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Sampling and Analysis Plans

In its 2000 session, the Wyoming Legislature created new opportunities, procedures, and standards for voluntary remediation of contaminated sites. These provisions, enacted as Articles 16, 17, and 18 of the Wyoming Environmental Quality Act and implemented by the Wyoming Department of Environmental Quality (DEQ), will govern future environmental cleanups in Wyoming.

This fact sheet provides information that should be included in a sampling and analysis plan. The methods identified as examples in this fact sheet are not intended to preclude use of other appropriate methods. An example table of contents for a sampling analysis plan is provided as an attachment to this fact sheet. This example table of contents is intended to be used as a guide and is not the required format for a sampling and analysis plan. Section-specific references are included at the end of each section, as appropriate.

Standard Operating Procedures (SOPs) are documents, which give a step-by-step description of how a specific operation, method, or procedure is performed. SOPs may be submitted in lieu of applicable portions of a sampling and analysis plan. Volunteers should consult with the DEQ project manager to ensure that all sampling and analysis plan requirements are met by any SOP documents.

1. Site Characterization Planning

Volunteers should review Fact Sheet #8 *Site Characterization* for additional information on site characterization prior to preparing a sampling and analysis plan. Sampling approaches for risk assessment may be different than sampling approaches for characterization of sites where risk assessment will not be performed. Therefore, if a risk assessment may be conducted at a site, Volunteers should also review Fact Sheet #11 *Risk Assessment,* Fact Sheet #14 *Ecological Risk Screening,* and Fact Sheet #20 *Human Health Risk Assessment.* Samples of potentially impacted media must be collected and analyzed for appropriate constituents based on the most current site conceptual model and the Data Quality Objectives (DQOs) for the project or project phase. (See Fact Sheet #28 *Data Quality Objectives* for more information.)

2. Soil Sample Collection

The sampling and analysis plan should identify the soil sample locations, the soil depth intervals to be collected for laboratory analysis and for physical observation, the constituents for which to analyze, the laboratory methods to be used, the sample type (e.g., environmental vs. geotechnical, disturbed vs. undisturbed), the sampling method(s), sampling equipment, field screening procedures, and sample collection procedures (e.g., preservation and containers, QA).

Field evaluation of samples (often referred to as screening) prior to collecting subsamples for laboratory analyses is often performed to identify soil intervals that may contain detectable concentrations of contaminants. For example, organic vapors due to contamination present in the soil may be screened using a hand-held photoionization detector. Also, the presence of some petroleum hydrocarbons may be identified using an ultra-violet light. The specific techniques and procedures associated with using field screening methods should be outlined in the sampling and analysis plan. For more information on field screening methods and procedures see EPA's document *Subsurface Characterization and Monitoring Techniques*, *A Desk Reference Guide*, Volume II: *The Vadose Zone, Field Screening and Analytical Methods* (EPA 1993b).

The locations and depth intervals at which soil samples are to be collected for laboratory analysis or for physical observation should be determined based on the most current site conceptual model and the DQOs for the project or project phase (see Fact Sheet #28 *Data Quality Objectives*). Soil sample locations can be biased or random depending on the size, history, and/or known environmental conditions of the site. The depth intervals may be selected to fill data gaps, or determined based on the depth to groundwater, the nature of the potential contaminant source (e.g., surface spill or subsurface release), or field observations and screening.

At sites where sufficient data does not exist from previous investigations, combinations of biased and non-biased samples are collected. For example, a sample may be collected from:

- The upper one to two feet of soil; AND
- The unsaturated zone (above the water table) from at least one of the following locations:
    1) Where there are indications of contamination (e.g., positive field screening measurements using selected field instruments, the presence of staining and/or odor, etc). Additional soil samples may be collected at depths below the depth where contamination was identified (but above the groundwater table) to assist with the evaluation of the vertical extent of soil contamination; or
    2) The bottom of the boring above the groundwater table.

In situations where data exist from previous investigations (e.g., when performing risk assessments or remedy evaluations), sampling schemes may involve taking representative samples from each vertical interval defined in the data quality objectives (DQOs), as opposed to biased sampling.

Incremental Sampling Methodology (ISM) is another approach that Volunteers may incorporate into the soil sampling design at their site. Refer to ITRC's ISM document for detailed guidance on the effective design and implementation of ISM at your site.

For guidance on developing a sampling design see EPA and ITRC guidance documents: *Guidance on Choosing a Sampling Design for Environmental Data Collection, for Use in Developing a Quality Assurance Project Plan* (EPA 2002a), Incremental Sampling Methodology (ITRC 2012), and *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual* (EPA 2001a).

There are generally two exploration methods that can be used for soil sample collection: test pits and borings. Test pits may be shallow hand-dug holes for collecting surface and shallow subsurface samples or may be deeper and wider excavations where soil is removed using a backhoe or similar equipment. Borings may be drilled using heavy drilling equipment (e.g., hollow-stem auger, air-rotary, cable tool, direct-push, etc.) or using a small hand-held auger tool. Soils should be visually logged from the ground surface to the bottom of the test pit or boring, under the supervision of a professional geologist. Prior to drilling of any borehole or excavation of a test pit, Volunteers should consult DEQ's Water Quality Division Water Quality Rules, Chapter 3, located at http://deq.wyoming.gov/wqd/resources/rules-regs/ for permitting requirements.

