MONITORING WELL DEVELOPMENT

CONTENTS

1.0 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to provide an overview of monitoring well development practices. The development of a monitoring well (herein development) removes fine-grained material and/or drilling fluids from the well screen and filter pack. This activity is necessary to restore the formation properties disturbed during the drilling process, to improve the hydraulic characteristics of the filter pack, and to recondition hydraulic communication between the well and the hydrologic unit adjacent to the well screen because fine-grained materials or fluids may interfere with water quality analyses [American Society for Testing and Materials (ASTM) D5092M-16 (Reapproved 2016)].

Development allows groundwater to flow freely from the geological formation (herein formation) into the monitoring well and also reduces the turbidity of the groundwater during sampling. There are several factors to be considered when choosing a development method. These factors include but are not limited to: well construction; aquifer characteristics and hydraulic conductivity of the formation surrounding the well screen; groundwater quality of the water-bearing zone being monitored; consequences of introducing foreign fluids into the well and aquifer; drilling method used during borehole installation; depth to static water level and water column height in the well; type and portability of available equipment; time available for development; and cost effectiveness of the method (ASTM D5521M-13). The most common well development methods are surging, hydraulic jetting, over-pumping, bailing and air lifting.

A Quality Assurance Project Plan (QAPP) in Uniform Federal Policy (UFP) format describing the project objectives must be prepared prior to deploying for a sampling event. The sampler needs to ensure that the methods used are adequate to satisfy the data quality objectives listed in the UFP-QAPP for a particular site.

The procedures in this SOP may be varied or changed as required, dependent on site conditions, equipment limitations or other procedural limitations. In all instances, the procedures employed must be documented on a Field Change Form and attached to the UFP-QAPP. These changes must also be documented in the final deliverable.

2.0 METHOD SUMMARY

The chosen development method should not interfere with the setting of the monitoring well seal. After construction, a well should not be disturbed for up to 48 hours to allow grout/concrete to cure. This is especially important, if a vigorous development method (i.e. hydraulic surging) is being used. If a less vigorous method is used (i.e. bailing), it may be initiated shortly after installation.

Several activities must take place prior to development. First, open the monitoring well, take initial measurements (i.e., headspace air monitoring readings, groundwater level, total depth of the well, etc.), and record results in a site logbook and/or field data sheet. Develop the well by the appropriate method to accommodate site conditions and project objectives. The most common development methods are surging, hydraulic jetting, over-pumping, bailing and air lifting. These methods are described below:

- **Surging** involves raising and lowering a surge block or surge plunger inside the monitoring well. The resulting surging motion forces water into the formation and loosens sediment, pulled from the formation into the well. Occasionally, sediments must be removed from the well with a sand bailer to prevent sand locking of the surge block. This method may cause the sandpack around the screen to be displaced to a degree that damages its value as a filtering medium. Channels or voids may form near the screen if the filter pack sloughs away during surging (Keel and Boating, 1987).

- **Hydraulic jetting** involves lowering a small diameter pipe into the monitoring well and injecting a high velocity horizontal stream of water or air through the pipe into the screen openings. This method is especially effective at breaking down filter cakes developed during mud-rotary drilling. Simultaneous air lift pumping is usually used to remove fine particles.

- **Over-pumping** involves pumping at a high rate to increase drawdown as low as possible and then allowing the well to recharge to near the original level before repeating the process until the purge water is sediment-free.

- **Bailing** includes the use of a simple manually operated check-valve bailer to remove groundwater from the monitoring well. The bailing method, like many other methods, should be repeated until the purge water is sediment-free. Bailing may be the method of choice in a shallow monitoring well or on a monitoring well that recharges slowly.

- **Air lifting** is done by injecting a sudden charge of compressed air into the well with an air-line in a way that water is forced through the monitoring well screen, or extracted from the well using air as the lifting medium (air-lift pumping). The air injection is cycled allowing the water column to rapidly rise and fall repeatedly in the well pipe. Periodically, the airline is pulled up into a pipe string known as the eductor pipe. The air injection cycling is repeated until the purge water is sediment-free. Method variations include leaving the air line in the pipe string at all times or using the monitoring well casing as the eductor pipe.

Once a monitoring well is developed (i.e., purge water is sediment free), record readings (e.g., pH, temperature, and specific conductivity) in a site logbook and/or field data sheet. Containerize all purge water from the monitoring well with known or suspected contamination. Label containers with the location where purge waters will be stored. Decontaminate monitoring well development equipment prior to use in the next well.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

The following problems are often encountered during development activities:

- Over-pumping is not as vigorous as surging and hydraulic jetting, even though it is the most desirable development method.

