

ROCKY FLATS  
ENVIRONMENTAL TECHNOLOGY SITE  
PRO-1620-AWB  
REVISION 0

ABANDONMENT OF WELLS AND BOREHOLES

Responsible K-H Organization: Environmental Media Management Effective Date: May 27, 2002

Approved By: MANAGER, WATER PROGRAMS / 5/22/02  
Title Date

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Not Applicable  
*Print Name of Responsible Manager (N/A if RM is Approval Authority)*

The Responsible Manager Has Determined The Following Organizations' Review Is Required. Review Documentation Is Contained In The Document History File:

K-H Environmental Media Management

**IMPORTANT NOTES**  
Periodic Review Frequency: 4 years from Effective Date  
Supercedes: RMRS/OPS-PRO.117, Plugging and Abandonment of Boreholes; and RMRS/OPS-PRO.122, Plugging and Abandonment of Wells

REVIEWED FOR CLASSIFICATION/ UCNI (If Required)  
By: Not Required, per J Rosen Date: 5/22/02  
[Signature]

ADMIN RECORD

PADC-2002-00212

1/22

SW-A-006149

LIST OF EFFECTIVE PAGES

<u>Page</u>	<u>Effective Date</u>	<u>Page</u>	<u>Effective Date</u>
1-22	5/27/02		

Total number of pages: 22

The following changes are active for this document

None

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## 1.0 PURPOSE

This standard operating procedure (SOP) contains procedures that will be used at the Rocky Flats Environmental Technology Site (RFETS or Site) to abandon monitoring wells, piezometers, and boreholes. For the purpose of this SOP, the terms well and piezometer are synonymous. The proper abandonment of obsolete, redundant, non-useful, or damaged wells and open boreholes is necessary to prevent the entry of contaminants to groundwater through the borehole and prevent the intermingling of groundwater from different saturated zones through the borehole. The abandonment of wells which are no longer intended for use is a requirement of the Rules and Regulations for Water Well Construction, Pump Installation, and Monitoring and Observation Hole/Well Construction, 2 CCR 402-2 (effective date June 1, 2000), as administered by the State of Colorado, Office of the State Engineer, State Board of Examiners of Water Well Construction and Pump Installation Contractors.

The term abandonment refers to plugging a well or borehole with grout and/or other approved materials, and the completion and documentation of all requirements of this SOP. For the purpose of this SOP, a well (or piezometer) is defined as a cased, below ground, installation intended for monitoring the chemical, physical or potentiometric properties of groundwater. (In this SOP the definition of well also covers previously cased, below ground installations of unknown status.) For the purpose of this SOP, a borehole is defined as a ground penetration that is drilled or pushed (for example, using a Geoprobe) primarily for obtaining geologic and environmental information. Generally, a borehole will provide core, cuttings, and geophysical data. Boreholes may be cased or partially cased. Unless the status of a borehole is changed to that of a well, it will be abandoned immediately after the desired data are collected.

## 2.0 SCOPE

This document, which supersedes procedures RMRS/OPS-PRO.117, Plugging and Abandonment of Boreholes and RMRS/OPS-PRO.122, Plugging and Abandonment of Wells, applies to all Water Programs personnel and subcontractors conducting work at the Site. The procedures described herein will be followed whenever well or borehole abandonments and associated activities are being performed.

Well abandonment at RFETS will be performed under the direct supervision and with the approval of the Water Programs Group. The procedures contained within this SOP apply to all boreholes advanced and wells installed, owned, and/or permitted by DOE or their subcontractors at RFETS. This SOP also establishes the administrative requirements for incorporation of the Colorado Office of the State Engineer's Rules and Regulations for Water Well Construction, Pump Installation, and Monitoring and Observation Hole/Well Construction into Water Programs well abandonment activities.

Prior to beginning any specific well abandonment activity, the Water Programs Project Manager shall be notified by subcontractor or Water Programs field personnel. The notification will allow for the final opportunity to perform any necessary sampling and/or hydrologic measurements, and to allow time for other logistical decisions, for example the disposition of cuttings from a deep, casing removal, well abandonment.

### 3.0 REQUIREMENTS

A Water Programs or subcontractor representative with experience in well and borehole abandonments will conduct oversight and supervision of any field operations that will provide for the abandonment of wells and boreholes by the methods covered under this SOP.

The following sections identify the personnel qualifications, the equipment, and the procedures required to perform borehole and well abandonment operations and/or related activities.

#### 3.1 Personnel Qualifications

Only qualified personnel will be allowed to perform these procedures. Required qualifications vary depending on the activity to be performed. The subcontractor Field Supervisor will document personnel qualifications related to this procedure in the subcontractor project QA files. Personnel overseeing the abandonment of wells and boreholes will be geologists, engineers, or technicians with an appropriate amount of applicable field experience and training under the supervision of a qualified senior geologist or engineer who has experience in well and borehole abandonment.

Personnel performing these procedures are required to have completed the 40-hour OSHA classroom training that meets the Department of Labor requirements of 29 CFR 1910.120(e)(3)(i), and must maintain a current training status by completing the annual 8-hour OSHA refresher course. Personnel must also have read and signed the Health and Safety Plan for the Groundwater Monitoring Program (HASP).

Prior to conducting well or borehole abandonment operations and other related work, personnel are required to have a complete understanding of the procedures described within this and certain related SOPs that are referenced in this document, as well as the manufacturer's instructions for any equipment to be used in these activities. Personnel will receive specific training regarding these procedures as necessary.

#### 3.2 Materials and Equipment

Depending on the well abandonment method, the following materials and equipment may be required:

- Drill rig and associated equipment (including tools to perforate or rip casing) and/or grout plant
- Reduced pH bentonite grout (American Colloid "Pure Gold" or approved equivalent)
- Inert, clean sand (Colorado Silica 16/40 filter pack or approved equivalent)
- Funnel
- Bentonite pellets or chips, granular bentonite
- Cement
- Water Programs downhole cutting tool and appropriate blades
- Appropriate container(s) for collection of purged groundwater and diluted grout
- Mud balance
- Tremie pipe
- Weighted tape measure
- Mirror and/or flashlight

- Sledgehammer(s) for breaking up concrete well pads
- High pressure steamer/sprayer
- Phosphate-free, laboratory-grade detergent (e.g., Liquinox)
- Distilled or deionized water (for decontamination) and approved Site water (for grout, cement)
- Health and safety monitoring equipment and personal protective equipment (PPE) as per HASP
- Well/Borehole abandonment form and any other required forms
- Field logbook
- Black or blue permanent marking pens

The following materials and equipment may be required for the abandonment of a borehole:

