New Jersey
Department of Environmental Protection

Site Remediation and
Waste Management Program

Historically Applied Pesticide Site Technical Guidance

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1.0 Intended Use of Guidance

This guidance is designed to help the person responsible for conducting the remediation to comply with the New Jersey Department of Environmental Protection (NJDEP) requirements established by the Technical Requirements for Site Remediation (Technical Rules), N.J.A.C. 7:26E, dated May 2012. 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 that uses this guidance to remediate a contaminated site on behalf of a remediating party, including the remediating party itself.

The procedures for a person to vary from the technical requirements in regulation are outlined in the Technical Rules 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 NJDEP guidance issued on this topic, specifically the 1999 "Findings and Recommendations for the Remediation of Historic Pesticide Contamination". The link to the 1999 guidance is attached as Appendix A as it provides a reference on the historic use and application of pesticides.

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

Pesticides have routinely and consistently been applied to control pests and increase crop yield over the past 100 years. Guidance has been sought to address concerns (AOCs) regarding residuals from historically applied pesticides (HAP). A definition of HAP can be found in Appendix B. A list of acronyms can be found in Appendix C.

If a Response Action Outcome (RAO) addressing a HAP AOC or an entire site RAO is to be issued by an LSRP, this guidance should be utilized to provide direction to practitioners in their assessment, investigation, delineation and remediation of HAP contamination.

This document provides the investigator with methods for identifying HAP on former agricultural and other properties, outlines investigative techniques and describes options to remediate HAP.

In March 1999, the Historic Pesticide Task Force issued a final report entitled "Findings and Recommendations for the Remediation of Historic Pesticide Contamination". This document addressed the many inquiries NJDEP received regarding residual pesticides found in soil at agricultural sites above the NJDEP residential direct contact soil cleanup criteria (RDCSCC; in use at the time) as these agricultural properties were being developed for residential use. Strategies and recommendations were provided to address potential human health and environmental impacts and to identify technical and economically viable strategies to limit human exposure at former agricultural sites. Strategies included capping impacted soil with clean fill, blending impacts to reduce concentrations and excavation and off-site disposal. Since the time that document was published, NJDEP has approved compliance averaging of HAP and in some cases the excavation and relocation of impacted soils to adjacent parcels that will remain as farmland.

This guidance provides the investigator with a more streamlined approach to the investigation, delineation and remediation of HAP than the 1999 guidance. In preparation of this guidance, stakeholders have incorporated knowledge gained since development of the 1999 guidance, and have reviewed more recent technical information on historic pesticide investigations in New Jersey and other states. This guidance document will assist investigators who may be addressing HAP to meet the requirements to protect human health and the environment pursuant to the Site Remediation Reform Act.

This document does not provide guidance for discharges of pesticides in areas such as pesticide mixing areas, pesticide dump areas, and pesticide spill areas. If the results of sampling in any such area indicate that the area is contaminated, then the Site Investigation/Remedial Investigation/Remedial Action (SI/RI/RA) guidance documents should be used in lieu of this document.

Agricultural properties where HAP has been identified or is assumed to be present because of the prior and/or current use may defer the requirements associated with investigation and remediation of the HAP unless or until there is a change of use to a school, child care center or residence, or if there is a newly identified Immediate Environmental Concern (IEC) condition at which time all SRP guidance, including this guidance, should be used. When HAP is identified at an agricultural property the SRP contact for historic pesticides which can be found at http://www.nj.gov/dep/srp/srra/srra_contacts.htm should be contacted for advice on how to proceed.

Residential properties where HAP may be present do not require investigation and remediation of the HAP unless there is a newly identified IEC condition, at which time all relevant SRP guidance, including this guidance, should be used.

3.0 Document Overview

The Document provides guidance on the following:

- How to identify if HAP were used at the site
- How to conduct a site investigation for HAP
- How to determine if naturally occurring compounds exist at the site above the RDCSRS
- When to conduct a ground water investigation
- How to conduct a RI for HAP
- Remedial options that are most commonly implemented for HAP

Upon completion of the remedial action, demonstration of attainment must be completed in accordance with the Remediation Standards (N.J.A.C. 7:26D), Technical Requirements for Site Remediation (N.J.A.C. 7:26E) and the Administrative Requirements for the Remediation of Contaminated Sites (ARRCS, N.J.A.C. 7:26C) at the time when a RAO is to be issued.

4.0 Site Investigation

Historical information (e.g., aerial photographs, maps, interviews) for the site should be reviewed to identify areas on the property that were used for agricultural purposes and suspected areas of HAP (see map in Appendix E). Historic aerial photographs are a good source of such information and are readily available for New Jersey (e.g., www.historicaerials.com). . If a whole site RAO is to be issued, it is necessary to follow all SRP guidance including Preliminary Assessment Technical Guidance Document which can be found at http://www.nj.gov/dep/srp/guidance/#pa_soils.

