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"Run to failure" is a costly approach to well maintenance and rehabilitation. Shifting to a proactive maintenance strategy can extend pump and well service life, save money, and keep water quality consistent. BY MICHAEL JUDKINS AND MICHAEL KENNISON

WATER WELL MANAGEMENT: A PROACTIVE MAINTENANCE PROGRAM PAYS OFF

WATER WELLS REQUIRE regular maintenance to ensure adequate water flow, efficient operation, and optimal water quality. The traditional approach to well rehabilitation and maintenance is "run to failure," or "monitor to failure," meaning the well continues to operate with no preventive maintenance until the production rate declines to an unacceptable level or water quality can't be tolerated by residents or regulatory standards. A more effective strategy is a proactive water well asset management approach.

Time-based, preventive maintenance of all well structures, equipment, and accessories is important to provide long-term, trouble-free service. Effective well asset management maintains an established production rate, consistent water quality, and lower pumping costs during the well's life span, helping to extend the service life of the well and pump. The primary goal of any well maintenance program is to preserve the well's formation porosity with time-based treatments and cleaning, thereby avoiding total formation fouling, which leads to extensive rehabilitation or costly emergency repairs.

The current industry standard is to perform well maintenance based on the pump repair cycle, as this is the most opportune time to access the borehole for maintenance cleanings. Pump manufacturers typically suggest a pump should be pulled from a well for repairs every eight to 10 years for a preventive maintenance overhaul, so most well owners follow this same cycle for well maintenance. This is far too long to allow a well to operate without maintenance or repairs.

PHOTOGRAPH: SUEZ

Population growth and rapid urbanization are pushing groundwater supplies to the limit, making it more important than ever for water utilities to keep their water supply wells at peak design capacity and extend well service life through preventive maintenance.

WHAT CAUSES WELL FAILURE?

When a well is pumped, water is drawn through the formation toward the borehole for extraction by the pumping equipment. The water is exposed to oxidizing factors as it approaches the borehole, and it experiences changes in temperature, pressure, and oxygen exposure. Oxidation may cause any minerals to precipitate and become lodged in the formation's pore space. The formation begins to act like a typical filter, capturing the precipitated minerals.

These deposited minerals can become a nutrition source for the naturally occurring bacteria in groundwater, which can result in rapid growth and further increase the plugging of the formation pores. This plugging is further accelerated as fine silts and sand become lodged in the debris. Unlike a typical filter, removing this mineralogical, bacteriological, and mechanical plugging is difficult because there's no way to "backwash" the formation.

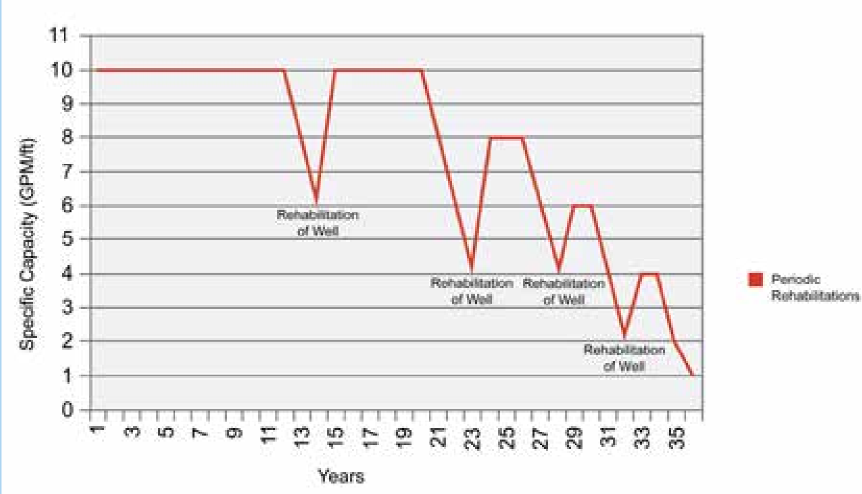
Traditional methods for rehabilitating and cleaning wells, such as chemical treatment, are ineffective at reclaiming most of the plugged pore space. As the formation begins to plug, the well simply reacts and allows the water to flow from the remaining available pore space.

The water will always take the path of least resistance, a phenomenon that can limit the effectiveness of traditional well cleaning methods. Where a well can produce water, it can also drink water. As a result, the introduction of chemicals by gravity flow from the surface will only penetrate the open pores in the formation and not enter the plugged pores. This leads to a super-cleaning of the already open pore space and limited or no cleaning of the pores that will not accept flow, resulting in a limited amount of reclaimed pore space.

When the well is placed back into service, all the flow will be localized in the limited pores that were cleaned, resulting in accelerated plugging. Therefore, most wells will experience progressively shorter run cycles between rehabilitations, eventually leading to well failure (see figure above).

Typical Well Yield Decline Over Time

Without preventive maintenance, well production rates steadily decline to an unacceptable level.



Well operators are limited in their ability to detect the deterioration of a well's condition, as it's impossible to physically touch or see the formation and pore space as it plugs. One can only conceptually visualize the plugging taking place. The only way to detect formation decline is by witnessing a change in water quality or a decline in the well's production.

The water well industry uses specific capacity (gpm per ft of drawdown) as a true calculation of a well's overall efficiency for producing water. Operators are taught to record and chart specific capacity and react once a decline is measurable. However, the use of specific capacity to detect and monitor the amount of formation plugging may be shortsighted. A well is rarely designed to pump at its full productive capacity, as excess pore space is made available in the design phase to ensure efficient operating conditions. As a well is pumped, minerals and bacteria consume the additional pore space.

