OUTLINE SPECIFICATIONS FOR DIRECT-USE WELLS AND EQUIPMENT

Edited by:

Kevin Rafferty, P.E.

Geo-Heat Center
Oregon Institute of Technology
3201 Campus Drive
Klamath Falls, OR 97601

Prepared for:

U.S. Department of Energy
Office of Geothermal Technologies
1000 Independence Avenue SW
Washington, DC 20585
Administered by Idaho Operations Office
Grant No. DE-FG07-90ID 13040

September 1998

DISCLAIMER STATEMENT

This report was prepared with the support of the U.S. Department of Energy (DOE Grant No. DE-FG07-90ID 13040). However, any opinions, findings, conclusions, or recommendations expressed herein are those of the author(s) and do not necessarily reflect the view of DOE.

TABLE OF CONTENTS

OUTLINE SPECIFICATIONS FOR DIRECT-USE WELLS AND EQUIPMENT

INTRODUCTION

This package contains outline specifications for water wells and equipment commonly used in direct use geothermal applications. This material was developed in partial fulfilment of USDOE Contract DE-FG07-90ID 13040.

Included in the package are the following outline specifications:

water well completed in consolidated material
water well completed in unconsolidated materials
enclosed lineshaft pump (oil lubricated)
open lineshaft pump (water lubricated)
submersible well pump

The specifications are written for the general case and blanks or options are presented to accommodate specific applications. An appendix is attached and presents more detailed information on various water well issues.

Water well specifications were drawn from two primary sources:

Manual of Water Well Construction Practices
Published by the Office of Water Supply
U.S. Environmental Protection Agency, 1976
(Originally developed by the Water Well
Standards Committee of the National
Water Well Association now known as the
National Ground Water Association)

The Engineers Manual for Water Well Design
Roscoe Moss Company, Los Angeles, 1985

Both of the references are quite detailed and include a great deal of guidance on applications other than the general cases covered in this document. In addition to the material from the above two references, some editing of the text was done to reflect the experience of the Geo-Heat Center staff in water well construction

Although care has been taken in the preparation of this material, the engineers judgement will be required in all cases to adapt the material contained here to a particular project. The Geo-Heat Center does not guarantee the correctness of the material contained in this document and does not assume any responsibility for specifications written or construction undertaken using this information.

SECTION 1 WATER WELL SPECIFICATIONS FOR CONSOLIDATED FORMATION / OPEN HOLE COMPLETION

OPEN HOLE COMPLETION - CONSOLIDATED FORMATION

1.0 GENERAL

1.1 SCOPE OF WORK

The work includes the furnishing of all labor, material, transportation, tools, supplies, plant, equipment and appurtenances, unless specifically excepted, necessary to the complete and satisfactory construction, and testing ready for service of well(s) herein specified.

Final design of the well will be contingent upon subsurface conditions. Preliminary design consists of drilling a _____inch borehole to a minimum depth of _____ft (or if impermeable strata are present between the ground surface and the target aquifer, to a depth at which a minimum penetration of 5 ft into an impermeable strata can be made). If materials in this portion of the borehole are caving a _____in nominal diameter temporary surface casing will be set. Drilling a _____in borehole to a depth of approximately _____ ft and installing a _____in nominal diameter pump chamber casing to a depth of _____ ft.

1.2 OWNER FURNISHED FACILITIES

The Owner shall furnish free of cost to the Contractor at the work site, the following:

_____

_____

(**Water for drilling, electricity, site access etc**)

1.3 DESCRIPTION OF WELL SITE

The Contractor shall drill the well(s) at the approximate location(s) shown on the drawings or if required, at a location in the same vicinity on land having similar terrain.

The Owner shall provide land and rights-of-way for the work specified in this contract and make suitable provisions for access. The contractor shall not enter on or occupy with men, tools, equipment, or material, any ground outside the property of the Owner without written consent of the owner of such ground. Other contractors, employees or agents of the Owner may, for business purposes, enter the work site and premises used by the Contractor. The Contractor shall conduct his/her work so as not to impede unnecessarily any work being done by others on or adjacent to the site.

Excepting as otherwise stated herein, the Contractor shall protect all structures, walks, pipelines, trees, shrubbery, lawns, etc., during the progress of his/her work; and shall remove from the site all cuttings, debris, and unused materials. Upon completion of the work, the Contractor shall restore the site as nearly as possible to its original condition, including the replacement, at the Contractor's expense, of any facility or landscaping which has been damaged beyond restoration.

It shall be the Contractor's responsibility to obtain and maintain at his/her own expense an adequate supply of water for his/her construction and domestic consumption. This includes all necessary supply piping and components, but only at such locations and in a manner approved by the Engineer. All water shall be carefully conserved. Before final acceptance of the well, temporary connections and piping installed by the Contractor shall be removed in a manner satisfactory to the Engineer.

Disposal of drill fluid and water produced by test pumping or other operations will be by such methods and to such locations that damage to, or interference with structures, roads or utilities, or with other construction projects will not occur. Method and place of disposal shall be approved by the Engineer. All cost incurred in connection with the disposal of drill mud and water will be borne by the Contractor.

Logs of wells in the immediate vicinity are shown on attached sheets. It is expected that drilling will be into **(through)** _____formation(s) consisting of _____ (**lithologic description)** _____.(**This information can be found in the completion reports of nearby wells. Examples appear in the appendix.)** This information is intended to assist in evaluating the amount and character of the work that might be required. It is given, however, without the assumption of responsibility for its accuracy, or for any conclusions that the Contractor might draw therefrom. **(Note: These blanks can be completed based on information from previous wells at the site or on nearby wells)**

Contractor shall inform himself/herself by personal investigation of all local conditions affecting his/her work. Neither use of information contained in this specification, nor from the Owner or his/her employees, shall act to relieve the Contractor from any responsibility hereunder, nor from fulfilling all the terms and requirements of the contract.

1.4 REQUIREMENT FOR NOISE CONTROL (Optional)

The Contractor shall comply with applicable Federal, State, and local laws, orders, and regulations concerning the prevention, control, and abatement of excessive noise. In addition, the Contractor will be required to operate in such a manner that the sound intensity does not exceed the following levels at the locations specified:

A nighttime limitation (8:00 PM - 7:00 AM) of NPL = 75 dB measured outdoors at residences or other noise sensitive areas, A daytime limitation (7:00 AM - 8:00 PM) of NPL = 80 dB measured outdoors at residences or other noise sensitive areas.

NPL is the noise pollution level. It is defined in:

- HUD Report No. TE/NA 172 "Noise Assessment Guidelines, Technical Background."
- "Noise and Vibration Control", Beranek, McGraw-Hill, 1971.
- "Community Noise", NT1D300.3, 1971, available from the Superintendent of Documents, U.S. Government Printing Office, Washington DC 20402.
- "Noise from Construction Equipment", NT1D300.1, available from the Superintendent of Documents.

Operations producing high intensity impact noise, such as nighttime blasting, jackhammer use, or pile driving, may be performed only upon approval of the Engineer.

Noise will be monitored by the Engineer, and any data obtained will be made available to the Contractor.

Method of calculating NPL:

NPL will be calculated by the Engineer from the formula:

$NPL = L_{50} + d + d^2/60$

where :

d	=	$(L_{10} - L_{90})$, dB(A)
L_{10}	=	noise level exceeded 10% of the time during the observation period, dB(A).
L_{90}	=	noise level exceeded 90% of the time during the observation period, dB(A).
L_{50}	=	median noise level, dB(A)

The observation period shall be designated by the Engineer and shall be at least 10 minutes. Equipment and techniques will conform to standard ANSI or IEC Practice wherever applicable. Contractor shall be aware of the need for noise control and include the cost of compliance with this section in his/her bid.

1.5 ARCHAEOLOGICAL OR HISTORICAL RESOURCE (Optional)

Should a potential archaeological or historical resource be discovered during the construction of the well(s), the contractor shall cease all excavation work until a qualified archaeologist provided by the Owner has evaluated the situation. Work shall not resume until review by the State Department of _____ and approval by the Engineer.

1.6 CONTRACTOR QUALIFICATIONS

The bidder shall have been engaged in the business of constructing _____ **(type of well, i.e., cable tool, gravel envelope, etc.)** _____ wells of diameter, depth, and capacity similar to the proposed well(s) for a period of at least _____ years. The bidder shall submit a list of _____ or more owners for whom the bidder has drilled similar wells. The list shall show the owner's name and address, an individual who may be contacted for reference, casing diameter and depth, and the well's maximum production and specific capacity. The individuals offered as references will be contacted. Failure to submit this list, or unsatisfactory responses from the references shall, in the Engineer's sole judgement, be grounds for bid rejection.

The bidder shall employ competent workers on this project, and all work shall be performed under the direct supervision of an experienced drilling superintendent satisfactory to the Engineer.

Prior to submitting a bid, the bidder shall have been issued a Well Drilling License by the State of _____ Department of _____ a copy of which shall be submitted with the bid.

The bidder shall incorporate in his/her proposal a list of all subcontractors whose work is included in the bid, and a description of the work to be done by each subcontractor. Each bidder is required to perform a minimum of _____ % of the total dollar value of the contract with his/her own equipment and workers. The Engineer may require references from each subcontractor similar to those required from the bidder, and unsatisfactory subcontractor submittals may be basis for bid rejection.

1.7 PERMITS AND LICENSES

The Contractor shall, at his/her own expense, procure all permits, certificates and licenses required by law for the execution of his/her work. He shall comply with all federal, state, and local laws, ordinances, rules, and regulations relating to the performance of the work.

2.0 WELL CONSTRUCTION PROCEDURE

2.1 METHODS OF CONSTRUCTION

2.1.1 The CONTRACTOR shall choose the construction method(s) to be used. Acceptable methods for this well include:

Cable Tool
Air Rotary
Air Hammer

2.2 DRILLER'S LOGS AND REPORTS

2.2.1 *Driller's Log*. During the drilling, the Contractor shall prepare and keep a complete log setting forth, the following:

1. The reference point for all depth measurements.
2. The depth at which each change of formation occurs.
3. The depth at which the first water was encountered.
4. The depth at which each stratum was encountered.
5. The thickness of each stratum.
6. The identification of the material of which each stratum is composed, such as:
   a. Clay
   b. Sand or Silt
   c. Sand and Gravel-Indicate whether gravel is loose, tight, angular or smooth; color.
   d. Cemented formation-Indicate whether grains (if present) have natural cementing material between them; e.g silica, calcite, etc.
   e. Hard rock-Indicate whether sedimentary bedrock, or igneous (granite-like, basalt-like, etc.)
7. The depth interval from which each water and formation sample was taken.
8. The depth at which hole diameters (bit sizes) change.
9. The depth to the static water level (SWL) and changes in SWL with well depth.

2.2.2 *Geophysical/Mechanical Logs.* When called for under the provisions of the contract the CONTRACTOR shall perform or have performed the following logs: _____, _____, _____, _____,

A. Spontaneous-Potential Logging
B. Resistance Logging
C. Resistivity Logging
D. Natural-Gamma Logging
E. Acoustic Logging

F. Caliper Logging
G. Temperature Logging
H. Fluid-Movement Logging
I. Photographic Logging

(Note: Logs are not commonly run in shallow, low cost holes of the type used for low temperature geothermal or ground source heat pump applications. Logs A, B and C can only be run in uncased holes and are used to identify the boundaries of strata. Log D can be used for similar purposes in a cased well. Log F is used to measure the diameter of a bore.)

2.3 FORMATION SAMPLING

.

2.3.1 *Acceptable Methods*

2.3.1.1. Bailer Method. In clay and consolidated formations the sample shall be taken by bailing the hole clean then advancing the drill bit and collecting cuttings. In sand and gravel the sample shall be taken by driving casing ahead of the drill bit then bailing with a flat bottom or suction bailer. In stable unconsolidated formations, samples shall be taken by drilling _____**(5)** feet and bailing before and after driving the casing to the bottom of the drilled interval.

2.3.1.2 Core Barrel Method. A core barrel shall be advanced, by being rotated or driven, its full length into the undisturbed formation. Once the core barrel has penetrated the desired interval, it shall be withdrawn and the core recovered and stored in a suitable core container. A core recovery of less than _____ percent will not be acceptable.

2.3.1.3 Piston Tube Method. A piston tube sampler shall be driven into the undisturbed material at the bottom of the drilled hole to take formation core samples. This method is used to prevent the material in the core from expanding and to assure that the full core be held securely as the sampler is removed from the test hole. The cores are to be minimum of _____ inches in diameter and _____ inches in length. Upon removal to the surface the sample is to be capped and sealed in its tube, placed in a sample box and stored in a safe place by the CONTRACTOR.

2.3.1.4 Split Spoon Method. A steel cylinder shall be driven vertically into the undisturbed formation at the bottom of the drilled hole. The cylinder will be returned to the surface and transferred to a suitable core container. No sample recovery of less than 50 percent will be accepted.

2.3.1.5 Side-Hole Core Method. Formation samples will be taken using a _____ inch diameter side-hole core sampler. This unit must be set at depths as directed in such a way as to assure penetration of the hole wall to a sufficient depth to provide a recovery of a _____ inch-long core. Side-hole cores will be taken after geophysical logs have been made, at depths specified by the OWNER or his/her representative. The samples shall be placed in a suitable container and identified as specified in section 2.3.3, and stored by the CONTRACTOR.

2.3.2 *Sampling Interval*. Formation samples shall be collected each _____ foot **(10, ten**), starting at _____, (**20, twenty ft**) and at any pronounced change of formation.

Special care shall be used for collecting samples from zones that are expected to be producing zones, wherein samples shall be collected at _____ foot (**5, five**) intervals.

2.3.3. *Size of Sample, Containers, Identification, Storage and Transfer.*

_____ (**2, two**) of _____ (**1 quart ea**) representative samples shall be obtained from each sampling interval. In most instances more cuttings will be recovered than required. The total volume of cuttings shall be thoroughly mixed and quartered until the number of volume of samples required are obtained as a residual.

Immediately after retrieval, formation samples shall be placed in approved containers, securely closed to avoid spillage and contamination, and clearly labeled with the following information:

l. Location of the well
2. Name or number of the well
3. Depth interval represented by the sample
4. Date taken
5. Time taken

Formation samples, immediately after being placed in container, shall be labeled clearly, either directly on the container or on a tag attached thereto, using ink, indelible pencil, or other medium that is resistant to moisture and sunlight. The label shall not be readily removable from the container. The CONTRACTOR shall be responsible for the safe storage of formation samples until such times as they are accepted by the OWNER. Time, place, and mode of delivery shall be as directed by the OWNER.

For wells which may or will utilize screens, the CONTRACTOR shall obtain additional samples as required in water-bearing formations for analysis by a laboratory or screen manufacturer. Duplicate samples shall be retained in a safe place until the results of the analysis are received.

2.3.4 *Temporary Capping.* Any well that is to be temporarily removed from service, or which is completed for a period prior to being placed in service, or is left uncompleted due to a recess or delay in construction shall be capped with a water-tight welded or threaded cap or equipped with some other type of "vandal-proof" cover satisfying applicable state or local regulations or recommendations

3.0 WELL CASING SELECTION AND INSTALLATION

3.1 . WELL CASING SELECTION

3.1.1 *Material* Casing and liner shall be in new or like new condition, free of pits or breaks and shall meet minimum American Society of Testing Materials (ASTM) A-120 specifications. Minimum wall thickness for casing shall be as set forth in the following table:

Minimum Casing Wall Thickness (in)

Depth (ft.)	Nominal Diameter (in.)				
	6	8	10	12	14
<100	0.250	0.250	0.250	0.250	0.250
100 - 200	0.250	0.250	0.250	0.250	0.250
200 - 300	0.250	0.250	0.250	0.250	0.250
300 - 400	0.250	0.250	0.250	0.250	0.250
400 - 600	0.250	0.250	0.250	0.250	0.250
600 - 800	0.250	0.250	0.250	0.250	0.313
800 - 1000	0.250	0.250	0.250	0.250	0.313
1000 - 1500	0.250	0.250	0.313	0.313	0.313

3.1.2 *Temporary Surface Casing.* Temporary surface casing shall have a minimum wall thickness of 0.250 in. And shall be a minimum of 4 inches larger in diameter than the nominal diameter of the pump chamber casing.

3.1.3 *Pump Chamber Casing Diameter*. The pump chamber casing shall be nominal _____(**for required pump chamber casing size see table in appendix**) in material with a wall thickness of _____in.**(from table above).**

3.2 METHODS OF INSTALLATION

3.2.1 *Lowering.* The lowering method is used to install a jointed casing string in a pre-drilled hole. The casing shall be lowered with the drilling machine, utilizing clamps, elevators or other mechanical devices.

3.2.2 *Floating.* Where the casing load is extremely large it may be desirable to "float" the casing into place. A float collar shall be installed on the casing at the appropriate place in the casing string or a float plug shall be installed in the casing string near the bottom. Where a float collar or float shoe is to be used a casing-size dummy (40 ft. minimum length) shall be run into the hole first to insure that the hole is straight and free from obstruction which could result in a stuck casing.

3.3 METHOD OF JOINING

3.2.1 *Joining.* Casing lengths shall be joined watertight by a method appropriate to the material used, as selected by the CONTRACTOR and approved by the OWNER, so that the resulting joint shall have the same structural integrity as the casing itself. If *metallic casing* is welded, the standards of the American Welding Society (AWS) shall apply.

If *threaded and coupled joints* are used, couplings shall be American Petroleum Institute (API) or equivalent, made up so that when tight all threads will be buried in the lip of the coupling.

Welding shall conform to AWS B 3.0 and D 1.1. Cut off casing shall become the property of the CONTRACTOR and shall be removed from the site.

3.4 CASING SEATING

3.4.1 *Consolidated Formations.* In consolidated formations the casing should extend at least five feet into the formation to assure a proper seat and bottom seal. It shall be the responsibility of the CONTRACTOR to effect a proper seal. Where the casing is to be driven it shall be fitted with a drive shoe and shall be driven to refusal. Where the casing is to be placed (rather than driven), cement grout shall be placed in the bottom of the hole in accordance with Section 4.1.

4.0 WELL GROUTING

4.1 GROUTING MATERIALS

4.1.1. *Neat Cement Grout.* A mixture of Portland cement (ASTM C150) and not more than six (6) gallons of clean water per bag (one cubic foot or 94 pounds) of cement, shall be used. The use of special cements, bentonite to reduce shrinkage or other admixtures (ASTM C494) to reduce permeability, increase fluidity, and/or control time of set, and the composition of the resultant slurry must be approved by the OWNER or PROJECT REPRESENTATIVE.

4.2 INSTALLATION OF GROUT - ACCEPTABLE METHODS

4.2.1 *Positive Placement-Interior Method-Two Plug.* Grout shall be placed by the two-plug cementing method (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The first spacer plug, which shall be a drillable plug such as a plaster-type material, shall then be inserted and the casing capped. A measured volume of grout shall be pumped in which shall be of sufficient quantity to grout the casing in place. The casing shall then be uncapped, the second plug shall be inserted, and the casing recapped. A measured volume of water slightly less than the volume of the casing shall then be pumped into the casing until the second plug is pushed to the bottom of the casing, expelling the grout from the casing up and into the annular space. The water in the casing shall be maintained constant to prevent

back flow until the grout has set. Pressure shall be maintained for a minimum of 24 hours or until such time as a sample of the grout indicates a satisfactory set. Cement grout shall be used for this procedure with a minimum annular space thickness of l 1/2 inches completely surrounding the casing. Curing time before construction may be resumed: Portland Cement Type I-minimum 72 hours; Type III-minimum 36 hours. Concrete grout cannot be used with this method.

4.2.2 *Positive Placement-Interior Method-Upper Plug.* Grout shall be placed by the upper plug casing method (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). A measured quantity of grout, sufficient to grout the casing in place, shall be pumped into the capped casing. Because this grout is in direct contact with the drilling fluid there will be a narrow zone of weak grout between the drilling fluid and the good grout. The casing shall be uncapped, and a drillable plug, constructed of plastic or other suitable material shall be inserted on top of the grout and the casing recapped. A measured volume of water, equal to the volume of the casing, shall be pumped into the casing, forcing the plug to the bottom of the casing and expelling the grout into the annular space surrounding the casing. Utilizing this method the weak grout zone at the interface of grout and drilling fluid will not be located at the critical position at the bottom of the casing. The water in the casing shall be maintained under pressure to prevent back flow until the grout has set. Pressure shall be maintained for a minimum of 24 hours or until such time as a sample of the grout indicates a satisfactory set. Neat cement or sand-cement grout shall be used for this procedure, with a minimum annular space opening of l 1/2 inches completely surrounding the casing. Curing time before construction may be resumed: Portland Cement Type I-minimum 72 hours; Type III-minimum 36 hours. Concrete grout cannot be used with this method.

4.2 3 *Positive Placement-Interior Method-Capped Casing.* Grout shall be placed by pumping or air pressure injection through the grout pipe installed inside the casing from the casing head to a point 5 feet above the bottom of the casing (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The grout pipe shall extend airtight, through a sealed cap on the casing head of the well casing. The casing head shall be equipped with a relief valve and the drop pipe shall be equipped at the top with a valve permitting injection. The lower end of the drop pipe and the casing shall be open. Clean water shall be injected down the grout pipe until it returns through the casing head relief valve. The relief valve is then closed and injection of water is continued until it flows from the bore hole *outside* of the casing to be grouted in place. This circulation of water is intended to clean the hole and condition it to better take the grout. Without significant interruption, grout shall be substituted for water and, in a continuous manner, injected down the grout pipe until it returns to the surface outside of the casing. A small amount of water, not to exceed seventeen gallons per hundred lineal feet of 2 inch drop pipe may be used to flush the grout pipe, but pressure shall be maintained constant on the inside of the grout pipe and the inside of the casing until the grout has set. Pressure shall be maintained for at least 24 hours, or until such time as a sample of the grout indicates a satisfactory set. Neat cement or sand-cement grout shall be used for this procedure with a minimum annular space of 1 1/2 inches completely surrounding the casing. Curing time before construction may be resumed: Portland Cement Type I-minimum 72 hours; Type III-minimum 36 hours. Concrete grout cannot be used with this method.

4.2.4 *Continuous Injection Method.* Grout shall be placed by the float shoe continuous injection method, (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The bottom of the casing shall be fitted with a suitable drillable

float shoe equipped with a back pressure valve. Tubing or pipe shall be run to the float shoe to which it shall be connected by a bayonet fitting, left hand thread coupling, or similar release mechanism. Water or other drilling fluid shall be circulated through the tubing and up through the annular space outside the casing. When the annular space is clean and open, grout shall be pumped down the pipe or tubing and forced by continual pumping out into the annular space surrounding the casing. Pumping shall continue until the entire zone to be grouted is filled. The grout pipe shall then be detached from the float shoe and raised to the surface for flushing. After the grout has set the float shoe, back pressure valve, and any concrete plug remaining in the bottom of the casing shall be drilled out. A neat cement or sand-cement grout shall be used for this procedure with a minimum annular space of 1 1/2 inches completely surrounding the casing. Curing time required before construction may be resumed shall be 72 hours for Type I Portland Cement and 36 hours for Type III. Concrete grout cannot be used with this method.

4.2.5 *Grout Displacement Method.* The hole shall be filled with the estimated volume of grout required for the purpose intended. The casing fitted at the bottom with a drillable back pressure valve, metal plate, or similar seal shall be lowered through the grout to the bottom of the hole. If necessary to maintain the bottom of the casing at the bottom of the hole, the casing shall be filled with water, or drilling fluid, and in some cases by applying a load on the bottom with drill pipe. The load shall be maintained until the grout has set, after which the bottom plug is drilled out and the well deepened. Use of this method is limited to wells not more than 100 feet in depth.

4.3 LOCATION OF GROUT

(The following specification should be considered a minimum. For more complete information on well sealing based on various subsurface conditions see the diagrams and specifications in the appendix)

4.3.1 *Surface Formation Seal.* The annular space to be grouted, and surrounding the permanent well casing at the upper terminus of the well, shall be not less than a nominal 2 inches. The length of the grout seal shall be whatever is necessary to prevent the entrance of surface water or undesirable subsurface water into the well. In any circumstance, the length of seal shall not be less than the minimum specified in the state or locally applicable construction code.

