Hydrogeologic Investigation Guide

Delaware Department of Natural Resources and Environmental Control

Tank Management Section

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Division of Waste and Hazardous Substances

Tank Management Section

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Check below if included:

____ Project information

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Facility Project #: ________________________________
Facility Name: ________________________________
Facility Address: ________________________________
Tax Parcel ID: ________________________________

____ Responsible Party information

Responsible Party: ________________________________
Address: ________________________________
Contact: ________________________________

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List of Acronyms

AST	Aboveground Storage Tank
ASTM	American Society for Testing and Materials
CMP	Contaminant Migration Pathway
COC	Chemical of Concern
CSM	Conceptual Site Model
DERBCAP	Delaware Risk Based Corrective Action Program
DNREC	Department of Natural Resources and Environmental Control
HI	Hydrogeologic Investigation
HIR	Hydrogeologic Investigation Report
ID	Identification
LIF	Laser Induced Fluorescence
LCSM	LNAPL Conceptual Site Model
LUST	Leaking Underground Storage Tank
MIP	Membrane Interface Probe
MTBE	Methyl Tertiary Butyl Ether
NFA	No Further Action
PE	Professional Engineer
PG	Professional Geologist
POC	Point of Compliance
POE	Point of Exposure
QA	Quality Assurance
QC	Quality Control
RAWP	Remedial Action Work Plan
RBCA	Risk Based Corrective Action
RBSL	Risk Based Screening Level
RP	Responsible Party
TMS	Tank Management Section
UST	Underground Storage Tank

Hydrogeologic Investigation Guide

Part I – Introduction

1.0 Introduction

1.1 The Hydrogeologic Investigation Guide (referenced as "this guide") is one document in a series of guidance documents that the Department of Natural Resources and Environmental Control, Tank Management Section (DNREC-TMS) has created (or will create) to assist consultants, responsible parties, and the public with following the requirements of Part E of DE Admin. Code 1351, State of Delaware *Regulations Governing Underground Storage Tank Systems* (the UST Regulations).

1.2 This guide will focus on how to successfully complete the Hydrogeologic Investigation (HI) requirements as required in Part E §4.2 of the UST Regulations.

1.3 This guide is to be used in conjunction with the Delaware Risk-Based Corrective Action Program (DERBCAP).

1.4 The HI is perhaps the most important part of the corrective action process (Corrective Action Process Flow Chart in appendix) because it defines the extent of the confirmed release.

1.5 The intention for this guide is to elicit complete HIs to allow for better protection of human health, safety, and the environment. In addition, Leaking Underground Storage Tank (LUST) projects will progress more quickly towards a no further action (NFA) determination by the DNREC-TMS.

1.6 Since all projects are driven by risk, the completion of every task covered in this document is not necessary for all situations.

2.0 Responsibility

2.1 It is the responsibility of the Responsible Party (RP) to successfully complete the HI requirements as stated in the UST Regulations, the *Hydrogeologic Investigation Required* letter, and all subsequent correspondence concerning a confirmed release.

2.2 Part E § 4.2.2 of the UST Regulations requires the RP to submit the ***complete*** *Hydrogeologic Investigation Report (HIR)* to the DNREC-TMS within 120 days following receipt of the *Hydrogeologic Investigation Required* letter. Incomplete HIRs will not be accepted and will not be considered for meeting the 120 day deadline.

2.3 Two copies of the HIR should be submitted to the DNREC-TMS project officer for review. One of the copies should be an electronic copy.

2.4 In general, the RP hires a qualified environmental professional, or consultant, to assist them in meeting the investigation and reporting requirements of the HI and HIR.

2.5 ***It is important to realize that although the RP hires a consultant, it is ultimately the responsibility of the RP (not the consultant) to meet the requirements and deadlines set in the UST Regulations and by the DNREC-TMS; therefore, it is important for the RP to make sure the consultant is meeting deadlines on their behalf.***

2.6 Unless the RP is well-versed in conducting a HI, it is recommended that the RP requests proposals from multiple consultants. To address the same LUST project, different consultants will have different approaches that come with varying time frames and costs.

2.7 The RP should hire a consultant based on, but not limited to, weighing the following factors:

- Experience
- Professionalism
- PG and/or PE licenses as necessary
- References
- Cost
- Approach
- Reliability

2.8 The hydrologists at the DNREC-TMS are always available to discuss different approaches and technologies.

2.9 During the process of the HI, the reporting requirements of Part E § 1 of the UST Regulations must be followed. The DNREC-TMS must be notified **immediately** if any of the following observations are made:

- Any private or public well impact
- The appearance of mobile or free light non-aqueous phase liquid (LNAPL)
- Any surface water impact resulting in a sheen
- Anytime there is an immediate threat to human health and safety or the environment.

3.0 Work Plans

3.1 The DNREC-TMS recently reviewed its corrective action process to more efficiently move projects toward NFA determinations and to lessen the burden of administrative work (report and work plan reviewing, letter writing, etc.).

3.2 The first step in streamlining the DNREC-TMS's corrective action process was the elimination of the requirement to submit a HI work plan for the initial investigations. Work required after the submittal of the initial HIR will still require a work plan.

3.3 In the past, the scopes of *approved* work plans were sometimes insufficient in delineating the full extent of the contamination. In these cases decisions to expand the investigations could have been made in the field to more quickly delineate the plume and provide useful information for the project. However, these "expanded" investigations were not performed because they were not pre-approved by the DNREC-TMS. As a result, several weeks were added to the project life and additional costs were incurred by the RP through the development of additional work plans, field mobilizations, etc.

3.4 The DNREC-TMS expects that by eliminating the work plan step in the corrective action process, a more flexible, field-driven investigation will be performed. Decisions made in real time will allow for an additional field mobilization, if necessary, within the 120 day deadline. Better field time management will permit time for more complete data collection, allowing for more constructive recommendations for a path forward or a warranted request for a NFA determination.

3.5 ***While a work plan will no longer be required for a HI, the DNREC-TMS welcomes and encourages meetings or teleconferences to discuss your planned investigation in advance of any field mobilizations.***

4.0 How to use the Hydrogeologic Investigation Guide

4.1 The purpose of the HI checklist is to act as a quick visual guide to ensure that the HI is complete and contains the appropriate sections and report appendices.

4.2 The HI checklist **must** be filled out and included as the cover of the HIR. It is acceptable to place the HI checklist behind your hired consultant's coversheet.

4.3 This guidance document is intended to help the RP and their hired consultant understand what the DNREC-TMS expects in terms of a complete HI for a range of projects.

4.4 Although this guide covers a topic of a technical nature, it is written in such a way that a non-technical reader can form a general understanding of the concepts and use the information to review a consultant's report and recommendations. However, the majority of the material in this guidance document assumes the reader has a basic technical background and is geared toward the professionals that will be conducting the HI.

4.5 The content of this guide is intended to ensure that good quality data is collected and allow for good professional decision making and accommodate a wide variety of LUST projects and situations to be addressed.

4.6 The sections of this guidance document beginning in Part II are organized as follows:

4.6.1 The section title will begin a new section (e.g., 1.0) and will be printed in bold. The section title will correspond to the table of contents and loosely to the HI checklist.

4.6.2 The first subsection (e.g., 1.1) will have the title of *Topics of discussion*, and will be a bulleted list of topics which will make up the body of the report for that section.

4.6.3 The second subsection (e.g., 1.2) will have the title of *Report Appendices to be included*, and will be a bulleted list of appendices (i.e., figures, tables, lab reports, etc.) that should accompany the HIR. The appendices will be relevant to the section. If during the investigation it is found that appendices listed are not applicable to the project, they do not need to be submitted.

4.6.4 The third subsection (e.g., 1.3) will be the guidance on how to create and submit required Report Appendices and how to sufficiently investigate and report on topics which are integral to the report.

4.7 Some requirements are repeated in several sections. Double submittal is not expected and combining requirements is recommended. For example, in Part II Sections 3.0 and 4.0, figures are required to be submitted detailing the locations of borings and sample points. If the data required in said parts can be clearly depicted with one figure, one figure is all that is needed.

