Procedures for the Collection of Water-Quality Samples From Water-Supply Wells

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Introduction

Groundwater samples often are collected from water-supply wells already completed in an aquifer for reasons of cost or expediency (drilling monitoring wells is expensive and time consuming). The water-supply wells referred to in this document are wells completed for domestic, irrigation, or public water supplies. All are equipped with pumps and have a water tap (generally a spigot with garden-hose threads) available near the well. The selection criteria for these wells are not addressed in this document.

Water-supply wells have the advantages of less expense and greater expediency for sampling water from an aquifer, but water-supply wells have disadvantages too. Water supply wells generally are optimized for greater flow, and may tap more than one water-bearing zone, and thus the produced water may represent a mixture of water from different zones. The equipment, pump, and plumbing in a water-supply well may not be ideal for obtaining water samples. Nonetheless, once the decision to use water-supply wells to obtain water samples is made, the goal is to obtain water samples that represent the water produced by the well.

This document describes two procedures relative to obtaining representative samples from water-supply wells: (1) obtaining samples using sampling equipment that does not alter the water of the water produced at the water tap, referred to herein as "clean-sampling methods", and (2) quality-assurance and quality-control procedures to verify that the water samples are representative of the water produced at the tap, referred to herein as "QA/QC".

Disclaimer: This document is not intended to be a comprehensive description of water sampling or QA/QC procedures; rather, it is intended to document procedures used by the New Mexico Bureau of Geology and Mineral Resources for obtaining groundwater samples from water-supply wells.

Clean-Sampling Procedures

Obtaining water samples that are representative of the groundwater in an aquifer requires the well to be purged of water resident in the well casing. Water residing in the well casing while the well is not pumped is exchanging gases with the atmosphere and well equipment and may have different chemistry than water in the aquifer. Wells are purged in a continuous manner, that is, without the well being started and stopped. Starting and stopping a well can cause water from the pump column to return to the well casing, and thus affecting the water chemistry.

Some water properties are measured as the well is purged, including pH, specific conductance, temperature, dissolved oxygen, and oxidation-reduction potential; these water properties are indicative that the well has been purged of the casing water and are important measures of the water chemistry that can't be determined in the samples sent to the analytical laboratory because these properties may change in the sample bottles. Some types of analyzes require filtered water samples to remove sediment from the water. Thus, collecting water samples is not as simple as filling a bottle from the water tap.

A simple apparatus, referred to herein as a manifold, was designed and built at the New Mexico Bureau of Geology to facilitate obtaining groundwater samples that meet the requirements described above.

Sampling Manifold

The sampling manifold was designed to (1) facilitate cleaning, so the manifold is used only once at each well and then cleaned; (2) allow the well to be pumped continuously, without starting and stopping; (3) connect to an instrument that measures water properties on the water pumped from the well; and (4) allows both filtered and unfiltered samples to be collected.

Design and Construction

The sampling manifold consists of plastic tubing and fittings (figure 1). Various types of plastic were used for manifold materials instead of metal to reduce the possibility that the manifold could contaminate the water samples with metals; the project for which the manifold was initially designed is concerned with contamination of an aquifer by metals. A list of parts used to make the sampling manifold is included in Appendix 1.

The sampling manifold was constructed by cutting tubing to specific lengths (listed on figure 1) and pressing the fittings into the tubing. The fittings are barbed fittings but hose clamps are needed to keep the fittings in the tubing when the manifold is pressurized by inflow from the well. The hose clamps are not shown in figure 1; photos of the assembled manifold (including the hose clamps) are shown in figure 2.

Cleaning

The sampling manifold is cleaned prior to attaching to the well, and care is exercised to avoid contaminating the clean manifold. Sufficient manifolds are required so that a clean manifold can be used for every well each day. The clean manifold is always handled while wearing clean, disposable gloves.

The manifold is cleaned thoroughly before initial use and after each field excursion. A less thorough cleaning is done in the field, generally in the evening in the hotel. The difference between the thorough cleaning and the field cleaning is the inclusion of an acid bath as part of the thorough cleaning. The acid bath is available at the New Mexico Bureau of Geology in Socorro, NM.

The cleaning procedure starts by cleaning white plastic tubs (figure 3) with laboratory soap and tap water, followed by a rinse with deionized water. When the tubs are transported, they are not stacked but placed in individual clean, clear plastic bags.

