California Groundwater Association

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CGA STANDARD PRACTICE SERIES

ARTICLE 550 – MANAGEMENT OF SURFACE ARTESIAN FLOWS DURING VERTICAL WELL CONSTRUCTION

BACKGROUND

Flowing artesian wells are the result of water percolating into an aquifer, which is confined or semi-confined beneath an impermeable layer that is in turn penetrated by a well boring. When the surface of the water charging the aquifer is higher than the ground level of the well, water flows at the well head onto the ground. For purposes of this standard, the term "flowing artesian well" applies to vertical wells where water flows at the well head onto the ground.

The California Water Code addresses flowing artesian wells in Division 1, Chapter 2.5, Article 4, Sections 300-311. These sections define a flowing artesian well; what constitutes waste; beneficial use of water flowing from an artesian well; and the maximum annual accumulated flow that can be used. In section 305 the Article states that an artesian well which is not capped or equipped with a mechanical controlling device is a public nuisance. Further, the article provides that any person who permits such a public nuisance to exist or permits water to flow unnecessarily to waste is punishable by a fine, or imprisonment, or both.

Containment of flowing water on the land is allowed, provided the California Water Code's usage and volume restrictions are met. However, if containment on the land is not possible, or if allowable usage is exceeded, the only solutions described in the Article for preventing flow to waste are by capping the well and/or equipping it with a controlling device such as a valve. While this is a reasonable solution for undeveloped wells without installed pumping equipment, there are potential problems once submersible pumps are installed or when periodic access to the well is required. Problems also arise during the well construction process if artesian flows are not properly managed.

The purpose of this standard is to define these potential problems as well as provide basic guidelines and solutions that will make compliance with Article 4 possible and yet still allow intended usage of the well.

DISCUSSION

The California Water Code does not make a distinction between "artesian" and "flowing artesian" wells. According to the definition found in Section 300 of the California Water Code an "artesian hole" is any penetration of the surface through which water flows to the surface for any length of time. Section 301 of the California Water Code defines as "waste" any water flowing from an artesian well that runs into natural water courses, streets, highways, or upon land, unless it is used for irrigation, domestic purposes, or the propagation of fish. Water from an artesian well may be contained by means of an artificial pond or reservoir if the water is used thereafter for a beneficial use. Even if the artesian water is used for a beneficial use, Section 304 limits the amount of water used to one tenth of one miner's inch of water per acre, perpetual flow, with the ability to accumulate that amount within any period of each year. In 1901, the California legislature dictated that a miner's inch is to be equal to 1.5 cubic feet of water per minute (11 gallons per minute), while in southern California, "regardless of the legal definition," a miner's inch is considered equal to 1.2 cubic feet of water per minute (9 gallons per minute). Furthermore, Section 305 requires that artesian wells be capped or equipped with a mechanical appliance which will readily and effectively arrest and prevent the flow of any water from the well.

California Water Code Sections 306 and 307 place liability upon any person owning, possessing, or occupying any land with an artesian well that fails to control and fails contain the water and to comply with the other conditions of the California Water Code. The consequences of not complying with the provisions of the California Water Code are potentially large fines, imprisonment, and civil liability for aquifer and environmental damage.

Flowing artesian wells occur in confined aquifers where the potentiometric pressure is sufficient to push water above the ground surface once the confined aquifer is tapped. Since the static water level is above the ground surface in an artesian condition, the water flows out of the borehole. The amount of pressure the flowing artesian condition creates is dependent upon how high the static water level is above the ground level; for every 2.31 feet of hydrostatic head one pound per square inch (psi) of hydrostatic pressure is generated. The amount of flow and total flow volume is related to aquifer volume, soil porosity, and recharge rates. Depending on the source of the artesian flow, flowing artesian wells may be permanent, intermittent, or may discharge seasonally variable volumes and pressures. In certain instances, the artesian pressure may only occasionally be high enough to cause surface flow, such as during an unusually wet winter or following a heavy rainfall. Additionally, pumping a flowing artesian well may result in a temporary, or even permanent, loss of hydrostatic pressure and/or flow due to drawdown in the confined aquifer.

Any method that is employed to contain an artesian flow should be able to withstand the lifting pressure that the artesian condition may exert. The artesian pressure will exert a lifting force on the top of the well, well casing, and annular seal. Therefore, the downward force exerted by casing weight, pump and pipe weight, and friction on the pipe due to the

annular seal must be greater than the upward force exerted by the artesian condition. Thus, it is oftentimes better to rely on "overbuilding" a flowing artesian well; methods such as, but not limited to, heavier well casing material, deeper annular seal, and stronger grout in the annular seal can be utilized to control the artesian flow.