Equipment used to collect samples depends on the type of exploration method. For test pits, samples are collected directly from the sidewall or bottom of the test pit, typically with hand-held shovels or spoons or from the excavation equipment bucket. At borings, samples are typically collected by driving or pushing split-spoon sampling equipment ahead of the drilling equipment or by collecting drill cuttings when the drilling method cannot accommodate driven or pushed sampling equipment (e.g., during air-rotary drilling). When using hand-held augers, the soil samples are collected directly from the auger.

Procedures for collecting soil samples may include scraping the test pit sidewall prior to sample collection, using brass rings or plastic tubes in split-spoon sampling equipment to collect undisturbed soil samples, and homogenizing the soil sample in a bowl prior to placing in a sampling container.

For samples to be analyzed for volatile organic compounds (VOCs) or gasoline-range petroleum hydrocarbons, samples should not be homogenized but placed into the appropriate sample container directly from the sampling equipment. Compositing samples may be accomplished (with prior approval from DEQ) by either: 1) placing discrete samples (in equal amounts) from each interval into several individual containers (labeled and grouped clearly for compositing in the lab), or 2) placing discrete samples of equal amounts directly into the same container. Instructions on how the lab is to homogenize the samples should be noted in both the sampling and analysis plan and the forms accompanying the samples to the laboratory. In some instances, DEQ may approve averaging of discrete sample results instead of physical compositing. If implementing ISM techniques at your site, Section 5.4.2. of the ITRC ISM Guidance (ITRC 2012) should be followed for sample collection for VOCs.

Soil samples that are to be analyzed for VOCs also require special handling, screening, and analytical techniques to ensure that VOCs are not lost during these processes. The U.S. Army Corps of Engineers (USACE) has prepared a "Strategies" document to guide its staff in sample collection and handling procedures that minimize VOC losses from soil samples. The USACE document supplements existing guidance provided in SW-846 Method 5035 (http://clu-in.org/download/char/5035a_rev1.pdf), and addresses selected aspects of sample collection, handling, preparation, and shipment. For additional information, see http://clu-in.org/download/stats/sampling.pdf. The New Jersey Department of Environmental Protection

(NJDEP) also provides excellent guidance on soil sample collection, screening, and preservation for VOC analysis in their 2005 Field Sampling Procedures Manual, Chapter 6 (NJDEP 2005).

It should be noted in the sampling and analysis plan that samples should be collected in the appropriate sample containers supplied by the laboratory performing the analyses, and containers should be filled (as applicable) in the order of VOCs first, followed be semi-volatile organics (SVOCs), pesticides, and inorganics.

See EPA and NJDEP documents *Subsurface Characterization and Monitoring Techniques*, *A Desk Reference Guide*, Volume 1: *Solids and Groundwater* (EPA 1993a);*Guidance, Preparation of Soil Sampling Protocols: Sampling Techniques and Strategies* (EPA 1992b), *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual* (EPA 2001b), and Field Sampling Procedures Manual (NJDEP 2005) for further information on soil sampling techniques.

Soil boreholes should be properly backfilled after drilling and sample collection is complete, except where monitoring wells are planned. Soil borings should be backfilled to the ground surface with either high-solids bentonite chips or a high solids bentonite grout. For soil borings extending below the groundwater level, a tremie pipe may be necessary to insure that the backfill material extends the full length of the borehole. Test pit explorations must also be backfilled, but are typically backfilled with the excavated soil. Residual wastes from drilling or excavation (e.g., drill cuttings, decontamination fluids, and contaminated personal protective equipment) will need to be managed, as discussed in Section 11 of this fact sheet.

3. Monitoring Wells

The sampling and analysis plan should identify the number, locations, and types of wells to be installed for groundwater sampling at the site, the well construction design, the installation procedures, and the procedures for developing the well.

Prior to installation and construction of a monitoring well, the DEQ Water Quality Division Water Quality Rules, Chapter 3 should be consulted.

There are two types of monitoring wells that can be used to collect groundwater samples during site characterization: permanent and temporary. Permanent monitoring wells allow long-term groundwater sampling. Permanent monitoring wells may be installed in a drilled or direct-push soil boring. Soil borings can be drilled using different types of drill rigs (e.g., hollow-stem auger, air-rotary, cable tool, etc.); however, drilling methods that require drilling fluid to be added to boreholes should be avoided. Permanent wells require sand filter packs to be installed around the screen, a seal above the well screen, and a monument around the top of the well to protect the well head.

