
USACE / NAVFAC / AFCEA / NASA UFGS-33 20 00 (April 2006)

Preparing Activity: USACE Replacing without change
UFGS-02521 (September 2003)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2007

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DIVISION 33 - UTILITIES

SECTION 33 20 00

WATER WELLS

04/06

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SECTION 33 20 00

WATER WELLS 04/06

NOTE: This guide specification covers the requirements for drilling of water supply wells in addition to extraction, and injection wells at hazardous, toxic, and radioactive waste (HTRW) sites, and furnishing and installing the pump, and associated testing.

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 and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

PART 1 GENERAL

NOTE: TO DOWNLOAD UFGS GRAPHICS

Go to <http://wbdg.org/ccb/NAVGRAPH/graphdoc.pdf>.

DRAWINGS

Drawings should include the following and any other information necessary to indicate layout and general configuration of the well.

Diameter of drilled hole

Casing sizes - outside casing, inside casing

Well screen size

Minimum depth of outer casing and minimum depth of well screen

Limits of gravel envelope around inside casing and screens

Limits of neat cement grout around outer casing

Location of air line and altitude gage

Type of cap, cover, or seal required at top of well

Required well capacity in gallons per minute.

1.1 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.

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
AWWA A100	(2006) Water Wells
AWWA B300	(2004) Hypochlorites

AWWA B301	(2004) Liquid Chlorine
AWWA C200	(1997) Steel Water Pipe - 6 In. (150 mm) and Larger
AWWA C206	(2003) Field Welding of Steel Water Pipe
AWWA C654	(2003) Disinfection of Wells
ASTM INTERNATIONAL (ASTM)	
ASTM A 139/A 139M	(2004) Standard Specification for Electric-Fusion (ARC)-Welded Steel Pipe (NPS 4 and over)
ASTM A 312/A 312M	(2006) Standard Specification for Seamless, Welded, and Heavily Worked Austenitic Stainless Steel Pipes
ASTM A 53/A 53M	(2006a) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM C 136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C 150	(2005) Standard Specification for Portland Cement
ASTM D 1586	(1999) Penetration Test and Split-Barrel Sampling of Soils
ASTM D 1587	(2000) Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
ASTM D 1785	(2006) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D 2216	(2005) Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D 2239	(2003) Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter
ASTM D 2487	(2006) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 2488	(2006) Description and Identification of Soils (Visual-Manual Procedure)
ASTM D 4318	(2005) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D 4750	(1987; R 2001) Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)

ASTM D 5079	(2002) Preserving and Transporting Rock Core Samples
ASTM D 5088	(2002) Decontamination of Field Equipment Used at Nonradioactive Waste Sites
ASTM D 5299	(1999) Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities
ASTM D 5521	(1994; E 1998) Development of Ground-Water Monitoring Wells in Granular Aquifers
ASTM D 5608	(2001) Decontamination of Field Equipment Used at Low Level Radioactive Waste Sites
ASTM F 480	(2002) Thermoplastic Well Casing Pipe and Couplings Made in Standard Dimension Ratios (SDR), SCH 40 and SCH 80

U.S. ARMY CORPS OF ENGINEERS (USACE)

CED TR GL-85-3	(1985) Geotechnical Descriptions of Rock and Rock Masses
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U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

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

NOTE: Separate pay items for test holes and water wells must be included in the contract.

Payment for each specified item will be made at the contract unit price for that item. Payment will include 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. Depth, logging, installation, casing, riser pipe, and well screen shall be measured by linear distance. Payment will not be allowed for test holes or wells abandoned due to construction practices not in accordance with this specification, faulty construction practices or for the convenience of the Contractor.

1.2.1 Test Hole

Compensation for the test hole will be made at the contract unit price and will include material, equipment, and labor required to drill and perform

tests on the test hole. Depth shall be measured as the total linear distance between ground surface and bottom of hole. If the total depth of hole is greater than that specified on the contract for "Test Hole," the additional depth will be paid for at the contract unit price for "Additional Test Hole Depth." If the test hole is developed into the permanent well with no increase in diameter, the Contractor will be compensated as described below, and separate payment will not be made for the test hole.

1.2.2 Water Well

Compensation for the water well will be made at the contract unit price and will include material, equipment, and labor required to drill, develop, perform tests, and complete the permanent well. Depth shall be measured as the total linear distance between ground surface and bottom of hole. If the total depth of well is greater than that specified in the contract for "Water Well," the additional depth will be paid for at the contract unit price for "Additional Water Well Depth."

1.2.3 Observation Well

Compensation for an observation well will be made at the contract unit price and will include material, equipment and labor required to drill, install, and complete the observation well, as well as perform tests and permanently grout it after use. Depth shall be measured as the total linear distance between ground surface and bottom of hole. If the total combined depth of observation wells is greater than that specified in the contract for "Observation Wells," the additional depth will be paid for at the contract unit price for "Additional Observation Well Depth."

1.2.4 Geophysical Logging

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

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

1.2.5 Well or Test Hole Decommissioning/Abandonment

Permanent decommissioning/abandonment of wells or test holes will be 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 will include 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.

1.2.6 Site Cleanup

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

1.3 GENERAL REQUIREMENTS

NOTE: The geologist must be aware of the approximate depth of well and length of screen required to provide sufficient water to fulfill project requirements and the quality of water to be expected at that depth. (The Post, or Resident Engineers office, or local USGS office is a good source for this information.) This knowledge is necessary to estimate well drilling costs and to determine what type of treatment is required to make the water usable. Any such site-specific conditions or criteria for individual projects should be included in this paragraph. The geologist must ensure that well design meets or exceeds Federal, state, and local installation requirements. Additional criteria may apply for wells at radioactive, mixed, biological, solid, or medical waste sites. Guidance on water well construction may be found in Environmental Protection Agency (EPA) Manual of Water Well Construction Practices (570/9-75/001).

The well shall be located [as shown] [where directed], and be constructed in accordance with these specifications. Each well shall be installed to prevent aquifer contamination by the drilling operation and equipment, intra- and inter-aquifer contamination, and vertical seepage of surface water adjacent to the well into the subsurface, especially the well intake zone.

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. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" 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.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Diagrams[; G][; G, [____]].

As-built installation diagram for each well installed, prepared by the geologist present during well installation operations, within [____] working days of the completion of the well installation procedure.

SD-03 Product Data

Well Installation Plan[; G][; G, [____]].

A plan as specified in paragraph WELL INSTALLATION PLAN describing the drilling methods, sampling, and well construction and well development [30] [____] calendar days prior to beginning drilling operations. Mobilization activities may start prior to submittal of the plan. The plan shall be approved and signed by an experienced geologist as specified in paragraph QUALIFICATIONS.

Well Material

Catalog data, and name of supplier, for 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, pumps, and chemical specifications on drill lubricants, tracers, disinfecting agents, and drill fluid additives, if used. Catalog data shall include any information, written or otherwise, supplied by the manufacturers or suppliers of the above listed items.

Qualifications

Personnel qualification documentation.

Site Conditions

A copy of all permits, licenses, or other legal requirements necessary for execution of the work shall be furnished [____] working days before commencement of the work.

Geophysical Logging

The Contractor shall prepare a graphic boring log to scale showing the required details. [Five] [_____] prints of the boring log drawing shall be submitted within [_____] working days after completion of the test hole. This drawing shall be used for determining the well design, design of the filter pack, well screen location and screen openings.

SD-06 Test Reports

Survey Maps and Notes

Survey maps and notes, including a tabulated list of all wells and monuments, copies of all field books, maps showing the locations, and elevations of all wells, datum used (e.g. state plane NAD27, NAD83, UTM, etc.), elevation datum, units of measurement, and all computation sheets shall be submitted within [_____] working days after completion of the survey. Also, a diagram showing where on the top of the well the elevation was determined by the surveyor.

Well Development Records

A well development record, for each well, within [_____] working days of the completion of development.

Geophysical Logs

Interpreted geophysical logs shall be submitted within [_____] working days of the completion of said logging.

