SPECIFICATIONS - DETAILED PROVISIONS
Section 02733 - Water Well Drilling, Casting and Gravel Installation, Development, and Testing

C O N T E N T S

SECTION 02733
WATER WELL DRILLING, CASTING AND GRAVEL
INSTALLATION, DEVELOPMENT, AND TESTING

PART 1 - GENERAL

1.01 DESCRIPTION

The work includes the furnishing of all labor, materials, supplies, equipment, tools, transportation, recommendations, testing, services, and appurtenances, unless hereinafter specifically excepted, necessary to move-in, move-out, disinfect, and clean-up; satisfactorily complete reverse circulation rotary drilled pilot boreholes, log, obtain and secure cuttings, analyze cuttings, E-log, & Gamma-Ray log the pilot boreholes; secure pilot boreholes; construct reverse circulation, rotary drilled gravel packed wells, including but not limited to drill, construct, disinfect, test, log, maintain/test drilling fluid, gravel pack, develop, clean, pump, test pump, video log, test sand production, guarantee sand production, check casing plumbness and alignment, perform final bore hole caliper survey, obtain and analyze water samples as specified, place two (2) sounder pipe and two (2) gravel make-up pipes and caps, and well cap; and submittals of logs, videos, and test results.

1.02 QUALITY ASSURANCE

The Contractor shall have been engaged in the business of test pumping, constructing test holes, and hydraulic reverse circulation rotary-drilled gravel envelope wells of diameter, depth, and anticipated production equivalent to the proposed production wells for a period of at least fifteen (15) years.

The Contractor shall submit a list of the last three (3) municipal well owners other than the District for whom the Contractor has drilled equivalent municipal-domestic wells. The list shall include the owner's name and address, phone number, casing diameter, type, and depth, capacity, specific capacity, and sand production.

The Contractor shall employ only competent workers for the execution of the work and all such work shall be performed under the direct supervision of an experienced test hole driller, well driller, and test pumper satisfactory to the District. Field superintendent shall have a minimum of five (5) years recent experience in this type of drilling.

1.03 RECORDS

The Contractor shall keep a log and progress record at the site readily available for inspection during construction of the pilot hole and well development, logging, testing and disinfection and copies of such shall be available to the District. The Contractor shall keep records providing the following information:

A. A log of the formations drilled from surface to total depth showing each change in formation, sample locations, and rates of penetration.

B. A collection of two (2) sets of samples from each borehole from surface to total depth placed in separate bags or containers for each interval, plainly marked with the well name and sample depth. Samples shall be taken each five (5) feet and at each change of formation. The method of taking samples shall be approved by the District. Sieve analyses on up to six (6) samples from each borehole may be requested by the District and furnished by the Contractor. Duplicate samples will be taken to retain one at well site and other for submittal to lab. A specific sample will be taken of bottom material after clearing/circulating drilling fluid. Cuttings will discharge to a shaker screen.

C. An electric log and Gamma-Ray log shall be provided upon completion of the pilothole. The E-log shall consist of one spontaneous potential curve and three (3) resistivity curves, and be of the same depth scale as the Gamma ray log and the final bore caliper log. One (1) copy of each to be submitted to the District.

D. A dissolved mineral quality analysis of a composite water sample shall be provided upon completion of the pilot borehole when required in the special conditions.

E. A dissolved gasses analysis of a composite water sample shall be provided upon completion of the pilot borehole when required in the special conditions.

F. A final well log shall show: formation log; diameter, wall thickness, depths and quantities of casings and screens installed; details of insulating flange; type and aperture size, and pattern of perforations; final borehole diameter; cemented conductor casing; sealed zones; gradation of gravel envelope; quantity of gravel initially installed; quantity of gravel added during development operations; static water level; drawdown after time with constant pump rate; and all other pertinent details.

   Development and test records shall be dated and time noted showing production rate, static water level, pumping level, drawdown, production of sand, and all other pertinent information concerning the method of development and test pumping.

G. Two plots of casing plumbness and alignment in planes oriented at 90 degrees with respect to each other.

H. Caliper survey of finished borehole.

I. Calculation of annulus volume between casing and final bore.

J. The final developed and completed well shall have water quality and bacteriological analyses as required by Department of Health Services and as specified herein.