- Drill rig and associated equipment and/or grout plant
- Reduced pH bentonite grout (American Colloid "Pure Gold" or approved equivalent)
- Appropriate container(s) for collection of purged groundwater and diluted grout
- Mud balance
- Tremie pipe
- Bentonite pellets, chips and/or granular bentonite for small diameter boreholes
- Distilled or deionized water (for decontamination) and approved Site water (for grout, cement)
- Weighted tape measure
- Mirror and/or flashlight
- High pressure steamer/sprayer
- Phosphate-free, laboratory-grade detergent (e.g., Liquinox)
- Health and safety monitoring equipment and PPE as per the HASP
- Well/Borehole abandonment form and any other required forms
- Field logbook
- Black or blue permanent marking pens

#### 4.0 PROCEDURES

Equipment for abandoning wells and boreholes shall be used according to the requirements of SOP RMRS/OPS-PRO.114, Drilling and Sampling Using Hollow-Stem Auger and Rotary Drilling and Rock Coring Techniques. These requirements include using only contaminant-free lubricants and performing visual inspection of equipment for hydraulic fluid, fuel or oil leaks. If necessary, project-specific requirements will be addressed in a project-specific Work Plan. All procedures will be conducted in accordance with the HASP.

Environmental material handling issues pertaining to well abandonment activities are addressed in the RFCA Standard Operating Protocol for Asphalt and Soil Management; the RFCA Standard Operating Protocol for Recycling Concrete; and Section 6.0 of this SOP, Handling and Storage of Waste Materials. Decontamination procedures pertaining to well abandonment activities are addressed in PRO-1455-FDO, Field Decontamination Operations and PRO-1389-MDF, Equipment Decontamination at Decontamination Facilities.

Four methods of well abandonment are addressed in the following sections: casing pulling, casing destruction, overdrilling, and abandonment in place. Selection of the appropriate method of abandonment for a given well shall be addressed in a project-specific Work Plan or Work Plan

Addendum, based on information compiled for the well. Factors to be considered in selecting the abandonment method for a specific well include:

- Hydrogeologic conditions
- Location of zone(s) where contamination occurs
- Type of casing material
- Overall well casing condition and knowledge of obstruction(s), if any
- Well location, depth, and plumbness
- Diameter of casing and borehole
- Type and quality of original annular seal
- Objective(s) of the abandonment

The method selected for abandonment of a specific well should be consistent with the following purposes of well abandonment:

- To prevent groundwater and soil contamination via the well or borehole
- To prevent intermixing of subsurface waters via the well or borehole
- To conserve the hydraulic characteristics of the hydrogeologic units beneath the Site
- To minimize physical hazards to workers

#### 4.1 Pre-Abandonment Activities

Pre-abandonment activities, including radiation screening when necessary (or more stringent radiation assessment depending on soil sampling data and/or specific work area postings) and work site preparation, shall be conducted at each abandonment site in accordance with the HASP and RMRS/OPS-PRO.102, Borehole Clearing. Radiological Control Technicians (RCTs), per the requirements of K-H Radiological Engineering, shall collect any required field radiological measurements. Certain monitoring wells may be sampled prior to their abandonment depending on location and well viability. In addition, the following pre-abandonment activities shall be performed:

- Measure and record the depth to groundwater and total depth of the well from the top of the well casing as described in RMRS/OPS-PRO.105, Water Level Measurements in Wells and Piezometers (or its successor document).
- Compare the water level to the depth of the top of the well screen, being careful to use the same reference datum (top of casing or ground surface).
- Calculate the volume of water contained within the well as described in RMRS/OPS-PRO.113, Groundwater Sampling (and add approximately 20 percent to account for diluted grout) to ensure that a waste liquid container of sufficient volume is available.
- Purge the well (optional, but reduces the volume of waste fluids that must be containerized and handled as waste).
- For wells with aboveground surface protection, cut the well casing at a depth of approximately three feet below ground surface. The well casing must be completely severed. This allows removal of the surface protection.

- Remove the surface protection. If the well protection is aboveground, a forklift may constitute the most efficient means of removal.
- If performing casing pulling (Section 4.2.1 below), casing destruction (Section 4.2.2 below) or overdrilling (Section 4.2.3 below), remove the concrete well pad and protective casing. The protective casing and concrete can then be surveyed by an RCT if necessary. The concrete shall then be separated from the protective casing, broken up, and disposed of as described in the RFCA Standard Operating Protocol for Recycling Concrete. The well and protective casing shall be handled as waste or recycled as appropriate.

If the well is to be abandoned in place (Section 4.2.4 below), surface protection removal shall be subsequent to sand and/or grout placement. Before a lifting device such as a forklift is used to lift well protection, it shall be determined that the forklift is appropriately rated for the activity. The lower edge of the concrete pad shall be exposed on one side; the forklift shall approach the pad from the exposed side and extend its tines beneath the pad and lift the entire assembly. For flush-mount wells, it may be necessary to break up concrete in which the flush-mount assembly is seated and remove it by hand.

Wastes from pre-abandonment activities will be monitored and decontaminated if necessary in accordance with PRO-1455-FDO, Field Decontamination Operations. Clean material will be disposed of as described in Section 6.0 of this SOP. Decontamination and wash water will be handled in accordance with SOP RMRS/OPS-PRO.112, Handling of Field Decontamination Water. Material that is determined to be contaminated shall be handled as described in Section 6.0 of this SOP.

#### 4.2 Well Abandonment Methods

Upper Hydrostratigraphic Unit (UHSU) wells that are to be abandoned at RFETS will generally be abandoned in place. This method conforms to the abandonment standards required under the Colorado Office of the State Engineer's Rule 16, Standards for Plugging, Sealing, and Abandoning Wells and Boreholes, 2 CCR 402-2. The abandonment in place method has been selected for shallow wells because the volume of waste generated is minimized and the method poses no threat of cross-contamination to the deeper portion of the saturated zone at a given UHSU well location. If this abandonment method is not appropriate because of unforeseen conditions, such as an obstructed or damaged well casing, the well shall be abandoned by one of the other three methods described below that involve physical removal of the well casing. All well casings that are abandoned in place shall be cut off a minimum of three feet below ground surface (bgs) in compliance with Rocky Flats Closure Contract Number DE-AC34-00RF01904.

In the case where a well is not abandoned in place, some of the annular materials may be removed to promote an adequate seal between the borehole wall and the grout used to fill and plug the borehole. The cuttings generated from casing removal well abandonments must be contained, handled and disposed of in accordance with the RFCA Standard Operating Protocol for Asphalt and Soil Management. Fluids (groundwater and diluted grout) generated from well abandonment will be handled as described in RMRS/OPS-PRO.113, Groundwater Sampling. Section 6.0 of this SOP deals with the handling and disposition of wastes generated during well abandonments.

