
USACE / NAVFAC / AFCEA / NASA UFGS-33 24 13 (August 2008)

Preparing Activity: USACE Superseding
UFGS-33 24 13 (April 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2012

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08/08

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SECTION 33 24 13

GROUNDWATER MONITORING WELLS 08/08

NOTE: This guide specification covers the requirements for ground water monitoring wells for hazardous and non-hazardous waste sites.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

PART 1 GENERAL

NOTE: Use Section 33 24 00.00 20
[EXTRACTION] [MONITORING] WELLS for ground water extraction and associated testing to contain and remove groundwater from the aquifer.

In most monitoring wells, because optimum yield from the well is not as critical to achieve as it is in production or extraction wells, and because extensive development is more difficult to accomplish in small diameter wells, screens are usually designed to have smaller openings, so that less formation material will be pulled into the well during the development and sampling.

Use Section 33 20 00 WATER WELLS for water supply

wells and associated testing.

Use Section 33 26 00.00 10 RELIEF WELLS for projects relating to the relief of excess hydrostatic pressures adjacent to dams, locks, levees or other water retaining structures.

Coordinate and specify the appropriate pump for the specified well in a separate section.

Include the following in the drawings, and any other information necessary to indicate layout and general configuration of the well:

1. Diameter of drilled hole
2. Casing diameter
3. Well screen diameter, length, location, and slotted opening size
4. Minimum depth of casing and minimum depth well screen
5. Limits of primary and secondary filter packs
6. Limits of bentonite seal and grout seal
7. Type of cap, cover, or seal required at top of well.

Include the applicable state and local regulatory references where appropriate in the body of the specification.

Use the following specifications in conjunction with this section:

UFGS 00 22 13 SUPPLEMENTARY INSTRUCTIONS TO BIDDERS

UFGS 01 35 26 GOVERNMENTAL SAFETY REQUIREMENTS

UFGS 01 35 29.13 HEALTH, SAFETY, AND EMERGENCY RESPONSE PROCEDURES FOR CONTAMINATED SITES

UFGS 01 32 01.00 10 PROJECT SCHEDULE

[UFGS 01 32 16.00 20 CONSTRUCTION PROGRESS DOCUMENTATION] or

[UFGS 01 32 17.00 20 NETWORK ANALYSIS SCHEDULES (NAS)]

UFGS 01 45 00.00 20 QUALITY CONTROL

UFGS 01 45 00.00 10 QUALITY CONTROL

UFGS 01 35 45.00 10 CHEMICAL DATA QUALITY CONTROL

UFGS 02 81 00 TRANSPORTATION AND DISPOSAL OF
HAZARDOUS MATERIALS

[1.1 UNIT PRICES

NOTE: This paragraph will be deleted if the work is in one lump-sum contract price. If it is retained and more detail is needed, items of consideration may include: test holes, monitoring well drilling and sampling, geophysical logging, non-hazardous sludge, pumpable liquids, analytical (PCB & asbestos), analytical (contaminated water), piping removal or capping and sealing, and remainder of work. Coordinate this paragraph with the bidding schedule.

Payment for each specified item is made at the contract unit price for that item. Payment includes full compensation for equipment, materials and labor for drilling; removal and disposal of temporary casing, cuttings, and drill fluid; preparation of borehole logs; and sample handling, containers, storage, and testing. Measure depth, logging, installation, casing, riser pipe, and well screen by linear distance. Payment is not allowed for test holes or monitoring wells abandoned due to construction practices not in accordance with this specification, or for the convenience of the Contractor. Submit catalog data for monitoring well screens (to include the screen slot size), casing, riser pipe, filter pack material, bentonite, cement, centralizers, surface protective covers, well vaults, locking caps, airline oil filters for pneumatic drilling, dedicated sampling equipment, and chemical specifications on drill lubricants and tracers, if used. Include any information, written or otherwise, supplied by the manufacturers or suppliers of the above listed items.

1.1.1 Test Holes

If the total depth of the test hole is greater than that specified in the contract for "Test Holes, and Samples," the additional depth is paid for at the contract unit price for "Additional Test Hole Depth." If the test hole is developed into the permanent monitoring well, no separate payment is made for the test hole.

1.1.2 Monitoring Well Drilling and Sampling

If the total depth of the monitoring well is greater than that specified in the contract for "Monitoring Wells and Samples," the additional depth is paid for at the contract unit price for "Additional Monitoring Well Depth."

1.1.3 Geophysical Logging

The "Geophysical Logging" unit price includes interpretation of the logs and their delivery to the Government.

1.1.4 Casing/Riser Pipe Selection and Installation

Payment is made for length of blank casing actually installed in the well. Payment includes compensation for decontamination and installation of the casing/riser pipe, cap, tail piece (if any), end cap and centralizers; and

for the furnishing and installing of the well identification tag with information recorded thereon, or well marking in accordance with contract.

1.1.1.5 Monitoring Well Screen

Payment is made for monitoring well screen actually installed in the well.

1.1.1.6 Filter Pack Construction

Filter pack construction is measured by the cubic meter foot. Payment includes compensation for furnishing, delivering, storage, decontamination, analytical testing, and installing the filter pack.

1.1.1.7 Bentonite Seal

The bentonite seal is measured by the cubic meter foot. Payment includes full compensation for hydrating, and tremieing necessary for the work.

1.1.1.8 Grout Placement

The cement and/or bentonite grout ASTM C1107/C1107M, and ASTM D4380, used in the annulus above the bentonite seal is paid by the cubic meter foot used. Payment includes compensation for cement, mixing of the grout, and pumping of grout, bentonite, mixing of bentonite grout, and pumping of bentonite grout, necessary for the work.

1.1.1.9 Monitoring Well Development

Payment for monitoring well development is made by the hour. Payment includes compensation for pumping, surging, bailing, sample photograph, discharge water containers, and disposal.

1.1.1.10 Monitoring Well Completion Aboveground

Payment includes compensation for protective covers, keyed-alike padlocks, locking caps, project photographs, concrete well pads, gravel, and protective steel posts.

1.1.1.11 Monitoring Well or Test Hole Decommissioning/Abandonment

Permanent decommissioning/abandonment of monitoring wells or test holes is paid for only if it becomes necessary to abandon a well or test hole as specified, and only for work completed and accepted as specified. Payment includes compensation for drilling, casing removal, well sampling, materials, cement, mixing of cement, bentonite, and water, pumping of grout, equipment, removal of foreign objects, and transportation necessary to abandon the well or test hole and for the required well or test hole abandonment records.

1.1.1.12 Site Cleanup

Separate payment is not made for cleanup of the site. Cleanup means restoring the site to its pre-construction condition, in accordance with paragraph SITE CLEANUP. Cleanup is considered part of and incidental to the drilling, construction, and/or decommissioning of the monitoring well.

]1.2 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

State and/or local regulations/requirements may also need to be referenced.

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA 10084 (2005) Standard Methods for the Examination of Water and Wastewater

ASTM INTERNATIONAL (ASTM)

ASTM A312/A312M (2011) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes

ASTM C1107/C1107M (2011) Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)

ASTM C136 (2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

ASTM C150/C150M (2011) Standard Specification for Portland Cement

ASTM C387/C387M (2011) Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete

ASTM D1586 (2008a) Penetration Test and Split-Barrel Sampling of Soils

ASTM D1785 (2006) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120

ASTM D2216 (2010) Laboratory Determination of Water

	(Moisture) Content of Soil and Rock by Mass
ASTM D2487	(2011) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2488	(2009a) Description and Identification of Soils (Visual-Manual Procedure)
ASTM D422	(1963; R 2007) Particle-Size Analysis of Soils
ASTM D4318	(2010) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4380	(1984; R 2006) Standard Test Method for Density of Bentonitic Slurries
ASTM D4750	(1987; R 2001) Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)
ASTM D5079	(2008) Preserving and Transporting Rock Core Samples
ASTM D5088	(2002; R 2008) Decontamination of Field Equipment Used at Nonradioactive Waste Sites
ASTM D5092	(2004; R 2010e1) Design and Installation of Ground Water Monitoring Wells in Aquifers
ASTM D5299	(1999; R 2005) Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities
ASTM D5521	(2005) Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers
ASTM D5608	(2010) Decontamination of Field Equipment Used at Low Level Radioactive Waste Sites
ASTM D6725	(2004; R 2010) Standard Practice for Direct Push Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers
ASTM F 480	(2006be1) Thermoplastic Well Casing Pipe and Couplings Made in Standard Dimension Ratios (SDR), SCH 40 and SCH 80