Decommissioning/Abandonment Records

A well decommissioning record, for each well, or test hole abandoned, within [_____] working days of the completion of the abandonment procedure.

Project Photographs

Before, during, and after completion of the work, the Contractor shall take photographs of each well installation site. Photographs shall also be taken of any rock that is cored at the site.

Water Source

Decontamination and drilling water source analytical test results shall be submitted within [_____] working days before beginning drilling operations.

Filter Pack

Filter pack material test results; sieve and chemical analyses, shall be submitted within [_____] working days after completion of the test hole.

Tests.

Test Reports within [_____] [24] hours following the conclusion

of each test.

SD-07 Certificates

NOTE: Edit the submittal requirements based on the
type of well (consolidated or unconsolidated). If
the specification is written for a consolidated
well, delete the well components which are not
normally required in consolidated formations, such
as inner casing, well screen, and gravel fill.

Casing

Cement and Bentonite Grout

Air line and gauge

Drilling mud

[Well Screens]

Water removed

Graveling equipment list

Construction of Filter Pack

1.5 WELL INSTALLATION PLAN

The following requirements shall be incorporated into the Contractor's Well Installation Plan and followed in the field. The plan shall include, but shall not be limited 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, [air line and gauge](#), tailpiece (if used), filter pack and filter pack gradation, bentonite or [drilling mud](#), 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. The maximum frost penetration for the site shall be included 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 well capacity testing techniques.
- l. Description and discussion of geophysical techniques to be employed at the site.
- m. Description of permanent pump to be installed, and discussion of pump operating tests to be employed at the site.
- n. Description of specific methods to be employed to control potential contamination or pollution arising from well installation activities.

1.6 QUALIFICATIONS

NOTE: When installing extraction, or injection wells for environmental purposes, it is important that the Contractor have personnel experienced in hazardous waste projects, and have the proper safety training in accordance with 29 CFR 1910.120.

A geologist with at least [3] [_____] years experience in [hazardous waste projects,] soil and rock logging, and well installation, [registered in the state of [_____,] shall be on site and responsible for all geophysical and borehole logging, drilling, well installation, developing and testing activities. The driller shall be licensed in the state of [_____,] according to the state requirements. Geophysical log interpretation shall be done by a qualified log analyst. The log analyst shall be able to demonstrate competence through background, training, and experience when so called upon. The Contractor shall have a minimum of [_____] years of well installation experience. [The Contractor's staff shall include appropriate health and safety personnel as specified in Section 01 35 30 SAFETY, HEALTH AND EMERGENCY RESPONSE (HTRW/UST), 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.]

1.7 TEST HOLES AND OBSERVATION WELLS

1.7.1 Test Holes

NOTE: The test hole and capacity test should be specified if there is reason to believe that the

well may not produce the required yield at the design depth. If the required yield is not obtained, the test hole may be drilled deeper or the location changed before the complete well is constructed. Requirements for the test hole may be deleted if the well is to be constructed in an area where other wells of similar depth and design are performing adequately. However, a drill log should be made and capacity test should be performed for all wells to provide an "as built" record.

Before starting construction of the well, a test hole of at least [100] [] mm [4] [] inches in diameter shall be drilled at the location of the well into the target water bearing [stratum] [strata] as directed by the Contracting Officer. Test holes should be drilled in a manner to protect the subsurface from surface contamination. Test holes should be carefully advanced and sampled to determine the presence of the upper aquiclude if one exists. The boring should then be properly cased, grouted, and sealed into the aquiclude before the boring is advanced through the aquiclude into the aquifer. The test hole shall be used to determine the expected yield from the well, water quality, optimum depth, and to log the strata encountered. Before conducting a capacity test, the well shall be cased, and screened in accordance with these specifications. Test holes shall be logged in accordance with paragraph BOREHOLE LOGS. A temporary casing [may] [shall] be used. If used, the temporary casing shall be seated [into the top of the rock] [at the top of the stratum being tested]. The test hole may be converted to the permanent well, in accordance with these specifications. If the test hole is not used for the permanent well, the test hole shall be abandoned as specified in paragraph WELL DECOMMISSIONING/ABANDONMENT.

1.7.2 Sampling

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 QUALIFY CONTROL for sampling for chemical analysis. When sampling at an HTRW site, properly decontaminated stainless steel samplers should always be used. If rock is cored at the site, properly decontaminated stainless steel samplers should always be used. 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 1110-1-1901, 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 D 5079.

1.7.3 Sampling for Chemical Analysis

Sampling requirements for obtaining and preserving samples for chemical analysis shall be included in the Sampling and Analysis Plan as required in Section 01 35 45.00 10 CHEMICAL DATA QUALITY CONTROL.

1.7.4 Sampling for Geotechnical Analysis

Samples shall be taken of all materials penetrated by each drilled well/test hole. Soil sampling shall be done with a [split] [thin-walled] tube sampler using standard sampling techniques in accordance with [ASTM D 1586] [ASTM D 1587]. Samples shall be extracted from their in-situ environment in as near an intact, minimally disturbed condition as technically practical. Samples shall be obtained continuously through the area expected to be screened. The Contractor shall provide sieve analyses of all drive-sampled material. Sieve analyses shall be conducted in accordance with ASTM C 136. The gradation of the natural formation shall be determined by the Contractor through the use of sieve analyses performed on formation samples taken from the areas to be screened. Drive-sampled materials shall be placed in airtight containers and labeled as specified in paragraph SAMPLE CONTAINERS. Samples shall be delivered to the Contracting Officer designated facility. Representative soil samples shall be tested for grain-size distribution by mechanical means (sieves down to the 0.074 mm No. 200 size according to ASTM C 136), moisture content according to ASTM D 2216 and Atterberg limits according to ASTM D 4318. Description and identification of soils shall be done in accordance with ASTM D 2488. Laboratory classification of soils shall be done in accordance with ASTM D 2487. Sampling shall be performed to allow completion of the documents described in paragraph BOREHOLE LOGS.

1.7.5 Observation Wells

NOTE: In some cases an observation well or wells should be drilled an appropriate distance from the test hole or pump well. The observation wells (piezometers) should be monitored during the yield test of the test hole and/or capacity test of the pump well so that valid information of aquifer potential and character may be obtained. The observation wells must be designed, installed and removed from service in a manner that precludes the possibility of future groundwater contamination resulting from their existence. If the decision is made to keep the observation well for future sampling, or for use in future pumping tests, the observation wells must be properly completed as specified in this section, or other USACE guidance, such as UFGS 33 24 13 GROUND-WATER MONITORING WELLS. When installing extraction, or injection wells at an HTRW site, consideration should also be given to leaving some observation wells in place, to be used for longterm operation and maintenance (O&M) of the extraction, and injection wells

After completion of the [test hole] [pump well] [____], [1] [____] observation well(s) [, or more as directed], at least [45] [____] mm

[1-3/4] [_____] inches in diameter shall be drilled to the target water bearing stratum, [at the location(s) indicated on the drawings] [at a location [_____] m [_____] feet from] [at an appropriate location near] the [test hole] [pump well] [_____]. The observation well shall be used in conjunction with the [yield test of the test hole] [and] [capacity test of the pump well]. After final acceptance of the pump well by the Contracting Officer, the observation well shall be [abandoned as specified in paragraph WELL DECOMMISSIONING/ABANDONMENT] [left in place for future monitoring of the well system].

1.8 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 may not be 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 D 5753.

The total depth of each test hole drilled shall be geophysically logged. Geophysical logging shall be documented in accordance with paragraph Geophysical Logs. The Contractor shall 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. Log analyses and interpretations shall be made by a person qualified in accordance with paragraph QUALIFICATIONS.

1.9 ABANDONMENT OF WELLS

If the Contractor fails to construct a well of the required capacity, or if the well is abandoned because of loss of tools, or for any other cause, the Contractor shall abandon the hole as specified in paragraph WELL DECOMMISSIONING/ABANDONMENT.

