Article 230–Sand Discharge in Wells

Adopted by the CGA Board of Directors on October 1, 1994

BACKGROUND

Causes of Sand Pumping

A sand pumping well can result from one or more of several reasons, including the following:

- Incomplete development. Well development procedures are designed to alleviate the damage which occurs to aquifers during well drilling and construction. Well development is also designed to create a stable, effective filter zone around the screen, using either the natural aquifer materials or an artificial gravel pack, which will result in minimal sand production. A well which is not fully developed may produce an unacceptable amount of sand.
- Inadequately designed intake sections. Sand pumping in a naturally developed well can result from selection of a screen slot size which is too large for the aquifer materials. Sand pumping in a gravel packed well can result from the selection of a gravel pack which results in a pack/aquifer ratio which is too large.
- Wells completed in certain consolidated rock formations (such as sandstone) without casing and/or screened intake sections may eventually pump sand.
- Other causes of sand pumping include voids in the filter pack, localized enlargement of slot or screen openings, holes in the screen or casing due to corrosion or abrasion, a break in the screen or casing, and the settling and bridging of the gravel pack over time.

Effects of Sand Pumping

Sand pumping has several detrimental effects. Sand may plug pipelines, sprinkler systems, valves, plumbing, and other components of a distribution system. Drip irrigation systems are particularly susceptible to plugging by sand. Sand is very destructive to pump bowls and impellers; and sand pumping can significantly reduce the life of a pump.

Sand which is drawn into the well, but not removed with the water, settles to the bottom of the well. If sufficient sand accumulates, a portion of the screen could be blocked, leading to increased drawdown, increased entrance velocity, and perhaps even accelerated corrosion and incrustation. The accumulation of sand in the bottom of the well could also result in difficulty in removing the pump due to sand locking.If enough sand is removed from the surrounding aquifer, the formation may collapse, which could lead to deformation or breakage of the well casing.

Methods of Measuring Sand Content

- **Imhoff Cone.** The sand content of water from a well should be measured during development pumping and surging as well as during final test pumping. During the initial stages of pumping and surging, gross sand content can be measured with an Imhoff cone. Care should be taken that the sample is not drawn from some point in the discharge pipe where sand may have accumulated. After a sample from the discharge is collected, the cone is set in a holder to permit the contents to settle for approximately 10 minutes, and then the sand content by volume is estimated. The smallest division on a cone is 0.1 ml. About one tenth of the smallest division on the scale is approximately 10 ppm. Because the Imhoff cone is incapable of accurately measuring sand content below 10 ppm, it is not suitable for determining the sand content with regards to final acceptance of the well.
- **Rossum Sand Tester.** This device is also known as a centrifugal sand sampler. When operated over a period of approximately ten minutes, it is capable of accurately measuring sand content as low as 0.5 ppm. The Rossum Sand Tester is connected to a small diameter pipe tapped horizontally in the well discharge pipe close to the pump head. The connection should be made at the midline of the discharge pipe. Flow through the device is maintained at 0.,5 gpm by means of a flow control valve. The small radius of the device and the high velocity of the water create a large centrifugal acceleration which separates the sand particles from the water. The sand falls into a clear, calibrated tube. Recording their total quantity of sand with time allows calculation of the sand content of the discharge water.
- **Automatic particle counters.** These instruments operate on the principles of light blockage and scattering. Currently, they are used mostly to measure the amount and size of very fine particles contained in liquids where their control of suspended solids is critical. Particle counters are widely used by water agencies and water treatment facilities. However, these instruments are not well suited for measuring the sand content of discharge from water wells in the field. They require a source of AC electricity, are expensive (generally costing several thousand dollars or more), and often require a computer for data analysis.