FORESTRY SUPPLIERS INC. (FSUP)

FSUP 77341	(1999) Munsell (R) Soil Color Charts
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GEOLOGICAL SOCIETY OF AMERICA (GeoSA)

GSA RCC00100R (2009) Geological Rock Color Chart
(Munsell)

NSF INTERNATIONAL (NSF)

NSF/ANSI 14 (2011a) Plastics Piping System Components
and Related Materials

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1 (2008; Errata 1-2010; Changes 1-3 2010;
Changes 4-6 2011) Safety and Health
Requirements Manual

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 530/F-93/004 (1993; Rev O; Updates I, II, IIA, IIB, and
III) Test Methods for Evaluating Solid
Waste (Vol IA, IB, IC, and II) (SW-846)

EPA 600/4-79/020 (1983) Methods for Chemical Analysis of
Water and Wastes

EPA SW-846 (Third Edition; Update IV) Test Methods
for Evaluating Solid Waste:
Physical/Chemical Methods

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

49 CFR 172 Hazardous Materials Table, Special
Provisions, Hazardous Materials
Communications, Emergency Response
Information, and Training Requirements

1.3 SYSTEM DESCRIPTION

**NOTE: Designer must ensure that well design meets
or exceeds Federal, state, and local installation
requirements. Additional criteria may apply for
monitoring wells at radioactive, mixed, biological,
solid, or medical waste sites.**

Construct each monitoring well to yield chemically representative ground
water samples of the screened interval for chemical analysis, and to allow
for the accurate measurement of ground water depths relative to the top of
the well riser, by use of electrical, wetted tape, or acoustical methods.
The screened interval is that portion of a monitoring well which is
directly open to the host aquifer by way of openings in the well screen and
indirectly open to the aquifer by way of the filter pack (or other
permeable material) extending continuously below and/or above the screen.

[1.3.1 Prepacked Screen Monitoring Wells

Materials and installation of prepacked screen monitoring wells are to
conform to the requirements of ASTM D6725.

]1.3.2 Installation Plan

NOTE: The Monitoring Well Installation Plan may need to be included as a part of the Field Sampling Plan (FSP) which is a part of the Sampling and Analysis Plan (SAP) required in Section 01 35 45.00 10 CHEMICAL DATA QUALITY CONTROL.

The FSP is described in EM 200-1-3, Requirements for the Preparation of Sampling and Analysis Plans. EM 200-1-3 outlines the SAP format requirements, which include monitoring well installation.

EM 200-1-3 may be downloaded at the following Internet site:

NOTE: The Monitoring Well Installation Plan may need to be included as a part of the Field Sampling Plan (FSP) which is a part of the Sampling and Analysis Plan (SAP), and as required in Section 00 22 13 SUPPLEMENTARY INSTRUCTIONS TO BIDDERS.

Submit a plan, describing the drilling methods, sampling, and monitoring well construction and well development [30] [_____] calendar days prior to beginning drilling operations. Mobilization activities may start prior to submittal of the plan. Provide the plan approved and signed by a geologist [experienced in hazardous waste projects] as specified in paragraph QUALIFICATIONS. Incorporate the following requirements into the Contractor's Monitoring Well Installation Plan and follow in the field. Sampling and Testing is to be conducted in accordance with the guidelines as stated in: "Department of Defense Policy and Guidelines for Acquisitions Involving Environmental Sampling or Testing", November 2007. Include in the plan, but do not limit to a discussion of the following:

- a. Description of well drilling methods, and installation procedures, including any temporary casing used, placement of filter pack and seal materials, drill cuttings and fluids disposal, and soil/rock sample disposition.
- b. Description of well construction materials, including well screen, riser pipe, centralizers, tailpiece (if used), filter pack and filter pack gradation, bentonite, drilling fluid additives (if used), drilling water, cement, and well protective measures.
- c. Description of quality control procedures to be used for placement of filter pack and seals in the boring, including depth measurements.
- d. Forms to be used for written boring logs, installation diagrams of wells, geophysical logs, well development records, well sampling data records, state well registration forms, and well abandonment records.
- e. Description of contamination prevention and well materials and equipment decontamination procedures.

- f. Description of protective cover surface completion procedures, including any special design criteria/features relating to frost heave prevention. Include the maximum frost penetration for the site in this description.
- g. Description of well development methods to be used.
- h. List of applicable publications, including state and local regulations and standards.
- i. List of personnel assignments for this project, and personnel qualifications.
- j. Description of well decommissioning/abandonment procedures.
- k. Description of in-situ permeability determination techniques, if testing is required.
- l. Description and discussion of geophysical techniques to be employed at the site.

1.3.3 Performance Requirements

Install each monitoring well to prevent aquifer contamination by the drilling operation and equipment, intra- and inter-aquifer contamination, and vertical [or horizontal] seepage of surface water adjacent to the well into the subsurface, especially the monitoring well intake zone. Perform work in conformance with EPA 530/F-93/004, EPA 600/4-79/020, [and] EPA SW-846 [.] [, and] [EM 385-1-1.]

1.4 SUBMITTALS

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force
and NASA projects, or choose the second bracketed
item for Army projects.

Government approval is required for submittals with a "G" designation;
submittals not having a "G" designation are for [Contractor Quality Control
approval.] [information only. When used, a designation following the "G"
designation identifies the office that will review the submittal for the
Government.] Submit the following in accordance with Section 01 33 00
SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Diagrams[; G][; G, [____]]
Survey Maps and Notes[; G][; G, [____]]

SD-03 Product Data

Borehole Logs[; G][; G, [____]]
Installation Diagrams[; G][; G, [____]]
Well Development Records[; G][; G, [____]]
Geophysical Logs[; G][; G, [____]]
Well Decommissioning/Abandonment Records[; G][; G, [____]]
Project Photographs[; G][; G, [____]]
Monitoring Wells[; G][; G, [____]]
Qualifications[; G][; G, [____]]
Permits[; G][; G, [____]]
Installation Plan[; G][; G, [____]]
Documentation and Quality Control Reports[; G][; G, [____]]

SD-06 Test Reports

Water Source[; G][; G, [____]]
Filter Pack[; G][; G, [____]]
Drilling Fluid Additive[; G][; G, [____]]

1.5 QUALITY ASSURANCE

1.5.1 Notification

Notify the [Installation Environmental Coordinator (IEC)] [____] [and] the
Contracting Officer [____] days prior to drilling. The [Contracting
Officer] [Contractor] [Installation Environmental Coordinator (IEC)]
[____] [is] [are] responsible for contacting the [State of [____]]
[USEPA] in accordance with the applicable reporting requirements.

1.5.2 Qualifications

Submit personnel qualification documentation. Provide an onsite geologist
with at least [3] [____] years experience in hazardous waste projects,
soil and rock logging, and monitoring well installation, registered in the
state of [____], responsible for all geophysical and borehole logging,
drilling, well installation, developing and testing activities. Provide a
driller licensed in the state of [____], according to the state
requirements. Perform and provide geophysical log interpretation done by a
qualified log analyst, demonstrating competence through background,
training, and experience when so called upon. Furnish Contractor

documentation proving a minimum of [_____] years of monitor well installation experience, and appropriate health and safety personnel on staff as specified in Section 01 35 29.13 HEALTH, SAFETY, AND EMERGENCY RESPONSE PROCEDURES FOR CONTAMINATED SITES, and personnel qualified to perform the necessary chemical sampling as presented in the approved Sampling and Analysis Plan, prepared as specified in Section 01 35 45.00 10 CHEMICAL DATA QUALITY CONTROL.

1.6 DELIVERY, STORAGE, AND HANDLING

Store and maintain monitoring well materials in a clean, uncontaminated condition throughout the course of the project.

