AGENDA TITLE: Information Item – Phosphorus Removal Update at the Water Resource Recovery Facility

PRESENTERS:
Joe Taddeucci, Director of Public Works for Utilities
Christopher Marks, Treatment Process Engineer
Chris Douville, Wastewater Treatment Manager
Cole Sigmon, Engineering Project Manager

EXECUTIVE SUMMARY:
This memo is intended to share with WRAB the current understanding and status of a Phosphorus Removal strategy for the Boulder Water Resource Recovery Facility (BWRRF). Included are the regulatory and technical drivers for performing chemical phosphorus removal (Chem-P) testing, previously investigated during 2017 and additionally piloted full-scale in Q3 and Q4 of 2019. The main motivation for the 2019 testing was to confirm the capability to meet future Regulation 85 limits, and further refine the economic and operational impacts of Chem-P treatment. Since WRAB is primarily responsible for making recommendations regarding the capital improvement program, this memo aims to present relevant information to inform the decisions regarding next steps for addressing upcoming phosphorus regulations at the BWRRF.

BACKGROUND:
Information on phosphorus was previously provided to WRAB in November 2012 and August 2017. A 2012 study established that the BWRRF has a carbon deficiency which limits the treatment capacities of biological phosphorus removal (Bio-P) and denitrification (removal of nitrate). Brewery waste and acetic acid are already being used as carbon sources for denitrification. Chemical phosphorus removal (Chem-P) is an important consideration because it does not require additional carbon sources.

Phosphorus is not currently regulated by the BWRRF’s discharge permit, but based on 2012 regulations, limits will be introduced into permits upon renewal. Monitoring of phosphorus in influent/effluent increased at the BWRRF to prepare for Regulation 85 (Reg-85), and in 2012 the Nutrient Compliance Study (NCS) was performed to assess pathways for treatment of both nitrogen and phosphorus. Industry and collection system monitoring were performed, and no high discharges of phosphorus were identified for source control. The NCS identified phosphorus removal as secondary to nitrogen removal with respect to Reg-85 compliance priorities (based on a three-phased strategic project plan). A tertiary chemical phosphorus removal treatment system was recommended as well as more investigation. For the past 20 years, the primary goal of treatment has been the removal of nitrogen compounds (ammonia and nitrate/nitrite) in the wastewater to prevent eutrophication of receiving bodies of water, aquatic life toxicity, and public health impacts. Focus on phosphorus treatment has increased recently as this nutrient also causes eutrophication in receiving waters.
Colorado Department of Public Health and Environment’s (CDPHE) Reg-85 defines an annual median effluent total phosphorus (TP) limit of 1.0 mg/L that will be included with the next permit cycle and creates a primary driver for investigations into phosphorus removal technology. Regarding the BWRRF discharge permit, CDPHE has been administratively extending permit renewal since 2016. In a May 2019 meeting between Boulder Utilities staff and staff from the CDPHE Water Quality Control Division, CDPHE staff indicated that the BWRRF discharge permit would not be addressed until after a Rulemaking Hearing in June 2020 on Regulation 38. This suggests that the new permit may be issued in early 2021, and that compliance with Reg-85 TP limits will likely be required by 2026 based on an expected five-year compliance schedule. Peer utilities including Longmont, Broomfield, and Westminster were recently issued permits based on a five-year compliance schedule. A five-year compliance schedule would require completion of a phosphorus removal project in 2026. However, the city’s participation in Colorado’s Voluntary Incentive Program (VIP) adds a layer of complexity to the timing of the phosphorus project and creates a secondary driver for investigations into phosphorus removal technology.

Colorado’s VIP for Early Nutrient Reductions (WQCC Policy 17-1) is incentivizing facilities to outperform Reg-85 limits from 2018 to 2027 by offering an augmented compliance schedule for Regulation 31 (Reg-31); scheduled for regulatory implementation after 2027. Details of the VIP were shared with WRAB previously, in January 2019 as part of the 2018 Year in Review. The intention of the VIP is to out-perform Reg-85 limits and achieve improved receiving water quality sooner than would otherwise occur, resulting in a higher overall environmental and public health benefit.

Currently, the BWRRF is on course to gain 7.5 VIP incentive years for reducing effluent TIN beyond Reg-85 limits using prior investments in nitrogen treatment technology (activated sludge, brewery waste, post-aerobic digestion) and over a decade of operational experience. Out-performing Reg-85 phosphorus limits would allow up to 2.5 years of additional compliance schedule years. If the city were removing phosphorus by 2023, an annual median effluent concentration of 0.7 mg/L could be targeted from 2025 to 2027 to gain an additional 2.5 years for Reg-31 compliance. The additional years to compliance achieved through the VIP program will allow the city maximum flexibility in meeting Reg-31 considering feasible technology to meet the regulation, other capital improvement needs and effects on utility rates and the interests of other water quality stakeholders in the Boulder Creek watershed. The city could choose to implement improvements sooner should the need arise.

