

# Soil and Ground Water Assessments Performed During Site Investigations

## Guidance Document 4-01

Petroleum Remediation Program

This guidance document describes the procedures and techniques to be used when performing soil and ground water assessments. Vapor intrusion assessments, which are also a necessary part of the site investigation process, are discussed in Guidance Document 4-01a *Vapor Intrusion Assessments Performed During Site Investigations*. As discussed in Guidance Document 1-01 *Petroleum Remediation Program General Policy*, the two types of site investigations used to evaluate petroleum contamination are Limited Site Investigations (LSIs) and Remedial Investigations (RIs).

The objective of an LSI is to quickly evaluate the level of risk associated with a petroleum release site and identify those low risk sites where further investigation or remedial actions are not necessary. The LSI provides a “snapshot” of site conditions. Information collected during the LSI helps determine whether monitoring wells (RI) will be necessary. An RI measures ground water contaminant concentrations over time to establish plume stability relative to potential receptors. Permanent monitoring wells are necessary for an RI.

**The Minnesota Pollution Control Agency (MPCA) encourages completing the potential water well, surface water, and vapor receptor surveys (Guidance Document 4-02 *Potential Receptor Surveys and Risk Evaluation Procedures at Petroleum Release Sites*) prior to investigation activities.** Consider the locations of potential receptors and the possible exposure pathways to those receptors when planning investigation activities. Risks are evaluated by measuring the extent and magnitude of contamination, assessing likely exposure pathways, and determining whether the contamination has or will reach receptors before naturally attenuating.

## I. Soil Contamination Assessment

For both LSIs and RIs, the soil investigation defines site geology and the vertical and horizontal extent and magnitude of soil contamination. The components of a soil investigation include the following:

### A. Drilling Methods

Preferred drilling methods include hollow-stem auger and sonic drilling, or, for LSIs where conditions are appropriate, push probes. Do not use solid-stem flight augers for soil borings unless approved by the MPCA project hydrologist. Perform continuous soil sampling unless MPCA staff approve an alternative approach. For all borings, follow the procedures listed below:

- Completely clean all down-hole equipment and tools prior to each use to avoid cross-contamination. Cleaning methods include power spray wash, brushing with appropriate cleaning solution, and clean water rinse.
- Bore holes that are not completed as monitoring wells should be sealed in accordance with the Minnesota Department of Health (MDH) well code (Minn. R. ch. 4725).
- Complete a drilling log for every soil boring advanced. When monitoring wells are completed in a boring, provide well construction diagrams as described in section II.B, below. At a minimum, information in the logs should include:
  1. Depth to start and finish of each soil sample interval attempted (feet).
  2. Recovery for each soil sample interval attempted (feet).
  3. Soil classification in accordance with the 1952 Unified Soil Classification System (USCS) or with American Society for Testing Materials (ASTM) methods D2487 or D2488.
  4. Further description of soil (grain size, sorting, color, geologic origin, etc.)
  5. Depth of significant changes in material (feet).

6. Approximate position of the water table (feet); include date and time of measurement.
7. Organic vapor measurements (ppm).
8. Comments regarding significant geologic and hydrogeologic features, visual, or olfactory evidence of contamination, etc.
9. Depth to top and bottom of open hole or exposed screen if collecting water samples from an open boring or temporary well.
10. Date and time boring started and completed.
11. Name of driller and consultant, as well as others present during drilling.
12. Drilling method.
13. Boring identification number.
14. Penetration test records, if applicable.
15. Ground surface elevation (feet, relative to identified datum). To establish ground surface elevation, survey all boring locations.

## B. Drilling Locations

**Magnitude of soil contamination and source identification:** Advance a soil boring in or immediately adjacent to any potential contamination source areas (e.g., underground storage tank basins, aboveground tank areas, product transfer area, lines, pump islands, remote fill pipes, known spill areas, and areas with visible surface staining).

**Horizontal definition:** Drill a number of soil borings sufficient to define the horizontal extent of soil contamination, keeping in mind that the most extensive soil contamination may not be near the ground surface. The number of borings will vary depending on site conditions, extent of contamination, and the locations of potential receptors. Horizontal definition can be considered defined if there is no visual evidence of contamination, there are no petroleum odors, and photoionization detector (PID) readings are less than 10 ppm.

