Burns & McDonnell
SINCE 1898

Wastewater Treatment Facility Upgrade Project

STONEGATE
Village Metropolitan District

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Project No. 69228

November, 2012

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prepared for

Stonegate Village Metropolitan District
Colorado

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prepared by

Burns & McDonnell Engineering Company, Inc.

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E.0 EXECUTIVE SUMMARY

Stonegate Village Metropolitan District (District) requested that Burns & McDonnell (BMcD) evaluate the condition of its Wastewater Treatment Facility (WWTF) and develop alternatives to assist the District in planning improvements for the long term utilization of the WWTF. This executive summary serves to briefly describe the evaluation, and the associated alternatives evaluated in this report.

E.1 OPERATIONAL DATA AND DISCHARGE PERMIT REVIEW

The first objective of this study was to establish plant design parameters, including design flows and effluent goals. Documentation provided by the District in the form of past studies and O&M manuals were evaluated for design flow information. Table E-1 presents the design flows that were selected based on the most recent study of the WWTF's service area.

Table E-1. WWTF Design Flows

	Flow (MGD)
Average Day	1.0
Maximum Month	1.1
Peak Day	2.1
Peak Hour	3.5
Source: *Wastewater Utility Plan Update (2010). Richard P. Arber Associates.*	

The WWTF's discharge permit was compared with other neighboring plants discharging to the same location to determine whether more stringent limits are likely in the future. Effluent goals were established for the WWTF based on the discharge permit review, recent nutrient limits established for all plants in Colorado, and BMcD's experience as professional consultants. These effluent goals as well as typical discharges for the existing WWTF are presented in Table E-2. The basis for selecting these values are included in Section 2.5.1.

Table E-2. WWTF Target Effluent Concentrations

Constituent	Target Effluent Concentration	Typical Effluent Concentration
BOD	25 mg/L	3 mg/L[1]
TSS	25 mg/L	6 mg/L[1]
Ammonia	1.5 mg/L	3 mg/L[1] (0.19 since Feb. 09)[1]
TIN	5 mg/L	6 mg/L[1,2]
TP	0.05 mg/L	0.03 mg/L[1]
E-Coli	84/100 mL	1.2/100 mL[1]
Copper	18 µg/L	27 µg/L[3]
Iron	50 µg/L	21 µg/ L[3]
Manganese	50 µg/L	15 µg/ L[3]
Zinc	254 µg/L	75 µg/ L[3]
Se	3.0 µg/L	0.7 µg/ L[3]

1. *2007 through 2011 Discharge Monitoring Reports*
2. *TIN is the sum of ammonia, nitrite, and nitrate. Assumes nitrite contribution is negligible.*
3. *Summary of DMR Data for 2008 through 2010, Stonegate NPDES Permit.*

These effluent goals only serve to establish treatment requirements for process selection and budgetary level construction and operational costs. Treatment requirements should be confirmed with the Colorado Department of Public Health and Environment (CDPHE) prior to making major process changes at the WWTF.

E.2 CONDITION ASSESSMENT

BMcD conducted multiple walk-throughs of the WWTF while accompanied by District staff. The purpose of the walk-throughs was to review the condition of the District's existing facilities with respect to treatment process, structural, mechanical, and electrical disciplines. The review team observed and identified the WWTF's critical components and assessed their condition. The evaluation assessed key unit processes and other infrastructure in the plant, including:

- Headworks Building
- Mixing/Splitter Box

- Secondary Treatment Processes
- Final Clarifiers
- Tertiary Treatment
- Disinfection
- Digestion/Solids Handling
- Administration Building
- Emergency Power System
- General Plant Observations

The condition assessment provided a basis for the alternative plant improvements described throughout this report. Throughout the alternatives analysis, several new treatment processes are proposed for the WWTF.

E.3 TREATMENT PROCESS DESCRIPTIONS

Section 4.0 introduces alternative processes for secondary treatment, tertiary treatment, and disinfection. The following is a brief summary of the processes presented in Section 4.0:

E.3.1 Secondary Treatment – Conventional Activated Sludge

Conventional activated sludge is a suspended growth process, meaning that the organisms treating wastewater are kept in suspension in the process basins. Solids separation is accomplished using gravity clarification. Conventional activated sludge is the process used at the existing WWTF.