The entire space to be grouted must be open and available to receive the grout at the time the grouting operation is performed. If a section of larger pipe (conductor pipe) is installed to keep the entire space open (in caving materials), this larger pipe must be removed, as the grout is installed, from the zone where the seal is required.

The effective length of grout seal (for sanitary purposes) shall be that distance measured from the deepest limit of the seal up to the depth of frost penetration. If a pitless adapter or unit is to be installed, the upper limit of the seal shall be one foot below the field connection of the adapter or unit. (**See diagrams 3 through 10 in the appendix for examples of acceptable sealing. These diagrams could be incorporated into the construction documents**)

4.4 CENTRALIZERS

4.4.1 *Centralizers at Bottom of Hole and other Critical Points.* Centralizers shall be attached to the bottom of the casing at other critical grouting points such as zones of unsuitable water quality.

4.5 PRESSURE TESTING OF GROUTING SEAL

Pressure testing of the grout seal shall be employed following the appropriate time for curing of the grout according to all appropriate provisions in this Article. A pressure of 7 to 10 pounds of air per square inch is to be maintained within the well, without the addition of more air, for a period of not less than one hour. Any loss of air shall be construed as indicating a defective seal. To correct such a defect, the OWNER shall require the CONTRACTOR to make the necessary repairs by re-cementing and pressure testing at 15 psi for one hour.

5.0 PLUMBNESS AND ALIGNMENT (select 1. "A" would suffice in cases where the well is very shallow (and a submersible pump will be used). "B" is appropriate for a deeper well (300 ft) and where a submersible pump will be used. "C" should be selected where a line shaft type well pump will be used)

A.) The completed well shall be sufficiently plumb and straight so that there will be no interference with installation, alignment, operation or future removal of the permanent well pump.

B.) All wells should be constructed and all casings and liners set round, plumb, and true to line as defined herein. To demonstrate the compliance of the work with the requirements, the CONTRACTOR shall furnish all labor, tools and equipment and perform the test or tests described herein. The test for plumbness and alignment shall be made following construction of the well, and before test pump equipment is installed.

Alignment shall be tested by lowering into the well to a depth of at least _____ feet **(lowest anticipated pump setting)** a section of pipe 40 feet long or a dummy of the same length. The outer diameter of the pipe or dummy shall be not more than 1/2 inch smaller than the inside diameter of that part of the casing or hole being tested when the casing diameter is a nominal 10 inches or less. When the nominal diameter of the casing being tested is 12 inches or greater, the outer diameter of the test pipe or dummy shall not be more than 1 inch smaller than the inside diameter of that part of the casing or hole being tested. The dummy when lowered into the casing shall pass freely the entire depth of the well.

C.) The Contractor shall guarantee that the well when completed shall be sufficiently straight and plumb for the free installation and operation of a turbine pump of ____ inch (**pump bowl diameter is a function of pump capacity. See table in appendix**) nominal bowl diameter with

bowls set ____ feet below ground surface. To demonstrate compliance with this requirement the Contractor shall furnish all labor, tools, and equipment, and make a caging test to the satisfaction of the Engineer. The test shall be performed after completion of the well construction and before

its acceptance. The completed well shall be drilled in such vertical alignment that a line drawn from the center of the well casing at ground surface to the center of the well casing ____ (**pump bowl setting depth**) feet below the ground surface shall not deviate from the vertical more than 6 inches in 100 feet of length.

6.0 WELL DEVELOPMENT (Development may not be necessary for wells completed in hard rock (granite, basalt) sequences)

6.1 ACCEPTABLE METHODS

6.1.1 *Surging and Bailing (Utilizing Bailer).* The development process shall include surging and bailing the well. The surging shall be accomplished by utilizing the bailer as a surging device. If fines have been drawn into the well and have settled on the bottom and accumulated to a depth where they block 10 percent or more of the total screen length, the well shall be bailed or otherwise cleaned to the bottom before resumption of surging. On completion of development the well shall be cleaned to the bottom.

6.1.2 *Surging and Bailing (Utilizing Surge Block).* The development process shall be carried out by surging and bailing the well. The surging shall be done by a single or double solid (or valved) surge block. Surging shall start at the bottom of the lowest screen in the well and proceed upwards.

6.1.3 *Surging and Pumping.* The development process shall include surging and pumping the well. The surging shall be done by either a solid or valved surge block. The pumping shall be done through the surge block which incorporates a piece of the suction pipe in the fabrication of the block. Pumping shall be done simultaneously with the surging at rates up to 1/2 of the design capacity. Fines drawn into the well shall be pumped out periodically before such accumulation reaches 10 percent of the screen length. Upon completion of the development work the well shall be cleaned to the bottom

6.1.4 *Hydraulic Jetting.* Hydraulic jetting shall only be used in conjunction with one of the other approved development methods in this section. Development shall be accomplished by simultaneous high-velocity, horizontal-jetting and pumping. The outside diameter of the jetting tool shall be one inch less in diameter than the screen inside diameter. The minimum exit velocity of the jetting fluid at the jet nozzle shall be 150 ft./sec. The tool shall be rotated at a speed less than one rpm. It shall be positioned at one level for not less than two minutes and then shall be moved to the next level which shall be no more than 6 inches vertically from the preceding jetting level. The jetting shall proceed from the bottom of the screen to the top. Pumping from the well shall be at a rate of 5 to 15 percent more than the rate at which water is introduced through the jetting tool. Water to be used for jetting must contain less than 1 ppm suspended solids.

6.2 DEVELOPMENT AIDS

6.2.1 *Washing with Water.* Clean, clear water shall be circulated to remove sediment from the well. A pump of sufficient size shall be utilized for the washing process which will agitate the

formation for the purpose of preventing bridging of the sand particles and removing a large portion of the finer material. The use of any chemicals, if pay is to be received, must be approved by the OWNER or PROJECT REPRESENTATIVE.

6.2.2 *Washing with Chemicals.* Where applicable and required, mud dispersing agents (such as glassy phosphate), acids for washing limestone, and other chemicals applicable to standard procedures may be used in accordance with the approval or direction of the OWNER or his/her representative.

6.3 SAND CONTENT LIMITS (sand content limits are a function of the design of the design of the system. For applications in which an injection well is used, the well should be sand free (< 1.0 ppm). For applications using surface disposal, the limit should be 5 ppm.)

6.3.1 *Sample.* Well development shall continue until sand production is less than _____ (**5, 15**) ppm within _____(**10**) minutes after commencement of pumping at a minimum rate of _____ (**peak system flow rate**) gpm and is not more than an average of _____ (**0.9, 5.0**) ppm after a pumping cycle of two hours. Sand production shall be measured with a centrifugal sand separating device as described in the Journal of American Water works Association Vol 46 No 2, Feb 1954.

6.3.2 *Recording Measurements.* A record shall be made showing time, type of operation, specific capacity during pumping, pumping rate and the sand content measured and recorded. These records shall be submitted to the OWNER or his/her representative along with a _____(**2.0**) lb sample of the sand collected.

7.0 WELL FLOW TESTING

(**Select either 7.1 or 7.2. The constant rate test is simpler but without the monitoring of nearby well water levels, produces less information about the aquifer than the step drawdown test. The step drawdown test can be shortened by eliminating the constant rate test at the end assuming that the water level in the well stabilized sufficiently during the final stage of the step test.**

7.1 CONSTANT RATE METHOD

The CONTRACTOR shall furnish, install and remove the necessary measuring instruments and pumping equipment capable of pumping to the required point of discharge a minimum of _____ gpm (**peak system flow rate**), with a pumping level of _____ feet (**determined from nearby wells**), and with satisfactory throttling devices, so that the discharge

may be reduced to _____ gpm (**25% of peak system flow rate**). The pumping unit shall be complete with an ample power source, controls and appurtenances and shall be capable of being operated without interruption for a period of _____(**72**) hours.

The well shall be pumped at a discharge rate of _____ gpm (**peak system flow rate**) for a minimum of _____(**12**) hours. The test pump shall have its intake at least 5 feet below the estimated lowest pumping level, and shall have sufficient power and capacity to achieve the designated discharge rate. Discharge shall be measured with an accurate totalizing meter and stopwatch, a circular orifice meter, or a Venturi meter, any of which are subject to approval by the OWNER or his/her representative. Discharge shall be maintained within plus or minus 5 percent of the designated rate by means of a gate valve or throttling device. Discharge shall be checked and adjusted, if necessary, every 10 minutes during the first hour of pumping and at 30-minute intervals thereafter. The discharge and time of measurement shall be recorded each time it is checked and a note made of any adjustments. The static or non-pumping water level trend shall be established prior to the start of the test. Drawdown shall be measured according to the following schedule: 0 to 10 minutes-every minute; 10 to 45 minutes--every 5 minutes; 45 to 90 minutes-every 15 minutes; 90 to 180 minutes--each half hour; 180 minutes to the end of the test-each hour. Should the measurements not be made exactly at the times specified, the actual time of each measurement shall be recorded. On completion of pumping, recovery measurements shall be made according to the above drawdown schedule.

7.2 STEP-CONTINUOUS COMPOSITE METHOD

The CONTRACTOR shall furnish, install and remove the necessary measuring instruments and pumping equipment capable of pumping to the required point of discharge a minimum of _____ gpm (**peak system flow rate**), with the pumping level of _____ feet (**determined based on the performance of nearby wells**), and with satisfactory throttling devices, so that the discharge may be reduced to _____ gpm (**25% of peak system flow rate**). The pumping unit shall be complete with an ample power source, controls and appurtenances and shall be capable of being operated without interruption for a period of _____ (**16)** hours.

Prior to starting the pump, water level measurements shall be made at least hourly, for a minimum of eight hours, in the production well and all observation wells, and these measurements shall be recorded on the same note sheets to be used during the pumping test. The well shall be "step" tested at rates of approximately 25%, 50%, 75% and 100% of the design capacity of _____ gpm (**peak system flow rate**). The complete test is estimated to require a minimum of approximately _____(**4**) hours. The CONTRACTOR shall operate the pump and change the discharge as directed by the OWNER. Discharge of the pump shall be controlled by a gate valve, if electric driven, and both gate valve and engine throttle if engine driven. The discharge shall be controlled and maintained at approximately the desired discharge for each step with an accuracy of plus or minus 5 percent. Pump discharge shall be measured with a totalizing meter and stopwatch, circular orifice meter, or Venturi meter as approved by the OWNER. A 2-

wire electric probe calibrated so as to permit water level measurement accuracy of +/- 0.05 ft shall be used to measure the static water level and drawdown in the well. A clearly marked convenient reference point shall be set at the top of the pipe. The probe shall be furnished by the

CONTRACTOR.

After recovery from the step test is complete, a constant rate test shall be conducted by pumping the well at the design rate or at maximum yield for a period of not less than _____(**4**) hours or until the pumping level remains constant for at least 4 hours, or until the OWNER or his/her representative terminates the test.

Measurements of pumping rate and water level shall be made every 1 minute for the first 10 minutes of the test, every 2 minutes for the next 10 minutes, every 5 minutes for the next 40 minutes, every 15 minutes for the next hour, every 30 minutes for the next 3 hours, and hourly for the remainder of the pumping period. Recovery water-level measurements shall be made with the same frequency until sufficient data have been collected to extrapolate the full recovery of the well or until the OWNER requires no further data.

7.3 ABORTED TEST

Whenever continuous pumping at a uniform rate has been specified, failure of pump operation for a period greater than one per cent of the elapsed pumping time shall require suspension of the test until the water level in the pumped well has recovered to its original level. For the purposes of this Article, recovery shall be considered "complete" after the well has been allowed to rest for a period at least equal to the elapsed pumping time of the aborted test- except that if any three successive water level measurements spaced at least 20 minutes apart show no further rise in the water level in the pumped well, the test may be resumed immediately. The (**Engineer, Owner's Representative**) shall be the sole judge as to whether this latter condition exists.

7.3 DISCHARGE WATER

Discharged water shall be conducted from the pump to the nearest surface-water body, storm sewer, or ditch, as approved by the OWNER or his/her representative or at least a distance of _____ feet through approved piping or lined ditches to prevent recirculation of discharged water into the aquifer being tested. It is imperative to insure that no damage by flooding or erosion is caused to the chosen drainage structure or disposal site.

7.4 RECORDS

The CONTRACTOR shall keep accurate records of the pumping test and furnish copies of all records to the OWNER or his/her representative upon completion of the test. The records shall also be available to the OWNER or his/her representative for inspection at any time during the test. For each well used in the test, the records shall include physical data describing the construction features such as, but not limited to: well depth and diameter, complete screen description, length, and setting; a description of the measuring point and its measured height above land surface and/or mean sea level; the methods used in measuring water levels and pumping rates. An accurate description or sketch map of the well locations with identifying names or numbers and distances between wells or from bodies of water shall be provided on each set of

records. Records of measurements shall include the date of the test, the clock time and elapsed pumping time of each measurement, the depth to water below the measuring point, the pumping rate at the time of measurement, and any pertinent comments on conditions that may affect the measurements. Frequency of water-level measurements before, during, and after pumping shall be as specified by the OWNER or his/her representative.

7.5 MEASUREMENT OF WATER LEVELS - ACCEPTABLE METHODS

7.5.1 *Electric Probe Method.* A 2-wire electric probe calibrated so as to permit water level measurement accuracy of +/- 0.05 ft shall be used to measure the static water level and drawdown in the well.

7.6 WATER SAMPLES AND ANALYSIS

7.6.1 *Specific Constituent-Analysis.* Analysis for the following specific constituents shall be made:

pH	Carbonate	Stability Index
Iron	Bicarbonate	Saturation Index
Calcium	Sulphate	Carbon Dioxide
Magnesium	Chloride	Hydrogen Sulphide
Sodium	Alkalinity	Oxygen
Potassium	Total Hardness	Total Dissolved Solids

7.6.2 *Sample Collection.* A _____ (**1/2**) gallon sample of water shall be collected for chemical analysis. The water sample shall be collected in a chemically cleaned container supplied by the laboratory that will make the analysis. The sample shall be collected from the water discharged during development or flow test pumping of the well, no less than _____(**1**) hours after pumping has commenced..

7.6.3 *Wellhead Tests.* The temperature and pH of the water shall be taken immediately upon collection of the water sample and recorded on the sample container and drillers log. Tests shall be conducted according to procedures prescribed by the manufacturer of the test equipment employed, local health or water agencies, or as set forth in standard publications dealing with this method of analysis. Test for the presence of dissolved gasses identified in Section 9.7.1 shall be made immediately following the collection in accordance with procedures prescribed by the manufacturer of the test equipment.

7.6.4. *Laboratory Requirements.* Laboratory tests shall consist of those specified by the regulations of local or state government or as described herein for the proposed use of the water. In addition, such other tests prescribed by the OWNER will be made. All laboratory tests shall be

performed by a laboratory approved by the OWNER or his/her representative. Analytical techniques and methods shall be as prescribed *in Standard Methods for the Examination of Water and Waste Water,* a joint publication of the American Public Health Association, American Water Works Association, and Water Pollution Control Federation. All samples shall be appropriately identified as to geographic location, date, time, method of collection, point of collection, water bearing formation(s), depth and diameter of well, water level and yield, and shall include the name of the sample collector, CONTRACTOR, driller and OWNER.

8.0 WELL DISINFECTION

8.1 SCHEDULING DISINFECTION

The CONTRACTOR shall provide for disinfection as soon as construction of the well and cleaning procedures have been completed. The CONTRACTOR shall carry out adequate cleaning procedures immediately preceding disinfection where evidence indicates that normal well construction and development work have not adequately cleaned the well. All oil, grease, soil, and other materials, which could harbor and protect bacteria from disinfectants, shall be removed from the well. Unless prior approval is obtained for employing chemicals or unusual cleaning methods, the cleaning operation is to be carried out by pumping and swabbing only. Where test pumping equipment is to be utilized, such equipment shall be installed prior to or during disinfection and be thoroughly hosed, scrubbed or otherwise cleaned of foreign material.

8.2 DISINFECTANTS

Chlorine or other compounds approved by state or local regulatory agencies shall be used as disinfectants. The disinfectant shall be delivered to the site of the work in original closed containers bearing the original label indicating the percentage of available chlorine. The disinfectant shall be recently purchased. Chlorine compounds in dry form shall not be stored for more than one year and storage of liquid compounds shall not exceed 60 days. During storage, disinfectants shall not be exposed to the atmosphere or to direct sunlight. Unless superseded by governmental regulation, the quantity of chlorine compounds used for disinfection shall be sufficient to produce a minimum of 100 ppm (parts per million) available chlorine in solution when mixed with the total volume of water in the well.

8.3 INTERIM DISINFECTION

Should a delay of three days or more be anticipated between the completion of the well and the regularly scheduled well disinfection an interim disinfection shall be provided by the CONTRACTOR. The CONTRACTOR shall install an approved disinfecting agent in an amount equal to 10 percent of the amount required for final disinfection. For this purpose the disinfecting agent shall be furnished or prepared in liquid form and placed in the well through a hose or tremie of sufficient length to extend to the bottom of the well. The disinfecting agent shall be applied

through the hose, which is to be raised and lowered, to achieve uniform distribution of the solution throughout the well.

8.4 DAILY OPERATIONS DISINFECTION

Daily chlorination of the well shall be carried out by the CONTRACTOR during drilling operations. The CONTRACTOR shall discuss with the OWNER the amount of disinfecting agent to be used and its method of use in advance of initiating the work. Chlorine compound dosages and method of utilization shall be satisfactory to the OWNER in its entirety.

8.5 DISINFECTION PROCEDURE

Unless otherwise modified-due to problems involved with the specific well or conflict with local, state or federal governmental regulatory, agency requirements-disinfection procedure shall include, but not be limited to the following:

Provide reliable means for insuring that the disinfecting agent is uniformly applied throughout the entire water depth of the well without relying on subsequent mechanical or surging action for dispersing the disinfectant; the dispersion of the disinfectant shall be assisted by pouring into the well a volume of water equal to the volume of the screen, after the disinfectant has been emplaced. This will cause the disinfectant to flow out of the well into the area adjacent to the screen.

All accessible portions of the well above the water level shall be maintained in a damp condition with water containing the required concentration of disinfecting agent for a period of not less than 20 minutes. The disinfecting agent shall be left in the well for a period of at least 12 hours. After a 12 hour, or longer, contact period the well is to be pumped to clear it of the disinfecting agent. The disposal point for the purged water shall be as selected so as to minimize potential damage to aquatic life or vegetation.

8.6 DISINFECTION OF WATER TABLE WELLS - ACCEPTABLE METHODS

8.6.1. *Dry Chlorine Compounds.* A doubly capped, perforated pipe container filled with the appropriate amount of a granular chlorine compound to produce an available chlorine concentration of _____(**100**) ppm in the well shall be moved up and down the entire well bore until the material has dissolved.

8.6.2 . *Stock Solution (I).* A stock solution sufficient to produce _____(**100**) ppm of available chlorine shall be added to the well at different intervals from top to bottom and then agitated to distribute it evenly throughout the well.

8.6.3 *Stock Solution (II).* A stock chlorine solution of 15,000 ppm shall be added to a continuous flow of water into the well to produce a _____(**100)** ppm concentration of available chlorine throughout the well.

8.6.4 *Prepared Solution.* The chlorine solution of the appropriate concentration to disinfect the well shall be prepared on the surface in containers having an aggregate volume equal to at least twice the volume of water in the well and then rapidly discharged into the well so as to thoroughly flush that portion of the casing which is above the water level.

8.7 DISINFECTION OF FLOWING ARTESIAN WELLS - ACCEPTABLE METHODS

8.7.1 *Dry Chlorine Compounds.* A doubly capped, perforated pipe container filled with a granular chlorine compound shall be placed at a point on or below the top of the producing horizon. This process shall be repeated as often as necessary to achieve and maintain the standard 50 ppm concentration for a period of not less than one hour.

8.7.2 *Controlled Flow Disinfection.* Flow shall be controlled by either capping or by a suitable standpipe. In the event the well is capped a stock chlorine solution shall be injected, under pressure, by means of a drop pipe to the bottom of the well. The cap shall be equipped with a suitable one-inch valve. After the injection is complete air shall be injected for agitation while simultaneously opening the valve in the cap permitting the chlorine solution to be dispersed to the surface. The valve shall then be closed and the flow stopped. The chlorine concentration shall be maintained at 100 ppm for six hours.

In the event flow can be controlled by a suitable standpipe the chlorine treatment can be conducted as though the well was non-flowing.

8.7.3 *Stock Solution.* A stock chlorine solution shall be applied for a period of not less than one hour at a point at or below the top of the producing zone. The rate of application will be such that the standard 100 ppm concentration is achieved and maintained during the application period.

9.0 WELL ABANDONMENT

9.1 AQUIFER SEALING CRITERIA

Aquifers shall be filled with disinfected, dimensionally stable materials, compacted mechanically if necessary to avoid later settlement. (Cement, cement-and-sand, and concrete do not require disinfection.)

Disinfection of aquifer fill materials shall be accomplished by using chlorine compounds such as sodium hypochlorite or calcium hypochlorite. Aquifer fill materials shall be clean (relatively free of clays and organic materials) before placement in the well. Disinfection shall be accomplished by dissolving sufficient chlorine compound to produce a calculated concentration of at least 100 ppm available chlorine in double the volume of water in the well. The fill material shall be placed in the well after the water in the well has been so treated

9.2 PERMANENT BRIDGES

Permanent bridges may be used to avoid having to fill very deep holes below the deepest point at which a permanent seal is required. Permanent bridges shall be composed only of cement or cement-bearing minerals. The cement shall be allowed to harden for at least 24 hours, if Type I cement is used, or for at least 12 hours if Type III (high early strength) cement is used, before backfilling is continued. Temporary bridges used to provide a base for the permanent bridge shall consist only of inorganic materials--except that patented devices containing expandable neoprene, plastic, and other elastomers, and specifically designed for use in well construction are acceptable.

9.3 PLACEMENT OF GROUT

9.3.1 *Placement Operations.* Concrete, sand-and-cement grout, or cement grout used as a sealing material in abandonment operations shall be introduced at the bottom of the well or interval to be sealed (or filled) and placed progressively upward to the top of the well. All such sealing materials shall be placed by the use of grout pipe, tremie, cement bucket or dump bailer, in such a way as to avoid segregation or dilution of the sealing materials. Dumping grout material from the top shall not be permitted.

Seals intended to prevent vertical movement of water in the well or bore hole shall be composed of cement, sand-and-cement, or concrete--except that where such seals must be placed within casing or liners, only neat cement grout may be used. The cement-water ratio shall be that specified in section 4.1. Cement seals shall be placed by means of pumping through drop pipe or by use of a dump-bailer, with placement beginning at the bottom and continuing upward. The minimum cement seal length, wherever dimensions permit, shall be 10 feet.

9.3.2 *Intermediate Seals.* Intermediate seals of cement, sand-and-cement, or concrete shall be placed in impermeable strata between aquifers which are identifiable as, or are suspected of being, hydraulically separated under natural, undisturbed conditions. Once the required cement seal has been installed, the remainder of the impermeable zone or non-producing zone between aquifers shall be filled with sand, sand and gravel, or cement-bearing mineral material.

9.3.3 *Seal at Uppermost Aquifer.* A cement, sand-and cement, or concrete seal shall be installed in the least permeable zone immediately above the uppermost water-producing zone. Such seals shall be placed only in quiescent (non-flowing) water.

9.3.4 *Seals Placed Within Casing, Liners, Filters, etc.* Seal which must be placed in casing, liners, or filters require special attention. The material between the well and the face of the bore hole shall be thoroughly perforated, ripped, or otherwise disintegrated as the necessary first step. Neat cement only, or neat cement with a maximum of 5 percent by weight of commercially processed bentonite clay, shall be used as the seal. Either of two methods may be used.

1. The calculated amount of grout required to fill the well interval plus the annular space outside the lining shall be placed within the space to be cemented, running the cement through a special cementing packer manufactured for this purpose and installed immediately above the perforated or ripped zone. The cement shall be injected at a pressure calculated to be at least 50 psi greater than the normal hydrostatic pressure within the well at the point of injection.