The goal of SI sampling is to determine if HAP are present at levels exceeding the Department's Soil Remediation Standards. Soil samples should be compared to the Residential Direct Contact Soil Remediation Standards (RDCSRS).

Sampling should be conducted in accordance with the NJDEP Field Sampling Procedures Manual and analysis conducted by certified laboratories pursuant to the Technical Rules, N.J.A.C. 7:26E-2.

4.1 Site Investigation Sampling

The following provides an overview of recommended HAP SI sampling location, extent, depth and frequency.

4.1.a Sample Location/Extent

If the areas of historical pesticide application are known, collect samples in accordance with the frequencies discussed below. Locations should be biased if site-specific information is known. If the extent of historical pesticide application cannot be determined, the entire property should be sampled.

SI sampling locations should be biased toward suspected or known areas of highest contamination, including but not limited to, low-lying areas, orchards, drainage features and cultivated fields.

4.1.b Sample Depth

Collect discrete soil samples from the surficial six (6) inch top soil interval, as this is where the greatest pesticide concentrations are anticipated. Note, if fill was brought onto the site subsequent to the agricultural use, the depth of the top soil interval should be determined prior to sampling and should be based on original grade.

4.1.c Sample Frequency

Sampling frequency is dependent on the size of the HAP area. Use the following information to determine sampling frequency:

- For the first 10 acres, collect one sample for every 2 acres with a minimum of two samples;
- For larger HAP areas, collect five samples, plus one additional sample for every 5 acres greater than 10 acres.

A reduced sampling frequency may be appropriate for very large HAP areas, over 100 acres.

4.1.d Analytical Parameters

All samples should be analyzed for arsenic, lead and Target Compound List (TCL) pesticides.

4.2 Ecological Evaluation

An Ecological Evaluation in accordance with N.J.A.C. 7:26E-1.16 must be conducted to identify sensitive receptors on or adjacent to the HAP site. Sampling and delineation of impacts to other media, including sediment and surface water, may be required as detailed in N.J.A.C. 7:26E-4.1(a)1. For further information, consult the NJDEP Ecological Evaluation Technical Guidance document available at http://www.nj.gov/dep/srp/guidance/#eco_eval.

4.3 Natural Background Investigation

Historically, arsenic-based pesticides were widely used and, beginning in the 1940's, were gradually supplanted with the advent of organochlorine pesticides. Lead arsenate was a common arsenical; however, copper, sodium and calcium-based arsenicals were also used. Due to limited

mobility, arsenic residues remain where arsenical pesticides were applied, with the highest levels typically being detected in the surficial soils or within the cultivated zone.

Arsenic is a naturally occurring element and, due to the presence of elevated levels of arsenic in soils in New Jersey, a background-based Soil Remediation Standard of 19 parts per million (ppm) has been established, rather than a strictly health-based level of less than 1 ppm. Utilization of the background-based standard still results in naturally occurring arsenic being present above the standard in some locations throughout the state. Where arsenic is naturally elevated above the standard it would be impracticable to remediate to the standard, and regulation prohibits the NJDEP from requiring remediation beyond natural background levels. The Technical Rules (N.J.A.C. 7:26E-3.8) provide the general regulations regarding the establishment of natural background. More detailed natural background guidance, including procedures for evaluating data outliers and determining the site-specific maximum background concentrations, can be found in "Technical Guidance for Site Investigation of Soil, Remedial Investigation of Soil, and Remedial Action Verification Sampling for Soil," available at http://www.nj.gov/dep/srp/guidance/#si_ri_ra_soils.

Background guidance stipulates sample collection from nearby areas unaffected by current and historical operations. When sampling agricultural properties within larger areas of current or historical farming, it may be difficult to find true background locations unaffected by previous pesticide application. In such situations it may be possible to locate samples in wind breaks, along wetland margins, roadways or on residential portions of the farm property. A second option is to evaluate the levels of arsenic present below any expected depth of impact from topical arsenical applications (typically >2 feet depth, dependent upon cultivation depths). Preference should be placed on the first option but both options can be used either separately or together to confirm background levels.

Natural background investigations should concentrate on locations with as similar as possible physical and geological conditions. It is recommended that a minimum of five locations be investigated with samples collected from the surficial six inch layer as well as at least one sub-surface depth interval at each location (minimum of 10 samples). The standard sub-surface depth through practice has been 18-24 inches; however, sampling deeper or collecting additional depth interval samples has been found to be useful in evaluating natural background in HAP areas. Experience has also reinforced the importance of selecting locations targeting any specific soil types and elevations where the highest levels of arsenic were first identified.