E.3.2 Secondary Treatment - Membrane Bioreactor

Membrane bioreactors (MBR) use a suspended growth process, similar to conventional activated sludge, but use membrane filters for solids separation rather than gravity clarification. MBR plants have smaller footprints than conventional activated sludge plants of the same capacity, and can accomplish both secondary and tertiary treatment in the same process basins.

E.3.3 Secondary Treatment - Integrated Fixed-Film Activated Sludge

Integrated fixed-film activated sludge (IFAS) uses both fixed-film and suspended growth processes. Fixed-film media placed in the basins allows nitrifying bacteria to grow at lower solids retention times than conventional activated sludge, reducing the plant footprint and mitigating filamentous organism growth. Solids separation is accomplished using gravity clarification.

E.3.4 Tertiary Treatment - Adsorption Clarifiers/Filtration

The adsorption clarification/conventional filtration process is a packaged treatment process which is currently used at the WWTF, where it is commonly referred to as the advanced water treatment (AWT) process. The process consists of chemical injection, rapid mix, upflow clarification, and conventional filtration.

E.3.5 Tertiary Treatment - Membrane Bioreactors

Using MBRs described in E.3.2 as a secondary treatment process can eliminate the need for downstream tertiary treatment.

E.3.6 Tertiary Treatment - Ballasted Flocculation/Cloth Media Disc Filtration

The ballasted flocculation process uses small sand particles to seed floc and provide weight during chemical precipitation and settling. A cloth media disc filter located downstream of the settling tank removes any remaining particles from the wastewater.

E.3.7 Disinfection - Bulk Sodium Hypochlorite

Bulk sodium hypochlorite systems feed liquid sodium hypochlorite (bleach) to the water, which oxidizes and kills organisms. Dechlorination is required for hypochlorite systems, requiring two chemical feed systems. The existing WWTF currently uses this approach for disinfection and dechlorinates by feeding sodium bisulfite.

E.3.8 Disinfection - Ultraviolet Light

Disinfection with ultraviolet (UV) light does not oxidize and kill organisms, but rather disrupts their DNA and prevents them from replicating. UV systems do not have the same chemical handling requirements as hypochlorite, are commonly used throughout the state, and do not create the same byproducts generated by chlorine based disinfectants regulated in drinking water.

E.4 ALTERNATIVE EVALUATION

Five primary alternatives are described in this report (Alternatives 1 through 5). Each alternative makes progressively more substantial improvements to the plant than the previous. Some of these alternatives include sub-alternatives, presenting multiple options for various treatment processes. Alternatives 1 through 3 focus on critical improvements to the facility, replacing aging equipment, and depending on the alternative, proposes new treatment processes. Alternatives 4 and 5 effectively replace the entire treatment plant, but re-use some process basins that are suitable for the new plant processes. Alternative 5 is the only option that increases the hydraulic capacity of the WWTF. Table E-3 summarizes key components associated with each alternative.

Table E-3. Alternative Key Process Modifications

Alternative	Aeration/Digester Blower Improvements	Existing Equipment and Piping Improvements[1]	New Administrative Building	New Headworks	Integrated Fixed Film Activated Sludge (IFAS)	Secondary Flow Equalization	Increase AWT Capacity	New Final Clarifiers	Membrane Bioreactor	Ballasted Flocculation/ Disc Filtration	UV Disinfection	Sodium Hypochlorite Disinfection	Build New Aerobic Digesters	WAS Thickening	Dewatering
1	X	X				X	X					X			
2A	X	X				X	X					X	X	X	
2B	X	X				X	X				X		X	X	
3A	X	X			X			X		X		X	X	X	X
3B	X	X							X		X		X	X	X
4A	X		X	X	X			X		X		X	X	X	X
4B	X		X	X					X		X		X	X	X
5A	X		X	X	X			X		X	X		X	X	X
5B	X		X	X					X		X		X	X	X

Equipment and piping improvements vary between each alternative. See Chapter 5.0 for details of each alternative.

