Columbia Wastewater and Stormwater IMP

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Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Technical Memorandum 6 *Wastewater Treatment Alternatives*

Columbia Wastewater and Stormwater Integrated Management Plan

Columbia, Missouri
January 5, 2018

HDR

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Section 1. Introduction

The City of Columbia, Missouri (City) is working to develop an Integrated Management Plan (IMP) for the City's wastewater and stormwater utilities. The goal of the IMP is to develop an adaptable and affordable long-term plan that addresses the City's wastewater and stormwater management needs and meets Clean Water Act requirements. The IMP will be developed based on guidance presented in US Environmental Protection Agency's (EPA) *Integrated Municipal Stormwater and Wastewater Planning Approach Framework* (Stoner 2012).

Early in the IMP process, the City and their project team worked to evaluate the City's environmental resources and infrastructure assets to better define the existing condition, performance, and needs of its systems. Results from these efforts were documented in the following technical memoranda:

- Technical Memorandum 1 – Surface Water Quality and Biological Conditions
- Technical Memorandum 2 – Wastewater Collection System Assessment
- Technical Memorandum 3 – Wastewater Treatment System Assessment
- Technical Memorandum 4 – Stormwater System Assessment

These needs assessments were useful in guiding initial prioritization of potential wastewater and stormwater improvements. Priorities were further refined during a series of community outreach meetings. Information developed from these activities formed the basis for identifying potential capital and programmatic alternatives that should be evaluated as part of the IMP. Outcomes from these efforts have been documented in the following technical memoranda:

- Technical Memorandum 5 – Wastewater Collection System Alternatives
- Technical Memorandum 6 – Wastewater Treatment System Alternatives
- Technical Memorandum 7 – Stormwater System Alternatives

The purpose of this memorandum is to describe the assumptions and methods used to develop potential funding requirements for addressing future wastewater treatment needs at the Columbia Regional Wastewater Treatment Plant (CRWWTP).

Given the inherent uncertainty associated with the regulatory environment, as well as data gaps identified in the existing systems analysis, the alternatives outlined in this memorandum are only intended to serve as planning level estimates. These alternatives and associated costs should be refined as additional information is developed and sanitary sewer system improvements are made during future phases of the IMP. Findings from the wastewater treatment system alternatives analysis are documented in the sections that follow.

Section 2. Treatment Alternative Costs

In December 2016, representatives from the City, HDR Engineering, Inc. (HDR), and Black and Veatch, Inc. (B&V), met to discuss and identify treatment alternatives necessary to improve existing operations at the CRWWTP; address regulatory drivers related to the wet-weather program, disinfection, nutrient removal, and more stringent ammonia limits; and continue to provide for efficient and effective treatment practices. The following treatment plant improvements were identified during that meeting:

- Wet Weather Capacity Improvements
- Expanded Nitrification Capacity
- Biological Nutrient Removal
- Chemical Disinfection
- Constructed Wetlands Improvements
- Biosolids System Improvements
- Alternate Effluent Outfall Location

Planning level capital and operations and maintenance (O&M) costs were developed for these alternatives by updating estimates from the City's 2004 Sanitary Sewer Utility Facilities Planning Report (2004 Master Plan), as well as using recent HDR and B&V experience with similar projects in the region. HDR met with City staff on March 8 to review and confirm information and assumptions used to formulate the final alternatives presented in this memorandum.

2.1 Wet Weather Capacity Improvements

Inflow and infiltration into the City's sewer system has caused sewer backups and overflows for decades. A sewer system evaluation survey completed in 1978 identified inflow and infiltration flows in excess of 48 million gallons per day during a storm with a 5 year frequency and 4.5 hour duration. The reports from the 1978 survey recommended immediate rehabilitation of portions of the sewer collection system. In addition, the 1978 survey recommended expansion of the City's maintenance program to include continuing system rehabilitation to prevent additional inflow and infiltration due to deterioration of the system. The City's maintenance program was not expanded and inflow and infiltration has continued to increase, nearing 140 million gallons per day during a heavy rainfall event. Increased inflow and infiltration burdens the collection system and wastewater treatment plant, resulting in sewer overflows and backups into buildings.

Since 2014, significant collection system rehabilitation and inflow and infiltration reduction projects have been completed. In addition, sewer maintenance and operations personnel have completed repairs and equipment modifications and implemented operational changes at the WWTP that have significantly reduced sewer overflows along the major trunk sewers, mostly near the wastewater treatment plant. Despite these recent improvements, the wastewater treatment plant is currently unable to manage peak wet weather flows in a manner that effectively limits the number of SSOs within the collection system during very large events. As mentioned in TM 5, wet weather LOS goals for the collection system will be developed by the City and a design storm will be determined. When wet weather flows from the selected design storm result in a peak flow that exceeds design capacities of the individual treatment processes at the WWTP, pumping capacity improvements, process expansion or storage of the excess flows will be required. For infrequent wet weather flows, storage options are typically more cost effective. However, there are some process scenarios or pumping solutions that may address treatment requirements and overflow reduction needs more effectively that need to be evaluated while keeping in mind the reality that there will always be some rainfall events that result in sewer overflows.

Several treatment and storage alternatives are available to potentially address peak wet weather flows. For planning purposes, a peak mechanical plant capacity of 50.4 million gallons per day (MGD) (12.6 MGD per train; 4 trains) and the projected 2030 peak hourly flow rate of 143 MGD, identified in the 2004 Master Plan, were used to identify combined wet weather alternatives that would manage approximately 90 MGD of excess flow. Individual alternatives evaluated to potentially address the wet weather issues included improving influent pumping capacity, adding storage, adding peak flow clarifiers, adding chemical disinfection with an alternate outfall at Hinkson Creek near the Perche Creek confluence, and increasing conveyance capacity to the wetland treatment units (WTU). These alternatives were combined to provide a recommended approach to wet weather treatment and management.

2.1.1 Influent Pump Station Capacity Improvements

The design capacity of the existing influent pump station is not sufficient to address the 2030 peak hourly flow rate of 143 MGD that was identified in the 2004 Master Plan. The current influent pump station consists of six vertical, dry-pit, non-clog centrifugal pumps and two 5/8-inch vertical, front-cleaned bar screens with an approximately 50-foot deep wet well. According to City staff, capacity of the pump station with all pumps in service is approximately 90 MGD that can be routed to the mechanical treatment plant or to wet weather treatment.

The assumed influent pump station capacity improvements are based on doubling the existing pump station firm capacity to accept the 2030 peak hourly flow. The new pump station would be constructed of a concrete below grade structure with brick and block superstructure adjacent to and matching the existing influent pump station.

Total project cost for this alternative is $21,993,400 in 2017 dollars with approximately $121,900 anticipated in annual operations and maintenance costs. See Attachment A, Table A.1. for detailed cost estimates.

2.1.2 Wet Weather Storage

Storage is needed when wet weather flows exceed the capacity of downstream treatment process or conveyance capacities. In Columbia, storage may be added out in the collection system or at the treatment plant. Preliminary assessments indicated that collection system storage immediately upstream of the influent pump station is not cost-effective compared to storage at the treatment plant. Storage further upstream in the collection system may be cost-effective to address conveyance limitations. However, additional assessments and hydraulic modeling are needed to fully consider collection system alternatives.

Wet weather storage capacity at the treatment plant currently includes a 6.1 million gallon (MG) peak flow lagoon. The City also plans to repurpose a 6.8 MG sludge storage lagoon into excess flow storage during the first implementation period of the IMP, providing a total of 12.9 MG of wet weather storage capacity. However, the location of the existing peak flow lagoon may be needed for siting new peak flow clarifiers as discussed in the following section. Therefore, the storage provided in the existing peak flow lagoon was not included in the wet weather capacity improvement alternatives. For planning purposes, an additional 4 to 10 MG of storage depending on the combination of alternatives is estimated to provide adequate storage at the 2030 peak hourly flow rate of 143 MGD. Storage capacities were calculated by halving the excess flow rates, which is a reasonably conservative assumption in the absence of hydraulic modeling results. Total project costs to install 4 and 10 MG excess flow basins are approximately $6,250,000 and $15,600,000, respectively, in 2017 dollars. See Attachment A, Table A.2. for detailed cost estimates.

