Technical Guidance for the Attainment of Remediation Standards and Site-Specific Criteria

Contaminated Site Remediation & Redevelopment

New Jersey Department of Environmental Protection

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Appendices

1.0 INTENDED USE OF GUIDANCE DOCUMENT

This guidance is designed to help the person responsible for conducting the remediation to comply with the New Jersey Department of Environmental Protection (Department) requirements established by the Technical Requirements for Site Remediation (Technical Requirements), N.J.A.C. 7:26E. This guidance will be used by many different people involved in the remediation of a contaminated site, such as Licensed Site Remediation Professionals (LSRP), Non-LSRP environmental consultants and other environmental professionals. Therefore, the generic term "investigator" will be used to refer to any person who uses this guidance to remediate a contaminated site on behalf of a remediating party, including the remediating party itself.

The procedures for an investigator to vary from the technical requirements in regulation are outlined in the Technical Requirements at N.J.A.C. 7:26E-1.7. Variances from a technical requirement or departure from guidance must be documented and adequately supported with data or other information. In applying technical guidance, the Department recognizes that professional judgment may result in a range of interpretations on the application of the guidance to site conditions.

This guidance supersedes previous Department guidance issued on this topic. Technical guidance may be used immediately upon issuance. However, the Department recognizes the challenge of using newly issued technical guidance when a remediation affected by the guidance may have already been conducted or is currently in progress. To provide for the reasonable implementation of new technical guidance, the Department will allow a six-month "phase-in" period between the date the technical guidance is issued final (or the revision date) and the time it should be used.

This guidance was prepared with stakeholder input. The following people were on the committee who prepared this document:

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2.0 PURPOSE

This guidance presents recommended procedures for demonstrating compliance with applicable remediation standards, alternative remediation standards, and/or site-specific criteria pursuant to the Department's Remediation Standards (N.J.A.C. 7:26D) and in accordance with the Technical Requirements for Site Remediation (N.J.A.C. 7:26E). The investigator should follow this guidance to determine if remediation is necessary and to demonstrate if remediation satisfies regulatory requirements including the Department's Remediation Standards.

This guidance applies to the Site Investigation (SI), Remedial Investigation (RI) and Remedial Action (RA) phases of the remedial process. Specific recommended procedures are provided for applying this guidance to soil, ground water, sediment, and surface water in each of these phases to assess remedial requirements, i.e., to demonstrate compliance with remediation standards. In addition to the procedures presented in this guidance, the investigator is also referred to additional media-specific and pathway-specific technical guidance for detailed methodologies (e.g., vapor intrusion, light non-aqueous phase liquids (LNAPL), soil site investigation/remedial investigation (SI/RI), ground water SI/RI, etc.). These technical guidance documents are available for viewing and downloading on the Department website at https://dep.nj.gov/srp/guidance/.

3.0 DOCUMENT OVERVIEW

This technical guidance provides the investigator with several options to demonstrate compliance with the applicable remediation standards throughout the remediation process (i.e., site investigation, remedial investigation, remedy selection, remedial action), including "point by point" compliance at individual sampling points, relatively simple statistical tests to allow for identification and elimination of data outliers, and more robust numerical and spatial statistical methods. In addition, this technical guidance includes, where noted, the option to use rounding of analytical data in conjunction with the options noted above. In order to determine which option would be used to demonstrate compliance with the Department's Remediation Standards, the investigator should evaluate the data available and apply professional judgment.

The use of this guidance does not replace the need for documenting procedures and/or methodologies for proper remediation in accordance with Department regulatory requirements. The demonstration of attainment of the Department's Remediation Standards must be documented in the appropriate remediation document(s) and submittal(s) pursuant to the Technical Requirements and the Administrative Requirements for the Remediation of Contaminated Sites (ARRCS), N.J.A.C. 7:26C.

Detailed procedures for demonstrating attainment with the Department's Remediation Standards are presented in the following sections of the guidance:

Section 4.0 – Introduction: Overview of content and identification of document scope and limitations.

Section 5.0 – General Concepts: This section presents the technical approach for applying Remediation Standards during the site investigation, remedial investigation, and remedial action phases.

Section 6.0 – Soil: This section identifies each of the exposure pathways for soil impacts including 1) the Direct Contact Soil Ingestion – Dermal Exposure Pathway, 2) the Direct Contact Soil Inhalation Exposure Pathway, and 3) the Migration to Ground Water Exposure Pathway. In addition, this section references the methodologies for developing alternative remediation standards for each exposure pathway. This section also discusses Ecological Soil and Sediment Exposure Pathways, as well as alternatives for demonstrating attainment of the Soil Remediation Standards during the Site Investigation, Remedial Investigation and Remedial Action phases. This includes procedures for determining the need for remedial action for each of the soil exposure pathways.

Section 7.0 – Ground Water: This section reviews applicable Remediation Standards and Vapor Screening Levels for ground water and alternatives for demonstrating attainment of the Standards during the Site Investigation, Remedial Investigation, and Remedial Action phases. This includes procedures for determining the need for remedial action for each of the ground water exposure pathways.

Section 8.0 – Surface Water: This section reviews applicable Remediation Standards for surface water and alternatives for demonstrating attainment of the Standards during the Site Investigation, Remedial Investigation and Remedial Action phases. This includes procedures for determining the need for remedial action.

Section 9.0 - Extractable Petroleum Hydrocarbons
Section 10.0 - Ecological
Section 11.0 - Vapor Intrusion

The three sections noted above inform the investigator that these contaminants/pathways are not addressed in this guidance document in terms of how to select or develop standards or utilize compliance averaging. The investigator is directed to the specific guidance documents for additional information.

Section 12.0 - Compliance Averaging Options for the Ingestion-Dermal, Inhalation, and Migration to Ground Water Exposure Pathways: This section addresses the development of functional areas and provides details on the use of the arithmetic mean, 95% Upper Confidence Level of the Mean, spatially weighted averaging, and the 75%/10x compliance option.

4.0 INTRODUCTION

The Department adopted the Remediation Standards (N.J.A.C. 7:26D) in June 2008 and amended the Remediation Standards in May 2021 for use at remediation sites. The Remediation Standards set forth numeric and narrative standards for soils, ground water, and surface water. Prior to adoption of the Remediation Standards, the Department had used "soil cleanup criteria" (SCC), Ground Water Quality Standards (N.J.A.C. 7:9C), and Surface Water Quality Standards (N.J.A.C. 7:9B) as site specific numeric remediation standards. Adoption of the Remediation Standards served to administratively document the process that the Department has been implementing for many years.

The purpose of this guidance document is two-fold: (1) to assist the investigator with identifying and applying appropriate remediation standards, criteria, and conditions for detected contaminants in all media during each phase of a remediation (site investigation, remedial investigation, and remedial action); and (2) to determine compliance with these remediation standards, criteria, and conditions to ensure protection of human health and of the environment.

When determining appropriate remediation standards and criteria, it is critical that the investigator have an understanding of the intended use of the site once remediation is complete ("end use"). Questions to be considered include whether the site will be used for residential or nonresidential purposes, and whether the use of institutional and/or engineering controls is acceptable at the site. While compliance

has traditionally been based on single point determinations (see definition in Appendix D), the number of points required to demonstrate that the remediation is protective of human health and of the environment, and the manner in which the data are evaluated may vary depending on the remedial phase and the intended end use of the property. It should be noted that this document will not set forth guidelines for determining the technical aspects of the sampling investigation (i.e., appropriate sampling strategies, number of samples to be collected, etc.). The investigator is referred to the Technical Requirements, as well as the applicable guidance documents prepared by the Department that address these issues.

The investigator is encouraged to develop a conceptual site model (CSM) following Department guidance to develop and provide a framework that can be used to aid and document site characterization and remedial action decisions throughout the life of the remediation. The CSM is a written and/or illustrative representation of the physical, chemical, and biological processes that control the transport, migration, and potential impacts to receptors. Development and refinement of the CSM will help identify data gaps in the characterization process and can ultimately support remedial decision making. The Department accepts the CSM as a valid scientific approach when applied in accordance with applicable regulatory requirements and guidance documents.

This Department technical guidance document will provide direction on how to comply with soil ingestion-dermal remediation standards, soil inhalation remediation standards, migration to ground water remediation standards, ground water remediation standards, surface water remediation standards, and indoor air samples.

Media include soil, ground water, surface water, sediment, and air. Soil exposure pathways include ingestion-dermal, inhalation, migration to ground water, and ecological. Ground water exposure pathways include both drinking water and vapor intrusion. As defined in the "*Vapor Intrusion Technical Guidance*" (https://dep.nj.gov/srp/guidance/vapor-intrusion) vapor intrusion is the migration of volatile chemicals from the subsurface into overlying buildings. Surface water exposure pathways include both human health and aquatic.

It should be noted that this document does not fully address compliance for the following:

- Petroleum hydrocarbons. Compliance issues regarding petroleum hydrocarbons can be found in the Department guidance document "*Evaluation of Extractable Petroleum Hydrocarbons in Soil Technical Guidance June 2019 Version 1.0*" (https://dep.nj.gov/srp/guidance/#eph_soil)

- Ecological. Compliance issues regarding ecological issues, with the exception of certain surface water standards, can be found in the Department "*Ecological Evaluation Technical Guidance*" (https://dep.nj.gov/srp/guidance/#eco_eval)

- Vapor intrusion. Compliance issues regarding vapor intrusion are found in the Department "*Vapor Intrusion Technical Guidance*" (https://dep.nj.gov/srp/guidance/vapor-intrusion/)

Table 4-1 below provides details on the above information.

Table 4-1: Summary of Media, Exposure Pathways, Standards/Criteria

MEDIA	PATHWAY(S)	STANDARDS/CRITERIA	CITATION
Soil	Direct Contact (ingestion-dermal, inhalation)	Residential and Nonresidential Remediation Standards for the Soil Ingestion-Dermal Exposure Pathway Residential and Nonresidential Remediation Standards for the Soil Inhalation Exposure Pathway	N.J.A.C. 7:26D
	Migration to Ground Water	Soil and Soil Leachate Remediation Standards for the Migration to Ground Water Exposure Pathway	N.J.A.C. 7:26D-4
Ground Water	Ground Water	Ground Water Remediation Standards	N.J.A.C. 7:26D-2 (N.J.A.C. 7:9C)[1]
Surface Water	Human Health	Human Health Surface Water Quality Standards	N.J.A.C. 7:26D-3 (N.J.A.C. 7:9B)[2]
	Ecological	Aquatic Surface Water Quality Standards	N.J.A.C. 7:9B
Sediment	Human Health (Direct Contact Soil)	See Soil	N.J.A.C. 7:26D-4
	Ecological	Ecological Evaluation Technical Guidance	https://dep.nj.gov/srp/guidance/#eco_eval
		Extractable Petroleum Hydrocarbons	https://dep.nj.gov/srp/guidance/vapor-intrusion
Vapor Intrusion	Ground Water, Soil Gas	Vapor Intrusion Technical Guidance	https://dep.nj.gov/srp/guidance/vapor-intrustion
	Indoor Air	Indoor Air Remediation Standards for the Vapor Intrusion Exposure Pathway	N.J.A.C. 7:26D

1 The Ground Water Remediation Standards reference the Ground Water Quality Standards, N.J.A.C. 7:9C.

2 The Surface Water Remediation Standards reference the Surface Water Quality Standards, N.J.A.C. 7:9B.

Pursuant to the Technical Requirements, the person responsible for conducting the remediation is required to determine appropriate remediation standards, site-specific alternative remediation standards (if desired), and/or site-specific criteria for each contaminant detected at the site or area of concern (AOC) for all media and exposure pathways (as appropriate). For the purposes of this guidance document, the phrase "applicable remediation standard" is to be applied to the remediation standard, alternative remediation standard, and/or site-specific criterion.

The applicable remediation standard for a given contaminant depends upon the current and reasonably anticipated future use of the site (e.g., residential or nonresidential), as well as potential exposure pathways that are being assessed (e.g., ground water, surface water, migration to ground water). In general, attainment of compliance refers to the process by which analytical data from a site or AOC are compared against all applicable remediation standards and a determination is made as to whether existing site conditions meet or exceed those standards. Based on this determination, a decision is then made regarding the need for remediation at the site or AOC, including but not limited to, additional delineation sampling and/or remedial actions. Compliance determinations should be performed at the conclusion of each phase of a remediation (site investigation, remedial investigation, and remedial action).

Specific to remedial actions, pursuant to N.J.S.A. 58:10B-12g(4), the person responsible for conducting the remediation is not required to remediate contamination to below background concentrations. Refer to the Technical Requirements for regulatory obligations regarding background investigations (N.J.A.C. 7:26E-3.8).

5.0 GENERAL CONCEPTS

5.1 Site Investigation

Pursuant to N.J.A.C. 7:26E-3.3(a), the purpose of the site investigation is to "determine if additional remediation is necessary because contaminants are present at the site or area of concern, or because contaminants have emanated or are emanating from the site or area of concern, above any applicable remediation standard or criterion."

In general, single point compliance is employed during the site investigation using the most stringent applicable remediation standard. Rounding of single point compliance data is acceptable. Rounding should be carried out to the number of significant figures expressed in the applicable remediation standard as described in Appendix B. The Technical Requirements allow the person responsible for conducting the remediation to either conduct a remedial investigation or to immediately commence a remedial action. This decision is made by the person responsible for conducting the remediation, based on the appropriate Department guidance, and is not discussed in this document.

5.2 Remedial Investigation

Pursuant to N.J.A.C. 7:26E-4.1(a)1, the purpose of the remedial investigation is to "delineate the horizontal and vertical extent of contamination to the remediation standard, in each environmental medium at a contaminated site …".

The goal of the remedial investigation should be to achieve delineation and characterization of the nature and extent of contamination, as appropriate, to determine the necessity for and the proposed extent of a remedial action in order to support the development and evaluation of proposed alternatives in the remedy selection process.

As with the site investigation, in general, single point compliance is employed during the remedial investigation using the most stringent applicable remediation standard. Put simply, if contaminant

concentrations are determined to be present at the site during the remedial investigation above the applicable remediation standard, the person responsible for conducting the remediation is required to determine whether it is necessary to conduct a remedial action. Rounding of single point compliance data is acceptable. Rounding should be carried out to the number of significant figures expressed in the applicable remediation standard as described in Appendix B.

In lieu of discrete sampling, the LSRP may use other means for determining the extent of the contamination. As such, samples indicating contaminant concentrations that are at or below the applicable remediation standards (i.e., clean zone samples) are not required for all environmental media to complete the remedial investigation. See "*Interpretation of Technical Requirements for Site Remediation requirement to "complete the remedial investigation" (N.J.A.C. 7:26E-4.10)"* (https://dep.nj.gov/wp-content/uploads/srp/ri_complete_policy_statement_202001.pdf).

While the remedial investigation does not need to include actual clean zone sampling data to demonstrate contaminant delineation to the applicable remediation standards, such sampling data are required to demonstrate attainment of the applicable remediation standards and screening criteria at the conclusion of the remedial action and prior to the Department issuing a remedial action permit, if applicable, and the LSRP issuing the Response Action Outcome (RAO).

As noted in Sections 12.2 Arithmetic Mean, 12.3 95% UCL, and 12.4 Spatially Weighted Averaging, "complete horizontal and vertical delineation using single point compliance, must first be completed" to utilize these averaging methods. Pursuant to N.J.A.C. 7:26E-5.7(b) and by reference N.J.A.C 7:26E-1.6(b)8, maps and figures documenting complete delineation for the area(s) of concern where averaging is being applied should be included within the remedial phase report where the use of an attainment methodology is proposed. The location of the maps and figures used to document complete delineation should be referenced in the narrative discussing the application of the averaging methodology selected.

Sections 6 (soil) and 7 (ground water) detail alternatives for demonstrating that compliance has been achieved for each specified exposure pathway using compliance averaging. Rounding may be applied in conjunction with compliance averaging, as specified in Sections 6 and 7.

5.3 Remedial Action

If through the site investigation and/or remedial investigation it is determined that contamination is present at a site or AOC at concentrations not in compliance with the applicable remediation standard, a remedial action is required. Requirements pertaining to the type of remedial action are contained in the Department guidance "*Ground Water Technical Guidance: Site Investigation/Remedial Investigation/Remedial Action Performance Monitoring*" (https://dep.nj.gov/srp/guidance/#pa_si_ri_gw) and "*Soil Investigation Technical Guidance - Site Investigation/Remedial Investigation/Remedial Action (SI/RI/RA)*" (https://dep.nj.gov/srp/guidance/#si_ri_ra_soils).

After completion of the remedial action, if contaminants are still present above the applicable remediation standard, compliance averaging as specified in Sections 6 and 7 may be used (for each exposure pathway) to determine if the site or AOC is in compliance or if additional remedial action is warranted. Rounding may be applied in conjunction with compliance averaging, as specified in Sections 6 and 7.

6.0 SOIL

This section presents the process for determining the applicable remediation standard, and is organized as follows:

- 6.1 - Direct contact soil exposure pathways soil remediation standards
- 6.2 - Migration to ground water soil exposure pathway soil remediation standards
- 6.3 - Site-specific standards for contaminants not in the table
- 6.4 - Ecological soil and sediment screening levels
- 6.5 - Petroleum hydrocarbon soil screening levels
- 6.6 - Vapor intrusion soil screening levels

The final subsection (6.7) discusses how to demonstrate attainment of compliance with those standards and screening levels, again by exposure pathway.

6.1 Direct Contact Exposure Pathways Soil Remediation Standards

Direct contact pathways include both the soil ingestion-dermal exposure pathway as well as the soil inhalation exposure pathway. In addition, for each of these pathways, there are both residential and nonresidential exposure scenarios.

6.1.1 Direct Contact Remediation Standards or Criteria

Applicable numerical remediation standards for the two direct contact exposure pathways include:

- Ingestion-dermal remediation standards promulgated in Tables 1 and 2 of Appendix 1 in the Remediation Standards (N.J.A.C. 7:26D)
- Inhalation remediation standards promulgated in Tables 3 and 4 of Appendix 1 in the Remediation Standards (N.J.A.C. 7:26D)
- Alternative remediation standards developed pursuant to the Remediation Standards (N.J.A.C. 7:26D-8, and either Appendix 6 [ingestion-dermal exposure pathway] or Appendix 7 [inhalation exposure pathway])

All direct contact soil remediation standards (residential and nonresidential) are rounded to two significant figures using the rounding rules contained in Appendix B of this guidance document.

Any alternative remediation standards developed for soil pursuant to the Remediation Standards (N.J.A.C. 7:26D) should be rounded to two significant figures using the rounding rules contained in Appendix B of this guidance document.

Additional criteria for other contaminants that have been developed for human-health receptors are found in guidance documents for those contaminants (e.g., chromium). These criteria are rounded to two significant figures using the rounding rules contained in Appendix B of this guidance document.

6.1.2 Alternative Remediation Standards

In lieu of selecting the remediation standard from N.J.A.C.7: 26D, Appendix 1, Tables 1 through 4, if sufficient information is available, then the investigator may choose to develop a site-specific alternative remediation standard for each contaminant detected at the site or AOC pursuant to N.J.A.C. 7:26D-8

Pursuant to N.J.A.C. 7:26D-8.4(a), the investigator is required to complete and submit the form "*Alternative Soil Remediation Standard and/or Screening Level Application Form*" available at https://dep.nj.gov/srp/guidance/. This must include the Remediation Standard Notification Spreadsheet.

6.1.2.1 Ingestion-Dermal Exposure Pathway

Use N.J.A.C. 7:26D-Appendix 6 (Development of Alternative Remediation Standards for Soil for the Ingestion-Dermal Exposure Pathway) and the "*Alternative Remediation Standards Technical Guidance for Soil for the Ingestion-Dermal and Inhalation Exposure Pathways*" (https://dep.nj.gov/srp/guidance/#ars_ingestion).

Note that pursuant to N.J.A.C. 7:26D-Appendix 6, any alternative soil remediation standard developed for the ingestion-dermal exposure pathway requires Department approval prior to their use at a site or AOC.

6.1.2.2 Inhalation Exposure Pathway

Use N.J.A.C. 7:26D-Appendix 7 (Development of Alternative Remediation Standards for Soil for the inhalation Exposure Pathway) and the "*Alternative Remediation Standards Technical Guidance for Soil for the Ingestion-Dermal and Inhalation Exposure Pathways*" (https://dep.nj.gov/srp/guidance/#ars_ingestion).

Note that pursuant to N.J.A.C. 7:26D-Appendix 7, an alternative remediation standard developed in accordance with Section III(a) of this appendix must be approved by the Department prior to use at the specific site or area of concern. An alternative remediation standard developed in accordance with III(b) of Appendix 7 does not require approval by the Department prior to use at the specific site or area of concern.

6.2 Migration to Ground Water Exposure Pathway Soil Remediation Standards

The migration to ground water exposure pathway needs to be addressed for each contaminant that exceeds the Soil Remediation Standards for the Migration to Ground Water Exposure Pathway (SRS-MGW) at N.J.A.C. 7:26D-4.4.

An alternative soil remediation standard may be developed using the guidance in "*Alternative Remediation Standards Technical Guidance for Soil and Soil Leachate for the Migration to Ground Water Exposure Pathway*" at https://dep.nj.gov/srp/guidance/#ars_migration. Any alternative SRS-MGW developed pursuant to the aforementioned guidance should be rounded to two significant figures.

Soil Leachate Remediation Standards for the migration to ground water exposure pathway standards are listed in N.J.A.C. 7:26D-4.4. All Soil Leachate Remediation Standards are rounded to two significant figures.

An alternative soil leachate remediation standard may be developed using the guidance in "*Alternative Remediation Standards Technical Guidance for Soil and Soil Leachate for the Migration to Ground Water Exposure Pathway*" at NJDEP SRP - Guidance Library https://dep.nj.gov/srp/guidance/#ars_migration. Any alternative soil leachate remediation standard developed pursuant to the aforementioned guidance should be rounded to two significant figures.

If more than one of the methods listed in the "*Alternative Remediation Standards Technical Guidance for Soil and Soil Leachate for the Migration to Ground Water Exposure Pathway*" is used to develop an alternative soil or soil leachate remediation standard SRS-MGW for a given contaminant, then the greatest value calculated should be used as the alternative remediation standard.

6.2.1 Department Pre-Approval Not Required

See Section 2.2 in "*Alternative Remediation Standards Technical Guidance for Soil and Soil Leachate for the Migration to Ground Water Exposure Pathway*" (https://dep.nj.gov/srp/guidance/#ars_migration) for options where pre-approval is not required.

