DEPARTMENT OF ENVIRONMENTAL PROTECTION
Petroleum Restoration Program

STANDARD OPERATING PROCEDURES PCS-006 Revised 9/3/2025

DESIGN, INSTALLATION, and PLACEMENT of MONITORING WELLS

Executive Summary

The Florida Department of Environmental Protection (FDEP) Petroleum Restoration Program(PRP) presents this guidance document to clarify issues related to monitoring well design, installation, and placement in the Petroleum Cleanup Program (Program). Where practical, industry standard documents from the United States Environmental Protection Agency (USEPA) and the American Society for Testing and Materials (ASTM) have been referenced, with additions and exceptions noted where necessary to meet Program needs in a cost-effective manner. Any variance to this guidance must be approved by the PRP in advance. Water Management District and/or Local Government rules, policies, and procedures must be followed if they are more stringent than those included in this guidance document. This guidance document replaces the August 1993 FDEP document entitled, Bureau of Waste Cleanup, "Monitoring Well Construction Specifications and Related Issues."

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Design and Installation

The PRP requires monitoring well construction to be completed pursuant to the USEPA Region 4 guidance document entitled "Design and Installation of Monitoring Wells, SESDGUID-101-R2" (https://www.epa.gov/sites/default/files/2016-01/documents/design_and_installation_of_monitoring_wells.pdf),hereafter referred to as USEPA Region 4 guidance document, and microwell construction to be completed pursuant to the ASTM document entitled "Standard Guide for Direct Push Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers." However, special exceptions and additions to this document are discussed below for a more comprehensive and practical guidance for monitoring well installations within the Florida PRP program.

Well Permitting

The various Water Management Districts (WMDs) in Florida differ in the permitting requirements and the permitting costs for monitoring wells and piezometers. A copy of all applicable Water Management District permits must be included in the reports that are submitted to the PRP.

Utility Clearance

A utility markout should be completed prior to any drilling activity. All boreholes need to be cleared to a minimum depth of four feet with a hand auger or post hole digger. The size of the borehole for the utility clearance should be at least as wide as the largest diameter auger or other equipment that will be placed within the borehole. Borings that are located in the vicinity of underground storage tanks (USTs), integral piping, or underground utility lines may require the borehole to be advanced to a deeper depth. Special caution should be taken for borings or wells located within 20 feet of power lines. If a monitoring well is needed within 20 feet of a power line, special precautions with the appropriate power company may be necessary (i.e., voltage of the line should be considered and if necessary the power company may need to shield the power lines to prevent arcing). Vacuum extraction techniques render the soil samples inadequate for OVA screening and laboratory analyses and should not be used for utility clearance for soil borings and wells unless prior approval is obtained from the PRP. For a more detailed discussion on utility clearance for soil borings and wells placed near the petroleum storage and dispensing system, refer to the September 25, 2000 "Investigations Near Petroleum Storage Systems" (Exclusion Zone) memo prepared by the PRP.

Drilling Methods

There are several drilling methods that can be used to install acceptable monitoring and remediation wells in the Program. Presented in Attachment B is a list of drilling methods that are commonly used along with a brief description of the main advantages and disadvantages for each method. Additional information on the various drilling methods can be found in Section 6.3.1 of the USEPA Region 4 guidance document and Sections 7-9 of the ASTM D6724-01 guidance document.

Listed below are some comments to consider when using auger or rotary drilling methods:

Hand Bucket Auger:

> If a hand bucket auger will be used to install a permanent monitoring well, prior approval from the PRP should be obtained before the well is installed.

Hollow Stem Auger:

> During hollow stem auger drilling, soil samples for lithology, laboratory analyses, and OVA screening must be collected from either split-spoon samplers or Shelby tubes, and not from off of the auger flights or from the pile of drill cuttings. The boring logs should clearly indicate the method that was used to obtain the soil samples and the amount of recovery of the sample. ASTM 5784-95 provides a useful and practical discussion on the use of split spoons.

Rotary Methods:

> Section 6.3.4 of the USEPA Region 4 guidance document states that the best rotary method is water, followed by air, then mud. In Florida, the water or air rotary methods often are not appropriate due to the fine sand and silty sand lithologies that are commonly encountered, making the mud rotary method preferable. The water method may be practical in some clayey sediments because the clay formation could mix with the water and create a slurry with the appropriate consistency to carry the cuttings to the surface and keep the borehole open. However, some clays in the unsaturated zone may swell with the water causing swelling of the borehole walls and shrinking of the width of the borehole.
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> Although sonic and mud rotary are often used for the same difficult drilling conditions, there has been an increased use of sonic drilling during the past few years. The preference of sonic drilling over mud rotary drilling is partly due to issues associated with the drilling mud disposal costs and the problems associated with the retention of the drilling mud in the aquifer when mud rotary drilling is utilized.

Boring Log Requirements

Boring logs are required for all borings/wells that are installed. Boring log requirements are discussed in the PRP document "Soil Assessment and Sampling Methods" dated October 1, 2001 (the web link is: http://www.dep.state.fl.us/waste/quick_topics/publications/pss/pcp/a-soil-MEMO.pdf). Since the October 1, 2001 guidance document was issued, the PRP has permitted environmental consultants to use their own version of a boring log as long as all of the information that is specified in the October 1, 2001 guidance document is included on the boring logs. However, the PRP has observed that the majority of the boring logs that are submitted do not contain all of the information that is required by the October 1, 2001 guidance document. The incomplete boring logs are due to the geologist not recording all of the required information in the field or because the boring log does not contain a column or a reminder to record the data for each sampled interval, such as moisture content. To address the issue of the incomplete boring logs, the PRP has developed a boring log form that contains all of the information that should be recorded during the completion of the soil borings and wells. The boring log is presented as Attachment A and the log is also available as an electronic copy at the Petroleum Cleanup Program's web site. The PRP strongly recommends that the PRP version of the boring log be used for all borings/wells that are installed. If the PRP version of the boring log is not used, then all of the data that are included on the PRP version of the log must be included on the environmental consultant's version of the boring log.

