Report for
Madison Metropolitan
Sewerage District, Madison, Wisconsin

2016 Liquid Processing Facilities Plan

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August 2017
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ES.01 PROJECT BACKGROUND

The Madison Metropolitan Sewerage District (MMSD or District) has a long history of proactive planning to best serve its customers and the greater Dane County area in a sustainable and fiscally responsible manner. This Liquid Processing Facilities Plan (Facilities Plan) is focused on the future needs and opportunities related to the Nine Springs Wastewater Treatment Plant (NSWWTP) liquid treatment processes. The most recent NSWWTP focused planning studies were developed as noted in the following:

- Tenth Addition Facilities Plan–2003
- 50-Year Master Plan–2009
- Solids Handling Facilities Plan (Eleventh Addition)–2009/2010
- Energy Baseline and Optimization Roadmap Study–2014

The District is a municipal corporation located in Madison, Wisconsin that provides wastewater conveyance and treatment for 43 communities and sanitary districts in the Madison metropolitan area. The MMSD service area includes approximately 182 square miles with a population of approximately 365,000 people. The District’s conveyance system includes 94 miles of interceptor sewers, 48 miles of force mains, and 18 pumping stations. All the wastewater collected in the MMSD service area is conveyed to the NSWWTP for treatment and returned to the environment.

This Facilities Plan was prepared for the purpose of developing a plan for liquid processing and treatment at the NSWWTP through the planning year of 2040. The scope of work for the Facilities Plan includes the following:

ES.02 MMSD STRATEGIC GOALS AND OBJECTIVES

While the District has always been committed to providing excellent services at low costs to its ratepayers, the District has more recently established goals that focus on achieving sustainability targets. For example, the District now seeks certification for capital improvement projects to increase the transparency of decisions and to develop the most sustainable solutions for implementation. All decisions and capital improvement projects need consider sustainability objectives based on business case evaluations (including triple bottom line objectives and analyses) to develop the best overall plan for the District and its customers. Specific target areas of the Facilities Plan are described in the following:

1. Peak Capacity Management

   With the construction of Pump Station No. 18 and upgrades to Pump Station No. 11, there is the potential of exceeding the hydraulic capacity of the NSWWTP. In addition, peak flow management constraints within the NSWWTP limit the flexibility and treatment capacity of the plant. The goal of this targeted task is to develop a plan to improve the capacity, resiliency, and flexibility to manage peak flows into the NSWWTP.

   It is noted that the analysis did not include a climate change impact for the District, but it did summarize two recent climate change impact analyses that were completed for the Milwaukee Metropolitan Sewerage District. In general, large wet weather events tended to become larger and more intense, while smaller events tended to become smaller and less frequent, with the
average annual rainfall anticipated to remain approximately the same. The climate change scenarios affected the distribution of intensities, rather than the average annual rain amount. The studies predicted a relatively small change in peak sanitary sewer flows of less than 10 percent. Climate change impacts in Madison could be expected to be similar to the Milwaukee study results. With due respect for the uncertainties in the model results, the impacts of climate change in an upper Midwest location like Madison may be a modest variation from the current pattern, rather than a major hydrologic shift.

2. Activated Sludge Facilities

The NSWWTP activated sludge facilities are an exceptionally well operated set of processes within the NSWWTP. However, the majority of the equipment and systems related to these processes were installed in the 1980s and 1990s, and these systems will need to be replaced within the planning horizon of this plan. In addition, the Energy Baseline and Optimization Roadmap Study identified the activated sludge facilities as a primary opportunity to reduce energy consumption at the NSWWTP. The focus of this major planning element was to identify process upgrades and enhancements to reduce energy while meeting current and projected future loading conditions and permit requirements.

3. Headworks Facilities

The headworks facilities include screening and grit removal processes at the head end of the plant, as well as the facilities devoted to receiving trucked-in wastes at the NSWWTP. These facilities were installed as part of the Tenth Addition in about 2005, and generally have required considerably more maintenance and operator attention than was anticipated or should be expected, especially with respect to the screening and hauled waste receiving facilities. The focus of the Headworks Facilities planning is to provide a plan to reduce maintenance, improve operations flexibility and process resiliency, and develop a plan to maximize the use of the existing system while planning for its replacement within the next 10 years.

4. Ultraviolet (UV) Disinfection System

This system is critical to the NSWWTP in terms of meeting its WPDES permit for effluent fecal coliform, as all wastewater that is pumped to the District’s two outfall locations is disinfected through this system. The existing UV disinfection system was started-up in 1996 and has been operational for more than 20 years. While the system is still functional, the equipment manufacturer has not supported this equipment for about 20 years, and replacement parts are becoming more difficult to source and/or produce. The focus of this major planning element is to develop a plan to upgrade or replace the system.

5. NSWWTP Electrical Reliability

The NSWWTP includes a significant electrical distribution system with several aging substations and related equipment. Providing safe and reliable power to all NSWWTP processes is critical to maintaining treatment performance and environmental protection. This portion of the planning effort was focused on upgrading and/or replacing unit substations U11, U12, and U13, as well as the Headworks Facilities backup power, east and west blower controls, and the east and west blower switchgear.
6. Asset Management and Condition Assessment

The District is developing a comprehensive asset management plan for all District assets under a different project. However, the process review required for this Facilities Plan was leveraged to provide condition assessments for a large percentage of the assets related to liquid treatment processes at the NSWWTP.

ES.03 APPROACH TO THIS FACILITIES PLANNING PLANNING

This Facilities Plan was developed over the course of approximately 16 months and included significant collaboration between the District and the consultant team, numerous workshops and review meetings, and a series of nine technical memoranda, each devoted to a specific topic and/or area of the NSWWTP planning study. Each of these technical memoranda are included as appendices to the summary facilities planning document. The technical memoranda are outlined below for the reader’s information:

Technical Memorandum No. 1–Sustainability Management System (Appendix A)
Technical Memorandum No. 2a–Regulatory Projections (Appendix B)
Technical Memorandum No. 2b–Flow and Loading Projections (Appendix B)
Technical Memorandum No. 3–Condition Assessments (Appendix C)
Technical Memorandum No. 4–Peak Flow Management (Appendix D)
Technical Memorandum No. 5–Biological Nutrient Removal Alternatives Evaluation (Appendix E)
Technical Memorandum No. 6–Headworks and Hauled Waste Receiving (Appendix F)
Technical Memorandum No. 7–Effluent Disinfection (Appendix G)
Technical Memorandum No. 8–Electrical Improvements (Appendix H)

Each major planning element listed included at least one initial meeting between the District and consultant team to discuss direction, elements to include in the analyses, preliminary alternatives, and related information. Following the initial meeting, the consultant team developed a preliminary document that summarized the current issues and concerns, and identified an initial list of technical alternatives that could be evaluated. This document (one for each technical area) was submitted to the District, and one or more workshops were then held to review the background and potential alternatives in detail with District staff. Following the workshops, the technical memoranda identified above were developed and submitted to the District for review. The District provided consolidated comments to the consultant for each technical memorandum, and one or more revisions of each of the technical memoranda were developed to address the District’s comments.

ES.04 KEY RESULTS AND RECOMMENDATIONS

Recommendations of capital improvements and related investigations are made throughout the Facilities Plan and within the associated technical memoranda. A summary of the recommended upgrades and modifications for the NSWWTP is summarized by process/major facilities planning area in Table ES.04-1. Also included are the drivers for the recommendations, opinion of capital costs for the improvements, benefits anticipated, potential concerns, and references to the Facilities Planning report sections and technical memoranda to provide more information and background to the interested reader.
## Table ES.04-1: Summary of Recommended Capital Improvements

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<th>Main Concern(s) and/or Drivers</th>
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<th>Opinion of Capital Cost</th>
<th>Project Phasing (Near, Mid, Future)</th>
<th>Anticipated Benefits</th>
<th>Associated Facilities Plan Section</th>
<th>Associated Technical Memorandum</th>
</tr>
</thead>
</table>
| Overall Peak Flow Management | Hydraulic Upgrades | Improve treatment reliability. Environmental impact from major hydraulic overflow at plant. | Alt. PF10--Construct hydraulic improvement and provide ability to operate in biological contact stabilization mode. | $5,200,000 | Near | ▪ Improves flexibility and capacity to manage peak flows.  
▪ Improves treatment performance at peak flows. | 4 | TM4 |
| Overall Peak Flow Management | Aggressive I/I Removal | Reduce peak flows. | Alt. PF4--Consider aggressive I/I reduction; consider pilot studies to gauge potential success. | See Facilities Plan | TBD | ▪ Establish accountability and communications with customer communities.  
▪ Potentially reduce flows at the source. | 4 | TM4 |
| Overall Peak Flow Management | Local Discharge to Nine Springs Creek | Reduce energy use. Infrastructure risk and replacement costs. | Alt. PF9--Begin long-term planning to determine regulatory and political viability. | See Facilities Plan | TBD | ▪ Reduce energy by eliminating effluent pumping station  
▪ Reduce infrastructure risk and replacement costs related to very long and old effluent force main. | 4 | TM4 |
| Headworks and Hauled Waste Receiving | Influent Flow Metering | Operational problems. Screen bypassing. | Alt. IFMS- Relocate existing venturi flow meters to lower elevation | $2,100,000 | Near | ▪ Allows reuse of the existing flow meters.  
▪ Improves screening and screenings handling operations while reducing maintenance.  
▪ Reduces likelihood of bypassing the mechanical screens. | 5 | TM6 |
| Headworks and Hauled Waste Receiving | Screening and Screenings Handling | Reduce maintenance. | Alt. S1--Screen sluiced screenings or Alt. S3--Install new step screens and wash presses | $3,400,000 | Mid | ▪ Simpler system will reduce maintenance and operator attention. | 5 | TM6 |
| Headworks and Hauled Waste Receiving | Grit Management | Equipment replacement. | Alt. G1--Replace equipment in the future. | $2,000,000 | Mid | ▪ Minor benefit; new equipment in the future. | 5 | TM6 |
▪ Reduce road icing safety concerns.  
▪ Reduce operator attention.  
▪ Improve access for haulers as well as accountability and monitoring.  
▪ Increase hauled waste revenue. | 5 | TM6 |
## Executive Summary

<table>
<thead>
<tr>
<th>Process or Component</th>
<th>Subcomponent</th>
<th>Main Concern(s) and/or Drivers</th>
<th>Recommended Modifications or Action</th>
<th>Opinion of Capital Cost*</th>
<th>Project Phasing (Near, Mid, Future)**</th>
<th>Anticipated Benefits</th>
<th>Associated Facilities Plan Section</th>
<th>Associated Technical Memorandum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activated Sludge</td>
<td>Clarifier Stress Testing</td>
<td>Cost avoidance.</td>
<td>Conduct clarifier stress testing and hydraulic modeling.</td>
<td>$130,000</td>
<td>Near</td>
<td>• Potentially eliminate future need to construct two final clarifiers. • Establish maximum loadings to the final clarifiers.</td>
<td>6</td>
<td>TM5</td>
</tr>
<tr>
<td>Activated Sludge</td>
<td>Nitrile Shunt Full-Scale Demonstration</td>
<td>Relatively new process—demonstrate viability.</td>
<td>Convert West Plant No. 3 or 4 to nitrile shunt operations; includes new diffusers, aeration piping, polymer feed, ammonia versus nitrate (AVN) controls, and miscellaneous modifications.</td>
<td>$2,260,000</td>
<td>Mid</td>
<td>• Demonstrate full-scale viability before investing in complete upgrade; relatively new process.</td>
<td>6</td>
<td>TM5</td>
</tr>
<tr>
<td>Activated Sludge</td>
<td>Nitrile Shunt Full Plant Conversion</td>
<td>Reduce energy use. Future nitrogen removal.</td>
<td>Alt. AS4—Convert remaining plants to nitrile shunt; construct two new final clarifiers.</td>
<td>$17,860,000</td>
<td>Future</td>
<td>• Reduce energy use at the activated sludge plant. • Improve nitrogen removal efficiency while not impacting phosphorus removal.</td>
<td>6</td>
<td>TM5</td>
</tr>
<tr>
<td>Activated Sludge</td>
<td>Aeration Cross-Connect</td>
<td>Reduce energy use. Cost avoidance.</td>
<td>Construct interconnection aeration piping between east and west plants.</td>
<td>$2,160,000</td>
<td>Mid</td>
<td>• Reduce energy use by the aeration systems. • Provide improved redundancy and system reliability. • Avoid the need to replace the east side blowers and switchgear.</td>
<td>6</td>
<td>TM5</td>
</tr>
<tr>
<td>Activated Sludge</td>
<td>West Side Blowers</td>
<td>Reduce energy use. Improve reliability.</td>
<td>Replace three west blowers; east side blowers do not need to be replaced if the cross connect is installed.</td>
<td>$6,300,000</td>
<td>Mid and Future</td>
<td>• Reduce energy use with more efficient and appropriately sized blowers.</td>
<td>6</td>
<td>TM5</td>
</tr>
<tr>
<td>Activated Sludge</td>
<td>Misc. Upgrades</td>
<td>Reduce energy use. Improve reliability.</td>
<td>Miscellaneous upgrades to RAS pumping control and activated sludge process.</td>
<td>$520,000</td>
<td>Mid</td>
<td>• Reduce energy use. • Improve reliability and reduce maintenance.</td>
<td>6</td>
<td>TM5</td>
</tr>
<tr>
<td>Disinfection</td>
<td>Install New UV System</td>
<td>Improve reliability.</td>
<td>Replace UV system with new UV system in the existing channels.</td>
<td>$3,800,000</td>
<td>Near</td>
<td>• Improve disinfection reliability. • Reduce energy use.</td>
<td>7</td>
<td>TM7</td>
</tr>
<tr>
<td>Electrical Reliability</td>
<td>East Blower Controls</td>
<td>Improve reliability.</td>
<td>Replace the east side blower control panel and controls.</td>
<td>$390,000</td>
<td>Near</td>
<td>• Improve aeration system reliability and control.</td>
<td>8</td>
<td>TM8</td>
</tr>
<tr>
<td>Electrical Reliability</td>
<td>East Blower Switchgear</td>
<td>Improve reliability.</td>
<td>Replace the east side blower switchgear (only if new east side blowers are installed).</td>
<td>$1,140,000</td>
<td>Future</td>
<td>• Improve electrical reliability and safety.</td>
<td>8</td>
<td>TM8</td>
</tr>
<tr>
<td>Electrical Reliability</td>
<td>West Blower Switchgear</td>
<td>Improve reliability.</td>
<td>Replace west switchgear when west blowers are replaced.</td>
<td>$900,000</td>
<td>Future</td>
<td>• Improve electrical reliability and safety.</td>
<td>8</td>
<td>TM8</td>
</tr>
<tr>
<td>Electrical Reliability</td>
<td>Unit Substation U11, U12, U13</td>
<td>Improve reliability.</td>
<td>Construct one new unit substation and eliminate three unit substations.</td>
<td>$3,100,000</td>
<td>Near</td>
<td>• Improve electrical reliability and safety.</td>
<td>8</td>
<td>TM8</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Primary Tanks 1 and 2 Rehabilitation</td>
<td>Improve reliability.</td>
<td>Rehabilitate Primary Tanks 1 and 2 concrete structure.</td>
<td>$450,000</td>
<td>Near</td>
<td>• Improve reliability and structure longevity.</td>
<td>9</td>
<td>TM3</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>54-inch Primary Influent</td>
<td>Improve reliability.</td>
<td>Inspect this sewer; replace or rehabilitate sewer following inspection.</td>
<td>$800,000</td>
<td>Near</td>
<td>• Improve reliability. • Avoid potential catastrophic failure.</td>
<td>9</td>
<td>TM3</td>
</tr>
<tr>
<td>Process or Component</td>
<td>Subcomponent</td>
<td>Main Concern(s) and/or Drivers</td>
<td>Recommended Modifications or Action</td>
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</tr>
<tr>
<td>Miscellaneous</td>
<td>East-West Plant Flow Metering</td>
<td>Improve operations.</td>
<td>Install new insertion-type flow metering devices within the existing east and west main gravity sewers.</td>
<td>$150,000</td>
<td>Near</td>
<td>• Improve operations flow measurement data and reliability.</td>
<td>9</td>
<td>TM5</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Effluent Force Main Standpipe Revisions</td>
<td>Public perception.</td>
<td>Replace and/or modify the existing standpipe to eliminate treated wastewater from being forced out of the existing standpipe with excessive air.</td>
<td>$100,000</td>
<td>Near</td>
<td>• Reduce minor discharge of fully treated water to area around standpipe.</td>
<td>9</td>
<td>TM4</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>PCS Upgrades, Phase II</td>
<td>Improve reliability.</td>
<td>Implement Phase II of the PCS upgrades that were planned in the PCS Facilities Plan (2012).</td>
<td>$1,500,000</td>
<td>Near</td>
<td>• Improve aeration system monitoring, reliability, and control.</td>
<td>9</td>
<td>NA (^c)</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
<td></td>
<td>$57,160,000</td>
<td>Varies</td>
<td></td>
<td>10</td>
<td>TM4–TM8</td>
</tr>
</tbody>
</table>

\(^a\)All costs are in 2nd quarter, 2017 dollars.

\(^b\)Near indicates years 2017 to 2022; Mid indicates years 2020 to 2025; Future indicates year 2024 and after. Refer to Table 10.02-1 for more detail.

\(^c\)This project was evaluated in the 2012 PCS Facilities Plan.
A. Peak Flow Management

The main focus of the peak flow management evaluations was to provide the ability to manage the anticipated peak flows without overflowing NSWWTP structures and while continuing to meet effluent permit limits. We recommend the District implement Alternative PF10, which includes hydraulic capacity upgrades to the following facilities at the NSWWTP:

1. Construct bypass channel for west primary clarifiers.
2. Raise west final clarifier influent channel walls by 1 foot and modify channel at roadway crossing to prevent overflows.
3. Construct new effluent structure to control diversion to the lagoons and flow conveyed from the east plant to the disinfection building.
4. Construct upgrades to the east and west activated sludge facilities to provide the ability to operate in a biological contact process mode during high flow events.

We also recommended that the District begin evaluating in more detail potential paths forward related to implementing a local permitted discharge to Nine Springs Creek as a first step toward a potential continuous future discharge to Nine Springs Creek at the District.

The District may also consider initiating an aggressive infiltration/inflow (I/I) reduction pilot study focused on identifying one or more areas with high I/I rates, and then implementing aggressive I/I reduction measures with the goal of quantifying successes and challenges for future additional measures in other areas.

B. Headworks and Hauled Waste Receiving

The main concern with the existing headworks facilities include a requirement to control the screening channel water depth within a very narrow range, which results in continuous screening equipment operation and significant maintenance concerns. In addition, the hauled waste receiving facilities require considerable operator attention and result in high grit loadings to the screening channels. The recommended headworks and hauled waste receiving improvements consist of the following:

1. IFM5–Relocate Venturis to Lower Elevation
2. S1–Screen Sluiced Screenings or S3–Install New Step Screens and Wash Presses
3. G1–Replacement of Grit Classifiers with Grit Washers; Replace Other Equipment (Year 10)
4. HW1–Construction of a Drive-Through Hauled Waste Receiving Station at the Headworks Building
The timing of the execution of the improvements to these facilities may be adjusted to accommodate the condition of the various equipment involved or to combine or separate project elements to fit the needs of the District.

C. Activated Sludge and Nutrient Removal

The existing biological phosphorus removal activated sludge facilities have operated well for many years and continue to serve the near-term needs of the District. The main focus of the facilities planning evaluations was energy efficiency and future upgrades to remove nitrogen. The recommended aeration system capital improvements consist of full-plant implementation of nitrite shunt (Alternative AS4) with high efficiency membrane diffusers, new west blowers and aeration piping cross-connect, and new secondary clarifiers. However, because this process is relatively new and does not have many full-scale operating installations, the District is currently conducting bench-scale pilot testing of the nitrite shunt process. If the bench-scale testing proves to be successful, full-scale pilot testing of nitrite shunt operation is recommended. In addition, final clarifier stress testing is recommended to be conducted to verify clarifier performance and to potentially eliminate the requirement to construct new final clarifiers.

The recommended plan is summarized in the following (assuming successful bench-scale testing):

1. Conduct clarifier stress testing.
2. Implement Nitrite Shunt Full-Scale Demonstration Study-Install new membrane strip diffusers, polymer feed system, and AVN instrumentation and control system in Plant No. 3 or 4 on the west side.
3. If demonstration testing is successful, implement nitrite shunt operations in the remaining activated sludge plants, including membrane strip diffusers, AVN instrumentation, control valves and flow meters, construction of two new final clarifiers (unless stress testing indicates these are not required), and construction of postaeration facilities.
4. Construct aeration system efficiency improvements, including interconnecting the east and west aeration systems and installing new west side blowers. These improvements will likely be phased to coincide with nitrite shunt upgrades noted above. The east side blowers may not require replacement if this cross-connection is put into place.
5. Implement miscellaneous activated sludge system improvements noted during planning, including scum beach icing control, replacement of Plant 2 RAS control valves, and increasing drainage pumping capacity.
6. Improve RAS pump energy efficiency, including new high-efficiency motors for some of the RAS pumps. Alternative improvements include new VFDs or modifying the control of the RAS pumps.
D. Disinfection

The main concern with the existing UV disinfection system is its age. This system was installed in the mid 1990s and is operating beyond the typical useful life for this type of equipment. In addition, the manufacturer of the equipment has not supported this particular system for about 20 years, and replacement parts are becoming more difficult to source or produce. The recommended capital improvements for disinfection include the installation of new UV disinfection equipment within the existing channels (Disinfection Alternative D1 or D2).

E. Electrical Reliability

Electrical improvement alternatives for the NSWWTP included in this facilities planning effort included evaluations related to upgrading or providing the headworks backup power, blower controls, blower medium voltage switchgear, and unit substations U11, U12, and U13. The main goal of these evaluations was to improve systems and overall NSWWTP reliability. The recommended plan consist of the following:

1. No change to the headwork facility backup power situation.
2. Replace the east blower control panel.
3. Replace the east and west blower building switchgear in conjunction with future blower replacements. This may result in no east blower switchgear replacement if the aeration system cross connect is constructed.
4. Construct one new unit substation to replace the existing substations U11, U12, and U13.

F. Miscellaneous Improvements

Miscellaneous improvements were included in the overall scope of the Facility Plan to evaluate upgrades to some of the aging infrastructure. The following improvements are recommended:

1. Rehabilitate primary clarifier tanks 1 and 2–These tanks, which date back to the early 1930s and were part of the First Addition to the NSWWTP, are in need of some concrete restoration.
2. Replace or rehabilitate the 54-inch primary influent pipe from the east primary junction chamber to the east primary clarifiers. The most recent inspection is from 2007 and showed that the pipe had deteriorated. We recommended an additional inspection before proceeding with replacement or rehabilitation.
3. Install flow metering equipment to measure flows to the east and west plants. This will provide improved process monitoring and control.
4. Construct a new, wider effluent force main standpipe to eliminate effluent wastewater from spilling to the ground.
ES.05 IMPACTS ON USER RATES

This facilities plan covers numerous projects over approximately 10 years. The effects on user charges depend on the actual timing and cost of the projects, the CWF interest rate, the growth in district loadings, and the allocation of the annual revenue requirement for capital and annual operating costs over the District’s billing parameters. The long time period covered by the projects in this facilities plan further complicates the analysis, and a detailed user charge study is outside the scope of this report. As a general guideline, based on the District’s analysis, $1.0 million in debt service equates to $6 to $7 for a typical residential household’s annual bill.

Table 10.02-1 shows phasing for the recommended projects in several time periods: Near term (2017-2022), Mid term (2020-2025) and Future (2024+). The costs in Table 10.02-1 are on a 2017 cost basis. Table ES.05-1 summarizes the effects of the proposed projects on the typical residential customer.

<table>
<thead>
<tr>
<th>Phase</th>
<th>2017 to 2022</th>
<th>2020 to 2025</th>
<th>2024+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 10-02-1 Costs</td>
<td>$20,620,000</td>
<td>$12,540,000</td>
<td>$24,000,000</td>
</tr>
<tr>
<td>Estimated Cost in Year of Construction</td>
<td>$22,500,000</td>
<td>$14,500,000</td>
<td>$30,400,000</td>
</tr>
<tr>
<td>Estimated Annual Debt Service</td>
<td>$1,710,000</td>
<td>$1,100,000</td>
<td>$2,310,000</td>
</tr>
<tr>
<td>Residential Rate Impact, per year</td>
<td>$10.50 to $12.00</td>
<td>$6.50 to $7.50</td>
<td>$14.00 to $16.00</td>
</tr>
<tr>
<td>Year of Rate Analysis</td>
<td>2020</td>
<td>2022</td>
<td>2025</td>
</tr>
<tr>
<td>Estimated Total Annual Residential Charge</td>
<td>$360</td>
<td>$400</td>
<td>$460</td>
</tr>
</tbody>
</table>

Table ES.05-1 Sewer User Charge Impacts
1.01 BACKGROUND

The Madison Metropolitan Sewerage District (MMSD or District) is a municipal corporation located in Madison, Wisconsin that provides wastewater conveyance and treatment for 43 communities and sanitary districts in the Madison metropolitan area. The MMSD service area includes approximately 182 square miles with a population of approximately 365,000 people. The District’s conveyance system includes 94 miles of interceptor sewers, 48 miles of force mains, and 18 pumping stations. All of the wastewater collected in the MMSD service area is conveyed to the Nine Springs Wastewater Treatment Plant (NSWWTP) for treatment and return to the environment.

Liquid treatment at NSWWTP consists of influent flow measurements with venturi meters, fine screening, vortex grit removal, primary clarification, activated sludge secondary treatment using an enhanced biological phosphorus removal (EBPR) process, secondary clarification, ultraviolet disinfection, and effluent pumping. The District has two discharge locations, one at Badfish Creek and another at Badger Mill Creek on the northeast side of Verona. Most of the effluent is pumped to Badfish Creek, with up to 3.6 million gallons per day (mgd) pumped to Badger Mill Creek during normal flow conditions. NSWWTP also has facilities to handle peak flows, including effluent storage for flows that exceed the plant effluent pumping capacity, and an overflow structure to divert flows in excess of the storage volume or disinfection capacity to a storage lagoon. This lagoon can store approximately 40 million gallons prior to overflowing to a channel that discharges to Nine Springs Creek and ultimately to Lake Waubesa.

Solids treatment facilities at NSWWTP consist of primary and waste activated sludge thickening, phosphorus release tanks, acid/methane-phased anaerobic digestion, and digested biosolids gravity belt thickening for liquid biosolids management in the District’s Metrogro program. Some of the biosolids can also be centrifuged to produce a dewatered cake material. A struvite harvesting system was incorporated into the plant’s digested biosolids dewatering process to recover phosphorus from the biosolids thickening and dewatering recycle streams, as well as from the waste activated sludge prior to digestion.

In this Liquid Processing Facilities Plan (Facilities Plan), the capacity and performance of all liquid treatment processes are evaluated, including peak flow management facilities. Future flows and loadings are projected, and capacity analyses of all liquid process treatment facilities are conducted to assess the impact of future conditions on the existing NSWWTP infrastructure. Recommended improvements related to hydraulic capacity, treatment performance, and electrical components at the facility are presented.

1.02 PROJECT DEFINITION

This Facilities Plan was prepared for the purpose of developing a plan for liquid processing and treatment at the NSWWTP for the next 20 years and beyond. A planning year of 2040 was established for this plan. The scope of work for the Facilities Plan includes the following:
1. Evaluate future loading conditions and regulatory constraints.

2. Conduct condition assessments for structures, equipment, controls, and instrumentation associated with the project. The output from the condition assessments will provide the data needed to populate the District’s Asset Management Database being developed in parallel with this Facilities Plan.

3. Evaluate current and future peak flow conditions, as well as potential schemes for managing peak wet weather flows.

4. Evaluate aeration systems for treatment performance, energy efficiency, facility impacts, and costs to meet future process and nutrient removal requirements.

5. Develop an overall plan to meet the future hydraulic requirements of the influent screening, grit removal, and screenings/ grit management systems.

