By Pat McCool, KRWA Consultant

Addressing High Nitrates in an Unconventional, Possibly Better Way

The conventional way of addressing high nitrate levels in public water systems in Kansas typically is to construct a nitrate-removal water treatment plant. This has been and may be the best option in some circumstances. But such a plant is very expensive and other options might be possible.

Evaluating options

The city of Cunningham has approximately 450 residents; the city is located in western Kingman County in south-central Kansas. The city has two water supply wells; both are located in the city park. For the last four years the nitrate levels in the city wells have averaged in the 9.0 to 9.6 mg/l range for Well #1 and in the 7.3 to 7.9 mg/l range for Well #2. Historically, these two wells had nitrate levels around 4.5 to 7 mg/l in the 1960s thru the early 1970s.

The city council is investigating how to lower the nitrate levels in the drinking water. The council considered constructing a nitrate-removal water treatment plant as some other cities in Kansas have. But because the high costs of constructing, financing, operating and maintaining such a plant would create high monthly water bills to the residents discouraged this option. Typically, a nitrate-removal plant for a community the size of Cunningham would cost approximately $2 million.

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The Cunningham city wells and storage tank are typical of many Kansas cities.

The council thought that if the method and rate of pumping the present city wells and the construction of another city well in the same area could be successful, then considerable costs would be saved compared to constructing a treatment plant or a well at a more distant location.

The council employed the services on consulting geologist Ned Marks of Terrane Resources, Stafford, KS, to investigate if the nitrates could be lowered depending how the city pumps water from the aquifer. Ned Marks has been successful in other situations in determining how nitrates get into the water being pumped by investigating from what levels water is being pumped. Also, Ned has determined how water can be pumped so as to lower the nitrates and how wells can be constructed in the same vicinity but have lower nitrates in the water being pumped.

Addressing the problem below ground

There are many important variables that need to be investigated and evaluated to determine how nitrates get into the water being pumped. Readers of this article should note that it is the water being pumped that is important and not necessarily all the water in the aquifer. Once these variables are known, then possibly there are several actions that can be taken to reduce the nitrate levels in the water being pumped.

There are two important concepts to understand when investigating and evaluating high levels of nitrates in water being pumped. First, in many situations the nitrate enters the groundwater aquifer at the top of the aquifer. This is from nitrates in the soil transporting down through the soil and subsurface formations to the aquifer. Thus, the nitrate levels at the top of the aquifer can be much higher than in the middle or the bottom of an aquifer.

The difference in the levels of nitrates in an aquifer can vary depending on the depth to groundwater, the saturated thickness of the aquifer, precipitation, the source and location of the pollution source, and any wells in the area that can allow water at the top to move to the lower levels.

Monitoring well being constructed in the Cunningham city park by Clarke Well & Equipment of Great Bend, Kansas

One aquifer in Kansas has a nitrate level of 1.4 mg/l in the lower water at the bottom of the aquifer, 6.5 mg/l in the middle water, and 24.1 mg/l in the water at the top of the aquifer. Such a situation requires careful consideration because it is possible to construct and pump a well so that only the low nitrate water at the bottom of well will be pumped. Unfortunately, in Kansas most existing water supply wells are not constructed in a manner that can accomplish such pumping.

Sand and gravel from the aquifer, subsurface formation

Well construction

The second important concept to consider is how existing wells in the nearby area are constructed and how will any new water well be constructed so that the nitrate level in the water being pumped from the new well will be lower in nitrate. The possible problem with existing wells and the proper construction of new wells concerns how a well is sealed during construction.

For example, a well is drilled with a bore hole diameter of 30 inches. Then a 12-inch diameter steel casing pipe is installed. This results in a void space of nine inches between the outside of the casing pipe and the bore hole. This void space is called the annulus or annular space. It is the annular space that possibly provides the direct path for nitrate contamination to enter the water being pumped.