1.10 NOTIFICATION

The [Installation Environmental Coordinator (IEC)] [_____] [and the] Contracting Officer shall be notified [_____] days prior to drilling. The [Contracting Officer] [Contractor] [Installation Environmental Coordinator (IEC)] [_____] shall be responsible for contacting the [State of [_____] [USEPA] in accordance with the applicable reporting requirements. Before beginning work, the local United States Geological Survey office (USGS) [and the] [State Environmental Protection office] [State Geological Agency] [state health department] [local health department] shall be notified of

the type and location of wells to be constructed, the method of construction and anticipated schedule for construction of the wells.

1.11 DELIVERY, STORAGE, AND HANDLING

Well materials shall be stored and maintained in a clean, uncontaminated condition throughout the course of the project. Filter pack material shall not be allowed to freeze before installation.

1.12 SITE CONDITIONS

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

Access to each 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]. Obtaining rights-of-entry is the responsibility of the [Contractor] [Government]. The Contractor shall 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 agree on a suitable clearing, or relocation plan, and the location of any required access road.

PART 2 PRODUCTS

2.1 CASING

NOTE: Well components do not have to be made of the same materials to be compatible. With the proper connectors, different materials can be used together without causing detrimental results. When using different materials together, the manufacturer should be consulted.

All casing, screen, and other well material shall be of compatible materials to prevent galvanic reaction between components of the completed well.

2.1.1 Steel Casing and Couplings

Steel casing shall be new [carbon steel, conforming to ASTM A 139/A 139M Grade B] [standard weight [galvanized] [black] steel pipe, conforming to ASTM A 53/A 53M] [steel pipe conforming to AWWA C200] [[type 304] [or] [type 316] stainless steel] and shall be nominal [_____] mm [_____] inch diameter, [_____] mm [_____] inch wall thickness [schedule 5S meeting the requirements of ASTM A 312/A 312M], as applicable. Joints shall be either threaded and coupled, or field welded in accordance with AWWA C206. [Casings shall be provided with [drive shoes] [_____].]

2.1.2 Plastic Casing and Couplings

NOTE: ASTM F 480 covers several different types of

pipe materials and coupling configurations. If any of these materials or couplings are to be prohibited, this paragraph should clearly point out which are or are not allowed. When installing extraction or injection wells, for environmental purposes, thermal or solvent welded couplings on plastic pipe should not be used.

Plastic casing pipe and couplings shall be schedule [80] [____], threaded flush joint (or other joint type as approved by the Contracting Officer) and conform to [ASTM F 480](#) and [ASTM D 1785](#).

2.2 WELL SCREENS

NOTE: Well screens will be specified when the developed well requires assurance of relatively free entry of water into the casing at low velocity, when surrounding sand from the unconsolidated formation must be prevented from entering the intake, or when a structural retainer is required to support the borehole in the unconsolidated material. Type of screen and casing will be designer's option and nonapplicable type of screen will be deleted. Metal screens and casings will be specified when strength of screen and casing must be greater than that provided by plastic or when maximum open area for the screen diameter is required. Plastic screens and casing may be specified when water quality is such that screen selection requires corrosive-resistant materials, or when economy is of prime importance. Blanks in the well screen may be appropriate if more than one water bearing zone is encountered in an aquifer, or when it is necessary to place a centering device (centralizer) in the screened area. However, screening more than one aquifer in the same well should be avoided whenever possible due to the possibility of cross-contamination.

Well Screens shall be a minimum of [100] [____] mm [4] [____] inches nominal diameter, and shall be directly connected to the bottom of the inner casing by an approved method. The length of the screen shall be sufficient to provide an intake area capable of passing not less than the minimum required yield of the well, at an entrance velocity not exceeding 30.5 mm/s 0.1 fps. The opening, or slot size of the screen, shall be [[____] mm [____] inch] [determined by the Contractor] [designed based on analysis of the distribution of the grain size of the [aquifer materials encountered during drilling] [artificial filter pack]], be compatible with the material surrounding the screen, and shall be submitted for approval as part of the well installation plan. The well screen shall be of sufficient size and design to hold back and support the [gravel used in the filter pack envelope] [and] [in-situ material surrounding the screen]. The screen and all accessories required for satisfactory operation shall be essentially standard products of manufacturers regularly engaged in the production of such equipment. Field constructed screen is not acceptable. "Blanks" in the well screen may be utilized in nonproductive zones, or

where centering devices are needed in the screened area, and shall be considered "casing." The bottom section, below the screen, shall be sealed watertight by means of a [flush threaded] [welded] end cap of the same material as the well screen.

2.2.2.1 Metal Screen

Metal screen shall be of an approved wire-wound type and shall be [type 304] [or] [type 316] stainless steel, conforming to the applicable requirements of [AWWA A100](#). A wire-wound screen manufactured with supporting bars or core of material different from the wire will not be acceptable. Joints shall be made of threaded couplings of the same material as the screens or by brazing or welding in accordance with [AWWA C206](#).

2.2.2 Plastic Screen

2.2.2.1 Plastic Pipe

Plastic pipe shall be thermoplastic manufactured by a molding, extrusion or sonic welding process. The plastic compounds shall be uniform in composition and shall not contain additives or foreign matter. The molding or extrusion process shall produce pipe that is homogeneous throughout and free from visible cracks, holes, foreign inclusions or other defects. Pipe produced by simultaneous multiple extrusion shall have strong uniform bonds between any two layers so that the layers cannot be separated. Plastic pipe shall be uniform in color, opacity, density and other physical properties. Plastic pipe, and screen material shall conform to [ASTM F 480](#). All PVC plastic pipe shall conform to [ASTM D 1785](#).

2.2.2.2 Bonding Materials

**NOTE: When sampling for trace level contaminants in
a well, the use of any solvents to join casing
should not be allowed.**

Bonding materials, proportions and preparation of adhesives, the method of application, and the procedure used for making and curing the connections shall conform to the recommendations of the plastic pipe manufacturer and [ASTM F 480](#). The pot life, initial setting time and external heating requirements for curing of the adhesive shall be suitable for the procedure and climatic and other conditions and shall be varied as required to suit changes in climatic and other conditions. The system for making joints at the well site shall provide a curing period adequate to develop the ultimate strength of the completed joint. Self-tapping screws or other devices for holding adhesive-coated pipe in the couplings during the setting period [may] [shall not] be utilized. Newly-made joints in the casing shall not be stressed, lowered into the well or submerged in water prior to complete curing of the adhesive.

2.2.2.3 Plastic Well Screen

Plastic well screen shall be provided with perforations which shall consist of either machine-sawed slots, continuous wrap or wound, or drilled, formed, or molded openings, and which shall have smooth, sharp-edged openings free of burns, chipped edges, or broken pieces on the interior and exterior surfaces of the pipe. The pattern of the openings shall be

uniformly spaced around the periphery of the well screen. Compatible slot sizes of screens and [filter-pack gradations] [surrounding material] shall be designed by the Contractor and furnished to the Contracting Officer [, with a representative sample of materials in which the screen is to be placed]. The plastic pipe screen strength properties shall be equivalent to those for the plastic casing with which the screen is used.

2.3 FILTER PACK

NOTE: The use of artificial filter-pack construction is recommended in formations where the screen slot opening, selected on the basis of a naturally developed well, is smaller than 0.25 mm (0.010 inch) (No. 10 slot). Artificial filter-pack material should also be specified when fine uniform material, or extensively laminated, non-homogenous formations are encountered. Guidance for designing and selecting the screen slot size, and filter pack gradation may be found in EPA's "Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells", (EPA document number 600/4-89/034); or "Groundwater and Wells", by Fletcher G. Driscoll, published by Johnson Well Screens, 1986.

If the well is not a filter pack type, this paragraph should be deleted in its entirety, along with other references to filter pack wells throughout the specification. Sterilizing the filter material before being placed is not required for extraction and injection wells installed at hazardous, toxic, and radioactive waste (HTRW) sites. When requiring sterilization, the strength of the sterilizing agent should be stated, and how much is required per cubic yard of filter pack.