Monitoring Well Versus Piezometer

There are many definitions in the literature for monitoring wells and piezometers. For the purposes of this guidance document, the PRP will use the definitions provided in Subsections 62-770.200(31) and (41), Florida Administrative Code (F.A.C.) and listed below:

"Monitoring Well means a well constructed with a surface seal and a sand filter pack in accordance with accepted design practices in order to provide for the collection of representative groundwater samples for laboratory analyses. Such wells may also be used to detect the presence of free product or collect water-level elevation data to aid in determining the direction of groundwater flow." A pre-packed microwell (direct-push well) is considered a type of monitoring well.

"Piezometer means a permanent or temporary well that may be designed and constructed without the surface sealing or sand filter pack requirements of a monitoring well. This type of well is primarily used to detect the presence of free product or collect water-level elevation data to aid in determining the direction of groundwater flow."

Piezometers (often referred to as temporary wells) are generally installed and removed on the same day, but in some cases may remain on-site for longer periods. Examples of applications for piezometers include groundwater samples that are obtained for screening purposes with a direct-push rig or from a hand-augered boring, wells that are installed early in an assessment to obtain data on the groundwater flow direction to help in later placement of permanent monitoring wells, or wells that are installed and backfilled with native material and are used for free product measurements and delineation.

It is often helpful early in an assessment to obtain groundwater samples from piezometers for screening purposes, but the data that come from a piezometer without a sand pack should be used mostly for screening. There are cases where the laboratory data from a piezometer without a sand pack can be used for closure, but all the other information about the site (such as soil information, direction of groundwater flow, visual observations, and site history) must support the closure option and it must be demonstrated that the screen for the piezometer intersected the water table at the time that the sample was collected.

Well Construction

Well construction specifications for monitoring wells installed with conventional drill rigs are outlined in Sections 6.4 through 6.6 of the USEPA Region 4 guidance document and for direct-push microwells in Section 7 of the ASTM D6725-01 document. The construction of the wells should conform to the USEPA and ASTM documents, except as noted below in this guidance document.

A. Borehole Annular Space

Because of the need for a 2-inch sand pack, the minimum borehole diameter for a 2-inch inside diameter (ID) monitoring well installed with a non-direct-push rig is six inches. Therefore, permanent wells installed with a conventional drilling rig require a minimum of two inches for the annulus located between the well screen and the wall of the borehole. For example, a 4 ¼-inch ID hollow-stem auger with 2-inch auger flighting will drill an 8 ¼-inch diameter borehole that will allow sufficient space for setting the well and placement of the minimum 2-inch sand pack. Hollow-stem augers with less than a 4 ¼-inch ID and/or less than 2-inch auger flighting do not allow sufficient room for proper well and sand pack placement. In some circumstances, such as when the aquifer is composed of sand that is similar to the sand pack material, exceptions to the minimum two-inch annular space for monitoring wells can be made. Variances to the two-inch annular space requirement must be approved by the PRP prior to the installation of the wells.

The addition of water into the borehole during well installation is discouraged. However, in areas where flowing sands/silts may flow into the hollow-stem auger during well installation, caution should be taken to protect the integrity of the sand pack, such as filling the ID of the hollow-stem auger with water to compensate for the pressure of the flowing sands. If water must be introduced into the borehole, well development must be thorough and the well should not be sampled for seven days to ensure that the true formation waters are being sampled.

For 1-inch ID or greater microwells installed with a direct-push rig, there is no minimum annular space requirement because the microwells must be installed with pre-packed well screens. However, microwells are not well suited for installation in finer-grained materials such as silts and/or clays. If a combination direct-push/hollow-stem auger rig is used to install the monitoring well, then the two-inch minimum annular size requirement would apply if the hollow-stem auger method was used to install the well screen and riser.

B. Overdrilling the Borehole

If a borehole was vertically overdrilled by five feet or greater, care should be taken to not allow a migration pathway through the undesired lower part of the borehole. Either backfill the bottom of the borehole with bentonite to the appropriate depth or properly abandon the borehole and then complete a borehole to the proper depth. Backfilling the borehole with sand is not permitted by the PRP due to the potential for creating pathways for contamination migration.

C. Riser and Screen Size, Materials, and Connections

As a general rule, the ID casing size for most permanent monitoring wells must be two inches; however, exceptions can be made to install larger diameter casings, with prior PRP approval. For permanent microwell installations, the minimum ID riser and screen size must be one inch.

Based on the fine sand lithologies that are commonly encountered in Florida, the preferable screen slot size for monitoring wells and microwells is 0.01 inch. If slot sizes greater than 0.01 inch are utilized, then a corresponding increase in the filter pack sand is required.

The preferred materials for monitoring well and microwell risers and screens are either Schedule 40 PVC or stainless steel. Variances to the Schedule 40 PVC or stainless steel requirement for monitoring wells or microwells must be approved by the PRP prior to the installation of the well.

Sections of the screen and riser must be connected with flush threaded joints. If the sections can not be connected with threaded joints, then they must be mechanically fastened with slip caps that are permanently fastened with stainless steel screws. Glued or welded joints are not permitted.

D. Filter Pack Material and Placement

In general, the filter pack material for a 0.01 slot screen should be between 20 and 40 mesh silica sand. Refer to Section 6.6 of the USEPA Region 4 guidance document and the ASTM Standard D5092-90 for a discussion on determining the filter pack sizes for other screen slot sizes. A sieve analysis is not necessary for standard monitoring well installations in the Program to determine the size of the filter pack material. However, the collection of Shelby tube samples for sieve, hydrometer, bulk density, porosity, and permeability testing may provide useful information on site-specific hydrogeologic parameters and for the design of remediation wells if active remediation will be performed at the site.

The tremie method must be used for filter pack placement in monitoring wells. A cap must be placed on the end of the riser prior to filter pack placement to prevent sand from entering. Another acceptable method to set the filter pack is to pour the material directly into the annular space of the borehole provided that a PVC pipe is used as a tamping device to prevent bridging of the filter pack and that the amount of filter pack sand is continuously tagged during emplacement by the driller. In addition, the auger must be retrieved slowly to allow the filter pack to spread into the area of the well annulus occupied by the auger flights.

The filter pack sand should generally be placed to a depth of two feet above the well screen to allow settling of the filter pack during well development. For wells that have the top of the well screen beginning at depths of less than five feet, the amount of filter pack above the screen should be decreased in order to obtain a proper filter pack seal and surface seal for the well.

For microwells, pre-packed well screens must be utilized. U-pack wells and pouring, tamping, or using the tremie method for placing the filter pack sand into the direct-push borehole are not permitted by the PRP.