Temporary monitoring wells typically allow for a one-time sample collection and are typically abandoned the day that they are installed. Temporary monitoring wells are often installed using a direct-push method (Geoprobe or similar). Temporary wells may be constructed without a sand filter pack around the well screen, but complete development may be difficult. Construction of both types of wells includes a well screen and well casing. Both permanent and temporary monitoring wells can be used to measure groundwater levels; however, wells used for collection of hydraulic conductivity data, transmissivity data, etc., must be installed with a filter pack unless permission is obtained from DEQ. Temporary wells installed without a filter pack or incompletely developed wells are also more likely to yield turbid samples than completely developed permanent monitoring wells, potentially resulting in false positive analytical results or analytical results that are biased high for constituents that may be associated with particulate matter in the sample. For more information on the use of temporary wells see Wisconsin Department of Natural Resource's document: *A Fact Sheet of Frequently Asked Questions about Temporary Monitoring Wells for Remediation and Redevelopment Program Sites* (Wisconsin DNR 2001*).*

The construction design of the well should be determined based on information known about the subsurface geology and hydrogeology. The well should be constructed with materials that are compatible with the anticipated geochemical and physical environment and the well should be designed to allow maximum flow of groundwater into the well screen, but not allow material from the surrounding formation (i.e., soil particles) to flow into the well. Installation of the well (soil boring methods and depth of the well) should be determined based on the type and size of the well to be installed, the depth of the aquifer to be sampled, and the seasonal fluctuation of groundwater levels.

Following installation of a permanent or temporary groundwater monitoring well, the well should be developed by over-pumping using a pump or bailer. During drilling and installation of a monitoring well, the soil surrounding the well can be disturbed or smeared and bridging of fines can occur that may cause a reduction in hydraulic conductivity of the materials surrounding the well. Development allows the formation water to enter the well casing more freely, ensures more representative samples, and enhances the yield of the well. Typically, development includes removing water until the turbidity of the extracted water is visibly low or until at least 5 to 10 casing volumes have been removed.

Abandonment procedures for permanent and temporary monitoring wells should also be described in the workplan. Proper abandonment is important so that the wells or boreholes do not act as conduits for migration of contaminants. Specific procedures for well abandonment are provided in *Section 11, Chapter 26, Water Quality Rules and Regulations* (DEQ 2012).

Notes

Construction and installation of monitoring wells must be conducted in accordance with the requirements described in *Chapter 26, Water Quality Rules and Regulations.* The Office of the State Engineer (Groundwater Division 307-777-6163) must be notified prior to installation of any monitoring well (permanent or temporary) with a casing larger than a nominal 4-inch diameter.

The Wyoming DEQ recommends GPS coordinates for all wells.

If the well is going to be used to monitor groundwater levels, a reference point should be identified (typically at the top of the well casing) and marked, and the elevation of the reference point surveyed to the nearest hundredth of a foot.

4. Groundwater Sample Collection

The sampling and analysis plan should identify the sampling point locations, equipment and procedures that will be used to collect representative groundwater samples, constituents being analyzed, laboratory methods to be used, and sampling frequency.

The types of equipment used to collect groundwater samples typically include a pump, discharge tubes, and sample containers. The type of equipment used to extract groundwater from the well should be selected based on the type and size of well construction, depth to groundwater, type of contamination [presence of liquid nonaqueous phase liquid (LNAPL) or dense nonaqueous phase liquid (DNAPL)], sample analyses, frequency of sampling events, ease of equipment decontamination, and cost. Types of equipment that are typically used for groundwater extraction include peristaltic and bladder pumps. All equipment that comes in contact with the groundwater (e.g., pumps and discharge tubes) should be dedicated (i.e., never used at another location) or properly decontaminated prior to reuse. Samples should be collected in the appropriate pre-cleaned and preserved sample containers supplied by the laboratory performing the physical or chemical analyses.

Procedures for collecting groundwater samples described in the sampling and analysis plan may include pumping rates; low-flow sampling; multi-level groundwater sampling; measurement of field parameters (e.g., pH, conductivity, temperature, and turbidity); and how the samples should be identified. If sampling for dissolved constituents is approved by DEQ, designated procedures should also include whether or not the groundwater sample will be filtered in the field when analyzing for dissolved metals or if the lab will perform the filtering.

Sampling frequency is typically quarterly for the first year. The frequency of sampling for subsequent years should be discussed with the DEQ project manager.

For more information on groundwater sampling see Wisconsin DNR document: *Groundwater Sampling Field Manual* (Wisconsin DNR 1996a) or EPA documents referenced below.

Notes

To collect representative groundwater samples, the samples should be collected from either a temporary or permanent monitoring well (discussed in section 2). A newly completed monitoring well should not be developed for at least 24 hours after the surface pad and outer protective casing are installed. This is to allow sufficient time for the cement and/or grout to cure before development procedures are initiated. The main purpose of well development is to remove any residual materials introduced during well installation, and to re-establish the natural hydraulic flow conditions of the aquifer which may have been disturbed by well construction around the immediate vicinity of each well.

Once a monitoring well has been developed, groundwater sampling should not be initiated until a minimum of 24 hours have passed since well development and the groundwater has re-equilibrated to a static water level, is free of visible sediment, and water quality parameters have stabilized. If using compressed air to develop a monitoring well, sampling should not be initiated until at least 7 days have passed since well development. Collection of groundwater samples should be performed using a low-flow minimal-drawdown method to minimize sample disturbance. While purging the well, the flow rate must be adequate to minimize water level drawdown in the well. Drawdown during purging should typically be less than 0.33 feet; however, it is more important that the drawdown level remains stable throughout the purging and sampling process. Water level measurements should be taken at regular intervals (30 seconds to 5 minutes apart) to monitor the level of drawdown. Groundwater samples should only be collected after all water quality parameters have stabilized.* Please contact your DEQ Project Manager if sampling will be conducted outside of the conditions described above. Otherwise, the DEQ may consider the data for screening purposes only and may require subsequent sampling event(s). (EPA 2002b, EPA 1996a,b).