During well completion, the artesian flow will also cause problems when trying to work on the well head unless provisions are made to temporarily reroute the water away from the well head. Putting a diversion pipe and valve mechanism below the well head, but above the ground surface, will provide a mechanism to reroute the water away from the well head while work is being performed in this area.

Once the artesian flow is temporarily rerouted, it is easier to control artesian flows and pressures in artesian wells. In wells that are to be permanently capped, watertight modifications can now be made easier, e.g. welding or other means of permanently placing a cap. In wells that may require periodic access or wells with pumps installed, containment of artesian flows is more difficult. Oftentimes, the well top will be equipped with a mechanical appliance such as a pump sanitary seal through which the pump column pipe, pump electrical cable, and other appurtenances pass. Typically, this seal consists of rubber sandwiched between two plates made of steel or composite material. As the steel plates are compressed, the rubber expands, forming a watertight seal. To be effective, the well casing, annular seal, pump sanitary seal and other appurtenances must also be watertight and able to overcome any upward force that may be imposed when artesian pressures are permanently or intermittently elevated.

During well drilling operations, well construction, and for the life of the flowing artesian well, flowing artesian water can create a myriad of problems for the well drilling contractor and property owner. For the mud rotary driller, the increased water tends to reduce the weight of the drilling fluid, which can cause problems with borehole stability and surface water runoff. For the air rotary driller, the water can lead to borehole collapse, ground surface instability, as well as water runoff issues. For the pump installer, the artesian flow causes waterproofing and containment issues. The property owner faces liability issues for waste of water as well as the potential for increased well construction costs. For all parties involved, the problems associated with flowing artesian wells will have to be mitigated or the borehole may have to be abandoned in entirety.

RECOMMENDATIONS

1. The owner, occupant, or tenant of a property with a flowing artesian well should be informed of their responsibilities to control the artesian flow and to review California Water Code, Division 1, Chapter 2.5, Article 4, Sections 300-311. The URL is <http://www.leginfo.ca.gov/calaw.html>.

2. Components used by the well drilling contractor during construction of an artesian well should be capable of withstanding anticipated artesian flows and pressures.

3. The well drilling contractor should, whenever possible, learn about the area and anticipate artesian flow.

4. The well drilling contractor who anticipates the possibility of artesian flow should exercise locally and regionally established “best management practices” (BMPs).

5. If an artesian flow is anticipated, the drilling contractor should plan to install a conductor casing prior to reaching the anticipated artesian condition. The conductor casing and sealing material should have sufficient structural strength and depth to withstand anticipated forces exerted by the artesian pressure.

6. Where artesian flow is not anticipated and an annular seal must be installed after artesian flow is encountered, the drilling contractor may need to install a pump in the well that can pump at a higher rate than the artesian flow to allow the annular seal to be placed. All annular seals should be placed via tremie pipe.

7. When mud rotary drilling, the best way to deal with artesian flow is to increase the weight of the drilling mud by using weight adding products, such as barite.

8. Steel cased wells may be capped with a solidly welded plate, pump sanitary seal, or other appropriate flow arresting device. Plastic cased wells may be capped with a solvent welded cap, pump sanitary seal, or other appropriate flow arresting device. Pump sanitary seals should be tightened against the casing sufficiently to prevent leakage. Strapping or other methods can also be used to help the pump sanitary seal withstand the potential upward force from the artesian condition. Additionally, a flange and blind flange sanitary seal may be considered.

9. Cased artesian wells should be outfitted with a diversion pipe and valve of sufficient size and pressure rating to allow maximum artesian flow to exit the well below the top of the well head. This discharge pipe eases well head service and acts as a controlled discharge of artesian water in accordance with the California Water Code. Discharge piping from the controlling valve should terminate with a screened covering or cap when not in use.

10. For wells with installed pumping equipment, electrical conduits should be sealed to prevent water flow and should be capable of withstanding the potential artesian pressure. Conduit connections through the pump sanitary seal should be plugged with a suitable sealing agent, such as resin epoxy. If a well vent is installed, the well vent should be capable of stopping water flow or installed with a check valve.

11. In cases where the quantity of the artesian flow is of immediate concern, or where drilling operations must cease temporarily, adequate means to control the artesian condition should be utilized.

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Adopted by the CGA Board of Directors on October 13, 2007