E. Filter Pack Seal Material and Placement

The materials that are acceptable for use as a filter pack seal are bentonite and fine sand. Bentonite that is not properly hydrated will not form an effective seal for the filter pack. For this reason, the PRP requires that fine sand be used as a filter pack seal for "shallow" (water-table) wells and either bentonite or fine sand be used if the filter pack seal will be placed below the water table (e.g. vertical extent wells). Please note that if free product is present and the bentonite is in contact with the free product, then the bentonite may not hydrate properly.

The tremie method or the tamping method (see filter pack installation) must be used to install the bentonite or fine sand. The thickness of the fine sand or the hydrated thickness of the bentonite should be a minimum of two feet. If fine sand is used, the thickness should be a minimum of two feet. For wells that have the top of the well screen beginning at depths of less than five feet, the amount of the filter pack seal must be proportionately decreased in order to maintain a proper amount of sand pack above the well screen and grout surface seal above the filter pack seal.

Elevated pH levels may indicate that the filter pack seal was improperly installed. Special attention must be paid to the pH levels while purging the well for the first time to determine if the bentonite or fine sand provided an effective seal for the grout surface seal.

F. Surface Seal Material and Placement

The purpose of the surface seal is to prevent surface water run-off from migrating down the outside of the well casing or the borehole. For a list of materials that can be used for grouting the annular space, please consult Section 6.4.5 of the USEPA Region 4 guidance document. The annular space of the monitoring wells and microwells must also be grouted according to WMD regulations.

G. Well Surface Completion

Monitoring wells that are completed above grade may or may not require a protective steel casing, depending on whether or not they are located in a heavy traffic area. The amount of stickup of the well should not exceed 2.5 feet and the exact height above the land surface should be proportional to how difficult it is to find the well (such as in vegetation or non-consolidated material), whether the well will be a traffic concern, and whether surface water levels may rise and reach the well location.

Flush-to-grade wells must be installed with a manhole set in a concrete well pad that has a minimum size of two feet wide by two feet long. For manholes that are larger in diameter than 10 inches, the well pad size should be proportionately increased. A minimum of one inch of the finished pad must be below grade to prevent washing and undermining by soil erosion. It may not be necessary to install a two-foot by two-foot concrete pad if the well is installed in a concrete paved surface. The concrete well pad must be domed slightly to prevent surface water runoff from entering the manhole, but should not be excessively domed as to create a tripping hazard. If the well is completed flush-to-grade and is installed in a heavy traffic area, a bolt-down manhole cover must be installed.

Requirements for Monitoring Well Caps: Well caps serve two main functions: to prevent liquids and gases from entering or escaping from the well, and to discourage tampering with the well. The PRP requires certain construction standards to ensure that the integrity of the well cap is sufficient, and to either prevent unauthorized access to the well or leave evidence of tampering if it has occurred. Below is a description of the requirements that must be inherent in the design and materials used in the manufacturing of a monitoring well cap. If any of the requirements listed below are not followed, or if the cap is faulty, then the cap will need to be replaced at the environmental contractor's or responsible party's expense.

1. The cap must not contain any corrosive metals that have the potential to leach from the cap into the monitoring well. If metal parts exist that have the potential to leach into the well, they must be composed of stainless steel or other non-corrosive metal types.

2. The well plug should be liquid/air tight to prevent liquids and gases from entering or escaping from the well. A quality well plug must be able to withstand hydrostatic pressures/vacuums from the formation and should be constructed of materials that will not degrade in an unreasonable time frame at a typical site and compromise the seal. The requirement that the cap be liquid/pressure tight applies to all wells, including small-diameter direct-push microwells. Water-tight manhole covers should not substitute for the requirement that the plug be liquid/pressure tight.

3. The well casing must be sealed along the inside diameter (ID) or outside diameter (OD) of the casing with a one-piece liquid/air tight rubber gasket. The gasket material must have a broad range of chemical resistance and absorption properties. Such recommended materials include Santoprene®, Geolast® or Buna-nitrile. Use of the proper gasket materials guards against well intrusion and will withstand repeated use.

4. The caps must be tamper resistant (capable of locking and with a thick plastic tie used to lock the cap). The plastic tie must be of sufficient thickness so that it can only be removed by cutting the tie. Each time the well is accessed, the plastic tie should be cut and replaced. Padlocks should not be used to lock the cap. The well designation must be secured to the plastic tie or permanently affixed to the well pad using a steel tag or etched into the concrete pad. Locking well caps must be inserted and tightened according to the manufacturer's instructions. The cap must not be pulled out of the well casing using the plastic tie. The purpose of a locking well cap is to keep intruders out and/or to inform the owner/operator of the well that unauthorized access has occurred. If a well cap has been maliciously and forcefully wrenched from its casing, it must have characteristics in its construction **not** allowing it to be stepped, stomped, jammed, or hammered back into the well casing.

5. The expansion caps need to be inspected each time the well is accessed and replaced if faulty (such as if the expansion cap is stripped or the seal on the cap is worn).

H. Well Construction Details

Well construction details need to be included in the report that is submitted to the PRP. A copy of the required Well Construction and Development Log that needs to be provided for each well that is installed is provided in Attachment C. An electronic copy of the Well Construction and Development Log is also available at the Program's web site. This form should not be modified and must be entirely filled out.

I. Well Development

For a discussion of various well development techniques, refer to Section 6.8 of the USEPA Region 4 guidance document.

Development is required for all permanent water-table and vertical extent monitoring wells, and microwells. Adding water to a monitoring well for development purposes is not permitted. The wells should be developed after a sufficient amount of water has recharged into the well. The amount of the water removed from the well during the development process should be a function of one or more of the following:

1. If possible, adding water to a monitoring well during the drilling process should be avoided or minimized. If water must be added during the drilling of the borehole, then at least five times as much water as was added to the borehole during the drilling process must be removed during the development of the well. Exceptions may be warranted during the drilling of well borings where significant water was lost in a pervious hydrologic zone, if adequately documented in field notes and written approval received from the Department. In such cases, well development should continue until representative water; free of drilling fluids, cuttings, or other materials introduced during well construction is obtained. If water is added to the monitoring well during the drilling process, a minimum of 14 days of should be allowed between development and the first sampling event.