2.1.3 High Rate Wet Weather Treatment

The current wet weather treatment capacity needs to be increased as it is not adequate to address the 2030 hourly peak flow rate. The current wet weather treatment facilities consists of two 115-foot diameter clarifiers, a peak flow sludge pump station, and a 6.1 MG peak flow lagoon. At the 2030 peak hourly flow rate of 143 MGD and a peak mechanical plant capacity of 50.4 MGD, approximately 90 MGD of wet weather treatment capacity would be required without additional storage. Plant staff has observed that each peak flow clarifier is hydraulically limited to 13 MGD (1300 gpm/sf surface overflow rate; SOR). Wet weather clarifiers similar to primary clarifiers can be designed up to a SOR of 2400 gpm/sf without chemical addition and to as high as 7000 gpm/sf SOR with the addition of chemically enhanced settling (CES). Assuming no modifications to the existing wet weather clarifiers, new wet weather treatment facilities would be required to address the remaining 64 MGD of wet weather flow.

This alternative is based on the addition of one to two (depending on the storage alternative) 130-foot diameter CES clarifiers with a new solids pumping station, chemical feed building, and modifications to the existing diversion structure. Additional testing of the existing clarifiers and potential modification would be required to optimize the size and SOR design for the new clarifiers.

Space near the existing peak flow clarifiers is limited by the 100-year floodplain at elevation 581’, which may require new facilities to be constructed at the location of the existing peak flow lagoon. For these planning purposes, the existing peak flow lagoon is assumed to be decommissioned with utilization of this space for peak flow clarifiers.

Total project cost for this alternative is $11,824,200 in 2017 dollars with approximately $180,400 anticipated in annual operations and maintenance costs. Cost to construct only one peak flow clarifier is $7,809,000 in 2017 dollars with approximately $169,000 in annual operations and maintenance costs. See Attachment A, Table A.3. for detailed cost estimates.

2.1.4 Effluent Conveyance to Wetland Treatment Units

Currently flow through the process trains combines with excess flow at the diversion structure prior to flowing through a 72-inch diameter pipeline to the WTUs (approximately 2.3 miles). The current pipeline is hydraulically limited to approximately 60 MGD of gravity flow. This restriction prevents adequate management of wet weather flows. In order to convey the 2030 peak flow rate, a parallel 78-inch diameter pipe would be required. Temporary storage of wet weather flows in WTU 4 would then mitigate conveyance limitations through the remainder of the WTUs and the effluent pump station.

Total project cost for to install a second 78-inch diameter parallel pipe from the treatment plant to the WTUs is $14,800,500 in 2017 dollars with approximately $6,900 anticipated in annual operations and maintenance costs. The total conveyance capacity of this option would exceed143 MGD to the WTUs. See Attachment A, Table A.4. for detailed cost estimates.

2.1.5 Wet Weather Chemical Disinfection and Alternate Outfall

An effective wet weather management strategy could be to discharge secondary treated flows to Hinkson Creek near the Perche Creek confluence during wet weather events that exceed the hydraulic capacity of the effluent conveyance line to the WTUs. Implementation of this discharge would require effluent disinfection based on Missouri regulations. No other treatment improvements are assumed to be required due to the high receiving water flows, temporary duration of the discharge, and the high quality of the mechanical plant effluent.

Chlorination is considered the best disinfection method for this application given the infrequent nature of the discharge, disinfection effectiveness, and relatively low capital and operational costs. Dechlorination would also be needed prior to discharge. Required improvements include chemical storage and handling, a chlorination/dechlorination contact basin, intermediate pumping, effluent conveyance, and a new outfall. Total project cost for wet weather disinfection facilities is $10,053,400 in 2017 dollars and approximately $103,500 in annual operations and maintenance costs. Total project cost for the effluent conveyance and outfall structure is approximately $766,200 in 2017 dollars and approximately $6,900 in annual operations and maintenance costs. See Attachment A, Table A.5. for detailed cost estimates.

2.1.6 Wet Weather Capacity Improvements Alternatives Analysis

Combinations of the wet weather management alternatives described above were evaluated to determine the most cost-effective wet weather management approach to improve the existing facility (Figure 1). These alternatives should be reevaluated as the City develops a better understanding of wet weather peak flows and volumes. Wet weather flow monitoring and modeling, evaluation of cost-effective inflow and infiltration reductions, collection system conveyance improvements, and level of service expectations should form the basis for selection of the optimal wet weather management strategy at the CRWWTP.

The following combinations of wet weather capacity improvements were evaluated:

- Alternative A: Wet Weather Conveyance to WTUs with Additional Treatment
- Alternative B: Wet Weather Conveyance to WTUs with Additional Treatment and Storage
- Alternative C: Wet Weather Conveyance to WTUs with Additional Treatment and Discharge of Secondary Treated Flows to Hinkson Creek near Perche Creek Confluence

Capital and annual operation and maintenance costs for Alternative A were selected for IMP planning purposes since they represent the lowest cost option. All alternatives require increased wet weather influent pumping capacity and additional peak flow treatment capacity. Alternatives B and C are more costly due to the cost of increased on-site storage required to adequately treat and convey wet weather flows. Alternative C could become the most cost-effective, depending on the amount of wet weather storage needed to implement this solution. Alternative C also provides additional benefits other than the potential lowest cost option, including addition of chemical disinfection facilities that could be leveraged if further dry weather disinfection requirements are imposed, an additional outfall location to provide greater flexibilities, and reducing flows to the WTUs and Eagle Bluffs Conservation Area (EBCA) during wet weather conditions.

ALTERNATIVE A: WET WEATHER CONVEYANCE TO WTUS WITH ADDITIONAL TREATMENT

- Increase influent pumping capacity
- 2 new 130-ft CES peak flow clarifiers
- Parallel 78-inch line to the wetlands
- See Figure 2 for process flow schematic

Table 1. Construction and Operation and Maintenance Cost Estimate for Wet Weather Alternative A in 2017 Dollars.

Improvement	Flow (mgd)	Comments	Construction Cost	Additional O&M Cost
Mechanical Plant	50.4	-	-	
Peak Flow Clarifiers (Existing)	13 mgd x 2 =	Plant observed hydraulic limitation	-	
	26			
Peak Flow Clarifiers (New)	66.6	2 new 130 ft CES	$11,824,200	$180,400
		2500 gpd/sf SOR		
Peak Flow Storage	-	-	-	
Total Flow	**143**	-	-	
Influent Pumping	143	-	$21,993,400	$121,900
Conveyance	143	Parallel 78" diameter	$14,800,500	$6,900
Total			**$48,618,100**	**$309,200**

ALTERNATIVE B: WET WEATHER CONVEYANCE TO WTUS WITH ADDITIONAL TREATMENT AND STORAGE

- Increase influent pumping capacity
- 1 new 130-ft CES peak flow clarifier
- 4 million gallons (MG) of excess flow storage
- Parallel 78-inch line to the WTUs
- See Figure 3 for process flow schematic

Table 2. Construction and Operation and Maintenance Cost Estimate for Wet Weather Alternative B in 2017 Dollars.

Improvement	Flow (mgd)	Comments	Construction Cost	Additional O&M Cost
Mechanical Plant	50.4	-	-	
Peak Flow Clarifiers (Existing)	13 mgd x 2 = 26	Plant observed hydraulic limitation	-	
Peak Flow Clarifier (New)	46.6	1 new 130 ft CES 3600 gpd/sf SOR	$7,809,000	$168,990
Peak Flow Storage	20	10 MG needed, 6 MG existing, 4 MG new	$6,250,000	
Total Flow	**143**	-	-	
Influent Pumping	143	-	$21,993,400	$121,900
Conveyance	143	Parallel 78” diameter	$14,800,500	$6,900
Total			**$50,852,900**	**$297,790**

ALTERNATIVE C: WET WEATHER CONVEYANCE TO WTUS WITH ADDITIONAL TREATMENT AND DISCHARGE OF SECONDARY TREATED FLOWS TO HINKSON CREEK NEAR PERCHE CREEK CONFLUENCE WITH INCREASE OF INFLUENT PUMPING CAPACITY

- Increase influent pumping capacity
- 1 new 130-ft CES peak flow clarifiers
- 10 million gallons (MG) of excess flow storage
- Disinfection to secondary treated flow during excess wet weather flows prior to discharge to Hinkson Creek
- New effluent conveyance and outfall for secondary treated flows to Hinkson Creek during peak flows above 60 mgd
- See Figure 4 for process flow schematic

Table 3. Construction and Operation and Maintenance Cost Estimate for Wet Weather Alternative C in 2017 Dollars.