**Vertical definition:** Drill soil borings to 5 feet below the water table or, if contamination extends below the water table, to 10 feet below the deepest measurable contamination, whichever is deeper. If the water table is very deep and you have drilled 10 feet below the deepest measurable contamination in the unsaturated zone, discontinue drilling. Vertical definition can be considered defined if there is no visual evidence of contamination, there are no petroleum odors, and PID readings are less than 10 ppm. If bedrock is encountered, contact the MPCA staff to discuss whether bedrock monitoring wells are necessary.

### Vertical definition examples:

- If contamination extends to 10 feet and the water table is at 20 feet, advance the boring to 25 feet.
- If contamination extends to 20 feet and the water table is at 15 feet, advance the boring to 30 feet.
- If contamination extends to 20 feet and the boring has been advanced to 30 feet without encountering the water table, then end the boring at 30 feet.

**Site stratigraphy:** To evaluate site stratigraphy, complete at least one soil boring to 20 feet below the deepest site contamination. If the water table is encountered, at least one boring a minimum of 20 feet below the water table is necessary. If the water table is very deep and you have drilled 20 below the deepest sit contamination in the unsaturated zone, call the MPCA staff for approval to discontinue drilling deeper. Locate the soil boring near the suspected release point but not within a free product area. If there is a risk of cross-contamination by piercing a confining unit, complete the boring in an uncontaminated area. If additional site stratigraphy data are available, the MPCA staff may waive this requirement with prior approval.

### Site stratigraphy examples:

- If contamination extends to 10 feet and the water table is at 20 feet, advance the boring to 40 feet.
- If contamination extends to 25 feet and the water table is at 20 feet, advance the boring to 45 feet.
- If contamination extends to 20 feet and the boring has been advanced to 40 feet without encountering the water table, then call the MPCA staff for approval to discontinue drilling deeper.

**Contaminated surface soil:** See Guidance Document 3-01 *Excavation of Petroleum Contaminated Soil and Tank Removal Sampling* for requirements pertaining to contaminated surface soil identification, delineation, and excavation.

**Utility backfill investigation:** In situations where it appears likely that underground utilities (sanitary and storm sewer lines, water mains, etc.) intercept either the impacted soil or contaminated ground water, advance hand-driven or hand-augured soil borings in the utility backfill to investigate the potential for preferential migration of free product and contaminated ground water along these conduits. This information is especially important when sediments of low permeability (e.g., clay) occur near the surface.

## C. Soil Sampling

**Stratigraphy:** Record geologic descriptions for all soil samples collected and note changing drilling conditions that provide relevant geologic and stratigraphic information. Be sure to note the presence and thickness of sand and gravel lenses within less permeable soils.

**Grain size sampling:** Collect sediment samples for grain size analysis at all sites whether ground water is encountered. Grain size analysis is required for the purposes of verifying field classification of soils and estimating hydraulic conductivity. Analyze samples using ASTM D422 “Standard Test Method of Particle-Size Analysis of Soils,” ASTM International, West Conshohocken, PA, [www.astm.org](http://www.astm.org).

Collect and analyze a minimum of three (3) soil samples from different locations/horizons. In saturated conditions, collect the samples from horizons that appear to have high permeability. If a wide range of aquifer materials is present, collect samples from areas of apparent primary ground water flow. Record the depth of collected samples on the boring logs.

**Organic vapor sampling:** Collect and evaluate soil samples for organic vapors at least every 5 feet in uncontaminated horizons, at changes in material, and at least every 2.5 feet in contaminated horizons. Screen in accordance with Part I of Guidance Document 4-04 *Soil Sample Collection and Analysis Procedures*. Record the depth of collected samples and the organic vapor readings on the boring logs.

**Laboratory analysis sampling:** Collect soil samples for analysis at the zone of maximum organic vapor concentration and the water table interface or, if ground water is not encountered, at the terminus of the boring, unless MPCA staff approve other sampling guidelines. If soil contamination extends below the water table, continue to collect soil samples in the saturated zone that exhibit the highest field instrument reading. If the entire boring appears uncontaminated based on field screening, collect only one soil sample at the water table interface or at the terminus of the boring. Record the depth of collected samples on the boring logs. Refer to Guidance Document 4-04 *Soil Sample Collection and Analysis Procedures*.

**Water levels:** Measure water depth in all borings and compute ground water elevations. Record the time at which water depth measurements are made. Inspect soils for evidence of a fluctuating water table and a seasonal high water table (i.e., mottling). If soil borings in silt or clay appear unsaturated, record on the boring log the amount of time the boring was left open for water level measurement. Borings may be left open up to 72 hours to facilitate accurate water level measurements and collection of ground water samples.

