Utah Division of Waste Management and Radiation Control
Solid Waste Management Program

WASTE MANAGEMENT & RADIATION CONTROL

Mailing Address
P.O. Box 144880
Salt Lake City, Utah 84114-4880

Office Location
195 North 1950 West
Salt Lake City, Utah 84116

Phone (801) 536-0200
Fax (801) 536-0222
www.deq.utah.gov

Ground Water Monitoring Plan Guidance

Acknowledgments

The following is an outline of several of the necessary steps that will result in reliable and representative results from ground water monitoring programs. This discussion has been adapted from *Groundwater Sampling Desk Reference*, PUBL-DG-037 96, produced by the Wisconsin Department of Natural Resources Bureau of Drinking Water and Groundwater by Steve Karklins and edited by Jordana Lenon. Changes have been made to adapt the document to Utah rules and statutes. A copy of the original document, in two parts, can be obtained at http://dnr.wi.gov/org/water/dwg/gw/pubs/desk_a.pdf and http://dnr.wi.gov/org/water/dwg/gw/pubs/desk_b.pdf.

Disclaimer

The mention of trade names or commercial products in this document does not constitute an endorsement or recommendation. Also, while this document and the accompanying *Ground Water Sampling Guidance* include a brief mention of health and safety issues, neither document adequately addresses all health and safety issues and requirements. Both documents should be supplemented with other appropriate references, requirements and training on health and safety.

This guidance is not a rule. It has been prepared to give the reader information, in plain language, about how the Division of Waste Management and Radiation Control expects to interpret Rule R315-308. In the event questions arise regarding the matters discussed in this guidance, the text of the rule will govern.

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1. Introduction

Utah *Solid Waste Permitting and Management Rules* require that all Class I, IIIa, IVa, and V landfills have ground water monitoring unless an exemption is approved. Monitoring of ground water is a very important part of the environmental protection provided by the rules. Proper ground water monitoring requires that the operator of the facility have a well planned and executed program. Without this well planed program the data obtained will not represent the quality of the ground water beneath the site and may result in extensive costs for the facility and the environment.

Primary components of a successful ground water monitoring and sampling program include: determining data objectives; developing and following an effective site-specific sampling plan; preparing carefully before sampling; and meticulously documenting each sampling event.

2. Objectives and Plans

2.1 Data Objectives

Before any monitoring is done, it is critical to identify and understand the purpose for monitoring and how the resultant data will be used. Ground water quality data are collected to meet a variety of objectives, including, but not limited to, protection of public health and the environment, facility performance evaluations, or assessment of ground water remediation efforts.

2.1.1 Establishing Data Quality Objectives

The data quality objective (DQO) process is a systematic planning process for determining the type, quantity, and quality of data and information necessary to make well informed, valid, and defensible decisions. DQOs clarify the landfill's ground water monitoring goals and objectives. They explain what data and information will be used, and how and why it will be collected. DQOs also specify acceptable levels of uncertainty or errors in data, and the risks of making wrong decisions.

The following DQO process steps have been extracted from various U.S. Environmental Protection Agency (EPA) guidance documents. They describe project design optimization and can be used in varying degrees for monitoring projects at landfills in Utah.

1) **State the Problem:** Concisely state the problem to be studied. Generally this will be to sample ground water under the landfill and detect any changes in the contaminants listed in Utah Administrative Code (UAC) R315-308-4, which is a list of the analytes and protection standards for solid waste landfills.

2) **Identify the Decision:** Identify what questions the study will attempt to answer and what actions may result.

3) **Identify Inputs to the Decision:** Identify the data and measurements necessary to resolve the decision. Consider any factors influencing the decision such as cost or public perception of risk.

4) **Define the Study Boundaries:** Specify the time periods and spatial area to which the decision will apply and when and where to collect data.

5) **Develop a Decision Rule:** Consider the parameters of interest, the action or cleanup

levels and alternative actions. Choose among the alternative actions.

6) **Specify Limits on Decision Errors:** Determine tolerable limits on decision errors based on consideration of the consequences of making an incorrect decision.

7) **Optimize the Design:** Generate alternative data collection designs and choose the most resource-effective design that meets all DQOs.

The following considerations should also be addressed to ensure that the data collected meets DQOs:

- Regulatory objectives and requirements.
- Contaminant considerations.
- Sampling considerations.
- Data quality and quantity.
- Laboratory constraints: methods, limits of detection and analytical data quality.

2.1.1.1 Regulatory Objectives and Requirements

UAC R315-303-3(7)(b), requires that certain landfilling and other solid waste activities, that may affect ground water quality, have a ground water monitoring program. The regulatory objectives of the ground water monitoring program for solid waste facilities are found in UAC R315-303-2 and R315-308.

UAC R315-308-2(5) requires that ground water quality samples be analyzed by a laboratory certified by the state of Utah and approved for the procedures and analytes for which tests are being conducted.

UAC R315-308 includes the complete process that responsible parties must follow to monitor landfills and report, investigate, and clean up ground water contamination. This incorporates several aspects of the DQO process including identifying what data are needed, the study boundaries and investigation requirements, and decision processes. These aspects of the DQO process strongly encourage the most effective means to meet all project DQOs.