K. Final well casing video tape.

1.04 SUBMITTALS

All records shall be available to the District at all times at the job site. One (1) copy (each) of all records shall be typed and submitted to the District through CIPO to convey information adequately. They shall include:

A. Driller's lithologic log

B. E-log (to be of same depth scale as Gamma and caliper logs)

C. Gamma-Ray log (to be of same depth scale as E-log and caliper log)

D. Penetration rate of drilling fluid additives

E. Drilling fluid additives (Type and Quantity)

F. All construction entities and information necessary to complete a State and Riverside County Driller's Log. (Log will be reviewed and approved by the District prior to submittals).

G. Drill hole caliper log (to be same depth scale as E-logs and Gamma log)

H. Alignment/Plumb log

I. Swabbing and surging/air lift pumping records

J. Development pumping records

K. Step Test pumping records including specific capacities, drawdowns, pumping rates

L. Sand production records

M. Constant pumping rate, drawdown, times, and specific capacity

N. A VHS Video Cassette of the color video log of the well casing/screen.
NOTE: Only one (1) copy of the video log is required to be submitted to the District.

O. Sieve analyses results

P. Gravel pack sieve analyses

Q. Water Quality/bacteria test

R. Submittals on:

1. casing
2. screen
3. gravel pack pipes
4. sounder tubes
5. cement slurry grout
6. concrete

1.05 JOB CONDITIONS

Special job conditions are set forth in the Special Conditions, SC1-Special Provisions.

1.06 GUARANTEE

A. Guaranteed Conditions. For a period of one year after acceptance of the well by the District, the Contractor shall make the following guarantees and accept the following responsibilities concerning his work;

1. Sand production shall be less than 5 ppm within 15 minutes after start of pumping at the constant pump test rate of the well.

2. Sand production shall be less than 1 ppm within two (2) hours after start of pumping at the constant pump test rate of the well.

3. The well casing and screen shall remain intact throughout its entire length.

4. Plumbness and alignment shall remain within tolerances set forth in specifications.

B. Demonstration of Compliance.

1. To demonstrate compliance with the above, the Contractor shall perform after six (6) months of operation, and again, after eleven (11) months of operation, a test of the well. These tests shall be witnessed by representatives of the District and certified copies of the test results shall be furnished to EMWD. EMWD shall be notified 48 hours prior to the scheduled test. The tests shall consist of a Rossum sand test of the well in accordance with Section 1.06 A.

2. To insure compliance with the terms of this section, the Contractor shall furnish a one (1) year maintenance bond. The one (1) year maintenance bond period shall begin at the time of notice of final acceptance.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Drilling Fluid Additives. When and only if it becomes necessary to add clays or chemicals to the drilling fluid, it must be borne in mind that it is desirable to maintain a mud system containing a minimum of clay and fine sand and to obtain representative lithologic samples and minimize sealing of well with mudcake or mud invasion into formation. If there should be a conflict between the mud requirements for ease in drilling and the mud requirements for sample attainment and minimal sealing; then the ruling requirements shall be those for sample attainment and minimal sealing.

B. Gravel Pack. The gravel to be installed shall be composed of sound, durable, well-rounded particles, containing no silt, clay, organic matter, gypsum, iron, manganese or other deleterious materials. It shall be selected by the Contractor with the District's approval based on the Test Hole log, E-log, and Gamma-Ray log, and formation analysis. Material shall have an average specific gravity of not less than 2.5 and a uniformity coefficient no greater than 2.0. Gradation shall conform to that required to retain the 50th percentile of the finest aquifer material encountered in the zone(s) where screens are to be placed. Under no circumstances shall crushed rock be installed in the well. A certificate of quality and gradation of the gravel from an approved testing laboratory shall be submitted to the District prior to gravel being delivered to the site. The District may elect to have a certified testing laboratory perform an independent sieve analysis to verify conformance with submitted sample. Failure of the submitted sample to meet gradation requirements shall be grounds for rejection. Gravel shall be of the type provided by Colorado Silica Sand, Inc.; Heart of Texas; or approved equal.

2.02 MIXES

A. Cement Slurry Grout. The annular space around the conductor casing shall be filled with a cement slurry grout mixed in the following proportions by volume:

1. 1 - part cement; 1-1/2 parts sharp, clean sand; and 6/10 - part water. The addition of any additives to prevent shrinkage shall be approved by the District. The water shall be potable and the sand free of clay, silt, organics, or other deleterious matter. The grout shall be left undisturbed for a period of not less than 48 hours.