2. The calculated amount of cement grout required to fill the casing interval plus the annular space outside the lining, plus sufficient cement grout to fill an additional 10 feet of the lining, shall be introduced at the bottom of the interval to be cemented.

9.4 PLACEMENT OF FILL

Non-producing zones above the aquifer shall be filled with stable materials such as sand, sand-and-gravel, cement, cement-and-sand, or concrete. Non-producing zones above the uppermost aquifer seal shall be filled with materials less permeable than the surrounding undisturbed formations. The uppermost 5 feet of the bore hole (at land surface) shall be filled with a material appropriate to the intended use of the land.

9.5 SPECIAL CONDITIONS

An abandoned well which has already been affected by salt water intrusion or any other contaminants shall be considered a special case, and the method of filling and sealing such wells shall be subject to individual review and written approval by the regulatory agency involved.

In the sealing of a double or multiple cased well, the CONTRACTOR shall submit a drawing thereof with a description of the proposed procedure and materials to be used, for prior approval by the regulatory agency involved.

Mineral exploration holes, solution or "in situ" mining wells, de-watering wells, temporary service wells, construction water wells, process wells, and/or other structures which affect the withdrawal or quality of ground water, or the elevation of the water table, regardless of location or intended length of life of the structure, shall be abandoned according to standards and minimums as described herein for water supply wells.

9.6 WELL ABANDONMENT RECORDS

Before equipment is removed from the site, the exact location of the abandoned well or hole shall be determined and recorded, "tying in" the location with permanent reference points, or as prescribed by the state or local regulatory agency. All information relative to the abandonment procedures and the location of the abandoned well shall be prepared and assembled as prescribed by the state or local regulatory agency, with copies supplied to the respective agency and the owner of the land.

Modifications to Open-Hole Completion - Consolidated Specifications

Modifications for Air Rotary

Sampling - Substitute the following and re-number other paragraphs in the 2.3.1 section as necessary.

2.3.1 *Contractor's Choice.* The method of sampling will be left to the discretion of the CONTRACTOR; however, the CONTRACTOR must collect, identify and store representative samples in accordance with Section 2.2, collected with sufficient frequency and at sufficient increments of depth to permit a thorough evaluation of the water-bearing properties of the formations encountered in drilling the test hole.

2.3.2. *Return Flow Method (Continuous).* A return flow sample shall be taken by removing from the circulating drilling fluid a representative sample of the formation by either collecting same in a cutting sample box, a "shale shaker", a baffle in a ditch, or catching it in a bucket and allowing the sample-to settle out. Provision shall also be made to obtain a record of circulation time and probable depth of the formation from which the cuttings are derived. Drill cutting samples collected at specified depth intervals shall be placed in approved containers and identified as specified in Section 2.2 . The samples shall be stored in a safe place by the CONTRACTOR.

2.3.3. *Return Flow Method (Circulated).* A return flow sample shall be taken by removing from the discharge fluid a representative sample of the formation by either collecting same in a cutting sample box, a "shale shaker", a baffle in a ditch, or catching it in a bucket and allowing the sample to settle out. The penetration of the bit shall stop when the bottom of the sampling interval is reached for such time as is required for all the cuttings to move from the last drilled section of the hole and settle at the sampling point. The return ditch and sample catching device shall be cleaned of all cuttings after each sample is taken. A cutting sample shall be carefully collected from the sampling point. Drill cutting samples collected at specified depth intervals shall be taken by the CONTRACTOR. The total sample obtained from each interval shall be mixed and quartered until sufficient sample remains to furnish _____ (number) _____ (volume), representative samples. Drill cuttings shall be placed in approved containers and identified as specified in Section 2.2 . The samples shall be stored in a safe place by the CONTRACTOR.

2.3.4 *Auger Method.* Formation samples obtained using the auger method are to be representative of the formation being penetrated. The samples will be collected, placed in approved containers, and stored in a safe place by the CONTRACTOR.

For small low-temp geothermal and for ground source heat pump wells:

Substitute the following for grout installation ahead of the existing paragraphs and re-number as necessary:

4.2.1 *Gravity Filling Without Tremie Method.* Grout material shall be uniformly poured into the annular space without the aid of a tremie or grout pipe (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). This method shall be employed only where the interval to be grouted is clearly visible from the surface and is dry. Maximum allowable depth to bottom of grout interval shall be 30 feet.

4.2.2 *Tremie Method.* Grout material shall be placed by tremie pouring (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The tremie method shall only be used where there is a minimum annular space of 3 inches between the outside surface of the inside casing and the inside surface of either the external casing or the borehole. The minimum size tremie pipe utilized shall be 2 inches inside diameter. Where concrete grout is used the minimum size tremie pipe used shall be three inches inside diameter.

When making a tremie pour, the tremie pipe shall be lowered to the bottom of the zone being grouted, and raised slowly as the grout material is introduced. The tremie pipe shall be kept full continuously from start to finish of the grouting procedure, with the discharge end of the tremie pipe being continuously submerged in the grout until the zone to be grouted is completely filled. Curing time before construction may be resumed: Portland Cement Type I-minimum 72 hours; Type III-minimum 36 hours.

For injection wells:

Sealing of an injection well is more critical than for a production well particularly if the well is expected to operate with a positive injection pressure at the surface. Effective sealing of the well prevents the possibility of injection fluid moving vertically along the well bore to the surface. As a result, sealing of an injection well should, at a minimum, follow the method outlined in figure 7 and preferably the method outlined in figure 10 (continuous grouting). The text accompanying these figures can be substituted for the "surface formation seal" text currently found in section 4.3.1. As an alternative, if continuous grouting is chosen, the following text from the National Water Well Association Water Well Specifications may be used.

4.3.1 *Continuous Grouting*. Grout shall be placed in the annular space surrounding the casing by the method specified. Grouting shall be continuous from the bottom of the permanent casing to the land surface; or, where a filter pack has been installed, from the top of the pack (following development) to the land surface; or, where a well screen only has been installed, from a point 5 feet above the screen to the land surface. When a pitless adapter or unit is to be installed, the grout shall extend from such depth to within one foot of the field connection of the adapter or unit.

Injection wells should always be equipped with an injection tube. This is a pipe through which the water flows into the well. The tube extends from the surface to well below the static water level in the well. The purpose of the injection tube is to reduce the tendency for "cascading of water from the surface to the static level. Cascading results in air entrainment in the injected water. Entrained air bubbles, if carried into the aquifer can result in plugging of the area immediately around the well in the same manner as entrained particulate matter.

SECTION 2 WATER WELL SPECIFICATIONS FOR UNCONSOLIDATED FORMATION / SCREEN and/or GRAVEL PACK COMPLETION

SCREEN AND/OR GRAVEL PACK - UNCONSOLIDATED AQUIFER

1.0 GENERAL

1.1 SCOPE OF WORK

The work includes the furnishing of all labor, material, transportation, tools, supplies, plant, equipment and appurtenances, unless specifically excepted, necessary to the complete and satisfactory construction, and testing ready for service of the well(s) herein specified.

Final design of the well will be contingent upon subsurface conditions. Preliminary design consists of drilling a _____inch borehole to a minimum depth of _____ft (or if impermeable strata are present between the ground surface and the target aquifer, to the depth at which a minimum penetration of 5 ft can be made into an impermeable stratum) and setting a temporary _____in nominal diameter surface casing. Drilling a _____in borehole to a depth of approximately _____ and installing a nominal _____in pump chamber casing from ground surface to a depth of _____and suitable screen from that point to total depth. An artificial filter shall be installed contingent upon the results of a laboratory analysis of drilling samples.

1.2 OWNER FURNISHED FACILITIES

The Owner shall furnish free of cost to the Contractor at the work site, the following:

_____

_____

(**Water for drilling, electricity, site access etc**.)

1.3 DESCRIPTION OF WELL SITE

The Contractor shall drill the well(s) at the approximate location(s) shown on the drawings or if required, at a location in the same vicinity on land having similar terrain.

The Owner shall provide land and rights-of-way for the work specified in this contract and make suitable provisions for access. The contractor shall not enter on or occupy with men, tools, equipment, or material, any ground outside the property of the Owner without written consent of the owner of such ground. Other contractors, employees or representatives of the Owner may, for business purposes, enter the work site and premises used by the Contractor. The Contractor shall conduct his/her work so as not to impede unnecessarily any work being done by others on or adjacent to the site.

Excepting as otherwise stated herein, the Contractor shall protect all structures, walks, pipelines, trees, shrubbery, lawns, etc., during the progress of his/her work; and shall remove from the site all cuttings, debris, and unused materials. Upon completion of the work, the Contractor shall restore the site as nearly as possible to its original condition, including the replacement, at the Contractor's expense, of any facility or landscaping which has been damaged beyond restoration.

It shall be the Contractor's responsibility to obtain and maintain at his/her own expense an adequate supply of water for his/her construction and domestic consumption. This includes all necessary supply piping and components, but only at such locations and in a manner approved by the Engineer. All water shall be carefully conserved. Before final acceptance of the well, temporary connections and piping installed by the Contractor shall be removed in a manner satisfactory to the Engineer.

Disposal of drill fluid and water produced by test pumping or other operations will be by such methods and to such locations that damage to, or interference with structures, roads or utilities, or with other construction projects will not occur. Method and place of disposal shall be approved by the Engineer. All cost incurred in connection with the disposal of drill mud and water will be borne by the Contractor.

Logs of wells in the immediate vicinity are shown on attached sheets. It is expected that drilling will be into (**through**) _____formation(s) consisting of _____ (**lithologic description**) _____.(**this information is available from completion reports on nearby wells. Examples are included in the appendix**) This information is intended to assist in evaluating the amount and character of the work that might be required. It is given, however, without the assumption of responsibility for its accuracy, or for any conclusions that the Contractor might draw therefrom.

Contractor shall inform himself/herself by personal investigation of all local conditions affecting his/her work. Neither use of information contained in this specification, nor from the Owner or his/her employees, shall act to relieve the Contractor from any responsibility hereunder, nor from fulfilling all the terms and requirements of the contract.

1.4 REQUIREMENT FOR NOISE CONTROL (Optional)

The Contractor shall comply with applicable Federal, State, and local laws, orders, and regulations concerning the prevention, control, and abatement of excessive noise. In addition, the Contractor will be required to operate in such a manner that the sound intensity does not exceed the following levels at the locations specified:

A nighttime limitation (8:00 PM - 7:00 AM) of NPL = 75 dB measured outdoors at residences or other noise sensitive areas, A daytime limitation (7:00 AM - 8:00 PM) of NPL = 80 dB measured outdoors at residences or other noise sensitive areas.

NPL is the noise pollution level. It is defined in:

2. HUD Report No. TE/NA 172 "Noise Assessment Guidelines, Technical Background."

3. "Noise and Vibration Control", Beranek, McGraw-Hill, 1971.

4. "Community Noise", NT1D300.3, 1971, available from the Superintendent of Documents, U.S. Government Printing Office, Washington DC 20402.

5. "Noise from Construction Equipment", NT1D300.1, available from the Superintendent of Documents.

Operations producing high intensity impact noise, such as nighttime blasting, jackhammer use, or pile driving, may be performed only upon approval of the Engineer.

Noise will be monitored by the Engineer, and any data obtained will be made available to the Contractor.

Method of calculating NPL:

NPL will be calculated by the Engineer from the formula:

$NPL=L_{50} + d + d^2 /60$

where :

d	=	$(L_{10} - L_{90})$, dB(A)
L_{10}	=	noise level exceeded 10% of the time during the observation period, dB(A).
L_{90}	=	noise level exceeded 90% of the time during the observation period, dB(A).
L_{50}	=	median noise level, dB(A)

The observation period shall be designated by the Engineer and shall be at least 10 minutes. Equipment and techniques will conform to standard ANSI or IEC Practice wherever applicable. Contractor shall be aware of the need for noise control and include the cost of compliance with this section in his/her bid.

1.5 ARCHAEOLOGICAL OR HISTORICAL RESOURCE (Optional)

Should a potential archaeological or historical resource be discovered during the construction of the well(s), the contractor shall cease all excavation work until a qualified archaeologist provided by the Owner has evaluated the situation. Work shall not resume until review by the State Control Board (or other appropriate agency) and approval by the Engineer.

1.6 CONTRACTOR QUALIFICATIONS

The bidder shall have been engaged in the business of constructing _____ (**type of well, i.e., cable tool, gravel envelope, etc**.) _____ wells of diameter, depth, and capacity similar to the proposed well(s) for a period of at least _____ years. The bidder shall submit a list of _____ or more owners for whom the bidder has drilled similar wells. The list shall show the owner's name and address, an individual who may be contacted for reference, casing diameter and depth, and the well's maximum production and specific capacity. The individuals offered as references will be contacted. Failure to submit this list, or unsatisfactory responses from the references shall, in the Engineer's sole judgement, be grounds for bid rejection.

The bidder shall employ competent workers on this project, and all work shall be performed under the direct supervision of an experienced drilling superintendent satisfactory to the Engineer.

Prior to submitting a bid, the bidder shall have been issued a Well Drilling License, by the State of _____ Department of_____ a copy of which shall be submitted with the bid.

The bidder shall incorporate in his/her proposal a list of all subcontractors whose work is included in the bid, and a description of the work to be done by each subcontractor. Each bidder is required to perform a minimum of _____ % of the total dollar value of the contract with his/her own equipment and workers. The Engineer may require references from each subcontractor similar to those required from the bidder, and unsatisfactory subcontractor submittals may be basis for bid rejection.

1.7 PERMITS AND LICENSES

The CONTRACTOR shall, at his/her own expense, procure all permits, certificates and licenses required by law for the execution of his/her work. The CONTRACTOR shall comply with all federal, state, and local laws, ordinances, rules, and regulations relating to the performance of the work.

2.0 WELL CONSTRUCTION PROCEDURE

2.1 METHODS OF CONSTRUCTION

The CONTRACTOR shall choose the construction method(s) to be used. Acceptable methods for this project include:

Conventional Fluid Rotary Drilling
Reverse Circulation Rotary Drilling
Air Rotary Drilling
Down-the-hole Drilling
Cable Tool

2.2 DRILLER'S LOGS AND REPORTS

2.2.1 *Stratigraphic Log.* The stratigraphic log shall be prepared by a qualified geologist to accompany the set of drilling samples, noting depth, strata thickness, lithology, including size, range and shape of constituent particles, smoothness, rock type, rate of penetration, and such special notes as might be helpful.

Driller's's Log. During the drilling of the test hole the CONTRACTOR shall prepare a complete log setting forth the following:

1. The reference point for all depth measurements.
2. The depth at which each change of formation occurs.
3. The depth at which the first water was encountered.
4. The depth at which each stratum was encountered.
5. The thickness of each stratum.
6. The identification of the material of which each stratum is composed, such as:
    a. Clay
    b. Sand or Silt
    c. Sand and Gravel-Indicate whether gravel is loose, tight, angular or smooth; color.
    d. Cemented formation-Indicate whether grains have natural cementing material between them; e.g., silica, calcite, etc.
    e. Hard rock-Indicate whether sedimentary bedrock or igneous (granite-like, basalt-like, etc.)
7. The depth at which each sample was taken.
8. The depth at which hole diameters (bit sizes) change.
9. The depth to the static water level (SWL) and changes in SWL with well depth.

Daily Driller's Report. During the drilling of the test hole or its conversion into a test well, a daily, detailed driller's report shall be maintained and delivered upon request to the OWNER or his/her representative at the well site. The report shall give a complete description of all formations encountered, number of feet (meters) drilled, number of hours on the job, shutdown

due to breakdown, the water level in the well at the beginning and end of each shift, the water level at each change of formation if readily measurable with the drilling method used, feet of casing set, and such other pertinent data as requested by the OWNER or his/her representative. In rotary drilling, the fluid level in the hole should be measured daily prior to starting pumps.

Penetration Rate Log. During the drilling of the hole, a time log shall be kept showing the actual penetration time required to drill each foot of hole. The types of bits used in each portion of the hole shall be noted in this log-drag, roller, button or percussion type and whether designed for soft, medium or hard formations, together with approximate weight on the bits during the drilling of the various types of formations in the various sections of the hole.

2.2.2 *Geophysical/Mechanical Logs.* When called for under the provisions of the contract the CONTRACTOR shall perform or have performed the following logs: _____, _____, _____,

A. Spontaneous-Potential Logging
B. Resistance Logging
C. Resistivity Logging
D. Natural-Gamma Logging
E. Acoustic Logging
F. Caliper Logging
G. Temperature Logging
H. Fluid-Movement Logging
I. Photographic Logging

(With the exception of temperature, logs are rarely run in the shallow, low cost wells used in geothermal direct use and ground source heat pump applications. Logs A, B and C can only be run in uncased holes and are used to identify the borders between strata. Log D is used for the same purpose in cased holes. Log F is used to measure the diameter of the hole.)

2.3 FORMATION SAMPLING

2.3.1 *Acceptable Methods*

2.3.1.1. Return Flow Method (Continuous). A return flow sample shall be taken by removing from the circulating drilling fluid a representative sample of the formation by either collecting same in a cutting sample box, a "shale shaker", a baffle in a ditch, or catching it in a bucket and allowing the sample-to settle out. Provision shall also be made to obtain a record of circulation time and probable depth of the formation from which the cuttings are derived. Drill cutting samples collected at specified depth intervals shall be placed in approved containers and identified as specified in Section 2.3.3. The samples shall be stored in a safe place by the CONTRACTOR.

2.3.1.2 Return Flow Method (Circulated*)*. A return flow sample shall be taken by removing from the discharge fluid a representative sample of the formation by either collecting same in a cutting sample box, a "shale shaker", a baffle in a ditch, or catching it in a bucket and allowing the sample to settle out. The penetration of the bit shall stop when the bottom of the sampling

interval is reached for such time as is required for all the cuttings to move from the last drilled section of the hole and settle at the sampling point. The return ditch and sample catching device shall be cleaned of all cuttings after each sample is taken. A cutting sample shall be carefully collected from the sampling point. Drill cutting samples collected at specified depth intervals shall be taken by the CONTRACTOR. The total sample obtained from each interval shall be mixed and quartered until sufficient sample remains to furnish _____ (**2**), _____(**1**) quart, representative samples. Drill cuttings shall be placed in approved containers and identified as specified in Section 2.3.3. The samples shall be stored in a safe place by the CONTRACTOR.

2.3.1.3 Auger Method. Formation samples obtained using the auger method are to be representative of the formation being penetrated. The samples will be collected, placed in approved containers, and stored in a safe place by the CONTRACTOR.

2.3.1.4 Bailer Method. In clay and consolidated formations the sample shall be taken by bailing the hole clean then advancing the drill bit and collecting cuttings. In sand and gravel the sample shall be taken by driving casing ahead of the drill bit then bailing with a flat bottom or suction bailer. In stable unconsolidated formations, samples shall be taken by drilling _____(**5**) feet and bailing before and after driving the casing to the bottom of the drilled interval.

2.3.1.5 Core Barrel Method. A core barrel shall be advanced, by being rotated or driven, its full length into the undisturbed formation. Once the core barrel has penetrated the desired interval, it shall be withdrawn and the core recovered and stored in a suitable core container. A core recovery of less than _____ percent will not be acceptable.

2.3.1.6 Piston Tube Method. A piston tube sampler shall be driven into the undisturbed material at the bottom of the drilled hole to take formation core samples. This method is used to prevent the material in the core from expanding and to assure that the full core be held securely as the sampler is removed from the test hole. The cores are to be minimum of _____ inches in diameter and _____ inches in length. Upon removal to the surface the sample is to be capped and sealed in its tube, placed in a sample box and stored in a safe place by the CONTRACTOR.

2.3.1.7 Split Spoon Method. A steel cylinder shall be driven vertically into the undisturbed formation at the bottom of the drilled hole. The cylinder will be returned to the surface and transferred to a suitable core container. No sample recovery of less than 50 percent will be accepted.

2.3.1.8 . Side-Hole Core Method. Formation samples will be taken using a _____ inch diameter side-hole core sampler. This unit must be set at depths as directed in such a way as to assure penetration of the hole wall to a sufficient depth to provide a recovery of a _____ inch-long core. Side-hole cores will be taken after geophysical logs have been made, at depths specified by the OWNER or his/her representative. The samples shall be placed in a suitable container and identified as specified in Section 2.3.3, and stored by the CONTRACTOR.

2.3.2. *Sampling Interval*. Formation samples shall be collected each _____ (**10**) foot, starting at _____(**20**) ft, and at any pronounced change of formation. Special care shall be used for collecting samples from zones that are expected to be producing zones, wherein samples shall be collected at _____ (**5)** foot interval

2.3.3 *Size of Sample, Containers, Identification, Storage and Transfer.*

_____ (2) _____ (1 quart ea) representative samples shall be obtained from each sampling interval. In most instances more cuttings will be recovered than required. The total volume of cuttings shall be thoroughly mixed and quartered until the number of volume of samples required are obtained as a residual.

Immediately after retrieval, formation samples shall be placed in approved containers, securely closed to avoid spillage and contamination, and clearly labeled with the following information:

l. Location of the well
2. Name or number of the well
3. Depth interval represented by the sample
4. Date taken
5. Time taken

Formation samples, immediately after being placed in container, shall be labeled clearly, either directly on the container or on a tag attached thereto, using ink, indelible pencil, or other medium that is resistant to moisture and sunlight. The label shall not be readily removable from the container. The CONTRACTOR shall be responsible for the safe storage of formation samples until such times as they are accepted by the OWNER. Time, place, and mode of delivery shall be as directed by the OWNER.

For wells which may or will utilize screens, the CONTRACTOR shall obtain additional samples as required in water-bearing formations for analysis by a laboratory or screen manufacturer. Duplicate samples shall be retained in a safe place until the results of the analysis are received.

2.4 DRILLING FLUID CONTROL PROGRAM

2.4.1 *Production Zone Protection.* Material used by CONTRACTOR to prepare the drilling fluid shall be composed of fresh, non-polluted water and sodium bentonite type drilling clay commercially processed to meet or surpass the viscosity specification in the American Petroleum Institute "Std. 13-A for Drilling Fluid Materials". All other drilling fluid additives used will comply with recognized industry standards and practices, and they will be applied and used as prescribed by the manufacturer. It is expressly understood that toxic and/or dangerous substances will not be added to the drilling fluid.

The drilling fluids program should be agreed to by the CONTRACTOR and the OWNER or PROJECT REPRESENTATIVE. Selection and use of the drilling fluid materials shall be a part of this agreement. The CONTRACTOR shall be responsible for maintaining the quality of the drilling fluid to assure 1) protection of water bearing and potential water bearing formations exposed in the bore hole, and 2) good representative samples of the formation materials.

The drilling fluid properties required will depend on: 1) the type and size of drilling equipment to be used, and 2) down hole conditions anticipated or encountered. Properties of the drilling fluid are to be measured in accordance with the procedures of the American Petroleum Institute R.P. 13-B-"Procedures for Testing Drilling Fluids". Samples tested are those caught at

the rig pump suction with care taken to assure a true and representative sample. Tests should be conducted: 1) every 50 feet of depth or 2) every four circulating hours or 3) whenever conditions appear to have changed or problems arise.

1. Mud density: should be in the range of 9 pounds per gallon.
2. Mud viscosity: should be maintained in the range of 32 to 38 seconds per quart and at all times as thin as practical and still retain formation stability and adequate hole cleaning.
3. Sand content: should not exceed 2 percent of volume.
4. Filter cake 3/32" maximum.

The CONTRACTOR shall maintain current records on the site at all times to show: 1) time, depth and results of all mud tests, 2) all materials added to the system-kind, amount, time and depth, and 3) variances or modifications from agreed to mud program-time, depth, reason and authorization.

The CONTRACTOR is responsible for the removal of the drilling mud from the hole and the development of the well, as per Section 8.0 and related specifications on well development.

