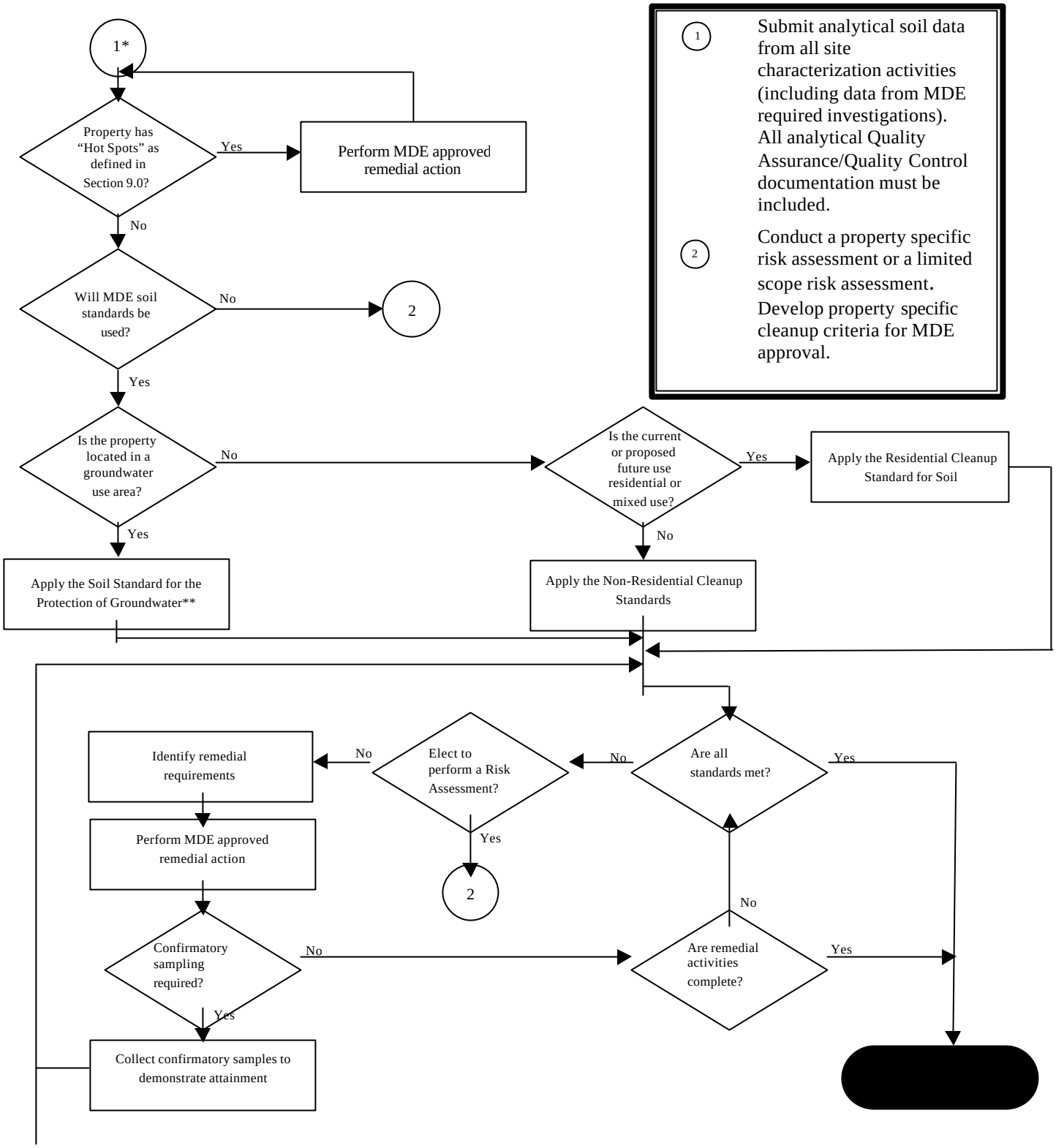
	Groundwater Standards	Soil Standards		
	Type I and II aquifers	***Residential Clean-up Standard***	***Non-Residential Clean-up Standard***	***Standard for the Protection of Groundwater*** [a]
Analyte	***(mg/L)***	***(mg/kg)***	***(mg/kg)***	***(mg/kg)***
Endosulfan I	9.4E-03	6.6E+00	6.6E+00	4.2E-01
Endosulfan II	9.4E-03	4.7E+01	1.2E+02	--
Endosulfan Sulfate	9.4E-03	4.7E+01	1.2E+02	--
Endrin	2.0E-03	2.3E+00	6.2E+00	5.0E-01
Endrin Aldehyde	4.7E-04	2.3E+00	6.2E+00	--
Endrin Ketone	4.7E-04	2.3E+00	6.2E+00	--
Heptachlor	4.0E-04	7.4E-01	3.9E+00	1.1E+01
Heptachlor Epoxide	2.0E-04	1.0E-01	2.7E-01	3.3E-01
Methoxychlor	4.0E-02	2.6E+01	2.6E+01	7.8E+01
Toxaphene	3.0E-03	5.2E+00	1.6E+01	1.5E+01
Aroclor 1016	5.0E-04	5.5E-01	1.5E+00	--
Aroclor 1221	5.0E-04	2.9E+00	8.8E+00	--
Aroclor 1232	5.0E-04	2.9E+00	8.8E+00	--
Aroclor 1242	5.0E-04	2.9E+00	8.8E+00	--
Aroclor 1248	5.0E-04	2.9E+00	8.8E+00	--
Aroclor 1254	5.0E-04	1.6E-01	4.1E-01	--
Aroclor 1260	5.0E-04	2.9E+00	8.8E+00	--
Total PCBs	--	1.0E+00[d]	--	--
Inorganics				
Aluminum	2.0E-01[b]	7.8E+03	2.1E+04	--
Antimony	6.0E-03	3.1E+00	8.3E+00	--
Arsenic	5.0E-02	2.3E+00	6.2E+00	--
Barium	2.0E+00	5.5E+02	1.5E+03	--
Beryllium	4.0E-03	1.6E+01	4.1E+01	--
Cadmium	5.0E-03	7.8E+00	2.1E+01	--
Chromium	1.0E-01	2.3E+01	6.2E+01	--
Cobalt	9.4E-02	4.7E+02	1.2E+03	--
Copper	1.0E+00[b]	3.1E+02	8.3E+02	--
Iron	4.7E-01	2.3E+03	6.2E+03	--
Lead	5.0E-02	4.0E+02	4.0E+02	--
Manganese	5.0E-02[b]	1.6E+02	4.1E+02	--
Mercury	2.0E-03	1.0E-01	1.2E-01	5.6E-03
Nickel	1.0E-01	1.6E+02	4.1E+02	--
Selenium	5.0E-02	3.9E+01	1.0E+02	--
Silver	1.0E-01[b]	3.9E+01	1.0E+02	--
Thallium	2.0E-03	5.5E-01	1.5E+00	--
Tin	9.4E-01	4.7E+03	1.2E+04	--
Vanadium	1.1E-02	5.5E+01	1.5E+02	--
Zinc	5.0E+00[b]	2.3E+03	6.2E+03	--
Cyanide	2.0E-01	1.6E+02	4.1E+02	--

[a] Standard is based on the residential groundwater cleanup standard using a dilution attenuation factor (DAF) of 10
[b] Standard is based on the National Secondary Drinking Water Regulation
[c] MTBE standard is based on the value developed by the Oil Control Program of the Maryland Department of the Environment
[d] Congener specific analyses are required

TABLE 2 – GENERIC NUMERIC CLEANUP STANDARDS FOR GROUNDWATER AND SOIL FOR TOTAL PETROLEUM HYDROCARBON

Analyte	Groundwater Standards – Residential Cleanup Standards (mg/L)	Soil Standards		
		Residential Cleanup Standards (mg/kg)	Non-Residential Cleanup Standards (mg/kg)	Protection of Groundwater (mg/kg)
Gasoline Range Organics (GRO)	4.7E-02	2.3E+02	6.2E+02	--
Diesel Range Organics (DRO)	4.7E-02	2.3E+02	6.2E+02	--

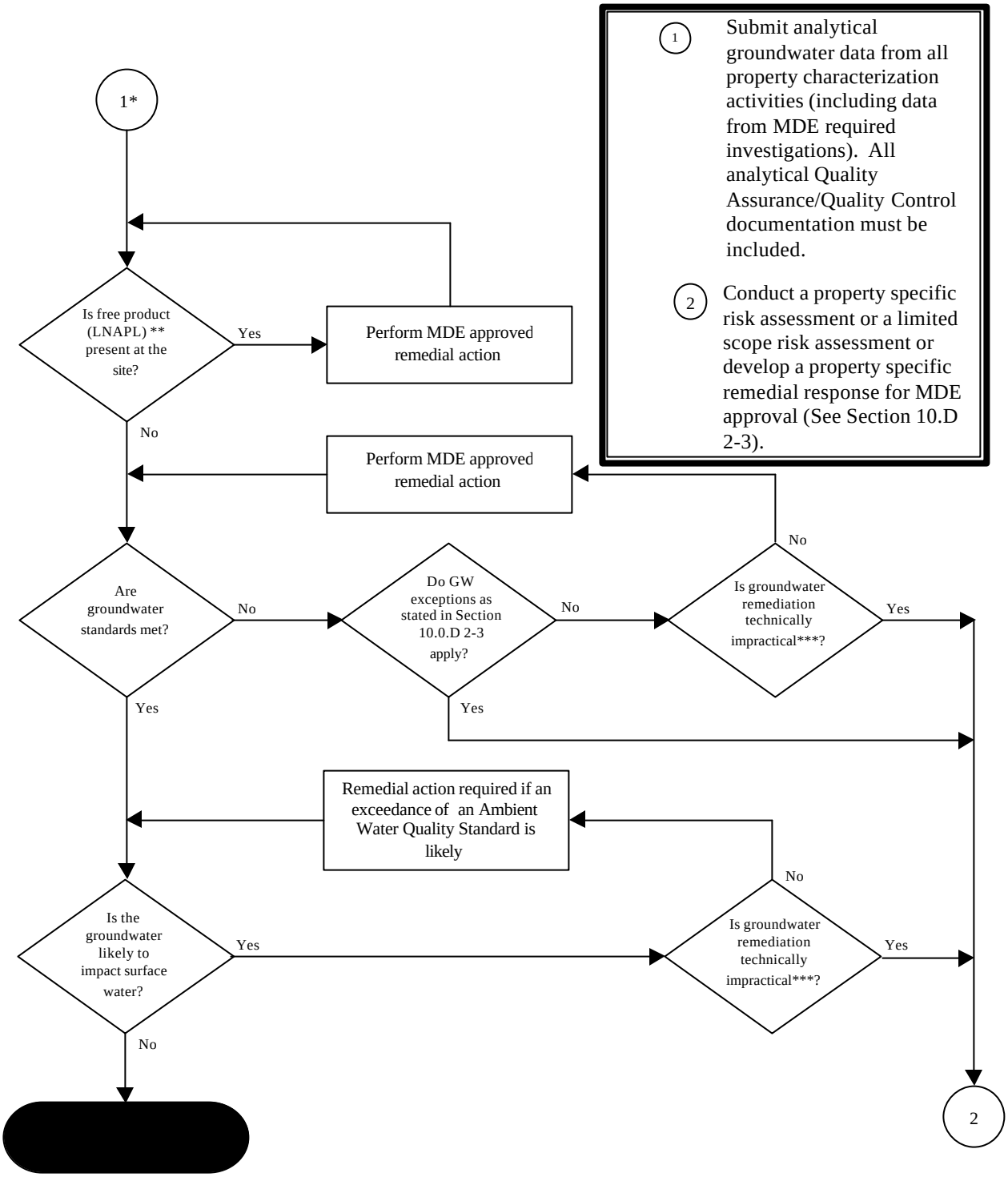
Figure 1. Flowchart for the Application of MDE Soil Cleanup Standards



* Contingent on MDE approval of either a soil investigation or remediation.

** Apply the soil standard for the protection of groundwater or the appropriate land use soil standard, whichever is lower. If no soil standard for the protection of groundwater exists then apply the appropriate land use soil standard.

Figure 2. Flowchart for the Application of MDE Groundwater Cleanup Standards



* Contingent on MDE approval of either a groundwater investigation or remediation.
** Light non-aqueous phase liquids.
*** See Section 10.0.D 1.

Figure 3. Calculation of the 95 Percent Upper Confidence Limit (UCL) of the Arithmetic Mean For Normal And Log Normal Distributions

Normal Distributions:

$$UCL = \bar{\chi} + t\left(\frac{s}{\sqrt{n}}\right)$$

Where:

UCL = upper confidence limit
$\bar{\chi}$ = mean (untransformed data)
t = t-statistic (95% confidence level)
s = standard deviation (untransformed data)
n = number of samples

Sample ID	Chromium in soil Conc. (mg/kg)
Sample 1	7
Sample 2	15
Sample 3	21
Sample 4	30
Sample 5	39
Sample 6	55
Sample 7	70
Sample 8	95
Sample 9	99
Sample 10	123
Sample 11	129
Sample 12	170
Sample 13	203
Sample 14	300
Sample 15	970
Mean =	155
Std. Dev. =	239
95 % UCL =	**264**

n =	15
$\sqrt{n}$ n-1 =	14
=	3.87
$t_{0.1}$ =	1.345
$t_{0.05}$ =	1.761
$t_{0.025}$ =	2.145
$t_{0.01}$ =	2.624
$t_{0.005}$ =	2.977

Lognormal Distributions:

$$UCL = e^{\left(\bar{\chi} + 0.5\, s^2 + \frac{sH}{\sqrt{n-1}}\right)}$$

Where:

UCL = upper confidence limit
e = constant (equals 2.718)
$\bar{\chi}$ = mean (untransformed data)
H = H-statistic (95% confidence level)
s = standard deviation (untransformed data)
n = number of samples

Chromium in soil Conc. (mg/kg)	Chromium in soil *ln* (Conc.)
7	1.95
15	2.71
21	3.04
30	3.40
39	3.66
55	4.01
70	4.25
95	4.55
99	4.60
123	4.81
129	4.86
170	5.14
203	5.31
300	5.70
970	6.88
Mean =	4.32
Std. Dev. =	1.25
95 % UCL =	**479**

$\sqrt{n-1}$ n =	15
=	3.74
H =	3.163

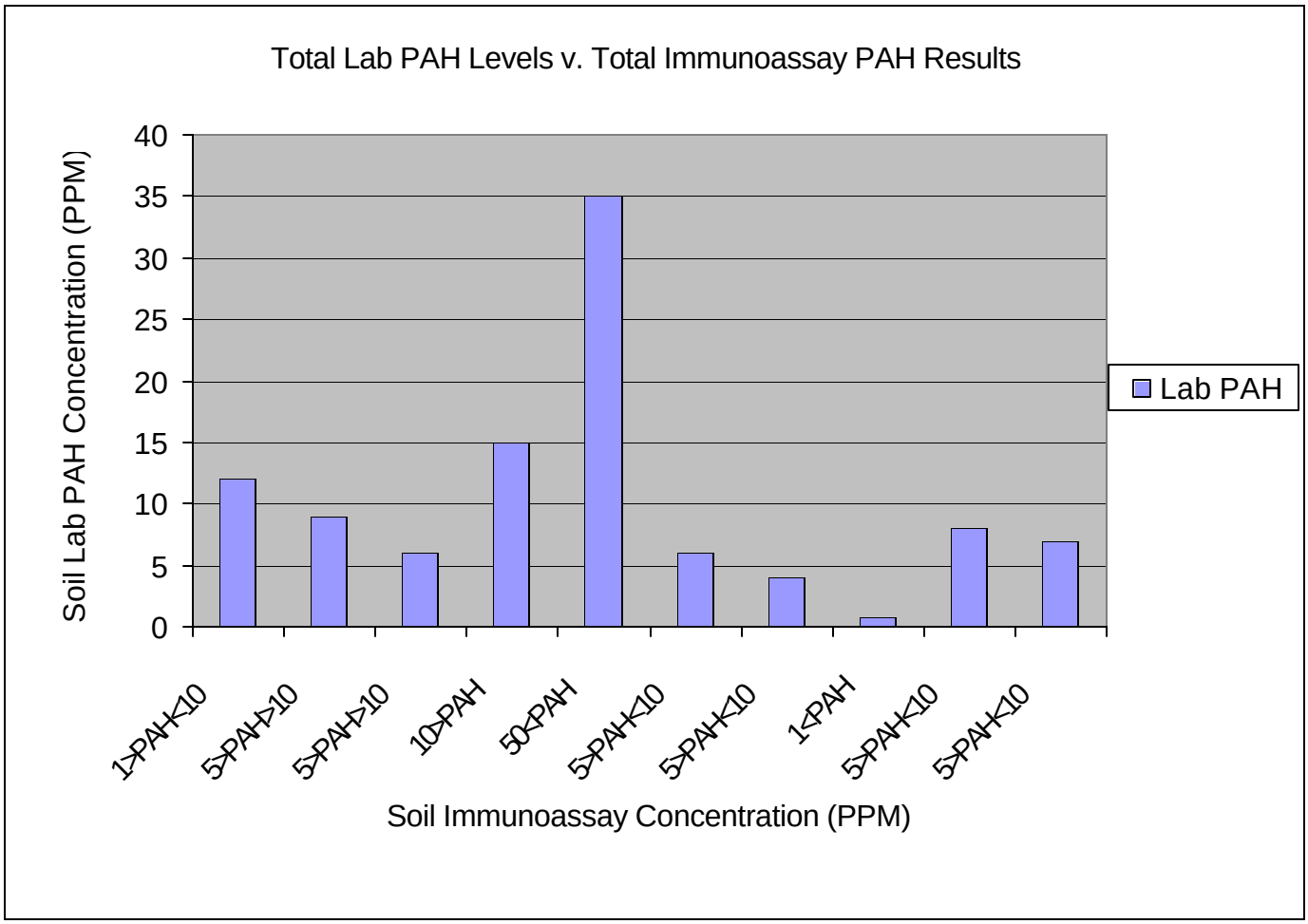
Select $t_{0.95}$ from the Student's t distribution table based on degrees of freedom (n-1) and α level (α = 0.05).

Select the H statistic based on the number of samples (n) and standard deviation (s_y); see Gilbert 1987.

Figure 4. Example Correlation of Immunoassay Technology Analytical Results with Fixed Laboratory Analytical Results

Sample Point	Immunoassay PAH	Lab PAH	
A	1>PAH<10	12	***
B	5>PAH>10	9	
C	5>PAH>10	6	
D	10>PAH	15	
E	50<PAH	35	***
F	5>PAH<10	6	
G	5>PAH<10	4	
H	1<PAH	0.8	
I	5>PAH<10	8	
J	5>PAH<10	7	

*** = no correlation between Lab result and Immunoassay Result
All units are in Parts Per Million (PPM)

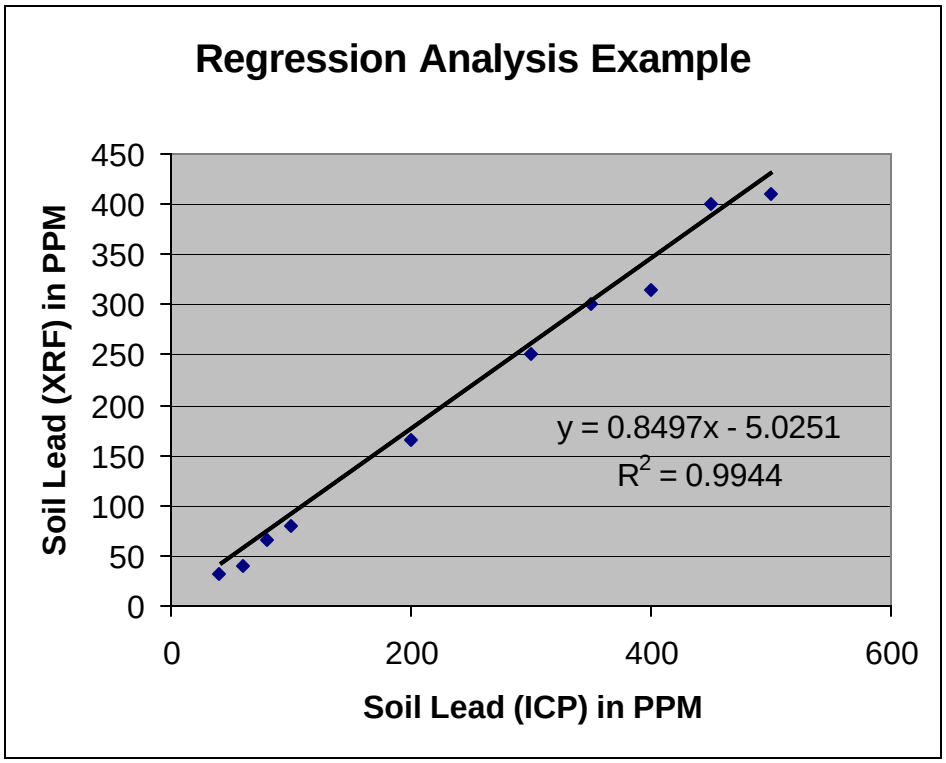


Since 8 of 10 immunoassay results (i.e. 80%) conform with the Fixed Laboratory Total PAH result, all immunoassay results are considered valid. The PAH immunoassay results may be considered to represent the most toxic contaminant in the PAH series for the purposes of applying the cleanup standards.

Figure 5. Regression Analysis Example

Sample Point	Lead XRF	Lead ICP	Corrected XRF Data			
A	100	80	79.945			
B	200	165	164.915			
C	300	250	249.885			
D	400	315	334.855			
E	500	410	419.825			
F	80	65	62.951			
G	350	300	292.37			
H	40	32	28.963			
I	450	400	377.34			
J	60	40	45.957			
k	1000	no sample	844.675			
l	700	no sample	589.765			
m	35	no sample	24.714			
n	402	no sample	336.554			

Equation used to derive Corrected XRF Data is the slope of a line y = mx + b
where y = Corrected XRF Data, m = .8497, x = Lead XRF, and b = 5.0251.
All data is in Parts Per Million (PPM)



Since the XRF results have a high goodness of fit (i.e. >90%), with the Fixed Laboratory result, these data can be applied in either the assessment of risk, or in the application of a cleanup standard. Note the XRF samples k-n may also be used for these purposes even though there is no comparable Fixed Laboratory result.