1.7 SITE CONDITIONS

**NOTE: If needed, edit and add Section 31 11 00
CLEARING AND GRUBBING.**

Access to each monitoring well site, including any utility clearance, permits, licenses, or other requirements and the payment thereof necessary for execution of the work is the responsibility of the [Contractor] [Government]. Submit a copy of all permits, licenses, or other requirements necessary for execution of the work. Before beginning work, notify local United States Geological Survey office (USGS) [and the] [State Environmental Protection office] [State Geological Agency] [state health department] [local health department] [Department of natural Resources] of the type and location of wells to be constructed, the method of construction and anticipated schedule for construction of the wells. Furnish a copy of all such correspondence. Obtaining rights-of-entry is the responsibility of the [Contractor] [Government]. Visit each proposed well location to observe any condition that may hamper transporting equipment or personnel to the site. [If clearing or relocation is necessary, the [Contractor,] [Installation Environmental Coordinator,] and the Contracting Officer [shall] [will] agree on a suitable clearing, or relocation plan and the location of any required access road.]

PART 2 PRODUCTS

2.1 WELL CASING

NOTE: The selection of well casing/riser pipe, and screen materials should be made with due consideration to geochemistry, anticipated lifetime of the monitoring program, well depth, chemical parameters to be monitored, and other site-specific factors. Normally 50 or 100 mm (2 or 4 inch) inside diameter well casing, and screen should be used; however, larger casing diameters may be necessary where dedicated purging, or sampling equipment is used, or where the well is screened in a deep formation. Schedule 40 casing is commonly used for monitoring wells, but schedule 80 is sometimes used for larger diameter PVC casing.

Welding is not a recommended procedure for the installation of a monitoring well; however, there

may be occasions when it is necessary to weld outer/protective casing, or drive casing at the site. It may be unsafe to weld if certain volatile organics are present. Safety precautions should be addressed in the site safety and health plan. In addition to the safety consideration, it may be undesirable to use metal well casing if metals are the contaminants of concern, which would preclude welding of metal well pipe. Appropriate welding standards, such as AWWA C206, Field Welding of Steel Water Pipe, must be referenced if welding is anticipated.

Provide new monitoring well casing/riser [102] [_____] mm [4] [_____] inch nominal internal diameter, schedule [40] [_____] flush-joint threaded [[ASTM D1785 polyvinyl chloride (PVC)] [PTFE] [_____] pipe, meeting the requirements of NSF/ANSI 14, with required fittings conforming to ASTM F 480 flush thread male by female fittings] [Type 304 stainless steel. The minimum wall thickness shall be schedule 5S meeting the requirements of ASTM A312/A312M]. Do not use pop rivets or screws. Provide a [PVC] [stainless steel] [PTFE] [_____] , [locking] [non-locking] cap, that threads or slips onto the top of the well casing.

2.2 CENTRALIZERS

Attach [stainless steel] [PVC] [PTFE] centralizers to the well casing when monitoring wells are over [6] [_____] m [20] [_____] feet in length. Centralizers are not required if the monitoring wells are installed through hollow-stem augers.

2.3 WELL SCREEN

NOTE: Continuous wrap screen is commonly used for monitoring wells; the type screen is not normally designated by schedule; however, the end fittings are, and must be, compatible with the schedule of the well casing. The schedule of the end fittings of the screen and the screen must be specified, if slotted pipe well screen is required.

The screen slot size for monitor wells is commonly 0.25 mm (0.010 inch) for fine-grained formations or 0.5 mm (0.020 inch) for coarser grained formations.

Monitoring well screen length is typically 1.5 to 3 meters (5 to 10 feet), but should be designed for the particular case to be monitored; however, when monitoring ground water quality at the top of the water table, screen lengths of 3 and 6 meters (10 and 20 feet) are commonly used. Screens of more than 6 meters (20 feet) are rarely used.

Provide monitoring well screen, designed and constructed in accordance with paragraph SYSTEM DESCRIPTION, consisting of new commercially fabricated flush-joint threaded [102] [_____] mm [4] [_____] inch nominal internal diameter [polyvinyl chloride (PVC)] [type 304 stainless steel]

[_____] [continuous wrap] [schedule 40] [_____] slotted], non-clogging design. [Provide schedule 40] [_____] end fittings on the continuous wrap screen.] Provide required fittings conforming to ASTM F 480, flush thread male by female. Provide screen slot size [as determined by the Contractor, and approved by the Government] [[0.25] [0.50] [_____] mm [0.010] [0.020] [_____] inch], and screen length of [[_____] meters feet] [or as determined by the Contractor]. Seal the bottom section of the screen watertight by means of a flush threaded end cap of the same material as the well screen, within 150 mm 6 inches of the open portion of the screen.

2.4 FILTER PACK

Provide filter pack consisting of clean, washed, rounded to sub-rounded siliceous material free from calcareous grains or material. Submit filter pack material test results; sieve and chemical analyses. Organic matter, soft, friable, thin, or elongated particles are not permissible. Determine the gradation of the filter pack using the grain size analysis data obtained as required in paragraph Sampling. Use a uniformity coefficient for the filter pack material not exceeding 2.5. Fill an airtight liter pint size [plastic] [glass] container with a sample of filter pack material and furnish to the Contracting Officer for each well to serve as a quality control.

2.5 BENTONITE SEAL

NOTE: Slurry seals can be used as when the seal location is too far below water to allow for pellet or containerized-bentonite placement, or within a narrow well-borehole annulus.

See paragraph BENTONITE SEAL note.

Provide a bentonite seal, intended to keep grout from entering the filter pack, consisting of hydrated granular, or pelletized, sodium montmorillonite furnished in sacks or buckets from a commercial source, free of impurities which adversely impact the water quality. If the bentonite seal is located above any borehole fluid levels, place a layer of fine sand at the top of the bentonite seal, to provide an additional barrier to any downward migration of grout.

2.6 CEMENT AND BENTONITE GROUT

Provide cement grout with a mixture of a maximum of 26 liters of approved water per 42.6 kg 7 gallons of approved water per 94 lb bag of portland cement, conforming to ASTM C150/C150M, Type [I] [_____] . Add no more than 5 percent by weight of bentonite powder to reduce shrinkage, hold the cement in suspension prior to the grout set. Use sodium bentonite powder and/or granules for high-solids bentonite grout. Mix water from an approved source with these powders or granules to form a thick bentonite slurry, consisting of a mixture of bentonite and the manufacturer's recommended volume of water to achieve an optimal seal. The slurry shall contain at least 20 percent solids by weight and have a density of 4.3 kg per liter 9.4 lb per gallon of water or greater. Provide additional construction details for grout placement above the bentonite seal for frost heave protection as directed in paragraph Protective Cover Placement.

2.7 CONCRETE PAD OR GRAVEL BLANKET

Construct a [concrete pad] [coarse gravel blanket] around the protective cover at the ground surface.

2.8 PROTECTIVE COVERS

Equip monitoring wells with [a steel] [a stainless steel] [a cast iron] [an aluminum] lockable protective casing/enclosure set over the well casing, set in the concrete pad or surface seal. Provide weather resistant padlocks which use the same key (keyed-alike) on the protective covers, or lockable caps for all wells. Cap any well that is to be temporarily removed from service or left incomplete due to delay in construction with a watertight cap and equipped with a vandal resistant cover.

2.9 PROTECTIVE POSTS

Provide and place [four] [_____] [75] [_____] mm [3] [_____] inch diameter, [schedule 40 carbon steel] [_____] , [2] [_____] meter [6] [_____] foot long, primed and painted, conforming to Section 09 90 00 PAINTING, GENERAL, [orange] [_____] protective posts around the monitoring well.

2.10 CONTAINERIZATION OF DEVELOPMENT WATER, AND DRILL CUTTINGS

Provide D.O.T. approved drums, containers, or vessels for containment of water removed during development and testing operations, and cuttings from the drilling operations, as specified in 49 CFR 172. Furnish polyethylene and steel drums with lids, lid gaskets, bolts, chain of custody forms and drum labels. Mark each drum label in accordance with 49 CFR 172 in addition to the following information:

- a. drum number,
- b. site name,
- c. well name and number,
- d. contents and date,
- e. approximate depth of material contained in each drum, and
- f. the name and phone number of the [Installation Environmental Coordinator (IEC)] [Contracting Officer] [_____].