Improvement	Flow (mgd)	Comments	Construction Cost	Additional O&M Cost
Mechanical Plant	50.4	-	-	
Peak Flow Clarifiers (Existing)	13 mgd x 2 = 26	Plant observed hydraulic limitation	-	
Peak Flow Clarifier (New)	34	1 new 130 ft CES 2500 gpd/sf SOR	$7,809,000	$168,990
Peak Flow Storage	32.6	16 MG needed, 6 MG existing, 10 MG new	$15,625,000	
Total Flow	**143**	-	-	
Disinfection & Intermediate Pumping	50.4	-	$10,020,600	$46,192
Influent Pumping	143	-	$21,993,400	$121,900
Conveyance	50.4	Conveyance to Hinkson Creek at Perche Creek Confluence	$766,200	$6,900
Total			**$56,214,200**	**$343,982**

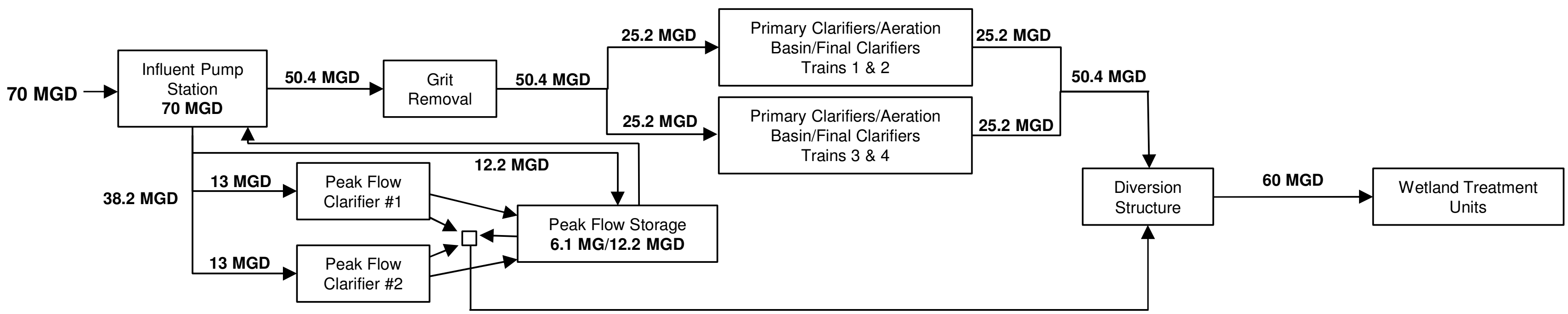

Figure 1. Process Flow Schematic for the Existing CRWWTP.

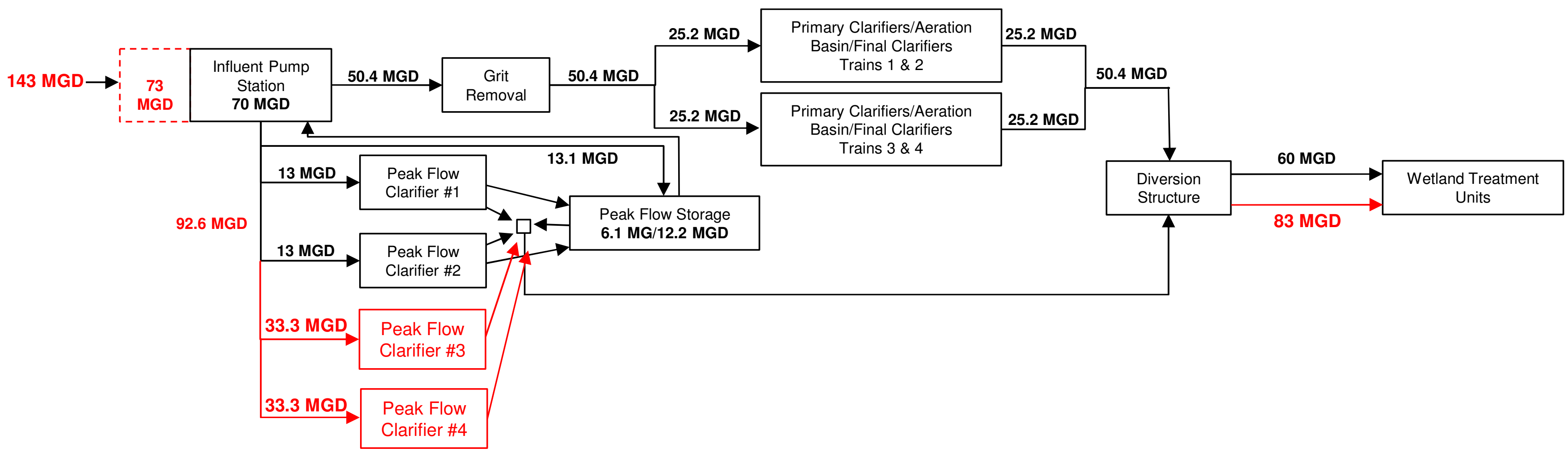

Figure 2. Process Flow Schematic for Wet Weather Alternative A.

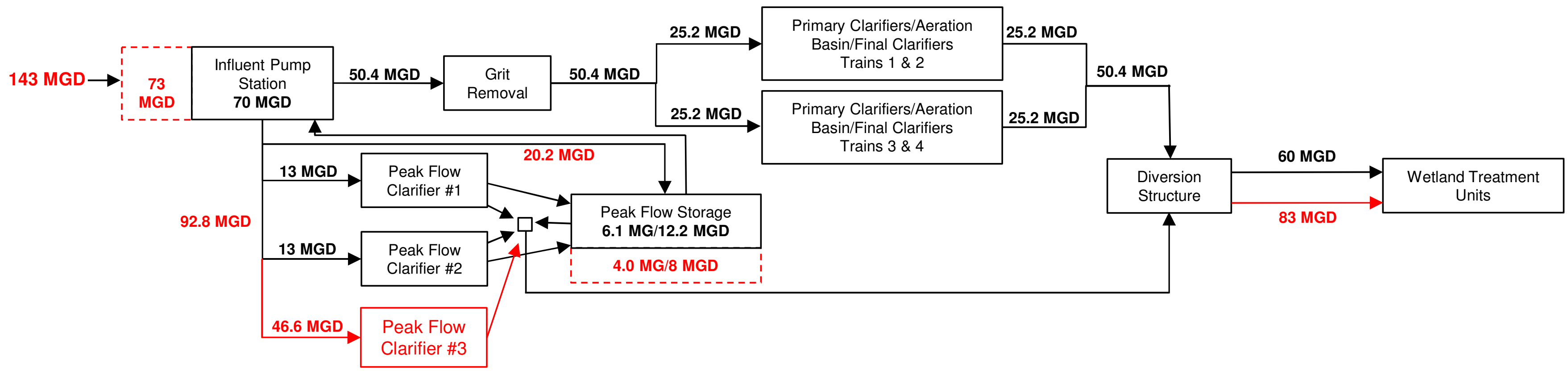

Figure 3. Process Flow Schematic for Wet Weather Alternative B.

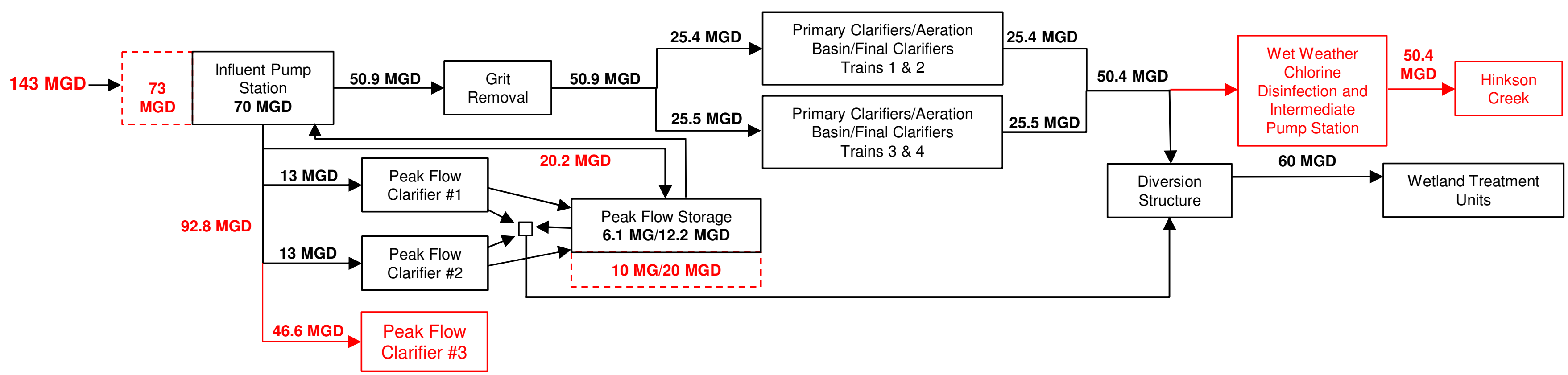

Figure 4. Process Flow Schematic for Wet Weather Alternative C.