Filter pack material shall be a product of a commercial sand and gravel supplier, shall be properly sized and graded for the surrounding soil encountered, and shall be composed of clean, round, hard, waterworn siliceous material, free of flat or elongated pieces, organic matter, or other foreign matter. The filter material shall be of a size which will allow the maximum flow of water into the well and prevent the infiltration of sand and silt. The gradation of the filter material shall be such that the uniformity coefficient is not more than 2.5. The filter material shall be [thoroughly sterilized with chlorine or hypochlorite immediately before being placed] [placed as directed].

2.4 BENTONITE SEAL

NOTE: Before installing an annular seal, the state regulatory agency should be consulted. The state, or local municipality, where the well is being installed, may have specific requirements for sanitary, and/or wellhead protection.

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

2.5 CEMENT AND BENTONITE GROUT

2.5.1 Cement Grout

Cement grout shall consist of Portland cement conforming to ASTM C 150, Type I or II, sand and water. Cement grout shall be proportioned not to exceed 2 parts, by weight, of sand to 1 part of cement with not more than 23 liters 6 gallons of water per 42.6 kg 94 lb bag of Portland cement, with a mixture of such consistency that the well can be properly grouted. No more than 5 percent by weight of bentonite powder may be added to reduce shrinkage.

2.5.2 Bentonite Grout

High-solids bentonite grout shall be made from sodium bentonite powder and/or granules. Water from an approved source shall be mixed with these powders or granules to form a thick bentonite slurry. The slurry shall consist 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/L 9.4 lb/gallon of water or greater.

2.6 PERMANENT PUMP

NOTE: The pump and motor diameter should be at least 25 mm (1 inch) smaller than the inside diameter of the well screen or casing, whichever is smaller, in order to allow it to be removed for servicing after buildup of scale on the outside of the pump and inside of the well screen and casing. Pump components need to be compatible with the contaminants of concern, when installed at an HTRW site. A permanent pump should not be specified until it is known how much the well will produce. The installation of the permanent pump may need to be in a separate section, (refer to UFGS 43 21 39 PUMPS: WATER, VERTICAL TURBINE).

Permanent pump shall be an approved [submersible] [jet] [or] [_____] type with a capacity sufficient to deliver [_____] L/s gpm. The pump shall be connected to the pump controls by a three-wire drop line. Piping for the well drop line shall be [polyethylene plastic pipe conforming to ASTM D 2239] [galvanized steel pipe conforming to ASTM A 53/A 53M]. The pump shall operate on [208] [_____] volts, 60 Hz, [3] [single]-phase power, and the motor shall be of sufficient size to operate the pump under the maximum operating conditions without exceeding its rating. Pump shall be equipped with necessary controls to provide for automatic operation of the pump.

The pump and motor unit shall be no larger than [_____] mm inches in diameter at any point.

2.7 CONTAINERIZATION OF DEVELOPMENT WATER, AND DRILL CUTTINGS

NOTE: If installing extraction, or injection wells at a hazardous waste site, the investigation-derived waste (IDW) such as development water, or drill cuttings may have to be containerized. If this is not the case, this paragraph may be deleted.

Water removed during development and testing operations, and cuttings from the drilling operations shall be contained in D.O.T.-approved drums, containers, or vessels as specified in 49 CFR 172. The Contractor shall furnish polyethylene and steel drums with lids, lid gaskets, bolts, chain of custody forms and drum labels. The Contractor shall mark each drum label in accordance with 49 CFR 172 in addition to the following information: drum number, site name, well name and number, contents and date, approximate depth of material contained in each drum and the name and phone number of the [Installation Environmental Coordinator (IEC)] [Contracting Officer] [_____].

2.8 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 1110-1-1901, EM 200-1-3, EM 1110-1-1804, and EM 1110-1-4000.

Drill cuttings and driven samples for geotechnical purposes shall be placed in air-tight liter pint size [plastic] [glass] containers and labeled with the project name, date of sample, well number and depth at which the sample was taken. Both the container and lid shall be labeled in permanent indelible ink. Jars shall be placed in partitioned [cardboard] [_____] boxes. Boxes shall be labeled with project number and well number. Containers and boxes shall be furnished by the Contractor. Core samples shall be preserved and prepared for transport as described in ASTM D 5079. Cored rock samples shall be placed in [wooden] [_____] core boxes as indicated on the drawings. Spacers shall be placed in the proper positions in the core boxes to show the location and actual extent of voids and core losses as clearly as possible. The spacers shall be made of [wood] [_____] [or some other relatively light material] which is of sufficient strength to withstand jarring and crushing in handling. Spacers shall be of a strongly contrasting color pattern so that core losses will be accented either by direct observation or in photographs. In the smaller sizes, up to and including 150 mm 6 inches, the spacers shall be the same width as the cores. The outside and the inside of the core box lid shall be labeled with the project name, hole number, date sampled, location, surface elevation, core box number, and interval of depth of core. The information on the label shall be such that it can clearly be read in photographs of the core box. Both ends of the core box shall also be labeled with the hole number and box number. The core shall be placed in the core box starting at the left hand corner on the hinge side and running to the right. Successive cores down the hole shall be placed 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

The Contractor shall maintain existing survey monuments and wells, and protect them from damage from equipment and vehicular traffic. Any items damaged by the Contractor shall be repaired by the Contractor. Wells requiring replacement due to Contractor negligence shall be re-installed according to these specifications. Wells scheduled for abandonment shall be protected from damage so that abandonment may be performed according to these specifications. Prior to excavation, the Contractor shall 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

NOTE: It may not be necessary to decontaminate the drilling equipment if not installing wells at an HTRW site. However, given that drilling equipment can be, and is used at both HTRW, as well as non-HTRW sites, it may be prudent to also require that the equipment be decontaminated before use at a non-HTRW site.

The drill rig, drill rods, drill bits, augers, temporary casing, well developing equipment, tremie pipes, grout pumping lines, and other associated equipment shall be cleaned with high-pressure hot water/steam prior to drilling at each well location. Decontamination shall be done in accordance with ASTM D 5088 or ASTM D 5608. Decontamination shall be performed at a central decontamination station. Cleaning shall be performed in an area that is remote from, and cross- or down-gradient from the well being drilled. Screen and well casing shall be cleaned 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. Samplers shall be decontaminated in accordance with the Sampling and Analysis Plan as required in Section 01 35 45.00 10 CHEMICAL DATA QUALITY CONTROL. The water used for cleaning shall be from a Government approved source. The water source used for cleaning shall be sampled and tested for the constituents specified in the Sampling and Analysis Plan prior to use at the site.

3.2.2 Decontamination Station

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

The Contractor shall construct a temporary decontamination pad onsite. The pad shall be bermed and slightly inclined towards a sump located in one of

the back corners of the pad. Plastic sheeting shall line the pads and berms to contain decontamination water. Plywood sheeting, exterior grade, shall be placed over the plastic sheeting to prevent damage to the plastic and allow the drill rig and heavy equipment to use the pad. The minimum dimensions of the pad shall be the length and width of the drill rig, plus 1.2 meters 4 feet per side to allow access and steam cleaning. Yellow ribbon shall be used to encircle the decontamination pad. Water collected in the sump shall be pumped using a "trash" pump to transfer water to a 200 liter 55 gallon drum labeled "Decontamination Pad Sump Water." Solid waste shall be transferred to a separate 200 liter 55 gallon drum labeled "Decontamination Pad Sump Sludge."

3.2.3 Water Source

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

If well drilling/installation requires the use of water, prior to its use at the site, the water source shall be sampled and tested, and approved by the Contracting Officer for the constituents specified in the Sampling and Analysis Plan as required in Section 01 35 45.00 10 CHEMICAL DATA QUALITY CONTROL. The Contractor shall be responsible for locating the source, obtaining the water from the source, transporting it to, and storing it at the site. A water sample shall be obtained from the container used in transporting the water to the site before the water is used for decontamination. This sample shall be tested and approved in accordance with the above requirements.

3.3 WELL CONSTRUCTION

NOTE: Delete prohibition against organic drilling
fluid, and grease, oil, and fuel leaks on equipment
if not installing wells at an HTRW site, or if not
applicable for the project.