4.8 Due to the risk-based nature of the DNREC-TMS Program, written justification explaining why completing a requirement as prescribed in this guide is not applicable due to the risk posed by a facility is as sufficient as completing the requirement as outlined in this guide when the risk warrants its completion. For example, door-to-door well surveys may not be necessary if the exposure pathway can be eliminated.

5.0 Summary of Intent

5.1 The DNREC-TMS recognizes that each LUST project presents its own unknowns and complications and that some methods for completing a HI are more beneficial than others for different sites and at different times (e.g. temporary direct push sampling versus permanent monitoring wells and vice versa).

5.2 The DNREC-TMS would like to see all projects move as efficiently towards a NFA determination as possible while providing for the protection of human health and safety, and the environment. The DNREC-TMS understands that achieving every task in this document is not necessary for completing that goal and does not expect extra, non-value-added work to be conducted.

5.3 The DNREC-TMS is always available for guidance.

6.0 Professional Geologist (PG), Professional Engineer (PG) Signature Requirements

6.1 According to Part E §4.2.3 of the UST Regulations, a HIR is required to be signed by a Delaware-licensed PG or PE. This requirement is in place to ensure the quality of the investigation and accuracy of data interpretation because it has a direct impact on the well-being of the environment and individuals.

6.2 In some cases, when a release is limited and an investigation can be completed through Tier 0 soil sampling only, PG or PE signature may not be necessary. However, prior **DNREC-TMS approval will be required.**

Here is an example of 6.2:

A 550-gallon heating oil UST is removed with composite and grab soil samples collected and groundwater is not encountered. The samples are analyzed for DRO with the results of the grab sample being reported at 1,800 mg/Kg, which is over the action level of 1,000 mg/Kg. A HI is then required. The RP hires a consultant who plans to collect a soil sample from a deeper depth and from four locations around the former UST with all samples being analyzed for DRO. The results of this investigation do not need to be signed by a PG or PE.

7.0 Aboveground Storage Tanks (ASTs)

7.1 While this guide was created to aid in completing a HI for a LUST facility, the general principals are applicable for AST facilities with a confirmed release and this guidance should be followed to complete the investigation required in Part E, § 1.0 in the DE Admin. Code 1352, State of Delaware *Regulations Governing Aboveground Storage Tanks* (the AST Regulations).

7.2 When following this guide to complete an investigation at an AST facility with a confirmed release, it is important to remember that the AST Regulations use different terminology and definitions and that the AST Regulations must be followed.

7.3 Just as in LUST projects, the DNREC-TMS project officer is available for teleconferences or meetings.

7.4 For additional guidance, please review the Aboveground Storage Tank Site Assessment Guidance document found at: http://www.dnrec.delaware.gov/tanks/Pages/Corrective-Action-Program.aspx

Part II – Data Collection and Reporting

1.0 Release Information

1.1 Topics of discussion:

- Identify how the leak was caused, when the leak began, and how the leak was identified.
- Report the estimated volume of the release and what was released.
- Report any actions conducted as an emergency effort by any party to minimize the release (e.g. trenching, pumping).

1.2 Report Appendices to be included:

- Documentation supporting release volume calculation, including inventory records
- Repair documentation
- Photos
- Field Orders and/or Secretary Orders from DNREC emergency personnel
- General Site Figure
- Regional Figure
- Other applicable documentation

1.3 Guidance

1.3.1 The cause of a release is sometimes very difficult to pinpoint, but professional judgment based on how the release was identified can provide assistance. A release is commonly identified during UST removal activities, retrofit activities, or during a Phase II assessment. The location of contamination will aid in producing an approximate cause of the release. In addition, this data is now required to be collected under the Energy Policy Act of 2005 (Pub.L. 109-58) and is important in the development of a conceptual site model (CSM) (Part III Section 5 of this guide).

1.3.2 Carefully review all data available for the specific site. Review UST removal or closure-in-place reports, data on previous LUST projects at the facility, and basic information on nearby LUST facilities (especially if a second source is a potential).

1.3.3 Speak to the DNREC-TMS compliance officer, if one is assigned. The project officer can and will provide you with this information.

1.3.4 Other than in emergency situations, determining the exact time that a leak began may be impossible. Estimates of when the release began may be aided by reviewing inventory records and product delivery receipts and looking for continuous net losses or receiving excessive deliveries. This documentation may be obtained from the UST operator, DNREC-TMS files, or the UST owner.

1.3.5 Inventory records and product delivery receipts can also aid in approximating the volume of product released. In addition, by defining the extent of soil contamination, a loose estimate of volume released can be obtained.

1.3.6 If remedial actions were taken before receipt of the letter informing the RP that a HI is required, details of those actions and backup documentation must be gathered and submitted.

1.3.7 A general figure of the facility must be prepared and submitted with the HIR. The figure must be set to an appropriate scale, have a north arrow and legend, and include the locations of present and former USTs, present and former dispensers, present and former piping runs and utilities, and all structures.

1.3.8 A figure of the region must be prepared and submitted with the HIR. The figure must be scaled appropriately to allow someone who is not familiar with the area to find the facility.

2.0 Quality Assurance and Quality Control

2.1 Topics of discussion

- Briefly discuss the QA/QC that was performed during this HI
- Discuss any potential problems that have been identified through your QA/QC efforts.

2.2 Report Appendices to be included:

- QA/QC Plan
- Chain of Custody forms with appropriate information
- Field logs
- Calibration logs
- Analytical summary reports

2.3 Guidance

2.3.1 QA/QC is crucial for ensuring that the data reported and decisions made from that data are sound. Part E § 4.3 of the UST Regulations requires the development, implementation, and submittal of a QA/QC plan.

2.3.2 Analytical reports must always include a chain of custody.

2.3.3 When relinquishing the chain of custody, signatures, times, and dates must be documented. In addition, the temperature of the samples when received by the lab must be noted on the chain of custody or documented in a laboratory summary report. If your lab does not currently provide this service, it should be requested.

2.3.4 All groundwater and soil sampling events from which volatile compounds are being analyzed for must include one trip blank per cooler.

2.3.5 One equipment blank sample must be collected per day when non-dedicated equipment is used.

2.3.6 All samples must be collected and placed in the appropriate, sterile containers.

2.3.7 All effort must be made to deliver samples to the laboratory within 24 hours of the sampling event. If this is not possible, a description of the handling of the samples must be included in the QA/QC section of the HIR.

2.3.8 Samples must be kept at ≤ 6 °C until delivered to the laboratory.

2.3.9 Contaminant and analytical method specific holding times must be met.

2.3.10 If sample results are reported with expired holding times or excessive temperatures, the DNREC-TMS may not accept the results and may require the samples be recollected.

2.3.11 Field blanks, duplicate samples, and split sampling may be necessary.

2.3.12 Having the lab run matrix spikes and matrix spike duplicates is recommended.

2.3.13 Lab reports must include the results of matrix spikes, matrix spike duplicates, and instrument calibration results.

2.3.14 All sampling equipment that is not dedicated or disposable must go through proper decontamination procedures to protect against cross contamination. ASTM practice D5088 provides procedures for decontamination.

2.3.15 Instruments used for collecting field measurements should be properly calibrated according to the manufacturer’s standards. Calibration dates and times must be recorded in field books, field logs, or equipment logs.

2.3.16 Further guidance and explanation is available in the appendix.

3.0 Defining the Vertical and Horizontal Extent of Soil Contamination

3.1 Topics of discussion:

- Interpret analytical and screening data collected to date to determine the volume of soil contamination.
- Discuss sampling methods.
- Discuss screening methods.
- Discuss how source mass is contributing to daughter plumes.
- Report any identified data gaps and propose how they will be filled.