The ground water rules require the monitoring of ground water quality to meet some or all of the following regulatory objectives or requirements:

- Reduce ground water pollution and prevent contamination of ground water that results from landfilling activities.
- Provide a basis for facility or practice design, construction and operation.
- Evaluate a facility's or site's performance and environmental impacts.
- Protect public health and the environment.
- Evaluate the need for a change or revision of a facility's or site's monitoring, design, construction, operation, waste treatment or disposal practices.

- Evaluate the need for closure and abandonment of a facility.
- Evaluate the degree, extent and environmental fate of ground water contamination.
- Evaluate and verify the remediation of ground water contamination.

2.1.1.2 Contaminant Considerations

Determining and evaluating the type, concentration, and stability of contaminants and parameters collected or measured is important. The susceptibility of contaminants to extraneous contamination or loss during purging, sampling, and handling will help define the rigor and stringency of chosen procedures and protocols.

During monitoring of contaminants that are unstable, that are subject to alteration during collection, or that may be present at concentrations near the analytical detection limit; rigorous purging, sampling, handling, and decontamination procedures are necessary. Sensitive substances such as volatile organic compounds (VOCs) and dissolved metals, usually analyzed for and regulated at the micrograms per liter (µg/l) or parts per billion (ppb) level, fall into this category. Strict and rigorous sampling procedures, quality assurance/quality control (QA/QC) procedures, and careful documentation of the sampling event are necessary.

2.1.1.3 Sampling Considerations

The more complex a site's hydrogeology the more rigorous and detailed the sampling plan should be. This is also true for sites with known contamination. The site's stratigraphy, hydrogeology, and complexity in relation to the fate and transport of contaminants should be determined and evaluated. Any restraints or considerations these factors may place on establishing sampling procedures, QA/QC procedures, and documentation procedures should be noted.

Timing and frequency of data collection is also an important consideration. Depth to ground water; participation, both type and amount; ground water flow velocity; and soil types, among many other factors, may have an effect on ground water.

A common monitoring goal is to determine the actual concentrations of contaminants present in ground water. Due to the nature of collecting ground water samples, the true levels present in the ground water may be underestimated. The decision on how to treat analytical error and bias, how closely contaminant concentrations approach the actual concentrations present in the ground water, depends on how sampling and handling errors are controlled. Ultimately, sample integrity drives the quality of analytical results.

2.1.1.4 Overall Data Quality and Quantity Needs

The quality of a data set relates to the level of uncertainty or error inherent in that set, usually expressed as precision, accuracy, bias, representativeness, comparability, or completeness. Unfortunately, determinations of data quality often focus solely on the laboratory component, overlooking or avoiding the significant contribution of sampling and handling.

Data quality for a specific project or site specifies the level of uncertainty that will be tolerated in a set of environmental data. The higher the data quality, the more confidence an individual will have in the accuracy and representativeness of a data set. The quality of a data set is expressed:

1) qualitatively as a specified set of procedures and protocols used for collecting the data (i.e., purging and sampling procedures) and

2) quantitatively as the amount of acceptable variation and error (precision, accuracy and bias) inherent in the data set attributable to sampling equipment, sampling procedures, analytical methods and the concentration of the contaminant in relationship to method detection limits.

Analytical laboratories are required to follow approved methods, specify QA/QC procedures, and keep detailed records. However, field sampling activities and procedures typically are not as defined or stringent as the analytical procedures. Because of this, the level of uncertainty inherent in a data set attributable to field sampling procedures and protocols is often difficult to quantify or is unknown. Therefore, identifying project data quality needs, creating and following a site-specific sampling and analysis plan and QA/QC plan, and carefully documenting each sampling event will go a long way in controlling the uncertainty in the measurements and minimizing the risks to decision-making.

In addition to quality considerations, the quantity of data available is an important consideration, particularly during application of statistics to the data set. Data quantity is the number of samples needed to support the decision at the specified level of uncertainty. The question "How many data points do you need to make a decision?" is deceptively simple. Answering it may be considerably more difficult, particularly when you assess the risks of making the wrong decision. Anyone who has worked with a statistician to design a monitoring project realizes that it is frequently not practical or feasible to collect enough samples to achieve the desired level of certainty. The risks to decision-making must be weighed against physical, regulatory, and fiscal constraints.

QA/QC requirements and procedures should match the level of data quality required and the DQOs derived for a site or project. Refer to Section 2.3.1 for further discussion of QA/QC requirements, procedures and development of a QA/QC plan. Brynes (1994) and EPA (1995) provide detailed discussions of the overall data quality objectives process.

2.1.1.5 Laboratory Constraints: Methods, Limits of Detection, and Analytical Data Quality

How close the laboratory's limit of detection for a contaminant is to the suspected concentration and regulatory limit (e.g., ES or PAL) for the project should indicate the level of care needed in sampling for a given contaminant or parameter. For example, if contaminants may be present near the analytical limit of detection, then particular attention should be paid to sampling procedures to avoid contaminating the sample or losing the contaminant.

The EPA has identified five separate analytical quality levels (EPA 1987) that may be appropriate for a site or project. **Table 1** summarizes the levels and their appropriateness in relation to data uses, types of analysis, limitations, and the data quality that each level should provide. For most ground water monitoring and contamination investigation/remediation projects regulated under UAC R315-308, and not subject to CERCLA or RCRA requirements, level III, with lab certification, will meet data quality needs. Levels IV and V may be appropriate for special needs such as Superfund sites and obtaining strong, legally defensible results.