The drilling method shall be as approved by the Contracting Officer and shall conform to all state and local standards for water well construction. The execution of the work shall be by competent workmen and shall be performed under the direct supervision of an experienced well driller. The drilling method shall prevent the collapse of formation material against the well screen and casing during installation of the well. The inside diameter of any temporary casing used shall be sufficient to allow accurate placement of the screen, riser, centralizer(s), filter pack, seal and grout. [Any drilling fluid additive used shall be inorganic in nature, but be phosphate free. 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. The drill rig shall be free from leaks of fuel, hydraulic fluid, and oil which may contaminate the borehole, ground surface or drill tools.] Casing pipe, well screens, and joint couplings shall be of compatible materials throughout each well. The well shall be a [filter pack well] [naturally developed well] activated in the [overburden] [water-bearing stratum] [stratum based on test hole data]. The well shall be drilled straight, plumb, and circular from top to bottom. The well shall be initially drilled from the ground surface to the [uppermost level of the water bearing strata] [top of rock] [_____] and the bottom of the

outer casing set at this elevation. The hole below the outer casing shall penetrate the water bearing stratum a sufficient depth to produce the required amount of water without causing excessive velocities through the aquifer. During construction of the wells, precautions shall be used to prevent tampering with the well or entrance of foreign material. Runoff shall be prevented from entering the well during construction. If there is an interruption in work, such as overnight shutdown or inclement weather, the well opening shall be closed with a watertight uncontaminated cover. The cover shall be secured 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.

3.3.1 Setting Outer Casing

**NOTE: There is a provision for temporary casing, as
extraction and/or injection wells may not require a
permanent outer casing.**

The outer casing shall not be less than [200] [_____] mm [8] [_____] inches in diameter. The hole shall be of sufficient size to leave a concentric annular space of not less than [65] [_____] mm [2-1/2] [_____] inches and not more than [150] [_____] mm [6] [_____] inches between the outside of the outer casing and the walls of the hole. The annular space between the outer casing and the walls of the holes shall be filled with cement grout. Acceptable methods of grouting are detailed in [AWWA A100](#); the approved method shall specify the forcing of grout from the bottom of the space to be grouted towards the surface. A suitable grout retainer, packer, or plug shall be provided at the bottom of the inner casing so that grout will not leak into the bottom of the well. Grouting shall be done continuously to ensure that the entire annular space is filled in one operation. After grouting is completed, drilling operations shall not be resumed for at least [72] [_____] hours to allow proper setting of the grout.

3.3.2 [Temporary Casing

Temporary well casing of either iron or steel of sufficient length to case to the bottom of all borings shall be available at the construction site. The Contracting Officer will direct the use of a temporary casing to the bottom of the boring during drilling and placement of screen, riser, and filter pack when he believes it is necessary to provide adequate support to the sides of the hole. When the walls of the boring will require support only during development operations a temporary casing will be required to extend only to a depth 1 m 3 feet below the top of the filter pack. The temporary casing, shall have an inside diameter of not less than [_____] mm inches, shall have sufficient thickness to retain its shape and maintain a true section throughout its depth, and may be in sections of any convenient length. The temporary casing shall be such as to permit its removal without disturbing the filter pack, riser, or well screen. The setting of temporary casing shall be such that no cavity will be created outside of it at any point along its length. In the event the temporary casing should become unduly distorted or bent it should be discarded and a new casing should be used during installation of any additional well.]

3.3.3 Construction of Inner Casing and Screen

After the grout has set, the hole below the outer casing shall be reamed at the required diameter, to the required depth, by an approved method which

will prevent caving of the hole before or during installation of the filter pack, well screen and inner casing. In lieu of reaming, the entire well may be drilled to the diameter of the filter pack with an annular space between the inner casing and outer casing equal to the thickness of the filter pack. The outer casing shall be increased in size to provide for this space, if this option is elected. The well screen and inner casing shall be firmly attached, and lowered into the hole by a method which will allow for control of the rate of fall of the well screen and inner casing at all times. Well screen and inner casing shall not be dropped or allowed to fall uncontrolled into the hole. The inner casing shall extend up through the outer casing to [_____] meters feet [above][below] the ground surface. Approved centering devices shall be installed at a spacing of 120 degrees, between the outer casing and inner casing prior to well construction at [intervals not exceeding [8] [_____] m [25] [_____] feet along the length] [the top of the inner casing and the bottom of the outer casing]. If the screen length is greater than [8] [_____] meters [25] [_____] feet, a [1] [_____] meter [3] [_____] foot length of blank casing shall be placed in the middle of the screen interval for placement of centering devices. Centering devices shall not be placed on the screened interval, or within the bentonite seal, if used.

3.3.4 Construction of Filter Pack

NOTE: If the natural formation is developed as the well filter, then this paragraph may be deleted. If development of the well is done after the filter pack is installed, but before the bentonite, or annular seal is installed, additional filter pack material may have to be added, if the level of the top of the filter pack drops below the specified elevation for the top of the filter pack. When installing extraction, or injection wells at HTRW sites, the top of the filter pack should be no more than 1.5 m (5 feet) above the top of the screen.

After the screen and inner casing have been concentrically set in the hole below the outer casing, the approved filter pack shall be constructed around the screen by filling the entire space between the screen and the wall of the hole in the water bearing stratum with filter pack material. A tremie pipe having an inside nominal diameter of not less than [40] [_____] mm [1-1/2] [_____] inches shall be lowered to the bottom of the well between the hole and screen. The tremie pipe shall be arranged and connected, at the surface of the ground, to water pumping and **graveling equipment** so that water and filter material, fed at uniform rates, are discharged as the filter material fills the hole from the bottom up. The tremie pipe shall be raised at a rate that will keep the bottom of the pipe no more than [1] [_____] m [3] [_____] feet above the filter material level at all times. If the Contractor desires to use methods of placing filter material other than those specified, the details of the method and equipment proposed shall be submitted to the Contracting Officer, before filter pack placement is begun; however, dumping filter pack material from the surface of the ground and agitating the well in an effort to settle the filter will not be allowed. The filter pack shall be installed continuously and without interruption until the filter pack has been placed to within [300 mm 1 foot of the top of the inner casing] [1.5 m 5 feet of the ground surface] [[10] [_____] m [30] [_____] feet above the top of the screen]. The depth to the top of the filter pack shall be directly

measured, and recorded. Any water added to the filter pack material shall be obtained in accordance with paragraph Water Source. Filter pack material shall be protected 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. Filter pack material shall not be allowed to freeze before installation. Filter pack material shall be transported to the well site in a manner which prevents contamination by other soils, oils, grease, and other chemicals. Temporary drill casing, if installed, or hollow stem auger, shall be removed simultaneously with the above operation. Filter pack material shall be placed in no greater than 1 m 3 foot lifts prior to retraction of the temporary casing/auger. A minimum of 150 mm 6 inches of filter pack shall remain in the temporary casing/auger at all times during filter pack installation. Frequent measurements shall be made inside the annulus during retraction to ensure that the filter pack is properly placed.

3.3.5 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. It is recommended that the bentonite seal be placed in lifts, with each lift allowed to hydrate for a minimum period of time. Slurry seals may be used when the seal location is too far below water to allow for pellet or other containerized-bentonite placement, or within a narrow well-borehole annulus. For more guidance consult EM 1110-1-4000.

After the inner casing and [well screen] [and filter pack] have been installed, [and after predevelopment of the well,] the annular space between the inner and outer casings shall be sealed by use of a bentonite seal. A minimum 1 m 3 foot thick hydrated bentonite seal shall be placed on top of the filter pack in a manner which prevents bridging of the bentonite in the annulus. The bottom of the bentonite seal shall be a minimum of 2 m 5 feet above the top of the well screen. The depth to the top of the bentonite seal shall be directly measured, and recorded immediately after placement, without allowance for swelling. If the bentonite seal is located above any borehole fluid levels, a [300] [] mm [1] [] foot layer of fine sand shall be placed at the top of the bentonite seal.