6.2.2 Department Pre-Approval Required

See Section 2.2 in "*Alternative Remediation Standards Technical Guidance for Soil and Soil Leachate for the Migration to Ground Water Exposure Pathway*" at https://dep.nj.gov/srp/guidance/#ars_migration for options where pre-approval is required.

6.3 Site-Specific Standards for Contaminants Not in the Table

For contaminants that are not included in any of the above tables, see the Remediation Standards (N.J.A.C. 7:26D-6) for the process for developing interim soil remediation standards.

6.4 Ecological Soil and Sediment Screening Levels

Ecological soil and sediment screening levels are discussed in the Department "*Ecological Evaluation Technical Guidance*" (https://dep.nj.gov/srp/guidance/#eco_eval). Additionally, the ecological screening level for petroleum hydrocarbons is discussed in the Department "*Evaluation of Extractable Petroleum Hydrocarbons in Soil Technical Guidance*" document (https://dep.nj.gov/srp/guidance/#eph_soil).

6.5 Petroleum Hydrocarbon Soil Screening Levels

Applicability of compliance averaging of extractable petroleum hydrocarbon health-based criteria and product levels is discussed in the Department "*Evaluation of Extractable Petroleum Hydrocarbons in Soil Technical Guidance*" document (https://dep.nj.gov/srp/guidance/#eph_soil).

6.6 Vapor Intrusion Soil Screening Levels

There are no soil-based standards, criteria, or screening levels for the vapor intrusion exposure pathway. See Sections 2.1.9 of the Department's "*Vapor Intrusion Technical Guidance"* for further discussion of this issue (https://dep.nj.gov/srp/guidance/vapor-intrusion).

6.7 Compliance

6.7.1 General

Compliance with the applicable soil remediation standards typically will involve comparison of contaminant concentrations to the most stringent (i.e., lowest) soil remediation standard. In most cases, this will be either the direct contact soil remediation standard or the SRS-MGW.

In addition to this Technical Guidance, the investigator should consult the Technical Requirements for Site Remediation (N.J.A.C. 7:26E) for special site investigation, remedial investigation, and remedial action requirements for historic fill, and special site investigation and remedial investigation requirements for landfills (https://dep.nj.gov/wp-content/uploads/rules/rules/njac7_26e.pdf). In addition, the investigator should consult the "*Historically Applied Pesticides Technical Guidance*" for special site investigation, remedial investigation, and remedial action requirements (https://dep.nj.gov/srp/guidance/#hap).

6.7.2 Site Investigation

During the site investigation, compliance for all contaminants for all exposure pathways for all soil remediation standards will be based on single point compliance.

The single point compliance comparison will be made to the lower of either the residential direct contact soil remediation standard or the SRS-MGW.

If any contaminant concentration level in any sample exceeds the lower of either the residential direct contact soil remediation standard or the SRS-MGW, then the person responsible for conducting the remediation is required to conduct a remedial investigation for the site or AOC pursuant to N.J.A.C. 7:26E-4. Rounding of single point compliance data is acceptable. Rounding should be conducted to the number of significant figures expressed in the applicable remediation standard. Alternatively, pursuant to N.J.A.C. 7:26E-4.2(c), the person responsible for conducting the remediation can proceed directly to the remedial action (N.J.A.C. 7:26E-5).

Additional actions may be required relative to ecological issues; refer to the Department "*Ecological Evaluation Technical Guidance*" (https://dep.nj.gov/srp/guidance/#eco_eval).

6.7.3 Remedial Investigation - Delineation

As previously presented in Section 5.2, there are two separate determinations regarding compliance with the applicable soil remediation standards as part of the remedial investigation. This subsection (6.7.3) describes the process of determining whether both horizontal and vertical delineation are complete, as appropriate. The following subsection (6.7.4) describes the process of determining whether and what type of remedial action is required. To determine whether delineation is complete, single point compliance is to be used. Rounding of single point compliance data is acceptable. Rounding should be conducted to the number of significant figures expressed in the applicable remediation standard.

In lieu of discrete sampling, the LSRP may use other means for determining the extent of the contamination. As such, samples indicating contaminant concentrations that are at or below the applicable remediation standards (i.e., clean zone samples) are not required for all environmental media to complete the remedial investigation. See "*Interpretation of Technical Requirements for Site*

Remediation requirement to "complete the remedial investigation" (N.J.A.C. 7:26E-4.10)" (https://dep.nj.gov/wp-content/uploads/srp/ri_complete_policy_statement_202001.pdf).

While the remedial investigation does not need to include actual clean zone sampling data to demonstrate contaminant delineation to the applicable remediation standards, such sampling data are required to demonstrate attainment of the applicable remediation standards and screening criteria at the conclusion of the remedial action and prior to the Department issuing a remedial action permit, if applicable, and the LSRP issuing the Response Action Outcome (RAO).

6.7.3.1 Delineation - Direct Contact Exposure Pathways

For direct contact exposure pathways, horizontal and vertical delineation compliance is dependent upon the type of remedial action selected (i.e., current and/or future end use) for the site or AOC, as well as whether the applicable direct contact soil remediation standard is determined by the ingestion-dermal exposure pathway or the inhalation exposure pathway. It should also be noted that for direct contact exposure pathways, delineation is to continue until the applicable soil remediation standard is achieved, regardless of whether ground water is encountered or not. Delineation does not stop at the water table.

Regardless of the type of remedial action presumed for the site, the investigator must:

- Demonstrate delineation compliance with the migration to ground water exposure pathway soil remediation standards, as applicable (i.e., only apply in the unsaturated zone; see Section 6.7.3.2 below) pursuant to the Technical Requirements (N.J.A.C. 7:26E-4) (https://dep.nj.gov/wp-content/uploads/rules/rules/njac7_26e.pdf).

- Delineate for the presence of free and/or residual product pursuant to the Technical Requirements (N.J.A.C. 7:26E-2.1(a)14, N.J.A.C. 7:26E-4.2(a)4, and N.J.A.C. 7:26E-4.3(a)3). Free and/or residual product is to be remediated pursuant to the Technical Requirements (N.J.A.C. 7:26E-5.1(e)). The "*Light Non-aqueous Phase Liquid (LNAPL) Initial Recovery and Interim Remedial Measures Technical Guidance*" (https://dep.nj.gov/srp/guidance/#lnapl) should be consulted if there is a measurable thickness (>0.01 feet) of LNAPL product present.

- If applicable, evaluate for the presence of sheen pursuant to the Department policy (https://dep.nj.gov/srp/guidance/sheen/) in effect as of the date the evaluation is performed in the field. If sheen is present that needs to be addressed pursuant to the sheen policy, then the necessary corrective actions are to be taken pursuant to the Department policy in effect as of the date the report is submitted.

6.7.3.1.1 Unrestricted Use Remedial Action

For sites or AOC for which an unrestricted use remedial action is selected, horizontal and vertical delineation is to proceed to the residential direct contact soil remediation standard.

Horizontal and vertical delineation for direct contact purposes is considered complete for unrestricted use scenarios when all perimeter soil contaminant concentrations are less than or equal to the applicable residential direct contact soil remediation standard for each contaminant present.

6.7.3.1.2 Limited Restricted Use Remedial Action

For sites or AOC for which a limited restricted use remedial action is selected, horizontal and vertical delineation, as applicable, is to proceed to the nonresidential direct contact soil remediation standard for the site or AOC that will be subject to the restriction. In addition, pursuant to N.J.A.C. 7:26E-4.2(a)2, the investigator shall determine whether contamination has migrated off the property, both horizontally and vertically, as appropriate, to the residential direct contact soil remediation standard.

6.7.3.1.3 Restricted Use Remedial Action

For sites or AOC for which a restricted use remedial action is selected, horizontal and vertical delineation is to consist of the following, as applicable:

- For residential sites: to the residential direct contact soil remediation standard at the boundary of the restricted area.

- For nonresidential sites: to the nonresidential direct contact soil remediation standard at the boundary of the restricted area, and to the residential direct contact soil remediation standard at the property boundary.

In addition, pursuant to N.J.A.C. 7:26E-4.2(a)2, the investigator shall determine whether contamination has migrated off the property, both horizontally and vertically, as appropriate, to the residential direct contact soil remediation standard.

6.7.3.2 Delineation - Migration to Ground Water Exposure Pathway

Horizontal and vertical delineation for the migration to ground water exposure pathway will be considered complete when all soil contaminant concentrations are less than or equal to the applicable SRS-MGW selected pursuant to Section 6.2 above. It should also be noted that for the migration to ground water exposure pathway, delineation is only required within the vadose zone.

6.7.4 Remedial Investigation - Determine Need for Remedial Action

Following completion of delineation (using single point compliance) to the applicable soil remediation standard, the investigator is to determine whether compliance with the applicable soil remediation standard has now been achieved using one of the compliance options detailed below. To determine whether a remedial action is required based upon the ingestion-dermal, inhalation, and migration to ground water exposure pathways, either single point compliance or compliance averaging can be used. Additionally, rounding may be applied in conjunction with both single point compliance and compliance averaging as described in Appendix B. If compliance has not been achieved, then a remedial action is required.

6.7.4.1 Direct Contact Exposure Pathways

To determine whether a remedial action is required based upon the ingestion-dermal and the inhalation exposure pathways, use either single point compliance or compliance averaging.

Any of the following compliance options can be used to determine if a remedial action is required for both the ingestion dermal and inhalation exposure pathways:

- Single point compliance
- Compliance averaging by calculating the arithmetic mean
- Compliance averaging at the 95% upper confidence limit (UCL) of the mean
- Compliance averaging using a spatially weighted average (e.g., Thiessen polygons)
- Rounding of laboratory analytical data (in conjunction with single point compliance) or rounding of computed average concentrations (in conjunction with the above-noted compliance averaging options)

See Section 12.0 for detailed guidance on compliance averaging using the arithmetic mean of the data set, the 95% UCL of the mean, spatially weighted averaging, and the 75%/10x compliance option. Appendix B contains detailed guidance on the use of rounding to demonstrate compliance.

Other methods may be proposed by the investigator, where such an approach is relevant and appropriate to site conditions in the professional judgment of the investigator. Consultation with the Department is recommended if methods not discussed in this document are used.

If single point compliance is used and the concentration of each contaminant is less than or equal to its applicable direct contact exposure pathway soil remediation standard, then no remedial action is required for soils for the direct contact exposure pathways for the site or AOC. Rounding of single point compliance data is acceptable. Rounding should be conducted to the number of significant figures expressed in the applicable remediation standard. If compliance averaging is used for appropriate ingestion-dermal and/or inhalation exposure pathway contaminants and the average contaminant concentration of each contaminant is less than or equal to its applicable direct contact exposure pathway soil remediation standard, then no remedial action is required for soils for the direct contact exposure pathways for the site or AOC. Only the averaged contaminant concentration may be rounded; the individual contaminant concentrations should not be rounded prior to their use in compliance averaging. Rounding should be conducted to the number of significant figures expressed in the applicable remediation standard. Individual data points should not be rounded prior to conducting compliance averaging.

If the average concentration of any contaminant exceeds its applicable direct contact soil remediation standard, then the person responsible for conducting the remediation is required to select and conduct a remedial action pursuant to N.J.A.C. 7:26E-5.

If delineation indicates that contamination extends offsite at any depth, then delineation and compliance with the direct contact soil remediation standard is to be determined by applying the most stringent direct contact soil remediation standard to the offsite contaminated area. The contaminated offsite area shall be addressed separately using either single point compliance or compliance averaging in accordance with N.J.A.C. 7:26E 4.2 (a) 1.i, 2, and 3. The contaminants in the offsite area are to be compared to the most stringent direct contact soil remediation standard, irrespective of its current land use. Rounding is acceptable as described above.

In all situations, the actual type of remedial action required will depend upon the end use of the site or AOC (i.e., residential or nonresidential). This decision is to be made on a case-by-case basis and is not discussed in this guidance document.

The investigator still must demonstrate compliance with the migration to ground water exposure pathway soil remediation standards, as applicable (see Section 6.7.4.2 below).

6.7.4.2 Migration to Ground Water Exposure Pathway

To determine whether a remedial action is required based upon the migration to ground water pathway, any of the following compliance options can be used:

- Single point compliance
- Compliance averaging by calculating the arithmetic mean
- Compliance averaging at the 95% UCL of the mean
- Compliance averaging using a spatially weighted average (e.g., Thiessen polygons)
- Rounding of laboratory analytical data (in conjunction with single point compliance) or rounding of computed average concentrations (in conjunction with the above-noted compliance averaging options)

Averaging and compliance options should not be utilized where SRS-MGW have been obtained using SESOIL and SESOIL/AT123D. The distribution profile values should not be averaged.

See Section 12.0 for detailed guidance on compliance averaging using the arithmetic mean of the data set, the 95% UCL of the mean, spatially weighted averaging, and the 75%/10x compliance option. Appendix B contains detailed guidance on the use of rounding data to demonstrate compliance. Unlike the direct contact exposure pathways, determining compliance for the migration to ground water exposure pathway is based on the full extent of the contamination. Onsite and offsite areas are not evaluated separately. The reason for this is because the receptor, the ground water, is not confined to a site, but extends across the adjacent site and beyond. The same compliance procedures are used whether an AOC extends offsite or not. The investigator is referred to Section 12.0 for additional details.

Other methods may be proposed by the investigator, where such an approach is relevant and appropriate to site conditions in the professional judgment of the investigator. Consultation with the Department is recommended if methods not discussed in this document are used.

Alternatively, the investigator can demonstrate that no further remediation is required for the migration to ground water exposure pathway by meeting the requirements of the narrative standards as detailed in Sections 9.0 and 10.0 in "*Alternative Remediation Standards Technical Guidance for Soil and Soil Leachate for the Migration to Ground Water Exposure Pathway*" at https://dep.nj.gov/srp/guidance/#ars_migration.

6.7.5 Remedial Action Verification

After a remedial action has been conducted, to determine whether compliance with the applicable soil remediation standard has been achieved and no further action is warranted or whether additional remediation is required, either single point compliance or compliance averaging can be used as detailed below. Additionally, rounding may be applied in conjunction with both single point compliance and compliance averaging.

6.7.5.1 Direct Contact Exposure Pathways

Similar to the remedial investigation, determining compliance for direct contact exposure pathway soil remediation standards for the remedial action is dependent upon both the end use for the site or AOC, and whether the applicable direct contact soil remediation standard is determined by the ingestion-dermal exposure pathway or the inhalation exposure pathway.

For all soil remedial actions performed due to exceedances of either ingestion-dermal or inhalation direct contact exposure pathway remediation standards, any of the following compliance options can be used to determine if the remediation is complete for the ingestion-dermal and inhalation pathways:

- Single point compliance
- Compliance averaging by calculating the arithmetic mean
- Compliance averaging at the 95% UCL of the mean
- Compliance averaging using a spatially weighted average (e.g., Thiessen polygons)
- Compliance averaging using the 75%/10x procedure
- Rounding of laboratory analytical data (in conjunction with single point compliance and the 75 percent/10x procedure) or rounding of computed average concentrations (in conjunction with compliance averaging using the arithmetic mean, 95% UCL, and spatially weighted averaging)

See Section 12.0 for detailed guidance on compliance averaging using the arithmetic mean of the data set, the 95% UCL of the mean, spatially weighted averaging, and the 75%/10x compliance option. Appendix B contains detailed guidance on the use of rounding to demonstrate compliance with remediation standards.

Other methods may be proposed by the investigator, where such an approach is relevant and appropriate to site conditions in the professional judgment of the investigator. Consultation with the Department is recommended if methods not discussed in this document are used.

The remedial action is considered complete for soils for the direct contact exposure pathways for the site or AOC if:

- single point compliance is used, and the concentration of each contaminant is less than or equal to its applicable direct contact exposure pathway soil remediation standard;

- compliance averaging is used for appropriate ingestion-dermal and/or inhalation exposure pathway contaminants and the average contaminant concentration of each contaminant is less than or equal to its applicable direct contact exposure pathway soil remediation standard; or

- rounding of analytical data is applied and the concentration of each contaminant (single point compliance) or the average contaminant concentration of each contaminant (compliance averaging) is less than or equal to its applicable direct contact exposure pathway soil remediation standard.

If the concentration of any contaminant exceeds its applicable direct contact exposure pathway soil remediation standard using either single point compliance, compliance averaging, and/or rounding, the person responsible for conducting the remediation can choose to either:

- Continue with the remedial action until the concentration of each contaminant is less than or equal to its applicable direct contact exposure pathway soil remediation standard; or
- Implement an institutional control and/or engineering control (if appropriate) pursuant to N.J.A.C. 7:26C-7. It should be noted that if an institutional control and/or engineering control is implemented at a site, the person responsible for conducting the remediation will be responsible for all remedial action permits and remedial action protectiveness certification requirements pursuant to N.J.A.C. 7:26C-7, as well as all soil remedial action permit fees and obligations pursuant to N.J.A.C. 7:26C-4.6 and N.J.A.C. 7:26C-7, respectively.

The investigator still must demonstrate compliance with the migration to ground water exposure pathway soil remediation standards (see Section 6.7.5.2 below).

6.7.5.1.1 Unrestricted Use Soil Remedial Actions

Pursuant to N.J.A.C. 7:26E-1.8, unrestricted use remedial action means "any remedial action that does not require the continued use of either engineering or institutional controls to meet the established health risk or environmental standards."

Unrestricted use soil remedial actions are where contaminant concentrations are less than or equal to the most stringent direct contact exposure pathway soil remediation standard. This is determined by either single point compliance or compliance averaging, in conjunction with the application of rounding, as appropriate.

6.7.5.1.2 Limited Restricted Use Soil Remedial Actions

Pursuant to the definition in the Technical Requirements (N.J.A.C. 7:26E-1.8), limited restricted use soil remedial actions do not apply to residential sites.

Limited restricted use soil remedial actions are where contaminant concentrations exceed the applicable residential soil remediation standard but are less than or equal to the applicable nonresidential soil remediation standard. This is determined by either single point compliance or compliance averaging, in conjunction with the application of rounding, as appropriate.

For those areas not included within the institutional control, compliance in accordance with the Section "Unrestricted Use Soil Remedial Actions" (6.7.5.1.1 above) is to be demonstrated.

6.7.5.1.3 Restricted Use Soil Remedial Actions

Pursuant to N.J.A.C. 7:26E-1.8, restricted use remedial action means "any remedial action that requires the continued use of engineering and institutional controls in order to meet the established health risk or environmental standards."

By definition, restricted use soil remedial actions can apply to both residential and nonresidential sites.

For residential uses, if the concentration of any contaminant exceeds its applicable direct contact exposure pathway residential soil remediation standard, then it will be necessary to establish both institutional and engineering controls pursuant to N.J.A.C. 7:26C-7.

For nonresidential uses, if the concentration of any contaminant exceeds both its applicable direct contact exposure pathway residential and nonresidential soil remediation standards, then it will be necessary to establish both institutional and engineering controls pursuant to N.J.A.C. 7:26C-7.

Those areas not included within an engineering control are restricted to nonresidential uses, provided that concentrations do not exceed the applicable nonresidential soil remediation standard.

For those areas not included within the institutional control, compliance in accordance with the Section "Unrestricted Use Soil Remedial Actions" (6.7.5.1.1 above), is to be demonstrated.

6.7.5.2 Migration to Ground Water Exposure Pathway

Any of the following compliance options can be used to determine if the remediation is complete for the migration to ground water exposure pathway:

- Single point compliance
- Compliance averaging by calculating the arithmetic mean
- Compliance averaging at the 95% UCL of the mean
- Compliance averaging using a spatially weighted average (e.g., Thiessen polygons)
- Compliance averaging using the 75% /10x procedure
- Rounding of laboratory analytical data (in conjunction with single point compliance and the 75% /10x procedure) or rounding of computed average concentrations (in conjunction with compliance averaging using the arithmetic mean, 95% UCL, and spatially weighted averaging)

Averaging and compliance options should not be utilized where soil remediation standards for the migration to ground water exposure pathway have been obtained using SESOIL and SESOIL/AT123D. The distribution profile values should not be averaged.

See Section 12.0 for detailed guidance on compliance averaging using the arithmetic mean of the data set, the 95% UCL of the mean, spatially weighted averaging, and 75%/10x compliance option. Appendix B contains detailed guidance on the use of rounding of analytical data to demonstrate compliance.

Other methods may be proposed by the investigator, where such an approach is relevant and appropriate to site conditions in the professional judgment of the investigator. Consultation with the Department is recommended if methods not discussed in this document are used.

The remedial action is considered complete for soils for the migration to ground water exposure pathway for the site or AOC if:

- single point compliance is used, and the concentration of each contaminant is less than or equal to its applicable SRS-MGW;
- compliance averaging is used, and the average contaminant concentration of each contaminant is less than or equal to its applicable SRS-MGW; or
- rounding of analytical data is applied and the concentration of each contaminant (single point compliance) or the average contaminant concentration of each contaminant (compliance averaging) is less than or equal to its applicable SRS-MGW.

Once the remediation is complete for soil for the migration to ground water exposure pathway for the site or AOC, the remediating party still must demonstrate compliance with the ingestion-dermal and inhalation exposure pathways soil remediation standards as described in Section 6.7 above.

If the concentration of any contaminant exceeds its applicable SRS-MGW using either single point compliance or compliance averaging, in conjunction with the application of rounding, the person responsible for conducting the remediation shall continue with the remedial action until the concentration of each contaminant is less than or equal to its applicable SRS-MGW pursuant to N.J.A.C 7:26E 5.1(b)1.

Every effort must be made to remediate soils to the applicable migration to ground water soil remediation standards, except where technically impracticable. Engineering controls, such as capping, may be used in lieu of soil treatment or excavation to address this exposure pathway. See "*Capping of Inorganic and Semivolatile Contaminants for the Impact to Ground Water Pathway*" March 2014 Version 1.0 (https://dep.nj.gov/srp/guidance/#igw_capping) and "*Capping of Volatile Contaminants for the Impact to Ground Water Pathway*" January 2019 Version 1.1 (https://dep.nj.gov/srp/guidance/#igw_vo_capping).

NOTE: For sites that consist of historic fill that extend beyond the property boundary, it is not necessary to remediate soils to the migration to ground water exposure pathway soil remediation standard(s) for those contaminants associated with the historic fill. For additional information see the Technical Requirements for Site Remediation N.J.A.C. 7:26E (https://dep.nj.gov/wp-content/uploads/rules/rules/njac7_26e.pdf) and the "*Historic Fill Material Technical Guidance"* (https://dep.nj.gov/srp/guidance/#historic_fill).