E.5 COST ANALYSIS

Conceptual level capital and operation and maintenance (O&M) cost opinions for each alternative were generated for comparative purposes. These cost opinions are based upon the alternatives presented in this study and rely primarily on BMcD's experience and judgments as professional consultants, combined with information from past experience, vendors, and published sources. Cost data from recent construction projects were utilized where appropriate. Other budgetary prices were obtained from equipment representatives. Standard percentages were used for additional project costs such as site work, contractor markups such as mobilization, and non-construction costs such as engineering, construction services, and startup costs.

E.5.1 Capital Construction Cost Opinions

The capital construction costs opinions for Alternatives 1 through 5B are summarized in Table E-4 below. These costs include engineering, construction phase services, contractor markups, and startup costs. Alternatives that include an MBR ("B" designations) as the tertiary treatment option have a lower overall capital cost opinions when compared to the Alternatives that require new IFAS, final clarifiers, ballasted flocculation, and disc filtration for tertiary treatment ("A" designations).

Table E-4. Alternative Capital Construction Costs

Alternative	Capital Construction Cost (Million Dollars)
Plant Capacity = 1.1 MGD - Short Term Solution	
1	$5.47
Plant Capacity = 1.1 MGD – Long Term Solution	
2A	$10.04
2B	$9.91
3A	$13.59
3B	$11.57
4A	$17.44
4B	$15.82
Plant Capacity = 2.2 MGD – Long Term Solution	
5A	$23.10
5B	$20.24
1) Costs include engineering, construction services, contractor markups, and startup costs	

E.5.2 Net Present Value Analysis

In addition to capital construction costs, operation and maintenance (O&M) costs were developed to calculate the net present value (NPV) for each alternative. O&M costs take into consideration the amount of power and chemical used as well as the amount of sludge generated by each alternative. Comparing alternatives based on NPV gives a more holistic approach to alternative selection. Alternatives with low capital cost can sometimes have high annual O&M costs and therefore represent an overall higher long term project cost when compared to alternatives with higher capital costs and lower O&M costs. Table E-5 summarizes the O&M costs in addition to the overall 20 year NPV for each alternative.

Table E-5. Alternative Net Present Values

Alternative	Capital Construction Cost (Million Dollars)	Annual Chemical Cost (Million Dollars)	Annual Energy Cost (Million Dollars)	Annual Sludge Disposal Cost (Million Dollars)	Total Annual O&M Cost (Million Dollars)	Total NPV (Million Dollars)
Safety, Permit Compliance, Emergency Items – Short Term Solution						
1	$5.47	$0.155	$0.143	$0.226	$0.524	N/A
Alternative 1 plus Re-model and Improve Some Processes – Long Term Solution						
2A	$10.04	$0.155	$0.143	$0.226	$0.524	$22.60
2B	$9.91	$0.141	$0.155	$0.226	$0.522	$22.55
Performance Improvements plus Sustainability – Long Term Solution						
3A	$13.59	$0.078	$0.149	$0.056	$0.283	$22.82
3B	$11.57	$0.053	$0.165	$0.056	$0.274	$20.57
New 1.1 MGD Facility – Long Term Solution						
4A	$17.44	$0.064	$0.162	$0.056	$0.282	$26.62
4B	$15.82	$0.053	$0.165	$0.056	$0.274	$24.65
New 2.2 MGD Facility – Long Term Solution						
5A	$23.10	$0.128	$0.306	$0.111	$0.545	$38.98
5B	$20.24	$0.098	$0.305	$0.111	$0.514	$35.22

1. *Alternative 1 does not provide a long term solution for the operation of the WWTF; therefore the NPV is not comparable with other alternatives.*
2. *Alternative 2 could provide a 20+ year solution if future permit limits remain the same as current day limits.*
3. *Presentation of costs does not reflect capacity, safety, regulatory, and other non-economic factors addressed by some alternatives and not by others.*