3.3.6 Grout Placement

NOTE: Before installing an annular seal, the state regulatory agency should be consulted. The state, or local municipality, where the well is being installed, may have specific requirements for sanitary, and/or wellhead protection. There is a provision for placing a high-solids bentonite grout in the annulus above the bentonite seal rather than cement grout. Advantages and disadvantages of using a bentonite grout instead of cement grout are discussed in EM 1110-1-4000. 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.

After the inner casing and [well screen] [filter pack] have been installed, a [non-shrinking cement] [high-solids bentonite] grout, shall be mechanically mixed in accordance with paragraph CEMENT AND BENTONITE GROUT, and placed by tremie pipe, in one continuous operation into the annulus between the inner and outer casings above the bentonite seal to [within [_____] mm feet of] [the ground surface] [the maximum depth of frost penetration (frost line)]. Grout injection shall be in accordance with AWWA A100. If the casing interval to be grouted is less than 4.5 m 15 feet, and without fluids after any drill casing is removed, the grout may be placed either by pouring or pumping. The tremie pipe shall be thoroughly cleaned with high pressure hot water/steam before use in each well. The bottom of the tremie pipe shall be constructed to direct the discharge to the sides rather than downward. The discharge end of the tremie pipe shall be submerged at all times. Additional grout shall be added from the surface to maintain the level of the grout [within [_____] mm feet of the ground surface] [at the land surface] as settlement occurs. Work shall not be conducted in the well within [24] [_____] hours after cement grouting. The alignment of the well shall be verified 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. The pipe section shall be thoroughly cleaned with high pressure hot water/steam prior to each test.

3.4 WELL DEVELOPMENT

NOTE: There is a provision for predevelopment, or development after the filter pack is installed, but before the bentonite seal is installed.

Well development criteria, such as the measurement of certain ground-water parameters, may be deleted if the well is not installed at an HTRW site.

Within 7 days of completion of each well, but no sooner than [48] [_____] hours after cement grouting is completed, the well shall be developed.

[Predevelopment, or development after the filter pack has been installed, but before the annular seal is installed, may be initiated before this minimum 48 hour period.] The well shall be developed in accordance with the Well Installation Plan, by approved methods until the water pumped from the well is substantially free from sand, and until the turbidity is less than 5 on the Jackson Turbidity Scale specified in AWWA 10084. Developing equipment shall be of an approved type and of sufficient capacity to remove all cutting fluids, sand, rock cuttings, and any other foreign material. The well shall be thoroughly cleaned from top to bottom before beginning the well tests. Development shall be performed using only mechanical surging, over pumping, or jetting, or a combination thereof per ASTM D 5521.

Details of the proposed development method shall be included in the Well Installation Plan. At the time of development of any well, the well shall be free of drawdown or surcharge effects due to pump testing, developing or drilling at another location. The Contractor shall be responsible for maintaining at the well site the needed access and work area and clearance, necessary to accomplish development. The Contractor shall furnish, install, or construct the necessary discharge line and troughs to conduct and dispose of the discharge [a sufficient distance from the work areas to prevent damage] [as directed in paragraph CONTAINERIZATION OF DEVELOPMENT WATER, AND DRILL CUTTINGS]. Development shall be conducted to achieve a stable well of maximum efficiency and shall be continued until a satisfactory sand test, as specified in paragraph Sand Test, is obtained. During predevelopment of the well, filter pack material shall be added to the annular space around the screen to maintain the top elevation of the filter pack to the specified elevation. The Contractor shall provide an open tube or other approved means for accurately determining the water level in the well under all conditions. If, at any time during the development process it becomes apparent in the opinion of the Contracting Officer that the well may be damaged, development operations shall be immediately terminated. The Contracting Officer may require a change in method if the method selected does not accomplish the desired results. The Contracting Officer may order that wells which continue to produce excessive amounts of fines after development for [6] [] hours be abandoned, plugged, and backfilled, and may require the Contractor to construct new wells nearby. All materials pulled into the well by the development process shall be removed prior to performing the pumping test.

3.4.1 Jetting

Jetting should be performed using either a single or double ring jet. If a double ring jet is used the rings should be 600 mm 2 feet apart. The jetting tool shall be constructed of high-strength material and conservatively designed and proportioned so that it will withstand high pressures. The jetting tool shall have [two [7] [8] [10] mm [3/16] [1/4] [3/8] inch diameter hydraulically balanced nozzles spaced 180 degrees] [four [7] [8] [10] mm [3/16] [1/4] [3/8] inch diameter holes spaced 90 degrees] apart and which shall exert the jetting force horizontally through the screen slots. The rings shall be constructed such that the tips of the jets shall be within 13 mm 1/2 inch from the inner surface of the well screen. The pump used in conjunction with the jetting tool shall be capable of providing [pressures up to [1700] [] kPa [250] [] psi.] [a minimum jetting fluid exit velocity of 45 m/s 150 f/s]. Prior to commencing jetting, and following each jetting cycle, all sand and/or other materials shall be removed from inside the screen. The jetting process shall start at the bottom of the screen and consist of rotating the jetting tool [slowly] [1 cycle per 30 seconds] [[] cycles per [] seconds] while rotating the pipe [180] [90] degrees for two minutes at each location then raising the pipe [150] [] mm [6] [] inches. All wells, more

than 100 mm 4 inches in diameter, shall be pumped during the jetting cycle to remove incoming sand and other material. Such pumping shall be at a rate not less than 115 percent of the rate at which fluid is introduced through the jetting tool. This will allow a flow of material into the well as it is being developed. Water used for development shall be free of sand. The contracting officer may require other means of developing the well such as intermittent pumping method, variation of the intermittent pumping method, or surge block if it appears that the development of the well is not producing the desired results.

3.4.2 Intermittent Pumping

NOTE: Backflow through the pump, while starting and stopping a pump intermittently, with the check valve removed, to produce rapid changes in the pressure head within the well during development, called "rawhiding," is allowed for developing extraction and injection wells at HTRW sites. The alternate lifting and dropping of a column of water in the pump discharge pipe creates a surging action in the well. For more information on this development process, consult ASTM D 5521.

Intermittent pumping shall be performed by pumping the well at a capacity sufficient to produce a rapid drawdown of approximately [_____] m feet stopping the pump (backflow through pump will not be permitted) to permit the water surface to rise to its former elevation, and repeating this procedure. Cycle time for this procedure will vary as directed but will not be more than 3 cycles per minute. A pump discharge in excess of [_____] L/s gpm will be required. A deep well turbine pump, or electric submersible pump with check valve, shall be used with any attachment necessary to accomplish rapid starting and stopping for intermittent pumping. The intake shall be set at least 3 m 10 feet below the maximum expected drawdown in the well. Prior to commencing intermittent pumping, and periodically during development by this method, all sand and/or other materials shall be removed from inside the screen. The amount of drawdown may be decreased if, in the opinion of the Contracting Officer, the efficiency of the well might otherwise be impaired.

3.4.3 Surging

Surging of the well shall require use of a circular block, or multiple blocks, which are approximately 25 mm 1 inch smaller in diameter than the inside diameter of the well and is constructed of a material which will not damage the screen if the block comes in contact with the screen, and a bailer or pump to remove materials drawn into the well. The surging shall be continued for a period of approximately [one][_____] hour, or until little or no additional material from the foundation or filter pack can be pulled through the screen. The surge block shall be moved by a steady motion up and down the full length of the well screen. Prior to commencing surging, and periodically during development by this method, all sand and/or other materials shall be removed from inside the screen. All materials pulled into the well by the surging process shall be removed by the Contractor.

3.4.4 Well Development Criteria

NOTE: The U.S. Environmental Protection Agency (EPA) may, according to their Technical Enforcement Guidance Document (TEGD), 530/R-93/001, consider a well installed at an HTRW site 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.