2.2 Expanded Nitrification Capacity

In 2013, the CRWWTP was upgraded in part to meet an average monthly ammonia effluent limit of 6.0 mg/L ammonia at the design flow of 25.2 MGD. The CRWWTP was designed to meet this limit by combining the effluent from the two original trains (Trains 1 & 2) that partially nitrify with effluent from the two new trains (Trains 3 & 4) that fully nitrify. Trains 1 & 2 are each rated for biochemical oxygen demand treatment of 6.3 MGD annual average flow and 2.2 MGD annual average flow for nitrification per the 2009 Phase 1 Improvements project. Trains 3 and 4 constructed in the 2009 Phase 1 Improvements project are each rated for 6.3 MGD annual average flow for nitrification and denitrification. Under current flow conditions (approximately 15 MGD), this combination produces a high quality effluent that is generally less than 1.0 mg/L of ammonia (as nitrogen) and should be expected to maintain this performance up to approximately 17 MGD. Further process optimization may extend capacity above the 17 MGD rating.

As average flows at the CRWWTP increase over time, ammonia effluent concentrations will also increase. Future ammonia effluent limits may also be lowered due to changes in statistical assumptions that are used to calculate limits or revisions to the underlying water quality criteria on which the limits are based. During permitting discussions over the last several years, Missouri Department of Natural Resources (MDNR) staff has expressed the potential need to reevaluate the methods and data used to calculate the CRWWTP ammonia limit. These reevaluations would result in a 30% reduction in the existing effluent limit.

MDNR is also considering adopting more stringent ammonia criteria during one of the next water quality standards rule updates. These criteria were proposed by EPA in 2013 and are designed to protect freshwater mussels and snails against ammonia toxicity. Although the adoption and implementation schedule in Missouri remains unclear, these new criteria would result in a 90% reduction in the existing effluent limit.

Additional nitrification capacity will be needed if ammonia limits are reduced and average flows increase above 17 MGD. Addition of two new activated sludge treatment trains (Trains 5 & 6) would be needed to meet potential future ammonia limits (<1 mg/L NH_3 as nitrogen). New trains include primary clarifiers, primary sludge pumping station, aeration basins, final clarifiers, final sludge pumping stations, and the replacement of two existing blowers with larger units. All new buildings and structure estimates include facilities to be constructed on foundations of auger cast piles due to known soil concerns at the site. Total nitrification capacity of the plant would be increased to 29.6 MGD annual average if these two new trains are added.

Total project cost for this alternative is $38,110,000 in 2017 dollars with approximately $661,200 anticipated in annual operations and maintenance costs. See Attachment A, Table A.6. for detailed cost estimates.

2.3 Biological Nutrient Removal

Unlike ammonia, the timing and impact of nutrient drivers are somewhat less certain because statewide nutrient regulations have not yet been proposed by EPA or MDNR. MDNR has been working to develop statewide nutrient regulations since 2005. In 2011, EPA partially disapproved statewide reservoir nutrient criteria proposed by MDNR. Since that time, MDNR has been working to address the disapproval and expects to propose new reservoir criteria in 2017. These reservoir criteria will not impact the CRWWTP directly, but the scientific basis will likely set a precedent for development of stream and river criteria in the future.

The regional nature of nutrient issues in the Mississippi River Basin has led regulators to support adaptive-type approaches as a first step in reducing nutrients. In 2014, MDNR completed the Missouri Nutrient Loss Reduction Strategy (NLRS). The strategy outlines actions and adaptive management steps that will be taken to reduce nutrients over the next five years. For point sources, one of those actions includes identifying reasonable and cost-effective treatment technologies that could be implemented under future iterations of the NLRS. Among other state nutrient reduction plans, biological nutrient removal (BNR) technologies are generally targeted unless localized water quality impacts warrant more advanced treatment.

The CRWWTP is not currently required or designed to remove nutrients, although some TN and TP reduction occurs in the WTUs and EBCA wetlands before effluent is discharged to the Missouri River. However, nutrient criteria development efforts or future iterations of the NLRS could require upgrades to BNR during the IMP planning period.

Modifications to existing Trains 3 & 4 and future Trains 5 & 6 are planned for expanded nitrification capacity in order to achieve potential BNR requirements. BNR limits were assumed to be <1 mg/L ammonia as nitrogen, 10 mg/L total nitrogen, and 1 mg/L phosphorus. Modifications to Trains 1 and 2 were not included in this alternative. Implementation of this alternative would provide a total plant BNR capacity of 25.2 MGD annual average. The following items are included in this alternative:

- Preanoxic, anaerobic, and anoxic zones added to Trains 5 and 6
- Preanoxic and anaerobic zones added to Trains 3 and 4
- Modifications to existing Gravity Thickeners for use as fermenters
- Add polymer tote system for the waste activated sludge cetrifuges located in an existing building

Total project cost for this alternative is $13,564,300 in 2017 dollars with approximately $200,400 anticipated in annual operations and maintenance costs. See Attachment A, Table A.7. for detailed cost estimates.

2.4 Chemical Disinfection

The CRWWTP is not currently required or designed to chemically disinfect because bacteria criteria are not currently applied to the EBCA wetlands. However, the City has proactively measured bacteria concentrations in both the mechanical plant and final effluents. The bacteria measurements show that following the plant upgrade, the combination of the mechanical plant and the constructed treatment wetlands reduce bacteria to levels that are generally below the secondary contact recreation water quality criterion of 1134 colony forming units per 100 milliliters (CFU/100mL) of *Escherichia coli (E. coli*).

In 2012, EPA modified the federal recreational water quality criteria. These recommendations no longer allow states to implement tiered primary contact recreational uses, as is currently the case in Missouri, and are silent on the appropriateness of secondary contact recreation criteria. Missouri has not yet adopted the 2012 criteria but have indicated that they will during a future water quality standards update. EPA is also currently considering the use of F-specific and somatic coliphages as possible indicators of fecal contamination in ambient water. There is evidence to suggest that coliphages, which are a subset of bacteriophages (viruses that infect bacteria), are better indicators of human health risk than traditional fecal bacteria. Coliphage-based criteria may have operational implications for wastewater treatment facilities because UV disinfection alone may not be sufficiently effective at typical dosage rates.

Adoption of these new criteria at the state level could result in stringent bacteria effluent limits for the CRWWTP. For planning purposes, both ultraviolet (UV) and chlorine disinfection alternatives were evaluated. However, chlorine disinfection has several distinct advantages over UV disinfection at the CRWWTP. First, chlorine disinfection is more cost-effective and less operationally intense than UV. Chlorine is also a more effective disinfectant for bacteria and particularly viruses. For planning purposes, it was assumed that chlorine will be added to the mechanical plant effluent using the conveyance line to the WTUs to provide the required chlorine contact time. It is also assumed that chlorine residuals will dissipate within the WTUs prior to discharge to Eagle Bluffs. See Attachment A, Table A.8. and A.9. for detailed disinfection cost estimates. Note that estimates included for chlorine disinfection in Table A.9. assume that chlorination facilities detailed in Table A.4. are not implemented as part of the wet weather capacity improvements. If these disinfection facilities are implemented as part of the wet weather capacity improvements, then capital costs will be less than those included in Table A.8. because the wet weather facilities can be leveraged to implement disinfection of the remaining flows.

2.5 Constructed Wetlands Improvements

The constructed WTUs provide additional treatment of mechanical plant effluent prior to discharge to Eagle Bluffs. Wastewater is discharged from the mechanical plant to Unit 4, and then flows by gravity through Units 1, 2, and 3. The WTUs enhance the overall treatment process by using physical, biological, and chemical processes to remove pollutants like organics, nutrients, ammonia, metals, and bacteria. These processes improve effluent quality and facilitate compliance with effluent discharge limits. Given these important water quality benefits, it is necessary to ensure that sufficient funding is available to maintain proper operation and maintenance of these structures.

The original WTUs 1, 2, and 3 have been in operation since 1994. In 2001, WTU 4 was added to increase overall capacity of the wetlands. In 2008, the City conducted a study to estimate solids accumulation in WTUs 4 and 1. These WTUs were evaluated because they are the first two wetlands in the series and therefore, would most likely be impacted by settling solids. The 2008 study found that sludge depth averaged less than a foot across the wetland cells in those WTUs. An extrapolation of those 2008 data suggests that as of 2016, sludge depth has increased to approximately 1.8 feet in WTU 4 and 1.6 feet in WTU 1. The sludge in these WTUs should be removed to ensure that the wetlands continue to provide effective wastewater treatment.

Sludge removal costs include costs associated with removing existing vegetation ($4,800/WTU cell), removing and disposing existing sludge ($500/dry ton) and replanting vegetation ($24,000/WTU cell). Current sludge depths and volumes were estimated using data collected by the City in 2008.