6. Develop an overall plan to meet the future hydraulic requirements of the ultraviolet disinfection system.

7. Assess the electrical systems and power reliability for the liquid processing facilities and identify required electrical upgrades.

1.03 CONDITION ASSESSMENTS AND REPLACEMENT COSTS

The District is currently developing an asset management plan under a separate contract with a third party. One of the goals of this Facilities Plan was to establish baseline asset data by conducting Level 2 condition assessments for the major assets and asset groups included within the scope of this planning project. These assessments included the equipment, control panels and electrical distribution equipment, structures, and related infrastructure associated with the NSWWTP headworks, primary clarifiers, activated sludge process, final clarifiers, ultraviolet (UV) disinfection, and hydraulic control elements. The main focus was to capture condition assessment data and estimate the remaining life and replacement costs for these assets. Condition, remaining life, and replacement costs are core elements of compiling the "null-alternative" in each of the evaluated systems. As a result of this effort, the underlying data collected is available for ongoing planning and maintenance tasks. More information related to the assessment process and results is presented in Technical Memorandum No. 3 (Appendix C).

With respect to including equipment replacement costs within the various alternatives evaluated throughout this Facilities Plan and, in particular, with respect to identifying the costs associated with the null alternatives, the null alternative was treated somewhat different depending on the specific alternatives being considered. Sections 4 through 8 of this facilities plan each identify how the null alternative replacement costs were applied.
1.04 SUSTAINABILITY

The District is committed to sustainable performance of infrastructure projects to advance its mission: “to protect public health and the environment by providing exceptional wastewater conveyance, treatment and related services.” According to the District’s Sustainability Management System (SMS), it strives to be a leader in regulatory compliance, customer service, employee development, and innovation, and continues to work on behalf of the communities it serves to inspire and increase sustainable performance. The District envisions that:

- MMSD will not only enrich the community by improving living conditions for people, plants, and animals, but also educate others so they too can take steps to conserve our resources.

- By changing the way we think about and use water, together we have the power to enhance the quality of life on our planet.

- By making small changes and respecting every drop of water we have today, we can set the tone for a resource-conscious and sustainable community tomorrow.

The District carries this vision into project planning as indicated in the District’s SMS infrastructure project sustainability policy statement:

**MMSD will use the Envision rating system as a sustainability framework and use the SMS-IP as a tool to manage, measure, and continuously enhance sustainability performance for infrastructure projects.**

The District has developed a Sustainability Management System for Infrastructure Project (SMS-IP) that documents sustainability objectives and establishes processes and procedures to facilitate implementation and quality control throughout the planning, design, construction, and operational phases of any given project. Technical Memorandum No. 1 (TM-1) provides the SMS-IP for this planning project. This document identifies the responsible parties for ensuring the sustainability vision aligns with the strategic vision of the District, for ensuring tools align with the mission and vision of the District, for developing project-specific goals and objectives, and for ensuring that sustainability aspects and performance measures are incorporated into the project.

The goal of this Facilities Plan is to find long-term, cost effective solutions that meet the District’s sustainability objectives, including flexibility and resilience. In addition, this Facilities Plan establishes the framework for future infrastructure projects to meet the District’s sustainability objectives related to capital project delivery.

1.05 PROJECT DOCUMENTATION

This Facilities Plan development has been documented through eight technical memoranda that are attached to this Facilities Plan as appendices. The technical memoranda were developed as independent reports, and submitted as draft documents to the District. The District provided review comments to the consultant team, and each technical memorandum went through one or more
revisions prior to approval by the District. The final versions of the technical memorandum are included in the appendices to this Facilities Plan.

The main body of this Facilities Plan summarizes each of the technical memoranda to provide a more concise planning document. The main body includes the results of the analyses and evaluations, and the reader is referred to the appendices if more information and background on the evaluations are required.

1.06 PLANNING AREA

The planning area for this Facilities Plan includes the District’s existing service area as indicated in Figure 1.06-1. The service area encompasses approximately 219 square miles in Dane County. The majority of the service area is in the Rock River and Sugar River watersheds, with a small portion in the northwest located in the Wisconsin River Watershed.

1.07 PREVIOUS PLANNING STUDIES

The District completed a Solids Handling Facilities Plan in 2010 that evaluated all of the solids handling processes at the plant and recommended improvements as necessary. The District also completed a 50-Year master Plan in 2009, as well as an Energy Roadmap in 2013. This current Facilities Plan builds on these documents, and the energy efficiency components of this Facilities Plan are the direct result of the 2013 Energy Roadmap document.

1.08 ABBREVIATIONS AND ACRONYMS

A/O  anaerobic/aerobic
ABAC  ammonia based aeration control
AM  adaptive management
AOB  ammonia-oxidizing bacteria
AVN  ammonia versus nitrate
BC  biological contact
BMP  best management practice
BNR  biological nutrient removal
BOD  biochemical oxygen demand
CBOD$_5$  five-day carbonaceous biochemical oxygen demand
CCTV  closed circuit television
CEC  compounds of emerging concerns
CEPT  chemically enhanced primary treatment
CFD  computational fluid dynamics
cfs  cubic feet per second
cfu/100mL  colony-forming units per 100 mL
CHP  combined heat and power
CMOM  Compliance, Management, Operation, and Maintenance
District  Madison Metropolitan Sewerage District
DO  dissolved oxygen
EBPR  enhanced biological phosphorus removal
F&P  Fischer & Porter
DISTRICT BOUNDARY

2016 LIQUID PROCESSING FACILITIES PLAN
MADISON METROPOLITAN SEWERAGE DISTRICT
DAANE COUNTY, WISCONSIN

Legend

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community.
Facilities Plan Liquid Processing Facilities Plan
FeCl₃ ferric chloride
GHG greenhouse gas
gpm gallons per minute
HBP headworks backup power
HMI human-machine interface
hp horsepower
HVAC heating, ventilation, and air conditioning
I/I infiltration/inflow
IMLR internal mixed liquor recycle
I/O input/output
MATPB Madison Area Transportation Planning Board
MCC motor control center
MG million gallons
MG&E Madison Gas & Electric
mg/L milligrams per liter
mgd million gallons per day
MLR mixed liquor recycle
MLSS mixed liquor suspended solids
MMSD Madison Metropolitan Sewerage District
N₂O nitrous oxide
NH₃-N ammonia nitrogen
NO₂-N nitrate nitrogen
NOₓ nitrate + nitrate
NSWWTP Nine Springs Wastewater Treatment Plant
O&M operation and maintenance
PCCP prestressed concrete cylinder pipe
PLC programmable logic controller
PS pump station
PVC polyvinyl chloride
RAS return activated sludge
scfm standard cubic feet per minute
SLR solids loading rates
SMS Sustainability Management System
SMS-IP Sustainability Management System for Infrastructure Project
SPA state point analysis
SSO sanitary sewer overflow
Strand Strand Associates, Inc.®
SUO sewer use ordinance
SVI sludge volume index
TMDL total maximum daily load
TN total nitrogen
TN/L total nitrogen per liter
TSS total suspended solids
UCT University of Cape Town
USEPA United States Environmental Protection Agency
UV  ultraviolet
V   volt
VFD variable frequency drive
WDNR Wisconsin Department of Natural Resources
WPDES Wisconsin Pollutant Discharge Elimination System
WQBEL water quality based effluent limit
WQT  water quality trading
WWTP wastewater treatment plant
This section includes a summary of Technical Memorandum No. 2a (TM-2a, Appendix B), which reviewed the existing and foreseeable future regulatory issues potentially affecting the District’s Facilities Plan through the year 2040. A meeting to discuss relevant water quality and regulatory issues was held with the Wisconsin Department of Natural Resources (WDNR) on April 21, 2016. Information from that meeting, the MMSD 50-Year Master Plan, and from our regulatory work with other clients forms the basis for this section.

2.01 CURRENT PERMIT REQUIREMENTS

The MMSD NSWWTP is presently operating under Wisconsin Pollutant Discharge Elimination System (WPDES) Permit No. WI-0024597-08-0 (Appendix B). The permit expiration date was September 30, 2015. Because the permit application for reissuance was submitted more than 180 days prior to the expiration date, MMSD is allowed to operate under the conditions of the expired permit. Relevant permit limits for Badfish Creek and Badger Mill Creek are presented in Tables 2.01-1 and 2.01-2, respectively.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Limit Type</th>
<th>Limit and Units</th>
<th>Notes</th>
</tr>
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<tbody>
<tr>
<td>BOD₅, Total</td>
<td>Monthly Average</td>
<td>19 mg/L</td>
<td></td>
</tr>
<tr>
<td>BOD₅, Total</td>
<td>Monthly Average</td>
<td>7,923 lbs/day</td>
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</tr>
<tr>
<td>BOD₅, Total</td>
<td>Weekly Average</td>
<td>20 mg/L</td>
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</tr>
<tr>
<td>BOD₅, Total</td>
<td>Weekly Average</td>
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<td>Suspended Solids, Total</td>
<td>Monthly Average</td>
<td>20 mg/L</td>
<td></td>
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<tr>
<td>Suspended Solids, Total</td>
<td>Monthly Average</td>
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<td>Suspended Solids, Total</td>
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<tr>
<td>Dissolved Oxygen</td>
<td>Daily Minimum</td>
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</tr>
<tr>
<td>pH Field</td>
<td>Daily Maximum</td>
<td>9.0 s.u.</td>
<td></td>
</tr>
<tr>
<td>pH Field</td>
<td>Daily Minimum</td>
<td>6.0 s.u.</td>
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</tr>
<tr>
<td>Phosphorus, Total</td>
<td>Monthly Average</td>
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</tr>
<tr>
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<td>Nitrogen, Ammonia, (NH₃-N) Total</td>
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<tr>
<td>Chloride</td>
<td>Weekly Average</td>
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<td>Target limit.</td>
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<tr>
<td>Chloride</td>
<td>Weekly Average</td>
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<tr>
<td>Mercury, Total Recoverable</td>
<td>Daily Maximum</td>
<td>5.7 ng/L</td>
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Table 2.01-1 Relevant WPDES Permit Effluent Limits for Badfish Creek Outfall 001
<table>
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<th>Parameter</th>
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<td>10 mg/L</td>
<td>Limit applies May to October.</td>
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<td>Suspended Solids, Total</td>
<td>Monthly Average</td>
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<td>Dissolved Oxygen</td>
<td>Daily Minimum</td>
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<td>See Section 3.2.2.7 regarding compliance with this limit.</td>
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<td>pH Field</td>
<td>Daily Minimum</td>
<td>6.0 s.u.</td>
<td></td>
</tr>
<tr>
<td>Phosphorus, Total</td>
<td>Monthly Average</td>
<td>1.5 mg/L</td>
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<tr>
<td>Fecal Coliform</td>
<td>Geometric Mean</td>
<td>400 #/100 ml</td>
<td>Limit applies May to September</td>
</tr>
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<td>Nitrogen, Ammonia, (NH&lt;sub&gt;3&lt;/sub&gt;-N) Total</td>
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<td>Limit applies year-round.</td>
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<td>Weekly Average</td>
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<td>Mercury, Total Recoverable</td>
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</tbody>
</table>

Table 2.01-2 Relevant WPDES Permit Effluent Limits for Badger Mill Creek Outfall 005

2.02 NUTRIENT REGULATIONS

A. Phosphorus

The District’s current phosphorus effluent limit is 1.5 mg/L based on an alternative limit for facilities that employ biological phosphorus removal, as provided by NR 217.04(2). The applicable water quality criterion, for MMSD’s receiving streams, which would also likely be the water quality based effluent limit (WQBEL), is 0.075 mg/L in accordance with NR 102.06(3)(b). This WQBEL would be expressed as two six-month averages, with a monthly average of three times that value and compliance schedules of up to nine years are provided for meeting these stringent WQBELs.

NR 217.16 has provisions for incorporating less stringent total maximum daily load (TMDL)-based WQBELs into permits in some cases. This is generally allowed for two permit terms but may be extended if significant nonpoint source load reductions are expected to occur. There are also specific requirements for new dischargers to a phosphorus-impaired water in an area with an approved TMDL which may require a corresponding offset by making an equivalent or greater load reduction elsewhere in the TMDL reach.

Additional compliance alternatives are available, including water quality trading (WQT) and watershed adaptive management (AM). WQT is allowed in Wisconsin as NR 217.14 and requires the identification of other potential load reductions in the watershed or TMDL reach, modeling of any proposed best management practices (BMPs), registration of the trades, and installation, verification and maintenance of BMPs. Watershed AM is described in NR 217.18 and allows a wastewater treatment plant (WWTP) to partner with other sources of phosphorus loading to make load reductions elsewhere in its watershed, often including nonpoint source load reductions.
Watershed AM may be used for both phosphorus and total suspended solids (TSS) and essentially extends the phosphorus compliance schedule to 20 years. Interim phosphorus limits of 0.6 and 0.5 mg/L are applied to the outfall in the first and second permit terms of AM, and a 0.5 mg/L is expected to be applied in the third permit term based on the District’s communications with WDNR. Receiving stream water quality monitoring is required with this alternative.

The District has already determined, based on cost-effectiveness and triple bottom line considerations, that it will pursue AM for its BFC outfall compliance option. The District is collaborating with multiple partners in the Yahara River watershed on this effort. In 2016 this AM program, called Yahara Watershed Improvement Network (Yahara WINs), is in its fourth year as a pilot project and is transitioning to a full-scale program. MMSD prepared a draft AM Plan and submitted it to WDNR in December 2015. The WDNR indicated the draft AM Plan is approvable and formal AM Plan approval is expected after reissuance of the District’s WPDES permit. Because this facilities planning period will coincide with the Yahara WINs AM compliance period (20 years), and the NSWWTP already routinely meets AM interim limits, no additional improvements are necessarily required for the NSWWTP associated with the BFC outfall. However, if MMSD can reduce effluent phosphorus at the NSWWTP at a lower cost than its payments into the Yahara WINs program, the District may consider implementing upgrades at the NSWWTP within the 20-year planning period.

After the WPDES permit is reissued (potentially in late 2017) the District will need to evaluate alternatives for compliance with an expected 0.075 mg/L six-month average and 0.23 mg/L monthly average limit for the BMC outfall. Alternatives may include WQT, AM, tertiary treatment of the BMC return flow, or discontinuing discharge to BMC completely.

B. Total Nitrogen (TN) and Nitrate-Nitrogen

Since around 2000, the United States Environmental Protection Agency (USEPA) has been maintaining the position that states must develop numeric TN criteria or demonstrate that they are not needed. The WDNR’s current position and progress on TN is provided in Wisconsin’s Nutrient Reduction Strategy of November 2013. In 2011 and 2012, water chemistry and biotic data was collected on streams, with laboratory analysis completed in 2012. Statistical analysis and expert review of the data was planned for 2013 and 2014, though it is not clear whether that analysis was ever completed.

Based on the WDNR Triennial Standards Review (2015 to 2017) document, development of nitrogen water quality criteria is listed within Category “E,” which means that barriers exist to the development of a scientifically based standard. The document indicates that it will address nitrogen standards as resources become available. We expect that TN rule revisions are not likely within 10 years, and possibly not within the planning horizon of this report based on the amount of time it took to adopt phosphorus criteria in Wisconsin. The magnitude of potential future effluent TN limits is unknown at this time, although nearby states have proposed TN effluent goal on the order of 8 to 10 mg/L.

MMSD commissioned a cost evaluation for NSWWTP to meet potential phosphorus and nitrogen limits and used TN limits of 3 and 10 mg/L for that study; the 10 mg/L limits were assumed for scenarios 4 through 6. For this Facilities Plan, a future monthly average TN goal of 10 mg/L will be assumed, although the final recommended plan may not include TN removal to meet this limit.
2.03 ROCK RIVER BASIN TMDL

The Rock River Basin phosphorus and sediment TMDL affects the BFC discharge and would affect any future outfalls in the Yahara River Watershed of the Rock River Basin. The TMDL was approved by the USEPA in 2011.

A. Phosphorus TMDL

MMSD’s wasteload allocations for total phosphorus at BFC range from 1,624 to 1,887 pounds per month, which corresponds to effluent concentrations in the range of 0.12 to 0.15 mg/L at the future design flow of 53.6 mgd. The Yahara WINs AM program will be used to meet phosphorus wasteload allocations.

B. Sediment/Total Suspended Solids (TSS) TMDL

MMSD’s wasteload allocations for TSS range from 138,120 to 252,980 pounds per month, which corresponds to effluent concentrations in the range of 10 to 19 mg/L at the future design flow of 53.6 mgd. Corresponding TMDL-based weekly average TSS limits will also be included in the reissued permit; these are expected to be approximately 1.3 times higher than the monthly average limits.

MMSD should not need to implement any special provisions at the NSWWTP to meet these TSS wasteload allocations. The Yahara WINs AM program can be used to help meet TSS wasteload allocations if needed.

2.04 OTHER REGULATORY PARAMETERS

In August of 2013 the State of Wisconsin published administrative rule revisions at NR 210 that prohibit sanitary sewer overflows (SSOs) and create a consistent set of factors that will be used to determine when and what enforcement will occur if an SSO occurs. The SSO rule revisions also contain provisions to develop a Compliance, Management, Operation, and Maintenance (CMOM) program and an SSO monitoring and reporting scheme for collection system permittees. The District has been addressing these regulations including implementing projects to reduce infiltration/inflow (I/I) in its collection system and updating its sewer use ordinance (SUO).

The administrative rule revisions also allow the WDNR to approve permit conditions allowing blending during wet weather if a municipality can show that there are no feasible alternatives. The NSWWTP does not currently have provisions for wet weather blending in its WPDES permit. However, there are provisions for storing secondary effluent in the lagoons and for monitoring any overflows from the lagoons to Nine Springs Creek. On rare occasions in the past, some overflow of treatment plant structures has occurred during very high flow events. As part of this facilities planning effort, future wet weather flows are projected and alternatives to reduce I/I and better manage peak flow events at the NSWWTP are evaluated.
2.05 RECREATIONAL STANDARDS

The USEPA released final recommendations on November 26, 2012, for recreational water quality criteria that are designed to protect primary contact recreation and are based on the use of two bacterial indicators of fecal contamination, *E. coli* and enterococci. The WDNR has not yet drafted water quality standards based on these recommendations, but it may do so within the next three to five years.

The USEPA is also working to develop recreational water quality criteria based on coliphage or other organisms as an indicator for the presence of viruses. Research related to how bacteriophages behave in wastewater treatment plants, how they are affected by current disinfection practices, and how their levels compare to those of current indicator organisms is ongoing. The USEPA has indicated that they intend to begin drafting coliphage criteria in late 2017.

Assuming the USEPA finalizes the virus-based criteria in 2018, Wisconsin could adopt associated criteria as early as 2019 and incorporate limits into MMSD’s next reissued WPDES permit (i.e., around 2022). If the WDNR and the District believe significant disinfection system modifications are required for compliance with any new effluent limits for viruses, a compliance schedule will likely be included in the reissued WPDES permit.

2.06 THERMAL REGULATIONS

The State of Wisconsin has adopted thermal standard rule revisions in NR 102 and NR 106 of the Wisconsin Administrative Code. MMSD has completed effluent and in-stream temperature monitoring and provided data to the WDNR in its permit application for reissuance, along with a request for Alternative Effluent Limits (AEL) for temperature for BMC, which has been approved. A temperature limit for BFC is not anticipated because of its NR 104 variance status. Should the WDNR include water quality based effluent temperature limits in future reissued permits, the District may have an opportunity to perform a dissipative cooling analysis on one, or both, of the receiving streams to determine if the limits are necessary. Modifications resulting from this Facilities Plan are not expected to have a measurable impact on effluent wastewater temperature, nor will measures to reduce effluent temperature be considered within this plan.

2.07 CHLORIDE REGULATIONS

Wisconsin’s chloride standards are included in s. NR 105, and the acute and chronic standards are 757 mg/L and 395 mg/L, respectively. NR 106 includes a variance procedure for facilities that are unable to meet their chloride limits that need to be renewed with each permit application and reviewed and approved by the USEPA.

Chloride concentrations in MMSD effluent continue to increase primarily because of the use of in-home water softeners and I/I containing road deicing salts. MMSD currently has a variance and a 430 mg/L target limit for chloride in its WPDES permit, along with a source reduction program that includes public education and other initiatives. Recently, MMSD has requested winter and summer limits for chloride in its upcoming permit, and WDNR has agreed to include separate winter and summer limits. The limits are anticipated to be 430 mg/L for the months of April through October and 465 mg/L for the months of November through March. In the future, it may be possible for the District to address chloride
requirements at least in part through regulatory measures such as changes to water quality standards or by using WQT.

This facilities planning effort will not address chlorides directly, but will consider the potential impact on effluent chlorides from changes to treatment processes.

2.08 AMMONIA REGULATIONS

The current Wisconsin water quality standards for ammonia are based primarily on toxicity to fish. The USEPA developed more stringent ammonia criteria for surface waters that have the ability to support mussels and snails, which are more sensitive to ammonia. The USEPA has adopted these criteria but the schedule for subsequent state implementation is unknown at this time. It appears this initiative could result in more stringent effluent ammonia-nitrogen limits for the NSWWTP outfalls to BFC and BMC within approximately the next five to ten years.

The WWTP currently discharges an average effluent ammonia concentration that is well below permit limits, and District staff do not expect the new criteria and potential lower limits to be a major consideration. This facilities planning effort will consider the more stringent limits if ammonia removal will be impacted by any of the biological treatment alternatives.

2.09 OTHER CURRENT OR UPCOMING WATER QUALITY REGULATIONS

A. Designated Use Changes and Site Specific Criteria

The WDNR is in the process of developing rule revisions related to designated uses and site specific criteria and District staff is involved with the technical advisory committee for this process. These revisions may apply to the District’s receiving streams, potentially resulting in more stringent effluent limits for parameters such as dissolved oxygen. It is unclear at this time the overall impact these revisions will have on the District’s future permit requirements.

Additionally, the rule revisions should also result in a process for determining site specific criteria for phosphorus or other parameters which may be worth pursuing for BFC and/or BMC if AM is not successful in meeting the 0.075 mg/L water quality criterion.

B. Mercury

Mercury effluent limits are based on wildlife criteria and are set equal to the criterion (1.3 ng/L) in accordance with NR 106.06(6) because the background concentration in Wisconsin surface waters exceeds the wildlife criterion. The District currently has a mercury variance with an alternative effluent limit and has adopted a Mercury Pollutant Minimization Program. The variance may be renewed with each permit application and is subject to approval by the USEPA. The WDNR has not indicated any plans for changing the approach to mercury compliance during this facilities planning period.
C. Pharmaceuticals and Other Compounds of Emerging Concern (CECs)

The WDNR does not currently have rules related to microconstituents like pharmaceuticals or CECs. The District has undertaken initiatives for pollution prevention and source reduction and these efforts may continue to be the best approach for these parameters during the facilities planning period. Approaches like lifestyle changes may be a future focus.

D. Antidegradation Rule Revisions

The WDNR is just beginning a rule revision process related to antidegradation. The intent is to provide a more transparent antidegradation review process that is consistent with federal regulations. These rule revisions could result in more stringent effluent limits in the future, proportional to increases in design flows.

2.10 AIR QUALITY REGULATIONS

Several air quality-related regulations or initiatives may impact MMSD’s liquid processing operations. These include state air regulations (covering parameters such as carbon monoxide, nitrogen and sulfur oxides, and volatile organic compound), federal air regulations (which would apply to a major reconstruction project that would increase hazardous air pollutant emissions), and requirements related to greenhouse gas emissions.

The District’s Operating Permit requires that the District “follow good engineering practices to minimize emissions of hazardous air pollutants” from treatment operations and requires that all biogas produced from the digesters be combusted to reduce greenhouse gas emissions. Potential changes to air-quality related requirements should be review if a major change to the liquid process is proposed.

2.11 GROUNDWATER DISCHARGE REQUIREMENTS

Groundwater recharge using effluent is being practiced in several locations around the state, particularly in the Wisconsin River Valley and other locations where soils are sandy and thus conducive to infiltration. Typical methods of effluent groundwater recharge are to use seepage cells (also called absorption ponds), which are regulated under NR 206, or injection wells, which would require effluent to meet NR 140 standards. Some potentially favorable groundwater infiltration locations have been identified in Dane County but may not be cost-effective when considering conveyance and additional treatment required compared to the volume recharged.

2.12 EFFLUENT REUSE REQUIREMENTS

Wastewater effluent is being used for industrial noncontact cooling and other noncontact uses in some locations, particularly where fresh water is scarce. Wisconsin currently has no specific standards for the treatment of effluent for use in an industrial facility.

The use of MMSD effluent was considered for the University of Wisconsin West Campus Cogeneration facility in 2002, but was ultimately not pursued because of cost and location concerns. The concept of reusing MMSD effluent for industrial noncontact cooling water could be explored with the largest water users in Dane County who are believed to use fresh water for nonpotable uses. Other potential uses of
effluent that were identified in the 50-Year Master Plan include restored wetlands, ethanol production facilities (if sited nearby), sod farms, and large agricultural operations that use fresh water for flushing systems in barns or for other purposes. Residential or commercial landscape watering and crop irrigation were also reviewed. While these uses do not appear sufficiently cost-effective and beneficial at this time, this could change. Depending on the ultimate use, effluent reuse may require treatment to Wisconsin drinking water standards or similar (i.e., California Title 22) standards.

2.13 RECOMMENDED PERMIT LIMITS AND CONSIDERATIONS FOR FACILITIES PLANNING

Strand Associates, Inc., on behalf of the District, submitted a facilities planning-level effluent limitations request to the WDNR in May 2016. The WDNR responded to the request in a February 2017 draft memorandum, which was later updated in August 2017, and is included in Technical Memorandum 2a–Regulatory Projections (Appendix B). Based on this memorandum and the information presented above, the following summarizes the planning-level effluent limits and related considerations for this Facilities Plan. Table 2.13-1 and 2.13-2 present the anticipated limits for Outfalls 001 and 005, respectively.

- Biochemical oxygen demand (BOD) and TSS effluent concentration limits will be essentially the same as existing limits.
- Based on new USEPA water quality criteria, effluent ammonia limits may decrease in the future, but near term effluent ammonia limits will be essentially the same as current limits.
- For the purposes of this Facilities Plan, the plan identifies potential effluent TP concentrations that can be biologically achieved without addition of an external carbon source under different process configurations, as well as with chemical polishing and filtration. The District plans to use AM to comply with effluent phosphorus limits to the BFC outfall. To minimize AM-related costs to the District, effluent TP concentrations would need to be consistently below about 0.26 to 0.28 mg/L under current and near future flows.
- Effluent phosphorus limits at the Badfish Creek outfall will be driven by the District’s decision to employ (AM) to comply with effluent phosphorus reduction requirements. The anticipated effluent phosphorus limit (six-month average) is 0.6 mg/L in the next permit, and 0.5 mg/L in the following two permit cycles.
- This Facilities Plan does not develop a plan to meet potential future effluent TP limits (0.075 mg/L) at the BMC discharge. If such low limits are implemented, the District indicated that it may consider discontinuing the discharging to that outfall. If the outfall is maintained, the District could potentially meet these requirements through WQT or AM in the Sugar River watershed.
- There will be no effluent TN limits during this planning period. However, the Facilities Plan evaluations develop scenarios to reduce TN discharges from current levels and perhaps meet a future effluent TN target of approximately 10 mg/L. This value is based on similar limits seen elsewhere in the country and based on a reasonable estimate of what the MMSD WWTP could meet without supplemental carbon addition.
Emergency discharges to Nine Springs Creek will continue to be allowed with monitoring only, even if the frequency of such discharges increases somewhat as projected in this planning document.

A “wet weather only,” or excess flow, discharge to Nine Springs Creek will need to be completely offset through trading with respect to total phosphorus and TSS loadings. Such a discharge could have a phosphorus limit that is lower than the water quality criterion of 0.075 mg/L according to WDNR correspondence.

It is assumed that a continuous discharge to Nine Springs Creek will not be allowed without considerable long-term testing, improved treatment, trading to offset phosphorus and TSS loadings, and demonstration of positive triple bottom line factors including energy and carbon footprint reductions, environmental protection, social acceptance, and related factors.