A well development record shall be maintained in accordance with paragraph Well Development Records. Development is complete when all of the following criteria are met:

- a. Well water is clear to the unaided eye [,and turbidity less than or equal to [5] [____] Nephelometric Turbidity Units (NTUs)],
- 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 is removed 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 shall mean [variation of less than 0.2 pH units, variation of plus or minus \pm 0.5 degrees C 1 degree F, \pm 3 percent change in specific conductance; and less than a \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] [____]. ORP shall be determined in accordance with AWWA 10084. Temperature, specific conductance, DO, turbidity, and pH readings shall be conducted in accordance with EPA 600/4-79/020. At completion of well development, approximately 0.5 liter 1 pint of well water shall be collected in a clear glass jar. The jar shall be labeled with project name, well number and date; and photographed using 35 mm color print film. The photograph (minimally 125 x 174 mm 5 x 7 inch) shall be a suitably backlit close-up which shows the clarity of the water and any suspended sediment. The photograph and negative shall become 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 [____] m feet from the well in a down gradient area].]

3.5 TESTS

After the wells have been developed, the Contractor shall notify the

Government and shall make the necessary arrangements for conducting the capacity tests. If the capacity test indicates that the required capacity can be obtained, the tests for quality of water shall be made. If the capacity and quality tests indicate that the required capacity and quality can be obtained, the permanent well, as specified, shall be completed at that depth. Prior to making quality tests, drilling equipment, tools and pumps contacting well water shall be cleaned with live steam.

3.5.1 Capacity Test

NOTE: This test should be used to verify that the well is developed properly and will produce the required yield. Test pump should be capable of a range of pumping rates, varying from about 50 percent to about 200 percent of the design capacity of the well. Since there are a wide variety of pump test methods, the designer should refer to a good water wells reference book (such as "Ground Water and Wells," by Fletcher G. Driscoll, published by Johnson Well Screens, 1986) for test procedures which best apply.

The Contractor shall furnish and install an approved temporary test pump, with discharge piping of sufficient size and length to conduct the water being pumped to [point of discharge] [____], and equipment necessary for measuring the rate of flow and water level in the well. An [8] [____] hour [constant-rate] [step-drawdown] capacity test shall be run with the pumping rate and drawdown at the pump well and observation wells recorded every [[30] [____] minutes] [1/2 minute during the first 5 minutes after starting the pump; then every 5 minutes for an hour; then every 20 minutes for 2 hours. From this point on, readings taken at hourly intervals, until the water level stabilizes, shall be sufficient]. [Observation wells (piezometers) shall be read on the same schedule as the pump well.] [During the step-drawdown test, the pumping rate shall be increased in steps at [regular] [[2] [____] hour] intervals. Specific capacity shall be measured for each step.] The test shall begin at the rate of [the expected capacity of well] [[____] L/s gpm] and at least that rate maintained throughout the duration of the [test] [step interval]. [The well shall be "step" tested at rates of approximately [1/2, 3/4, 1 and 1 1/2] [____] times the design capacity of [____] L/s gpm.] If this capacity cannot be maintained for the test period, the capacity test shall be terminated and the test hole drilled deeper or relocated as directed. When the pump is shut off, water level readings shall be taken during the rebound period for the same intervals of time as the drawdown test. The record of the test, in triplicate, shall be delivered to the Contracting Officer.

3.5.2 Test for Plumbness and Alignment

Upon completion of the permanent well, plumbness and alignment shall be tested by lowering into the well, to the total depth of the well, a plumb [12] [____] m [40] [____] feet long or a dummy of the same length. The outer diameter of the plumb shall not be more than 13 mm 1/2 inch smaller than the diameter of that part of the hole being tested. If a dummy is used, it shall consist of a rigid spindle with three rings, each ring being [300] [____] mm [12] [____] inches wide. The rings shall be cylindrical and shall be spaced one at each end of the dummy and one in the center. The central member of the dummy shall be rigid so that it will maintain the

alignment of the axis of the rings. The dummy shall be decontaminated as specified in paragraph Decontamination, before use. If the plumb or dummy fail to move freely throughout the length of the casing or well screen for the depth of well or should the well vary from the vertical in excess of two-thirds the inside diameter of that part of the well being tested for each 30 m 100 feet of depth, the plumbness and alignment of the well shall be corrected by the Contractor. If the faulty alignment and plumbness is not correctable, as determined by the Contracting Officer, the well shall be abandoned as specified in paragraph WELL DECOMMISSIONING/ABANDONMENT and a new well drilled at no additional cost to the Government.

3.5.3 Test for Quality of Water

NOTE: The Post, or Resident Engineer, or the USGS
should be consulted to determine if any additions or
deletions should be made to the Water Quality
Analysis table.

When the capacity test in the test hole has been completed, and again after the yield in the permanent well and drawdown test or capacity test have been completed, the Contractor shall secure samples of the water in suitable containers, and of sufficient quantity, to have bacterial, physical, and chemical analyses made by [a recognized testing laboratory] [____], except that the bacterial analysis may be made by the applicable State Board of Health, if desired. Water Quality Analysis shall address each item specified in the Water Quality Analysis Table at the end of this section. Expenses incident to these analyses shall be borne by the Contractor and the results of the analyses shall be furnished to the Contracting Officer. All sampling and analyses shall be performed using EPA and State approved methods, procedures, and holding times.

3.5.4 Sand Test

As part of each capacity test, or at the end of each intermittent pumping, a determination of the amount of sand (filter pack and/or foundation material) a well is producing shall be performed. Prior to starting the sand test all material shall be removed from the bottom of the tailpipe. The Contractor shall test each well by pumping at a rate [of [____] L/s gpm] [sufficient to produce approximately [____] m feet of draw-down]. After the pump is at the desired pumping rate the flow from the discharge shall be diverted [into a container that will collect all the sand being carried by the water] [through a Rossum Sand Tester]. Development of the well is satisfactory if the amount of sand collected is less than 0.5 L per 100,000 L 1 pint per 25,000 gallons of water pumped at the specified rate. Upon completion of the test the amount of sand in the tailpipe shall be determined to verify that no material is being deposited in the bottom of the well.

3.6 INSTALLATION OF PERMANENT PUMP

NOTE: The yearly change in the regional water table
should be determined before specifying the minimum
pump depth.

The permanent well pump shall be installed in the well at a minimum depth of [8] [] m [25] [] feet below the maximum drawdown groundwater level after the drawdown test has been completed. The pump shall be secured at the required elevation as recommended by the pump manufacturer. After installation of the pumping units and appurtenances is complete, operating tests shall be carried out to assure that the pumping installation operates properly. Tests shall assure that the pumping units and appurtenances have been installed correctly, that there is no objectionable heating, vibration, or noise from any parts, and that all manual and automatic controls function properly.

3.7 DISINFECTING

After completion of tests of well, or installation of permanent pump, or at time of tests for yield and drawdown test, whichever is later, the wells shall be disinfected by adding chlorine, conforming to AWWA B301, or hypochlorite, conforming to AWWA B300, in sufficient quantity so that a concentration of at least 50 ppm of chlorine shall be obtained in all parts of the well. Chlorine solution shall be prepared and introduced into the well in an approved manner and shall remain in the well for period of at least 12 hours but not more than 24 hours. Information on methods for preparing chlorine solution and introducing it into the well may be found in AWWA C654. After the contact period, the well shall be pumped until the residual chlorine content is not greater than 1.0 ppm. The well shall be pumped to waste for an additional 15 minutes with less than 1 ppm chlorine residual after which two samples shall be taken not less than 30 minutes apart and tested for the presence of coliform bacteria. The well shall be disinfected and re-disinfected as may be required until two consecutive samples of water are found upon test to be free from Coli Acrogenes group of organisms.

3.8 PUMPHOUSE AND SLAB

NOTE: In some instances, a pumphouse and base slab may not be appropriate. In such cases, alternate designs must ensure that surface water cannot infiltrate into the well and that the pump and well head are protected.

Pumphouse and slab shall be constructed preventing the infiltration of surface water or precipitation into the well. The slab shall be [1.2] [] m square by [150] [] mm thick [4] [] feet square by [6] [] inches thick and constructed of reinforced concrete. The top of the outer casing shall extend [300] [] mm [12] [] inches above the top of the slab. The top of the slab shall be at elevation [] or higher. The pumphouse shall be constructed on the slab and thermally insulated.