3.2 Report Appendices to be included:

- Figure with soil sample and boring locations
- Figure with interpreted extent and concentrations of soil contamination
- Lab analytical reports
- Table of soil sample analytical results
- Boring log(s)
- Cross section(s)

3.3 Guidance

3.3.1 Part E §4.2.1.2 and §4.2.1.3 of the UST Regulations require that the horizontal and vertical extent and distribution of the Release be determined. This requirement includes ***soil contamination***. Defining the extent of soil contamination is a critical part of a HI. Note that the data gathered may come from many phases of work at a tank site, from tank removal or closure-in-place through HI and remediation.

3.3.2 Soil samples must be collected in the proper laboratory-provided bottleware, according to the method of analysis.

3.3.3 Defining the extent of soil contamination is integral to the following:

- Estimating the amount of source mass contributing to dissolved and vapor contamination;
- Aiding in selection of locations for groundwater sampling or monitor well installation;
- Aiding in remedial design or modeling;
- Estimating the potential extent of soil overexcavation, either during underground storage tank removal or as a remedial strategy;
- Determining risks, such as potential for exposure to contaminated soil during excavation. This includes long term stewardship of a property, when residual contamination is left in soil, following a risk-based NFA determination.

3.3.4 Collection of data can occur in every phase of corrective action, but early determination of the extent of soil contamination will serve to guide further corrective actions. Techniques such as membrane interface probe (MIP) or laser-induced fluorescence (LIF) are quick ways to develop a 3-dimensional picture of contamination at the site. These investigative tools may cost more initially but can lower costs through the collection of fewer soil samples, less staff time associated with field mobilizations and sample collection, and providing the ability to target well placement.

3.3.5 Ensure that soil data collection is integrated with groundwater data.

3.3.6 All opportunities for collecting soil data, such as during monitor well installation, excavation, installation of remediation systems, etc., should be exploited.

3.3.7 It is beneficial to review soil analytical data from tank system removal, closure-in-place, and retrofit reports to aid in defining extent of soil contamination. You may need to check the DNREC-TMS facility file for the information.

3.3.8 Field screening information is a part of delineating soil contamination. Ensure that QC is employed in screening data collection, data is recorded accurately, and equipment is properly calibrated.

3.3.9 Field screening techniques must be used in selecting representative soil samples for laboratory analyses. Samples collected, bagged and used for headspace readings must **not** be submitted to the lab for analysis.

- Grab soil samples must be collected from the points of highest screening readings or areas of staining and at the interval directly above the water table.
- If screening readings are non-detect, a grab sample can be collected from the interval above the water table.

- If detections are detectable but uniform, a grab sample from above the water table and a composite sample of the boring must be collected.

3.3.10 Soil borings must continue until evidence of contamination is screened out. Soil borings that stop at the water table and still exhibit signs of contamination do not vertically delineate contamination

3.3.11 Soil samples must be collected below the water table from a representative number of locations if staining is observed. However, borings may be terminated if a confining layer of two feet or greater is encountered below the surface aquifer.

3.3.12 You must clearly describe in the HIR how the extent of contamination was determined. That is, describe what laboratory and/or field screening data was used in determining the lateral and vertical extent of soil contamination.

3.3.13 A figure must be included displaying the horizontal extent of soil contamination and defining areas of varying concentrations. The figure must be to scale with a north arrow and legend. All soil borings and sample locations related to the current release should be included on the figure.

3.3.14 A table must be prepared summarizing analytical results. The table must include local identification (SB-1), DNREC well permit number, proposed RBSLs, and laboratory detection limit if result is not detected. An example is included in the appendix.

3.3.15 A cross-section displaying the extent of soil contamination (soil sample locations, screening results, observed staining, lithology, etc.) as well as groundwater sampling data (lithology, sample locations, well screens, screening results, water elevations, etc.) must be prepared to support the discussion on the vertical extent of soil contamination.

3.3.16 Boring/well logs must include field screening information, including notation of intervals from which screening information and soil samples were collected. Boring logs must also include drilling method, local identification (SB-1) and the DNREC well permit number (if applicable). In addition, lithology must be described by using common nomenclature such as the Unified Soil Classification System (ASTM D2488). An example is included in the appendix.

3.3.17 For releases near subsurface structures, consider where released product may have migrated, such as into drains, trenches, along walls, pipes, etc. Soil contamination may "hide" in such areas.

4.0 Groundwater Flow Direction

4.1 Topics of discussion:

- Discuss how the groundwater flow direction was determined.
- Interpret data collected to date to determine the migration of a groundwater contamination plume.
- Starting with the larger conduits or preferential pathways consider the potential for them to influence groundwater flow and the overall CSM (Part III Section 5.0).
- Discuss the ultimate discharge location of groundwater
- Report any identified data gaps and propose how they will be filled.

4.2 Report Appendices to be included:

- Figure with sample and groundwater gauging locations
- Figure(s) with inferred groundwater elevation and flow direction
- A figure with preferential pathways identified
- Well Permits
- A table with gauging or groundwater elevation data

4.3 Guidance

4.3.1 If groundwater contamination is confirmed, the RP will need to determine in what direction groundwater flows to determine if any POEs are at risk.

4.3.2 In early stages of an investigation, or perhaps as the only means in a limited investigation, topographic maps, information on nearby sites, published works, or information on drainage basins can be used.

4.3.3 The best way to determine groundwater flow direction is through an installed monitoring well network. For the outcome of the gauging data to be acceptable the following principles must be followed:

- A minimum of three wells must be used and the wells must be installed in a configuration that allows for determining groundwater flow, like an equilateral triangle. In other words, the wells must be well distributed over the area of interest. Wells installed in a straight line or near straight line will not provide useful data in determining groundwater flow.
- Wells used in determining groundwater flow must be screened at approximately the same interval. Deep well data should not be used for determining shallow groundwater flow or vice versa.
- Wells to be used for determining groundwater flow should not be installed in former tank pits or other areas of non-native fill. Groundwater elevations tend to be distorted in these areas and will affect results. However, wells installed in these areas can provide useful contamination data.
- Wells used to assess the surficial aquifer must be screened several feet above the groundwater table to allow for fluctuation in the water level and to allow LNAPL to flow into the well.
- Groundwater monitoring wells must be adequately developed to provide good communication with the aquifer. ASTM guide D5521 provides a framework for well development.
- While a professional survey of wells is not required, a survey must be conducted by skilled individuals to obtain top of casing elevations.
- Well elevations must be in reference to an immobile and permanent benchmark. This benchmark should be noted in the discussion of how groundwater flow direction was determined to allow for the replication of the survey data if necessary.
- Groundwater elevations can be collected from temporary wells or from screen points. However, that data should not be used as the only means of determining groundwater flow direction due to the variability associated with those installation methods.

4.3.4 When groundwater elevations are collected, a scaled figure must be prepared with groundwater elevations, contours and groundwater flow direction indicated.

4.3.5 Groundwater gauging data must be tabulated. The table must include the well ID, depth to water, top of screened interval height, groundwater elevation, depth to product, and product thickness. An example can be found in the appendix of this guide.

4.3.6 Preferential pathways in the form of man-made conduits (former UST system trenches, sewer lines, electric lines, etc.) affect the flow of groundwater and vapors and the overall distribution of contamination. Possible effects of man-made conduits must be considered.

4.3.7 RBSLs established in the DERBCAP Guide were created using generic parameters (hydraulic conductivity, seepage velocity, gradient). You are required to establish estimates of hydraulic conductivity and gradient based on the information available.

5.0 Defining the Vertical and Horizontal Extent of Groundwater Contamination

5.1 Topics of discussion:

- Interpret data collected to date to determine the vertical and horizontal extent of groundwater contamination.
- Discuss any impacted or potentially impacted off site properties.
- Discuss the potential for plume diving to occur.
- Report any identified data gaps and propose how they will be filled.