<table>
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<td>Monthly Geometric Mean</td>
<td>400 #/100 ml</td>
<td>Limit applies April 15 to October 15.</td>
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<tr>
<td>Fecal Coliform</td>
<td>Weekly Geometric Mean</td>
<td>780 #/100 ml</td>
<td>Limit applies April 15 to October 15.</td>
</tr>
<tr>
<td>Nitrogen, Ammonia, (NH₃-N)</td>
<td>Monthly Average</td>
<td>1.8 mg/L</td>
<td>Limit applies May to September.</td>
</tr>
<tr>
<td>Nitrogen, Ammonia, (NH₃-N)</td>
<td>Monthly Average</td>
<td>4.1 mg/L</td>
<td>Limit applies October to April.</td>
</tr>
<tr>
<td>Nitrogen, Ammonia, (NH₃-N)</td>
<td>Weekly Average</td>
<td>4.4 mg/L</td>
<td>Limit applies May to September.</td>
</tr>
<tr>
<td>Nitrogen, Ammonia, (NH₃-N)</td>
<td>Weekly Average</td>
<td>10 mg/L</td>
<td>Limit applies October to April.</td>
</tr>
<tr>
<td>Chloride</td>
<td>Weekly Average</td>
<td>430 mg/L</td>
<td>Limit applies April to October.</td>
</tr>
<tr>
<td>Chloride</td>
<td>Weekly Average</td>
<td>465 mg/L</td>
<td>Limit applies November to March.</td>
</tr>
<tr>
<td>Mercury, Total Recoverable</td>
<td>Daily Maximum</td>
<td>3.4 ng/L</td>
<td>Variance limit.</td>
</tr>
</tbody>
</table>

Table 2.13-1 Anticipated WPDES Permit Effluent Limits for Badfish Creek Outfall 001
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Limit Type</th>
<th>Limit and Units</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD₅, Total</td>
<td>Weekly Average</td>
<td>16 mg/L</td>
<td>Limit applies November to April.</td>
</tr>
<tr>
<td>BOD₅, Total</td>
<td>Weekly Average</td>
<td>7.0 mg/L</td>
<td>Limit applies May to October.</td>
</tr>
<tr>
<td>Suspended Solids, Total</td>
<td>Monthly Average</td>
<td>10 mg/L</td>
<td>Limit applies May to October.</td>
</tr>
<tr>
<td>Suspended Solids, Total</td>
<td>Monthly Average</td>
<td>16 mg/L</td>
<td>Limit applies November to April.</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>Daily Minimum</td>
<td>5.0 mg/L</td>
<td>See Section 3.2.2.7 regarding compliance with this limit.</td>
</tr>
<tr>
<td>pH Field</td>
<td>Daily Maximum</td>
<td>9.0 s.u.</td>
<td></td>
</tr>
<tr>
<td>pH Field</td>
<td>Daily Minimum</td>
<td>6.0 s.u.</td>
<td></td>
</tr>
<tr>
<td>Phosphorus, Total</td>
<td>Six-Month Average</td>
<td>0.6 mg/L</td>
<td>Interim limit.</td>
</tr>
<tr>
<td>Phosphorus, Total</td>
<td>Monthly Average</td>
<td>0.225 mg/L</td>
<td>Final limit.</td>
</tr>
<tr>
<td>Phosphorus, Total</td>
<td>Six-Month Average</td>
<td>0.075 mg/L</td>
<td>Final limit.</td>
</tr>
<tr>
<td>Phosphorus, Total</td>
<td>Six-Month Average</td>
<td>2.25 lbs/day</td>
<td>Final limit.</td>
</tr>
<tr>
<td>Fecal Coliform</td>
<td>Monthly Geometric Mean</td>
<td>400 #/100 ml</td>
<td>Limit applies May to September</td>
</tr>
<tr>
<td>Fecal Coliform</td>
<td>Weekly Geometric Mean</td>
<td>780 #/100 ml</td>
<td>Limit applies May to September</td>
</tr>
<tr>
<td>Nitrogen, Ammonia, (NH₃-N)</td>
<td>Monthly Average</td>
<td>1.1 mg/L</td>
<td>Limit applies May to September.</td>
</tr>
<tr>
<td>Nitrogen, Ammonia, (NH₃-N)</td>
<td>Monthly Average</td>
<td>3.8 mg/L</td>
<td>Limit applies October to April.</td>
</tr>
<tr>
<td>Nitrogen, Ammonia, (NH₃-N)</td>
<td>Weekly Average</td>
<td>2.6 mg/L</td>
<td>Limit applies May to September.</td>
</tr>
<tr>
<td>Nitrogen, Ammonia, (NH₃-N)</td>
<td>Weekly Average</td>
<td>8.7 mg/L</td>
<td>Limit applies October to April.</td>
</tr>
<tr>
<td>Nitrogen, Ammonia, (NH₃-N)</td>
<td>Daily Maximum</td>
<td>11 mg/L</td>
<td>Limit applies year-round.</td>
</tr>
<tr>
<td>Chloride</td>
<td>Weekly Average</td>
<td>430 mg/L</td>
<td>Limit applies April to October.</td>
</tr>
<tr>
<td>Chloride</td>
<td>Weekly Average</td>
<td>465 mg/L</td>
<td>Limit applies November to March.</td>
</tr>
<tr>
<td>Mercury, Total Recoverable</td>
<td>Daily Maximum</td>
<td>3.4 ng/L</td>
<td>Variance limit.</td>
</tr>
</tbody>
</table>

Table 2.13-2  Anticipated WPDES Permit Effluent Limits for Badger Mill Creek Outfall 005
SECTION 3
WASTELOAD AND FLOW FORECASTS
This section summarizes Technical Memorandum No. 2b (TM-2b, Appendix B) with respect to the existing NSWWTP influent flows and loadings, as well as the projected future influent flows and loadings through the planning year 2040. These projected flows and loadings are used within the future process and peak flow alternatives to evaluate required or recommended upgrades and modifications to the NSWWTP.

### 3.01 CURRENT FLOWS AND LOADINGS

TM-2b presents an analysis of influent flows and loadings based on historical data. Per capita flows/loads and peaking factors for each constituent were estimated in this analysis for use in the projection of future flow and loadings. Table 3.01-1 below presents a summary of the current average influent flows and loadings and associated per capita values. For reference, the existing service area population is estimated at approximately 370,000.

<table>
<thead>
<tr>
<th></th>
<th>Flow (mgd)</th>
<th>Per Capita Flow (gcd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Influent Flow¹</td>
<td>41.3</td>
<td>117</td>
</tr>
<tr>
<td>Annual Average Influent Loading²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BOD</td>
<td>78,500</td>
<td>0.22</td>
</tr>
<tr>
<td>TSS</td>
<td>75,500</td>
<td>0.21</td>
</tr>
<tr>
<td>TKN</td>
<td>14,000</td>
<td>0.039</td>
</tr>
<tr>
<td>NH₃-N</td>
<td>8,900</td>
<td>0.025</td>
</tr>
<tr>
<td>TP</td>
<td>1,869</td>
<td>0.0052</td>
</tr>
</tbody>
</table>

¹ Average of 2006-2015 influent data.
² Average of 2011-2015 influent data.

Table 3.01-1 Current Flow and Loadings Summary

### 3.02 PROJECTED FLOWS AND LOADINGS

Population projections provided by the Madison Area Transportation Planning Board (MATPB) for the MMSD service area were used to estimate future design average flows and loadings to NSWWTP. In TM-2b, design average flows and loadings for the future years of 2020, 2030, and 2040 were developed by multiplying the projected populations in those future years by the average per capita flows and loadings. To estimate future maximum 30-day, maximum 7-day, and maximum day flows, the peaking factors determined using historical data were multiplied by the future design average flows. Summaries of future design flows and future design wasteloads are presented in Tables 3.02-1 and 3.02-2, respectively.
### Table 3.02-1 Future Design Flow Summary

<table>
<thead>
<tr>
<th></th>
<th>Peaking Factor</th>
<th>2020</th>
<th>2030</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MMSD Population Projection</strong></td>
<td>---</td>
<td>383,904</td>
<td>419,596</td>
<td>455,288</td>
</tr>
<tr>
<td><strong>Design Flow Summary</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Day (mgd)</td>
<td>---</td>
<td>42.00</td>
<td>47.80</td>
<td>53.60</td>
</tr>
<tr>
<td>Maximum 30-day (mgd)</td>
<td>1.32</td>
<td>55.63</td>
<td>63.31</td>
<td>71.00</td>
</tr>
<tr>
<td>Maximum 7-day (mgd)</td>
<td>1.72</td>
<td>72.35</td>
<td>82.34</td>
<td>92.34</td>
</tr>
<tr>
<td>Maximum Day (mgd)</td>
<td>1.97(^1)</td>
<td>82.74</td>
<td>94.17</td>
<td>105.59</td>
</tr>
<tr>
<td>Peak Hourly Flow (mgd)</td>
<td>3.36(^2)</td>
<td>141</td>
<td>160</td>
<td>180</td>
</tr>
</tbody>
</table>

\(^1\)99.95th percentile highest daily flow used to calculate peaking factor.
\(^2\)Based on modeling results presented in Technical Memorandum No. 4.

### Table 3.02-2 Future Design Wasteload Summary

<table>
<thead>
<tr>
<th></th>
<th>Peaking Factor</th>
<th>2020</th>
<th>2030</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MMSD Population Projection</strong></td>
<td>---</td>
<td>383,904</td>
<td>419,596</td>
<td>455,288</td>
</tr>
<tr>
<td><strong>Design BOD Loading Summary</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Day (lbs/day)</td>
<td>---</td>
<td>82,904</td>
<td>90,671</td>
<td>98,438</td>
</tr>
<tr>
<td>Maximum 30-day (lbs/day)</td>
<td>1.14</td>
<td>94,167</td>
<td>102,989</td>
<td>111,811</td>
</tr>
<tr>
<td>Maximum 7-day (lbs/day)</td>
<td>1.31</td>
<td>108,437</td>
<td>118,597</td>
<td>128,756</td>
</tr>
<tr>
<td>Maximum Day (lbs/day)</td>
<td>1.85</td>
<td>153,236</td>
<td>167,592</td>
<td>181,948</td>
</tr>
<tr>
<td><strong>Design TSS Loading Summary</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Day (lbs/day)</td>
<td>---</td>
<td>79,276</td>
<td>86,703</td>
<td>94,130</td>
</tr>
<tr>
<td>Maximum 30-day (lbs/day)</td>
<td>1.17</td>
<td>92,552</td>
<td>101,223</td>
<td>109,894</td>
</tr>
<tr>
<td>Maximum 7-day (lbs/day)</td>
<td>1.69</td>
<td>133,964</td>
<td>146,515</td>
<td>159,065</td>
</tr>
<tr>
<td>Maximum Day (lbs/day)</td>
<td>3.02</td>
<td>239,700</td>
<td>262,157</td>
<td>284,613</td>
</tr>
<tr>
<td><strong>Design TKN Loading Summary</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Day (lbs/day)</td>
<td>---</td>
<td>15,019</td>
<td>16,426</td>
<td>17,832</td>
</tr>
<tr>
<td>Maximum 30-day (lbs/day)</td>
<td>1.13</td>
<td>16,997</td>
<td>18,567</td>
<td>20,158</td>
</tr>
<tr>
<td>Maximum 7-day (lbs/day)</td>
<td>1.18</td>
<td>17,695</td>
<td>19,353</td>
<td>21,010</td>
</tr>
<tr>
<td>Maximum Day (lbs/day)</td>
<td>1.46</td>
<td>21,942</td>
<td>23,997</td>
<td>26,052</td>
</tr>
<tr>
<td><strong>Design Ammonia-Nitrogen Loading Summary</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Day (lbs/day)</td>
<td>---</td>
<td>9,560</td>
<td>10,455</td>
<td>11,350</td>
</tr>
<tr>
<td>Maximum 30-day (lbs/day)</td>
<td>1.14</td>
<td>10,929</td>
<td>11,953</td>
<td>12,976</td>
</tr>
<tr>
<td>Maximum 7-day (lbs/day)</td>
<td>1.19</td>
<td>11,388</td>
<td>12,433</td>
<td>13,498</td>
</tr>
<tr>
<td>Maximum Day (lbs/day)</td>
<td>1.52</td>
<td>14,535</td>
<td>15,896</td>
<td>17,258</td>
</tr>
<tr>
<td><strong>Design Total Phosphorus Loading Summary</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Day (lbs/day)</td>
<td>---</td>
<td>1,979</td>
<td>2,164</td>
<td>2,349</td>
</tr>
<tr>
<td>Maximum 30-day (lbs/day)</td>
<td>1.11</td>
<td>2,204</td>
<td>2,410</td>
<td>2,617</td>
</tr>
<tr>
<td>Maximum 7-day (lbs/day)</td>
<td>1.16</td>
<td>2,299</td>
<td>2,514</td>
<td>2,729</td>
</tr>
<tr>
<td>Maximum Day (lbs/day)</td>
<td>1.65</td>
<td>3,274</td>
<td>3,580</td>
<td>3,887</td>
</tr>
</tbody>
</table>
This section includes a summary of the peak flow modeling, in-plant hydraulic analyses, and peak flow management alternatives that were conducted as part of the facility planning for the NSWWTP. In addition, more detailed evaluations of the shortlisted peak flow management alternatives are presented with opinions of probable construction cost and discussion of non-monetary considerations. Additional detail on this evaluation is presented in Technical Memorandum No. 4 (TM-4, Appendix D).

4.01 DESCRIPTION OF EXISTING NSWWTP HYDRAULICS

A process flow schematic of NSWWTP is presented in Figure 4.01-1.

Currently, all flows from the MMSD service area are pumped by five major pumping stations and two smaller pumping stations to the NSWWTP for treatment. Pumped flows are discharged at the preliminary treatment building where they receive screening and vortex grit removal. Flow from the preliminary treatment facility is then split between two complexes for primary and secondary treatment (designated herein as the west plant and the east plant) using a splitter structure. Currently, under normal flow conditions, District staff try to achieve a flow split of approximately 55 percent to the west plant and 45 percent to the east plant to efficiently use existing blower capacities. During high flow events, the flow split is changed to send more flow to the east plant because of hydraulic limitations within the west plant, as well as limitations within the lagoon diversion structure within the east plant.

During high flow events, secondary effluent flows greater than the approximate 100 mgd capacity of the UV disinfection facilities are discharged directly to the lagoons. This discharge is hydraulically controlled in the Effluent Structure northwest of the east plant final clarifiers via a fixed-elevation weir within this structure. The Effluent Structure receives flow from East Final Clarifier Nos. 4 through 11, while flow from East Final Clarifier Nos. 1 through 3 discharge to a junction chamber downstream of the Effluent Structure. Secondary effluent from the west plant flows directly to the disinfection building, requiring all forward flow from the west plant to be conveyed through the disinfection channels and into the effluent pump station wet well.

Because of the existing hydraulic layout and connections on the east and west side of the plant, if flow is to be diverted directly to the lagoons without being disinfected, the flow must pass through the east plant or backflow in the east plant secondary effluent piping from the Effluent Building. Based on hydraulic modeling of the plant, the weir elevation in the Effluent Structure is reached when approximately 50 mgd is conveyed from the east plant to the Effluent Building. Therefore, under current conditions, the east plant handles approximately 50 mgd plus any flow to be discharged directly to the lagoons upstream of disinfection. If the plant is operating under an extreme condition in which the water level in the Effluent Building is high enough, secondary effluent from the west plant could backflow to the east plant, allowing west plant flow to be discharged to the lagoons. However, this condition is more likely to result in flooding of the Effluent Building because it would require the water level at the building to be higher than the Effluent Structure overflow elevation.

Any disinfected secondary effluent in excess of the effluent pumping capacity of the plant (about 80 mgd total, 75.5 mgd without the Badger Mill Effluent Pumps in operation) flows to two Effluent Storage Reservoirs. If there continues to be disinfected secondary effluent flow in excess of the effluent pumping capacity after these reservoirs are full, the reservoirs will flow to the Effluent Structure and flow will be combined with any nondisinfected secondary effluent prior to discharge to the lagoons.
4.02 PEAK FLOW MODELING

Peak influent flows to the NSWWTP were modeled for current and future conditions for use in evaluating alternatives to manage peak flows. This analysis included an estimated future flow increase of 29 percent, proportional to the 29 percent population projection increase from 2015 to 2040 for the service area.

Based on the peak flow modeling performed, a future peak design flow of 180 mgd was selected for evaluation of hydraulic upgrades that may be required at the NSWWTP through the year 2040. This corresponds to the highest peak instantaneous flow encountered in the future flow modeling and provides a level of service between 50 and 60 years. While the absolute maximum pumping capacity to NSWWTP is greater than 180 mgd (closer to 210 mgd with Pump Station 18 on line), the level of service that would be provided by designing for such extreme events would be in excess of 100 years. Curves showing the recurrence interval for the current and future peak flows are presented in Figure 4.02-1. A detailed approach and description of this modeling is presented in TM-4.

![Figure 4.02-1 Future Peak Hourly Flow Frequency and Levels of Service](image)

It is noted that the analysis did not include a climate change impact for the District, but it did summarize two recent climate change impact analyses that were completed for the MMSD. In general, large wet weather events tended to become larger and more intense, while smaller events tended to become smaller and less frequent, with the average annual rainfall anticipated to remain approximately the same.
The climate change scenarios affected the distribution of intensities, rather than the average annual rain amount. The studies predicted a relatively small change in peak sanitary sewer flows of less than 10 percent. Climate change impacts in Madison could be expected to be similar to the Milwaukee study results. With due respect for the uncertainties in the model results, the impacts of climate change in an upper Midwest location like Madison may be a modest variation from the current pattern, rather than a major hydrologic shift.

A hydraulic model of the NSWWTP was developed by Black & Veatch as part of the 10th Addition design. A modified version of this hydraulic model was used in the peak flow analysis for the development of this Facilities Plan to identify hydraulic bottlenecks at the plant and to evaluate potential changes to alleviate these bottlenecks. Modifications made to the model include changes to more accurately portray current plant operation based on discussions with MMSD staff, to better account for situations that may occur during high flow events such as submerged weirs or orifices, and to evaluate peak flow management alternatives.

Based on the current plant hydraulics, flows above about 145 mgd would create hydraulic problems at the screening facilities, and the bypass channel would need to be used. In addition, hydraulic bottlenecks at the west plant primary clarifiers and in the west final clarifier influent channels would create an overflow at the plant site. Diverting flows above approximately 65 mgd to the east plant could be done to avoid these overflows. However, the primary flow splitter to the east and west plants requires manually changing gate positions, which is not an easy or safe procedure and is often required to be completed under poor weather conditions.

Furthermore, the Effluent Structure that controls the diversion to the lagoons is hydraulically controlled by the flow from the east plant to the disinfection building as described earlier, and therefore approximately 50 mgd must be sent to the disinfection building from the east plant prior to a diversion to the lagoons occurring. This means that at the future peak flow of 180 mgd, over 130 mgd must be sent thought the east plant (50 mgd to disinfection and 80 mgd diversion to lagoons). Based on hydraulic modeling analysis, the east plant is not capable of passing flows in excess of approximately 90 mgd with the existing Effluent Structure controlling the water surface elevation downstream of the final clarifiers, and therefore cannot pass the flow required to maintain a maximum of 100 mgd sent to the Effluent Building with the excess 80 mgd sent to the lagoon.

At the future peak flow of 180 mgd without plant improvements, overflows of structures in both the west and east plants would occur and District staff would have a reduced ability to hydraulically control flow splitting throughout the plant.

### 4.03 PEAK FLOW MANAGEMENT ALTERNATIVES SCREENING

Peak Flow Management Workshop No. 4a (WS 4a) was held on May 9, 2016. The purpose of the workshop was to present the peak flow modeling calibration and results, to identify a range of alternatives that could be used to improve peak flow management, and to conduct preliminary screening on these alternatives. Based on these discussions, the following alternatives were selected to be evaluated further:

- Alternative PF0–No Change (Null Alternative)
- Alternative PF4–Aggressive I/I Removal (high level assessment)
- Alternative PF6–Influent Equalization at NSWWTP


- Alternative PF7–Upgrade NSWTP Hydraulics
- Alternative PF8–Expand Effluent Pumping Capacity
- Alternative PF9–Upgrade NSWTP Hydraulics and Increase Nine Springs Creek Discharges
- Alternative PF10–High-Rate Wet Weather Treatment at NSWTP

### 4.04 DESCRIPTION OF ALTERNATIVES EVALUATED

This section includes a description of each short-listed peak flow management alternative.

#### A. Alternative PF0–No Change (Null Alternative)

In this alternative, the null alternative is equivalent to a “do nothing” alternative. Peak flow management at NSWTP would remain unchanged and there is no investment in additional infrastructure to handle peak flows. As described earlier, the existing plant is not capable of passing the anticipated future peak flows and hydraulic analyses indicate that structure overflows would result from flows over approximately 145 mgd. This would result in untreated or partially treated wastewater overflowing to the NSWTP site and potentially flooding buildings or flowing off-site and discharging to surface waters.

We note that the null alternative, as defined above, is likely not an acceptable solution to the peak flow management analysis, but it was defined as such at the time of the Peak Flow Management Technical Memorandum development. If an alternative definition of the null alternative were used, such as implementing the minimal improvements to address and eliminate in-plant overflows at the projected peak flow of 180 mgd, the null alternative would have been defined very similar to, if not identically to, Alternative PF7–Upgrade NSWTP Hydraulics.

#### B. Alternative PF4–Aggressive I/I Removal

This alternative describes a program to aggressively reduce I/I in MMSD’s conveyance system and the community customer systems tributary to MMSD’s system. In the past, the District has not taken an aggressive approach to reduce I/I, particularly with its community customers. This is partly because I/I levels have generally been manageable within the District’s system and at the NSWTP, and significant wet weather problems have been rare. However, the peak flow projections developed for this planning project indicate higher peak flows at the NSWTP, and I/I levels will only be expected to become more significant over time if I/I reduction is not a focus of the District and its community customers. In addition, the District has important energy and sustainability initiatives that support addressing wet weather concerns at the source through I/I reduction rather than building infrastructure to manage increasing levels of wet weather peak flows. This I/I reduction alternative was included to help define the level of effort and high level costs to establish, implement, and administer a program to aggressively reduce I/I.

The vast majority of the sewer infrastructure is in the customer community and private collection systems. Therefore, any program to aggressively reduce I/I will need to include these systems as well as the MMSD’s interceptor system. An overall strategy for implementing this alternative is outlined below:

1. Demonstrate initial cost-effectiveness of I/I reduction program relative to other alternatives to manage peak flows.
2. Initiate stakeholder involvement program to gain stakeholder buy-in.

3. Perform I/I evaluation at plant, pump station basin, and sub-basin scales to identify high I/I areas.

4. Identify treatment plant capital and operations and maintenance costs avoided with I/I reduction.

5. Perform conveyance system evaluation to estimate conveyance improvement costs avoided with I/I reduction.

6. Identify risk and cumulative cost of damages of basement backups and SSOs sustained by choosing not to reduce I/I or increase conveyance. (This is the ongoing cost of the “do-nothing” alternative.)

7. Implement a pilot source detection program to identify sources and costs to mitigate sources.

8. Re-evaluate the cost-effectiveness of I/I reduction using the information gathered from Steps 3 to 7.

9. If I/I reduction cost-effectiveness is confirmed, establish I/I reduction targets or allowable peak flow performance standards in conjunction with stakeholders.

10. Implement comprehensive source detection program at all system levels.

11. Conduct pilot program to test rehabilitation technologies and demonstrate effectiveness of I/I reduction efforts.

12. Implement comprehensive I/I reduction program.

13. Measure effectiveness of I/I reduction program as it progresses.

A successful I/I reduction program for MMSD will require a partnership with the MMSD’s customer communities because most of the I/I in the system is generated in either the customer community or private systems. There are several approaches that MMSD can take to accomplish I/I reduction:

- Establish performance standards
- Establish design and construction standards for the design and construction of sewers
- Ordinances
- Asset Management
- Financial incentives
- I/I Mitigation Bank

Additional details on an I/I reduction program are presented in Technical Memorandum No. 4.
C. Alternative PF6–Influent Equalization at NSWWTP (and pass 145 mgd through the NSWWTP)

In this alternative, peak flows up to 145 mgd, the approximate hydraulic capacity of the existing NSWWTP facilities, will be conveyed to the plant. The disinfection and effluent pumping capacities of the plant will remain at 100 mgd and 80 mgd, respectively, and therefore diversions to the lagoon will still occur when these capacities are exceeded. Future peak flows above 145 mgd will be stored in a new influent equalization structure and released to the plant as flows subside following high flow events. This alternative was included in the District’s 2017 Capital Improvements Plan Plant Peak Capacity Improvements analysis.

Included in this alternative are the following modifications:

- Construct new influent equalization tank [approximately 10 million gallons (MG)].
- Install a new interceptor to convey peak flows above about 145 mgd to the equalization tank from the splitter structure upstream of the primary clarifiers at NSWWTP.
- Install a drain line from the equalization tank to Pump Station No. 11 and flushing system.
- Alternative Consideration: If the tank were constructed near Pump Station No. 11, flow could be diverted directly to the tank from the pump station.

This alternative (with 10 MG) would not significantly reduce the lagoon overflow frequency or volume to NSC. To provide the same lagoon overflow frequency as existing, approximately 200 to 250 million gallons of equalization volume would be required.

D. Alternative PF7–Upgrade NSWWTP Hydraulics

In this alternative, all wet weather flows are conveyed to and through the NSWWTP in a manner that minimizes plant operational impacts and process overflows and provides the capability to have a more equitable flow split between the west and east plants during peak flow events to better utilize the capacity within the west plant. A goal of this alternative is to improve hydraulics through the plant to allow more flow to be sent to the west plant during peak flow events, better utilizing the existing infrastructure and improving treatment efficiency, while eliminating hydraulic bottlenecks that may lead to overflows of in-plant structures.

In the evaluation of this alternative, the plant hydraulic model was used to evaluate necessary upgrades for wet weather flows up to 180 mgd to be conveyed through secondary treatment at the NSWWTP, with flows above approximately 100 mgd being sent to the lagoons prior to disinfection and effluent pumping. At these peak flows, the hydraulic analysis was completed for approximately 90 mgd sent to both the west plant and the east plant at the primary influent flow splitter structure. This alternative achieves the goals of better utilizing the west plant, better controlling the flow split between the west and east plants, better controlling the flow to the lagoons and the disinfection building, and preventing in-plant overflows.

Included in this alternative are the following modifications to improve plant hydraulics at peak flows:

- Construct bypass channel for west primary clarifiers.
- Raise west final clarifier influent channel walls.
- Construct new lagoon diversion structure to provide flexible flow control to the lagoons and flow conveyed from the east plant to the disinfection building.
- Upgrade lagoon return pump station and force main.
E. Alternative PF8–Double NSWWTP Effluent Pumping Capacity

This alternative would eliminate diversions to the lagoons and Nine Springs Creek by improving plant hydraulics and increasing process capacities so that the 180 mgd peak flow can be disinfected and pumped to the discharges at Badfish Creek and Badger Mill Creek.

It is anticipated that peak flows would be split approximately evenly between the west and east plant in this alternative, and therefore the west plant hydraulic improvements included in Alternative PF7 to allow 90 mgd to be sent through the west plant are also included in this alternative. An additional secondary effluent pipe to convey flow from the east plant to the disinfection building would also be required. In addition, the UV disinfection capacity of the plant would be increased from the current capacity of approximately 100 mgd to the future peak flow of 180 mgd.

This alternative includes larger and/or more effluent pumps and a second force main from NSWWTP to the outfall location at Badfish Creek. A second force main was assumed to be necessary based on the age of the existing piping (approximately 60 years) and a surge analysis conducted on the effluent force main for this planning project.

Included in this alternative are several modifications that are also included in Alternative PF7:

- Construct bypass channel for west primary clarifiers.
- Raise west final clarifier influent channel walls by 1 foot and modify channel at roadway crossing to prevent overflows.
- Construct new effluent structure to control diversions to lagoons and flow conveyed from the east plant to the disinfection building.