It isn't until the excess pore space has been consumed that flow restriction from the formation occurs and a recordable drop in pumping level is detected. Similar to the throttling of a gate valve, it isn't until the valve is almost fully closed that an increase in back pressure is recorded.

Similarly, it isn't until the excess pore space has been consumed by plugging and the remaining pores are incapable of meeting the demand that the flow turns from laminar to turbulent flow, indicated by a noticeable drop in the pumping level. It isn't until considerable formation damage has been caused by plugging that it's possible to notice a reduction in specific capacity. Once a formation is plugged to this extent, a comprehensive rehabilitation is needed to recover the pore space. Therefore, a means to detect formation plugging must be used to proactively manage a well and clean the formation before well failure.

REHABILITATION TECHNOLOGY

Effective water well asset management programs are designed to employ

A comprehensive preventive maintenance program can save utilities thousands of dollars and mitigate risk from unhappy customers and regulators.

optimal rehabilitation technologies to restore well porosity as close as possible to the original condition. Rehabilitation technologies are selected based on an initial comprehensive condition assessment, including historical data gathering, water quality review, and downhole video inspection.

Appropriate rehabilitation technology should be applied based on information from the condition assessment. The technology must allow for energy to be directed into and throughout the entire formation. Effective delivery of the development energy is necessary to thoroughly dislodge and disrupt the encrustation within the formation pore space, but this does little to extract debris.

A critical step in well rehabilitation is following up rehabilitation measures with a redevelopment process. A double-disk surge block equipped with a submersible or air lift pump will help draw the dislodged debris from the pores in the formation. A properly deployed surge block operation can create high-energy inrush flows capable of drawing debris into the borehole. Removing plugging materials and reclaiming the original pore space are critical to regaining the well's full productive capacity and increasing longevity.

Well maintenance companies should conduct a postdevelopment video inspection to confirm cleaning results and inspect the casing/screen for integrity. Once the formation's redevelopment is complete and the pore space has been reclaimed, it's important to manage the formation through time-based preventive maintenance cleanings to avoid the traditional run-to-failure cycle.

Most well treatment technologies require the pumping equipment's removal for the process to be deployed. However, advancements in well rehabilitation technology allow for sufficient energy to be released downhole to clean the formation without removing the pump, reducing maintenance costs.

The objective of well preventive maintenance is to cause sufficient energy downhole on a time-based cycle to disrupt potential deposition before it solidifies. This approach to managing the pore space maintains the well's performance and efficiency. An effective maintenance program will extend the well's service life in addition to reducing—and potentially eliminating—the need for rehabilitations.

MAINTENANCE OPTIONS

Third-party well maintenance programs can be a cost-effective option for utilities. First-year costs typically include the well's comprehensive rehabilitation, the pumping equipment's repair or replacement, and the maintenance tooling's installation. These upfront costs are often spread over years to help utilities with budget constraints.

In addition, most companies offer a perpetual guarantee to maintain the well's production after initial rehabilitation through time-based cleanings. Pumping equipment and motors are usually included in the guarantee in addition to emergency repairs, allowing utilities to avoid unforeseen expenses.

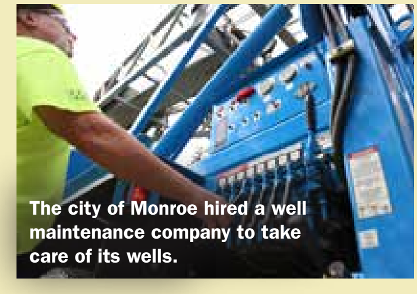
Other benefits of a well maintenance program include extended asset life, reduced operational costs, improved and consistent well performance and water quality, and greater knowledge of the well's condition through maintenance reporting.

Regardless of whether utilities outsource their well maintenance programs or perform the work themselves, maintaining clean, reliable water sources is vital to helping preserve effective water treatment plants and distribution systems. Water is produced from different zones within a well, and each of these geologic layers can have differing water characteristics. A clean, properly maintained well will provide a stable blend of water from these formation layers.

A comprehensive preventive maintenance program can save utilities thousands of dollars and mitigate risk from unhappy customers and regulators. In addition, properly maintaining existing wells and ensuring a reliable output capacity help utilities avoid the need to construct additional wells.

CASE STUDY

OUTSOURCING WELL MAINTENANCE DELIVERS WIDESPREAD BENEFITS



The city of Monroe hired a well maintenance company to take care of its wells.

PHOTOGRAPH: SUEZ

In 2015, the city of Monroe, Wis., was facing a dire situation with its municipal water wells. One of its five wells needed repair and would have to be pulled aboveground for rehabilitation (at a cost of $500,000). This came only five years after the same well was repaired for $400,000. Several other city wells also needed rehabilitation and repair in the next few years. With a 2016 well maintenance budget of only $124,000, the city was faced with either tapping into emergency funds or borrowing from other budgets to properly maintain the wells.

Instead, the city contracted with a well maintenance company, which provides oversight, maintenance, and repairs of all five wells for an annual perpetual adjusted fixed rate of $120,000. City employees are no longer responsible for maintaining the wells beyond daily operations. The well maintenance company is accountable for upfront rehabilitation, proactive monitoring, and maintenance. Also, because the costs are spread out over 10 years, the city can easily fit them into its budget.