3.0 WELL CASING SELECTION AND INSTALLATION

3.1 . WELL CASING SELECTION

3.1.1 *Material* Casing and liner shall be in new or like new condition, free of pits or breaks and shall meet minimum American Society of Testing Materials (ASTM) A-120 specifications. Minimum wall thickness for casing shall be as set forth in the following table:

Minimum Casing Wall Thickness (in)

Depth (ft.)	Nominal Diameter (in.)				
	6	8	10	12	14
<100	0.250	0.250	0.250	0.250	0.250
100 - 200	0.250	0.250	0.250	0.250	0.250
200 - 300	0.250	0.250	0.250	0.250	0.250
300 - 400	0.250	0.250	0.250	0.250	0.250
400 - 600	0.250	0.250	0.250	0.250	0.250
600 - 800	0.250	0.250	0.250	0.250	0.313
800 - 1000	0.250	0.250	0.250	0.250	0.313
1000 - 1500	0.250	0.250	0.313	0.313	0.313

3.1.2 *Temporary Surface Casing.* Temporary surface casing shall have a minimum wall thickness of 0.250 in. And shall be a minimum of 4 inches larger in diameter than the nominal diameter of the pump chamber casing.

3.1.3 *Pump Chamber Casing Diameter*. The pump chamber casing shall be nominal _____(see **table in appendix**) in material with a wall thickness of _____in and an inside diameter of _____in. (**from table above)**

3.2 METHODS OF INSTALLATION

3.2.1 *Lowering.* The lowering method is used to install a jointed casing string in a pre-drilled hole. The casing shall be lowered with the drilling machine, utilizing clamps, elevators or other mechanical devices.

3.2.2 *Floating.* Where the casing load is extremely large it may be desirable to "float" the casing into place. A float collar shall be installed on the casing at the appropriate place in the casing string or a float plug shall be installed in the casing string near the bottom. Where a float collar or float shoe is to be used a casing-size dummy (40 ft. minimum length) shall be run into the hole first to insure that the hole is straight and free from obstruction which could result in a stuck casing.

3.3 METHOD OF JOINING

Contractor's Choice. Casing lengths shall be joined watertight by a method appropriate to the material used, as selected by the CONTRACTOR and approved by the OWNER, so that the resulting joint shall have the same structural integrity as the casing itself.

Welding shall conform to AWS B 3.0 and D 1.1. Cut off casing shall become the property of the CONTRACTOR and shall be removed from the site.

If *threaded and coupled joints* are used, couplings shall be API or equivalent, made up so that when tight all threads will be buried in the lip of the coupling.

3.4 CASING SEATING

3.4.1 *Consolidated Formations.* In consolidated formations the casing should extend at least five feet into the formation to assure a proper seat and bottom seal. It shall be the responsibility of the CONTRACTOR to effect a proper seal. Where the casing is to be driven it shall be fitted with a drive shoe and shall be driven to refusal. Where the casing is to be placed (rather than driven), cement grout shall be placed in the bottom of the hole in accordance with Section 4.0.

3.4.2 *Pressure Testing of Seating.* Where casing has been driven, pressure testing shall be employed immediately following installation to determine whether an air-tight seating has been accomplished. An appropriate temporary airtight cap is to be installed and a pressure of 7 to 10 pounds per square inch is to be maintained within the well, without the addition of more air, for a period of not less than one hour. Any loss of air shall be construed as indicating a defective seal.

To correct such a defect, the OWNER shall require the CONTRACTOR to make the necessary repairs by either cementing the seating zone or by other means acceptable to both the OWNER and CONTRACTOR.

4.0 GROUTING

4.1 GROUT MATERIALS

A mixture of Portland cement (ASTM C150) and not more than six (6) gallons of clean water per bag (one cubic foot or 94 pounds) of cement, shall be used. The use of special cements, bentonite to reduce shrinkage or other admixtures (ASTM C494) to reduce permeability, increase fluidity, and/or control time of set, and the composition of the resultant slurry must be approved by the OWNER or PROJECT REPRESENTATIVE.

4.2 INSTALLATION OF GROUT-ACCEPTABLE METHODS

4.2.1 *Positive Placement-Interior Method-Two Plug.* Grout shall be placed by the two-plug cementing method (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The first spacer plug, which shall be a drillable plug such as a plaster-type material, shall then be inserted and the casing capped. A measured volume of grout shall be pumped in which shall be of sufficient quantity to grout the casing in place. The casing shall then be uncapped, the second plug shall be inserted, and the casing recapped. A measured volume of water slightly less than the volume of the casing shall then be pumped into the casing until the second plug is pushed to the bottom of the casing, expelling the grout from the casing up and into the annular space. The water in the casing shall be maintained constant to prevent back flow until the grout has set. Pressure shall be maintained for a minimum of 24 hours or until such time as a sample of the grout indicates a satisfactory set. Cement grout shall be used for this procedure with a minimum annular space thickness of l 1/2 inches completely surrounding the casing. Curing time before construction may be resumed: Portland Cement Type I-minimum 72 hours; Type III-minimum 36 hours. Concrete grout cannot be used with this method.

4.2.2 *Positive Placement-Interior Method-Upper Plug.* Grout shall be placed by the upper plug casing method (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). A measured quantity of grout, sufficient to grout the casing in place, shall be pumped into the capped casing. Because this grout is in direct contact with the drilling fluid there will be a narrow zone of weak grout between the drilling fluid and the good grout. The casing shall be uncapped, and a drillable plug, constructed of plastic or other suitable material shall be inserted on top of the grout and the casing recapped. A measured volume of water, equal to the volume of the casing, shall be pumped into the casing, forcing the plug to the bottom of the casing and expelling the grout into the annular space surrounding the casing. Utilizing this method the weak grout zone at the interface of grout and drilling fluid will not be located at the critical position at the bottom of the casing. The water in the casing shall be maintained under pressure to prevent back flow until the grout has set. Pressure shall be maintained for a minimum of 24 hours or until such time as a sample of the grout indicates a

satisfactory set. Neat cement or sand-cement grout shall be used for this procedure, with a minimum annular space opening of l 1/2 inches completely surrounding the casing. Curing time before construction may be resumed: Portland Cement Type I-minimum 72 hours; Type III-minimum 36 hours. Concrete grout cannot be used with this method.

4.2.3 *Positive Placement-Interior Method-Capped Casing.* Grout shall be placed by pumping or air pressure injection through the grout pipe installed inside the casing from the casing head to a point 5 feet above the bottom of the casing (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The grout pipe shall extend airtight, through a sealed cap on the casing head of the well casing. The casing head shall be equipped with a relief valve and the drop pipe shall be equipped at the top with a valve permitting injection. The lower end of the drop pipe and the casing shall be open. Clean water shall be injected down the grout pipe until it returns through the casing head relief valve. The relief valve is then closed and injection of water is continued until it flows from the bore hole *outside* of the casing to be grouted in place. This circulation of water is intended to clean the hole and condition it to better take the grout. Without significant interruption, grout shall be substituted for water and, in a continuous manner, injected down the grout pipe until it returns to the surface outside of the casing. A small amount of water, not to exceed seventeen gallons per hundred lineal feet of 2 inch drop pipe may be used to flush the grout pipe, but pressure shall be maintained constant on the inside of the grout pipe and the inside of the casing until the grout has set. Pressure shall be maintained for at least 24 hours, or until such time as a sample of the grout indicates a satisfactory set. Neat cement or sand-cement grout shall be used for this procedure with a minimum annular space of 1 1/2 inches completely surrounding the casing. Curing time before construction may be resumed: Portland Cement Type I-minimum 72 hours; Type III-minimum 36 hours. Concrete grout cannot be used with this method.

4.2.4 *Continuous Injection Method.* Grout shall be placed by the float shoe continuous injection method, (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The bottom of the casing shall be fitted with a suitable drillable float shoe equipped with a back pressure valve. Tubing or pipe shall be run to the float shoe to which it shall be connected by a bayonet fitting, left hand thread coupling, or similar release mechanism. Water or other drilling fluid shall be circulated through the tubing and up through the annular space outside the casing. When the annular space is clean and open, grout shall be pumped down the pipe or tubing and forced by continual pumping out into the annular space surrounding the casing. Pumping shall continue until the entire zone to be grouted is filled. The grout pipe shall then be detached from the float shoe and raised to the surface for flushing. After the grout has set the float shoe, back pressure valve, and any concrete plug remaining in the bottom of the casing shall be drilled out. A neat cement or sand-cement grout shall be used for this procedure with a minimum annular space of 1.5 inches completely surrounding the casing. Curing time required before construction may be resumed shall be 72 hours for Type I Portland Cement and 36 hours for Type III. Concrete grout cannot be used with this method.

4.2.5 *Grout Displacement Method.* The hole shall be filled with the estimated volume of grout required for the purpose intended. The casing fitted at the bottom with a drillable back pressure valve, metal plate, or similar seal shall be lowered through the grout to the bottom of the hole. If necessary to maintain the bottom of the casing at the bottom of the hole, the casing shall

be filled with water, or drilling fluid, and in some cases by applying a load on the bottom with drill pipe. The load shall be maintained until the grout has set, after which the bottom plug is drilled out and the well deepened. Use of this method is limited to wells not more than 100 feet in depth.

4.3 LOCATION OF GROUT (The following specification should be considered a minimum. For more complete information on the sealing of wells based on various subsurface conditions see the additional specifications and diagrams in the appendix)

4.3.1 *Surface Formation Seal.* The annular space to be grouted, and surrounding the permanent well casing at the upper terminus of the well, shall be not less than a nominal 2 inches. The length of the grout seal shall be whatever is necessary to prevent the entrance of surface water or undesirable subsurface water into the well. In any circumstance, the length of seal shall not be less than the minimum specified in the state or locally applicable construction code.

The entire space to be grouted must be open and available to receive the grout at the time the grouting operation is performed. If a section of larger pipe (conductor pipe) is installed to keep the entire space open (in caving materials), this larger pipe must be removed, as the grout is installed, from the zone where the seal is required.

The effective length of grout seal (for sanitary purposes) shall be that distance measured from the deepest limit of the seal up to the depth of frost penetration. If a pitless adapter or unit is to be installed, the upper limit of the seal shall be one foot below the field connection of the adapter.

4.4 CENTRALIZERS

4.4.1 *Centralizers at Bottom of Hole and other Critical Points.* Centralizers shall be attached to the bottom of the casing at other critical grouting points such as zones of unsuitable water quality.

4.5 PRESSURE TESTING OF GROUTING SEAL

Pressure testing of the grout seal shall be employed following the appropriate time for curing of the grout according to all appropriate provisions in this Article. A pressure of 7 to 10 pounds of air per square inch is to be maintained within the well, without the addition of more air, for a period of not less than one hour. Any loss of air shall be construed as indicating a defective seal. To correct such a defect, the OWNER shall require the CONTRACTOR to make the necessary repairs by re-cementing and pressure testing at 15 psi for one hour.

5.0 PLUMBNESS AND ALIGNMENT

(select one. "A" would suffice for shallow (<200 ft) wells where a submersible type pump will be used. "B" is appropriate for deeper wells where a submersible pump will be used. "C" should be selected where a lineshaft type pump will be used for production.)

A . The completed well shall be sufficiently plumb and straight so that there will be no interference with installation, alignment, operation or future removal of the permanent well pump.

B. All wells should be constructed and all casings and liners set round, plumb, and true to line as defined herein. To demonstrate the compliance of the work with the requirements, the CONTRACTOR shall furnish all labor, tools and equipment and perform the test or tests described herein. The test for plumbness and alignment shall be made following construction of the well, and before test pump equipment is installed.

Alignment shall be tested by lowering into the well to a depth of at least _____ feet **(lowest anticipated pump setting)** a section of pipe 40 feet long or a dummy of the same length. The outer diameter of the pipe or dummy shall be not more than 1/2 inch smaller than the inside diameter of that part of the casing or hole being tested when the casing diameter is a nominal 10 inches or less. When the nominal diameter of the casing being tested is 12 inches or greater, the outer diameter of the test pipe or dummy shall not be more than 1 inch smaller than the inside diameter of that part of the casing or hole being tested. The dummy when lowered into the casing shall pass freely the entire depth of the well.

C.) The Contractor shall guarantee that the well when completed shall be sufficiently straight and plumb for the free installation and operation of a turbine pump of ____ inch (**bowl diameter is a function of pump capacity. See table in appendix)** nominal bowl diameter with bowls set ____ feet below ground surface. To demonstrate compliance with this requirement the Contractor shall furnish all labor, tools, and equipment, and make a caging test to the satisfaction of the Engineer. The test shall be performed after completion of the well construction and before its acceptance. The completed well shall be drilled in such vertical alignment that a line drawn from the center of the well casing at ground surface to the center of the well casing ____ feet below the ground surface shall not deviate from the vertical more than 6 inches in 100 feet of length.

6.0 SCREEN

6.1 DESIGN BASIS

All screen and artificial filter design shall be based upon the results of a sieve test of samples retrieved from the aquifer interval as per Section 2.3 during the drilling process.

For a non-homogeneous aquifer, having a uniformity coefficient (sieve size that will retain 40 percent of the aquifer material divided by the sieve size that will retain 90 percent of the aquifer material) less than 3.0 and an effective grain size (sieve size that will retain 90 percent of the aquifer material) less than 0.01 inches, an artificial filter shall be used as described in Section 7.0.

For non-homogeneous aquifers less than 5 feet thick and separated vertically by less than 5 feet, the artificial filter will be used as described in Section 7.0, providing that more than 5 feet of the screen is required, and regardless of the uniformity coefficient of the aquifer material.

In the event that an artificial filter is not required, selection of screen aperture size shall be based upon criteria of Section 6.4. In the event that an artificial filter is required, selection of screen aperture size shall be based upon criteria of Section 7.2.

6.2 SCREEN-TYPE SELECTION

6.2.1 *Louvered Pipe.* The screen shall consist of a pipe that has punched openings in it where material has not been removed. The openings formed shall be between the corner of the outside of the pipe and the punched-out area, and the corner of the inside of the punched portion and its side. The openings shall be uniform and their total area shall be such that the entrance velocity at the design condition shall not exceed 6 feet per minute (0.1 foot per second).

6.2.2 . *Continuous Slot Wire Wound Screen.* The screen shall be constructed of wound wire, reinforced with longitudinal bars, the bars having a cross section that will form an opening between each adjacent coil of wire that is shaped in such a manner as to increase in size inward. The wire shall be firmly attached to the bars which will, in turn, be attached to a coupling adapter. The total open area shall be such that the entrance velocity at the design condition shall not exceed 6 feet per minute (0.1 foot per second).

6.3 ENTRANCE VELOCITY

In no case shall the entrance velocity through the screen exceed 0.1 ft/sec for production wells and 0.05 ft/sec for injection wells.

6.4 APERTURE SIZE SELECTION CRITERIA

The screen aperture size shall be based on the following criteria

6.4.1 Where the uniformity coefficient of the aquifer is greater than 6 and the aquifer is overlain by an essentially non-caving formation, the aperture size shall be that which retains 30 percent of the aquifer sample.

6.4.2 Where the uniformity coefficient of the aquifer is greater than 6 and the aquifer is overlain by a readily caving formation, the aperture size shall be that which retains 50 percent of the aquifer sample.

6.4.3 Where the uniformity coefficient of the aquifer is 3 or lower and the aquifer is overlain by an essentially non-caving formation, the aperture size shall be that which retains 40 percent of the aquifer sample.

6.4.4 Where the uniformity coefficient of the aquifer is 3 or lower and the aquifer is overlain by a caving formation, the aperture size shall be that which retains 60 percent of the aquifer sample.

6.4.5 For conditions between the extremes listed, the CONTRACTOR shall interpolate to obtain the proper screen aperture size.

6.4.6 Where a formation to be screened has layers of differing grain sizes and gradations, use the following rule: If the 50 percent size of the coarsest layer is less than 4 times the 50 percent size of the finest layer, the aperture size shall be selected on the basis of the finest layer, or for each specific layer is indicated in 6.4.1, 6.4.2, 6.4.3, 6.4.4, 6.4.5.

6.4.7 If the water is corrosive or the accuracy of the chemical analysis is in doubt, select an aperture size that will retain 10 percent more than is indicated in the above paragraphs.

6.4.8 Where fine sand overlies coarse sand, use the fine sand size aperture for the top two feet of the underlying coarse sand. The coarse size aperture shall not be larger than twice the fine sand size.

6.4.9 Where an artificial filter is to be used the aperture size selection criteria shall be in accordance with Section 7.2.

6.5 SCREEN LENGTH

The length of the screen for an artesian aquifer shall be such that at least 80 percent of the aquifer is screened. The screen shall be centered in the aquifer. The length of the screen for a water table aquifer shall be between 1/3 and 1/2 of the aquifer thickness. The screen should be positioned in the lower 1/3 or 1/2 of the aquifer. In no instance shall the well screen entrance velocity exceed 0.1 foot per second (Aquifer thickness as used here is the total thickness of the sand formation to be screened or, where geophysical logs indicate a specific water-bearing zone, the term refers to the total thickness of the sand formation as indicated by the geophysical log.) For any specified discharge screen of sufficient length shall be installed to obtain an entrance velocity not exceeding 6 feet per minute (0.1 foot per second).

6.6 SCREEN INSTALLATION - ACCEPTABLE METHODS

6.6.1. *Suspended From Surface Method.* The screen, with closed bottom, shall be attached by an approved manner to the casing and lowered into the well with the casing. In no instance shall it be driven or forced. It shall remain suspended from the surface until the formation has collapsed against it or until a filter material or formation stabilizer has been added.

6.7 JOINING

6.7.1 *Joining Screen to Screen.* Screen sections for a single interval shall be joined by threaded and coupled joints, socket-type fittings and solvent welding, or electric arc or acetylene welding. Welding rods and methods recommended by the screen manufacturer shall be employed. Resulting joint(s) must be straight, sand tight and retain 100 percent of the screen strength.

Blank spacers for multiple interval screen shall be of the same material as the casing, unless otherwise specified. They shall be joined to the screen by the threaded and coupled joints, socket-type fittings and solvent welding, or electric arc or acetylene welding using materials and procedures specified in Section 3.3. The resulting joints must be straight, sand tight and retain 100 percent of the screen strength.

6.7.2 *Joining Screen to Casing*

6.7.2.1 Neoprene or Rubber Seal. A neoprene or rubber seal especially made for this purpose shall be attached to the top of the screen. It shall be designed to be self-sealing in the well casing.

6.7.2.2 Threaded, Coupled, Welded Joints. The casing and screen shall be joined by threaded and coupled joints, socket fitting and solvent welding, or electric arc or acetylene welding using materials and procedures specified in Section 3.3. The resulting joints must be straight, sand tight and retain 100 percent of the screen strength.

6.8 METHODS OF SEALING BOTTOM

The bottom of the deepest screen shall have a plate of the same material as the screen welded to it to seal it.

7.0 ARTIFICIAL FILTER

7.1 REQUIREMENT FOR ARTIFICIAL FILTER

If the formation is non-homogeneous, has a uniformity coefficient greater than 3.0, and has an effective grain greater than 0.01 inches, an artificial filter shall not be required.

7.2 SELECTION OF FILTER GRAIN SIZE AND SCREEN APERTURE SIZE

The filter grain size shall be determined by multiplying the 70 percent retained grain size of the finest formation by a value not less than 4 and not greater than 6. The resulting value is the 70 percent retained grain size of the filter material to be used. The uniformity coefficient (the size of sieve that retains 40 percent of the sample divided by the size that retains 90 percent) of the filter material shall not be greater than 2.5. The gradation of the filter material shall form a

smooth and gradual size distribution curve when plotted. The screen aperture openings shall be of such size as to retain a minimum of 85 percent of the filter material. The thickness of the filter shall range from a minimum of 3 inches to approximately 8 inches.

7.3 LENGTH OF ARTIFICIAL FILTER

7.3.1 The filter material shall extend from a point equal in distance to 2 1/2 times the largest diameter of the well below the lowest screen to the same distance above the highest screen. Sand, cement, or additional filter material shall be placed between the filter material and the lower limit of the sanitary seal, according to state and local regulations. The size of the sand shall be such that it will not infiltrate into the filter material.

7.3.2 The filter material shall extend from a point equal in distance to 2 1/2 times the largest diameter of the well below the lowest screen to a point 50 feet above the lower end of the outer, or surface, casing where well depth permits.

7.3.3 . The filter shall extend from a point equal in distance 2 1/2 times the largest diameter of the well below the lowest screen to the land surface. Suitable accompanying well design features will include (1) filter zone in the upper section of the well will be surrounded with casing and (2) cemented into place via the provisions applicable in Sections 3.0 and 4.0 to insure a sanitary seal.

7.4 INSTALLATION OF FILTER MATERIAL-ACCEPTABLE METHODS

7.4.1 *Tremie Placed with Fluid.* The filter shall be placed by the use of a tremie pipe lowered to the bottom of the space to be packed and slowly raised as the filter is placed. Water or thin drilling fluid shall be pumped from the inner casing and allowed to flow into or be pumped in with the filter material.

7.4.2 *Tremie with Ell.* A tremie pipe with an ell formed on its bottom to direct its discharge perpendicular to the long axis of the screen shall be lowered to the bottom of the space to be packed and the filter shall be placed by pumping water or drilling fluid through the tremie pipe with the filter material being added to the fluid being pumped. Pressure shall be maintained that will keep the filter material in suspension in the annulus. The tremie shall be gradually raised as the pack is injected.

7.4.3 *Crossover Tool.* The filter material shall be placed by pumping it to a point above the screen through a "cross-over" tool and then allowed to fall as the drilling fluid is circulated through the bottom of the screen via an inner removable pipe.

8.0 WELL DEVELOPMENT

8.1 ACCEPTABLE METHODS

8.1.1 *Surging and Bailing (Utilizing Surge Block).* The development process shall be carried out by surging and bailing the well. The surging shall be done by a single or double solid (or valved) surge block. Surging shall start at the bottom of the lowest screen in the well and proceed upwards.

8.1.2 *Surging and Pumping.* The development process shall include surging and pumping the well. The surging shall be done by either a solid or valved surge block. The pumping shall be done through the surge block which incorporates a piece of the suction pipe in the fabrication of the block. Pumping shall be done simultaneously with the surging at rates up to 1/2 of the design capacity. Fines drawn into the well shall be pumped out periodically before such accumulation reaches 10 percent of the screen length. Upon completion of the development work the well shall be cleaned to the bottom.

8.1.3 *Hydraulic Jetting.* Hydraulic jetting shall only be used in conjunction with one of the other methods described in this section. Development shall be accomplished by simultaneous high-velocity, horizontal-jetting and pumping. The outside diameter of the jetting tool shall be one inch less in diameter than the screen inside diameter. The minimum exit velocity of the jetting fluid at the jet nozzle shall be 150 ft./sec. The tool shall be rotated at a speed less than one rpm. It shall be positioned at one level for not less than two minutes and then shall be moved to the next level which shall be no more than 6 inches vertically from the preceding jetting level. The jetting shall proceed from the bottom of the screen to the top. Pumping from the well shall be at a rate of 5 to 15 percent more than the rate at which water is introduced through the jetting tool. Water to be used for jetting must contain less than 1 ppm suspended solids.

8.2 DEVELOPMENT AIDS

8.2.1 *Washing with Water.* Clean, clear water shall be circulated to remove sediment from the well. A pump of sufficient size shall be utilized for the washing process which will agitate the formation for the purpose of preventing bridging of the sand particles and removing a large portion of the finer material. The use of any chemicals, if pay is to be received, must be approved by the OWNER or PROJECT REPRESENTATIVE.

8.2.2 *Washing with Chemicals.* Where applicable and required, mud dispersing agents (such as glassy phosphate), acids for washing limestone, and other chemicals applicable to standard procedures may be used in accordance with the approval or direction of the OWNER or his/her representative.

8.3 SAND CONTENT LIMITS

(Sand content limits are a function of the design of the system. For applications in which an injection well will be used, the well should be sand free (< 1.0 ppm). For systems using surface discharge, a sand limit of 5 ppm should be used)

8.3.1 Well development shall continue until sand production is less than _____(**5, 15**)ppm within _____(**10**) minutes after commencement of pumping at a minimum rate of _____(**peak system flow rate**) gpm and is not more than an average of _____(**0.9, 5.0**) ppm after a pumping cycle of two hours. Sand production shall be measured with a centrifugal sand separating device as described in the Journal of American Water works Association Vol 46 No 2, Feb 1954

8.3.2 *Recording Measurements.* A record shall be made showing time, type of operation, specific capacity during pumping, pumping rate and the sand content measured and recorded. These records shall be submitted to the OWNER or his/her representative along with a _____(**2)** lb. sample of the sand collected.