The existing WTUs were constructed using an earthen liner. The useful life of an earthen liner can vary significantly depending on the materials used, thickness, and hydrology of the site, but can generally be expected to average approximately 30 years. Little data is currently available regarding existing WTU liner integrity. For planning purposes however, it was assumed that the liner in WTU 1 should be replaced over the IMP period. Liner replacement was limited to WTU 1 because it is one of the oldest units and provides significant treatment benefits due to its size and location in the wetland series. Lining costs for Unit 1 ($938,000/WTU cell) were estimated based on experience from comparable projects in the Midwest. The City should evaluate liner integrity in all of the WTUs to better refine these assumptions going forward.

Total project cost for removing sludge in WTUs 1 and 4, and replacing the liner in WTU 1 is $23,593,000 in 2017 dollars. See Attachment A, Table A.10. for detailed cost estimates.

2.6 Biosolids System Improvements

There are no new regulatory drivers for these projects. However, digester rehabilitation and capacity enhancements must be completed to address aging infrastructure and ensure sound operation of the existing facility. Current solids treatment at the plant consists of three 60-foot diameter primary digesters and one 60-foot diameter secondary digester. Waste activated sludge is thickened through two centrifuges and primary sludge is thickened in two 25-foot diameter gravity thickeners prior to combining in the primary digesters. Any peak flow sludge is also sent through the gravity thickeners prior to digestion. Digested sludge is sent to two dewatering centrifuges prior to land application. Solids are dewatered to approximately 25% solids.

Digester Rehabilitation: This alternative includes new fixed steel covers for the primary digesters, new floating steel cover for the secondary digester, pumped mixing systems added for primary digesters, and odor reduction improvements. Cleaning and inspection of the digesters was included in the costs.

Total project cost for this alternative is $8,711,700 in 2017 dollars.

New Primary Digester: Solids analysis from the 2008 Conceptual Design Report indicates that digester capacity is not sufficient for Class B compliance (10 day solids retention rate) at 2030 max month conditions. Additional capacity may be necessary within the next 10 to 15 years but will depend on the actual organic loading increases over that time. This alternative includes costs for a new 60-foot concrete primary digester with a fixed steel cover, pumped mixing, digester heating system, odor control, and a new digester building.

Total project cost for this alternative is $4,234,000 in 2017 dollars with approximately $49,100 anticipated in annual operations and maintenance costs.

See Attachment A, Table A.11. and A.12. for detailed cost estimates.

2.7 Alternate Effluent Outfall

The City of Columbia has reclaimed wastewater effluent for maintenance of water levels in EBCA since the early 1990s. This arrangement has provided MDC a valuable reclaimed water source rather than pumping water from the Missouri River, which would add significant long-term operational and maintenance costs and jeopardize the economic viability of EBCA. However, the City may reconsider this arrangement if increased regulatory pressures such as more stringent ammonia criteria drive additional treatment requirements. Instead of discharging to EBCA, the City could move the discharge to the Missouri River to take advantage of large dilution flows.

The estimated cost to install a new 72-inch diameter pipe from the WTUs to the Missouri River (approximately 1.5 miles) is $10,567,300 in 2017 dollars with approximately $6,900 anticipated in annual operations and maintenance costs. If an alternate effluent outfall to the Missouri River is implemented, disinfection and potentially nutrient removal should also be considered. Given the current beneficial arrangement between the City and MDC and the lack of pressing regulatory drivers that would require additional treatment investments, costs for construction of an alternate outfall to the Missouri River were not considered through the remainder of this planning process.

See Attachment A, Table A.13. for detailed cost estimates.

Section 4. Funding Scenario Development

For the CRWWTP, planning level estimates were identified to characterize the level of investment required to improve existing operations, address future regulatory drivers, and provide for more sustainable treatment practices over the next 20 years (the IMP planning period). It is important to note that these estimates represent the investments and activities needed in addition to the resources the Sewer Utility currently manages. Three potential funding level scenarios were used to guide the analysis. They are broadly defined as follows:

- **Level 1 Funding (Level 1) –** Funding needed to **provide the minimum** LOS that meets both community-wide expectations and **existing** regulatory requirements over the 20-year IMP planning period.
- **Level 2 Funding (Level 2) –** Funding needed to **exceed the minimum** LOS based that meets community-wide expectations and **more proactively** meets existing regulatory requirements over the 20-year IMP planning period.
- **Level 3 Funding (Level 3) –** Funding needed to **address all** forecasted infrastructure needs and proactively meet **both** existing and forecasted regulatory requirements over the 20-year IMP planning period.

The estimates include potential capital costs, operation and maintenance costs, and costs associated with necessary planning or data collection activities needed over the IMP planning period. The resulting total and annual spending differences between each funding level presented above are the product of assumptions related to the total project implementation cost, project scheduling, and the timing of known regulatory drivers.

For the wastewater treatment system, the nominal capital and O&M costs estimated within each project category was assumed to be equal across the three funding levels; total cost differences between levels resulted from implementing projects earlier during the IMP planning period (Level 3) as opposed to later (Level 1) to address known regulatory drivers or infrastructure needs. For example, the total cost for expanded nitrification capacity in Level 3 ($46 million) is approximately $6.0 million more than in Level 1 ($40 million) because Level 3 assumes expanded nitrification capacity to meet stringent ammonia discharge requirements will be required 10 years earlier than in Level 1. The $6.0 million difference reflects the additional 10 years of O&M costs that result from implementing the project earlier.

Assumptions related to the timing of wastewater treatment system improvements for each of the three funding levels are presented in Attachment B, Table B.1. Detailed cost forecasts for each funding level are presented in Attachment B, Tables B.2. through B.4.

Section 5. Summary

The City, HDR, and B&V worked to identify wastewater treatment system improvements that would be needed to improve existing operations at the CRWWTP and address regulatory drivers over the 20-year IMP planning period. Alternatives include improving wet-weather capacity, implementing chemical disinfection, installing biological nutrient removal, enhancing nitrification capacity, and providing for more sustainable treatment practices.

Potential capital and programmatic alternatives and planning level costs were identified to characterize the expected additional level of investment that would be needed to fund these improvements. Cost estimates include potential additional capital, operation and maintenance, and necessary planning or data collection costs. Estimates were developed for three potential funding level scenarios and six project categories. The three funding levels represent increasingly proactive investments that the City could pursue to make infrastructure upgrades and water quality improvements through the IMP.

Results of the alternatives evaluation indicate that between $132 million and $158 million of additional investment will be needed to address wastewater treatment system needs over the IMP planning period (**Table 4**). In subsequent analyses, these cost estimates will be combined with estimates for the wastewater collection and stormwater systems and evaluated to identify the level of investment that appropriately balances overall costs with anticipated community benefits. These subsequent evaluations will also consider impacts on future residential utility bills and community-wide affordability.

Table 4. Summary of Wastewater Treatment System Capital and Programmatic Costs in 2017 Dollars.

Project Categories	20-Year Funding Scenario		
	Level 1	**Level 2**	**Level 3**
Wet Weather Capacity Improvements	$50,164,000	$51,710,000	$52,329,000
Expanded Nitrification Capacity	$40,094,000	$41,416,000	$46,044,000
Biological Nutrient Removal	$0	$13,965,000	$14,967,000
Chemical Disinfection	$4,481,000	$5,088,000	$7,210,000
Constructed Wetlands Improvements	$23,593,000	$23,593,000	$23,593,000
Digester Rehabilitation	$8,712,000	$8,712,000	$8,712,000
Digester Capacity Improvements	$4,823,000	$4,823,000	$4,823,000
Total	**$131,867,000**	**$149,307,000**	**$157,678,000**

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Technical Memorandum 6 Attachments

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Attachment A. Wastewater Treatment Alternatives Costs

Table A.1. Influent Pump Station Capacity Improvements Capital and Operation and Maintenance Cost Estimates in 2017 Dollars.

Capital Costs	Unit Price	Total
Expand Influent Pump Station		$9,260,100
Electrical/I&C	20%	$1,852,100
Mechanical	7%	$648,300
Sitework	15%	$1,389,100
General Requirements	10%	$926,100
Contingency	25%	$3,519,000
Total Construction Cost		**$17,594,700**
ELA	25%	$4,398,700
Total Project Cost		**$21,993,400**

O&M Costs	Unit Price	Unit	Qty	Total
Power	0.08	$/kwh	544,282	$43,600
Natural Gas	0.83	$/therm		
Labor-Operators	40	$/hr	520	$20,800
Labor-Maintenance	40	$/hr	78	$3,100
Equipment Maintenance	2%	of equipment cost	2,720,703	$54,400
Total O&M Cost				**$121,900**

Table A.2. Excess Flow Basin Capital Cost Estimates in 2017 Dollars.