2.03 FABRICATION AND MANUFACTURER

A. Conductor Casing. Conductor casing shall be new and fabricated in the United States in accordance with AWWA Standard C200, except that requirements for hydrostatic testing are waived. Material shall be prime quality, hot rolled steel plate, conforming to ASTM A283, Grade B, containing not less than 0.20% copper. The casing shall be factory-assembled in sections not less than 20 feet long and shall contain not more than one longitudinal seam parallel to the axis of the casing and not more than one circumferential seam in 10 feet. The inside diameter and minimum thickness are set forth in the Special Conditions, SC1-Special Provisions. For field assembly by welding, ends of sections may be either belled or furnished with collars in accordance with the following standards:

1. Plain Ends Fitted With Collars - Collars shall be of the same thickness and have the same chemical and physical properties as the corresponding casing section, shall be 6-inches in width, shall be rolled to fit the outside diameter, and shall be welded to the casing section. Longitudinal welds on the plain end shall be ground to plate surface a sufficient distance from the end. The inside edge of the collars and the outside edge of the adjacent casing length shall be ground or sufficiently scraped to remove sharp edges or burrs. Section ends shall be machined flat perpendicular to the axis of the casing and shall not vary more than 0.010 inch at any point from a true plane at right angles to the axis of the casing.

   Three 1-inch by 3/8-inch alignment holes shall be provided in each collar to insure proper matching of the sections.

2. Bell Ends - The inside diameter of the bell shall be 1/32 to 3/32 inch greater than the outside diameter of the plain end. The ends of each section shall not vary more than 0.010 inch at any point from a true plane at right angles to the axis of casing.

3. Butt welded joints shall be per AWWA C-206.

B. Blank Steel Well Casing. The blank well casing shall be manufactured in accordance with ASTM Standard A139 Grade B with the following additions:

1. The steel from which the casing is manufactured shall be mild steel and contain not less than 0.20% copper by ladle analysis.
2. The inside diameter and minimum wall thickness are set forth in the Special Conditions, SC1-Special Provisions.

3. The casing shall be factory assembled in not less than twenty foot sections. Casing shall be spiral welded in accordance with ASTM-139. There shall be no burrs or protrusions into the casing I.D.

4. For field assembly welding, ends of sections may be either belled or furnished with collars in accordance with the following standards:

   a) Plain Ends Fitted With Collars. Collars shall be of the same thickness and have the same chemical and physical properties as the corresponding casing section, shall be 6-inches in width, shall be rolled to fit the outside diameter, and shall be welded to the casing section. Longitudinal welds on the plain end shall be ground to plate surface a sufficient distance from the end. The inside edge of the collars and the outside edge of the adjacent casing length shall be ground or sufficiently scraped to remove sharp edges or burrs. Section ends shall be machined flat perpendicular to the axis of the casing and shall not vary more than 0.010 inch at any point from a true plane at right angles to the axis of the casing.

      Three 1-inch by 3/8-inch alignment holes shall be provided in each collar to insure proper matching of the sections. The casing gap shall be welded full-double pass within the holes as well as hole edges.

   b) Bell Ends. The inside diameter of the bell shall be 1/32 to 3/32 inch greater than the outside diameter of the plain end. The ends of each section shall not vary more than 0.010 inch at any point from a true plane at right angles to the axis of the casing.

   c) Butt welded joints shall be per AWWA C-206.

C. Blank Corten Steel Well Casing. The blank Corten steel well casing shall be manufactured in accordance with ASTM Standard A-242 with atmospheric corrosion resistance equal to Kaisaloy 50CR or Corten or equal with the following additions:

1. The steel from which the casing is manufactured shall be high tensile-low alloy structural steel and contain not less than 0.41% copper by ladle analysis.

2. The inside diameter and minimum wall thickness are set forth in the Special Conditions, SCI-Special Provisions.

3. The casing shall be factory assembled in not less than twenty foot sections. Casing shall be spiral welded in accordance with ASTM A-139. There shall be no burrs or protrusions into the casing I.D.

4. For field assembly welding double pass - full, ends of sections may be either belled or furnished with collars in accordance with the following standards:

   a) Plain Ends Fitted With Collars. Collars shall be of the same thickness and have the same chemical and physical properties as the corresponding casing section, shall be 6-inches in width, shall be rolled to fit the outside diameter, and shall be welded to the casing section. Longitudinal welds on the plain end shall be ground to plate surface a sufficient distance from the end. The inside edge of the collars and the outside edge of the adjacent casing length shall be ground or sufficiently scraped to remove sharp edges or burrs. Section ends shall be machined flat perpendicular to the axis of the casing and shall not vary more than 0.010 inch at any point from a true plane at right angles to the axis of the casing.