When analyzing water for metals, a total metals analysis should be performed. This means that the water sample is not filtered prior to analysis. Water samples that will be analyzed for metals should be sampled using low-flow minimal-drawdown methods. Based on the total metals results, analysis for dissolved metals (water samples are filtered prior to analysis) may be appropriate; however, this must be discussed with DEQ prior to sample collection. In addition, if field parameter data indicate turbidity greater than 20 NTUs after implementing low-flow minimal-drawdown purging and sampling methods, then consult with DEQ for approval of dissolved metals analysis.

Preserving VOC samples requires minimizing aeration when filling sample bottles. The bottle should be filled so that it is completely full and there is no visible headspace when inverted (zero-headspace). If air bubbles are present after the sample is collected and zero-headspace is attempted, then the sample should be recollected using a new sample bottle with preservative. If effervescence is noted in the sample and is believed that some constituent in the groundwater is reacting with the acid preservative to cause effervescence, then the sample should be recollected using an unpreserved sample bottle. The holding times should be adjusted accordingly (typically 7 days for an unpreserved sample) and noted in the data and report. The laboratory supplied containers should be filled (as applicable) in the following order: VOCs (first), SVOCs, pesticides, inorganics, other unfiltered samples, and filtered samples (last).

If static groundwater levels are to be obtained, then groundwater levels in the well should be collected prior to any pumping (i.e., prior to purging the well).

*Water quality parameters are considered stable when three successive readings, collected 3-5 minutes apart, are within (EPA 2010):

- ± 3% for temperature,
- ± 0.1 for pH,
- ± 3% for specific electrical conductance (SEC),
- ± 10 mv for redox potential (ORP),
- ± 10% for dissolved oxygen (DO) for values greater than 0.5 mg/L; if three consecutive DO values are less than 0.5 mg/L, the values may be considered stable, and
- ± 10% for turbidity if > 5 Nephelometric Turbidity Units (NTUs); if three consecutive turbidity values are less than 5 NTU, the values may be considered stable.

If water quality parameters do not stabilize within these ranges during successive sampling events, then the sampler should examine the equipment (and possibly replace it) and field methods to correct the problem. The serial number for all equipment should be recorded in the field datasheets and notes. Regarding turbidity, whenever possible, and especially when sampling for contaminants that may be biased by the presence of turbidity, the turbidity reading should stabilize at a value below 10 NTUs. If repeated sampling events produce visually significant turbidity (turbidity readings above 999 NTUs for field readings) the well may need to be redeveloped or different field collection applications utilized.

5. Sediment Sample Collection

If sediment samples are to be collected, the sampling and analysis plan should identify the sampling locations, the sediment depth intervals to be collected for laboratory analysis and/or for physical observation, the sampling method(s) and equipment, the constituents for which to analyze, the laboratory methods to be used, and sample processing. In some cases, it may also be beneficial to collect samples of the water in the pore spaces of the sediment and, in this case, the sampling and analysis plan should provide the pore water sampling procedures. Whether or not to collect sediment pore water should be discussed in advance with the DEQ project manager.

The first consideration for determining a sediment sampling plan should be the planned locations. If the sediment to be collected is below water then a vessel may be required to access the locations. The lifting capacities of the vessel may affect the type of sampling equipment that can be operated from the vessel. The depth of the water may also affect the type of sampling equipment used.

There are two main types of sediment sampling equipment used for environmental sampling purposes: grab samplers and core samplers. Grab samplers are typically used to collect surficial sediments. Core samplers are typically used to collect subsurface sediments.

Procedures for processing samples for chemical or physical analysis from the grab or core samplers should be well defined in the sampling and analysis plan and may include siphoning overlying water from the grab sampler, removal of the sample from the core sampler, sample homogenization, compositing, and placement of the sample in the appropriate containers.

6. Surface Water Sample Collection

If surface water samples are to be collected during the investigation, the sampling and analysis plan should identify the sample locations, provide procedures for collecting the samples, list the constituents for which to analyze, and the laboratory methods to be used.

There are typically two techniques for collecting surface water samples: a grab sampling technique and a continuous flow technique. The principle of the grab sampling technique is to fill a sample bottle by rapid immersion in water and capping to minimize exposure to the atmosphere and airborne particulate matter. Whenever possible, samples are collected facing upstream and upwind to minimize impacts from sample collection on the water sample. The continuous-flow technique typically uses a peristaltic or submersible pump and tubing. A filter is added to the sample train when sampling for dissolved metals.

7. Air Sample Collection

If collecting ambient or indoor air samples, soil vapor samples, or gas samples (e.g., landfill gas), the sampling and analysis plan should identify the types of samples to be collected, the methods and procedures for collecting the samples, the sampling locations, the constituents for which to analyze, the laboratory methods to be used, and the sampling frequency.