5.2 Report Appendices to be included:

- Figure with sample locations
- Figure(s) with interpreted extent and inferred concentration isopleths of groundwater contamination
- Lab analytical reports
- Table of groundwater analytical results
- Boring and well logs
- Well Permits
- Cross-section(s)

5.3 Guidance

5.3.1 The goal of this section is to determine the distribution of groundwater contamination. Part E §4.2.1.2 and §4.2.1.3 of the UST Regulations requires that the horizontal and vertical extent and distribution of the Release be determined. While this requirement is straightforward, it is also time consuming, costly, and difficult to accomplish.

5.3.2 Groundwater samples must be collected in the proper laboratory provided bottleware according to the method of analysis. ASTM standards D6452, D6634, and D6771 provide methods for sampling monitoring wells as well as information on sampling devices.

5.3.3 Wells installed for the purposed of collecting groundwater samples must not have well screen lengths greater than 15 feet without first getting approval from the DNREC-TMS project officer.

5.3.4 Wells used to assess the surficial aquifer must be screened several feet above the groundwater table to allow for fluctuation in the water level and to allow LNAPL to flow into the well.

5.3.5 Groundwater samples must be collected from the source zone or expected area of worst contamination.

5.3.6 Groundwater samples must be collected up-gradient of the area of contamination. This data may confirm an off-site source, another previously unknown area of contamination, show fluctuation in groundwater flow direction, or provide background data.

5.3.7 Groundwater samples must be collected from the downgradient property boundary to establish a point of compliance (POC).

- LUST projects that require a HI and have concentrations of chemicals of concern (COCs) in excess of the DERBCAP <50 foot RBSLs are typically fueling stations. Generally, fueling stations are relatively small and POC wells are easily impacted. This requires an off-site investigation and may warrant some type of interim remedial action.
- LUST projects located on a large parcel of land are more likely to have a clean POC well. However, the extent of the plume will not necessarily be defined, in which case samples will need to be collected between the source zone and the POC well to aid in determining distribution, plume stability, and fluctuations in groundwater flow.

5.3.8 As long as screened intervals are appropriate, samples can be collected and lateral distribution and extent can be determined from both permanent and temporary wells.

5.3.9 A figure must be prepared showing a graphical representation of lateral contamination distribution. Several figures may be necessary if multiple COCs are "driving" the project. For example, if benzene and MTBE concentrations exceed RBSL, two figures will need to be drafted if the data is too jumbled or confusing when represented on one figure.

5.3.10 Groundwater contamination can migrate to deeper depths when influenced by geology, drawdown from a well, surface water infiltration, and contaminant density.

5.3.11 Groundwater samples should be collected from varying depths to determine the vertical extent of contamination. This can be accomplished by installing nesting well units or collecting temporary samples from multiple depths.

5.3.12 A cross-section displaying the well network and locations of temporary wells (lithology, well screens, screening results, water elevations, etc.) as well as soil contamination data (soil sample locations, screening results, lithology, observed staining, etc.) must be prepared to backup the discussion on the vertical extent and potential for diving plumes.

5.3.13 A table must be prepared summarizing analytical results. The table must include local identification (SB-1), DNREC well permit number, proposed RBSLs, and laboratory limits of quantitation if analyte is not detected. An example is included in the appendix.

5.3.14 Boring/well logs must include field screening information, including notation of intervals from which screening information and soil samples were collected. Boring logs must also include drilling method, local identification (SB-1), and the DNREC permit number. In addition, lithology must be described by using common nomenclature such as the Unified Soil Classification System (ASTM D2488). Well logs must include construction details of the well. An example is included in the appendix.

Note: *Ideally a permanent well network or network of temporary well samples will include samples collected from the fringe and the core of the plume with concentrations of COCs above laboratory detection limits but below the <50' RBSLs. Wells significantly outside the footprint of the plume provide little information.*

6.0 Points of Exposure (POEs)

6.1 Topics of discussion:

- Discuss methods used to identify POEs.
- Discuss identified POEs.
- Report any identified data gaps and propose how they will be filled.

6.2 Report Appendices to be included:

- Figure identifying POEs
- DNREC Water Resource well records
- Table of all identified POEs
- Results of a neighborhood receptor search
- Drilling records and logs for nearby wells

6.3 Guidance:

6.3.1 POEs are sensitive receptors where a person, population, or wildlife may come in contact with contamination and include, but are not limited to the following:

- Private and public wells,
- Wellhead protection areas,
- Surface water bodies,
- Building basements,
- Underground utility vaults, and
- Areas considered to be environmentally sensitive (see Section 6.3.2 of this Part)

6.3.2 Areas that are considered environmentally sensitive include but are not limited to the following:

- Recharge Water Resource Protection Areas (WRPAs) located in New Castle County,
- Areas in Kent and Sussex Counties that are identified as areas of excellent recharge,
- Wellhead protection areas, and
- Surface water bodies

6.3.3 Protecting human health and safety and the environment is the ultimate mission of the DNREC-TMS. The first step in protecting them from a release is accurately identifying POEs.

6.3.4 With the HI being the initial step in the corrective action process, POEs with the greatest potential to become impacted must be considered first. Initially, the DNREC-TMS requires that all POEs within at least 500 feet of the contaminant plume be considered at risk of becoming impacted.

6.3.5 When identifying POEs, the DNREC-TMS requires that DNREC's Division of Water Resources, Water Supply Section be contacted at (302) 739-9945. They keep a database of permitted water wells throughout Delaware and can provide a list of permitted wells within 500 feet of the facility. Copies of records received from the Division of Water Resources must be submitted as supporting documentation.

6.3.6 DNREC-Water Supply's database only tracks wells that have gone through the permitting process since 1969. If a well was installed before 1969 or never received a permit, it will not be identified in the search. In addition, records for relatively old wells may not be reliable.

6.3.7 Due to the shortcomings of the database used to track well permits, it is necessary to conduct a neighborhood receptor search to verify locations of identified wells and located previously unknown wells. The neighborhood receptor search may be conducted in a phased approach as more is learned about the risk posed by the LUST. In addition to gathering information on wells, information on buildings with basements should also be collected.

6.3.8 Local water companies can also be contacted to learn who is not served by public water within the 500 foot radius.

6.3.9 The required figure must be drawn to scale with a clear legend and north arrow. All POEs identified within 500 feet of the plume boundaries must be represented on the figure.

6.3.10 All identified POEs must be compiled in tabular form, which must include each POE's distance from the plume boundary. If wells are identified, the table must include each well's location, the property owner, and, if available, well construction details including depth, screened interval, and date installed.

Part III – Data Interpretation

1.0 Contaminant Migration Pathways (CMPs)

1.1 Topics of discussion:

- Discuss how contamination may travel through each of the contaminant migration pathways and impact potential POEs.
- Discussion and representation of any calculations used.
- Report any identified data gaps and propose how they will be filled.

1.2 Report Appendices to be included:

- Figures with utility corridors/conduits/other preferential pathways

1.3 Guidance:

1.3.1 CMPs are the routes that COCs take from a contaminant source to a sensitive receptor or POE through soils, groundwater, and air. There are three (3) exposure routes that DNREC-TMS is concerned with:

- dermal or physical contact with the contamination
- inhalation or vapor issues, refer to Section 2.3.8 of this Part for a link to additional guidance
- ingestion, primarily through drinking impact water

1.3.2 The RP is responsible for determining how far contaminants have migrated through each pathway and to determine if any POEs are either impacted or in danger of being impacted by the release of regulated substances.

2.0 Risk Assessments

2.1 Topics of discussion:

- Discuss what RBSLs are recommended to be implemented
- Indicate whether or not concentrations discovered are above applicable RBSLs
- Based on concentrations discovered and POEs identified, determine if CMPs are or may potentially become complete.
- Report any identified data gaps and propose how they will be filled.

2.2 Report Appendices to be included:

- Any backup documentation or supporting documentation

2.3 Guidance:

2.3.1 The DERBCAP Guidance Manual should be referred to for more background and details on RBSLs, risks, and risk assessments.

2.3.2 Based on the distance to POEs and property boundaries determine what scenario in the DERBCAP Guidance Manual (pages 27-35) is appropriate for this LUST project.