   Three 1-inch by 3/8-inch alignment holes shall be provided in each collar to insure proper matching of the sections. The casing gap shall be welded full-double pass within the holes as well as hole edges.

   b) Bell Ends. The inside diameter of the bell shall be 1/32 to 3/32 inch greater than the outside diameter of the plain end. The ends of each section shall not vary more than 0.010 inch at any point from a true plane at right angles to the axis of the casing.

   c) Butt welded joints shall be per AWWA C-206.

D. Blank Stainless Steel Well Casing. The blank stainless steel well casing shall be manufactured in accordance with ASTM A 409, Grade TP 316 with the following additions:

1. The inside diameter and minimum wall thickness are set forth in the Special Conditions, SCI-Special Provisions.

2. The casing shall be factory assembled in not less than twenty foot sections. There shall be no burrs or protrusions into the casing I.D.

3. For field assembly welding double pass-full, ends of sections may be either belled or furnished with collars in accordance with the following standards:

a) Plain Ends Fitted With Collars. Collars shall be of the same thickness and have the same chemical and physical properties as the corresponding casing section, shall be 6-inches in width, shall be rolled to fit the outside diameter, and shall be welded to the casing section. Longitudinal welds on the plain end shall be ground to plate surface a sufficient distance from the end. The inside edge of the collars and the outside edge of the adjacent casing length shall be ground or sufficiently scraped to remove sharp edges or burrs. Section ends shall be machined flat perpendicular to the axis of the casing and shall not vary more than 0.010 inch at any point from a true plane at right angles to the axis of the casing.

Three 1-inch by 3/8-inch alignment holes shall be provided in each collar to insure proper matching of the sections. The casing gap shall be welded full-double pass within the holes as well as hole edges.

b) Bell Ends. The inside diameter of the bell shall be 1/32 to3/32 inch greater than the outside diameter of the plain end. The ends of each section shall not vary more than 0.010 inch at any point from true plane at right angles to the axis of the casing.

c) Butt welded joints shall be per AWWA C-206.

E. Well Screen. The well screen shall be of the continuous slot, wire-wound design in order to provide maximum inlet area consistent with strength requirements. It shall be fabricated by circumferentially wrapping a triangularly shaped wire around a circular array of internal rods. The wire configuration must produce inlet slots with sharp outer edges, widening inwardly so as to be non-clogging. For maximum collapse strength, each juncture between the horizontal wire and the vertical rods will be fusion welded under water by the electrical resistance method. End fittings will be welded to the screen body. The well screen and attached end fittings shall be fabricated from corrosion-resistant type 316 stainless steel and meet the following conditions:

1. For bidding purposes, the inside diameter and screen slot size are set forth in the Special Conditions, SC1-Special Provisions. Actual screen slot size used will be selected upon mechanical sieve analyses of the natural water bearing sediments, the artificially introduced gravel pack material and the sand production guarantee.

2. The actual slot size shall not vary from the specified slot size by more than $\pm$ 10 percent, as measured by wire gages.

3. The blank welding pieces on the ends of the screens shall be the minimum length required for connections, welding, satisfactory fabrication, and adequate strength. The ends of the screen and blank sections shall be beveled for welding and shall meet the same standards as the beveled ends of the blank casing.

4. The Contractor is responsible for insuring that the materials utilized will be adequate for the actual conditions encountered.

5. End fittings shall be welded to the screen body with electrical insulation provided between stainless steel and other metallic materials. Insulation joints shall be provided between screen and casing as required by screen placement.

6. The screen length and wire shape shall be chosen so that the maximum velocity of the water entering the screen shall not exceed 0.1 foot per second at the desired yield. The screen shall be selected by the Contractor and submitted with supporting calculations for approval by the District.

7. The screen shall be manufactured by Johnson Division, Cook Industries, Roscoe Moss Company or an approved equal.

F. Sounder Tube. The two (2) sounder tubes shall be 1-inch minimum, schedule 80 threaded PVC pipe with 20 foot long screen section at bottom of tube or approved equal.

G. Gravel Make Up Pipes. The two (2) gravel make up pipes shall be 3-inch minimum schedule 80 pipe and of the same material as the casing pipe.