9.0 WELL FLOW TESTING

(**Select either 7.1 or 7.2. The constant rate test is simpler but without the monitoring of nearby well water levels, produces less information about the aquifer than the step drawdown test. The step drawdown test can be shortened by eliminating the constant rate test at the end assuming that the water level in the well stabilized sufficiently during the final stage of the step test.**

9.1 CONSTANT RATE METHOD

The CONTRACTOR shall furnish, install and remove the necessary measuring instruments and pumping equipment capable of pumping to the required point of discharge a minimum of _____ (**peak system flow rate**) gpm, with a pumping level of _____ feet **(determined from nearby wells**) and with satisfactory throttling devices, so that the discharge may be reduced to _____ gpm (**25% of peak system flow rate**). The pumping unit shall be complete with an ample power source, controls and appurtenances and shall be capable of being operated without interruption for a period of _____(**72)** hours.

The well shall be pumped at a discharge rate of _____ gpm (**peak system flow rate**) for a minimum of _____ (**12**) hours. The test pump shall have its intake at least 5 feet below the estimated lowest pumping level, and shall have sufficient power and capacity to achieve the designated discharge rate. Discharge shall be measured with an accurate totalizing meter and stopwatch, a circular orifice meter, or a Venturi meter, any of which are subject to approval by the OWNER or his/her representative. Discharge shall be maintained within plus or minus 5 percent of the designated rate by means of a gate valve or throttling device. Discharge shall be checked and adjusted, if necessary, every 10 minutes during the first hour of pumping and at 30-minute intervals thereafter. The discharge and time of measurement shall be recorded each time it is checked and a note made of any adjustments. The static or non-pumping water level trend shall be established prior to the start of the test. Drawdown shall be measured according to the following schedule: 0 to 10 minutes-every minute; 10 to 45 minutes--every 5 minutes; 45 to 90 minutes-every 15 minutes; 90 to 180 minutes--each half hour; 180 minutes to the end of the test-each hour. Should the measurements not be made exactly at the times specified, the actual time of each measurement shall be recorded. On completion of pumping, recovery measurements shall be made according to the above drawdown schedule.

9.2 STEP-CONTINUOUS COMPOSITE METHOD

The CONTRACTOR shall furnish, install and remove the necessary measuring instruments and pumping equipment capable of pumping to the required point of discharge a minimum of _____ gpm (**peak system flow rate**), with the pumping level of _____ feet (**determined from nearby wells**), and with satisfactory throttling devices, so that the discharge may be reduced to _____ gpm (**25% of peak system flow rate**). The pumping unit shall be complete with an ample power source, controls and appurtenances and shall be capable of being operated without interruption for a period of _____(**16**) hours.

Prior to starting the pump, water level measurements shall be made at least hourly, for a minimum of eight hours, in the production well and all observation wells, and these measurements shall be recorded on the same note sheets to be used during the pumping test. The well shall be "step" tested at rates of approximately 25%, 50%, 75%, and 100% of the design capacity of _____ gpm (**peak system flow rate**). The complete test is estimated to require a minimum of approximately _____(**4**) hours. The CONTRACTOR shall operate the pump and change the discharge as directed by the OWNER. Discharge of the pump shall be controlled by a gate valve, if electric driven, and both gate valve and engine throttle if engine driven. The discharge shall be controlled and maintained at approximately the desired discharge for each step with an accuracy of plus or minus 5 percent. Pump discharge shall be measured with a totalizing meter and stopwatch, circular orifice meter, or Venturi meter as approved by the OWNER. A 2-wire electric probe calibrated so as to permit water level measurement accuracy of +/- 0.05 ft shall be used to measure the static water level and drawdown in the well. The probe shall be furnished by the CONTRACTOR.

After recovery from the step test is complete, a constant rate test shall be conducted by pumping the well at the design rate or at maximum yield for a period of not less than _____(**4**) hours or until the pumping level remains constant for at least 4 hours, or until the OWNER or his/her representative terminates the test.

Measurements of pumping rate and water level shall be made every 1 minute for the first 10 minutes of the test, every 2 minutes for the next 10 minutes, every 5 minutes for the next 40 minutes, every 15 minutes for the next hour, every 30 minutes for the next 3 hours, and hourly for the remainder of the pumping period. Recovery water-level measurements shall be made with the same frequency until sufficient data have been collected to extrapolate the full recovery of the well or until the OWNER requires no further data.

9.3 ABORTED TEST

Whenever continuous pumping at a uniform rate has been specified, failure of pump operation for a period greater than one per cent of the elapsed pumping time shall require suspension of the test until the water level in the pumped well has recovered to its original level. For the purposes of this Article, recovery shall be considered "complete" after the well has been allowed to rest for a period at least equal to the elapsed pumping time of the aborted test- except that if any three successive water level measurements spaced at least 20 minutes apart show no further rise in the water level in the pumped well, the test may be resumed immediately. The (**Engineer, Owner's Representative**) shall be the sole judge as to whether this latter condition exists.

9.4 DISCHARGE WATER

Discharged water shall be conducted from the pump to the nearest surface-water body, storm sewer, or ditch, as approved by the OWNER or his/her representative or at least a distance of _____ feet through approved piping or lined ditches to prevent recirculation of discharged water into the aquifer being tested. It is imperative to insure that no damage by flooding or erosion is caused to the chosen drainage structure or disposal site.

9.5 RECORDS

The CONTRACTOR shall keep accurate records of the pumping test and furnish copies of all records to the OWNER or his/her representative upon completion of the test. The records shall also be available to the OWNER or his/her representative for inspection at any time during the test. For each well used in the test, the records shall include physical data describing the construction features such as, but not limited to: well depth and diameter, complete screen description, length, and setting; a description of the measuring point and its measured height above land surface and/or mean sea level; the methods used in measuring water levels and pumping rates. An accurate description or sketch map of the well locations with identifying names or numbers and distances between wells or from bodies of water shall be provided on each set of records. Records of measurements shall include the date of the test, the clock time and elapsed pumping time of each measurement, the depth to water below the measuring point, the pumping rate at the time of measurement, and any pertinent comments on conditions that may affect the measurements. Frequency of water-level measurements before, during, and after pumping shall be as specified by the OWNER or his/her representative.

9.6 MEASUREMENT OF WATER LEVELS - ACCEPTABLE METHODS

9.6.1 *Electric Sonde Method.* A 2-wire electric probe calibrated so as to permit water level measurement accuracy of +/- 0.05 ft shall be used to measure the static water level and drawdown in the well. The probe shall be furnished by the CONTRACTOR.

9.7 WATER SAMPLES AND ANALYSIS

9.7.1 *Specific Constituent-Analysis.* Analysis for the following specific constituents shall be made:

pH	Carbonate	Stability Index
Iron	Bicarbonate	Saturation Index
Calcium	Sulphate	Carbon Dioxide
Magnesium	Chloride	Hydrogen Sulphide
Sodium	Alkalinity	Oxygen
Potassium	Total Hardness	Total Dissolved Solids

9.7.2 *Sample Collection.* A _____ (**1/2**) gallon sample of water shall be collected for chemical analysis. The water sample shall be collected in a chemically cleaned container supplied by the laboratory that will make the analysis. The sample shall be collected from the water discharged during development or flow test pumping of the well, no less than _____**(1)** hours after pumping has commenced.

9.7.3 *Wellhead Tests.* The temperature and pH of the water shall be taken immediately upon collection of the water sample and recorded on the sample container and drillers log. Tests shall be conducted according to procedures prescribed by the manufacturer of the test equipment employed, local health or water agencies, or as set forth in standard publications dealing with this method of analysis. Test for the presence of dissolved gasses as identified in Section 9.7.1 shall be made immediately following the collection in accordance with procedures prescribed by the manufacturer of the test equipment.

9.7.4. *Laboratory Requirements.* Laboratory tests shall consist of those specified by the regulations of local or state government or as described herein for the proposed use of the water. In addition, such other tests prescribed by the OWNER will be made. All laboratory tests shall be performed by a laboratory approved by the OWNER or his/her representative. Analytical techniques and methods shall be as prescribed *in Standard Methods for the Examination, of Water and Waste Water,* a joint publication of the American Public Health Association, American Water Works Association, and Water Pollution Control Federation. All samples shall be appropriately identified as to geographic location, date, time, method of collection, point of collection, water bearing formation(s), depth and diameter of well, water level and yield, and shall include the name of the sample collector, CONTRACTOR, driller and OWNER.

10.0 WELL DISINFECTION

10.1 SCHEDULING DISINFECTION

The CONTRACTOR shall provide for disinfection as soon as construction of the well and cleaning procedures have been completed. The CONTRACTOR shall carry out adequate cleaning procedures immediately preceding disinfection where evidence indicates that normal well construction and development work have not adequately cleaned the well. All oil, grease, soil, and other materials, which could harbor and protect bacteria from disinfectants, shall be removed from the well. Unless prior approval is obtained for employing chemicals or unusual cleaning methods, the cleaning operation is to be carried out by pumping and swabbing only. Where test pumping equipment is to be utilized, such equipment shall be installed prior to or during disinfection and be thoroughly hosed, scrubbed or otherwise cleaned of foreign material.

10.2 DISINFECTANTS

Chlorine or other compounds approved by state or local regulatory agencies shall be used as disinfectants. The disinfectant shall be delivered to the site of the work in original closed containers bearing the original label indicating the percentage of available chlorine. The disinfectant shall be recently purchased. Chlorine compounds in dry form shall not be stored for

more than one year and storage of liquid compounds shall not exceed 60 days. During storage, disinfectants shall not be exposed to the atmosphere or to direct sunlight. Unless superseded by governmental regulation, the quantity of chlorine compounds used for disinfection shall be sufficient to produce a minimum of 100 ppm (parts per million) available chlorine in solution when mixed with the total volume of water in the well.

10.3 INTERIM DISINFECTION

Should a delay of three days or more be anticipated between the completion of the well and the regularly scheduled well disinfection an interim disinfection shall be provided by the CONTRACTOR. The CONTRACTOR shall install an approved disinfecting agent in an amount equal to 10 percent of the amount required for final disinfection. For this purpose the disinfecting agent shall be furnished or prepared in liquid form and placed in the well through a hose or tremie of sufficient length to extend to the bottom of the well. The disinfecting agent shall be applied through the hose, which is to be raised and lowered, to achieve uniform distribution of the solution throughout the well.

10.4 DAILY OPERATIONS DISINFECTION

Daily chlorination of the well shall be carried out by the CONTRACTOR during drilling operations. The CONTRACTOR shall discuss with the OWNER the amount of disinfecting agent to be used and its method of use in advance of initiating the work. Chlorine compound dosages and method of utilization shall be satisfactory to the OWNER in its entirety.

10.5 DISINFECTION PROCEDURE

Unless otherwise modified-due to problems involved with the specific well or conflict with local, state or federal governmental regulatory, agency requirements-disinfection procedure shall include, but not be limited to the following:

Provide reliable means for insuring that the disinfecting agent is uniformly applied throughout the entire water depth of the well without relying on subsequent mechanical or surging action for dispersing the disinfectant; the dispersion of the disinfectant shall be assisted by pouring into the well a volume of water equal to the volume of the screen, after the disinfectant has been emplaced. This will cause the disinfectant to flow out of the well into the area adjacent to the screen.

All accessible portions of the well above the water level shall be maintained in a damp condition with water containing the required concentration of disinfecting agent for a period of not less than 20 minutes. The disinfecting agent shall be left in the well for a period of at least 12 hours. After a 12 hour, or longer, contact period the well is to be pumped to clear it of the disinfecting agent. The disposal point for the purged water shall be as selected so as to minimize potential damage to aquatic life or vegetation.

10.6 DISINFECTION OF WATER TABLE WELLS - ACCEPTABLE METHODS

10.6.1. *Dry Chlorine Compounds.* A doubly capped, perforated pipe container filled with the appropriate amount of a granular chlorine compound for the well shall be moved up and down the entire well bore until the material has dissolved.

10.6.2 . *Stock Solution (I).* A stock solution sufficient to produce _____**(100**) ppm of available chlorine shall be added to the well at different intervals from top to bottom and then agitated to distribute it evenly throughout the well.

10.6.3 *Stock Solution (II).* A stock chlorine solution of 15,000 ppm shall be added to a continuous flow of water into the well to produce a _____**(100)** ppm concentration of available chlorine throughout the well.

10.6.4 *Prepared Solution.* The chlorine solution of the appropriate concentration to disinfect the well shall be prepared on the surface in containers having an aggregate volume equal to at least twice the volume of water in the well and then rapidly discharged into the well so as to thoroughly flush that portion of the casing which is above the water level.

10.7 DISINFECTION OF FLOWING ARTESIAN WELLS - ACCEPTABLE METHODS

10.7.1 *Dry Chlorine Compounds.* A doubly capped, perforated pipe container filled with a granular chlorine compound shall be placed at a point on or below the top of the producing horizon. This process shall be repeated as often as necessary to achieve and maintain the standard 50 ppm concentration for a period of not less than one hour.

10.7.2 *Controlled Flow Disinfection.* Flow shall be controlled by either capping or by a suitable standpipe. In the event the well is capped a stock chlorine solution shall be injected, under pressure, by means of a drop pipe to the bottom of the well. The cap shall be equipped with a suitable one-inch valve. After the injection is complete air shall be injected for agitation while simultaneously opening the valve in the cap permitting the chlorine solution to be dispersed to the surface. The valve shall then be closed and the flow stopped. The chlorine concentration shall be maintained at 100 ppm for six hours.

In the event flow can be controlled by a suitable standpipe the chlorine treatment can be conducted as though the well was non-flowing.

10.7.3 *Stock Solution.* A stock chlorine solution shall be applied for a period of not less than one hour at a point at or below the top of the producing zone. The rate of application will be such that the standard 100 ppm concentration is achieved and maintained during the application period.

11.0 WELL ABANDONMENT

11.1 AQUIFER SEALING CRITERIA.

Aquifers shall be filled with disinfected, dimensionally stable materials, compacted mechanically if necessary to avoid later settlement. (Cement, cement-and-sand, and concrete do not require disinfection.)

Disinfection of aquifer fill materials shall be accomplished by using chlorine compounds such as sodium hypochlorite or calcium hypochlorite. Aquifer fill materials shall be clean (relatively free of clays and organic materials) before placement in the well. Disinfection shall be accomplished by dissolving sufficient chlorine compound to produce a calculated concentration of at least 100 ppm available chlorine in double the volume of water in the well. The fill material shall be placed in the well after the water in the well has been so treated

11.2 PERMANENT BRIDGES

Permanent bridges may be used to avoid having to fill very deep holes below the deepest point at which a permanent seal is required. Permanent bridges shall be composed only of cement or cement-bearing minerals. The cement shall be allowed to harden for at least 24 hours, if Type I cement is used, or for at least 12 hours if Type III (high early strength) cement is used, before backfilling is continued. Temporary bridges used to provide a base for the permanent bridge shall consist only of inorganic materials--except that patented devices containing expandable neoprene, plastic, and other elastomers, and specifically designed for use in well construction are acceptable.

11.3 PLACEMENT OF GROUT

11.3.1 *Placement Operations.* Concrete, sand-and-cement grout, or cement grout used as a sealing material in abandonment operations shall be introduced at the bottom of the well or interval to be sealed (or filled) and placed progressively upward to the top of the well. All such sealing materials shall be placed by the use of grout pipe, tremie, cement bucket or dump bailer, in such a way as to avoid segregation or dilution of the sealing materials. Dumping grout material from the top shall not be permitted.

Seals intended to prevent vertical movement of water in the well or bore hole shall be composed of cement, sand-and-cement, or concrete--except that where such seals must be placed within casing or liners, only neat cement grout may be used. The cement-water ratio shall be that specified in Section 4.1. Cement seals shall be placed by means of pumping through drop pipe or by use of a dump-bailer, with placement beginning at the bottom and continuing upward. The minimum cement seal length, wherever dimensions permit, shall be 10 feet.

11.3.2 *Intermediate Seals.* Intermediate seals of cement, sand-and-cement, or concrete shall be placed in impermeable strata between aquifers which are identifiable as, or are suspected of being, hydraulically separated under natural, undisturbed conditions. Once the required cement seal has been installed, the remainder of the impermeable zone or non-producing zone between aquifers shall be filled with sand, sand and gravel, or cement-bearing mineral material.

11.3.3 *Seal at Uppermost Aquifer.* A cement, sand-and cement, or concrete seal shall be installed in the least permeable zone immediately above the uppermost water-producing zone. Such seals shall be placed only in quiescent (non-flowing) water.

11.3.4 *Seals Placed Within Casing, Liners, Filters, etc.* Seal which must be placed in casing, liners, or filters require special attention. The material between the well and the face of the bore hole shall be thoroughly perforated, ripped, or otherwise disintegrated as the necessary first step.

Neat cement only, or neat cement with a maximum of 5 percent by weight of commercially processed bentonite clay, shall be used as the seal. Either of two methods may be used.

1. The calculated amount of grout required to fill the well interval plus the annular space outside the lining shall be placed within the space to be cemented, running the cement through a special cementing packer manufactured for this purpose and installed immediately above the perforated or ripped zone. The cement shall be injected at a pressure calculated to be at least 50 psi greater than the normal hydrostatic pressure within the well at the point of injection.

2. The calculated amount of cement grout required to fill the casing interval plus the annular space outside the lining, plus sufficient cement grout to fill an additional 10 feet of the lining, shall be introduced at the bottom of the interval to be cemented.

11.4 PLACEMENT OF FILL

Non-producing zones above the aquifer shall be filled with stable materials such as sand, sand-and-gravel, cement, cement-and-sand, or concrete. Non-producing zones above the uppermost aquifer seal shall be filled with materials less permeable than the surrounding undisturbed formations. The uppermost 5 feet of the bore hole (at land surface) shall be filled with a material appropriate to the intended use of the land.

11.5 SPECIAL CONDITIONS

An abandoned well which has already been affected by salt water intrusion or any other contaminants shall be considered a special case, and the method of filling and sealing such wells shall be subject to individual review and written approval by the regulatory agency involved.

In the sealing of a double or multiple cased well, the CONTRACTOR shall submit a drawing thereof with a description of the proposed procedure and materials to be used, for prior approval by the regulatory agency involved.

Mineral exploration holes, solution or "in situ" mining wells, de-watering wells, temporary service wells, construction water wells, process wells, and/or other structures which affect the withdrawal or quality of ground water, or the elevation of the water table, regardless of location or intended length of life of the structure, shall be abandoned according to standards and minimums as described herein for water supply wells.

11.6 WELL ABANDONMENT RECORDS

Before equipment is removed from the site, the exact location of the abandoned well or hole shall be determined and recorded, "tying in" the location with permanent reference points, or as prescribed by the state or local regulatory agency. All information relative to the abandonment

procedures and the location of the abandoned well shall be prepared and assembled as prescribed by the state or local regulatory agency, with copies supplied to the respective agency and the owner of the land.

MODIFICATIONS FOR INJECTION WELLS

The extent to which construction of the injection well differs from the production well depends upon the philosophy of the system design. In some systems the designer specifies that a production pump will be installed in the injection well. This allows the injection well to serve as a backup production well. Under these conditions, the well would be completed the same as the production well except for the issue of entrance velocity (0.05 ft/sec instead of 0.1 ft/sec) as discussed in section 6.3 and sealing.

Sealing of an injection well is more critical than for a production well particularly if the well is expected to operate with a positive injection pressure at the surface. Effective sealing of the well reduces the possibility of injection fluid moving vertically along the well bore to the surface. As a result, sealing of an injection well should, at a minimum, follow the method outlined in figure 7 and preferably the method outlined in figure 10 (continuous grouting). The text accompanying these figures can be substituted for the "surface formation seal" text currently found in section 4.3.1.

Screen and gravel pack selection for an injection well can be made in a less detailed fashion compared to a production well (assuming that the well will not be used for production) since the function of the gravel pack is simply to increase permeability in the area of the well bore rather than to filter aquifer materials. The gravel pack is more of a formation stabilizer in this case. As a result a common formation stabilizer specification such as:

US Std Sieve	3	4	6	8	16	20
Size in inches	0.250	0.187	0.130	0.093	0.047	0.033
% Passing	100	85-95	55-70	25-35	5-20	2-10

can be used in place of the selection method in section 7.2.

Screen aperture size for a formation stabilizer such as this would be 3/32". A specification that the aperture size shall be 3/32" can be substituted for the aperture size selection method in section 6.4. The formation stabilizer size and screen slot size should be judged in the context of the aquifer materials as well. The 50% passing grain size (sometimes referred to as the d_{50} size) of the stabilizer should be at least 5 times the 50% size of the aquifer materials and the screen aperture sized accordingly.

Screen length and/or diameter should be adjusted such that the entrance (actually "exit" in an injection well) velocity is <0.05 ft/sec.

There is little guidance in the literature concerning screen type selection for injection wells. The National Groundwater Association Water Well specifications suggest that punched and slotted pipe, wire wrapped punched pipe, louvered pipe and wire wound continuous slot type screen are all satisfactory. It seems reasonable however that wire wrapped designs, in which the wire is of triangular cross-section, forming an aperture opening inward in such a way as to be non clogging in the production mode, may be just the opposite in the injection mode. This potential for clogging, could be compounded by the greater difficulty in cleaning such a screen due to the configuration of the ID surface (vertical reinforcing rods obstruct access to the aperture). As a result louvered type screen may warrant consideration for injection applications.

Injection wells should always be equipped with an injection tube. This is a pipe through which the water flows into the well. The tube extends from the surface to well below the static water level in the well. The purpose of the injection tube is to reduce the tendency for “cascading of water from the surface to the static level. Cascading results in air entrainment in the injected water. Entrained air bubbles, if carried into the aquifer can result in plugging of the area immediately around the well in the same manner as entrained particulate matter.

SECTION 3 WELL PUMP SPECIFICATIONS

A. ENCLOSED, OIL-LUBRICATED LINESHAFT PUMP
B. OPEN, WATER-LUBRICATED LINESHAFT PUMP
C. SUBMERSIBLE PUMP

OIL LUBRICATED, ENCLOSED LINESHAFT TURBINE PUMP

The contractor shall provide and install a complete oil lubricated lineshaft turbine type well pump including intake strainer, pump bowl assembly, enclosed type column with shaft, bearings and enclosing tube, surface pedestal and vertical hollow shaft electric motor.

Operating Conditions:

1.) Pump housing casing diameter _____ inches
2.) Well total depth _____ ft
3.) Static water level (below casing top) _____ ft
4.) Pumping level (at design flow) _____ ft
5.) Total pump head (exclusive of column) _____ ft
6.) Required pump capacity _____ ft
7.) Well water temperature _____ F
8.) Expected operating flow range _____ to _____gpm

Materials

Column, Enclosing Tube and Shaft

The lineshaft shall be of carbon steel turned and ground. It shall be furnished in interchangeable sections not more than _____ **(5)** ft in length. The butting faces shall be machined square with the axis of the shaft. The diameter of the shaft shall be not less than that determined by ASA

Specifications B58, Section 4.5, Table 5.6. Material shall be AISI C 1045 carbon steel and shall be of sufficient diameter that the elongation due to the combination of hydraulic thrust and dead weight loads shall not exceed the axial clearance available to the impellers in the bowls.

Shaft sections shall be joined by steel couplings of a design which incorporates a safety factor of 1.5 times the shaft safety factor. Coupling threads shall be left hand. A flame sprayed stainless steel or chrome plated section shall be provided on the shaft surface at each bearing.

The shaft enclosing tube shall be schedule 80 carbon steel pipe in interchangeable sections not more than _____ **(5)** ft in length. The ends of the tube sections shall be machined square with the axis of the tube. The tube shall stabilized by rubber (suitable for continuous operation in _____ **(temperature of well water)** F water) spiders at no less than _____ **(50)** ft intervals.