Appendix 1. Risk Assessment Equations and Tables

Groundwater Ingestion:

Noncarcinogenic:

$$CW\ (mg/l) = \frac{HI \times RfD_o \times BW \times AT_n}{IR_{dw} \times EF \times ED} \quad (1)$$

Carcinogenic (age adjusted):

$$CW\ (mg/l) = \frac{CR \times AT_c}{IF_{dw} \times EF \times CSF_o} \quad (2)$$

Carcinogenic:

$$CW\ (mg/l) = \frac{CR \times BW \times AT_c}{IR_{dw} \times EF \times ED \times CSF_o} \quad (3)$$

Inhalation of Volatiles in Groundwater:

Noncarcinogenic:

$$CW\ (mg/l) = \frac{HI \times RfD_i \times BW \times AT_n}{InhR \times EF \times ED \times ET \times VF} \quad (4)$$

Carcinogenic (age adjusted):

$$CW\ (mg/l) = \frac{CR \times AT_c}{IF_{inh} \times EF \times CSF_i \times VF} \quad (5)$$

Carcinogenic:

$$CW\ (mg/l) = \frac{CR \times BW \times AT_c}{InhR \times EF \times ED \times ET \times CSF_i \times VF} \quad (6)$$

Soil Ingestion:

Noncarcinogenic:

$$CS\ (mg/kg) = \frac{HI \times RfD_o \times BW \times AT_n}{IR_{soil} \times CF \times EF \times ED} \quad (7)$$

Carcinogenic (age adjusted):

$$CS\ (mg/kg) = \frac{CR \times AT_c}{CF \times IF_{soil} \times EF \times CSF_o} \quad (8)$$

Carcinogenic:

$$CS\ (mg/kg) = \frac{CR \times BW \times AT_c}{CF \times IR_{soil} \times EF \times ED \times CSF_o} \quad (9)$$

Inhalation of Particulates and Volatiles in Soil:

Noncarcinogenic:

$$CS\,(mg/kg) = \frac{HI \times RfD_i \times BW \times AT_n}{InhR \times EF \times ED \times ET \times \left[\left(\frac{1}{VF}\right) + \left(\frac{1}{PEF}\right)\right]} \qquad (10)$$

Carcinogenic (age adjusted):

$$CS\,(mg/kg) = \frac{CR \times AT_c}{IF_{inh} \times EF \times CSF_i \times \left[\left(\frac{1}{VF}\right) + \left(\frac{1}{PEF}\right)\right]} \qquad (11)$$

Carcinogenic:

$$CS\,(mg/kg) = \frac{CR \times BW \times AT_c}{InhR \times EF \times ED \times ET \times CSF_i \times \left[\left(\frac{1}{VF}\right) + \left(\frac{1}{PEF}\right)\right]} \qquad (12)$$

Particulate Emission Factor[h]:

$$PEF = Q/C \times \frac{3600\ sec/hour}{0.036 \times (1 - V) \times \left(\frac{U_m}{U_t}\right)^3 \times F(x)} \qquad (13)$$

Where:

Parameter	Definition	Default
PEF	Particulate Emission Factor (m^3/kg)	7.8E07
Q/C	Inverse of Mean Concentration at Center of Square Source (g/m^2-s per kg/m^3)	56.12[l]
0.036	Respirable Fraction (g/m^2-hr)	0.036[h]
V	Fraction of Vegetative Cover (unitless)	0.5[h]
U_m	Mean Annual Wind Speed (m/sec)	4.69[h]
U_t	Equivalent Threshold Value of Wind Speed at 7 Meters (m/sec)	11.32[h]
F(x)	Function dependent of U_m/U_t derived using Cowherd et al. (1985) (unitless)	0.194[h]

Soil to Air Volatilization Factor[h]:

$$VF = Q/C \times \frac{(3.14 \times D_a \times T)^{\frac{1}{2}}}{(2 \times \rho_b \times D_a)} \times 10^{-4}\ (m^2/cm^2) \qquad (14)$$

Where:

$$D_a = \frac{\left[\left(\theta_a^{\frac{10}{3}} \times D_i H' + \theta_w^{\frac{10}{3}} \times D_w\right)/n^2\right]}{\rho_b K_d + \theta_w + \theta_a H'} \qquad (15)$$

Parameter	Definition	Default
VF	Volatilization Factor (m^3/kg)	
D_a	Apparent Diffusivity (cm^2/sec)	
Q/C	Inverse of the Mean Concentration at Center of Square Source (g/m^2-sec per kg/m^3)	56.12[I]
T	Exposure Interval (sec)	9.5E08[h]
ρ_b	Dry Soil Bulk Density (g/cm^3)	1.5[h]
θ_a	Air-filled Soil Porosity (L_{air}/L_{soil})	0.28[h]
n	Total Soil Porosity (L_{pore}/L_{soil})	0.43[h]
θ_w	Water-filled Soil Porosity (L_{water}/L_{soil})	0.15[h]
ρ_s	Soil Particle Density (g/cm^3)	2.65[h]
D_i	Diffusivity in Air (cm^2/sec)	Chemical Specific
H′	Henry's Law Constant (dimensionless)	Chemical Specific
D_w	Diffusivity in Water (cm^2/sec)	Chemical Specific
K_d	Soil-Water Partition Coefficient (cm^3/g) [K_{oc}*f_{oc}]	Chemical Specific
K_{oc}	Soil Organic Carbon-Water Partition Coefficient (cm^3/g)	Chemical Specific
f_{oc}	Organic Carbon Content of Soil (g/g)	0.006 (0.6%)[h]

<u>Migration to Groundwater Pathway (inorganics)[h]:</u>

$$C_t = C_w\left[K_d + \left(\Theta_w + \Theta_a H'\right)/\rho_b\right] \qquad (16)$$

$$C_w = GW_c \times DF \qquad (17)$$

Where:

C_t	Cleanup Level in Soil (mg/kg)	
C_w	Target Soil Leachate Concentration (mg/l)	MD groundwater standard
K_d	Soil-Water Partition Coefficient	Chemical Specific
GW_c	Target Groundwater Concentration	Chemical Specific
DF	Dilution Factor	10
Θ_w	Water-filled Soil Porosity (L_{water}/L_{soil})	0.3 (30%)
Θ_a	Air-filled Soil Porosity (L_{air}/L_{soil})	0.13
H'	Dimensionless Henry's Law Constant	(H x 41)
H	Henry's Law Constant (atm-m3/mol)	Chemical Specific
ρ_b	Dry Soil Bulk Density (kg/l)	1.5

Migration to Groundwater Pathway (organics)[h]:

$$C_t = C_w \left[\left(K_{oc} \times f_{oc} \right) + \left(\Theta_w + \Theta_a H' \right) / \rho_b \right] \quad (18)$$

$$C_w = GW_c \times DF \quad (19)$$

Where:

C_t	Cleanup Level in Soil (mg/kg)	
C_w	Target Soil Leachate Concentration (mg/l)	MD groundwater standard
K_{oc}	Soil-Water Partition Coefficient	Chemical Specific
f_{oc}	Organic Carbon Content of Soil (kg/kg)	0.002 (0.2%)
GW_c	Target Groundwater Concentration	Chemical Specific
DF	Dilution Factor	10
Θ_w	Water-filled Soil Porosity (L_{water}/L_{soil})	0.3 (30%)
Θ_a	Air-filled Soil Porosity (L_{air}/L_{soil})	0.13
H'	Dimensionless Henry's Law Constant	(H x 41)
H	Henry's Law Constant (atm-m3/mol)	Chemical Specific
ρ_b	Dry Soil Bulk Density (kg/l)	1.5

Soil Saturation Limit[h]:

$$C_{sat} = \frac{S}{\rho_b} \left(K_d \times \rho_b + \Theta_w + H' \times \Theta_a \right) \quad (20)$$

Where

C_{sat}	Soil Saturation Concentration (mg/kg)	
S	Solubility in Water (mg/l-water)	Chemical Specific
ρ_b	Dry Soil Bulk Density (kg/l)	1.5
K_d	Soil-Water Partition Coefficient (l/kg)	K_{oc} x f_{oc}
K_{oc}	Soil Organic Carbon/Water Partition Coefficient (l/kg)	Chemical Specific
f_{oc}	Fraction Organic Carbon of Soil (g/g)	0.006 (0.6%)
Θ_w	Water-filled Soil Porosity (l_{water}/l_{soil})	0.15
H'	Dimensionless Henry's Law Constant	(H x 41)
H	Henry's Law Constant	Chemical Specific
Θ_a	Air-filled Soil Porosity (l_{air}/l_{soil})	0.28

Dermal Contact with Groundwater:

Noncarcinogenic:

$$CW\ (mg/l) = \frac{HI \times RfD_{abs} \times BW \times AT_n}{CF \times SSA \times PC \times EF \times ED \times ET} \quad (21)$$

Carcinogenic (age adjusted):

$$CW\ (mg/l) = \frac{CR \times AT_c}{CF \times DF_{dc} \times PC \times EF \times ET \times CSF_{abs}} \quad (22)$$

Carcinogenic: $$CW\ (mg/l) = \frac{CR \times BW \times AT_c}{CF \times SSA \times PC \times EF \times ED \times ET \times CSF_{abs}} \quad (23)$$

<u>Dermal Contact with Soil:</u>

Noncarcinogenic: $$CS\ (mg/kg) = \frac{HI \times RfD_{abs} \times BW \times AT_n}{CF \times SSA \times AF \times ABS \times EF \times ED} \quad (24)$$

Carcinogenic (age adjusted): $$CS\ (mg/kg) = \frac{CR \times AT_c}{CF \times AF \times DF_{dc} \times ABS \times EF \times CSF_{abs}} \quad (25)$$

Carcinogenic: $$CS\ (mg/kg) = \frac{CR \times BW \times AT_c}{CF \times SSA \times AF \times ABS \times EF \times ED \times CSF_{abs}} \quad (26)$$

Default exposure parameters for groundwater and soil pathways are presented in Tables 1 – 4.

Appendix 1 - Table 1. Default ingestion parameters used to calculate the risk based concentrations for groundwater.

Parameter		Pathway / Population				
		Adult	**Youth (>6 - <18 Years)**	**Child (<6 Years)**	**Construction Worker**	**Age-Adjusted Resident**
HI	Hazard Index	0.1	0.1	0.1	0.1	
CR	Excess Lifetime Cancer Risk	1E-05	1E-05	1E-05	1E-05	1E-05
BW	Body Weight (kg)	70[a, b, c, d]	40[a]	15[a, b, c]	70[a, b, c, d]	
		Ingestion - Residential				
Ir_{dw}	Ingestion Rate/Drinking Water (l/day)	2[a]	2[a]	1[a]	3[a]	
If_{dw}	Age-Adjusted Ingestion Factor (l-yr/kg-day)					1[e]
EF	Exposure Frequency (days/year)	350[d, f]	350[d, f]	350[d, f]	250[c, d]	350[d, f]
ED	Exposure Duration (years)	30[a, b]	12[a]	6[a, b]	1[c]	
		Ingestion - Commercial				
Ir_{dw}	Ingestion Rate/ Groundwater (l/day)	1[c]	2[a]	1[a]	3[a]	
If_{dw}	Age-Adjusted Ingestion Factor (l-yr/kg-day)					1[e]
EF	Exposure Frequency (days/year)	250[c, d]	132[b, g]	132[b, g]	250[c, d]	132[b, g]
ED	Exposure Duration (years)	25[c, d]	12[a]	6[a, b]	1[c]	
		Ingestion - Industrial				
Ir_{dw}	Ingestion Rate/Drinking Water (l/day)	1[c]	2[a]		3[a]	
EF	Exposure Frequency (days/year)	250[c, d]	132[b, g]		250[c, d]	
ED	Exposure Duration (years)	25[c]	12[a]		1[c]	

Note: The following body weight values were used in deriving the standards; 70 kg for the adult and construction worker; 40 kg for youths, and 15 kg for the child population.

Appendix 1 - Table 2. Default inhalation parameters used to calculate the risk based concentrations for groundwater.

	Parameter	Inhalation of Volatiles While Showering - Residential				
		Adult	**Youth (>6 - <18 Years)**	**Child (<6 Years)**	**Construction Worker**	**Age-Adjusted Resident**
InhR	Inhalation Rate (m^3/hour)	0.833[a, b, c]	0.56[a]	0.32[a]		
If_{inh}	Age-Adjusted Inhalation Factor (m^3-year/kg-day)				0.22[e]	
EF	Exposure Frequency (days/year)	350[d, f]	350[d, f]	350[d, f]	350[d, f]	
ED	Exposure Duration (years)	30[a, b]	12[a]	6[a, b]		
ET	Exposure Time (hours/day)	0.5 [a]	0.5 [a]	0.5 [a]		
VF	Volatilization Factor (l/m^3)	0.5[k]	0.5[k]	0.5[k]	0.5[k]	
		Inhalation of Volatiles While Showering - Commercial				
InhR	Inhalation Rate (m^3/hour)	0.833[c,a,b,c]	0.56[a]	0.32[a]		
If_{inh}	Age-Adjusted Inhalation Factor (m^3-year/kg-day)				0.15[e]	
EF	Exposure Frequency (days/year)	250[c, d]	132[b, g]	132[b, g]	132[b,g]	
ET	Exposure Time (hours/day)	0.5[a]	0.5[a]	0.5[a]		
ED	Exposure Duration (years)	25[c, d]	12[a]	6[a, b]		
VF	Volatilization Factor (l/m^3)	0.5[k]	0.5[k]	0.5[k]	0.5[k]	
		Inhalation of Volatiles While Showering - Industrial				
InhR	Inhalation Rate (m^3/hour)	0.833[a,b,c]	0.56[a]			
EF	Exposure Frequency (days/year)	250[c, d]	132[b, g]			
ET	Exposure Time (hours/day)	0.5[a]	0.5[a]			
ED	Exposure Duration (years)	25[c, d]	12[a]			
VF	Volatilization Factor (l/m^3)	0.5[k]	0.5[k]			

Note: The following body weight values were used in deriving the standards; 70 kg for the adult and construction worker; 40 kg for youths, and 15 kg for the child population.

Appendix 1 - Table 3. Default ingestion parameters used to calculate the risk based concentrations for soil.

	Parameter	Ingestion - Residential				
		Adult	**Youth (>6 - <18 Years)**	**Child (<6 Years)**	**Construction Worker**	**Age-Adjusted Resident**
Ir_{soil}	Ingestion Rate/Soil (mg/day)	100[a, b, c, d]	100[a, b, c, d]	200[a, b]	480[c]	
If_{soil}	Age-Adjusted Ingestion Factor (mg-yr/kg-day)					127[e]
CF	Conversion Factor (kg/mg)	1E-06 [b]	1E-06[b]	1E-06[b]	1E-06[b]	1E-06[b]
EF	Exposure Frequency (days/year)	350[d, f]	350[d, f]	350[d, f]	250[c, d]	350[d, f]
ED	Exposure Duration (years)	30[a, b]	12[a]	6[a, b]	1[c]	
		Ingestion - Commercial				
Ir_{soil}	Ingestion Rate/Soil (mg/day)	50[c, d]	100[a, b, c, d]	200[a, b]	480[c]	
If_{soil}	Age-Adjusted Ingestion Factor (mg-yr/kg-day)					110 [e]
EF	Exposure Frequency (days/year)	250[c, d]	132[b, g]	132[b, g]	250[c, d]	132[b, g]
ED	Exposure Duration (years)	25[c, d]	12[a]	6[a, b]	1[c]	
		Ingestion - Industrial				
Ir_{soil}	Ingestion Rate/Soil (mg/day)	50[c, d]	100[a, b, c, d]		480[c]	
CF	Conversion Factor (kg/mg)	1E-06[b]	1E-06[b]		1E-06[b]	
FI	Fraction Ingested (unitless)	1	1		1	
EF	Exposure Frequency (days/year)	250[c, d]	132[b, g]		250[c, d]	
ED	Exposure Duration (years)	25[c]	12[a]		1[c]	

Note: The following body weight values were used in deriving the standards; 70 kg for the adult and construction worker; 40 kg for youths, and 15 kg for the child population.

Appendix 1 - Table 4. Default inhalation parameters used to calculate the risk based concentrations for soil.

	Parameter	Inhalation - Residential				
		Adult	**Youth (>6 - <18 Years)**	**Child (<6 Years)**	**Construction Worker**	**Age-Adjusted Resident**
InhR	Inhalation Rate (m^3/hour)	0.833[a, b, c]	0.56[a]	0.32[a]	1.5[a]	
If_{inh}	Age-Adjusted Inhalation Factor (m^3-year/kg-day)					11[e]
EF	Exposure Frequency (days/year)	350[d, f]	350[d, f]	350[d, f]	250[c, d]	350[d, f]
ED	Exposure Duration (years)	30[a, b]	12[a]	6[a, b]	1[c]	
ET	Exposure Time (hours/day)	24	24	24	8	
VF	Volatilization Factor (m^3/kg)	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific
PEF	Particulate Emission Factor (m^3/kg)	7.8E07	7.8E07	7.8E07	7.8E07	7.8E07
		Inhalation - Commercial				
InhR	Inhalation Rate (m^3/hour)	1.0[c, d]	0.56[a]	0.32[a]	1.5[a]	
If_{inh}	Age-Adjusted Inhalation Factor (m^3-year/kg-day)					1.0[e]
EF	Exposure Frequency (days/year)	250[c, d]	132[b, g]	132[b, g]	250[c, d]	
ET	Exposure Time (hours/day)	8	4	4	8	
ED	Exposure Duration (years)	25[c, d]	12[a]	6[a, b]	1[c]	
VF	Volatilization Factor (m^3/kg)	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific
PEF	Particulate Emission Factor (m^3/kg)	7.8E07	7.8E07	7.8E07	7.8E07	7.8E07
		Inhalation - Industrial				
InhR	Inhalation Rate (m^3/hour)	1.0[c, d]	0.56[a]		1.5[a]	
EF	Exposure Frequency (days/year)	250[c, d]	132[b, g]		365[c, d]	
ET	Exposure Time (hours/day)	8	4		8	
ED	Exposure Duration (years)	25[c, d]	12[a]		1[c]	
VF	Volatilization Factor (m^3/kg)	Chemical Specific	Chemical Specific		Chemical Specific	
PEF	Particulate Emission Factor (m^3/kg)	7.8E07	7.8E07		7.8E07	

Note: The following body weight values were used in deriving the standards; 70 kg for the adult and construction worker; 40 kg for youths, and 15 kg for the child population.

Appendix 1 - Table 5. Default dermal contact parameters used to calculate the risk based concentrations for groundwater.

	Parameter	Dermal Contact – Residential				
		Adult	**Youth (>6 - <18 Years)**	**Child (<6 Years)**	**Construction Worker**	**Age-Adjusted Resident**
SSA	Skin Surface Area (cm^2)	18150[a]	13100[a]	6560[a]	5670[a]	
PC	Permeability Constant (cm/hr)	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific
ET	Exposure Time (hour/day)	0.5[a]	0.5[a]	0.5[a]	4[l]	0.5[a]
DF_{dc}	Age-Adjusted Dermal Factor (cm^2-yr/kg)					9661[e]
EF	Exposure Frequency (events/year)	350[d, f]	350[d, f]	350[d, f]	250[c, d]	350[d, f]
ED	Exposure Duration (years)	30[a, b]	12[a]	6[a, b]	1[c]	
		Dermal Contact – Commercial				
SSA	Skin Surface Area (cm^2)	5670[a]	13100[a]	6560[a]	5670[a]	
PC	Permeability Constant (cm/hr)	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific
ET	Exposure Time (hour/day)	8[d]	0.5[a]	0.5[a]	4[l]	
DF_{dc}	Age-Adjusted Dermal Factor (cm^2-year/kg)					6550[e]
EF	Exposure Frequency (days/year)	250[c, d]	132[b, g]	132[b, g]	250[c, d]	132[b, g]
ED	Exposure Duration (years)	25[c, d]	12[a]	6[a, b]	1[c]	
		Dermal Contact – Industrial				
SSA	Skin Surface Area (cm^2)	5670[a]	13100[a]		5670[a]	
CF	Conversion Factor (l/1000 cm^3)	0.001	0.001		0.001	
PC	Permeability Constant (cm/hour)	Chemical Specific	Chemical Specific		Chemical Specific	
ET	Exposure Time (hour/day)	8[d]	0.5[a]		4[l]	
EF	Exposure Frequency (days/year)	250[c, d]	132[b, g]		250[c, d]	
ED	Exposure Duration (years)	25[c, d]	12[a]		1[c]	

Note: The following body weight values were used in deriving the standards; 70 kg for the adult and construction worker; 40 kg for youths, and 15 kg for the child population.

Appendix 1 – Table 6. Default dermal contact parameters used to calculate the risk based concentrations for soil.

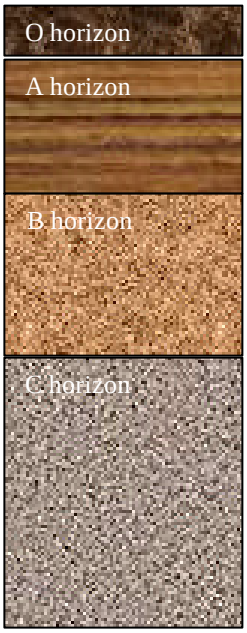
	Parameter	Dermal Contact – Residential				
		Adult	**Youth (>6 - <18 Years)**	**Child (<6 Years)**	**Construction Worker**	**Age-Adjusted Resident**
SSA	Skin Surface Area (cm^2)	5700[a]	4320[a]	2350[a]	3280[a]	
CF	Conversion Factor (kg/mg)	1E-06[b]	1E-06[b]	1E-06[b]	1E-06[b]	1E-06[b]
ABS	Absorption Factor (unitless)	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific
AF	Soil to Skin Adherence Factor (mg/cm^2-event)	0.07[a, j]	0.07[a, j]	0.5[a, j]	0.08[a, j]	
DF_{dc}	Age-Adjusted Dermal Factor (mg-year/kg-event)					629[e]
EF	Exposure Frequency (events/year)	350[d, f]	350[d, f]	350[d, f]	250[c, d]	350[d, f]
ED	Exposure Duration (years)	30[a, b]	12[a]	6[a, b]	1[c]	
		Dermal Contact – Commercial				
SA	Skin Surface Area (cm^2/event)	3280[a]	4320[a]	2350[a]	3280[a]	
CF	Conversion Factor (kg/mg)	1E-06[b]	1E-06[b]	1E-06[b]	1E-06[b]	
ABS	Absorption Factor (unitless)	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific	
AF	Soil to Skin Adherence Factor (mg/cm^2)	0.07,[j]	0.07,[j]	0.5,[j]	0.08,[j]	
DF_{dc}	Age-Adjusted Dermal Factor (mg-year/kg-event)					
EF	Exposure Frequency (days/year)	250[c, d]	132[b, g]	132[b, g]	250[c, d]	
ED	Exposure Duration (years)	25[c, d]	12[a]	6[a, b]	1[c]	
		Dermal Contact – Industrial				
SA	Skin Surface Area (cm^2/event)	3280[a]	4320[a]		3280[a]	
CF	Conversion Factor (kg/mg)	1E-06[b]	1E-06[b]		1E-06[b]	
ABS	Absorption Factor (unitless)	Chemical Specific	Chemical Specific		Chemical Specific	
AF	Soil to Skin Adherence Factor (mg/cm^2)	0.07[a, j]	0.07[a, j]		0.08[a, j]	
EF	Exposure Frequency (days/year)	250[c, d]	132[b, g]		250[c, d]	
ED	Exposure Duration (years)	25[c, d]	12[a]		1[c]	

Note: The following body weight values were used in deriving the standards; 70 kg for the adult and construction worker; 40 kg for youths, and 15 kg for the child population.

Appendix 2

REFERENCE LEVELS OF METALS AND TRACE ELEMENTS IN SOILS OF MARYLAND

As Indicated by Background Soil Samples
Collected As Part of National Priorities List, Federal Facility,
And CERCLA Investigations Conducted
Throughout Maryland



INTRODUCTION

The 1980 Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) established a national process for investigating and remediating sites contaminated with hazardous substances. Since that time the environmental industry and government sectors have labored to establish cleanup standards that are practical and protective of human health and the environment.

One remediation approach commonly considered is clean up to “background.” Many regulatory agencies define “background” as the concentration of a hazardous substance, if any, existing in the environment at the site prior to the release of a hazardous substance. The establishment of “background” as a cleanup standard results in the necessity of determining the concentration of a chemical prior to any releases. This approach is particularly significant when cleanup standards are being developed for naturally occurring metals and trace elements that are present in the soil.

The soil media is of particular concern during site investigations since it is commonly the first media that is impacted by a release of hazardous material. Soils also serve as the pathway to other environmental media, such as air (via dust) or groundwater (via seepage), or surface water (via runoff). As a result, establishing the “background” concentration for metals and trace elements in soils is one of the most critical components of a site investigation.

OBJECTIVE

The Annotated Code of Maryland § 7-501 defines "background level" as the level of a substance occurring naturally at the site prior to any manmade spill or release.

The objective of this study is to evaluate previously collected information on "background" concentrations of metals and trace elements in Maryland and use statistical methods to develop "reference levels" for metals and trace elements in the soil. The information generated from this study has been used by the MDE in developing cleanup standards for metals and trace elements in soil.

PROCESS

For the purpose of this study, the geographic area of the state has been divided into three provinces based upon broad differences in age, chemistry, and structure of the geologic units in each province. These provinces include Eastern Maryland, Central Maryland, and Western Maryland. Figure 1 depicts the boundaries of these provinces.

This study utilized laboratory derived analytical data collected on metals in soil from environmental investigations overseen by the MDE. The soil data used in this study were extracted from Federal Facility, National Priorities List, and CERCLA investigations completed throughout the state of Maryland. These soil samples were identified as "background" grab surface soil samples for the particular site subject to investigation by the MDE. A complete list of sites included in this study and the analytic results are provided in Attachment 1.

All soil samples were collected after 1990. The samples were analyzed using methods approved by the United States Environmental Protection Agency (EPA) and/or other approved methods for various programs within the MDE. Therefore, the data set used in this study is considered to be acceptable for the objectives identified.

STATISTICAL ANALYSIS

Statistical analyses were conducted on data for each analyte included in the investigation. The statistical analyses included the mean, standard deviation, and maximum and minimum values. Since each particular site investigation has specific sampling objectives, not all samples were analyzed for all metals included in this study. Analytes that were not analyzed were not included in the statistical analysis. If an analyte was not detected, then a value equivalent to half the detection limit was used in the statistical analysis unless otherwise noted. The results of the analysis are presented in Attachment 2.

Values defined as the "Anticipated Typical Concentration" represent "reference levels" for each analyte. The Anticipated Typical Concentration (ATC) represents the mean concentration plus one standard deviation. The ATC represents a value that either matches or exceeds the majority of background concentration samples. ATC values were calculated for metals and trace elements in each of the three provinces of the state of Maryland identified in this study.

SUMMARY TABLES

Background soil concentration data collected from environmental investigations overseen by the MDE for each geologic province is summarized in Attachment 1. Information present in Attachment 2 includes a statistical summary of metal species, the ATC, United States Geologic Survey (USGS) concentrations, and the proposed Maryland cleanup standards. The USGS concentrations represent the average concentrations of metals and trace elements in soils and other surficial material in the conterminous United States as reported by the USGS in 1984[1].

The proposed Maryland Cleanup Standards represent concentration levels at which no further remedial response action would be required based upon the potential threat posed by these substances to human health within the constraints of current knowledge. The soil concentration values for residential sites are intended for properties that are zoned for residential use, or have a projected future residential use.

RESULTS

Comparison of the ATC to the Proposed Maryland Cleanup Standards for Residential sites shows that the reference levels for the following elements exceed the Maryland Cleanup Standards:

	Anticipated Typical Concentration (ATC)			**Proposed Maryland Cleanup Standards**
Analyte	**Eastern Maryland**	**Central Maryland**	**Western Maryland**	**(residential)**
Aluminum	1.1 E+04	1.9 E+04	2.0 E+04	7.8 E+03
Antimony	6.0 E+00	6.7 E+00	3.2 E+00	3.1 E+00
Arsenic	3.6 E+00	4.9 E+00	1.1 E+01	2.3 E+00
Chromium (total)	2.8 E+01	3.0 E+01	4.2 E+01	2.3 E+01
Iron	1.5 E+04	2.6 E+04	3.9 E+04	2.3 E+03
Manganese	4.8 E+02	1.4 E+03	1.5 E+03	1.6 E+02
Mercury	5.1 E-01	1.4 E-01	1.1 E-01	1.0 E-01
Thallium	3.8 E+00	1.5 E+00	4.5 E+00	5.5 E-01
Vanadium	-------	-------	1.2 E+02	5.5 E+01

All values are reported in parts per million.