Common soil series containing naturally elevated levels of arsenic include: Kresson, Marlton, Freehold, Collington, Holmdel, Shrewsbury, Keyport, Adelphia and Tinton. These soils have been identified based upon experience, but this list is by no means exclusive and site-specific evaluation is recommended. The presence of glauconite and ironstone has also been associated with naturally elevated arsenic. Where naturally occurring arsenic is present, levels typically remain consistent or increase with depth in the soil profile. Where sampling indicates the highest levels of arsenic to be in the surficial soils with a decrease in sub-surface results, it is likely the result of a historic topical arsenical application.

Due to the widespread use of lead arsenate, particularly in orchards, the correlation between the levels of lead and arsenic can be a useful tool in determining whether elevated arsenic is related

to natural background or pesticide residues. A ratio of lead to arsenic of roughly 4:1 in surficial soil samples is a good indicator that HAP residuals exist. So although initial sampling may indicate that only arsenic is present above standards, it may be of value to continue including lead as an analyte during subsequent sampling to provide data to differentiate between natural background and HAP. In situations where naturally elevated arsenic alone occurs, lead levels will typically show no correlation and will normally be below 50 mg/kg.

The most difficult evaluation of natural versus arsenical pesticide-related arsenic is where both occur at the same site. The surficial soil results may indicate the presence of elevated arsenic and lead with a lead arsenate characteristic ratio, and deeper soil samples may show a decrease in lead and loss of the ratio; however, the arsenic may continue to exceed standards or even increase with depth. In these situations a more thorough evaluation of the soil profile and natural background is warranted. A natural background level could be established in excess of the 19 mg/kg standard, but remediation of the pesticide-impacted surficial soils above that site specific level may be necessary.

4.4 Attainment of Remediation Standards at HAP Sites (Site Investigation)

If pesticide concentrations are identified during the SI sampling, the areas should not immediately be treated as a localized hot spot. This may be indicative of possible site-wide pesticide use. The RI sampling guidance presented below should be followed.

The Department's "Technical Guidance for the Attainment of Remediation Standards and Site-Specific Criteria" (attainment guidance) was issued on September 24, 2012 (version 1.0) http://www.nj.gov/dep/srp/guidance/#attainment_comp. This guidance specifies single point compliance during the SI phase. However, NJDEP has historically accepted compliance averaging of data collected during the SI of a HAP area.

Compliance averaging of SI data for a HAP area may be appropriate when the analytical data identifies relatively uniform application across the area. For instance, if a pesticide is detected within most SI samples, but only a few of the samples exceed the applicable remedial standard, averaging the results during the SI may be appropriate. If the pesticide was detected above the applicable remedial standard in one sample, but was not detected in the remaining samples, the single detection may be indicative of a localized hot spot and compliance averaging may not be appropriate until a RI is performed.

The NJDEP attainment guidance specifies the evaluation of analytical data using horizontal functional areas based on site use (i.e., when using the 95% Upper Confidence Limit of the Mean or Spatially Weighted Average methods). However, for HAP areas, it may be appropriate to define the horizontal functional area based on patterns in the data or the configuration of historic crop types as determined based on review of historical aerial photographs or other historical data source. The NJDEP attainment guidance specifies a horizontal functional area of 0.25 acres for residential use and 2 acres for non-residential use. For HAP, there are no limitations on the shape or size of the functional area when compliance averaging the SI data. As indicated in the attainment guidance, excessive data from uncontaminated areas should not be included when compliance averaging.

If SI sampling attains the RDCSRS, no further evaluation of HAP is needed.

5.0 Remedial Investigation – Soil

Purpose & Goals

The goal of the soil RI for HAP is to evaluate the following:

- Nature and extent of HAP compounds found during the SI that exceeded the RDCSRS
- Known and potential impacts to receptors presented by HAP
- Need for a remedial action
- If a remedial action is necessary, collection of information to support the evaluation of potential remedial alternatives

5.1 Horizontal Delineation

Sampling for HAP beyond the site boundary is not required. Multiple lines of evidence should be used for determination of the horizontal extent of HAP contamination. Typical lines of evidence that may be used include the following:

- Historical Aerial Photography: Aerial photographs can be used to determine the extent of agricultural use, as well as the crop type and location through time.

- Interviews: The property owner or farmer may have specific knowledge of pesticide application practices.

- Drainage Patterns: Historical and current drainage features should be considered since they may have an influence on HAP distribution. Drainage features may, depending on the type of pesticide application, act as buffers for lateral migration of HAP.

5.2 Vertical Delineation

The highest concentrations of HAP are typically found in the cultivated zone since HAPs are typically applied to the surface and bind to soil organic matter. The uniformity of the HAP concentrations within the surficial organic layer may vary depending on whether the soil was historically cultivated. Cultivation typically results in a surficial organic layer with a thickness that may exceed 12 inches. Concentrations may be fairly uniform within topsoil that has been subjected to cultivating for many years following the historical topical pesticide application. For non-agricultural pesticide applications cases where cultivation is not common, HAP concentrations may decrease with depth within the topsoil layer. Consider the historic use of the site as well as visual observations/logging of the soil column when determining sample depths for vertical delineation.