At the start of the cleaning procedure, the tubs are filled with tap water and the amount of laboratory soap appropriate to the volume of water in the tub. The filled tubs are placed on clean plastic on a laboratory bench or counter in the hotel. The cleaned tubs are always handled while wearing disposable gloves.

Cleaning consists of disassembling the manifold (while wearing disposable gloves), rinsing the fittings and tubing with tap water, and placing the fittings and tubing in the soap and water filled tubs. The fittings and tubing are left to soak for at least 30 minutes. After soaking, the components are retrieved from the soap and water and rinsed with tap water. For the thorough cleaning in the laboratory, the components are then acid rinsed, followed by rinsing with deionized water. For field cleaning in the hotel, the acid rinse is not performed, so the components are removed from the soap and water tub, rinsed with tap water, followed by a rinse with deionized water.

	Laboratory Cleaning	Field Cleaning
1.	Soak in soap and tap water (>30 minutes)	Soak in soap and tap water (>30 minutes)
2.	Rinse with tap water	Rinse with tap water
3.	Acid rinse	Rinse with deionized water
4.	Rinse with deionized water	

In the laboratory, cleaning is relatively easy because of the availability of a tap for deionized water and laboratory benches. In a hotel room, the cleaning generally is done in the bathroom. Clear the bathroom counter and cover with plastic. Tap water rinsing is generally easiest using the tap in the shower. A small carboy of deionized water on the side of the bathtub can be used for the deionized water rinse step.

The components are reassembled and placed in clean Ziploc-type bags, one manifold per bag. The sampling manifold was designed to fit in a 1-gallon Ziploc bag. If assembling the manifold requires setting equipment down, place components on clean plastic sheeting. The Ziploc bags are placed in a clear, clean plastic tub with a cover, and taken to the field.

Filter holders are cleaned in exactly the same manner as the manifold. Disposable 47-millimeter diameter, 0.45-micron filters are loaded into the filter holders when they are assembled. Filters and filter holders can be placed in the same clean Ziploc bags as the cleaned manifold, one filter holder per bag.

Field Operation

At the well to be sampled, the water level is measured prior to collecting the water sample. When time to sample, the inlet arm of the manifold is attached to the faucet at the well (shown as connection fitting A in figure 1) using a female garden-hose fitting. The manual pinch valve is closed so no water can exit through the sampling arm of the manifold when the well pump is started. A brass garden-hose splitter is attached to the outlet arm of the manifold (shown as connection B in figure 1); brass can be used for this connection because no water that will be sampled flows through the outlet arm of the manifold. A water-quality multi-parameter sonde (shown in figure 1 as "YSI") is attached to one side of the brass splitter and a garden hose is attached to the other side of the splitter. When the equipment is attached, the well pump is started and the purging phase begins (the well purging procedure is not described in this document) and water-quality parameters from the sonde are recorded.

When the well is purged and ready for sampling, sampling begins through the sampling arm of the manifold. The order the sample bottles are filled is determined by the principle investigator, but generally unfiltered samples are collected before filtered samples. The pinch valve is opened slowly and a small volume of water should be allowed to flow through the sampling arm tubing to condition the tubing (approximately 500 ml). The person collecting samples should be wearing clean, disposable gloves. The sample collection procedure is not discussed in detail in this document, but generally bottles are rinsed 3 times prior to filling. Filtered samples are collected by connecting the filter holder to the end of the sampling arm; allow a small volume (about 100 ml) of well water to flow through the filter holder prior to sampling.

When the sample bottles are filled, the well is shut off. Although the manifold is no longer considered to be clean, an effort should be made to minimize contamination of the manifold. For example, do not set the manifold on the ground. The manifold needs to be cleaned, either in the field or back at the New Mexico Bureau of Geology, prior to reuse, so minimize the amount of cleaning by exercising care with the manifold.

Generally, the first step to disassemble the sampling equipment after filling the sample bottles is to unscrew the brass splitter while the hose and sonde are still attached, and then unscrew the manifold. Remove the filter holder and place the manifold and filter holder into the same plastic bag used to transport the manifold to the well. The plastic bag is then placed into a tub (with lid) for used manifolds. Removing the manifold first minimizes contamination of the manifold because the other equipment, such as the garden hose, often are quite dirty. After the bag is in the tub, then disassemble the remaining sample apparatus (garden hose, sonde, etc.) and prepare for transport to the next well.

Field Cleaning

Field cleaning should be performed at the hotel in the evening. The field cleaning also should be performed after last day of sampling to avoid dirt and contaminants bonding with the sampling manifold from prolonged storage. Laboratory cleaning should be performed at the New Mexico Bureau of Geology a short time prior to each field excursion.