**Free product:** If free product is found during boring advancement, notify the State Duty Officer (651-649-5451 or 1-800-422-0798) within 24 hours and immediately begin free product recovery efforts. Install permanent monitoring wells as soon as possible to define the free product plume. If there are questions about whether to convert a boring to a monitoring well when free product is discovered or appears likely to be present, contact MPCA staff to discuss. Refer to Guidance Document 2-02 *Free Product: Evaluation and Recovery*.

**Petroleum saturated soil:** Use the petroleum sheen test described in Guidance Document 4-04 *Soil Sample Collection and Analysis Procedures* to determine if soil is petroleum saturated.

## II. Ground Water Contamination Assessment

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### A. Limited Site Investigations

At sites where contaminated soil is in contact with ground water, or ground water contamination appears likely, a ground water contamination assessment is necessary as part of the LSI. The objectives of the assessment are to determine whether ground water is, or likely to be, impacted with petroleum contamination and whether the impacted hydrogeologic unit is considered an aquifer.

LSI ground water assessments accomplish the following:

- Collect ground water samples from temporary monitoring wells (e.g., push probes, hollow-stem augers, etc.) taking note of the vertical interval sampled. Provide well construction diagrams (see below) for each temporary monitoring well;
- Collect ground water samples from the “worst case” temporary monitoring well and a sufficient number of other points to document contaminant concentrations horizontally and, if necessary, vertically;
- Analyze for the appropriate parameters (see Guidance Document 4-05 *Ground Water Sample Collection and Analysis Procedures*); and
- Determine whether the hydrogeologic unit is an aquifer based on stratigraphy and permeability measurements (generally from grain size distribution). The stratigraphic data gives the context within which the permeability estimate can be assessed. For the purpose of the Petroleum Remediation Program, a hydrogeologic unit is an aquifer if:
  - The hydrogeologic unit supports a sustained yield of at least 5 gallons per minute. Because sustained yield is usually an inconvenient measurement (e.g., if no supply well is available for testing), for the purpose of the Petroleum Remediation Program, hydrogeologic units with a transmissivity of greater than **50 ft<sup>2</sup>/day** are considered aquifers.
  - The sediments at the site are primarily sand or gravel.
  - The formation (even one with low permeability) produces water to a supply well or spring.

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#### **An RI is necessary if the LSI determines that:**

- An aquifer has been (or is likely to be) contaminated by petroleum compounds at concentrations above drinking water standards or above 1 mg/L gasoline range organics (GRO) or diesel range organics (DRO);
- Soil contamination is likely to leach to ground water;
- Surface water has been (or is likely to be) contaminated by petroleum compounds at concentrations above applicable surface water standards or above 1 mg/L GRO or DRO;
- Free product is encountered; or
- The plume does not behave according to the conceptual model (Guidance Document 1-01).

*An RI may be necessary if certain other site-specific conditions are present.*

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## B. Remedial Investigations

Remedial Investigations (RIs) measure ground water contaminant concentrations over time to determine whether a plume is stable using monitoring wells. The following text explains the placement, completion, and evaluation of data from monitoring wells.

### Monitoring well placement

**Worst-case monitoring wells:** Place monitoring wells within or close to any likely source areas (e.g., underground storage tank basins, aboveground storage tank areas, product transfer areas, buried lines, pump islands, remote fill pipes, and known spill areas). Install monitoring wells to define free product (if present).

**Lateral and downgradient monitoring wells:** Place monitoring wells to define plume width and length. Place monitoring wells in an arrangement that defines the downgradient extent of the ground water contaminant plume (any contamination exceeding MDH Health Risk Limits - HRLs).

**Deep wells - vertical definition of ground water contamination:** A deep monitoring well may be necessary if soil borings show that petroleum contamination occurs at a depth greater than 5 feet below the water table or an evaluation of the hydrogeologic data indicate that downward contaminant migration is likely. In some cases deep monitoring wells are necessary to determine if deeper aquifers are impacted or threatened by petroleum contamination. If so, a network of deep monitoring wells may be necessary to determine the three-dimensional extent of the plume and calculate flow direction.

Review the geologic data from well logs obtained during the water well receptor survey, and install deep monitoring wells if water supply aquifers are impacted or threatened. Before installing a deep monitoring well, contact the MPCA project hydrogeologist. Be prepared to discuss site stratigraphy and potential receptors during this call.