7.0 GROUND WATER

7.1 Ground Water Remediation Standards

Pursuant to the Remediation Standards at N.J.A.C. 7:26D-2, ground water remediation standards are, by reference, the ground water quality standards developed pursuant to N.J.A.C. 7:9C (https://dep.nj.gov/wp-content/uploads/rules/rules/njac7_26d.pdf). For each contaminant detected in ground water at the site or AOC, the investigator is to select the ground water remediation standard pursuant to N.J.A.C. 7:26D-2 for the ground water classification where the discharge occurs. This includes Class I (exceptional ecological areas; Pinelands), Class II (potable), Class IIIA (aquitards), and Class IIIB (saltwater intrusion) ground waters, as defined pursuant to N.J.A.C. 7:9C-1.5. Numeric criteria for Class II-A ground waters are as indicated at N.J.A.C. 7:9C-1.7(c). All ground water remediation standards for Class II-A ground water are rounded to one significant figure with the exception of ground water standards for chloride, copper, 1,4-dichlorobenzene, hardness, perfluorononanoic acid (PFNA), perfluorooctanoic acid (PFOA), and perfluorooctanesulfonic acid (PFOS), pH, and sulfate which are rounded to two significant figures.

In Class II-A ground water, for contaminants that do not have a standard listed as above, see the Ground Water Quality Standards at N.J.A.C. 7:9C-1.7(c)2 through 6 for the process of developing interim ground water quality standards. Any interim ground water quality standards developed by the Department pursuant to the above are rounded to one significant figure.

Narrative standards are used to determine numeric criteria for Class I and III ground waters per N.J.A.C. 7:9C-1.7(a), (b), (e) or (f), as applicable. Note that pursuant to N.J.A.C. 7:26D-2.2(b), alternative remediation standards for ground water are not allowed. Ground water remediation standards developed for Class I and Class III ground water should be rounded to the number of significant figures used in establishing the Class II ground water quality/remediation standard for the contaminant in question.

See Section 7.3.2 regarding averaging of ground water analytical results to determine whether a ground water remedial investigation is triggered.

7.2 Vapor Intrusion Exposure Pathway

Ground water screening levels for the vapor intrusion exposure pathway are discussed in the Department "*Vapor Intrusion Technical Guidance*" (https://dep.nj.gov/srp/guidance/vapor-intrusion/). All ground water screening levels for the vapor intrusion exposure pathway are rounded to two significant figures.

See Section 7.3.2 regarding averaging of ground water analytical results to determine whether a vapor intrusion investigation is triggered.

7.3 Compliance

7.3.1 General

The investigator is to use single point compliance to determine compliance with the applicable ground water remediation standards for all phases of investigation (site investigation, remedial investigation, and remedial action). While compliance averaging over spatial areas is acceptable for soils, it is not an acceptable strategy for ground water. The averaging process for ground water, as described in the

following sections, is applicable only to ground water samples collected from a single sampling location over a limited time period.

7.3.2 Site Investigation

The following options can be used to determine ground water compliance during the Site Investigation phase:

If there are no exceedances of the applicable ground water remediation standards for any contaminants, then no further action is required for ground water at the site or AOC relative to the ground water remediation standards. Rounding of single point compliance data is acceptable. Rounding should be conducted to the number of significant figures expressed in the applicable ground water remediation standard.

If, after rounding as discussed above, the concentration of any contaminant in any ground water sample exceeds its applicable ground water remediation standard, the ground water may be resampled to confirm the presence of contamination. Two confirmation samples should be collected approximately 30 days apart and using similar purging and sampling techniques within a 60-day time period of the initial sampling event. Average the results from the original sampling event along with the two confirmation sampling events to determine compliance with the applicable standard. Averaging is not allowed for demonstrating attainment when the initial result is more than three times (3x) the applicable ground water standard or screening level for example, if the initial result is more than three times the vapor intrusion ground water screening level, a vapor intrusion investigation is triggered without exception. If the average does not exceed the applicable ground water remediation standard, then no further action is required for ground water at the site or AOC. Individual sample results should not be rounded prior to calculating the average contaminant concentration. Rounding of the average concentration value is acceptable and should be conducted to the number of significant figures expressed in the applicable ground water remediation standard.

The rounding process described in the paragraph above can also be applied to the evaluation of ground water screening levels to address the vapor intrusion exposure pathway.

The user is directed to the Department's "*Vapor Intrusion Technical Guidance*" (https://dep.nj.gov/srp/guidance/vapor-intrusion/) regarding additional compliance issues for the vapor intrusion pathway.

If the concentration of any contaminant in any ground water sample exceeds its applicable ground water remediation standard, then the person responsible for conducting the remediation is required to conduct a remedial investigation of ground water for the site or AOC pursuant to N.J.A.C. 7:26E-4 and the Department's ground water technical guidance, "*Ground Water Technical Guidance: Site Investigation/Remedial Investigation/Remedial Action Performance Monitoring*" (https://dep.nj.gov/srp/guidance/#pa_si_ri_gw).

7.3.3 Remedial Investigation

The following options can be used to determine ground water compliance during the Remedial Investigation phase:

Horizontal and vertical delineation for ground water will be considered complete for the site or AOC when ground water contaminant concentrations in the perimeter monitoring wells are less than or equal to the applicable ground water remediation standard for each contaminant present. This only applies to ground water impacts originating from the site or AOC. Rounding of single point compliance data is acceptable. Rounding should be conducted to the number of significant figures expressed in the applicable remediation standard.

If, after rounding, as discussed above, the initial concentration of any contaminant originating from the site or AOC in any ground water delineation sample exceeds its applicable ground water remediation standard, the ground water may be resampled to confirm the presence of contamination. Two confirmation samples should be collected approximately 30 days apart using similar purging and sampling techniques within a 60-day time period of the initial sampling event. Average the results from the original sampling event along with the two confirmation sampling events to determine compliance with the applicable standard. Averaging is not allowed for demonstrating attainment when the initial result is more than three times (3x) the applicable ground water standard or screening level. For example, if the initial result is more than three times the ground water remediation standard, compliance with the standard cannot be achieved and additional delineation is required. If the average does not exceed the applicable ground water remediation standard, then ground water delineation at the point of sample collection is considered to be complete. Individual sample results should not be rounded prior to calculating the average contaminant concentration. Rounding of the average concentration value is acceptable and should be conducted to the number of significant figures expressed in the applicable ground water remediation standard.

If the ground water contaminant concentration in any perimeter sample exceeds its applicable ground water remediation standard, then the investigator should continue to collect ground water samples until delineation is completed pursuant to the preceding paragraphs or select an appropriate method to demonstrate delineation is completed. This is applicable for both horizontal and vertical delineation of all contaminated ground water impacts originating from the site or AOC.

Once ground water delineation is complete, a Classification Exception Area (CEA) is required to be established pursuant to N.J.A.C. 7:26E-4.9 and N.J.A.C. 7:26C-7 for all ground water impacted by contamination originating from the site or AOC.

7.3.4 Remedial Action

Pursuant to N.J.A.C. 7:26E, ground water contamination associated with an on-site discharge remaining above the applicable ground water remediation standards needs to be remediated. This requires some form of remedial action such as active remediation or passive remediation (monitored natural attenuation [MNA]), the establishment of a CEA, and the issuance of a Ground Water Remedial Action Permit.

The following options can be used to determine ground water compliance during the Remedial Action phase:

If the concentration of any site-related contaminant exceeds its applicable ground water remediation standard, then the ground water remedial action will not be considered complete. When contamination

remains, the person responsible for conducting the remediation is to continue with the ground water remedial action until compliance with applicable ground water remediation standards is achieved within the delineated extent of site-related contamination. A CEA and a Ground Water Remedial Action Permit are to remain in effect until compliance with the applicable ground water remediation standards is achieved at all locations within the delineated extent of site-related contamination. Any ground water impacts associated with historic fill should be addressed by the establishment of a CEA for historic fill related contamination. Once established, the historic fill CEA becomes the responsibility of the Department.

Compliance with the ground water remediation standards is achieved for the site or AOC when the concentration of each site-related contaminant is less than or equal to its applicable ground water remediation standard for two consecutive confirmatory sampling events, taken far enough apart so that the time between sampling events accounts for seasonal variations such as ground water table fluctuations (N.J.A.C. 7:26C-7.9(f)). This applies to all locations within the delineated extent of contamination associated with the site or AOC.

Rounding of single point compliance data is acceptable. Rounding should be conducted to the number of significant figures expressed in the applicable remediation standard. Refer to N.J.A.C. 7:26C-7.9(f) for the requirements for conducting the confirmation sampling and removal of the CEA.

For the two confirmatory sampling events, if, after rounding as discussed above, the concentration of any contaminant in any ground water sample within the ground water monitoring well network exceeds its applicable ground water remediation standard, the ground water may be resampled to confirm the presence of contamination for that specific sampling event. Two confirmation samples should be collected approximately 30 days apart using similar purging and sampling techniques within a 60-day time period of the initial sampling event. Average results from the initial sampling event along with the two confirmation sampling events to determine compliance with the applicable standard. Averaging is not allowed for demonstrating compliance when the initial sample result is more than three times (3x) the applicable ground water standard or screening level. Individual sample results should not be rounded prior to calculating the average contaminant concentration. Rounding of the average concentration value is acceptable and should be conducted to the number of significant figures expressed in the applicable ground water remediation standard. If the average does not exceed the applicable ground water remediation standard, then ground water at that monitoring well is considered to be in compliance for that confirmatory sampling event.

The user is directed to the Department's "*Vapor Intrusion Technical Guidance*" (https://dep.nj.gov/srp/guidance/vapor-intrusion/) regarding additional compliance issues for the vapor intrusion pathway.

7.3.5 Receptor Evaluation – Ground Water

Pursuant to 7:26E-1.14, a receptor evaluation of ground water shall be conducted when any contaminant is detected in ground water in excess of any Class II ground water quality standard and certain triggers are met. Potable water data used to determine if an immediate environmental concern (IEC) exists is conducted using single point compliance. Rounding of such data should not be conducted. Potable water data used to determine the effectiveness of an engineered water treatment system is conducted using single point compliance. Rounding of such data should not be conducted.

8.0 SURFACE WATER

8.1 Surface Water Quality Standards

Pursuant to the Remediation Standards at N.J.A.C. 7:26D-3, surface water remediation standards are, by reference, the surface water quality standards developed pursuant to N.J.A.C. 7:9B (https://dep.nj.gov/wp-content/uploads/rules/rules/njac7_26d.pdf). For each contaminant originating from the site or AOC detected in surface water or in ground water samples collected immediately adjacent to surface water (and where it has been demonstrated that ground water is discharging into surface water), the investigator is to select human health-based surface water remediation standards pursuant to N.J.A.C. 7:26D-3. The surface water remediation standards should be selected based on the surface water classification applicable to where the discharge and impacts occur.

All surface water quality criteria for toxic substances are rounded to two significant figures. Note that pursuant to N.J.A.C. 7:26D-3.2(b), alternative remediation standards for surface water are not allowed.

8.2 Ecological Surface Water Screening Levels

Ecological surface water screening levels are discussed in the Department "*Ecological Evaluation Technical Guidance*" (https://dep.nj.gov/srp/guidance/#eco_eval).

8.3 Compliance

8.3.1 Site Investigation

The investigator is to use single point compliance to determine compliance with the applicable surface water remediation standards during the site investigation. Rounding of single point compliance data is acceptable. Rounding should be conducted to the number of significant figures expressed in the applicable remediation standard. If there are no exceedances of the applicable surface water remediation standards for any contaminants originating from the site or AOC, then no further action is required for surface water at the site or AOC relative to the surface water remediation standards. However, it is still necessary to determine whether there are exceedances of any surface water screening levels for the ecological evaluation of the site or AOC; refer to the Department "*Ecological Evaluation Technical Guidance*" (https://dep.nj.gov/srp/guidance/#eco_eval).

If the concentration of any contaminant originating from the site or AOC exceeds its applicable surface water remediation standard in any surface water sample, then the investigator is to conduct a remedial investigation of surface water for the site or AOC pursuant to N.J.A.C. 7:26E-4.4 and the Department's "*Ecological Evaluation Technical Guidance*" (https://dep.nj.gov/srp/guidance/#eco_eval).

8.3.2 Remedial Investigation

If the investigator chooses to use single point compliance for the remedial investigation of surface water, then the remedial investigation will be considered complete when surface water contaminant concentrations that are originating from the site or AOC are less than or equal to the applicable surface water remediation standard for each contaminant present. Rounding of single point compliance data is

acceptable. Rounding should be conducted to the number of significant figures expressed in the applicable remediation standard.

Alternative methods for determining compliance can be applied on a site-specific basis using applicable technical guidance as specified in the Site Remediation Reform Act (SRRA, N.J.S.A. 58:10C-14c).

If concentrations of contaminants originating from the site or AOC detected in surface water exceed the applicable surface water remediation standard, then the investigator is to continue to collect surface water samples until the remedial investigation is completed pursuant to the preceding paragraph. The investigator should consult the Department's "*Ecological Evaluation Technical Guidance*" (https://dep.nj.gov/srp/guidance/#eco_eval) or other applicable technical guidance as specified in SRRA.

8.3.3 Remedial Action

The investigator is to determine whether the surface water remedial action is protective of human health and of the environment, and whether additional remediation or no further action is required for surface water. As with the remedial investigation, either single point compliance or an alternative compliance method may be used. Rounding of single point compliance data is acceptable. Rounding should be conducted to the number of significant figures expressed in the applicable remediation standard.

If the concentration of each contaminant originating from the site or AOC is less than or equal to its applicable surface water remediation standard, then the surface water remedial action will be considered complete. However, it is still necessary to determine whether there are exceedances of any surface water screening levels for the ecological evaluation of the site or AOC; refer to the Department "*Ecological Evaluation Technical Guidance*" (https://dep.nj.gov/srp/guidance/#eco_eval).

If the concentration of any contaminant originating from the site or AOC exceeds its applicable surface water remediation standard, then the surface water remedial action will not be considered complete, and the investigator is to continue with the surface water remedial action until compliance with the applicable surface water remediation standards is achieved for all contaminants originating from the site or AOC.

9.0 EXTRACTABLE PETROLEUM HYDROCARBONS

Requirements for investigations of extractable petroleum hydrocarbons (EPH) are found in the Department guidance document "*Evaluation of Extractable Petroleum Hydrocarbons in Soil Technical Guidance*" document (https://dep.nj.gov/srp/guidance/#eph_soil) in effect as of the date the report is submitted. The user is directed to this guidance document for information regarding how to select and/or develop the applicable remediation standards for petroleum hydrocarbons.

10.0 ECOLOGICAL

Requirements for conducting ecological investigations are found in the Technical Requirements, at N.J.A.C. 7:26E-1.16 and N.J.A.C. 7:26E-4.8. Additional guidance is found in the Department

"*Ecological Evaluation Technical Guidance*" (https://dep.nj.gov/srp/guidance/#eco_eval) in effect as of the date the report is submitted. The user is directed to this guidance document for information regarding how to select and/or develop the applicable remediation standards for ecological evaluations.

Site-specific ecological risk-based remediation goals for soil and sediment are rounded in the same way as direct contact exposure pathway soil remediation standards. Ecological remediation goals should be rounded to two significant figures using the rounding rules in Appendix B of this document. If ecological screening criteria are used directly as remediation goals, the same rounding procedure would apply.

Site data used to demonstrate compliance with the ecological remediation goals should be rounded to the same number of significant figures expressed in the ecological remediation goal using the rounding rules in Appendix B of this document.

11.0 VAPOR INTRUSION

The primary guidance for investigations of the vapor intrusion exposure pathway is the Department "*Vapor Intrusion Technical Guidance*" (https://dep.nj.gov/srp/guidance/vapor-intrusion/) in effect as of the date the report is submitted. The user is directed to this guidance document for information regarding how to select and/or develop the applicable remediation standards for the various media involved in a vapor intrusion investigation. Indoor air data used to determine if a vapor intrusion immediate environmental concern (IEC) or vapor concern (VC) exists is conducted using single point compliance. Rounding of such data should not be conducted. Indoor air data used to determine the effectiveness of an engineered vapor control system is conducted using single point compliance. Rounding of such data should not be conducted.

Ground water screening levels and soil gas screening levels associated with vapor intrusion investigations are evaluated using single point compliance. Rounding of ground water and soil gas screening level data is acceptable when such data are evaluated using single point compliance. Rounding should be conducted to the number of significant figures in the applicable screening level using the rounding rules in Appendix B of this document.

In addition, ground water screening level data associated with vapor intrusion investigations may be averaged pursuant to Section 12.0 of this guidance.

12.0 COMPLIANCE AVERAGING OPTIONS FOR THE INGESTION-DERMAL, INHALATION, AND MIGRATION TO GROUND WATER EXPOSURE PATHWAYS

12.1 Functional Areas

The use of functional areas facilitates the process of evaluating contaminated areas of the site. The purpose of the functional area is to help select the samples to be included in the compliance averaging process to define representative exposure concentrations within residential and nonresidential land uses. Compliance averaging using the arithmetic mean, 95% UCL of the mean concentration, and spatially

weighted averaging employs a fixed area approach ("functional area"). The data to be selected are to include those required to delineate the AOC encompassed by the functional area(s). Data below regulatory concern other than those needed to delineate the AOC would not be included (except in the case of spatially weighted averaging, see Section 12.4). Data from AOCs that are not of regulatory concern also would not be included. To the degree practicable, the placement of the initially assessed functional area shall be biased to the worst-case contaminant concentrations for the ingestion-dermal and inhalation exposure pathways.

Ingestion-Dermal and Inhalation Pathways

For the ingestion-dermal and inhalation exposure pathways the "functional areas" correspond to the areas of typical residential and nonresidential sites, which in some cases are constrained by the extent or distribution of contamination, or the size of the property under investigation.

For example, if the site is five acres in size, but contamination is limited to only two acres, only this two-acre portion of the site requires evaluation. To determine whether to use the residential or nonresidential functional area, the anticipated future land use should be taken into account. The investigator then assesses whether there is an exceedance of the remediation goal within each individual functional area. If the site is less than the functional area size, the functional area size defaults to that of the site.

Migration to Ground Water Pathway

For the migration to ground water exposure pathway, the functional area is based on the size of the AOC. The relevant dimension is the length of the AOC in the direction parallel to ground water flow (see Section 12.1.1.3). The width of the AOC in the direction perpendicular to ground water flow is based upon the delineated extent of contamination.

12.1.1 Size of Functional Area

The purpose of the functional area is to help select the samples to be included in the compliance averaging process to define representative exposure concentrations within residential and nonresidential land uses.

12.1.1.1 Inhalation Exposure Pathway

The functional area for residential inhalation exposure scenarios will be 0.5 acre, and 2.0 acres for nonresidential exposure scenarios. For the explanation of how these functional area sizes were developed, refer to Appendix H - Site Size Justification of the document "*Soil Remediation Standards for the Inhalation Exposure Pathway, Basis and Background*", May 2021 (https://dep.nj.gov/srp/guidance/rs/).

If more than one functional area is to be evaluated, and the contaminated areas of the site cannot be divided exactly, the size of the final functional area to be evaluated can be increased by up to 50 percent. Examples are as follows:

Residential site - functional area = 0.5 acres

- Site size is 0.75 acres, the entire site can be evaluated as one functional area

- Site size is 1.2 acres, would require two functional areas, the first being 0.5 acres, the second 0.7 acres

Nonresidential site - functional area = 2.0 acres

- Site size is 3.0 acres, the entire site can be evaluated as one functional area.
- Site size is 4.3 acres, would require two functional areas, the first being 2.0 acres, and the second 2.3 acres

Similarly, if the site size is less than 0.5 acres for a residential site or less than 2.0 acres for a nonresidential site, the default functional area is applied, and the applicable residential or nonresidential inhalation soil remediation standard applied.

It should be noted that use of a 2.0-acre functional area within a nonresidential site to achieve compliance with a nonresidential inhalation SRS requires the establishment of an institutional control-only Deed Notice[1], Soil Remedial Action Permit (S-RAP) and Limited Restricted Response Action Outcome (RAO). This is necessary to ensure that the remedy remains protective in the event of future land use changes to residential use. A 2.0-acre functional area cannot be used to achieve compliance with a residential inhalation SRS to support an Unrestricted Use RAO. A functional area size of 0.5 acre is necessary to achieve compliance with residential inhalation SRS and Unrestricted Use.

12.1.1.2 Ingestion-Dermal Exposure Pathway

The functional area for residential ingestion-dermal exposure scenarios will be 0.25 acres. In the case of the non-residential exposure scenarios, the functional area will be 2.0 acres, the default nonresidential site lot size. The residential ingestion-dermal exposure scenario of 0.25 acres represents one-half of the residential lot size and assumes that ingestion of contamination is occurring in either the front yard or the back yard of the residence.

If more than one functional area is to be evaluated, and the contaminated areas of the site cannot be divided exactly, the size of the final functional area to be evaluated can be increased by up to 50 percent Examples are as follows:

Residential site - functional area = 0.25 acres

- Site size is 0.33 acre, the entire site can be evaluated as one functional area.
- Site size is 1.1 acres, would require four functional areas, three being 0.25 acres, and the fourth 0.35 acres

Nonresidential site - functional area = 2.0 acres

- Site size is 2.3 acres, the entire site can be evaluated as one functional area.
- Site size is 4.3 acres, would require two functional areas, the first being 2.0 acres, and the second 2.3 acres

[1] An institutional control-only Deed Notice and associated S-RAP does not entail placement of an engineering control (e.g cap) and does not require financial assurance (FA). It does require payment of an annual remedial action permit fee and submittal of a Biennial Certification by the site PRCR/co-permitee, with certification by an LSRP.

Similarly, if the site size is less than 0.25 acres for a residential site or less than 2 acres for a nonresidential site, the default functional area is applied, and the applicable residential or nonresidential ingestion-dermal soil remediation standard applied.

It should be noted that use of a 2.0 acre functional area within a nonresidential site to achieve compliance with a nonresidential direct contact SRS requires the establishment of an institutional control-only Deed Notice[2], Soil Remedial Action Permit (S-RAP) and Limited Restricted Response Action Outcome (RAO). This is necessary to insure that the remedy remains protective in the event of future land use changes to residential use. A 2.0-acre functional area cannot be used to achieve compliance with a residential direct contact SRS to support an Unrestricted Use RAO. A functional area size of 0.25 acre is necessary to achieve compliance with a residential direct contact SRS and Unrestricted Use.

