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A comprehensive approach to improving well performance

The long-term performance of a well is probably the most neglected component in the well field operation. Traditionally, much of the maintenance effort is focused on the water distribution system (pumps and pipes) or treatment requirements for water quality, not performance – until a problem occurs in the form of declining well yields.

When the well is not producing enough water to meet supply demands, the well owner assumes that it is a pump problem and calls a pump contractor or driller. If the pump is not the problem, the next step is a quick rehabilitation before placing the well back online.

This approach to managing well performance is analogous to operating a car, while never changing the oil until the red oil warning light comes on. It shortens the life span of a car and ends up costing the owner more money in maintenance.

In recent years, well owners in Europe, Canada and the US are opting for a more holistic approach to well operation and maintenance, by managing the entire lifecycle of their wells to optimize long-term well performance.

The key factors that influence well performance include well design and construction, operation, biological and mechanical plugging and maintenance. The extra attention and money expended to address these factors will result in wells with maximized production capacity and minimized repair downtimes.

In well design and construction, it is best to maximize the screen or water producing interval of the well to the entire thickness of the aquifer and to match the screen slot size design with the formation material. This may require drilling a little deeper than anticipated or collecting additional formation samples, but the payoff is a more efficient well that minimizes factors that affect well performance, such as biological and mechanical plugging.

A common error in new well construction is insufficient development time. New well development is essentially the same as rehabilitation of an old well. The goal is to get enough energy into the surrounding formation to remove finer grained material and develop a zone of relatively unobstructed pore spaces, allowing water to flow as directly as possible into the well. The more laminar flow is obstructed, the more the well is stressed and the less efficiently it will operate. This inefficiency results in greater pumping costs and leads to faster development of biological deposits and the re-introduction of fines into the pore spaces (mechanical plugging).

Well plugging problems

An aquifer's natural microbiology usually proliferates when a well is installed and operating. The available supply of dissolved minerals and oxygen greatly increases around the borehole of the well and screen interval, due to increased flow velocity and turbulence. This allows for more rapid growth of biological deposits or formation of mineral encrustations that can plug screen openings and the pore spaces near the screen and borehole. Routine pumping also pulls back in fines from the surrounding formations that plug the pore spaces, eventually reducing the open area for water to enter the well.

In all wells, the primary water producing zone is not uniformly distributed across the entire length of a screen interval. For example, in a 20-foot screen interval, a significant portion of the well's capacity might come from a five-foot section of the screen. This zone suffers the most functional impairment from biological and mechanical plugging. Likewise, impairment of the localized zone pushes other portions of the water bearing zone to supply water to maintain the desired capacity. Ultimately, added stress on the well reduces efficiency and increases biological and mechanical plugging problems. One of the best ways to minimize plugging includes recognizing and repairing problems early.

Monitoring specific capacity is a simple, reliable way to spot plugging problems. A well's specific capacity equals the discharge rate (in gpm) divided by the water level drawdown (in feet). For example, a well with a pumping rate of 100 gpm and 10 feet of drawdown has a specific capacity of 10 gpm/ft of drawdown. By keeping track of the specific capacity over time, a well owner can assess when conditions are beginning to affect well performance and schedule maintenance accordingly.

If plugging conditions are not addressed early, the decline in specific capacity will increase faster over time, and the lost specific capacity will become more difficult to regain. A good rule of thumb is to initiate maintenance before specific capacity declines 10%.

Ideally, well maintenance should not wait until there is a loss in specific capacity. Like regular oil changes in a car, regular well maintenance extends well life and results in lower long-term operational costs. When a well pump is pulled, a video inspection can help determine if biological plugging is occurring and if it is time to rehabilitate. A periodic pumping test will help determine if a well has lost efficiency which, if there is no biological plugging, could indicate mechanical plugging from the migration of fines.