H. Bullnose. To be same material and thickness as casing.

I. Insulation Joints. At locations where dissimilar metals are to be joined, the Contractor shall submit the proposed method of connection to the District for approval prior to starting this work. The following methods of connection of dissimilar metals are to be considered as the minimum acceptable methods by the District:

1. Stainless steel screen may be direct welded to the casing pipe utilizing the appropriate type of welding rods provided that the casing pipe for a minimum of 10 feet adjacent to the stainless steel screen has the same inside diameter as the screen and a wall thickness of at least twice that of the stainless steel screen section.

2. A mechanical connection may be used that does not require direct welding of dissimilar materials. This style of connection shall be similar to that supplied by Roscoe Moss Company upon review and approval of the connection on an application-by-application basis by the District.

PART 3 - EXECUTION

3.01 DISINFECTION PRIOR TO START OF DRILLING

Contractor to clean and disinfect all equipment prior to moving on to site.

3.02 DRILLING AND INSTALLING CONDUCTOR CASING

The conductor casing shall be set plumb and centered in a plumb hole not less than 6-inches in diameter larger than the conductor casing O.D. It shall be securely anchored at the ground surface to prevent falling. It is estimated that the setting will be to a minimum depth of 50' or as set forth in the Special Conditions, SC1-Special Provisions; however, the District may order the setting to a greater depth if found advisable.

After the conductor casing has been installed, it shall be sealed by filling the annular space between the reamed bore and the conductor casing to the ground surface or top of the conductor casing, in accordance with the enclosed Exhibit No. 1, with a cement slurry grout. The placing of the cement slurry grout shall be done in a manner such that the conductor casing is entirely sealed against infiltration of water. After cementing operations are completed, the cement shall be left undisturbed for a period of not less than 48 hours.

3.03 DRILL AND LOG PILOT HOLE

The pilot bore shall be drilled to a depth as set forth in the Special Conditions, SC1-Special Provisions. The diameter shall not be greater than 12 inches nor less than 6 inches unless such hole is the first pass for a production well, then a maximum of 18" is allowable. The bore shall be sampled, logged, E-logged, and Gamma-Ray logged. The bore shall be a pilot hole for the final well, unless the contractor elects to abandon the hole, or the hole is directed to be abandoned by the District. If the hole is abandoned, it shall be filled with cement slurry grout by pressure grouting with a tremie pipe from the hole bottom to the ground surface. All abandonment operations shall be conducted in accordance with the requirements of Riverside County and the State of California Department of Water Resources.

The Contractor shall keep a log and progress record available at the site readily available for inspection during drilling and a copy submitted to the District. The contractor shall call for all required inspections, if any, by the county.

The Contractor shall keep records providing the following information with copies to the District:

A. A log of the formations drilled from surface to total depth showing each change in formation, sample locations, drilling rates, and variations in and the amounts and types of any additives, consistencies of drilling fluids required and any additives during drilling. The depths at which these changes occur shall also be noted.

B. A collection of samples from surface to total depth placed in separate, secure and durable bags or containers for each interval, plainly marked with the well name or number and sample depth. Samples shall be taken each 5 feet and at each change of formation and at the bottom of bore. The method of taking samples shall be a shaker screen or as approved by the District. Sieve analyses on up to 6 samples per borehole shall be approved by the District and shall be furnished by the Contractor.

C. Copies of electric logs and Gamma-Ray log shall be submitted through CIPO to the District upon completion of the pilot borehole. The E-log shall consist of one spontaneous potential curve and three resistivity curves. The District will analyze the logs and submit a casing and screen schedule to the Contractor within five (5) working days, excluding holidays and weekends, of receipt of same. No standby charges will be allowed during this time.

3.04 DRILLING AND INSTALLING WELL CASING AND SCREEN

The hole shall be drilled with diligence and without undue delays. Drilling shall be done on a 24 hour per day work schedule including weekends and holidays unless prohibited in the Special Conditions. The Contractor shall make recommendations for type of casing, screen schedule, type of screen casing, for approval by the District.

All material must be on-site prior to the completion of the reaming operation. The gravel must be at the well site so there will be no waiting on gravel once the casing has been installed. From the base of the conductor casing, the bore shall be drilled to a diameter as set forth in the Special Conditions, SC1-Special Provisions. Casing and screen installation shall be by approved methods that will insure no damage. The casing and screen shall be suspended above the bottom of the hole. The casing and screen shall be fitted with approved centering guides or brackets, installed at points as directed by the District, but not more than forty (40) feet apart, in order to center and hold the casing in the proper position until the gravel is in place. Guide placement shall be made based on the caliper survey to avoid large diameter areas. Guides will be joined by a continuous double pass fillet weld. The sounder and gravel makeup tubes shall be racked or skewed in the upper 40 feet so the O.D. of the sounder tubes are against the I.D. of the surface conductor. Likewise, the sounder and makeup tubes shall favor the I.D. of the surface conductor to allow clearance between the water box base or right angle drive base during development and test pumping and future pumping. Grout placement in the upper well casing annulus shall be preceded by District approval of tube locations.