The combination lineshaft bearings and shaft enclosing tube couplings shall be constructed of SAE 660 bronze and spaced not more than _____ **(5)** ft apart. The bearing shall contain spiral grooves to accommodate oil flow to lower bearings.

The column shall be of butt welded steel pipe in interchangeable sections not more than _____**(20)** ft in length. The ends of the section shall be faced parallel and machined to permit the ends to butt and insuring alignment when connected to standard mill couplings.

No coatings shall be applied to the wetted surfaces of the column assembly without approval of the Engineer.

Pump

The pump supplied under this specification shall be of the multi-stage turbine type. It shall be fitted with a stainless steel (410 or 416) shaft. Impellers shall be of SAE 40 bronze or enamel lined cast iron. Bowls (impeller housings) shall be of close grained cast iron with allowances for replacement of the wear rings. Bowls shall include sufficient clearance for impeller movement resulting from the combination of thermal expansion, dead weight and hydraulic thrust.

Impellers shall be securely fastened to the shaft using stainless steel split bushings. Impellers shall be adjustable vertically by an external means.

Pump shaft bearings shall be of SAE 660 bronze and shall be located above and below each impeller. The length of the top and bottom bearings shall be a minimum of 3 times the shaft diameter.

The pump shall be designed for continuous operation in _____ F **(well water temperature)** water of the chemical character described in the attached analysis results. Pump shall be selected for a minimum efficiency at the design flow rate of _____ %.

A suction pipe of _____ **(10)** ft in length and the same diameter as the column shall be attached to the pump intake. A strainer having a net open area of not less than 4 times the area of the suction pipe shall be attached to the suction pipe. Strainer openings shall be a minimum of 3/4" in diameter.

Discharge Head

A discharge head constructed of _____ (cast iron, fabricated steel) shall be provided to support the weight of the pump assembly and to provide a conduit for the production flow. A nominal _____ inch 125 lb flanged outlet shall be provided with a companion flange threaded for _____ inch pipe.

The head shaft shall be of type 416 stainless steel and not less than 10 ft in length. An adjusting method shall be provided at the top of the head shaft to allow impeller adjustment.

Motor

The motor shall be a vertical, hollow shaft, TEFC, induction type, premium efficiency with a guaranteed minimum efficiency of _____ % at full load. It shall be design for operation at _____ VAC and equipped with Class _____ **(F)** insulation suitable for operation with a variable frequency drive.

The motor shall contain sufficient thrust bearings to carry the weight of all the rotating parts plus the hydraulic thrust of the pump impellers at the point of maximum thrust. A non reversing ratchet mechanism shall be installed on top of the motor to prevent pump back spin on shut down. **(A non-reversing ratchet is recommended for pumps on wells with static water levels below 50 ft)**

Lubrication

A _____**(20)** gal lubricating oil reservoir shall be installed at the well head and connected to the shaft seal with copper tubing in such a way as to permit gravity flow of the oil from the reservoir to the pump shaft . The oil line shall be nominal 3/8 " type l copper and shall be equipped with ball valves at the reservoir and shaft seal. A 50 gal drum of _____ lubricating oil shall be provided by the contractor.

OPEN LINESHAFT, WATER LUBRICATED TURBINE PUMP

The contractor shall provide and install a complete water lubricated, open lineshaft turbine type well pump including intake strainer, pump bowl assembly, open type column with shaft and bearings, surface pedestal and vertical hollow shaft electric motor.

Operating Conditions:

1.) Pump housing casing diameter _____ inches
2.) Well total depth _____ ft
3.) Static water level (below casing top) _____ ft
4.) Pumping level (at design flow) _____ ft
5.) Total pump head (exclusive of column) _____ ft
6.) Required pump capacity _____ ft
7.) Well water temperature _____ F
8.) Expected operating flow range _____ to _____gpm

Materials

Column, Shaft and Bearings

The lineshaft shall be of carbon steel turned and ground. It shall be furnished in interchangeable sections not more than _____ **(10)** ft in length. The butting faces shall be machined square with the axis of the shaft. The diameter of the shaft shall be not less than that determined by ASA Specifications B58, Section 4.5, Table 5.6. Material shall be _____ **(ASTM C1045)** steel and shall be of sufficient diameter that the elongation due to the combination of hydraulic thrust and dead weight loads shall not exceed the axial clearance available to the impellers in the bowls.

Shaft sections shall be joined by steel couplings of a design which incorporates a safety factor of 1.5 times the shaft safety factor. Coupling threads shall be left hand. A flame sprayed stainless steel or chrome plated section shall be provided on the shaft surface at each bearing.

The lineshaft bearings shall be constructed of _____ **(neoprene)** and spaced not more than _____ **(10)** ft apart. The bearing shall contain spiral grooves to accommodate water flow.

The column shall be of butt welded steel pipe in interchangeable sections not more than _____ **(20)** ft in length. The ends of the section shall be faced parallel and machined to permit the ends to butt and insuring alignment when connected to standard mill couplings.

No coatings shall be applied to the wetted surfaces of the column assembly without approval of the Engineer.

Pump

The pump supplied under this specification shall be of the multi-stage turbine type. It shall be fitted with a stainless steel (410 or 416) shaft. Impellers shall be of SAE 40 bronze or enamel lined cast iron. Bowls (impeller housings) shall be of close grained cast iron with allowances for replacement of the wear rings. Bowls shall include sufficient clearance for impeller movement resulting from the combination of thermal expansion, dead weight and hydraulic thrust.

Impellers shall be securely fastened to the shaft using stainless steel split bushings. Impellers shall be adjustable vertically by an external means.

Pump shaft bearings shall be of SAE 660 bronze and shall be located above and below each impeller. The length of the top and bottom bearings shall be a minimum of 3 times the shaft diameter.

The pump shall be designed for continuous operation in _____ F **(well water temperature)** water of the chemical character described in the attached analysis results. Pump shall be selected for a minimum efficiency at the design flow rate of _____ %.

A suction pipe of _____ **(10)** ft in length and the same diameter as the column shall be attached to the pump intake. A strainer having a net open area of not less than 4 times the area of the suction pipe shall be attached to the suction pipe. Strainer openings shall be a minimum of 3/4" in diameter.

Discharge Head

A discharge head constructed of cast iron, fabricated steel shall be provided to support the weight of the pump assembly and to provide a conduit for the production flow. A nominal _____ inch 150 lb flanged outlet shall be provided with a companion flange threaded for _____ inch pipe.

The head shaft shall be of type 416 stainless steel and not less than 10 ft in length. An adjusting method shall be provided at the top of the head shaft to allow impeller adjustment.

Motor

The motor shall be a vertical, hollow shaft, TEFC, induction type, premium efficiency with a guaranteed minimum efficiency of _____ % at full load. It shall be design for operation at _____ VAC and equipped with Class _____ **(F)** insulation suitable for operation with a variable frequency drive.

The motor shall contain sufficient thrust bearings to carry the weight of all the rotating parts plus the hydraulic thrust of the pump impellers at the point of maximum thrust. A non reversing ratchet mechanism shall be installed on top of the motor to prevent pump back spin on shut down. **(A non reversing ratchet is recommended for pumps on wells with static water levels below 50 ft)**

Open lineshaft pumps should not be used without a bearing preflush arrangements in wells with static water levels below 30 ft. Preflush requires a source of water at a pressure sufficient to cause flow through the required surface piping and to the lineshaft bearings. If other pumps are included in the system, flow can be diverted around the well head check valve for preflush. For a system served by a single pump, a pressurized tank or an external source must be provided for the source.

SUBMERSIBLE WELL PUMP

The contractor shall provide and install a complete submersible type well pump including intake strainer, pump bowl assembly, column, surface pedestal and submersible electric motor.

Operating Conditions:

1.) Pump housing casing diameter	_____ inches
2.) Well total depth	_____ ft
3.) Static water level (below casing top)	_____ ft
4.) Pumping level (at design flow)	_____ ft
5.) Total pump head (exclusive of column)	_____ ft
6.) Required pump capacity	_____ ft
7.) Well water temperature	_____ F
8.) Expected operating flow range	_____ to _____gpm
9.) Distance from wellhead to starter	_____ ft
10.) Operating voltage	_____ volts

Motor

The submersible electric motor shall conform to the latest National Electrical Manufacturers Association (NEMA) specifications for submersible motors. The motor thrust bearing shall be sized to carry the weight of all rotating parts plus the hydraulic thrust of the motor regardless of the direction of rotation.

The motor shall be of squirrel cage induction type, suitable for across the line starting (and variable speed operation in conjunction with an adjustable frequency drive) and continuous operation in _____ F **(well water temperature)** water. The output shaft shall be 416 stainless steel. All fasteners exposed to the well water shall be of stainless steel.

Pump/Motor Coupling

The coupling shall be of 416 stainless steel and shall be capable of transmitting the total torque of the unit, regardless of the direction of rotation.

Inter-connector

The inter-connector shall be constructed of close grained cast iron and shall connect the motor and bowl unit. It shall incorporate a bronze bearing with a length to shaft ration of at least 3:1. This bearing shall be protected from sand by a labyrinth type sand slinger. The inter-connector shall include a suction screen which has a net open area of at least 4 times the eye of the impeller. The screen shall be made of corrosion resistant material.

Pump

The pump supplied under this specification shall be of the multi stage turbine type. It shall be fitted with a stainless steel (410 or 416) shaft. Impellers shall be of SAE 40 bronze or enamel lined cast iron. Bowls (impeller housings) shall be of close grained cast iron with allowances for replacement of the wear rings. Bowls shall include sufficient clearance for impeller movement resulting from the combination of thermal expansion, dead weight and hydraulic thrust.

Impellers shall be securely fastened to the shaft using stainless steel split bushings. Impellers shall be adjustable vertically by an external means.

Pump shaft bearings shall be of SAE 660 bronze and shall be located above and below each impeller. The length of the top and bottom bearings shall be a minimum of 3 times the shaft diameter.

The pump shall be designed for continuous operation in _____ F **(well water temperature)** water of the chemical character described in the attached analysis results. Pump shall be selected for a minimum efficiency at the design flow rate of _____ %.

Surface Plate

The base plate shall be constructed of carbon steel plate of a minimum 1" thickness and shall rigidly support the weight of the motor, column pipe, pump, cable bowl assembly and column of water. It shall be equipped with a nominal _____ inch, 150 lb flanged connection for the production flow connection to the system.

Column

The column pipe shall be standard weight carbon steel pipe sized for a velocity at peak flow of not greater than _____ **(5)** ft/sec.

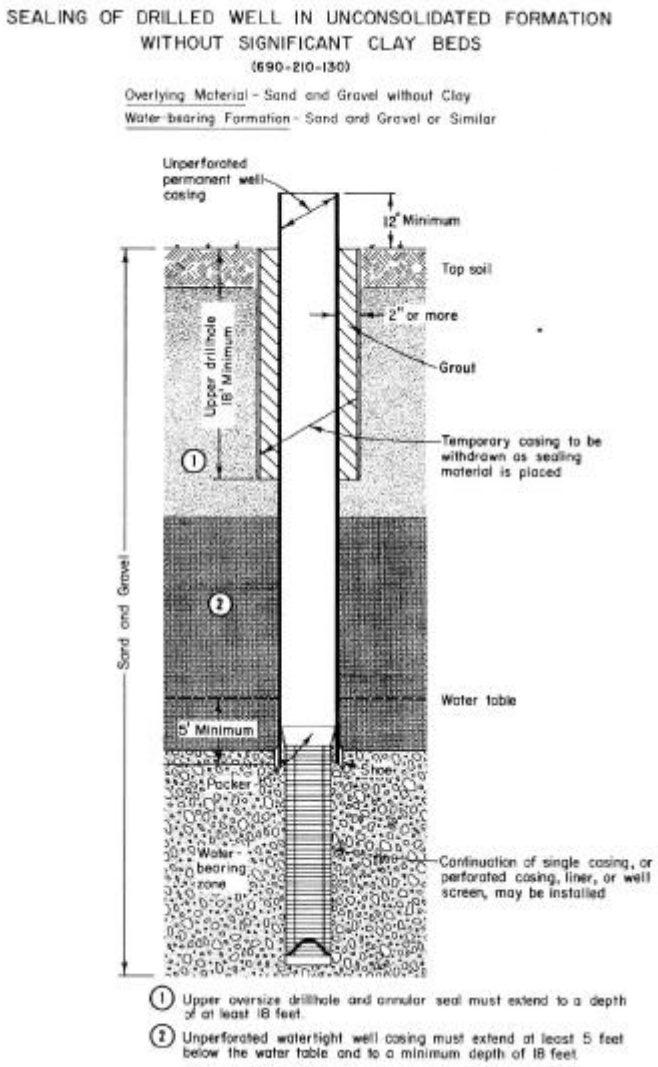
Submersible Cable

The cable shall be sized to limit the voltage drop to less than 2% at the motor terminals. Three separate conductors shall be furnished. The conductor insulation shall be water and oil resistant and suitable for continuous immersion.

The length of the cable to be furnished shall be the sum of the pump setting depth, including the bowl assembly, plus one foot for each 50 feet of setting, plus _____ **(50)** feet to extend from the well head to the pump panel or junction box. The cable will be suitably supported from the pump column.

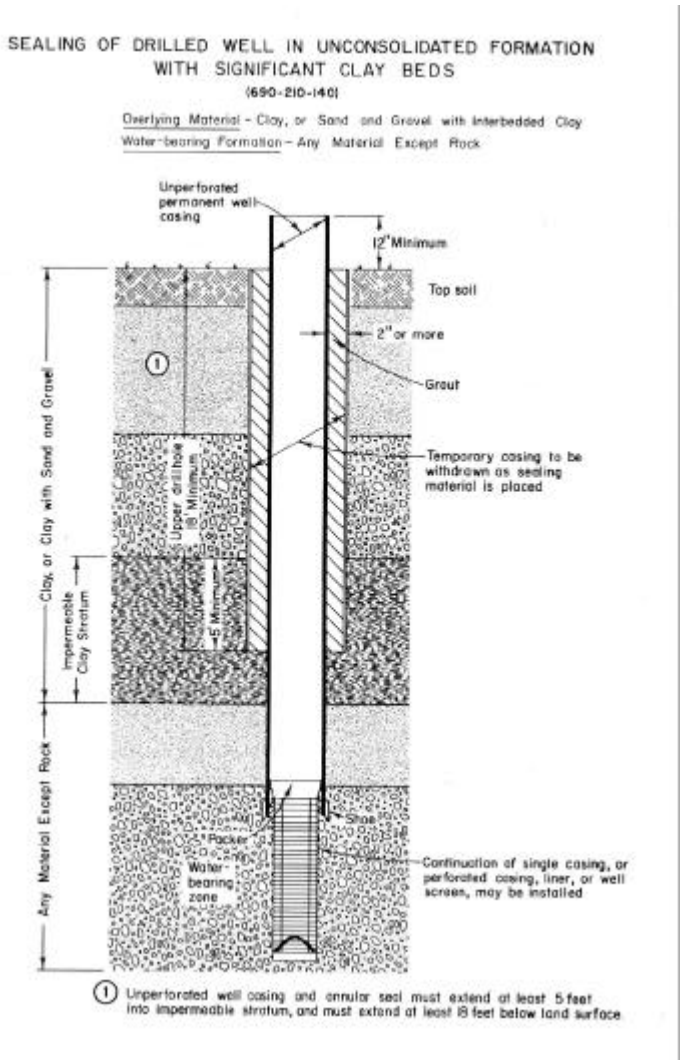
APPENDIX A WELL SEALING DETAILS

From "Rules and Regulating Prescribing General Standards for the Construction and Maintenance of Wells in Oregon," Oregon Water Resources Department, November 1986



Sealing of Wells in Unconsolidated Formations Without Significant Clay Beds (fig 3)

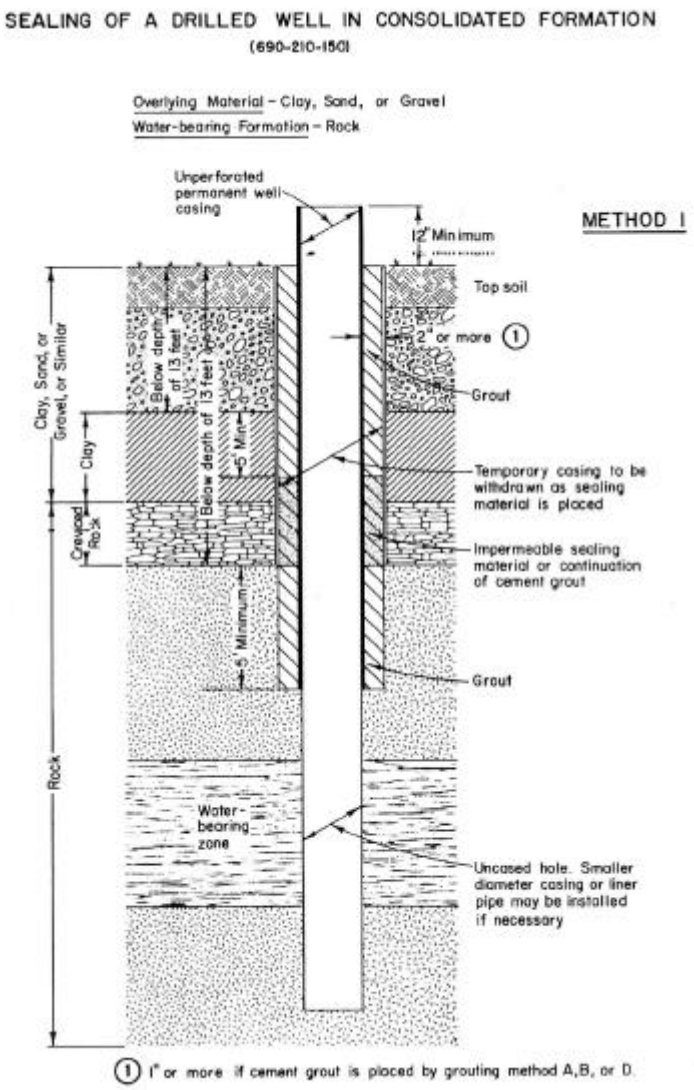
Wells drilled into unconsolidated, water bearing strata overlain by unconsolidated materials such as sand, silt, or sand and gravel, without significant clay beds, shall have a water tight, unperforated well casing extending at least five (5) feet below the top of the water table. If the water table is 13 ft or less below the land surface, a water tight, unperforated permanent well casing shall extend to a minimum depth of 18 feet. An upper oversize drillhole, four (4) inches larger in diameter than the nominal diameter of the casing shall be constructed to a minimum depth of 18 ft. To prevent caving, a temporary surface casing, at least 18 ft in length shall be used throughout the construction of the annular seal space. The annular space between the permanent well casing and the temporary surface casing shall be completely filled and sealed from a depth of at least 18 ft to land surface with grout in accordance with Section _____ after the permanent well casing is set into it's final position. The temporary surface casing shall be removed as the annular space is filled with grout.



Sealing of Wells in Unconsolidated Formations With Significant Clay Beds (fig 4)

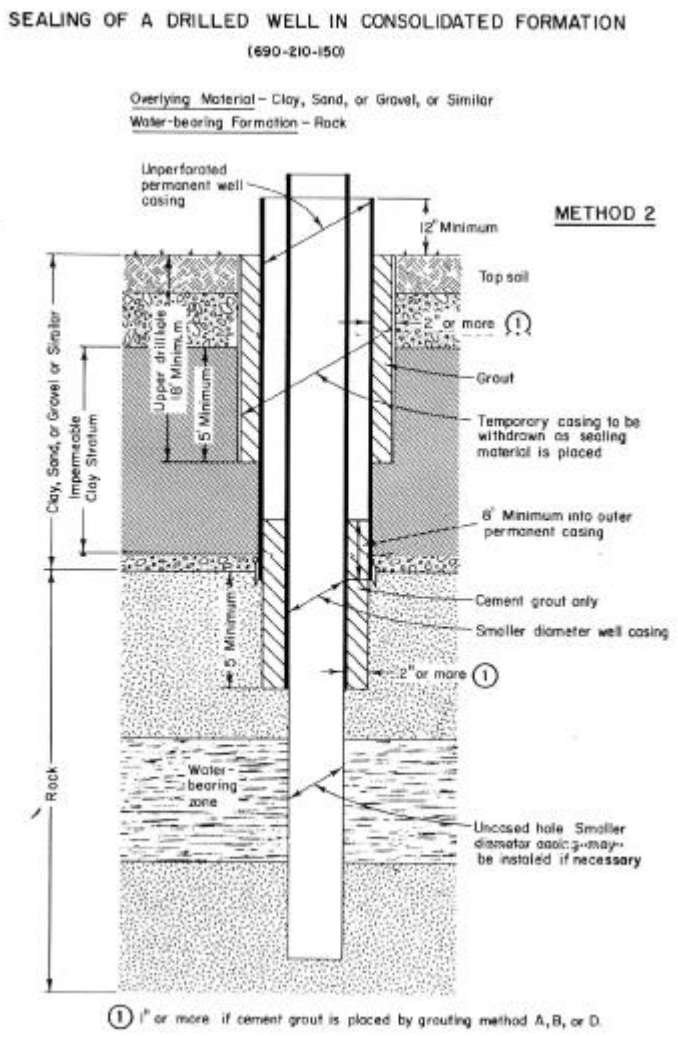
Wells drilled into water bearing strata overlain by unconsolidated deposits of clay, or sand and gravel in which significant interbeds of clay are present, shall have a water tight, nonperforated, permanent well casing extending at least five (5) ft into a clay or other impermeable stratum overlying the water bearing zone. In all cases, an upper, oversize drillhole, at least four (4) inches greater in diameter than the nominal diameter of the permanent well casing shall be constructed to this same depth. In the event that the subsurface materials penetrated by the upper borehole cave, or tend to cave, an outer, temporary surface casing shall be used to case out caving materials throughout the construction of the oversize drillhole. If the clay or other impermeable stratum is 13 ft or less below the land surface, the water tight, unperforated casing and the upper, oversize drillhole shall extend to a minimum depth of 18 ft below the land surface.

The annular space between the permanent well casing and the temporary surface casing shall be completely filled and sealed from a depth of at least 18 ft to land surface with grout in accordance with Section _____ after the permanent well casing is set into it's final position. The temporary surface casing shall be removed as the annular space is filled with grout.



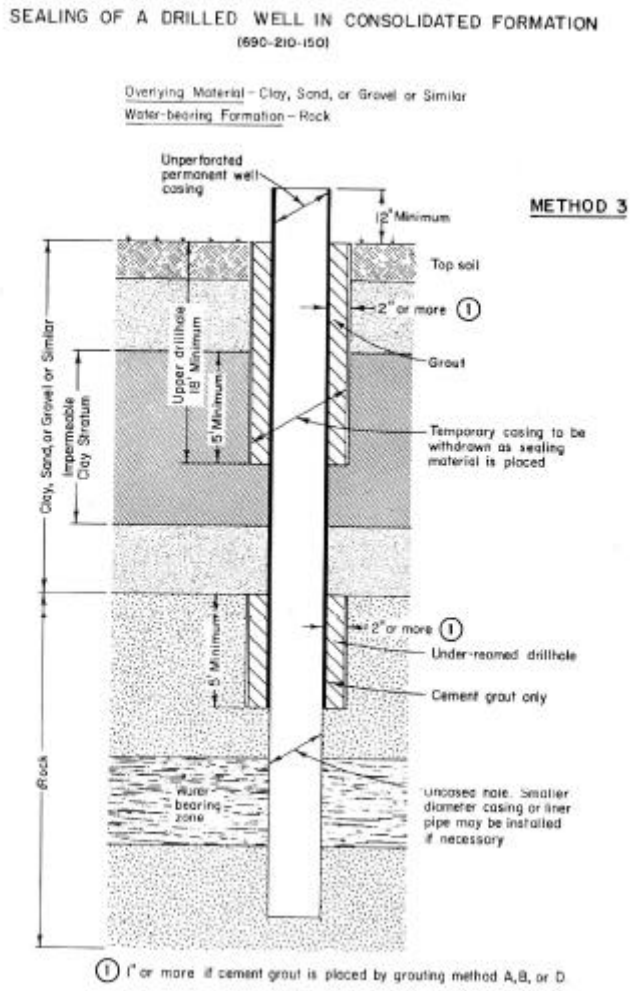
Sealing of Wells in Consolidated Formations Method 1 (fig 5)

An upper drillhole, 4 inches greater in diameter than the nominal diameter of the permanent well casing to be installed, shall extend from land surface to at least 5 ft into solid, uncreviced consolidated rock overlying the water bearing rock formation below a depth of 13 ft. Un-perforated permanent well casing shall extend to this same depth. The annular space between the well casing and the borehole wall, within the rock formation, shall be filled with cement grout. The upper annular space between casing and the borehole wall shall be filled from the land surface to at least 5 ft into an impermeable clay stratum below a depth of 13 ft. The annular space between the upper and lower sealing intervals shall be filled with an impermeable sealing material or cement grout. If the cement grout is placed by pumping from the bottom of the casing, the upper drillhole diameter may be reduced to 2 inches larger than the nominal diameter of the permanent casing.