Additional modifications for this alternative are as follows:

- Install additional pipe to convey flow from the east plant to the disinfection building.
- Increase UV disinfection capacity to 180 mgd.
- Double effluent pumping capacity and construct new effluent force main.

F. Alternative PF9–Upgrade NSWWTP Hydraulics and Increase Nine Springs Creek Discharge

This alternative is nearly the same as Alternative PF7 except that some flow would be directly discharged to Nine Springs Creek during wet weather/peak flow events in addition to overflows from the lagoons. The current UV disinfection capacity of 100 mgd and effluent pumping capacity of approximately 80 mgd will be maintained in this alternative. Effluent from the disinfection building in excess of the effluent pumping capacity will continue to be conveyed to the Effluent Storage Reservoirs. The flow from these reservoirs will combine with any secondary effluent from the east plant at a new effluent diversion structure as described in Alternative PF7. Peak flows from this structure will be split to two locations: a portion of the flow may be sent to the lagoons and a portion discharged directly to Nine Springs Creek. During peak flow events above the effluent pumping capacity of 80 mgd, but less than about 100 mgd, all diversion flow at this structure will be sent to the lagoons. When flows exceed 100 mgd, the flow in
excess of 100 mgd will be sent to a high rate disinfection system located near the diversion structure and discharged directly to Nine Springs Creek. Therefore, during a peak flow event of 180 mgd, approximately 80 mgd would be discharged using the existing effluent pumping system, 80 mgd would be disinfected and discharged to Nine Springs Creek, and 20 mgd would be discharged to the lagoons.

Based on WDNR’s draft water quality memorandum received on February 13, 2017, any permitted discharge to Nine Springs Creek would also need to receive tertiary treatment and would need to improve water quality in the phosphorus impaired segment, which would require limits that are less than the water quality criteria. These requirements are based on Nine Springs Creek being listed as impaired for phosphorus and TSS. Therefore, this alternative would also require a new tertiary treatment facility to receive secondary effluent. For planning purposes, these include a new filter influent pumping stations, new deep bed granular media filters, chemical addition facilities, and chemical coagulation facilities.

Included in this alternative are the modifications that are included in Alternative PF7:

- Construct bypass channel for west primary clarifiers.
- Raise west final clarifier influent channel walls by 1 foot and modify channel at roadway crossing to prevent overflows.
- Construct new effluent structure to control diversion to the lagoons and flow conveyed from the east plant to the disinfection building.
- Upgrade lagoon pump station and force main.

Additional modifications for this alternative are as follows:

- Install tertiary treatment facilities for phosphorus removal.
- Install additional effluent piping from the new tertiary treatment facilities to the Nine Springs Creek outfall.

In addition to the regulatory and technical (level of treatment) hurdles that would need to be addressed, public perception of this alternative may be substantially negative. In our experience, new wastewater discharges are not typically well received, especially when the discharge is to recreational use waters that are heavily used by the community. In summary, this alternative is not considered as a viable, constructible alternative within the planning period of this Facilities Plan. However, we believe there is ultimately a significant benefit to establishing a local discharge to Nine Springs Creek, and we recommended the District begin evaluating in more detail potential paths forward related to such a discharge.

G. Alternative PF10–High-Rate Wet Weather Treatment at NSWWTP

This alternative includes the implementation of a biological contact (BC) high-rate treatment process in which mixed liquor or return activated sludge (RAS) is combined with wet weather flows in a small contact chamber. This would occur in Pass 3 of each of the 10 aeration basin trains. The BC process relies on
the removal of particulate and colloidal material by biological flocculation in the contact chamber and provides limited soluble substrate uptake. Biological contact has generally been shown to be a cost-effective solution for WWTPs with flow peaking factors up to approximately three to four times the average design flow rate.

Effluent quality from the BC process is expected to achieve less than 15 mg/L of TSS and five-day carbonaceous biochemical oxygen demand (CBOD₅) in a well operating clarifier. Daily effluent ammonia nitrogen (NH₃-N) and TP could be higher than conventional secondary treatment depending upon the level of dilution and treatment and would need to be further investigated during preliminary design if this alternative is selected for implementation.

Included in this alternative are the modifications that are included in Alternative PF7:

- Construct bypass channel for west primary clarifiers.
- Raise west final clarifier influent channel walls by 1 foot and modify channel at roadway crossing to prevent overflows.
- Construct new effluent structure to control diversion to the lagoons and flow conveyed from the east plant to the disinfection building.
- Upgrade lagoon return pump station and force main.

Additional modifications for this alternative are as follows:

- New slide gates and control valves with electric actuators at pass 3 of each aeration train.

4.05 PRESENT WORTH ANALYSIS

Table 4.05-1 provides a summary of the opinion of present worth values for the alternatives. A detailed breakdown of present worth costs is included in TM-4.

Since Alternative PF9 was not considered viable within the planning horizon of this Facilities Plan, costs are not included costs for this alternative. We believe inclusion of these costs for Alternative PF9 would only make sense if the long-term (beyond 20 years) costs were included for the other alternatives, and these costs would need to include the costs related to compliance with nutrient regulations in a comprehensive triple bottom line analysis to truly be comparable.
### Table 4.05-1 Opinion of Present Worth Summary

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Total Opinion of Capital Cost</th>
<th>PF0 Null</th>
<th>PF4 Aggressive I/I(^a)</th>
<th>PF6 Influent EQ</th>
<th>PF7 NSWWTP Hydraulic Upgrades</th>
<th>PF8 Effluent Pumping Upgrades</th>
<th>PF10 Biological Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>PF0 Null</td>
<td>$0</td>
<td>$4,100,000</td>
<td>$65,300,000</td>
<td>$4,100,000</td>
<td>$71,300,000</td>
<td>$5,200,000</td>
<td></td>
</tr>
<tr>
<td>Annual O&amp;M</td>
<td>$773,000</td>
<td>$11,000,000 to $16,000,000</td>
<td>$777,000</td>
<td>$774,000</td>
<td>$738,000</td>
<td>$782,000</td>
<td></td>
</tr>
<tr>
<td>O&amp;M Cost PW</td>
<td>$10,200,000</td>
<td>$80,000,000 to $175,000,000</td>
<td>$10,200,000</td>
<td>$10,200,000</td>
<td>$9,700,000</td>
<td>$10,300,000</td>
<td></td>
</tr>
<tr>
<td>Salvage PW</td>
<td>$0</td>
<td>($400,000)</td>
<td>($7,300,000)</td>
<td>($400,000)</td>
<td>($6,500,000)</td>
<td>($400,000)</td>
<td></td>
</tr>
<tr>
<td>Total Opinion of Present Worth</td>
<td>$10,200,000</td>
<td>$84,100,000 to $179,100,000</td>
<td>$68,200,000</td>
<td>$13,900,000</td>
<td>$74,500,000</td>
<td>$15,100,000</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)Annual O&M and present worth costs are the total projected program costs for the District, its customers, and private efforts.

Alternative PF0—No Change has the lowest capital and long-term present worth costs, based on the fact that no capital improvements would be required within the planning period. It is likely that all of the hydraulic and process structures would continue to operate efficiently under most flow conditions. However, the frequency and severity of peak flows through the plant are anticipated to increase over time, and as these events continue to occur, the potential of a larger process or hydraulic failure increases. In addition, the current split of flow through the plant during high flow events does not provide the optimum use of the existing infrastructure. Therefore, we do not recommend Alternative PF0.

Alternative PF7—Upgrade NSWWTP Hydraulics Only has the next lowest opinion of capital and present worth costs, however it does not consider the process requirements to maintain acceptable clarifier solids loading rates discussed in Section 5—Activated Sludge. To achieve both hydraulic improvement objectives of processing higher flows and process objectives of maintaining acceptable clarifier solids loading rates, Alternative PF10 is required. In addition, this alternative provides hydraulic upgrades that should minimize structure overflows through the plant and optimize the use of both the east and west plant facilities.

### 4.06 NONMONETARY EVALUATION

Nonmonetary considerations for each alternative were evaluated and are summarized in Table 4.06-1 and 4.06-2. Since Alternative PF10 is not directly comparable to the other peak flow management alternatives because it focuses on improving treatment performance during wet weather events, this alternative is compared to dedicated excess flow treatment scheme such as BioACTIFLO.
### Table 4.06-1 Peak Flow Management Alternative Nonmonetary Considerations Summary

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alternative PF0—No Change</strong>&lt;br&gt;(Null Alternative)</td>
<td>• No changes in plant equipment or processes for staff to become accustomed to.</td>
<td>• Does not address hydraulic constraints in the plant that will lead to tank overflows at future peak flows. • Does not improve the level of service with respect to diversion to lagoons and overflow of lagoons to Nine Springs Creek. • Health and safety concerns associated with overflows of untreated wastewater on-site. • Potential to discharge untreated wastewater to the environment as a result of tank overflows running off-site. • Risk of damage to structures and equipment during overflow events. • Legal and regulatory opposition to overflows and operating a plant without adequate capacity. • Negative public perception from lack of action related to plant capacity issues.</td>
</tr>
<tr>
<td><strong>Alternative PF4—Aggressive I/I Removal</strong></td>
<td>• Addresses peak flow problem at the source so costs for correcting problem are aligned with the source of the problem. • Promotes local responsibility for addressing peak flows at the community customer and property owner level. • Reduces the risk of basement backups (costs, health risks, and emotional stress). • If successful, can reduce or eliminate the costs associated with collection system and treatment plant infrastructure upgrades associated with hydraulic capacity. • Improves system resiliency, if successful. • Potentially reduces energy consumption as a result of reduced pumping. • Could help to promote/improve public perception of MMSD as a good steward of the environment and resources. • Could help to promote customer community/MMSD cooperation.</td>
<td>• Long time frame is required for implementation. • Success is difficult to demonstrate in the short-term. • Requires significant cooperation among numerous governmental entities; difficult to coordinate. • There may be resistance from property owners if they are required to undertake private property repairs. • Public perception of MMSD could be negative if benefits of program are not properly communicated or if the program does not meet expectations. • Could create tension between community customers and MMSD if requirements for I/I reduction at community customer level are perceived as onerous. • Successful results and outcomes cannot be assumed, and infrastructure capacity upgrades may, therefore, still be required before I/I reduction success can be demonstrated. • MMSD’s overall wet weather peaking factors are relatively low, which equates to lower confidence in achieving desired outcomes.</td>
</tr>
<tr>
<td><strong>Alternative PF5—Influent Equalization at NSWWTP and pass 145 MGD through NSWWTP</strong></td>
<td>• Provides improved peak flow management, flexibility, and control to operations staff for both short-term and long-term operations. • Reduces extreme peak flow rates through the NSWWTP, which could improve overall treatment performance during extreme wet weather events and eliminate in-plant overflows. • Provides more efficient use of the West Plant facilities, which should improve treatment efficiency during wet weather events. • Low construction risk and low risk of failure; relatively simple to construct. • Does not require significant space at the plant. • Dual-purpose site could become a public recreational asset (e.g., soccer fields)</td>
<td>• Does not significantly improve the level of service with respect to diversion to lagoons and overflow of lagoons to Nine Springs Creek. • Potential staff safety and public aesthetics concerns during tank cleaning. • Requires staff to go off-site for maintenance activities. • Tank cleaning will result in solids handling and management requirements; may be able to flush to Pump Station 11. • Repumping of influent wastewater is required (higher energy). • Likely would be constructed on a greenfield site; loss of farmland and the natural setting. May be public concerns regarding siting. • Potential odors following wet weather events. • Discharges to Nine Springs Creek might be permitted differently in the future.</td>
</tr>
<tr>
<td><strong>Alternative PF7—Upgrade NSWWTP Hydraulics to Pass 180 mgd</strong></td>
<td>• Provides improved peak flow management, flexibility, and control to operations staff for both short-term and long-term operations. • Provides more efficient use of the West Plant facilities, which should improve treatment efficiency during wet weather events. • Low construction risk and low risk of failure; relatively simple to construct. • Does not require additional space at the plant or greenfield development. • Eliminates in-plant overflows, protecting existing equipment and facilities. • Public perception of alternative likely to be positive.</td>
<td>• Does not meet process objective of maintaining acceptable clarifier solids loading rates at high flows during wet weather events.</td>
</tr>
</tbody>
</table>

Prepared by Strand Associates, Inc.

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**Alternative PFF–Double NSWWTP Effluent Pumping Capacity and Upgrade Plant Hydraulics to Pass 180 mgd**

- Provides improved peak flow management, flexibility, and control to operations staff for both short-term and long-term operations.
- Provides more efficient use of the West Plant facilities, which should improve treatment efficiency during wet weather events.
- Provides full treatment of all flows.
- Eliminates lagoon overflow concerns; significantly reduces or eliminates the associated unknown future permit requirements associated with a Nine Springs Creek discharge.
- Provides redundant effluent pumping capacity for improved reliability of that critical system.
- Provides redundant effluent force main. Allows for more cost-effective maintenance and rehabilitation work.
- Maintains discharge flow to Badfish Creek.

**Benefits**

- Difficult construction of additional large diameter piping to the disinfection building, as well as for the additional effluent pump station and effluent force main through the NSWWTP site.
- Requires some additional space at the plant in congested areas.
- Requires significant infrastructure investment that would largely be unutilized or underutilized during much of its life.
- Construction impacts through environmental corridors and green fields for the force main installation.
- Potential public perception issues related to construction and traffic impacts.
- Potential impacts to Badfish Creek with respect to streambank erosion from higher peak flows; uncertainty if increased flow would be able to be permitted.
- Potentially takes the District in a direction away from a potential future local discharge to Nine Springs Creek and the Madison Lakes.
- Potentially takes the District in a direction away from decentralized treatment opportunities because of the significant cost to implement.
- Does not meet process objective of maintaining acceptable clarifier solids loading rates at high flows.

**Limitations**

**Alternative PF9–Upgrade NSWWTP Hydraulics to Pass 180 mgd with Increased Nine Springs Creek Discharge Frequency**

- Eliminates effluent pumping costs, which would enable the District to better meet its energy and efficiency goals. It is noted, however, that any future tertiary treatment on site will likely require the addition of an intermediate pump station. Power use will decrease overall, however.
- Eliminates the significant risk associated with a potential failure of the effluent force main to Badfish Creek.
- Would provide the ability to meet future low level phosphorus limits if Badfish Creek and Badger Mill Creek discharges continue and adaptive management and/or trading programs are not deemed to be cost-effective.
- Directs resources at the District to towards initiating a long-term plan and program to establish a future local discharge to Nine Springs Creek and the Madison Lakes on a continuous basis. It changes the concept of peak flow management and potential long-term discharge locations.
- Provides improved peak flow management, flexibility, and control to operations staff for both short-term and long-term operations.

**Benefits**

- The regulatory viability of a local Nine Springs Creek discharge is unknown at this time.
- May require political strategies to change state statutes related to a Nine Springs Creek discharge.
- Requires significant additional space at the plant.
- Would likely require load trading for the relatively small amount of phosphorus and TSS discharged to Nine Springs Creek through the new outfall.
- Does not meet process objective of maintaining acceptable clarifier solids loading rates at high flows.

**Limitations**

**Alternative PF10–High-Rate Treatment at NSWWTP**

- Low construction impact. Installation of West Primary Clarifier high flow channel to the primary effluent channel significantly less disruptive than alternatives requiring additional tankage and processes. Significantly less large diameter piping required. Less construction will translate into fewer impacts on neighbors from dust, traffic, and noise.
- Maximizes investment in existing infrastructure while improving peak flow treatment by using existing tankage and aeration equipment for treatment.
- The environmental impacts of new storage or treatment facilities construction are avoided.
- Saves NSWWTP space for other uses or future construction.
- No chemicals required.
- Fast start-up under wet weather conditions.
- Simple operations compared to operating a dedicated wet weather treatment plant.
- Reduces asset management requirements and maintenance requirements compared to a dedicated wet weather treatment facility.
- Proven wet weather treatment system.
- Nonproprietary.
- Similar or better treatment efficiency anticipated.
- Eliminates concerns with permitting a wet weather treatment facility.
- Meets both process and hydraulic capacity goals.

**Benefits**

- Does not increase overall NSWWTP wet weather treatment capacity relative to a dedicated excess flow treatment technology; however, the existing plant has adequate hydraulic capacity with the improvements included in this alternative to treat peak flows in existing tankage.
4.07 RECOMMENDED PLAN

Based on the evaluations included herein, the following recommendations are provided with respect to peak flow management for the District and at the NSWWTP:

1. Implement Alternative PF10, which includes the hydraulic capacity upgrades at the NSWWTP included in Alternative PF7, as well as upgrades to allow the activated sludge process to operate in a biological contact process mode during high flow events. This alternative provides protection against in-plant tank overflows and will provide improved treatment under high flow conditions.

2. Begin evaluating in more detail potential paths forward related to implementing Alternative PF9, which includes initiation of a local permitted discharge to Nine Springs Creek. This alternative would be a first step towards a potential continuous future discharge to Nine Springs Creek at the District, which could significantly reduce energy consumption at the NSWWTP by eliminating the effluent pump station, and would account for a large percentage of the needed energy reduction goals to ultimately attain electrical neutrality at the NSWWTP. Our recommendation is to begin planning with the WDNR for an approximate 5 or 10 mgd tertiary treatment facility that would provide acceptable effluent for discharge to Nine Springs Creek for wet weather events. Added benefits of this alternative include the ability to evaluate low level phosphorus removal over a long term to develop costs for comparison to the adaptive management planning program and to act a first step in establishing a continuous, local discharge to Nine Springs Creek.

3. Consider initiating an aggressive I/I reduction pilot study (Alternative PF4). The study would be focused on identifying one or more areas with high I/I rates, and then implementing aggressive I/I reduction measures with the goal of quantifying successes and challenges for future additional measures in other areas. In addition to the pilot study, The District should consider evaluating a monetized triple bottom line for this alternative to help compare the potential total costs with other alternatives. An aggressive I/I program will require public and private investment, significant coordination and collaboration from multiple communities and entities, and a concentrated long-term effort from the District, and a triple bottom line analysis would help in quantifying the significant social and environmental benefits and costs.

The remaining alternatives were not recommended for the following reasons:

- Alternative PF0 (No Change–Null Alternative) does not address any of the hydraulic concerns that are the focus of this Facilities Plan.
- Alternative PF6 (Influent Equalization) has very high capital and present worth costs, and does not significantly improve overall plant hydraulics and flexibility. In addition, the potential public/aesthetic concerns could result in poor public perception.
- Alternative PF8 (Effluent Pumping Upgrades) has very high capital and present worth costs, and implementation of this alternative could make it more difficult to justify future local discharges to NSC because of the high sunk costs associated with the redundant force main.
This section includes a summary of the influent flow measurement, screening and screenings handling, grit washing, and hauled waste receiving analyses that were conducted as part of the facility planning for the NSWWTP. In addition, detailed evaluations of the shortlisted alternatives are presented with opinions of probable construction cost and discussion of nonmonetary considerations. Additional detail on this evaluation is presented in Technical Memorandum No. 6 (TM-6).

5.01 EXISTING HEADWORKS FACILITIES

A. Description of Existing Facilities

The existing Headworks Facility at the NSWWTP was constructed as part of the 10th Addition project and was brought on-line in approximately 2005. The Headworks Facility is located on the south side of the grounds between the Struvite Harvesting Facility and the Metrogro Storage Tanks. Five force mains from collection system pump stations (PS) enter the west side of the Headworks Facility into the basement Meter Vault Room. Flows are measured using venturi flow meters and sampled. The force mains discharge into a common channel in the Screen Room. Flows are split to pass through up to three center-flow band screens to remove coarse solids from the influent wastewater. After screening, the flows recombine in a channel before being split to flow to the three vortex grit removal tanks. Screened and degritted wastewater then flows to the Flow Splitter Structure where flows are split to the east and west plants. The current capacity of the three screens is estimated at about 140 to 145 mgd. The maximum estimated peak flow that the facilities will be required to process is 180 mgd (Appendix D).

Material removed from the wastewater by the screens is sluiced via the screenings launder trough to the Maci well from which it is pumped to the secondary grit tank, Lisep and Lipactor, for degritting, dewatering, and compacting before being discharged to the haul-off waste container. Grit that accumulates in the Maci well is pumped periodically by the grit pump to the grit snail that dewater the grit and discharges it to the haul-off waste container.

Grit that is removed from the forward flow in the vortex grit tanks is pumped by the grit pumps to the three grit concentrators/classifiers, which remove some of the organics from the grit and then dewater the grit before discharging it to the haul-off waste container.

The NSWWTP hauled waste receiving facilities are located at the Headworks Facility. The hauled waste facilities includes a covered open trough into which up to two trucks can discharge hauled wastes. The trough discharges into the screening channel just upstream of Screen No. 4. There is no screen or rock removal mechanism in the receiving trough to prevent large objects from discharging to the screening facilities.

B. Summary of Concerns

Flow measurement of the influent wastewater is an important aspect of the Headworks Facility, not only for compliance with regulatory requirements, but because billing of customer communities is based on this metering and process decisions are dependent on accurate flow metering. As such, the flow metering must be reliable and defensible. The existing venturi flow meters meet these requirements, but the meters were installed at an elevation such that the downstream screening channel water level needs to be managed to provide sufficient water depth to maintain meter submergence. This is accomplished by
operating the screens to maintain a higher water elevation than intended during design. This results in increased settlement of grit and a greater likelihood of overflow of unscreened wastewater to the bypass channels on either side of the main screening channels. Because all the flows are pumped to the NSWWTP, the influent flow rates can and do change quickly, resulting in a very difficult level control situation upstream of the screens. One screen is always operating on variable speed control to maintain an upstream water level. This control strategy could result in channel overflows, inaccurate metering, or both. Additionally, Screen No. 4 needs to be in service at virtually all times to prevent an undesirable accumulation of grit and rocks in front of this screen resulting from the hauled waste discharge upstream of the screen. The requirement to have Screen No. 4 in constant service leads to excessive wear on this screen in comparison to the other screens.

In addition to the screening channel level control problem, there are a number of issues related to screenings handling with the existing equipment, which are as follows:

1. The trough that conveys the screenings from the screens to the Maci well is relatively flat, resulting in settling of material in the trough. The lack of pitch in the trough also requires constant flow of as much as 100 gallons per minute (gpm) of W4.

2. During higher flows, grit conveyed to the Maci well increases because of the scouring of interceptors and force mains. The increase of grit requires more operator attention to pump grit from the Maci well every 30 to 60 minutes, which is a significant time constraint on the operations staff.

3. Grit captured by the screens settles in the Maci pit and causes excessive wear on the Maci pumps. These pumps are also susceptible to plugging from heavy loads of rags and require very frequent maintenance. In addition, the parts for the Maci pumps are expensive and entail long lead times because of a lack of domestic availability.

4. The need to have a screen run continuously results in continual addition of W4 water to clean the screens. This sends more water to the screenings handling equipment and results in more run time on this equipment than was expected during design.

5. The Lisep and Lipactor screenings handling equipment are susceptible to plugging from heavy grease loads, particularly from hauled waste. The loads require frequent manual cleaning of this equipment.

The grit removal and handling facilities and equipment generally operate well with little attention required. Wear on the cyclone grit concentrators installed on the grit classifiers requires replacement of those units. The nominal capacity of the grit tanks is 50 mgd each, for a total capacity of 150 mgd. Although this capacity is less than the future maximum flow of 180 mgd, it is not recommended to add a fourth grit tank given the infrequency of flow above this nominal capacity of 150 mgd and since the results of exceeding their capacity is simply a reduction in grit removal efficiency for the duration of the high flow event. Hydraulic calculations performed for analysis of the alternatives assumed three grit tanks in service.
The hauled waste facilities receive wastes from about 50 to 60 trucks per day, and in 2015 accepted between 1.6 million and 2.8 million gallons of hauled waste per month. The demand for this service is expected to increase into the future. The hauled waste receiving facilities also have a number of issues that need to be addressed. These issues are detailed in a memorandum prepared by the District and included in TM-6. Some of the main concerns are listed in the following:

1. The existing receiving trough arrangement allows large material including rocks, nuts, bolts, and other objects to enter the influent channels and damage or otherwise hamper operation of the screens and screenings handling equipment.
2. As mentioned above, the location of the discharge pipes from the hauled waste trough necessitate near constant operation of Screen No. 4.
3. The requirement for trucks to back into the discharge trough is not an efficient traffic arrangement. A drive-through arrangement with one-way traffic would be preferred.
4. The slope of the existing unloading area does not allow some trucks to discharge completely.
5. Ice accumulates in the area in the winter, creating slippery conditions.
6. Haulers are on an "honor system" with respect to the volumes they discharge. This system is susceptible to abuse as well as inaccurate and inequitable billing for service.

5.02 INFLUENT FLOW MEASUREMENT ALTERNATIVES IDENTIFICATION AND SCREENING

The Influent Flow Measurement alternatives were discussed during Workshop No. 6. Based on discussion at the workshop and a more detailed hydraulic analysis of the screening channels, the following alternatives were selected to be evaluated further:

- Alternative IFM0–Maintain the Existing Influent Flow Metering Facilities (No Change)
- Alternative IFM1–New Venturi Metering Vaults on NSWWTP Site
- Alternative IFM2–New Influent Parshall Flumes
- Alternative IFM4–Install Venturi Flow Meters at PSs
- Alternative IFM5–Reinstall Venturi Flow Meters at a Lower Elevation

Each of these alternatives are evaluated further in the following sections.

5.03 DESCRIPTION OF INFLUENT FLOW MEASUREMENT ALTERNATIVES

This section includes a description of each of the short-listed influent flow measurement alternatives, including any structural, hydraulic, or operational changes necessary to accommodate the alternative.

A. Alternative IFM0–Maintain the Existing Influent Flow Metering Facilities (No Change)

In the null alternative, the current method of operating the screens to maintain adequate depth in the screening channels to fully submerge the venturis will continue. There are no current capital costs for this alternative since it is feasible to continue operating the existing system as is. Operating costs included in this analyses are the current maintenance costs of the screens. Note that the operation and maintenance
(O&M) costs for the other alternatives are relative to the null alternative, and they include the expected change in maintenance costs and pumping (electrical) costs for the PSs that discharge directly to the NSWWTP for the various alternatives.

B. **Alternative IFM 1–New Metering Vaults on NSWWTP Site**

In this alternative a new metering vault would be constructed in the open space to the west of the Headworks Building to house the venturis for the force mains from PS Nos. 2, 7, 8, and 18. This structure would be approximately 55 feet long, 25 feet wide, and 25 feet deep. The proximity of the influent force mains to the 54-inch effluent force main will require sheeting along the southwest side of the proposed structure to allow construction. A second structure to the south of the Headworks Building would be constructed to house the force main from PS No. 11. This structure would be approximately 25 feet by 25 feet and 25 feet deep. The intent of this alternative would be to reuse the existing venturis in the new metering vaults. These structures are assumed to be ventilated and include a staircase for entry, similar to the access provided to the east end of the grit pump room, to enable these spaces to be accessed without requiring a confined space entry.

There is space for an additional force main and venturi in the Headworks Building. No provisions are made in this alternative to accommodate this future force main and, as such, flow from this future force main would need to be measured at the pumping station from which it originates.

C. **Alternative IFM 2–New Influent Parshall Flumes**

The alternative would include construction of a new building structure west of the existing Headworks Building that would house five Parshall flumes with provisions for a sixth. The building housing the flumes would be approximately 50 feet by 55 feet. To maintain 1.5 feet of freeboard at 180 mgd, based on the calculations extended from the hydraulic model, the flumes would be 70 percent submerged at 180 mgd, which is the limit of accuracy for a 4-foot Parshall flume.

The ductile iron force mains would be modified to have the force mains discharge into the flume structure at elevation 15.0 feet for the force mains from PS Nos. 7 and 8, and elevation 21.0 feet for the force mains from PS Nos. 2 and 18. Force main from PS No. 11 would have to be reconfigured slightly to allow it to enter the west end of the flume structure at elevation 25.5 feet.