**ANALYSIS:**

Chem-P uses metal salts that bond with phosphorus so that it can be removed by settling. Full-scale Chem-P trials were performed at the BWRRF during the second half of 2019, as an in-depth follow-up to the testing performed in 2017, which confirmed that Chem-P can meet Reg-85 limits for phosphorus. Ferric chloride was tested for one month and aluminum sulfate was tested for two months. The major costs associated with Chem-P are the chemical facility construction, and an increase in operational expenses to purchase chemicals. Preliminary chemical usage estimates and potential costs based on the current phosphorus load are as follows:

- Ferric Chloride: 580 gallons per day // $366,000 per year
- Aluminum Sulfate: 930 gallons per day // $360,000 per year

Preliminary results of the 2019 testing, as compared to the 2017 CoMag® pilot, show that dosing metal salts upstream of secondary clarification requires ~25% more chemical, but wouldn’t require the construction of an additional and separate treatment process like CoMag®. The other factors that need further analysis for understanding overall cost impacts are:
• Increases to volume/mass of biosolids hauled per year and land application impacts
• Increases in polymer demand for solids dewatering processes
• Solids stabilization process performance changes (i.e. digestion)

Positive aspects of implementing the Chem-P treatment option are:

• It has been proven to be a viable method for compliance with Reg-85
• It can be incrementally replaced by Bio-P as those methods develop
• The capital cost is mostly associated with a single building construction
• A Chem-P system can remain as a backup treatment system if another treatment option were implemented in the future, and
• The investment in a chemical dosing system would not become a sunk cost because other studies already indicated that upstream chemical dosing will either reduce overall chemical use or simply provide a backup system in the event of primary system failure.

A non-treatment related negative of Chem-P is that the public perception of using metal salts to remove phosphorus may not be attractive to stakeholders when compared to the biological methods that include mineral recovery. However, all currently known options will involve the use of some kind of chemical, whether for direct removal or for biological nutrient support due to biodegradable carbon deficiency.

The BWRRF team is following significant industry progress on several other phosphorus removal options, including Bio-P. However, major concerns regarding Bio-P include known and expected increases in the formation of struvite, a mineral scale that forms on surfaces of digestion vessels, glass lined pipes, and in centrifuges. Struvite concentrations at the BWRRF solids treatment system already cause scaling. One particular system produces enough struvite each year that valves, pump impellers, and piping must be cleaned via hammer and chisel as well as chemical methods. In 2017, struvite precipitation in the centrifuges caused damage to rotating equipment and resulted in a $400,000 mandatory equipment rehabilitation effort. Such scaling issues may render Bio-P infeasible for the BWRRF.

Regardless of what route is chosen for compliance with Reg-85 phosphorus, the course of action will require a significant capital project and have O&M impacts for the WW Utility. The planning-level capital project schedule currently anticipated in the 6-year CIP is as follows:

• 2020: ~$900k for consultant evaluation / pre-design
• 2021: ~1.8M for design/bidding
• 2022: ~$18M for construction

**NEXT STEPS:**

Upon completion of a report for the 2019 pilot testing, considerations should be made regarding changes to the CIP schedule for the phosphorus project as part of the year 2021/2022 budget cycle. A consultant should also be hired to reassess other realistic phosphorus treatment options for BWRRF by the end of 2020.
ATTACHMENTS:
A: August 2017 – Wastewater Treatment Update
AGENDA TITLE: Information Item – Wastewater Treatment Update

PRESENTERS:
Jeff Arthur, Director of Public Works for Utilities
Chris Douville, Wastewater Treatment Manager
Douglas Sullivan, Acting Principal Engineer for Water, Wastewater and Stormwater
Cole Sigmon, Treatment Process Engineer (Wastewater)

EXECUTIVE SUMMARY
This Information Packet Memorandum summarizes a few key highlights for the city’s 75th Street Wastewater Treatment Facility (WWTF). A significant regulatory-driven capital project was recently completed, and the WWTF is performing at a new level of advanced nitrogen removal. Next year will mark 50 years of operation for the WWTF, and staff are strategically planning for the next major capital improvement project necessary for removal of phosphorus. Replacement of aging infrastructure is an increasing focus at the WWTF.

BACKGROUND
The 75th Street WWTF will achieve its 50th year of operation in 2018. The WWTF is in the early stages of being rebranded as a Water Resource Recovery Facility – WRRF – after following the lead from our national professional organization (the Water Environment Federation) who has endorsed the term and encouraged its use. While capacity is not currently driving capital projects, regulations and aging infrastructure are and will continue to in the years to come.

Previous updates on wastewater treatment and the associated WWTF were provided to WRAB at the following meetings:

- July 20, 2015 - Wastewater Treatment Update
- November 19, 2012 - Update on Wastewater Treatment Facility Nutrient Compliance Study
ANALYSIS

Nitrogen Upgrades Project

The Nitrogen Upgrades Project (NUP) was necessary to meet regulatory limits for ammonia and nitrate, as well as comply with upcoming Regulation 85 nitrogen limitations. Prior to the upgrades, the WWTF was removing approximately 50-55% of the influent nitrogen. Improved nitrogen removal was necessary to comply with permit effluent limits, and the solution is what’s known as enhanced denitrification. Enhanced denitrification has been implemented at the WWTF by modifying the process reactors to allow more time for denitrification and by providing a readily biodegradable food source (i.e. carbon) for the microorganisms. The two new carbon sources (acetic acid and brewery weak wort) are stored in the new External Carbon Storage and Feed Facility. The NUP was completed in early 2017, before new ammonia and nitrate limitations go into effect on December 1, 2017. The general contractor, Aslan Construction, has remained onsite to assist the city with other important projects due to their availability and demonstrated capability of executing quality improvements.