In consideration of the above it may be most efficient for vertical delineation to begin with the six inch interval below the cultivated zone because the cultivated zone should have been sampled

during the SI (i.e. below the surficial layer that is often characterized by higher organic content and lack of stratigraphic features).

5.3 Soil Sampling to Evaluate the Feasibility of Blending

Evaluating the feasibility of blending requires a thorough understanding of the horizontal and vertical extent of the HAP concentrations. Generally this requires more analytical data when compared to other remedial options to account for the variability across the site (and mitigate the potential for an incomplete remedial action.)

Sampling at varying depths should be performed to develop a vertical profile of HAP concentrations to obtain the data needed to perform soil averaging calculations through the planned blending zone. This will typically include samples collected within the cultivated zone where HAP are generally higher (to determine the thickness of the contaminated zone), and samples collected below the cultivated zone where HAP are generally lower (to evaluate concentrations in the depth interval that will serve as 'clean' soil for blending). Samples collected for vertical profiling should not be collected across the boundary between the surficial organic layer (topsoil) and the subsoil, so as not to artificially skew the surface data.

The thickness of the impacted surficial organic layer should be measured at each sampling location since this data is critical when performing soil averaging calculations because more impacted soil will require more non-impacted soil to be blended. (as described below)

When evaluating the feasibility of blending where arsenic is the HAP of concern, naturally-occurring arsenic concentrations should be considered, even if they are present below the RDCSRS of 19 mg/kg. Naturally occurring arsenic concentrations can vary significantly with depth, and concentrations often increase with depth. Samples should be collected at each six inch interval through the proposed blending depth. The investigator should include naturally-occurring arsenic concentrations in the soil averaging calculations. To increase the probability of successful blending (and reduce the risk of repeating remediation), the investigator may wish to use the "worst case" concentration of naturally-occurring arsenic identified; however, this may vary with location or depth based on soil type. (as described below)

5.3.a Soil Averaging for the Purpose of Blending

This section explains the calculations needed to help the investigator determine how deep blending needs to extend at a given site AOC in order to achieve the applicable soil standards.

Examples of contaminant profiles and soil blending calculations are presented below. The average is calculated using dieldrin concentrations present within each depth interval. In Scenario A, the soil averaging calculation suggests a blending depth of 24 inches would be appropriate since blending to a depth of less than 24 inches would not achieve the desired outcome.

Scenario A

Inches below grade	Dieldrin results	Running average
6”	0.127	0.127
12”	0.01224	0.070
18”	ND(0)	0.046
24”	ND(0)	0.035
	Soil Standard: 0.04 ppm	Average 0.035ppm

In Scenario B, although the calculations indicate compliance at 24 inches, the investigator may wish to consider blending to the next depth interval to ensure compliance and compensate for variability in concentrations of HAP. Note that in Scenario B, the concentration within the upper 12 inches is considered twice in the calculation (once for each 6 inch depth interval) since the sample was collected from the 0-12 inch interval.

Scenario B

Inches below grade	Dieldrin Results	Running Average
	0.070	
12”	0.070	0.070
18”	0.021	0.054
24”	ND(0)	0.04
30”	ND(0)	0.033
	Soil standard 0.04	Average 0.033ppm

Elevated concentrations of naturally occurring arsenic may impact the effectiveness of blending and should be considered in soil averaging calculations, even if they are present below the RDCSRS of 19 mg/kg. In Scenario C, elevated naturally-occurring arsenic present at depths from 18-36” extends the required blending depth to 60” where lower levels of arsenic are present.

Scenario C

Inches below grade	Arsenic Results	Running Average
6”	62	62
12”	25	43.5
18”	12	33
24”	17	29
30”	22	27.6
36”	21	26.5
42”	10	24.1
48”	7	22
54”	5	20.6
60”	3	18.3
	Soil Standard: 19 ppm	Average 18.3 ppm

5.4 Attainment of Remediation Standards at HAP Sites (Remedial Investigation)

The NJDEP attainment guidance specifies the evaluation of analytical data using horizontal functional areas based on site use (when using the 95% Upper Confidence Limit of the Mean or Spatially Weighted Average methods). However, for HAP areas, it may be appropriate to define the horizontal functional area based on patterns in the data or the configuration of historic crop types as determined based on review of historical aerial photographs or other historical data source. The NJDEP attainment guidance specifies a horizontal functional area of 0.25 acres for residential use and 2 acres for non-residential use. For HAP, there are no limitations on the shape or size of the functional area when compliance averaging the RI data. As indicated in the referenced guidance, excessive data from uncontaminated areas should not be included when compliance averaging.