3.9 SITE CLEAN-UP

After completion of the work, tools, appliances, surplus materials, temporary drainage, rubbish, and debris incidental to work shall be removed. Excavation and vehicular ruts shall be backfilled and dressed to conform with the existing landscape. Utilities, structures, roads, fences,

or any other pre-existing item which must be repaired or replaced due to the Contractor's negligence shall be the Contractor's responsibility; repair or replacement shall be accomplished prior to completion of this contract.

3.10 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 an HTRW 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.

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 shall be disposed of by [_____].

3.11 SURVEYS

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

Coordinates and elevations shall be established for each well/test hole. Horizontal coordinates shall be determined 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, an existing local grid system shall be used. A ground elevation to the closest 30 m 0.1 foot shall be obtained at each well. The highest point on the top of the riser pipe will serve as a measurement point. The elevation of the well shall reference this point, and shall be surveyed to the nearest 3 mm 0.01 foot using the [National Geodetic Vertical Datum of 1929] [North American Vertical Datum of 1988]. If the datum is not readily available, the existing local vertical datum shall be used. The location, identification, coordinates, and elevations of the well and monuments shall be plotted on maps with a scale large enough to show their location with reference to other structures.

3.12 WELL DECOMMISSIONING/ABANDONMENT

**NOTE: Guidance for decommissioning of 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 D 5299,] 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. Test holes decommissioned/abandoned for any reason shall be grouted 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. The top [____] mm feet shall be backfilled with [material appropriate for the intended land use] [____]. The Contractor shall maintain a well decommissioning/abandonment record as specified in paragraph Well Decommissioning/Abandonment Records. Groundwater levels, if encountered before the decision is made for decommissioning/abandonment, shall be measured in all borings prior to backfilling. These water levels shall be included in the well decommissioning/abandonment records. No well shall be decommissioned/abandoned without the approval of the Contracting Officer.

3.13 DOCUMENTATION AND QUALITY CONTROL REPORTS

The Contractor shall 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:

3.13.1 Borehole Logs

**NOTE: Borehole logging requirements can be found in
EM 1110-1-4000. Requirements can also be found in
ASTM D 2113 and ASTM D 5434. 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 D 6032. Item o. has a provision for
recording the level of non-aqueous phase liquids
(NAPLs). This only pertains to wells installed at a
hazardous waste site.**

A borehole log shall be completed for each boring drilled. Borehole logs shall be prepared by the geologist present onsite during all well drilling and installation activities. The log scale shall be [10] [____] mm equals [300] [____] mm [1] [____] inch equals [1] [____] foot. Copies of complete well logs shall be kept current in the field at each well site and shall be available at all times for inspection by the Contracting Officer.

Information provided on the logs shall include, but not be limited to, 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. Information shall include hammer weight and drop distance. Information such as rod size, bit type, pump type, etc., shall be recorded. 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 shall be included. If measured, mud viscosities and weight shall be recorded.
- 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 D 2488] [____], and/or standard rock nomenclature in accordance with [CED TR GL-85-3] [____], as necessary. Soil parameters for logging shall include, but shall not be limited to, classification, depositional environment and formation, if known, Unified Soil Classification Symbol, secondary components and estimated percentages, color, plasticity, consistency (cohesive soil), density (non-cohesive soil), moisture content, structure and orientation, and grain angularity. Rock core parameters for logging shall include, but shall not be limited to, rock type, formation, modifier denoting variety (shaly, calcareous, siliceous, etc.), color, hardness, degree of cementation, texture, crystalline structure and orientation, degree of weathering, solution or void conditions, primary and secondary permeability, and lost core. The results of any chemical field screening shall also be included on the boring log. Classification shall be prepared in the field at the time of sampling. The results of visual observation of the material encountered, and any unusual odor detected shall also be duly noted and recorded.
- m. Depth of any observed fractures, weathered zones, or any abnormalities encountered.

- n. 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.
- o. 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. The Contractor shall 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. The device shall be available onsite at all times and measuring wire shall be graduated in mm 0.01 foot. The method of measuring the liquid level shall be noted on the boring log. Water [and NAPL] level measurements shall be taken to the nearest mm 0.01 foot. It shall be noted on the boring log if the boring was purged and allowed to recover at intervals during the installation, or that water used in drilling was allowed to dissipate into the formation prior to measuring the water level.
- p. Box or sample number. Depths and the number of the core boxes and/or samples shall be recorded at the proper interval.
- q. Percent Rock Core Recovery. The percent core recovery for the individual drill runs, if rock is cored, shall be shown.

3.13.2 Installation Diagrams

The well will not be accepted before the geologic logs and installation diagrams are received. The diagram shall illustrate the as-built condition of the well and include, but not be limited 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), if used.
- 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 (if used), 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.

3.13.3 Well Development Records

NOTE: Delete item k. if not applicable for the project.

A well development record shall be prepared for each well installed under the supervision of the geologist present during well installation operations. Information provided on the well development record shall include, but not be limited 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 as per **ASTM D 4750** from top of the casing, immediately after pumping/development, and 24 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.

3.13.4 Geophysical Logs

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

Geophysical logs shall be prepared and completed for each well/test hole installed. Information provided on the logs shall include, as a minimum, the following:

- a. Project name.
- b. Test hole/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.

3.13.5 Well Decommissioning/Abandonment Records

Decommissioning/abandonment records shall include, 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.
- f. All materials used in the decommissioning/abandonment procedure and the interval in which test materials were placed.
- g. Casing, and or other items left in hole by depth, description, and composition.
- h. Description and total quantity of grout used initially.
- i. Description and daily quantities of grout used to compensate for settlement.
- j. Water or mud level (specify) prior to grouting and date measured.
- k. The reason for decommissioning/abandonment of the well/test hole.

3.13.6 Project Photographs

Before, during, and after completion of work, the Contractor shall take a minimum of [one view] [] views] of each well installation. If rock is cored at the site, after the core has been logged, the core shall be dampened, if it has dried, neatly arranged in the core box, and

photographed. Photographs shall be [80] [] x [120] [] mm [3] [] x [5] [] inch color prints. The photographs shall be mounted and enclosed back-to-back in a double face clear plastic sleeve punched to fit standard three ring binders. Each color print shall show an information box, [20] [] x [50] [] mm [1-1/2] [] x [3-1/2] [] inches. The box shall be typewritten and arranged as follows:

Project No. Contract No.

Contractor/Photographer:

Photograph No. Date/Time:

Description:

Direction of View:

3.13.7 Survey Maps and Notes

A tabulated list of all wells and monuments, copies of all field books, maps showing the locations, and elevations of all wells, datum used (e.g. state plane NAD27, NAD83, UTM, etc.), elevation datum, units of measurement, and all computation sheets shall be prepared as a submittal. The tabulation shall consist of the designated number of the well or monument, the X and Y coordinates, and all the required elevations. Also, a diagram showing where on the top of the well the elevation was determined by the surveyor shall be prepared.

WATER QUALITY ANALYSIS TABLE

Physical Characteristics

Color	Resistivity in ohms per cubic
Taste	centimeter and 25 degrees C.
Threshold odor number	pH value
Turbidity	Temperature

Chemical Characteristics (Expressed as mg/L)

Arsenic	Total Hardness as CaCO(3)
Barium	Endrin
Cadmium	Lindane
Chromium	Methoxychlor
Copper	Toxaphene
Lead	2-4-D
Mercury	2, 4, 5 TP Silvex
Selenium	Total Organic Halogens
Silver	TOC
Zinc	Sulphates as SO(4)
Fluoride as F	Chlorides as Cl
Manganese as Mn (dissolved and total)	Bicarbonates as HCO(3)
Iron as Fe (dissolved and total)	Carbonates as CO(3)
Suspended Solids	Nitrates as NO(3)
Total Dissolved Solids	Alkalinity (methyl-orange)

Chemical Characteristics (Expressed as mg/L)

Calcium as Ca	(Phenolphthalein) as CaCO_3
Magnesium as Mg	Silica as SiO_2
Sodium and Potassium as Na	

-- End of Section --