- Level I data are collected with portable field screening instruments such as an organic vapor instrument (e.g., PID, FID). Results are not compound specific, detection limits are high (e.g., ±mg/L) and results are in real time (i.e., seconds to minutes).

- Level II data are collected with more sophisticated portable analytical instruments (e.g., a

mobile laboratory equipped with a gas chromatograph). Level II data quality depends on the calibration standards used, reference materials, sample preparation equipment and training and skill of the instrument's operator. Results are available within minutes or several hours. Level I and II data are used in site characterization and defining the degree and extent of contamination.

. Level III data are analyzed at a non-portable laboratory and are commonly analyzed using SW-846, drinking water, or waste water procedures. In Utah, a laboratory certified under the Utah Environmental laboratory Certification Program administered by the Utah Department of Health must analyze this data. The laboratory does not have to be approved under the EPA Contract Lab Program (CLP). The data are not subject to special validation and documentation procedures.

Level IV data are analyzed by a Contract Lab Program (CLP) analytical laboratory following CLP procedures. Level IV data analysis is characterized by rigorous QA/QC protocols and documentation. In Utah, certain projects may require CLP protocols and data packages but allow a non-CLP laboratory to perform the analysis.

. Level V data are analyzed by nonstandard analytical methods. Analysis may or may not be performed by a CLP laboratory (CLP special analytical services are level V). Analytical method development or modification of an existing method may be required for a specific constituent or to meet required detection limits.

TABLE 1: SUMMARY OF ANALYTICAL LEVELS APPROPRIATE TO DATA USES

ANALYTICAL LEVEL	DATA USES	TYPE OF ANALYSIS	LIMITATIONS	DATA QUALITY
LEVEL I	. Site characterization . Monitoring	. Total organic/inorganic field instruments . Field test kits	. Results are not compound specific . High detection limits . Naturally-occurring interferences	. With proper calibration and data interpretation, general indication of degree and extent of contamination
LEVEL II	. Site characterization . Remedial alternatives evaluation . Engineering design . Monitoring	. Variety of organics by GC; inorganics by AA . Tentative identification; analyte specific . Detection limits vary from low ppm to low ppb	. Tentative identification . Techniques and instruments limited mostly to volatiles and metals	. Dependent on the QA/QC steps employed . Dependent on training and skill of instrument operator . Data typically reported in concentration ranges
LEVEL III	. Site characterization . Remedial alternatives evaluation . Engineering design . Monitoring . PRP determination . Risk evaluation	. Organics/inorganics using SW-846 . In WI, laboratory must be ch. NR 149 certified . RCRA characteristics tests	. Tentative identification in some cases . Data is not subject to validation and documentation as CLP	. Similar detection limits as CLP . Less rigorous QA/QC . Can provide data of same quality as LEVEL IV
LEVEL IV	. Remedial alternatives evaluation . Engineering design . PRP determination . Risk evaluation	. CLP laboratory following CLP procedures . Organics/inorganics by GC/MS; AA; ICP . Low ppb detection limits	. Rigorous QA/QC procedures may cause long turn-around time for results	. Rigorous QA/QC protocols, documentation and validation . Produces data of known quality; legally defensible
LEVEL V	. PRP determination . Risk evaluation	. Non-conventional parameters/methods . Method-specific detection limits . Modification of existing method	. May require method development/modification . Mechanism to obtain services requires special lead time . May or may not be a CLP laboratory	. Method-specific

(Modified from USEPA, 1987)

2.2 Maintaining Data Quality Objectives

Meeting and maintaining an established level of data quality can be accomplished by:

1. Following a sampling and analysis plan (SAP) and QA/QC plan specifically tailored to a site or project.

2. Documenting the samples collected, measurements taken, and procedures followed during each sampling and monitoring event. The SAP and QA/QC procedures can serve as documentation of equipment and procedures used; however, any deviations from the established procedures and protocols must be documented.

3. Strictly adhering to the DQOs and QA/QC procedures established for the project.

2.2.1 Developing Site-specific Plans

2.2.1.1 Sampling and Analysis Plan (SAP)

A SAP should be site-specific and should bring the sampling and monitoring procedures and protocols, DQOs and other project requirements into one clear plan. The sampling plan should document the equipment and procedures used during a sampling event. The procedures and protocols specified in the SAP should be consistently followed throughout the life of a project. Any deviations, including reasons for the deviations, should always be clearly documented.

Depending on a project's complexity and regulatory requirements, a SAP may be fairly short and simple, or long and complex. UAC R315-308 specifies site investigation work plans, field investigations and sampling and analysis requirements for monitoring conducted at landfills.

If a SAP is modified during the life of a project, the modifications must be considered when evaluating the data generated from the project.

> **Important note:** Collect ground water data from all project wells using the same sampling and purging procedures and equipment throughout the project's life. This should generate ground water data that is complete, with few, if any, "outliers;" are representative, reflecting conditions in the ground water; and is comparable to other data sets. Comparability of data collected from a project's wells is important when performing statistical analysis. Dedicated (left in the well) sampling systems typically produce ground water data that are complete, representative, comparable and of high quality. Summers et al., (1987) provides a good discussion on the accuracy, bias, precision, representativeness, completeness and comparability of ground water data collected from monitoring wells.