When an ATC concentration for a given province exceeds the "Proposed Maryland Cleanup Standards (Residential)", the ATC value for the appropriate province may be proposed as an acceptable alternative to the risk derived value presented in the "Proposed Maryland Cleanup Standards (Residential)."

DISCUSSION OF RESULTS

Several of the MDE derived reference levels for metals in soils exceed the proposed Maryland Cleanup Standards under a residential use setting. This result is a consequence of multiple factors and does not necessarily indicate that a hazard is posed to either human health or the environment in areas of the state where the reference levels exceed the proposed Residential Cleanup Standards.

The concentration of metals in soil under natural conditions are a result of both chemical and physical weathering processes on parent rock. The degree to which soils contain naturally occurring metals is dependent on the chemical make-up of the parent rock from which the soil was derived, and the degree of chemical and physical weathering and transport of eroded parent rock material to the soil media. This erosion and deposition relationship results in a high degree of variability with respect to the concentration of metals in soil.

All soil types contain metals. In most cases, the metals in the soil media are not present in their elemental form, but are present as ionic compounds. Ionic compounds are chemical combinations of metals (i.e. cations) and non-metals (i.e. anions) that bond together through a process of electron transfer. Metal compounds can form stable chemical complexes that exhibit markedly different characteristics from their elemental forms, and may pose less of a risk (i.e. lower bioavailability) to human health or the environment.

Metals that are bound up in relatively stable mineral complexes do not readily degrade and are not as readily bioavailable as metals in a pure form. Different valences of metals can produce dramatically different toxicities and different matrices may render them more or less bioavailable. These factors have ramifications for determining the potential health risks associated with metal reference concentrations that exceed soil Cleanup Standards. For example, property specific soil conditions such as moisture content, PH, cation exchange capacity, and total organic carbon content and the use of the land will affect the amount of metal species that are available to pose a health risk.

State and federal environmental regulatory programs routinely require the soil media to be tested by approved analytical laboratories for metal concentrations at properties subject to investigation. The laboratory analytical methods commonly used by regulatory programs do not, however, differentiate between metals that are in a pure form and metals that are bound up in chemical complexes. These analytical methods use acid digestions and other destructive methods to dissolve the soil, parent rock or organic complexes which results in the release of metals in a free state. The outcome of these analytical methods are concentrations that reflect the total amount of the elemental metal in the soil and do not typically consider the percentage of metal bound up in mineral or organic complexes.

MDE derived reference levels for metals in the soil are intended to represent concentrations that exist in the natural environment absent anthropogenic effects. Comparison of the reference levels to USGS background metal concentrations in native soil for the Conterminous United States indicates a good correlation exists between the data sets. With the exception of Selenium and Antimony, all derived reference concentrations are within one order of magnitude of the USGS average concentrations. In many instances the reference concentrations are lower than the USGS background concentrations. In light of the conservative risk based approach used to derive the cleanup standards for metals (i.e. all metals present in soil are assumed to exist as bioavailable free metals), the option to use reference levels rather

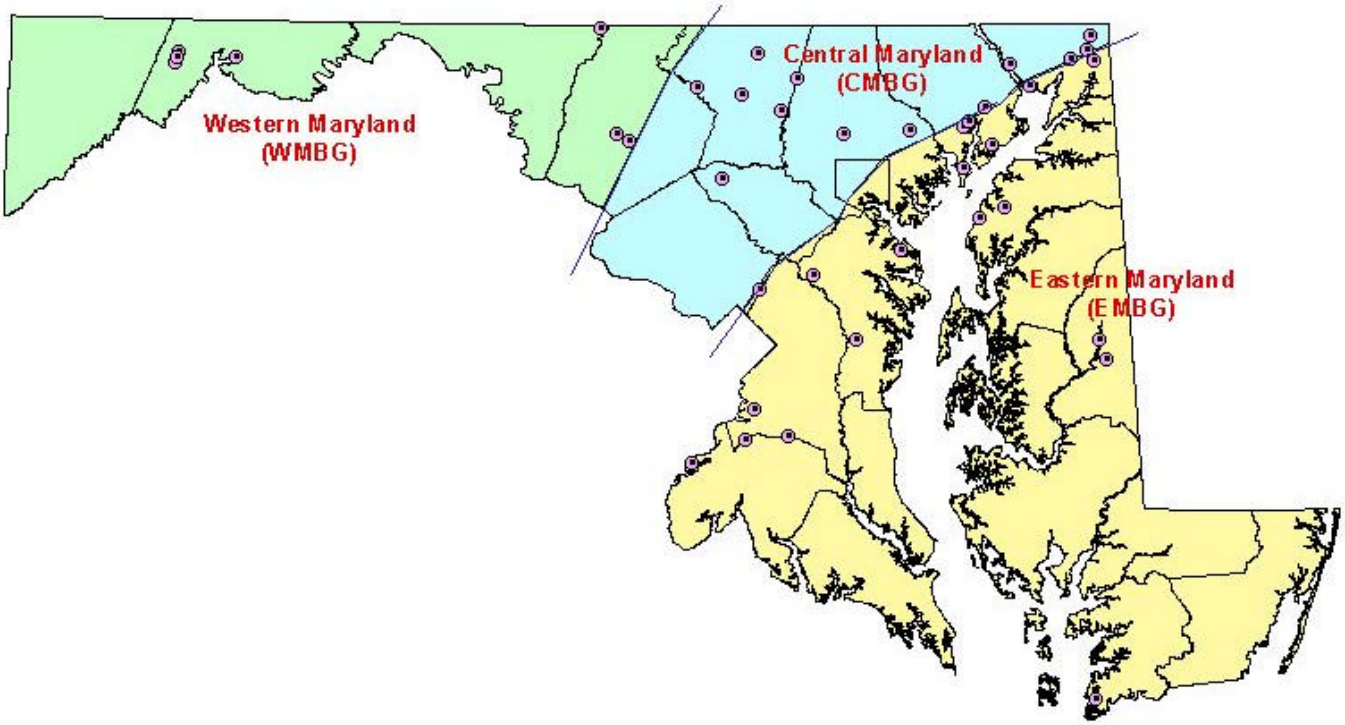
than the proposed Maryland Cleanup Standards is not expected to result in unacceptable levels of risk. This may be a viable alternative when analytical data indicates metal concentrations are above the standards.

STUDY LIMITATIONS

This investigation does not constitute a rigorous scientific analysis conducted in a controlled experimental setting. However, ATC reference levels can serve as general indicators of background levels of metals and trace elements in soil until a more rigorous and thorough background investigation can be completed.

REFERENCES

1) Shacklett, H.T. and Boerngenm, J.G., 1984: Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States; USGS Professional Paper 1270.



Appendix 2 – Figure 1

Location of hazardous substance properties used to derive reference levels for metals in Maryland. The State has been divided into three geological provinces for the purposes of developing regional reference levels.

APPENDIX 2 - ATTACHMENT 1

BACKGROUND SOIL METAL DATA FROM

MDE SITE INVESTIGATIONS USED IN THIS STUDY

EASTERN

Site Name	Province	Designation	Aluminum	Antimony	Arsenic	Barium
Aberdeen Proving Ground	EMBG	S-1	3.7E+03	*3.5E+00*	2.8E+00	1.8E+01
Aberdeen Proving Ground	EMBG	S-1 DUP	3.3E+03	*3.5E+00*	2.4E+00	2.1E+01
Aberdeen Proving Ground	EMBG	S-2	5.8E+03	*3.0E+00*	1.7E+00	2.7E+01
Aberdeen Proving Ground	EMBG	S-3	8.4E+03	*3.5E+00*	2.5E+00	6.5E+01
Aberdeen Proving Ground	EMBG	S-4	9.2E+03	*4.9E+00*	2.7E+00	4.7E+01
Aberdeen Proving Ground	EMBG	S-5	1.4E+03	*2.7E+00*	1.3E+00	1.1E+01
Aberdeen Proving Ground	EMBG	S-6	3.2E+03	*2.8E+00*	1.2E+00	1.0E+01
Aberdeen Proving Ground	EMBG	S-6 DUP	3.4E+03	*2.8E+00*	1.0E+00	1.1E+01
Aberdeen Proving Ground	EMBG	S-7	6.9E+03	*2.9E+00*	1.5E+00	5.7E+01
Aberdeen Proving Ground	EMBG	S-8	5.8E+03	*3.3E+00*	2.1E+00	4.2E+01
Aberdeen Proving Ground	EMBG	S-9	8.3E+03	*3.0E+00*	2.7E+00	4.4E+01
Aberdeen Proving Ground	EMBG	S-10	2.7E+03	*3.1E+00*	1.1E+00	1.2E+01
Aberdeen Proving Ground	EMBG	S-11	2.8E+03	*2.9E+00*	1.1E+00	1.7E+01
Aberdeen Proving Ground	EMBG	S-12	1.7E+04	*3.6E+00*	1.5E+00	9.0E+01
Aberdeen Proving Ground	EMBG	S-13	7.7E+03	*3.1E+00*	2.3E+00	5.6E+01
Aberdeen Proving Ground	EMBG	S-13 DUP	1.1E+04	*3.3E+00*	2.1E+00	6.4E+01
Aberdeen Proving Ground	EMBG	S-14	7.7E+03	*3.2E+00*	1.2E+00	9.0E+01
Aberdeen Proving Ground	EMBG	S-15	2.6E+03	*3.0E+00*	*1.2E-01*	9.8E+00
Aberdeen Proving Ground	EMBG	S-16	9.6E+03	*3.1E+00*	3.0E+00	3.6E+01
Aberdeen Proving Ground	EMBG	S-17	4.8E+03	*3.1E+00*	2.1E+00	3.3E+01
Aberdeen Proving Ground	EMBG	S-17 DUP	5.6E+03	*3.0E+00*	2.0E+00	3.5E+01
Aberdeen Proving Ground	EMBG	S-18	5.9E+03	*3.2E+00*	1.3E+00	2.0E+01
Aberdeen Proving Ground	EMBG	S-19	1.6E+04	*3.1E+00*	2.4E+00	7.4E+01
Aberdeen Proving Ground	EMBG	S-20	8.5E+03	*3.1E+00*	2.2E+00	3.4E+01
Aberdeen Proving Ground	EMBG	S-21	9.8E+03	*3.0E+00*	3.7E+00	4.5E+01
Aberdeen Proving Ground	EMBG	S-23	6.1E+03	*3.2E+00*	2.9E+00	5.4E+01
Aberdeen Proving Ground	EMBG	S-24	1.3E+04	*3.2E+00*	3.5E+00	6.3E+01
Aberdeen Proving Ground	EMBG	S-25	1.1E+04	*3.5E+00*	3.2E+00	8.1E+01
Aberdeen Proving Ground	EMBG	S-26	7.3E+03	*3.3E+00*	2.8E+00	6.2E+01
Aberdeen Proving Ground	EMBG	S-27	8.4E+03	*3.0E+00*	3.7E+00	4.4E+01
Aberdeen Proving Ground	EMBG	S-28	9.1E+03	*2.9E+00*	1.5E+00	4.7E+01
Aberdeen Proving Ground	EMBG	S-29	4.6E+03	*3.5E+00*	2.2E+00	1.8E+01
Aberdeen Proving Ground	EMBG	S-30	5.9E+03	*3.3E+00*	3.5E+00	2.4E+01
Indian Head	EMBG	BGDSS0010101	1.1E+04	*5.1E-01*	2.1E+00	5.2E+01
Indian Head	EMBG	BGDSS0020101	2.0E+03	*2.1E-01*	7.8E-01	1.3E+01
Indian Head	EMBG	BGDSS0030101	1.0E+04	*5.1E-01*	3.2E+00	6.7E+01
Indian Head	EMBG	BGDSS0040101	7.5E+03	*7.1E-01*	2.8E+00	4.8E+01
Indian Head	EMBG	BGDSS0050101	7.5E+03	*5.3E-01*	2.5E+00	3.6E+01

EASTERN

Indian Head	EMBG	BGDSS0060101	2.6E+03	*5.4E-01*	1.7E+00	1.9E+01
Indian Head	EMBG	BGDSS0070101	1.1E+04	*4.2E-01*	2.1E+00	3.7E+01
Indian Head	EMBG	BGDSS0080101	1.3E+04	*4.2E-01*	3.1E+00	4.6E+01
Indian Head	EMBG	BGDSS0090101	6.5E+03	*2.8E-01*	8.5E-01	3.4E+01
Indian Head	EMBG	BGDSS0100101	6.2E+03	*4.8E-01*	2.5E+00	3.1E+01
Indian Head	EMBG	S25-MW03-001	4.0E+03	*1.8E-01*	2.2E+00	3.0E+01
Indian Head	EMBG	S26-MW03-001	1.3E+04	*1.9E-01*	3.3E+00	8.5E+01
Fort Meade	EMBG	SSB-1	7.0E+03	*2.5E+00*	1.0E+00	*2.0E+01*
Fort Meade	EMBG	SSB-2	5.6E+03	*2.5E+00*	2.8E+00	*2.0E+01*
Fort Meade	EMBG	SSB-3	2.5E+03	*2.5E+00*	1.1E+00	*2.0E+01*
Fort Meade	EMBG	SSB-4	1.8E+03	*2.5E+00*	1.2E+00	*2.0E+01*
Fort Meade	EMBG	SSB-4X	1.8E+03	*2.5E+00*	1.3E+00	*2.0E+01*
Fort Meade	EMBG	SSB-5	3.0E+03	*2.5E+00*	1.3E+00	*2.0E+01*
Tolchester	EMBG	MCHT13-S-4	1.1E+04	*4.0E+00*	4.0E+00	7.9E+01
Crisfield City Dump	EMBG	Background Soil	1.1E+04	*6.0E+00*	1.5E+00	3.8E+01
Old Fort Road	EMBG	Background Soil	1.8E+04	*6.0E+00*	2.9E+00	5.0E+01
Nicholson Landfill	EMBG	Background Soil	5.5E+03	NA	2.7E+00	3.0E+01
Union Road	EMBG	Background Soil	8.4E+03	1.7E+00	3.9E+00	7.2E+01
Braxton Property	EMBG	Background Soil	1.6E+04	*6.0E+00*	6.1E+00	5.5E+01
Abingdon Landfill	EMBG	Background Soil	7.3E+03	*4.0E+00*	2.6E+00	3.9E+01
Waldorf Control	EMBG	Background Soil	6.3E+03	*6.0E+00*	4.0E+00	5.2E+01
Vicon	EMBG	Background Soil	5.0E+03	9.6E+00	2.6E+00	2.0E+01
Firestone Perryville	EMBG	Background Soil	4.6E+03	5.2E+00	2.2E+00	3.4E+01
SkipJack Chemicals	EMBG	Background Soil	6.8E+03	6.0E+00	*1.0E+00*	3.2E+01
Old West Denton Landfill	EMBG	Background Soil	2.4E+03	NA	*1.0E+00*	1.7E+01
Fort Smallwood Control	EMBG	Background Soil	1.9E+03	*6.0E+00*	*1.0E+00*	1.0E+01
Fort Smallwood Launch	EMBG	Background Soil	1.9E+03	*6.0E+00*	2.1E+00	1.1E+01
Davidsonville Launch	EMBG	Background Soil	1.1E+04	*1.6E+01*	6.9E+00	1.2E+02
US Naval Research Lab Waldorf	EMBG	SO 54A	2.3E+03	*6.0E+00*	*1.0E+00*	*2.0E+01*
US Naval Research Lab Waldorf	EMBG	SO 54B	3.4E+03	*6.0E+00*	*1.0E+00*	*2.0E+01*
US Naval Research Lab Waldorf	EMBG	SO 55A	7.3E+03	*6.0E+00*	*1.0E+00*	5.8E+01
US Naval Research Lab Waldorf	EMBG	SO 55B	4.5E+03	*6.0E+00*	2.5E+00	*2.0E+01*
US Naval Research Lab Waldorf	EMBG	SO 56	6.6E+03	*6.0E+00*	1.8E+00	4.1E+01
US Naval Research Lab Waldorf	EMBG	SO 57	6.4E+03	*6.0E+00*	2.5E+00	*2.0E+01*
US Naval Research Lab Waldorf	EMBG	S0 58	1.1E+04	*6.0E+00*	2.5E+00	*2.0E+01*
US Naval Research Lab Waldorf	EMBG	SO 59	1.0E+04	*6.0E+00*	4.9E+00	1.7E+02
US Naval Research Lab Waldorf	EMBG	SO 59(D)	1.0E+04	*6.0E+00*	5.2E+00	1.6E+02
US Naval Research Lab Waldorf	EMBG	SO 60	1.1E+04	*6.0E+00*	3.7E+00	7.4E+01

EMBG = Eastern Maryland Background, CMBG = Central Maryland Background, WMBG = Western Maryland Background. All values reported in parts per million. Not detected analytes reported at one half the detection limit. Not detected analytes italicized. NA = not applicable.

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Site Name	Province	Designation	Beryllium	Cadmium	Calcium	Chromium (Total)	Cobalt
Aberdeen Proving Ground	EMBG	S-1	*3.5E-01*	*3.5E-01*	1.4E+02	6.7E+00	2.6E+00
Aberdeen Proving Ground	EMBG	S-1 DUP	*3.5E-01*	*3.5E-01*	1.9E+02	7.0E+00	2.0E+00
Aberdeen Proving Ground	EMBG	S-2	*3.0E-01*	*3.0E-01*	1.4E+02	6.1E+00	6.4E+00
Aberdeen Proving Ground	EMBG	S-3	*3.5E-01*	*3.5E-01*	1.3E+03	3.5E+01	9.2E+00
Aberdeen Proving Ground	EMBG	S-4	1.4E+00	*4.9E-01*	1.1E+03	1.2E+01	1.6E+01
Aberdeen Proving Ground	EMBG	S-5	*2.7E-01*	*2.7E-01*	6.7E+01	3.5E+00	1.2E+00
Aberdeen Proving Ground	EMBG	S-6	*2.8E-01*	*2.8E-01*	7.6E+01	3.6E+00	6.8E-01
Aberdeen Proving Ground	EMBG	S-6 DUP	*2.8E-01*	*2.8E-01*	6.4E+01	4.4E+00	1.2E+00
Aberdeen Proving Ground	EMBG	S-7	6.2E-01	*2.9E-01*	4.8E+02	*1.2E+01*	6.9E+00
Aberdeen Proving Ground	EMBG	S-8	*3.3E-01*	*3.3E-01*	6.9E+02	1.4E+01	9.1E+00
Aberdeen Proving Ground	EMBG	S-9	*3.0E-01*	*3.0E-01*	7.2E+02	1.7E+01	3.9E+00
Aberdeen Proving Ground	EMBG	S-10	*3.1E-01*	*3.1E-01*	7.1E+01	7.5E+00	*6.2E-01*
Aberdeen Proving Ground	EMBG	S-11	*2.9E-01*	*2.9E-01*	1.4E+03	5.3E+00	1.1E+00
Aberdeen Proving Ground	EMBG	S-12	1.1E+00	*3.6E-01*	8.6E+02	2.9E+01	1.5E+01
Aberdeen Proving Ground	EMBG	S-13	*3.0E-01*	*3.0E-01*	1.0E+03	7.1E+01	1.9E+01
Aberdeen Proving Ground	EMBG	S-13 DUP	*3.2E-01*	*3.2E-01*	1.1E+03	6.7E+01	1.6E+01
Aberdeen Proving Ground	EMBG	S-14	*3.2E-01*	*3.2E-01*	6.4E+02	9.4E+00	5.2E+00
Aberdeen Proving Ground	EMBG	S-15	*3.0E-01*	*3.0E-01*	8.2E+01	*1.9E+01*	1.8E+00
Aberdeen Proving Ground	EMBG	S-16	*3.0E-01*	*3.0E-01*	9.2E+01	1.8E+01	5.1E+00
Aberdeen Proving Ground	EMBG	S-17	*3.1E-01*	*3.1E-01*	2.2E+03	1.3E+01	3.6E+00
Aberdeen Proving Ground	EMBG	S-17 DUP	*3.0E-01*	*3.0E-01*	1.8E+03	1.3E+01	3.9E+00
Aberdeen Proving Ground	EMBG	S-18	*3.2E-01*	*3.2E-01*	7.2E+01	1.0E+01	1.5E+00
Aberdeen Proving Ground	EMBG	S-19	7.6E-01	*3.1E-01*	7.4E+02	1.8E+01	1.2E+01
Aberdeen Proving Ground	EMBG	S-20	*3.1E-01*	*3.1E-01*	1.3E+02	1.2E+01	3.6E+00
Aberdeen Proving Ground	EMBG	S-21	*3.0E-01*	*3.0E-01*	3.6E+02	1.4E+01	5.3E+00
Aberdeen Proving Ground	EMBG	S-23	9.0E-01	*3.1E-01*	6.2E+02	1.3E+01	1.4E+01
Aberdeen Proving Ground	EMBG	S-24	7.5E-01	*3.1E-01*	1.2E+02	1.6E+01	2.6E+01
Aberdeen Proving Ground	EMBG	S-25	*3.5E-01*	1.4E+00	9.2E+02	1.7E+01	5.0E+00
Aberdeen Proving Ground	EMBG	S-26	*3.2E-01*	*3.2E-01*	1.3E+03	1.5E+01	9.1E+00
Aberdeen Proving Ground	EMBG	S-27	*3.0E-01*	*3.0E-01*	9.8E+02	1.1E+01	6.6E+00
Aberdeen Proving Ground	EMBG	S-28	*2.9E-01*	*2.9E-01*	1.8E+02	2.8E+01	1.6E+01
Aberdeen Proving Ground	EMBG	S-29	*3.5E-01*	*3.5E-01*	1.1E+02	8.7E+00	2.0E+00
Aberdeen Proving Ground	EMBG	S-30	*3.3E-01*	*3.3E-01*	1.1E+02	4.3E+01	2.7E+00
Indian Head	EMBG	BGDSS0010101	5.6E-01	*6.5E-02*	1.2E+02	1.3E+01	4.2E+00
Indian Head	EMBG	BGDSS0020101	*5.0E-02*	*5.5E-02*	9.9E+01	3.5E+00	5.8E-01
Indian Head	EMBG	BGDSS0030101	5.3E-01	*6.0E-02*	1.3E+02	1.9E+01	1.5E+01
Indian Head	EMBG	BGDSS0040101	5.3E-01	*6.5E-02*	1.4E+02	1.3E+01	7.9E+00
Indian Head	EMBG	BGDSS0050101	1.7E-01	*7.0E-02*	1.1E+02	1.3E+01	2.3E+00

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Indian Head	EMBG	BGDSS0060101	4.7E-01	2.5E-01	2.8E+02	1.2E+01	3.0E+00
Indian Head	EMBG	BGDSS0070101	3.4E-01	2.2E-01	1.4E+02	1.3E+01	2.5E+00
Indian Head	EMBG	BGDSS0080101	6.0E-01	2.6E-01	1.5E+02	1.6E+01	4.2E+00
Indian Head	EMBG	BGDSS0090101	2.4E-01	1.5E-01	1.5E+02	7.7E+00	2.2E+00
Indian Head	EMBG	BGDSS0100101	1.5E-01	*1.4E-01*	1.2E+02	9.2E+00	2.7E+00
Indian Head	EMBG	S25-MW03-001	2.0E-01	5.4E-01	1.0E+02	1.1E+01	3.5E+00
Indian Head	EMBG	S26-MW03-001	6.1E-01	*2.9E-01*	4.1E+02	2.1E+01	1.5E+01
Fort Meade	EMBG	SSB-1	3.8E-01	*2.5E-01*	8.3E+02	1.4E+01	4.3E+00
Fort Meade	EMBG	SSB-2	6.3E-01	*2.5E-01*	7.7E+02	9.4E+00	4.4E+00
Fort Meade	EMBG	SSB-3	1.1E-01	*2.5E-01*	*5.0E+01*	6.0E+00	*1.0E+00*
Fort Meade	EMBG	SSB-4	1.7E-01	*2.5E-01*	*5.0E+01*	6.4E+00	*1.0E+00*
Fort Meade	EMBG	SSB-4X	1.2E-01	*2.5E-01*	*5.0E+01*	7.0E+00	*1.0E+00*
Fort Meade	EMBG	SSB-5	1.7E-01	*2.5E-01*	*5.0E+01*	1.2E+01	2.7E+00
Tolchester	EMBG	MCHT13-S-4	*5.0E-01*	3.1E-01	9.5E+02	1.4E+01	9.0E+00
Crisfield City Dump	EMBG	Background Soil	2.3E-01	*5.0E-01*	4.3E+03	1.1E+01	1.2E+00
Old Fort Road	EMBG	Background Soil	4.8E-01	*5.0E-01*	7.7E+01	1.8E+01	3.5E+00
Nicholson Landfill	EMBG	Background Soil	7.1E-01	NA	7.7E+02	9.2E+00	3.8E+00
Union Road	EMBG	Background Soil	4.8E-01	*5.0E-01*	1.2E+03	5.7E+01	1.3E+01
Braxton Property	EMBG	Background Soil	5.3E-01	*5.0E-01*	3.5E+02	2.4E+01	1.2E+01
Abingdon Landfill	EMBG	Background Soil	3.9E-01	*1.0E+00*	2.8E+02	8.3E+00	7.0E+00
Waldorf Control	EMBG	Background Soil	NA	*5.0E-01*	1.3E+03	1.4E+01	6.5E+00
Vicon	EMBG	Background Soil	1.8E-01	9.0E-01	9.9E+01	1.7E+01	1.9E+00
Firestone Perryville	EMBG	Background Soil	4.0E-01	*5.0E-01*	9.7E+02	2.0E+01	4.8E+00
SkipJack Chemicals	EMBG	Background Soil	*5.0E-01*	*5.0E-01*	1.3E+03	7.1E+00	*5.0E+00*
Old West Denton Landfill	EMBG	Background Soil	*5.0E-01*	*5.0E-01*	3.8E+02	2.0E+00	*5.0E+00*
Fort Smallwood Control	EMBG	Background Soil	*5.0E-01*	*5.0E-01*	*5.0E+02*	3.4E+00	*5.0E+00*
Fort Smallwood Launch	EMBG	Background Soil	*5.0E-01*	*5.0E-01*	1.1E+02	3.9E+00	*5.0E+00*
Davidsonville Launch	EMBG	Background Soil	9.2E-01	1.0E+00	1.8E+03	2.6E+01	3.5E+00
US Naval Research Lab Waldorf	EMBG	SO 54A	*5.0E-01*	*5.0E-01*	*5.0E+02*	4.0E+00	*5.0E+00*
US Naval Research Lab Waldorf	EMBG	SO 54B	*5.0E-01*	*5.0E-01*	*5.0E+02*	7.4E+00	*5.0E+00*
US Naval Research Lab Waldorf	EMBG	SO 55A	*5.0E-01*	*5.0E-01*	*5.0E+02*	1.1E+01	*5.0E+00*
US Naval Research Lab Waldorf	EMBG	SO 55B	*5.0E-01*	*5.0E-01*	*5.0E+02*	6.3E+00	*5.0E+00*
US Naval Research Lab Waldorf	EMBG	SO 56	*5.0E-01*	*5.0E-01*	*5.0E+02*	1.1E+01	*5.0E+00*
US Naval Research Lab Waldorf	EMBG	SO 57	*5.0E-01*	*5.0E-01*	*5.0E+02*	1.8E+01	*5.0E+00*
US Naval Research Lab Waldorf	EMBG	S0 58	*5.0E-01*	*5.0E-01*	*5.0E+02*	1.9E+01	*5.0E+00*
US Naval Research Lab Waldorf	EMBG	SO 59	1.0E+00	1.9E+00	1.4E+03	1.7E+01	*5.0E+00*
US Naval Research Lab Waldorf	EMBG	SO 59(D)	*5.0E-01*	1.3E+00	1.4E+03	1.7E+01	*5.0E+00*
US Naval Research Lab Waldorf	EMBG	SO 60	*5.0E-01*	1.3E+00	*5.0E+02*	2.5E+01	*5.0E+00*

EMBG = Eastern Maryland Background, CMBG = Central Maryland Background, WMBG = Western Maryland Background. All values reported in parts per million. Not detected analytes reported at one half the detection limit. Not detected analytes italicized. NA = not applicable.