The vertical functional area to be used when compliance averaging RI data will consist of the upper two feet of soil since SI samples are typically collected from the upper six inches.
If evaluation of the RI data indicates the applicable soil remediation standards have not been attained, then remediation is warranted. Additional RI sampling should be performed if needed to evaluate remedial alternatives.

6.0 Ground Water Remedial Investigation at HAP Sites

Since there is a potential for pesticide contamination to be present in ground water at HAP sites, the investigator should assess whether or not a ground water investigation is necessary as part of the RI.

Determining the necessity of a ground water investigation can be facilitated by adhering to the following guidelines (Also refer to Section 2.3 "Considerations for When a Site Investigation of Ground Water is Necessary" of the Ground Water Technical Guidance SI/RI/RA; http://www.nj.gov/dep/srp/guidance/#pa_si_ri_gw):

1) Determine the site-specific depth to ground water.

    a) The approximate depth of the water table (DTW) may be determined from the use of existing soil and topographic mapping data.

    b) If DTW is concluded to be less than 10 feet below grade using mapping data, then it is recommended that the DTW be determined by means of direct measurements within select borings installed during the RI soil investigation.

2) After HAP has been characterized, consider the following factors when determining whether a groundwater investigation is needed:

    a) HAP exceeding the Impact to Ground Water Soil Remediation Standards (IGWSRS) intersects the water table;

b) The HAP above the RDCSRS are not on the immobile chemicals list (http://www.nj.gov/dep/srp/guidance/rs/immobile_chemicals.pdf) and the buffer zone is less than two feet thick, between the bottom of the zone where HAP exceed RDCSRS and the water table; or

c) The end use of the site will include the installation of potable wells.

3) If after evaluating 1 and 2 above it is determined that a ground water investigation is warranted:

a) Predict ground water flow direction based on data from existing ground water monitoring wells, topographic relief, the location of surface water bodies, structural controls in bedrock or soils, location of pumping wells and subsurface conduits at or below the water table.

b) Collect ground water samples beneath areas with higher levels of contamination in soil and/or in areas where the water table intersects the contaminated soil zone (Also refer to Section 2.5.1 of the Ground Water Technical Guidance SI/RI/RA; http://www.nj.gov/dep/srp/guidance/#pa_si_ri_gw).

Ground water samples should be analyzed for those site-specific HAP that exceed RDCSRS as identified in the soil SI/RI. The ground water sample collection and analysis methods should be based on the criteria in the NJDEP "Field Sampling Procedures Manual" (http://www.nj.gov/dep/srp/guidance/fspm/).
The NJDEP cautions against the exclusive use of temporary well points to sample ground water at HAP sites. This caution is particularly important for metals and/or where HAP exceeding the RDCSRS are present in soil in close proximity to the water table. Ground water samples obtained from temporary well points may be turbid and could falsely elevate the detected concentrations. Consequently, the NJDEP recommends the use of low-flow sampling methods to minimize sediment in the sample to reduce the likelihood of a false positive result.

In addition, the use of filtered versus unfiltered analyses can be used as part of a lines of evidence approach to evaluate whether or not elevated pesticide concentrations in ground water are due to turbidity.

c) Establish a classification exception area (CEA) if site-related ground water contamination is confirmed. The web page for the CEA guidance can be found at http://www.nj.gov/dep/srp/guidance/cea/cea_guide.htm. See also Section 7.7 of this guidance about CEAs for HAP sites.

7.0 Remedial Actions

The investigator should complete an analysis of the data generated in the RI to determine if compliance can be achieved without remediation. This generally requires an analysis of all RI results in accordance with the compliance attainment options for the site or that portion of the site under consideration. Based on that analysis the investigator should determine if the entire subject area requires remediation or if only a portion of the site requires remediation. Often the most practical approach requires a review of the analysis eliminating one or more "hotspot" areas to achieve the remediation standard using a suitable compliance averaging approach.

The following standard remediation strategies are generally applicable to the remediation of HAP and can be used in any combination – for the entire site or selected portions of the site – to achieve remediation:

- Removal
- Engineering and institutional controls
    - capping in place
    - consolidation and capping
    - deed notice
- Soil blending
- Treatment

7.1 Removal

Soils impacted with residual pesticides in excess of the applicable remediation standard can be excavated and handled as follows:

- Managed with engineering and institutional controls (see discussion in Section 7.2)
- Moved to an area of a site where agricultural use will continue
- Used as alternative fill on site
- Used as alternative fill off site
- Transported off site to a suitably licensed disposal facility

When excavated soil will continue to be used for agricultural purposes, it can be relocated to other areas of the site. As the NJDEP considers this to be a beneficial reuse of agriculturally important topsoil, the reuse would be an acceptable variance from the Department's like-on-like and 75th percentile rules (N.J.A.C. 7:26E-5.2(b)2). This action does not require a Deed Notice for the receiving area as long as the receiving area continues to be used for agricultural purposes.