The most appropriate method of abandonment for a particular well depends upon analysis of the factors listed above in Section 4.1; the Colorado Office of the State Engineer's Rules and Regulations for Water Well Construction, Pump Installation, and Monitoring and Observation Hole/Well

Construction; and professional judgement. Abandonment methods shall be outlined on a well-by-well basis and presented in appropriate work control documents, such as the yearly WARP Work Plan addenda.

Four general methods of well abandonment are available and appropriate for monitoring wells at RFETS:

- Casing Pulling
- Casing Destruction (drilling out PVC casing)
- Overdrilling
- Abandonment in Place (may include ripping or perforation of well casing)

The following sections describe the four methods of well abandonment.

#### 4.2.1 *Casing Pulling*

Two-inch wells with stainless steel casings shallower than approximately 50 feet can potentially be abandoned by casing pulling. This is not the preferred method of abandoning these wells but may need to be employed if a stainless steel well needs to be physically removed from a given location. Casing may be pulled from the borehole using hydraulic jacks, a forklift, or the lifting capabilities of a drill rig. To perform casing pulling, it will be necessary to attach the well casing to the drilling rig hydraulic feed, the hydraulic jack, or the forklift. The appropriate and safest method for accomplishing this shall be determined by field personnel based on existing conditions at a particular well. A vibration hammer may be used to augment casing pulling by hammering on the well casing to loosen and break it free from the annular materials. Bentonite grout shall be placed in the well casing, in a consistency enabling flow through the well screen, to minimize collapse (or the effects of collapse) of the borehole as the casing is pulled and to implement the grouting of the borehole. Because the integrity of the annular materials may be high, it is possible that casings in some of these wells will exceed the available lifting capabilities of the drilling rig or jacking equipment, making it necessary to resort to overdrilling (Section 4.1.3 below). Should the stainless steel casing pull apart at the threads or break, a drill rig equipped with hollow-stem augers shall be utilized, as described in the Sections 4.2.2 or 4.2.3, to remove the remainder of the well casing and screen.

Small diameter PVC (0.5, 0.75, and 1-inch) monitoring wells will be abandoned by casing pulling if possible. These wells were installed in small diameter boreholes advanced with a Geoprobe rig. Those wells smaller than 1-inch diameter will have very little sand pack and annular seal to lock them in place. Accordingly, these wells should be removed completely because of the lack of well construction and borehole seal integrity associated with the small borehole size. While this is not the case with 1-inch diameter wells, casing pulling may also be appropriate for them. Small diameter wells will be removed by either hand winching with a tripod-mounted winch, or by casing pulling with a Water Programs Geoprobe unit.

Sealing the borehole as the well casing is removed is necessary because the borehole may collapse as the casing is withdrawn. There are several ways to accomplish this. One is to lift the well casing several inches, use a length of rebar or similar tool to break off the bottom of the well and, after withdrawing the tool, use the well casing (while being withdrawn) as a tremie pipe to place grout into the borehole. Another method is to use an appropriately sized, small diameter, steel tremie pipe with a pointed steel bottom and perforations in the lower two or three feet that can be inserted into the well casing after it has been lifted a few inches off the borehole bottom. The tremie pipe will be used to

break the bottom of the well off. The borehole will then be grouted from the bottom up and the PVC well casing removed as the tremie pipe is raised and removed. This abandonment method specifically meets the Colorado Office of the State Engineer's Rule 16.2.1 of 2 CCR 402-2.

If the above methods will not work, as may be the case with 0.5-inch PVC well casing and small diameter stainless steel wells, the well casing shall be totally removed from the borehole. The tremie pipe shall then be inserted into the borehole as far as possible and grout will be pumped until it reaches the ground surface and then allowed to settle. The grout level in abandonments of this type shall be checked within 24 hours and topped off if settling has occurred.

Monitoring locations that were constructed of 0.25-inch or 0.40-inch Teflon or polyethylene tubing shall be removed by pulling the tubing. The tubing was installed in 1-inch steel drive casing that was pulled back and the borehole was allowed to collapse around the tubing. Many of these wells have a 1-inch PVC protective casing (approximately 1-2 feet long) cemented in place over the tubing. This well protection shall be collected and disposed of. Granular bentonite shall be placed in the remaining borehole and hydrated. If it appears to the abandonment crew that the bentonite is not penetrating at least one foot into the borehole, the hole will be physically reamed with a metal rod or similar tool to at least one foot bgs and a granular bentonite seal placed and hydrated. Only deionized, distilled or approved Site water shall be placed in any borehole.

#### 4.2.2 *Casing Destruction*

Casing destruction can only be used on wells constructed with PVC well casing. In-place destruction of the casing can be accomplished by drilling out the casing. The casing destruction method may be utilized where a PVC monitoring well needs to be physically removed from a given location. Hollow stem auger and/or rotary drilling methods may be used as appropriate. A center bit or pilot bit attached to the lead auger or tricone bit, respectively, is advanced utilizing the well casing as a guide in drilling out the casing. In the case of rotary drilling, bentonite drilling mud may be utilized as the boring is advanced. Some or all of the original annular material will be removed from the borehole during the casing destruction run. The Field Supervisor will determine that total depth has been reached through the thorough examination of cuttings. When all of the PVC well casing and screen that is disseminated throughout the cuttings has been removed from the borehole, drilling will be terminated. Proposed well abandonments at RFETS are not anticipated to require the casing destruction method very often.

#### 4.2.3 *Overdrilling*

For the purpose of this SOP, overdrilling refers to the use of a hollow-stem auger to disrupt and/or remove annular materials from around the casing to isolate and free it for removal. Overdrilling may need to be employed if a stainless steel well needs to be physically removed from a given location and the casing cannot be pulled. The hollow-stem auger should have an inside diameter slightly larger than the well casing and the auger flights should be approximately the same diameter as the original borehole. Realistically, if the inside diameter of the augers is only slightly larger than the well casing, then the diameter of the auger flights will probably be slightly smaller than the original borehole.

The augers will be advanced to the total depth of the installed well casing. When this has been accomplished, the well casing will be removed (pulled), if possible, with the augers still in the borehole. If the well casing becomes stuck within the augers, and cannot be freed, the casing will be pulled simultaneously with the augers. Reaming the original borehole will not be necessary; some or

all of the original annular material (depending on the size of the augers utilized) will be removed from the borehole during the overdrilling run.