2.11 SAMPLE CONTAINERS

NOTE: Delete requirements for boxing core, if rock coring is not anticipated at the site. Rock core samples should be containerized, boxed and stored in accordance with ER 1110-1-1803, EM 200-1-3, EM 1110-1-1804, and EM 1110-1-4000.

- a. Place cuttings, and driven samples for geotechnical purposes, in air-tight liter pint size [plastic] [glass] Contractor furnished containers and labeled with the project name, date of sample, monitoring well number and depth at which the sample was taken.
- b. Label both the container and lid in permanent indelible ink. Place jars in partitioned [cardboard] [_____] Contractor furnished boxes. Label boxes with project number and well number.
- c. Prepare and preserve core samples for transport as described in

ASTM D5079. Place cored rock samples in [wooden] [_____] core boxes as indicated on the drawings. Place spacers in the proper positions in the core boxes to show the location and actual extent of voids and core losses as clearly as possible. Make the spacers of [wood] [_____] [or some other relatively light material], which is of sufficient strength to withstand jarring and crushing in handling, and of a strongly contrasting color pattern so that core losses are accented either by direct observation or in photographs. In the smaller sizes, up to and including 150 mm 6 inches, provide spacers of the same width as the cores. Label the outside and the inside of the core box lid with the project name, hole number, date sampled, location, surface elevation, core box number, and interval of depth of core. Show the information on the label such that it can clearly be read in photographs of the core box. Also label both ends of the core box with the hole number and box number. Place the core in the core box starting at the left hand corner on the hinge side and running to the right. Place successive cores down the hole in successive troughs, starting from the back and working toward the front of the box so that the core can be read in the same manner as a printed page, from left to right, when standing in front of the open box.

PART 3 EXECUTION

3.1 PROTECTION OF EXISTING CONDITIONS

Maintain all existing survey monuments and monitoring wells, and protect them from damage from equipment and vehicular traffic. Immediately report and repair any items damaged by the Contractor. Re-install monitoring wells requiring replacement due to Contractor negligence according to these specifications. Protect wells scheduled for abandonment from damage so that abandonment may be performed according to these specifications. Prior to excavation, obtain written approval from the local utility companies to drill at each site, to avoid disturbing buried utilities.

3.2 PREPARATION

3.2.1 Decontamination

- a. Clean the drill rig, drill rods, drill bits, augers, temporary casing, well developing equipment, tremie pipes, grout pumping lines, and other associated equipment with high-pressure hot water/steam prior to drilling at each monitoring well location. Perform decontamination in accordance with ASTM D5088 ASTM D5608, at a central decontamination station located in an area that is remote from, and cross- or down-gradient from the well being drilled.
- b. Clean screen and well casing with high-pressure hot water immediately prior to installation in the well. The use of factory sealed (plastic wrapped) screen and well casing does not waive this requirement for pre-installation cleaning. Decontaminate samplers in accordance with the Sampling and Analysis Plan.
- c. Use only water for cleaning from a Government approved source. Sample and test the water source used for cleaning for the constituents specified in the Sampling and Analysis Plan prior to use at the site.

3.2.2 Decontamination Station

- a. Construct a temporary decontamination pad onsite, bermed and slightly

inclined towards a sump located in one of the back corners of the pad. Line the pads and berms with plastic sheeting to contain decontamination water. Place plywood sheeting, exterior grade, over the plastic sheeting to prevent damage to the plastic and allow the drill rig and heavy equipment to use the pad.

- b. Make the minimum dimensions of the pad the length and width of the drill rig, plus 1.2 m 4 feet per side to allow access and steam cleaning. Use yellow ribbon to encircle the decontamination pad.
- c. Pump water collected in the sump using a "trash" pump to transfer water to a 200 liter 55 gallon drum labeled "Decontamination Pad Sump Water." Transfer solid waste to a separate 200 liter 55 gallon drum labeled "Decontamination Pad Sump Sludge."

3.2.3 Water Source

If well drilling/installation requires the use of water, prior to its use at the site, sample and test the water source, and obtain approval from the Contracting Officer for the constituents specified in the Sampling and Analysis Plan. Submit decontamination and drilling water source analytical test results. The Contractor is responsible for locating the source, obtaining the water from the source, transporting it to, and storing it at the site. Obtain a water sample from the container used in transporting the water to the site before the water is used for decontamination, and sample, test, and secure approval in accordance with the above requirements.

3.3 INSTALLATION

3.3.1 Drilling Method

**NOTE: Delete prohibition against drilling aids
where such aids are required and not otherwise
prohibited.**

- a. Use a drilling method which prevents the collapse of formation material against the well screen and casing during installation of the well. Make the inside diameter of any temporary casing used sufficient to allow accurate placement of the screen, riser, centralizer(s), filter pack, seal and grout.
- b. The use of drilling aids such as bentonite, other clay-based agents, or any other foreign matter capable of affecting the characteristics of the ground water is prohibited. Any drilling fluid additive used shall be inorganic in nature. Grease or oil on drill rods, casing, or auger joints are not permitted; however, PTFE tape or vegetable oil (in solid phase form) are acceptable. Submit manufacturer's data, if available, including analytical test results of the additive, if not a part of the manufacturer's data.
- c. Provide a drill rig free from leaks of fuel, hydraulic fluid, and oil which may contaminate the borehole, ground surface or drill tools. During construction of the wells, use precautions to prevent tampering with the well or entrance of foreign material, and prevent runoff from entering the well during construction. If there is an interruption in work, such as overnight shutdown or inclement weather, close the well opening with a watertight uncontaminated cover. Secure the cover in

place or weighted down so that it cannot be removed except with the aid of the drilling equipment or through the use of drill tools.

3.3.2 Test Hole Requirements

Drill one test hole for every monitoring well or well cluster installed. A well cluster, as defined in this specification, is two or more wells completed (screened) to different depths in a single borehole or in a series of boreholes in close proximity (3 m 10 feet or less) to each other. The test hole may be converted to the permanent monitor well. Log test holes in accordance with paragraph BOREHOLE LOGS, and if temporary casing is used, use in accordance with paragraph Decontamination.

3.3.3 Sampling

NOTE: Sampling and Testing is to be conducted in accordance with the guidelines as stated in: "Department of Defense Policy and Guidelines for Acquisitions Involving Environmental Sampling or Testing", November 2007.

NOTE: Sampling for chemical and geotechnical analysis may be combined to allow for obtaining samples for both if that accomplishes project requirements. If this is done, however, the geotechnical sampling must be coordinated with the requirements in Section 01 35 45.00 10 CHEMICAL DATA QUALITY CONTROL for sampling for chemical analysis. If rock is cored at the site, and it is determined that it should be retained, it should be boxed, and photographed. Its storage, and later disposal should be in accordance with ER 1110-1-1803, and the proper storage and handling protocol for such material as may be required by other Federal, state, or local laws, regulations and permits. Sampling procedures are described in EM 200-1-3, Requirements for the Preparation of Sampling and Analysis Plans. Guidance for preserving and preparing core samples for transport can be found in ASTM D5079

3.3.3.1 Sampling for Chemical Analysis

Include sampling requirements for obtaining and preserving samples for chemical analysis in the Sampling and Analysis Plan, conforming to: DoD Policy and Guidelines for Acquisitions Involving Environmental Sampling or Testing, November, 2007.

3.3.3.2 Sampling for Geotechnical Analysis

- a. Take samples of all materials penetrated by each drilled well/test hole. Perform soil sampling with a stainless steel split tube sampler using standard sampling techniques in accordance with ASTM D1586. Extract samples from their in-situ environment in as near an intact, minimally disturbed condition as technically practical. Retrieve samples according to ASTM D1586 at least every [1] [_____] meter [5]

[_____] feet from each test hole. Obtain samples continuously through the area expected to be screened.

