NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

WATER WELL

(No.)

CODE 642

DEFINITION

A hole drilled, dug, driven, bored, jetted or otherwise constructed to an aquifer for water supply.

PURPOSE

- Provide water for livestock, wildlife, irrigation, and other agricultural uses
- Facilitate proper use of vegetation, such as keeping animals on rangeland and pastures and away from streams, and providing water for wildlife

CONDITION WHERE PRACTICE APPLIES

This practice applies on all land uses where the underground supply of water is sufficient in quantity and quality for the intended purpose.

This practice applies only to production water wells. Specifically excluded are any types of wells installed solely for monitoring or observation purposes, injection wells, and piezometers. The standard does not apply to pumps installed in wells; above ground installations, such as pumping plants, pipelines, and tanks; temporary test wells; and decommissioning of wells (refer to NRCS-CA standard 351, Water Well Decommissioning).

CRITERIA

Laws and Regulations. The investigation, design, or installation of water wells according to this standard shall adhere to all applicable local, State, Tribal, and Federal laws and regulations.

In California, counties (and some cities) administer and enforce laws or ordinances pertaining to the construction, alteration, maintenance, and destruction of water wells, using standards that equal or exceed those developed by the Department of Water Resources (DWR, Southern District, 1998). Key provisions in the State Standard that are either not explicitly addressed or are more stringent than what is included in the NRCS standard, are included in italicized format. In all cases, more stringent requirements set forth by the local enforcing agency shall supercede those set forth in this standard.

Water wells shall be installed by licensed C-57 water well drilling contractors, except where exempted by law.

Suitability of Site. The availability of groundwater for its intended use at the site shall be determined by using reliable local experience and reviewing all available relevant geologic maps and reports; well records maintained by State and Federal agencies; and design, construction, and maintenance records of nearby wells. An appropriate level of investigation, including test well drilling, is conducted on-site, as needed, prior to well construction to determine site-specific hydrogeologic conditions.

The site shall be suitable for safe operation of the drilling equipment.

Well Head Protection. Wells shall be located at safe distances from potential sources of pollution, including unsealed abandoned wells. The allowable distance shall be based on consideration of site-specific hydrogeologic factors and shall comply with requirements of all applicable local, State, Tribal, or Federal regulations or construction codes. *California State well standards list the following horizontal separation distances that are generally considered adequate where a significant layer of unsaturated, unconsolidated*

sediment less permeable than sand is encountered between the ground surface and groundwater:

Potential Pollution or Contamination Source	***Minimum Horizontal SeparationDistance between Well and Known or Potential Source***
Any sewer (sanitary, industrial, or storm; main or lateral	*50 feet*
Watertight septic tank or subsurface sewage leaching field	*100 feet*
Cesspool or seepage pit	*150 feet*
Animal or fowl enclosure	*100 feet*

Local conditions may require greater distances to ensure groundwater quality protection; where, in the opinion of the local regulatory agency, adverse conditions exist, the above separation distances shall be increased, or special means of protection (such as increasing the depth/length of the annular seal) shall be provided.

Lesser distances than those listed above must be approved by the local regulatory agency.

Surface runoff and drainage from potential sources of contamination shall be diverted away from the well head.

Wells shall be located a safe distance from both overhead and underground utility lines and other safety hazards.

Borehole. Drilled, jetted, bored, and driven wells shall be sufficiently round, straight, and of adequate diameter, to permit satisfactory installation of inlet, well casing, filter pack, and annular seal, and passage of tremie pipe (including couplings), if used.

Use of Casing. Casing shall be installed to seal out undesirable surface or shallow groundwater and to support the side of the hole through unstable earth materials. The intake portion of a well through stable geologic materials may not require casing.

Refer to State and local requirements where temporary or permanent conductor casing is required to stabilize the hole.

Casing shall be equipped with centering guides or 'centralizers' to ensure the even radial thickness of the annular seal and filter pack.

Casing Diameter: Casing diameter shall be sized to permit satisfactory installation and efficient operation of the pump, and large enough to assure that uphole velocity is 5 feet per second or less for the designed discharge to protect against excessive head loss.

Casing Materials. Casings may be of steel, iron, stainless steel, copper alloys, plastic, fiberglass, concrete or other material of equivalent strength and durability consistent with the intended use of the water and the maximum anticipated differential head between the inside and outside of the casing, using depth and material tables.

Steel well casings shall meet or exceed requirements specified in ASTM A 589. Steel pipe manufactured for other purposes may be used if the quality of the pipe meets or exceeds requirements specified in ASTM A 589.