D. **Alternative IFM 4–Install Venturi Flow Meters at Pump Stations**

This alternative consists of installing venturi flow meters at individual pump stations to meter flow from each station to NSWWTP.

- A new meter vault at PS No. 2, which is located in Brittingham Park. The vault would be approximately 20 feet long, 16 feet wide, and 12 feet deep. It may be difficult to locate this vault without intruding on the sand volleyball courts in the park.

- A venturi meter for PS No. 3 installed in a manhole adjacent to the PS. The vault would be approximately 20 feet long, 16 feet wide, and 10 feet deep.

- A new meter vault at PS No. 8 adjacent to the north side of the building where the discharge pipe exits the building. The vault would be approximately 20 feet long, 16 feet wide, and 18 feet deep.
- A new meter vault at PS No. 11 adjacent to the east side of the building where the discharge pipe exits the building. The vault would be approximately 20 feet long, 16 feet wide, and 24 feet deep.

- A new meter vault at PS No. 18 on the east side of the building underneath the asphalt access drive where the discharge pipe exits the building. The vault would be approximately 20 feet long, 16 feet wide, and 24 feet deep.

A venturi meter vault could not be constructed at PS No. 7 given the site constraints and that the flows from this PS are conveyed in two force mains. The flows could be measured in a vault on the NSWWTP grounds after the point where the two force mains are combined. This vault would be located to the north of the west final clarifiers and would be approximately 20 feet long, 16 feet wide, and 15 feet deep.

E. Alternative IFM5–Reinstall Venturi Flow Meters at a Lower Elevation

The alternative would involve lowering the elevation at which the influent venturis are installed to allow them to be full at all times, regardless of the water elevation in the screening channels. This would be accomplished by relocating the pipe so that the top of the force main would be below the floor of the screening channels. This would result in the venturis being completely submerged whenever there is flow in the screening channels. A concrete box would be installed for each force main on the east wall of the Meter Vault Room into which the force main would discharge. The influent wastewater would flow up the box and enter the screening channels through the existing 48-inch pipe opening. The existing sluice gates would remain in place to allow isolation of each force main as needed. The Meter Vault Room would likely need to be extended approximately 5 feet to the west to maintain the distance required downstream of the venturis for accurate flow measurement; however, this requirement should be further investigated during the design phase. The pipes and venturis would be installed at approximately floor elevation (pipe centerline elevation 22.75) and a grating platform would be constructed over the pipes, essentially covering the entire room, except for the area of the sump pit in the northeast corner. The samplers would be replaced and relocated on the grating platform. Access stairs or ladders would be installed from the grating level to the floor to provide access to the venturi meters for calibration and maintenance.

The force mains would be removed back to the 45 degree elbows and re-laid to the Headworks Building at the new venturi elevation. A temporary pipe would be installed at the location of the future force main to accept flow from each of the force mains when they are being re-laid at the new elevation. The force main from PS No. 11 is at a higher elevation (centerline 25.5) than the proposed new venturi elevation, which would result in a high point at the transition to the new elevation. For the purposes of this evaluation, an air release valve is assumed to be required. Since this force main is the southernmost in the Meter Vault Room, it may be possible to have the venturi for this force main relocated to the centerline 25.5 elevation without hampering access to the other venturis. Having the venturi at this elevation would require a minimum of 9 inches of water in the screening channels at all times to maintain submergence. This concept should be considered prior to final design to avoid the need for an air release valve in the force main.
5.04 INFLUENT FLOW MEASUREMENT PRESENT WORTH SUMMARY

Table 5.04-1 presents a summary of the costs for each of the Influent Flow Measurement alternatives. Alternative IFM5 has the lowest capital and total present worth opinion of cost, and addresses the issue of screening channel overflow and screen control by providing a much larger variation between the minimum and maximum water level in the screening channels. This alternative also does not require additional space on-site for new metering structures.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>IFM0 No Change</th>
<th>IFM1 New Metering Vaults at NSWWTP</th>
<th>IFM2 New Flumes at NSWWTP</th>
<th>IFM4 New Metering Vaults at PS’s</th>
<th>IFM5 Relocate Venturis to Lower Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Opinion of Capital Cost</td>
<td>$0</td>
<td>$3,180,000</td>
<td>$2,894,000</td>
<td>$2,919,000</td>
<td>$2,096,000</td>
</tr>
<tr>
<td>Annual O&amp;M</td>
<td>$81,000</td>
<td>$53,000</td>
<td>$86,000</td>
<td>$63,000</td>
<td>$52,000</td>
</tr>
<tr>
<td>O&amp;M Cost PW</td>
<td>$1,065,000</td>
<td>$697,000</td>
<td>$1,131,000</td>
<td>$828,000</td>
<td>$684,000</td>
</tr>
<tr>
<td>Total Opinion of Present Worth</td>
<td>$1,065,000</td>
<td>$3,877,000</td>
<td>$4,025,000</td>
<td>$3,747,000</td>
<td>$2,780,000</td>
</tr>
</tbody>
</table>

Table 5.04-1 Influent Flow Measurement Opinion of Present Worth Summary

5.05 INFLUENT FLOW MEASUREMENT NONMONETARY EVALUATION

Nonmonetary considerations for each alternative were evaluated and are summarized in Table 5.05-1.

5.06 INFLUENT SCREENING AND SCREENINGS HANDLING ALTERNATIVES SCREENING

The Influent Screening and Screenings Handling alternatives were discussed during Workshop No. 6. Based on these discussions, none of the preliminary alternatives was excluded from further consideration. Therefore, the following alternatives were selected for further evaluation:

- Alternative S0—Maintain the Existing System (Null Alternative)
- Alternative S1—Install Screen and Wash Press for Sluiced Screenings
- Alternative S2—Install New Band Screens and Dedicated Wash Presses
- Alternative S3—Install Step Screens and Dedicated Wash Presses
- Alternative S4—Install Travelling Rake Screens and Dedicated Wash Presses
- Alternative S5—Install Perforated Plate Screens and Dedicated Wash Presses
- Alternative S6—Install Moving Media Screens and Dedicated Wash Presses
- Alternative S7—Install Chopper Pumps and Wash Presses

Each of these alternatives is further described and evaluated in the following.

5.07 DESCRIPTION OF INFLUENT SCREENING AND SCREENINGS HANDLING ALTERNATIVES EVALUATED

This section includes a description of each of the short-listed influent screening and screenings handling alternatives, including any structural, hydraulic, or operational changes necessary for each alternative.
<table>
<thead>
<tr>
<th>Alternative</th>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>IFM0—Maintain the Existing Influent Flow Metering Facilities (No Change)</td>
<td>- No disruption of current operations.</td>
<td>- No reduction of grit accumulation in channels without septage receiving improvements. - No improvement to screening operations or reductions in maintenance.</td>
</tr>
<tr>
<td>IFM 1—New Metering Vaults on NSWWTP Site</td>
<td>- Better influent screen performance, which should reduce pass-through of material and downstream maintenance concerns. - Reduced accumulation of grit in influent channels. - All construction on NSWWTP grounds.</td>
<td>- Construction adjacent to effluent force main presents a risk. - Uses areas on-site that may limit construction in those areas in the future.</td>
</tr>
<tr>
<td>IFM 2—New Influent Flumes</td>
<td>- Better influent screen performance, which should reduce pass-through of material and downstream maintenance concerns. - All construction on NSWWTP grounds.</td>
<td>- Construction adjacent to effluent force main presents a risk. - Uses areas on-site that may limit construction in those areas in the future. - Limits access to the Hypochlorite Room and Mechanical Room.</td>
</tr>
<tr>
<td>IFM 4—Install Venturi Flow Meters at PS Nos. 2, 3, 4, 7, 8, 11, 18</td>
<td>- Better influent screen performance reducing pass-through of material. - Reduced accumulation of grit in influent channels.</td>
<td>- Construction at multiple sites including at pump stations and at NSWWTP. - Decentralizes flow metering operations and potentially makes troubleshooting more difficult. - Potential construction impacts to neighboring residences and entities, including noise, vibration, truck traffic, and dust. - Confined space entry requirements at each metering location.</td>
</tr>
<tr>
<td>IFM5—Reinstall Venturi Flow Meters at a Lower Elevation</td>
<td>- Better influent screen performance, which should reduce pass-through of material and downstream maintenance concerns. - All construction on NSWWTP grounds. - Reuse of existing equipment and facilities.</td>
<td>- None.</td>
</tr>
</tbody>
</table>
A. **Alternative S0—Maintain the Existing System (Null Alternative)**

In this alternative, the existing band screens and screenings handling equipment would be maintained. Replacement of the existing equipment, including the screens, Maci pumps, Lisep, Lipactor, macerator grit pump, and grit snail, and installation of a fourth band screen and Lisep and Lipactor is assumed in Year 10 given the age and condition of the equipment and the need to accommodate the projected maximum flow. This definition of the null alternative is not a “do nothing” alternative, since the existing equipment is replaced at year 10, but rather a “business as usual” alternative utilizing the same screening and screenings handling processes as the existing facilities.

B. **Alternative S1—Install Screens and Wash Press for Sluiced Screenings**

In this alternative, the existing band screens and sluicing trough would be maintained. The trough would discharge into new channels in which two screens, likely 1/8-inch perforated plate screens to provide the maximum capture of the screened material, would be installed. These screens, which would only be required to handle the volume of sluicing water, would discharge to two screenings wash presses. The washed screenings would discharge directly to the haul-off waste container.

Given the space restrictions and the size of the equipment, specifically the wash presses, it does not appear that there is available space for installation of two screens and wash presses in the Maci pit area. It may be possible, however, to extend the trough to the north and construct concrete channels at floor level under the mezzanine in which the screens could be installed. The wash presses would be installed on top of the channels under the mezzanine and discharge directly into the haul-off waste container. Given District staff comments about the inadequacy of the existing trench drains to handle flows from the grit classifiers, it would be necessary to cut new trench drains into the floor to convey the screened sluicing water back into the screening channels.

C. **Alternative S2—Install New Band Screens and Dedicated Wash Presses**

In this alternative, new band screens would be installed with dedicated wash presses at each screen. It is necessary to replace the existing screens to use dedicated wash presses because the discharge elevation of the existing screenings is too low to permit installation of a wash press. The wash presses would be positioned on the west side of the screens and would discharge onto a belt conveyor, which would transport the screenings to the haul-off waste container. The ability of the conveyor to reach the container without major modifications to the mezzanine would need to be verified during detailed design.

This alternative would eliminate use of the screenings trough and associated sluicing water, the Maci pumps, the macerator grit pumps, the secondary grit tank, the Lisep and Lipactor, and the grit snail. This alternative also includes cost for installation of a fourth band screen and wash press in Year 10 to accommodate the projected maximum flow.

D. **Alternative S3—Install Step Screens and Dedicated Wash Presses**

In this alternative new step screens would be installed with dedicated wash presses serving each screen. Significant channel modifications would be required to allow proper flow to the screens and for proper installation of the new screens in the area currently occupied by the existing center-flow band screens.
The wash presses would be positioned on the east side of the screens and would discharge onto a belt conveyor located on the west side of the screens. The conveyor would transport the screenings to the haul-off waste container. The isolation slide gates upstream of the screens would also need to be replaced because of the channel modifications.

This alternative would eliminate use of the screenings trough, the Maci pumps, the macerator grit pumps, the secondary grit tank, the Lisep and Lipactor, and the grit snail. The capacity of the step screens allows the projected maximum flow of 180 mgd to be achieved without installation of a fourth screen.

E. **Alternative S4–Install Travelling Rake Screens and Dedicated Wash Presses**

This alternative is the same as Alternative S3, except that travelling rake screens would be installed instead of step screens. Travelling rake screens have the advantage of being more robust than step screens and are constructed to sustain impacts from large objects.

This alternative would eliminate use of the screenings trough, the Maci pumps, the macerator grit pumps, the secondary grit tank, the Lisep and Lipactor, and the grit snail.

F. **Alternative S5–Install Perforated Plate Screens and Dedicated Wash Presses**

This alternative is the same as Alternative S3 except that perforated plate screens would be installed instead of step screens. This alternative would eliminate use of the screenings trough, the Maci pumps, the macerator grit pumps, the secondary grit tank, the Lisep and Lipactor, and the grit snail. This alternative also includes the installation of a fourth screen and wash press in Year 10 to accommodate the projected maximum flow.

G. **Alternative S6–Install Moving Media Screens and Dedicated Wash Presses**

This alternative is the same as Alternative S3, except that moving media screens would be installed instead of step screens. This alternative would eliminate use of the screenings trough, the Maci pumps, the macerator grit pumps, the secondary grit tank, the Lisep and Lipactor, and the grit snail. This alternative also includes the installation of a fourth screen in Year 10 to accommodate the projected maximum flow.

H. **Alternative S7–Install Chopper Pumps and Wash Presses**

This alternative involves the use of chopper pumps instead of the Maci pumps. Chopper pumps may be less susceptible to wear and plugging than Maci pumps. Three wash presses would be installed in the mezzanine in place of the existing secondary grit tanks, Lisep equipment, and Lipactors. Each wash press would discharge to the belt conveyor over the haul-off waste container.

This alternative would retain use of the existing band screens, the screenings trough, the Maci pit, macerator grit pumps, and grit snail until this equipment is replaced in 10 years. New band screens (four) and grit pumps would be installed in 10 years, similar to Alternative S2.
5.08 INFLUENT SCREENING AND SCREENINGS HANDLING PRESENT WORTH SUMMARY

The alternatives evaluated herein each provide a minimum influent screening capacity of 180 mgd by or before Year 10. The existing equipment has been in service for about 12 to 13 years, and likely could last another 10 years before it would be absolutely required to be replaced. However, we believe it is in the District’s best interest to update the screenings handling equipment before the end of the remaining useful life of the equipment because of the significant and frequent maintenance required on this equipment.

Table 5.08-1 provides an opinion of present worth summary, and more detailed analysis is included in TM-6. Alternative S0 (null alternative) has the lowest opinion of 20-year total present worth, but it is only about 4 percent less than Alternative S3 (new step screens). For the purpose of this Facilities Plan, these costs are considered equal. The null alternative does not resolve any of the operational or maintenance issues related to influent screening. Alternative S3–New Step Screen and Wash Presses would provide an entirely new screening and screenings handling system that would be simpler to maintain over time. This alternative does have a lower “clean screen” screenings capture efficiency but if the screens are allowed to be operated to build “a mat,” the screenings capture efficiency increases to approach that of the band screens.

Alternative S1, which includes replacing the screening sluicing, macerating, and dewatering equipment with two fine screens and screenings washer/compactors, is within 10 percent of the recommended Alternative S3. This alternative could be considered for more detailed evaluation as it continues the use of the most efficient screening equipment (band screens) yet simplifies the screenings handling equipment and processes.

5.09 INFLUENT SCREENING AND SCREENINGS HANDLING NONMONETARY EVALUATION

Nonmonetary considerations for each alternative were evaluated and are summarized in Table 5.09-1.
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Opinion of Current Capital Cost</td>
<td>---</td>
<td>$1,677,000</td>
<td>$4,145,000</td>
<td>$3,390,000</td>
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<td>$3,590,000</td>
<td>$3,869,000</td>
<td>$1,304,000</td>
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<tr>
<td>Total Opinion of Future Capital Cost</td>
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<td>$4,224,000</td>
<td>$1,713,000</td>
<td>---</td>
<td>---</td>
<td>$1,415,000</td>
<td>$1,169,000</td>
<td>$4,673,000</td>
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<tr>
<td>Annual O&amp;M</td>
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<td>$69,000</td>
<td>$69,000</td>
<td>$69,000</td>
<td>$69,000</td>
<td>$69,000</td>
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<td>Present Worth O&amp;M</td>
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<td>$907,000</td>
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<td>$907,000</td>
<td>$907,000</td>
<td>$1,368,000</td>
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<tr>
<td>Future Costs</td>
<td>$3,626,000</td>
<td>$2,753,000</td>
<td>$1,116,000</td>
<td>---</td>
<td>---</td>
<td>$473,000</td>
<td>$762,000</td>
<td>$3,045,000</td>
</tr>
<tr>
<td>Salvage</td>
<td>($1,182,000)</td>
<td>($897,000)</td>
<td>($363,000)</td>
<td>---</td>
<td>---</td>
<td>($153,000)</td>
<td>($248,000)</td>
<td>($992,000)</td>
</tr>
<tr>
<td>Total Opinion of Present Worth</td>
<td>$4,022,000</td>
<td>$4,795,000</td>
<td>$5,805,000</td>
<td>$4,297,000</td>
<td>$4,756,000</td>
<td>$4,817,000</td>
<td>$5,290,000</td>
<td>$4,725,000</td>
</tr>
</tbody>
</table>
### Table 5.09-1  Influent Screening and Screenings Handling Alternative Nonmonetary Considerations Summary

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>S0-Maintain the Existing System (Null Alternative)</td>
<td>• Continues use of equipment with remaining useful life (screens, Liseps, Lipactors, Maci pumps, macerator grit pump).</td>
<td>• Still has water requirement for sluicing of the screenings. &lt;br&gt;• Continues using equipment that has been problematic and requires frequent attention and maintenance (Liseps, Lipactors, Maci pumps, macerator grit pump, and grit snail).</td>
</tr>
<tr>
<td>S1-Install Screens and Wash Press for Sluiced Screenings</td>
<td>• Provides improved and simpler screenings handling process with fewer pieces of equipment. &lt;br&gt;• Significantly reduces maintenance required for screenings handling. &lt;br&gt;• Wash presses are less susceptible to plugging with heavy grease loads. &lt;br&gt;• Eliminates the grit snail and associated maintenance. &lt;br&gt;• If one of the two sluicing screens or wash presses is out of service, that does not require any of the main channel screens to be taken out of service.</td>
<td>• Still has water requirement for sluicing of the screenings to the new screens. &lt;br&gt;• Replaces equipment that has remaining useful life (Lisep, Lipactor, Maci pumps, and macerator grit pumps). &lt;br&gt;• May create cramped space with channels and equipment under the mezzanine. &lt;br&gt;• Requires a fourth screen to provide 180 mgd.</td>
</tr>
<tr>
<td>S2-Install New Band Screens and Dedicated Wash Presses</td>
<td>• Provides improved and less complicated screenings handling process with fewer pieces of equipment. &lt;br&gt;• Reduces maintenance required for screenings handling. &lt;br&gt;• Wash presses are less susceptible to plugging with heavy grease loads. &lt;br&gt;• Eliminates water requirement for sluicing of the screenings to the Maci pit. &lt;br&gt;• Least intrusive construction of the screenings alternatives. No changes to screenings channels required.</td>
<td>• Conveyor across length of building. &lt;br&gt;• Will require fourth screen for 180 mgd. &lt;br&gt;• Replaces equipment that has remaining useful life (Lisep, Lipactor, Maci pumps, and macerator grit pumps). &lt;br&gt;• Access to slide gates is limited.</td>
</tr>
<tr>
<td>S3-Install Step Screens and Dedicated Wash Presses</td>
<td>• Provides improved and simpler screenings handling process with fewer pieces of equipment. &lt;br&gt;• Reduces maintenance required for screenings handling. &lt;br&gt;• Wash presses are less susceptible to plugging with heavy grease loads. &lt;br&gt;• Eliminates water requirement for sluicing of the screenings to the Maci pit. &lt;br&gt;• Fourth screen not required for 180 mgd.</td>
<td>• Constructability concerns. Significant removal of concrete from channels required to install different style screen. &lt;br&gt;• Step screens are more susceptible to damage from larger objects. &lt;br&gt;• Conveyor across length of building. &lt;br&gt;• Substantial channel modifications required. &lt;br&gt;• Replaces equipment that has remaining useful life (Lisep, Lipactor, Maci pumps, and macerator grit pumps). &lt;br&gt;• Access to slide gates is limited. &lt;br&gt;• Screenings capture is unlikely to be as good as band screens.</td>
</tr>
<tr>
<td>S4-Install Travelling Hake Screens and Dedicated Wash Presses</td>
<td>• Provides improved and simpler screenings handling process with fewer pieces of equipment. &lt;br&gt;• Reduces maintenance required for screenings handling. &lt;br&gt;• Wash presses are less susceptible to plugging with heavy grease loads. &lt;br&gt;• Eliminates water requirement for sluicing of the screenings to the Maci pit. &lt;br&gt;• Screens are sturdy and better able to handle large objects without damage. &lt;br&gt;• Fourth screen not required for 180 mgd.</td>
<td>• Conveyor across length of building. &lt;br&gt;• Substantial channel modifications required. &lt;br&gt;• Replaces equipment that has remaining useful life (Lisep, Lipactor, Maci pumps, and macerator grit pumps). &lt;br&gt;• Screenings capture is unlikely to be as good as band screens.</td>
</tr>
<tr>
<td>S5-Install Perforated Plate Screens and Dedicated Wash Presses</td>
<td>• Provides improved and less complicated screenings handling process with fewer pieces of equipment. &lt;br&gt;• Improved screenings capture over Alternatives S3 and S4. &lt;br&gt;• Reduces maintenance required for screenings handling. &lt;br&gt;• Wash presses are less susceptible to plugging with heavy grease loads. &lt;br&gt;• Eliminates water requirement for sluicing of the screenings to the Maci pit. &lt;br&gt;• Provides opportunity to design screens for existing hydraulic conditions.</td>
<td>• Screenings discharge requires a brush, which is a maintenance item. &lt;br&gt;• Conveyor across length of building. &lt;br&gt;• Substantial channel modifications required. &lt;br&gt;• Will require fourth screen for 180 mgd. &lt;br&gt;• Replaces equipment that has remaining useful life (Lisep, Lipactor, Maci pumps, and macerator grit pumps).</td>
</tr>
<tr>
<td>S6-Install Moving Media Screens and Dedicated Wash Presses</td>
<td>• Provides improved and simpler screenings handling process with fewer pieces of equipment. &lt;br&gt;• Improved screenings capture over Alternatives S3 and S4. &lt;br&gt;• Reduces maintenance required for screenings handling. &lt;br&gt;• Wash presses are less susceptible to plugging with heavy grease loads. &lt;br&gt;• Eliminates water requirement for sluicing of the screenings to the Maci pit.</td>
<td>• Screenings discharge requires a brush, which is a maintenance item. &lt;br&gt;• Conveyor across length of building. &lt;br&gt;• Substantial channel modifications required. &lt;br&gt;• Requires a fourth screen to provide 180 mgd of capacity. &lt;br&gt;• Replaces equipment that has remaining useful life (Lisep, Lipactor, Maci pumps, and macerator grit pumps).</td>
</tr>
<tr>
<td>S7-Install Chopper Pumps and Wash Presses</td>
<td>• Replaces Maci pumps with pumps better suited to pumping screenings. &lt;br&gt;• Reduced maintenance of screenings handling equipment. &lt;br&gt;• Wash presses are less susceptible to plugging with heavy grease loads.</td>
<td>• Proposed solution is not substantially different than the existing system, and may not improve maintenance requirements. &lt;br&gt;• Alternative does not address issues associated with existing systems. &lt;br&gt;• Alternative does not address issues associated with screenings trough. &lt;br&gt;• Operation of grit snail is still required. &lt;br&gt;• Water use is still high. &lt;br&gt;• Replaces equipment that has remaining useful life (Lisep, Lipactor, Maci pumps, and macerator grit pumps).</td>
</tr>
</tbody>
</table>
5.10 GRIT WASHING ALTERNATIVES SCREENING

The Grit Washing alternatives were discussed during Workshop No. 6. Based on this discussion, the following alternatives were selected for further evaluation:

- Alternative G0–No Change (Null Alternative)
- Alternative G1–Replacement of Grit Classifiers with Grit Washers

Each of these alternatives is further described and evaluated below.

5.11 DESCRIPTION OF GRIT WASHING ALTERNATIVES

A. Alternative G0–No Change (Null Alternative)

In this alternative the existing grit system would be unchanged. There would be no initial capital costs and the annual operating costs (the sum of mechanical, operations, and supplies and parts cost categories) would be unchanged from current levels. We have assumed that new grit concentrators, grit tank mechanisms, and grit pumps would be installed in 10 years to replace the existing units, which will be more than 20 years old at that time.

B. Alternative G1–Replacement of Grit Classifiers with Grit Washers

In this alternative the existing grit classifiers would be replaced with grit washers. The grit washers occupy more space than the existing classifiers but there is sufficient room on the mezzanine to install this equipment. This alternative includes the installation of the grit washers in 10 years, which coincides with the approximate end of the useful life of this equipment. The grit tank mechanisms and grit pumps are also assumed to be replaced at this time given their age. Similar to the null alternative for the screening equipment, this is not a “do nothing” alternative, but rather a “business as usual” alternative, assuming the District will continue to manage grit as it does now.

5.12 GRIT WASHING PRESENT WORTH SUMMARY

Table 5.12-1 provides an opinion of present worth summary for the grit handling alternatives. Given that the existing equipment is expected to last for another 10 years, replacement of the equipment in 10 years should be with new state-of-the-art equipment, which includes new grit washers (Alternative G1) in lieu of grit classifiers (Alternative G0–Null Alternative). However, this recommendation is dependent on the screening alternative selected since the mezzanine is not large enough to accommodate three new grit washers without eliminating the existing screening handling equipment on that level.
5.13  GRIT WASHING NONMONETARY EVALUATION

Nonmonetary considerations for each alternative were evaluated and are summarized in Table 5.13-1.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>G0–No Change (Null Alternative)</td>
<td>Continued use of existing equipment.</td>
<td>Equipment susceptible to wear and breakdowns.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dewatered grit product not as clean as with grit waters; higher odors.</td>
</tr>
</tbody>
</table>

Table 5.13-1  Grit Washing Alternative Nonmonetary Considerations Summary

5.14  HAULED WASTE RECEIVING ALTERNATIVES SCREENING

Originally, four alternatives for the hauled waste receiving facility were discussed at Workshop No. 6. However, various concerns were raised, including the desire to maintain the current metering and sampling program, as well as potential public perception and aesthetic concerns with the alternate locations for the facility. For these reasons only the following alternatives were considered for further review:

- Alternative HW0–No Change (Null Alternative)
- Alternative HW1–Construction of a Drive-Through Hauled Waste Receiving Station at the Existing Receiving Location
5.15 DESCRIPTION OF HAULED WASTE RECEIVING ALTERNATIVES EVALUATED

A. Alternative HW0—No Change (Null Alternative)

In this alternative hauled waste receiving facilities and operations would be unchanged. There would be no capital costs for this alternative, and the annual operating costs are unchanged from the existing costs. Similar to the influent follow metering null alternative, this alternative is truly a “do nothing” alternative. However, it also mimics the current operations and hauled waste management facilities, and is a viable 20-year solution with no capital upgrades.

B. Alternative HW1—Construction of a Drive-Through Hauled Waste Receiving Station at the Existing Receiving Location

In this alternative the existing hauled waste receiving area will be widened to allow installation of two mechanical receiving stations equipped with rock traps and screening equipment. Note that the District pilot tested a potential hauled waste receiving system during the summer of 2017, and a summary of the pilot testing results (provided by the District) is included in an appendix to Technical Memorandum No. 6 (Appendix F to this Facilities Plan). The existing trough would be removed and the drive would be extended to allow one-way traffic through the receiving area and to eliminate the need for trucks to back in. The drive would be sloped to allow trucks to be completely emptied. Receiving stations would be installed in an approximately 27- by 53-foot building. Because of the location and size of the building, it is likely that the existing canopy will have to be removed and several pipes will have to be relocated. Additional facilities will need to be added to allow dumping from irregular sources such as barrels, totes, porta-potties, and grease trailers. A proposed preliminary layout for the drive and building is shown in Figure 9, although other layouts should also be considered that may allow the existing canopy to remain in place. An existing stormwater bioswale would be disturbed by construction of the drive that would have to be relocated and likely enlarged to accommodate increased runoff from the increased impervious area. The ventilation system would be designed to incorporate odor control in the future if needed. No costs for an odor control system are included.

Modification of the hauled waste receiving facilities would include incorporation of more security and tracking measures to reduce the potential for unauthorized or inaccurately reported discharges. The measures would include a card or keypad activated entry gate and flow meters on the two receiving stations.