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Site Name	Province	Designation	Copper	Iron	Lead	Magnesium	Manganese
Aberdeen Proving Ground	EMBG	S-1	8.4E+00	5.1E+03	5.0E+01	2.0E+02	5.9E+01
Aberdeen Proving Ground	EMBG	S-1 DUP	8.6E+00	4.7E+03	5.0E+01	2.1E+02	5.0E+01
Aberdeen Proving Ground	EMBG	S-2	5.1E+00	5.4E+03	1.0E+01	3.6E+02	1.9E+02
Aberdeen Proving Ground	EMBG	S-3	2.8E+01	1.8E+04	1.2E+02	2.1E+03	3.0E+02
Aberdeen Proving Ground	EMBG	S-4	1.3E+01	8.9E+03	3.0E+01	1.5E+03	1.8E+02
Aberdeen Proving Ground	EMBG	S-5	4.8E+00	2.6E+03	1.4E+01	9.5E+01	6.9E+00
Aberdeen Proving Ground	EMBG	S-6	3.3E+00	3.6E+03	8.0E+00	2.0E+02	1.2E+01
Aberdeen Proving Ground	EMBG	S-6 DUP	3.4E+00	3.6E+03	9.8E+00	2.2E+02	9.2E+00
Aberdeen Proving Ground	EMBG	S-7	5.9E+00	1.0E+04	1.1E+01	1.1E+03	4.0E+02
Aberdeen Proving Ground	EMBG	S-8	1.4E+01	1.2E+04	3.0E+01	7.1E+02	2.6E+02
Aberdeen Proving Ground	EMBG	S-9	7.7E+00	1.5E+04	1.3E+01	1.2E+03	1.1E+02
Aberdeen Proving Ground	EMBG	S-10	3.7E+00	4.2E+03	8.6E+00	1.3E+02	8.4E+00
Aberdeen Proving Ground	EMBG	S-11	4.0E+00	4.5E+03	1.1E+01	2.0E+02	4.0E+01
Aberdeen Proving Ground	EMBG	S-12	2.3E+01	2.4E+04	2.1E+01	3.9E+03	1.0E+03
Aberdeen Proving Ground	EMBG	S-13	1.3E+01	1.6E+04	3.0E+01	1.4E+03	6.5E+02
Aberdeen Proving Ground	EMBG	S-13 DUP	1.4E+01	1.7E+04	2.7E+01	1.7E+03	5.3E+02
Aberdeen Proving Ground	EMBG	S-14	5.6E+00	8.6E+03	1.6E+01	8.8E+02	2.7E+02
Aberdeen Proving Ground	EMBG	S-15	4.6E+00	3.2E+03	5.5E+00	6.3E+01	5.0E+00
Aberdeen Proving Ground	EMBG	S-16	5.7E+00	1.5E+04	2.2E+01	6.9E+02	1.5E+02
Aberdeen Proving Ground	EMBG	S-17	9.3E+00	9.3E+03	3.0E+01	8.1E+02	1.7E+02
Aberdeen Proving Ground	EMBG	S-17 DUP	8.7E+00	9.4E+03	2.7E+01	8.7E+02	1.5E+02
Aberdeen Proving Ground	EMBG	S-18	3.0E+00	7.6E+03	1.2E+01	3.6E+02	2.1E+01
Aberdeen Proving Ground	EMBG	S-19	1.6E+01	1.9E+04	1.6E+01	3.1E+03	5.6E+02
Aberdeen Proving Ground	EMBG	S-20	5.0E+00	1.2E+04	1.6E+01	1.0E+03	7.2E+01
Aberdeen Proving Ground	EMBG	S-21	7.5E+00	1.4E+04	2.2E+01	9.8E+02	2.9E+02
Aberdeen Proving Ground	EMBG	S-23	8.0E+00	9.8E+03	2.0E+01	4.7E+02	1.1E+03
Aberdeen Proving Ground	EMBG	S-24	6.7E+00	1.7E+04	3.4E+01	1.1E+03	1.1E+03
Aberdeen Proving Ground	EMBG	S-25	1.3E+01	2.0E+04	5.7E+01	1.4E+03	4.4E+02
Aberdeen Proving Ground	EMBG	S-26	1.5E+01	1.5E+04	2.1E+01	1.2E+03	4.5E+02
Aberdeen Proving Ground	EMBG	S-27	6.2E+00	1.4E+04	2.0E+01	1.3E+03	2.2E+02
Aberdeen Proving Ground	EMBG	S-28	1.2E+01	1.9E+04	1.7E+01	5.7E+02	7.1E+02
Aberdeen Proving Ground	EMBG	S-29	9.3E+00	8.9E+03	2.8E+01	3.4E+02	3.7E+01
Aberdeen Proving Ground	EMBG	S-30	3.6E+00	1.8E+04	1.2E+01	3.7E+02	5.2E+01
Indian Head	EMBG	BGDSS0010101	4.6E+00	9.4E+03	7.4E+00	7.1E+02	2.5E+02
Indian Head	EMBG	BGDSS0020101	1.8E+00	2.8E+03	9.0E+00	1.4E+02	2.5E+01
Indian Head	EMBG	BGDSS0030101	5.4E+00	1.5E+04	1.0E+01	7.5E+02	3.8E+02
Indian Head	EMBG	BGDSS0040101	5.4E+00	1.2E+04	9.4E+00	5.7E+02	1.8E+02
Indian Head	EMBG	BGDSS0050101	4.6E+00	9.6E+03	1.5E+01	4.8E+02	6.3E+01

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Indian Head	EMBG	BGDSS0060101	2.1E+00	7.3E+03	6.7E+00	3.5E+02	1.1E+02
Indian Head	EMBG	BGDSS0070101	5.3E+00	1.0E+04	9.8E+00	6.7E+02	4.7E+01
Indian Head	EMBG	BGDSS0080101	1.7E+01	1.3E+04	1.5E+02	1.1E+03	8.1E+01
Indian Head	EMBG	BGDSS0090101	3.1E+00	4.4E+03	5.5E+00	4.5E+02	2.3E+01
Indian Head	EMBG	BGDSS0100101	3.3E+00	6.5E+03	7.8E+00	4.0E+02	2.0E+02
Indian Head	EMBG	S25-MW03-001	2.5E+00	7.9E+03	1.0E+01	2.4E+02	1.2E+02
Indian Head	EMBG	S26-MW03-001	4.4E+00	2.5E+04	9.9E+00	1.1E+03	8.8E+02
Fort Meade	EMBG	SSB-1	8.2E+00	1.2E+04	1.4E+01	1.2E+03	1.2E+02
Fort Meade	EMBG	SSB-2	4.6E+00	7.7E+03	1.6E+01	8.4E+02	1.5E+02
Fort Meade	EMBG	SSB-3	3.2E+00	5.1E+03	*3.8E+00*	2.1E+02	2.0E+01
Fort Meade	EMBG	SSB-4	4.6E+00	7.7E+03	9.8E+00	1.1E+02	2.5E+01
Fort Meade	EMBG	SSB-4X	4.2E+00	8.9E+03	1.1E+01	1.2E+02	2.5E+01
Fort Meade	EMBG	SSB-5	6.6E+00	1.2E+04	1.6E+01	3.1E+02	3.0E+01
Tolchester	EMBG	MCHT13-S-4	9.3E+00	1.1E+04	3.8E+01	1.5E+03	2.3E+02
Crisfield City Dump	EMBG	Background Soil	4.8E+00	5.5E+03	*1.6E+01*	9.1E+02	2.8E+01
Old Fort Road	EMBG	Background Soil	5.3E+00	1.5E+04	9.4E+00	1.1E+03	4.9E+01
Nicholson Landfill	EMBG	Background Soil	8.7E+00	1.1E+04	9.2E+00	8.5E+02	1.2E+02
Union Road	EMBG	Background Soil	1.5E+01	1.4E+04	4.2E+01	1.7E+03	9.0E+02
Braxton Property	EMBG	Background Soil	1.1E+01	2.3E+03	1.3E+01	2.6E+03	2.3E+02
Abingdon Landfill	EMBG	Background Soil	6.7E+00	8.4E+03	6.7E+01	7.1E+02	3.5E+02
Waldorf Control	EMBG	Background Soil	1.0E+01	7.9E+03	4.4E+01	8.3E+02	1.2E+02
Vicon	EMBG	Background Soil	1.5E+01	1.2E+04	9.9E+00	3.4E+02	5.1E+01
Firestone Perryville	EMBG	Background Soil	1.2E+01	9.8E+03	2.2E+01	7.4E+02	2.7E+02
SkipJack Chemicals	EMBG	Background Soil	*2.5E+00*	5.3E+03	6.0E+01	5.0E+02	1.8E+02
Old West Denton Landfill	EMBG	Background Soil	5.0E+00	1.0E+03	2.3E+01	1.2E+02	4.3E+01
Fort Smallwood Control	EMBG	Background Soil	1.1E+01	2.1E+03	4.1E+00	*5.0E+02*	1.9E+01
Fort Smallwood Launch	EMBG	Background Soil	6.1E+00	3.0E+03	2.0E+01	9.5E+01	2.0E+01
Davidsonville Launch	EMBG	Background Soil	1.3E+01	1.3E+04	3.5E+01	1.7E+03	1.0E+02
US Naval Research Lab Waldorf	EMBG	SO 54A	*2.5E+00*	3.7E+03	7.3E+00	*5.0E+02*	1.4E+02
US Naval Research Lab Waldorf	EMBG	SO 54B	*2.5E+00*	5.4E+03	4.0E+00	*5.0E+02*	1.0E+01
US Naval Research Lab Waldorf	EMBG	SO 55A	*2.5E+00*	1.2E+04	1.7E+01	*5.0E+02*	3.0E+02
US Naval Research Lab Waldorf	EMBG	SO 55B	*2.5E+00*	8.3E+03	5.0E+00	*5.0E+02*	1.1E+02
US Naval Research Lab Waldorf	EMBG	SO 56	*2.5E+00*	5.8E+03	3.0E+01	*5.0E+02*	1.3E+01
US Naval Research Lab Waldorf	EMBG	SO 57	*2.5E+00*	7.6E+03	7.8E+00	*5.0E+02*	1.0E+02
US Naval Research Lab Waldorf	EMBG	S0 58	*2.5E+00*	1.4E+04	7.7E+00	*5.0E+02*	8.0E+01
US Naval Research Lab Waldorf	EMBG	SO 59	6.3E+00	1.5E+04	3.1E+01	*5.0E+02*	1.9E+02
US Naval Research Lab Waldorf	EMBG	SO 59(D)	6.7E+00	1.4E+04	3.3E+01	*5.0E+02*	1.7E+02
US Naval Research Lab Waldorf	EMBG	SO 60	5.0E+00	1.4E+04	1.7E+01	1.1E+03	2.5E+02

EMBG = Eastern Maryland Background, CMBG = Central Maryland Background, WMBG = Western Maryland Background. All values reported in parts per million. Not detected analytes reported at one half the detection limit. Not detected analytes italicized. NA = not applicable.

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Site Name	Province	Designation	Mercury	Nickel	Potassium	Selenium	Silver
Aberdeen Proving Ground	EMBG	S-1	NA	4.3E+00	1.6E+02	4.6E-01	*3.5E-01*
Aberdeen Proving Ground	EMBG	S-1 DUP	NA	4.8E+00	1.8E+02	4.8E-01	*3.5E-01*
Aberdeen Proving Ground	EMBG	S-2	*6.2E-02*	6.1E+00	1.8E+02	*1.6E-01*	*3.0E-01*
Aberdeen Proving Ground	EMBG	S-3	*3.5E-02*	1.7E+01	3.2E+02	4.4E-01	*3.5E-01*
Aberdeen Proving Ground	EMBG	S-4	NA	2.0E+01	5.4E+02	*3.0E+00*	*4.9E-01*
Aberdeen Proving Ground	EMBG	S-5	*5.0E-02*	2.6E+00	7.1E+01	*1.3E-01*	*2.7E-01*
Aberdeen Proving Ground	EMBG	S-6	*5.5E-02*	1.4E+00	1.0E+02	*1.4E-01*	*2.8E-01*
Aberdeen Proving Ground	EMBG	S-6 DUP	*4.6E-02*	2.6E+00	1.6E+02	*1.4E-01*	*2.8E-01*
Aberdeen Proving Ground	EMBG	S-7	*5.8E-02*	8.0E+00	3.5E+02	*1.5E-01*	*2.9E-01*
Aberdeen Proving Ground	EMBG	S-8	7.0E-02	1.0E+01	2.4E+02	*1.7E-01*	*3.3E-01*
Aberdeen Proving Ground	EMBG	S-9	*5.9E-02*	6.4E+00	3.4E+02	*1.5E-01*	*3.0E-01*
Aberdeen Proving Ground	EMBG	S-10	*6.1E-02*	*9.3E-01*	1.2E+02	*1.5E-01*	*3.1E-01*
Aberdeen Proving Ground	EMBG	S-11	*2.9E-02*	*8.6E-01*	9.6E+01	*1.4E-01*	*2.9E-01*
Aberdeen Proving Ground	EMBG	S-12	*3.3E-02*	2.1E+01	1.7E+03	*1.8E-01*	*3.6E-01*
Aberdeen Proving Ground	EMBG	S-13	*6.0E-02*	2.4E+01	3.7E+02	*1.6E-01*	*3.0E-01*
Aberdeen Proving Ground	EMBG	S-13 DUP	*6.2E-02*	2.4E+01	4.2E+02	*1.6E-01*	*3.2E-01*
Aberdeen Proving Ground	EMBG	S-14	*3.2E-02*	6.2E+00	2.2E+02	NA	*3.2E-01*
Aberdeen Proving Ground	EMBG	S-15	*3.1E-02*	*9.1E-01*	*3.6E+01*	NA	*3.0E-01*
Aberdeen Proving Ground	EMBG	S-16	*3.1E-02*	4.5E+00	1.8E+02	NA	*3.0E-01*
Aberdeen Proving Ground	EMBG	S-17	*6.3E-02*	6.7E+00	3.1E+02	*1.6E-01*	*3.1E-01*
Aberdeen Proving Ground	EMBG	S-17 DUP	*6.2E-02*	6.8E+00	2.8E+02	*1.6E-01*	*3.0E-01*
Aberdeen Proving Ground	EMBG	S-18	*6.7E-02*	2.7E+00	1.8E+02	*1.6E-01*	*3.2E-01*
Aberdeen Proving Ground	EMBG	S-19	*6.1E-02*	1.4E+01	1.5E+03	*1.6E-01*	*3.1E-01*
Aberdeen Proving Ground	EMBG	S-20	*3.1E-02*	6.4E+00	2.1E+02	NA	*3.1E-01*
Aberdeen Proving Ground	EMBG	S-21	*3.0E-01*	6.9E+00	3.8E+02	NA	*3.0E-01*
Aberdeen Proving Ground	EMBG	S-23	*3.1E-02*	9.0E+00	2.2E+02	NA	*3.1E-01*
Aberdeen Proving Ground	EMBG	S-24	*3.3E-02*	7.8E+00	2.5E+02	5.0E-01	*3.1E-01*
Aberdeen Proving Ground	EMBG	S-25	*6.9E-02*	1.1E+01	5.6E+02	*1.7E-01*	*3.5E-01*
Aberdeen Proving Ground	EMBG	S-26	*3.2E-02*	9.0E+00	4.6E+02	NA	*3.2E-01*
Aberdeen Proving Ground	EMBG	S-27	*3.1E-02*	8.0E+00	3.4E+02	NA	*3.0E-01*
Aberdeen Proving Ground	EMBG	S-28	*3.1E-02*	1.5E+01	1.8E+02	NA	*2.9E-01*
Aberdeen Proving Ground	EMBG	S-29	*7.0E-02*	3.2E+00	2.3E+02	*1.8E-01*	*3.5E-01*
Aberdeen Proving Ground	EMBG	S-30	*6.7E-02*	4.5E+00	3.1E+02	*1.7E-01*	*3.3E-01*
Indian Head	EMBG	BGDSS0010101	4.0E-02	5.8E+00	4.7E+02	3.0E-01	*3.5E-02*
Indian Head	EMBG	BGDSS0020101	3.0E-02	1.7E+00	1.3E+02	*1.1E-01*	6.0E-02
Indian Head	EMBG	BGDSS0030101	3.0E-02	7.8E+00	5.2E+02	7.0E-01	*3.0E-02*
Indian Head	EMBG	BGDSS0040101	3.0E-02	5.5E+00	3.1E+02	8.3E-01	*3.5E-02*
Indian Head	EMBG	BGDSS0050101	4.0E-02	3.2E+00	2.5E+02	5.1E-01	7.0E-02

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Indian Head	EMBG	BGDSS0060101	3.0E-02	2.5E+00	7.5E+02	5.4E-01	1.0E-01
Indian Head	EMBG	BGDSS0070101	5.0E-02	4.9E+00	5.1E+02	5.3E-01	*3.5E-02*
Indian Head	EMBG	BGDSS0080101	5.0E-02	8.6E+00	7.9E+02	7.9E-01	*3.5E-02*
Indian Head	EMBG	BGDSS0090101	3.0E-02	4.5E+00	4.5E+02	4.6E-01	1.0E-01
Indian Head	EMBG	BGDSS0100101	2.0E-02	3.4E+00	3.0E+02	5.3E-01	*7.5E-02*
Indian Head	EMBG	S25-MW03-001	8.0E-02	2.3E+00	2.2E+02	1.7E-01	*5.5E-02*
Indian Head	EMBG	S26-MW03-001	7.0E-02	1.1E+01	7.8E+02	*8.5E-02*	*5.5E-02*
Fort Meade	EMBG	SSB-1	*5.0E-02*	9.4E+00	5.0E+02	*5.0E+00*	*2.5E-01*
Fort Meade	EMBG	SSB-2	*5.0E-02*	6.3E+00	3.5E+02	*5.0E+00*	*2.5E-01*
Fort Meade	EMBG	SSB-3	*5.0E-02*	4.0E+00	1.3E+02	*5.0E+00*	*2.5E-01*
Fort Meade	EMBG	SSB-4	*5.0E-02*	3.9E+00	1.2E+02	*5.0E+00*	*2.5E-01*
Fort Meade	EMBG	SSB-4X	*5.0E-02*	4.4E+00	*5.0E+01*	*5.0E+00*	*2.5E-01*
Fort Meade	EMBG	SSB-5	*5.0E-02*	7.9E+00	2.1E+02	*5.0E+00*	*2.5E-01*
Tolchester	EMBG	MCHT13-S-4	1.4E-01	1.2E+01	4.9E+02	6.2E-01	*1.0E+00*
Crisfield City Dump	EMBG	Background Soil	*5.0E-02*	5.7E+00	6.2E+02	*2.3E-01*	*1.0E+00*
Old Fort Road	EMBG	Background Soil	*5.0E-02*	5.7E+00	7.7E+02	2.3E-01	*1.0E+00*
Nicholson Landfill	EMBG	Background Soil	3.5E+00	3.6E+00	4.4E+02	2.1E-01	1.0E+00
Union Road	EMBG	Background Soil	*5.0E-02*	2.8E+01	3.3E+02	*5.0E-01*	*1.0E+00*
Braxton Property	EMBG	Background Soil	*5.0E-02*	1.3E+01	5.8E+02	*5.0E-01*	*1.0E+00*
Abingdon Landfill	EMBG	Background Soil	*1.0E-01*	5.8E+00	2.6E+02	NA	*1.5E+00*
Waldorf Control	EMBG	Background Soil	*5.0E-02*	5.6E+00	6.1E+02	*5.0E-01*	*1.0E+00*
Vicon	EMBG	Background Soil	1.2E-01	3.0E+00	1.5E+02	3.5E-01	9.0E-01
Firestone Perryville	EMBG	Background Soil	*5.0E-02*	1.0E+01	2.9E+02	*5.0E-01*	*1.0E+00*
SkipJack Chemicals	EMBG	Background Soil	*5.0E-02*	*4.0E+00*	*5.0E+02*	*5.0E-01*	*1.0E+00*
Old West Denton Landfill	EMBG	Background Soil	*5.0E-02*	*4.0E+00*	9.1E+01	*5.0E-01*	*1.0E+00*
Fort Smallwood Control	EMBG	Background Soil	*1.0E-01*	*4.0E+00*	*5.0E+02*	*5.0E-01*	*2.7E-01*
Fort Smallwood Launch	EMBG	Background Soil	*1.0E-01*	*4.0E+00*	*5.0E+02*	*5.0E-01*	*2.6E-01*
Davidsonville Launch	EMBG	Background Soil	*1.0E-01*	7.3E+00	1.1E+03	2.0E+00	NA
US Naval Research Lab Waldorf	EMBG	SO 54A	*5.0E-02*	*4.0E+00*	*5.0E+02*	*5.0E-01*	*1.0E+00*
US Naval Research Lab Waldorf	EMBG	SO 54B	*5.0E-02*	*4.0E+00*	*5.0E+02*	*5.0E-01*	*1.0E+00*
US Naval Research Lab Waldorf	EMBG	SO 55A	*5.0E-02*	*4.0E+00*	*5.0E+02*	*5.0E-01*	2.7E+00
US Naval Research Lab Waldorf	EMBG	SO 55B	*5.0E-02*	*4.0E+00*	*5.0E+02*	*5.0E-01*	*1.0E+00*
US Naval Research Lab Waldorf	EMBG	SO 56	*5.0E-02*	*4.0E+00*	*5.0E+02*	*5.0E-01*	*1.0E+00*
US Naval Research Lab Waldorf	EMBG	SO 57	*5.0E-02*	*4.0E+00*	*5.0E+02*	*5.0E-01*	*1.0E+00*
US Naval Research Lab Waldorf	EMBG	S0 58	*5.0E-02*	*4.0E+00*	*5.0E+02*	*5.0E-01*	*1.0E+00*
US Naval Research Lab Waldorf	EMBG	SO 59	*5.0E-02*	8.3E+00	*5.0E+02*	*5.0E-01*	*1.0E+00*
US Naval Research Lab Waldorf	EMBG	SO 59(D)	*5.0E-02*	9.1E+00	*5.0E+02*	*5.0E-01*	*1.0E+00*
US Naval Research Lab Waldorf	EMBG	SO 60	*5.0E-02*	7.5E+00	1.4E+03	*5.0E-01*	*1.0E+00*

EMBG = Eastern Maryland Background, CMBG = Central Maryland Background, WMBG = Western Maryland Background. All values reported in parts per million. Not detected analytes reported at one half the detection limit. Not detected analytes italicized. NA = not applicable.