12.1.1.3 Migration to Ground Water Exposure Pathway

The functional area for the migration to ground water exposure pathway is defined by the area of concern (AOC). The length is defined as the part of the AOC parallel to ground water flow and is not necessarily the longest dimension of the AOC. The 100 foot length is the AOC length value included in the dilution attenuation factor (DAF) equation utilized in the derivation of the soil remediation standards for the migration to ground water exposure pathway the Remediation Standards at N.J.A.C. 7:26:D Appendix 1, Table 5.

For AOCs with a length up to and including 100 feet in the direction parallel to ground water flow, a length of 100 feet in the direction parallel to ground water flow can be used as the functional area if the investigator:

- Wants to use the soil remediation standards for the migration to ground water exposure pathway found in the Remediation Standards at N.J.A.C. 7:26:D Appendix 1, Table 5.; or

- Has already calculated a site-specific standard using a default length of 100 feet in the direction parallel to ground water flow but with other site-specific parameter values.

Delineated AOCs situated downgradient of each other whose total length (including "gaps" between AOCs) does not exceed 100 feet can be combined into a single functional area.

If the size of the AOC is larger than 100 feet in the direction parallel to ground water flow, the investigator can evaluate the AOC using the following approaches:

- If the default DAF is used, multiple functional areas of 100 feet length in the direction parallel to the direction of ground water flow as described above. To the degree practicable, the placement of the initially assessed functional area should be biased to the worst-case contaminant concentrations; or

[2] An institutional control-only Deed Notice and associated S-RAP does not entail placement of an engineering control (e.g cap) and does not require financial assurance (FA). It does require payment of an annual remedial action permit fee and submittal of a Biennial Certification by the site co-permittee, with certification by an LSRP.

- The entire delineated AOC as the functional area. If this option is chosen, then a site-specific DAF and an alternative soil remediation standard for the migration to ground water exposure pathway are to be calculated using the length of the entire AOC as the functional area parallel to the direction of ground water flow.

12.1.2 Shape of Functional Area

12.1.2.1 Ingestion-Dermal and Inhalation Exposure Pathways

Pursuant to the existing "*Alternative Remediation Standards Technical Guidance for Soil for the Ingestion-Dermal and Inhalation Exposure Pathways* " (https://dep.nj.gov/srp/guidance/#ars_ingestion), the preferred shape of the functional area is that of a square (Figure 1 below) but can vary somewhat based on site configuration and contamination distribution. However, it is preferred that the length of the functional area be kept to no more than four times the width (Figure 2 below). For consistency, the same shape restrictions apply to both the ingestion-dermal and inhalation exposure pathways.

Figure 1: Preferred shape of functional area - square

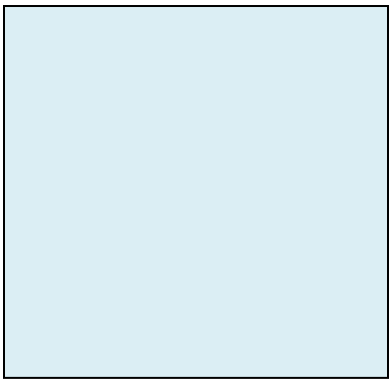
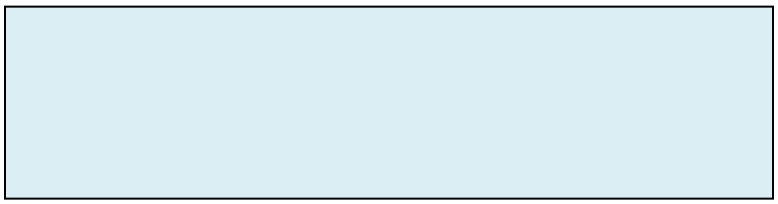


Figure 2: Maximum offset shape of functional area



12.1.2.2 Migration to Ground Water Exposure Pathway

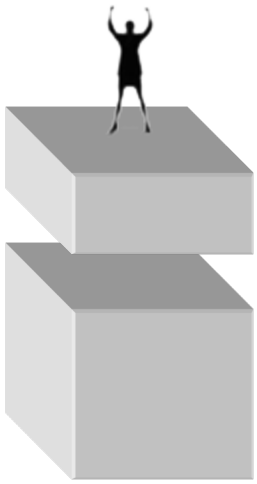
The shape of the functional area is based on the length of the AOC in the direction parallel to ground water flow (default maximum length of 100 feet), and the delineated extent of contamination in all other directions.

12.1.3 Vertical Definition of Functional Area

12.1.3.1 Ingestion-Dermal and Inhalation Exposure Pathways

In all cases, there is a surface zone of 0 to 2 feet below ground surface (bgs) and one subsurface zone (greater than 2 feet bgs) associated with the site being evaluated (Figure 3). The surface zone will encompass both surface samples (0.0 to 0.5 feet) as well as any other samples taken at 2 feet of depth or less. The final vertical depth for the subsurface zone shall be determined pursuant to the delineation requirements set forth in N.J.A.C. 7:26E. These depth intervals are based on general assumptions on the potential and likelihood of soil disturbance. Based on the contaminant distribution pattern in both the surface and subsurface zones, the functional areas within the subsurface vertical zones may need to be placed and evaluated distinctly from the comparable functional areas within the surface vertical zone.

Figure 3: Vertical definition of functional area - ingestion-dermal and inhalation exposure pathways



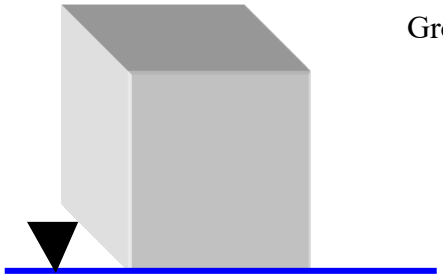
Surface (0 to 2 feet bgs) vertical zone

Subsurface (greater than 2 feet bgs) vertical zone

12.1.3.2 Migration to Ground Water Exposure Pathway

For the migration to ground water exposure pathway there is a single vertical zone, consistent with the assumptions inherent in the soil-water partition equation used to calculate default SRS-MGW. This zone is from the ground surface to the depth of the water table. Unlike the direct contact exposure pathways, the receptor for migration to ground water exposure pathway is the ground water. Only those samples present in the vadose zone (ground surface to water table) are to be included in the evaluation; samples collected from below the water table should be excluded from the calculation.

Figure 4: Vertical definition of functional area - migration to ground water exposure pathway



Ground surface (0 feet) to the depth of water table (site specific)

12.1.4 Offsite Compliance

12.1.4.1 Ingestion-Dermal and Inhalation Exposure Pathways

For the ingestion-dermal and inhalation exposure pathways, if delineation indicates that contamination has migrated offsite at any depth, then delineation and compliance with the applicable soil remediation standard shall be determined by applying the most stringent applicable standard to the offsite contaminated area. Pursuant to the Technical Requirements, contamination migrating offsite is to be delineated to the unrestricted use standard (N.J.A.C. 7:26E-4.2(a)2). Therefore, the contaminated offsite area shall be addressed separately, and the calculated average compared to the most stringent soil remediation standard, irrespective of its current land use.

If the functional area compliance evaluation for the offsite area indicates that there are no exceedances of the most stringent soil remediation standard in the worst-case area, then no further remediation of the offsite contamination is required for either the ingestion-dermal or the inhalation exposure pathways. This does not preclude the need for additional remediation for the offsite area being evaluated based on the migration to ground water exposure pathway. If the compliance evaluation for the offsite functional area indicates that there is an exceedance of the most stringent soil remediation standard, a remedial action will be required; this may involve removal, treatment, or establishment of an institutional control, with or without an engineering control.

12.1.4.2 Migration to Ground Water Exposure Pathway

For the migration to ground water exposure pathway, the functional area is defined by the associated AOC, which may extend across property boundaries.

12.1.5 Functional Area Size Development with an Alternate Remediation Standard

This document establishes guidance on the size of functional areas associated with residential and nonresidential site use as discussed in Section 12.1.1. If an Alternate Remediation Standard (ARS) is developed pursuant to the Department's "*Alternative Remediation Standards Technical Guidance for Soil for the Ingestion-Dermal and Inhalation Exposure Pathways"* (https://dep.nj.gov/srp/guidance/#ars_ingestion) based on an exposure scenario other than residential or nonresidential (e.g., recreational land use), which is approved by the Department, and the investigator chooses to utilize compliance averaging in conjunction with the ARS and also develop functional area sizes that are different than those contained in this guidance, then a Technical Consultation with the Department should be requested. Also note that use of this option requires the establishment of an

institutional control-only Deed Notice[3], Soil Remedial Action Permit (S-RAP) and Limited Restricted Response Action Outcome (RAO). This is necessary to ensure that the remedy remains protective in the event of future land use changes to residential use.

12.2 Compliance Averaging Using the Arithmetic Mean

Compliance averaging using the arithmetic mean is to be applied in those situations where analytical data from nine or fewer distinct sample points are used in the calculation of an average. Samples collected vertically from a single coring location are considered distinct sampling points. This situation commonly occurs at areas of concern (AOCs) where the extent of contamination is small, and delineation of contamination can be accomplished using nine or fewer delineation samples. This situation also occurs when small volume soil excavations require nine or fewer post excavation samples. Calculation of the arithmetic mean is used in lieu of calculation of the 95% Upper Confidence Level (UCL) of the mean as too few samples may result in an unrealistically high estimate of the 95% UCL and may call the validity of the analysis into question. Therefore, a minimum of 10 samples are required to calculate the 95% UCL of the mean.

If this compliance option is to be used in the remedial investigation phase, complete horizontal and vertical delineation using single point compliance must first be completed. Pursuant to N.J.A.C. 7:26E-3.4(a), sampling shall be biased towards the AOC. This compliance averaging method should not include excessive sampling of uncontaminated areas. For the purposes of this document, "excessive sampling" is considered as more than the minimum needed to complete the delineation as defined by N.J.A.C. 7:26E.

To determine the arithmetic mean value of the data set, add up all the sample values, and divide by the total number of samples. For non-detect (ND) values, enter ½ of the Reporting Limit (RL) concentration for the specific analyte as reported in the laboratory analytical data package. For each sample where ½ of the RL is being used to replace a ND in the calculation, the Analytical Results Summary Form (N.J.A.C 7:26E - Appendix A, II Reduced Deliverable Requirements at (b)1, (c)1, (d)1, and (e)1) shall be included in the report (i.e. RAW or RAR) where compliance averaging is being utilized. Please see Appendix C for additional information on how to address NDs. While the median value option may be preferentially selected by statisticians (as opposed to the arithmetic mean value), the arithmetic mean value is to be used as a measure of conservatism to avoid the allowance of hot spots to go unremediated. The data as reported by the laboratory should not be rounded prior to calculating the arithmetic mean. However, the resultant mean value may be rounded to the number of significant figures in the applicable remediation standard.

In addition, compliance averaging using the arithmetic mean is also applied in those situations where analytical data from more than nine distinct sample points are used in the calculation but there are no more than two distinct sample concentration values. For example, 10 samples are used for compliance averaging with values of 2, 2, 2, 2, 2, 2, 3, 3, 3, and 3 mg/kg. While there are 10 distinct samples, there are only two distinct sample concentration values. Under this scenario, compliance averaging using the arithmetic mean should be used. This scenario does not occur often, with the typical scenario being a single sample with a contaminant level in excess of the remediation standard and all delineation samples

[3] An institutional control-only Deed Notice and associated S-RAP does not entail placement of an engineering control (e.g. cap) and does not require financial assurance (FA). It does require payment of an annual remedial action permit fee and submittal of a Biennial Certification by the site co-permittee, with certification by an LSRP.

surrounding the initial contaminated sample being non-detect (i.e., ½ of the RL as noted above, which is considered a sample concentration). ProUCL software cannot accurately calculate the 95% UCL of the mean when there are less than three distinct sample concentrations in the data set.

To determine if an arithmetic mean concentration is protective of human health and the environment, an appropriate application area (functional area) should be first defined, using the procedures discussed in Sections 12.1 through 12.1.3. above. Once the functional area has been defined, the average can be estimated as follows: In all cases, each individual contaminant detected in the vertical zones (surface, subsurface) of the functional area (Section 12.1.3) is evaluated by comparing the arithmetic mean of the selected data set against the applicable standard. The data to be selected are to include those required to delineate the AOC encompassed by the functional area. Data below regulatory concern other than those needed to delineate the AOC would not be included.

12.3 Compliance Averaging at the 95% Upper Confidence Limit of the Mean

As indicated in Sections 6.7.4.1, 6.7.4.2, 6.7.5.1 and 6.7.5.2, compliance averaging at the 95% Upper Confidence Limit (UCL) can be conducted for these exposure pathways in the remedial investigation and/or the remedial action phases. If this compliance option is to be used in the remedial investigation phase, complete horizontal and vertical delineation using single point compliance must first be completed. Pursuant to N.J.A.C. 7:26E-3.4(a), sampling shall be biased towards the AOC. This compliance averaging method should not include excessive sampling of uncontaminated areas. For the purposes of this document, "excessive sampling" is considered as more than the minimum needed to complete the delineation as defined by N.J.A.C. 7:26E. Sample results used in calculation of the 95% UCL should not be rounded. The resultant 95% UCL value, however, may be rounded. Rounding should be conducted to the number of significant figures in the applicable remediation standard.

To determine compliance with the applicable soil remediation standard, the investigator can estimate the average of the sample concentrations at the 95% UCL, using appropriate statistical methods. These calculations should be performed by a person qualified in statistical analysis. The use of the software application ProUCL is suggested. Statistics manuals provide recommendations for the minimum number of samples needed for this type of analysis. Too few samples may result in an unrealistically high estimate and may call the validity of the analysis into question. Therefore, a minimum of 10 distinct samples are required for the use of the 95% UCL. In addition, ProUCL cannot calculate a 95% UCL if there are two or fewer distinct sample values (see the discussion in Section 12.2 above).

To estimate a compliance average that is protective of human health and the environment, an appropriate application area (functional area) must be first defined, using the procedures discussed above in Section 12.1. Once the functional area has been defined, the average can be estimated as described below. In all cases, each individual contaminant detected in the vertical zones (surface, subsurface) is evaluated by comparing the 95% UCL of the mean of the selected data against the applicable standard. The data to be selected are to include those required to delineate the AOC encompassed by the functional area(s). Data below regulatory concern other than those needed to delineate the AOC would not be included.

The 95% UCL of the mean approach is used by the United States Environmental Protection Agency (U.S. EPA) for situations where, from a statistical perspective, there is a limited amount of data for a given AOC or site. All data necessary for delineation within a given functional area and vertical zone(s) are utilized in the evaluation.

An algorithm that properly addresses non-detect results should be used to evaluate the data. The program ProUCL is widely used and can be downloaded from the U.S. EPA website (go to https://www.epa.gov/land-research/proucl-software for the most up-to-date version of this software). The investigator can elect to utilize other software, but they must provide documentation on the algorithm used, and the underlying assumptions and techniques employed. For non-detect (ND) values, enter ½ of the RL concentration for the specific analyte as reported in the laboratory analytical data package. For each sample where ½ of the RL is being used to replace a ND value in the calculation, the Analytical Results Summary Form (N.J.A.C 7:26E - Appendix A, II Reduced Deliverable Requirements at (b)1, (c)1, (d)1, and (e)1) shall be included in the report (i.e. RAW or RAR) where compliance averaging is being utilized. Please see Appendix C for additional information on how to address NDs.

If more than one suggested UCL is provided by the algorithm used, the lower value should be selected in the evaluation.

If the calculated UCL is greater than all values in the data set, the maximum sample value in the data set should be used for evaluation.

12.4 Compliance Averaging using a Spatially Weighted Average

As indicated in Sections 6.7.4.1, 6.7.4.2, 6.7.5.1 and 6.7.5.2, compliance averaging using a weighted average can be conducted for all exposure pathways in the remedial investigation and/or the remedial action phases. If this compliance option is used, complete horizontal and vertical delineation using single point compliance is required for completion of the remedial investigation. Sample results used in spatially weighted averaging should not be rounded when constructing polygons and calculating the spatially weighted average. The resultant spatially weighted average, however, may be rounded. Rounding should be conducted to the number of significant figures in the applicable remediation standard.

To determine compliance with the applicable soil remediation standard, a spatially weighted average (area weighted mean) may be used whereby the sampling results are weighted according to the area they represent. The corresponding area may be defined using Thiessen Polygons (also known as Voronoi or Dirichlet tessellations). Polygons define individual areas of influence around each set of points. Thiessen polygons are polygons whose boundaries define the area that is closest to each point relative to all other points; they are mathematically defined by the perpendicular bisectors of the lines between all points. These calculations are typically performed using CAD or GIS software[4], or can be performed manually. The results of each sample are adjusted for the percentage of the overall area the corresponding sample represents, and the adjusted values are averaged. Since the sample results as part of this averaging method are weighted relative to each other, all samples located within a functional area may be included in the SWA calculation (this is in contrast to the arithmetic mean and 95% UCL averaging methods, where the samples used in the calculations are limited to those used to define the AOC or AOCs with the functional area).

The methods for determining the size of the functional area and for the vertical subsurface zones to be used for the analyses are the same as defined for the 95% UCL of the mean in Sections 12.1.1 (size) and

[4] For example, in ESRI ARCVIEW, by selecting ArcToolbox > Analysis Tools > Proximity > Create Thiessen Polygons.

12.1.3 (vertical definition) above. As with the 95% UCL of the mean, the size and vertical definition of the functional area will be determined by the appropriate exposure pathway (ingestion-dermal, inhalation, or migration to ground water).

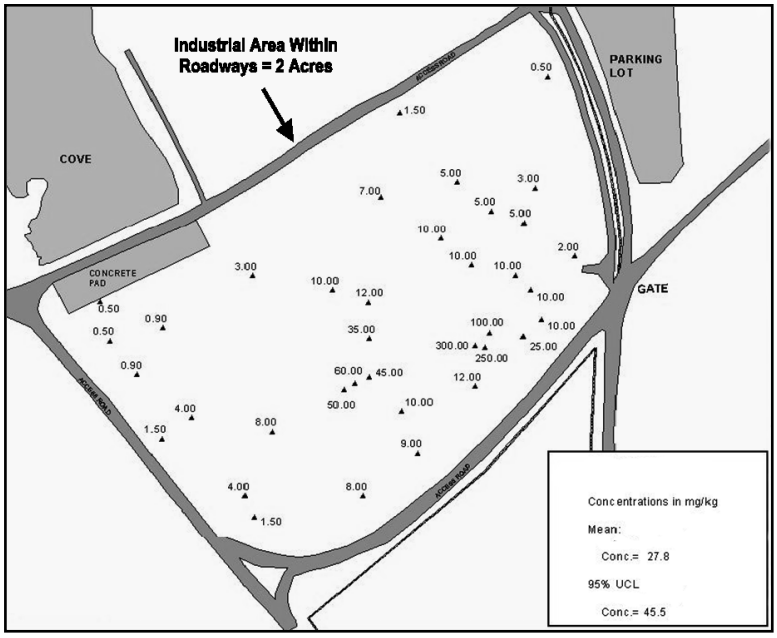
The spatial analysis must be performed within each of the vertical zones within which contaminant concentrations exceed the applicable remediation standard. If multiple samples exist within a boring within a single vertical zone (e.g., 2 feet through 12 feet bgs), the greatest concentration within that zone should be used in the analysis. For sites greater in size than the functional area (0.25 acres for residential and 2.0 acres for nonresidential land uses), multiple functional areas may be defined. To the degree practicable, the placement of the initially assessed functional area shall be biased to the worst-case contaminant concentrations.

To apply the spatially weighted average method, an iterative analysis is typically performed for each contaminant that exceeds the applicable remediation standard; this is illustrated in Figures 5 through 9 for a hypothetical contaminant in the surface zone (0 to 2 feet bgs). In these figures, the entire industrial site is approximately two (2) acres (representing the functional area for compliance averaging), and the applicable remediation standard is 8 mg/kg. In the first step, the data points are plotted (Figure 5). In the second step, the polygon boundaries are determined, and the initial area weighted mean concentration is calculated (Figure 6[5]). If this initial area weighted mean concentration is below the applicable remediation standard, then no further action is required. If this initial area weighted mean concentration is above the applicable remediation standard, then appropriate remedial action(s) must be evaluated. The first step in this evaluation is to replace the most highly contaminated polygon with a fill or background concentration, and then recalculate the area weighted mean concentration (Figure 7[5]). For non-detect (ND) values, enter ½ of the RL concentration for the specific analyte as reported in the laboratory analytical data package. For each sample where ½ of the RL is being used to replace a ND in the calculation, the Analytical Results Summary Form (N.J.A.C 7:26E - Appendix A, II Reduced Deliverable Requirements at (b)1, (c)1, (d)1, and (e)1.I) shall be included in the report (i.e. RAW or RAR) where compliance averaging is being utilized. Please see Appendix C for additional information on how to address NDs. This process continues progressively with the next most contaminated polygon(s) until the area weighted mean for the functional area is at or below the applicable remediation standard (Figures 8 and 9[5]). All polygons "removed" (replaced with actual analytical data for the fill, or, if such data are not available, a background concentration) as part of this evaluation are required to be remediated. For unrestricted use, "removed" polygons would be remediated to the fill or background concentration used in the calculation of the area weighted mean concentration. For limited restricted and restricted use, "removed" polygons would be subject to institutional and possibly engineering controls, as well as a remedial action permit for soil.

The construction of the polygons should be done using the data as reported by the laboratory. The spatially weighted average should be calculated using data that has not been rounded. The spatially weighted average may be rounded. Rounding should be conducted to the number of significant figures in the applicable remediation standard.