Capital Costs	Unit Price	Total
4 MG basin		$4,000,000
Surface Aerators		$0
Electrical/I&C	20%	$0
Mechanical	7%	$0
Sitework	15%	$0
General Requirements	10%	$0
Contingency	25%	$1,000,000
Total Construction Cost		**$5,000,000**
ELA	25%	$1,250,000
Total Project Cost		**$6,250,000**

Capital Costs	Unit Price	Total
10 MG basin		$10,000,000
Surface Aerators		$0
Electrical/I&C	20%	$0
Mechanical	7%	$0
Sitework	15%	$0
General Requirements	10%	$0
Contingency	25%	$2,500,000
Total Construction Cost		**$12,500,000**
ELA	25%	$3,125,000
Total Project Cost		**$15,625,000**

Table A.3. High Rate Wet Weather Treatment Capital and Operation and Maintenance Cost Estimates in 2017 Dollars.

Capital Costs	Unit Price	Total
Add 1 new 130' CEPT Basins		$1,430,000
Additional I/I Sludge Pump Station		$704,900
CEPT Chemical Feed Building		$1,103,000
Diversion Structure Modifications		$50,000
Electrical/I&C	20%	$657,600
Mechanical	7%	$230,200
Sitework	15%	$493,200
General Requirements	10%	$328,800
Contingency	25%	$1,249,500
Total Construction Cost		**$6,247,200**
ELA	25%	$1,561,800
Total Project Cost		**$7,809,000**

O&M Costs	Unit Price	Unit	Qty	Total
Power	0.08	$/kwh	11,817	$940
Natural Gas	0.83	$/therm		
Labor-Operators	40	$/hr	40	$1,600
Labor-Maintenance	40	$/hr	10	$400
Equipment Maintenance	1%	quipment	423,375	$8,450
Chemicals				
Ferric Chloride	1.27	$/gal	95,606	$121,700
Polymer	2.5	$/lb	34,221	$35,900
Total O&M Cost				**$168,990**

Capital Costs	Unit Price	Total
Add 2 new 130' CEPT Basins		$2,860,000
Additional I/I Sludge Pump Station		$965,500
CEPT Chemical Feed Building		$1,103,000
Diversion Structure Modifications		$50,000
Electrical/I&C	20%	$995,700
Mechanical	7%	$348,500
Sitework	15%	$746,800
General Requirements	10%	$497,900
Contingency	25%	$1,891,900
Total Construction Cost		**$9,459,300**
ELA	25%	$2,364,900
Total Project Cost		**$11,824,200**

O&M Costs	Unit Price	Unit	Qty	Total
Power	0.08	$/kwh	23,633	$1,880
Natural Gas	0.83	$/therm		
Labor-Operators	40	$/hr	80	$3,200
Labor-Maintenance	40	$/hr	20	$800
Equipment Maintenance	1%	of equipment cost	846,751	$16,900
Chemicals				
Ferric Chloride	1.27	$/gal	95,606	$121,700
Polymer	1.05	$/lb	34,221	$35,900
Total O&M Cost				**$180,400**

Table A.4. Parallel Line to WTUs Capital and Operation and Maintenance Cost Estimates in 2017 Dollars.

Capital Costs	Unit Price	Total
78" Diameter, 2.3 miles		$8,611,100
Electrical/I&C	0%	$0
Mechanical	0%	$0
Sitework	0%	$0
General Requirements	10%	$861,200
Contingency	25%	$2,368,100
Total Construction Cost		**$11,840,400**
ELA	25%	$2,960,100
Total Project Cost		**$14,800,500**

O&M Costs	Unit Price	Unit	Qty	Total
Power	0.08	$/kwh	0	$0
Natural Gas	0.83	$/therm	0	$0
Labor-Operators	40	$/hr	48	$1,900
Labor-Maintenance	40	$/hr	1	$5,000
Equipment Maintenance	2%	of equipment cost	0	$0
Total O&M Cost				**$6,900**

Table A.5. Wet Weather Chemical Disinfection and Alternate Outfall Capital and Operation and Maintenance Cost Estimates in 2017 Dollars.

5b1 - Chlorination - Wet Weather Facility

Capital Costs	50.4 MGD	
Chlor/DeChlor Disinfection Facility at Mechani(		$2,245,600
Intermediate Pumping Station		$2,283,500
Electrical/I&C	20%	$905,800
Mechanical	7%	$317,000
Sitework	15%	$679,400
General Requirements	10%	$452,900
Contingency	25%	$1,132,300
Total Construction Cost		**$8,016,500**
ELA	25%	$2,004,100
Total Project Cost		**$10,020,600**

O&M Costs	**Unit Price**	**Unit**	**Qty**	**Total**
Power	0.08	$/kwh		$86
Natural Gas	0.83	$/therm		
Labor-Operators	40	$/hr		
Labor-Maintenance	40	$/hr		
Equipment Maintenance				
Chemicals				
Sodium Hypochlorite	1.00	$/gal	2,019	$40,390
Sodium Bisulfite	0.17	$/lb	1,681	$5,717
Total O&M Cost				**$46,192**

Line to Hinkson (78" Diameter, 500 feet)

Capital Costs	**Unit Price**	**Total**
78" Diameter, 500 feet		$354,600
Effluent Structure		$100,200
Electrical/I&C	0%	$0
Mechanical	0%	$0
Sitework	0%	$0
General Requirements	10%	$35,500
Contingency	25%	$122,600
Total Construction Cost		**$612,900**
ELA	25%	$153,300
Total Project Cost		**$766,200**

O&M Costs	**Unit Price**	**Unit**	**Qty**	**Total**
Power	0.08	$/kwh	Qty	$0
Natural Gas	0.83	$/therm	0	$0
Labor-Operators	40	$/hr	48	$1,900
Labor-Maintenance	5000		1	$5,000
Total O&M Cost				**$6,900**

Table A.6. Nitrification Capital and Operation and Maintenance Cost Estimates in 2017 Dollars.

Capital Costs	Unit Price	Total
Primary clarifiers (5 & 6) - 105 ft Diameter		$2,306,200
New Aeration Basins (5 & 6) (deduct anoxic zor		$4,792,700
Final Clarifier (trains 5&6)- 115 ft Diameter		$2,660,600
RAS/WAS Pump Stations (train 5&6)		$1,200,000
Primary Sludge Pump Station (for Train 3)		$704,900
Primary Sludge Pump Station (for Train 4)		$260,600
Blower Replacement		$846,800
Piles		$3,274,300
Electrical/I&C	20%	$3,209,300
Mechanical	7%	$1,123,300
Sitework	15%	$2,407,000
General Requirements	10%	$1,604,700
Contingency	25%	$6,097,600
Total Construction Cost		**$30,488,000**
ELA	25%	$7,622,000
Total Project Cost		**$38,110,000**

O&M Costs	Unit Price	Unit	Qty	Total
Power	0.08	$/kwh	6,949,385	$555,900
Natural Gas	0.83	$/therm		
Labor-Operators	40	$/hr	520	$20,800
Labor-Maintenance	40	$/hr	338	$13,500
Equipment Maintenance	2%	of equipment cost	3,549,085	$71,000
Total O&M Cost				**$661,200**

Table A.7. Biological Nutrient Removal Capital and Operation and Maintenance Cost Estimates in 2017 Dollars.

Capital Costs	Unit Price	Total
Add Anaerobic/Preanoxic zones		$4,007,300
Utilize Gravity Thickeners for Fermentation		$90,000
Add Anoxic zones to Trains 5 & 6		$1,516,800
Polymer Tote System (Chemical feed System*)		$97,000
Electrical/I&C	20%	$1,142,300
Mechanical	7%	$399,800
Sitework	15%	$856,700
General Requirements	10%	$571,200
Contingency	25%	$2,170,300
Total Construction Cost		**$10,851,400**
ELA	25%	$2,712,900
Total Project Cost		**$13,564,300**

O&M Costs	Unit Price	Unit	Qty	Total
Power	0.08	$/kwh	1,483,436	$118,700
Natural Gas	0.83	$/therm		
Labor-Operators	40	$/hr	520	$20,800
Labor-Maintenance	40	$/hr	702	$28,100
Equipment Maintenance	2%	of equipment cost	918,833	$18,400
Chemicals				
Ferric Chloride	1.27	$/gal		
Polymer	1.05	$/lb	13,700	$14,400
Total O&M Cost				**$200,400**

Table A.8. Chlorine Disinfection Capital and Operation and Maintenance Cost Estimates in 2017 Dollars. Estimates assume that improvements outlined in Table A4 are not implemented.