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Site Name	Province	Designation	Sodium	Thallium	Vanadium	Zinc
Aberdeen Proving Ground	EMBG	S-1	4.4E+02	*1.8E-01*	1.8E+01	1.4E+01
Aberdeen Proving Ground	EMBG	S-1 DUP	4.4E+02	*1.8E-01*	2.0E+01	1.8E+01
Aberdeen Proving Ground	EMBG	S-2	3.8E+02	*1.6E-01*	1.1E+01	1.7E+01
Aberdeen Proving Ground	EMBG	S-3	6.6E+02	*1.7E-01*	4.7E+01	9.6E+01
Aberdeen Proving Ground	EMBG	S-4	9.4E+02	*2.4E-01*	2.0E+01	7.4E+01
Aberdeen Proving Ground	EMBG	S-5	2.3E+02	*1.3E-01*	1.3E+01	1.1E+01
Aberdeen Proving Ground	EMBG	S-6	2.0E+02	*1.4E-01*	7.9E+00	6.6E+00
Aberdeen Proving Ground	EMBG	S-6 DUP	2.1E+02	*1.4E-01*	9.7E+00	7.5E+00
Aberdeen Proving Ground	EMBG	S-7	3.8E+02	*1.5E-01*	1.8E+01	2.6E+01
Aberdeen Proving Ground	EMBG	S-8	4.5E+02	*1.7E-01*	2.3E+01	4.1E+01
Aberdeen Proving Ground	EMBG	S-9	4.2E+02	*1.5E-01*	2.7E+01	3.4E+01
Aberdeen Proving Ground	EMBG	S-10	4.9E+02	*1.5E-01*	1.6E+01	4.9E+00
Aberdeen Proving Ground	EMBG	S-11	3.4E+02	*1.4E-01*	1.2E+01	1.1E+01
Aberdeen Proving Ground	EMBG	S-12	5.5E+02	*1.8E-01*	4.1E+01	6.1E+01
Aberdeen Proving Ground	EMBG	S-13	4.0E+02	*1.6E-01*	2.9E+01	4.0E+01
Aberdeen Proving Ground	EMBG	S-13 DUP	4.4E+02	*1.6E-01*	3.2E+01	4.6E+01
Aberdeen Proving Ground	EMBG	S-14	4.8E+02	*1.6E-01*	1.6E+01	2.9E+01
Aberdeen Proving Ground	EMBG	S-15	4.7E+02	*1.6E-01*	2.2E+01	2.1E+01
Aberdeen Proving Ground	EMBG	S-16	4.3E+02	*1.5E-01*	2.9E+01	2.1E+01
Aberdeen Proving Ground	EMBG	S-17	4.5E+02	*1.6E-01*	1.7E+01	3.5E+01
Aberdeen Proving Ground	EMBG	S-17 DUP	3.4E+02	*1.6E-01*	1.8E+01	3.7E+01
Aberdeen Proving Ground	EMBG	S-18	4.4E+02	*1.6E-01*	1.6E+01	1.1E+01
Aberdeen Proving Ground	EMBG	S-19	4.0E+02	*1.6E-01*	3.2E+01	5.0E+01
Aberdeen Proving Ground	EMBG	S-20	4.4E+02	*1.5E-01*	2.0E+01	2.0E+01
Aberdeen Proving Ground	EMBG	S-21	4.3E+02	*1.5E-01*	2.3E+01	2.8E+01
Aberdeen Proving Ground	EMBG	S-23	4.6E+02	*1.6E-01*	1.9E+01	2.9E+01
Aberdeen Proving Ground	EMBG	S-24	3.8E+02	*1.7E-01*	2.6E+01	2.8E+01
Aberdeen Proving Ground	EMBG	S-25	4.7E+02	*1.7E-01*	2.9E+01	3.2E+01
Aberdeen Proving Ground	EMBG	S-26	4.6E+02	*1.6E-01*	2.7E+01	2.4E+02
Aberdeen Proving Ground	EMBG	S-27	4.9E+02	*1.5E-01*	3.1E+01	4.7E+01
Aberdeen Proving Ground	EMBG	S-28	4.3E+02	*1.5E-01*	1.8E+01	3.0E+01
Aberdeen Proving Ground	EMBG	S-29	4.4E+02	*1.8E-01*	5.9E+01	2.7E+01
Aberdeen Proving Ground	EMBG	S-30	5.0E+02	*1.7E-01*	1.6E+01	1.5E+01
Indian Head	EMBG	BGDSS0010101	*1.2E+01*	*1.3E-01*	2.2E+01	2.2E+01
Indian Head	EMBG	BGDSS0020101	2.2E+01	*1.1E-01*	1.3E+01	6.2E+00
Indian Head	EMBG	BGDSS0030101	4.1E+01	3.8E-01	2.8E+01	2.6E+01
Indian Head	EMBG	BGDSS0040101	5.1E+01	5.2E-01	2.3E+01	2.2E+01
Indian Head	EMBG	BGDSS0050101	2.6E+01	5.2E-01	1.9E+01	1.6E+01

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Indian Head	EMBG	BGDSS0060101	3.9E+01	*1.3E-01*	1.2E+01	2.3E+01
Indian Head	EMBG	BGDSS0070101	5.2E+01	*1.3E-01*	2.4E+01	2.0E+01
Indian Head	EMBG	BGDSS0080101	5.0E+01	2.6E-01	2.9E+01	2.8E+01
Indian Head	EMBG	BGDSS0090101	5.2E+01	*1.4E-01*	1.2E+01	1.5E+01
Indian Head	EMBG	BGDSS0100101	5.3E+01	*2.7E-01*	1.3E+01	1.1E+01
Indian Head	EMBG	S25-MW03-001	*9.6E+00*	*1.4E-01*	9.8E+00	1.1E+01
Indian Head	EMBG	S26-MW03-001	*1.0E+01*	*1.4E-01*	3.9E+01	3.1E+01
Fort Meade	EMBG	SSB-1	3.5E+02	*1.0E+01*	2.4E+01	2.3E+01
Fort Meade	EMBG	SSB-2	3.7E+02	*1.0E+01*	1.6E+01	2.2E+01
Fort Meade	EMBG	SSB-3	4.0E+02	*1.0E+01*	1.1E+01	7.4E+00
Fort Meade	EMBG	SSB-4	3.3E+02	*1.0E+01*	1.4E+01	1.2E+01
Fort Meade	EMBG	SSB-4X	3.3E+02	*1.0E+01*	1.6E+01	1.3E+01
Fort Meade	EMBG	SSB-5	3.3E+02	*1.0E+01*	2.0E+01	1.7E+01
Tolchester	EMBG	MCHT13-S-4	5.7E+01	NA	2.2E+01	5.5E+01
Crisfield City Dump	EMBG	Background Soil	5.5E+02	*3.4E-01*	1.6E+01	1.9E+01
Old Fort Road	EMBG	Background Soil	3.8E+01	*1.0E+00*	3.1E+01	2.3E+01
Nicholson Landfill	EMBG	Background Soil	1.9E+01	NA	1.4E+01	NA
Union Road	EMBG	Background Soil	1.0E+02	*1.0E+00*	2.6E+01	6.6E+01
Braxton Property	EMBG	Background Soil	7.7E+01	*1.0E+00*	3.8E+01	3.6E+01
Abingdon Landfill	EMBG	Background Soil	7.8E+01	2.5E-01	4.3E+01	9.0E+00
Waldorf Control	EMBG	Background Soil	2.3E+01	*1.0E+00*	1.6E+01	1.0E+02
Vicon	EMBG	Background Soil	2.9E+01	3.5E-01	2.0E+01	2.4E+01
Firestone Perryville	EMBG	Background Soil	3.5E+01	*1.0E+00*	1.4E+01	4.3E+01
SkipJack Chemicals	EMBG	Background Soil	8.5E+01	*1.0E+00*	1.1E+01	3.4E+01
Old West Denton Landfill	EMBG	Background Soil	*5.0E+02*	*1.0E+00*	2.5E+00	5.5E+01
Fort Smallwood Control	EMBG	Background Soil	*5.0E+01*	*1.0E+00*	6.1E+00	2.2E+01
Fort Smallwood Launch	EMBG	Background Soil	1.6E+01	*1.0E+00*	9.1E+00	4.4E+01
Davidsonville Launch	EMBG	Background Soil	7.0E+01	1.0E+00	2.3E+01	6.6E+01
US Naval Research Lab Waldorf	EMBG	SO 54A	*5.0E+02*	*1.0E+00*	*5.0E+00*	1.5E+01
US Naval Research Lab Waldorf	EMBG	SO 54B	*5.0E+02*	*1.0E+00*	1.1E+01	7.0E+00
US Naval Research Lab Waldorf	EMBG	SO 55A	*5.0E+02*	*1.0E+00*	1.9E+01	2.8E+01
US Naval Research Lab Waldorf	EMBG	SO 55B	*5.0E+02*	*1.0E+00*	1.5E+01	1.1E+01
US Naval Research Lab Waldorf	EMBG	SO 56	*5.0E+02*	*1.0E+00*	1.3E+01	1.2E+01
US Naval Research Lab Waldorf	EMBG	SO 57	*5.0E+02*	*1.0E+00*	1.2E+01	2.1E+01
US Naval Research Lab Waldorf	EMBG	S0 58	*5.0E+02*	*1.0E+00*	2.5E+01	1.8E+01
US Naval Research Lab Waldorf	EMBG	SO 59	*5.0E+02*	*1.0E+00*	2.2E+01	4.1E+01
US Naval Research Lab Waldorf	EMBG	SO 59(D)	*5.0E+02*	*1.0E+00*	2.3E+01	4.2E+01
US Naval Research Lab Waldorf	EMBG	SO 60	*5.0E+02*	*1.0E+00*	2.3E+01	5.2E+01

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CENTRAL

Site Name	Province	Designation	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium
Ordnance Products (7/99)	CMBG	BG-01 (0 - 0.5 feet)	6.9E+03	*6.0E+00*	2.2E+00	4.5E+01	4.2E-01	*5.0E-01*
Ordnance Products (7/99)	CMBG	BG-02 (0 - 0.5 feet)	9.3E+03	7.3E-01	3.1E+00	5.6E+01	5.8E-01	*5.0E-01*
Ordnance Products (7/99)	CMBG	BG-03 (0 - 0.5 feet)	9.8E+03	*6.0E+00*	3.1E+00	4.2E+01	5.4E-01	*5.0E-01*
Ordnance Products (7/99)	CMBG	BG-04 (0 - 0.5 feet)	9.0E+03	NA	3.4E+00	4.3E+01	3.9E-01	*5.0E-01*
Bush Valley Landfill	CMBG	SUS1 (8/92, 0-6")	9.7E+03	NA	*1.6E+00*	3.8E+01	*1.3E-01*	*1.2E+00*
Bush Valley Landfill	CMBG	SUS2 (8/92, 0-6")	9.5E+03	NA	*7.5E-01*	6.2E+01	2.9E-01	*1.3E+00*
Bush Valley Landfill	CMBG	SUS3 (8/92, 0-6")	1.1E+04	NA	*8.0E-01*	6.4E+01	4.3E-01	*1.3E+00*
Mullinex Farms	CMBG	Background Soil	1.3E+04	*8.5E+00*	1.5E+00	8.5E+01	5.1E+00	*1.0E+00*
MullinexFarms	CMBG	Background Soil	1.0E+04	*8.5E+00*	4.3E+00	1.1E+02	7.0E-01	*1.0E+00*
Hopkins Quarry	CMBG	Background Soil	1.7E+04	*5.0E-01*	2.8E+00	8.2E+01	9.0E-01	*2.5E-01*
Childs Property	CMBG	Background Soil	1.1E+04	*6.0E+00*	5.3E+00	6.7E+01	6.4E-01	*5.0E-01*
Big Elk Chapel Road	CMBG	Background Soil	2.2E+04	*2.1E+00*	3.4E+00	7.3E+01	7.2E-01	*4.7E-01*
Power Matic	CMBG	Background Soil	1.4E+04	1.1E+01	*1.0E+00*	7.0E+01	8.7E-01	1.8E+00
LeHigh Portland Cement	CMBG	Background Soil	1.6E+04	*6.0E+00*	5.3E+00	2.0E+02	9.4E-01	*5.0E-01*
Langs Junkyard	CMBG	Background Soil	9.7E+03	NA	3.8E+00	8.0E+01	8.1E-01	*1.0E+00*
Kate Wagner Landfill	CMBG	Background Soil	1.5E+04	*6.0E+00*	3.8E+00	7.1E+01	6.7E-01	*5.0E-01*
Bachmans Valley Landfill	CMBG	Background Soil	1.2E+04	*6.0E+00*	6.5E+00	4.3E+01	3.7E-01	1.6E+00
Maryvale Prep School	CMBG	Background Soil	1.2E+03	NA	2.9E+00	1.0E+02	8.1E-01	*1.3E-01*
Fork Control	CMBG	Background Soil	3.7E+04	9.2E-01	2.5E+00	9.0E+01	2.1E+00	*5.0E-01*
White Oak	CMBG	BG 04 SS	8.5E+03	5.7E-01	3.1E+00	4.2E+01	6.0E-02	*3.5E-02*
White Oak	CMBG	BG 05 SS	1.0E+04	5.6E-01	4.2E+00	5.3E+01	1.9E-01	*3.0E-02*
White Oak	CMBG	BG 06 SS	7.6E+03	5.6E-01	2.2E+00	4.9E+01	2.0E-02	1.2E-01
White Oak	CMBG	BG 101 SS	6.5E+03	5.6E-01	2.1E+00	4.3E+01	2.0E-02	1.1E-01
White Oak	CMBG	BG 07 SS	9.5E+03	5.5E-01	4.2E+00	4.1E+01	1.6E-01	*3.0E-02*
White Oak	CMBG	BG 10 SS	1.2E+04	5.8E-01	4.6E+00	7.7E+01	5.0E-02	8.0E-02
White Oak	CMBG	BG 09 SS	1.7E+04	6.6E-01	5.2E+00	4.3E+01	*1.0E-02*	3.6E-01
White Oak	CMBG	BG 100 SS	2.1E+04	6.4E-01	6.7E+00	4.9E+01	2.0E-02	5.9E-01
White Oak	CMBG	BG 102 SS	5.2E+03	6.6E-01	2.5E+00	2.0E+01	*1.0E-02*	1.5E-01

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CENTRAL

Site Name	Province	Designation	Calcium	Chromium(Total)	Cobalt	Copper	Iron	Lead
Ordnance Products (7/99)	CMBG	BG-01 (0 - 0.5 feet)	3.9E+02	2.0E+01	8.2E+00	5.6E+00	1.2E+04	1.2E+01
Ordnance Products (7/99)	CMBG	BG-02 (0 - 0.5 feet)	3.4E+02	2.1E+01	9.0E+00	5.9E+00	1.3E+04	1.8E+01
Ordnance Products (7/99)	CMBG	BG-03 (0 - 0.5 feet)	1.3E+02	2.8E+01	6.7E+00	1.3E+01	2.1E+04	1.6E+01
Ordnance Products (7/99)	CMBG	BG-04 (0 - 0.5 feet)	*5.0E+02*	1.3E+01	3.3E+00	7.0E+00	9.1E+03	3.3E+01
Bush Valley Landfill	CMBG	SUS1 (8/92, 0-6")	1.6E+03	1.9E+01	3.6E+00	1.1E+01	1.6E+04	2.9E+01
Bush Valley Landfill	CMBG	SUS2 (8/92, 0-6")	1.4E+03	2.0E+01	1.0E+01	1.8E+01	1.8E+04	1.1E+01
Bush Valley Landfill	CMBG	SUS3 (8/92, 0-6")	1.4E+03	2.1E+01	8.9E+00	1.9E+01	2.0E+04	1.3E+01
Mullinex Farms	CMBG	Background Soil	8.1E+02	3.2E+01	5.7E+01	3.4E+01	2.5E+04	1.4E+01
MullinexFarms	CMBG	Background Soil	3.3E+03	7.1E+00	7.7E+01	1.6E+01	1.9E+04	4.1E+01
Hopkins Quarry	CMBG	Background Soil	1.4E+03	6.0E+00	6.1E+00	1.6E+01	2.1E+04	3.2E+01
Childs Property	CMBG	Background Soil	3.5E+03	1.9E+01	4.6E+00	1.2E+01	1.6E+04	5.3E+01
Big Elk Chapel Road	CMBG	Background Soil	8.0E+02	1.3E+01	6.1E+00	3.5E+01	1.7E+04	7.4E+00
Power Matic	CMBG	Background Soil	3.7E+04	3.4E+01	1.8E+01	4.4E+01	2.6E+04	1.8E+02
LeHigh Portland Cement	CMBG	Background Soil	3.0E+04	2.0E+01	1.3E+01	2.9E+01	2.5E+04	3.4E+01
Langs Junkyard	CMBG	Background Soil	1.6E+03	1.2E+01	1.1E+01	9.1E+00	1.7E+04	3.8E+01
Kate Wagner Landfill	CMBG	Background Soil	2.5E+03	2.2E+01	4.1E+01	2.8E+01	3.7E+04	3.4E+00
Bachmans Valley Landfill	CMBG	Background Soil	7.9E+02	1.8E+01	1.6E+01	2.5E+01	2.9E+04	3.8E+01
Maryvale Prep School	CMBG	Background Soil	8.9E+02	3.0E+01	NA	1.9E+01	2.6E+03	1.9E+01
Fork Control	CMBG	Background Soil	6.7E+02	3.1E+01	4.7E+01	2.9E+01	3.4E+04	1.4E+01
White Oak	CMBG	BG 04 SS	9.3E+01	1.2E+01	7.1E+00	4.8E+00	1.1E+04	2.8E+01
White Oak	CMBG	BG 05 SS	1.7E+02	2.1E+01	1.4E+01	9.4E+00	1.6E+04	2.5E+01
White Oak	CMBG	BG 06 SS	3.8E+02	1.2E+01	3.5E+00	1.9E+01	9.6E+03	4.2E+01
White Oak	CMBG	BG 101 SS	3.0E+02	1.0E+01	2.8E+00	1.7E+01	8.7E+03	3.6E+01
White Oak	CMBG	BG 07 SS	2.6E+02	1.3E+01	3.0E+00	5.5E+00	1.0E+04	1.8E+01
White Oak	CMBG	BG 10 SS	1.1E+03	5.6E+01	6.3E+00	1.3E+01	1.6E+04	3.1E+01
White Oak	CMBG	BG 09 SS	2.8E+02	1.9E+01	7.3E+00	1.2E+02	1.9E+04	1.3E+01
White Oak	CMBG	BG 100 SS	8.8E+01	2.7E+01	3.7E+00	1.1E+01	2.6E+04	1.2E+01
White Oak	CMBG	BG 102 SS	8.3E+01	8.4E+00	7.9E-01	3.4E+00	6.0E+03	1.8E+01

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CENTRAL

Site Name	Province	Designation	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium
Ordnance Products (7/99)	CMBG	BG-01 (0 - 0.5 feet)	6.4E+02	3.8E+02	*5.0E-02*	7.9E+00	2.6E+02	7.9E-01
Ordnance Products (7/99)	CMBG	BG-02 (0 - 0.5 feet)	9.7E+02	4.9E+02	*5.0E-02*	7.9E+00	3.6E+02	9.0E-01
Ordnance Products (7/99)	CMBG	BG-03 (0 - 0.5 feet)	1.8E+03	2.7E+02	*5.0E-02*	9.0E+00	5.7E+02	1.8E+00
Ordnance Products (7/99)	CMBG	BG-04 (0 - 0.5 feet)	7.2E+02	1.3E+02	*5.0E-02*	6.8E+00	3.7E+02	8.2E-01
Bush Valley Landfill	CMBG	SUS1 (8/92, 0-6")	1.1E+03	9.6E+01	*6.5E-02*	5.1E+00	4.2E+02	8.1E-01
Bush Valley Landfill	CMBG	SUS2 (8/92, 0-6")	3.2E+03	4.4E+02	*6.5E-02*	1.3E+01	1.6E+03	7.5E-01
Bush Valley Landfill	CMBG	SUS3 (8/92, 0-6")	3.4E+03	4.7E+02	1.4E-01	1.2E+01	1.6E+03	6.4E-01
Mullinex Farms	CMBG	Background Soil	2.5E+03	2.2E+03	NA	4.1E+01	4.4E+02	NA
MullinexFarms	CMBG	Background Soil	5.0E+02	3.4E+03	NA	*8.0E+00*	2.2E+02	NA
Hopkins Quarry	CMBG	Background Soil	2.8E+03	8.0E+02	*5.0E-02*	8.0E+00	4.1E+03	*2.5E-01*
Childs Property	CMBG	Background Soil	1.6E+03	2.6E+02	2.1E-01	1.9E+01	8.2E+02	9.2E-01
Big Elk Chapel Road	CMBG	Background Soil	2.3E+03	2.3E+02	*6.0E-02*	6.1E+00	1.4E+03	6.3E-01
Power Matic	CMBG	Background Soil	8.3E+03	4.3E+02	1.0E-01	3.0E+01	2.9E+03	*1.0E+00*
LeHigh Portland Cement	CMBG	Background Soil	3.1E+03	2.0E+03	1.2E-01	1.5E+01	1.4E+03	*5.0E-01*
Langs Junkyard	CMBG	Background Soil	6.4E+02	6.8E+02	*1.0E-01*	5.1E+00	8.3E+02	*1.5E+00*
Kate Wagner Landfill	CMBG	Background Soil	1.1E+03	NA	*8.5E-02*	*4.0E+00*	NA	*5.0E-01*
Bachmans Valley Landfill	CMBG	Background Soil	2.3E+03	6.4E+02	1.7E-01	1.7E+01	1.5E+02	*5.0E-01*
Maryvale Prep School	CMBG	Background Soil	9.4E+02	1.1E+03	*5.5E-02*	1.1E+01	5.2E+02	*4.8E-01*
Fork Control	CMBG	Background Soil	6.7E+03	5.4E+02	4.0E-02	3.3E+01	6.9E+03	6.9E-01
White Oak	CMBG	BG 04 SS	6.5E+02	2.4E+02	7.0E-02	4.9E+00	3.1E+02	*3.1E-01*
White Oak	CMBG	BG 05 SS	9.2E+02	3.0E+02	6.0E-02	8.0E+00	5.4E+02	*3.1E-01*
White Oak	CMBG	BG 06 SS	3.7E+02	7.4E+01	2.1E-01	6.5E+00	3.6E+02	6.2E-01
White Oak	CMBG	BG 101 SS	3.1E+02	5.5E+01	1.8E-01	5.4E+00	3.0E+02	7.4E-01
White Oak	CMBG	BG 07 SS	7.7E+02	1.5E+02	4.0E-02	6.4E+00	3.6E+02	*3.0E-01*
White Oak	CMBG	BG 10 SS	1.2E+03	4.9E+02	1.1E-01	2.9E+01	8.6E+02	6.5E-01
White Oak	CMBG	BG 09 SS	1.7E+03	1.8E+02	4.0E-02	1.0E+01	1.0E+03	5.5E-01
White Oak	CMBG	BG 100 SS	1.2E+03	7.2E+01	2.0E-02	7.5E+00	1.0E+03	7.3E-01
White Oak	CMBG	BG 102 SS	3.2E+02	2.0E+01	5.0E-02	2.8E+00	2.4E+02	5.4E-01