During construction some of the annular space is filled with grout or bentonite clay. The grout is a cement-water mixture. The grout or bentonite clay produces an impervious seal or barrier to the flow of water and contamination down the annular space to the water being pumped.

Most public water supply wells are sealed from the ground surface down the annular space for 20 feet. This is done to prevent water and contamination near the surface around the well from contaminating the well. Without grout or a bentonite seal below the 20-foot level, water and contamination can move down the annular space to the well screen and then enter the water being pumped.

There are two main categories of aggregate that fill the annular space where there is not grout or bentonite seal. First, a sand aggregate is used to fill the space so as to give structural support to the pipe and to prevent any cave-ins of geological formations into the annular space. The sand aggregate is usually installed below the sealing grout or bentonite clay and above the gravel pack.

The second category of aggregate is a specified size of gravel called "gravel pack" that is sized to allow the easy flow of water to the well screen while stopping the flow of smaller sand that could reduce the flow of water at the screen. Gravel pack is usually installed around the well screen and possibly at levels somewhat above the well screen.

When the annular space of an existing well or a new well is not properly sealed, then high nitrate contamination at the top of an aquifer can enter the water being pumped, thus causing higher nitrate levels than if only water at the bottom of an aquifer were being pumped. This is a simple explanation of what can be a complex problem because other variables can make the investigation and evaluation even more difficult or easier. A knowledgeable groundwater geologist is most valuable in such matters.

Cunningham's approach

In November 2012, monitoring wells sometimes also called "test holes") were constructed near the city of Cunningham's wells. The subsurface formations were logged and water samples were collected. The well logs showed that there are two somewhat separate aquifers and these two aquifers appear to be separated by three feet of impervious clay. This is important because the clay prevents water and contamination from the upper aquifer getting into the lower aquifer.

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The analyses of the water samples showed an upper aquifer nitrate level of 9.3 mg/l and a lower aquifer nitrate level of around 4 mg/l. As a result, the city appears to have several options. First, the city could construct a well that only pumps water from the lower aquifer. That water could be pumped directly to the residents or blended with the city existing well water to lower the nitrate level of the existing well water.

Second, the city could install small capacity water wells in the upper aquifer upgradient of the city's existing wells to intercept the higher nitrate water at the top of the aquifer and use that water from the intercepting well(s) to irrigate the football field. This would further reduce pumping on the city water supply wells and possibly reduce nitrates in the water being pumped from the city's existing wells.

The city and its consulting groundwater geologist, Ned Marks, have further evaluations and testing to complete, but it appears that they have several options and decisions in the future to reduce nitrates without incurring the high costs of constructing a nitrate-removal water treatment plant.

Nitrates in groundwater

Any city or rural water district that has nitrate levels exceeding or approaching the 10 mg/l maximum contaminant level (MCL) should consider the advantages of addressing the problems in the subsurface. They should determine if it is possible to lower nitrate levels by addressing contamination conduits such as an existing well and by constructing a new well in the same vicinity that pumps only low nitrate water from the bottom of the aquifer.

Learn more

The upcoming KRWA Conference has a host of presentations dealing with water quality issues. Ned Marks is scheduled to present a preconference session on Tuesday, March 26. The session is entitled "Kansas Groundwater and Public Water Supply Wells". This session will include the discussion of many topics including water well construction and contamination. This session will be beneficial to anyone interested in knowing more about groundwater and water wells. I hope every city and rural water district that has wells, or has concerns about groundwater quality issues will attend this session.

I also encourage anyone from any city or rural water district in Kansas to discuss options that are available when evaluating nitrate problems. The last thing any system should do is to only consider constructing a capital-intensive nitrate removal system. KRWA staff members are available to meet with cities and RWDs to review the situation and also to comment on options that are likely available.

Pat McCool has worked as a consultant to KRWA since January 2004. He previously worked for KDHE for 30 years. Pat has a bachelor degree in Chemical Engineering and a masters degree in Environmental Engineering from the University of Kansas.