**Legal access for off-site monitoring wells:** Legal access for off-site monitoring well locations may prove difficult in some locations. If legal access is not obtained after two written attempts, contact the MPCA project manager for assistance.

### Screen placement

- Install water table monitoring wells so the water table intersects the screen. Document and justify any exceptions in the RI report.
- Deep monitoring well screens do not intersect the water table. Screen placement depends on the purpose of the well. If the well is installed to measure vertical gradient, the top of the screen should be at least twenty feet below the water table (but within the same aquifer). If the well is installed to monitor water quality in a deeper aquifer, place the screen entirely within that aquifer.
- During monitoring well construction at sites where geologic conditions make it difficult to determine the actual depth to water:
  - Allow the borehole to remain open at least 24 hours prior to monitoring well completion to allow water level stabilization.
  - Consider using a slightly longer well screen (15-20 feet) to compensate for water table fluctuations.
- Phased well installation may be appropriate. This allows for determination of the approximate water table depth in one or two wells, and then the remaining wells can be installed with proper screen placement.

## Monitoring well construction

- Construct monitoring wells in accordance with the MDH water well construction code.
- Properly clean all monitoring well materials prior to installation.
- In general, avoid the use of liquid drilling fluids. However, they may be approved by the MPCA on a site-specific basis.
- Properly develop all wells to ensure adequate hydraulic connection with the aquifer and to remove any drilling fluid if used. Document the development procedures and results.

Complete monitoring well construction diagrams for every monitoring well constructed. The minimum information required includes, but is not limited to:

1. Diagram of major well features (bore hole annulus, top and bottom of screen, casing/riser, top and bottom of sand pack, top and bottom of pack seal, grout, surface seal, protective casing, etc.)
2. Depth from ground surface to all major well features including top of casing (feet).
3. Well screen slot size (inches).
4. Sand pack size (inches).
5. Inner diameters of riser casing, screen, protective casing, and borehole (inches).
6. Well development information (date, start/end times, methods used, gallons pumped, turbidity, recharge, etc.)
7. Well construction materials.
8. Unique well number and project identification number.
9. Date well begun and completed.
10. Driller and consultant names.
11. Elevation of ground surface and measurement point, i.e., top of riser casing (feet, relative to identified datum).

## Sampling frequency

Submit Guidance Document 4-06 *Investigation Report Form* after two quarters of ground water sampling. Continue quarterly sampling from all monitoring wells until site closure or the MPCA project hydrologist approves a new sampling schedule.

## Web pages and phone numbers:

MPCA staff:	<a href="http://www.pca.state.mn.us/pca/staff/index.cfm">http://www.pca.state.mn.us/pca/staff/index.cfm</a>
MPCA phone:	<b>651-296-6300 or 1-800-657-3864</b>
Petroleum Remediation Program Web page:	<a href="http://www.pca.state.mn.us/programs/lust_p.html">http://www.pca.state.mn.us/programs/lust_p.html</a>
MPCA Info. Request:	<a href="http://www.pca.state.mn.us/about/inforequest.html">http://www.pca.state.mn.us/about/inforequest.html</a>
MPCA VIC program:	<a href="http://www.pca.state.mn.us/cleanup/vic.html">http://www.pca.state.mn.us/cleanup/vic.html</a>
MPCA Petroleum Brownfields Program:	<a href="http://www.pca.state.mn.us/programs/vpic_p.html">http://www.pca.state.mn.us/programs/vpic_p.html</a>
MPCA SRS Guidance Documents:	<a href="http://www.pca.state.mn.us/cleanup/riskbasedoc.html">http://www.pca.state.mn.us/cleanup/riskbasedoc.html</a>
MDH HRLs:	<a href="http://www.health.state.mn.us/divs/eh/groundwater/hrltable.html">http://www.health.state.mn.us/divs/eh/groundwater/hrltable.html</a>
MDH DW Hotline:	<b>1-800-818-9318</b>
Petrofund Web page:	<a href="http://www.state.mn.us/cgi-bin/portal/mn/jsp/content.do?id=-536881377&amp;agency=Commerce">http://www.state.mn.us/cgi-bin/portal/mn/jsp/content.do?id=-536881377&amp;agency=Commerce</a>
Petrofund phone:	<b>651-215-1775 or 1-800-638-0418</b>
<b>State Duty Officer:</b>	<b>651-649-5451 or 1-800-422-0798</b>