E.6 CONCLUSIONS AND RECOMMENDATIONS

The overall purpose of this study was to assess the condition of the existing WWTF and to provide a number of alternatives that will help the District determine the future direction of the WWTF. Currently, the WWTF is in poor condition and requires increased daily operations effort and cost in order to maintain the facility such that discharge limits can be consistently met. Efforts required to operate the WWTF prevent operators from performing other tasks, such as equipment preventative maintenance (PM) and process optimization. To varying degrees, all of the developed alternatives provide more reliable facilities that will require less O&M effort to operate and maintain and will allow operators to focus on PM and process optimization activities.

The treatment technologies available to the District are numerous, and this report only describes a handful of viable options for the purpose of defining realistic budgetary level capital and operational costs. Using the budgetary numbers determined in this study, the District will have several treatment technologies to choose from. If the District wishes to further explore alternatives not described in this report, those processes should be evaluated during design.

Based on the results of the condition assessment and cost evaluation, selecting an alternative that utilizes AWT filters is not recommended (Alternatives 1 and 2). The existing AWT filters rely on very high doses of alum for phosphorus removal and are intolerant of algae washout from the clarifiers, creating high annual O&M costs. In addition, the AWT filters have been a continnual operational challenge for plant staff. The addition of more AWT filters would also require construction of both a new building and an additional equalization tank.

An alternative that utilizes either ballasted flocculation/disc filtration or MBRs (Alternative 3 or higher, "A" or "B" designations, respectively) for tertiary phosphorus removal are recommended. These technologies are proven for removal of phosphorus to low effluent levels. Capital cost opinions for MBR alternatives are lower than alternatives that utilize ballasted flocculation/disc filtration. When directly compared with ballasted flocculation/disc filtration, the MBR capital cost opinion is higher. However, the ballasted flocculation/disc filtration alternatives also require IFAS media and the construction of new clarifiers, neither of which are required for the MBR alternatives.

MBR alternatives will use smaller quantities of chemicals when compared to ballasted flocculation/disc filtration alternatives. Less coagulant is required for phosphorus removal using MBRs, although MBRs require a number of membrane chemicals for occasional cleaning in place (CIP) operations. The difference in power usage between MBRs and ballasted flocculation/disc filtration is negligible.

Alternatives that utilize UV disinfection ("B" Designations and Alternatives 4 and 5) should be considered. Although UV disinfection uses more power than chemical disinfection, it is safer from a chemical handling perspective, and does not create the same disinfection byproducts, as hypochlorite. UV disinfection will also decrease the amount of chemical truck traffic at the treatment site.

Other considerations that are not captured with a NPV analysis such as footprint, expandability, and ease of operation should be considered. From the perspective of footprint and expandability, alternatives that incorporate MBR with UV disinfection would have the smallest footprint and leave the most room on the existing site for future expansion. As previously mentioned, ballasted flocculation/disc filtration alternatives would require construction of new secondary clarifiers, which would take up additional footprint not required for the MBR alternatives.

Each alternative makes progressively more substantial improvements to the WWTF than the previous, thus increasing the overall useful life of the facility. Based on the results of this condition assessment and alternatives analysis, BMcD recommends the District pursue Alternative 3 or higher. Neither Alternatives 1 nor 2 fully address the capacity issues identified within the condition assessment, nor do they upgrade the plant's secondary process, which may be required by later discharge permits or changing drinking water sources. Alternative 3 is recommended as the minimum level of improvements because it provides robust, reliable treatment processes while addressing operational difficulties and capacity deficiencies. From a cost perspective, the Alternative 3 options have similar net present values to Alternative 2 while being only marginally more expensive from a capital standpoint. If Alternative 4 or 5 were selected, the District would be making a long term investment in new infrastructure. Alternative 5 becomes an attractive option for the District if capital and operational costs can be shared with a partner utility, thus providing a more reliable facility, while minimizing costs. Further refinement of the selected alternative should be evaluated during the design phase. For example, thickening, dewatering, and other equipment types should be evaluated in detail during design.

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