Existing Guidelines for Sand Discharge

The California Department of Water Resources establishes a guideline of 5 ppm by weight, measured 15 minutes after the start of pumping, and suggests a centrifugal sand sampler for the means of measurement. The sand content should be tested after development and test pumping (DWR, 1981,Bull. 74-81,p. 18). The United States Environmental Protection Agency and the National Water Well Association have recommended the following limits based on the intended use of the water (USEPA and NWWA, 1976, pp. 109- 110):

> **15 ppm** for wells supplying water for flood-type irrigation where the nature of the water-bearing formations and the overlying strata are such that pumping 15 ppm sand will not seriously shorten the useful life of the well (p. 109).
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> **10 ppm** for wells supplying water to sprinkler irrigation systems, industrial evaporative cooling systems, and other uses where a moderate amount of sand is not especially harmful (p. 109).
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> **5 ppm** for wells supplying water to homes, institutions, municipalities, and industries other than those mentioned above or below (p. 110).
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> **1 ppm** for wells supplying water to be used in contact with or in the processing of food and beverages (p. 110).

The EPA and the NWWA suggest the centrifugal sand sampler as a method of measuring the sand content (p. 106).

The American Water Works Association has recommended that development of a well continue until the average sand production is not more that 5mg/1 (average of 10 measurements) for a complete pumping cycle of at least two hours at the designated pumping capacity. The AWWA specifies the Rossum Sand Tester for measuring the sand content.

The City of Bakersfield, Kern County, California, has set a limit of 1 ppm sand for domestic wells.

Recommended Guidelines for Sand Discharge

Any guidelines for allowable sand discharge should take into account the intended use of the water and the attributes of the distribution system. Flood-type irrigation systems can tolerate more sand than a system with many small valves and orifices, such as a drip irrigation system. In all cases, sand production should be kept below the limit at which significant damage to pumps occurs.

Sand production from a well is considerably greater after the initiation of a pumping cycle than it is after a period of continuous operation. With continued operation, sand production eventually reaches a constant level. In some wells, pumping a small amount of sand is necessary and beneficial, and usually occurs when pumping starts after a surge. Pumping a reasonable amount of sand after a surge flushes encroaching aquifer fines from the filter zone and removes them from the well. This minimizes plugging and maintains specific capacity. Ideally, sand production should be limited to the first few minutes of pumping and the quantity should rapidly drop with time. Guidelines for allowable sand production should take these facts into account.

The term "*sand-free*" is used differently by different authors. Driscoll defines "sand-free water" as water that contains less than 8 mg/1 of sand, silt, or clay (Driscoll, 1986, p. 526). The Roscoe Moss Company defines the term "sand-free" as a sand content less than 1 ppm (Roscoe Moss Co., 1985,p. 32). In previous meetings, members of the CGA Specifications Committee have suggested that the term "sand-free" be defined as a sand content of 2 ppm or less. However, because disagreement exists as to what constitutes "sand-free" water and because acceptable sand content differs for different end uses, the Committee may wish not to adopt a definition of the term "sand-free water".

RECOMMENDATIONS

The California Groundwater Association recommends the following guidelines for allowable sand production. These guidelines are similar to those recommended by the USEPA and the NWWA. The USEPA and NWWA guidelines have been sited by several authors, including Driscoll (1986) and the Roscoe Moss Company (1990).

> **15 ppm** for wells supplying water for flood-type irrigation, where the aquifer and the distribution system will not be negatively affected by 15 ppm sand (USEPA and NWWA, 1976, p. 109; Driscoll, 1986, p. 528; Roscoe Moss Co., 1990 p. 273).
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> **10 ppm** for wells supplying water for sprinkler irrigation systems, industrial evaporative cooling systems, and other uses where a moderate amount of sand is not harmful (USEPA and NWWA, 1976, p. 109; Driscoll, 1986,p. 527; Roscoe Moss Co., p. 273).
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> **5 ppm** for wells supplying water to individual homes, institutions, municipalities, and industries (USEPA and NWWA, 1976,p. 110; Driscoll, 1986, p. 527; Roscoe Moss Co. 1990, p. 273).
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> **1 ppm** for wells supplying water to drip irrigation and other systems which are very susceptible to plugging by sand, and for water to be used in contact with or the processing of food and beverages (USEPA and NWWA, 1976, p. 110; Driscoll, 1986, p. 527 and p. 655; Roscoe Moss Co., 1990, p. 273).

The Rossum Sand Tester should be specified to measure the sand content during the final test pumping of the well, and the limits for sand content should be met at the design pumping rate.

REFERENCES

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