Tubes, casing, and surface conductor shall extend above ground surface to heights to accommodate development and test pumping. See Exhibit No. 2 for the well surface finish.

3.05 SOUNDER AND GRAVEL MAKE UP TUBES

The sounder tube and the gravel make up tubes shall be placed in the gravel pack zone from two (2) feet above ground surface to the specified feet below ground surface as set forth in the Special Conditions, SC1-Special Provisions. The tubes shall be adequately and securely held in place to preclude disruption or movement during tube installation, gravel placement, and any grout placement.

3.06 SELECT FILTER GRAVEL PLACEMENT

When the assembled casing and screen are plumbed and centered in the bore hole, tubing or drill pipe with a swab(s) shall be inserted. Clear, domestic, water shall be circulated while installing the gravel. The gravel shall be placed by pumping through a gravel feed line extending to the bottom of the casing-hole annulus. The feeder line shall gradually be withdrawn as the gravel is placed. Swabbing and circulating shall be continued during placement of gravel until the gravel pack is completely in place. Before the gravel packing operation begins, the Contractor shall treat the select filter gravel with a solution containing 50 ppm free chlorine residual and make adequate preparations to insure that circulation will be continuous. In addition to the chlorine, a solution of sodium hexametaphosphate, not exceeding 5 pounds per 100 gallons of water, should be added to the circulating water to aid in the removal of the drilling mud. After the gravel is in place, circulating and swabbing shall continue in stages opposite the entire screen section until the gravel is consolidated and cleaned. As gravel settles more shall be added. A careful record shall be kept of the amount of gravel added during placement and consolidation. Care shall be taken to not disturb the sounder tube and gravel make up tubes.

3.07 GROUT PLACEMENT

The upper portion of the annular space between the casing and the borehole shall be filled with cement slurry grout within the limits as set forth in the Special Conditions, SC1-Special Provisions. The placing of the grout shall be from the bottom up with a tremie or pipe. Care shall be taken to not disturb the sounder or gravel makeup tubes.

A record shall be kept of the volume of grout placed to compare to the void space as determined from the bore caliper survey. Grout volume shall equal void volume.

3.08 DEVELOPMENT BY AIR LIFT PUMPING/SWABBING

Within 3 days after installation of the casing, screens, tubes, gravel pack, and sanitary seal, the Contractor shall commence development of the well by swabbing and air lift pumping as a preliminary step to pumping development. If grout placement was made in part 3.06, development shall not commence prior to 48 hrs. after grouting finished.

The following general procedure shall be used, as described on Page 515 in "Groundwater and Wells", 2nd Edition, published by Johnson Division, UOP. 1986.

A. An isolation tool with packer elements 5 feet apart shall be attached to the bottom of the drill pipe of suitable diameter, with an air-line eductor.

B. Beginning at the top of the screened section, each 5-foot interval will be developed by surging and air-lift pumping until the produced water is essentially clear and no further movement of the gravel pack is noted.

C. During this process, a suitable sounding device shall be employed to measure the level of the gravel in the annulus. Gravel will be checked and added as needed and volume noted.

D. The procedure shall be repeated for each 5-foot interval of screen until the bottom of the screened section is reached.

An air compressor having sufficient capacity (volume and pressure) for satisfactory development of the lowest screened interval shall be employed. Material drawn into the well shall be removed from time-to-time and disposed of by the Contractor.

Water discharged will be sampled/checked by the District during surging/pumping and the contractor shall assist in sampling.

Upon completion of air swabbing development, the gravel envelope shall be a continuous column completely surrounding the casing and completely filling the annulus between the well casing and borehole. The quantity of gravel placed in the annulus shall not be less than the computed volume of the annulus. A quantity less than the computed volume will be judged as an indication of voids and corrective measures shall be undertaken at the Contractor's expense. The contractor shall compute the annulus volume and submit a copy to the District through CIPO.