The first step in field cleaning is to clear a work space, probably the bathroom counter in the bathroom in the hotel. Remove all items from the counter, and then cover the counter with clean plastic sheeting. The work surface should be sufficiently large to accommodate 2 pre-cleaned white plastic tubs and some extra surface area (about 1 by 1 foot) to set clean equipment. Rinsing of equipment with often is easiest in the bathtub, so place plastic sheeting on the side of the bathtub near the faucet. Place 2 pre-cleaned white plastic tubs on the plastic sheeting on the counter and the 1-gallon carboy of deionized water on the plastic sheeting on the bathtub, with the spigot facing into the bathtub. Fill one white plastic tub on the counter with laboratory soap and tap water.

Wearing clean, disposable gloves, remove a sampling manifold and the filter holder from the plastic bag in the tub of used manifolds. Open the filter holder and remove the used filter. Rinse the filter holder under tap water (from the sink if the sink is large enough, otherwise, from the bathtub, and drop the filter holder parts into the tub of soap and water. Rinse the manifold under tap water (from the sink if the sink is large enough, otherwise, from the bathtub) and disassemble the manifold into component parts. Drop the manifold parts in the tub of soap and water. Repeat with each filter holder and sampling manifold. Discard the used plastic bags. Allow the filter holders and manifold parts to soak at least 30 minutes, longer if possible. This is a good time to go to dinner.

After soaking, and wearing new clean, disposable gloves, thoroughly rinse the individual filter holder and manifold parts under tap water. Take care to rinse all surfaces, inside and outside the filter holder and manifold parts. When thoroughly rinsed, rinse again using the deionized water from the carboy on the edge of the bathtub. Place the assembled, rinsed filter holder parts and assembled manifold into the second white plastic tub on the counter.

Place the container of new 47-millimer, 0.45-micron filters on a clean plastic sheet, along with a pair of tweezers. Assemble the filter holders, inserting a new filter, and return to the white plastic tub. Assemble the manifold parts, taking care not to allow the parts to touch any surface or fixture in the bathroom. The small 1x1 foot area of clean plastic may be helpful for assembling the manifold. Close the manual pinch valve because the first step is to purge the well and not allow water to flow through the sampling arm of the manifold. Place one filter assembly (holder and filter) and one clean manifold into a new 1-gallon Ziploc bag, and place the Ziploc bag in a tub designated for cleaned manifolds. Do not attach the filter assembly to the manifold because the first bottles to be filled will be unfiltered sample bottles.

At this point, the filter assemblies and manifolds are ready for the next day of sampling. Carefully stow the white plastic tubs and the carboy of deionized water in plastic bags and travel containers to minimize the possibility of contamination.

Laboratory Cleaning

After each field excursion, a more thorough cleaning of the filter holder and manifold is done at the laboratory at the New Mexico Bureau of Geology. Laboratory cleaning is the same as field cleaning, with the addition of several steps.

During the cleaning of the filter holder and manifold, after the tap water rinse, the filter holder and manifold parts are placed in an acid bath. The acid solution is a 5-percent volumetric dilution of ACS trace-element-grade hydrochloric acid (HCl) in deionized water. A 10-percent by volume HNO3- solution can be used instead of HCl if samples to be collected with the equipment will not be analyzed for nitrogen species. The parts should soak for 30 minutes, then be rinsed thoroughly with deionized water.

NOTE: Care should be exercised to never allow any metal parts to be immersed in an acid solution.

During the laboratory cleaning, in addition to the acid rinse step, all other equipment (plastic tubs, carboys for deionized water, tweezers, or any other equipment used for handle the filter holders and manifolds) should be cleaned with laboratory soap and rinse with tap and deionized water.