All the following items may not be necessary for a project's SAP. Include those items applicable to the specific project, established data quality objectives and as required by applicable local, state, and federal rules and regulations:

1. The project or site name and location (include maps).

2. A brief history of the site.

3. Regulatory objectives and data quality objectives.

4. Type, concentration and form of contaminants and parameters to be measured and sampled.

5. Transportation to the site and site access arrangements (e.g., meeting times, keys, permission).

6. Sampling team personnel and their duties.

7. The location of all wells (include map), well names or numbers, well diameters, screen lengths and well depths.

8. Order in which wells are sampled, prior site sampling history and problems/constraints.

9. Which documentation sheets and forms (e.g., well specific field sheet, chain of custody form, etc.,) should be completed for each sampling/monitoring event.

10. Equipment, procedures and protocols for:

    a. measuring static water level,

    b. measuring and sampling immiscible layers,

    c. purging and sampling wells,

    d. filling sample containers and preserving samples,

    e. taking water quality measurements and

    f. filtering samples.

11. Laboratory analytical methods and limits of detection for each contaminant being sampled.

12. Laboratory analytical data submittal form (e.g., electronic, tables, forms) and regulatory data submittal deadlines.

13. The QA/QC plan and procedures including the handling, storing, transporting, and shipping of samples and the collection of quality assurance samples. The QA/QC plan and procedures should be incorporated into the SAP, or less preferably, can be created as its own separate plan (see Section 2.3.1).

2.2.2 Health and Safety Plan (HSP)

While specific health and safety concerns and regulatory requirements are beyond this document's scope, some health and safety considerations common to ground water contamination and monitoring activities include:

1. A hazard analysis for each site task (including a list of contaminants, concentrations and associated health hazards).

2. List of sampling personnel, site safety and health supervisor, hazardous waste training, and personnel medical monitoring received.

3. Level and type of personal protective equipment required (e.g., level A, B, C, or D). Check the compatibility of the personal protective equipment with the types and concentrations of known or suspected contaminants at the site. Manufacturers of personal protective equipment often have Charts and tables for choosing appropriate types and materials of protective wear applicable to a variety of contaminants.

4. Frequency and type of air monitoring, personnel monitoring, environmental sampling and instrumentation to be used.

5. Site control (access) measures.

6. Personal hygiene and decontamination procedures.

7. An emergency response and contingency plan (including emergency phone numbers and map to nearest medical facility).

8. Work limits for inclement weather, confined space entry, etc.

9. A spill containment plan.

Another potentially useful resource related to health and safety includes the NIOSH *Pocket Guide to Chemical Hazards*, DHHS (NIOSH) Publication No. 90-117. Copies of this and other NIOSH documents are available by calling (513) 533-8287.

2.2.3 Other Preparations

Careful planning, and advanced checking and preparing of equipment before heading into the field will save time, money and problems.

2.2.3.1 Pre-field Work Procedures Checklist

The following checklist should help you conduct a smooth, effectively prepared ground water sampling program for your project. This checklist, in abbreviated form, is also included in Appendix A of the *Groundwater Sampling Guidance*.

All the following procedures may not be necessary for each sampling event. Use those procedures applicable to your sampling plan or customize this list as appropriate.

Logistics

1. Arrange for site access with property owner. Besides avoiding site access delays, pre-arranging site access will help maintain good relations with the site's owner.

2. Locate the nearest post office, UPS office, or Fedex drop off spot if you will be mailing the samples from the field. (UPS has a 70 pound weight restriction per container.) Make sure you have the proper materials for shipping samples (e.g., sufficient coolers and ice).

3. Determine how the purge water and wastewater will be stored and discarded. If the purge water and wastewater will be disposed of into a sanitary sewer, contact the water utility department and receiving wastewater treatment facility to obtain permission and establish where, when and how much wastewater will be disposed of into the sanitary sewer system.

Laboratory Arrangements

1. Select a laboratory to perform the sample analysis. Pay careful attention to the laboratory selection process. Selection based on price and turnaround alone may doom the project. Evaluate quality objectives for the project and laboratory analyses. Evaluate reporting requirements and other considerations specific to the project. Check that the laboratory (and subcontracted laboratory) is certified or registered to

perform the required sample analysis. Check that the laboratory will follow the proper analytical methods and can meet required limits of detection.

2. Discuss with the laboratory who will supply what sample containers. If the laboratory will supply some or all of the containers, make arrangements for delivery of the number and type needed - **get extras!** Don't forget QA/QC sample containers and trip blanks if VOC samples will be collected. Appendix B of the *Groundwater Sampling Guidance* specifies container types and provides recommendations on the minimum sample volumes for a variety of analytical parameters.

3. Discuss sample preservation, holding time and shipping requirements with the laboratory. Some laboratories provide preservative already in sample containers, or in other containers (e.g., ampules) that you can later dispense into the sample containers. Discuss QA/QC expectations and the type of information that should accompany analytical results.

4. Inform the laboratory of when and how many samples will be sent. This will help the laboratory prepare for analyzing your samples and meet sample holding times.

5. Familiarize yourself with chain of custody and other sample tracking procedures.

6. Discuss any other procedures required by the laboratory (e.g., noting gross sample contamination, field turbidity readings if metal samples are to be analyzed). Some laboratories request previous analytical results for each well to help determine appropriate sample dilutions up front.