Overdrilling can be used on shallow to moderately deep wells where the well casing is embedded in relatively soft or unconsolidated lithologic material, and where the annular seal is composed of bentonite or a bentonite grout. A cement annular seal or lithified bedrock conditions can present problems for overdrilling with hollow-stem augers. In some situations, overdrilling may be used to a certain depth, possibly the interface between unconsolidated deposits and bedrock, with the portion of the well below the interface abandoned in place. Proposed well abandonments at RFETS are not anticipated to require the overdrilling method very often.

#### 4.2.4 *Abandonment In Place*

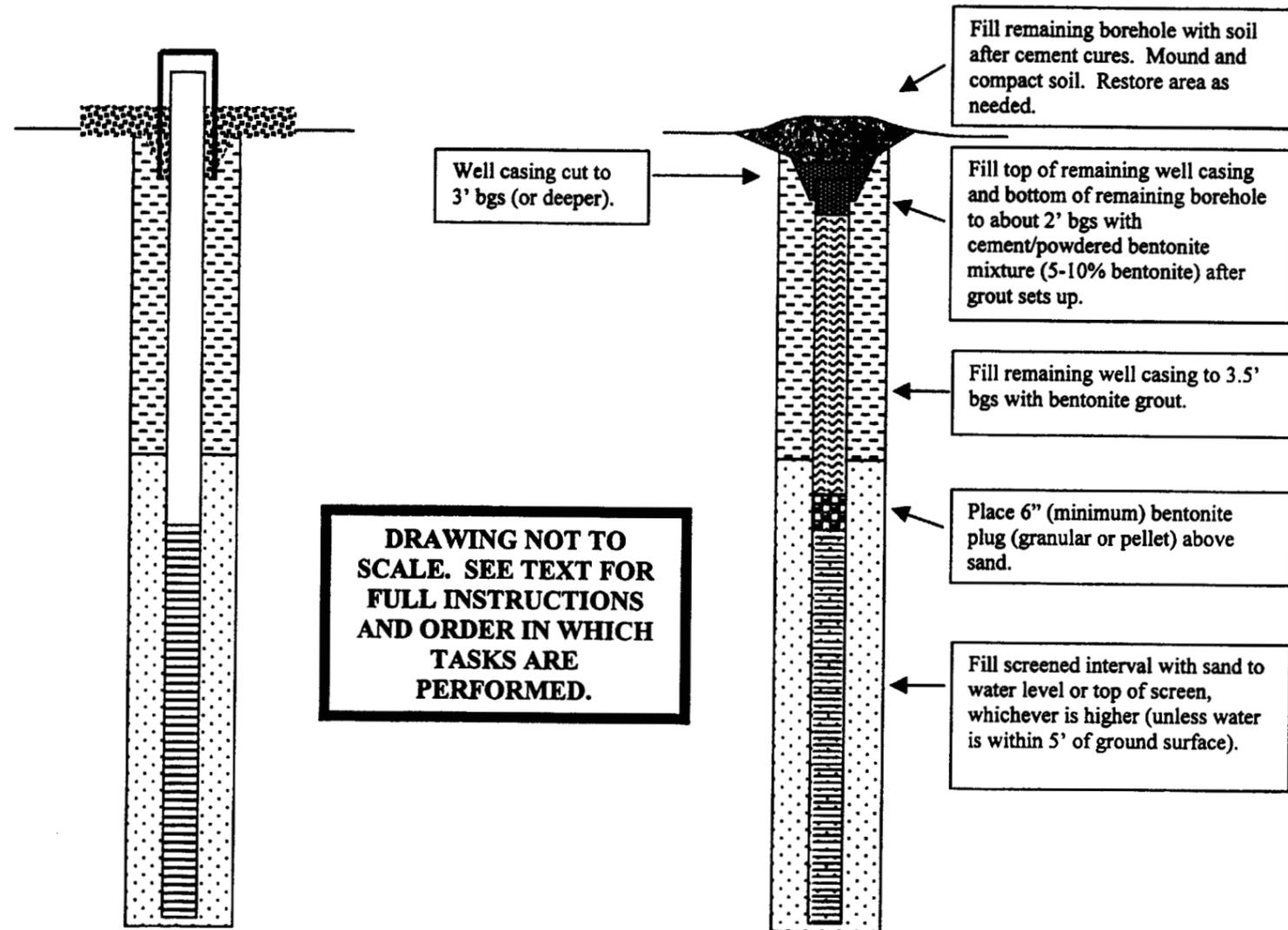
Wells that do not need to have the well casing physically removed may be abandoned in place. Except as noted below for Lower Hydrostratigraphic Unit (LHSU) wells, the well casing will be filled to the static water level or to the top of the well screen, whichever is higher, with clean inert sand (preferably Colorado silica sand sized slightly greater than the screen slot size). A six-inch bentonite plug (pellets or chips; granular bentonite may be placed above the water table) shall be placed above the sand to keep grout from infiltrating the sand. The plug shall be hydrated with a minimal amount of deionized, distilled, or approved Site water if the water level within the well casing after sand placement is not high enough to hydrate it. The rest of the well casing will be grouted as described in the next section. This method of well abandonment specifically meets (and exceeds) the Colorado Office of the State Engineer's Rule 16.2 of 2 CCR 402-2. See Figure AWB-1 for details.

In no case shall sand be placed in a well casing at a depth less than 5 feet bgs. If the water level is shallower than 5 feet bgs, the bentonite plug (pellets or chips) shall be placed at the five-foot level and allowed to hydrate. If the well screen is shallower than 5 feet bgs, the bentonite plug shall begin at the five-foot level and continue to at least 6 inches above the top of the screen. In either of these cases it is acceptable to complete the bentonite plug to approximately 3.5 feet bgs; bentonite grout need not be prepared to fill the small distance left between the top of the bentonite plug and the ground surface. Figure AWB-2 presents sketches of shallow-screened wells abandoned in place.

