Centrate Treatment Provides Benefits in Colorado

Wastewater utilities across the country are facing more stringent effluent nutrient limits. Modifying existing facilities to comply with these standards often calls for innovative process upgrades that minimize the impact on rate payers. Sidestream treatment is a cost-effective method to reduce high concentrations of ammonia generated through anaerobically digested biosolids. This is important because centrate (or filtrate) sidestreams represent 20 to 40 percent of a plant's total ammonia load. The CaRRB (Centrate and RAS Reaeration Basin) process is used to nitrify centrate ammonia prior to return to the mainstream secondary treatment process. Although some agencies have experimented with similar processes since the early 1990s, Carollo took sidestream treatment to a new level by better integrating the CaRRB process with mainstream treatment to optimize the benefits of this unique configuration.

Unlike other "separate sludge" sidestream processes, CaRRB is seeded using the nitrifiers in the mainstream process through RAS return. This eliminates the need for sidestream clarifiers and pumping systems.

Key Benefits of the CaRRB Process

CaRRB offers several benefits to wastewater utilities, including:

- Treatment of concentrated sidestream ammonia loads in a smaller footprint than conventional aeration basins.
- Bioaugmentation via the return of nitrifiers to the mainstream aeration basins.
- Reduction of mixed liquor return (MLR) pumping requirements and associated capital and operation costs through the generation of nitrate in CaRRB, fed to mainstream anoxic zones for denitrification.
- Creation of an inventory of high mixed liquor suspended solids (MLSS) in the CaRRB basins, allowing for lower mainstream aeration basin MLSS and a reduced solids load on the secondary clarifiers.
- Reduction of impacts of washout during high peak flow storm events by providing biomass storage.

CaRRB can reduce the cost of expansion of mainstream secondary treatment facilities while helping meet more stringent nitrogen removal performance requirements.

Largest Full-Scale Application of CaRRB Technology at the Metro Wastewater Reclamation District

The Metro Wastewater Reclamation District (MWRD) in Denver, Colorado, operates the 220-mgd Robert W. Hite Treatment Facility (RWHTF), which includes two separate primary and secondary complexes. The North Secondary Complex (NSEC) uses a BNR air-activated sludge process in nitrification-denitrification mode, and the South Secondary Complex (SSEC), which is converting a high-purity oxygen activated sludge process to a BNR air activated sludge plant. Both complexes share common solids handling facilities.

Presently, all of the nitrogen-rich centrate from the solids dewatering process is returned to the NSEC. The effluent criteria for discharge include monthly limits for ammonia and a weekly maximum limit for NOx (nitrate plus nitrite).

Using the CaRRB process, high ammonia return flows (centrate) generated through dewatering are fed to the head of the sidestream treatment basins along with a portion of RAS. CaRRB effluent (partially nitrified centrate plus RAS) is returned to the mainstream process with primary effluent.
In 2004, MWRD began planning improvements at the RWHTF to comply with more stringent limits for ammonia, NOx, and phosphorus. The initial strategy included two new aeration basins and secondary clarifiers to supplement the existing 12 aeration basins and secondary clarifiers. As an alternative approach, Carollo evaluated the concept of centrate sidestream treatment with RAS in reaeration basins. The concept envisioned the construction of common CaRRB basins instead of two new aeration basins and secondary clarifiers. Construction of CaRRB was completed in June 2009.

The CaRRB approach afforded several important advantages over the original improvements strategy.

**Higher Capacity at a Lower Cost.** Because solids in CaRRB are inventoried at RAS concentrations (significantly higher than the MLSS concentrations in the aeration basins), the same solids retention time (SRT) can be maintained at a lower bioreactor volume using the CaRRB approach. This results in lower solids concentrations entering the secondary clarifiers, subsequently increasing clarification capacity. The result is that the CaRRB approach yields a higher capacity at a lower cost.

The original NSEC improvements strategy would have required two aeration basins with a combined volume of 4.1 million gallons and two 130-foot-diameter secondary clarifiers. The CaRRB approach yielded approximately 20 percent more capacity than the original strategy with the construction of only 2.7 million gallons of centrate reaeration basins and without any new secondary clarifiers. This increased capacity resulted in a reduction in anticipated capital cost of approximately $17 million when compared to the original strategy.

**Reduction in Required MLR Return Pumping.** CaRRB also allowed a reduction in the required MLR pumping rate. Due to nitrification of centrate occurring in CaRRB, a significant amount of nitrate is generated and returned to the anoxic zones in the mainstream aeration basins, offsetting some of the MLR pumping requirements. At MWRD, the CaRRB process generates approximately 6,000 to 8,000 ppd of nitrate as N, that is fed to mainstream anoxic zones. This is equivalent to 70 to 100 mgd of MLR, or a reduction of 6 to 8 mgd per aeration basin. This reduction in MLR pumping allows installation of smaller pumps and provides an energy cost savings of approximately $80,000 per year.

**Improved Nitrification.** The CaRRB process yields a steady seeding of nitrifiers from the centrate reaeration basins to the mainstream aeration basins. The bioaugmentation effect appears to allow nitrification at slightly lower aerobic SRTs. The CaRRB process was designed to provide 50 percent centrate ammonia reduction when operated at design loadings. The degree of nitrification is limited by the operating pH and alkalinity available in the RAS. With adequate pH control, ammonia reduction in CaRRB can be higher than 50 percent.

**Mapping the Future**
CaRRB performance has met expectations and confirmed the benefits offered by this process. The 106-mgd MWRD NSEC CaRRB application is the largest full-scale application of this technology worldwide. Based on this success, CaRRB is also being incorporated into MWRD’s new 114-mgd SSEC BNR facility.

Carollo is currently working with MWRD to evaluate and demonstrate, through full-scale application, the incorporation of nitrogen reduction through nitrification in the CaRRB process. The flexibility of sidestream treatment processes may provide other treatment benefits in the future.

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For MWRD, four CaRRBs (top right) provided sufficient capacity to avoid construction of two additional aeration basins and secondary clarifiers.

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At MWRD, CaRRB provides consistent removal of ammonia from return flows, normally ranging from 50 percent to as much as 90 percent ammonia removed.