Typically two methods are used for collecting air, vapor, or gas samples. The most common is drawing air into an evacuated vessel (e.g., Tedlar bag, glass bulb, or a stainless-steel air canister). This is often referred to as a whole air sample. The second method involves pulling air through a sorbent. The contaminants are removed from the air either by absorption on the sorbent surface or by reacting with a coating on the sorbent to form a derivative of the contaminant.

To extract vapors or gas below the ground surface or below a landfill, gas monitoring wells or probes are often installed. If the wells or probes are not part of an active soil vapor extraction system, the well/probe will need to be purged prior to sample collection. A vacuum pump, lung box, or syringe is typically used to purge the air from a well. At least three well probe and tubing volumes should be purged. Refer to API (2005) regarding soil vapor sample collection and to EPA (2002) regarding indoor air sample collection and interpretation.

Notes

Vessels and sorbents used to collect air samples should be supplied by the analytical laboratory.

The methods for analyzing air samples typically require a specific sample collection method, type of vessel, etc., and should be reviewed prior to preparing a sampling plan.

Gas monitoring wells or probes must be properly constructed for that purpose (e.g., representative portion of well screen above the groundwater table, well is screened within the contaminated zone, etc.) and a proper seal must be achieved in order to collect a representative sample.

8. Innovative Sampling Technologies

There are many emerging technologies for sampling soil, sediment, air, groundwater, and surface water that may be pertinent depending on the project DQOs. For example, diffusion samplers are becoming more common for monitoring VOCs in groundwater, and X-ray fluorescence is being used in the field for measuring trace elements in soil and sediment. As with any sampling technique, all pertinent information should be supplied in the sampling and analysis plan for approval by DEQ. For more information on innovative sampling, see EPA's Technology Innovation Program website at http://clu-in.org.

9. Laboratory Analyses

The sampling and analysis plan should identify the laboratory analyses to be performed on each sample collected. The constituents for which to analyze should be selected to meet the data quality objectives for the project (see Fact Sheet #28 *Data Quality Objectives)* and may be determined based on types of chemicals that may have been used at the site, known environmental conditions, or to fill data gaps. Often, more than one method is available to analyze for a specific constituent or group of constituents. The analytical method should be selected based on the reporting limits that can be achieved by that method. Reporting limits should not be greater than VRP screening levels for protection of human health, groundwater, and ecological receptors (see Fact Sheets #12, #13, and #14, respectively). Reporting limits vary among laboratories and instrumentation. Typically, a reporting limit represents the lowest point of the initial calibration curve for a particular analysis and instrument. Reporting limits should not be confused with method detection limits (MDLs). MDLs are always lower than reporting limits and are statistically derived for each laboratory. However, because the MDL is below the initial calibration curve, any concentration above the MDL, but below the reporting limit, is only an estimate. Typically, concentrations below the reporting limit should not be reported by the laboratory unless they are qualified as estimated values.

Reporting limits for an analytical method may vary significantly among laboratories. Therefore, if reporting limits at or below VRP screening levels cannot be achieved by a given laboratory, reporting limits available from other laboratories should be evaluated. Additionally, more than one method may be available to analyze for a compound or group of compounds. Reporting limits for different analytical methods may vary significantly. Therefore, if reporting limits at or below VRP screening levels cannot be achieved by one analytical method, alternative analytical methods should be considered. If choosing another laboratory or an alternative analytical method does not result in low enough reporting limits, the issue should be discussed with the DEQ project manager. In certain cases, a reporting limit may be raised during analysis of a project sample. The raised reporting limit is often due to matrix interferences or required dilutions during analysis. Raised reporting limits should be discussed with the DEQ project manager.

Common and accepted methods for the analysis of groundwater, surface water, soil, and sediment samples are included in the current versions of:

- EPA Test Methods for Evaluating Solids Wastes (SW-846)
- EPA RCRA Ground-Water Monitoring Technical Enforcement Guidance Document (TEGD) (OSWER-9950.1)
- Public Health Association, American Water Works Association, and Water Environment Federation Standard Methods for the Examination of Water and Wastewaters

Common and accepted methods for the analysis of air and soil vapor samples are included in the current versions of:

- EPA Compendium Ambient Air Methods for Organic Compounds (EPA/625/R-96/010b)
- EPA Compendium Ambient Air Methods for Inorganic Compounds (EPA/625/R96/010a)

Notes

EPA has updated guidance to reflect the latest evaluation of currently available technologies for VOC sample handling and preservation procedures for solid samples. The procedures are designed to minimize VOC losses through volatilization and biodegradation. This guidance appears in SW-846 Method 5035A, which includes an accompanying 30-page appendix of detailed explanatory material.

The U.S. Army Corps of Engineers (USACE) has prepared a "Strategies" document to guide its staff in sample collection and handling procedures that minimize VOC losses from solid samples. The USACE document supplements existing guidance provided in SW-846 Method 5035, and addresses selected aspects of sample collection, handling, preparation, and shipment. A decision tree is also provided to guide the selection of high-level and low-level sample preservation methods. The New Jersey Department of Environmental Protection also provides guidance on soil sample collection, screening, and preservation for VOC analysis in Chapter 6 of the 2005 Field Sampling Procedures Manual (NJDEP 2005).

Because reporting limits vary by laboratory, an individual laboratory's reporting limits should be evaluated prior to selecting that laboratory to perform the analyses.