- Surging and jetting development methods have the potential of distorting the monitoring well filter pack.

- Introduction of other source (s) water or air by jetting may alter the hydrochemistry of the aquifer.

- Air lifting may produce “air locking” in some formations, preventing water from flowing into the well.

- The use of surge blocks in clay-rich formations may plug/smear the well screen.

- Small (two-inch nominal diameter) submersible pumps that fit in two-inch diameter well casings are especially susceptible to clogging if used in well development applications.

- Improper decontamination of drilling equipment may cause cross-contamination in monitoring well.

5.0 EQUIPMENT/APPARATUS

The type of equipment used for development is dependent on the well diameter and the development method. For example, the diameter of most submersible pumps is too large to fit into a two-inch inner diameter (ID) monitoring well; thus other development methods should be used. Obtaining the highest possible yield is not usually an objective in developing monitoring wells and vigorous development is not always necessary. Many monitoring wells are constructed in fine-grained formations that would not normally be considered aquifers. Specifications for the drilling contract should include the necessary monitoring well development equipment (e.g., air compressors, pumps, air lines, surge blocks, generators, etc.).

6.0 REAGENTS

Chemicals [e.g., polyphosphates (a dispersing agent), acids, or disinfectants] are often used in development, but should be avoided for monitoring wells in which groundwater quality is most important. Polyphosphates should not be used in thinly bedded sequences of sands and clays. The use of decontamination solutions may also be necessary. If decontamination of equipment is required at a monitoring well, refer to the Environmental Response Team (ERT) SOP, *Sampling Equipment Decontamination* and the site-specific UFP-QAPP.

7.0 PROCEDURES

7.1 Preparation

1. Coordinate site access and obtain keys to access monitoring well.

2. Obtain information on each well to be developed [i.e., drilling method, well diameter, well depth, screened interval, presence of contaminants; (if any)].

3. Obtain a water level meter, a depth sounder, air monitoring instruments, materials for decontamination, and water quality instrumentation. The water quality instrumentation needs to be capable of measuring, at a minimum, pH, specific conductivity, temperature, turbidity, dissolved oxygen (DO) and oxidation-reduction potential. Choose a development method and proceed (Refer to Section 2.0 *Method Summary*).

4. Assemble and label containers for temporary storage of water produced during development. Containers must be structurally sound, compatible with suspected contaminants, and easy to manage in the field. The use of truck-mounted or roll-off tanks may be necessary in some cases; alternately, a portable water treatment unit (i.e.: granulated activated carbon) may be used to treat purge water.

7.2 Operation

Development should be performed as soon as it is practical after the monitoring well is installed, but at least 48 hours after monitoring well installation to allow grout/cement to cure.

1. Assemble necessary equipment on a plastic sheet surrounding the monitoring well.

2. Record pertinent information in a site logbook and/or field data sheet (personnel, time, location ID, etc.).

3. Open monitoring well, wait at least three to five seconds and take air monitor readings at the top of casing and in the breathing zone (BZ), as appropriate.

4. Measure depth to groundwater and the total depth of the monitoring well. Calculate the water column volume of the monitoring well (Equation 1, Section 8.0).

5. Begin development and measure/record the initial pH, temperature, turbidity, specific conductivity, DO and oxidation-reduction potential of the groundwater. Note the initial color, clarity, and odor of the groundwater.

6. Continue to develop the well and periodically measure the water quality parameters indicated in step 5. Depending on project objectives and available time, development should proceed until the water color and clarity are transparent or near transparent and all silt to sand purged from the well. The development water should reach a turbidity of less than 50 nephelometric turbidity units (NTUs). Most important is to confirm that sand from the surrounding sandpack is not entering the wells.

   Note: In practice, well development should continue until water quality parameters stabilize; however, this is not always possible. The addition of drilling fluids (e.g., mud, foam, or lost-circulation additives (LCA)) may require the sandpack to be flushed for an extended period under ambient flow conditions. Wells installed in bedrock commonly intersect isolated water bearing fractures and may require some time to re-establish equilibrium.

7. All water produced by development of contaminated or suspected contaminated wells must be containerized or treated. Each container must be clearly labeled with the location ID, date collected, and sampling contractor. Determination of the appropriate disposal method will be based on the analytical results from each well.

8. No water will be added to the well to assist development without prior approval by the ERT Work Assignment Manager (WAM). In some cases, small amounts of potable water may be added to help develop a poor yielding well. It is essential that at least five times the amount of water injected must be recovered from the well in order to assure that all injected water is removed from the formation.