Figure 1 shows effluent nitrate performance since 2012, compared with expected future limitations. Effluent ammonia performance is summarized in Figure 2. While initial nitrate performance provides a high level of confidence with permit compliance, ammonia will remain an ongoing permit challenge due to the low limits, short (one day) compliance period, and variable process nature of wastewater microbiology.

![Figure 1: December, 2017 daily maximum nitrate limits (black line) superimposed on historic daily effluent nitrate performance (grey diamonds).]
Aging Infrastructure

The traditional approach to replacing aging infrastructure has been to incorporate asset replacements with large capital projects for a given treatment process area. While effective and efficient for many cases and systems, this approach has also extended the operational timeline for some systems well beyond their useful life. Utilities staff have increasingly implemented a more strategic approach to replacing assets outside of traditional regulatory or capacity driven projects. Two current projects are good examples:

1. **Process Automation Systems Phase 1** – The first of three projects, this effort was born from a Strategic Plan effort to review critical systems related to process control, network, communications, monitoring, and alarms. Legacy systems are being replaced, single-points-of-failure eliminated, and emerging technologies are being implemented. This ~$1,000,000 project is near completion.

2. **Motor Control Center and Load Center Replacement Project** – This project is dedicated to replacing and modernizing eight of the oldest motor control centers and three of the oldest electrical load centers at the WWTF. Focusing on key electrical infrastructure is vital to continued permit compliance and reliable performance. This project is in the design phase and has an estimated construction cost of $2,300,000.

*Figure 2: December, 2017 daily maximum ammonia limits (black lines) superimposed on historic daily effluent ammonia performance (grey diamonds).*
While the process automation and electrical systems are actively being replaced, the asset class that has received the least amount of attention is the buried process piping. The WWTF campus has a complex network of buried pipe runs, which makes many of the replacement projects difficult and expensive. The need for significant heightened attention to buried infrastructure has been reinforced over the past several years due to multiple failures/leaks:

- Return Activated Sludge Piping: Two leaks on large 30-inch pipe buried under concrete floor (July 2005 and June 2017)
- Natural Gas: Three leaks on low pressure sub-systems (January 2015, December 2015, and July 2017)
- Potable Water: One significant leak on the potable water main feeding the WWTF, which was repaired by city utilities maintenance crews (April 2016)

A strategic plan to phase in proactive system replacements in advance of future failures is required. As an important preliminary step, the wastewater treatment team has worked with city GIS technicians to update and complete mapping of the various systems, to assist in proactive work or reactive emergency shutdowns/repairs.

**IBM Lift Station Upgrades Project**

The IBM Lift Station was upgraded in 2016 to address overflow protection measures required by the State of Colorado, and aging infrastructure concerns. The upgraded lift station has been performing extremely well, and there have been no overflow events from the upgraded station. The station now has enhanced monitoring and control provisions, as well as increased electrical and mechanical redundancy. The upgrades have resulted in reduced operations and maintenance hours, allowing that time to be spent on higher priority items at the WWTF.

**Chemical Phosphorus Pilot**

To better inform a future decision on phosphorus removal technology, chemical phosphorus removal trials are taking place at the WWTF over the next few months. The State of Colorado approved a pilot plan to test chemical phosphorus removal at the primary clarifiers, secondary clarifiers, and a tertiary location upstream of the UV disinfection process. While chemical phosphorus removal with metal salt addition is well proven, decisions relating to chemical selection, dose, and injection location have not yet been determined. The leading manufacturer technology identified during the 2012 Nutrient Compliance Study, called CoMag®, will be piloted with the manufacturer’s trailer system to prove the technology on Boulder’s specific effluent in an effort to establish dosing requirements for meeting Regulation 85 and eventual Regulation 31 phosphorus levels (established at 1.0 mg/L and 0.1 mg/L, respectively). After the
CoMag ® pilot is tested, evaluation of the secondary and primary clarifiers will be performed. A wastewater process optimization intern has joined the wastewater treatment team to assist with piloting efforts. Results of the pilot study will influence future decisions on the phosphorus removal project, which is currently identified as an $18M capital project for year 2022.

**NEXT STEPS**

- Utilities staff will develop a strategic plan for phased replacement of aging infrastructure, specifically buried piping systems.
- Utilities staff will provide WRAB an update on the results of the chemical phosphorus removal trials, and ongoing planning efforts to achieve upcoming phosphorus regulations.
- WRAB will have the opportunity to further consider capital investments for the WWTF as part of next year’s CIP budget process to recommend a 2019 CIP budget.