Capital Costs		143 MGD
Chlor/DeChlor Disinfection Facility at Mechanical Plant		$1,768,000
Intermediate Pumping Station		$0
Electrical/I&C	20%	$353,600
Mechanical	7%	$123,800
Sitework	15%	$265,200
General Requirements	10%	$176,800
Contingency	25%	$442,000
Total Construction Cost		**$3,129,400**
ELA	25%	$442,000
Total Project Cost		**$3,571,400**

O&M Costs	Unit Price	Unit	Qty	Total
Power	0.08	$/kwh		$1,116
Natural Gas	0.83	$/therm		
Labor-Operators	40	$/hr		
Labor-Maintenance	40	$/hr		
Equipment Maintenance				
Chemicals				
Sodium Hypochlorite	1.00	$/gal	1,162	$302,122
Sodium Bisulfite	0.17	$/lb	0	$0
Total O&M Cost				**$303,237**

Table A.9. Ultraviolet Disinfection Capital and Operation and Maintenance Cost Estimates in 2017 Dollars.

Capital Costs	Unit Price	Total
UV Disinfection Facility at WLPS		$7,658,000
Intermediate Pumping Station		$5,625,811
Electrical/I&C	20%	$2,656,800
Mechanical	7%	$929,900
Sitework	15%	$1,992,600
General Requirements	10%	$1,328,400
Contingency	25%	$5,047,900
Total Construction Cost		**$25,239,411**
ELA	25%	$6,309,900
Total Project Cost		**$31,549,311**

O&M Costs	Unit Price	Unit	Qty	Total
Power	0.08	$/kwh	380,464	$30,400
Natural Gas	0.83	$/therm		
Labor-Operators	40	$/hr	520	$20,800
Labor-Maintenance	40	$/hr	348	$13,900
Equipment Maintenance	450	$/lamp	70	$23,000
Total O&M Cost				**$88,100**

Table A.10. Constructed Wetlands Improvements Capital Cost Estimates in 2017 Dollars.

Capital Costs	Unit Price	Total
Total Cells		13
Sludge Removal and Lining Cost		$17,004,000
Cattail Removal Cost		$62,400
Cattail Planting Cost		$312,000
Contingency	30%	$5,214,300
Total Construction Cost		**$22,592,700**
ELA		$1,000,000
Total Project Cost		**$23,592,700**

Table A.11. Digester Rehabilitation Capital and Operation and Maintenance Cost Estimates in 2017 Dollars.

Capital Costs	Unit Price	Total
Drain, clean and inspect digester interior		$160,000
Removal and disposal of existing 60' dia fixed/f		$160,000
Secondary Cover		$700,000
Primary Covers (3) replacement		$1,555,700
Odor Control		$194,200
Primary Digester Mixing		$1,028,600
Electrical/I&C	20%	$695,700
Mechanical	7%	$243,500
Sitework	15%	$521,800
General Requirements	10%	$379,900
Contingency	25%	$1,329,900
Total Construction Cost		**$6,969,300**
ELA	25%	$1,742,400
Total Project Cost		**$8,711,700**

O&M Costs	Unit Price	Unit	Qty	Total
Power	0.08	$/kwh	0	$0
Natural Gas	0.83	$/therm		
Labor-Operators	40	$/hr	0	$0
Labor-Maintenance	40	$/hr	0	$0
Equipment Maintenance	2%	of equipment cost	0	$0
Total O&M Cost				**$0**

Table A.12. Digester Capacity Improvements Capital and Operation and Maintenance Cost Estimates in 2017 Dollars.

Capital Costs	Unit Price	Total
Primary Cover		$518,600
Odor Control		$64,800
Primary Digester Mixing		$342,900
Concrete		$352,800
Heating		$48,700
New Building		$386,500
Electrical/I&C	20%	$342,900
Mechanical	7%	$120,100
Sitework	15%	$257,200
General Requirements	10%	$171,500
Contingency	25%	$677,500
Total Construction Cost		**$3,387,200**
ELA	25%	$846,800
Total Project Cost		**$4,234,000**

O&M Costs	Unit Price	Unit	Qty	Total
Power	0.08	$/kwh	434,467	$34,800
Natural Gas	0.83	$/therm		
Labor-Operators	40	$/hr	40	$5,200
Labor-Maintenance	40	$/hr	40	$1,300
Equipment Maintenance	2%	of equipment cost	391,600	$7,800
Total O&M Cost				**$49,100**

Table A.13. New Line from WTUs to Missouri River Capital and Operation and Maintenance Cost Estimates in 2017 Dollars.

Capital Costs	Unit Price	Total
72" Diameter, 1.5 miles pipeline		$6,047,900
Effluent Structure		$100,200
Electrical/I&C	0%	$0
Mechanical	0%	$0
Sitework	0%	$0
General Requirements	10%	$614,900
Contingency	25%	$1,690,800
Total Construction Cost		**$8,453,800**
ELA	25%	$2,113,500
Total Project Cost		**$10,567,300**

O&M Costs	Unit Price	Unit	Qty	Total
Power	0.08	$/kwh	0	$0
Natural Gas	0.83	$/therm	0	$0
Labor-Operators	40	$/hr	48	$1,900
Labor-Maintenance	5000		1	$5,000
Total O&M Cost				**$6,900**

Attachment B. 20-Year Funding Scenarios

Table B.1. Wastewater Treatment System Improvement Timing Assumptions. The dark blue represents initiation of capital expenditures and light blue represents ongoing O&M expenditures.

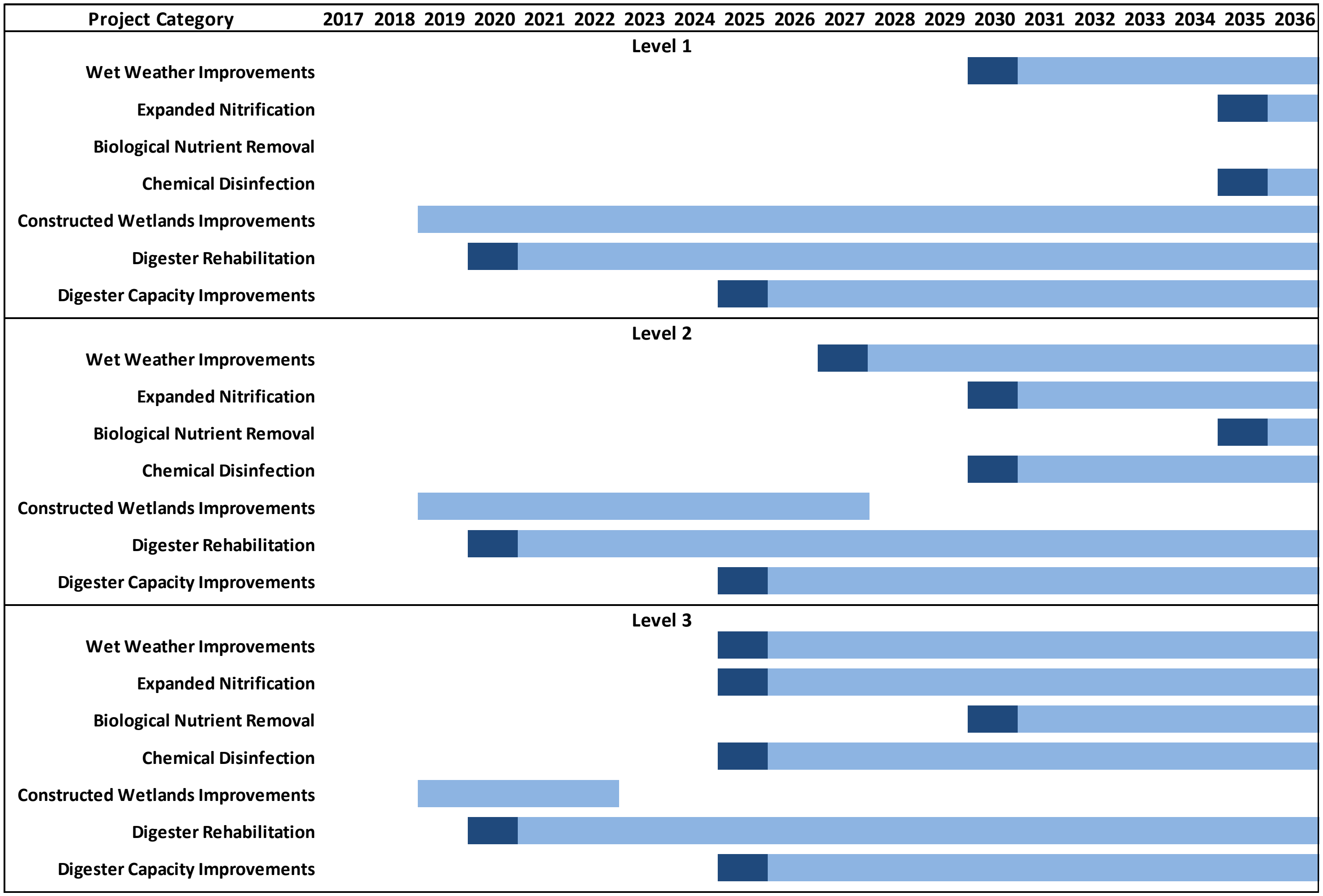

Table B.2. Level 1 Wastewater Treatment System Capital and Programmatic Cost Forecast in 2017 Dollars.