An important consideration of this alternative is the displacement of hauled waste receiving activities during construction. An alternate location for trucks to discharge would need to be identified and any temporary measures, such as a rental receiving station, would need to be put in place prior to the start of construction.

5.16 HAULED WASTE RECEIVING PRESENT WORTH SUMMARY

Table 5.16-1 provides an opinion of present worth summary for the hauled waste receiving alternatives. We recommend implementing Alternative HW1, which includes construction of a drive-through hauled waste receiving station to improve the operations, safety, maintenance, and function of the facility and the downstream headworks processes. The District’s hauled waste receiving facilities provide a valuable
resource to the community, local industry, and septage haulers. The existing facilities, while functional, require significant attention for operations and maintenance, and winter time traffic is a safety concern with icing roadways and difficult truck maneuvering. In addition, the new system would include an automated card reader system, which will provide improved tracking, billing, and management for the various haulers and for the District.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW0–No Change (Null Alternative)</td>
<td>▪ No interruption to existing receiving area. ▪ Reuses existing facilities that have remaining useful life.</td>
<td>▪ The numerous issues with hauled waste receiving are not addressed.</td>
</tr>
<tr>
<td>HW1–Construction of a Drive-Through Hauled Waste Receiving Station at the Headworks Building</td>
<td>▪ Improved traffic flow. ▪ Improved safety for haulers and operators. ▪ Reduced operator attention regarding unloading operations. ▪ Rocks and larger objects removed prior to screening channels; reduced associated maintenance. ▪ Improved security and tracking. ▪ More accurate and equitable billing for services. ▪ Improved accessibility to haulers.</td>
<td>▪ Hauled waste receiving operations displaced during construction.</td>
</tr>
</tbody>
</table>

Table 5.17-1 Hauled Waste Receiving Alternative Nonmonetary Considerations Summary
5.18 RECOMMENDED PLAN

The recommendations related to the Headworks Facility and hauled waste receiving are a combination of the alternatives presented and discussed above. The timing of the execution of the improvements to these facilities may be adjusted to accommodate the condition of the various equipment involved or to combine or separate project elements to fit the needs of the District.

The recommendations for improvements include:

- IFM5—Relocate Venturis to Lower Elevation
- S1—Screen Sluiced Screenings or S3—Install New Step Screens and Wash Presses
- G1—Replacement of Grit Classifiers with Grit Washers; Replace Other Equipment (Year 10)
- HW1—Construction of a Drive-Through Hauled Waste Receiving Station at the Headworks Building

Lowering the venturis will allow the venturis to remain fully submerged regardless of the water level in the screening channels. Screening Alternative S1 allows continued use of the existing screens and has the least invasive construction requirements of the screenings alternatives. Screening Alternative S3 has the lowest present worth cost of the screenings alternatives that addresses the maintenance and operational issues related to screenings and screenings handling. The grit alternative G1—Replacement of Grit Classifiers with Grit Washers is recommended to be executed when the grit classifiers are at the end of their useful life, which is about 10 years. The HW1 alternative, Construction of a Drive-Through Hauled Waste Receiving Station at the Headworks Building, is also recommended to alleviate the issues with the existing hauled waste receiving operations. Proposed layouts for each of these alternatives are presented in Figures 5.18-1 through 5.

Figure 5.18-1 Alternative IFM5—Section View of Relocated Venturis
Figure 5.18-2 Alternative S1–Sluiced Screening Preliminary Layout

Figure 5.18-3 Alternative S3–Proposed Step Screens and Wash Presses Layout
Table 5.18-1 present the Year 0 and Year 10 opinions of probable cost of the recommended alternatives. Because of the significant ongoing concerns with the screening and hauled waste receiving operations, we have assumed the screening and hauled waste receiving improvements would occur in the near future and the grit management improvements would proceed in about 10 years. However, none of these improvements need to happen in the very near future, since all of the equipment likely has another 5 to 10 years of useful life remaining. Therefore, the timing of the project(s) can be tailored to fit the budgetary needs of the District.
### Table 5.18-1  Summary of Capital Costs and Recommended Alternatives

<table>
<thead>
<tr>
<th>Project Element</th>
<th>Opinion of Capital Cost Year 0</th>
<th>Opinion of Capital Cost Year 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative IFM5–Relocate Venturis to Lower Elevation</td>
<td>$2,096,000</td>
<td>$0</td>
</tr>
<tr>
<td>Alternative S1–Screen Sluiced Screenings$</td>
<td>$1,667,000</td>
<td>$4,224,000</td>
</tr>
<tr>
<td>Alternative S3–New Step Screens and Wash Presses$</td>
<td>$3,390,000</td>
<td>$0</td>
</tr>
<tr>
<td>Alternative G1–New Grit Washers</td>
<td>$0</td>
<td>$1,956,000</td>
</tr>
<tr>
<td>Alternative HW1–Drive-Through Hauled Waste Station</td>
<td>$2,864,000</td>
<td>$0</td>
</tr>
<tr>
<td>Totals</td>
<td>$6,627,000 to $8,350,000</td>
<td>$1,956,000 to $6,180,000</td>
</tr>
</tbody>
</table>

$ These screening alternatives are mutually exclusive. District to select an alternative to implement.
This section includes an evaluation of biological nutrient removal (BNR) alternatives to improve nutrient removal, accommodate influent load growth, and consider how renewal of the existing aeration system components should be coordinated with these improvements. Additional detail on the evaluations included in this section are presented in Technical Memorandum No. 5 (TM-5, Appendix E).

6.01 EXISTING ACTIVATED SLUDGE SYSTEM

A. Process Configuration

The existing NSWWTP activated sludge facilities consist of two complexes. The east complex includes 18 aeration basins configured as six 3-pass aeration train with 11 secondary clarifiers. The west complex includes 12 aeration basins configured as four 3-pass aeration trains with 8 secondary clarifiers. Both complexes operate an EBPR process. A majority of the WWTP, with the exception of two treatment trains in the east complex, use the modified University of Cape Town (UCT) process. This process configuration consists of wastewater entering an anaerobic zone where it is combined with mixed liquor from the downstream anoxic zone. RAS is pumped to the anoxic zone where nitrate is reduced to nitrogen gas before a portion of the mixed liquor is pumped to the upstream anaerobic zone. Flow from the anoxic zone that is not returned continues to the aerated zone for BOD removal and nitrification. The modified UCT configuration improves EBPR performance by maintaining the integrity of the anaerobic zone through the denitrification of the RAS in the anoxic zone prior to entering the anaerobic zone. A flow configuration layout for the modified UCT process is presented in Figure 6.01-1.

Two treatment units in the east complex use the anaerobic/aerobic (A/O) process, which includes an anaerobic zone upstream of an aerated zone and does not have a nitrified mixed liquor recycle.

![Figure 6.01-1 Modified UCT Flow Configuration](image)

Design criteria of the existing modified UCT process is presented in Table 6.05-1 later in this section.
B. Aeration Blowers

NSWWTP operates two sets of blowers serving the east and west sides of the plant. The two sets of blowers are operated and controlled independently.

There are five east blowers with varying types and capacities, as summarized in Table 6.01-1 below. Approximately 2,500 standard cubic feet per minute (scfm) (roughly 15 percent) of the east aeration air is diverted to channel mixing and agitation air for the headworks.

<table>
<thead>
<tr>
<th>East Blower No.</th>
<th>Type and Output Control</th>
<th>Capacity</th>
<th>Motor Size</th>
</tr>
</thead>
</table>
| 1               | Positive displacement; gas engine (biogas) | 7,875 cfm @ 600 rpm  
9,185 cfm @ 700 rpm  
10,500 cfm @ 800 rpm | ~ 500 hp @ 800 rpm  
160,000 scfm biogas/day |
| 2               | Centrifugal Variable inlet vanes | 7,000 to 11,500 cfm  | 600 hp; 4,000 V |
| 3               | Centrifugal Variable inlet vanes | 7,000 to 11,500 cfm  | 600 hp; 4,000 V |
| 4               | Positive displacement; 2-speed motor | 7,760 cfm @ low speed  
10,850 cfm @ high speed | 375/500 hp; 4,000 V |
| 5               | Positive displacement; 2-speed motor | 5,840 cfm @ low speed  
9,070 cfm @ high speed | 325/450 hp; 4,000 V |

Table 6.01-1 East Blower Summary

East blower 1 is driven by a gas engine using biogas from the NSWWTP anaerobic digesters and is normally in service to maximize the use of biogas and reduce electrical demands. Blower 1 is approximately 30 years old. During the condition assessment inspectors observed an oil leak and that the blower was running hot, but it is otherwise in acceptable condition. MMSD intends to continue operating this blower for several more years because it is an integral part of its biogas utilization program. Under most operating conditions, either blower 4 (low or high) or blower 5 (low or high) provides the base air demand in parallel with the variable-speed operation of blower 1. The starting and stopping of these blowers is a manual process, as is the selection of the blower high or low speed, but changes to the blower operations are infrequent. Blowers 4 and 5 are nearly 50 years old. Mechanical issues documented by the condition assessment include shaft, supports, and bearing deterioration, vibration of blower 5, and deteriorated condition of electrical distribution system.

The two centrifugal blowers (2 and 3) are approximately 30 years old and are seldom operated.

Three 1,250 horsepower (hp) single-stage centrifugal blowers provide air to activated sludge plants 3 and 4, as summarized in Table 6.01-2. Only one blower is operated at a time and the typical blower output is between 16,000 and 20,000 scfm. Inlet guide vanes on the blower inlet are modulated based on system pressure in the air main. A small quantity of air is diverted from the west blowers for primary channel mixing.
The primary concern with the west blowers is their inability to turn down to match normal diurnal load fluctuations, with aeration basin dissolved oxygen (DO) concentrations rising to 5 mg/L at night. The blowers seldom use the high end of their capacity range, but if loads are very high the blower’s motors can overload. To avoid this condition, power monitoring to each blower is used to initiate alarms if the power use rises above 900 kW (~1,200 hp).

<table>
<thead>
<tr>
<th>East Blower No.</th>
<th>Type and Output Control</th>
<th>Capacity</th>
<th>Motor Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Centrifugal</td>
<td>25,000 cfm</td>
<td>1,250 hp; 4,000 V</td>
</tr>
<tr>
<td></td>
<td>Variable inlet vanes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Centrifugal</td>
<td>25,000 cfm</td>
<td>1,250 hp; 4,000 V</td>
</tr>
<tr>
<td></td>
<td>Variable inlet vanes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Centrifugal</td>
<td>25,000 cfm</td>
<td>1,250 hp; 4,000 V</td>
</tr>
<tr>
<td></td>
<td>Variable inlet vanes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6.01-2 West Blower Summary

The west blowers were added during the 7th Addition to the NSWWTP in 1986, and are about 31 years old. However, because the plant is able to operate with one of the three blower units, the operating hours are moderate for equipment of this age. Maintenance concerns noted in the conditions assessment include:

- Service support issues leading to prolonged outages and concerns about adequate redundancy.
- Shaft, supports, and bearing deterioration.
- Oil on top of drive and filter smoking (blowers 2 and 3).
- Vibration/oscillation (blower 3).

C. Aeration Diffusers

The aerated zones in the four activated sludge plants currently use 9-inch ceramic fine-pore diffusers and polyvinyl chloride (PVC) air distribution grids that were installed as part of the MMSD 7th Addition to the NSWWTP project in 1986. The east and west plants were constructed in phases, with differing tank depths, ranging from 14.7 to 15.8 feet and with diffuser submergence ranging from 14.7 to 15.8 feet.

Plant staff reported that diffuser grid maintenance issues have been infrequent, but are disruptive to operations when they occur. Maintenance issues have included couplings that loosened and a few cracked pipes that needed to be repaired.

It is difficult to forecast the remaining useful life of the PVC diffuser grid based on industry experience as no WWTPs have operating systems significantly older than NSWWTP’s. Materials testing would be required to determine whether the PVC piping has degraded and needs to be replaced to maintain aeration reliability.
D. Aeration Controls

The existing aeration control system for the NSWWTP BNR system uses DO control. DO sensors are located at one-third down the length of Pass 2 and at the end of Pass 3 of the aeration tanks. These sensors measure the bulk fluid DO and the measured value is relayed back to a controller. The controller compares the value to a set point and adjusts the control valves in the air supply piping accordingly. Current DO set points are 1.5 mg/L in Pass 2 and 3.5 mg/L in Pass 3. The DO concentration in Pass 1 is controlled by the DO measurement in Pass 2 such that if the Pass 2 DO drops below 0.4 mg/L, more air is supplied to Pass 1.

The aeration blowers are controlled on a pressure set point. If more air is required, the valves in the piping system open, which reduces the pressure in the system and calls for blowers to be ramped up or additional units to be brought online. The existing control valves installed in the air supply piping are the same size as the piping. This is a common situation that can lead to poor airflow control. The valve requires an adequate pressure drop to effectively control the airflow, which requires a valve several diameters smaller than the pipe size in aeration systems.

E. Postaeration

NSWWTP WPDES permit includes a minimum effluent DO requirement of 5.0 mg/L. The DO concentration is continuously monitored in the effluent pump wet well and a correlation is used to estimate the DO at the Badfish Creek outfall. Operators are notified when low DO conditions occur.

Under current normal plant operating conditions the minimum effluent DO concentration is achieved through reaeration via weirs, and other cascading flow downstream of the aeration tank. When plant effluent flow rates are high this reaeration is reduced. In general, plant staff have indicated that when two effluent pumps are running they need to increase the Pass 3 DO set point to 2 to 3 mg/L to provide additional DO to meet the minimum effluent DO concentration, and when three pumps are running a Pass 3 DO of 3 to 4 mg/L may be used. Plant operators choose whether these manual DO set point adjustments are warranted as flows increase. The use of elevated Pass 3 DO set points is reportedly infrequent and roughly estimated by plant staff to be on the order of 10 hours per year.

6.02 ACTIVATED SLUDGE BNR ALTERNATIVES SCREENING

Workshop Nos. 5a through 5c were held at the NSWWTP to discuss activated sludge operations, alternatives, and related information. Based on discussion at these workshops, the following BNR alternatives were selected for further evaluation:

- Alternative AS0—Maintain Existing Activated Sludge System (Null Alternative)
- Alternative AS1—Existing Modified University of Cape Town (UCT)
- Alternative AS2—UCT
- Alternative AS3—UCT with Sidestream Deammonification
- Alternative AS4—Main Stream Nitrite Shunt
- Alternative AS5—Chemically Enhanced Primary Treatment (CEPT) with Nitrite Shunt
These alternatives differ in their ability to reduce effluent TN discharges. Alternatives AS0 and AS1, Modified UCT, which also includes the two A/O trains within East Plant No. 1, are capable of achieving current permit limits but does not address reducing effluent TN discharges. In contrast, Alternatives AS2 through AS5 are targeted at achieving current permit discharge limits plus reducing TN discharges. All alternatives include step feed capabilities to route flows greater than 110 mgd to Pass 3 (as described in Section 4) to minimize secondary clarifiers solids loading rates (SLRs) and maximize TSS removal.

6.03 DESCRIPTION OF BNR ALTERNATIVES EVALUATED

This section presents descriptions of the short-listed alternatives evaluated, including facility requirements, predicted effluent quality, and changes in operations such as chemical usage or biosolids production. Design flows and loadings and effluent criteria used in this evaluation are presented in Sections 2 and 3, respectively. See TM-5 for more detailed information on the process screening and alternative evaluation.

A. Alternative AS0–Maintain Current Activated Sludge Operation (Null Alternative)

The Null Alternative assumes continued operation of existing modified UCT process with the existing aeration equipment, including blowers and diffusers. Excluding the two A/O trains in East Plant 1, the anaerobic and anoxic zones compose roughly 16 percent and 5 percent of the total aeration basin volume, respectively.

The capacity status of the major components of the existing system is as follows:

- **Blower capacity:** The forecast future peak airflow for continued use of the modified UCT process under the Null Alternative is within the firm capacity of the existing east and west blower systems, assuming that diffuser air transfer efficiency is maintained at roughly current levels. However, turndown limitations limit the ability of the plant to save energy by minimizing airflow, especially on the west side of the plant.
- **Diffuser capacity:** The existing diffuser system capacity is sufficient, but the target minimum airflow per diffuser of 1 scfm to minimize diffuser fouling restricts blower turndown.
- **Airflow control valves:** The existing process airflow control valves appear to be oversized for the projected airflow rates.
- **RAS pumps:** Based upon rated capacity, the existing RAS pumps have adequate firm capacity for normal load conditions and total capacity for future peak conditions. According to MMSD staff, RAS flow testing is recommended to confirm that the installed RAS pumping capacity matches the rated capacity.

The existing aeration basin sizing and layout are sufficient to meet the target effluent criteria at an aerobic SRT of 9 days. Step feed of peak hour flows is not required to maintain clarifier SLRs below critical levels; however, routing flows to Pass 3 when influent flows exceed 110 mgd is recommended to minimize
negative impacts on anaerobic selector/EBPR performance and maximize clarifier TSS removal performance. This alternative assumes that the East Plant 1 two A/O trains are not modified.

Much of the existing equipment associated with the activated sludge system is near or beyond its useful life, including ceramic diffusers, blowers, flow meters, and control valves. The age of this equipment leads to higher risk of failure as well as increased O&M costs for this alternative.

This null alternative is truly a “do nothing” alternative. The viability of this alternative to serve the needs of the District through the year 2040 is questionable, if not doubtful, without significant rehabilitation costs throughout the planning period. However, the null alternative was presented as such to help identify and communicate the potential energy and O&M costs savings that may be realized by replacing the major aeration system components (i.e., Alternative AS1).

B. Alternative AS1–Existing Modified University of Cape Town (UCT) Process

Alternative AS1 includes maintaining the existing modified UCT flow scheme described in Alternative AS0. System improvements under this alternative include the replacement of the existing aeration blowers, replacement of the existing ceramic disc diffusers with EPDM discs, and new aeration control valves and flow meters. This alternative assumes that the East Plant 1 two A/O trains are not modified. The replacement of old and outdated equipment in this alternative reduces O&M costs as well as the risk of equipment failure for equipment that is beyond its useful life.

As long as MMSD continues to operate using the modified UCT, the existing control strategy based on DO measurement can be continued. Alternatively, ammonia based aeration control (ABAC) could be added to provide more control and reduce aeration demands. The aeration savings from adding ammonia inputs to the aeration control system is highly dependent on how low the DO set points are in the DO-only control system. Given the low summer month NH₃-N permit limitations of 2 mg/L, ABAC would provide the greatest benefit during winter conditions when the monthly average NH₃-N limit is 4 mg/L.

C. Alternative AS2–UCT Process

Alternative AS2 modifies the existing plant flow scheme to the UCT process to reduce TN discharges. This is accomplished by adding a mixed liquor recycle (MLR) flow from the last aerobic zone to the first anoxic zone, increasing the size of the existing anoxic zone, and adding a carbon source to reduce annual TN discharges below 10 mg T-N/L.

Simulations showed that the UCT system is carbon-limited and therefore methanol addition was included to reduce the nitrate concentration leaving the anoxic zone to 0.5 mg/L, which maintains current EBPR performance. This alternative assumes that the aerated grids in Pass 1 and the first aerated grid (33 percent) of Pass 2 are converted to anoxic zones, simplifying design and construction. In this alternative, the East Plant 1 A/O trains are also converted to the UCT flow scheme.

Plant modifications to incorporate the UCT process configuration include the following:
- New 18,000-gallon methanol storage and metering system to feed methanol to the East and West plant secondary influent channels.

- Convert Pass 1 and the first aerated grid in Pass 2 to anoxic zones by removing the associated aeration grid/system, adding two mixers to each zone, and adding a baffle wall to Pass 2.

- Relocate the existing anoxic recycle pumps to the last anoxic zone and add piping to reconnect to existing recycle piping.

- Add MLR pumping to achieve 300 percent MLR flows at maximum month flows.

- Add three nitrate-nitrite (NO\textsubscript{2}) sensors per plant to control methanol feed and MLR flows.

- Relocate the existing Pass 2 DO sensors to farther down the pass.

Aeration control upgrades include relocating the DO sensors is Pass 2 farther downstream at about the midpoint of the last third of the tank. A NO\textsubscript{2} sensor is included in the last anoxic zone prior to the aerated zones and is used to pace the methanol addition and MLR to the anoxic zone.

This alternative also includes a new post-aeration system with positive-displacement blowers and diffusers to increase effluent DO, especially during high flow conditions, without negatively impacting BNR performance. Biosolids production in this alternative remains essentially the same with UCT as additional solids generated from methanol addition are offset by the longer solids retention time (SRT), which reduces solids production.

D. Alternative AS3–UCT Process with Sidestream Deammonification

Alternative AS3 combines sidestream deammonification with Alternative AS2's UCT configuration in an effort to reduce UCT carbon and energy demands. Deammonification processes convert roughly 50 percent of the sidestream influent NH\textsubscript{3}-N to nitrate nitrogen (NO\textsubscript{2}-N) using ammonia-oxidizing bacteria (AOB). The resulting NO\textsubscript{2}-N and remaining NH\textsubscript{3}-N are then converted to nitrogen gas via anammox bacteria without carbon. The key advantage of the deammonification process is that no carbon is needed to convert sidestream ammonia loadings to nitrogen gas.

This alternative assumes that a sidestream deammonification system treating the Ostara effluent is provided to maximize nitrogen removal and minimize methanol needs in the main stream process. Effluent quality for the UCT with sidestream deammonification alternative is similar to Alternative 2, UCT, decreasing the average effluent TN to 14 to 15 mg N/L without methanol addition. If effluent TN is reduced below 10 mg N/L, deammonification reduces average methanol doses by approximately 10 percent.

This alternative also includes a new post-aeration system with positive-displacement blowers and diffusers to increase effluent DO without negatively impacting BNR performance.

E. Alternative AS4–Main Stream Nitrite Shunt

Alternative AS4 modifies the existing operations to promote nitrite-shunt in which ammonia is oxidized to nitrite and then reduced to nitrogen gas. Key advantages of this alternative are no carbon addition is needed to meet TN reduction goals and reduced aeration demands. For this evaluation, the A/O flow
scheme operated at controlled DO levels was selected. Nitrite shunt pilot testing at MMSD is being conducted to verify the kinetic parameters for detailed design.

Alternative AS4 can reduce average effluent TN discharges below 10 mg N/L without carbon addition and does not negatively impact EBPR performance. The existing aeration tank modifications to implement nitrite shunt consist of the following changes:

- Add ammonia/NO₃ sensor to Pass 3B and a DO sensor to Pass 1 for ammonia versus nitrite/nitrate (AVN) control.
- Add a baffle wall between the second and third aeration grids in Pass 3.
- Add a new aeration control valve, meter, and DO sensor to control the aeration airflow in Zone 3C.
- Operationally, route RAS flow to the first anaerobic zone and stop pumping flow from the existing anoxic zone back to the first anaerobic zone.

This alternative also includes two additional 116-foot secondary clarifiers in the West Plant and a polymer addition system for both the East and West plants to address poor sludge quality (SVI) resulting from low DO operation. A new postaeration system with positive-displacement blowers and diffusers to increase effluent DO without negatively impacting BNR performance is also included in this alternative.

One of the major impacts of incorporating a nitrite shunt process is increased process control complexity. This includes AVN control to operate at the optimal point on a TN reduction using ammonia and NO₃ sensors. These sensors determine whether aeration in Pass 1, 2, and the first two-thirds of Pass 3 should be increased or decreased to maintain the ammonia and nitrogen oxides (NOX) concentration in Zone 3B at equal levels. The DO in the final aeration zone of Pass 3 must be tightly controlled by a new control valve, airflow meter, and DO sensor to reduce ammonia levels to comply with permit requirements.

F. **Alternative AS5–CEPT with Nitrite Shunt**

Alternative AS5, CEPT with nitrite shunt, combines Alternative AS4 with CEPT to divert more carbon to the anaerobic digesters for increased biogas/energy production while reducing TN discharges without adding carbon (methanol).

CEPT is implemented by adding ferric chloride (FeCl₃) and polymer upstream of the primary clarifiers in locations such as the grit tank influent and effluent channels. The amount of FeCl₃ added to promote additional carbon capture must be balanced with maintaining sufficient primary effluent phosphate (PO₄-P) to promote EBPR, which is needed for the existing Ostara struvite recovery process. This alternative assumes that 15 mg/L of FeCl₃ is added to reduce primary effluent PO₄-P by 1 mg/L or 35 percent of the Alternative AS4 primary effluent PO₄-P to enhance energy production and still maintain struvite recovery.

It is estimated that CEPT will result in an increase in annual biogas production by roughly 65 scfm or 15 percent. In the near term, use of this additional gas would be limited by the existing engine capacity and heat demands. If a new biogas combined heat and power (CHP) system is installed in the future, this additional gas could be used to increase the CHP output by approximately 260 kW.
Compared to Alternative AS0 and AS1, this alternative would increase biosolids production by approximately 1.1 dry tons per day (DT/d) and reduce struvite production by approximately 0.9 DT/d. Adding 15 mg/L of FeCl₃ results in increasing the effluent chloride levels by roughly 10 mg/L, but is not expected to impact UV system operation.

As in Alternative AS4, this alternative also includes two additional 116-foot secondary clarifiers in the West Plant and a polymer addition system for both the East and West plants to offset the decrease in sludge quality resulting from low DO operation. In addition, Alternative AS5 includes a chemical building with FeCl₃ storage tank, FeCl₃ metering pumps, and polymer feed equipment.

A new postaeration system with positive-displacement blowers and diffusers to increase effluent DO without negatively impacting BNR performance is also included in this alternative.

6.04 AERATION SYSTEM ALTERNATIVE EVALUATION

A. Aeration Diffusers

Table 6.04-1 summarizes the predicted average and peak process airflow requirements and the selected DO profile for each alternative. Ceramic diffusers were not considered for Alternatives AS2 through AS5. In Alternatives AS4 and AS5, diffuser airflows less than 1 scfm/diffuser are desired to maintain low operating DO levels. Lower airflows are also desired in Alternatives AS2 and AS3 to reduce Pass 3C operating DO levels to 1 mg/L to minimize DO recycled in MLR.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>DO set point (Pass 1/2/3)</td>
<td>0.3/0.8/2.0</td>
<td>-/0.8/2.0</td>
<td>-/0.8/2.0</td>
<td>0.1/0.1/0.1</td>
<td>0.1/0.1/0.1</td>
</tr>
<tr>
<td>Existing Ceramic Diffusers (Null Alternative)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Total average airflow, scfm</td>
<td>34,100</td>
<td>30,700</td>
<td>30,500</td>
<td>29,300</td>
<td>58,800</td>
</tr>
<tr>
<td>Total peak airflow, scfm</td>
<td>62,500</td>
<td>30,500</td>
<td>29,300</td>
<td>22,300</td>
<td>58,800</td>
</tr>
<tr>
<td>Membrane Disc Diffusers b</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total average airflow, scfm</td>
<td>30,700</td>
<td>30,500</td>
<td>29,300</td>
<td>58,800</td>
<td>55,700</td>
</tr>
<tr>
<td>Total peak airflow, scfm</td>
<td>55,000</td>
<td>53,900</td>
<td>52,000</td>
<td>58,800</td>
<td>55,700</td>
</tr>
<tr>
<td>Membrane Strip Diffusers c</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total average airflow, scfm</td>
<td>28,400</td>
<td>28,200</td>
<td>27,100</td>
<td>54,800</td>
<td>51,800</td>
</tr>
<tr>
<td>Total peak airflow, scfm</td>
<td>53,000</td>
<td>51,900</td>
<td>50,100</td>
<td>54,800</td>
<td>51,800</td>
</tr>
</tbody>
</table>

a For Alternatives 2–5 the DO in last third of Pass 3 set a 1 mg/L. DO at peak demand set to 0.5 mg/L for all alternatives.
b Membrane disc airflow–engineer’s estimate.
c Membrane strip airflows based on vendor designs received for Alternatives 1 and 4.
d Represents average DO in nitrite shunt simulation. Setpoints may vary depending upon bench and pilot scale testing.