Excavated soil can be reused off site as alternative fill provided the soil movement complies with the NJDEP like-on-like and 75th percentile rules (N.J.A.C. 7:26E-5.2(b)2) and the relocated soil is remediated pursuant to N.J.A.C. 7:26E. The NJDEP notes that municipal approval and an acknowledgement by the owner of the receiving property may be required.

Alternatively, the excavated soil can be transported to a suitably licensed disposal facility capable of managing the soil in accordance with NJDEP regulations.

7.2 Engineering and Institutional Controls

Where HAP residuals will remain on a site that will no longer be used for agricultural purposes and the HAP concentrations exceed remediation standards, institutional and/or engineering controls may be required. The use of an institutional control (Deed Notice) or and engineering control (cap) also require a Remedial Action Permit for Soil to be issued by the NJDEP. The permit will require long term maintenance of the engineering controls (if applicable) and biennial certifications submitted to the NJDEP in accordance with the Technical Rule and ARRCS.

The potential for future impact to ground water should be considered as part of the evaluation of a remedy (see Section 7.7). The investigator should consider the mobility of the HAP of concern, the anticipated depth to ground water, and the greatest depth where HAP concentrations exceed the RDCSRS in determining if soils remediated through engineering controls would represent a future concern to ground water. In general, HAP above the RDCSRS should not be placed in close proximity to the water table during consolidation.

7.2.a Consolidation

HAP above the RDCSRS can be consolidated on site and placed under a suitable engineering control such as buildings, roads, landscaping or aesthetic berms, or otherwise capped to prevent direct contact exposure as long as the receiving area has similar levels of HAP. Consolidation allows for a reduction in the size of the cap, which may reduce the financial assurance amount. Construction of landscaping berms may also help meet municipal requirements and can be used as consolidation areas, with suitable engineering and/or institutional controls.

7.2.b Capping In Place

HAP above the RDCSRS can be capped in place. Soils to be used for capping should meet the specifications provided in the *Alternative and Clean Fill Guidance for SRP Sites* available at http://www.nj.gov/dep/srp/guidance/#fill_srp, Capping of Sites Undergoing Remediation at http://www.nj.gov/dep/srp/guidance/#capping and Presumptive and Alternative Remedy Guidance at http://www.nj.gov/dep/srp/guidance/#presumptive_alt_remedy.

7.3 Soil Blending

NJDEP has determined that soil blending is a unique remediation strategy applicable only to the remediation of HAP. Blending (physical mixing) of impacted soil with clean soil may be used to achieve compliance with the applicable soil remediation standards. This approach may only be used for soils which exhibit residual pesticide levels characteristic of a topical pesticide application (i.e., not a spill). Blending is often the most economical way of addressing HAP.

Successful blending requires a thorough understanding of the vertical and horizontal profile of the soils within the AOC under consideration, as discussed in the soil averaging section above (Section 5.3a). Generally this requires significantly more analytical data prior to remediation to ensure that the planned blending will meet the objective of achieving the applicable remediation standard. This may be accomplished using a sampling grid established across the impacted area with samples obtained from a series of depth horizons at each node of the grid. Sample analysis can be limited to the HAP of concern as established in the RI.

Typically, samples are analyzed sequentially with depth to determine the vertical profile of contaminated soil at impacted nodes. Once the vertical and horizontal profile has been determined, the data should be analyzed to determine the quantity of native or clean soil required to achieve the blending objective within each grid.

Blending of soils with HAP concentrations that are greater than five times the applicable remediation standard is generally not recommended because it will be difficult to achieve compliance and to get enough clean soil. If such excessive blending is attempted and fails to achieve the standard, a significantly larger volume of contaminated soil will have been generated and have to be addressed using other, potentially more cost-intensive remedial options.

Blending may be achieved in-situ using clean subsurface soils or imported clean soil from off site. In the case of imported soils, they should be evaluated to confirm their acceptability using the current *Alternative and Clean Fill Guidance for SRP Sites* available at http://www.nj.gov/dep/srp/guidance/#fill_srp and to determine if the pesticide concentrations in the imported soil are suitable for use in blending (i.e., they do not contain elevated concentrations of pesticides).

Blending may also be performed ex-situ, where contaminated soils are excavated and mixed in piles or in designated areas of a site where staged (impacted) soil is spread over an area then blended using a typical in-situ blending strategy.

There are several types of equipment that have been utilized for blending, including rototillers, trenchers, excavators, and disc tilling equipment. Each has their own set of advantages and disadvantages, which should be explored prior to making a selection on their use. For example, trenching equipment does a very good job of blending and can blend to a depth of four feet or more, but is very slow and can be costly. Specialized rototillers and disc tilling equipment can blend a greater area in a day, but can be limited by depth. Blending using excavators and pans should be limited to the ex-situ blending scenario since their success with an in-situ blending strategy has been demonstrated to be marginal at best. The key to successful blending is to ensure that vertical mixing is successfully completed across the zone. Grading equipment is effective at completing horizontal mixing only.