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CENTRAL

Site Name	Province	Designation	Silver	Sodium	Thallium	Vanadium	Zinc
Ordnance Products (7/99)	CMBG	BG-01 (0 - 0.5 feet)	3.6E-01	1.7E+02	1.3E+00	2.6E+01	1.8E+01
Ordnance Products (7/99)	CMBG	BG-02 (0 - 0.5 feet)	5.6E-01	2.5E+02	1.7E+00	2.6E+01	2.5E+01
Ordnance Products (7/99)	CMBG	BG-03 (0 - 0.5 feet)	6.9E-01	2.3E+02	2.9E+00	3.2E+01	3.1E+01
Ordnance Products (7/99)	CMBG	BG-04 (0 - 0.5 feet)	*1.0E+00*	2.3E+02	*1.0E+00*	2.0E+01	2.3E+01
Bush Valley Landfill	CMBG	SUS1 (8/92, 0-6")	*7.5E-01*	7.9E+01	*2.5E-01*	2.6E+01	3.9E+01
Bush Valley Landfill	CMBG	SUS2 (8/92, 0-6")	*8.0E-01*	7.0E+01	*2.7E-01*	3.3E+01	5.1E+01
Bush Valley Landfill	CMBG	SUS3 (8/92, 0-6")	*8.0E-01*	1.0E+02	*2.6E-01*	3.4E+01	5.9E+01
Mullinex Farms	CMBG	Background Soil	*5.0E-01*	1.1E+02	NA	3.3E+01	7.2E+01
MullinexFarms	CMBG	Background Soil	*5.0E-01*	8.0E+01	NA	1.9E+01	4.4E+01
Hopkins Quarry	CMBG	Background Soil	*5.0E-01*	*1.0E+02*	*2.5E-01*	1.7E+01	7.2E+01
Childs Property	CMBG	Background Soil	*1.0E+00*	1.4E+02	*1.0E+00*	2.0E+01	1.1E+02
Big Elk Chapel Road	CMBG	Background Soil	*2.2E-01*	5.9E+01	*5.5E-01*	5.6E+00	1.7E+01
Power Matic	CMBG	Background Soil	1.0E+00	8.6E+01	4.3E-01	4.2E+01	1.1E+02
LeHigh Portland Cement	CMBG	Background Soil	1.5E+00	3.8E+02	3.4E-01	3.2E+01	6.0E+01
Langs Junkyard	CMBG	Background Soil	NA	3.8E+01	NA	1.9E+01	3.2E+01
Kate Wagner Landfill	CMBG	Background Soil	*1.0E+00*	8.8E+01	*1.0E+00*	1.6E+01	4.3E+01
Bachmans Valley Landfill	CMBG	Background Soil	*1.0E+00*	3.6E+01	*1.0E+00*	1.9E+01	7.5E+01
Maryvale Prep School	CMBG	Background Soil	*6.0E-01*	5.0E+01	*2.4E-01*	3.8E+01	2.9E+01
Fork Control	CMBG	Background Soil	*1.0E+00*	*5.0E+02*	3.1E+00	3.7E+01	1.1E+02
White Oak	CMBG	BG 04 SS	*8.5E-02*	4.4E+01	*3.2E-01*	2.6E+01	1.9E+01
White Oak	CMBG	BG 05 SS	*8.5E-02*	*4.3E+01*	*3.2E-01*	*1.2E+01*	2.6E+01
White Oak	CMBG	BG 06 SS	1.3E+00	7.7E+01	*3.2E-01*	3.1E+01	2.3E+01
White Oak	CMBG	BG 101 SS	9.9E-01	5.8E+01	*3.1E-01*	2.7E+01	1.8E+01
White Oak	CMBG	BG 07 SS	*8.5E-02*	*4.2E+01*	*3.1E-01*	2.2E+01	2.0E+01
White Oak	CMBG	BG 10 SS	*9.0E-02*	6.5E+01	*3.3E-01*	2.8E+01	4.4E+01
White Oak	CMBG	BG 09 SS	*1.1E-01*	1.2E+02	*2.8E-01*	3.2E+01	3.1E+01
White Oak	CMBG	BG 100 SS	*1.1E-01*	1.3E+02	*2.7E-01*	4.3E+01	2.6E+01
White Oak	CMBG	BG 102 SS	*1.1E-01*	*1.5E+01*	*2.7E-01*	1.4E+01	7.8E+00

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WESTERN

Site Name	Province	Designation	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium
Ft. Detrick	WMBG	BORMWA1-A	NA	NA	2.3E+01	5.5E+02	NA	NA
Ft. Detrick	WMBG	BORMWA1-B	NA	NA	2.2E+01	5.3E+02	NA	NA
Ft. Detrick	WMBG	BORMWA2-B	NA	NA	NA	5.5E+02	NA	NA
Ft. Detrick	WMBG	BORMWA3-A	NA	NA	1.1E+01	5.0E+02	NA	NA
Ft. Detrick	WMBG	BORMWA3-B	NA	NA	NA	5.6E+02	NA	NA
Ft. Detrick	WMBG	BORMW9D-A	NA	NA	NA	6.4E+02	NA	NA
Ft. Detrick	WMBG	BORMW9D-B	NA	NA	1.2E+01	5.6E+02	NA	NA
Ft. Detrick	WMBG	BMW36D-A	2.4E+04	5.0E+00	1.0E+01	1.6E+02	8.7E-01	2.5E-01
Ft. Detrick	WMBG	AMWA3--0	2.0E+04	5.0E+00	1.0E+01	1.5E+02	1.1E+00	2.5E-01
Ft. Detrick	WMBG	AMWA1-0.5	2.5E+04	5.0E+00	2.7E+01	1.1E+02	2.1E+00	2.5E-01
Ft. Detrick	WMBG	AMWA2-0.5	2.1E+04	5.0E+00	2.0E+01	1.7E+02	2.7E+00	2.5E-01
Ft. Detrick	WMBG	BMW47D-0	2.1E+04	5.0E+00	1.0E+01	1.2E+02	8.3E-01	2.5E-01
Frederick Tool and Die	WMBG	Background Soil	1.9E+04	3.3E+00	6.0E+00	1.1E+02	9.5E-01	3.7E-01
Vale Summit	WMBG	Background Soil	7.2E+03	NA	NA	1.6E+02	1.7E+00	1.2E+01
Old Cumberland Land Fill	WMBG	Background Soil	7.0E+03	4.3E+00	8.2E+00	1.5E+02	6.1E-01	8.1E-01
Hoffman Land fill	WMBG	Background Soil	8.3E+03	NA	7.9E+00	1.4E+02	1.1E+00	4.3E-01
Cabin Run Land Fill	WMBG	Background Soil	6.3E+03	6.0E+00	6.1E+00	3.7E+01	3.0E-01	5.0E-01
Fort Ritchie	WMBG	BKSS07	7.3E+03	2.5E-01	1.1E-01	6.5E+01	2.1E-01	3.1E-01
Fort Ritchie	WMBG	BKSS08	9.3E+03	2.6E-01	5.5E-02	1.1E+02	3.7E-01	3.7E-01
Fort Ritchie	WMBG	BKSS09	8.0E+03	2.6E-01	5.5E-02	1.4E+02	4.0E-01	3.7E-01
Fort Ritchie	WMBG	BKSS11	4.9E+03	2.6E-01	4.1E-01	6.2E+01	1.2E-01	3.6E-01
Fort Ritchie	WMBG	BKSS12	7.1E+03	2.5E-01	2.1E-01	3.4E+01	1.5E-01	4.0E-01
Fort Ritchie	WMBG	BKSS13	5.4E+03	2.6E-01	1.4E-01	4.3E+01	1.3E-01	3.0E-01
Fort Ritchie	WMBG	BKSS14	7.7E+03	NA	4.5E-01	3.9E+01	4.0E-02	7.6E-01
Fort Ritchie	WMBG	BKSS15	6.2E+03	3.9E-01	5.9E-01	3.2E+01	4.0E-02	5.4E-01
Fort Ritchie	WMBG	BKSS16	7.4E+03	2.8E-01	4.4E-01	8.2E+01	2.3E-01	3.5E-01
Fort Ritchie	WMBG	BKSS17	9.1E+03	2.6E-01	5.5E-02	1.1E+02	4.2E-01	3.5E-01
Fort Ritchie	WMBG	BKSS18	1.6E+04	2.8E-01	6.5E-01	2.9E+02	1.3E+00	5.5E-01
Fort Ritchie	WMBG	BKSS37	8.1E+03	3.9E-01	3.0E+00	3.8E+01	1.9E-01	1.5E-01
Fort Ritchie	WMBG	BKSS38	6.6E+03	3.8E-01	2.3E+00	5.0E+01	1.6E-01	9.8E-01
Fort Ritchie	WMBG	BKSS39	5.6E+03	3.2E-01	2.7E+00	3.4E+01	1.2E-01	1.2E-01
Fort Ritchie	WMBG	BKSS40	5.2E+03	3.2E-01	2.3E+00	2.3E+01	6.0E-02	1.3E-01
Fort Ritchie	WMBG	BKSS19	1.8E+04	2.6E-01	1.1E-01	4.8E+01	3.4E-01	1.8E-01
Fort Ritchie	WMBG	BKSS20	1.9E+04	7.6E-01	4.7E-01	7.0E+01	4.0E-01	3.6E+00
Fort Ritchie	WMBG	BKSS21	1.5E+04	2.8E-01	6.0E-02	2.9E+01	3.0E-01	2.1E-01
Fort Ritchie	WMBG	BKSS22	1.8E+04	2.6E-01	2.1E-01	5.7E+01	4.9E-01	2.1E-01
Fort Ritchie	WMBG	BKSS23	1.4E+04	2.8E-01	3.2E-01	7.2E+01	5.5E-01	2.5E-01
Fort Ritchie	WMBG	BKSS24	1.9E+04	8.6E-01	8.5E-01	6.6E+01	3.9E-01	3.8E+00

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Fort Ritchie	WMBG	BKSS25	2.1E+04	2.7E-01	6.0E-02	9.0E+01	4.3E-01	2.3E-01
Fort Ritchie	WMBG	BKSS26	2.2E+04	2.8E-01	6.0E-02	1.6E+02	5.1E-01	2.0E-01
Fort Ritchie	WMBG	BKSS27	1.9E+04	3.1E-01	7.0E-02	1.3E+02	4.6E-01	5.4E-01
Fort Ritchie	WMBG	BKSS28	1.5E+04	2.9E-01	6.0E-02	1.1E+02	8.3E-01	3.8E-01
Fort Ritchie	WMBG	BKSS29	1.6E+04	2.8E-01	1.9E-01	8.1E+01	5.2E-01	3.1E-01
Fort Ritchie	WMBG	BKSS30	2.0E+04	1.0E+00	1.2E-01	7.3E+01	2.8E-01	4.0E+00
Fort Ritchie	WMBG	BKSS31	1.5E+04	7.3E-01	3.4E-01	5.2E+01	2.0E-01	2.1E+00
Fort Ritchie	WMBG	BKSS32	2.0E+04	4.8E-01	1.2E-01	4.6E+01	3.1E-01	1.5E+00
Fort Ritchie	WMBG	BKSS33	1.9E+04	1.5E+00	1.2E+00	2.0E+02	3.9E-01	3.0E+00
Fort Ritchie	WMBG	BKSS34	2.0E+04	1.0E+00	1.2E-01	8.5E+01	3.0E-01	2.4E+00
Fort Ritchie	WMBG	BKSS35	1.7E+04	1.1E+00	1.0E+00	3.5E+01	3.2E-01	5.1E+00
Fort Ritchie	WMBG	BKSS36	1.6E+04	8.4E-01	1.6E-01	1.1E+02	3.3E-01	2.1E+00

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Site Name	Province	Designation	Calcium	Chromium (Total)	Cobalt	Copper	Iron	Lead
Ft. Detrick	WMBG	BORMWA1-A	2.3E+03	NA	NA	2.8E+01	3.8E+04	2.8E+01
Ft. Detrick	WMBG	BORMWA1-B	2.7E+03	NA	NA	3.2E+01	6.1E+04	2.3E+01
Ft. Detrick	WMBG	BORMWA2-B	1.9E+03	NA	2.3E+01	NA	3.6E+04	1.5E+01
Ft. Detrick	WMBG	BORMWA3-A	1.5E+03	NA	NA	NA	2.3E+04	2.0E+01
Ft. Detrick	WMBG	BORMWA3-B	3.5E+02	NA	NA	NA	3.5E+04	1.2E+01
Ft. Detrick	WMBG	BORMW9D-A	2.3E+03	NA	NA	2.0E+01	4.1E+04	2.3E+01
Ft. Detrick	WMBG	BORMW9D-B	3.5E+03	NA	NA	NA	3.9E+04	2.0E+01
Ft. Detrick	WMBG	BMW36D-A	1.4E+03	2.1E+01	9.7E+00	1.2E+01	2.6E+04	2.2E+01
Ft. Detrick	WMBG	AMWA3--0	5.4E+03	2.0E+01	1.3E+01	9.0E+00	2.1E+04	1.7E+01
Ft. Detrick	WMBG	AMWA1-0.5	4.3E+03	3.7E+01	1.5E+01	2.4E+01	3.6E+04	2.7E+01
Ft. Detrick	WMBG	AMWA2-0.5	1.9E+04	1.9E+01	1.6E+01	1.4E+01	2.6E+04	2.2E+01
Ft. Detrick	WMBG	BMW47D-0	3.3E+03	2.1E+01	1.0E+01	1.2E+01	2.4E+04	3.3E+01
Frederick Tool and Die	WMBG	Background Soil	3.3E+03	2.6E+01	1.2E+01	2.5E+01	2.2E+04	1.4E+02
Vale Summit	WMBG	Background Soil	1.6E+03	2.3E+01	3.0E+01	4.8E+01	7.1E+04	4.5E+01
Old Cumberland Land Fill	WMBG	Background Soil	3.7E+03	2.1E+01	5.8E+00	1.6E+01	2.1E+04	3.4E+01
Hoffman Land fill	WMBG	Background Soil	2.6E+03	1.2E+01	1.9E+01	2.9E+01	3.4E+04	3.5E+01
Cabin Run Land Fill	WMBG	Background Soil	5.9E+02	1.0E+01	3.6E+00	2.0E+01	2.5E+04	1.2E+01
Fort Ritchie	WMBG	BKSS07	5.7E+01	3.7E+00	1.1E+00	1.4E+00	5.1E+03	3.7E+00
Fort Ritchie	WMBG	BKSS08	1.2E+02	4.2E+00	2.6E+00	1.6E+00	5.4E+03	5.4E+00
Fort Ritchie	WMBG	BKSS09	2.1E+02	3.4E+00	2.3E+00	1.4E+00	4.8E+03	7.6E+00
Fort Ritchie	WMBG	BKSS11	1.3E+02	3.7E+00	8.7E-01	2.6E+00	5.2E+03	1.4E+01
Fort Ritchie	WMBG	BKSS12	6.1E+01	5.2E+00	1.3E+00	1.3E+00	6.7E+03	6.6E+00
Fort Ritchie	WMBG	BKSS13	9.5E+01	3.6E+00	8.0E-01	2.9E+00	4.5E+03	2.8E+01
Fort Ritchie	WMBG	BKSS14	1.0E+02	3.1E+00	3.8E-01	9.0E-02	5.6E+03	3.0E+00
Fort Ritchie	WMBG	BKSS15	7.2E+01	1.7E+00	4.3E-01	4.4E-01	4.3E+03	2.2E+01
Fort Ritchie	WMBG	BKSS16	1.4E+02	3.4E+00	2.0E+00	1.8E+00	4.8E+03	1.4E+01
Fort Ritchie	WMBG	BKSS17	1.3E+02	3.7E+00	2.3E+00	2.0E+00	4.8E+03	1.1E+01
Fort Ritchie	WMBG	BKSS18	3.9E+02	4.5E+00	5.8E+00	5.7E+00	6.9E+03	2.0E+01
Fort Ritchie	WMBG	BKSS37	8.9E+02	7.8E+00	2.1E+00	3.8E+00	1.0E+04	1.5E+01
Fort Ritchie	WMBG	BKSS38	7.2E+02	5.4E+00	1.0E+00	3.2E+00	7.1E+03	1.8E+01
Fort Ritchie	WMBG	BKSS39	8.7E+01	1.9E+01	3.9E-01	1.1E+00	7.0E+03	7.4E+00
Fort Ritchie	WMBG	BKSS40	9.9E+01	4.9E+00	3.8E-01	1.7E+00	6.8E+03	8.9E+00
Fort Ritchie	WMBG	BKSS19	8.1E+02	5.1E+01	4.2E+01	3.8E+01	3.0E+04	6.7E+00
Fort Ritchie	WMBG	BKSS20	8.3E+02	3.8E+01	3.3E+01	2.4E+01	2.9E+04	1.4E+01
Fort Ritchie	WMBG	BKSS21	9.4E+02	5.1E+01	2.4E+01	1.4E+01	2.5E+04	5.3E+00
Fort Ritchie	WMBG	BKSS22	6.1E+02	5.5E+01	4.8E+01	3.8E+01	3.2E+04	5.0E+00
Fort Ritchie	WMBG	BKSS23	9.3E+02	5.1E+01	4.5E+01	1.7E+01	2.7E+04	2.1E+01
Fort Ritchie	WMBG	BKSS24	3.5E+03	3.8E+01	4.5E+01	2.4E+01	3.3E+04	1.8E+01

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Fort Ritchie	WMBG	BKSS25	8.4E+02	3.8E+01	3.1E+01	3.3E+01	3.0E+04	7.7E+00
Fort Ritchie	WMBG	BKSS26	7.6E+02	3.5E+01	3.8E+01	4.2E+01	3.4E+04	1.1E+01
Fort Ritchie	WMBG	BKSS27	2.2E+03	3.0E+01	3.1E+01	4.3E+01	3.1E+04	3.4E+01
Fort Ritchie	WMBG	BKSS28	2.3E+03	5.3E+01	4.5E+01	3.0E+01	3.4E+04	1.9E+01
Fort Ritchie	WMBG	BKSS29	2.5E+03	7.4E+01	3.7E+01	3.2E+01	3.0E+04	1.4E+01
Fort Ritchie	WMBG	BKSS30	1.7E+03	3.0E+01	3.0E+01	2.7E+01	3.5E+04	2.2E+01
Fort Ritchie	WMBG	BKSS31	3.9E+02	1.7E+01	1.7E+01	1.4E+01	2.4E+04	1.4E+01
Fort Ritchie	WMBG	BKSS32	4.4E+02	2.1E+01	2.2E+01	1.5E+01	2.3E+04	1.1E+01
Fort Ritchie	WMBG	BKSS33	2.2E+03	4.0E+01	3.0E+01	6.1E+01	3.7E+04	1.7E+02
Fort Ritchie	WMBG	BKSS34	3.5E+03	3.3E+01	3.1E+01	2.3E+01	3.0E+04	2.3E+01
Fort Ritchie	WMBG	BKSS35	1.6E+03	5.0E+01	3.2E+01	3.9E+01	3.5E+04	7.0E+00
Fort Ritchie	WMBG	BKSS36	1.7E+03	2.8E+01	3.3E+01	2.6E+01	3.2E+04	1.7E+01

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Site Name	Province	Designation	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium
Ft. Detrick	WMBG	BORMWA1-A	NA	1.0E+03	NA	NA	4.3E+04	NA
Ft. Detrick	WMBG	BORMWA1-B	NA	4.8E+02	NA	NA	3.9E+04	NA
Ft. Detrick	WMBG	BORMWA2-B	NA	2.7E+02	NA	NA	2.7E+04	NA
Ft. Detrick	WMBG	BORMWA3-A	NA	1.0E+03	NA	NA	1.8E+04	NA
Ft. Detrick	WMBG	BORMWA3-B	NA	3.1E+02	NA	NA	2.1E+04	NA
Ft. Detrick	WMBG	BORMW9D-A	NA	1.5E+03	NA	NA	2.0E+04	NA
Ft. Detrick	WMBG	BORMW9D-B	NA	1.7E+03	NA	NA	2.0E+04	NA
Ft. Detrick	WMBG	BMW36D-A	2.7E+03	4.3E+02	5.0E-02	1.6E+01	2.6E+03	5.0E+00
Ft. Detrick	WMBG	AMWA3--0	2.6E+03	1.1E+03	5.0E-02	1.5E+01	2.5E+03	8.2E+00
Ft. Detrick	WMBG	AMWA1-0.5	6.2E+03	9.0E+02	5.0E-02	2.9E+01	4.4E+03	9.6E+00
Ft. Detrick	WMBG	AMWA2-0.5	4.1E+03	1.5E+03	5.0E-02	2.0E+01	3.6E+03	5.0E+00
Ft. Detrick	WMBG	BMW47D-0	2.5E+03	5.5E+02	5.0E-02	1.4E+01	1.7E+03	5.0E+00
Frederick Tool and Die	WMBG	Background Soil	2.2E+03	8.3E+02	6.0E-02	1.6E+01	1.6E+03	7.3E-01
Vale Summit	WMBG	Background Soil	1.4E+03	1.7E+03	4.0E-02	4.7E+01	1.9E+03	8.6E-01
Old Cumberland Land Fill	WMBG	Background Soil	6.5E+02	1.1E+02	6.0E-02	8.8E+00	5.7E+02	1.2E+00
Hoffman Land fill	WMBG	Background Soil	1.0E+03	1.2E+03	1.0E-01	2.2E+01	1.2E+03	3.5E-01
Cabin Run Land Fill	WMBG	Background Soil	2.5E+02	4.1E+01	5.0E-02	1.8E+00	1.0E+03	NA
Fort Ritchie	WMBG	BKSS07	3.3E+02	5.7E+01	6.0E-02	1.9E+00	7.0E+02	9.0E-01
Fort Ritchie	WMBG	BKSS08	4.8E+02	1.8E+02	6.0E-02	4.0E+00	8.7E+02	4.1E-01
Fort Ritchie	WMBG	BKSS09	4.4E+02	4.5E+02	6.0E-02	3.0E+00	5.6E+02	1.0E+00
Fort Ritchie	WMBG	BKSS11	2.7E+02	1.7E+02	8.0E-02	2.1E+00	1.5E+02	7.0E-01
Fort Ritchie	WMBG	BKSS12	4.1E+02	1.7E+02	8.0E-02	2.6E+00	1.9E+02	7.1E-01
Fort Ritchie	WMBG	BKSS13	2.4E+02	9.9E+01	8.0E-02	2.0E+00	1.7E+02	9.6E-01
Fort Ritchie	WMBG	BKSS14	1.9E+02	4.4E+01	7.0E-02	1.4E+00	2.4E+02	5.9E-01
Fort Ritchie	WMBG	BKSS15	9.1E+01	1.5E+02	9.0E-02	7.5E-01	6.2E+02	9.0E-01
Fort Ritchie	WMBG	BKSS16	2.9E+02	1.9E+02	8.0E-02	2.4E+00	5.3E+02	6.7E-01
Fort Ritchie	WMBG	BKSS17	4.2E+02	1.6E+02	8.0E-02	4.0E+00	5.7E+02	9.9E-01
Fort Ritchie	WMBG	BKSS18	5.8E+02	2.4E+03	1.2E-01	1.3E+01	6.1E+02	1.8E+00
Fort Ritchie	WMBG	BKSS37	6.6E+02	1.1E+02	7.0E-02	4.7E+00	5.7E+02	3.6E-01
Fort Ritchie	WMBG	BKSS38	3.7E+02	5.9E+01	8.0E-02	2.9E+00	5.2E+02	6.4E-01
Fort Ritchie	WMBG	BKSS39	2.4E+02	4.0E+01	7.0E-02	8.4E+00	3.7E+02	5.3E-01
Fort Ritchie	WMBG	BKSS40	2.5E+02	2.3E+01	6.0E-02	2.1E+00	3.9E+02	4.0E-01
Fort Ritchie	WMBG	BKSS19	1.3E+04	9.5E+02	7.0E-02	5.3E+01	1.1E+02	1.7E+00
Fort Ritchie	WMBG	BKSS20	8.9E+03	1.1E+03	1.3E-01	4.4E+01	1.4E+02	1.8E+00
Fort Ritchie	WMBG	BKSS21	1.2E+04	3.3E+02	3.5E-02	5.2E+01	1.1E+02	1.5E+00
Fort Ritchie	WMBG	BKSS22	8.3E+03	9.1E+02	6.0E-02	4.9E+01	1.3E+02	1.6E+00
Fort Ritchie	WMBG	BKSS23	4.4E+03	1.9E+03	9.0E-02	3.4E+01	1.8E+02	1.9E+00
Fort Ritchie	WMBG	BKSS24	8.6E+03	1.4E+03	1.0E-01	3.8E+01	2.2E+02	2.4E+00

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Fort Ritchie	WMBG	BKSS25	1.3E+04	8.0E+02	7.0E-02	4.8E+01	1.5E+02	1.7E+00
Fort Ritchie	WMBG	BKSS26	1.4E+04	1.1E+03	8.0E-02	5.3E+01	1.5E+02	1.6E+00
Fort Ritchie	WMBG	BKSS27	1.2E+04	1.8E+03	1.3E-01	4.2E+01	4.3E+02	2.2E+00
Fort Ritchie	WMBG	BKSS28	6.9E+03	2.1E+03	1.1E-01	3.8E+01	1.5E+02	2.2E+00
Fort Ritchie	WMBG	BKSS29	1.1E+04	1.9E+03	9.0E-02	5.2E+01	1.3E+02	2.2E+00
Fort Ritchie	WMBG	BKSS30	9.8E+03	8.6E+02	9.0E-02	3.8E+01	1.8E+02	2.1E+00
Fort Ritchie	WMBG	BKSS31	4.1E+03	1.4E+03	8.0E-02	1.9E+01	1.9E+02	1.0E+00
Fort Ritchie	WMBG	BKSS32	1.3E+04	4.4E+02	1.2E-01	3.0E+01	1.6E+02	1.5E+00
Fort Ritchie	WMBG	BKSS33	1.3E+04	2.0E+03	1.7E-01	4.6E+01	2.1E+02	2.4E+00
Fort Ritchie	WMBG	BKSS34	1.4E+04	1.3E+03	1.8E-01	4.3E+01	2.0E+02	2.1E+00
Fort Ritchie	WMBG	BKSS35	1.3E+04	6.3E+02	8.0E-02	5.8E+01	1.3E+02	2.4E+00
Fort Ritchie	WMBG	BKSS36	1.1E+04	1.9E+03	1.5E-01	3.7E+01	1.2E+02	2.1E+00