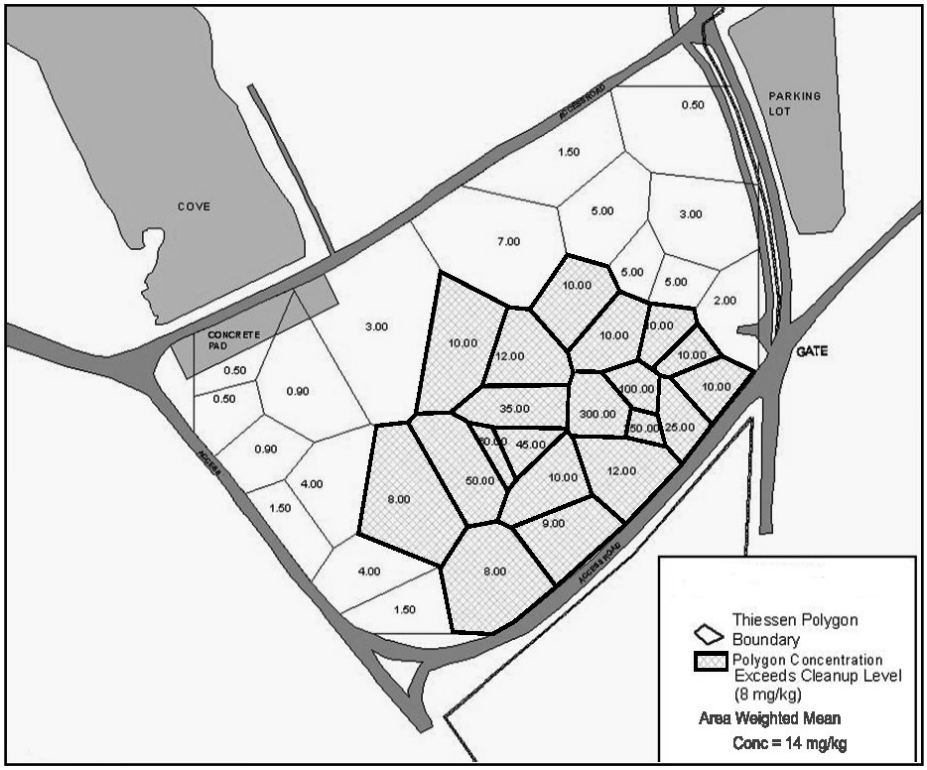
[5] Regarding Figures 6, 7, 8, and 9: These figures, obtained from a technical paper, are provided to illustrate the general application of spatially weighted averaging but do not necessarily address all provisions of this guidance regarding the appropriate size, shape, and placement of functional areas (contained in Section 12.1).

Figure 5: Location and concentration of surficial (0 - 2 feet) soil samples



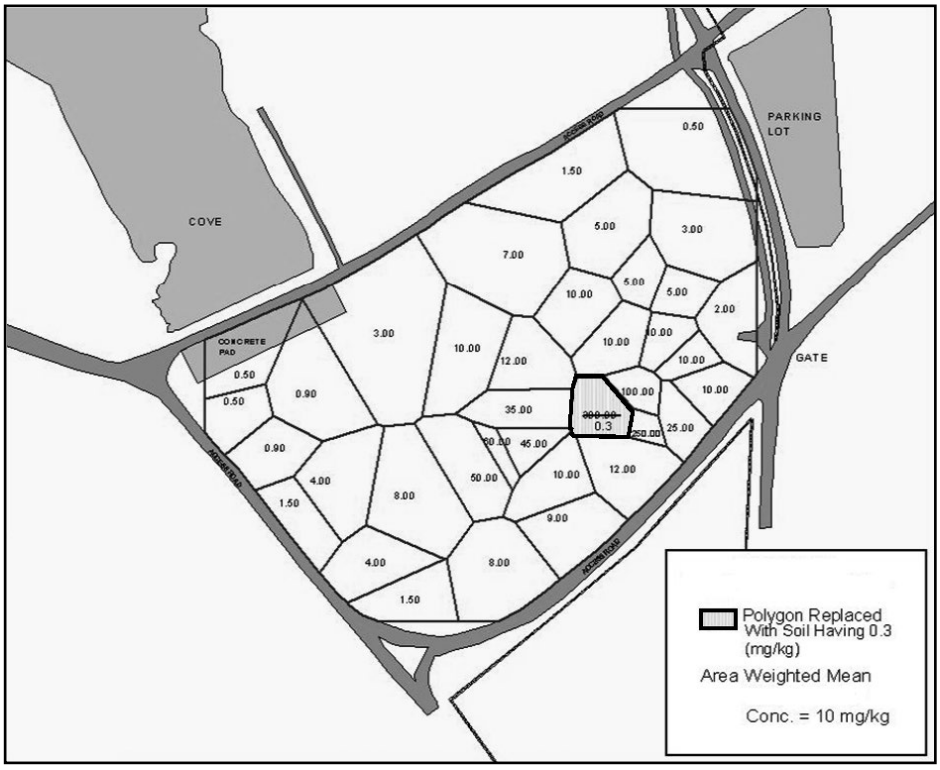
Source: Anderson and Samuelian, 2000

Figure 6: Delineation of Thiessen polygons indicating associated areal concentrations



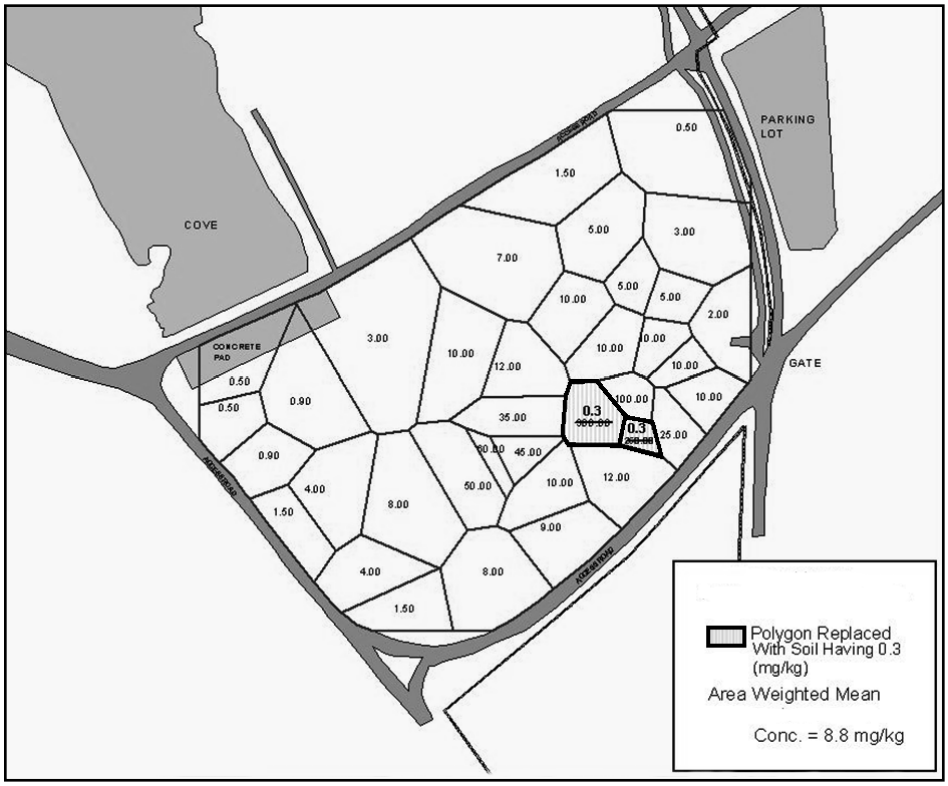
Source: Anderson and Samuelian, 2000

Figure 7: Iteration 1 - replacement of greatest concentration polygon with "background" concentration



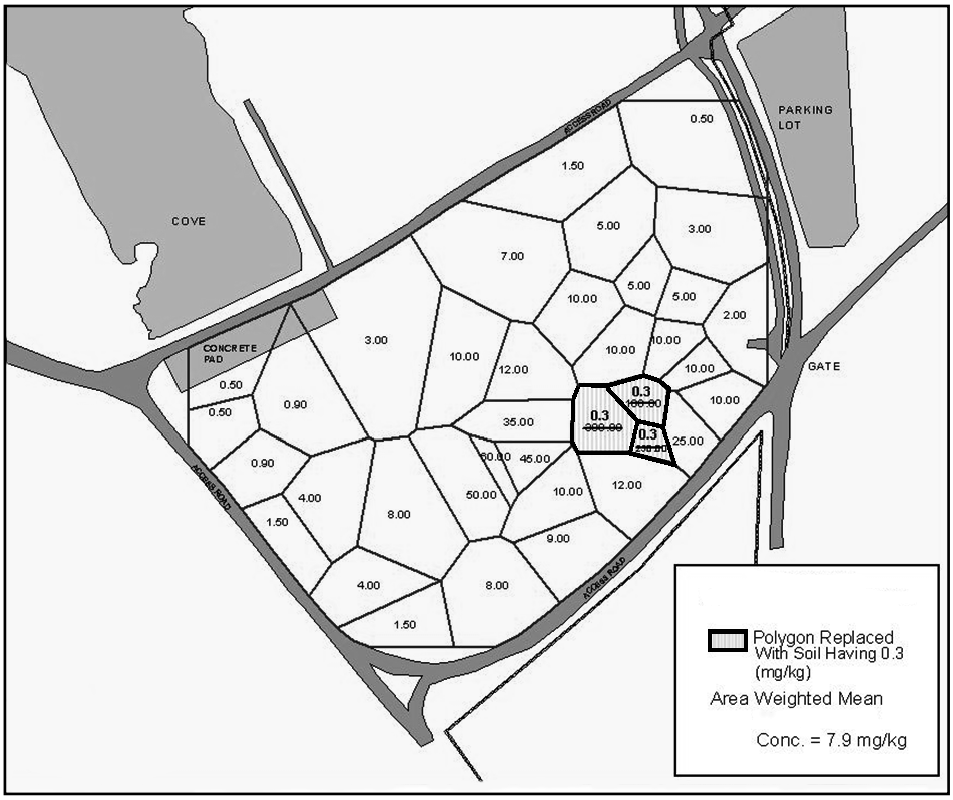
Source: Anderson and Samuelian, 2000

Figure 8: Iteration 2 - replacement of next greatest concentration polygon with "background" concentration



Source: Anderson and Samuelian, 2000

Figure 9: Iteration 3 - replacement of next greatest concentration polygon with "background"



Source: Anderson and Samuelian, 2000

12.5 Historic Fill – Special Considerations:

In addition to the methods identified in the "*Historic Fill Technical Guidance*" (https://dep.nj.gov/srp/guidance/#historic_fill), the contaminants associated with historic fill may be addressed with any of the methodologies contained in this guidance document. Functional areas must be established using the procedures discussed in Sections 12.1 through 12.1.3. For most AOCs with point discharges, the samples collected during the RI to fully delineate the contamination are usually sufficient to support the calculations for the methods contained in this guidance (i.e., 95% UCL, spatially weighted averaging, arithmetic mean). However, the options to address historic fill as presented in the "*Historic Fill Technical Guidance"* document may result in the collection of a limited number of samples, or even no sampling if one opts to assume the historic fill is contaminated ("*Historic Fill Technical Guidance"* – Section 5.4). This is problematic if the investigator chooses to apply compliance averaging options, in that one must have a sufficient number of samples in each functional area to support such averaging techniques.

If the investigator elects to address the contaminants associated with historic fill with a compliance averaging option, then functional areas must be established across the full extent of historic fill, with that extent determined pursuant Section 5.3 of the "*Historic Fill Technical Guidance"*. If remediation to the nonresidential SRS is being selected, then 2.0 acre sized functional areas would be appropriate; if remediation to the residential SRS is selected, then 0.25 acre sized functional areas (ingestion-dermal exposure pathway) or 0.5 acre sized functional areas (inhalation exposure pathway) would be appropriate. For each functional area, a minimum number of samples are needed to adequately characterize the historic fill and support the calculation as follows:

- Compliance with a residential ingestion-dermal based SRS will require 0.25 acre sized Functional Areas and a minimum of 3 samples per functional area, (see Figure 10).
- Compliance with a residential inhalation-based SRS will require 0.5 acre sized functional areas and a minimum of 4 samples per functional area (see Figure 11).
- Compliance with a nonresidential SRS will require a 2-acre sized functional area, and a minimum of 9 samples per functional area. (see Figure 12).

Note that in all of the above cases, use of the 95% UCL compliance option is not appropriate unless the required minimum of 10 samples are collected from each functional area.

Examples:

Figure 10

Compliance with a residential ingestion-dermal based SRS for 1 acre site = Four 0.25 acre-sized functional areas with 3 samples in each one

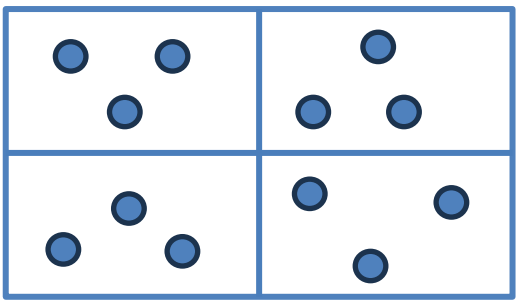


Figure 11

Compliance with a residential inhalation-based SRS for 1 acre site = Two 0.5 acre-sized functional areas with 4 samples in each one

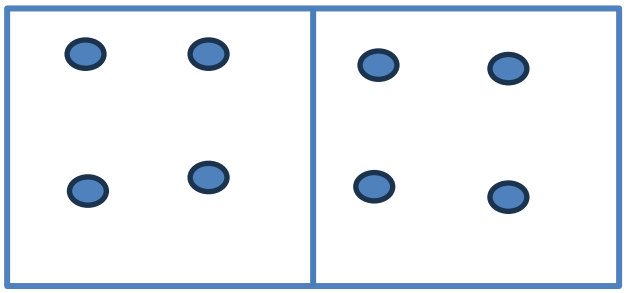
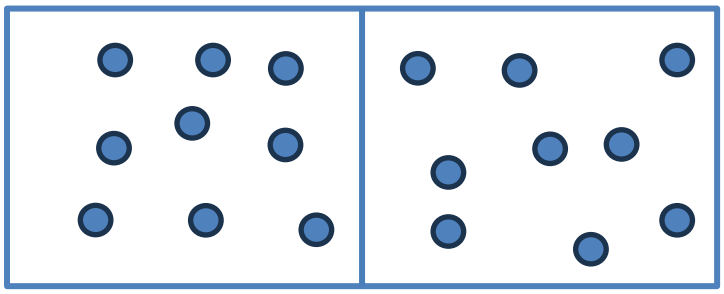


Figure 12

Compliance with a nonresidential SRS for a 4 acres site = Two 2 acre-sized functional areas, with a minimum of 9 samples in each one.



Samples used to characterize the historic fill within each functional area should be evenly distributed over the entire area to be representative.

12.6 Compliance Option using the 75%/10x Procedure

As indicated in Sections 6.7.5.1 and 6.7.5.2, compliance averaging using the 75%/10x procedure can only be conducted for the soil ingestion-dermal, inhalation and the migration to ground water exposure pathways after a remedial action has been conducted. This sampling scheme has been used successfully by the Pennsylvania Department of Environmental Protection (see Pennsylvania Department of Environmental Protection "Technical Guidance Manual" [January 19, 2019]).

A minimum of eight post-remedial samples are required per AOC for this compliance option to be utilized. Any smaller sample populations cannot use this method. The sample number is also based on the volume of soil excavated. To use this compliance option, 8 post-remedial samples are required for up to 125 cubic yards of excavated soil; 12 post-remedial samples for up to 3,000 cubic yards; and 12 additional samples for each soil volume up to 3,000 cubic yards thereafter. In addition, all collected samples used to demonstrate compliance must be collected within the zone of impact from the contaminants of concern. For example, if impacts above remediation standards were found at depths ranging from 2 to 4 feet and overlying soils were not impacted above standards, all samples used to demonstrate compliance must be taken from the 2 to 4-foot depth interval.

If 75% of all post-remedial samples are below the applicable soil remediation standard and none of the remaining samples exceed the applicable standard by an order of magnitude (10x), the remedial action is considered to have met the remedial objective and no further action is necessary. Individual sample results are not subjected to mathematical calculations when using this protocol. Therefore, individual sample results can be rounded. Rounding should be conducted to the number of significant figures in the applicable remediation standard.

In scenarios where remediation is performed in close proximity to a property line, professional judgement should be used to determine if remaining contamination along the boundary requires further

delineation to ensure that contamination is not migrating off-site at concentrations above the residential soil remediation standards for the ingestion-dermal and inhalation exposure pathways and SRS-MGW exposure pathway pursuant to N.J.A.C. 7:26E 4.2 (a) 1.i, 2, and 3. If additional property line and (or) off-site delineation is not performed in such cases, a variance and supporting documentation must be submitted pursuant to N.J.A.C 7:26E 1.7.

12.7 Supporting Data Deliverables and Examples

It is necessary for the Department to have a complete understanding of the location and characteristics of samples used to perform compliance averaging in accordance with the methods contained in this guidance. To this end, Appendix A contains examples of the data deliverables (tables, figures, data sheets, etc.) that should be submitted with the remedial phase report where these methods are utilized. The requested data deliverables should be readily available, as they are necessary for the calculation of the compliance averaging methods.

REFERENCES

Anderson, P.D. and J.H. Samuelian. 2000. *Iterating the Baseline Risk Assessment*. Ogden Environmental and Energy Services (currently AMEC Environment and Infrastructure).

ASTM. 2013. Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications. E29-13.
Florida DEP. 2011. Memorandum: Rounding Analytical Data for Site Rehabilitation Completion. November 2011.

ITRC. 2012. *Incremental Sampling Methodology*. February 2012.

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McHugh T.E., L.M. Beckley, C.Y. Liu, and C.J. Newell. 2011. *Factors Influencing Variability in Groundwater Monitoring Data Sets*. Ground Water Monitoring & Remediation, Volume 31 Issue 2. Spring 2011.

NJDEP. 2012. *Administrative Requirements for the Remediation of Contaminated Sites (N.J.A.C. 7:26C)*. May 2012.

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NJDEP. 2012. *Technical Requirements for Site Remediation (N.J.A.C. 7:26E)*. May 2012.

Oregon DEQ. 2013. The Use of Significant Figures and Rounding Conventions in Water Quality Permitting. DEQ11-WQ-050. Rev 1.3. December 2013.

PADEP. 2011. *Administration of Land Recycling Program, Demonstration of Attainment (§250.701 et seq.)*. January 2011.

USEPA. 1981. Memorandum: Procedures for Rounding-Off Analytical Data to Determine Compliance with Maximum Contaminant Levels Present in NIPDWR. WSG 20. April 1981.

USEPA. 2010. *ProUCL Version 4.1.00 Technical Guide (Draft)*. EPA/600/R-07/041. May 2010.

USEPA. 2017. Letter from Michael H. Shapiro, Acting Assistant Administrator to Dr. Edward Askew. Re: Clarification for the use of significant figures and rounding of results as they apply to regulatory compliance monitoring. July 2017.

Appendix A

Supporting Data Deliverables and Examples

Table of Contents

Figures and Tables

Appendix A

Supporting Data Deliverables and Examples

This appendix describes the data deliverables that should be submitted when using the averaging methods present in Section 12 of the guidance. It also includes some examples of figures/tables that illustrate how these averaging methods may be implemented.

A 1.0 Arithmetic Mean and 95% Upper Confidence Level of the Mean Methods

The following section includes an example of deliverables for the application of the 95% Upper Confidence Level (95% UCL) of the mean method. However, many of the deliverables also apply for the arithmetic mean method. If the application of 95% UCL of the mean or the arithmetic mean involves multiple functional areas and contaminants, please include a figure showing the different functional areas.

Description of Tables and Figures

Figure 1 provides an example of a figure that illustrates that horizontal and vertical delineation is complete, shows the location of each sample, depicts which samples are omitted from the compliance averaging calculations, provides sample concentrations and depths, and shows how the samples fit into the relevant functional area size. A scale bar and compass rose should be provided on the figures. Table 1 provides example of data tables which depict the sample name, depth, and concentration of the relevant contaminant for the samples used in the compliance averaging calculation for each functional area. It should be noted that figures and tables similar to Figure 1 and Table 1 should be provided for arithmetic mean calculations as well as 95% UCL.

Table 2 provides examples, for each functional area, of the format used for data inputs into EPA's ProUCL program used to calculate 95% UCL averages. The first column consists of concentrations of the contaminant of concern while the second column consists of 1s and 0s which indicate to the ProUCL program which concentrations are detects and non-detects, respectively. It should be noted that non-detect samples are input using ½ the laboratory Reporting Limit rather than a concentration of zero. Figures 2A and 2B provide abridged examples of an output from the ProUCL program where summary statistics are presented at the beginning and a 95% UCL is calculated at the end. It should be noted that the included ProUCL outputs are screenshots of only a portion of the full ProUCL program outputs. The inputs and outputs for each 95% UCL calculation should be provided to help expedite review of the compliance averaging procedure. The investigator is free to use the statistical program of their choice to calculate the 95% UCL; however, the input and output data should still be provided for other programs.