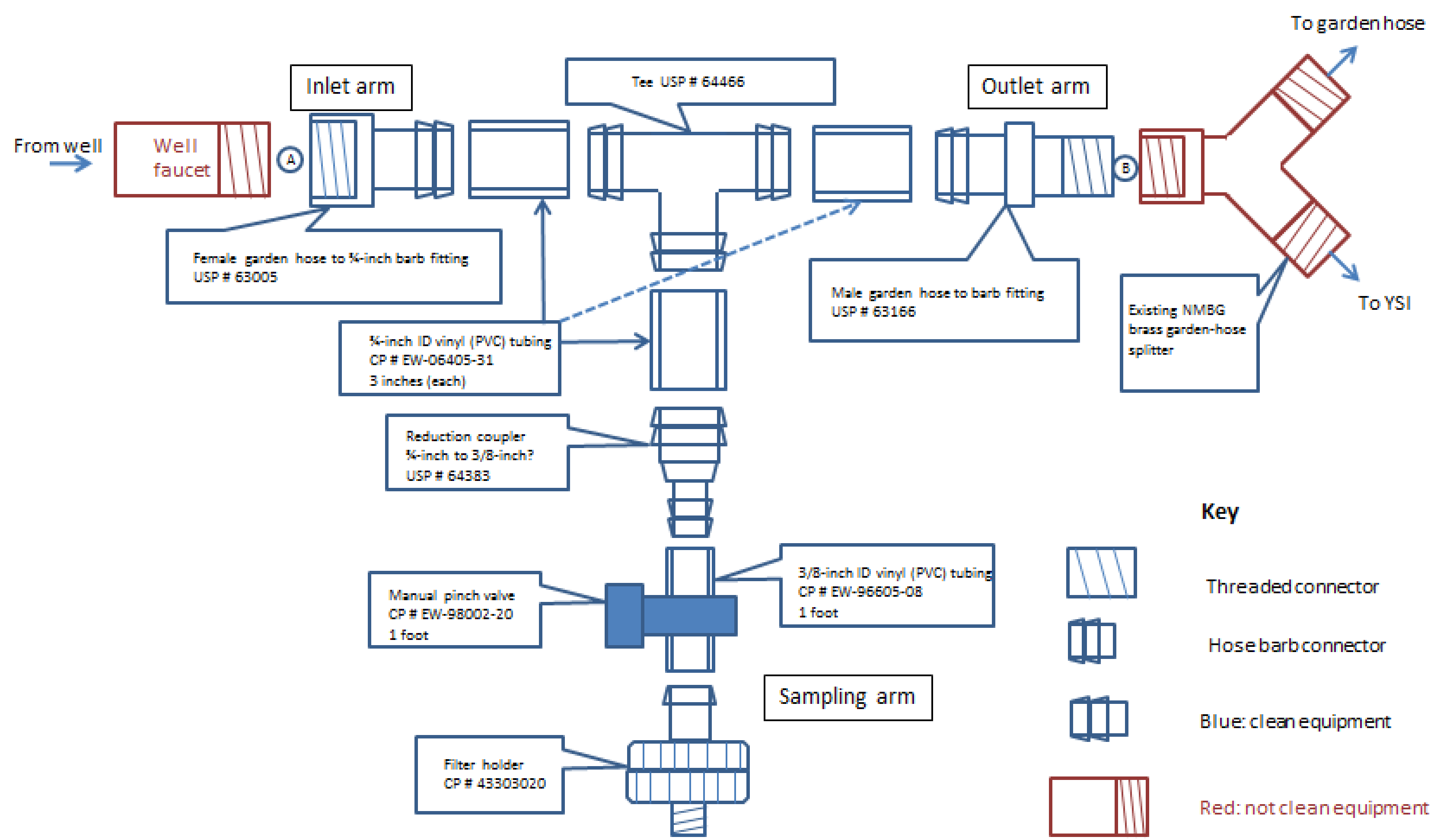

Figure 1. Sampling manifold and filter holder

Quality Assurance/Quality Control Procedures

Collection of quality assurance/quality-control (QA/QC) samples is an important component of sample collection for water-quality studies. QA/QC samples are collected to identify, quantify, and document bias and variability in data resulting from the collection, processing, shipping, and handling of samples by field and laboratory personnel. The bias and variability associated with data must be known so that environmental data can be adequately interpreted (Wilde and others, 2006).

A comprehensive discussion of quality assurance/quality-control samples is outside the scope of this document. This document establishes basic procedures for the Animas project for the New Mexico Bureau of Geology.

Two types of QA/QC samples are discussed herein, blank and replicate samples.

Blank Samples

The primary purpose of a blank sample is to identify potential sources of sample contamination and assess the magnitude of contamination with respect to concentration of target analytes (Wilde and others, 2006). Blank water is passed sequentially through each component of the sampling equipment that is used for collecting and processing environmental samples. Blank samples test the components of the sampling equipment, assess the potential of sample contamination, and assess the adequacy of equipment-cleaning procedures associated with each component of the equipment system to be used for field work analytes (Wilde and others, 2006).