- b. Provide sieve analyses of all drive sampled material, conducted in accordance with ASTM C136. Clean drive sample tools with high-pressure hot water/steam between sampling events within the same boring. Place drive-sampled materials in airtight containers and label as specified in paragraph SAMPLE CONTAINERS, and deliver to the Contracting Officer designated facility. Test representative soil samples for grain-size distribution by mechanical means ASTM D422 (sieves down to the 0.074 mm (No. 200) No. 200 size according to ASTM C136), moisture content according to ASTM D2216 and Atterberg limits according to ASTM D4318. Prepare description and identification of soils in accordance with ASTM D2488, laboratory classification of soils in accordance with ASTM D2487, and perform sampling to allow completion of the documents described in paragraph Borehole Logs.

3.3.4 Geophysical Logging

NOTE: The requirement to obtain borehole geophysical surveys is optional. While it may not be necessary to require a borehole geophysical survey at a site where a great deal is known about the subsurface, at another site, where very little, or nothing is known, it may be prudent to require a borehole geophysical survey. When it is deemed necessary to require a borehole geophysical survey, the specific type of survey should be specified. This recommendation is made by the project geologist. The project geologist should also determine what geophysical logging is not allowed by state regulations, before specifying them. See EM 1110-1-1802, Geophysical Exploration. Guidance for planning and conducting borehole geophysical logging may be found in ASTM D5753.

Geophysically log the total depth of each test hole drilled. Document geophysical logging in accordance with paragraph Geophysical Logs. Run [one successful natural gamma ray or gamma-gamma for the full depth, (top to bottom of test hole);] [one successful neutron in the fluid filled portion of the hole, (top to bottom of test hole);] [one successful (top to bottom of test hole) spontaneous potential (self-potential);] [and,] [one successful (top to bottom of test hole) resistivity log], for each test hole. Perform log analyses and interpretations by a person qualified in accordance with paragraph QUALIFICATIONS.

3.3.5 Borehole Diameter and Depth

NOTE: State regulations may require more than 50 mm (2 inches) of annular space between the boring wall and the sides of the entered riser pipe and screen.

Provide sufficient diameter in borings for monitoring well installation to permit at least 50 mm 2 inches of annular space between the boring wall and all sides of the centered riser pipe and screen. Determine depths of

individual borings [as specified in the approved Monitoring Well Installation Plan] [as indicated on the drawings] [____], with actual depth adequate to allow for the collection of representative ground water samples for chemical analysis at the time of initial sampling.

3.3.6 Screen, Well Casing/Riser Pipe Placement

NOTE: Depending on the nature of the contaminants to be sampled, the screen may be required to be placed below or across the water table. Caps for the flush-to-ground, or manhole type surface completion should not be vented, or loose fitted. Caps for these type completions should be water tight. Delete the requirements for centralizers if they are not required per paragraph CENTRALIZERS.

- a. Provide the monitoring well screen in length [as shown on the drawings] [[____] mm feet long] [as determined by the Contractor and approved by the Government], with specified bottom cap securely attached, set to the appropriate depth.
- b. Place the bottom of the well screen no more than 1 m 3 feet above the bottom of the drilled borehole. Place the well screen in the appropriate location in the borehole so that the completed monitoring well functions in accordance with paragraphs SYSTEM DESCRIPTION and WELL ACCEPTANCE.
- c. Provide sieve analyses of all drive sampled material, conducted in accordance with ASTM C136. Place the well screen [as specified on the drawings] [at [____]]. Join the screen and well casing/riser pipe sections by flush threaded watertight joints, with the well casing/riser pipe extending upwards from the screen to an elevation appropriate for the surface completion described in paragraph Protective Cover Placement. Do not allow the well screen and riser pipe to drop or fall uncontrolled into the borehole. Clean the screen and well casing/riser pipe with high pressure hot water/steam just prior to installation; allowing no foreign material to remain on the screen and well casing before installation. The use of factory-sealed (plastic wrapped) screen, free from painted markings, does not waive requirements for pre-installation cleaning.
- d. Provide watertight flush threaded joints and fastenings ; solvent glue or set screws are not permitted.
- e. Make the well centered and plumb by the use of a minimum of [____] stainless steel centralizers, in accordance with paragraph CENTRALIZERS, spaced 120 degrees apart at intervals not exceeding [6] [____] m [20] [____] feet along the length of the casing. Do not place centralizers on the screened interval or within the bentonite seal. Verify the alignment of the well by passing a 1500 mm 5 foot long section of rigid pipe 6 mm 1/4 inch smaller in diameter than the inside diameter of the casing through the entire well. If the pipe does not pass freely, the well will not be accepted. Thoroughly clean the pipe section with high pressure hot water prior to each test. Use temporary casing, hollow stem augers or other measures, as necessary, to prevent collapse of the boring against the well screen and well casing/riser pipe prior to placement of the filter pack and sealing

materials. Install a cap on the top of the riser pipe, either vented, or a telescopic fit, constructed to preclude binding to the well casing caused by tightness of fit, unclean surfaces, or weather conditions. Make cap secure enough to preclude the introduction of foreign material into the well, yet allow pressure equalization between the well and the atmosphere.

3.3.7 Filter Pack Placement

- a. After the screen and well casing have been concentrically placed in the hole, construct the approved filter pack around the screen by filling the entire space between the screen and the wall of the hole over the selected screened interval. Place the lowermost [300] [] mm [1] [] foot of filter pack in the boring prior to installation of the well screen, serving as a base on which to place the screen. Lower a tremie pipe having an inside nominal diameter of not less than 25 mm 1 inch, to the bottom of the annulus between the hole and well. Clean the tremie pipe with high pressure hot water/steam prior to each use. Arrange the tremie pipe so that water and filter pack material fed at uniform rates are discharged as the filter pack material fills the hole from the bottom up. Raise the tremie pipe at a rate that will keep the bottom of the pipe no more than [1500] [] mm [5] [] feet above the top of the surface of the filter pack level, and no more than [600] [] mm [2] [] feet below the surface of the filter pack level at all times.
- b. Dumping filter pack material from the surface of the ground and agitating the well in an effort to settle the filter material is not allowed. Install the filter pack continuously and without interruption until the filter pack has been placed [to a minimum of 1 meter 3 feet above the top of the screen in the monitoring well] [to a height equal to 20 percent of the length of the screen] [to within no more than [] meters feet of the top of the ground surface]. Directly measure the depth to the top of the filter pack and record. Obtain any additional water required to be added to the filter pack material in accordance with paragraph Water Source.
- c. Protect filter pack material from contamination prior to placement by either storing it in plastic lined bags, or in a location protected from the weather and contamination on plastic sheeting. Transport filter pack material to the well site in a manner which prevents contamination by other soils, oils, grease, and other chemicals. Remove temporary drill casing, if installed, or auger simultaneously with the above operation. Minimize lifting of the riser pipe when withdrawing the temporary casing/auger. Place filter pack material in lifts no greater than 1 m 3 foot prior to retraction of the temporary casing/auger. Leave a minimum of 150 mm 6 inches of filter pack in the temporary casing/auger at all times during filter pack installation. Take frequent measurements inside the annulus during retraction to ensure that the filter pack is properly placed.

3.3.8 Bentonite Seal

NOTE: Sufficient time should be allowed for the bentonite seal to hydrate and form a low permeable seal before grout is placed in the annular space above the bentonite seal. By not allowing enough time, grout material could infiltrate into the seal

and possibly into the filter pack. It is recommended waiting a minimum of 3 to 4 hours for hydration of bentonite pellets, or tablets. If bentonite chips are used, the minimum hydration time could be twice as long. Normally bentonite chips should only be used if it is necessary to install a seal in a deep water column. Because of their high moisture content and slow swelling tendencies, chips can be dropped through a water column more readily than a material with low moisture content, such as pellets or tablets. Bentonite chips should not be placed in the vadose zone. When installing a bentonite seal in the vadose zone, potable water should be added to the bentonite for it to properly hydrate. The amount of water is dependent on the formation. It is recommended that the bentonite seal be placed in lifts, with each lift allowed to hydrate for a minimum period of time. For more guidance consult EM 1110-1-4000.

Place a minimum 1 m 3 foot thick hydrated bentonite seal on top of the filter pack in a manner which prevents bridging of the bentonite in the annulus, such that the bottom of the bentonite seal is a minimum of 1 m 3 feet above the top of the filter pack. Directly measure the depth to the top of the bentonite seal and record immediately after placement, without allowance for swelling. If the bentonite seal is located above any borehole fluid levels, place a [300] [] mm [1] [] foot layer of fine sand at the top of the bentonite seal.