The following are other considerations when evaluating the potential efficacy of blending, based upon the experience of the guidance team:

- Blending is generally not feasible at sites with both high background arsenic concentrations and arsenic as a HAP of concern.

- Blending generally requires significantly more analytical data prior to selection as a remedial option.

- A suitable blending methodology is required to ensure the desired blending is achieved. For example, if the primary goal is to blend deeper clean soils with contaminated surface soils, the methodology selected must be capable of blending through the entire required depth zone or the blending operation will fail to achieve the desired result. Soil types and moisture also impact the effectiveness of some blending methodologies.

- Blending topsoil will generally distribute organic material throughout the blended depth, which may affect the suitability of the blended soil for structural support (e.g., under roadways or buildings). Accordingly, it is common to strip soil from proposed roadways and building pads and redistribute these soils to other areas prior to blending.

- The investigator must consider the mobility of the HAP of concern, the depth of the blending zone, and the anticipated depth to ground water to evaluate the potential for blending to create ground water impacts.

- Blending should not be used when the seasonal high water table is within the blending zone.

- The soil type and its ability to be blended should be considered when assessing the likely efficacy of blending. For example, soils that are high in clay content, or contain heavy, wet clays tend to form clumps and are often poor candidates for blending. Where uncertainty exists, it may be desirable to conduct a field pilot test.

7.4 Treatment

The treatment (i.e., using chemical additives or biological processes) of pesticide contaminated soil is not considered to be a practicable option at this time. Treatment technologies may exist, but would generally be cost prohibitive for HAP sites. However, a feasible treatment method may be utilized with appropriate verification and any applicable permits.

7.5 Remediation Verification

For remedial verification sampling following in-situ blending, excavation, or treatment, it is recommended that four soil samples be collected for each acre of soil remediated/blended. For blending and treatment, these samples will be collected from the surface interval. Where excavation is conducted, the samples would be collected from the six-inch interval below the excavation (unless RI delineation samples are being used).

For blending sites, one profile sampling location should also be evaluated for every four acres of soil to be blended (minimum one location per site). The profile location is sampled vertically in six-inch increments through the blended zone.

As an example, if 8 acres are blended to a depth of two feet, 32 surface samples (0-6 inches) would be obtained, and at two of these locations, additional samples would be obtained at 6-12 inches, 12-18 inches, and 18-24 inches, for a total of 38 samples. Sample analysis need be only for the HAP of concern. This sampling methodology should also be used when soils are excavated and relocated to a designated blending area (i.e., in-situ blending after relocation) to verify site conditions following remediation.

If post-remediation sampling results exceed the applicable remediation standard after considering the compliance/attainment concepts outlined in this guidance, re-blending or resampling of the affected area represented by the contaminated sample would be warranted. Remedial verification sampling after re-blending should follow the frequency outlined above, including vertical incremental sampling throughout the blended zone. Alternatively, the area may be re-sampled to confirm that the original sample point is representative. If supplemental sampling of the affected area shows the area is acceptable, the attainment guidance should be used to determine if further remediation is required.

7.6 Attainment of Remediation Standards at HAP Sites (Remedial Action)

The NJDEP attainment guidance specifies the evaluation of remedial verification analytical data using functional areas (when using the 95% Upper Confidence Limit of the Mean or Spatially Weighted Average methods). It may be appropriate to deviate from the methods used to define these functional areas for topically applied HAP areas, as described below.

In the attainment guidance, horizontal functional areas used to evaluate the ingestion/dermal pathway are based on planned site use, or limited to the size of the AOC, whichever is smaller. For HAP areas, it may be appropriate to evaluate remedial verification analytical data (post-excavation or post-blending) for the ingestion/dermal and inhalation pathways without consideration of planned site use, and within the full extent of the remediated area. Most HAP cases are remediated in preparation for development. It is common practice for developers to stockpile then redistribute topsoil during development, further mixing the topsoil. This mixing of soil supports establishing larger horizontal functional areas for HAP areas. There are no limitations on the shape of the functional area when compliance averaging the remedial verification data.

In the attainment guidance, vertical functional areas established for evaluating the ingestion/dermal pathway are based on depth relative to the ground surface (two zones, 0-2 feet and greater than 2 feet). In-situ blending is often selected as a remedial option for HAP, and blending may be performed to depths exceeding the surface vertical functional area of 0-2 feet specified for the ingestion/dermal pathway. When evaluating post-blending remedial verification results, it is acceptable to establish a vertical function area that corresponds to the entire blended depth.

Establishing functional areas is generally not appropriate when evaluating remedial verification results for ex-situ remedial actions (e.g., ex-situ blending). The investigator should refer to the sampling recommendations provided in Table 2 – Sampling Frequency Guide for Clean Fill of the attainment guidance.