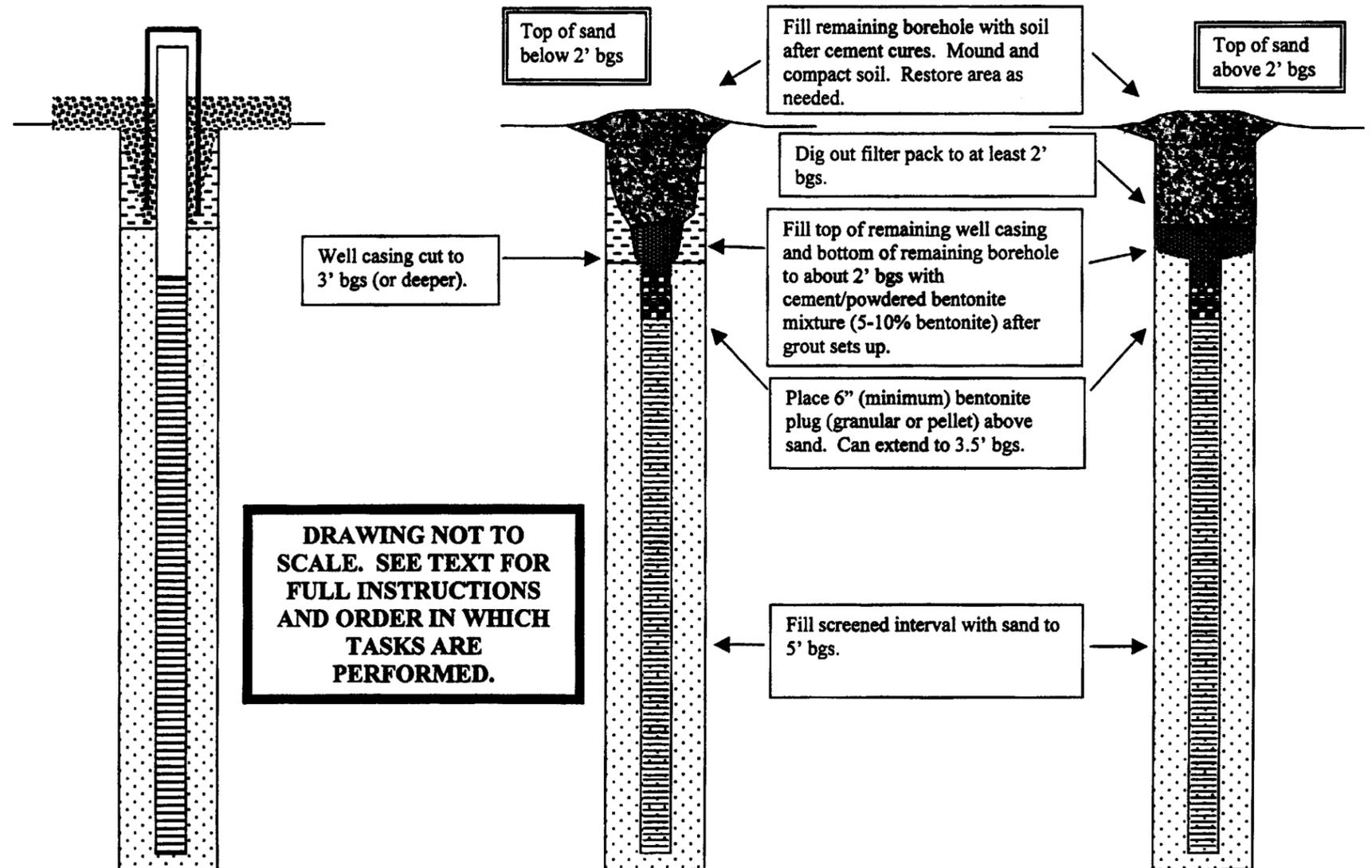
If a well is dry, it shall be filled with clean inert sand to the top of the well screen (unless it is less than 5 feet bgs) and the bentonite plug shall be placed and hydrated; then it shall be grouted as described in the next section. This method of well abandonment specifically meets (and exceeds) the Colorado Office of the State Engineer's Rule 16.2 of 2 CCR 402-2.

Wells penetrating more than one aquifer (LHSU wells) may also be abandoned with the casing left in place, provided that well construction documentation indicates that the casing opposite each confining layer or between two contaminant zones was properly grouted. These wells shall be completely filled from top to bottom with cement grout, as shown in Figure AWB-3. The grout shall be applied by the tremie method in as thick a state as can be pumped. If a well penetrating more than one aquifer is known to be non-viable because of absent or inadequate annular grout seal, or the construction records are incomplete, the well casing will either be completely removed from the borehole (by overdrilling or casing destruction) or be perforated or ripped opposite the confining layer prior to grouting with cement. Grout plugs in this instance will be designed to withstand the maximum potential hydrostatic pressure differential between the aquifers or saturated zones. This abandonment method specifically meets the Colorado Office of the State Engineer's Rule 16.3 of 2 CCR 402-2. The drilling subcontractor shall supply the tool(s) needed for well casing perforation or ripping.

**FIGURE AWB-1: UHSU well with top of screen and top of filter pack below 5' bgs**



**FIGURE AWB-2: UHSU well with top of screen and/or top of filter pack above 5' bgs**





Monitoring wells abandoned under this SOP are generally proposed to be abandoned in place except for the small diameter (1-inch or less) PVC and tubing installations. Abandonment in place is an appropriate method because most well completions are in the unconfined UHSU consisting of alluvial and weathered bedrock materials, the deep LHSU wells have good well completion documentation, and because the method will reduce the volume of waste. The actual abandonment method for a specific well will be determined based on the physical condition of the well and/or any relevant issues regarding the location of the well.

#### 4.3 Grouting

The specifications and procedures for grouting wells and boreholes are essentially the same. For the purpose of this SOP, the term "grout" refers to a slurry having a specific consistency, used to fill and seal a borehole, well, or annulus, depending on the application. The slurry may be composed of powdered, reduced pH, bentonite (e.g., Pure Gold or equivalent) or cement (e.g., Portland Type 2) mixed with the appropriate volume of distilled, deionized, or approved Site water.

The density of each batch of bentonite grout shall be checked with a mud balance prior to pumping. The bentonite grout shall contain at least 30 percent solids by weight and have a minimum density of 9.9 pounds/gallon after mixing, or be in compliance with the manufacturer's recommendations. (This specification may be waived in the instance where a well is being grouted through the well screen as the well casing/screen is being pulled.)

Grout will be pumped by the tremie method from the bottom of the borehole or well casing upward, through either a tremie pipe or drill rod. The bottom of the grout placement pipe shall always be located at least two feet below the top of the grout slurry. If the borehole or well casing is less than six feet deep, the seal may instead consist of bentonite pellets or chips slowly poured into the borehole or well casing. In order to minimize borehole collapse, boreholes with the well casing already removed shall be tremie grouted by inserting the tremie pipe through the hollow-stem augers (or other temporary casing) used for casing destruction or overdrilling the well, with auger sections being removed as grouting progresses.

In the case of LHSU wells, as per the Colorado Office of the State Engineer's specifications, grout shall consist of pure cement grout placed throughout the entire length of the well, including the screen. This grout shall be mixed as thick as it can be pumped to the base of the well via tremie pipe.