2. For wells installed using the mud-rotary method, a more aggressive development method must be utilized for an extended period of time to remove the drilling mud from the filter pack and formation.

3. The well must be developed until the water is clear of any visible suspended particulate matter. Collection and documentation of turbidity measurements during development is recommended.

4. If all of the particulate matter in the development water can not be removed after a sufficient amount of time, then the development can be stopped at the discretion of the consultant, but must be documented in the comment section of the Well Construction and Development Log. In these cases, turbidity measurements should be taken and documented in the well development log. Every effort should be made to properly develop a well, because proper development will produce a more representative groundwater sample from the formation and will reduce the amount of time that it takes for parameters to stabilize during future groundwater sampling activities for the well.

Generally, when developing a permanent monitoring well, the aquifer should be stressed in order to remove the fine-grained particles that are trapped in the filter pack and adhered to the borehole wall. Therefore, avoid developing 2-inch and greater diameter wells with pumps that pump at a low flow rate, such as peristaltic pumps.

The purpose of developing piezometers is often to just remove the bulk of the suspended particulate matter located in the well casing or direct-push screen point sampler prior to obtaining a groundwater sample for lab analyses. Therefore, when developing a piezometer that will be sampled immediately after development, minimize the amount of development time by not developing for a prolonged period to obtain a perfectly clear sample and avoid purging more than five water well volumes from the piezometer.

The monitoring of pH, temperature, specific conductance, and dissolved oxygen readings are not necessary while developing a well. However, it is recommended to measure and document turbidity during well development (or redevelopment as applicable). Recording the estimated amount of drawdown, development pumping rate, and whether the well purges dry during development can provide useful information that can be used at a later date for estimating the initial pumping rate during groundwater purging activities prior to sampling, and provides information concerning the hydraulic characteristics of the aquifer.

For all permanent monitoring wells and microwells, a well development log is required to be submitted to PRP with the reports. A copy of the required Well Construction and Development Log that needs to be provided for each well that is developed is provided in Attachment C.

Piezometers can be sampled immediately after development. Monitoring wells should not be sampled until at least 24 hours after development. In cases where water was added to the monitoring well during the drilling activities or air development methods were used, groundwater sampling should not be performed for at least seven days after the well development activities were completed (see Section I). Waiting seven days ensures that the chemistry of the groundwater has not been altered by the addition of water or air during development of the well.

J. Soil Boring and Well Abandonment

Soil borings need to be properly abandoned so that they do not serve as a preferential conduit for contamination. Monitoring wells need to be abandoned after the site rehabilitation activities are completed or after the well is determined to be damaged/unrepairable or no longer useful so that the well can not be used in the future for unauthorized access. The soil borings and wells need to be abandoned in accordance with the WMD requirements, and any exceptions to the grouting requirements must be approved by the appropriate WMD. For information on soil boring and well abandonment, consult the appropriate WMD and refer to Section 6.9 of the USEPA Region 4 guidance document and ASTM Standard D5299-92.

With the increased use of direct-push rigs, the PRP has observed in recent years that there have been a greater number of soil borings that have been completed to assess the soil and to determine the proper placement for permanent monitoring wells. In many instances the soil borings have been backfilled with the native soils or with sand. If the material that is placed in a soil boring is more permeable than the surrounding formation, the backfilled material in the former soil boring will serve as a preferential pathway for contamination.

For sites that have a very shallow water table, where soils are contaminated down to the water table, or where the lithology consists of homogeneous sand, grouting the soil boring is not always necessary. As a general guideline, the PRP presents the following rules to follow when determining if a soil boring needs to be properly abandoned with grout:

1. If the soil boring is suspected to have penetrated a perched zone or a confining or semi-confining interval.

2. If the site has a deep water table and the lithology consists of heterogeneous sands and clays.

3. If soil contamination is identified, but the groundwater is not suspected of being impacted by the contamination.

4. If a direct-push rig is utilized to collect groundwater samples or lithologic data from below the water table to characterize the lithology and to determine the vertical extent of the plume.

Whenever there is doubt as to whether the soil boring will serve as a preferential pathway for the migration of contaminants, the soil boring must be grouted. The method used for abandonment of the soil boring must be included on the boring log.

Boreholes and wells must be grouted from the bottom up by means of a tremie pipe. In addition, dry bentonite pellets must not be placed into the borehole due to the difficulty in hydrating the bentonite pellets to form an effective seal.

When abandoning monitoring wells, the well pad and manhole must be removed but the riser and the screen must be left in place unless there is evidence that the monitoring well was improperly constructed. The riser and screen must be filled with grout, the manhole should be removed, and the area that was formerly occupied by the well pad should be repaired so that the concrete or asphalt is flush with the existing grade. A copy of each well abandonment form must be included in the report to the PRP.

K. Investigation-Derived Waste (IDW)

During the well installation event, the environmental consultant should make a determination as to whether the development water and the drill cuttings should be drummed for off-site disposal.

1. Generally, development water should be pumped slowly to a paved surface to allow for evaporation, as long as surface runoff to an unpaved area, stormwater collection system (e.g., catch basin, pond, etc.), or water body does not occur. The exceptions to pumping the development water to a paved surface are:

   a. If free product is detected at the water table interface during the installation of the well.

   b. Dissolved contaminants are suspected in the groundwater and there are no paved surfaces at the site. Discharging the development water in the unpaved source area would contaminate soil at the surface that has not been impacted by the petroleum discharge or would contaminate a different aquifer zone (e.g., a perched zone).

2. In the past, soil was drummed during well installation or soil boring activities if there was no place on-site to spread it or if it was "excessively" contaminated (>500 ppm on the OVA for gasoline and >50 ppm for diesel). The implementation of soil cleanup target levels (SCTLs) makes spreading the soil based solely on OVA screening results inappropriate. If soil analytical data have not been collected at a site, then the drill cuttings should be drummed, sampled for laboratory analyses, and if the results indicate that SCTLs are exceeded, disposed of off-site. Soil cuttings should be placed in drums during the initial field event at a site, then future decisions about soil disposal will be based on laboratory data, with OVA correlations when possible. Under some circumstances, such

as at small sites, ultimate disposal decisions could be based on practicality and cost-effectiveness as well as laboratory data, as some cuttings might not exceed SCTLs but cannot be spread on the source property due to space limitations. All soil should be screened with an OVA during the advancement of the boring for the well unless an exception has been agreed to by the PRP.