Figure 1. 95% UCL Lead Sampling Map

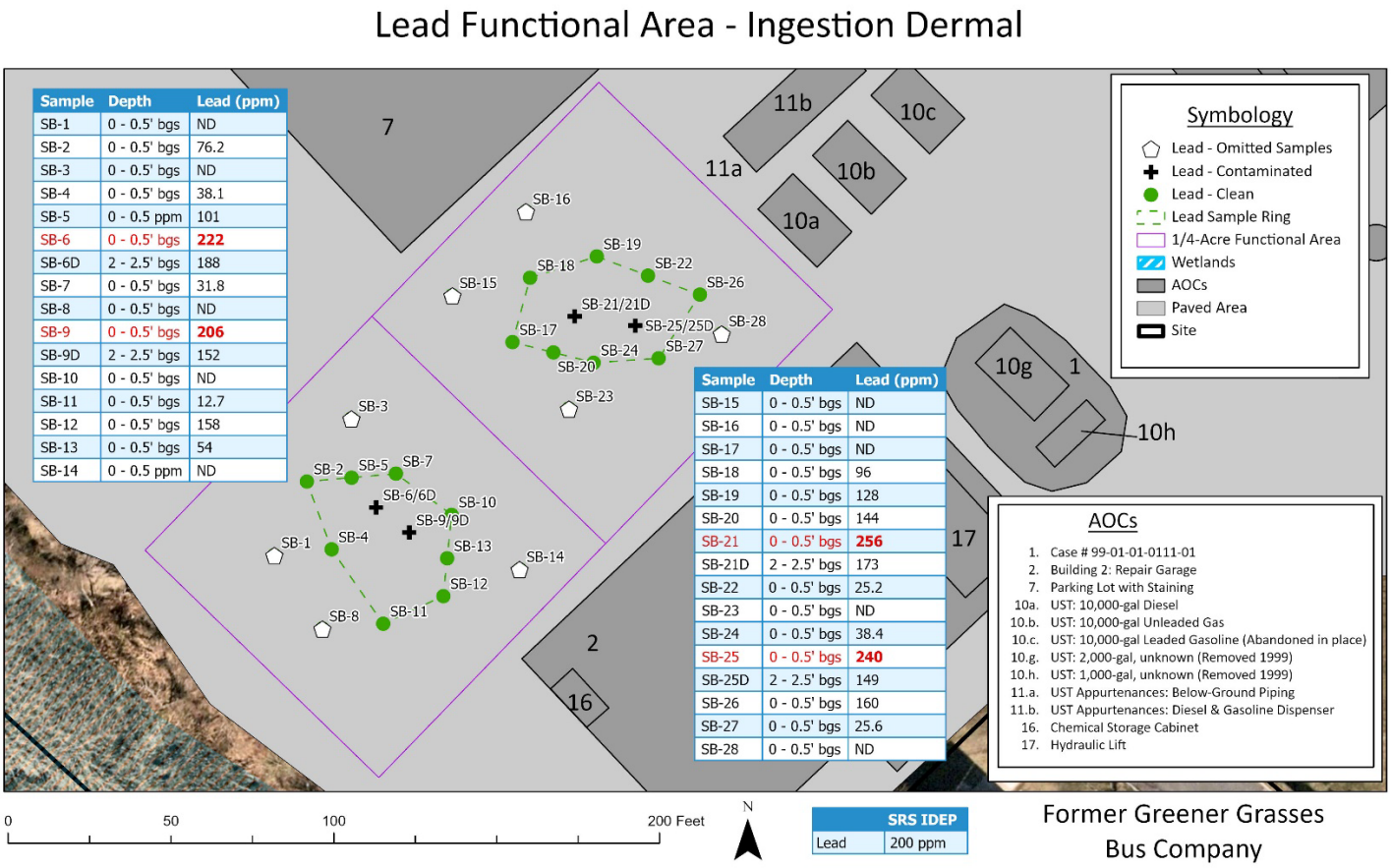


Table 1. Data Tables for Functional Areas 1 and 2

Functional Area 1		
Sample ID	**Depth (ft bgs)**	**Lead Concentration (mg/kg)**
SB-2	0-0.5	76.2
SB-4	0-0.5	38.1
SB-5	0-0.5	101
SB-6	0-0.5	222
SB-7	0-0.5	31.8
SB-9	0-0.5	206
SB-10	0-0.5	ND (0.31)*
SB-11	0-0.5	12.7
SB-12	0-0.5	158
SB-13	0-0.5	54.0

Functional Area 2		
Sample ID	**Depth (ft bgs)**	**Lead Concentration (mg/kg)**
SB-17	0-0.5	ND (0.31)*
SB-18	0-0.5	96.0
SB-19	0-0.5	128
SB-20	0-0.5	144
SB-21	0-0.5	256
SB-22	0-0.5	25.2
SB-24	0-0.5	38.4
SB-25	0-0.5	240
SB-26	0-0.5	160
SB-270	0-0.5	25.6

***the value in parentheses represents half of the laboratory reporting limit (RL)**

Table 2. ProUCL Inputs for Functional Areas 1 and 2

Functional Area 1	
Lead	**D_Lead**
76.2	1
38.1	1
101	1
222	1
31.8	1
206	1
0.31	0
12.7	1
158	1
54.0	1

Functional Area 2	
Lead	**D_Lead**
0.31	0
96.0	1
128	1
144	1
256	1
25.2	1
38.4	1
240	1
160	1
25.6	1

Figure 2A – Functional Area 1 ProUCL Output Example

UCL Statistics for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.2 4/2/2024 11:18:28 AM
From File	ProUCL Input_a.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Lead

General Statistics

Total Number of Observations	10	Number of Distinct Observations	10
Number of Detects	9	Number of Non-Detects	1
Number of Distinct Detects	9	Number of Distinct Non-Detects	1
Minimum Detect	12.7	Minimum Non-Detect	0.31
Maximum Detect	222	Maximum Non-Detect	0.31
Variance Detects	6034	Percent Non-Detects	10%
Mean Detects	99.98	SD Detects	77.68
Median Detects	76.2	CV Detects	0.777
Skewness Detects	0.643	Kurtosis Detects	-1.199
Mean of Logged Detects	4.264	SD of Logged Detects	0.953

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.895	**Shapiro Wilk GOF Test**
1% Shapiro Wilk Critical Value	0.764	Detected Data appear Normal at 1% Significance Level
Lilliefors Test Statistic	0.176	**Lilliefors GOF Test**
1% Lilliefors Critical Value	0.316	Detected Data appear Normal at 1% Significance Level

Detected Data appear Normal at 1% Significance Level

Note GOF tests may be unreliable for small sample sizes

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

KM Mean	90.01	KM Standard Error of Mean	25.37
90KM SD	75.64	95% KM (BCA) UCL	133.1
95% KM (t) UCL	136.5	95% KM (Percentile Bootstrap) UCL	131.2
95% KM (z) UCL	131.7	95% KM Bootstrap t UCL	149.8
90% KM Chebyshev UCL	166.1	95% KM Chebyshev UCL	200.6
97.5% KM Chebyshev UCL	248.4	99% KM Chebyshev UCL	342.4

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.22	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.733	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.145	**Kolmogorov-Smirnov GOF**
5% K-S Critical Value	0.284	Detected data appear Gamma Distributed at 5% Significance Level

Nonparametric Distribution Free UCL Statistics			
Detected Data appear Normal Distributed at 1% Significance Level			
Suggested UCL to Use			
95% KM (t) UCL	136.5		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness using results from simulation studies.			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			

Figure 2B – Functional Area 2 ProUCL Output Example

UCL Statistics for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.2 4/2/2024 11:49:12 AM
From File	ProUCL Input_b.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Lead

General Statistics

Total Number of Observations	10	Number of Distinct Observations	10
Number of Detects	9	Number of Non-Detects	1
Number of Distinct Detects	9	Number of Distinct Non-Detects	1
Minimum Detect	25.2	Minimum Non-Detect	0.31
Maximum Detect	256	Maximum Non-Detect	0.31
Variance Detects	7518	Percent Non-Detects	10%
Mean Detects	123.7	SD Detects	86.71
Median Detects	128	CV Detects	0.701
Skewness Detects	0.346	Kurtosis Detects	-1.105
Mean of Logged Detects	4.512	SD of Logged Detects	0.912

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.911	**Shapiro Wilk GOF Test**
1% Shapiro Wilk Critical Value	0.764	Detected Data appear Normal at 1% Significance Level
Lilliefors Test Statistic	0.171	**Lilliefors GOF Test**
1% Lilliefors Critical Value	0.316	Detected Data appear Normal at 1% Significance Level

Detected Data appear Normal at 1% Significance Level

Note GOF tests may be unreliable for small sample sizes

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

KM Mean	111.4	KM Standard Error of Mean	28.82
90KM SD	85.93	95% KM (BCA) UCL	157.7
95% KM (t) UCL	164.2	95% KM (Percentile Bootstrap) UCL	157.5
95% KM (z) UCL	158.8	95% KM Bootstrap t UCL	171.2
90% KM Chebyshev UCL	197.8	95% KM Chebyshev UCL	237
97.5% KM Chebyshev UCL	291.4	99% KM Chebyshev UCL	398.1

Gamma GOF Tests on Detected Observations Only

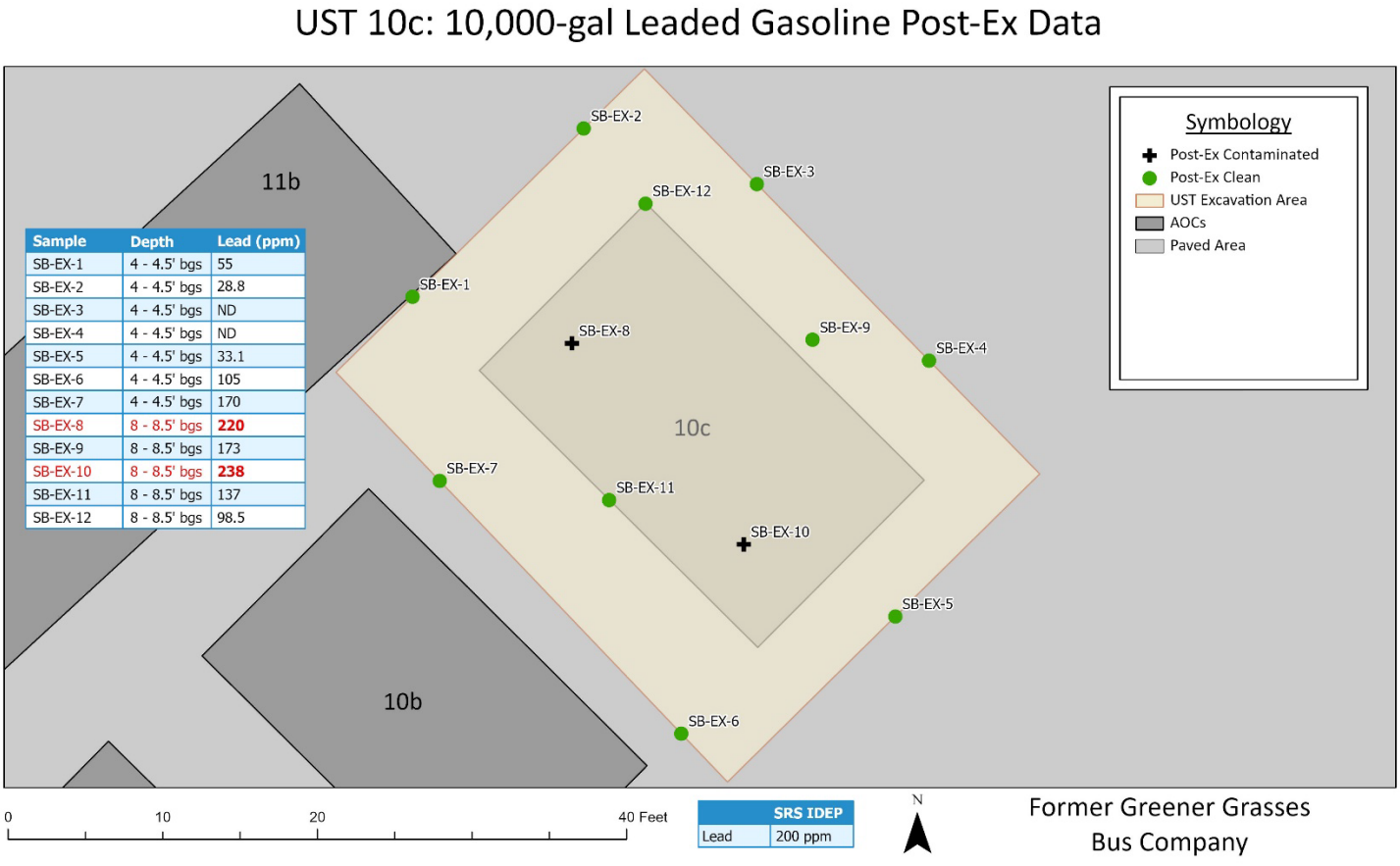
A-D Test Statistic	0.427	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.732	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.184	**Kolmogorov-Smirnov GOF**
5% K-S Critical Value	0.283	Detected data appear Gamma Distributed at 5% Significance Level

Nonparametric Distribution Free UCL Statistics		
Detected Data appear Normal Distributed at 1% Significance Level		
Suggested UCL to Use		
95% KM (t) UCL	164.2	
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.		
Recommendations are based upon data size, data distribution, and skewness using results from simulation studies.		
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.		

A 2.0 75%/10x

Though the 75%/10x procedure does not require calculations, figures and tables detailing the sample concentrations, depths, locations, and extent of the excavated area should still be provided. An example table and figure are provided below. The text of the report should also detail the volume of soil excavated to ensure the minimum number of samples were collected.

Figure 3. 75%/10x Lead Sampling Map



Sample	Depth	Lead (ppm)
SB-EX-1	4 - 4.5' bgs	55
SB-EX-2	4 - 4.5' bgs	28.8
SB-EX-3	4 - 4.5' bgs	ND
SB-EX-4	4 - 4.5' bgs	ND
SB-EX-5	4 - 4.5' bgs	33.1
SB-EX-6	4 - 4.5' bgs	105
SB-EX-7	4 - 4.5' bgs	170
SB-EX-8	8 - 8.5' bgs	**220**
SB-EX-9	8 - 8.5' bgs	173
SB-EX-10	8 - 8.5' bgs	**238**
SB-EX-11	8 - 8.5' bgs	137
SB-EX-12	8 - 8.5' bgs	98.5

Table 3. Data Table for 75%/10x

Sample ID	Depth (ft bgs)	Lead Concentration (mg/kg)
SB-EX-1	4-4.5	55.0
SB-EX-2	4-4.5	28.8
SB-EX-3	4-4.5	ND
SB-EX-4	4-4.5	ND
SB-EX-5	4-4.5	33.1
SB-EX-6	4-4.5	105
SB-EX-7	4-4.5	170
SB-EX-8	8-8.5	220
SB-EX-9	8-8.5	173
SB-EX-10	8-8.5	238
SB-EX-11	8-8.5	137
SB-EX-12	8-8.5	98.5

A 3.0 Spatially Weighted Averaging

Spatially Weighted Averaging (SWA) Examples

The following section provides examples of documentation associated with two scenarios involving the application of spatially weighted averaging (SWA). If the application of SWA involves multiple functional areas and contaminants, a figure indicating the location of the different functional areas should be provided.

Description of Tables and Figures

Two figures are provided for each scenario, an initial condition and a post-remediation condition. The figures identify soil samples used in the SWA calculation and are labeled with their Sample ID. A legend is included that clearly labels exceedances, detections, and non-detects. A scale bar and compass rose should be provided on the figures. The direction of ground water flow is also indicated on the figures for the SRS-MGW exposure pathway scenario because application of SWA to the MGW exposure pathway entails creation of 100-ft width investigation areas parallel to the direction of ground water flow. The post-remediation figures clearly demonstrate which polygons were addressed to achieve compliance with soil remediation standards (SRS). The corresponding data tables include Sample IDs and associated survey coordinates, sample depths, contaminant concentrations, polygon area (ft^2) and percent of total area, and weighted value (concentration multiplied by area). Exceedances are bolded and totals for the appropriate columns are provided. The post-remediation tables also include a column indicating which polygons have been remediated. The tables clearly indicate whether the SWA application resulted in attainment of SRS.

Example # 1

Figure 4 and Table 4 demonstrate the initial application of SWA for lead in surface zone soil (0-2 ft below ground surface) to meet the residential direct contact SRS for the ingestion-dermal exposure pathway of 200 mg/kg. The initial application of SWA failed for lead (590 mg/kg). Figure 5 and Table 5 provide a final iteration of the SWA analysis with the initial lead concentration of the polygon selected for remediation replaced with a non-detect concentration representative of clean fill (i.e., 1/2 the laboratory Reporting Limit, or 0.25 mg/kg in this case). As noted in Table 5, recalculation of the SWA with remediation of the selected polygon results in attainment of compliance, with an updated lead concentration of 96 mg/kg. Remediation of polygon sample SB-31A would bring this AOC into compliance with the residential direct contact SRS for the ingestion-dermal exposure pathway of 200 mg/kg.

Figure 4. Functional Area 1 Surface Zone Lead Ingestion-Dermal Exposure Pathway

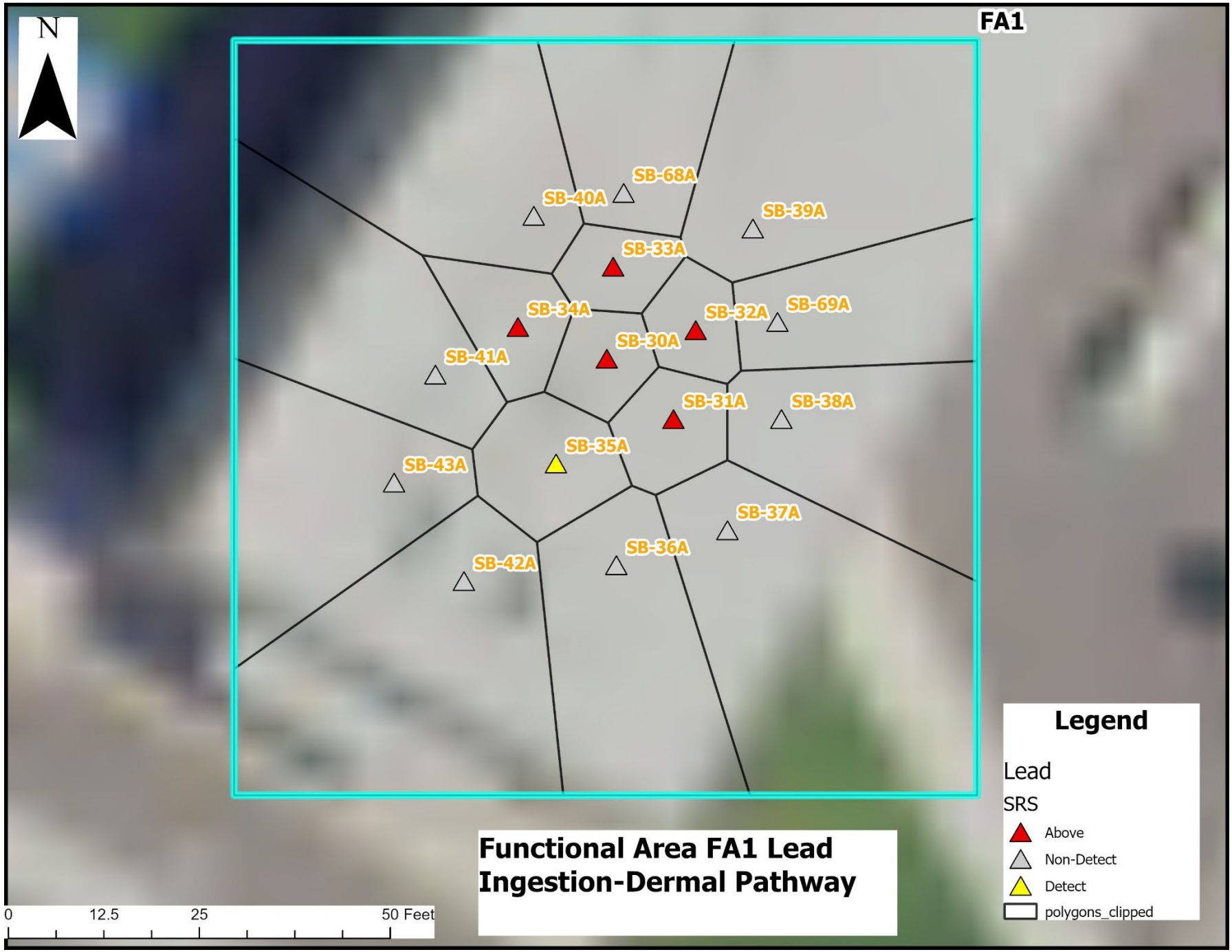


Table 4. Functional Area 1 Surface Zone Lead Ingestion-Dermal Exposure Pathway

Sample ID	X Coord	Y Coord	Depth (ft)	Lead (mg/kg)	Polygon Area (sq ft)	Percent of Total Area	Weighted Value (mg/kg)
SB-35A	325725.3861	405133.7283	1.5-2	175	269.404625	2.80%	4.904873172
SB-42A	325713.3314	405118.3485	1.5-2	0.25	1226.911928	12.76%	0.031910829
SB-31A	325740.766	405139.5479	1.5-2	**15000**	187.5823432	1.95%	292.730451
SB-36A	325733.2841	405120.4265	1.5-2	25	767.4088548	7.98%	1.995958471
SB-34A	325720.3979	405151.6027	1.5-2	**380**	211.4256395	2.20%	8.358453599
SB-37A	325747.8326	405124.999	1.5-2	0.25	1321.9576	13.75%	0.034382878
SB-41A	325709.5902	405145.3674	1.5-2	0.25	789.0181968	8.21%	0.020521623
SB-30A	325732.037	405147.4458	1.5-2	**3000**	149.379706	1.55%	46.62271296
SB-32A	325743.6758	405151.187	1.5-2	**1200**	150.3658844	1.56%	18.77220315
SB-69A	325754.3795	405152.2519	1.5-2	0.25	479.1328121	4.98%	0.012461795
SB-68A	325734.245	405169.139	1.5-2	0.25	479.0768515	4.98%	0.01246034
SB-33A	325732.8684	405159.5006	1.5-2	**680**	146.5097289	1.52%	10.36477942
SB-38A	325754.8992	405139.5479	1.5-2	0.25	660.3695262	6.87%	0.017175592
SB-39A	325751.1581	405164.4888	1.5-2	0.25	990.6148329	10.31%	0.025764963
SB-40A	325722.4764	405166.1512	1.5-2	40	1043.648047	10.86%	4.343089131
SB-43A	325704.1864	405131.2343	1.5-2	0.25	739.2277643	7.69%	0.019226621
				Totals	**9612.034341**	**100.00%**	**388.266**

SWA FAILED: 390 mg/kg > Residential Ingestion-Dermal Soil Remediation Standard 200 mg/kg

Figure 5. Functional Area 1 Surface Zone Lead Ingestion-Dermal Exposure Pathway Post-Remediation