Once the grout is to within 3-4 feet of the ground surface, the well casing will be cut (with a downhole PVC or stainless steel casing cutter) below the concrete pad/plug. (This does not apply to wells scheduled to be abandoned via casing removal or destruction. In those cases, the casing will be cut but not grouted.) The appropriate heavy equipment shall then be used to remove the concrete pad/plug and steel protective casing in one piece. The well casing shall be recut to its final depth (approximately 3 feet bgs) and well abandonment shall be completed (see Section 4.4). If necessary, the protective casing/concrete can then be surveyed by an RCT. The concrete shall be disposed of as described in the RFCA Standard Operating Protocol for Recycling Concrete.

Grouting shall be performed in as continuous a process from bottom to top as is practicable to minimize grout segregation, dilution, and bridging problems. If possible, the tremie pipe will be kept near the bottom of the borehole or well casing. Grouting shall continue until undiluted grout is observed emanating from the borehole or well casing. It is advantageous to purge the well casing or borehole of groundwater prior to grouting in order to minimize and more easily handle the quantity of

waste fluid that must be containerized and disposed. In slower producing LHSU wells, this will allow the cement grout to begin to cure relatively unaffected by dilution with groundwater.

#### 4.4 Surface Protection

Concrete markers for abandoned wells are no longer required at RFETS as per Site closure requirements. The ultimate goal of Site closure is to leave no trace of previous Site structures, including monitoring wells. The placement of a concrete slab at the ground surface at each abandoned well site from the present until Site closure shall not be performed. Well abandonment grouting will commence to approximately 3-4 feet bgs; well casings that remain in place will be removed to, or cut off at, a depth of approximately 3 feet bgs; and the protective casing and original concrete well pad shall be removed. The remaining hole will be filled with cement/bentonite grout (at a mix of approximately 1 gallon of cement to 11 ounces of bentonite) to 1-2 feet bgs. The cement shall be Portland Type 2 or equivalent and the bentonite shall be Pure Gold or equivalent; mixed only with distilled, deionized, or approved Site water. This grout will be allowed to cure and then fill dirt will be used to top off the hole to approximately the existing ground surface elevation. The surface fill material will be consistent with or of lower permeability than the surrounding surface soil and be slightly mounded after placement and compaction by foot pressure.

Any UHSU wells with screens extending to shallower than about 4 feet bgs may also have their sandpack extending to shallower than 2 feet bgs. The sand will be removed manually down to at least 2 feet bgs before the abandonment of the remaining hole. This removed sand can be spread on the ground around the wellsite to a thickness of not more than 0.5 inches.

All LHSU wells that are abandoned, whether stainless steel or PVC, shall have a watertight cover permanently attached to the top of the severed well casing as per the Colorado Office of the State Engineer's Rule 16.3 of 2 CCR 402-2. To satisfy this requirement, an appropriately sized permanent watertight cap will be installed inside the top of the well casing to seal off the well casing. The watertight cap will then be sealed within the cement surface protection. If, at a specific location, this option is deemed inappropriate, the Water Programs Project Manager will be contacted for direction.

Surface protection for boreholes shall be accomplished by tremie grouting with bentonite grout as described above to approximately 3 feet bgs, allowing the grout to set up for 48 – 72 hours, and then completing the abandonment with cement/bentonite grout to 1-2 feet bgs as described above. The cement/bentonite grout will be allowed to cure and then fill dirt will be used to top off the hole to approximately the existing ground surface elevation. The surface fill material will be consistent with or of lower permeability than the surrounding surface soil and be slightly mounded after placement and compaction by foot pressure. Concrete markers for abandoned boreholes are not required.

#### 5.0 **EQUIPMENT DECONTAMINATION**

Decontamination procedures described in SOP PRO-1455-FDO, Field Decontamination Operations, and SOP PRO-1389-MDF, Equipment Decontamination at Decontamination Facilities, shall be followed. Decontamination and wash water shall be handled according to SOP RMRS/OPS-PRO.112, Handling of Field Decontamination Water.

Hollow-stem augers, tremie pipe, or any other downhole tools or monitoring instruments shall not be used in two successive boreholes or wells without being decontaminated between locations.

## 6.0 HANDLING AND STORAGE OF WASTE MATERIALS

All intrusive work/excavations require a Soil Disturbance Permit (SDP), therefore, drilling activities related to well abandonment shall require an SDP. Wastes generated during well abandonment shall be handled per the procedures described below and sampled per the SDP and other work controlling documents (e.g., Waste Generator Instruction, Waste Release Evaluation) as appropriate. The Water Programs Project Manager, who shall be Waste Generator qualified, or a subcontractor Waste Generator qualified individual shall be available to ensure that potential hazardous and/or radioactive wastes are handled, packaged, and transferred as necessary. The specific handling of the well/borehole abandonment wastes listed below will be covered by the appropriate Waste Generator Instruction (WGI), Waste Release Evaluation (WRE), and/or other work control document.

As Site monitoring wells are abandoned, waste will be generated. This material will consist of, but may not be limited to, groundwater, excess (diluted) bentonite grout, well site decontamination and wash water, concrete pads, pipe (PVC and stainless steel well casing and screen, well protectors), drill cuttings, general site trash (plastic sheeting, etc.), and PPE. Abandonment in place generates minimal waste. A well that is abandoned in place will typically generate some groundwater (as it is purged either before or during grouting) and diluted grout, a well protector and concrete pad, and possibly some PPE and site trash. Casing pulling will generate more waste than abandonment in place. By far the greatest amount of waste will be generated at wells abandoned by either casing destruction or overdrilling. These methods, as well as casing pulling, will generate the actual well casing and screen. Casing destruction and overdrilling will also generate drill cuttings in addition to the waste that an abandonment in place or a casing pulling abandonment will generate.

Waste generated during well abandonment will generally comprise three waste streams:

1. Groundwater, diluted grout, and decontamination and wash water
2. Disseminated and whole concrete pads
3. The rest of the materials (includes cuttings, pipe, site trash, and PPE)

The following describes the methods that will typically be followed to handle and store these materials. However, the work control documents that apply specifically to the well(s) being abandoned shall take precedence over the following description.

### 6.1 Liquids

Groundwater (purge water) and diluted grout generated during well/borehole abandonments shall be collected at the wellhead and transferred to a temporary (satellite) holding container or a purge water collection container similar to those used in the Water Programs groundwater-sampling vehicles. The abandonment purge liquids shall be handled in the same manner as groundwater purged during routine sampling events at the Site; according to procedures outlined in RMRS/OPS-PRO.113, Groundwater Sampling. The amount of liquid generated during a well abandonment may vary from a few gallons to over a hundred gallons. The preferred method will be wellhead containment of the purged liquids with a collection funnel. The funnel is mounted in the wellhead and the tremie pipe is inserted through it. The displaced fluid collects in the funnel and either gravity flows through an exit hose (depending on if the well has a stickup or is flush mount) or is pumped or bailed into the collection container.

