

CHEMICALLY ENHANCED AQUIFER DEVELOPMENT IN UNCONSOLIDATED CLASTIC SEDIMENTS

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Abstract. The construction of high-yielding wells near the fall line is difficult due to the limited thickness of the Dublin-Midville aquifer, the hydraulic conductivity of this aquifer and the low elevation of the saturated zone. Chemically-enhanced aquifer development techniques have been used effectively to increase the yield of production wells completed in this aquifer.

INTRODUCTION

Golder Associates Inc. (Golder Associates) was retained by J. M. Huber Corporation (Huber) to assist in the development of additional process water supply for their facility located on the fall line approximately 6.2 miles north of Wrens, Georgia. This additional supply was necessary to support Huber's increased kaolin process capacity at the facility and to augment the surface-water supply that had proven unreliable during periods of drought. The challenge to Golder Associates was that:

- a sustainable yield of 600 gallons per minute (gpm) was required;
- the wells must be constructed on property controlled by Huber;
- the wells must be located as close as possible to the processing facility;
- a maximum of two wells could be constructed; and
- the new wells must not interfere with existing wells.

The purpose of this paper is to describe a case where the effective use of polyphosphate additives was crucial to the development of a successful water supply well field.

HYDROGEOLOGY

Physiography. The study area is located just south of where the metamorphic and igneous (basement) rocks of the Piedmont Physiographic Province are exposed through erosion of the sediments of the Coastal Plain Physiographic Province. This area is commonly referred to as the fall line due to the occurrence of water falls where the rivers cross this knickpoint. The ground surface in the study area ranges from 498 feet mean sea level (ft.MSL) to less than 290 ft.MSL. The property available for water supply development is located on a northwest-trending ridgeline that

is deeply incised by intermittent creeks flowing northeast to Brier Creek and southwest to Reedy Creek.

Stratigraphy. The basement rocks underlying the study area occur at an elevation of between approximately 165 to 220 ft.MSL. These rocks are covered by a weathering residuum that consists of 5 to 20 feet of dark- green, blue-green to gray clay. This residuum is overlain by Cretaceous- and Lower Tertiary-age sediments that consist of interbedded sands, clayey sands, sandy clays and clays.

Aquifer Characteristics. The coarser-grained sediments underlying the study area are part of the Dublin-Midville aquifer system (Clarke and others, 1985). These coarser-grained sediments occur in two zones. The upper zone occurs immediately below a thick (30 to 60 feet) kaolinitic clay between approximately 320 to 280 ft.MSL near the study area. The lower zone occurs between the top of residuum to as high as 280 ft.MSL. The static water level in the study area ranges from creek level (290 ft. MSL) to approximately 330 ft.MSL under the topographically higher areas.

WELL CONSTRUCTION AND TESTING

Two ground-water extraction wells were completed in the study area based on data obtained from the construction of 4 exploration borings and the two pilot borings for extraction well design. The first well completed, Hobbs Well #1, consisted of 75 feet of 24-inch grouted surface casing in a 30-inch borehole with 10-inch stainless steel screen set at depths from 120 to 140 feet (300 to 280 ft.MSL) and from 175 to 185 feet (245 to 235 ft.MSL) below the ground surface in a 23-inch borehole. The second well, Lewis Thiele Well #1, consisted of 88.5 feet of 24-inch grouted surface casing in a 30-inch borehole with 10-inch stainless steel screen set from 150 to 160 feet (310 to 300 ft.MSL), from 170 to 185 feet (290 to 275 ft.MSL) and from 215 to 265 feet (245 to 195 ft.MSL) below ground surface in a 23-inch borehole. The screen used was 0.040-inch spaced wire wrapped. The static water levels at the time of completion were approximately 333 ft.MSL in Hobbs Well #1 and 320 ft.MSL in Lewis Thiele Well #1.

Well development was conducted on both wells after construction. This development consisted of surging the well with a surge block and concurrently purging the well with compressed air introduced through the surge block. Well development was continued until the discharge from the well was clear immediately after surging. Each well was developed in this manner for at least a week before the discharge water cleared.