Table 6.04-1 BNR Alternatives 2040 Process Aeration Airflow Summary
Alternative AS1 airflow rates with membrane disc and membrane strip diffusers are 10 to 15 percent and 15 to 20 percent lower, respectively, than the existing ceramic diffusers. When comparing membrane disc diffusers, the average and peak airflow requirements for Alternatives AS1 through AS3 are within 5 percent and considered equal for planning purposes. Average airflow for Alternatives AS4 and AS5 decrease by 25 to 30 percent compared to Alternative AS1. Alternative AS4 peak total airflow rates increased by 5 percent while Alternative AS5 total peak airflow rates remained roughly the same as Alternative AS1. Membrane strip diffuser annual and peak airflow rates are 7 percent and 5 percent lower, respectively, than the membrane disc diffusers as a result of higher diffuser standard oxygen transfer efficiency (SOTE).

A diffuser net present worth evaluation was conducted to compare the net present worth of standard and high-efficiency fine-pore diffusers and is summarized in Table 6.04-2. This analysis is intended to evaluate whether the increased equipment cost of high-efficiency diffusers should be included in the alternative’s capital cost opinion, and is not intended to be a final diffuser technology recommendation. The net present worth evaluation indicates that under similar fouling assumptions the EPDM disc and membrane strip alternatives have essentially equivalent net present worth.

<table>
<thead>
<tr>
<th></th>
<th>Existing Ceramic Diffusers (Null Alternative)</th>
<th>EPDM Disc</th>
<th>Membrane Strip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Opinion of Capital Cost$\text{a,e}$</td>
<td>$0$</td>
<td>$2,630,000$</td>
<td>$3,630,000$</td>
</tr>
<tr>
<td>Present Worth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance$g$</td>
<td>$520,000$</td>
<td>$550,000$</td>
<td>$470,000$</td>
</tr>
<tr>
<td>Blower Energya,f</td>
<td>$10,400,000$</td>
<td>$8,600,000$</td>
<td>$7,800,000$</td>
</tr>
<tr>
<td>Replacement</td>
<td>$0$</td>
<td>$1,200,000$ b</td>
<td>$1,200,000$ c</td>
</tr>
<tr>
<td>Total Opinion of Present Worth</td>
<td>$11,000,000$</td>
<td>$12,900,000$</td>
<td>$13,100,000$</td>
</tr>
</tbody>
</table>

$a$Assumes new high efficiency blowers with turndown constraints relieved.
$b$7-year replacement cycle, $600,000$ per cycle (2016 dollars).
$c$15-year replacement cycle, $1,300,000$ per cycle (2016 dollars).
$g$Continued use of the biogas blower no. 1 is assumed, with an energy cost of “zero”.
$a,f$Diffuser maintenance estimated as $21,000/year for EPDM disc and $19,000 per year for membrane strips, covering cleaning and miscellaneous pipe repairs. Blower maintenance is not included in this estimate.

Table 6.04-2 Diffuser Alternative Opinion of Present Worth Summary

The net present worth analysis is dominated by the 20-year blower energy cost which was estimated using the average airflow rates shown in Table 6.04-1, with normal airflow variation. The blower energy estimate is influenced by both the original diffuser efficiency and the rate and degree of fouling. Differences in fouling assumptions can have a significant impact on the comparison between diffuser types in this analysis. Because the net present worth for the EPDM discs and membrane strips are essentially equal if unfouled conditions are assumed, any differences in rate of fouling and average...
A fouling condition will cause the slower-fouling system to be favored over the more fouled diffuser system. If the membrane strips (or one of the other diffuser technologies) can be fairly tested and found to have a fouling advantage, the high-efficiency diffusers would have a lower net present worth than the standard-efficiency diffusers. Because high-efficiency diffusers appear to be at least comparable to the standard-efficiency diffusers, additional capital budget for high-efficiency diffusers appears to be warranted.

B. Aeration Blowers

Although the existing blowers may be reaching the end of their useful life by conventional asset management expectations, the plant has maintained its equipment well and it does not appear that all blower units would need to be replaced concurrently. Instead, new blowers could be phased in over time to gain efficiency from one or two new blowers while the remaining blowers served as standby capacity. The following blower technologies were evaluated based on criteria such as available airflow capacity, energy efficiency, electrical requirements, and issues related to surge conditions:

- Single-Stage Integrally Geared Centrifugal Blowers
- High-Speed Turbo Blowers (Air or Magnetic Bearings)
- Screw Blowers
- Multistage Centrifugal Blowers

Single-stage integrally geared centrifugal blowers are available in sizes that are well matched to the sizes needed for a one-for-one replacement of west and east plant blowers and were used for estimating the capital cost and energy consumption for the BNR alternative present worth analysis in Section 6.07. High speed turbo blowers with magnetic bearings or screw positive displacement blowers are also potentially viable technologies that warrant further consideration during the final design of future blower retrofits.

6.05 BNR ALTERNATIVES DESIGN CRITERIA

Design criteria for each of the BNR alternatives, including operational parameters and chemical usage, are presented in Table 6.05-1. These criteria are used in the treatment performance evaluation simulations presented in Section 6.06 and the present worth analysis presented in Section 6.07.
### Table 6.05-1  BNR Alternatives Process Design Criteria

<table>
<thead>
<tr>
<th>Item</th>
<th>AS0/1 Existing Modified UCT</th>
<th>AS2 UCT</th>
<th>AS3 UCT with Sidestream Deammonification</th>
<th>AS4 Nitrite Shunt</th>
<th>AS5 CEPT with Nitrite Shunt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influent flow to East plant (average/peak), percent</td>
<td>50/50</td>
<td>50/50</td>
<td>50/50</td>
<td>50/43</td>
<td>50/43</td>
</tr>
<tr>
<td><strong>East Aeration Tanks</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total volume (existing), MG</td>
<td>12.15</td>
<td>12.15</td>
<td>12.15</td>
<td>12.15</td>
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<tr>
<td>Anaerobic volume, % total</td>
<td>4</td>
<td>28</td>
<td>28</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Aerobic/total SRT, Days</td>
<td>9/11</td>
<td>9/15</td>
<td>9/15</td>
<td>12/15</td>
<td>15/19</td>
</tr>
<tr>
<td>Maximum month MLSS, mg/L</td>
<td>2,400</td>
<td>3,600</td>
<td>3,500</td>
<td>3,200</td>
<td>3,200</td>
</tr>
<tr>
<td>Mixed liquor return *, % E. influent</td>
<td>--</td>
<td>300</td>
<td>300</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Anaerobic recycle *, % E. influent</td>
<td>73</td>
<td>73</td>
<td>73</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td><strong>East Secondary Clarifiers</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clarifiers in service, No.</td>
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<td>11</td>
<td>11</td>
<td>11</td>
<td>11</td>
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<tr>
<td>Pass 3 MLSS at peak hour flow, mg/L</td>
<td>2,400</td>
<td>3,100</td>
<td>3,000</td>
<td>2,750</td>
<td>2,750</td>
</tr>
<tr>
<td>RAS, mgd</td>
<td>34</td>
<td>42</td>
<td>42</td>
<td>37</td>
<td>37</td>
</tr>
<tr>
<td>Peak hour SLR, lb/ft²-d</td>
<td>28</td>
<td>38</td>
<td>37</td>
<td>30</td>
<td>30</td>
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<tr>
<td><strong>West Aeration Tanks</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of tanks</td>
<td>4</td>
<td>4</td>
<td>4</td>
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<tr>
<td>Total volume, MG</td>
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<td>11.78</td>
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<tr>
<td>Anaerobic volume, % total</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>21</td>
<td>21</td>
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<tr>
<td>Anoxic volume, % total</td>
<td>5</td>
<td>28</td>
<td>28</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Aerobic/total SRT, Days</td>
<td>9/10</td>
<td>9/15</td>
<td>9/15</td>
<td>12/15</td>
<td>15/19</td>
</tr>
<tr>
<td>Maximum month MLSS, mg/L</td>
<td>2,500</td>
<td>3,600</td>
<td>3,500</td>
<td>3,200</td>
<td>3,200</td>
</tr>
<tr>
<td>Mixed liquor return *, % W. influent</td>
<td>--</td>
<td>300</td>
<td>300</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Anaerobic recycle *, % W. influent</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>--</td>
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<tr>
<td><strong>West Secondary Clarifiers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clarifiers in service</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Pass 3 MLSS at peak hour flow, mg/L</td>
<td>2,500</td>
<td>3,100</td>
<td>3,000</td>
<td>2,750</td>
<td>2,750</td>
</tr>
<tr>
<td>RAS., mgd</td>
<td>34.4</td>
<td>34.4</td>
<td>34.4</td>
<td>34.4</td>
<td>34.4</td>
</tr>
<tr>
<td>Peak hour SLR, lb/ft²-d</td>
<td>25</td>
<td>31</td>
<td>30</td>
<td>24</td>
<td>24</td>
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<td><strong>Additional Annual Requirements</strong></td>
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<td></td>
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<tr>
<td>Methanol, gpd</td>
<td>--</td>
<td>2,250</td>
<td>2,000</td>
<td>0</td>
<td>0</td>
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<tr>
<td>FeCl₃, gpd</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>1,000</td>
</tr>
<tr>
<td><strong>Polymer, DT/yr</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Biosolids disposal, DT/d</strong></td>
<td></td>
<td>0.7</td>
<td>0.5</td>
<td>-2.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Struvite production, T/d</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0.9</td>
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<tr>
<td><strong>30% MgCl₂, T/d</strong></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-0.17</td>
</tr>
</tbody>
</table>

*aMixed liquor return (aerobic to anoxic) and anaerobic recycle (anoxic to anaerobic) capped at 300% and 75% of the plant influent maximum month flow, respectively.

*Assumes mixed liquor return is turned off during peak flow events to minimize Pass3 MLSS to clarifiers.

*Nitrite shunt polymer addition may also consist of RAS chlorination to minimize costs. Planning O&M costing based upon polymer addition only.
6.06 BNR ALTERNATIVES TREATMENT PERFORMANCE EVALUATION

Treatment performance for each alternative was evaluated, including clarifier loading analysis and whole-plant process modeling using a calibrated NSWWTP BioWin™ model. This evaluation used the Year 2040 projected influent flows and loadings presented in Section 3. For facility evaluation, three loading conditions were considered to define system requirements:

- **Condition 1**–Maximum month flows and loadings at the minimum month temperature to establish the mixed liquor suspended solids (MLSS) concentration for aeration basin/secondary clarifier sizing and peak aeration demands in latter zones of the aeration tank.
- **Condition 2**–Maximum month flows and loadings at the maximum month temperature to define the peak aeration system demands.
- **Condition 3**–Annual average flows, loadings, and temperature to define annual operating conditions.

The design temperatures are based on historical daily effluent temperatures from January 1, 2013, through April 28, 2016 (influent temperatures are not available). For evaluation purposes, the maximum, minimum, and average monthly temperatures of 22, 11, and 15 degrees Celsius (°C), respectively, were selected.

The secondary clarifier capacity was evaluated based upon the maximum allowable SLR capacity as determined using state point analysis (SPA) assuming all clarifiers, RAS pumps, and aeration tanks are in service during peak hour flow conditions. The peak hour flow for process evaluations was defined as the flow associated with a 5-year storm event of 135 mgd. The secondary clarifiers will also need to pass the peak hydraulic flow of 180 mgd. Because there is an inherent uncertainty in defining secondary clarifier capacity using SPA, the calculated maximum allowable SLR was decreased by 20 percent to account for non-ideal settling and thickening in the clarifiers resulting in a lower maximum SLR. It is recommended that the secondary clarifiers be stress-tested with subsequent computational fluid dynamics (CFD) modeling to confirm the secondary clarifiers solids loading rate capacity.

Table 6.06-1 summarizes the secondary clarifier design criteria used in this analysis. The nitrite shunt SVI of 175 mL/g is greater than the UCT-based alternatives as the low operating DO levels will negatively impact sludge quality. The design SVI of 175 mL/g assumes that RAS chlorination and/or polymer is added to control bulking sludge. For the nitrite shunt alternatives, the East Plant RAS pumping capacity was not increased above 37 mgd as higher RAS flows did not increase maximum SLR. Increasing the West plant RAS capacity from 34.4 mgd to 39 mgd could increase the West clarifiers' SLR capacity by 10 percent for both flow schemes, but was not considered for this evaluation. This analysis assumes polymer is added six months per year to reduce SVIs below 175 mL/g to estimate annual chemical requirements. Capital costs assume both RAS chlorination and polymer addition facilities are installed.
This evaluation assumes that each BNR alternative will incorporate biological contact treatment as described in Section 5, which step feeds primary effluent flows in excess of roughly 100 mgd to 110 mgd to Pass 3 of the aeration tanks.

Table 6.06-2 summarizes anticipated effluent ammonia, TP, and TN concentrations for each alternative.

Table 6.06-1 Secondary Clarifier Solids Loading Rate Capacity

Table 6.06-2 BNR Alternatives Predicted Effluent Quality Comparison
6.07  BNR ALTERNATIVES PRESENT WORTH ANALYSIS

Table 6.07-1 provides a summary of the opinion of present worth values for the six alternatives under both existing blower and new blower scenarios. A detailed breakdown of present worth costs is included in Technical Memorandum No. 5b (TM-5b). It is important to note that this alternative comparison includes alternatives with differing levels of service in terms of effluent quality and process risk.

Operating costs in this present worth analysis include energy and chemical use, biosolids production, and struvite operating costs for each alternative as well as a comparison of the annual operating costs of the existing blowers and new blowers with improved efficiency and improved turndown capabilities.

Energy use estimates includes reduced natural gas consumption for engine-driven blowers from improved aeration controls, turndown, and low DO operation (Alternatives AS4 and AS5) as well as increased biogas production from CEPT operation.

Alternatives AS0 and AS1 have the lowest net present worth in this analysis, but these alternatives have higher projected effluent TN concentrations than the other alternatives. The equivalent net present worth for Alternative AS0 and Alternative AS1 with new blowers indicates that the energy upgrades to the blowers, diffusers, and controls included in Alternative AS1 provide sufficient energy savings to balance the estimated capital cost over the 20-year planning period. Similarly, the existing and new blower life-cycle costs for the Alternatives AS2 through AS5 are effectively equal in this analysis. However, it should be noted that this blower upgrade scope is focused on energy savings and is limited to one new west blower and two new east blowers. TM-5 and Section 6.09 provide an expanded comparison of blower replacements that includes phased-in east-west cross-connection piping and staged replacement of additional blowers as they reach the end of their useful life.

A major factor in the life-cycle cost analysis is the secondary clarifier addition associated with the nitrite shunt alternatives. If the clarifier tank addition can be deferred or omitted based on stress testing and subsequent computational fluid dynamic modeling of the clarifiers, Alternative AS4 would become approximately equivalent on a new present worth basis with continued use of Modified UCT. Under current SLR assumptions the additional clarifiers would not be required until 2028 based upon current growth projections and assumed clarifier capacity.

6.08  BNR ALTERNATIVES NONMONETARY EVALUATION

Nonmonetary considerations related to process flexibility, operational complexity, chemical use, and technology risk for each alternative were evaluated and are summarized in Table 6.08-1. Other nonmonetary considerations are described in the following.

- **Blower Energy:** The nitrite shunt alternative significantly reduces blower energy. CEPT enhancement of nitrite shunt further reduces net energy by producing more biogas, but the chemical costs make this approach less financially feasible.

- **Non-Blower Energy:** The UCT process energy demands are greater than the existing because of addition of the MLR system and additional mixed zones.
Greenhouse Gas (GHG) Emissions: GHG emissions related to natural gas and electrical consumption vary between BNR alternatives as indicated by energy costs. UCT processes that use methanol as a carbon source incur a significant increase in GHG emissions because methanol is derived from fossil fuels. Some plants have begun to use alternative carbon sources such as glycerin products to reduce this impact. Nitrous oxide (N₂O) emissions associated with nitrogen treatment are relatively small, but their impact can be significant because N₂O has a GHG impact 300 times that of CO₂. Research to better understand and quantify the mechanisms of N₂O emissions is one of the most active research areas related to GHG emissions from wastewater management. In general, field measurements have shown that plants that achieve high levels of nitrogen removal emit less N₂O and most N₂O emissions occur in aerated zones because of air stripping. This area of research should continue to be monitored, especially as data regarding N₂O emissions from nitrite shunt processes become available.
Table 6.07-1  BNR Alternatives Opinion of Present Worth Summary

<table>
<thead>
<tr>
<th></th>
<th>Alternative AS0</th>
<th>Alternative AS1</th>
<th>Alternative AS2</th>
<th>Alternative AS3</th>
<th>Alternative AS4</th>
<th>Alternative AS5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Opinion of Capital Cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BNR Improvements</td>
<td>$0</td>
<td>$4,100,000</td>
<td>$16,800,000</td>
<td>$21,700,000</td>
<td>$18,500,000</td>
<td>$19,400,000</td>
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<tr>
<td>BNR Improvements and New Blowers</td>
<td>$0</td>
<td>$8,600,000</td>
<td>$21,300,000</td>
<td>$26,200,000</td>
<td>$22,900,000</td>
<td>$23,800,000</td>
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<tr>
<td>Annual O&amp;M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Existing Blowers</td>
<td>$960,000</td>
<td>$700,000</td>
<td>$2,700,000</td>
<td>$2,500,000</td>
<td>$610,000</td>
<td>$1,600,000</td>
</tr>
<tr>
<td>New Blowers</td>
<td>$590,000</td>
<td>$470,000</td>
<td>$2,500,000</td>
<td>$2,200,000</td>
<td>$390,000</td>
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<tr>
<td>O&amp;M</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Existing Blowers</td>
<td>$16,500,000</td>
<td>$13,000,000</td>
<td>$48,300,000</td>
<td>$45,700,000</td>
<td>$12,300,000</td>
<td>$30,200,000</td>
</tr>
<tr>
<td>New Blowers</td>
<td>$10,300,000</td>
<td>$8,000,000</td>
<td>$43,500,000</td>
<td>$41,500,000</td>
<td>$7,400,000</td>
<td>$25,300,000</td>
</tr>
<tr>
<td>Increased biogas production and reduced natural gas</td>
<td>$0</td>
<td>($100,000)(^b)</td>
<td>($50,000)</td>
<td>($100,000)</td>
<td>($80,000)</td>
<td>($300,000)</td>
</tr>
<tr>
<td>Total Opinion of Present Worth</td>
<td>$16,500,000</td>
<td>$17,000,000</td>
<td>$65,100,000</td>
<td>$67,300,000</td>
<td>$29,900,000</td>
<td>$46,700,000</td>
</tr>
<tr>
<td>Avoided clarifier tank addition (^a)</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>$17,800,000</td>
</tr>
</tbody>
</table>

\(^a\)Net present worth estimate for scenario in which clarifier stress testing finds that clarifier addition is not required prior to the end of the planning period in 2040. This estimate is based on the new blower scenario, but excludes $7,700,000 in clarifier capital costs and $3,900,000 in related contingency and technical services from the base case estimate.

\(^b\)Blower 1 fuel savings related to increased airflow turndown with membrane diffusers.
Table 6.08-1  BNR Alternative Nonmonetary Considerations Summary

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
</table>
| ASO: Null alternative| ▪ Plant staff familiarity  
▪ Performance well proven at NSWWTP  
▪ Opportunity to wait for emerging technologies to mature                                                                                           | ▪ Does not improve energy efficiency  
▪ Does not address risks related to aging equipment                                                                                               |
| AS1: Existing Modified UCT | ▪ Same as Null alternative  
▪ Blower turndown with membrane diffusers  
▪ New equipment                                                                                                                                   | ▪ Uncertainty related to site-specific fouling characteristics of new diffuser technologies                                                                                               |
| AS2: UCT             | ▪ Plant staff are familiar with this configuration  
▪ Can be designed for flexible operations in nitrite shunt mode                                                                                   | ▪ Internal mixed liquor recycle (IMLR) and supplemental carbon add some complexity for operations                                                                                                                                 |
| AS3: UCT with Sidestream Deammonification | ▪ Can be designed for flexible operations in nitrite shunt mode  
▪ Reduces supplemental carbon requirements by 10 percent compared to UCT alternative  
▪ Takes advantage of shortcut denitrification process to reduce carbon addition  
▪ Deammonification is a simple robust process that is automated  
▪ Potential to bioaugment mainstream with Anammox biomass                                                                                       | ▪ Deammonification systems are patented  
▪ Additional process to operate increases complexity  
▪ Heating required in sidestream reactor to maintain deammonification activity  
▪ Deammonification installations downstream of Ostara process not proven                                                                                                                              |
| AS4: Nitrite Shunt   | ▪ Emerging technology which could set precedence for other utilities to follow  
▪ Can be designed for flexible operations in modified UCT mode                                                                                   | ▪ Limited installations  
▪ The risk of exceeding effluent ammonia limits may be higher than with other alternatives  
▪ May require chemical addition for low effluent TP  
▪ More complex and potentially more labor required to operate than UCT alternatives—additional nitrogen sensors and accurate aeration control required, as well as potential chemical addition facilities  
▪ Reduced sludge volume index (SVI) impact on secondary clarifiers and anticipated polymer feed and RAS chlorination to control settling                                                                 |
| AS5: CEPT with Nitrite Shunt | ▪ Same as nitrite shunt                                                                                                                                                                                    | ▪ Same as nitrite shunt plus the following:  
▪ Additional aeration savings not predicted to be significant  
▪ CEPT operations add more complexity                                                                                                              |
6.09 EAST-WEST AERATION SYSTEM CROSS-CONNECTION EVALUATION

Currently the NSWWTP east and west blower complexes supply air to the east and west plants, respectively, and are completely separate systems. During development of the 2014 energy study MMSD staff suggested a possible cross-connection of the east and west aeration systems as a means to reduce energy consumption by using excess west blower capacity within Plants 1 and 2, especially if the transferred flow of air was sufficient to eliminate normal operation of blower 4 or 5. Two cross-connection scenarios were evaluated as part of this Facilities Plan:

- Partial blower cross-connect incorporating the 8-inch-diameter existing pipe to headworks.
- Full capacity east-west cross-connection using new 30-inch-diameter pipe.

After analyzing a partial blower cross-connection using the 8-inch-diameter existing piping, it was determined that this scenario was not feasible because it could not transfer enough air.

A preliminary concept design was developed for a full capacity cross-connection that includes the following components:

- Connection to the west aeration header in the west aeration gallery.
- 30-inch-diameter aeration piping through tunnel between Plant 3 and Plant 4, including insulation to mitigate the safety concern with high-temperature piping near the walkway.
- 30-inch-diameter above-grade piping from Aeration Building 4 to the East Blower building, including overhead pipe supports.
- Connection to east aeration header with valve in blower room.

The existing diffuser submergence is 1 foot greater on the west side than on the east side. In a cross-connected configuration this difference must be throttled so that the airflow from the west does not favor the east aeration tanks. Several options are available to create this balance. For this evaluation it was assumed that an air pressure control valve would be installed between east and west air headers with 1-foot pressure drop. However, other options, such as installing air pressure control valves only on tanks 1 through 6 with a lower diffuser mounting in tanks 7 through 18 when new diffusers are installed, should be considered prior to final design because it results in a more standard diffuser mounting level and reduces energy wasted through the balancing valve.

A benefit of the full-size east-west cross-connection piping is to provide some redundancy between the east and west blower systems. Under the infrequent standby operating condition when the east blowers are supplying air to the west, the aeration control valves would need to be manually adjusted to balance flows and in the east blower discharge pressure would increase from its current setting. With this increased head pressure condition, the east blower airflows are slightly reduced. With four east blowers in service, and under average east blower airflow conditions plus 25 percent for diurnal variation, 26,100 cubic feet per minute (cfm) would be available to supply west aeration. Based on this analysis it appears that the blower capacity in both the east and west facilities is sufficient to provide aeration in either direction.
The cross-connect also provides some energy reduction even with existing blowers by eliminating the need to operate blower 4 or 5 and by operating the west blower in a more efficient condition closer to 100 percent capacity. The energy costs used in the net present worth comparison are based on continued Modified UCT operation with increasing airflow due to growth over the planning period.

A present worth analysis was conducted to compare the installation of a cross-connection between the east and west blowers and the continued operation of separate aeration systems. Table 6.09-1 summarizes the phasing assumptions used for the net present worth analysis. Electrical consumption estimates were based on the “Normal Blower Mode”, with increasing airflows over the planning period. The biogas upgrade project and blower 1 decommissioning are assumed to occur around planning year 2025. At this time, under the cross-connected blower scenario all air would be supplied from the west side, using new blowers sized to provide the airflow required by the BNR approach selected for long term operations.

Demolition of the east blower equipment and building is not included in the capital cost estimate. However, the cross-connect scenario analysis assumed maintenance would decrease as the east blowers would not be actively maintained. As such, the east blowers would remain available as a backup only until they are no longer operable due to equipment failures. In other words, if no investments are made to the east blower mechanical and electrical equipment, the ability of the east blowers to serve as a back-up for the west blowers (as described above) could be compromised over time by equipment conditions in the East Blower building, especially if the east blower equipment is idle for extended periods. Conversely, MMSD could choose to make investments to keep the east blowers available for standby service, but these investments would diminish the life cycle cost advantage of the piping cross-connection.

Table 6.09-2 presents the net present worth comparison of the two scenarios. Based on the phasing assumptions in Table 6.09-1, the cross-connected blowers scenario has a lower net present worth because it eliminates east blower replacements and electrical distribution upgrades for the East Blower building and reduces the estimated blower electrical consumption. However, if no investments are made to the east blower mechanical and electrical equipment, the ability of the east blowers to serve as a back-up for the west blowers (as described above) could be compromised over time by equipment conditions in the East Blower building, especially if the east blower equipment is idle for extended periods.
### Table 6.09-1 Preliminary Blower Phasing Assumptions for Present Worth Analysis

<table>
<thead>
<tr>
<th>Years</th>
<th>West Blower Average Flow (scfm)</th>
<th>East Blower Average Flow (scfm)</th>
<th>Cross-Connected Blowers</th>
<th>Continued Separate East-West Blowers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Normal Blower Mode</td>
<td>Capital Improvements</td>
</tr>
<tr>
<td>2020 to 2025</td>
<td>11,300</td>
<td>11,800</td>
<td>• Existing west blower</td>
<td>• East-west piping</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Blower 1</td>
<td></td>
</tr>
<tr>
<td>2025 to 2030</td>
<td>12,100</td>
<td>12,700</td>
<td>• New west blower</td>
<td>• Two new west blowers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• West blower electrical upgrade</td>
</tr>
<tr>
<td>2030 to 2035</td>
<td>12,900</td>
<td>13,400</td>
<td>• New west blower</td>
<td>• Replace remaining west blower</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• New east blower(s)</td>
</tr>
<tr>
<td>2035 to 2040</td>
<td>13,600</td>
<td>14,100</td>
<td>• New west blower</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 6.09-2 Blower Cross-Connection Alternatives Opinion of Present Worth Summary

<table>
<thead>
<tr>
<th></th>
<th>Continued Separate East-West Blowers</th>
<th>Cross-Connected Blowers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Opinion of Capital Costa</td>
<td>$12,500,000</td>
<td>$9,300,000</td>
</tr>
<tr>
<td>Present Worth of O&amp;M</td>
<td>$14,900,000</td>
<td>$13,600,000</td>
</tr>
<tr>
<td><strong>Total Opinion of Present Worth</strong></td>
<td><strong>$27,400,000</strong></td>
<td><strong>$22,900,000</strong></td>
</tr>
</tbody>
</table>

*aBlower capital cost estimates includes replacement of all existing blowers over the course of the planning period in order to highlight the impact of the cross connection piping on future blower projects.*
6.10 BLOWER IMPROVEMENT STAGING

Table 6.09-1 presented alternate blower phasing scenarios with and without the proposed aeration cross-connection piping connection. The considerations described in this section were used to develop these proposed blower improvement sequences. Assuming the cross-connection piping alternative is implemented as described in Section 6.09, future blower improvement staging will be focused on the west blower complex.

Both the east and west blower complexes have adequate firm capacity to serve the forecast peak airflow conditions, so peak capacity is not a factor in establishing blower phasing. Similar to the BNR alternatives phasing, blower phasing can be approached through strategic support and phased implementation in conjunction with BNR decision points.