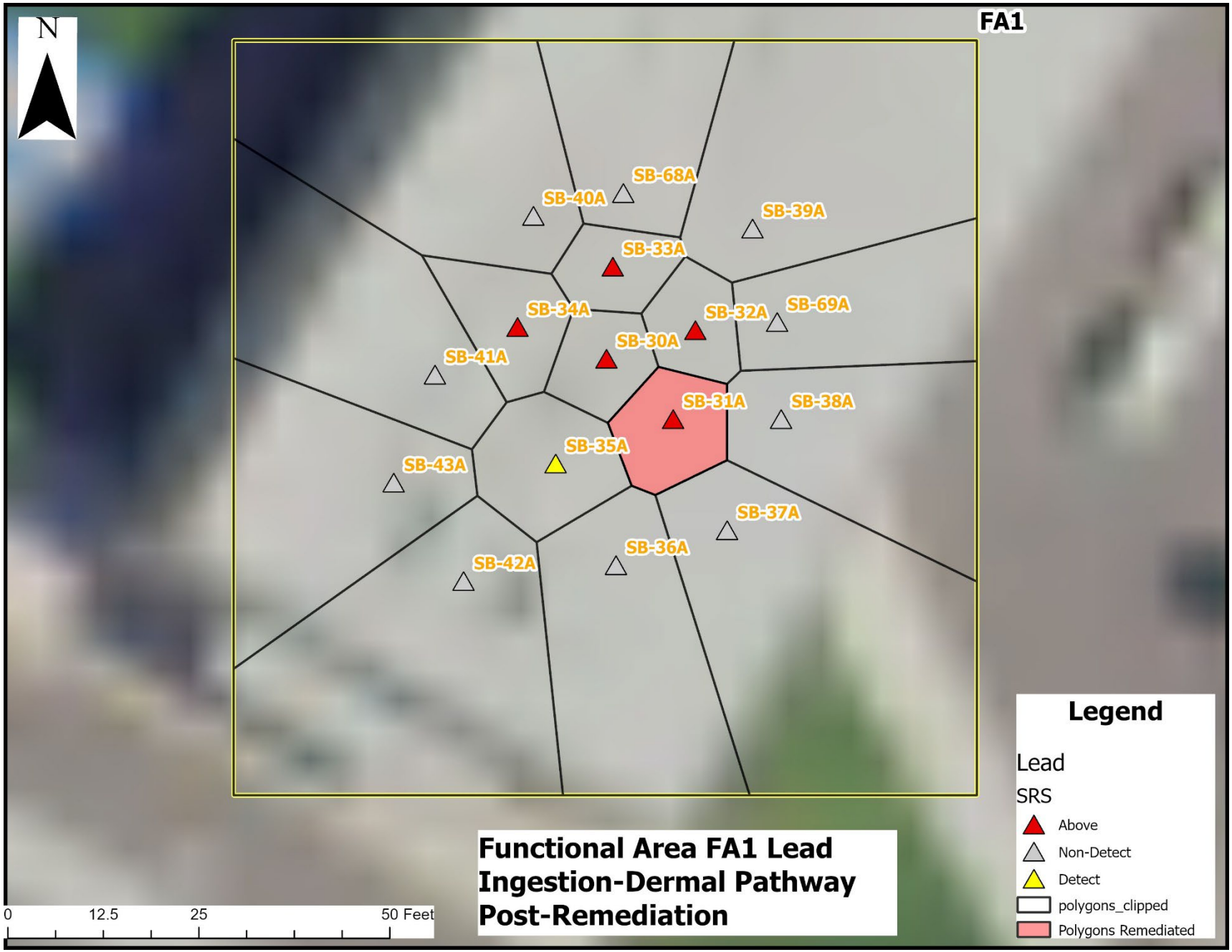


Table 5. Functional Area 1 Surface Zone Lead Ingestion-Dermal Exposure Pathway Post-Remediation

Sample ID	X Coord	Y Coord	Depth (ft)	Lead (mg/kg)	Polygon Area (sq ft)	Remediated	Percent of Total Area	Weighted Value (mg/kg)
SB-35A	325725.3861	405133.7283	1.5-2	175	269.404625	N	2.80%	4.904873172
SB-42A	325713.3314	405118.3485	1.5-2	0.25	1226.911928	N	12.76%	0.031910829
SB-31A	325740.766	405139.5479	1.5-2	0.25	187.5823432	Y	1.95%	0.004878841
SB-36A	325733.2841	405120.4265	1.5-2	25	767.4088548	N	7.98%	1.995958471
SB-34A	325720.3979	405151.6027	1.5-2	**380**	211.4256395	N	2.20%	8.358453599
SB-37A	325747.8326	405124.999	1.5-2	0.25	1321.9576	N	13.75%	0.034382878
SB-41A	325709.5902	405145.3674	1.5-2	0.25	789.0181968	N	8.21%	0.020521623
SB-30A	325732.037	405147.4458	1.5-2	**3000**	149.379706	N	1.55%	46.62271296
SB-32A	325743.6758	405151.187	1.5-2	**1200**	150.3658844	N	1.56%	18.77220315
SB-69A	325754.3795	405152.2519	1.5-2	0.25	479.1328121	N	4.98%	0.012461795
SB-68A	325734.245	405169.139	1.5-2	0.25	479.0768515	N	4.98%	0.01246034
SB-33A	325732.8684	405159.5006	1.5-2	**680**	146.5097289	N	1.52%	10.36477942
SB-38A	325754.8992	405139.5479	1.5-2	0.25	660.3695262	N	6.87%	0.017175592
SB-39A	325751.1581	405164.4888	1.5-2	0.25	990.6148329	N	10.31%	0.025764963
SB-40A	325722.4764	405166.1512	1.5-2	40	1043.648047	N	10.86%	4.343089131
SB-43A	325704.1864	405131.2343	1.5-2	0.25	739.2277643	N	7.69%	0.019226621
				Totals:	**9612.034341**		**100.00%**	**95.450**

SWA PASSED: 96 mg/kg < Residential Ingestion-Dermal Soil Remediation Standard 200 mg/kg

Example # 2

Figure 6 and Table 6 demonstrate the initial application of SWA for the trichloroethene (TCE) SRS-MGW exposure pathway to achieve compliance with the SRS-MGW. The initial application of SWA failed for TCE (0.2875 mg/kg) which is above the SRS-MGW of 0.0065 mg/kg. Figure 7 and Table 7 indicate recalculation of the SWA with remediation of selected polygons (shaded in red); TCE concentrations in the remediated polygons were replaced with ½ of the laboratory Reporting Limit (0.005 mg/kg). As indicated in Table 7, such remediation results in achievement of the TCE SRS-MGW, with an updated SWA concentration of (0.0064mg/kg).

Figure 6. Functional Area 4 Migration to Ground Water Exposure Pathway

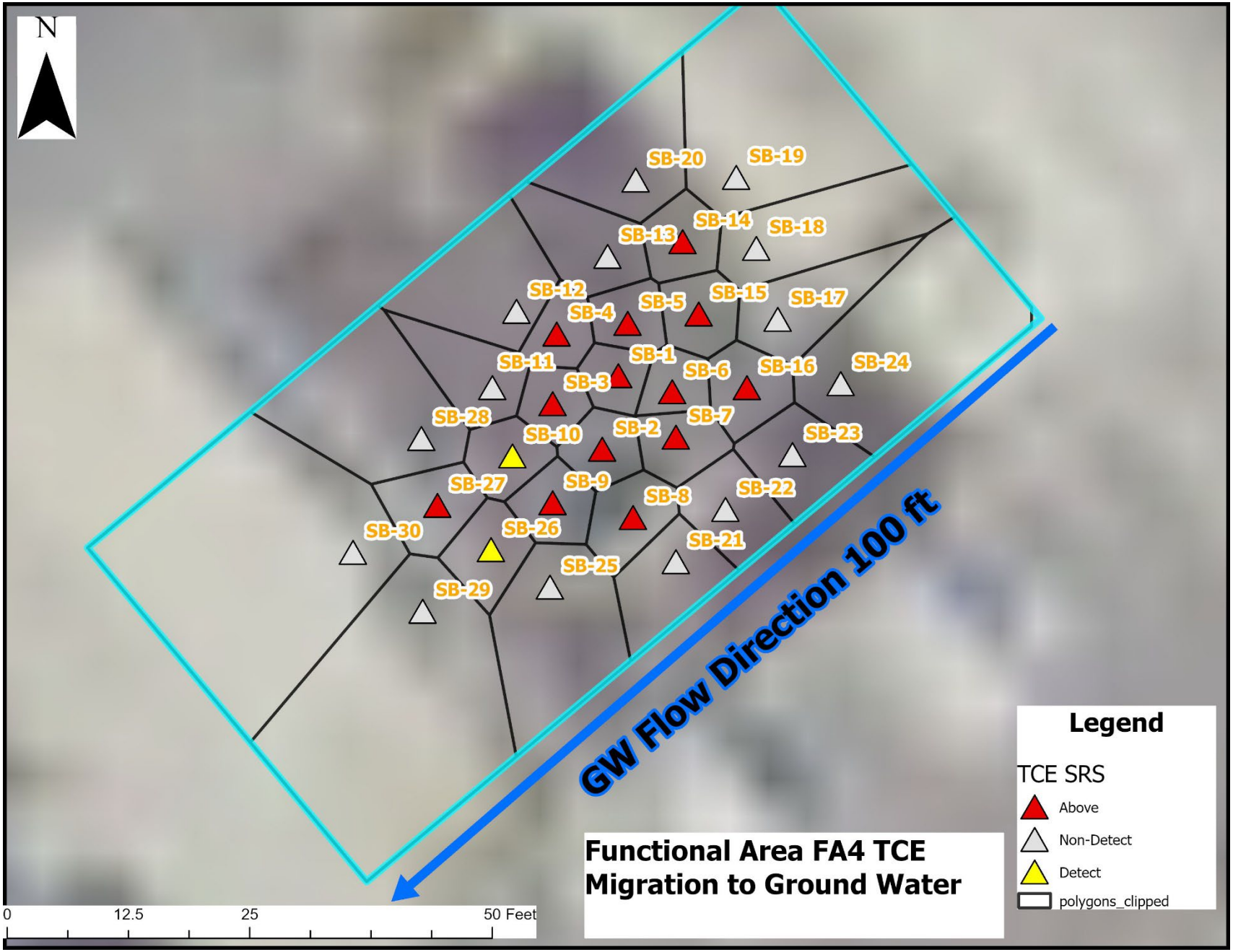


Table 6. Functional Area 4 Migration to Ground Water Exposure Pathway

Sample_ID	X_Coord	Y_Coord	TCE (mg/kg)	Depth (ft)	Polygon Area (sq ft)	Percent of Total Area	Weighted Value (mg/kg)
SB-25	524126.3	204360.2	0.005	4.5-5	205.4885	5.06%	0.000252863
SB-9	524126.6	204368.9	**1.2**	4.5-5	55.26169	1.36%	0.016320496
SB-29	524113.2	204357.7	0.005	4.5-5	525.3604	12.93%	0.00064648
SB-30	524106	204363.8	0.005	4.5-5	596.3473	14.68%	0.000733833
SB-26	524120.3	204364.1	0.0062	4.5-5	64.27059	1.58%	9.8069E-05
SB-8	524134.9	204367.4	**0.0781**	4.5-5	65.04412	1.60%	0.001250222
SB-3	524126.6	204379.2	**2.2**	4.5-5	43.91655	1.08%	0.023778192
SB-28	524113.1	204375.6	0.005	4.5-5	226.261	5.57%	0.000278425
SB-11	524120.4	204380.8	0.005	4.5-5	86.05135	2.12%	0.00010589
SB-4	524127	204386.3	**1.8**	5.5-6	45.9917	1.13%	0.020374168
SB-20	524135.2	204402.2	0.005	4.5-5	148.2334	3.65%	0.000182408
SB-10	524122.5	204373.8	0.0064	4.5-5	54.70357	1.35%	8.61635E-05
SB-27	524114.7	204368.7	**0.0182**	4.5-5	70.41834	1.73%	0.000315417
SB-2	524131.7	204374.5	**3.5**	4.5-5	51.65376	1.27%	0.044493633
SB-5	524134.4	204387.4	**0.98**	5.5-6	47.2348	1.16%	0.011392422
SB-12	524122.9	204388.7	0.005	4.5-5	155.1465	3.82%	0.000190915
SB-23	524151.3	204373.9	0.005	4.5-5	93.25865	2.30%	0.000114759
SB-21	524139.3	204362.9	0.005	4.5-5	96.58281	2.38%	0.00011885
SB-22	524144.4	204368.2	0.005	4.5-5	82.38646	2.03%	0.00010138
SB-6	524139.9	204381.6	**6.8**	4.5-5	41.95232	1.03%	0.070209004
SB-1	524133.4	204382	**5.5**	4.5-5	40.92191	1.01%	0.055391934
SB-7	524139.3	204375.7	**0.921**	4.5-5	56.42191	1.39%	0.012788964
SB-16	524146.7	204380.8	**0.285**	4.5-5	64.82655	1.60%	0.004547007
SB-18	524147.6	204395.2	0.005	4.5-5	170.877	4.21%	0.000210272
SB-13	524132.3	204394.3	0.005	4.5-5	98.19565	2.42%	0.000120834
SB-14	524140	204395.9	**0.985**	4.5-5	57.89346	1.42%	0.014034393
SB-15	524141.7	204388.4	**0.589**	4.5-5	58.61835	1.44%	0.008497219
SB-24	524156.3	204381.2	0.005	4.5-5	318.7936	7.85%	0.00039229
SB-17	524149.8	204387.9	0.005	4.5-5	106.7133	2.63%	0.000131316
SB-19	524145.5	204402.5	0.005	4.5-5	334.4108	8.23%	0.000411508
				Totals	**4063.236**	**100.00%**	**0.287569**

SWA FAILED: 0.2875 mg/kg > Migration to Ground Water Soil Remediation Standard 0.0065 mg/kg

Figure 7. Functional Area 4 Migration to Ground Water Exposure Pathway Post-Remediation

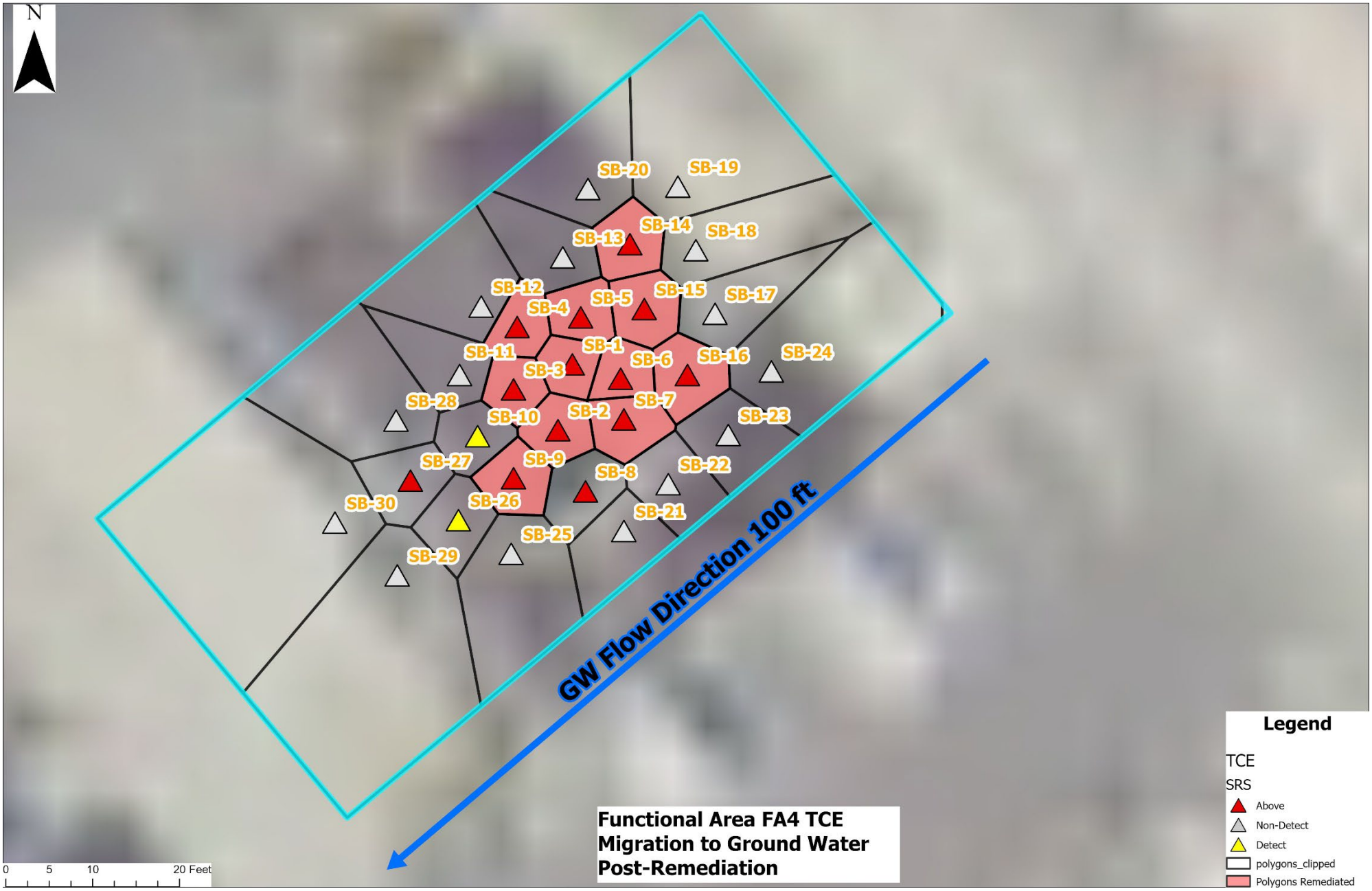


Table 7 Functional Area 4 Migration to Ground Water Exposure Pathway Post-Remediation

Sample_ID	X_Coord	Y_Coord	TCE (mg/kg)	Remediation	Depth (ft)	Polygon Area (sq ft)	Percent of Total Area	Weighted Value (mg/kg)
SB-25	524126.3492	204360.2326	0.005	N	4.5-5	205.4885	5.06%	0.000252863
SB-9	524126.6251	204368.9334	0.005	Y	4.5-5	55.26169	1.36%	6.80021E-05
SB-29	524113.2289	204357.7467	0.005	N	4.5-5	525.3604	12.93%	0.00064648
SB-30	524106.0471	204363.8235	0.005	N	4.5-5	596.3473	14.68%	0.000733833
SB-26	524120.2725	204364.0997	0.0062	N	4.5-5	64.27059	1.58%	9.8069E-05
SB-8	524134.9119	204367.4143	**0.0781**	N	4.5-5	65.04412	1.60%	0.001250222
SB-3	524126.6251	204379.1535	0.005	Y	4.5-5	43.91655	1.08%	5.40413E-05
SB-28	524113.0907	204375.5626	0.005	N	4.5-5	226.261	5.57%	0.000278425
SB-11	524120.4106	204380.8106	0.005	N	4.5-5	86.05135	2.12%	0.00010589
SB-4	524127.0395	204386.3349	0.005	Y	5.5-6	45.9917	1.13%	5.65949E-05
SB-20	524135.1881	204402.2174	0.005	N	4.5-5	148.2334	3.65%	0.000182408
SB-10	524122.4821	204373.7673	0.0064	N	4.5-5	54.70357	1.35%	8.61635E-05
SB-27	524114.7479	204368.6571	**0.0182**	N	4.5-5	70.41834	1.73%	0.000315417
SB-2	524131.7354	204374.4576	0.005	Y	4.5-5	51.65376	1.27%	6.35623E-05
SB-5	524134.3594	204387.4399	0.005	Y	5.5-6	47.2348	1.16%	5.81246E-05
SB-12	524122.8965	204388.683	0.005	N	4.5-5	155.1465	3.82%	0.000190915
SB-23	524151.3466	204373.9055	0.005	N	4.5-5	93.25865	2.30%	0.000114759
SB-21	524139.3312	204362.8566	0.005	N	4.5-5	96.58281	2.38%	0.00011885
SB-22	524144.4411	204368.2427	0.005	N	4.5-5	82.38646	2.03%	0.00010138
SB-6	524139.8837	204381.6394	0.005	Y	4.5-5	41.95232	1.03%	5.16243E-05
SB-1	524133.3925	204382.0363	0.005	Y	4.5-5	40.92191	1.01%	5.03563E-05
SB-7	524139.3312	204375.7007	0.005	Y	4.5-5	56.42191	1.39%	6.94298E-05
SB-16	524146.651	204380.8106	0.005	Y	4.5-5	64.82655	1.60%	7.97721E-05
SB-18	524147.6176	204395.1738	0.005	N	4.5-5	170.877	4.21%	0.000210272
SB-13	524132.2879	204394.3454	0.005	N	4.5-5	98.19565	2.42%	0.000120834
SB-14	524140.0218	204395.8644	0.005	Y	4.5-5	57.89346	1.42%	7.12406E-05
SB-15	524141.6789	204388.4067	0.005	Y	4.5-5	58.61835	1.44%	7.21326E-05
SB-24	524156.3183	204381.225	0.005	N	4.5-5	318.7936	7.85%	0.00039229
SB-17	524149.8275	204387.8542	0.005	N	4.5-5	106.7133	2.63%	0.000131316
SB-19	524145.546	204402.4937	0.005	N	4.5-5	334.4108	8.23%	0.000411508
					Totals	**4063.236**	**100.00%**	**0.006436**

SWA PASSED: 0.0064 mg/kg < Migration to Ground Water Soil Remediation Standard .0065 mg/kg

Appendix B

Use of Rounding to Demonstrate Compliance with Remediation Standards and Screening Levels

TABLE OF CONTENTS

B 1.0 Use of Rounding to Demonstrate Compliance with Remediation Standards and Screening Levels

Analytical data may be rounded as a mechanism to demonstrate compliance with remediation standards and screening levels. Rounding should be conducted to the number of significant figures in the applicable remediation standard or screening level. This concept is used by the USEPA (USEPA 1981; USEPA 2017) and by various state environmental agencies including Oregon (Oregon DEQ 2013), Massachusetts (Massachusetts DEP 2009), and Florida (Florida DEP 2011).

This Appendix will discuss:

- The number of significant figures in existing NJDEP remediation standards and screening levels
- Rounding rules when determining compliance with remediation standards and screening levels
- Proper use of rounding during each remedial phase
- Proper use of rounding for each compliance option

B 2.0 Number of Significant Figures in NJDEP Remediation Standards and Screening Levels

B 2.1 Soil

B 2.1.1 Soil Remediation Standards for the Ingestion-Dermal, and Inhalation Exposure Pathways

Soil remediation standards for the ingestion-dermal exposure pathway are listed in the Remediation Standards (N.J.A.C. 7:26D), Appendix 1, Tables 1 and 2. Soil remediation standards for the inhalation exposure pathway are listed in the Remediation Standards (N.J.A.C. 7:26D), Appendix 1, Tables 3 and 4 (https://dep.nj.gov/wp-content/uploads/rules/rules/njac7_26d.pdf). All soil remediation standards are rounded to two significant figures using the rounding rules in Section B 3.0 of this appendix.

Any interim remediation standards developed for soil pursuant to Subchapter 6 of the Remediation Standards (N.J.A.C. 7:26D) are rounded to two significant figures using the rounding rules in Section B 3.0 of this appendix.

Any updated remediation standards developed for soil pursuant to Subchapter 7 of the Remediation Standards (N.J.A.C. 7:26D) are rounded to two significant figures using the rounding rules in Section B 3.0 of this appendix.

Any alternative remediation standards developed for soil pursuant to Subchapter 8 of the Remediation Standards (N.J.A.C. 7:26D) should be rounded to two significant figures using the rounding rules in Section B 3.0 of this appendix.

B 2.1.2 Soil Remediation Standards for the Migration to Ground Water Exposure Pathway Remediation Standards

Soil remediation standards for the migration to ground water soil exposure pathway are listed in the Remediation Standards (N.J.A.C. 7:26D), Appendix 1, Table 5 (https://dep.nj.gov/wp-content/uploads/rules/rules/njac7_26d.pdf). All soil remediation standards for the migration to ground

water exposure pathway are rounded to two significant figures using the rounding rules in Section B 3.0 of this appendix.