When analyzing water for metals, a total metals analysis should be performed. This means that the water sample is not filtered prior to analysis. Based on the total metals results, analysis for dissolved metals (water samples are filtered prior to analysis) may be appropriate; however, this must be discussed with DEQ prior to sample collection. See Section 4 of this Fact Sheet for more information.

When analyzing for chromium, it is necessary to determine whether results for total chromium, chromium VI, or chromium III will be needed. Due to the significantly greater toxicity of chromium VI compared to chromium III, there are separate cleanup levels for chromium VI and chromium III. It is recommended that chromium VI be analyzed for only if it is expected to be present; otherwise, it is recommended that total chromium be analyzed and the results compared to the cleanup level for chromium III.

10. Quality Assurance / Quality Control (QA/QC) Samples

The sampling and analysis plan should specify the types of QA/QC samples that should be collected in the field and performed by the laboratory, the frequency with which QA/QC samples should be collected and analyzed, and the procedures for collecting the samples. The collection and/or analysis of QA/QC samples is recommended to evaluate the validity and representativeness of the project sample analytical results.

There are two general categories of QA/QC samples: field and laboratory. Field samples include blind field duplicates, trip blanks, and equipment rinsate blanks.

The blind field duplicate consists of a split sample collected at a single sample location and submitted "blind" to the laboratory.

The trip blank consists of deionized water sealed in a sample container by the analytical laboratory. The trip blank accompanies VOC and gasoline-range petroleum hydrocarbon containers during transportation to and from the field, and is then returned to the laboratory.

A field blank consists of pouring laboratory supplied distilled water directly into sample containers while being exposed to ambient air during collection of a sample. Field blanks are analyzed to evaluate the potential for contamination from media other than the sample material (e.g., air particulates, gloves, sample containers, solvents, etc.).

An equipment rinsate blank consists of laboratory supplied deionized water poured over and/or through non-dedicated decontaminated sampling equipment and collected in the appropriate sample containers.

Laboratory QA/QC samples include method blanks, laboratory control samples, matrix spikes and matrix spike duplicate samples, and laboratory duplicate samples. A description of each of these QA/QC samples can be provided by the analytical laboratory.

The types, numbers, and frequency of QA/QC samples to be collected should be determined based on the DQO for the investigation (see Fact Sheet #28 *Data Quality Objectives)*.

11. Sample Handling and Documentation

Procedures for sample documentation and handling should be described in the sampling and analysis plan. Proper documentation and handling is critical to maintaining the integrity of the sample from the time of sample collection to the time of analysis.

For all sampling events, a complete record of field activities, measurements, and observations should be maintained. This information should be maintained in field notebooks and appropriate field sampling forms (e.g., log of exploration forms, sample collection forms, as-built well completion forms, well development records, etc.). Other documentation that should be maintained includes sample container labels, photographs, and sample custody forms (typically known as chain-of custody forms).

Sample handling includes proper storage and preservation of the samples in the field until the samples are analyzed. Chemical preservation of the samples should be performed in accordance with the analytical methods that will be performed on the sample. Most of the analytical methods for soil, water, and sediment require that a sample be stored on ice at a temperature of 4 °C; however, the analytical method should be consulted to determine proper sample storage requirements. The duration of time that can elapse between sampling and analysis (referred to as holding time) for properly preserved samples is typically specified by the analytical method and also depends on the sample matrix (e.g., air, water, soil, sediment). Holding times and preservation should be specified in the sampling and analysis plan for each media and each analysis. Often these are listed in tabular format. Other sample handling procedures that should be included in the sampling and analysis plan include proper preparation of the samples for shipment to the laboratory.

12. Equipment Decontamination

The sampling and analysis plan should describe procedures for decontaminating non-dedicated sampling equipment to minimize the potential for cross contamination between samples. Decontamination typically consists of scrubbing surfaces of equipment that come in contact with the sample with brushes using an Alconox solution, rinsing the equipment with clean tap water, and then final rinsing the equipment with deionized water to remove tap water impurities.

Decontamination should occur on reusable sampling equipment between collection of each sample. When free product or a sheen is present, an appropriate solvent may be required prior to the tap water rinse to properly decontaminate the equipment.

For larger equipment (e.g., drilling rigs, augers, backhhoe buckets, etc.), decontamination typically consists of a hot water, high-pressure wash before each use and at completion of the project.

13. Management of Investigation-Derived Wastes

Investigation-derived wastes are wastes generated as a result of typical investigative activities. These include well development water, purge water, decontamination fluids, drill cuttings from soil borings or monitoring well installations, excess samples, and dirty personal protective equipment and clothing intended to be thrown away. The sampling and analysis plan should describe how these wastes will be managed. Different management options include returning soil to a boring or pit, or storing the waste for future treatment and/or disposal. If storage is the management option selected for a waste stream, the sampling and analysis plan should describe how the wastes will be stored (i.e., stockpiled, contained in 55-gallon drums, tanks, etc.), where these wastes will be temporarily stored, and proper labeling of the equipment used for containment. Disposal or treatment of the investigative-derived wastes will depend on the analytical results for the soil or water samples collected. In some cases, it may be necessary to sample the actual waste stream and submit the sample for analysis to determine proper treatment and/or disposal. If investigation-derived waste may be hazardous waste, disposal options should be discussed with the DEQ project manager.