7.7 Ground Water Remediation

If HAP-related ground water contamination is found, then it is necessary to establish a CEA. The size of the CEA can be limited to the horizontal and vertical extent of the on-site contamination or to the property boundaries. The duration of the CEA would be indeterminate if the contaminants are left in place. A Remedial Action Permit must be obtained in accordance with N.J.A.C. 7:26C-7 if ground water contamination will remain on the property.

The NJDEP discourages establishment of CEAs without confirmation that ground water has actually been contaminated by site-related HAP (e.g., the investigator should not rely on a ground water sample obtained from a temporary well point alone to demonstrate that ground water has been contaminated.)

A CEA should not be established for naturally occurring arsenic detected in ground water.

8.0 Response Action Outcome (RAO)

The same procedures should be followed for issuing an RAO for HAP as those used for other sites and areas of concern.

If HAP is not investigated, the following RAO insert can be used and can be found at: http://www.nj.gov/dep/srp/srra/listserv_archives/2014/20140620_srra.html.

Use of this Notice:
The following notice should be used anytime pesticides may have been historically applied at a site but were **not investigated** as part of the remediation (i.e., historical application of pesticides at an industrial facility not investigated). This Notice should not be used in situations where the manufacturing, mixing, or other handling of these chemicals resulted in a discharge to the environment. This Notice also would not be appropriate for properties going through a change of use to residences, schools, child care centers, and/or playgrounds.

> "Please be advised that the remediation that is covered by this Response Action Outcome does not address the remediation of contaminants that may exist from the historical application of pesticides. As a result, any risks to human health presented by the historical application of pesticides may remain. An evaluation of historical pesticides should be completed if there is a land use change to residences, schools, child care centers and playgrounds. This exclusion does not apply if the pesticide contamination is from a discharge due to manufacturing, mixing, or other handling of these chemicals and not from application."

APPENDICES

APPENDIX A

Findings and Recommendations for the Remediation of Historic Pesticide Contamination

Findings and Recommendations for the Remediation of Historic Pesticide Contamination

Historic Pesticide Contamination Task Force

Final Report - March 1999

The entire document can be viewed at the following link:
http://www.state.nj.us/dep/special/hpctf/final/index.html

APPENDIX B

Glossary

Glossary

Blending – The physical mixing of soil to attain compliance with standards.

HAP – Historically Applied Pesticide(s)- Pesticides that were found to have long lived residues and lasting health and environmental impacts. The pesticides of concern, which have not been widely used in many years, are arsenic, lead, DDT (and its metabolites, DDE and DDD), dieldrin, aldrin and chlorodane. For a complete list of organochloride pesticides can be found in Appendix D.

APPENDIX C

Acronyms

Acronyms

AOC	Area of Concern
ARRCS	Administrative Requirements for the Remediation of Contaminated Sites
CEA	Classification Exception Area
Cultivate	prepare and use (land) for crops
DTW	depth of the water table
HAP	Historically Applied Pesticides
LSRP	Licensed Site Remediation Professional
N.J.A.C.	New Jersey Administrative Code
NJDEP/Department	New Jersey Department of Environmental Protection
PA/SI	Preliminary Assessment / Site Investigation
ppm	parts per million
RA	Remedial Action
RAO	Response Action Outcome
RAP	Remedial Action Permit
RAR	Remedial Action Report
RDCSCC	Residential Direct Contact Soil Cleanup Criteria
RDCSRS	Residential Direct Contact Soil Remediation Standards
RI	Remedial Investigation

APPENDIX D

Organochlorine Pesticides List

Organochlorine Pesticides List

Compound	CAS Registry No.*
Aldrin	309-00-2
α-BHC	319-84-6
β-BHC	319-85-7
γ-BHC (Lindane)	58-89-9
δ-BHC	319-86-8
cis-Chlordane	5103-71-9
trans-Chlordane	5103-74-2
Chlordane -- not otherwise specified (n.o.s.)	57-74-9
Chlorobenzilate	510-15-6
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8
4,4'-DDD	72-54-8
4,4'-DDE	72-55-9
4,4'-DDT	50-29-3
Diallate	2303-16-4
Dieldrin	60-57-1
Endosulfan I	959-98-8
Endosulfan II	33213-65-9
Endosulfan sulfate	1031-07-8
Endrin	72-20-8
Endrin aldehyde	7421-93-4
Endrin ketone	53494-70-5
Heptachlor	76-44-8
Heptachlor epoxide	1024-57-3
Hexachlorobenzene	118-74-1
Hexachlorocyclopentadiene	77-47-4
Isodrin	465-73-6
Methoxychlor	72-43-5
Toxaphene	8001-35-2

*Chemical Abstract Service Registry Number

APPENDIX E

Aerial Photograph

Example of an Aerial Photograph