

Minnesota town achieves low nitrate and phosphorus with Orbal® oxidation ditch system

The city of Caledonia, Minnesota, sits in the hilly countryside of southeastern Minnesota. The Caledonia Wastewater Treatment Facility (WWTF) serves the city's 2,800 residents as well as local industry. The treatment facility currently receives an average of 200,000 gallons per day with a peak flow capacity of two million gallons per day.

Built in the 1970s, the Caledonia WWTF was aging and struggling to treat modern wastewater. Cold weather and stormwater, industrial wastewater from a local food hauler, and strict effluent limits were stressing the original sequencing batch reactor (SBR) system beyond its capacity. As a result, the plant consistently exceeded its nitrate, coliform, and other permit limits.

The impact of these exceedances was particularly dire because the WWTF discharges to groundwater, the local source for farm irrigation and city drinking water. Concerned about the risk of health impacts of high nitrates in water, such as Blue Baby Syndrome, the Minnesota Pollution Control Agency directed Caledonia to build a treatment process that could reliably meet permit.

But the city had design constraints. The new plant had to fit the current plant's footprint; the existing plant was landlocked and could not be expanded. Like many rural towns, the plant operators held various public works responsibilities, such as road work and animal control. The new plant could not require more of their time or more employees.

"We needed a system that only required one person to run it at a time," explained Jake Dickson, City Administrator of Caledonia.

Solution

Caledonia's consulting engineer, Donahue and Associates, evaluated the city's options and ultimately picked The Orbal System, due to its small footprint, proven denitrification performance, and process engineering support from Xylem.

The Orbal System for biological treatment uses an activated sludge process designed to address today's nutrient and stormflow demands.



Aerial view of the Caledonia, MN Wastewater Treatment Facility

Customer

Caledonia, MN, Wastewater Treatment Facility (WWTF)

Challenge

The Caledonia WWTF was facing aging infrastructure and required a solution that fit its existing plant footprint, complied with stricter regulations, and could be operated with minimal staff.

Solution

The Orbal system for biological treatment to address nutrient and stormflow demands.

Results

The Orbal system is consistently achieving total nitrogen levels of 1.2 mg/L far below the 10 mg/L permit limit with minimal operation requirements or maintenance

“It’s been operating great. It frees up quite a bit of time for my operators because there’s a lot that they don’t have to do anymore.”

Jake Dickson, City Administrator of Caledonia

The simultaneous nitrification/denitrification (SND) process features dedicated zones that operate in series during the treatment process. The system is designed to be easily modified to meet a large variation of effluent limits.

Donohue designed a first-of-its-kind multi-barrier Orbal® system that simultaneously addressed stormwater flows, industrial wastewater loading, and upcoming state nutrient limits. The original plant’s tanks were repurposed as equalization tanks, primary clarifiers were excluded to retain carbon in the system, and advanced sensors were installed to monitor dissolved oxygen, nitrogen, and oxidation-reduction potential to ease operator burden, save energy, and stabilize the treatment process.

Results

Within months of completion, the Caledonia WWTF consistently achieved total nitrogen levels of 1.2 mg/L, far below the 10 mg/L permit limit that the original plant struggled to meet.

While the plant’s nitrate removal was performing as designed, it was discovered that the plant was also removing phosphorus at concentrations below 1 mg/L, which was not accounted for in the design. Upon further investigation, it was determined that the plant had cultivated the bacteria *Azonexus*.

Previously identified only in laboratories, *Azonexus* has the capability to simultaneously remove nitrogen and phosphorus, performing the work of multiple bacterial communities and putting Caledonia ahead of upcoming phosphorus limits without additional chemical or biological inputs.

The plant reported phosphorus levels of 0.096 mg/L in March and April of 2026.

Caledonia’s Orbal system achieves exceptional nitrogen removal while significantly reducing aeration demand with its low dissolved oxygen approach. The approach was recognized by the Green Project Reserve grant through an award of over \$800,000 for the plant’s sustainable performance and environmental benefits.

“It’s been operating great. It frees up quite a bit of time for my operators because there’s a lot that they don’t have to do anymore,” said Dickson. “The system handles everything and that is not how we were operating before. We were having alerts constantly.”

As wastewater treatment facilities across Minnesota are preparing to meet the Minnesota Nutrient Reduction Plan, many small towns are studying Caledonia’s success with the Orbal System for biological treatment.



Xylem’s Orbal system in operation with Ox Disc Aerators providing superior mixing efficiency, low energy usage and minimal maintenance.