Only steel pipe casings shall be used in driven wells.

To prevent galvanic corrosion, dissimilar metals shall not be joined in direct contact.

Thermoplastic casings and joints made of acrylonitrile-butadiene-styrene (ABS), polyvinyl chloride (PVC), or styrene-rubber (SR) shall conform to material, dimensional and quality requirements specified in ASTM F 480.

Filament-wound fiberglass casings (glass-fiber-reinforced-thermosetting-resin pipe, RTRP) may be used if material meets requirements specified in ASTM D 2996. Tests for long-term cyclic pressure strength, long-term static pressure strength, and short-term rupture strength as required in ASTM D 2996 are not needed because the pipe is to be used for well casing.

Fiberglass pressure pipe (also called reinforced plastic mortar pipe, RPMP, or fiberglass pipe with aggregate) shall meet or

exceed requirements specified in ASTM D 3517.

Casing Strength. Well casing wall thickness shall be sufficient to withstand all anticipated static and dynamic pressures imposed on the casing during installation, well development and use. Required casing strength shall be determined as shown in NEH Part 631, Chapter 32, Well Design and Spring Development.

Joint Strength. Joints for well casings shall have adequate strength to carry the load due to the casing length and still be watertight, or shall be mechanically supported during installation to maintain joint integrity. Such mechanically supported casings shall terminate on firm material that can adequately support the casing weight.

Screen. Well screens shall be installed in any aquifer material likely to produce silt or sand. Well screens may be constructed of commercially manufactured screen sections, well points, or field-perforated sections.

The screen shall be constructed with the slot width determined from aquifer samples. Perforation by any method is allowable provided proper slot size and entrance velocity limits can be met. Screen open areas can range from 1 percent for field-perforated screens to 25 percent or more for continuous wire-wrapped screens. To assure good well efficiency, open areas should be designed to approximate aquifer porosity. High percentages of open area also make well development more effective.

The length and open area of the screen shall be sized to limit entrance velocity of water into the well in order to maximize water yield, while simultaneously preventing sand from being pumped into the well, and preventing screen corrosion and encrustation.

A conservative water well design will have a well screen entrance velocity of about 0.1 foot per second, which has been the common industry standard for many years. The American Water Works Association (AWWA) Standard A-100-06, however, no longer stipulates a maximum screen entrance velocity and cites recent research and testing that indicate that allowable well screen velocities are a function of the aquifer characteristics, the overall well design and intended performance, and the quality of the groundwater being pumped. For the purposes of this standard, the maximum recommended entrance velocity shall be less than or equal to 0.7 foot per second.

Depth of the aquifer below ground surface and the thickness of aquifer to be penetrated by the well shall govern the position of the screen in the well.

Maximum drawdown shall not be permitted below the top of the highest screen or pump intake.

Filter Pack. Installation of a filter pack around the well screen shall be considered under the following conditions: presence of a poorly graded, fine sand aquifer; presence of a highly variable aquifer, such as alternating sand and clay layers; presence of a poorly cemented sandstone or similar aquifer; a requirement for maximum yield from a low-yielding aquifer; and holes drilled by reverse circulation.

Pre-packed Well Screens. For heaving or caving sands, silty or fine-grained aquifers, and for horizontal or angled wells, a commercial pre-packed well screen may be substituted for a conventionally installed (by tremie) filter pack.

Installation. Casing shall extend from above the ground surface down through unstable earth materials to an elevation of at least 2 feet into stable material or to the top of the screen.

The top of the casing shall terminate at least 12 inches above the ground surface *and above known levels of flooding caused by drainage or runoff from the surrounding land*.

Casing for artesian aquifers shall be sealed into overlying, impermeable formations in such a manner as to retain confining pressure.

If a zone is penetrated that is determined or suspected to contain water of quality unsuitable for the intended use, the zone shall be sealed to prevent infiltration of the poor-quality water into the well and the developed portion of the aquifer.

Seals (Packers). A positive seal (grouted in place) or packer shall be provided between the casing and the less pervious material overlying

the aquifer of artesian wells, and in all aquifers where co-mingling of waters is undesirable.

The seal shall extend above and below the strata no less than 10 feet even should the confining formation be less than 10 feet in thickness.

The sealing material shall fill the annular space between the casing and the wall of the drilled hole in the interval to be sealed, and the surrounding void spaces which might absorb the sealing material.

The sealing material shall be placed from the bottom to the top of the interval to be sealed.

Telescoped screen assemblies shall be provided with one or more sand-tight seals between the top of the telescoped screen assembly and casing.