Sealing of Wells in Consolidated Formations - Method 2 (fig 6)

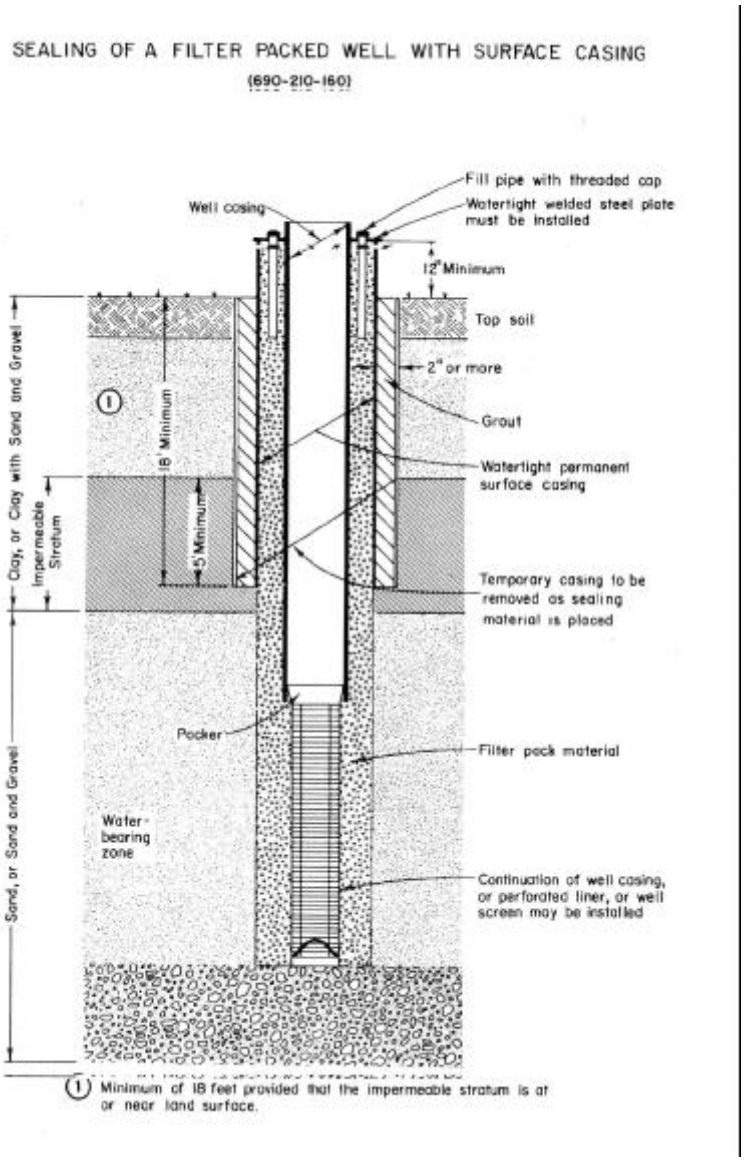
An upper drillhole, 4 inches greater in diameter than the nominal diameter of the permanent well casing to be installed, shall extend from land surface to at least 5 ft into solid, uncreviced consolidated rock overlying the water bearing rock formation below a depth of 13 ft. Unperforated, permanent well casing shall extend to and be driven into solid, uncreviced, consolidated rock overlying the water bearing rock formation. A lower drillhole, equal in diameter to the inside diameter of the upper permanent well casing, shall be constructed at least 5 ft into solid un-creviced rock overlying the water bearing formation. A smaller casing, at least 2 inches smaller in diameter than the upper permanent well casing, shall extend at least 5 ft into the lower drillhole and at least 8 ft into the upper permanent well casing. The annular space between the upper oversize drillhole and the permanent well casing and the annular space between the smaller diameter lower casing and the lower drillhole shall be completely filled with grout in accordance with Section _____ after the permanent well casing has been set into it's final position.



Sealing of Wells in Consolidated Formations - Method 3 (fig 7)

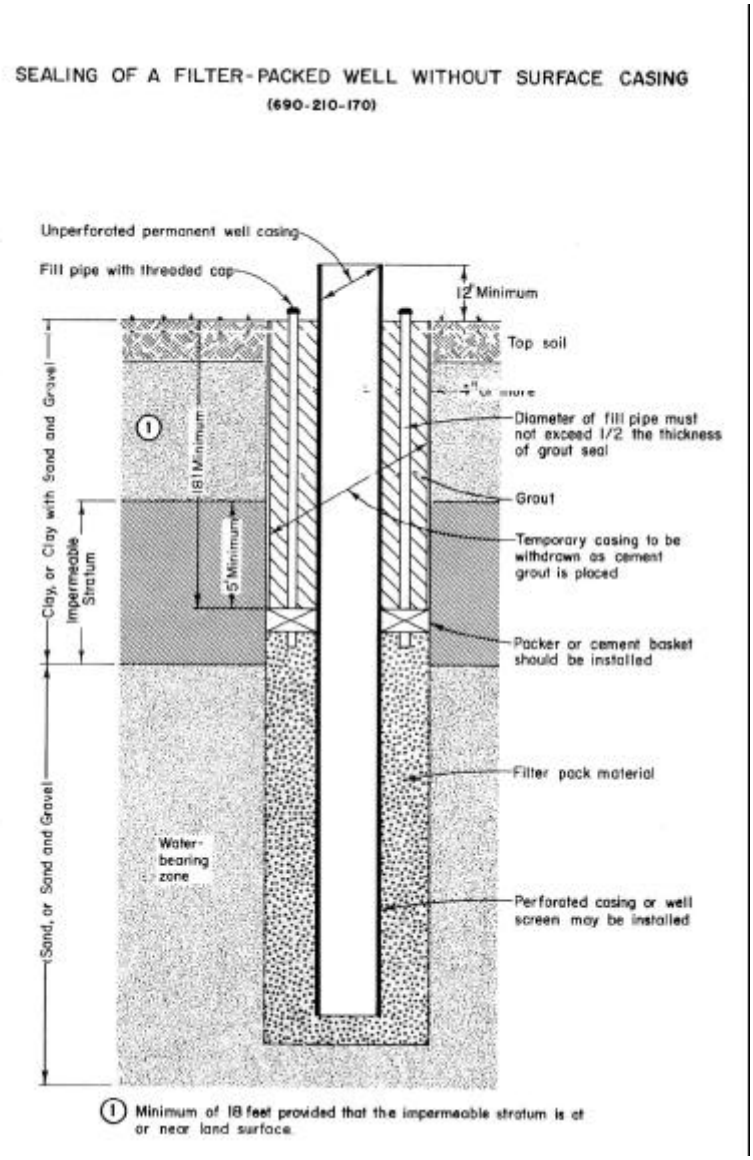
An upper drillhole, 4 inches greater in diameter than the permanent well casing to be installed, shall extend from land surface to at least 5 ft into an impermeable clay stratum below a depth of 13 ft. Unperforated, permanent well casing shall extend to and be driven into solid, uncreviced, consolidated rock overlying the water bearing formation. A lower drillhole, at least 2 inches greater in diameter than the upper permanent well casing shall be constructed at least 5 ft into solid, uncreviced, consolidated rock by under-reaming methods. The upper permanent well casing shall be lowered to the full depth of the lower oversize drillhole. The annular space between the lower oversize drillhole and the permanent well casing and between the upper oversize drillhole and the permanent well casing shall be completely filled with grout under pressure.

In the event that materials penetrated in the upper drillhole cave or tend to cave, a temporary well casing shall be used to case out the caving materials throughout the construction of the oversize drillhole. The temporary well casing shall be removed as the annular space is filled with grout.



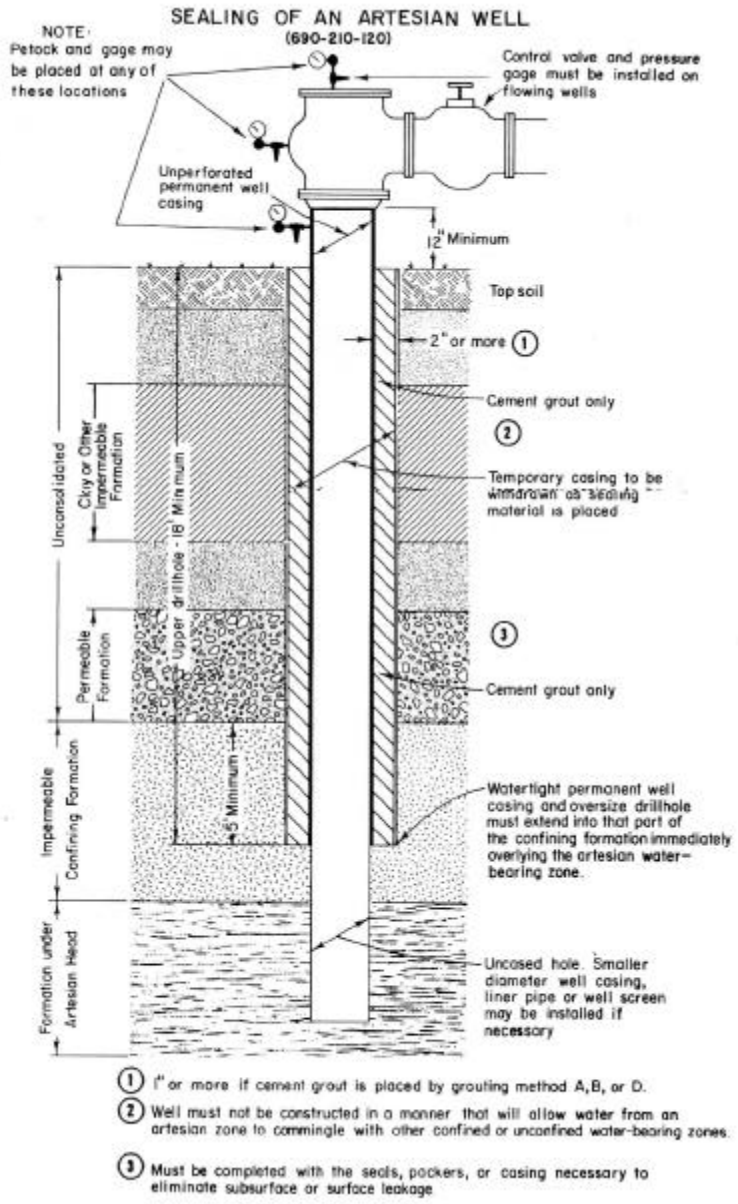
Sealing of Filter Pack Wells with Surface Casing (fig 8)

If a permanent surface casing is installed in the construction of a filter pack well, a well bore having a nominal diameter of at least 4 inches greater than the nominal diameter of the permanent well casing shall extend from the land surface to at least 5 ft into a clay or other impermeable formation overlying the water bearing zone. Unperforated, watertight casing shall extend to this same depth and the annular space between the well bore and the surface casing shall be filled with grout . If the clay or other impermeable stratum is at or near the surface, a minimum of 18 ft of unperforated casing shall be installed. A watertight, welded steel plate at least 3/16" of an inch in thickness shall be installed between the inner production casing and the outer surface casing at the well head. A water tight fill pipe with threaded cap may be installed for the purpose of adding pack material in the well.



Sealing of Filter Pack Wells Without Surface Casing (fig 9)

If permanent surface casing is not installed in the construction of a filter pack well, A bore hole having a nominal diameter of at least 8 inches greater than the nominal diameter of the permanent well casing shall extend from land surface to at least 5 ft into a clay or other impermeable formation overlying the water bearing zone. Unperforated, water tight casing shall extend to this same depth and the annular space between the well bore and the permanent casing shall be completely filled with grout. If the clay or other impermeable formation is at or near the land surface, the upper oversize drillhole and the unperforated permanent well casing shall extend to minimum depth of 18 ft below the land surface. A suitable packer shall be installed in the annular space between the filter pack material and the grout seal. A water tight fill pipe with threaded cap may be installed for the purpose of adding pack material in the well. The outside diameter of the fill pipe shall not exceed one half the thickness of the grout seal surrounding the permanent well casing and shall be centered in the annular space.



Artesian and Injection Wells (fig 10)

Wells penetrating into an artesian aquifer or wells used for injection purposes shall have an upper drillhole four (4) inches greater in diameter than the nominal diameter of the permanent well casing. Watertight, unperforated casing shall extend and be sealed at least five (5) ft into the confining formation overlying the artesian water bearing zone. For an injection well the casing and seal shall extend at least five (5) ft into the receiving aquifer in the absence of an impermeable strata immediately overlying the injection zone. The upper drillhole diameter may be reduced to two (2) inches larger than the nominal diameter of the casing if the cement is placed by pumping from the bottom of the casing.

APPENDIX B PUMP CHAMBER CASING DIAMETER GUIDELINES

From "Ground-Source Heat Pumps: Design of Geothermal Systems for Commercial and Institutional Buildings," Kavanaugh, S. and K. Rafferty, ASHRAE, Atlanta, GA, 1997.

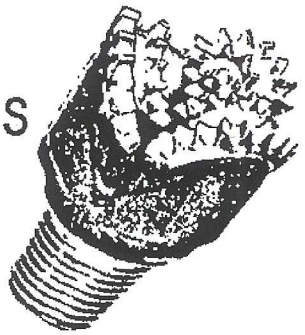
GUIDELINES FOR CASING SIZE REQUIREMENTS

Pump Bowl Diameter (in.)	Suggested Casing Size (in.)	Minimum Casing Size (in.)	Submersible Flow Range (gpm) 3450 rpm	Lineshaft Flow Range (gpm) 1750 rpm
4	6	5	<80	<50
6	10	8	80 - 350	50 - 175
7	12	10	250 - 600	150 - 275
8	12	10	360 - 800	250 - 500
9	14	12	475 - 850	275 - 550
10	14	12		500 - 1000
12	16	14		900 - 1300

APPENDIX C EXAMPLE WELL COMPLETION REPORTS

STOREY DRILLING SERVICES

P.O. BOX 98 - MIDLAND, OREGON 97634
503/884-3690 / 503/884-9504
CONTRACTOR'S LICENSES - ORE. 601 / CALIF. 583153



December 1, 1990

Merle West Medical Center
2865 Dagget Street
Klamath Falls Or 97601

DRILLING LOG/ REINJECTION WELL

0 -	4	Topsoil and gravel
4 -	6	Chalk Rock (soft)
6 -	124	Yellow shale with hard streaks
124 -	195	Grey shale with clay
195 -	209	Hard yellow chalk rock
209 -	267	Grey clay
267 -	430	Grey ash with grey clay
430 -	490	Hard black ash
490 -	562	Soft brown clay ash
562 -	694	Hard black ash
694 -	720	Grey clay ash
720 -	760	Black ash with clay streaks
760 -	947	Soft grey clay ash
947 -	986	Hard black ash
986 -	991	Hard broken black ash
991 -	1047	Hard broken black ash with clay streaks
1047 -	1120	Hard broken black ash
1120 -	1288	Hard black ash
1288 -	1324	Pink lava with clay streaks
1324 -	1377	Light brown ash with clay streaks
1377 -	1495	Red ash with red clay
1495 -	1498	Volcanic red gravel
1498 -	1512	Soft grey ash
1512 -	1526	Black ash
1526 -	1576	Hard broken black basalt
1576 -	1697	Hard black basalt
1697 -	1703	Hard broken black basalt
1703 -	1790	Hard black basalt
1790 -	1802	Broken black basalt
1802 -	1840	Hard black basalt
1840 -	1846	Hard broken black basalt
1846 -	1912	Black ash

WATER WELL REPORT
STATE OF OREGON

MARION

RECEIVED
FEB 17 1982
WATER RESOURCES DEPT
SALEM, OREGON

State Well No. 3S/1W-32 cd
State Permit No.
C

(1) OWNER:
Name Butteville Community Church
Address 10831 Arndt Rd. N.E.
City Aurora State Or.

(2) TYPE OF WORK (check):
New Well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:
Rotary Air ☒ Driven ☐
Rotary Mud ☐ Dug ☐
Cable ☐ Bored ☐

(4) PROPOSED USE (check):
Domestic ☒ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐
Thermal: Withdrawal ☐ Reinjection ☐

CASING INSTALLED:
Steel ☒ Threaded ☐ Plastic ☐ Welded ☒
6 " Diam. from 0 ft. to 100 ft. Gauge .250
" Diam. from ft. to ft. Gauge

LINER INSTALLED:
2 " Diam. from 90 ft. to 210 ft. Gauge .188

(6) PERFORATIONS:
Perforated? ☒ Yes ☐ No
Type of perforator used Torch
Size of perforations 8 in. by 1/4 in.
6 perforations from 197 ft. to 202 ft.
10 perforations from 204 ft. to 209 ft.
perforations from ft. to ft.

(7) SCREENS:
Well screen installed? ☐ Yes ☒ No
Manufacturer's Name
Type Model No.
Diam. Slot Size Set from ft. to ft.
Diam. Slot Size Set from ft. to ft.

(8) WELL TESTS:
Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? Driller
18 gal./min. with 22 ft. drawdown after 1 hrs.
" " " "
Air test gal./min. with drill stem at ft. hrs.
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m.
Temperature of water Depth artesian flow encountered ft.

(9) CONSTRUCTION:
Special standards: Yes ☐ No ☒
Well seal—Material used Cement
Well sealed from land surface to 20 ft.
Diameter of well bore to bottom of seal 10 in.
Diameter of well bore below seal 6 in.
Number of sacks of cement used in well seal 15 sacks
How was cement grout placed? Pressure grouted from 20 ft. to land surface.
Was pump installed? Yes Type Sub HP 1½ Depth 189 ft.
Was a drive shoe used? ☒ Yes ☐ No Plugs Size: location ft.
Did any strata contain unusable water? ☐ Yes ☒ No
Type of Water? depth of strata
Method of sealing strata off
Was well gravel packed? ☐ Yes ☒ No Size of gravel:
Gravel placed from ft. to ft.

(10) LOCATION OF WELL:
County Marion Driller's well number 205
SE ¼ SW ¼ Section 32 T. 3S R. 1W W.M.
Tax Lot # Lot Blk Subdivision
Address at well location: 10831 Arndt Rd. N.E. Aurora, Or.

(11) WATER LEVEL: Completed well.
Depth at which water was first found 197 ft.
Static level 52 ft. below land surface. Date 1/26/82
Artesian pressure lbs. per square inch. Date

(12) WELL LOG:
Diameter of well below casing 6"
Depth drilled 210 ft. Depth of completed well 210 ft.

Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level and indicate principal water-bearing strata.

MATERIAL	From	To	SWL
Top soil	0	2	
Clay, brown	2	28	
Clay, sand, blue, fine	28	52	
Clay, red	52	93	
Clay, brown	93	179	
Clay, blue	179	197	
*Sandstone, brown, broken	197	202	
Clay, blue	202	204	
*Sandstone, brown, broken	204	209	
Clay, blue	209	210	

Work started 1/15 19 82 Completed 1/26 1982
Date well drilling machine moved off of well 1/26 1982

Drilling Machine Operator's Certification:
This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.
[Signed] Bill Kunz (Drilling Machine Operator) Date 1/27, 1982
Drilling Machine Operator's License No. 994

Water Well Contractor's Certification:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Name B & G Drilling (Person, firm or corporation) (Type or print)
Address 10030 S. Macksburg Rd. Canby, Or.
[Signed] George J. Wainwright (Water Well Contractor)
Contractor's License No. 637 Date 1/27, 1982

NOTICE TO WATER WELL CONTRACTOR
The original and first copy of this report are to be filed with the
WATER RESOURCES DEPARTMENT, SALEM, OREGON 97310
within 30 days from the date of well completion.

SP*12658-690

NOTICE TO WATER WELL CONTRACTOR
The original and first copy of this report are to be filed with the WATER RESOURCES DEPARTMENT, SALEM, OREGON 97310 within 30 days from the date of well completion.

RECEIVED
JUL 9 1980
WATER RESOURCES DEPT.
SALEM, OREGON

MAR 1 8 1

WATER WELL REPORT
STATE OF OREGON
(Please type or print) (Do not write above this line)

State Well No. 7S/2W-29ca

State Permit No.

(1) OWNER:
Name: City of Newberg Well No. 6
Address: 414 E. First Street, Newberg, Oregon 97132

(2) TYPE OF WORK (check):
New Well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:
Rotary ☒ Driven ☐
Cable ☐ Jetted ☐
Bored ☐

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☐ Municipal ☒
Irrigation ☐ Test Well ☐ Other ☐

CASING INSTALLED:
Threaded ☐ Welded ☒

16 " Diam. from +3½ ft. to 70½ ft. Gage .375
14 " Diam. from 62 ft. to 70½ ft. Gage .375
4 " Diam. from 90½ ft. to 95½ ft. Gage .375

PERFORATIONS:
Perforated? ☐ Yes ☒ No
Type of perforator used
Size of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(7) SCREENS:
Well screen installed? ☒ Yes ☐ No
Manufacturer's Name: UOP Johnson
Type: telescope S.S. Model No.
Diam. 16TS Slot size .100 Set from 70½ ft. to 73½ ft.
Diam. 16TS Slot size .150 Set from 73½ ft. to 75½ ft.
16TS .250 75½ 90½

(8) WELL TESTS:
Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? SEI
Yield: 2575 gal./min. with 16 ft. drawdown after 24 hrs.
" " " "
" " " "
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m.
Temperature of water Depth artesian flow encountered ft.

(9) CONSTRUCTION:
Well seal—Material used: neat cement
Well sealed from land surface to: 34 ft.
Diameter of well bore to bottom of seal: 24 in.
Diameter of well bore below seal: 18 in. *
Number of sacks of cement used in well seal: 128 sacks
How was cement grout placed? pumped through grout pipe as 24" surface casing was removed
*24" dia from 34' to 43' annular space was filled with clay & bentonite
Was a drive shoe used? ☐ Yes ☒ No Plugs Size: location ft.
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? depth of strata
Method of sealing strata off
Was well gravel packed? ☐ Yes ☒ No Size of gravel:
Gravel placed from ft. to ft.

(10) LOCATION OF WELL:
County: Marion Driller's well number: 8008
NE ¼ SW ¼ Section 29 T. 3S R. 2W W.M.
Bearing and distance from section or subdivision corner

(11) WATER LEVEL: Completed well.
Depth at which water was first found: 35 ft.
Static level: 35 ft. below land surface. Date: 6/30/80
Artesian pressure lbs. per square inch. Date

(12) WELL LOG:
Diameter of well below casing: —
Depth drilled: 100 ft. Depth of completed well: 95 ft.

Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level and indicate principal water-bearing strata.