14. How can I get more information about the VRP?

To learn about VRP sites that may exist in your community, obtain copies of other VRP fact sheets/guidance documents, get answers to your questions, or volunteer for the program, contact DEQ at (307) 777-7752 or visit the DEQ VRP webpage.

The VRP website includes all of the fact sheets and other guidance documents for the VRP. This website is updated frequently and includes the latest information about DEQ's progress in developing guidance, policy, and other supporting documents for the VRP.

15. References

References for Soil Sampling

EPA. 2002a. *Guidance on Choosing a Sampling Design for Environmental Data Collection, for Use in Developing a Quality Assurance Project Plan*. EPA QA/G-5S Final. U.S. Environmental Protection Agency. EPA/240/R-02/005. December.

EPA. 2001a. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual.* U.S. Environmental Protection Agency, Region 4, Athens, Georgia. November.

EPA. 1993a. *Subsurface Characterization and Monitoring Techniques, A Desk Reference Guide, Volume I: Solids and Groundwater*. Prepared by: Eastern Research Group, Inc., Lexington, MA. Prepared for: Center for Environmental Research Information, U.S. EPA, Cincinnati, OH, and Environmental Monitoring Systems Laboratory, U.S. EPA, Las Vegas, NV. U.S. Environmental Protection Agency. EPA/625/R-93/003a. May.

EPA. 1993b. *Subsurface Characterization and Monitoring Techniques, A Desk Reference Guide, Volume II: The Vadose Zone, Field Screening and Analytical Methods*. Prepared by: Eastern Research Group, Inc., Bloomington, IN. Prepared for: Center for Environmental Research Information, U.S. EPA, Cincinnati, OH, and Environmental Monitoring Systems Laboratory, U.S. EPA, Las Vegas, NV. U.S. Environmental Protection Agency. EPA/625/R-93/003b. May.

EPA. 1992a. *Preparation of Soil Sampling Protocols: Sampling Techniques and Strategies*. U.S. Environmental Protection Agency. EPA/600/R-92/128. July.

EPA. 1989. *Soil Sampling Quality Assurance User's Guide*. U.S. Environmental Protection Agency. Second Edition. EPA/600/8-89/046. March.

ITRC. 2012. *Incremental Sampling Methodology.* Interstate Technology Regulatory Council.

NJDEP. 2005. *Field Sampling Procedures Manual.* New Jersey Department of Environmental Protection.

References for Monitoring Wells

DEQ. 2012. *Water Quality Rules and Regulations, Chapter 26, Well Construction Standards*. Wyoming Department of Environmental Quality.

EPA. 2001a. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual.* U.S. Environmental Protection Agency, Region 4, Athens, Georgia. November.

EPA. 1993a. *Subsurface Characterization and Monitoring Techniques, A Desk Reference Guide,* Volume I: *Solids and Groundwater*. Prepared by: Eastern Research Group, Inc., Lexington, MA. Prepared for: Center for Environmental Research Information, U.S. EPA, Cincinnati, OH, and Environmental Monitoring Systems Laboratory, U.S. EPA, Las Vegas, NV. U.S. Environmental Protection Agency. EPA/625/R-93/003a. May.

EPA. 1993b. *Subsurface Characterization and Monitoring Techniques, A Desk Reference Guide,* Volume II: *The Vadose Zone, Field Screening and Analytical Methods.* Prepared by: Eastern Research Group, Inc., Bloomington, IN. Prepared for: Center for Environmental Research Information, U.S. EPA, Cincinnati, OH, and Environmental Monitoring Systems Laboratory, U.S. EPA, Las Vegas, NV. U.S. Environmental Protection Agency. EPA/625/R-93/003b. May.

EPA. 1992b. *RCRA Ground-Water Monitoring: Draft Technical Guidance*. Office of Solid Waste, U.S. Environmental Protection Agency, Washington, D.C. November.

EPA. 1985. *Practical Guide for Ground-Water Sampling*. Prepared by: Barcelona, M.J., J.P. Gibbs, J.A. Helfrich, and E.E. Garske, Illinois State Water Survey, Department of Energy and Natural Resources, Champaign, IL. Prepared for U.S. Environmental Protection Agency, Ada, OK. EPA/600/2-85/104. September.

Wisconsin DNR. 2001. *A Fact Sheet of Frequently Asked Questions About Temporary Monitoring Wells for Remediation and Redevelopment Program Sites*. Wisconsin Department of Natural Resources. PUB-RR-647. May.

References for Groundwater Sample Collection

EPA. 2002b. *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers*. Groundwater Forum Issue Paper. Douglas Yeskis, Region 5, Chicago, IL and Bernard Zavala, Region 10, Seattle, WA, U.S. Environmental Protection Agency. May.

EPA. 2001a. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual.* U.S. Environmental Protection Agency, Region 4, Athens, Georgia. November.

EPA. 1996a. *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*. Groundwater Issue. Puls, Robert W., National Risk Management Research Laboratory, U.S. EPA, and Michael J. Barcelona, University of Michigan. Prepared for U.S. Environmental Protection Agency. EPA/540/S-95/504. April.