3.3.9 Grout Placement

NOTE: There is a provision for placing a high-solids bentonite grout in the annulus above the bentonite seal rather than cement grout. This may be better in areas of the country where the monitoring wells will be susceptible to frost heave. If it is required that the protective casing be anchored in-place with cement grout, this should be done in accordance with paragraph Protective Cover Placement. The depth of maximum frost penetration should be determined before design of the monitoring well installation. The susceptibility of the soils to frost action should also be determined beforehand. Guidance for determining frost penetration may be found in UFC 3-130-06 or FM 5-430-00-1. There may be a need for a provision to grout the annular space in lifts in deep wells to ensure that any PVC or other type casing will not be collapsed by the weight and/or heat created by the chemical reaction of cement grout. If grouting in lifts is for some reason not acceptable, the well should be designed to withstand greater external pressures. This may mean using higher schedule casing, or steel instead of PVC, for example.

Mechanically mix a [non-shrinking cement] [high-solids bentonite] grout, in accordance with paragraph CEMENT AND BENTONITE GROUT, and placed in one continuous operation into the annulus above the bentonite seal to [within [] mm feet of] [the ground surface] [the maximum depth of frost penetration (frost line)]. Make grout injection in accordance with ASTM D5092. If the casing interval to be grouted is less than 4.5 m 15 feet, and without fluids after any drill casing is removed, place the grout either by pouring or pumping. Thoroughly clean the tremie pipe with high pressure hot water/steam before use in each well. Construct the bottom of the tremie pipe to direct the discharge to the sides rather than downward, keeping the discharge end of the tremie pipe submerged at all times. Add additional grout from the surface to maintain the level of the grout at the land surface as settlement occurs. Work is not permitted in the well within [24] [] hours after cement grouting. Verify the alignment of the well by passing a 1.5 m 5 foot long section of rigid [PVC] [stainless steel] [PTFE] [] pipe 6 mm 1/4 inch smaller in diameter than the inside diameter of the casing through the entire well. If the pipe does not pass freely, the well will not be accepted. Thoroughly clean the pipe section with high pressure hot water/steam prior to each test.

3.3.10 Concrete or Gravel Pad Placement

NOTE: Some states may require that the surface seal extend to depths of 3 m (10 feet), or greater to ensure sanitary protection of the well. The surface seal may be an extension of the annular seal installed above the filter pack or it may be a separate "surface" seal emplaced on top of the annular seal. Also, in extreme cold climates, it may be better, if allowed by state and local regulations, to fill the annular space above the bentonite well seal, or filter pack, with bentonite grout and construct the well "pad" of coarse gravel, rather than concrete. Concrete well pads sometimes have a tendency to crack and breakup in cold regions.

Construct a [concrete pad with a minimum radius of [600] [] mm [2] [] feet from the protective casing and 100 mm 4 inch] [coarse gravel blanket with a minimum radius of [1200] [] mm [4] [] feet from the protective casing and 150 mm 6 inch] thick, sloped away from the well around the well casing at the final ground level elevation. [Prior to placement of the gravel blanket, backfill any depression existing around the well borehole to the level of the surrounding ground surface with [near-surface drill cuttings from the well] [clay] [].] [Furnish pre-packaged, dry, combined concrete materials for the well pads conforming to ASTM C387/C387M normal weight, normal strength concrete. Combine the dry materials with potable water and mix in an approved mixer or container until uniform in consistency and color. Limit water to the minimum amount possible.]

3.3.11 Protective Cover Placement

NOTE: If frost heave is not a concern at the site, the requirement for the annular space between the protective casing and the well riser to be filled with dry bentonite may be deleted. The cement grout

may then be placed outside of, and inside the protective casing to the ground surface as would be specified in paragraph Grout Placement.

It may be necessary to require that the protective posts be supplemented with barbed wire in livestock grazing areas. Additional guidance on monitoring well protection may be found in ASTM D5787

Provide all monitoring wells with a [steel] [_____] lockable protective enclosure set in the annular seal over the well casing with keyed-alike locks on the protective covers for all wells.

3.3.11.1 Protective Steel Casing

NOTE: Delete this paragraph if not applicable for the project.

- a. Install a protective steel casing around the well casing/riser pipe by placing the protective casing into the annular seal. Clean the protective casing with high-pressure hot water/steam prior to installation to ensure that it is free of any contamination. Provide a protective casing with an inside diameter of at least 100 mm 4 inches greater than the nominal diameter of the well riser. Fit the protective casing with a locking cap and install so that there is a maximum 61 mm 0.2 foot clearance between the top of the in-place inner well casing cap and the bottom of the protective casing locking cap when in the locked position.
- b. Position and maintain the protective casing in a plumb position. Extend the bottom of the protective casing a minimum of 750 mm 2.5 feet below the top of the ground surface; extending a minimum of [750] [_____] mm [2.5] [_____] feet below the maximum depth of frost penetration (frost line); and anchored into the cement grout annular seal; and also extending at least 750 mm 2.5 feet above the surface of the ground. Seal and immobilize the protective casing in concrete placed around the outside of the protective casing, then place dry bentonite pellets, or granules, in the annular space below ground level within the protective casing.
- c. Provide the protective casing with a 6 mm 1/4 inch diameter drain hole installed just above the top of the [concrete pad] [gravel blanket]. Place coarse sand or pea gravel in the annular space between the protective casing and the riser pipe, above the drain hole, to within 75 mm 3 inches from the top of the riser pipe. [Install [four] [_____] protective steel posts, located 1200 mm 4 feet from the well, equally spaced around the [concrete pad] [gravel blanket]. Fill the steel posts with cement. Do not install the posts in the concrete pad, but a 150-300 mm 0.5-1.0 foot distance from the edge of the concrete pad. Set the posts in cement, and extending a minimum of 1 m 3 feet above the ground surface, with at least one third of the posts' total length below ground surface.]

[3.3.11.2 Flush-to-Ground Utility Vault

NOTE: Delete this paragraph if not applicable for the project.

Install a flush-to-ground protective steel utility vault or manhole around the well casing/riser pipe which has been cut off below grade. Construct the flush mounted protective utility vault or manhole with a concrete ground surface seal. Extend the ground surface seal to, but not beyond, the total depth of the flush mounted protective utility vault. Install the ground surface seal around the flush mounted protective utility vault but do not place between the flush mounted protective utility vault and the well casing. Do not install the flush mounted protective utility vault in areas subject to ponding or flooding. Provide the wording "ground water monitoring well" on the flush mounted protective cover's lid or manhole cover on its outer surface. Install flush mounted protective utility vaults through an impervious surface such as asphalt or concrete. If an impervious surface does not exist, create one to support the weight of the traffic in the area. Provide a flush mounted protective utility vault consisting of a watertight metal casing with an inside diameter at least 100 mm 4 inches greater than the inside diameter of the monitoring well casing, made of one continuous metal piece or two metal pieces which are joined with a continuous weld; and a minimum length of [300] [] mm [12] [] inches. Allow no more than 200 mm 8 inches between the top of the monitoring well casing and the top of the flush mounted protective utility vault after installation. Provide the flush mounted protective utility vault with an exterior flange or lugs. Do not allow the flush mounted protective utility vault to extend below the top of the cement/bentonite annular space seal. To prevent damage from frost heave, extend the concrete surrounding the utility vault a minimum of 300 mm 1 foot below the frost line. Provide the flush mounted protective utility vault or the monitoring well with a locking mechanism and a watertight cap.

]3.3.12 Well Identification

NOTE: Local well identification requirements should be specified.

Affix a corrosion resistant metal tag to the exterior and interior of the protective cover. Provide the metal tag stamped with the [U.S. Army Corps of Engineers CE [] []], well identification number, elevation of the highest point on the rim of the well casing or riser pipe, elevation of the ground surface at the well, well coordinates, date of well installation, and the top of the protective casing elevation in meters feet as determined according to paragraph SURVEYS. Use identification numbers for the monitoring wells as indicated on the drawings.