MATERIAL	From	To	SWL
soil, brown, clay	0	3	
clay, brown, sandy	3	31	
sand, brown, fine	31	40	
sand, brown, fine-med w/ wood	40	50	
clay, gray, w/ wood	50	52	
sand, brown, fine w/wood	52	54	
sand, black, med-coarse w/ wood	54	66	
gravel, 3/4 minus w/ coarse sand	66	77	
gravel, 1" minus, loose	77	90	
clay, blue & Brown streaked	90	100	

Work started 5/2 19 80 Completed 6/28 19 80
Date well drilling machine moved off of well 6/28 19 80

Drilling Machine Operator's Certification:
This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.
[Signed] Donald G. Davis (Drilling Machine Operator) Date 7/1, 1980
Drilling Machine Operator's License No. 1085

Water Well Contractor's Certification:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Name Schneider Equipment, Inc. (Person, firm or corporation) (Type or print)
Address 21881 River Rd NE, St. Paul, Or 97137
[Signed] Stephen J. Schneider (Water Well Contractor)
Contractor's License No. 649 Date 7-1, 1980

(USE ADDITIONAL SHEETS IF NE

SP*45656-119

JUL 30 1996

WATER RESOURCES DEPT.
SALEM, OREGON

KLAM 50366

STATE OF OREGON
WATER WELL REPORT
(as required by ORS 537.765)

Instructions for completing this report are on the last page of this form.

(START CARD) # 70981

(1) OWNER: Well Number #1
Name ROUNDUP Y RESORT INC.
Address BOX 1215
City REDMOND State OREGON Zip 97756

(2) TYPE OF WORK
☑ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:
☐ Rotary Air ☑ Rotary Mud ☐ Cable ☐ Auger
☐ Other

(4) PROPOSED USE:
☐ Domestic ☑ Community ☐ Industrial ☑ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☐ Other

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☑ No Depth of Completed Well 473 ft.
Explosives used ☐ Yes ☑ No Type ____ Amount ____

HOLE Diameter	From	To	SEAL Material	From	To	Sacks or pounds
22	0	46	CEMENT	0	46	50 SKS
15	46	900				
15¼	300	512				

How was seal placed: Method ☐ A ☐ B ☑ C ☐ D ☐ E
☐ Other
Backfill placed from ____ ft. to ____ ft. Material ____
Gravel placed from 350 ft. to 512 ft. Size of gravel 3/8

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:	16	+1	46	.250	☑	☐	☑	☐
UNDER	12¾	+1	293	.250	☑	☐	☑	☐
UNDER	8⅝	293	473	.250	☑	☐	☑	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s) 473 FEET

(7) PERFORATIONS/SCREENS:
☑ Perforations Method ____
☑ Screens Type FABRICATED Material STEEL

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
SEE ATTACHED SHEET						☐	☑
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour
☑ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
750	@ 151½ FT		24 hr.

Temperature of water 56° F Depth Artesian Flow Found ____
Was a water analysis done? ☐ Yes By whom ____
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other ____
Depth of strata: ____

(9) LOCATION OF WELL by legal description:
County KLAMATH Latitude ____ Longitude ____
Township 38S N or S Range 8E E or W. WM.
Section 9 NE 1/4 SW 1/4
Tax Lot #100 Lot ____ Block ____ Subdivision ____
Street Address of Well (or nearest address) 16440 HIGHWAY 126 K FALLS

(10) STATIC WATER LEVEL:
82 ft. below land surface. Date 6/17/96.
Artesian pressure ____ lb. per square inch. Date ____

(11) WATER BEARING ZONES:
Depth at which water was first found 142 FEET

From	To	Estimated Flow Rate	SWL
142	512	750 GPM	

(12) WELL LOG:
Ground Elevation ____

Material	From	To	SWL
SEE ATTACHED SHEET			

Date started 4/5/96 Completed 6/17/96.

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.
WWC Number ____
Signed ____ Date ____

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.
WWC Number #6241
Signed ____ Date 7/7/96.

ORIGINAL & FIRST COPY-WATER RESOURCES DEPARTMENT SECOND COPY-CONSTRUCTOR THIRD COPY-CUSTOMER

STOREY DRILLING SERVICES

P.O. BOX 98 - MIDLAND, OREGON 97634
503/884-3990 / (800) 245-8122
CONTRACTOR'S LICENSES:
OR #601 / CA #583153 / NV #38199

Running Y Resort, Inc.
P. O. Box 1215
Redmond, Oregon 97756

START: April 4, 1996
FINISH: June 14, 1996

WELL LOCATION: Running Y Resort development site ½ mile north of Hwy 140 about 6 miles west of Klamath Falls, Oregon.
NE¼ SW¼ T38S R8E S9

LOG

0	-	1	Brown clay topsoil
1	-	12	Boulders & brown basalt
12	-	40	Broken brown basalt
40	-	50	Grey basalt
50	-	58	Brown basalt
58	-	69	Grey basalt
69	-	80	Broken brown lava
80	-	83	Grey basalt
83	-	86	Broken brown lava
86	-	96	Black basalt
96	-	107	Hard grey basalt
107	-	110	Broken brown lava
110	-	112	Red lava
112	-	126	Bubbly black lava
126	-	137	Hard black basalt
137	-	144	Broken brown lava
144	-	150	Hard broken black basalt
150	-	161	Bubbly brown lava with streaks red lava
161	-	186	Hard black basalt
186	-	198	Red lava
198	-	207	Hard broken black basalt
207	-	224	Hard grey basalt
224	-	236	Brown lava
236	-	247	Hard black basalt
247	-	259	Broken bubbly brown lava
259	-	263	Grey basalt
263	-	293	Broken black lava with streaks brown cinders
293	-	300	Broken black basalt
300	-	304	Grey basalt
304	-	305	Black lava
305	-	316	Hard broken black lava
316	-	329	Black lava
329	-	392	Grey basalt
392	-	425	Hard broken black basalt
425	-	426	Green clay
426	-	427	Coarse black sand
427	-	432	Black lava with streaks brown ash clay
432	-	467	Black coarse sand with streaks pea gravel
467	-	512.	Sandy brown clay

STOREY DRILLING SERVICES

P.O. BOX 98 - MIDLAND, OREGON 97634
503/884-3990 / (800) 245-8122
CONTRACTOR'S LICENSES:
OR #601 / CA #583153 / NV #38199

RECEIVED
JUL 30 1996
WATER RESOURCES DEPT.
SALEM, OREGON

Running Y Resort, Inc.
P. O. Box 1215
Redmond, Oregon 97756

START: April 4, 1996
FINISH: June 14, 1996

WELL LOCATION: Running Y Resort development site ½ mile north of Hwy 140 about 6 miles west of Klamath Falls, Oregon.
NE¼ SW¼ T38S R8E S9

LOG (continued)

47 feet of 16 inch O.D. x .250 wall steel casing set and cemented at 46 feet with rolled 16 inch steel casing drive shoe.
22 inch diameter hole drilled from 0 to 46 feet.
15 inch diameter hole drilled from 40 to 300 feet.
12½ inch diameter hole drilled from 300 to 512 feet.
Static water level 82 feet measured from top of casing.
Test pumped 750 GPM at 146 feet; Specific capacity is 11.7 GPM/foot.
Temperature 56 degrees Fahrenheit; pH 8; 4 grains hardness; 0.8 PPM iron

CASING AND SCREEN PLACEMENT SEQUENCE

+2	-	140	142 feet of 12 3/4 inch OD solid steel casing
140	-	160	20 feet of 12 3/4 inch OD perforated steel casing
160	-	180	20 feet of 12 3/4 inch OD solid steel casing
180	-	200	20 feet of 12 3/4 inch OD perforated steel casing
200	-	220	20 feet of 12 3/4 inch OD solid steel casing
220	-	290	70 feet of 12 3/4 inch OD perforated steel casing
290	-	293	12 3/4 inch OD to 8 5/8 inch OD casing bell reducer
293	-	343	50 feet of 8 5/8 inch OD perforated steel casing
343	-	433	90 feet of 8 5/8 inch OD solid steel casing
433	-	473	40 feet of 8 5/8 inch OD Johnson mild steel screen
473	-	493	20 feet of 8 5/8 inch OD solid steel casing

GRAVEL ENVELOPE: 3/8 to 1/8 inch minus pea gravel located 350 to 512 feet.

KLAM 11830

RECEIVED
SEP - 7 1962
STATE ENGINEER
SALEM, OREGON

File Original and First Copy with the STATE ENGINEER, SALEM, OREGON

WATER WELL REPORT
STATE OF OREGON

State Well No. 38/9-20 H(1)
State Permit No.

(1) OWNER:
Name OREGON TECHNICAL INSTITUTE
Address KLAMATH FALLS, ORE.

(2) LOCATION OF WELL:
County KLAMATH Owner's number, if any— #5
E½ SW¼ SE ¼ Section #20 T. 38S R. 9E W.M.
Bearing and distance from section or subdivision corner
SE NE

(3) TYPE OF WORK (check):
New Well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 11.

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☒

(5) TYPE OF WELL:
Rotary ☐ Driven ☐
Cable ☒ Jetted ☐
Dug ☐ Bored ☐

(6) CASING INSTALLED:
Threaded ☐ Welded ☒
12 3/4" Diam. from +1 ft. to 529'3" ft. Gage .250
10 3/4" Diam. from +1 ft. to 813'6" ft. Gage .250
8 5/8" Diam. from 790'6" ft. to 1109 ft. Gage .250
6 5/8" Diam. from 1062 ft. to 1716 ft. Gage .280

(7) PERFORATIONS:
Perforated? ☒ Yes ☐ No
Type of perforator used
SIZE of perforations 1/4 in. by 12 in.
perforations from ft. to ft.
216 perforations from 1632 ft. to 1715 ft.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(8) SCREENS:
Well screen installed ☐ Yes ☒ No
Manufacturer's Name
Type Model No.
Diam. Slot size Set from ft. to ft.
Diam. Slot size Set from ft. to ft.

(9) CONSTRUCTION:
Was well gravel packed? ☐ Yes ☒ No Size of gravel:
Gravel placed from ft. to ft.
Was a surface seal provided? ☒ Yes ☐ No To what depth? 529 ft.
Material used in seal— CUTTINGS
Did any strata contain unusable water? ☒ Yes ☐ No
Type of water? COLD Depth of strata 345
Method of sealing strata off CASING & BACK FILL

(10) WATER LEVELS:
Static level 358 ft. below land surface Date 8/10/62
Artesian pressure lbs. per square inch Date

Log Accepted by:
[Signed] (Owner) Date 19

(11) WELL TESTS:
Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? ENTER STATE

Yield:	gal./min. with	ft. drawdown after	hrs.
" 470	" 14	" 7	"
"	"	"	"

Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water 194° Was a chemical analysis made? ☐ Yes ☒ No

(12) WELL LOG:
Diameter of well FINISH 10" inches.
Depth drilled 1716 ft. Depth of completed well 1716 ft.
Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
See ATTACHED Sheet		

Work started 10/16 19 62 Completed 8/23/62 19

(13) PUMP:
Manufacturer's Name
Type: H.P.

Well Driller's Statement:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME E E STORY (Person, firm, or corporation) (Type or print)
Address 3831 Hope R. FALLS
Driller's well number #5 OTI
[Signed] E E Story (Well Driller)
License No. 74 Date 9/4/62 19

(USE ADDITIONAL SHEETS IF NECESSARY)

STATE ENGINEER
Salem, Oregon

State Well No. 38/9-20H(1)
County Klamath
Application No. G-2571

Well Log

Owner: Oregon Technical Institute Owner's No. # 5

Driller: E. E. Storey Well Drilling Date Drilled 8-23-62

CHARACTER OF MATERIAL	(Feet below land surface) From	To	Thickness (feet)
Chalk rock	0	30	30
Brown shale	30	43	13
Yellow clay	43	65	22
Pink lava	65	99	34
Pink shale	99	106	7
Brown lava	106	172	66
Red lava	172	246	74
Gray basalt, W.B.	246	372	126
Blue shale	372	375	3
Gray basalt, W.B.	375	459	84
Brown basalt	459	480	21
Grayish brown basalt	480	495	15
Brown lava	495	515	20
Red buff rock	515	533	18
Reddish brown rock	533	546	13
Gray basalt	546	559	13
Reddish brown basalt	559	571	12
Gray basalt	571	682	111
Black basalt	682	691	9
Red lava	691	697	6
Gray basalt	697	768	71
Red lava	768	780	12
Gray basalt	780	940	160
Black basalt	940	968	28

STATE ENGINEER
Salem, Oregon

State Well No. 38/9-20H(1)
County Klamath cont.
Application No. .....

Well Log

Owner: Oregon Technical Institute Owner's No. #5

Driller: E. E. Storey Well Drilling Date Drilled .....

CHARACTER OF MATERIAL	(Feet below land surface) From	To	Thickness (feet)
Gray basalt	968	977	9
Pink lava	977	1045	68
Red lava	1045	1057	12
Gray basalt	1057	1341	284
Red lava	1341	1396	55
Gray basalt	1396	1662	266
Black basalt, W.B.	1662	1700	38
Hard sandstone	1700	1716	16

#17 KIAM 10097

STATE OF OREGON

WATER WELL REPORT

(as required by ORS 537.765)

OCT 23 1990

WATER RESOURCES DEPT

38S/9E/28 CC

(START CARD) # 20025

(1) OWNER:

Well Number: (FIRE)

Name Balmiger Building, Inc.

Address 718 Loma Linda

City Klamath Falls, State OR Zip 97603

(2) TYPE OF WORK:

☒ New Well ☐ Deepen ☐ Recondition ☐ Abandon

(3) DRILL METHOD

☐ Rotary Air ☒ Rotary Mud ☐ Cable

☐ Other

(4) PROPOSED USE:

☐ Domestic ☐ Community ☐ Industrial ☐ Irrigation

☒ Thermal ☒ Injection ☐ Other

(5) BORE HOLE CONSTRUCTION:

Special Construction approval Yes ☐ No ☒ Depth of Completed Well 1,023 ft.

Explosives used Yes ☐ No ☐ Type Amount

HOLE Diameter	From	To	SEAL Material	From	To	Amount sacks or pounds
18	0	39½	cement	0	39½	39
12	40	221	cement	168	221	20

How was seal placed: Method ☐ A ☐ B ☒ C ☐ D ☐ E

☐ Other

Backfill placed from ft. to ft. Material

Gravel placed from ft. to ft. Size of gravel

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:	12	1	39½	250	☒	☐	☒	☐
	8	1½	221	250	☒	☐	☒	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s) 39½, 221

(7) PERFORATIONS/SCREENS:

☐ Perforations Method

☐ Screens Type Material

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour

☐ Pump ☐ Bailer ☒ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
125		239'	1 hr.

Temperature of water 158° Depth Artesian Flow Found

Was a water analysis done? NO ☐ Yes By whom

Did any strata contain water not suitable for intended use? ☐ Too little

☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☒ Other cold

Depth of strata: 18'

(9) LOCATION OF WELL by legal description:

County Klamath Latitude ' " Longitude ' "

Township 38S N or S, Range 9E E or W, WM.

Section 28 SW ¼ SW ¼

Tax Lot Lot Block Subdivision

Street Address of Well (or nearest address) 1345 Main St. Klamath Falls, OR

(10) STATIC WATER LEVEL:

8 ft. below land surface. Date 10/11/90

Artesian pressure lb. per square inch. Date

(11) WATER BEARING ZONES:

Depth at which water was first found

From	To	Estimated Flow Rate	SWL
5	18	2 gpm	24
658	1,023	125 gpm	8

(12) WELL LOG:

Ground elevation

Material	From	To	SWL
Gravel fill & blk clay	0	5	
Brn & gray shale	5	51	24
Gray clay & shale	51	185	
Gray basalt	185	350	
Gray basalt & shale	350	436	
~~XXX~~ Blk shale	436	443	
Blk basalt & shale	443	509	
Gray shale & clay w/iron pirites	509	521	
Gray basalt & iron pirites	521	574	
Gray shale & clay	574	658	
Gray broken (wb) basalt	658	668	8'
Broken gray shale	668	680	
Broken gray basalt & shale	680	777	
Broken red & gray shale	777	860	
Broken gray basalt	860	915	
Broken gray basalt, red&gray shale	915	1023	

Date started 8/31/90 Completed 10/11/90

(unbonded) Water Well Constructor Certification:

I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon well construction standards. Materials used and information reported above are true to my best knowledge and belief.

WWC Number

Signed Date

(bonded) Water Well Constructor Certification:

I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. all work performed during this time is in compliance with Oregon well construction standards. This report is true to the best of my knowledge and belief.

WWC Number 1228

Signed Larry H. DeLorain Date 10/15/90

ORIGINAL & FIRST COPY - WATER RESOURCES DEPARTMENT SECOND COPY - CONSTRUCTOR THIRD COPY - CUSTOMER

9509C 3/88

#17

KLAM 10124

36S/9E/20 dc

STATE OF OREGON
WATER WELL REPORT
(as required by ORS 537.765)

(START CARD) # 17061

(1) OWNER: Well Number: #2
Name MERLE WEST MEDICAL CENTER
Address 2865 DAGGETT ST
City KLAMATH FALLS State ORE Zip 97601

(2) TYPE OF WORK:
☑ New Well ☐ Deepen ☐ Recondition ☐ Abandon

(3) DRILL METHOD
☐ Rotary Air ☑ Rotary Mud ☐ Cable
☐ Other

(4) PROPOSED USE:
☐ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☑ Injection ☐ Other

(5) BORE HOLE CONSTRUCTION:
Special Construction approval Yes ☐ No ☑ Depth of Completed Well 1912 ft.
Explosives used Yes ☐ No ☑ Type ____ Amount ____

HOLE Diameter	From	To	SEAL Material	From	To	Amount sacks or pounds
20"	0	141	CEMENT	0	141	208 SKS.
12 1/4"	141	1583				
7 7/8	1583	1912				

How was seal placed: Method ☐ A ☐ B ☑ C ☐ D ☐ E
☑ Other 30 SACK CEMENT PLUG SET @ ANNULUS @ 600 FT.
Backfill placed from ____ ft. to ____ ft. Material ____
Gravel placed from ____ ft. to ____ ft. Size of gravel ____

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:	14"	+1	141	.250	☑	☐	☑	☐
					☐	☐	☐	☐
Liner:	8 5/8	+1.5	1583	.250	☑	☐	☑	☐
					☐	☐	☐	☐

Final location of shoe(s) 1583

(7) PERFORATIONS/SCREENS:
☑ Perforations Method TORCH CUT
☐ Screens Type ____ Material ____

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
1220	1267	1/2 x 6	296			☐	☑
1449	1549.5	1/2 x 6	740			☐	☑
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour
☑ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
			1 hr.
150	375		24 HRS

Temperature of water 136°F Depth Artesian Flow Found ____
Was a water analysis done? ☐ Yes By whom ____
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☑ Other COLD
Depth of strata: ABOVE 600 FT.

(9) LOCATION OF WELL by legal description:
County KLAMATH Latitude ____ Longitude ____
Township 36S N or S, Range 9E E or W, WM.
Section 20 SW ¼ NE ¼
Tax Lot 300 Lot ____ Block ____ Subdivision ____
Street Address of Well (or nearest address) 2865 DAGGETT ST
KLAMATH FALLS OREGON

(10) STATIC WATER LEVEL:
228 ft. below land surface. Date NOV 28, 90
Artesian pressure ____ lb. per square inch. Date ____

(11) WATER BEARING ZONES:
Depth at which water was first found INDETERMINATE

From	To	Estimated Flow Rate	SWL
INDETERMINATE	EXCEPT?		
PERFORATED	INTERVALS - SEE(7)	SEE(8)	SEE(10)

(12) WELL LOG: Ground elevation ____

Material	From	To	SWL
SEE ATTACHED LOG			

RECEIVED
DEC 13 1990
WATER RESOURCES DEPT
SALEM, OREGON

Date started AUG 18, 1990 Completed NOV 28, 1990

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon well construction standards. Materials used and information reported above are true to my best knowledge and belief.

WWC Number ____
Signed ____ Date ____

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. all work performed during this time is in compliance with Oregon well construction standards. This report is true to the best of my knowledge and belief.

WWC Number 601
Signed [signature] Date DEC 8, 1990

ORIGINAL & FIRST COPY - WATER RESOURCES DEPARTMENT SECOND COPY - CONSTRUCTOR THIRD COPY - CUSTOMER 9809C 3/88

WATER WELL REPORT
STATE OF OREGON

KLAM 11899

RECEIVED
APR 26 1983
WATER RESOURCES DEPT.
SALEM, OREGON

State Well No. 38S/9E-28bc

State Permit No. .....

PLEASE TYPE or PRINT IN INK

(1) OWNER:
Name Steve Eccles & Bob Kingzett
Address 1938 Manzanita
City Klamath Falls, State OR 97601

(2) TYPE OF WORK (check):
New Well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:
Rotary Air ☒ Driven ☐
Rotary Mud ☐ Dug ☐
Cable ☐ Bored ☐

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐
Thermal: Geo Withdrawal ☐ Reinjection ☐

(5) CASING INSTALLED:
Steel ☒ Threaded ☐ Plastic ☐ Welded ☒
8 " Diam. from +1 ft. to 25 ft. Gauge 250
" Diam. from ..... ft. to ..... ft. Gauge .....

LINER INSTALLED:
6 " Diam. from 0 ft. to 217 ft. Gauge 250

(6) PERFORATIONS:
Perforated? ☒ Yes ☐ No
Type of perforator used Torch
Size of perforations 6 in. by 3/8 in.
40 perforations from 218 ft. to 198 ft.
40 perforations from 118 ft. to 98 ft.
perforations from ..... ft. to ..... ft.

(7) SCREENS:
Well screen installed? ☐ Yes ☒ No
Manufacturer's Name .....
Type ..... Model No. .....
Diam. ..... Slot Size ..... Set from ..... ft. to ..... ft.
Diam. ..... Slot Size ..... Set from ..... ft. to ..... ft.

(8) WELL TESTS:
Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☒ No If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
Air test 200 gal./min. with drill stem at 100 ft. 1 hrs.
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m.
Temperature of water 210 Depth artesian flow encountered ..... ft.

(9) CONSTRUCTION:
Special standards: Yes ☐ No ☒
Well seal—Material used Cement
Well sealed from land surface to 18 ft.
Diameter of well bore to bottom of seal 12 in.
Diameter of well bore below seal 8 in.
Number of sacks of cement used in well seal 6 sacks
How was cement grout placed? Pumped
Was pump installed? NO Type ..... HP ..... Depth ..... ft.
Was a drive shoe used? ☐ Yes ☒ No Plugs ..... Size: location ..... ft.
Did any strata contain unusable water? ☐ Yes ☒ No
Type of Water? depth of strata
Method of sealing strata off
Was well gravel packed? ☐ Yes ☒ No Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

(10) LOCATION OF WELL:
County Klamath Driller's well number
SW ¼ NW ¼ Section 28 T. 38 S R. 9 E W.M.
Tax Lot # Lot Blk Subdivision
Address at well location:

(11) WATER LEVEL: Completed well.
Depth at which water was first found 120 ft.
Static level 83 ft. below land surface. Date 2-22-83
Artesian pressure lbs. per square inch. Date

(12) WELL LOG:
Diameter of well below casing 8"
Depth drilled 218 ft. Depth of completed well 218 ft.

Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level and indicate principal water-bearing strata.

MATERIAL	From	To	SWL
Sandy Top Soil	0	2	
Brown Clay	2	28	
Yellow Clay	28	35	
Blue Claystone	35	39	
Yellow Clay	39	99	
Blue Clay	99	120	
Soft Brown Rock	120	133	83'
Blue Clay with Streaks of -			
Soft Rock (Black)	133	203	83'
Soft Grey Rock	203	214	83'
Black Lava Rock	214	218	83'

Work started 2-14 1983 Completed 2-22 1983
Date well drilling machine moved off of well 2-22 1983

(unbonded) Water Well Constructor Certification (if applicable):
This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.
[Signed] Stephen R. Hughes Date 4-19, 1983

Bonded Water Well Constructor Certification:
Bond 208 211 34 (number) Issued by: Western Surety Co. (Surety Company Name)
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Name Norm Sevey Well Drilling, Inc. (Person, firm or corporation) (Type or print)
Address 800 Old Midland Rd. Klamath Falls, OR
[Signed] Norm Sevey (Water Well Constructor)
Date 4-19, 1983

NOTICE TO WATER WELL CONSTRUCTOR
The original and first copy of this report are to be filed with the WATER RESOURCES DEPARTMENT, SALEM, OREGON 97310 within 30 days from the date of well completion.

SP*45292-690