Any interim soil remediation standards for the migration to ground water exposure pathway developed pursuant to Subchapter 6 of the Remediation Standards (N.J.A.C. 7:26D) are rounded to two significant figures using the rounding rules in Section B 3.0 of this appendix.

Any updated soil remediation standards for the migration to ground water exposure pathway developed pursuant to Subchapter 7 of the Remediation Standards (N.J.A.C. 7:26D) are rounded to two significant figures using the rounding rules in Section B 3.0 of this appendix.

Any alternative soil remediation standards for the migration to ground water exposure pathway developed pursuant to Subchapter 8 of the Remediation Standards (N.J.A.C. 7:26D) should be rounded to two significant figures using the rounding rules in Section B 3.0 of this appendix.

B 2.1.3 Soil Leachate Remediation Standards for the Migration to Ground Water Exposure Pathway

Soil leachate remediation standards for the migration to ground water exposure pathway are listed in the Remediation Standards (N.J.A.C. 7:26D), Appendix 1, Table 6 (https://dep.nj.gov/wp-content/uploads/rules/rules/njac7_26d.pdf). All soil leachate remediation standards are rounded to two significant figures using the rounding rules in Section B 3.0 of this appendix.

Any interim soil leachate remediation standards for the migration to ground water exposure pathway developed pursuant to Subchapter 6 of the Remediation Standards (N.J.A.C. 7:26D) are rounded to two significant figures using the rounding rules in Section B 3.0 of this appendix.

Any updated soil leachate remediation standards for the migration to ground water exposure pathway developed pursuant to Subchapter 7 of the Remediation Standards (N.J.A.C. 7:26D) are rounded to two significant figures using the rounding rules in Section B 3.0 of this appendix.

Any alternative soil leachate remediation standards for the migration to ground water exposure pathway developed pursuant to Subchapter 8 of the Remediation Standards (N.J.A.C. 7:26D) should be rounded to two significant figures using the rounding rules in Section B 3.0 of this appendix.

B 2.2 Ground Water Remediation Standards

Pursuant to the Remediation Standards at N.J.A.C. 7:26D-2, ground water remediation standards are, by reference, the ground water quality standards developed pursuant to N.J.A.C. 7:9C (https://dep.nj.gov/wp-content/uploads/rules/rules/njac7_26d.pdf). Except as noted in Section 7.1, all Class II ground water quality standards are rounded to one significant figure.

All Class I and Class III ground water quality standards developed on a site-specific basis are rounded to one significant figure. All interim specific ground water quality standards (developed for Class II ground water), are rounded to one significant figure.

B 2.3 Surface Water Remediation Standards

Pursuant to the Remediation Standards at N.J.A.C. 7:26D-3, surface water remediation standards are, by reference, the surface water quality standards developed pursuant to N.J.A.C. 7:9B

(https://dep.nj.gov/wp-content/uploads/rules/rules/njac7_26d.pdf). All surface water quality criteria for toxic substances are rounded to two significant figures.

B 2.4 Indoor Air Remediation Standards, Ground Water Screening Levels, Soil Gas Screening Levels, and Rapid Action Levels for the Vapor Intrusion Exposure Pathway

Indoor air remediation standards for the vapor intrusion exposure pathway are listed in the Remediation Standards (N.J.A.C.7:26D), Appendix 1, Tables 7 and 8 (https://dep.nj.gov/wp-content/uploads/rules/rules/njac7_26d.pdf). All indoor air remediation standards for the vapor intrusion exposure pathway are rounded to two significant figures using the rounding rules in Section B 3.0 of this appendix.

Any interim indoor air remediation standards for the vapor intrusion exposure pathway developed pursuant to Subchapter 6 of the Remediation Standards (N.J.A.C. 7:26D) are rounded to two significant figures using the rounding rules in Section B 3.0 of this appendix.

Any updated indoor air remediation standards for the vapor intrusion exposure pathway developed pursuant to Subchapter 7 of the Remediation Standards (N.J.A.C. 7:26D) are rounded to two significant figures using the rounding rules in Section B 3.0 of this appendix.

Any alternative indoor air remediation standards developed pursuant to Subchapter 8 of the Remediation Standards (N.J.A.C. 7:26D) should be rounded to two significant figures using the rounding rules in Section B 3.0 of this appendix.

Ground water screening levels, soil gas screening levels and rapid action levels found in the "*Vapor Intrusion Screening Levels and Indoor Air Remediation Standards Tables*" (https://dep.nj.gov/srp/guidance/vapor-intrusion/) are rounded to two significant figures using the rounding rules in Section B 3.0 of this appendix.

B 3.0 Rounding Rules When Determining Compliance with Remediation Standards and Screening Levels

When rounding analytical data for the purposes of determining compliance with remediation standards and screening levels, the investigator should apply the rounding rules contained in Section 6 of the American Society for Testing and Materials (ASTM) Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications (ASTM E29-13). A copy of this standard practice is available from ASTM at webstore.ansi.org/SDO/ASTM. The rounding rules contained in ASTM E29-13 Section 6 should be applied as noted below.

B 3.1 Rounding Analytical Data When the Remediation Standard or Screening Level is One Significant Figure

If the first number beyond the significant figure is less than five, then the significant figure remains the same and the remaining numbers are dropped. For example, if 4.4 is rounded to one significant figure, the result is 4. Also, if 0.0218 is rounded to one significant figure, the result is 0.02.

If the first number beyond the significant figure is greater than five, then the significant figure increases by one and the remaining numbers are dropped. For example, if 4.668 is rounded to one significant figure, the result is 5. Also, if 0.0274 is rounded to one significant figure, the result is 0.03. If the first

number beyond the significant figure is five and there are other non-zero numbers beyond that five, then the significant figure increases by one and the remaining numbers are dropped. For example, if 4.5834 is rounded to one significant figure, the result is 5. Also, if 0.0256 is rounded to one significant figure, the result is 0.03.

If the first number beyond the significant figure is five, and there are no numbers beyond this five (except zeros), then the significant figure is rounded to the closest even number. For example, if 4.5 is rounded to one significant figure, then the result is 4; if 5.5 is rounded to one significant figure, the result is 6. Also, if 0.0350 is rounded to one significant figure, the result is 0.04; if 0.0650 is rounded to one significant figure, the result is 0.06.

B 3.2 Rounding Analytical Data When the Remediation Standard or Screening Level is Two Significant Figures

If the first number beyond the second significant figure is less than five, then the second significant figure remains the same, while the remaining numbers are dropped. For example, if 14.438 is rounded to two significant figures, the result is 14. Also, if 0.342 is rounded to two significant figures, the result is 0.34.

If the first number beyond the second significant figure is greater than five, then the second significant figure increases by one and the remaining numbers are dropped. For example, if 14.668 is rounded to two significant figures, the result is 15. Also, if 0.347 is rounded to two significant figures, the result is 0.35.

If the first number beyond the second significant figure is five and there are other non-zero numbers beyond that five, then the second significant increases by one and the remaining numbers are dropped. For example, if 14.5534 is rounded to two significant figures, the result is 15. Also, if 0.6753 is rounded to two significant figures, the result is 0.68.

If the first number beyond the second significant figure is five, and there are no numbers beyond this five (except zeros), then the second significant figure is rounded to the closest even number. For example, if 14.5 is rounded to two significant figures, then the result is 14; if 15.5 is rounded to two significant figures, the result is 16. Also, if 0.675 is rounded to two significant figures, the result is 0.68; if 0.665 is rounded to two significant figures, the result is 0.66.

B 4.0 Proper Use of Rounding During Each Remedial Phase

B 4.1 Site Investigation

Except as noted in B4.1.1 below, during the site investigation, compliance for all contaminants for all exposure pathways are based on single point compliance. Rounding of single point compliance data is acceptable. Rounding should be conducted to the number of significant figures in the applicable remediation standard.

B 4.1.1 Site Investigation - Ground Water

If, after rounding as discussed above, the concentration of any contaminant in any ground water sample exceeds its applicable ground water remediation standard, the ground water may be resampled to confirm the presence of contamination. Two confirmation samples should be collected approximately 30 days apart and using similar purging and sampling techniques within a 60-day time period of the

initial sampling event. Average the results from the original sampling event along with the two confirmation sampling events to demonstrate compliance with the applicable standard. Averaging is not allowed for demonstrating attainment when the initial result is more than three times (3x) the applicable ground water standard or screening level If the average does not exceed the applicable ground water remediation standard, then no further action is required for ground water at the site or AOC. Individual sample results should not be rounded prior to calculating the average contaminant concentration. Rounding of the average concentration value is acceptable and should be conducted to the number of significant figures in the applicable ground water remediation standard.

The process described in the paragraph above can be applied to the evaluation of ground water screening levels for the vapor intrusion exposure pathway.

B 4.2 Receptor Evaluation

The receptor evaluation may include sampling ground water used for potable purposes and sampling indoor air for vapor intrusion. Pursuant to the Technical Requirements, an exceedance of a ground water remediation standard from a ground water source used for potable purposes is an immediate environmental concern. Also pursuant to the Technical Requirements, an exceedance of an indoor air screening level is a vapor concern condition, and an exceedance of a rapid action level is an immediate environmental concern. For the instances described above, compliance would be based on single point compliance. Rounding of single point compliance data used in receptor evaluation of potable water and indoor air (vapor intrusion) should not be conducted. Indoor air data used to determine the effectiveness of an engineered vapor control system is conducted using single point compliance. Rounding of such data should not be conducted. Potable water data used to determine the effectiveness of an engineered water treatment system is conducted using single point compliance. Rounding of such data should not be conducted.

Ground water screening levels and soil gas screening levels associated with vapor intrusion investigations are evaluated using single point compliance. Rounding of ground water and soil gas screening level data is acceptable when such data is evaluated using single point compliance. Rounding should be conducted to the number of significant figures in the applicable screening level.

B 4.3 Remedial Investigation

There are two separate determinations regarding compliance with the applicable remediation standards as part of the remedial investigation. First is the process of determining whether both horizontal and vertical delineation are complete. To determine whether delineation is complete, single point compliance is to be used. Rounding of single point compliance data is acceptable. Rounding should be conducted to the number of significant figures in the applicable remediation standard. As noted in Section 5.2 of this guidance document, in lieu of discrete sampling, the LSRP may use other means for determining the extent of the contamination. However, clean zone sampling data to demonstrate contaminant delineation to the applicable remediation standards are required to demonstrate attainment of the applicable remediation standards at the conclusion of the remedial action and prior to the Department issuing a remedial action permit, if applicable, and the LSRP issuing the Response Action Outcome (RAO).

For ground water, the process described in Section B 4.1.1 of this appendix can be used to define clean zone samples.

Following completion of delineation to the applicable remediation standard, the investigator is to determine whether and what type of a remedial action is required. To determine whether a remedial action is required based upon the ingestion-dermal, inhalation, and migration to ground water exposure pathways, compliance averaging and rounding of analytical data can be used. If compliance averaging is used, individual sample results used in compliance averaging calculations should not be rounded. However, the resulting arithmetic mean, 95% upper confidence level of the mean, or spatially weighted average can be rounded to the number of significant figures in the applicable remediation standard when determining if compliance has been achieved. If compliance has not been achieved, then a remedial action is required.

Except for the process described in Section B 4.1.1 of this appendix, compliance averaging cannot be used for ground water data.

B 4.4 Remedial Action Verification - Soil

After a remedial action has been conducted, to determine whether compliance with the applicable soil remediation standard has been achieved and no further action is warranted or whether additional remediation is required, either single point compliance, compliance averaging, or rounding of analytical data can be used.

Rounding of single point compliance data is acceptable. As analytical data are not manipulated in using the 75%/10X protocol, results for each sampling point can be rounded. Rounding should be conducted to the number of significant figures in the applicable remediation standard.

If compliance averaging is used, individual sample results used in compliance averaging calculations should not be rounded. However, the resulting arithmetic mean, 95% upper confidence level of the mean, or spatially weighted average can be rounded to the number of significant figures in the applicable remediation standard when determining if compliance has been achieved.

B 4.5 Remedial Action Verification – Ground Water

To achieve compliance with applicable ground water remediation standards each sampling point within a Classification Exception Area would be sampled twice and each sample result must comply with the remediation standard (single point compliance). Rounding of single point compliance data is acceptable and should be conducted to the number of significant figures in the applicable ground water remediation standard. Except for the process described in Section B 4.1.1 of the appendix, compliance averaging cannot be used for ground water data.

B 5.0 Proper Use of Rounding for Each Compliance Option

B 5.1 Single Point Compliance

Results for all samples can be rounded to the number of significant figures in the applicable remediation standard

B 5.2 Arithmetic Mean

Results of individual samples should not be rounded prior to calculating the arithmetic mean. Only the mean value may be rounded. Rounding should be conducted to the number of significant figures in the applicable remediation standard.

B 5.3 95% Upper Confidence Level (UCL) of the Mean

Results of individual samples should not be rounded prior to calculating the 95% UCL of the mean. Only the 95% UCL of the mean value may be rounded. Rounding should be conducted to the number of significant figures in the applicable remediation standard.

B 5.4 Spatially Weighted Averaging

The construction of the polygons should be done using data that have not been rounded. The spatially weighted average should be calculated using data that has not been rounded. The spatially weighted average may be rounded to the number of significant figures in the applicable remediation standard.

B 5.5 75%/10X Protocol

Individual sample results are not manipulated when using this protocol. Therefore, individual sample results can be rounded. Rounding should be conducted to the number of significant figures in the applicable remediation standard.

B 5.6 Mann -Whitney U Test

Since this test is used only to demonstrate a decreasing trend in sample concentrations, rounding of sample results is not necessary.

Appendix C

Non-Detect Values

Appendix C

Non-Detect Values

Non-detect (ND) values should be replaced with ½ of the laboratory derived Reporting Limit (RL) concentration for the specific analyte(s) in data sets where averaging methodologies (arithmetic mean, 95% UCL, and spatially weighted averaging) are being selected to attain compliance with soil remediation standards (SRS). In instances where ½ of the laboratory derived RL concentration is **less than** the Method Detection Limit (MDL), then the laboratory derived MDL concentration for the specific analyte(s) should be used to replace ND.

Laboratory derived Reporting Limits are sample and analyte specific and may differ from sample-to-sample and may even differ amongst analytes within the same sample. For each analyte in a data set where a ND value is being replaced by ½ of the laboratory RL concentration, the **Analytical Results Summary Form**, as identified in N.J.A.C 7:26E - Appendix A, II Reduced Deliverable Requirements at (b)1, (c)1, (d)1, and (e)1., shall be submitted to document that the appropriate concentration has been used in the compliance averaging calculation. Reports submitted that utilize ½ for the laboratory RL concentration to replace NDs that do not provide the laboratory summary sheets will be considered incomplete. An example of this form is provided below for clarity.

Example - Analytical Results Summary Form

Client Sample Results

Client Sample ID: WC-NVBM
Date Collected: 10/05/18 13:55
Date Received: 10/05/18 17:05

Matrix: Solid
Percent Solids: 88.6

Method: 8260C - Volatile Organic Compounds by GC/MS

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
1,1,1-Trichloroethane	0.0022		0.0011	0.00025	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
1,1,2,2-Tetrachloroethane	0.00023	U	0.0011	0.00023	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
1,1,2-Trichloro-1,2,2-trifluoroethane	0.00032	U	0.0011	0.00032	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
1,1,2-Trichloroethane	0.00019	U	0.0011	0.00019	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
1,1-Dichloroethane	0.00022	U	0.0011	0.00022	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
1,1-Dichloroethene	0.00024	U	0.0011	0.00024	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
1,2,3-Trichlorobenzene	0.00019	U	0.0011	0.00019	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
1,2,4-Trichlorobenzene	0.000098	U	0.0011	0.000098	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
1,2-Dibromo-3-Chloropropane	0.00049	U	0.0011	0.00049	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
1,2-Dichlorobenzene	0.00015	U	0.0011	0.00015	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
1,2-Dichloroethane	0.00032	U	0.0011	0.00032	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
1,2-Dichloropropane	0.00045	U	0.0011	0.00045	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
1,3-Dichlorobenzene	0.00017	U	0.0011	0.00017	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
1,4-Dichlorobenzene	0.00011	U	0.0011	0.00011	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
1,4-Dioxane	0.0098	U	0.021	0.0098	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
2-Butanone (MEK)	0.0012	U	0.0053	0.0012	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
2-Hexanone	0.00083	U	0.0053	0.00083	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
4-Methyl-2-pentanone (MIBK)	0.00073	J	0.0053	0.00071	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Acetone	0.0040	U	0.0053	0.0040	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Benzene	0.00027	U	0.0011	0.00027	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Bromoform	0.00045	U	0.0011	0.00045	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Bromomethane	0.00050	U	0.0011	0.00050	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Carbon disulfide	0.00028	U	0.0011	0.00028	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Carbon tetrachloride	0.00019	U	0.0011	0.00019	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Chlorobenzene	0.00019	U	0.0011	0.00019	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Chlorobromomethane	0.00030	U	0.0011	0.00030	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Chlorodibromomethane	0.00021	U	0.0011	0.00021	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Chloroethane	0.00056	U	0.0011	0.00056	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Chloroform	0.00034	U	0.0011	0.00034	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Chloromethane	0.00046	U	0.0011	0.00046	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
cis-1,2-Dichloroethene	0.00016	U	0.0011	0.00016	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
cis-1,3-Dichloropropene	0.00029	U	0.0011	0.00029	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Cyclohexane	0.00024	U	0.0011	0.00024	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Dichlorobromomethane	0.00027	U	0.0011	0.00027	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Dichlorodifluoromethane	0.00036	U	0.0011	0.00036	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Ethylbenzene	0.00021	U	0.0011	0.00021	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Ethylene Dibromide	0.00019	U	0.0011	0.00019	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Isopropylbenzene	0.00013	U	0.0011	0.00013	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Methyl acetate	0.0046	U	0.0053	0.0046	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Methyl tert-butyl ether	0.00013	U	0.0011	0.00013	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Methylcyclohexane	0.00017	U	0.0011	0.00017	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Methylene Chloride	0.00019	J B	0.0011	0.00017	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
m-Xylene & p-Xylene	0.00019	U	0.0011	0.00019	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
o-Xylene	0.00010	U	0.0011	0.00010	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Styrene	0.00013	U	0.0011	0.00013	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
TBA	0.0035	U	0.011	0.0035	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Tetrachloroethene	0.00024	J	0.0011	0.00015	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
Toluene	0.00067	U	0.0011	0.00067	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1
trans-1,2-Dichloroethene	0.00026	U	0.0011	0.00026	mg/Kg	☼	10/06/18 14:45	10/09/18 01:32	1

Appendix D

Glossary

Appendix D

GLOSSARY

The following definitions are to be used throughout this guidance document. Where appropriate, definitions are referenced to existing definitions in the Technical Requirements N.J.A.C. 7:26E-1.8; https://dep.nj.gov/wp-content/uploads/rules/rules/njac7_26e.pdf).

"Applicable remediation standard" means the standard selected for the site, based on but not limited to the remediation standard as defined at N.J.A.C. 7:26D-1.5 and/or site-specific criterion, site-specific conditions, intended future use of the site, and chosen remedial action (i.e., unrestricted, limited restricted, restricted).

"Attainment of compliance" in general means the process by which analytical data from a site or area of concern are compared against all applicable remediation standards, and a determination made as to whether existing site conditions meet or exceed those standards. This process can be accomplished using either single point compliance or compliance averaging.

"Compliance averaging" means determining compliance for the soil direct contact (ingestion-dermal, inhalation), soil migration to ground water, and ground water exposure pathways using the methodologies described in this document, including but not limited to the arithmetic mean, the 95% upper confidence limit (UCL) of the mean, spatially weighted averaging (e.g., Thiessen polygons), and the 75%/10x procedure.

"Contaminant of concern" means site-specific compounds associated with a discharge(s) at or from a site that are detected in environmental media (soil, ground water, surface water, sediment, air) above regulatory criteria. It also includes the degradation byproducts from the COCs.

"Direct contact" soil exposure pathways include both the ingestion-dermal exposure pathway and the inhalation exposure pathway.

"Functional area" means an area of fixed size which corresponds to the areas of typical residential and nonresidential sites. The purpose of the functional area is to help select the samples to be included in the compliance averaging process.

"Limited restricted use remedial action" is as defined in the Technical Requirements (N.J.A.C. 7:26E-1.8).

"Method detection limit" or "MDL" means the minimum concentration of a substance that can be measured and reported with a 99 percent confidence that the analyte concentration is greater than zero and is determined from the analysis of a sample in a given matrix containing the analyte.

"Reporting limit" means, for a compound analyzed by a particular method, the sample equivalent concentration (that is, based on sample specific preparation and analysis factors), for organics, associated with the lowest concentration standard used in the calibration of the method

and for inorganics, derived from the concentration of that analyte in the lowest level check standard (which could be the lowest calibration standard in a multi-point calibration curve).

"Restricted use remedial action" is as defined in the Technical Requirements (N.J.A.C. 7:26E-1.8).

"Significant figure" means any of the figures 0 through 9 that are used with its place value to denote a numerical quantity to some desired approximation, excepting all leading zeros and some trailing zeros in numbers not represented with a decimal point. The number of significant figures in a measurement, such as 2.531, is equal to the number of digits that are known with some degree of confidence (2, 5, and 3) plus the last digit (1), which is an estimate or approximation.

"Single point compliance" means the comparison of an analytical result from a single sample to each applicable remediation standard for each medium and exposure pathway, to determine whether contamination is present and additional remediation is required at the site or area of concern.

"Unrestricted use remedial action" is as defined in the Technical Requirements (N.J.A.C. 7:26E-1.8).

Appendix E

Acronyms

Appendix E

ACRONYMS

AOC	Area Of Concern
ARRCS	Administrative Requirements for the Remediation of Contaminated Sites
bgs	below ground surface
CEA	Classification Exception Area
CSM	Conceptual Site Model
DAF	Dilution Attenuation Factor
FA	Financial Assurance
LNAPL	Light Non-Aqueous Phase Liquid
LSRP	Licensed Site Remediation Professional
MDL	Method Detection Limit
ND	Non-Detect
N.J.A.C.	New Jersey Administrative Code
N.J.S.A.	New Jersey Statutes Annotated
RA	Remedial action
RI	Remedial Investigation
RL	Reporting Limit
SI	Site Investigation
SRRA	Site Remediation Reform Act
SWA	Spatially Weighted Average
UCL	Upper Confidence Limit
U.S. EPA	United States Environmental Protection Agency