3.09 DEVELOPMENT BY PUMPING

The Contractor shall furnish, install, operate, and remove a deep-well turbine pump for developing the well. Pump setting to be as directed by the District. The pump and prime mover shall have a capacity in excess of 175% of the flow specified in the NIB. The prime mover shall be a variable-speed type. The Contractor shall furnish and install discharge piping for the pumping unit of sufficient size and length to conduct water to a point of discharge together with acceptable orifices, meters or other approved devices, which will accurately measure the flow rate in gpm. An air line, electric wire sounder, or approved equal, complete with properly calibrated gauge and source, shall be provided to measure the elevation of water in the well.

The Contractor shall make adequate provisions for disposal of water pumped from the well during development and production testing. Such provisions shall include, but not be limited to, the furnishing and installing of any necessary piping to carry the water to storm drains, catch basins, drainage channels or other facilities approved by the District.

No water shall be disposed of in streets of roads or in such a manner as to cause flooding of streets or properties. Contractor shall furnish to the District written authorization (s) from the appropriate agency (s) and/or property owner (s) to discharge said water onto their properties and/or facilities.

The initial pumping rate shall be restricted and as the water clears, shall be gradually increased until the maximum rate is reached. The maximum rate will be determined by the District and the Contractor after consideration of the well's drawdown and discharge characteristics. At proper intervals, the pump shall be stopped and the water in the pump column shall be allowed to surge back through the pump bowls and through the perforated area. While pumping and surging, a continuous stream of clean water shall be added to the top of the gravel envelope.

The Contractor shall continue development until, in the opinion of the District, the following conditions have been properly met:

A. The quantity of gravel placed in the annulus shall be at least as great as the calculated volume of the annulus.

B. There shall be no further settlement of the gravel envelope.

C. Specific capacity shall have reached a constant value: i.e., there shall be no increase in specific capacity during the last 24 hours of continuous pumping and surging.

3.10 DISINFECTION

The Contractor shall provide for disinfection prior to start up of and during construction of the well, and during pumping tests and conduct any cleaning procedures. 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 District approval is obtained for employing chemicals or other 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 disinfected prior to installation and use and be thoroughly hosed, scrubbed or otherwise cleaned of foreign material.

Chlorine or other compounds approved by State of California shall be used as disinfectants. The disinfectant shall be delivered to the site of the work in the 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 have been stored for more than one year and storage of liquid compounds shall not have exceeded 30 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 50 mg/l available chlorine or as required by regulation.

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% 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.

The Contractor shall discuss with the District the amount of disinfecting agent to be used and its method for use in advance of initiating the work. Chlorine compound dosages and method of utilization shall be satisfactory to the District in their entirety. 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:

A. Provide reliable means of 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 screened portion after the disinfectant has been placed. This will cause the disinfectant to flow out of the well into the area adjacent to the screen.

B. 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 selected with District approval so as to minimize potential damage to aquatic life or vegetation, of facilities, or exposure to public.

3.11 TESTING FOR YIELD AND DRAWDOWN

The Contractor shall furnish all necessary equipment and materials and make complete pumping tests of the well following the development work. The test pumping equipment shall have a capacity of not less than is listed under the Section "Development by Pumping" and shall be capable of delivering water from a level below the ground surface as specified by the District. Water shall be disposed of as approved by the District. During the progress of the test pumping, the Contractor shall provide an approved measuring device for measuring the rate of discharge of the pump and the level of the water within the well casing. Reading and recording of pump discharge shall be made by the Contractor at intervals directed by the District. Drawdown shall be measured by means of an air line, pressure gauge and air pump, electric wire sounder, or both. At the completion of the test pumping, all sand and debris shall be removed from the bottom of the well.

Measurement of time of start, stop and interval measurements must be made with reasonable accuracy (±6 seconds). Any irregular events (e.g. pump failure and restart occurring during the test cycle must be noted and their times recorded. Should these events occur, the District must be notified and decisions made as to the validity of the test. If the pumping test is interrupted due to Contractor's equipment malfunction, the test shall be rerun at the Contractor's expense. Pumping rate (Q) shall not vary by more than 5% (±).

Prior to test pumping, water-level measurements shall be taken on pumping and non-pumping wells in the nearby area as specified by the District. No pumping of the production well to be tested shall occur for at least 24 hours prior to start of pump test.

The time interval between water-level measurements may vary between acceptable limits. The following are minimum recommendations of measuring intervals after the start or stop of any discharge step:

Time after start or stop of new discharge step (minutes)	Recommended measuring interval (minutes)
1-10	1
10-20	2
20-30	5
30-60	10
60-120	15
120-300	30
300 to end of test	60

A. Step-Drawdown Test

The Contractor shall conduct a step-drawdown test of the well by pumping at a sufficient number of rates (at least 3) to determine the shape of the drawdown curve to the maximum capacity of the well, as approved and directed by the District and based on the development pumping.