3.3.13 Well Development

NOTE: Well development locally improves or restores the aquifer's hydraulic conductivity and removes undesirable materials from the aquifer near the well screen, thus yielding a more representative ground water sample. The most appropriate development method and acceptance criteria to use will vary according to the hydrologic characteristics of the aquifer, the drilling method used and the type of

well completion. The following specification is performance based. The designer may specify a method which has been shown to work well in the project area. In some instances, e.g., very fine-grained sediments, some karst terrains, the well development criteria may not be obtainable. Development criteria should be modified if such conditions are known or suspected to exist. The U.S. Environmental Protection Agency (EPA) may, according to their Technical Enforcement Guidance Document (TEGD), 530/R-93/001, consider a well improperly completed if a well yields turbid samples (turbidity greater than or equal to 5 NTUs) after development. If the local EPA Region enforces this criteria, it may be necessary to include a requirement that the well be developed until a turbidity of less than or equal to 5 NTUs is achieved.

Within 7 days of completion of each well, but no sooner than [48] [_____] hours after cement grouting is completed, develop the well. Perform development using only mechanical surging or over pumping or a combination thereof in accordance with ASTM D5521. Include details of the proposed development method in the Monitoring Well Installation Plan. Maintain a well development record in accordance with paragraph Well Development Records. Development is complete when:

- a. Well water is clear to the unaided eye,
- b. Sediment thickness in the well is less than [1 percent of the screen length] [30 mm 0.1 foot],
- c. A minimum of three times the standing water volume in the well plus three times the volume of all added water and drilling fluid lost during drilling and installation of the well is removed, and
- d. Temperature, specific conductivity, pH, oxidation-reduction potential (ORP), dissolved oxygen (DO), and turbidity readings, measured before, twice during and after development operations, have stabilized. Stabilization means [variation of less than 0.2 pH units, variation of \pm 1 degree Celsius, 1 degree Fahrenheit, \pm 3 percent change in specific conductance; \pm 10mV for ORP; and \pm 10 percent for DO, and turbidity, measured between three consecutive readings with one casing volume of water removed between each reading] [_____]. Determine ORP in accordance with AWWA 10084. Conduct temperature, specific conductance, DO, turbidity, and pH readings in accordance with EPA 600/4-79/020. At completion of well development, collect approximately 0.5 liter 1 pint of well water in a clear glass jar. Label the jar with project name, well number and date; and photographed using 35 mm color print film. Suitably backlight the subject in the photograph (minimally 125 x 174 mm 5 x 7 inch) close-up to show the clarity of the water and any suspended sediment. The photograph and negative are a part of the well development record. Water removed during development and testing operations shall be [contained in D.O.T. approved drums, containers or vessels and disposed of by [_____], in accordance with paragraphs CONTAINERIZATION OF DEVELOPMENT WATER, AND DRILL CUTTINGS, and Drilling Waste Disposal] [discharged to the ground surface at least [_____] meters feet from the well in a down gradient area].

3.3.14 In-Situ Permeability Determination

NOTE: In some fine grained aquifers, the period of time for the aquifer to reach equilibrium may exceed 24 hours and testing should be performed no sooner than 48 or more hours after the well is developed.

Determine the in-situ permeability for each well following development but no sooner than [48] [_____] hours after development. After the well is developed and allowed to equilibrate for at least 24 hours, and before in-situ permeability testing, measure and record the static water level in the well. Determine, for each well installed, the in-situ permeability of the screened formation using an appropriate method after the well has been developed. State proposed details of the methods expected to be used and references for those methods in the Monitoring Well Installation Plan. Except for formation water from the well, do not introduce any other water or liquid into the well.

3.3.15 Drilling Waste Disposal

NOTE: The designer must address disposal of drill cuttings, rock core, grout or bentonite slurry, and other solid or liquid materials bailed, pumped, or otherwise removed from the borehole during drilling, well installation, completion, and well development procedures within all appropriate regulatory requirements. The nature of these wastes (whether hazardous or not) will potentially vary between well sites on a single project. On a remedial action project, it may be prudent to dispose of drilling and well installation waste in coordination with other project waste streams. In some instances, rock core may be determined to be contaminated and must be handled accordingly. Refer to EPA/540/G-91/009, Management of Investigation-Derived Waste From Site Investigations and EPA OSWER Directive 9345.3-03FS, April 1992, Guide to Management of Investigation-Derived Wastes, for discussion of some issues relevant to Superfund projects. State/local regulations must also be considered.

Dispose of slurry, drill cuttings, rock core; other solid or liquid material bailed, pumped, or otherwise removed from the borehole during drilling, installation, completion, and well development procedures; and fluids from material/equipment decontamination activities by [_____] .

3.4 SURVEYS

NOTE: Guidance for installing survey markers can be found in EM 1110-1-1002 Survey Markers and Monumentation.

Establish coordinates and elevations for each monitoring well/test hole. Determine horizontal coordinates to the closest 300 mm 1.0 foot and referenced to the State Plane Coordinate System, or Universal Transverse Mercator (UTM). If the State Plane Coordinate System/UTM is not readily available, use an existing local grid system. Obtain a ground elevation to the closest 30 mm 0.1 foot at each well. The highest point on the top of the riser pipe serves as a measurement point; reference this elevation and survey to the nearest 3 mm 0.01 foot using the National Geodetic Vertical Datum of [1929] [1988]. If the datum is not readily available, use the existing local vertical datum. Plot the location, identification, coordinates, and elevations of the well and monuments on maps with a scale large enough to show their location with reference to other structures.

3.5 WELL DECOMMISSIONING/ABANDONMENT

NOTE: Guidance for decommissioning of monitoring wells may also be found in EM 1110-1-4000.

Any well disapproved by the Contracting Officer, or any well decommissioned/abandoned by the Contractor for any reason shall be decommissioned/abandoned according to the requirements of the State of [____], ASTM D5299, and the requirements of these specifications. Well decommissioning/abandonment includes the removal of all materials left in the borehole/well, excluding the filter pack, and including backfill materials, casing, screen, and any other material placed into the hole before the decision was made to abandon the borehole/well. Grout test holes decommissioned/abandoned for any reason from the bottom to within [____] mm feet of the top of the ground surface according to the protocol for grout/bentonite placement established in paragraph Grout Placement, using the grout mix specified in paragraph CEMENT AND BENTONITE GROUT. Backfill the top [____] mm feet with [material appropriate for the intended land use] [____]. Maintain a well decommissioning/abandonment record as specified in paragraph Well Decommissioning/Abandonment Records. Measure groundwater levels, if encountered before the decision is made for decommissioning/abandonment, in all borings prior to backfilling. Include these water levels in the well decommissioning/abandonment records. No well may be decommissioned/abandoned without the approval of the Contracting Officer.

3.6 WELL ACCEPTANCE

It is the responsibility of the Contractor to properly design, construct, install, develop, and test all monitoring wells according to the requirements of this specification so that they are suitable for the intended purpose. If the Contractor installs wells that are not functional or not in accordance with these specifications, the Contracting Officer will disapprove the well and direct the Contractor to repair or replace it, and to abandon the disapproved well in accordance with this specification.

3.7 SITE CLEANUP

After completion of the work, remove tools, appliances, surplus materials, temporary drainage, rubbish, and debris incidental to work. Backfill excavation and vehicular ruts and dress to conform with the existing landscape or terrain. Utilities, structures, roads, fences, or any other pre-existing item which must be repaired or replaced due to the

Contractor's negligence are the Contractor's responsibility; accomplish repair or replacement prior to completion of this contract.

3.8 DOCUMENTATION AND QUALITY CONTROL REPORTS

Submit reports for well construction and development. Establish and maintain documentation and quality control reports for well construction and development to record the desired information and to assure compliance with contract requirements, including, but not limited to, the following:

3.8.1 Borehole Logs

NOTE: Borehole logging requirements can be found in EM 1110-1-4000, Monitor Well Design, Installation, and Documentation at Hazardous and/or Toxic Waste Sites. Requirements can also be found in ASTM D2113 and ASTM D5434. If rock is cored at the site, and it is deemed necessary to determine the rock quality designation (RQD) of the core for design purposes, the RQD should also be shown on the boring log. Guidance for determining the RQD may be found in ASTM D6032.