Grouting and Sealing Materials. The annulus surrounding the permanent well casing at the upper terminus of the well shall be filled with mortar containing expansive hydraulic cement (ASTM C 845), bentonite-based grout, or bentonite chips and pellets, in accordance with State and local requirements. *Cuttings from drilling, or drilling mud, shall not be used for any part of the sealing material*.

Unamended bentonite clay seals should not be used where structural strength of the seal is required, where it will dry, or where flowing water might erode it.

Bentonite clay shall not be used as a sealing material if roots from trees and other deep rooted plants might invade and disrupt the seal, and/or damage the well casing.

Bentonite-based sealing material shall not be used for sealing intervals of fractured rock or sealing intervals of highly unstable, unconsolidated material that could collapse and displace the sealing material, unless otherwise approved by the enforcing agency.

Water used to prepare sealing mixtures should generally be of drinking water quality, shall be compatible with the type of sealing material used, be free of petroleum and petroleum products, and be free of suspended matter. In some cases water considered nonpotable, with a maximum of 2,000 milligrams per liter chloride and 1,500 mg/l sulfate, can be used for cement-based sealing mixtures.

Grouting and Sealing Placement. *The annular space shall be sealed as soon as practical after completion of drilling or a stage of drilling. In no case shall the annular space be left unsealed longer than 14 days following the installation of casing.*

All loose cuttings, or other obstructions to sealing shall be removed from the annular space before placement of the annular seal.

Sealing material shall be placed by methods (such as the use of a tremie pipe or equivalent) that prevent freefall, bridging, or dilution of the sealing material, or separation of sand or aggregate from the sealing material. Annular sealing materials shall not be installed by freefall unless the interval to be sealed is dry and no deeper than 30 feet below ground surface.

Sealing material shall be placed in one continuous operation from the bottom of the interval to be sealed, to the top of the interval. Where the seal is more than 100 feet in length, the deepest portion of the seal may be installed first and allowed to set or partially set. The deep initial seal shall be no longer than 10 feet in length. The remainder of the seal shall be placed above the initial segment in one continuous operation.

If thermoplastic well casing is used, monitor and control the heat of hydration generated during the setting and curing of cement in an annular seal as appropriate, to avoid potential weakening and collapse.

A minimum of 2 inches of sealing material shall be maintained between all casings and the borehole wall, within the interval to be sealed.

The length of the annular surface seal shall not be less than the minimum set forth by the local regulating agency. *California water well standards require a minimum 20-foot long annular surface seal, except where the water to be produced is at a depth less than 20 feet.* In no cases shall the length of the annular surface seal be less than 10 feet.

The casing shall be surrounded at the ground surface by a *minimum* 4-inch thick concrete slab extending at least 2 feet in all directions from the outside of the casing to prevent contamination. The slab shall slope away from well. *The slab shall be free of cracks, voids, or*

other significant defects likely to prevent water tightness. Contacts between the slab and the annular seal, and the slab and the well casing, must be water tight and must not cause the failure of the annular seal or well casing. Where cement-based annular sealing material is used, the concrete slab shall be poured before the annular seal has set, unless otherwise approved by the enforcing agency.

Well Development. Well development shall be performed to repair damage done to the formation by the drilling process, and to alter the physical characteristics of the aquifer surrounding the borehole so that water will flow more freely to the well.

The method of well development used shall be selected based on geologic character of the aquifer, type of drilling rig, and type of screen.

Aquifer Development. For massive, unfractured rock that is unresponsive to well development procedures, the use of aquifer stimulation techniques may be considered (as allowed by the local regulating agency) to improve well efficiency and specific capacity. Techniques may include dry ice, acidizing, explosives, or hydrofracturing, depending on the composition and structure of the formation.

Where hydrofracturing is used, good quality water that has been disinfected shall be used. Material used as 'propping' agents shall be free of pollutants and contaminants, shall be compatible with the use of a well, and shall be thoroughly washed and disinfected prior to placement in a well.

Where explosives are used, care shall be taken to prevent damage to the well structure and to any natural barriers to the movement of poor-quality water, pollutants, and contaminants. Explosives shall only be used by properly- trained personnel.

Wells subjected to chemicals or explosives during development shall be thoroughly pumped to remove such agents and residues immediately after the completion of operations. Chemicals, water, and other wastes removed from the well shall be disposed of in accordance with applicable local, State, and federal requirements.