Please note that pursuant to Standard Operating Procedures PCS-005, the PRP will require that calibration records be kept for all field equipment used (including the OVA) pursuant to Section FT 1000 of the Groundwater Sampling SOP. A calibration log for PRP sites is available for recording the calibration data in the field at the following link: https://floridadep.gov/waste/petroleum-restoration/documents/field-instrument-calibration-log and guidance is at the following link: https://floridadep.gov/waste/petroleum-restoration/documents/guidance-field-instrument-calibration-log. The PRP will require a calibration log to be filled out for all field equipment used in the gathering of data. Documentation of field calibration events must also be documented in the field log.

Placement

Strategy for Well Placement

The strategy for placement of monitoring wells can vary based on many factors at a site, including: the depth to the water table, the presence of perched intervals, access issues on-site and off-site, lithology and the presence of multiple aquifers, the type and amount of the discharge(s), and the location of soil contamination. A direct-push rig can often be used to obtain groundwater screening samples for determining the optimal locations for permanent water-table wells and the screen interval of vertical extent wells. Alternatively, an assessment investigation can also be initiated by installing permanent wells with a conventional drilling rig to determine the magnitude of petroleum contamination in the source area.

For any assessment investigation where contamination is detected, there needs to be a minimum of three water-table monitoring wells or piezometers installed in order to determine the direction of groundwater flow. The wells should not be installed in a line, but should be installed in a triangular manner so that the direction of groundwater flow can be determined with greater certainty.

As a general rule, additional monitoring wells that are installed outside of the source areas should be spaced apart by 30 to 50 feet. The larger spacing should be employed farther away from the source areas for sites that have very high dissolved concentrations and for sites that have very deep water tables. The spacing of wells may be decreased or increased depending on access issues, delineating the extent of free product, and the dissolved contaminant levels that are detected.

Vertical extent wells should be installed next to or slightly downgradient (within five feet) of the most contaminated source wells. For sites that have multiple source areas, a vertical extent well should be installed at each source area where the dissolved concentrations exceed the natural attenuation default source concentrations that are specified in Table V of Chapter 62-777, F.A.C.

Determining the Need for Additional Monitoring Wells

As an assessment progresses, the need for and placement of additional monitoring wells must be evaluated. The following are general guidelines to be followed:

1. If the dissolved contamination in the groundwater exceeds the natural attenuation default concentrations for source wells, then the plume should be "chased' horizontally and vertically. Exceptions to this are:

    a. Physical barriers in the way (e.g., buildings and very wide roads).

    b. The existence of a confining clay layer greater than 5-10' thick vertically that is laterally continuous across the area of the plume. The existence of the confining clay layer must be agreed upon by the consultant's Professional Geologist of record and the PRP's Professional Geologist of record. (NOTE: For the purposes of this guidance document the terms confining, semi-confining, and retarding are subjective. Geotechnical testing is rarely completed on the soils before monitoring well installation, so the lithology description is generally based on a field interpretation.)

c. The resampling of the vertical extent well indicates that the dissolved contamination detected in the first groundwater sampling event in excess of the natural attenuation criteria does not represent the actual dissolved concentrations in the formation. Frequently, the first groundwater sampling event that is conducted for a vertical extent well may erroneously indicate that the results are in excess of the natural attenuation criteria. This "false positive" occurs as the result of the "dragging down" of soil or groundwater contamination from the shallow zone during the installation of the single or double-cased vertical extent well. Before any additional vertical extent wells are installed to define the base or lateral extent of the plume in the deep zone, the vertical extent well should be evaluated for resampling to confirm the first groundwater analytical results.

2. If groundwater contamination exceeds the groundwater cleanup target levels (GCTLs) but is less than the natural attenuation default source concentrations, an evaluation of whether to "chase" the plume should be made on a case-by-case basis as outlined below:

   a. Temporary groundwater screening samples obtained using direct-push rigs are generally from very short-screened intervals located at the water table. Groundwater samples obtained from permanent monitoring wells that have a longer screened interval and are installed at the same locations of the direct-push groundwater screening locations often display a decrease or non-detect contaminant levels.

   b. Where GCTLs are only slightly exceeded in monitoring wells, it may be possible to use isoconcentration contour lines to estimate the extent of the plume on the source property, and avoid installing additional permanent monitoring wells to locate the exact spot where the dissolved contamination is at or below the cleanup target levels. Isoconcentration contour maps must be submitted with multiple contour lines, which demonstrate the concentration gradient across the plume. Logarithmic contour lines (e.g., 10,000 ug/L, 1,000 ug/L, 100 ug/L, 10 ug/L, and 1 ug/L) are preferred to show plume characteristics for sites with high concentrations.

   c. If potable well(s) or other receptors are reasonably close, especially in the downgradient direction, additional monitoring well installations to better define the plume are warranted.

   d. If the site will undergo natural attenuation monitoring and there are no off-site access issues, there must be a monitoring well demonstrating a clean downgradient point of compliance.

If contamination in the vertical extent well is confirmed at levels in excess of the natural attenuation default source concentrations, then additional vertical delineation of the contamination consisting of a deeper vertical extent well may be necessary and the horizontal extent of the "intermediate" contamination may also be required. The horizontal extent of intermediate contamination is often necessary when a downward vertical gradient is present suggesting that the intermediate impacted aquifer may have a different lithology, hydraulic gradient, and/or flow direction. Determining the horizontal extent of the intermediate zone contamination also might be necessary if the intermediate zone lithology appears to be more transmissive than the shallow zone materials. If the lithology is consistent through the depth of concern, additional horizontal delineation may not be necessary at that depth if the distribution of the contaminants of concern can be inferred from the concentrations in the shallower zone.