Decontamination water and wash water derived at the wellsite shall be containerized and handled in a similar manner as purged abandonment fluids (groundwater and diluted grout); according to the procedures outlined in RMRS/OPS-PRO.112, Handling of Field Decontamination Water.

Fluid wastes from well/borehole abandonment activities shall be containerized and eventually transferred to Building B891, the Consolidated Water Treatment Facility (CWTF). Segregation of different fluids (purge water, diluted grout, decontamination water) shall not be required. Prior arrangement shall be made with the Building B891 Facility Manager in advance of delivery of fluids.

Groundwater and diluted bentonite grout that is purged from monitoring wells located in the 903 Pad remediation area, any radiologically posted area, or any area that is determined to be radiologically impacted based on soil sampling data shall be handled and disposed of as typical groundwater. This is because the groundwater and diluted grout from these areas is not radiologically impacted; only the surface soils in the vicinity of the well(s) are potentially radiologically contaminated. Data supporting this conclusion includes radiological screening samples from wells across RFETS, including wells in radiologically impacted areas, none of which have ever recorded a result approaching the 2 nanocuries/milliliter Department of Transportation (DOT) limit for transport of liquid. Therefore, Water Programs treats this water like any other water that is collected from groundwater sampling, development, and abandonment activities.

#### 6.2 Concrete

Where feasible, concrete well pads, whether whole or broken up, shall be handled according to the RFCA Standard Operating Protocol for Recycling Concrete. If this is not feasible, the concrete shall be handled in accordance with Section 6.5 (if radiologically contaminated) or Section 6.6 (if not radiologically contaminated).

#### 6.3 Well Casing and Pipe

Pipe that will be generated during a casing removal well abandonment (either casing pulling or overdrilling) will typically consist of PVC or stainless steel casing and screen; and steel, generally 6-inch diameter, well protectors. Small diameter wells may have PVC well protectors and flush-mount assemblies or, in some cases, no well protection. Well casing will be cut into manageable (e.g., 20 foot) lengths as it is removed from the borehole and, when time permits, cut into sections between 5 and 10 feet long. The casing will be cleaned with a brush to remove visible dirt and/or debris and will be screened for VOCs by Water Programs or subcontractor personnel according to the procedures outlined in the HASP. RCTs will collect field radiological measurements of these materials per the requirements of K-H Radiological Engineering. All casing determined to be above any VOC or radiological background level will be handled and disposed of as described in Section 6.5 below.

#### 6.4 Cuttings

Cuttings that may be generated from casing removal well abandonments will be handled according to the RFCA Standard Operating Protocol for Asphalt and Soil Management and will generally consist of some in-place native soil combined with the annular well completion materials. If the casing destruction method is used, the cuttings may also include disintegrated PVC. Under no circumstance can cuttings containing disseminated PVC be spread on the ground as described in the following paragraph; this waste will be handled according to Sections 6.5 or 6.6 as appropriate. All of the cuttings material and potentially some groundwater may become mixed as they are brought up the borehole by the auger flights.

Prior to generating cuttings, the Subject Matter Experts (SMEs) for the RFCA Standard Operating

Protocol for Asphalt and Soil Management shall be contacted and informed of the planned activity, in particular the location(s) from which cuttings will be generated. If the SMEs so approve, a written record of the approval shall be kept and work may commence. The cuttings material shall be spread on the ground in the vicinity of the well abandonment to a thickness of no greater than 0.5-inches. Casing removal of a deep (LHSU) well will generate a relatively large amount of cuttings. K-H Ecology shall be consulted regarding the disposition of the cuttings at these locations, on a well by well basis, based on the amount of material generated with respect to the constraints of the specific location. If cuttings from a specific location cannot be spread around the wellsite, a rolloff container shall be lined with plastic to facilitate their disposal. Alternatively, the cuttings may be able to be spread on the surface of the Present Sanitary Landfill and incorporated into its post-closure cap. K-H Sanitary and Special Wastes Projects shall make this determination.

#### 6.5 Radiologically Impacted Wastes

As described above, all intrusive work requires an SDP and wastes generated during well/borehole abandonments shall be handled as described below and sampled per the SDP as appropriate. Specific areas at RFETS have radiological postings associated with them and the well/borehole abandonment wastes generated in those areas shall be screened and inspected by K-H Radiological Operations before their final disposition. Prior to commencing well/borehole abandonment fieldwork, all personnel involved with the field activity shall review the area of investigation. In the case of a well abandonment in a posted radiological area, an RCT shall be procured and available to screen the wastes as they are generated. Materials that are generated in posted radiological areas shall be surveyed by an RCT piece by piece. If it is determined that most of the material at a given location is radiologically contaminated, it can all be certified as Low-Level waste (LLW). These wastes will be handled and containerized per the waste SME, WGI, and any other applicable requirements. Regardless of how radiologically contaminated material is segregated, it will need to have a Waste Release Evaluation (WRE) prepared by K-H Radiological Engineering before the material can be disposed of.

Wastes generated in radiological areas will be segregated as two general types of waste. The two types are identified by hard surfaces (surface contaminated objects, or SCO); or soft pliable surfaces (low specific activity, or LSA objects). SCO shall consist of pipe and concrete; LSA shall consist of PPE, cuttings, paper and cardboard trash, and plastic sheeting. All SCO can be placed in the same container (e.g., crate); LSA will be placed in three different containers. PPE and plastic waste shall be placed in one, combustible trash (paper, cardboard and wood, if any) in another, and cuttings (managed under the RFCA Standard Operating Protocol for Asphalt and Soil Management) in a third container. The containers shall be located in a rolloff container that has a locking cover or other secured facility. These materials shall then be sent to the appropriate facility for counting or other non-destructive assay.

#### 6.6 Staging and Disposition of Non-Radiological Wastes

All uncontaminated waste materials (with the exception of fluids and most cuttings), including PPE and site trash, shall be staged and placed in a project dumpster or rolloff container. A waste characterization SME shall be available to the WARP project and shall be notified each time that a load of materials is transported to the waste container. The SME shall determine when he/she would like to inspect the waste materials before they are placed in the rolloff container.

## 7.0 QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance (QA) and quality control (QC) activities will be accomplished according to applicable project plans as well as quality requirements presented in this SOP. These activities will also comply with DOE Order 5700.6C and with the Water Programs Quality Assurance Program Plan (QAPP) for the Groundwater Monitoring Program (01-RF-00338).