Pumping shall continue at each rate for a sufficient length of time to bring about a stable (or predictable) water level trend in the well (i.e. a semi-logarithmic plot of pumping level versus time shows a straight-line trend).

The step-drawdown data shall be sufficient such that the following results may be obtained and submitted to the District:

1. Well efficiency diagram for the range of discharges tested.

2. Specific Capacity diagram showing formation and well loss curves for the range of discharges tested.

3. Recommended production pumping rate and lift based on system characteristics as defined by the District and furnished to the Contractor.

B. Constant Rate Pump Test

Contractor shall conduct a constant rate pump test for a minimum period of twenty-four (24) hours at a production rate as specified by the District. The constant rate pump test shall not be concluded until the drawdown has stabilized for at least eight (8) hours and under no circumstances, be less than 24 hours in duration. During the constant rate test, measurements of water levels and rates of production shall be made in the well being tested and in any nearby wells selected by the District at the time intervals recommended in the preceding section. The Contractor shall also plot the time-drawdown data onto 4 cycle semi-logarithic graph forms.

A Rossum sand test shall be conducted for a period of at least two (2) hours after commencement of pumping. Sand production as a function of time shall be determined with a graph to be drawn and submitted to the District as part of the permanent record of the well. Said production shall be as noted in Section 1.06 A.

At the end of the constant rate pump test, the Contractor shall shut off the pump unit and record the recovery of the water level in the well at the time intervals recommended in the preceding section. Monitoring of the recovery of the water level shall continue until such time as the water level has reached at least 95% of the initial static readings recorded prior to the start of testing.

Before shutdown of the pump during the test period, a complete set of water samples shall be taken by the Contractor. These samples shall be subjected to a full Title 22 analysis including, but not limited to, general mineral, general physical, trace metals, volatile organic constituents and toxics in accordance with State of California Title 22 requirements.

3.12 PLUMBNESS AND ALIGNMENT

The Contractor shall guarantee that the well when completed shall be sufficiently straight and plumb to permit the free installation and operation of a vertical turbine type pump regularly built for the casing size and installed with the bowls set at the location specified by the District. 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 District. Tests for plumbness and alignment shall be made after completion of the well construction and before its acceptance. The well shall be drilled in such vertical alignment that a line drawn from the center of the well casing at the ground surface to the center of the well casing 25-feet above the bottom of the well shall not deviate from the vertical more than 6-inches in 100-feet of length and that any bends shall be no closer to the inside wall of the casing than 4-inches. Contractor shall submit the original test to the District. If the well is not straight, plumb and free of any obstruction, as specified, the well shall be straightened, plumbed and freed of all obstructions or a new well shall be drilled at no additional cost to the District. In the event the contractor is unable to complete the well due to faulty materials, workmanship, operations of the contractor or a crooked hole, the District may require a new well to be drilled immediately and no payment will be made for the depth to which the original well was drilled and abandoned. The new well shall be completed in accordance with all the terms and conditions stated herein. If, however, inability to complete the well was not due to any fault of the Contractor the cost of the new well will be paid for by the District at the respective contract prices and the time for completion shall be extended proportionately; however no additional payment will be made for extended overhead costs to the Contractor. The abandoned hole shall be filled in accordance with the requirements of the District, County and State.

3.13 BACTERIOLOGICAL TESTS

Upon completion of all work in connection with disinfection, development, and test pumping, the Contractor shall perform, or have performed for him, bacteriological tests on the well. The results of such tests shall show that the well meets all bacteriological drinking water standards for the State of California Department of Health Services. In the event the well fails to meet such standards the disinfection, pumping and retesting shall be repeated until the standards are met. All costs for bacteriological testing shall be borne by the Contractor.

3.14 VIDEO LOG

Upon completion of pump testing, the Contractor shall Video Log the well in color on VHS tape no sooner than seven (7) days nor more than ten (10) days following final pumping. The Video Log shall be provided to the District.

3.15 WELL CAPPING AND CLEAN UP

Upon completion of all work, in connection with development, drilling, and test pumping, the well shall be capped by welding a minimum 1/4 inch steel plate over the top of the casing and a minimum 1/4-inch plate full welded over the top of the conductor casing. The sounding tubes and gravel tubes shall be capped with threaded caps. The site shall be returned to its original or better condition.

END OF SECTION 02733