2.3.3 Property boundaries are considered POCs and cannot be ignored in the determination of RBSLs.

2.3.4 A request for NFA may be appropriate when concentrations of all COCs are below applicable RBSLs, POEs are not impacted, vapor issues are not a concern, and LNAPL is not present or has been addressed in accordance with Part E, §3.3 of the UST Regulations.

2.3.5 If contamination can be shown to exist only in the subsurface soil on-site, contamination is below soil to groundwater RBSLs, and groundwater is not impacted, the ingestion migration pathway can generally be assumed to be incomplete and not pose a risk.

2.3.6 If contamination can be shown to exist only in the subsurface soil on-site, contamination is below soil to groundwater RBSLs, and groundwater is not impacted, the ingestion migration pathway can generally be assumed to be incomplete and not pose a risk.

2.3.7 As the degree of contamination increases or if LNAPL is present, the amount of details and sampling required for the risk assessment increases.

2.3.8 The results of the RP's consultant's risk assessment are used by DNREC-TMS to determine if active remediation will be required for each LUST site project and to assess if an appropriate RBSL has been proposed. For guidance on vapor intrusion, risks, and investigation, refer to the guidance document prepared by the DNREC-Site Investigation and Restoration Section which can be found at: http://www.dnrec.state.de.us/dnrec2000/Divisions/AWM/sirb/policy%20concern07008.pdf

2.3.9 The American Petroleum Institute has created a vapor intrusion model that estimates biodegradation of petroleum vapors. This model can be obtained at: http://www.api.org/ehs/groundwater/vapor/bio-vapor-intrusion.cfm

2.3.10 Please contact DNREC-TMS prior to proceeding with vapor intrusion investigation activities.

3.0 Human Risk Assessment and Management

3.1 Topics of discussion:

- Report all private/public wells that have been sampled and discuss results.
- Discuss interim remedial actions that have been performed to eliminate, temporarily or permanently, human risk. Examples include water filtration, well replacement, vapor recovery (passive or active), etc.
- Describe all points of exposure (i.e. potable wells, basements, conduits, etc.) as identified in Part II Section 6 of this guide that have the potential to be, or were, impacted by the release. The description should include, but is not limited to, the location, well ID, depth of wells, construction detail of wells and building foundations, sampling results, etc.
- Describe potential human health risks due to contaminant migration, future well installation, future construction, and utility work. All exposure pathways should be discussed in detail including dissolved, soil, and vapor phases.
- Report any identified data gaps and propose how they will be filled.

3.2 Report Appendices to be included:

- Copies of letters issued to property owners regarding well sampling
- Figure with locations of sampled private/public wells
- Well logs/records for potable wells
- Lab analytical reports

3.3 Guidance:

3.3.1 Prior to assessing human health risks, all immediate risks to human health and safety must be addressed and resolved. According to Part E § 4.2.1.4 of the UST Regulations, the RP must "*Evaluate, in accordance with DERBCAP or other Department approved procedures, the potential risks posed by the Release including identification of environmentally sensitive receptors, and an estimate of the impacts to human health and the environment that may occur as a result of the release*".

3.3.2 If groundwater contamination is discovered, regardless of concentration, any onsite potable wells must be sampled. However, if the ingestion contamination migration pathway for a specific drinking well can be show to be nonexistent due to the well's construction the well does not need to be sampled with the initial investigation. Exemption from sampling a well must be clearly justified in the report.

3.3.3 The RP must send the sampling results for potable wells to the property owner and tenant. The RP is not responsible for discussing health issues and may refer them to the DNREC-TMS.

3.3.4 If contamination is discovered in a potable well, the DNREC-TMS must be notified immediately by phone or email.

3.3.5 If contamination is discovered in a potable well in concentrations above the maximum contaminant levels recommended by the Environmental Protection Agency or above Delaware drinking water standards, the RP must provide an immediate response to insure the well's users have access to clean water.

3.3.6 At this initial phase of the corrective action process, all private/public wells within the maximum RBSL distance that was exceeded must be sampled. For example: if benzene is reported at a concentration of 120 µg/L, which exceeds the 51-100 foot RBSL, all wells located within 100 feet of the sample location must be sampled. However, if the ingestion contamination migration pathway for a specific drinking well can be show to be nonexistent due to the well's construction the well does not need to be sampled with the initial investigation. Exemption from sampling a well must be clearly justified in the report.

4.0 Environmental Risk Assessment and Management

4.1 Topics of discussion:

- Describe the potential environmental receptors that are impacted or in danger of being impacted (i.e. surface water body, wetlands, wildlife habitat, etc.).
- Describe the pathways through which the contamination is moving, or could potentially move, to cause an environmental risk.
- Report any identified data gaps and propose how they will be filled.

4.2 Report Appendices to be included:

- Lab analytical reports

4.3 Guidance:

4.3.1 Prior to assessing environmental risks, all immediate risks to human health, safety and the environment must be addressed and resolved. According to Part E § 4.2.1.4 of the UST Regulations, the Responsible Party must *"Evaluate, in accordance with DERBCAP or other Department approved procedures, the potential risks posed by the Release* ***including identification of environmentally sensitive receptors****, and an estimate of the impacts to human health and the environment that may occur as a result of the release"*.

4.3.2 It is not expected or required at this time that a full ecological survey be conducted. However, it is required that environmental receptors, POEs, be identified.

4.3.3 It should be noted that calculating risk, as is done for RBSLs, involves using mathematical equations relating to a variety of factors including, but not limited to, body weight, consumption rates, concentrations, and ingestion rates. The DERBCAP assumptions may not be appropriate for environmental risks.

5.0 Conceptual Site Model (CSM)

5.1 Topics of discussion:

- Interpret all data collected to date and explain the CSM model that guides the project forward.
- Report any identified data gaps and propose how they will be filled.

5.2 Report Appendices to be included:

- Figures or other graphically representations

5.3 Guidance:

5.3.1 A CSM must be designed based on all of the data collected to date. The CSM should attempt to explain why contamination is located where it is located and where it is going.

5.3.2 It is important to prepare a CSM because it will aid in determining what steps are needed next. The CSM should justify the recommendations.

5.3.3 The CSM should be updated as data comes in. New data can either confirm that the CSM is correct or that it is flawed.

5.3.4 The DNREC-TMS is not looking for a lengthy or costly CSM, but the DNREC-TMS is requiring that the CSM be described in the HIR.

5.3.5 Included in the appendix is a list of web sites describing CSMs and how you may want to produce one.

5.3.6 When LNAPL is present, Part E § 3.3 of the UST Regulations require that a LNAPL Conceptual Site Model (LCSM) be prepared. The LCSM should explain the observance of LNAPL or lack of LNAPL and its distribution. The LCSM must be conducted in accordance with Part E § 3.3 of the UST Regulations. Additional information and guidance can be found at the Interstate Technology & Regulatory Council web site, www.itrcweb.org.

6.0 Recommendation

6.1 Topics of discussion:

- Clearly report recommended next steps.

6.2 Report Appendices to be included:

- Figures with locations of proposed future investigations
- Access agreements
- Design information

6.3 Guidance:

6.3.1 According to Part E § 4.2.2 of the UST Regulations, "…*The hydrogeologic investigation report shall include recommendations for further action or a no further action determination…*". If such recommendations are not included in the HIR, the report will not be accepted by the DNREC-TMS as being complete. The HIR must include a recommendation for at least one of the following outcomes:

6.3.1.1 **No Further Action Recommendation**

- A NFA recommendation may be made if concentrations of all appropriate contaminants of concern are below DERBCAP Risk-Based Screening levels. This is assuming that the soil and groundwater samples adequately characterize the site.
- In some cases, it may be necessary to perform quarterly monitoring for a period of one year before a NFA may be granted.