Length and Placement of the Well Screen for Water-Table ("Shallow") Monitoring Wells

For water-table ("shallow") monitoring wells, 10 to 15 feet of screen should be used to bracket the water table during the seasonal fluctuations of the water table. Screen lengths of greater than 15 feet are inappropriate for the following two reasons:

1. A longer screen length can allow transfer of contaminants from the upper parts of the screen to the lower parts.

2. A longer screen length is often considered necessary to cover an apparently large fluctuation of the water table (for example 10 to 20 feet). In most cases, this apparent fluctuation is not an accurate representation of the true water table, but is usually due to a perched or semi-perched zone above the regional water table that tends to accumulate water for days, weeks, or even months after rain events. The perched or semi-perched zones can be seasonal and only support a water column when the influx of rain is greater than the perched or semi-perched zone's ability to allow it to percolate through or flow around the perched or semi-perched zone. Small amounts of finer material in the soils will impede the downward gravity flow of water from rain events. After rain events, or in the rainy season, water can be slow to infiltrate through the finer materials. If a site appears to have a water table fluctuation greater than 10 to 15 feet, rather than utilizing a screened interval of 20 feet or greater, it would be more appropriate to place two monitoring wells with shorter screened intervals clustered next to each other. The upper perched or semi-perched zone should be screened with one well, and the deeper zone should be screened by another well and the two screened intervals should not overlap in a manner that allows the migration of contaminants from one screened interval to the next. This way, contamination in the shallower and deeper zones will not mix and a more accurate estimate of where the depth of the contamination is can be made.

If a piezometer is being utilized for assessment of free product, the screened interval must include the capillary fringe area.

During an initial site assessment event, it can be difficult to determine the depth of the water table, especially when fine materials are present. Over the past few years, with the increased use of initial screening events utilizing direct-push rigs for quick screening of water levels and water quality, the PRP has seen an increased number of monitoring wells set to improper depths. It is apparent that sufficient time and appropriate methods are not being utilized for the water table to stabilize before the correct depth to water is being noted. An appropriate effort must be made to determine the proper depth to water to allow for proper placement of the well screens. The well screens should be placed to intersect the current water table at the time of the drilling event and should also intersect the estimated water table during seasonal fluctuations. As a standard practice, the top of the well screen should not always be arbitrarily placed two feet above the water table that was observed at the time of drilling. The effects of seasonal fluctuations have to be considered when determining the placement of the screen. The current depth to water and the seasonal fluctuation range observed at the site can be determined by the following:

a. Reviewing historical water-level data obtained from existing wells located at the site or from any nearby sites prior to the drilling event.

b. Considering the seasonal effects of precipitation and whether the site area is in a prolonged drought condition or abnormally wet period.

c. Gauging any existing wells on-site before installing any additional wells.

d. When taking water levels during direct-push screening events, if fines such as silts or clays are present, allow sufficient time for the water table to stabilize in the borehole before the final depth to water is determined. In some cases (such as in areas with finer-grained materials) this will require setting a length of well screen in the borehole and allowing the water table to stabilize as other work is being completed on the site. It is not uncommon for the water table to take hours to stabilize. If it doesn't recharge within 24 hours, the existence of a different water-bearing zone should be considered.

e. Observations about moisture content (e.g., dry, damp or moist, wet, saturated) as a boring is advanced should be noted and recorded on the boring log. Changes in the moisture content will help determine the existence and depth of the true water table or any perched zones that may be present. The different categories of water content will have varying observed properties depending on the lithology present and the drilling method used. A saturated sand will have different properties than a saturated clay. Field staff must be trained and sufficiently experienced to interpret the visual observations of moisture content and lithologies to help determine the depth at which the soils are saturated. Moisture content observations during the advancement of the borehole are also very helpful in determining the actual depth to the water table in aquifers that are under confining or semi-confining conditions.

f. Using observed spikes in the OVA concentrations obtained from above the current water table within the smear zone and away from the immediate source area to determine the approximate seasonal high water table.

g. If installing wells over multiple days for wells that have good to moderate recharge, gauge wells that were previously installed (e.g., the day before or earlier the same day) to determine the depth to water before drilling any additional wells.

If the depth to water is less than two feet, then the monitoring well screen should begin at a depth of two feet below land surface in order to allow proper placement of the filter pack above the screen, filter pack seal, and the surface seal. If free product is present at a site that has a water table of less than two feet, then piezometers should be installed in the area of the free product and screened across the water table (completed above grade when possible).

Criteria for Determining if Vertical Extent Wells are Necessary

Vertical extent wells are installed to help determine the vertical extent of groundwater contamination and to help describe the lithology of the treatment area when active remediation is being considered. Vertical extent wells should generally be installed when:

1. The petroleum contaminants of concern in the water-table wells are greater than the natural attenuation default source concentrations that are specified in Table V of Chapter 62-777, F.A.C.

2. Private or public supply wells are located in close proximity to the plume or supply well impacts have been documented.

3. In areas with a known or suspected high vertical (downward) hydraulic gradient or where there is sufficient reason to believe the plume is being pulled downward, such as in karstic formations (as determined by the consultant's Professional Geologist of record and agreed upon by the PRP's Professional Geologist of record).

Length and Placement of the Well Screen for Vertical Extent Wells

The maximum screen length for a vertical extent well should be five feet (or more if the screened portion of the aquifer is slow to recharge). Due to the short screened interval, proper placement of the screen within a permeable interval is preferable. If it is suspected that the vertical extent well will not yield a sufficient water sample due to the confining or retarding nature of the soils, then consideration should be given to collecting a soil sample for lab analyses at the base of the vertical extent well. This result will provide additional information along with the OVA data as to the vertical extent of the plume.

The placement of the five-foot screened interval should be based on the following:

1. If a confining (retarding) interval is identified during the drilling activities, the top of the filter pack for the vertical extent well screen should be at least two feet below the confining interval.

2. If an OVA/FID or PID is utilized for screening purposes, the data should be collected from above and below the water table. A sharp decrease in readings can be used as an indicator in determining the depth of the plume and the placement of the screened interval.

3. If a direct-push rig is utilized, groundwater samples can be obtained at approximately 10 to 15 foot intervals with the screen point sampler to

determine the base of the plume. If a retarding unit is encountered during the drilling activities, then this method should not be used below the retarding interval unless surface casing is driven into the retarding unit.

4. If the lithological data indicate that a retarding unit is not present and the OVA data can not be used to approximate the base of the plume, then the top of the screen for the vertical extent well should be installed between 10 to 20 feet below the bottom of the screens of the water-table wells.

5. The top of the filter pack for the vertical extent well screen should be separated from the surface casing by a minimum of 3 feet. This should help prevent any cross contamination resulting from the installation of the surface casing.