7. Include in the contract quality objectives (QA/QC, MDLs, etc.), project-specific requirements (e.g., providing a raw package with the report) and any special agreements made with the laboratory. This helps avoid misunderstandings about expectations and may provide additional tools to deal with data that falls far short of quality objectives.

Site History

Review the sampling and analysis plan and past water quality and sampling data.

Equipment and Field Preparation

1. Review the SAP and QA/QC plan or equivalent. Refer to Section 2.2 for developing a SAP and Section 2.3 for developing a QA/QC plan.

2. Organize ground water monitoring and sampling equipment. Do this at least one day ahead of the scheduled sampling day. Refer to Appendix A of the *Groundwater Sampling Guidance a*nd use the "Equipment Checklist " or customize your own equipment checklist.

3. Check that sampling equipment is in good working condition:

   ☐ Test and recharge/replace batteries as necessary.

   ☐ Test the equipment with tap water or calibration standards when possible.

   ☐ Inspect the equipment for defects, loose bolts, frayed wiring, etc.

   ☐ Check the instruments' ability to calibrate and function properly.

☐ Check its ability to operate in very cold, hot or wet weather.

4. Check that all the equipment is properly decontaminated and stored for transport.

5. Complete the well-specific field sheet (WSFS), data logs or other field data sheets as much as possible before going to the field.

Health and Safety Equipment and Preparation

If applicable, review the health and safety plan. Refer to Section 2.2 and applicable federal, state and local laws, codes and requirements related to health and safety requirements.

2.2.3.2 Equipment Checklist

A complete monitoring well sampling equipment checklist is included in Appendix A of the *Groundwater Sampling Guidance*. All of the items included in the checklist may not be necessary for each sampling event. Modify and customize this list as necessary and appropriate.

2.2.4 Documentation

Meticulous documentation of monitoring and sampling data and collection/measurement procedures is essential. Documentation provides a permanent record of data collected, equipment and procedures used, sampling personnel, and problems that occur at a site. This information will help ensure that data are collected consistently and that deviations in protocols are noted for later evaluation. Careful documentation also helps prepare a project's data for legal scrutiny.

Clearly document the methods, procedures and equipment used to collect ground water data in the data reports generated for a site or project. Also, clearly document any deviations from the standard sampling and monitoring protocol, along with a discussion of potential effects on the data.

2.2.4.1 Documentation of the Sampling Event

1. **Site-specific Sampling and Analysis Plan (SAP) or Equivalent.** A SAP or other sampling plan should act as documentation of the sampling event. All sampling personnel should read it before heading out to the field and should bring it to each sampling event. Document any deviations from the sampling plan; you can use the "Field Procedures Documentation" sheet included in Appendix A of the *Groundwater Sampling Guidance* to document any deviations.

2. **Well Specific Field Sheet**. Document well-specific purging, sampling and field water quality measurement data on this sheet (included in Appendix A of the *Groundwater Sampling Guidance*). Or, customize your own data sheet. Hand-held data loggers are becoming popular because they provide a permanent record of well data that can be easily downloaded to a computer.

3. **Field Procedures Documentation.** A SAP or other sampling plan should act as documentation of sampling procedures; however, if a sampling plan is not available, use the "Field Procedures Documentation" sheet included in Appendix A of the *Groundwater Sampling Guidance*. You can customize this sheet to meet specific needs.

4. **Chain of Custody Form (Appendix A).** Document the possession of ground water samples by filling out chain of custody or other sample tracking forms. Complete this, or

other tracking form for every sampling event no matter the size of the sample set. If a project is later subjected to legal action, chain of custody procedures and whether they were followed will likely be an important part of the case.

2.3 Quality Assurance/quality Control Plans

Following proper QA/QC procedures when collecting samples in the field will help minimize error, variability, and bias in results attributable to sampling and handling. Both the equipment and procedures used in collecting and handling ground water samples have limitations that introduce a certain level of error, variability, and bias into the final analytical results.

Quality assurance (QA) procedures for collecting ground water samples are the checks, such as documentation and quality assurance samples, that establishes the type and quality of collected data. For example, a trip blank verifies whether samples were exposed to extraneous contamination during storage and transport, while a field blank verifies whether equipment decontamination procedures were adequate.

Quality control (QC) refers to the plans, equipment and procedures used to verify and maintain the quality of collected data. One important QC procedure – if dedicated or disposable equipment is not used – is to sample wells from least, to most contaminated. Do this to avoid cross-contamination between wells and samples. Refer to Section 2.2 for further details.

2.3.1 Quality Assurance/Quality Control Plan

Incorporate QA/QC procedures into the entire sampling and monitoring process. Include the QA/QC procedures for a project in the site-specific sampling and analysis plan (SAP), or less preferably, create a QA/QC plan as a separate plan. The content and level of detail to include in a QA/QC plan will vary according to the project's data quality objectives. Important QA/QC procedures include:

1. Following a site-specific sampling plan based on data quality objectives.

2. Using appropriate purging and sampling equipment and procedures.

3. Decontaminating and storing equipment properly.

4. Collecting, handling and storing samples properly.

5. Following sample chain of custody procedures.

6. Documenting the entire sampling event.

7. Following proper equipment calibration procedures and properly using and maintaining the equipment.

Other references for developing QA/QC procedures and plans include Van Ee and McMillion (1988) and Kent and Payne (1988). References for evaluating and documenting the quality of ground water data, field instruments and measurements include Campbell and Mabey (1985) and Mackiewicz (1990).

2.3.2 Quality Assurance Samples

Trip Blank

The purpose of the trip blank is to determine if any volatile samples have become contaminated with extraneous substances during storage and transport.

Trip blanks are only necessary when collecting VOC, gasoline range organics (GRO), and petroleum volatile organic compound (PVOC) samples. Trip blanks should be prepared and provided by the laboratory analyzing the VOC, GRO or PVOC samples. Trip blanks should be prepared with laboratory ***reagent grade water*** and analyzed by the same laboratory that is analyzing the volatile samples. ***Do not*** prepare trip blanks with water (even if distilled or deionized) purchased at a store; there is no guarantee that store-bought water is contamination-free. The trip blank should remain in the same cooler in which the ground water samples are stored and shipped.

> **Note:** If trip blank holding times permit, trip blanks do not need to be analyzed if VOC, GRO and PVOC compounds are not detected in any of the ground water samples. Trip blanks have the same holding time as samples.

Include one trip blank per sample batch, that is, at least one per sampling event and one per cooler. If you use more than one vehicle to transport the samples, or if samples are not shipped together, include one trip blank per vehicle or one trip blank per cooler. The easiest way to minimize the number of trip blanks necessary is to store, transport and ship all VOC, GRO and PVOC samples in one cooler.

Field Blank

Field blanks are also commonly called field rinsate blanks, decontamination blanks and equipment blanks. A field blank evaluates the effectiveness of decontamination procedures when equipment is not dedicated to a well or disposed of after one use. If decontamination procedures are effective, there should be no contamination in the field blanks. Field blanks are not required if dedicated sampling equipment or disposable sampling equipment is used.

A field blank consists of a sample of the reagent grade water supplied by the laboratory and used in the final rinse step of the equipment decontamination procedure. Process the field blank water through the equipment the same way you process any other final rinse water.

Collect one field blank for every 10 or fewer samples collected. Analyze the field blank for the same parameters as the samples. If possible, collect the field blank after sampling the most contaminated well.

Field Duplicate

A field duplicate sample is collected to determine the variability of analytical results caused by the sampling equipment and procedures used. Collect field duplicates for sensitive parameters such as VOCs, sorptive organics, and trace metals. Try to choose wells in which the contaminant concentrations have been relatively stable over time and wells that are screened in relatively homogeneous material. This will minimize analytical variability caused by contaminant concentration gradients that may exist in the ground water system.

Collect one field duplicate for every 10 or fewer samples collected. This frequency can be reduced if the variability in duplicate samples has been consistently low. Collect and handle the original sample and field duplicate using the same procedures; however, label them differently so the

laboratory cannot tell they are duplicates; thus minimizing any potential bias. If possible, collect the duplicate and original sample from the same grab sampler, from a water discharge splitter if pumping, or immediately after each other if you do not use a discharge splitter.

Field duplicates can provide valuable information for determining if a change in the ground water quality has occurred. If analytical variability of sample duplicates is low, then there is greater confidence that the analytical results represent true values; if not, re-sampling with better equipment or procedures may be appropriate.

> **Technical note:** Generally the term "replicate" describes a practice required of laboratories. For the purposes of this document, use the term "field duplicate."

Field Split Samples

Field split samples are analyzed at more than one laboratory. The samples should be analyzed by identical laboratory analytical methods to be comparable. Split samples determine the analytical variability between laboratories, not analytical variability caused by the sampling procedures. The technique for collecting split samples is critical and can contribute to variability in laboratory results. Therefore, make sure you collect, store and transport split samples in the same exact manner.

In most cases, samples are split between the site owner or facility and its laboratory, and the Division and its laboratory. The analytical results are then compared to evaluate variability caused by the two laboratories. Take care when comparing split sample results. Ideally, identical sample handling and analytical procedures are used at both laboratories. If not, consider these factors when comparing split sample results. The Division may, at times, request to split samples. These samples are use to assess the quality of the sampling program at the facility.

Split samples are only required if requested by the Division or another regulatory agency or required by local or federal rules or codes. However, you may wish to compare the analytical abilities of two or more different laboratories.

If you are not collecting volatile or oxygen-sensitive samples (e.g., dissolved metals in reduced ground water), transfer a sample into one large container. Filter and preserve the sample if required and then split it into two or more separate containers. The containers should be of the same material and volume. Add the same type and quantity of preservative to each container. To avoid using a transfer container, when pumping a sample, use a splitter that divides the water discharge. This will avoid the bias associated with using a transfer container. If you are splitting dissolved metal samples and filtering is required, use direct in-line filtration in combination with a discharge splitter. Do not transfer dissolved metal samples before splitting. Never filter or transfer organic samples, especially VOC samples.

Sequential Samples

Sequential samples are those taken from the same well at the same time but with different sampling equipment or procedures. Sequential samples evaluate analytical variability caused by different sampling equipment or procedures. For example, a facility may use its own bailer to purge and sample a well for VOCs and a regulatory agency may use a low-flow bladder pump immediately afterwards to purge and sample the same well. You can reverse the order that different equipment is used in a well and use field duplicates to further detect and evaluate analytical variability caused by different sampling equipment and procedures.

When collecting sequential samples, try to choose wells in which the contaminant concentrations have been relatively stable over time and wells screened in relatively homogeneous material. This will minimize analytical variability caused by contaminant concentration gradients that may exist in the ground water system.

Handle, filter, preserve, store, and transport a set of sequential samples in the same exact manner. Use only one laboratory and one analytical method to analyze the samples. This will reduce these factors as potential errors and biases.

2.3.3 Equipment Decontamination

Follow proper equipment decontamination procedures to minimize the potential for cross-contamination between wells and maintain data quality. According to Nielsen (1991), without effective decontamination procedures, any data generated by an investigation or remediation are subject to critical scrutiny.

The level of rigor and stringency required for equipment decontamination will depend on 1) the type, concentration, sorption and limits of detection of analytes being sampled; 2) the risk of equipment coming into contact with contamination during storage and transport; 3) regulatory objectives and requirements; and 4) the level of QA/QC procedures required.

Include equipment decontamination procedures in your SAP or the QA/QC plan.

All equipment contacting well water or any unclean surface should be properly decontaminated after contact. Examples of equipment that require decontamination include: water level instruments; well purging and sampling devices and accessories; filtration apparatus; and instruments used for field water quality measurements (e.g., conductivity, pH, turbidity and dissolved oxygen probes and meters).

Address any health and safety issues related to decontamination chemicals, equipment and procedures in the site-specific health and safety plan (refer to Section 2.2).

Decontamination Procedures

The American Society for Testing and Materials (ASTM) Method D 5088-90 provides basic guidelines for the "Decontamination of Field Equipment Used at Nonradioactive Waste Sites." The ASTM Method D 5088-90 procedures recommend the following for decontaminating equipment that comes into contact with sample water:

Minimum decontamination procedures

1. Wash sample contact equipment with a non-phosphate detergent solution (e.g., Alquinox®, Liquinox®).

2. Thoroughly rinse the equipment with organic-free tap water.

More rigorous decontamination procedures

1. Wash equipment with a non-phosphate detergent solution and scrub with an inert brush. For internal mechanisms and tubing, circulate the detergent solution through the equipment.

2. Thoroughly rinse the equipment with organic-free tap water.

3. For **organic** sampling, rinse equipment with an organic desorbing agent (e.g., pesticide grade isopropanol, acetone, methanol or hexane). For **inorganic** sampling, rinse with an inorganic desorbing agent (e.g., dilute [0.1 Normal] reagent grade hydrochloric acid or nitric acid solution). For stainless and low-carbon steel, a more dilute hydrochloric acid solution (1 percent) is recommended.

Note: If organic or inorganic desorbing agents are to be used, check with your laboratory regarding potential analytical interferences or contamination potential and proper use of these desorbing agents.

4. Rinse with organic-free tap water (only if inorganic desorbing agent used).

5. Rinse with deionized (reagent grade organic free) water and allow to air dry.

6. Place equipment in an inert container or wrap in clean plastic or aluminum foil for storage and transport.

In addition, disassemble the equipment as much as possible and wash/scrub it with a non-phosphate detergent during decontamination. Because disassembling equipment can take time and be hard on the equipment, use your professional judgement to determine when this is necessary.

You may use the ASTM or similar decontamination procedures; however, some procedures may be substituted or modified to meet specific project requirements or more stringent regulatory requirements. Mickam et al., (1989) conducted an extensive survey of equipment decontamination procedures used or required by the EPA and state regulatory agencies. These procedures may prove to be a useful reference for a variety of decontamination needs.

Decontamination Documentation

At a minimum, decontamination ***documentation*** should include: 1) the location where decontamination occurred; 2) the individuals performing the decontamination; 3) the decontamination procedures, including the wash solution and rinse water used (e.g., tap water and reagent grade water); 4) equipment storage and transport procedures; and 5) the handling and disposal of decontamination wastewater. If you have already included this information in your site sampling plan, redocumentation is not necessary.

Disposal of Decontamination Wastewater

Depending upon the decontamination methods and solutions you use, your decontamination wastewater may be classified as a hazardous waste by virtue of the contaminants you encounter at the site and the solutions you use to decontaminate your equipment (e.g., hexane, acetone). This is usually not a significant problem if the decontamination wastewater can be treated on-site. If hazardous wastewater needs to be transported and treated/disposed of off-site, this will likely add additional cost to the project. Contact Division staff to determine if decontamination wastewater is considered a hazardous waste and the proper ways to manage it if generated.

If decontamination wastewater is classified as hazardous, the cost and time to properly treat and dispose of it can be substantial. A couple of methods for avoiding the generation of hazardous waste is to use dedicated equipment left in the well, thus minimizing or eliminating decontamination wastewater, or to use dedicated equipment not stored in the well but taken back to a laboratory after sampling to conduct proper decontamination procedures.

If the decontamination wastewater is not classified as hazardous waste, you may be able to dispose of it into a sanitary sewer, not a storm sewer. You must get approval from the receiving wastewater treatment plant (WWTP) beforehand. WWTP personnel will usually want to know the type and concentration of contaminants and the volume of wastewater in question. If approval is granted, make sure you don't pour silt-laden water into the sanitary sewer because silt may clog the sewer. Allow the silt to settle out and then decant the clear wastewater into the sanitary sewer. Nonhazardous wastewater may also be treated on-site.