Time to rehabilitate

Most well owners must eventually address well performance and rehabilitation. To maintain long-term performance and well life, rehabilitation should be planned at regular intervals. Primary rehabilitation options fall into three categories:

- Chemical – acids, bases, dispersants, antibacterial agents;
- Mechanical – surging, brushing, jetting, freezing; and
- Impulse generation – detonation cord, impulse generators.

Before selecting a particular method, the contractor should assess the well's condition and prepare a rehabilitation plan. Remember, a successful rehabilitation project is not related to one particular rehabilitation method. Rather, it is a process that may include using several of the approaches outlined above.

The contractor should monitor the rehabilitation work throughout the process to evaluate progress and document when further efforts are not necessary. Concluding the rehabilitation work too soon will result in a less efficient well and one that will likely need additional rehabilitation much sooner.

New rehabilitation alternative

Impulse generation has shown significant success when used to rehabilitate old wells and for development of new wells. The principle of this process lies in managing the sudden release of a compressed gas, which produces an elastic impulse and a secondary expansion of the gas bubbles, which cause the formation material and well screen to vibrate, loosening mechanically plugged sediment and biological deposits. The impulse generator is inserted and positioned in the well screen or water producing zone and, through a pressurized hose, temporal impulses of high pressure nitrogen are released. The impulse generator is equipped with a valve system that releases the accumulated energy (200 to over 2000 psi) in millisecond bursts, through a large cross sectional area.

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German city takes non-chemical approach to well rehabilitation

The city of Berlin, Germany gets its water exclusively from 850 wells. The well field consists of both traditional vertical wells and horizontal collector wells. The vertical wells were constructed over the past 50 years and include a variety of screen materials such as ceramic, steel and stainless steel. Most of the wells are between 100 and 350 feet deep, 16 to 24 inches in diameter and completed in glacial sand and gravel deposits.

The city's heavy dependence on this well field, as well as strict environmental laws, has driven city water management staff to develop and maintain a very aggressive research and development program on well performance monitoring, operation and maintenance and especially the development and enhancement of non-chemical well rehabilitation technologies.

Berlin's experience with long-term well performance monitoring and maintenance offers some unique approaches applicable to well systems in North America and other parts of the world.

One of the most effective non-chemical rehabilitation technologies used to maintain the Berlin well system includes an impulse generation device (Hydropuls®) used in conjunction with other traditional mechanical methods.

In addition to innovative rehabilitation technologies the City of Berlin Water Division has developed a comprehensive asset management approach to its well field. A key component to this process is tracking of well performance criteria such as yield, water levels, water quality, corrosion and biofouling potential. This data is combined with information about well age and construction to develop an asset profile for each well.

Today, Berlin's extensive well field operates at a high level of efficiency helping the city water staff maintain a quality drinking water supply.

In July 2003, published independent research by the Ground Water Research Center in Dresden, Germany compared the ability of various well rehabilitation technologies to impact the gravel pack and surrounding formation materials. The technologies evaluated included high and low pressure water jetting, sonic devices and impulse generation devices. The study focused on the ability of each method to generate energy at various distances into the formation surrounding a well. The impulse generator was shown as the most effective technology with respect to depth of penetration and measured energy beyond the well screen. Impulse generators can be used in a variety of well types including vertical and horizontal stainless steel screened wells, perforated or slotted steel casing, uncased open-hole wells and wells with PVC screens.

The US and European patented impulse generation tool – Hydropuls® – described above has been used in Europe and Germany for many years on hundreds of wells and is one of the primary methods the City of Berlin uses to maintain more than 850 wells.

This impulse generation tool has also been used effectively on many wells in Western Canada and the US for both new well development and rehabilitation. For example, on Vancouver Island, the Regional District of Nanaimo has been developing a comprehensive well maintenance program that uses a proactive approach to the long-term sustainability of its 27 wells. The District has used the impulse generation method as part of its well maintenance program since 2005. By addressing well performance issues early on, often before a noticeable decline in yield, they hope to extend the lives of their wells and minimize the need and expense associated with finding locations for and constructing new wells.

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