Equipment Blanks

Equipment blanks are processed under controlled conditions in an office laboratory, without exposure to the field environment (such as the inside of a field vehicle and wind-blown dust). An equipment blank is collected using the same equipment as environmental samples, and in fact should be collected with equipment prepared for collecting environmental samples. The equipment blanks collected for the Animas Project require an additional apparatus not involved in environmental sampling, a short length of peristaltic pump tubing and a fitting to connect the tubing to the sample manifold inlet (see figure 1). The additional equipment is necessary to pump blank water through the sampling manifold and the filter assembly.

The equipment blank procedure is essentially the same as described in the Field Operation section of this document, except in a laboratory at the New Mexico Bureau of Geology instead of at a field site. Wearing clean, disposable gloves, clean plastic sheeting is spread on a bench in the sample laboratory. A peristaltic pump is set on the bench next to the plastic sheeting. A clean sample manifold is withdrawn from the Ziploc bag and placed on the sheeting. No field parameters are measured for the equipment blank, so a pre-cleaned plug is screwed into the exhaust arm of the manifold (figure 1). A catch basin is placed near the sampling arm of the manifold. The inlet arm of the manifold is connected to the peristaltic pump tubing/fitting and the tubing is inserted into the blank water container. The manual pinch valve is opened and the peristaltic pump started. Blank water discharges through the sampling arm of the manifold, and allow at least 100 milliliters to discharge to the catch basin to rinse the sampling manifold. Samples are collected, unfiltered first then filtered, filling the same bottles used for the analytes of interest to the investigation. Samples are preserved using the same procedures as for environmental samples, using the same preservatives (such as hydrochloric acid) as for the environmental samples. The preservatives are literally the same bottles of preservatives, not new clean preservatives. After the bottles are filled and preserved, the manifold and filter assembly are treated exactly as equipment used at a well; the manifold and filter assembly are placed in the 1-gallon Ziploc bag and placed in the tub designated for used equipment.

Field Blanks

Field blanks are collected in the field at a well used for an environmental sample. Field blanks are exposure to the field environment (such as the inside of a field vehicle and wind-blown dust). A field blank is collected using the same equipment as environmental samples, and in fact should be collected with equipment prepared for collecting environmental samples. The field blanks collected for the Animas Project require an additional apparatus not involved in environmental sampling, a short length of peristaltic pump tubing and a fitting to connect the tubing to the sample manifold inlet (see figure 1). The additional equipment is necessary to pump blank water through the sampling manifold and the filter assembly.

The field blank procedure is essentially the same as described in the Field Operation section of this document. In general, the field blank is collected immediately after an environmental sample. Wearing clean, disposable gloves, clean plastic sheeting is spread on a small table. A peristaltic pump is set on the table next to the plastic sheeting. A clean sample manifold is withdrawn from the Ziploc bag and placed on the sheeting. No field parameters are measured for the field blank, so a pre-cleaned plug is screwed into the exhaust arm of the manifold (figure 1). The inlet arm of the manifold is connected to the peristaltic pump tubing/fitting and the tubing is inserted into the blank water container. The manual pinch valve is opened and the peristaltic pump started. Blank water discharges through the sampling arm of the manifold, and allow at least 100 milliliters to discharge to the catch basin to rinse the sampling manifold. Samples are collected, unfiltered first then filtered, filling the same bottles used for the analytes of interest to the investigation. Samples are preserved using the same procedures as for environmental samples, using the same preservatives (such as hydrochloric acid) as for the environmental samples. The preservatives are literally the same bottles of preservatives, not new clean preservatives. After the bottles are filled and preserved, the manifold and filter assembly are treated exactly as equipment used at a well; the manifold and filter assembly are placed in the 1-gallon Ziploc bag and placed in the tub designated for used equipment.

Replicate Samples

The primary purpose of replicate samples is to identify and (or) quantify the variability in all or part of the sampling and analysis system. Replicates—environmental samples collected in duplicate, triplicate, or higher multiples—are considered identical in composition and are analyzed for the same chemical properties (Wilde and others, 2006).

Several types of replicate samples are possible.

Sequential replicates are samples of environmental water that are collected consecutively instead of simultaneously. Sequential replicates are used to assess variability among samples resulting from collection, processing, shipping, and laboratory procedures conducted at different sampling times. The sequential replicate can be designed to assess sample variability from inhomogeneities in the system being sampled by spacing samples over short or long time periods.

References

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