James Gaunt, lead plant operator, on the oxidation ditch at the Great Bend treatment facility.

A Nutrient Reduction Bargain

A KANSAS OPERATIONS TEAM REDUCED EFFLUENT NITROGEN AND PHOSPHORUS WITH SIMPLE PROCESS ADJUSTMENTS AND AVOIDED A $6 MILLION INVESTMENT IN A NEW CLEAN-WATER PLANT

By Ted J. Rulseh

Facing a need to reduce effluent nitrogen and phosphorus, the Kansas city of Great Bend had a choice: Try to get it done with oxidation ditch process adjustments, or invest millions of dollars in a new clean-water plant.

The operations and laboratory team members chose process changes. With the advice of an operations specialist, the addition of a $25,000 variable-frequency drive, some diligent work and a little trial and error, they succeeded.

Effluent total nitrogen has come down from 8 to 12 mg/L to 3 to 6 mg/L on average, and total phosphorus has dropped from about 2 mg/L to 0.5 mg/L or less, against state-prescribed goals of 10 mg/L nitrogen and 1.0 mg/L phosphorus.

While the initiative is a work in progress and effluent nutrient levels are subject to seasonal variation, the work to date has met the approval of the Kansas Department of Health and Environment (KDHE).

If at some point the state sets actual permit limits on the two nutrients, "We won't treat it as a not-to-exceed," says Tom Stiles, director of the department's Bureau of Water. "It would be a rolling average over 12 months and would take the ebb and flow of the seasons into account, so they would not be penalized for that. Their performance has been great."

DOWNWARD PRESSURE

Great Bend, just about smack in the center of Kansas, is a mostly residential community of 15,000. It is home to the Fuller Brush Co. and lies just southwest of the Cheyenne Bottoms Wildlife Area, a major stopping point for migrating waterfowl.

Built in 1952 and upgraded in 1998, the wastewater treatment plant has a design flow of 3.6 mgd and an average flow of 1.28 mgd. The plant upgrade was completed at a time when the city was expected to grow, but then the local oil industry mostly faded away. Only one of the plant's two racetrack-style oxidation ditches (Ovivo) was ever placed in operation.

Influent wastewater passes through an automatic bar screen (Parkson Corporation) and newly installed grit removal system (Smith & Loveless). After the oxidation ditches, the water flows to a pair of secondary clarifiers, followed by UV disinfection (TrojanUV). Thickened biosolids are anaerobically digested and land-applied as a Class B liquid product.

In April 2020, the city received a letter from KDHE stating the goals of 10 mg/L total nitrogen and 1 mg/L total phosphorus. The city had tried five years earlier, unsuccessfully, to meet those goals.

Stiles notes that Kansas had made nutrient reduction a priority since the early 2000s, focusing on mechanical treatment plants and emphasizing biological nutrient removal. "Subsequent to that we had total maximum daily loadings come through on a variety of streams that were deemed to be impacted by phosphorus," says Stiles. "So the regulatory push has been nutrient reduction in the face of TMDLs that would result in permit limits."

TWO STEPS

To make the needed process adjustments, the city team worked with consultant Grant Weaver — a licensed wastewater operator, professional engineer and president of CleanWaterOps — who was under a contract with the state to provide technical advice on nutrient reduction strategies using equipment and resources on hand.

They devised a two-step plan. First, operate the main body of the oxidation ditch to continue the removal of ammonia, while also removing nitrate. This would enable the pre-anoxic zone designed for nitrate removal to be employed for phosphorus reduction. Second, make adjustments so that the pre-anoxic zone becomes anaerobic — and as it does, get it to work as a fermenter to support and drive biological phosphorus removal.

A key to the process changes was the addition of a variable-frequency drive to the vertical-shaft aeration rotor at the front end of the aeration ditch to enhance control of dissolved oxygen, notes James Gaunt, lead plant operator.

"Before we had a high and a low switch, and typically just always ran on high," Gaunt says. "Now we have automated control of that rotor speed through a DO probe (YSI, a Xylem brand) in the aeration basin. That enables us to create different zones with different levels of DO for better removal of nutrients, while still maintaining our ammonia level."

Weaver observes, "The operators began adjusting the DO setting downward in an effort to provide enough oxygen to continue converting ammonia-nitrogen to nitrate-nitrogen, while at the same time limiting the amount of oxygen added to the ditch. This allows a portion of the ditch to become sufficiently oxygen deficient (anoxic) to support nitrate-nitrogen conversion to nitrogen gas. It took a few months until they got it dialed in."

Next, they then closed the gate that lets flow recycle from the ditch into the pre-anoxic zone. In addition, says Gaunt, "The anoxic zone on the back side of the aeration basin had a mixer on it. We turned that off; now we run it for 15 minutes a day just to keep the water from going completely septic."

SEEING RESULTS

So far, the changes are having the desired effect. "For the last quarter of 2020, we saw 0.5 mg/L phosphorus and about 7 mg/L total nitrogen, of which about 5 mg/L was nitrate," Stiles says. "Those are good numbers from our perspective."

The accomplishments in Great Bend and similar Kansas cities are helping to pave the way for what Stiles calls an inverse trading program for nutrients, notably phosphorus, as a way to help reduce loadings to streams. "We're looking to invite cities to participate in water-quality trading, potentially spending money not in the city but in the rural areas to help farmers with nonpoint source loads," Stiles says.

"Instead of waiting for the farmers to generate credits, we've got the cities generating credits that allow them to expend resources out into the watershed to bring the agricultural sector more into line with reducing nutrient contributions."

Weaver sees the Kansas program as a way for communities to "take free advice" on innovative and affordable ways to reduce effluent phosphorus. "Great Bend is a good example, but it's not the only one," he says. "Other communities in the state, some working with me, some working with Kansas Rural Water circuit riders, some on their own without any outside support, have done great jobs. The state has given municipalities the chance to take some technical advice and run with it.

> "Operators can make this approach work or not. It's totally up to the operations team. The Great Bend team took the challenge to prove it workable."
> **GRANT WEAVER**

The Great Bend team includes, from left, Trenton Brown, operator; James Gaunt, lead operator; April Batt, lab technician; Reuben Martin, utilities superintendent; Jenna Pitchford, utilities supervisor; and Ben Frayer and Doug Prosser, operators.

TEAM EFFORT

"Great Bend took advantage of that and ended up saving a lot of money and getting it done quicker, and also more sustainably, because they're not using chemicals and they didn't have to build anything. They put their brains and energies to work. Operators can make this approach work or not. It's totally up to the operations team. This team took the challenge to prove it workable."

Jason Cauley, public works director, praises the plant team members for their effort: "We have to give James credit for a lot of this work. He has followed Grant's advice to a tee and has done a really great job in helping us meet the standards. April Batt, our lab technician, has supported the effort by performing the necessary tests along the way. Between those two we have done really well. They have worked really, really hard to get us to this point." tpo