EPA, Region I, 1996b, Updated 2010. *Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells*. January 19.

EPA. 1993a. *Subsurface Characterization and Monitoring Techniques, A Desk Reference Guide,* Volume I: *Solids and Groundwater*. Prepared by: Eastern Research Group, Inc., Lexington, MA. Prepared for: Center for Environmental Research Information, U.S. EPA, Cincinnati, OH, and Environmental Monitoring Systems Laboratory, U.S. EPA, Las Vegas, NV. U.S. Environmental Protection Agency. EPA/625/R-93/003a. May.

EPA. 1993b. *Subsurface Characterization and Monitoring Techniques, A Desk Reference Guide,* Volume II: *The Vadose Zone, Field Screening and Analytical Methods*. Prepared by: Eastern Research Group, Inc., Bloomington, IN. Prepared for: Center for Environmental Research Information, U.S. EPA, Cincinnati, OH, and Environmental Monitoring Systems Laboratory, U.S. EPA, Las Vegas, NV. U.S. Environmental Protection Agency. EPA/625/R-93/003b. May.

EPA. 1992b. *RCRA Ground-Water Monitoring: Draft Technical Guidance*. Office of Solid Waste, U.S. Environmental Protection Agency, Washington, D.C. November.

EPA. 1985. *Practical Guide for Ground-Water Sampling*. Prepared by: Barcelona, M.J., J.P. Gibbs, J.A. Helfrich, and E.E. Garske, Illinois State Water Survey, Department of Energy and Natural Resources, Champaign, IL. Prepared for U.S. Environmental Protection Agency, Ada, OK. EPA/600/2-85/104. September.

Wisconsin DNR. 1996a. *Groundwater Sampling Field Manual*. Steve Karklins (author) and Jordana Lenon (editor), Bureau of Drinking Water and Groundwater, Wisconsin Department of Natural Resources. PUBL-DG-038 96. September.

Wisconsin DNR. 1996b. *Groundwater Sampling Desk Reference*. Steve Karklins (author) and Jordana Lenon (editor), Bureau of Drinking Water and Groundwater, Wisconsin Department of Natural Resources. PUBL-DG-037 96. September.

Wyoming DEQ, Groundwater Sampling for Metals: Summary, April 6, 2005.

References for Sediment Sample Collection

EPA. 2001a. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual.* U.S. Environmental Protection Agency, Region 4, Athens, Georgia. November.

EPA. 2001b. *Method for Collection, Storage, and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual*. Office of Science & Technology, Office of Water, U.S. Environmental Protection Agency, Washington, D.C. EPA-823-B-01-002. October.

References for Surface Water Sample Collection

Baker, John R., David V. Peck, and Donna W. Sutton (editors). 1997. *Environmental Monitoring and Assessment Program Surface Water: Field Operations Manual for Lakes*. EPA/620/R-97/001. U.S. Environmental Protection Agency, Washington, D.C. June.

EPA. 2001a. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual.* U.S. Environmental Protection Agency, Region 4, Athens, Georgia. November.

EPA. 1996. *Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels*. EPA 821-R-96-008. U.S. Environmental Protection Agency. July.

References for Air Sample Collection

EPA. 2001b. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual.* U.S. Environmental Protection Agency, Region 4, Athens, Georgia. November.

EPA. 1993b. *Subsurface Characterization and Monitoring Techniques, A Desk Reference Guide,* Volume II: *The Vadose Zone, Field Screening and Analytical Methods*. Prepared by: Eastern Research Group, Inc., Bloomington, IN. Prepared for: Center for Environmental Research Information, U.S. EPA, Cincinnati, OH, and Environmental Monitoring Systems Laboratory, U.S. EPA, Las Vegas, NV. U.S. Environmental Protection Agency. EPA/625/R-93/003b. May.

API, 2005. Collecting and Interpreting Soil Gas Samples from the Vadose Zone: A Practical Strategy for Assessing the Subsurface Vapor-to-Indoor Air Migration Pathway at Petroleum Hydrocarbon Sites. Regulatory Analysis and Scientific Affairs, API Publication Number 4741, November 2005.

EPA, 2002. Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance). Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency. (Docket ID No. RCRA-2002-0033 November 2002).

References for QA/QC Samples

EPA. 2001a. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual.* U.S. Environmental Protection Agency, Region 4, Athens, Georgia. November.

References for Sample Handling and Documentation

EPA. 2001b. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual.* U.S. Environmental Protection Agency, Region 4, Athens, Georgia. November.

References for Equipment Decontamination

EPA. 2001a. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual.* U.S. Environmental Protection Agency, Region 4, Athens, Georgia. November.

References for Management of Investigation-Derived Wastes

EPA. 2001a. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual.* U.S. Environmental Protection Agency, Region 4, Athens, Georgia. November.

EPA. 1992c. *Guide to Management of Investigation-Derived Wastes*. U.S. EPA Quick Reference Fact Sheet OS-220W. Publication 9345.3-O3FS. Office of Emergency and Remedial Response Hazardous Site Control Division. U.S. Environmental Protection Agency. April.

ATTACHMENT 1
EXAMPLE SAMPLING AND ANALYSIS PLAN
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