Submit original borehole logs, within [_____] working days after completion of the boring and well installation procedures. Prepare and complete a borehole log for each boring drilled, prepared by the geologist present onsite during all well drilling and installation activities. Provide the log scale at [10] [_____] mm equals [300] [_____] mm [1] [_____] inch equals [1] [_____] foot. Keep copies current and complete of all well logs in the field at each well site and make available at all times for inspection by the Contracting Officer. Include, as a minimum, the following:

- a. Name of the project and site.
- b. Boring/well identification number.
- c. Location of boring (coordinates, if available).
- d. Make and manufacturer's model designation of drilling equipment and name of drilling firm.
- e. Date boring was drilled.
- f. Reference data for all depth measurements.
- g. Name of driller and name and signature of geologist preparing log.
- h. Nominal hole diameter and depth at which hole diameter changes.
- i. Total depth of boring.
- j. Method of drilling, including sampling methods and sample depths, including those attempted with no recovery. Indication of penetration resistance such as drive hammer blows given in blows per 150 mm 6 inches of driven sample tubes. Include in information hammer weight and drop distance. Record information such as rod size, bit type, pump type,

etc.. Also include a description of any temporary casing used, drill fluids and fluid additives used, if any, including brand name and amount used, along with the reason for and start (by depth) of its use, and, if measured, mud viscosities and weight.

- k. Depth of each change of stratum. If location of strata change is approximate, it shall be so stated.
- l. Description of the material of which each stratum is composed, in accordance with [ASTM D2488] [____], and/or standard rock nomenclature, as necessary. Include in soil parameters for logging, but do not limit to, classification, depositional environment and formation, if known, Unified Soil Classification Symbol, secondary components and estimated percentages, color (using FSUP 77341 or GSA RCC00100R), plasticity, consistency (cohesive soil), density (non-cohesive soil), moisture content, structure and orientation, and grain angularity.
- m. Include in rock core parameters for logging, but do not be limit to, rock type, formation, modifier denoting variety (shaly, calcareous, siliceous, etc.), color (using GSA RCC00100R), hardness, degree of cementation, texture, crystalline structure and orientation, degree of weathering, solution or void conditions, primary and secondary permeability, and lost core.
- n. Also include the results of any chemical field screening on the boring log. Prepare classification in the field at the time of sampling. Also duly note and record the results of visual observation of the material encountered, and any unusual odor detected.
- o. Depth of any observed fractures, weathered zones, or any abnormalities encountered.
- p. Depth and estimated percent of drill fluid loss or lost circulation. Measures taken to regain drill water circulation. Significant color changes in the drilling fluid return.
- q. Depth to water, and any non-aqueous phase liquids (NAPLs) and date measured before, during, and after each drilling shift, and prior to well installation. Provide and maintain at each well under construction a portable water, and NAPL level measuring device of sufficient length to measure the water/NAPL level to [50] [____] meter [165] [____] foot depth. Make the device onsite at all times and provide graduated measuring wire in mm 0.01 foot. Take water and NAPL level measurements to the nearest mm 0.01 foot.
- r. Box or sample number. Depths and the number of the core boxes and/or samples shall be recorded at the proper interval.
- s. Percent Rock Core Recovery. The percent core recovery for the individual drill runs, if rock is cored, shall be shown.

3.8.2 Installation Diagrams

Submit installation diagram for each monitoring well within [____] working days of the completion of the installation. The well will not be accepted before the geologic logs and installation diagrams are received. Submit as-built installation diagram for each monitoring well installed, prepared by the geologist present during well installation operations, within

[_____] working days of the completion of the well installation procedure. Clearly illustrate in the diagram the as-built condition of the well and include, but do not limit to the following items:

- a. Name of the project and site.
- b. Well identification number.
- c. Name of driller and name and signature of the geologist preparing diagram.
- d. Date of well installation.
- e. Description of material from which the well is constructed, including well casing/riser pipe and screen material, centralizer composition, if used, diameter and schedule of casing and screen, gradation of filter pack, lithologic description, brand name (if any), source, and processing method, and method of placement of the filter pack, bentonite seal type (pellets, granules, chips, or slurry), grout type (cement or high-solids bentonite) and type of protective cover (protective casing or flush-to-ground).
- f. Total depth of well.
- g. Nominal hole diameter.
- h. Depth to top and bottom of screen, and filter pack.
- i. Depth to top and bottom of any seals installed in the well boring (grout or bentonite).
- j. Type of cement and/or bentonite used, mix ratios of grout, method of placement and quantities used.
- k. Elevations/depths/heights of key features of the well, such as top of well casing/riser pipe, top and bottom of protective casing, ground surface, the depth of maximum frost penetration (frost line), bottom of well screen, top and bottom of filter pack, and top and bottom of seal.
- l. Other pertinent construction details, such as slot size and percent open area of screen, type of screen, and manufacturer of screen.
- m. Well location by coordinates. A plan sheet shall also be included showing the coordinate system used and the location of each well. A plan sheet is not required for each well installation diagram; multiple wells may be shown on the same sheet.
- n. Static water level upon completion of the well.
- o. Special problems and their resolutions; e.g., grout in wells, lost casing, or screens, bridging, etc.
- p. Description of surface completion.

3.8.3 Well Development Records

Prepare and submit a monitoring well development record for each monitoring well installed under the supervision of the geologist present during well installation operations, within [_____] working days of the completion of

development. Include the following information on the well development record , but do not limit to the following:

- a. Date, time, and elevation of water level in the well, before development.
- b. Depth to bottom of well, name of project and site, well identification number, and date of development.
- c. Method used for development, to include size, type and make of equipment, bailer, and/or pump used during development.
- d. Time spent developing the well by each method, to include typical pumping rate, if pump is used in development.
- e. Volume and physical character of water removed, to include changes during development in clarity, color, particulates, and odor.
- f. Volume of water added to the well, if any.
- g. Volume and physical character of sediment removed, to include changes during development in color, and odor.
- h. Source of any water added to the well.
- i. Clarity of water before, during, and after development. Nephelometric turbidity unit (NTU) measurements.
- j. Total depth of well and the static water level in accordance with [ASTM D4750](#) from top of the casing, immediately after pumping/development, and 24 consecutive hours after development.
- k. Readings of pH, specific conductance, DO, ORP, and temperature taken before, during, and after development.
- l. Name and job title of individual developing well.
- m. Name and/or description of the disposal facility/area, for the waters removed during development.

3.8.4 Geophysical Logs

Prepare, complete, and submit geophysical logs for each monitoring well/test hole installed, within [_____] working days of the completion of said logging. Include the following information on the logs as a minimum:

- a. Project name.
- b. Test hole/monitoring well identification number.
- c. Location of test hole (coordinates, and state, and county name).
- d. Date test hole was drilled.
- e. Fluid level in test hole before logging.
- f. Fluid type and temperature.
- g. Fluid resistance in ohm-m.

- h. Casing type, diameter, and elevation (top and bottom).
- i. Cement type and elevation (top and bottom).
- j. Screen type, diameter, and elevation (top and bottom).
- k. Date and time test hole was logged.
- l. Reference elevation for all depth measurements.
- m. Operator's name.
- n. Equipment name and address.
- o. Logger type and number.
- p. Tool type.
- q. Detector type (Nuclear Log only).
- r. Source type (Nuclear Log only).
- s. Source size (Nuclear Log only).
- t. Source spacing (Nuclear Log only).
- u. Tool length, cable head to detector.
- v. Calibration.
- w. Logging speed cm/min ft/min.
- x. Log vert. scale m/cm ft/in.
- y. Module settings.
- z. Recorder settings.
- aa. Document all field problems, including equipment malfunctions. This should include the steps taken to solve the problem and how the log might have been affected.

3.8.5 Well Decommissioning/Abandonment Records

Submit well decommissioning record, for each well, or test hole abandoned, within [_____] working days of the completion of the abandonment procedure. Include in decommissioning/abandonment records, as a minimum, the following:

- a. Project name.
- b. Well or test hole number.
- c. Well/boring location, depth and diameter.
- d. Date of decommissioning/abandonment.
- e. Method of decommissioning/abandonment.