## 8.0 DOCUMENTATION

The Field Supervisor or designee responsible for specific well/borehole abandonments shall document information required by this SOP on the Well/Borehole Abandonment form (form PRO.AWB). Environmental materials handling will be documented along with any pertinent information regarding well and borehole abandonments in a project field logbook, which will serve as the supporting documentation for form PRO.AWB. The Well/Borehole Abandonment Form and field logbook shall include, but not be limited to, the following information:

- Project name, date, and well/borehole number
- Crew members including drilling contractor crew and RCT(s), if applicable
- Weather conditions
- Description of equipment used (rig, tremie pipe, pump, etc.)
- Water level (if any) in well or borehole prior to abandonment
- Borehole depth/diameter
- Amount of sand placed and interval filled
- Amount of grout placed and interval filled
- Type/length/diameter of casing/screen removed
- Type/depth/diameter of casing/screen left in place
- Identity of all visitors
- Chronological record of activities

Pertinent information recorded on form PRO.AWB shall be entered into the soil and water database (SWD) and the Waste and Environmental Management System (WEMS) in accordance with procedure PRO-1058-ASD-005, Environmental Data Management.

Copies of the completed Well/Borehole Abandonment Form, signed by the Field Supervisor, shall be delivered to the Water Programs Project Manager. The Well/Borehole Abandonment Form and a State of Colorado Well Abandonment Report (State of Colorado Form No. GWS-09, 06/00) will be completed and provided to the Water Programs Project Manager. The State of Colorado Form No. GWS-09 is required only if the abandoned well had previously been permitted through the State of Colorado, Division of Water Resources. Water Programs shall submit Form No. GWS-09 to DOE for review, approval, and transmittal to the State of Colorado, Division of Water Resources. The Water Programs Project Manager shall supply blank copies of this form to the Field Supervisor. Form PRO.AWB is presented below after Section 9.0.

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**9.0 REFERENCES****9.1 Source References**

The following is a list of references reviewed prior to the writing of this procedure:

Aller, L., T.W. Bennett, G. Hackett, R.J. Petty, J.H. Lehr, H. Sedoris, D.M. Nielsen, and J.E. Denne.  
Handbook of Suggested Practices for the Design and Installation of Ground Water Monitoring  
Wells. EPA 600/4-89/034. National Water Well Association. 1989. 398 pp.

State of Colorado, Office of the State Engineer, State Board of Examiners of Water Well  
Construction and Pump Installation Contractors, 2 CCR 402-2. 2000. 53 pp.

**9.2 Internal References**

Related SOPs cross-referenced by this SOP are as follows:

- SOP PRO-1389-MDF, Equipment Decontamination at Decontamination Facilities
- SOP RMRS/OPS-PRO.102, Borehole Clearing
- SOP RMRS/OPS-PRO.112, Handling of Field Decontamination Water
- SOP RMRS/OPS-PRO.113, Groundwater Sampling
- SOP RMRS/OPS-PRO.114, Drilling and Sampling Using Hollow-Stem Auger and Rotary Drilling and Rock Coring Techniques
- SOP PRO-1455-FDO, Field Decontamination Operations
- RFCA Standard Operating Protocol for Asphalt and Soil Management
- RFCA Standard Operating Protocol for Recycling Concrete
- SOP PRO-1058-ASD-005, Environmental Data Management

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE  
FORM PRO.AWB (REV. 0)  
U.S. DEPARTMENT OF ENERGY

WELL/BOREHOLE ABANDONMENT FORM

WELL/BORING LOCATION: \_\_\_\_\_ DATE: \_\_\_\_\_  
PROJECT NAME: \_\_\_\_\_ SUBCONTRACTOR: \_\_\_\_\_

Well Specifics (as applicable)

CONSTRUCTED CASING DEPTH (FT): \_\_\_\_\_ BORING DIAMETER (IN): \_\_\_\_\_  
MEASURED DEPTH (FT): \_\_\_\_\_ WATER LEVEL (FT from TOC): \_\_\_\_\_  
SCREEN TYPE: \_\_\_\_\_ SCREEN DIAMETER AND LENGTH: \_\_\_\_\_  
SCREENED INTERVAL (FT): \_\_\_\_\_  
STICK UP OR FLUSH MOUNT: \_\_\_\_\_  
PENETRATES CONFINING LAYERS? (Y/N): \_\_\_\_\_  
AQUIFER(S) MONITORED: \_\_\_\_\_  
REASON FOR ABANDONMENT: \_\_\_\_\_

Abandonment Specifics (as applicable)

ABANDONMENT METHOD: \_\_\_\_\_  
ABANDONMENT START DATE: \_\_\_\_\_ END DATE: \_\_\_\_\_  
FIELD BOOK ID NUMBER: \_\_\_\_\_ PAGE NUMBER(S): \_\_\_\_\_  
WEATHER CONDITIONS: \_\_\_\_\_  
GEOLOGIST/FIELD SUPERVISOR: \_\_\_\_\_  
WATER PROGRAMS/SUBCONTRACTOR PERSONNEL: \_\_\_\_\_

DRILLING COMPANY/DRILLERS NAME: \_\_\_\_\_

RIG TYPE: \_\_\_\_\_ DRILLING METHOD: \_\_\_\_\_

INTERVAL SAND PLACED: \_\_\_\_\_

TREMIE & PUMPING EQUIPMENT: \_\_\_\_\_

GROUT VOLUME PLACED (FT<sup>3</sup> or GAL) AND INTERVAL: \_\_\_\_\_

CASING REMOVED? (Y/N): \_\_\_\_\_ TYPE: \_\_\_\_\_

DIAMETER (IN): \_\_\_\_\_ LENGTH (FT): \_\_\_\_\_

CASING LEFT IN PLACE? (Y/N): \_\_\_\_\_ TYPE: \_\_\_\_\_

DIAMETER (IN): \_\_\_\_\_ DEPTH INTERVAL (FT): \_\_\_\_\_

SURFACE SEAL DEPTH (FT): \_\_\_\_\_ DATE SET: \_\_\_\_\_

CONCRETE PAD/METAL ID PLATE INSTALLED? (Y/N): \_\_\_\_\_

IF YES, WHY?: \_\_\_\_\_

DISPOSITION OF MATERIAL REMOVED: \_\_\_\_\_

COMMENTS OR PROBLEMS ENCOUNTERED: \_\_\_\_\_

STATE ENGINEER'S WELL ABANDONMENT FORM GWS-09 COMPLETED? (Y/N): \_\_\_\_\_

DATE FORM SUBMITTED: \_\_\_\_\_ WELL PERMIT NUMBER \_\_\_\_\_

Completed by: \_\_\_\_\_ Date: \_\_\_\_\_

Print Name Signature

Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

Print Name Signature

22/22