6.3.1.2 **Remedial Action Work Plan (RAWP) -** If the site is adequately characterized according to Part II Sections 3 and 5 of this guide, and concentrations exceed DERBCAP RBSLs, the RP can recommend evaluating and implementing an active remedial action. This recommendation for remediation in the HI may come in several forms. The following are acceptable forms for the recommendation:

- A full scale RAWP that includes design information and everything that is required in a RAWP as per Part E §5 of the UST Regulations and appropriate guidance.
- A recommendation to perform pilot and feasibility testing in order to design an appropriate remedial action.
- A request to pursue evaluating remedial technologies with appropriate timeframes as to when a full RAWP will be submitted.
- A hybrid of any of the above with an interim remedial action to jump start the remedial process.

6.3.1.3 **Tier 2 Evaluation -** If the site is adequately characterized according to Part II Sections 3 and 5 but the concentrations exceed DERBCAP

RBSLs, the RP can recommend evaluating the site under Tier 2 of DERBCAP. This recommendation shall include, at a minimum, the following:

- A description of what additional data is needed in order to change the default parameters used to calculate the RBSLs in DERBCAP to create Site Specific Target Levels
- Justification for use of default or site-specific values for Site Specific Target Level calculation
- A timeframe as to when the data will be collected.
- A detailed work plan for how Site Specific Target Levels will be calculated or a timeframe for when such a work plan will be submitted if data is required to be collected prior to creating such a work plan.

6.3.1.4 **Quarterly Monitoring and Further Investigation –** In some cases, the initial investigation will be unsuccessful in meeting the minimum requirements of a complete HI or there is not enough data in order to make an appropriate recommendation. In such cases, the RP may recommend either performing additional quarterly monitoring (up to one year) or may need to continue the HI to further delineate the contamination. Such recommendations must include, at a minimum, the following justifications:

- A detailed description as to why additional monitoring is necessary.
- An explanation of what the additional information collected during the monitoring period will provide.
- Details on the locations of additional sampling points including maps, figures, and sampling methods.
- Reasons for sampling locations.
- Estimated timeframe for completion of additional investigation.
- Part E, § 4.2.4 of the UST Regulations requires that additional information must be submitted within 90 days of HIR approval.

6.3.1.5 **Other**

- Seeking evaluation under different programs such as Brownfields or Voluntary Clean Up

List of Attachments to be included with Hydrogeologic Investigation Report

Figures (one figure may serve several purposes)

- General Site Figure
- Regional Figure
- Figure identifying POEs
- Figure with locations of sampled private/public wells
- Figure with preferential pathways identified.
- Figure with sample and boring locations
- Figure with inferred groundwater elevation and flow direction
- Figure with interpreted extent and concentrations of soil contamination
- Figure(s) with interpreted extent and inferred concentrations of groundwater contamination

Tables

- Table of all identified POEs
- Results of a neighborhood receptor search
- DNREC Water Resource well records
- Groundwater gauging table
- Tables of analytical results

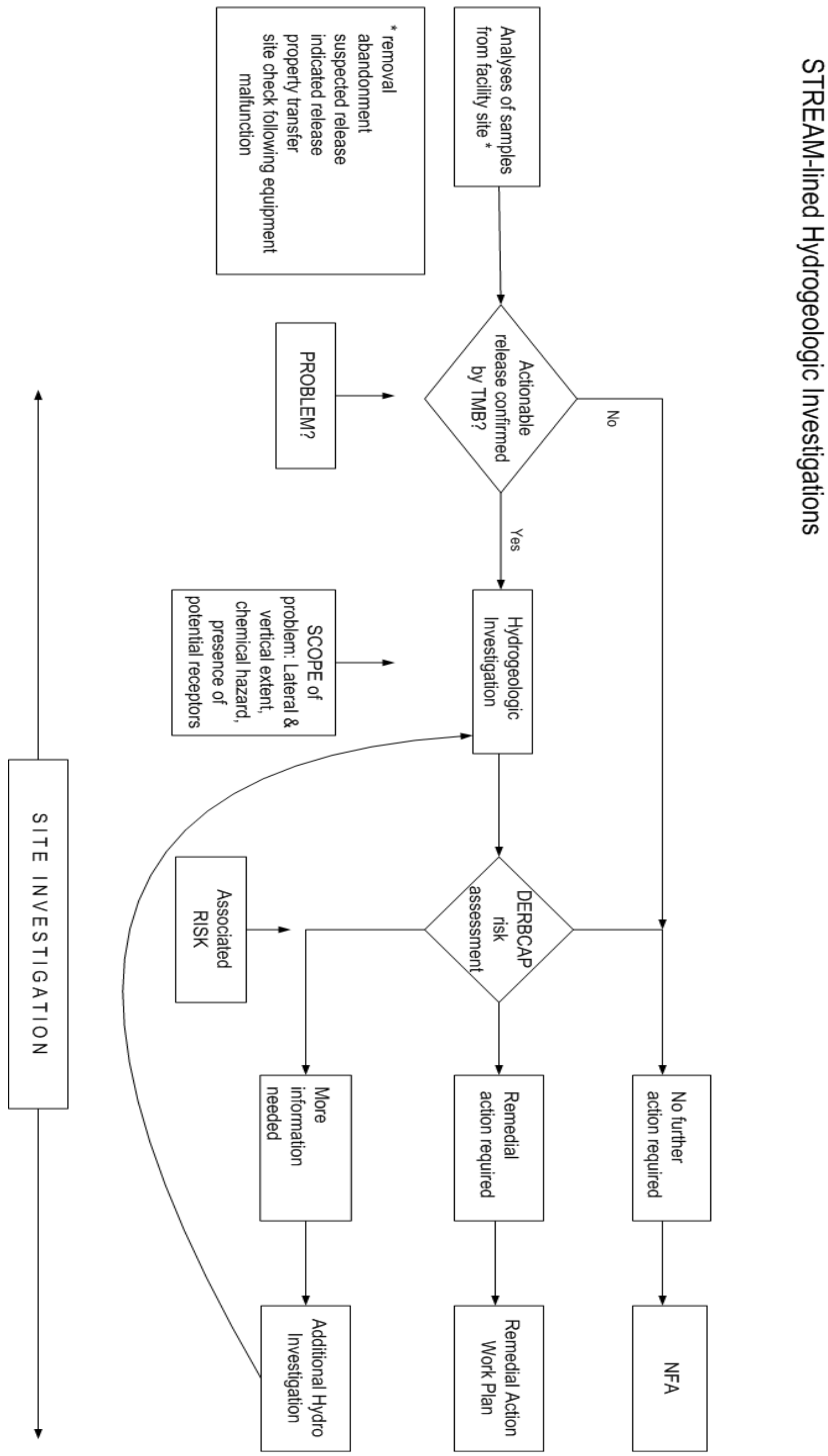
Other

- Hydrogeologic Investigation Checklist
- All Supporting/Backup documentation
- Lab analytical reports
- Photos
- Field Orders and/or Secretary Orders from DNREC emergency personnel
- QA/QC Plan
- Copies of letters issued to property owners regarding well sampling
- Well logs/records
- Drilling records and logs for nearby wells
- Boring logs
- Cross sections
- Well logs

Appendices

- Corrective Action Process Flow Chart
- QA/QC Guide
- Example boring/well log
- Soil classification guide
- Example Data Tables
- List of CSM weblinks
- Referenced ASTM Standards