Placement of the Surface Casing for Double- or Triple-Cased Vertical Extent Wells

The following criteria must be considered to determine whether a permanent or temporary surface casing should be used during installation of a vertical extent well:

1. To minimize the potential for drag-down of the surficial contamination during well installation. The installation of the surface casing should prevent the vertical extent well from acting as a conduit for downward migration of the groundwater contamination if free product or dissolved contamination exists in the upper section of the impacted aquifer.

2. If evidence exists of a perched water table, or when drilling in a heterogeneous stratified lithology (especially when there is concern that the well sand pack annulus might breach a retarding clay unit).

Triple casing may be considered at sites with very high contamination levels (free product), significantly contaminated intermediate zones, and/or large vertical hydraulic gradients. On a site-by-site basis, an evaluation should be made as to the need for additional casing to segregate lithologic/hydrologic units by separate casings.

Temporary casings used with direct-push and sonic drilling methods are acceptable, but the consultant should describe the backfilling techniques to ensure formation bridging is minimized.

The diameter of the surface casing should allow for the proper placement of the well casing and the 2-inch minimum annular space for the filter pack. Generally, the surface casing should extend at least a few feet past the bottom of the water-table well (or the adjacent impacted vertical extent well). The main goal is to isolate the vertical extent well from the source contamination at the screened interval of the adjacent impacted well. A reduction in OVA levels or lab data in soils retrieved from below the surficial aquifer can provide an indication as to the bottom of the source/smear zone. But the lithology should also be a determining factor when setting the depth of the surface casing. When screening a vertical extent well below a clay lens, set the casing within the upper two feet of the lens (if possible). Even if it is known that this is not a continuous unit, the clay will provide a good seat for the surface casing, which will minimize the drag-down of contamination.

If additional vertical extent wells are needed to determine the lateral extent of contamination observed in the initial vertical extent well, a review of the shallow aquifer contamination levels should be performed to determine if a surface casing is needed for any of the additional wells. This is especially important when the "intermediate" contaminant plume extends beyond the extent of the shallow contamination (as defined by the water-table monitoring wells). The evaluation of whether to double-case any additional vertical extent wells should be based on the following three factors:

- Lithology.
- Zone of contamination.
- Existence of a confining/retarding unit.

References Cited

ASTM, Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers (D5092-90, Reapproved 1995).

ASTM, Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities (D5299-92).

ASTM, Standard Guide for Use of Hollow-Stem Augers for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices (D5784-95, Reapproved 2000).

ASTM, Standard Guide for Installation of Direct Push Ground Water Monitoring Wells (D6724-01).

ASTM, Standard Guide for Direct Push Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers (D6725-01).

USEPA, Design and Installation of Monitoring Wells (SESDGUID-101-R2, 2018).

Other References

ASTM, Standard Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices (D5783-95, Reapproved 2000).

ASTM, Standard Guide for Direct-Push Water Sampling for Geoenvironmental Investigations (D6001-96).

FDEP, Interested Parties – 2, Technical Review Section, Bureau of Waste Cleanup (September 29, 1992).

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ATTACHMENT A

Boring Log

BORING LOG

Page 1 of ____

Boring/Well Number:	Permit Number:	FDEP Facility Identification Number:
Site Name:	Borehole Start Date: End Date:	Borehole Start Time: ☐ AM ☐ PM End Time: ☐ AM ☐ PM
Environmental Contractor:	Geologist's Name:	Environmental Technician's Name:

Drilling Company:	Pavement Thickness (inches):	Borehole Diameter (inches):	Borehole Depth (feet):
Drilling Method:	Apparent Borehole DTW (in feet from soil moisture content):	Measured Well DTW (in feet after water recharges in well):	OVA (list model and check type): ☐ FID ☐ PID

Disposition of Drill Cuttings [check method(s)]: ☐ Drum ☐ Spread ☐ Backfill ☐ Stockpile ☐ Other
(describe if other or multiple items are checked):

Borehole Completion (check one): ☐ Well ☐ Grout ☐ Bentonite ☐ Backfill ☐ Other (describe)

Sample Type	Sample Depth Interval (feet)	Sample Recovery (inches)	SPT Blows (per six inches)	Unfiltered OVA	Filtered OVA	Net OVA	Depth (feet)	**Sample Description** (include grain size based on USCS, odors, staining, and other remarks)	USCS Symbol	Moisture Content	**Lab Soil and Groundwater Samples** (list sample number and depth or temporary screen interval)
							1				
							2				
							3				
							4				
							5				
							6				
							7				
							8				
							9				
							10				
							11				
							12				

Sample Type Codes: **PH** = Post Hole; **HA** = Hand Auger; **SS** = Split Spoon; **ST** = Shelby Tube; **DP** = Direct Push; **SC** = Sonic Core; **DC** = Drill Cuttings
Moisture Content Codes: **D** = Dry; **M** = Moist; **W** = Wet; **S** = Saturated

BORING LOG

Page 2 of ______

Boring/Well Number:	FDEP Facility Identification Number:	Site Name:	Borehole Start Date: End Date:

Sample Type	Sample Depth Interval (feet)	Sample Recovery (inches)	SPT Blows (per six inches)	Unfiltered OVA	Filtered OVA	Net OVA	Depth (feet)	**Sample Description** (include grain size based on USCS, odors, staining, and other remarks)	USCS Symbol	Moisture Content	**Lab Soil and Groundwater Samples** (list sample number and depth or temporary screen interval)
							13				
							14				
							15				
							16				
							17				
							18				
							19				
							20				
							21				
							22				
							23				
							24				
							25				
							26				
							27				
							28				
							29				
							30				

Sample Type Codes: **PH** = Post Hole; **HA** = Hand Auger; **SS** = Split Spoon; **ST** = Shelby Tube; **DP** = Direct Push; **SC** = Sonic Core; **DC** = Drill Cuttings
Moisture Content Codes: **D** = Dry; **M** = Moist; **W** = Wet; **S** = Saturated

BORING LOG

Page _____ of __________

Boring/Well Number:	FDEP Facility Identification Number:	Site Name:	Borehole Start Date: End Date:

Sample Type	Sample Depth Interval (feet)	Sample Recovery (inches)	SPT Blows (per six inches)	Unfiltered OVA	Filtered OVA	Net OVA	Depth (feet)	**Sample Description** (include grain size based on USCS, odors, staining, and other remarks)	USCS Symbol	Moisture Content	Lab Soil and Groundwater Samples (list sample number and depth or temporary screen interval)