Short pumping tests were completed on the wells to assess their yield for pumping system design. The specific capacity of the Hobbs Well #1 was 11.3 gallons per minute per foot of drawdown after 200 minutes of pumping. The specific capacity of the Lewis Thiele Well #1 was 3.3 gallons per minute per foot of drawdown after 200 minutes of pumping.

CHEMICAL TREATMENT

Rationale. The pumping tests completed on the wells after construction indicated that the sustainable yield from these wells would not be adequate to satisfy the needs of the facility. The wells had been installed in a manner to provide the utmost efficiency and in locations with the greatest yield potential. The only option available to increase the yield from the wells was to find a way to increase the specific capacity of the well. Golder Associates recommended the use of polyphosphates in an attempt to deflocculate the clays that were introduced during drilling and not removed using standard well development techniques. In addition, we hoped to introduce the polyphosphate in a manner that naturally occurring clays disseminated in the aquifer would also be deflocculated and therefore more readily be removed during development.

Recipe. Two development fluids were used. The first was a chlorinated polyphosphate solution used to treat the clays. The second was a hypochlorite solution used to force the polyphosphate solution into the aquifer. The polyphosphate solution consisted of 15 pounds of powdered sodium tripolyphosphate and 2 pounds of powdered sodium hypochlorite per 100 gallons of water. The hypochlorite solution consisted of 2 pounds of powdered sodium hypochlorite per 100 gallons of water (Driscoll, 1986). The amount of each of these solutions needed was determined by calculating the wetted casing volume and the porosity volume of the filter. The intent was to introduce the polyphosphate into the aquifer, not simply the filter. The chlorine was added to the solutions to minimize the bacterial growth potential that could occur as a result of the introduction of the phosphate, which is a nutrient to bacteria.

The chemical solutions described above were mixed in 55-gallon batches prior to injection into the well. While this was very time consuming and tedious, it was effective given the equipment available at the time. A better approach might be to mix the chemicals in a large batch by recirculating water in a truck-mounted water tank from the back and

through a mud funnel mounted on the filler neck using a gasoline powered pump. The prescribed amount of powdered ingredients would simply be added to the top of the mud funnel and mixed into the stream from the pump.

APPLICATION

Completed Well. Prior to the decision to attempt chemical development, a permanent pumping system had been installed in the Hobbs Well #1. The development fluids, the chlorinated polyphosphate solution followed by the chlorinated water, were therefore introduced to the screened interval through a stilling well, installed to monitor the water level in the well. After the fluids had been introduced, the well was surged by introducing compressed air through the stilling well then left undisturbed overnight to give the development solutions time to react with the clay. The development fluids were then pumped out with their entrained sediment until the well discharge appeared clear.

Open Well. The test pump had been removed from the Lewis Thiele Well # 1 after the initial pumping test. This allowed the development fluids to be introduced through a surge block followed by standard well surging and air-lift pumping. The well was then developed until the water produced appeared clear.

TREATMENT EFFECTIVENESS

The results of pumping tests completed in the wells after chemical development confirmed the effectiveness of the chemically-enhanced development of the wells. The specific capacity of the Hobbs Well #1 had increased to 18.3 gallons per minute per foot of drawdown after 200 minutes of pumping. The specific capacity of the Lewis Thiele Well #1 had increased to 5.9 gallons per minute per foot of drawdown after 200 minutes of pumping. This represents a 62% increase in the specific capacity of the Hobbs Well #1 and a 79% increase in specific capacity of the Lewis Thiele Well #1 at 200 minutes into pumping. While the total capacity of each of these wells is still governed by the available drawdown, this increase in specific capacity resulted in the development of a successful water supply. It should be noted, however, that while the specific capacity data derived from such a short -duration pumping test is useful for the purposes described herein, it is not a reliable predictor of the ultimate sustainable yield from a well.

LITERATURE CITED

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