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Site Name	Province	Designation	Silver	Sodium	Thallium	Vanadium	Zinc
Ft. Detrick	WMBG	BORMWA1-A	NA	NA	NA	1.9E+02	7.9E+01
Ft. Detrick	WMBG	BORMWA1-B	NA	NA	NA	1.5E+02	6.3E+01
Ft. Detrick	WMBG	BORMWA2-B	NA	NA	NA	1.7E+02	6.1E+01
Ft. Detrick	WMBG	BORMWA3-A	NA	NA	NA	1.7E+02	6.2E+01
Ft. Detrick	WMBG	BORMWA3-B	NA	NA	NA	1.6E+02	6.6E+01
Ft. Detrick	WMBG	BORMW9D-A	NA	NA	NA	1.9E+02	9.0E+01
Ft. Detrick	WMBG	BORMW9D-B	NA	NA	NA	2.4E+02	7.5E+01
Ft. Detrick	WMBG	BMW36D-A	1.0E+00	9.6E+01	1.0E+01	5.4E+01	6.2E+01
Ft. Detrick	WMBG	AMWA3--0	1.0E+00	1.0E+02	1.0E+01	4.7E+01	5.4E+01
Ft. Detrick	WMBG	AMWA1-0.5	1.0E+00	9.3E+01	1.0E+01	6.1E+01	6.1E+01
Ft. Detrick	WMBG	AMWA2-0.5	1.0E+00	7.2E+01	1.0E+01	5.3E+01	5.9E+01
Ft. Detrick	WMBG	BMW47D-0	1.0E+00	7.4E+01	1.0E+01	5.2E+01	6.3E+01
Frederick Tool and Die	WMBG	Background Soil	1.7E+00	5.3E+01	4.8E-01	3.5E+01	1.1E+02
Vale Summit	WMBG	Background Soil	NA	NA	NA	3.4E+01	1.6E+02
Old Cumberland Land Fill	WMBG	Background Soil	2.2E-01	8.9E+01	4.3E-01	1.9E+01	1.3E+02
Hoffman Land fill	WMBG	Background Soil	1.0E+00	1.2E+02	1.0E+00	1.8E+01	7.8E+01
Cabin Run Land Fill	WMBG	Background Soil	1.0E+00	3.8E+01	1.0E+00	2.3E+01	2.5E+01
Fort Ritchie	WMBG	BKSS07	1.7E+00	7.2E+01	6.0E-02	7.8E+00	1.0E+01
Fort Ritchie	WMBG	BKSS08	1.7E+00	7.7E+01	1.2E-01	8.4E+00	1.8E+01
Fort Ritchie	WMBG	BKSS09	3.5E+00	7.4E+01	1.2E-01	7.2E+00	1.6E+01
Fort Ritchie	WMBG	BKSS11	1.8E+00	7.6E+01	1.2E-01	8.9E+00	1.0E+01
Fort Ritchie	WMBG	BKSS12	1.7E+00	7.0E+01	1.2E-01	1.1E+01	1.1E+01
Fort Ritchie	WMBG	BKSS13	1.7E+00	7.2E+01	1.2E-01	8.0E+00	1.0E+01
Fort Ritchie	WMBG	BKSS14	9.5E-02	8.4E+01	6.0E-02	7.5E+00	8.4E+00
Fort Ritchie	WMBG	BKSS15	2.1E-01	9.7E+01	6.5E-02	4.1E+00	5.5E+00
Fort Ritchie	WMBG	BKSS16	1.9E+00	7.5E+01	1.3E-01	7.5E+00	1.4E+01
Fort Ritchie	WMBG	BKSS17	1.7E+00	7.3E+01	1.2E-01	7.8E+00	2.0E+01
Fort Ritchie	WMBG	BKSS18	1.9E+00	8.0E+01	6.5E-02	7.4E+00	6.4E+01
Fort Ritchie	WMBG	BKSS37	9.5E-02	9.5E+01	6.0E-02	1.4E+01	2.5E+01
Fort Ritchie	WMBG	BKSS38	1.0E-01	1.1E+02	1.9E-01	9.7E+00	2.2E+01
Fort Ritchie	WMBG	BKSS39	9.5E-02	9.3E+01	6.0E-02	8.2E+00	1.0E+01
Fort Ritchie	WMBG	BKSS40	9.5E-02	9.4E+01	2.5E-01	8.6E+00	9.7E+00
Fort Ritchie	WMBG	BKSS19	1.7E+01	9.2E+01	6.0E-02	9.3E+01	6.3E+01
Fort Ritchie	WMBG	BKSS20	2.1E-01	1.0E+02	6.5E-02	7.3E+01	5.7E+01
Fort Ritchie	WMBG	BKSS21	1.9E+01	8.8E+01	6.5E-02	8.2E+01	5.3E+01
Fort Ritchie	WMBG	BKSS22	1.8E+01	7.7E+01	1.6E-01	1.1E+02	5.6E+01
Fort Ritchie	WMBG	BKSS23	1.9E+01	8.2E+01	1.5E-01	9.2E+01	4.7E+01
Fort Ritchie	WMBG	BKSS24	2.1E-01	1.2E+02	6.5E-02	7.8E+01	6.2E+01

WESTERN

Fort Ritchie	WMBG	BKSS25	1.8E+01	8.1E+01	1.5E-01	8.5E+01	8.7E+01
Fort Ritchie	WMBG	BKSS26	1.8E+01	8.0E+01	1.3E-01	1.1E+02	9.9E+01
Fort Ritchie	WMBG	BKSS27	2.1E+01	9.5E+01	7.5E-02	9.7E+01	1.0E+02
Fort Ritchie	WMBG	BKSS28	1.9E+01	1.0E+02	1.4E-01	1.1E+02	7.2E+01
Fort Ritchie	WMBG	BKSS29	1.9E+01	1.2E+02	1.4E-01	9.6E+01	7.2E+01
Fort Ritchie	WMBG	BKSS30	2.1E-01	1.3E+02	6.5E-02	8.7E+01	6.6E+01
Fort Ritchie	WMBG	BKSS31	1.0E-01	9.2E+01	6.5E-02	4.0E+01	3.2E+01
Fort Ritchie	WMBG	BKSS32	1.1E-01	1.2E+02	1.3E-01	3.7E+01	6.5E+01
Fort Ritchie	WMBG	BKSS33	1.1E-01	1.4E+02	1.3E-01	7.1E+01	2.8E+02
Fort Ritchie	WMBG	BKSS34	1.1E-01	1.8E+02	1.4E-01	6.0E+01	8.6E+01
Fort Ritchie	WMBG	BKSS35	5.0E-01	1.2E+02	1.5E-01	9.0E+01	6.0E+01
Fort Ritchie	WMBG	BKSS36	1.1E-01	1.2E+02	1.3E-01	6.0E+01	9.1E+01

EMBG = Eastern Maryland Background, CMBG = Central Maryland Background, WMBG = Western Maryland Background. All values reported in parts per million. Not detected analytes reported at one half the detection limit. Not detected analytes italicized. NA = not applicable. Not detected XRF data excluded from analysis due to elevated detection limits.

APPENDIX 2 - ATTACHMENT 2

ANTICIPATED TYPICAL CONCENTRATIONS (ATC)/REFERENCE LEVELS OF METALS IN THE STATE OF MARYLAND

Region		Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium (Total)	Cobalt	Copper	Iron	Lead
CMBG	**Number Samples**	28	22	28	28	27	28	28	28	27	28	28	28
CMBG	**Mean**	1.2E+04	3.4E+00	3.3E+00	6.5E+01	6.4E-01	5.9E-01	3.3E+03	2.0E+01	1.5E+01	2.1E+01	1.8E+04	2.9E+01
CMBG	**Std(n-1)**	6.6E+03	3.5E+00	1.6E+00	3.4E+01	9.8E-01	5.0E-01	8.6E+03	1.0E+01	1.9E+01	2.2E+01	8.2E+03	3.1E+01
CMBG	**Min**	1.2E+03	5.0E-01	7.5E-01	2.0E+01	1.0E-02	3.0E-02	8.3E+01	6.0E+00	7.9E-01	3.4E+00	2.6E+03	3.4E+00
CMBG	**Max**	3.7E+04	1.1E+01	6.7E+00	2.0E+02	5.1E+00	1.8E+00	3.7E+04	5.6E+01	7.7E+01	1.2E+02	3.7E+04	1.8E+02
CMBG	**ATC(n-1)**	1.9E+04	6.8E+00	4.9E+00	9.9E+01	1.6E+00	1.1E+00	1.2E+04	3.0E+01	3.3E+01	4.2E+01	2.6E+04	6.1E+01
	USGS Concentrations (average)	7.2E+04	6.6E-01	7.2E+00	5.8E+02	9.2E-01	NA	2.4E+04	5.4E+01	9.1E+00	2.5E+01	2.6E+04	1.9E+01
	Proposed Maryland Cleanup Standards Residential	7.8E+03	3.1E+00	2.3E+00	5.5E+02	1.6E+01	7.8E+00	NA	2.3E+01	4.7E+02	3.1E+02	2.3E+03	4.0E+02

Region		Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium (Total)	Cobalt	Copper	Iron	Lead
EMBG	**Number Samples**	76	74	76	76	75	75	76	76	76	76	76	76
EMBG	**Mean**	7.1E+03	3.6E+00	2.3E+00	4.3E+01	4.3E-01	4.2E-01	5.9E+02	1.5E+01	5.9E+00	7.4E+00	1.0E+04	2.2E+01
EMBG	**Std(n-1)**	3.9E+03	2.4E+00	1.2E+00	3.1E+01	2.3E-01	3.1E-01	6.6E+02	1.3E+01	4.9E+00	5.0E+00	5.2E+03	2.3E+01
EMBG	**Min**	1.4E+03	1.8E-01	1.2E-01	9.8E+00	5.0E-02	5.5E-02	5.0E+01	2.0E+00	5.8E-01	1.8E+00	1.0E+03	3.8E+00
EMBG	**Max**	1.8E+04	1.6E+01	6.9E+00	1.7E+02	1.4E+00	1.9E+00	4.3E+03	7.1E+01	2.6E+01	2.8E+01	2.5E+04	1.5E+02
EMBG	**ATC(n-1)**	1.1E+04	6.0E+00	3.6E+00	7.3E+01	6.6E-01	7.3E-01	1.3E+03	2.8E+01	1.1E+01	1.2E+01	1.5E+04	4.5E+01
	USGS Concentrations (average)	7.2E+04	6.6E-01	7.2E+00	5.8E+02	9.2E-01	NA	2.4E+04	5.4E+01	9.1E+00	2.5E+01	2.6E+04	1.9E+01
	Proposed Maryland Cleanup Standards Residential	7.8E+03	3.1E+00	2.3E+00	5.5E+02	1.6E+01	7.8E+00	NA	2.3E+01	4.7E+02	3.1E+02	2.3E+03	4.0E+02

Region		Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium (Total)	Cobalt	Copper	Iron	Lead
WMBG	**Number Samples**	43	40	46	50	43	43	50	43	44	46	50	50
WMBG	**Mean**	1.4E+04	1.3E+00	4.2E+00	1.6E+02	5.5E-01	1.2E+00	1.8E+03	2.4E+01	1.8E+01	1.9E+01	2.4E+04	2.3E+01
WMBG	**Std(n-1)**	6.2E+03	1.8E+00	6.9E+00	1.7E+02	5.5E-01	2.1E+00	2.8E+03	1.9E+01	1.6E+01	1.5E+01	1.5E+04	3.0E+01
WMBG	**Min**	4.9E+03	2.5E-01	5.5E-02	2.3E+01	4.0E-02	1.2E-01	5.7E+01	1.7E+00	3.8E-01	9.0E-02	4.3E+03	3.0E+00
WMBG	**Max**	2.5E+04	6.0E+00	2.7E+01	6.4E+02	2.7E+00	1.2E+01	1.9E+04	7.4E+01	4.8E+01	6.1E+01	7.1E+04	1.7E+02
WMBG	**ATC(n-1)**	2.0E+04	3.2E+00	1.1E+01	3.3E+02	1.1E+00	3.3E+00	4.6E+03	4.2E+01	3.4E+01	3.4E+01	3.9E+04	5.2E+01
	USGS Concentrations (average)	7.2E+04	6.6E-01	7.2E+00	5.8E+02	9.2E-01	NA	2.4E+04	5.4E+01	9.1E+00	2.5E+01	2.6E+04	1.9E+01
	Proposed Maryland Cleanup Standards Residential	7.8E+03	3.1E+00	2.3E+00	5.5E+02	1.6E+01	7.8E+00	NA	2.3E+01	4.7E+02	3.1E+02	2.3E+03	4.0E+02

USGS Concentrations as reported by Shacklette, H.T. and Boerngenm, J.G., 1984: Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States; USGS Professional Paper 1270.
Concentrations in Parts Per Million (PPM).

Region		Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
CMBG	**Number Samples**	28	27	26	28	28	26	27	28	25	28	28
CMBG	**Mean**	1.8E+03	6.0E+02	8.6E-02	1.2E+01	1.1E+03	7.0E-01	6.2E-01	1.2E+02	7.3E-01	2.6E+01	4.4E+01
CMBG	**Std(n-1)**	1.8E+03	7.8E+02	5.4E-02	9.7E+00	1.5E+03	3.5E-01	4.2E-01	1.1E+02	7.9E-01	9.1E+00	2.9E+01
CMBG	**Min**	3.1E+02	2.0E+01	2.0E-02	2.8E+00	1.5E+02	2.5E-01	8.5E-02	1.5E+01	2.4E-01	5.6E+00	7.8E+00
CMBG	**Max**	8.3E+03	3.4E+03	2.1E-01	4.1E+01	6.9E+03	1.8E+00	1.5E+00	5.0E+02	3.1E+00	4.3E+01	1.1E+02
CMBG	**ATC(n-1)**	3.7E+03	1.4E+03	1.4E-01	2.2E+01	2.6E+03	1.0E+00	1.0E+00	2.3E+02	1.5E+00	3.5E+01	7.3E+01
	USGS Concentrations (average)	9.0E+03	5.5E+02	9.0E-02	1.9E+01	1.5E+04	3.9E-01	NA	1.2E+04	9.4E+00	8.0E+01	6.0E+01
	Proposed Maryland Cleanup Standards Residential	NA	1.6E+02	1.0E-01	1.6E+02	NA	3.9E+01	3.9E+01	NA	5.5E-01	5.5E+01	2.3E+03

Region		Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
EMBG	**Number Samples**	76	76	73	76	76	66	75	76	74	76	75
EMBG	**Mean**	7.9E+02	2.2E+02	1.0E-01	7.2E+00	4.1E+02	8.5E-01	5.0E-01	3.1E+02	1.2E+00	2.1E+01	3.2E+01
EMBG	**Std(n-1)**	6.8E+02	2.6E+02	4.0E-01	5.5E+00	3.1E+02	1.4E+00	4.5E-01	2.1E+02	2.7E+00	9.9E+00	3.1E+01
EMBG	**Min**	6.3E+01	5.0E+00	2.0E-02	8.6E-01	3.6E+01	8.5E-02	3.0E-02	9.6E+00	1.1E-01	2.5E+00	4.9E+00
EMBG	**Max**	3.9E+03	1.1E+03	3.5E+00	2.8E+01	1.7E+03	5.0E+00	2.7E+00	9.4E+02	1.0E+01	5.9E+01	2.4E+02
EMBG	**ATC(n-1)**	1.5E+03	4.8E+02	5.1E-01	1.3E+01	7.2E+02	2.2E+00	9.4E-01	5.2E+02	3.9E+00	3.0E+01	6.3E+01
	USGS Concentrations (average)	9.0E+03	5.5E+02	9.0E-02	1.9E+01	1.5E+04	3.9E-01	NA	1.2E+04	9.4E+00	8.0E+01	6.0E+01
	Proposed Maryland Cleanup Standards Residential	NA	1.6E+02	1.0E-01	1.6E+02	NA	3.9E+01	3.9E+01	NA	5.5E-01	5.5E+01	2.3E+03

Region		Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
WMBG	**Number Samples**	43	50	43	43	50	42	42	42	42	50	50
WMBG	**Mean**	5.1E+03	8.3E+02	8.2E-02	2.4E+01	4.4E+03	1.9E+00	4.7E+00	9.3E+01	1.3E+00	6.5E+01	6.0E+01
WMBG	**Std(n-1)**	5.2E+03	6.8E+02	3.3E-02	2.0E+01	9.9E+03	1.9E+00	7.5E+00	2.5E+01	3.2E+00	5.9E+01	4.6E+01
WMBG	**Min**	9.1E+01	2.3E+01	3.5E-02	7.5E-01	1.1E+02	3.5E-01	9.5E-02	3.8E+01	6.0E-02	4.1E+00	5.5E+00
WMBG	**Max**	1.4E+04	2.4E+03	1.8E-01	5.8E+01	4.3E+04	9.6E+00	2.1E+01	1.8E+02	1.0E+01	2.4E+02	2.8E+02
WMBG	**ATC(n-1)**	1.0E+04	1.5E+03	1.2E-01	4.3E+01	1.4E+04	3.9E+00	1.2E+01	1.2E+02	4.6E+00	1.2E+02	1.1E+02
	USGS Concentrations (average)	9.0E+03	5.5E+02	9.0E-02	1.9E+01	1.5E+04	3.9E-01	NA	1.2E+04	9.4E+00	8.0E+01	6.0E+01
	Proposed Maryland Cleanup Standards Residential	NA	1.6E+02	1.0E-01	1.6E+02	NA	3.9E+01	3.9E+01	NA	5.5E-01	5.5E+01	2.3E+03

USGS Concentrations as reported by Shacklette, H.T. and Boerngenm, J.G., 1984: Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States; USGS Professional Paper 1270.
Concentrations in Parts Per Million (PPM).

APPENDIX 3

GUIDANCE ON THE CONTENT OF ENVIRONMENTAL INVESTIGATION WORK PLANS AND QUALITY ASSURANCE PROJECT PLANS INCLUDING DATA VERIFICATION AND VALIDATION

Guidance Document on the Content of Environmental Investigation Work Plans and Quality Assurance Project Plans

1.0 APPLICABILITY AND SCOPE

This document serves as guidance for environmental investigation work plans submitted to the Waste Management Administration of the Maryland Department of the Environment. This guidance is intended to apply to investigations conducted for the Voluntary Cleanup Program, the Brownfields and Site Assessment Program, and the State Superfund Program, and may also serve as a technical supplement for the Solid Waste Program, Hazardous Waste Program and the Oil Control Program.

2.0 WORK PLAN REQUIREMENTS

The final work plan documents should explicitly describe the objectives of the work to be completed (*Data Quality Objectives Process for Superfund*, EPA 540-R-93-071, 1993), the media to be sampled, the methodology to be used for sample collection, the number and type of samples to be collected, record-keeping for field activities, and plans for the management of investigation derived media and wastes.

The work plan document must include the following:

(A) A site conceptual model which shall include:

(1) the background and purpose for the work to be performed,
(2) a site history including types of hazardous materials used at the site and known releases or disposal,
(3) description of previous site characterization,
(4) description of potential contaminant migration pathways,
(5) previous remedial actions.

(B) A statement of the project/sampling objectives including, requirements on the quality of data to be collected, and background information to provide a historical and scientific perspective for the work to be completed.

(C) A description of the work to be performed and the schedule for implementation that describes in general terms the following, as needed:

(1) media or other materials to be sampled,
(2) sample types and purpose of the sample (e.g., surface soil for metals),
(3) methodology by which samples will be collected (e.g., hand auger, split spoon), which may reference Standard Operating Procedures (SOPs),
(4) number and type of samples to be collected including quality control samples as specified in the QAPP,
(5) sample preservation and packaging,
(6) sample designations and chain of custody requirements,
(7) sample handling and analysis requirements,
(8) site restoration activities (e.g., borehole filling).

(D) Requirements for fieldwork record keeping should include a specific description of the content and style of geologic logs of all borings and well constructions, well construction diagrams, and sample data sheets. (See Attachment A for examples.)

(E) A statement that describes the methods for handling investigation derived media (IDM) that conforms to the Waste Management Administration (WAS) policy on IDM (Attachment B). IDM are naturally occurring liquids, rocks, and soils that are generated by the activities associated with the described work and should be managed in accordance with WAS policy.

3.0 QUALITY ASSURANCE PROJECT PLAN REQUIREMENTS

The Quality Assurance Project Plan (QAPP) should detail the quality checks and requirements on the collection of all data for the given project. At a minimum, it must include a detailed description of the measurement/data acquisition, assessment/oversight, and data validation and usability processes.

(A) Measurement/Data Acquisition

This part of the QAPP should cover explicitly all aspects of measurement systems design and implementation including, sampling methods, analysis, data handling, and QC measures employed. All of these elements may be included in the QAPP as part of the laboratory methods and/or SOPs. If these requirements are addressed in the laboratory's documentation and credentials it must be cited in this section of the QAPP and provided as an appendix.

The following is a list of measurement/data acquisition elements that must be addressed in the QAPP:

(1) Sampling process design (Experimental Design) describing the type of quality control samples to be taken and protocols to be followed, including:

(a) Field duplicates (not included specifically as laboratory QC samples) should represent 10% of the total number of samples collected

(b) Trip blanks, which are samples of a laboratory reagent water which is placed in the appropriate bottle and accompanies the sample container (cooler) from the time it is shipped to the field to the time it is returned with samples from analysis to monitor contamination, should be no less than 1 per shipping episode.

(c) Rinsate blanks, which are samples of laboratory reagent water poured into the requisite sample container that are treated in the same manner as a field sample (i.e. poured over the sampling equipment after decontamination and collected), should represent no less than 1 sample per sampling episode.

(d) Field split samples, which are aliquots of field samples that the state will use for independent verification of laboratory results, will be at the discretion of the state project manager.

(2) Sampling method requirements describing the equipment and procedures for collection, identification, and preservation of samples. Methods including QC protocols should be identified by the appropriate regulatory citation and the specific performance requirements should be described (Attachment C).

With respect to laboratory QC samples, the following general protocols shall be required unless it can be demonstrated on a site-specific basis that one or more protocols are not necessary. Such a modification must be approved by MDE prior to initiation of the work.

(a) Method reagent blanks, which are samples of laboratory reagent water processed through the same analytical procedure as the sample, must be prepared and analyzed for each individual procedure every day that a sample is prepared. The method blank must contain less than or equal to three times the method detection limit (MDL) for compounds of interest. If this criterion is not met, then sample processing should be halted and corrective actions taken. All data collected during the out of control period will be reprocessed and reanalyzed.

(b) Fortified method blank spikes, consist of a standard solid matrix fortified with the analytes of interest and used to monitor analyte recovery, should be analyzed with every batch of 20 or fewer samples or as described in the accepted EPA method. Appropriate response actions to various blank levels are described in *USEPA Contract Laboratory Program National Functional Guidelines for Organic/Inorganic Data Review* (EPA 540/R-94/013/012, 1994)).

(c) Matrix spike samples, which consist of a field sample spiked with the analytes of interest to monitor matrix effects, should be chosen at random and be performed with every batch of 20 or fewer samples for organic analyses or as described in the accepted EPA method. The final spiked concentration of each analyte in the sample should be at least ten times the MDL, or as appropriate. Appropriate response actions are described in *USEPA Contract Laboratory Program National Functional Guidelines for Organic/Inorganic Data Review* (EPA 540/R-94/013/012, 1994).

(d) Surrogates are organic compounds that are similar to analytes of interest in chemical composition, but not normally found in environmental samples. These compounds are spiked into all blank, standards, samples, and spiked samples prior to analysis for organic parameters or as described in the accepted EPA method. Surrogate spike recoveries shall fall within the control limits set in accordance with procedures specified in the EPA method.

(3) Sample handling and custody requirements for all samples in the field, laboratory, and during transport. This is to include provisions for preservation, packing, shipment, and storage. Examples of appropriate sample labels, custody forms, and custody logs should be included (Attachment D).

(4) Analytical method requirements should identify the analytical methods, equipment, laboratory duplicates, and extraction procedures. These requirements shall include any specific performance requirements and turnaround needed.

Analytical methods should be identified by number, date, and regulatory citation. Any non-standard methods should comply with the USEPA's *"Guidelines to Establish Modified Analytical Requirements within the Contract Laboratory Program Statements of Work.*"

(5) A description or reference for the procedures and formulas to be used to calculate QC statistics, as well as precision and bias should be included. (See *USEPA Contract Laboratory Program National Functional Guidelines for Organic/Inorganic Data Review* [EPA 540/R-94/013/012, 1994])

(6) Instrument/Equipment testing, inspection, and maintenance requirements should describe how inspections and acceptance testing of environmental sampling and measurement systems and their components would be performed and documented and describe how deficiencies will resolved. This section should also address how and when periodic preventative maintenance will occur.

(7) Instrument calibration frequency requirements should identify all tools, gauges, instruments, and other sampling, measuring, and test equipment used for data collection to calibrate. This section should also describe or reference the methodology for calibration checks, including the use of continuing calibration blanks, and describe the maintenance of such calibration records.

(8) Inspection/acceptance requirements for supplies and consumables should clearly state acceptance criteria for things such as sample bottles, calibration gases, reagents, hoses, de-ionized water, and potable water.

(9) Data acquisition requirements for non-direct measurements such as computer databases, programs, literature files and historical databases should be specified. This will include acceptance criteria for the use of this data in the project and discuss any limitations on the use due to uncertainty in its quality.

(10) Data management requirements should describe the project data management scheme, tracing the path of the data from their generation in the laboratory to their formal storage. This section should include a description of the standard record keeping procedures for all data including the mechanism for preventing the loss of data. The laboratory or the PRP may be designated as the ultimate repository for all project related data.

A summary of the record keeping procedures for the field and laboratory work related to the project should be provided. If there is no existing provision for laboratory record keeping the laboratory should conform to the following or submit to MDE an equivalent plan for approval:

(a) Manual records will be maintained, for a period no less than five years (preferably a period lasting the life of the project), in bound laboratory notebooks. Each page of the notebook must be dated, numbered, and signed by the person performing the indicated activities and reviewed, dated, and signed by another staff member (i.e. immediate supervisor). A single diagonal line prior to dating and signing the page will mark incomplete pages. Errors will be corrected by drawing a single line through the incorrect entry, dating and initialing the change.

(b) Electronic data files should be maintained for all current and past activities related to the project on a diskette. All files should be organized within directories and sub-directories that consist of a combination of appropriate project and/or client names.