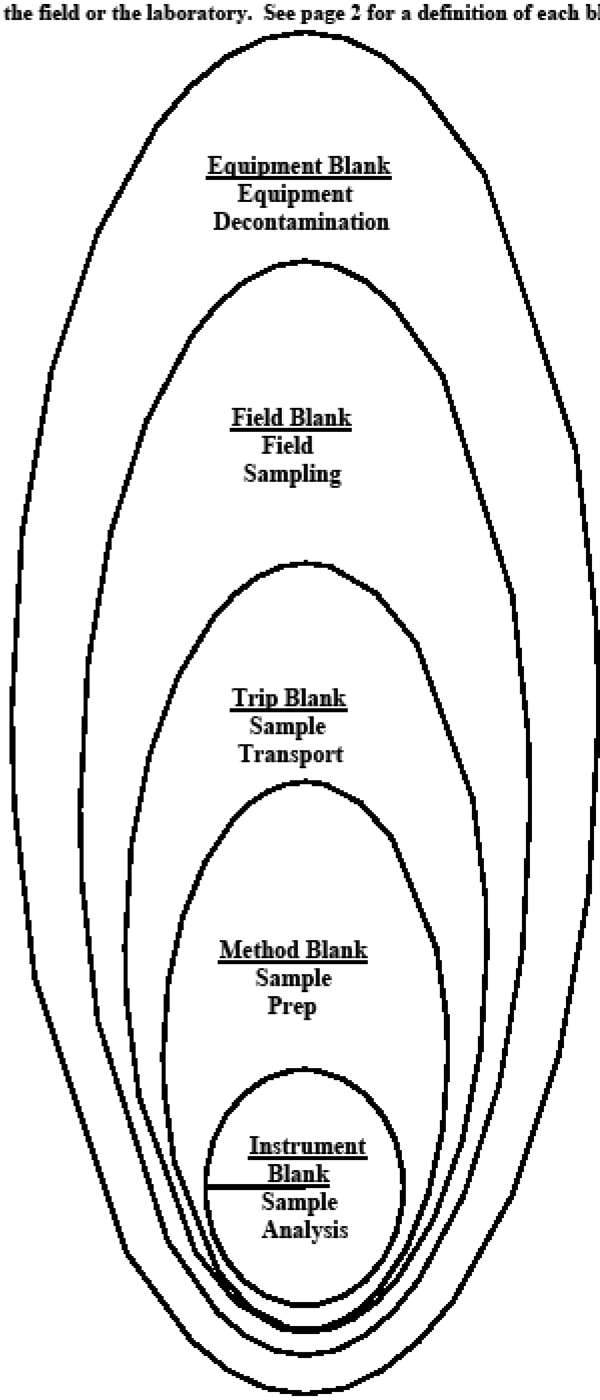
Corrective Action Process Flow Chart



QA/QC Guide

Region III Fact Sheet
Quality Control Tools: Blanks

The primary purpose of blanks is to trace sources of artificially introduced contamination. The diagram below shows how comparison of different blank sample results can be used to identify and isolate the source of contamination introduced in the field or the laboratory. See page 2 for a definition of each blank, its purpose and collection frequency.



Equipment Blank results include total field and laboratory sources of contamination.

Field Blank results include total ambient conditions during sampling and laboratory sources of contamination.

Trip Blank results include shipping and laboratory sources of contamination. Volatiles only.

Method Blank results show only laboratory sources of contamination.

Instrument Blank results show only laboratory sources of contamination.

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QA/QC Guide

FIELD BLANKS

Rinsate/Equipment Blank -A sample of analyte-free water poured over or through decontaminated field sampling equipment prior to the collection of environmental samples.
Purpose: Assess the adequacy of the decontamination process. Assesses contamination from the total sampling, sample preparation and measurement process, when decontaminated sampling equipment is used to collect samples.
Frequency- 1 blank/day/matrix or 1 blank/20 samples/matrix, whichever is more frequent.

Field Blank - A sample of analyte free water poured into the container in the field, preserved and shipped to the laboratory with field samples.
Purpose: Assess contamination from field conditions during sampling.
Frequency - 1 blank/day/matrix or 1 blank/20 samples/matrix, whichever is more frequent.

Trip Blank - A clean sample of a matrix that is taken from the laboratory to the sampling site and transported back to the laboratory without having been exposed to sampling procedures. Typically, analyzed only for volatile compounds.
Purpose: Assess contamination introduced during shipping and field handling procedures.
Frequency - 1 blank/cooler containing volatiles.

Laboratory Blanks Method Blank - A blank prepared to represent the matrix as closely as possible. The method blank is prepared/extracted/digested and analyzed exactly like the field samples.
Purpose: Assess contamination introduced during sample preparation activities
Frequency - 1 blank/batch (samples prepared at one time.)

Instrument Blank - A blank analyzed with field samples.
Purpose: Assess the presence or absence of instrument contamination.
Frequency - defined by the analytical method or at the analyst=s discretion (e.g., after high concentration samples.)

Comparing Blanks: The source of contamination introduced in the field or laboratory can be deduced by comparing blank results. An equipment blank could potentially be contaminated in the field, during transport to the lab or in the lab. The method blank, on the other hand, could only be contaminated in the lab. Using all blanks (appropriate for the project) described in this fact sheet will facilitate the identification of contamination sources.

Temperature Indicator (often called a Temperature Blank, but is not a blank) - A VOA vial or other small sample bottle filled with distilled water that is placed in each cooler. Upon arrival at the laboratory, the temperature of this vial is measured. The temperature indicator or blank is not analyzed and does not measure introduced contamination, therefore, is not a blank.
Purpose: To evaluate if samples were adequately cooled during sample shipment
Frequency: 1 blank/cooler

Example Boring/Well Log

Well Log Header									
Sample Log					Borehole Log				Well Design Log
Sample #	OVA/PID	Spl. results	Density (blows/ft.)	Depth in ft.	Depth in feet	USCS Symbol	Graphic Log	Geologic Description (soil type, color, grain, minor soil component, moisture, density, odor, etc.)	

Soil Classification Guide

UNIFIED SOIL CLASSIFICATION SYSTEM - ASTM D2488

MAJOR DIVISION			GROUP SYMBOL	LETTER SYMBOL	GROUP NAME
COARSE GRAINED SOILS CONTAINS MORE THAN 50% FINES	**GRAVEL AND GRAVELLY SOILS** MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVEL WITH < 5% FINES		GW	Well-graded GRAVEL
				GP	Poorly graded GRAVEL
		GRAVEL WITH BETWEEN 5% AND 15% FINES		GW-GM	Well-graded GRAVEL with silt
				GW-GC	Well-graded GRAVEL with clay
				GP-GM	Poorly graded GRAVEL with silt
				GP-GC	Poorly graded GRAVEL with clay
		GRAVEL WITH ≥ 15% FINES		GM	Silty GRAVEL
				GC	Clayey GRAVEL
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	SAND WITH < 5% FINES		SW	Well-graded SAND
				SP	Poorly graded SAND
		SAND WITH BETWEEN 5% AND 15% FINES		SW-SM	Well-graded SAND with silt
				SW-SC	Well-graded SAND with clay
				SP-SM	Poorly graded SAND with silt
				SP-SC	Poorly graded SAND with clay
		SAND WITH ≥ 15% FINES		SM	Silty SAND
				SC	Clayey SAND
FINE GRAINED SOILS CONTAINS MORE THAN 50% FINES	SILT AND CLAY	LIQUID LIMIT LESS THAN 50		ML	Inorganic SILT with low plasticity
				CL	Lean inorganic CLAY with low plasticity
				OL	Organic SILT with low plasticity
		LIQUID LIMIT GREATER THAN 50		MH	Elastic inorganic SILT with moderate to high plasticity
				CH	Fat inorganic CLAY with moderate to high plasticity
				OH	Organic SILT or CLAY with moderate to high plasticity
HIGHLY ORGANIC SOILS				PT	PEAT soils with high organic contents

NOTES:

1) Sample descriptions are based on visual field and laboratory observations using classification methods of ASTM D2488. Where laboratory data are available, classifications are in accordance with ASTM D2487.

2) Solid lines between soil descriptions indicate change in interpreted geologic unit. Dashed lines indicate stratigraphic change within the unit.

3) Fines are material passing the U.S. Std. #200 Sieve.