9. Note the final water quality parameters along with the following data:

   - Well designation (location ID)
   - Date(s) of monitoring well installation
   - Date(s) and time of development
   - Static water level before and after development
   - Quantity of groundwater removed; and initial and completion time
   - Type and capacity of pump or bailer used
   - Description of development techniques

7.3 Post-Operation

1. Decontaminate all equipment used. Refer to the site-specific UFP-QAPP and ERT SOP, *Sampling Equipment Decontamination.*

2. Secure holding tanks or containers of purge water.

3. Review analytical results and determine the appropriate water disposal method. Actual disposal of the purge water is generally carried out by the US EPA On-Scene Coordinator (OSC); however, at times ERT contractor personnel may be requested to contract someone to dispose of this material.

8.0 CALCULATIONS

To calculate the volume of water in the monitoring well, the following equation is used:

$$Well\,volume\,(V) = \pi\, r^2\, h\,(cf) \qquad \textbf{Equation 1}$$

Where:

π = Pi (3.14)
r = Radius of monitoring well in feet (ft)
h = Height of the water column in ft. (This may be determined by subtracting the depth to groundwater from the total depth of the well as measured from the same reference point)
cf = Conversion factor in gallons per cubic foot (in Equation 1, 7.48 gal/ft^3 is the conversion factor)

Monitoring well diameters are typically two, three, four, or six inches. A number of standard conversion factors can be used to simplify the above equation using the diameter of the monitoring well. The volume, in gallons per linear foot, for various standard monitor well diameters can be calculated as follows:

$$V\,(gal/ft) = \pi\, r^2\, h\,(cf) \qquad \textbf{Equation 2}$$

Where:

π = Pi (3.14)
r = Radius of monitoring well (feet)
cf = Conversion factor (7.48 gal/ft^3)

For example, a two-inch diameter monitoring well, the volume per linear foot can be calculated as follows:

$$V\ (gal\,/\,ft) = \pi\, r^2\, h\,(cf)$$

$$V = 3.14\ (1/12\ ft)^2\ 7.48\ gal/ft^3$$

$$V = 0.1631\ gal/ft$$

NOTE: The diameter must be converted to the radius in feet as follows:

<u>Well Diameter (in inches)</u> x 0.5 = Well Radius (feet)

The volume in gallons/feet for the common size monitoring wells is as follows:

Well diameter (inches):	2	3	4	6
Volume (gal/ft):	0.1631	0.3670	0.6524	1.4680

If the volumes for the common size wells above-mentioned are used, **Equation 1** is modified as follows:

Well volume = (h)(f)

Where:

h = height of water column (feet)
f = the volume in gal/ft calculated from **Equation 2**

9.0 QUALITY ASSURANCE/QUALITY CONTROL

Specific Quality Assurance/Quality Control (QA/QC) activities that apply to the implementation of these procedures will be listed in the QAPP prepared for the applicable sampling event. The following general QA procedures will also apply:

1. All well development data, including the items listed in Section 7.2, step 9, must be documented in site logbooks or on field data sheets.

2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer or instrument-specific SOPs, unless otherwise specified in the UFP-QAPP. Equipment checkout and calibration is necessary prior to purging and sampling and must be done according to the instruction manuals supplied by the manufacturer.

10.0 DATA VALIDATION

Data verification (completeness checks) must be conducted to ensure that all data inputs are present for ensuring the availability of sufficient information. This may include but is not limited to location information, water quality parameter measurements, development techniques, water levels, quantity of groundwater removed, date of monitor well installation, and date and time of development. These data are essential to providing an accurate and complete final deliverable. The ERT contractor's Task Leader (TL) is responsible for completing the UFP-QAPP verification checklist for each project.

11.0 HEALTH AND SAFETY

Based on Occupational Safety and Health Administration (OSHA) requirements, a site-specific health and safety plan (HASP) must be prepared for response operations under the Hazardous Waste Operations and Emergency Response (HAZWOPER) standard, 29 CFR 1910.120. Field personnel working for EPA's ERT should consult the Emergency Responder Health and Safety Manual currently located at https://response.epa.gov/_HealthSafetyManual/manual-index.htm for the development of the HASP, required personal protective equipment (PPE) and respiratory protection.

12.0 REFERENCES

ASTM International. 2013. Standard Guide for Development of Groundwater Monitoring Wells in Granular Aquifers. Designation: D-5521M-13.

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13.0 APPENDICES

This section is not applicable to this SOP.