(c) Project files will be established and maintained by the laboratory project manager (or the PRP) for each project. The project file will contain all correspondence associated with the project. All materials must be dated. Project files should include references to the location of raw analytical data for easy retrieval if necessary.

(d) Notebooks to be maintained include standards preparation log, instrument calibration log, instrument run log, sample preparation log, weighing log, and instrument maintenance log. Copies of all or some of these are to be included in the final data package.

(i) Standards Preparation Log shall be maintained and include the following information, as a minimum, for each sample prepared:

Unique sample ID #
Sample description
ID # of source or starting material
Weight/Volume of starting material
Volume and ID # of dilution solvent used
Final concentration
Date of preparation
Expiration date
Storage conditions and location
Signature of analyst preparing the solution
Initials and date of second level reviewer

(ii) Instrument Calibration Log shall be maintained for each instrument and should include the date, time, and results of each calibration and should be cross referenced with the standards preparation log, which documents the date and batch number (unique sample identification) of standard preparation for the standards used for each calibration. This can be incorporated into the instrument run log where appropriate.

(iii) Instrument Run Log must be maintained for each instrument used to analyze samples for any parameter. The analyst performing the task must complete the run log concurrently with the specific analysis. At a minimum, the following information must be contained in the instrument run log:

Sample number/ID
Preparation date (cross reference with sample preparation log)
Analysis date
Injected volume of analyte (µl or ml)
Total run time
File name

Analyst initials
Comments (i.e., signal intensity, baseline, re-run)
Calibration applied (cross-reference with instrument calibration log)

(iv) Sample Preparation Log (digestion/extraction) will be maintained to record the processing of samples prior to instrumental analyses. The log will include:

Date of processing
Samples processed
QC samples included in the analytical batch
Weights/volumes of sample aliquots
Final volume of extract/digestate
Standards used for spiking
*Note and document any deviations from SOPs

(v) Weighing Log will record the external calibrations of the balance as well as the daily calibrations. The ID for the specific set of weights used for calibration should be included as well as the last calibration date/certificate of the weight set. All sample, spike and other relevant weights should be recorded including ID #, date, and related project/client.

(vi) Instrument Maintenance Log will be required to record maintenance of any kind performed on laboratory instruments. Depending on the number of instruments in the lab, a separate log for each instrument is preferable.

(B) Assessment and Oversight

Assessment and corrective response actions should list and describe the type and frequency of field and laboratory/data assessments to be used in the project, as well as the distribution and context of project status reports. There should also be a description of the corrective response actions for deficiencies and how they are documented. The objectives of corrective action procedures are to ensure that recognized errors in performance of sample and data acquisition leads to effective remedial measures. The actions required to correct an existing condition are to be documented to provide assurance that any data quality deficiencies are recognized in later interpretation and are not recurrent in the course of the project.

The type and frequency of assessments and who will carry them out can be appropriately modified for each project but should include a Management Systems Review (MSR) and a Data Quality Assessment (DQA).

(1) The MSR is used to ensure that sufficient management controls are in place and carried out by the organization to adequately plan, implement, and assess the results of the project. See the *Guidance for the Management Systems Review Process* (EPA QA/G-3).

(2) The DQA involves the application of statistical tools to determine whether the data meet the assumptions that the DQOs and data collection design were developed under and whether the total error in the data is tolerable. See *Guidance for the Data Quality Assessment Process* (EPA QA/G-9).

(C) Data Validation and Usability

The criteria used to review and validate data should be provided. These criteria will be submitted to MDE for review and shall address the following topics:

(1) Data review, validation, and verification requirements that clearly state the criteria used to review and validate (i.e. accept, reject, or quantify) data (see *USEPA Contract Laboratory Program National Functional Guidelines for Organic/Inorganic Data Review* [EPA 540/R-94/013/012, 1994]). Any forms or checklists required and any project specific calculations should be included in the QAPP.

(2) Validation and verification methods must be described and precisely define the difference between verification and validation issues and the process to be used for each. This element should also describe who is responsible for data validation, how and by whom any issues will be resolved and how results are conveyed to the data users.

(a) Data Verification must include the following steps (see *Guidance on Environmental Data Verification and Validation* [EPA QA/G-8]):

(i) Compliance: This check ensures that data pass numerical quality control tests, including criteria on precision and accuracy as specified in SOPs and/or the QAPP (i.e., detection limits, bias, precision, representativeness of samples, comparability, completeness).

(ii) Correctness: This check ensures through a mechanical objective check that data collection plans and protocols have been followed and that basic operations and calculations were performed and documented properly.

(iii) Consistency (Comparability): This check ensures that data collection procedures were done in a similar manner for all sites and locations.

(iv) Completeness: This check ensures that a sufficient amount of data and information are present to perform a validation analysis.

(b) Data Validation process (see *Guidance on Environmental Data Verification and Validation* [EPA QA/G-8]):

(i) ensures that the measurement system (field and laboratory) meets the users needs;

(ii) assigns qualifiers to individual data values based on whether the analyte in question is detected and the associated degree of variability, with consideration given to the level of deviation from performance standards;

(iii) assess the relevancy of certain performance criteria used to make decisions on the observed data, given information obtained during the course of the project;

(iv) determine whether the data can proceed to Data Quality Assessment (DQA) and whether the DQOs were generally satisfied.

(3) Data Qualification

All individual analyses must be qualified so that the qualification indicates the degree to which a given value deviated from performance criteria. The preferred data qualifying codes are provided in Attachment E. The use of alternative qualifying codes should be approved by MDE prior to initiation of work.

Examples of data qualifications include:

analyte not detected above method detection limit,
quantity of analyte is approximate due to analysis limitations,
identification of the analyte is tentative,
identification of the analyte is uncertain (with a reason given, such as, interference) and,
quantity of analyte confirmed

Data may also be qualified based on the potential effect of several factors including holding times, sample condition, and QA and QC analysis results.

(4) Review of Performance Criteria

A review of the performance criteria is required to evaluate if they were specified adequately and appropriately with in the QAPP. This review should utilize information not available at the time the performance criteria were established (e.g., analytical errors) and should be performed by a qualified third party.

(5) Qualified Review

A determination by a qualified outside reviewer, unless otherwise specified in the QAPP, should be made as to whether the data are adequate to proceed to DQA.

(6) Reporting the Results of Data Validation

The report of the results of the data validation process should include an assessment of the usability of the test results. The type of assessment, who is responsible for performing the assessment, and how the results will be reported should be identified in the QAPP. Information in the data validation report should be provided in the form of tables or spreadsheets and should include a summary of environmental sample results, a summary of QA and QC results, and a full-verified copy of the raw data.

(a) Items to be included in the summary of environmental sample results include:

client and laboratory identification numbers,
sample matrix,
sample collection date,
sample extraction date,
sample extraction and/or analysis method,
ID of instrument used for analysis,
instrument specifications,
sample weight/volume,
dilution or concentration factor,
analytical results and associated units,
qualifier codes that are applied during verification and validation,
method detection limits or sample quantification units, and
definitions for any laboratory qualifiers used

(b) Items to be included in the summary of QA and QC results include:

sampling and analytical precision (field/laboratory replicates), analytical accuracy (surrogates, laboratory control samples, matrix spike samples, standard reference materials),decontamination and cross-contamination assessment (field, shipping, and method blanks),
method conformance (summary of analytical procedures), and,
a narrative statement that discusses any deviations from the QAPP, including QC failures, and the impact of those failures on the data.

SOIL AND SEDIMENT
SAMPLING DATA SHEET

HIGH CONCENTRATION EXPECTED? _____ HIGH HAZARD? _____

INSTALLATION/SITE _____ AREA _____
INST CODE _____ FILE NAME _____
SITE TYPE _____ SITE ID _____
FIELD SAMPLE NUMBER _____
DATE (MM/DD/YY) ____/____/____ TIME _____ AM PM SAMPLE PROG. _____
DEPTH (TOP) _____ DEPTH INTERVAL _____ UNIT _____
SAMPLING METHOD:
SPLIT SPOON _____ AUGER _____ SHELBY TUBE _____ SCOOP _____ OTHER _____

CHK	ANALYSIS	SAMPLE CONTAINER	NO.	REMARKS

TOTAL NUMBER OF CONTAINERS FOR SAMPLE _____

DESCRIPTION OF SITE AND SAMPLE CONDITIONS

SITE DESCRIPTION: _____

SAMPLE FORM _____ COLOR _____ ODOR _____
PID (HNu) _____ UNUSUAL FEATURES _____

WEATHER/TEMPERATURE _____
SAMPLER(S) _____

SOIL BORING LOG
Aberdeen Proving Ground

Page___ of ___

Project: _____
Location: _____
Total Depth Drilled: _____
Land Surface Elevation: _____
Engineer/Geologist: _____
Driller(s): _____
Drilling Rig/Method: _____
Auger or Bit Diameter: _____
Sampling Devices: _____

Boring Identification: _____
Date Started: _____ Date Completed: _____
Facility Coordinates
North: East:
of Foster Wheeler Enviresponse, Inc.,
of _____
Drilling Fluid: _____
Other/Comments: _____

Depth In Feet	Soil Sample NO.	SD.	REC.	Lithologic Description	LOG	USCS	Blows per Foot or TSF	PID (ppm)	Remarks or Observations

NO. Sample Identification Number
SD. Sampling Device (See Below)
REC. Length of recovered Sample (ft or %)
USCS Unified Soil Classification System
PID Photoionization Detection Reading (highest ppm @ sample surface)
▼ Obse
TD Total Depth

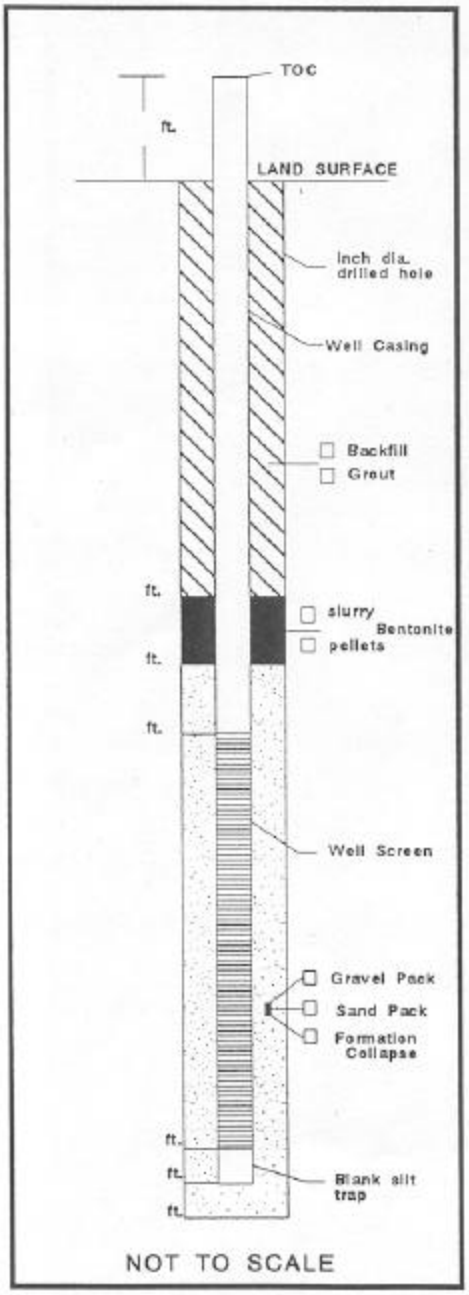
Split Spoon or Core Barrel Sampler
Auger
Thin Walled Tube Sampler
No Sample

Graphic Log Legend

Clay (CL,CH)
Silty Clay (CL)
Sandy Clay (ML)
Silt (ML)
Sandy Silt (ML)
Clayey Silt (MH)
Peat (OL,OH)
Sand (SW,SP)
Silty Sand (SM)
Clayey Sand (SC)
Gravel (GW,GP)
Fill/Debris
Waste

Comments

WELL CONSTRUCTION LOG
Aberdeen Proving Ground



Project: Well:

Location:

County: State:

Permit No.:

Land-Surface Elevation and Datum surveyed

feet AMSL estimated

Installation Date(s):

Drilling Method:

Drilling Contractor:

Drilling Fluid:

Fluid Loss During Drilling: gallons

Development Technique(s) and Date(s)

Water Removed During Development: gallons

Static Depth to Water: feet below TOC

Pumping Depth to Water: feet below TOC

Pumping Duration: hours

Yield: gpm Date:

Specific Capacity: gpm/ft

Well Purpose:

Remarks:

Prepared By:_____

APPENDIX 3 – ATTACHMENT B

IDM Comment

Investigatory derived media (IDM) describes the groundwater, surface water, soils and sediments that are collected during field activities to support the remedial investigation / feasibility study (RI/FS). Specifically, IDM may include development and purge water from monitoring wells, drill cuttings, and extra soils removed during sample collections. To evaluate whether the IDM must be managed as hazardous waste, the preliminary inquiry is whether the IDM is a solid waste, as defined in Maryland's Environment Article, § 7-201(t) and COMAR 26.13.02.02. Basically, uncontaminated IDM need not be considered a solid waste, as long as that IDM: 1) will not be abandoned in an environmentally unsound manner; and 2) is not inherently waste-like.

There must be some initial evaluation as to whether the IDM is contaminated or inherently waste-like. As guidance, IDM must be handled as a solid waste when:

1) It is visually or grossly contaminated;
2) It has activated any field monitoring device indicating the presence of volatile organic compounds (VOC) or metals;
3) On previous monitoring/sampling activity, it has exhibited levels of contamination above accepted environmental quality standards;
4) Based on historical information, the responsible party or the regulatory agency believes it warrants caution or additional testing.

IDM with contamination should be viewed as inherently waste-like unless or until the media is no longer contaminated, or is treated or recycled. As with any solid waste, the generator must perform a hazardous waste determination. If the waste is a hazardous waste, then it must be disposed of through an appropriate hazardous waste disposal facility. If the waste is not a hazardous waste, then that IDM may be disposed of through any permitted or authorized waste management facility willing to accept the waste, or recycled or reused in a manner permissible under the law.

Naturally occurring media which does not exhibit any of the characteristics or concerns described above need not be managed as a waste, particularly if the material will be returned to a suitable location on the facility. Unless otherwise specified, the handling or disposition of this material must be performed in such a manner, so that potential impacts to the environment are avoided. The facility must comply with all pertinent sediment and erosion control regulations. Also, seeding and the judicious discharge of non-contaminated water to ensure infiltration will be considered the minimum steps necessary to ensure non-degradation of the environment.

APPENDIX 3 – ATTACHMENT C

Required Test Methods, Sample Containers, Preservatives and Holding Times

			Soil			Aqueous	
Analysis	Test Method	Container	Preservative	Holding Time	Container	Preservative	Holding Time
Halogenated Volatile Compounds	8010	4 oz SSWM glass, Teflon™-lined lid	4°C	14 Days	2 x 40 ml glass Teflon™-lined septum	Hcl, 4°C	14 Days (7 Days without Hcl)
Explosive Residues	8330	8 oz SSWM glass Teflon™-lined lid	4°C	14 Days	2 x 40 ml glass Teflon™-lined septum	4°C	14 Days
Total Metals (Ag, As,Ba,Cd,Cr,Pb,Se)	6010	8 oz SSWM glass Teflon™-lined lid	4°C	180 Days	16 oz polyethylene Teflon™ - lined septum	HNO_3, 4°C	180 Days
Mercury	7471	Same bottle as Total Metals	4°C	28 Days	Same as Total Metals	HNO_3, 4°C	28 Days
Volatiles	8240	4 oz SSWM glass Teflon™-lined lid	4°C	14 Days	2 x 40 ml glass Teflon™-lined septum	Hcl, 4°C	14 Days (7 Days without Hcl)
Semivolatiles	8270	8 oz SSWM glass Teflon™-lined lid	4°C	14 Days-Extraction 40 Days-Analysis	2 x 32 oz WM Amber Teflon™-lined lid	4°C	7 Days-Extraction 40 Days-Analysis
pH	150.1	NA	NA	NA	8 oz polyethylene	None	Immediately
Temperature	170.1	NA	NA	NA	8 oz polyethylene	None	Field Analysis
Specific Conductance	120.1	NA	NA	NA	8 oz polyethylene	4°C	28 Days
Total Suspended Solids (TSS)	160.2	NA	NA	NA	16 oz polyethylene	4°C	7 Days
Total Dissolved Solids (TDS)	160.1	NA	NA	NA	Same as TSS	4°C	7 Days

			Soil			Aqueous	
Analysis	Test Method	Container	Preservative	Holding Time	Container	Preservative	Holding Time
Semivolatile Organics	625	NA	NA	NA	2 x 32 oz WM Amber Teflon™-lined lid	4°C	7 Days-Extraction 40 Days-Analysis

APPENDIX 3 – ATTACHMENT D

SAMPLE RECEIPT CHECKLIST

Sample #: _____
Company Name: _____
Date: _____
Time rcvd: _____
Rcvd By: _____

Carrier Name: _____
Prepared By: _____ _____
(initials) (date)
Project: _____
Site: _____
VOA Holding Blank ID#: _____

	YES	NO*
Shipping manifest present? Manifest# _____	___	___
Sample container in good condition	___	___
Custody seals present on shipping Container?	___	___
Condition: good ____ broken____		
Chain of custody present?	___	___
Chain of custody agrees with Sampling labels?	___	___
Chain of custody signed?	___	___
Custody seals on sample bottles?	___	___
Condition: good ____ broken____		
Packing present in shipping Container?	___	___
Type of packing _____		
Number of sample bottles ____		
Number of samples _____		
Correct sample volume for the test Indicated?	___	___

	YES	NO*
Trip Blank rcvd? # of sets rcvd _____	___	___
VOA vials zero headspace?	___	___
Preservatives added to sample?	___	___
pH check required? Performed by _____	___	___
Ice present in shipping container	___	___

CONTAINER #	TEMPERATURE

	Yes	No*
Samples intact?	___	___
Project Manager contacted? Name: _____ Date contacted: _____	___	___

* 'NO' responses must be detailed in the comment section below. If items are not applicable to particular samples or contracts, NA should be indicated in the 'NO' checkbox.

Comments: _____

Checklist completed by: _____ Date: _____

★ GPO:1994—507-247

Designate: Grab / Comp.

Time

Month/Day/Year

Station No.

Project Code

Samplers (Signatures)

Station Location

Preservative:
Yes ☐ No ☐

ANALYSES

BOD Anions Solids (TSS) (TDS) (SS)	
COD, TOC, Nutrients	
Phenolics	
Mercury	
Metals	
Cyanide	
Oil and Grease	
Organics GC/MS	
Priority Pollutants	
Volatile Organics	
Pesticides	
Mutagenicity	
Bacteriology	

Remarks:

Tag No. Lab Sample No.

3-2195689

EPA United States Environmental Protection Agency
Contract Laboratory Program

Inorganic Traffic Report & Chain of Custody Record

(For Inorganic CLP Analysis)

Case No.

1. Project Code	Account Code	2. Region No.	Sampling Co.	4. Date Shipped	Carrier
Regional Information		Sampler *(Name)*		Airbill Number	
Non-Superfund Program		Sampler Signature		5. Ship To	
Site Name		3. Purpose*			
City, State	Site Spill ID			ATTN:	

3. Purpose*

Lead: ☐ SF ☐ PRP ☐ ST ☐ FED

Early Action: ☐ CLEM ☐ PA ☐ REM ☐ RI ☐ SI ☐ ESI

Long-Term Action: ☐ FS ☐ RD ☐ RA ☐ O&M ☐ NPLD

6. Matrix *(Enter in Column A)*
1. Surface Water
2. Ground Water
3. Leachate
4. Field QC
5. Soil/Sediment
6. Oil (High only)
7. Waste (High only)
8. Other *(specify in Column A)*

7. Preservative *(Enter in Column D)*
1. HCl
2. HNO3
3. NaOH
4. H_2SO_4
5. $K_2CR_2O_7$
6. Ice only
7. Other *(specify in Column D)*
N. Not preserved

CLP Sample Numbers (from labels)	A Matrix (from Box 6) Other:	B Conc.: Low Med High	C Sample Type: Comp./ Grab	D Preservative (from Box 7) Other:	E – RAS Analysis: Diss. Metals	Total Metals	Cyanide	Low only: NO_2/NO_3	Fluoride	High only: pH	Conduct.	F Regional Specific Tracking Number or Tag Numbers	G Station Location Identifier	H Mo/Day/ Year/Time Sample Collection	I Corresponding CLP Organic Sample No.	J Sampler Initials	K Field QC Qualifier (B = Blank S = Spike D = Duplicate R = Rinsate PE = Perform. Eval. — = Not a QC Sample)

Shipment for Case Complete? (Y/N)	Page ____ of ____	Sample(s) to be Used for Laboratory QC	Additional Sampler Signatures	Chain of Custody Seal Number(s)

CHAIN OF CUSTODY RECORD

Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*
Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*
Relinquished by: *(Signature)*	Date / Time	Received for Laboratory by: *(Signature)*	Date / Time	Remarks Is custody seal intact? Y/N/none	

A21-012-13 REV

DISTRIBUTION: Green - Region Copy; White - Lab Copy for Return to Region; Pink - CLASS Copy; Yellow - Lab Copy for Return to CLASS

EPA Form 9110-1 (2/98)

SEE REVERSE FOR ADDITIONAL STANDARD INSTRUCTIONS
*SEE REVERSE FOR PURPOSE CODE DEFINITIONS

385425

EPA United States Environmental Protection Agency
Contract Laboratory Program

Organic Traffic Report & Chain of Custody Record
(For Organic CLP Analysis)

Case No.:

1. Project Code	Account Code	2. Region No.	Sampling Co.	4. Date Shipped	Carrier
Regional Information		Sampler *(Name)*		Airbill Number	
Non-Superfund Program		Sampler Signature		5. Ship To:	
Site Name		3. Purpose* Lead: ☐ SF ☐ PRP ☐ ST ☐ FED; Early Action: ☐ CLEM ☐ PA ☐ REM ☐ RI ☐ SI ☐ ESI; Long-Term Action: ☐ FS ☐ RD ☐ RA ☐ O&M ☐ NPLD		ATTN:	
City, State	Site Spill ID				

6. Matrix *(Enter in Column A)*
1. Surface Water
2. Ground Water
3. Leachate
4. Field
5. Soil/Sediment
6. Oil (High only)
7. Waste (High only)
8. Other *(specify in Column A)*

7. Preservative *(Enter in Column D)*
1. HCl
2. HNO3
3. NaHSO4
4. H2SO4
5. Ice only
6. Other *(specify in Column D)*
N. *Not Preserved*

CLP Sample Numbers (from labels)	A Matrix (from Box 6) Other:	B Conc.: Low Med High	C Sample Type: Comp./ Grab	D Preser-vative (from Box 7) Other:	E RAS Analysis: VOA	BNA	Pest/PCB	High Only / ARO/ TOX	F Regional Specific Tracking Number or Tag Numbers	G Station Location Identifier	H Mo/Day/ Year/Time Sample Collection	I Corresponding CLP Inorganic Sample No.	J Sampler Initials	K Field QC Qualifier (B = Blank S = Spike D = Duplicate R = Rinsate PE = Perform Eval. — = Not a QC Sample)

Shipment for Case Complete? (Y/N)	Page ___ of ___	Sample(s) to be Used for Laboratory QC	Additional Sampler Signatures	Chain of Custody Seal Number(s)

Chain of Custody Record

Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*
Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*
Relinquished by: *(Signature)*	Date / Time	Received for Laboratory by: *(Signature)*	Date / Time	Remarks: Is custody seal intact? Y/N/none	

A21-012-15 REV

Distribution: Blue - Region Copy; White - Lab Copy for Return to Region; Pink - CLASS Copy; Yellow - Lab Copy for Return to CLASS

EPA Form 9110-2 (2/99)

See Reverse for Additional Standard Instructions
*See Reverse for Purpose Code Definitions

392515

APPENDIX 3 – ATTACHMENT E

Glossary of Data Qualifier Codes (Organic)

Codes Relating to Identification
(Confidence concerning presence or absence of compounds):

U = Not detected. The associated number indicates approximate sample concentration necessary to be detected.

(No Code) = Confirmed identification

B = Not detected substantially above the level reported in laboratory or field blanks.

R = Unreliable result. Analyte may or may not be present in the sample. Supporting data necessary to confirm result.

N = Tentative identification. Consider present. Special methods may be needed to confirm its presence or absence in future sampling efforts.

Codes Related to Quantitation
(Can be used for both positive results and sample quantitation limits):

J = Analyte present. Reported value may not be accurate or precise.

K = Analyte present. Reported value may be biased high. Actual value is expected lower.

L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.

UJ = Not detected, quantitation limit may be inaccurate or imprecise.

UL = Not detected, quantitation limit is probably higher.

Other Codes:

Q = No analytic result.

NJ = Qualitative identification questionable due to poor resolution. Presumptively present at approximate quantity.

DATA QUALIFIER DEFINITIONS (METALS)

U = The analyte was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.

J = The associated value is an estimated quantity.

R = The data is unusable. (Note: the analyte may or may not be present.)

UJ = The analyte was analyzed for, but was not detected. The associated detection limit is an estimate and may be inaccurate or imprecise.

K = The analyte is present. The reported value may be biased high. The actual value is expected to be lower than reported.

L = The analyte is present. The reported value may be biased low. The actual value is expected to be higher than reported.

UL = The analyte was not detected, and the reported quantitation limit is probably higher than reported.