Columbia Wastewater Treatment System
Capital and Programmatic Cost Estimates - Level 1 Funding

Project Category	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Wet Weather Improvements	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Expanded Nitrification	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Biological Nutrient Removal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Chemical Disinfection	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Constructed Wetlands Improvements	$ -	$ -	$ 1,310,707	$ 1,310,706	$ 1,310,706	$ 1,310,706	$ 1,310,706	$ 1,310,706	$ 1,310,706	$ 1,310,706
Digester Rehabilitation	$ -	$ -	$ -	$ 8,849,700	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000
Digester Capacity Improvements	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 4,283,100	$ 49,100
Annual Total	**$ -**	**$ -**	**$ 1,310,707**	**$ 10,160,406**	**$ 1,448,706**	**$ 1,448,706**	**$ 1,448,706**	**$ 1,448,706**	**$ 5,731,806**	**$ 1,497,806**
Cumulative Total	**$ -**	**$ -**	**$ 1,310,707**	**$ 11,471,113**	**$ 12,919,819**	**$ 14,368,525**	**$ 15,817,231**	**$ 17,265,937**	**$ 22,997,743**	**$ 24,495,549**

Columbia Wastewater Treatment System
Capital and Programmatic Cost Estimates - Level 1 Funding

Project Category	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Wet Weather Improvements	$ -	$ -	$ -	$ 48,927,300	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200
Expanded Nitrification	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 38,771,200	$ 661,200
Biological Nutrient Removal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Chemical Disinfection	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 3,874,637	$ 303,237
Constructed Wetlands Improvements	$ 1,310,706	$ 1,310,706	$ 1,310,706	$ 1,310,706	$ 1,310,706	$ 1,310,706	$ 1,310,706	$ 1,310,706	$ 1,310,706	$ 1,310,706
Digester Rehabilitation	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000
Digester Capacity Improvements	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100
Annual Total	**$ 1,497,806**	**$ 1,497,806**	**$ 1,497,806**	**$ 50,425,106**	**$ 1,807,006**	**$ 1,807,006**	**$ 1,807,006**	**$ 1,807,006**	**$ 44,452,843**	**$ 2,771,443**
Cumulative Total	**$ 25,993,355**	**$ 27,491,161**	**$ 28,988,967**	**$ 79,414,073**	**$ 81,221,079**	**$ 83,028,085**	**$ 84,835,091**	**$ 86,642,097**	**$ 131,094,940**	**$ 133,866,383**

Table B.3. Level 2 Wastewater Treatment System Capital and Programmatic Cost Forecast in 2017 Dollars.

Columbia Wastewater Treatment System Capital and Programmatic Cost Estimates - Level 2 Funding										
Project Category	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Wet Weather Improvements	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Expanded Nitrification	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Biological Nutrient Removal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Chemical Disinfection	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Constructed Wetlands Improvements	$ -	$ -	$ 2,621,411	$ 2,621,411	$ 2,621,411	$ 2,621,411	$ 2,621,411	$ 2,621,411	$ 2,621,411	$ 2,621,411
Digester Rehabilitation	$ -	$ -	$ -	$ 8,849,700	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000
Digester Capacity Improvements	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 4,283,100	$ 49,100
Annual Total	**$ -**	**$ -**	**$ 2,621,411**	**$ 11,471,111**	**$ 2,759,411**	**$ 2,759,411**	**$ 2,759,411**	**$ 2,759,411**	**$ 7,042,511**	**$ 2,808,511**
Cumulative Total	**$ -**	**$ -**	**$ 2,621,411**	**$ 14,092,522**	**$ 16,851,933**	**$ 19,611,344**	**$ 22,370,756**	**$ 25,130,167**	**$ 32,172,678**	**$ 34,981,189**

Columbia Wastewater Treatment System Capital and Programmatic Cost Estimates - Level 2 Funding										
Project Category	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**
Wet Weather Improvements	$ 48,927,300	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200
Expanded Nitrification	$ -	$ -	$ -	$ 38,771,200	$ 661,200	$ 661,200	$ 661,200	$ 661,200	$ 661,200	$ 661,200
Biological Nutrient Removal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 13,764,700	$ 200,400
Chemical Disinfection	$ -	$ -	$ -	$ 3,874,637	$ 303,237	$ 303,237	$ 303,237	$ 303,237	$ 303,237	$ 303,237
Constructed Wetlands Improvements	$ 2,621,411	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Digester Rehabilitation	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000
Digester Capacity Improvements	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100
Annual Total	**$ 51,735,811**	**$ 496,300**	**$ 496,300**	**$ 43,142,137**	**$ 1,460,737**	**$ 1,460,737**	**$ 1,460,737**	**$ 1,460,737**	**$ 15,225,437**	**$ 1,661,137**
Cumulative Total	**$ 86,717,000**	**$ 87,213,300**	**$ 87,709,600**	**$ 130,851,737**	**$ 132,312,474**	**$ 133,773,211**	**$ 135,233,948**	**$ 136,694,685**	**$ 151,920,122**	**$ 153,581,259**

Table B.4. Level 3 Wastewater Treatment System Capital and Programmatic Cost Forecast in 2017 Dollars.

Columbia Wastewater Treatment System
Capital and Programmatic Cost Estimates - Level 3 Funding

Project Category	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Wet Weather Improvements	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 48,927,300	$ 309,200
Expanded Nitrification	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 38,771,200	$ 661,200
Biological Nutrient Removal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Chemical Disinfection	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 3,874,637	$ 303,237
Constructed Wetlands Improvements	$ -	$ -	$ 5,898,175	$ 5,898,175	$ 5,898,175	$ 5,898,175	$ -	$ -	$ -	$ -
Digester Rehabilitation	$ -	$ -	$ -	$ 8,849,700	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000
Digester Capacity Improvements	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 4,283,100	$ 49,100
Annual Total	**$ -**	**$ -**	**$ 5,898,175**	**$ 14,747,875**	**$ 6,036,175**	**$ 6,036,175**	**$ 138,000**	**$ 138,000**	**$ 95,994,237**	**$ 1,460,737**
Cumulative Total	**$ -**	**$ -**	**$ 5,898,175**	**$ 20,646,050**	**$ 26,682,225**	**$ 32,718,400**	**$ 32,856,400**	**$ 32,994,400**	**$ 128,988,637**	**$ 130,449,374**

Columbia Wastewater Treatment System
Capital and Programmatic Cost Estimates - Level 3 Funding

Project Category	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Wet Weather Improvements	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200	$ 309,200
Expanded Nitrification	$ 661,200	$ 661,200	$ 661,200	$ 661,200	$ 661,200	$ 661,200	$ 661,200	$ 661,200	$ 661,200	$ 661,200
Biological Nutrient Removal	$ -	$ -	$ -	$ 13,764,700	$ 200,400	$ 200,400	$ 200,400	$ 200,400	$ 200,400	$ 200,400
Chemical Disinfection	$ 303,237	$ 303,237	$ 303,237	$ 303,237	$ 303,237	$ 303,237	$ 303,237	$ 303,237	$ 303,237	$ 303,237
Constructed Wetlands Improvements	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Digester Rehabilitation	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000	$ 138,000
Digester Capacity Improvements	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100	$ 49,100
Annual Total	**$ 1,460,737**	**$ 1,460,737**	**$ 1,460,737**	**$ 15,225,437**	**$ 1,661,137**	**$ 1,661,137**	**$ 1,661,137**	**$ 1,661,137**	**$ 1,661,137**	**$ 1,661,137**
Cumulative Total	**$ 131,910,111**	**$ 133,370,848**	**$ 134,831,585**	**$ 150,057,022**	**$ 151,718,159**	**$ 153,379,296**	**$ 155,040,433**	**$ 156,701,570**	**$ 158,362,707**	**$ 160,023,844**