Virginia Department of Transportation

VDOT

UNIFIED SOIL CLASSIFICATION SYSTEM

UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART

COARSE-GRAINED SOILS (more than 50% of material is larger than No. 200 sieve size.)		
	Clean Gravels (Less than 5% fines)	
GRAVELS More than 50% of coarse fraction larger than No. 4 sieve size	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
	GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines
	Gravels with fines (More than 12% fines)	
	GM	Silty gravels, gravel-sand-silt mixtures
	GC	Clayey gravels, gravel-sand-clay mixtures
	Clean Sands (Less than 5% fines)	
SANDS 50% or more of coarse fraction smaller than No. 4 sieve size	SW	Well-graded sands, gravelly sands, little or no fines
	SP	Poorly graded sands, gravelly sands, little or no fines
	Sands with fines (More than 12% fines)	
	SM	Silty sands, sand-silt mixtures
	SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS (50% or more of material is smaller than No. 200 sieve size.)		
SILTS AND CLAYS Liquid limit less than 50%	ML	Inorganic silts and very fine sands, rock flour, silty of clayey fine sands or clayey silts with slight plasticity
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	OL	Organic silts and organic silty clays of low plasticity
SILTS AND CLAYS Liquid limit 50% or greater	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
	CH	Inorganic clays of high plasticity, fat clays
	OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS	PT	Peat and other highly organic soils

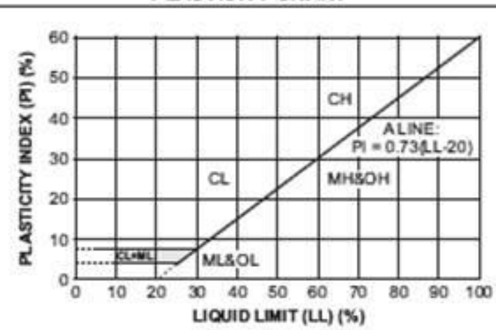
LABORATORY CLASSIFICATION CRITERIA

GW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3	
GP	Not meeting all gradation requirements for GW	
GM	Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
GC	Atterberg limits above "A" line with P.I. greater than 7	
SW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3	
SP	Not meeting all gradation requirements for GW	
SM	Atterberg limits below "A" line or P.I. less than 4	Limits plotting in shaded zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols.
SC	Atterberg limits above "A" line with P.I. greater than 7	

Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:

Less than 5 percent .... GW, GP, SW, SP
More than 12 percent .... GM, GC, SM, SC
5 to 12 percent .... Borderline cases requiring dual symbols

PLASTICITY CHART



Soil Texture

Step 1 (Get and moisten sample)

Use the triangle to determine the soil texture of your horizon.

Place some soil from a horizon (about the size of a small egg) in your hand, and, using the spray mist bottle, moisten the soil. Let the water soak in and then work the soil between your fingers until it is the same moisture throughout. Once the soil is moist, try to form a ball. If the soil forms a ball, go on to Step 2. If the soil does not form a ball, go to Step 5.

Step 2 (Test for Clay)

A. If the soil:
- Is really sticky
- Hard to squeeze
- Stains your hands
- Has a shine when rubbed
- Forms a long ribbon (5+ cm) without breaking,

Call it a **clay** and go to Step 3.
Otherwise, go to B.

B. If the soil:
- Is somewhat sticky
- Is somewhat hard to squeeze
- Forms a medium ribbon (between 2-5 cm)

Call it a **clay loam** and go to Step 3.
Otherwise, go to **C**.

C. If the soil is:
- Soft
- Smooth
- Easy to squeeze,
- At most slightly sticky,
- Forms a short ribbon (less than 2 cm)

Call it a **loam** and go to Step 3.
Otherwise, go to **D**.

D. If the soil forms a ball but **no** ribbon, go to Step 4.

Step 3 (Refine initial soil texture classification from Step 2 for relative amounts of **sand** and **silt**)

Wet a small pinch of the soil in your palm and rub it with a forefinger.
If the soil:
- Feels very gritty, go to **E**
- Feels very smooth, with no gritty feeling, go to **F**
- Feels only a little gritty, go to **G**

E. Add the word **sandy** to the initial classification.
Soil texture is (check one): ❑ sandy clay, ❑ sandy clay loam, ❑ sandy loam
Soil Texture is complete.

F. Add the word **silt** or **silty** to the initial classification.
Soil texture is (check one): ❑ silty clay, ❑ silty clay loam, ❑ silt loam
Soil Texture is complete.

G. Leave the original classification of (check one): ❑ clay, ❑ clay loam, ❑ loam
Soil Texture is complete.

Step 4 (Test for loamy sand or silt)

If the soil:
- Forms a ball
- Forms **no** ribbon
- And is
  - **H.** Very gritty
    Soil texture is: ❑ loamy sand
    Soil Texture is complete.

Or
  - **I.** Very soft and smooth with **no** gritty feeling,
    Soil texture is: ❑ silt
    Soil Texture is complete.

Step 5 (Test for sand)

If the soil:
Forms no ball and falls apart in your hand,
Soil texture is: ❑ sand
Soil Texture is complete.

Example Data Tables

Well Gauging Data June 25, 2008					
Local ID	DNREC Permit #	Depth to GW	Depth to LNAPL	LNAPL Thickness	GW Elevation
MW-1	123456	8.10	ND	N/A	9.54
MW-2	123457	12.43	12.06	0.37	9.47
MW-3	123458	9.92	ND	N/A	9.51

All distances in feet.

Groundwater Sample Analytical Results

Permit Number	Local ID	Screened Interval
123456	MW-1	10-15ft
123456	MW-2	11-16ft
654321	MW-3	10-15ft
654321	MW-4	9-14ft

Local ID Sample Date	RBSL <50 ft	RBSL 51-100 ft	RBSL 101-300 ft	MW-1 6/26/2008	MW-2 6/26/2008	MW-3 6/26/2008	MW-4 6/26/2008
Benzene	29	51	160				
Toluene	7300	>520,000	>520,000				
Ethylbenzene	3700	>630,000	>630,000				
Total Xylenes	73000	>200,000	>200,000				
MTBE	180	240	560				
TBA	N/A	N/A	N/A				
Other Analytes as Applicable							

All concentrations in µg/L

Soil Sample Analytical Results

Local ID Sample Date Sample Depth	RBSL <50 ft <50ft Soil GW	RBSL <50 ft <50 ft Soil DC	SB-1 6/26/2008 10-11ft	SB-2 6/26/2008 11-12ft	SB-3 6/26/2008 6-7ft	SB-4 6/26/2008 7-8ft
Benzene	0.23	19				
Toluene	210	3800				
Ethylbenzene	350	2300				
Total Xylenes	>500	43,900				
MTBE	0.13	200				
TBA	N/A	N/A				
Other Analytes as Applicable						

All concentrations in mg/Kg

Groundwater Analytical Results

Local ID	**Permit #**	**RBSLs**			
MW-1	123456	<50'			
Analyte (RBSL) **DATE**	**Benzene (29)**	**Toluene (7,300)**	**Ethylbenzene (3,700)**	**Total Xylenes (73,000)**	**MTBE (180)**

List of CSM Websites

http://www.ce.utexas.edu/prof/maidment/risk/lhwlect/scmv2/index.htm

http://www.epa.gov/region8/r8risk/hh_scm.html

http://www.co.sanmateo.ca.us/vgn/images/portal/cit_609/21/40/651311576Site%20Conceptual%20Model.pdf

http://www.newmoa.org/cleanup/cwm/csm/HuntWhatIsTheCSM.pdf

http://www.emd.saccounty.net/Documents/presentations/Site%20Conceptual%20Model_files/frame.htm

http://www.triadcentral.org/mgmt/splan/sitemodel/index.cfm

http://www.dnr.mo.gov/env/hwp/tanks/siteconceptualmodelsmrbca.pdf

www.co.san-diego.ca.us/deh/water/docs/sam_kkezer_scm.ppt

http://www.epa.gov/athens/learn2model/part-two/onsite/i2l0_onsite.htm

Referenced ASTM Standards

D2488 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)

D5088 Practice for Decontamination of Field Equipment Used at Non-Radioactive Waste Sites

D5521 Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers

D6452 Standard Guide for Purging Methods for Wells Used for Ground-Water Quality Investigations

D6634 Guide for the Selection of Purging and Sampling Devices for Ground-Water Monitoring Wells

D6771 Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations