Supplemental Guidelines for Plans and Operations of Monitoring Wells at Class I Injection Facilities

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION V

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Contents

Introduction

In October of 1989, the Underground Injection Control (UIC) Section of the United States Environmental Protection Agency (USEPA) Region V issued a document entitled "Region V Guidelines

For Class I Well Monitoring Plans". These guidelines informed operators of the topics that must be addressed in ground water monitoring plans (GWMPs) and explained requirements for operating monitoring wells. The document also informed operators that a GWMP must be approved before an operator may begin drilling and construction of a monitoring well, and provided some guidelines on fluid sampling and pressure monitoring.

Given the scope and complexity of the issues involved, Region V has recognized that additional guidance should be given to assist operators in planning and implementing effective ground water monitoring programs. These supplemental guidelines involve key aspects of a ground water monitoring program such as the criteria for selecting a monitored zone, ground water sampling procedures, assessment of ground water quality and formation pressure data, quality assurance, and other considerations. In addition, Region V has included guidelines on the three modes of ground water monitoring operations: detection monitoring, compliance monitoring and corrective action. Most sites may operate in the detection monitoring mode, but if contamination or significant pressure change is detected in the monitored zone, the program could operate in either compliance or corrective action modes, depending on the circumstances.

Purpose

An effective ground water monitoring operation must provide meaningful information, that is, information which has been gathered by appropriate and adequately controlled methods, and which will answer, with an acceptable degree of confidence, meaningful questions posed by the operator or the Agency. The new guidelines refine Region V's requirements for acceptable ground water monitoring and also serve to assist operators in selecting a suitable monitored zone and in designing and operating a monitoring program that will ensure accurate determination of ground water quality and formation pressure.

Deep ground water monitoring at C1ass I disposal well sites can serve various purposes. Perhaps the two most common are (1) to validate one or more assumptions included in a contaminant transport model submitted in support of a petition for exemption from land disposal restrictions, and (2) to serve as an "early warning" of waste migration which could endanger underground sources of drinking water. To fulfill the first, the injection zone itself must be monitored, but to fulfill the second, it may be desirable to monitor a higher zone. In some cases it may be possible to design a monitoring well to fulfill multiple purposes; but in all cases the operator must ensure that the monitoring well will adequately fulfill its intended purpose(s).

The following guidelines concern the selection of a monitored zone, well construction and development, measurement of formation pressure, purging and sampling, data analysis, operating and reporting practices, and other matters. Some of these guidelines add details to subjects already discussed more fully in the 1989 guidelines on ground water monitoring; others expound subjects which previously were only mentioned briefly. Three attachments to this document provide additional detail. Attachment A is a suggested outline for GWMPs. Attachment B provides specific recommendations regarding a number of ground water monitoring procedures. Attachment C provides information on sample preservation, volumes, and holding times for ground water samples.

A. Selection of a Monitored Zone

The proper selection of a zone to monitor is critical to the overall usefulness of a monitoring well. In the GWMP, the operator must justify the initial basis for selecting a geologic interval as the zone for monitoring using existing information such as hydrogeological tests, core data, drilling information, and geophysical logs, to show that the selected zone is likely to satisfy Region V's requirements. During drilling, the operator must evaluate the hydrogeological information obtained from all tests and demonstrate the suitability of the selected monitored zone, prior to completion in that formation. In instances where the proposed monitored zone may need better delineation or where there may be water-bearing fractures, Region V may require that the operator use specialized wireline logging/testing equipment to evaluate fluid entry into the wellbore. The zone selected for monitoring should be located at the base of a porous and permbable unit to facilitate the early detection of contaminants. Some recommended procedures that could be used to assist in defining a monitored zone are provided in Attachment B.

The zone selected for monitoring must possess adequate transmissivity and be reasonably thin (less than 30 feet) to yield representative water samples (described below) and yield meaningful formation pressure data. A suitable monitored zone will have acceptable transmissivity if it provides a constant and uninterrupted inflow of ground water while the well is developed, purged, and sampled, and if the zone provides enough water for a representative sample to be collected within a period of seven days after initiation of purging. It is essential that the monitored zone allow recovery of formation pressure to non- pumping levels in a time period comparable to the total pumping time. A zone which meets the above criteria and is less than 30 feet thick is likely to meet Region V's requirements for formation pressure monitoring, discussed in more detail in subsection C and Attachment B. A formation that possesses low hydraulic conductivity, but meets transmissivity requirements because of a large thickness, would not be acceptable to Regicn V because it would not provide meaningful pressure monitoring data and meaningful water quality data. A significant pressure change at the bottom of a thick monitored zone is not likely to be detected when monitoring the composite pressure. In addition, a thick monitored zone could minimize the radius of investigation during ground water sampling and dilution from multiple water bearing zones may preclude obtaining a representative sample of ground water.

B. Well Development

The GWMP must include plans for well development procedures, similar to those outlined in Aller et al., 1989, "Handbook of Suggested Practices for the Design and Installation of Ground Water Monitoring Wells", to be performed on the monitored zone after well completion. Adequate well development prevents frequent plugging of filtration devices when collecting samples, and minimizes the time required for field filtration. Proper well development can also remove particles that could bias chemical analysis results and can enhance the yield of the well. The latter may be particularly important if the well is completed in a monitored zone with a lower hydraulic conductivity and a slow recovery rate. The operational life of purging and sample collection equipment can also be extended through successful removal of fines that would otherwise cause premature wear. Some recommended procedures for well development are included in Attachment B.

C. Measurement of Formation Pressure

The GWMP should describe procedures that will ensure that formation pressure will be determined accurately and precisely, on a continuous basis, for the monitored zone. Formation pressure monitoring can be accomplished by one of two approaches: direct measurement or conversion of static water level measurements to equivalent down hole formation pressures. If the operator takes the latter approach, Region V requires that the determinations of formation pressure from static water level measurements provide the same accuracy and precision as is required of direct downhole pressure measurements. For the latter approach, the operator should ensure that careful attention is given to significant digits. Region V requires that the operator install monitoring equipment that allows formation pressure to be determined and/or measured to within + 0.05 psi, and; static water level measurements to within + 0.1 feet.

The GWMP also should provide estimates of water level or formation pressure fluctuations that may be caused by barometric pressure and tides/dilatation. It should describe the operator's plan to assess the effects of these on fluctuations of formation pressure and include consideration of any delays in the response of the monitored zone due to the well configuration. In monitoring wells where the water column is not isolated from the atmosphere, it will be required that the plan provide for collection of continuous barometric pressure measurements for at least the first quarter of operation. The response to changes in barometric pressure will be determined by periodic determinations of barometric efficiency based on several barometric cycles. These barometric efficiency determinations should be used by the operator to assess the need for applying barometric corrections to the measurements of static water level or formation pressure. If after the first quarter of operation, the operator can demonstrate that barometric fluctuations are not detectable within the approved sensitivity of the static water level or formation pressure measurements or that a pressure transducer device adequately compensates for barometric fluctuations, Region V may authorize the operator to discontinue barometric pressure monitoring.

Should unexplained fluctuations of static water levels or formation pressure be reported, Region V may require that continuous monitoring of barometric pressure be restored as part of the monitoring program. In some cases, Region V may stipulate that the monitoring well configuration involve isolation of formation pressure monitoring devices from atmospheric conditions, if there are significant fluctuations of formation pressure due to unexplained factors.

If the operator measures static water level in lieu of pressure, the plan should describe steps to be used by the operator to reliably convert to pressures in the monitored zone, including consideration of any possible specific gravity and temperature gradients in the well. The plan should describe tests that will be performed on or after well completion to determine both the specific gravity and temperature gradients in the well, and should provide for confirmation of those gradients, when requested.

Any method(s) of pressure monitoring must be regularly calibrated and should either singularly or collectively provide a continuous record of reliable measurements while ensuring that the well configuration allows for ground-water sampling. Continuous monitoring should involve obtaining direct measurements at intervals of no less than every 15 minutes, however, in some approved circumstances, data may obtained at reduced time intervals during and following (approximately a 2 week period) the sampling periods where static water level or formation pressure drops below the pre-pumping level. Regardless of the monitoring method employed, the selection of pressure transducers and gauges will be dependent upon the required measurement accuracy and precision, and the expected pressure measurement range. Some additional recommendations regarding measurement of pressure and static water levels are provided in Attachment B.

<u>D. Detection of Multiple Phases</u> In the event that a low density phase or "floating layer" is detected, the operator should determine the thickness of that layer prior to performing purging operations for each sampling event. Floating layers may consist of light phase immiscible liquids that can be detected by an interface probe that can differentiate between the relative resistivities of water and organic liquids. The operator should sample the floating layer with an appropriate bailer device. Should multiple phases be present, the operator should monitor pressure conditions below the interface of the two layers.

<u>E. Purging and Step Rate Pump Testing</u> The GWMP should include a description of how stagnant water within and adjacent to the well will be evacuated or purged prior to sampling, but without causing significant residual drawdown. Purging is necessary in order to remove waters that were exposed to atmospheric conditions and because oxidation-reduction conditions may differ significantly between the water in the well and in the surrounding rocks. The amount of time required to accomplish this task is dependent on several factors: 1) well construction, 2) aquifer properties, 3) type of equipment used, and 4) placement of pumping/purging equipment within the column of water. Region V requires that the operator purge a minimum of three well volumes and monitor several field parameters including pH, conductivity, temperature, and dissolved oxygen, until those parameters are stabilized in the ground water removed from the well. By purging at least three well volumes, it is assumed that stagnant water adjacent to the well will be removed along with stagnant water within the well. A well volume will be calculated by subtracting the static water level depth from the total well depth and then multiplying the difference by the cross sectional area. When the well installation is configured with tubing and a packer assembly, or when a drill stem or packer test is run during the drilling phase, the well volume will be calculated according to following formula:

Well Volume = (PD-SWLD) x CSAT + (TWD-PD) x CSAC

Where: Static Water Level Depth = SWLD

Total Well Depth = TWD
Packer Depth = PD
Cross Sectional Area of Drill Pipe/Tubing = CSAT
Cross Sectional Area of 0penhole/Casing = CSAC

The operator should carefully monitor the field parameters for stabilization, so that purging is kept to minimum. Unless it is specified by Region V, the operator should not perform excessive purging as such practices may damage the monitored zone.

The operator should show in the GWMP how purging procedures will be finalized through careful consideration of the results of hydrogeological testing performed during drilling and completion operations. Upon completion of the well and prior to the initial purging and sampling operation, the operator must accurately measure water level decline (drawdown) associated with pumping by performing a short step rate pump test. This pump test will be used to assess the capacity of the well and the monitored zone to yield ground water. Test results help the operator to select the optimum purging rate and estimate the length of time required to purge the well without causing significant residual drawdown.

Suitable rates for the pump test can be estimated from hydraulic conductivity measurements for the monitored zone obtained from drill stem tests and other hydrogeological test data, and from core measured permeability data. By measuring the drawdown associated with at least three equal length pump rate steps, the operator can establish the specific capacity, which is the quotient of a discharge rate and the resultant drawdown in the monitored zone. To obtain a realistic estimate of specific capacity and well efficiency, the difference between the smallest discharge rate and the largest rate should be at least 50 percent. The pump test should include at least 2 to 3 hours of total pumping time to reasonably establish the specific capacity. Depending on the magnitude of the specific capacity and the rate of water level recovery, additional testing, such as a constant rate pumping test, may be required by Region V to further define aquifer parameter values.

F. Collection of Ground-Water Samples

The operator must use a method of recovering ground water that results in an adequate assessment of in-situ ground water quality with minimal disturbance of the monitored zone. Samples must be collected in a manner that minimizes exposure to differing temperature, pressure, and atmospheric gases and that will not affect the chemical speciation (the stable ionic or molecular form) of the chemical constituents. The operator should collect samples directly from a discharge line connected to the wellhead, and this line should be configured with valves capable of adjusting the flow of water into sample containers. If the sample discharge line is bypassed during purging operations, the sampling discharge line should be purged adequately, to remove any residual fluid prior to collection of samples.

The operator must collect eight independent samples during the first year to establish baseline water quality; for each sampling event two independent samples should be collected separated by at least one casing/tubing volume. Once collected, the samples will need to be appropriately handled and preserved for analysis of various constituents according to approved methods. The operator must characterize the chemistry of the water recovered through initial sampling for all hazardous constituents which might be present at the site, including testing for toxicity characteristic (TC) constituents. Samples collected for analysis of dissolved metals must be filtered in the field prior to being preserved. Recommended procedures for sample preservation, filtration, and for conducting sampling are addressed in Attachments B and C.

G. Well Sampling Associated with Tests Performed During Drilling

Region V may require, in same cases, that ground water sampling be performed in conjunction with drill stem tests (DSTs) to provide samples that are representative of in-situ ground water quality. When testing selected water bearing zones, the operator must purge three or more well volumes by swabbing or another approved method that can recover the fluid from the well with minimal disturbance, and closely monitor field parameters, such as those required for purging of the monitored zone. For DSTs performed in formations that are not suited for monitoring and are marginally water bearing, we recommend that the operator collect a fluid sample from the initial tubing volume recovered from the well. Region V will require that, if additional fluid can be removed, the operator submit for chemical analysis the last sample removed, as it may more accurately reflect the ground water quality.

H. Quality Assurance

Region V requires that an operator provide a quality assurance project plan (QAPP) which delineates all sampling, monitoring, and analysis details in such a way that the Agency can evaluate sample representativeness and analytical precision. In the QAPP, the operator should describe, in detail, the quality assurance procedures that will be followed while running DSTs or other tests during the drilling phase, and ensure that test equipment is satisfactorily cleaned. Region V requires that those tests include certified pipe tallies and other information that can assure that depths of the tested intervals are correct. Regarding the monitoring operations, the QAPP should also include quality assurance procedures for accurate and precise measurement of formation pressure or static water level.

Region V requires that operators regularly calibrate pressure transducers and gauges used to measure formation pressure or static water levels with measurements from another device, so that the measurements can be corrected for instrument drift, and to enable an instrument to be replaced or repaired, when necessary, without loss of monitoring data. In monitoring wells that have a water column exposed to the atmosphere, calibration measurements may be obtained with an electronic measuring line or other acceptable methods. In monitoring wells that are configured to isolate the monitored zone from the atmosphere, the QAPP must demonstrate how the accuracy of the formation measuring device will be assured. The QAPP should contain a schedule for calibrating formation pressure or static water level measuring devices.

The operator must provide assurance in the QAPP that well development, purging, and sample collection will comply with procedures and criteria acceptable to Region V. The monitoring well should be developed until turbidity and drilling fluids have been successfully removed from the monitored zone. Graphical plots of turbidity and other field parameters versus cumulative pumping volume must be submitted to show that parameters stabilized prior to sample collection. The operator must also certify that the total volume of water purged for each sampling event is correct. The accuracy of the field parameter measurements must be assured by calibrating all equipment before each sampling event according to the manufacturer's specifications.

The QAPP must include quality assurance procedures for field filtration of samples and cleaning of equipment used in testing and sampling during the drilling, completion, and monitoring phases. Assurance must be provided through detailed field records that field filtration was performed properly and, if filtration cannot be performed within the sample transfer line from the wellhead, cleaning or equipment blanks must also be collected that will demonstrate that filtration equipment was thoroughly cleaned prior to each sampling event. The plan should indicate that thorough cleaning of testing/sampling equipment will be assured through periodic collection and chemical analysis of rinse water. Should representatives of Region V or other governmental agencies be unable to witness a sampling event, the operator may further assure that sampling was properly performed by submitting video cassette recordings, photographs, and/or additional documentation.

The QAPP must assure that at least one replicate sample is collected and analyzed for each sampling event and that these replicate samples will be taken according to quality assurance procedures for the designated analytical laboratory. As part of the QAPP, trip blanks should be used to demonstrate cleanliness of glass containers for each sampling event.

I. Statistical Analysis of Data

The operator must provide detection limits and practical quantitative limits for each chemical parameter analyzed with the first quarterly sampling report. Each constituent and characteristic analyzed should be plotted on a graph of concentration versus sampling date to identify any trends. Either a 95%/95% confidence interval or a Shewart/CUSUM control chart should be established for each constituent or characteristic that will be monitored over the long term. Either method must be performed following the USEPA's 1989 guidance entitled "Statistical Analysis of Ground Water Monitoring Data at RCRA Facilities". If, in the Agency's judgement, there is no sign of contamination or trends in the data, the initial baseline built on eight data points should be updated periodically, following the procedures outlined in the USEPA guidance cited above.

Provided that the operator has developed and sampled the well in the first guarter without causing prolonged recovery from residual drawdown, and that there is no visible trend in daily maximum or mean farmation pressures, the pressure data for the first quarter should be used as a baseline for future pressure data comparisons. If well data indicate that eguilibrium has not been restored to the well after the first quarter, the operator chauld determine a baseline from a subsequent quarter or quarters when equilibrium has been attained. If, in the Agency's judgment, there is no sign of injection-related fluctuation and there are no trends in the data, then a 95%/95% confidence interval, established with maximum daily or other appropriate measurements, should be used to determine when pressure change is significant.

J. Detection versus Compliance Monitoring

The ground water monitoring program will initially operate in the detection mode. The operation must advance to the compliance monitoring mode if events occur that the Agency believes may indicate contamination. If contamination is suspected because ground water quality data fall outside normal ranges, compliance monitoring begins with an option for re-sampling within 30 days. If all the constituents of the second sample are within acceptable ranges, and a satisfactory explanation is provided for the first sample results, the facility would return to detection monitoring. If the pressure measured in the monitored zone moves outside the acceptable range, compliance monitoring begins with an option to re-analyze the pressure data or utilize different pressure or water level monitoring equipment (after Agency approval) within 30 days. If upon review of new information, the Agency determines that there has been no significant change in pressure, the facility would return to detection monitoring. Conversely, if re-sampling, re-analysis, or re-measurement does not remove the Agency's suspicion of contamination or significant pressure change, the Agency will require the facility to submit a plan for continuing compliance monitoring. Such a plan could include, but not be limited to, the following: analysis for additional chemical constituents, more frequent sampling, changes in sampling methods or handling, changes in pressure monitoring methods or intervals, or expansion of the monitoring program to additional zones or locations.

K. Monitoring Reports

The operator is required to conduct ground water sampling quarterly, pursuant to USEPA regulations at 146.13(d)(2), and should establish a baseline for ground water quality evaluation during the first year. If Shewart/CUSUM control charts are used for statistical analysis, the first baseline should be determined from the analytical results of at least eight independent samples. Chemical analysis data should be reported quarterly and within 45 days of each sampling event. Any suspected contamination or anomalous pressure data must be reported to the Agency within 24 hours of the operator's receipt of the information.

The quarterly report must include documentation to demonstrate that sampling events were conducted correctly and that samples were properly handled. The operator must describe the documentation and the chain-of-custody program in the GWMP. An adequate program should provide for: 1) sample container labeling, 2) sample seals, 3) a detailed field logbook, 4) chain- of-custody records, 5) sample analysis request sheets, and 6) a laboratory logbook. Further guidelines on the sampling documentation are provided in Attachment B.

The operator must obtain an accurate record of formation pressure that will provide raw data and corrected measurements. The reporting of formation pressure should include daily maximum and daily mean values, and include applied corrections, if necessary. These monitoring data should be presented in tables and on graphical plots that also show daily maximum injection pressure for the operating injection wells. Graphical plots should begin with the data from the first quarter and be updated as data becomes available following each quarter. The operator should also report fluctuations of barometric pressure, determinations of barometric efficiency, and other determinations, measurements or tests, such as specific gravity gradients and temperature gradients. Region V requires the operator to maintain records of continuous static water level or formation pressure measurements at the site along with documentation on the calibration of the measuring devices. These monitoring data must be accessible to the Agency during site inspections. Formation pressure data must be included in the quarterly report which is to be submitted within 45 days of the sampling event.

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ATTACHMENT A

The following is a suggested outline for groundwater monitoring plans:

I. Siting
  -- distance from injection well(s)
  -- monitored zone: formation name, depth, thickness, lithology, -- expected hydraulic properties

II. Construction and Drilling
  -- proposed construction
  -- materials specifications
  -- potential for interaction with fluid samples
  -- drilling methods
  -- proposals to minimize effect on monitored zone
  -- associated geological evaluations, coring, testing and water sampling

III. Well Development
  -- proposed methods and pumping rates
  -- detection of multiple phases
  -- probable recovery time for monitored zone pressure
  -- hydrogeological testing

IV. Mechanical Integrity Testing
  -- upon completion
  -- periodic

V. Formation Pressure Monitoring
  -- proposed method and precision/accuracy
  -- equipment and installation
  -- supporting measurements equipment and methods
  -- data analysis methods
  -- reporting

VI. Fluid Sampling

A. Sampling Scheme
-- sampling frequency, baseline period and long-term
-- parameters to be analyzed

B. Purging
-- purging method/equipment, and installation
-- purging rates and volumes
-- method to assess stabilization of field parameters

C. Sampling
-- sampling method/equipment, withdrawal rate, and expected duration and drawdown
-- sample handling, filtration, preservation
-- sampling documentation
-- sample analysis methods

D. Reporting and Data Analysis
-- data analysis methods to be used on the step-rate test

VII. Quality Assurance Project Plan (QAPP)
-- correct testing depths
-- thorough cleaning of all testing and sampling equipment, cleaning blanks
-- calibration of pressure or static water level measuring devices
-- adequate well development and purging
-- calibration of field parameter measuring devices
-- replicate samples and trip blanks
-- EPA approved analytical methods

VIII. Closure
-- monitoring after closure of injection well(s)
-- plugging and abandonment plan
-- financial assurance

ATTACHMENT B

DELINEATION OF MONITORED ZONES

To assist in delineating monitored zones and the entry of fluid into the wellbore, Region V recognizes that fluid resistivity logs, temperature logs, spinner surveys or heat-pulse flow meters, caliper logs, conductivity logs, and/or sonic logs or acoustic televiewer logs could be useful in investigating fractures or for evaluating fluid entry. It is very important that the operator utilize appropriate means to narrowly define the nature of fluid entry into the wellbore within a geologic interval, so that the selected monitoring zone can be restricted in thickness and the monitoring results do not reflect formation pressure and water quality conditions for a composite zone. In some cases, Region V may require that the operator determine the degree of vertical isolation that exists immediately above the proposed monitored zone. This may be evaluated using core analysis data, wireline logging information, and data derived from formation pressure testing from DSTs, wireline pressure testing, or other hydrogeological tests.

SELECTION OF TUBING DIAMETER

A monitoring well should be designed with minimal casing and/or tubing diameter, so that the volume for the column of standing water required to be evacuated during sampling events is minimized, and so that pressure sensitivity is enhanced. An operator should recognize, however, that the tubing size must be large enough to provide reasonable access for the use of wireline tools and allow access for well maintenance. A minimal volume of water standing in the casing prevents unacceptably delayed responses to changes in formation pressure, which could otherwise occur when monitored zones that possess lower hydraulic conductivities. It is also desirable that the volume of purged water generated by each sampling event be kept to a minimum so that, if hazardous constituents are present, disposal will be manageable.

WELL DEVELOPMENT PROCEDURES

Well development may be satisfactorily performed by using a combination of two of the following methods or other comparable methods; swabbing through tubing attached to a packer assembly, alternately pumping at high and low rates for several cycles, and jetting operations. If an operator finds it necessary to use a development method involving addition of water to the wellbore, i.e., jetting operations, the operator must certify through chemical analysis results that the added water is free of contamination, and must certify that the volume of water added was measured and also recovered, prior to initiation of purging operations.

In performing well development procedures, the operator should analyze recovered fluid for key characteristics of the native brine, tracer-like constituents in the drilling fluid, or approved tracers added to the drilling fluid system until these constituents as well as turbidity have stabilized at negligible levels. In the GWMP the operator must detail the proposed well development method(s).

FORMATION PRESSURE MONITORING

The depth of the formation pressure and static water level monitoring devices, and the static water level measurements, if recorded directly, must be referenced to a control point established by a licensed surveyor. If a pressure transducer is used to measure static water levels, it needs to be fixed in the well and maintained at a constant depth so that cable stretch is minimized and the device can provide meaningful pressure monitoring. The operator needs to ensure that static water level measurements or formation pressures are obtained at all times including periods of purging and sampling. If the water level temporarily declines below the pressure transducer depth as a result of purging and sampling activities, Region V requires that operators obtain no less than daily measurements of static water level measurements using approved devices.

WELL PURGING PROCEDURES

The operator should indicate in the GWMP that, based on the results of the specific capacity determination, pumping operations will be controlled so that residual drawdown is minimal. However, it is recognized that the amount of residual drawdown would be lower in higher transmissivity formations. If an operator proposes to use a high capacity purging device for sample collection, it will be necessary to reduce pumping rates to levels that prevent the loss of chemical constituents during sample collection.

After removal of at least three well volumes, the recovered water can be considered representative when physical and chemical field parameter values stabilize, i.e. when consecutive field values differ by no more than 10 percent for at least three parameters between several discrete and independent samples. To ensure that the samples being monitored for field parameters are independent of one another, the operator should separate samples by pumping, different swabbing runs, and so forth. Field parameter results must be provided as a function of cumulative volume. At a minimum, the operator must accurately measure pH, temperature, conductivity, and dissolved oxygen parameters by means of in-line instrumentation involving a flow cell. A flow cell apparatus can provide for simultaneous measurement of the required field parameters under constant pressure conditions without exposure of the water sample to the atmosphere.

Purging must be performed with equipment that is constructed with materials that are chemically inert and will not impact the integrity of the recovered water samples. Some pumping methods may not be suitable for collection of ground water samples due to either significant exposure of samples to the atmosphere or as a result of conditions which may inhibit recovery and accurate measurement of organic compounds and other constituents. Acceptable purging devices include submersible pumps, bladder pumps, swabbing equipment, gas-driven piston pumps, and other approved methods. Submersible pumps can efficiently purge monitoring wells at higher rates than the other methods, but are limited in sampling depth by the total dynamic head developed by the pump. Bladder pumps or gas-operated squeeze pumps involve a collapsible membrane inside a gas-filled rigid housing in which the water sample is squeezed upward by the gas-filled annular space. Bladder pumps are very versatile purging and sampling devices, but cannot pump at as high a rate as submersible pumps. Gas-driven piston pumps, although costlier than other methods, can provide purging at low discharge rates, but these pumps have not yet been proven in the deep monitoring well applications and may require more frequent maintenance than other equipment.

SAMPLE COLLECTION PROCEDURES

The GWMP should provide that all aspects of the sampling procedures be designed to ensure that chemistry results obtained for the recovered sample are not severely affected by determinate or indeterminate error. Determinate errors can be either constant or systematic and result from contamination or laboratory procedures. Indeterminate errors are random and are caused by natural variability and human influences during collection and handling of samples. The operator should indicate in the GWMP how the effect of those possible errors on the precision, accuracy, bias, and the reasonableness of the water quality data will be considered in the assessment of the water quality data.

Sampling devices need to be constructed with non-reactive materials. When selecting a sample collection device the operator should assure that the chemical constituents monitored in ground water at the site will not be adversely affected through chemical transformations resulting from the sample collection method or from exposure to equipment components. There are several sample collection devices that can be appropriate under specific circumstances and these include 1) submersible pumps, 2) bladder pumps, 3) swabbing equipment, 4) downhole production fluid samplers, 5) gas-driven piston pumps, 6) bottom valve bailers, and 7) grab samplers. The operator will also need to select a method that will provide sufficient sample volumes for chemical analysis parameters, replicate samples, and for collection of split samples, in the event the Agency elects to require a split of the samples.

EQUIPMENT CLEANING PROCEDURES

The operator needs to detail in the GWMP that drilling and equipment used in well development, purging, and sampling operations will be thoroughly cleaned so that these procedures will not add foreign constituents that could result in contaminated samples of ground water. Equipment should be cleaned with high pressure steam, and when practical, Region V requires that non-phosphatic detergents and de-ionized water be also used to clean smaller equipment. During subsequent sampling events the equipment should be installed in the well in a dedicated manner so as to prevent contamination, otherwise non- dedicated equipment will require extensive re-cleaning prior to each use and additional quality assurance procedures.

FIELD FILTRATION PROCEDURES

Water samples collected for analysis of metals will be filtered at the well site, prior to preservation, with a device that has a 0.45 micron filter. Filter elements or cartridges should also be constructed of materials that are compatible with the chemistry of the recovered fluids. Region V strongly suggests that the samples be filtered in an in-line fashion, where the filtration equipment can be regularly connected to the sample transfer line, rather than transferring a sample between containers and utilizing a separate pumping apparatus to filter the samples. If filtration cannot be performed in-line, the operator must demonstrate that the proposed filtration apparatus can efficiently filter the samples with minimal handling of the sample and utilize an inert gas to inhibit changes in the sample chemistry.

SAMPLE PRESERVATION AND SPECIAL HANDLING C0NSIDERATIONS

The operator must consult the *Test Methods For Evaluating Solid Waste - Physical Chemical Methods*(SW-846, Section 1.4.6.2.3) to ensure that unstable constituents and characteristics are preserved. In addition, SW-846 (Section 1.2.2) specifies sample containers that should be used by owners/operators for each constituent. Sample collection should involve minimal transfers so that chemical constituents are not lost due to exposure to atmospheric conditions. The operator must collect groundwater samples in appropriate containers for analysis of various compounds as established by approved laboratory procedures. Attachment C provides information on appropriate containers. Contaminants in the trip blanks should be noted and explained, but not used to correct laboratory data. If significant contamination of the trip blanks occurs, re-sampling at the well should take place.

The labels on the sample containers must be sufficiently detailed so that samples are not misidentified and must provide a sample identification number, the name of the collector, requested chemical parameters, and the date, time, and place of collection. The operator must use seals on the sample containers in order to preserve sample integrity. Where several samples are placed on a common carrier (e.g., air freight) sample seals should be on the shipping container to ensure that it has not been disturbed.

DOCUMENTATION

A field logbook must record information about each sample during collection, and must include the following:

a) Identification of the subject well(s) and calibration data for water levels or formation pressure,
b) Detection of floating layers or separate phases and detection/measuring method, if previously encountered during drilling and completion of the monitoring well,
c) Well purging procedures/equipment and sample collection procedures/equipment,
d) Date and time of sample collection, types of containers, preservatives, and chemical parameters of analysis, and
e) Physical and chemical measurements collected in the field that document that stabilized parameters were obtained as well as other field observations that were made.

The chain-of-custody record must include the documentation necessary to trace sample possession from the time of collection to analysis, and must include the following information:

a) Identification of the sample, the signature of collector, and the date and time of collection.
b) The signature(s) of person(s) involved in the chain-of-custody, and the inclusive dates of possession.

In addition to the laboratory logbook mentioned earlier, the operator must provide sample analysis request sheets which serve as the official communication to the laboratory for each sample and to provide further evidence that the chain-of-custody is complete. These sheets should include at a minimum: the name of the person receiving the sample(s), the laboratory sample number (if different from the field number), the date of sample receipt, and the analyses to be performed.

ATTACHMENT C[1,2]

INFORMATION ON SAMPLE PRESERVATION, VOLUMES, AND HOLDING TIMES

Parameter	Preservative	Container[3]	Volume[4]	Max. Holding Time
Acidity	None required	P, G	100 ml	24 hours

Aluminum	Filter on site[5], acidify to pH < 2.0 w/HNO_3	P, G	1000 ml[6]	6 months
Arsenic	Filter on site[5], acidify to pH < 2.0 w/HNO_3	P G	1000 ml[6]	6 months
Barium	Filter on site[5], acidify to pH < 2.0 w/HNO_3	P, G	1000 ml[6]	6 months
Bromide	None required	P, G	100 ml	24 hours
Cadmium	Filter on site[5], acidify to pH < 2.0 w/HNO_3	P, G	1000 ml[6]	6 months
Calcium	Filter on site[5], acidify to pH < 2.0 w/HNO_3	P, G	1000 ml[6]	6 months
Chloride	Cool to 4°C[7]	T, P, G	50 ml	7 days
Chromium	Filter on site[5], acidify to pH < 2.0 w/HNO_3	P, G	1000 ml[6]	6 months
Chromium (VI)	Cool to 4°C[7]	P, G	400 ml	24 hours
Cyanide	Cool to 4°C[7], alkalize to pH>12.0 w/NaOH[9]	P, G	500 ml	14 days[8]
Fluoride	None required	T, P	300 ml	7 days
Iron (total)	Filter on site[5], acidify to pH < 2.0 w/HNO_3	T, P	200 ml	6 months
Lead	Filter on site[5], acidify to pH < 2.0 w/HNO_3	P, G	1000 ml[6]	6 months
Magnesium	Filter on site[5], acidify to pH < 2.0 w/HNO_3	P, G	1000 ml[6]	6 months
Manganese	Filter on site[5], acidify to pH < 2.0 w/HNO_3	T, P	200 ml	6 months
Mercury	Acidify to pH < 2.0 w/HNO_3	P, G	100 ml	28 days
Nitrate/Nitrite	Cool to 4°C[7], acidify to pH < 2.0 w/H_2SO_4	T, P, G	100 ml	28 days
Oil & Grease	Cool to 4°C[7], acidify to pH < 2.0 w/H_2SO_4	G only	100 ml	28 days
Pesticides	Cool to 4°C[7], adjust pH to 5 - 9[10]	T, G	4 x 1000 ml	7 days until extraction; 40 days after extraction
pH	None required	T, P, G	25 ml	Analyze

Phenols	Cool to 4°C[7], add 1 ml 0.008% Na_2SO_4[11]	G, T-lined cap	500 ml	7 days until extraction; 40 days after extraction
Potassium	Filter on site[5], acidify to pH < 2.0 w/HNO_3	P, G	1000 ml[6]	6 months
Radiological Tests (Radium, Alpha, Beta)	Acidify to pH < 2.0 w/HNO_3	P, G	4000 ml	6 months
Selenium	Filter on site[5], acidify to pH < 2.0 w/HNO_3	P, G	1000 ml[6]	6 months
Semivolatile, Nonvolatile Organic	Cool to 4°C[7]	7 T, G	1000 ml	14 days
Silica	Cool to 4°C[7]	P	50 ml	7 days
Silver	Filter on site[5], acidify to pH < 2.0 w/HNO_3	P, G[12]	1000 ml[6]	6 months
Sodium	Filter on site[5], acidify to pH < 2.0 w/HNO_3	T P	200 ml	6 months
Specific Conductance	Cool to 4°C[7]	T P G	100 ml	24 hours
Sulfate	Cool to 4°C[7]	T P G	50 ml	7 days
TOC (Total Organic Carbon)	Cool to 4°C[7], add 1 ml 0.008% Na_2SO_4[11]	G, amber, T-lined cap or septa[13]	4 X 15 ml	14 days
TOX (Total Organic Halogen)	Cool to 4°C[7], add 1 ml 0.008% Na_2SO_4[11]	G, amber, T-lined cap or septa[8]	4 X 15 ml	14 days
Volatiles	Cool to 4°C[7], acidify to pH < 2.0 w/1:1 HCl	G, T-lined cap[8]	2 X 40 ml	14 days
Zinc	Filter on site[5], acidify to pH < 2.0 w/HNO_3	P G	1000 ml[6]	6 months

1. The parameters specified herein represent minimal characterization of ground water chemistry. Region V recognizes that This list is not necessarily comprehensive and that site specific injection practices may require analysis for additional parameters to accurately portray ground water quality.

2. Pursuant to 40 C.F.R. §136.3 (Table II) - last update: June 1, 1990.

3. P=Plastic (polyethylene), G=Glass, T=Fluorocarbon resins (PFTE, Teflon, FFP, PFA, etc.)

4. Based on Region V's requirements for establishing baseline water quality in the first year, the owner/operator must collect a sufficient volume of fluid to allow for the analysis of one replicate.

5. Filtration, utilizing a 0.45 µm membrane, should take place as soon as possible after sample collection. Glass or plastic filtering apparatus using plain, non-grid marked, membrane filters are recommended to avoid possible contamination. For dissolved metal constituents, filter all samples. Do not filter samples if a total metal content analysis is to be run.

6. The 1000 ml volume collected for metal analyses is usually sufficient for all the cations of interest (exceptions being Cr^{6+} and Hg). The contracted laboratory should be able to provide adequate information regarding which metals can be detected simultaneously and the associated required volume.

7. Shipping containers (cooling chest with ice or ice pack) should be certified as to the 4°C temperature at the time of sample placement into these containers. Preservation of samples requires that the temperature of collected samples be adjusted to 4°C immediately after collection. Shipping coolers must be at 4°C and maintained at 4°C upon placement of the sample and during shipping. Maximum-minimum thermometers are to be placed into the shipping chest to record temperature history. Chain-of-custody forms will have Shipping/Receiving and In-transit (max/min) temperature boxes for recording data and verification.

8. Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before the pH adjustment in order to determine if sulfide is present. If sulfide is present, it can be removed by addition of cadmium nitrate powder until a negative spot test is obtained. The sample is then filtered and then NaOH is added to pH 12.

9. Add 0.6 g. ascorbic acid in the presence of oxidizing agents.

10. The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% Na_2SO_4.

11. Should only be used in the presence of residual chlorine.

12. Collection bottle should be dark-colored.

13. Do not allow any head space in the container.