Sample Type Codes: **PH** = Post Hole; **HA** = Hand Auger; **SS** = Split Spoon; **ST** = Shelby Tube; **DP** = Direct Push; **SC** = Sonic Core; **DC** = Drill Cuttings

Moisture Content Codes: **D** = Dry; **M** = Moist; **W** = Wet; **S** = Saturated

ATTACHMENT B

Drilling Methods Advantages and Disadvantages

Drilling Method	Main Advantages	Main Disadvantages
Hand Bucket Auger	• Inexpensive method for soil assessment and the installation of temporary and/or permanent monitoring wells with shallow water tables. • Appropriate for areas of difficult access (e.g., swamps, heavy woods, medians, or overhead utilities).	• Labor intensive. • Caving may occur during the well installation. • Limited to shallow depths (generally less than 10 feet). • Requires a core drill in areas covered with asphalt and/or concrete.
Hollow Stem Auger	• Appropriate in unconsolidated material to shallow and intermediate depths. • Facilitates the collection of soil samples from split-spoon samplers for lithologic and OVA data.	• Sample recovery is less reliable than soil samples collected with Direct-Push Rigs. • Access limitations with small sites, swamps, heavy woods, overhead utilities, and under canopies.
Rotary Method: Water, Air, Mud	• Appropriate in unconsolidated or consolidated material to shallow and deep depths. • Appropriate for many difficult drilling conditions that other methods can not properly overcome.	• Soil sampling is time consuming due to time required to remove the rotary drill bit and pipe from the borehole for sample collection. • Access limitations with small sites, swamps, heavy woods, overhead utilities, and under canopies. • Difficult to install wells in limestone with large voids due to circulation loss. • Increased well development time due to time required to remove the drilling mud. • Time consuming to install multiple cased wells. • Generates a large amount of investigation derived waste (IDW).

Sonic	• Appropriate in unconsolidated and consolidated material to intermediate and deep depths. • Preferred for installing monitoring wells in hard limestone with large voids. • Less IDW generated compared to mud rotary. • Temporary override casing instead of permanent surface casing, so reduced drilling time for multiple-cased wells. • Samples may be collected in the drill casings for lithologic characterization. • Appropriate for many difficult drilling conditions that other methods can not properly overcome.	• Cost prohibitive for most shallow monitoring wells. • Often more expensive than mud rotary. • Access limitations with small sites, swamps, heavy woods, overhead utilities, and under canopies (access limitations are less of a concern if a mini-sonic rig is used). • Samples from consolidated material are often pulverized. • Poor sample recovery from unconsolidated fine sand lithologies lacking clay.
Direct-Push (DPT)	• Appropriate in unconsolidated material to shallow depths. • Often good recovery of soil samples for lithology, laboratory analyses, and OVA data. • Sample liners prevent loss of volatiles. • Groundwater samples are collected using a screen point sampler or by placing PVC screen into the borehole. • Variety of DPT rig sizes to accommodate limited access. • Minimal IDW.	• Difficult in areas of swelling clays, well-sorted sands, or in former UST areas backfilled with pea gravel. • Not appropriate for consolidated material such as limestone or areas that are backfilled with concrete and asphalt fill. • Generally limited to shallow depths.

ATTACHMENT C

Well Construction
and
Development Log

WELL CONSTRUCTION AND DEVELOPMENT LOG

WELL CONSTRUCTION DATA

Well Number:	Site Name:	FDEP Facility I.D. Number:	Well Install Date(s):

Well Location and Type (check appropriate boxes): ☐ On-Site ☐ Right-of-Way ☐ Off-Site Private Property ☐ Above Grade (AG) ☐ Flush-to-Grade If AG, list feet of riser above land surface:	Well Purpose: ☐ Perched Monitoring ☐ Shallow (Water-Table) Monitoring ☐ Intermediate or Deep Monitoring ☐ Remediation or Other (describe)	Well Install Method: Surface Casing Install Method:

Borehole Depth (feet):	Well Depth (feet):	Borehole Diameter (inches):	Manhole Diameter (inches):	Well Pad Size: ____ feet by ____ feet

Riser Diameter and Material:	Riser/Screen Connections: ☐ Flush-Threaded ☐ Other (describe)	Riser Length: ____ feet from ____ feet to ____ feet
Screen Diameter and Material:	Screen Slot Size:	Screen Length: ____ feet from ____ feet to ____ feet
1st Surface Casing Material: also check: ☐ Permanent ☐ Temporary	1st Surface Casing I.D. (inches):	1st Surface Casing Length: ____ feet from 0 feet to ____ feet
2nd Surface Casing Material: also check: ☐ Permanent ☐ Temporary	2nd Surface Casing I.D. (inches):	2nd Surface Casing Length: ____ feet from 0 feet to ____ feet
3rd Surface Casing Material: also check: ☐ Permanent ☐ Temporary	3rd Surface Casing I.D. (inches):	3rd Surface Casing Length: ____ feet from 0 feet to ____ feet
Filter Pack Material and Size:	Prepacked Filter Around Screen (check one): ☐ Yes ☐ No	Filter Pack Length: ____ feet from ____ feet to ____ feet
Filter Pack Seal Material and Size:		Filter Pack Seal Length: ____ feet from ____ feet to ____ feet
Surface Seal Material:		Surface Seal Length: ____ feet from ____ feet to ____ feet

WELL DEVELOPMENT DATA

Well Development Date:	Well Development Method (check one): ☐ Surge/Pump ☐ Pump ☐ Compressed Air ☐ Other (describe)
Development Pump Type (check): ☐ Centrifugal ☐ Peristaltic ☐ Submersible ☐ Other (describe)	Depth to Groundwater (before developing in feet):

Pumping Rate (gallons per minute):	Maximum Drawdown of Groundwater During Development (feet):	Well Purged Dry (check one): ☐ Yes ☐ No

Pumping Condition (check one): ☐ Continuous ☐ Intermittent	Total Development Water Removed (gallons):	Development Duration (minutes):	Development Water Drummed (check one): ☐ Yes ☐ No

Water Appearance (color and odor) At Start of Development:	Water Appearance (color and odor) At End of Development:

WELL CONSTRUCTION OR DEVELOPMENT REMARKS