Access Port. An access port with a minimum diameter of 0.5 inch shall be installed to allow for unobstructed measurement of depth of the water surface, or for a pressure gage for measuring shut-in pressure of a flowing well. Access ports and pressure gages or other openings in the cover shall be sealed or capped to prevent entrance of surface water or foreign material into the well. Removable caps are acceptable as access ports.

Access openings designed to permit the entrance or egress of air or gas (air or casing vents) shall terminate above the ground and above known flood levels and shall be protected against the entrance of foreign material by installation of down-turned and screened "U" bends.

Disinfection. Wells shall be disinfected immediately following their construction or repair to neutralize any contamination from equipment, material, or surface drainage introduced during construction. The disinfection process shall comply with all Local or State requirements.

Water Quality Testing. Sampling and testing shall comply with all applicable Federal, State and Local requirements. These requirements vary according to the water quality parameters associated with the intended use(s) of the water.

Temporary Cover. *Whenever there is an interruption in work on the well such as overnight shutdown, during inclement weather, or waiting periods required for the setting up of sealing materials, for tests, for installation of the pump, etc., the well opening shall be closed with a cover to prevent the introduction of undesirable material into the well and to insure the public safety. The cover shall be held in place or "weighted-down" in such a manner that it cannot be removed except with the aid of equipment or through the use of tools.*

For interruptions lasting more than one week, a semipermanent cover shall be installed.

CONSIDERATIONS

The potential for adverse interference with existing nearby production wells should be evaluated in planning and designing the water well.

The potential for groundwater overdraft and the long-term safe yield of the aquifer should be considered in planning.

If practicable, wells shall not be located either in mapped/known flood zones, or down the groundwater gradient from potential sources of pollution or contamination. In determining gradient, both pumped and unpumped conditions should be considered.

Potential effects of installation and operation of the well on cultural, historical, archeological, or scientific resources at or near the site should be considered in planning.

To the degree practicable, locate wells an adequate distance from buildings and other structures to allow future access for well modification, maintenance, repair, and destruction.

The potential effects of installation and operation of the well on surface water hydrology and associated habitats, particularly those at or near the site that support Threatened and/or Endangered species and/or Species of Concern, should be considered in planning.

Because of their susceptibility to the entrance of poor-quality water, contaminants, and pollutants, well designs that incorporate well pits, vaults, or equivalent features to house the top of a well casing below ground surface should be avoided. Refer to State and local well standards for limitations/requirements for pit/vault design.

Where subsurface pressure causing the flow of water is significant, consider temporary measures to restrict groundwater flow into the well boring while placing sealing material, and maintain placement pressures long enough to allow cement-based sealing materials to properly set.

Fencing of the well and associated equipment should be considered to prevent contamination and damage by wildlife, livestock, or human activity.

PLANS AND SPECIFICATIONS

Plans and specifications shall be prepared for specific field sites in accordance with this standard and shall describe the requirements for applying the practice to achieve its intended uses. A record of the installation of this practice shall be made and shall include the following information:

- Location of the water well by Global Positioning System, latitude/longitude, township/range, or other georeferencing convention, of such precision that it can be readily re-located
- Date of completion of the water well
- Name of landowner
- Name, title, and address of person responsible for the water well
- Total depth of the water well
- Length of casing and screening
- Inside diameter of well bore or casing
- Type of casing material or schedule (e.g., standard weight steel, or PVC sch-80)
- Static water level measured from ground surface
- Water chemistry before and after disinfection

This information can be provided using California Department of Water Resources (DWR) Well Completion Report Forms. Completed forms must be submitted to DWR by the drilling contractor in accordance with relevant provisions of Section 13750 through 13754 of the California Water Code. . A copy of this report shall be provided by the well contractor to NRCS and shall be kept in the landowner's case file.

OPERATION AND MAINTENANCE

A plan for maintenance of a water well shall be prepared. The well construction records shall be kept on file with the maintenance plan by the owner/operator. As a minimum, the plan shall include a statement of identified problems, corrective action taken, date, and specific capacity (yield per unit drawdown) of water well before and after corrective action was taken.

REFERENCES

National Engineering Handbook, Part 631, Chapter 32, Well Design and Spring Development: online at http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=26985.wba.

California Department of Water Resources, Groundwater Information Center, 2011, Well Completion Reports: online at http://www.water.ca.gov/groundwater/well_info_and_other/well_completion_reports.cfm (modification dated 5/18/11).

California Department of Water Resources, Southern District, 1998, California Well Standards: online integration of DWR Bulletins 74-81 and 74-90, http://wwwdpla.water.ca.gov/sd/groundwater/california_well_standards/well_standards.html (modification dated December 20, 2007).