2.3.4 Equipment Storage and Transport

Properly storing and transporting equipment protects it from a variety of extraneous solid, liquid and airborne contaminants including oils, greases, fuels, solvents, paints and other VOCs.

Examples of appropriate storage include wrapping the equipment in clean aluminum foil, placing it in plastic bags, or placing it in a PVC carrying tube outfitted with end caps. The storage/transport device should be made of relatively inert materials that will not contaminate the equipment. For example, if you use a PVC tube to transport bailers, do not fasten the end caps to the PVC tube with glues that contain VOCs.

You may designate one storage container for contaminated equipment and another for decontaminated equipment. Clearly label the containers as such.

2.3.5 Chain of Custody, Sample Tracking and Security

Following proper chain of custody, tracking and security procedures is essential to maintain the integrity and legal validity of your samples. Sample and shipper security measures ensure that the samples were not tampered with before analysis. This can be very important if sample analytical results come under legal scrutiny. Remember, any project and its data can face legal challenge.

Chain of Custody

Chain of custody records document a sample from collection, through handling, storage and shipment, to final analysis. Such records and documentation include: labeling to prevent a sample mixup; container and shipper seals to prevent unauthorized tampering; and documenting who has custody of the samples and when. Accurate records provide a legal record of sample handling, possession and security. If a case is under enforcement action, failure to follow proper chain of custody procedures may cause irreparable damage to a legal case.

A chain of custody record must be completed for each sampling event. Each time a sample, a set of samples, or a sample shipper changes possession, the person relinquishing and the person receiving the samples or shipper must sign, date and record the time on the chain of custody record. Appendix A of the *Groundwater Sampling Guidance*, includes a sample chain of custody form; however, many laboratories prefer to provide their own forms. Check with the Division or laboratory regarding proper chain of custody procedures and required records or forms.

> **Note:** If you place the chain of custody record in a sealed shipper, the courier (e.g., UPS) does not need to sign, date and time the record beforehand; however, couriers should keep records of when they pick up samples and where they send them.

Sample Identification

Label samples to avoid misidentification. Use waterproof ink and securely attach labels to bottles, as ice used to cool samples can smear ink and cause labels to detach. Storing samples in plastic bags will help prevent these problems. Labels should include: 1) a unique sample number; 2) site or facility name; 3) date and time sample was collected; 4) sample collector's initials; 5) preservative added to the sample; and 6) the analysis required.

Shipping Custody Seals

As part of the chain of custody procedures, the sample shipping container (e.g., cooler) should be secured to prevent unauthorized access and tampering of samples. If you use a lock, make sure that only authorized personnel have access to the keys. If you use security tape, make sure that the tape must be cut or ripped to open the shipper. Use nylon-reinforced or equivalent tape that cannot be tampered with unnoticed. The tape should include the initials of the person sealing the container and the date and time of sealing.

3. References

Byrnes, M.E. 1994. *Field Sampling Methods for Remedial Investigations.* Lewis Publishers. Ann Arbor, Michigan.

Campbell, J.A. and W.R. Mabey. 1985. A Systematic Approach for Evaluating the Quality of Ground Water Monitoring Data. *Ground Water Monitoring Review* 5(4):58-62.

Kent, R.T. and D.E. Payne. 1988. Sampling Ground water Monitoring Wells - Special Quality Assurance and Quality Control Considerations. In: *Principles of Environmental Sampling*, L.H. Keith (ed.), ACS Professional Reference Book, American Chemical Society, Washington, DC, pp. 230-246.

Mackiewicz, M.C. 1990. A Simple 11-Step Procedure to Document the Accuracy, Precision and Significance of Measurements by Field Instrumentation. *Ground Water Management* 2:373-383 (4th National Outdoor Action Conference).

Mickam, J.T., R. Bellandi and E.C. Tifft Jr. 1989. Equipment Decontamination Procedures for Groundwater and Vadose Zone Monitoring Programs: Status and Prospects. *Ground Water Monitoring Review* 9(2):100-121.

Nielsen, G.L. 1991. Decontamination Program Design for Ground-Water Quality Investigations. In: *Practical Handbook of Ground-Water Monitoring,* Lewis Publishers, Chelsa, MI, pp. 625-636.

Summers, K.V. and S.A. Gherini. 1987. *Sampling Guidelines for Groundwater Quality.* EPRI EA-4952, Electric Power Research Institute, Palo Alto, CA.

U.S. Environmental Protection Agency (EPA). 1995. *Ground Water Sampling - A Workshop Summary*.
U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-94/205.

U.S. Environmental Protection Agency (EPA). 1987. *Data Quality Objectives for Remedial Response*
Activities. U.S. Environmental Protection Agency, Washington, D.C. EPA/540/G-87/003.

Van Ee, J.J. and Mcmillion, L.G. 1988. Quality Assurance Guidelines for Ground-Water Investigations: The Requirements. In: *Ground-Water Contamination: Field Methods,* A.G. Collins and A.I. Johnson (eds.), ASTM STP 963, American Society for Testing and Materials, Philadelphia, PA, pp. 27-34.