If MMSD chooses to implement blower improvements in a phased program, the west blowers should be given priority for the following reasons:

- The west blowers are limited by turndown and this constraint will limit future savings from either nitrite shunt or high-efficiency diffusers.
- The potential to realize energy savings from improved blower efficiency is higher on the west because it does not have an engine-driven blower.
- Despite being newer and having significant excess capacity, the west blower complex also appears to have the higher risk of prolonged outages that could impact firm blower capacity.

The biggest hurdle to near-term west blower replacement is uncertainty about BNR alternative implementation. Ideally, new blowers would have flexibility to operate over the range of airflows anticipated by potential future scenarios. However, the turndown range implied by this flexibility may be greater than the range of a single blower. As such, some combination of the following approaches could be pursued, bearing in mind that the final design would need to provide firm capacity to meet the projected peak flows with a combination of one large blower and one new blower:

- Installation of a blower model that could be modified via impeller replacement or speed modification in the future.
- Design for a separate channel blower to reduce aeration blower peak air demand.
- Reconfiguration of the blower layout to allow two smaller blowers.

The east blowers are not as limited by turndown and there are multiple redundant units, which mitigates the risk of a major aeration outage. In addition, if the nitrite shunt approach is successful it would allow Plants 1 and 2 to be operated with the engine-driven blower. However, the age and efficiency of the blowers make them candidates for replacement within the next 5 to 10 years.

Deferring the east motor-driven blower replacements will also allow for better coordination with the planned conversion to biogas engine-generators and possible east-west cross-connection piping.
6.11 ENHANCED PHOSPHORUS REDUCTION

Because of MMSD’s plan to continue with the Yahara WINs AM approach in the Badfish Creek (Rock River) watershed into the foreseeable future, it is unlikely that a TP limit below 0.5 mg/L (6-month average) would be incorporated into the NSWWTP WPDES permit within the planning period of this Facilities Plan. In addition, if very stringent TP limits were implemented for the Badger Mill Creek discharge location (Sugar River watershed), MMSD may discontinue discharge to Badger Mill Creek altogether, or perhaps seek trading partners to meet future water quality goals. In either case, it was decided that effluent TP limits of less than 0.5 mg/L would not be required to be met within the planning window of this facilities planning project. However, there is a potential that MMSD may want to maintain effluent TP levels in the range of 0.25 to 0.30 mg/L, or lower to maintain (or reduce) costs associated with the Yahara WINs program. As effluent TP loadings increase, the cost to participate in the Yahara WINs program also increases.

MMSD commissioned a recent high-level planning project in 2011 and 2012 (Preliminary Nutrient Removal Cost Estimates, prepared by CH2M Hill) to study the facilities needed to meet a range of monthly effluent TP limits of 0.13 and 0.225 mg/L, annual effluent TP limits of 0.075 mg/L, and monthly TN limits of 3 to 10 mg/L. The purpose of the discussion below is to present a summary of that report and additional comments pertaining to the impacts that low phosphorus limits and effluent filters may have on NSWWTP operations and facilities.

A. Six-Month Average Target Phosphorus of 0.25 to 0.30 mg/L

With respect to the current facilities planning effort, Scenario 1 from the CH2M Technical Memorandum represented the conditions that were most similar to the potential future effluent TP target of 0.25 to 0.30 mg/L on a 6-month average basis. Scenario 1 included a monthly TP limit of 0.225 mg/L, no total nitrogen limit, and existing ammonia limits. The effluent target of 0.11 mg/L TP was selected to achieve the 0.225 mg/L limit reliably. To meet this target effluent concentration, the following facilities were assumed:

- Deep-bed granular media filters.
- Metal salt storage and addition facilities.
- Secondary effluent pump station.

The filters and pumping facilities were sized to handle 79 mgd, which is approximately the capacity of the existing effluent pump station. This sizing criterion is slightly larger than the 71 mgd peak month flow criterion used for the BNR alternatives presented earlier in this Technical Memorandum, reflecting short-term higher flows to filtration. This maximum capacity may not be required to meet the future effluent TP limit, especially if the limit is a 6-month average limit such as is proposed under the current rules.

- The initial capital cost associated with this alternative was approximately $60 million in 2012 dollars. Annual O&M costs were estimated to be approximately $800,000.
B. Six-Month Average Target Phosphorus of 0.075 mg/L

This scenario represents the potential future effluent phosphorus limit based on water quality criteria for the discharge to Badger Mill Creek, and was presented as Scenario 3 in the CH2M Technical Memorandum:

- A target of 0.05 mg/L TP was selected to achieve the limit reliably.
- This alternative included the processes from Scenario 1, as well as a second feed point for metal salt addition, rapid-mix system, polymer storage and feed facility, flocculation basin, and lamella clarifiers.
- All processes were sized to handle a maximum flow rate of 79 mgd.
- Both the rapid-mix and flocculation systems consisted of four active trains plus a standby train.
- The initial capital cost associated with this alternative was approximately $91 million in 2012 dollars. Annual O&M costs were estimated to be approximately $2.4 million.

C. Chemical Addition for Tertiary Filtration

The addition of filters to meet an effluent TP limit of 0.25 to 0.30 mg/L is not expected to use a significant amount of metal salts. In fact, the previous study indicated that, on an average basis, no metal salts would need to be added. Therefore, operation of new effluent filters to reliably meet a limit in the range of 0.25 to 0.30 mg/L would not be expected to have a significant impact on the existing treatment processes and overall operation of NSWWTP. However, for an effluent TP limit of 0.10 mg/L or lower, the chemical addition required would be significant and could impact existing operations and effluent chloride levels. Waste sludge from such operations has a high concentration of “unused” coagulant. If this unused chemical is recycled back to the plant headworks or primary clarifiers rather than a dedicated solids processing system, it will react with influent ortho-phosphate. Ultimately, depending on actual coagulant doses required, the recycling of coagulant could negatively impact the production of struvite in the Ostara process, which would reduce revenue from the sale of the struvite product. Finally, sludge generation from metal salt addition side reactions would increase biosolids quantities significantly, resulting in higher solids management costs.

If future, low effluent TP limits are required to be met at NSWWTP, a concept that should be explored includes using the high metal salt recycle stream to replace the existing ferric feed to the digesters for hydrogen sulfide control. This could eliminate or reduce the purchase of virgin iron salts added for sulfide control.

6.12 RECOMMENDED PLAN

This section presents recommendations resulting from the study, including further investigations and BNR system issues to be addressed. The proposed approach to BNR and asset renewal is summarized in Table 6.12-1.
A. **Secondary Clarifier Stress Testing**

Secondary clarifier stress testing and subsequent CFD modeling are recommended to confirm the existing clarifier SLR capacity as each TN reduction alternative has secondary clarifiers SLR at the estimated maximum allowable levels at 2040 critical flow and loading conditions. Stress testing and analysis should be completed as part of the facility improvements predesign to confirm facility requirements. RAS pump hydraulic pumping capacity should also be tested to verify installed capacity meets design data.

B. **Pilot Test Nitrite Shunt Operation**

If bench-scale testing is successful, full-scale demonstration testing is recommended to further confirm process design criteria, impacts to sludge quality, and operational requirements. The full-scale demonstration test will require one plant to be operated as a nitrite shunt only plant. Converting the existing ceramic diffusers to membrane disc diffusers is required to reduce aeration airflow to the basins and provisions to independently control Zone 3C aeration is needed, or needs to be evaluated in further detail to ensure that combined discharges will meet the plant’s WPDES permit. Instrumentation associated with AVN control and Zone 3C DO is also required.

C. **Diffuser Grid: PVC Embrittlement Investigation**

Theoretically, the existing PVC diffuser grid could be reused and optimized for projected airflow requirements for each aeration zone. However, because the system has already been in operation for 30 years it is likely that the diffuser grid will need to be replaced during the planning period. The timing of this replacement will depend on the likelihood of increasing PVC fractures under normal operation or during future diffuser element plugging or grid modifications.

Bend and tensile testing can be used to determine whether the PVC has become embrittled with age and therefore more prone to failure. The testing results would be compared with a sample of new piping, which may not match the original, but would provide an “order of magnitude” comparison to assess. In addition, materials testing firms could do cross-sectioning and examination to see if any material degradation is evident.

D. **Diffuser Grid: Fouling Changes Following Ostara, Cleaning Implications**

Previous investigations into ceramic diffuser fouling have implicated mineral deposits, including phosphorus and magnesium. The plant has controlled this fouling by maintaining airflows above a minimum 1 scfm/diffuser rate to move the water/air interface out of the ceramic stone. The Ostara process has reduced the quantity of phosphate and magnesium recycled back to the aeration basins. The reduced phosphate concentrations also decrease the magnesium levels in the aeration basins as EBPR anaerobic phosphate release also releases magnesium into solution as magnesium serves as counter-ion to phosphate so phosphate can cross the cell membrane wall. When MMSD considers future diffuser projects and diffuser types, a small research project that revisits the Waddington (Waddington 1995) findings under current mineral loading rates could improve the accuracy of future diffuser alternatives evaluations. In addition, Sanitaire is now offering liquid cleaning systems that may also provide another means to control ceramic diffuser fouling.
E. **RAS Pump Energy Efficiency**

The existing RAS pumps are suitable for continued use under the future BNR alternatives. However, there may be opportunities to increase energy efficiency in the RAS system, including modifying the control system to include “most open valve” logic, evaluating variable frequency device (VFD) retrofits, and considering replacement of older motors with higher-efficiency motors.

F. **Addressing Other BNR System Maintenance Issues**

Plant staff identified other BNR operating issues:

- Scum beach icing control
- Plant 2 RAS control valves
- Drainage pump capacity
- Weir surcharge
- East and west plant flow measurement

Funding to address these issues should be included as capital budgets are established for the facility plan.
### Table 6.12-1 NSWWTP BNR Alternatives Phasing Strategy

<table>
<thead>
<tr>
<th>Item</th>
<th>Approach</th>
<th>Timing</th>
<th>Justifications</th>
</tr>
</thead>
</table>
| BNR strategy                  | Nitrite shunt bench testing                                             | Ongoing                                                                | • Evaluate cold weather performance  
• Improve accuracy of process modeling parameters                                                     |
| Nitrite shunt full-scale demonstration in one Plant | Following bench testing                                              |                                                        | • Verify cold weather performance  
• Confirm process modeling parameters  
• Confirm effluent quality  
• Gain experience with AVN automated controls                                                              |
| NSWWTP BioWin validation and design update | Predesign                                                               |                                                        | • Validate steady-state model calibration and confirm selected alternative(s) preliminary design evaluations |
| Clarifier stress test         | Predesign                                                               |                                                        | • Determine whether additional aeration tankage will be triggered by growth, especially under increased SVI associated with nitrite shunt  
• Improve accuracy of BNR alternatives evaluation  
• Confirm RAS pump hydraulic capacity                                                                     |
| Plant-wide implementation of nitrite shunt | Following demonstration, if successful                            |                                                        | • Energy reduction  
• Effluent quality improvement                                                                                                                                     |
| Postaeration improvements    | Concurrent with plantwide nitrite shunt                                 |                                                        | • Meet effluent DO requirements under high flow conditions                                           |
| UCT process improvements      | If future permit requires                                               |                                                        | • Implement only if nitrite shunt testing is unsuccessful or permit limits are lower than predicted nitrite shunt effluent quality  
• Proven TN removal process                                                                                         |
| Diffusers                     | PVC condition evaluation                                                | Near term                                                               | • Informed risk evaluation of continued near-term use of ceramic diffuser system  
• Accelerate diffuser replacement if evaluation suggests embrittlement or other PVC flaws                  |
| Replace diffusers in one plant with membrane diffusers | Concurrent with nitrite shunt demonstration                          |                                                        | • Match diffuser density to nitrite shunt process airflow requirements  
• Designed for expansion if demonstration is unsuccessful  
• Facilitate low DO conditions and precise DO set points  
• Life-cycle procurement to optimize diffuser energy performance                                                |
| Replace diffusers in remaining plant | Concurrent with plant-wide BNR improvements                           |                                                        | • Match diffuser density to process airflow requirements based on final BNR configuration              |
| Blowers                       | Replace two west blowers                                               | Mid term                                                                | • Reduce failure risk  
• Reduce energy consumption through improved blower efficiency and reduced turndowns  
• Blower sizing                                                                                               |
| Install east-west cross-connect piping | Mid term                                                              |                                                        | • Reduce blower energy consumption by minimizing or eliminating blower 4/5 run time  
• Provide redundancy between east and west blower systems                                                                 |
| Replace two east blowers*     | Concurrent with CHP project                                            |                                                        | • Coordinate new blower sizing with ongoing BNR improvements and phase-out of blower 1                  |

*East blower replacement not required if cross-connection piping is installed.
This section summarizes the content of Technical Memorandum No. 7 (TM-7) and includes a description of the existing UV disinfection system, discussion and screening of disinfection alternatives, and detailed discussion of the short-listed alternatives with opinions of probable construction cost and nonmonetary considerations.

7.01 EXISTING EFFLUENT DISINFECTION SYSTEM

The existing horizontal UV disinfection system was manufactured by Fischer & Porter (F&P) and was started-up in 1996. Soon after start-up of the UV system, F&P was acquired by Trojan Technologies. After the acquisition, the F&P UV product line was no longer manufactured, nor were replacement parts available from Trojan.

The system consists of 5 channels, 2 banks per channel, and 368 low-pressure UV lamps per bank for a total of 3,680 lamps. Two additional channels were constructed with 1 channel designated for future expansion and the other used as a bypass channel when the UV system is not in use. The nominal capacity of the 5 active UV channels is approximately 100 mgd. Flows above 100 mgd are diverted to the effluent storage lagoons and later recycled back to the NSWWTP for full secondary treatment. Overall, the system has performed well and disinfection permit requirements have been met. However, the system has required more maintenance, parts sourcing, and attention than anticipated. In addition, the system has been in service for more than 20 years and is operating beyond the 15 to 20-year typical life of UV equipment.

7.02 EFFLUENT DISINFECTION ALTERNATIVES SCREENING

Workshop No. 7 was held on October 5, 2016, at the NSWWTP to discuss disinfection operations, alternatives, and related information. The overall concept for several alternatives were presented, including high-level budgetary costs and nonmonetary considerations. Based on discussion at the workshop, the following alternatives were short-listed to be evaluated in greater detail:

- Alternative D0–Maintain Existing System (Null Alternative)
- Alternative D1–UV Disinfection (Trojan Technologies)
- Alternative D2–UV Disinfection (WEDECO-Xylem)
- Alternative D7–Refurbish Existing UV System (IronbrookUV)

All of the alternatives were considered for both 100 mgd and 180 mgd peak flows, and all alternatives were required to meet the current geometric mean fecal coliform limit of 400 colony-forming units per 100 milliliters cfu/100 mL, as well as potential future *E. coli* limits of 126 cfu/100 mL (geometric mean) and 410 cfu/100 mL (statistical threshold value).

7.03 DESCRIPTION OF ALTERNATIVES EVALUATED

This section includes a description of each of the short-listed disinfection alternatives, including any structural or hydraulic modifications necessary to accommodate the disinfection equipment.
A. Alternative D0–Maintain Existing F&P UV System (Null Alternative)

Alternative D0 would maintain the existing UV disinfection system without expanding the system or replacing equipment. Since the equipment is no longer manufactured, parts must be obtained through a third-party vendor. In addition, the control boards are currently supplied by third-party vendors. The ability to maintain a reliable supply of replacement parts and control boards may be limited in the future. This alternative also does not include expanding the system capacity beyond 100 mgd.

The existing system is operating at or beyond the normal useful service life of UV technology. We recommend planning to replace or significantly refurbish the UV system within the next 10 years to avoid a catastrophic system failure, as well as to safeguard against reliance on third-party vendors selling replacement parts for systems that are no longer manufactured. The collective market demand for such parts will reduce over time as the F&P systems installed in the 1990s are taken out of service, and at some point availability of parts will become critical. Therefore, we have assumed that the system will need to be replaced and/or refurbished within 10 years to avoid a significant risk with respect to parts availability and system failure. This definition of the null alternative was applied because we do not believe the existing equipment could operate through the planning horizon without replacement.

B. Alternative D1–UV Disinfection (Trojan Technologies)

Alternative D1 would replace the existing UV system with the Trojan Technologies Signa UV system. Trojan Technologies’ design for the 100-mgd system would require 3 channels with 3 UV banks per channel. The lamps for this system are 1,000-watt lamps provided only by Trojan Technologies or its equipment representatives. Trojan offers a 15,000-hour prorated warranty on each lamp. The lamps are 100 percent replaced up to 9,000 hours; the warranty is prorated from 9,000 to 15,000 hours.

The Signa UV system will require the channel bottoms to be lowered by approximately 14 inches because of the longer bulbs and taller overall height of the equipment. Raising the channel walls to provide the additional 14 inches of depth would not be feasible because of the upstream hydraulic control requirements. In addition to the equipment and structural costs to lower the channels, additional costs include new aluminum checker plate to cover the channels.

C. Alternative D2–UV Disinfection (WEDECO-Xylem)

Alternative D2 would replace the existing UV system with the Duron UV system manufactured by WEDECO-Xylem. WEDECO-Xylem’s design for the 100-mgd system would require 5 channels with 3 UV banks per channel. The lamps for this system are 600-watt lamps provided by WEDECO and other equipment vendors. WEDECO offers a 14,000 hour prorated warranty on each lamp. The lamps are 100 percent replaced up to 9,000 hours; the warranty is prorated from 9,000 to 14,000 hours.

The Duron banks will fit in the existing channels and only require the channels to be narrowed by approximately 2.25 inches. In addition to the equipment costs, additional costs include new aluminum checker plate to cover the channels and the cost to grout the channel walls.
D. **Alternative D7–Refurbish Existing UV System (IronbrookUV)**

Alternative D7 includes refurbishing the existing UV system with similar equipment provided by IronbrookUV. The refurbishment would include replacing control boards, ballasts, breakers, transformer, cables, UV intensity monitors, lamps and sleeves, among other items. The lamp racks would also be refurbished. Several F&P systems have been similarly refurbished by IronbrookUV in recent years, including the systems installed at the Glenbard Wastewater Authority in Illinois (16 mgd average, 47 mgd peak) and the San Bernardino facility in California (33 mgd peak capacity). This alternative does not include expanding the system beyond the existing 5 channels, although expanding into the 2 empty channels would bring total system capacity up to approximately 140 mgd.

Costs for equipment upgrades were provided by IronbrookUV and include removal and installation. In addition to the equipment costs, the opinion of probable cost for this alternative also includes replacement of the existing flow control gates with new downward opening weir gates. Confirmation of this style of level control for a refurbished horizontal UV system is pending at this time. If new weir gates are not sufficient for level control, then new weighted effluent gates would be included.

### 7.04 PRESENT WORTH ANALYSIS

Table 7.04-1 provides a summary of the opinion of present worth values for the four alternatives. A detailed breakdown in present worth costs is included in TM-7. Capital costs for all projects, except for the null alternative (Alternative D0), were assumed to be incurred at the beginning of a 20-year planning period to replace the existing UV system. TM-7 also includes a breakdown of O&M costs associated with each alternative, including the assumptions or data used to develop the O&M costs.

For Alternative D0, it was assumed the system would be replaced in Year 10 of the 20-year planning period. Given the critical nature of the effluent disinfection system to the environmental mission of the District, we do not recommend considering any alternative that does not replace the significant components of the system within the next 10 years. While the system remains functional, the main components have been in operation for 20 years, and we expect the system components to begin failing at a faster rate in the future.
Table 7.04-1 Opinion of Present Worth Summary

<table>
<thead>
<tr>
<th></th>
<th>Alternative D0 Existing F&amp;P</th>
<th>Alternative D1 Trojan</th>
<th>Alternative D2 WEDECO</th>
<th>Alternative D7 Ironbrook UV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Opinion of Capital Cost</td>
<td>$0</td>
<td>$3,593,000</td>
<td>$3,797,000</td>
<td>$2,153,000</td>
</tr>
<tr>
<td>Annual O&amp;M</td>
<td>$70,000-106,000(^1)</td>
<td>$52,000</td>
<td>$55,000</td>
<td>$70,000</td>
</tr>
<tr>
<td>Present Worth</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O&amp;M</td>
<td>$1,207,000</td>
<td>$684,000</td>
<td>$723,000</td>
<td>$920,000</td>
</tr>
<tr>
<td>Replacement</td>
<td>$1,403,000(^2)</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Salvage</td>
<td>($276,000)(^3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Opinion of Present Worth</td>
<td>$2,334,000</td>
<td>$4,277,000</td>
<td>$4,520,000</td>
<td>$3,073,000</td>
</tr>
</tbody>
</table>

\(^1\)$70,000/year is for years 11–20; $106,000 is for years 1–10.
\(^2\)Capital cost for Alt. D7 assumed in year 10, brought back to the present.
\(^3\)Salvage costs assume 50 percent of system life remaining at year 20, which is 10 years after replacement.

Alternatives D0 and D7, both of which include the refurbishment of the existing F&P system, have a lower overall present worth cost than the other two alternatives, mainly because of the significantly lower initial and future system installation costs for the Ironbrook UV equipment. The Ironbrook UV upgrades would continue to utilize many of the existing components, which helps reduce costs. The Trojan and WEDECO alternatives have lower annual O&M opinions of cost, which is mainly because of higher energy efficiency and reduced maintenance associated with the significantly fewer bulbs, ballasts, and associated systems.

For the purpose of this planning level evaluation, Alternatives D1 and D2 have approximately equal present worth costs, since the total present worth costs are within 10 percent of each other.

7.05 NONMONETARY EVALUATION

Nonmonetary considerations for each alternative were evaluated and are summarized in Table 7.05-1. While alternatives D0 and D7 have the benefit of familiarity to the District staff, there are numerous limitations with those alternatives that are addressed with Alternatives D1 and D2.
<table>
<thead>
<tr>
<th>Alternative</th>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>D0—Maintain Existing F&amp;P UV System (Null Alternative)</td>
<td>District staff is familiar with system and equipment.</td>
<td>Since this original equipment is no longer manufactured, replacement parts must be obtained through third-party vendors.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Replacement control boards must be obtained from third-party vendors.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The system is more than 20 years old now and is operating at or beyond its anticipated useful service life. This system will likely require more maintenance and attention over time than a new system would require.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Future availability of replacement parts may be diminished as other F&amp;P installations are replaced. This is a critical consideration and could result in a loss of parts availability over a relatively short period of time, especially if Ironbrook UV would cease operations.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Because of the number of lamps and associated head loss, capacity beyond 140 mgd is not possible without changing the system hydraulics and layout.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Existing flow control gates do not operate properly at high flows because of high water level in the downstream UV effluent channel.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Level control in the UV channels is more critical with horizontal UV lamps, which likely requires the continued use of the weighted level control gates. Continued evaluation of downward opening weir gates should be considered when this system is replaced.</td>
</tr>
<tr>
<td>D1—UV Disinfection (Trojan Technologies)</td>
<td>Proven technology developed by a world leader in UV system technology.</td>
<td>Requires channels to be lowered to accommodate the equipment.</td>
</tr>
<tr>
<td></td>
<td>Fewest number of lamps of all alternatives.</td>
<td>Utilizes 1,000-watt bulbs that must be purchased from Trojan currently; this could change in the future if 1,000-watt bulbs become more common. Guaranteed lamp pricing would need to be established.</td>
</tr>
<tr>
<td></td>
<td>Fewest number of channels required (3), which would allow the system to be expanded easily to 180 mgd.</td>
<td>Utilizes hydraulic system for sleeve cleaning that adds complexity and potential maintenance issues to system.</td>
</tr>
<tr>
<td></td>
<td>System includes both mechanical and chemical cleaning.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Most installations greater than 50 mgd of the short-listed alternatives.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Angled bulb arrangement requires less stringent flow control and provides the ability to replace the weighted gates with downward opening weir gates for level control.</td>
<td></td>
</tr>
<tr>
<td>D2—UV Disinfection (WEDECO-Xylem)</td>
<td>Proven technology developed by a world leader in UV system technology.</td>
<td>None identified.</td>
</tr>
<tr>
<td></td>
<td>Does not require channels to be lowered; simpler retrofit than Alternative D1.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>System includes mechanical cleaning.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Angled bulb arrangement requires less stringent flow control and provides the ability to replace the weighted gates with downward opening weir gates for level control.</td>
<td></td>
</tr>
<tr>
<td>D7—Refurbish Existing UV System (IronbrookUV)</td>
<td>District staff is familiar with system and equipment.</td>
<td>Future availability of replacement parts may be diminished as other F&amp;P installations are replaced. This is a critical consideration and could result in a loss of parts availability over a relatively short period of time, especially if IronbrookUV would cease operations.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Because of the number of lamps and associated head loss, capacity beyond 140 mgd is not possible without changing the system hydraulics and layout.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Older UV technology.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Minimal energy savings are anticipated.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Existing flow control gates do not operate properly at high flows because of high water level in the downstream UV effluent channel.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Level control in the UV channels is more critical with horizontal UV lamps, which likely requires the continued use of the weighted level control gates. Evaluation of downward opening weir gates or new weighted gates could be considered if this alternative is selected. Capital costs include replacement of the existing weighted gates.</td>
</tr>
</tbody>
</table>

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7.06 RECOMMENDED PLAN

The recommended alternative for long-term disinfection at the NSWWTP is Alternative D1 or D2, which include a new UV system using the latest in UV disinfection technology. While these alternatives have a higher present worth than Alternatives D0 and D7, the newer technology offers many advantages as described in the following.

- These systems provide improved electrical efficiency.
- These systems provide improved maintainability.
- These alternatives provide lower risk associated with the older UV technology not being supported throughout the useful service life of the equipment.
- As with any item that is improved over time, having the most recent technology may allow it to be upgraded more readily as the systems continue to improve.
This section includes a summary of electrical improvement evaluations that were conducted as part of the facility planning for the NSWWTP. The evaluations include Headworks Facility backup power, east and west blower controls, east and west blower medium-voltage switchgear, existing unit substations (U11, U12, and U13), and indoor versus outdoor substation transformers. A detailed discussion of the short-listed alternatives with opinions of probable construction cost and nonmonetary considerations are summarized herein, and additional detail on these evaluations is presented in Technical Memorandum No. 8 (TM-8, Appendix H).

8.01 EXISTING HEADWORKS FACILITY POWER DISTRIBUTION SYSTEM

The existing Headworks Facility has two 480-volt motor control centers (MCCs), MCC-HF1 and MCC-HF2. Each MCC has a 1,000-amp main circuit breaker and the two MCC busses are interconnected with a 1,000-amp tie circuit breaker. Each MCC houses several motor starters and branch circuit breakers serving the various facility electrical loads. The MCCs are each fed with a 480-volt, 1,000-amp feeder from unit substation U15, which is fed with redundant 4.16-kV power feeds from main switchgear S1. The main unit substation that feeds the main switchgear is fed with redundant 13.8-kV utility power feeds from the Madison Gas & Electric (MG&E) Nine Springs Unit Substation located adjacent to the northwest corner of the NSWWTP. The Nine Springs Unit Substation has an on-site generator able to provide backup power during a regional utility power outage; however, MG&E requires at least two to three hours to bring the generator online.

Over the past 20 years, NSWWTP experienced a single power outage event that resulted in a sustained loss of power at the Headworks Facility. This event occurred on June 14, 2005 and lasted approximately 45 minutes. Continuous operation of the influent screens at the Headworks Facility is critical to NSWWTP operations, and an outage lasting more than 5 minutes during high-flow events would likely cause the influent wastewater channel to flood resulting in unscreened wastewater bypassing the screens. If influent wastewater bypasses the screens, the downstream wastewater treatment processes are subject to potential solids plugging, and the resulting maintenance requirements could be significant. Specific concerns have been noted with the digestion heating system steam injectors, which are susceptible to solids plugging, as well as the potential to impact the District’s Class A biosolids product if objectionable materials from screening bypasses are found in the biosolids project.

8.02 HEADWORKS FACILITY BACKUP POWER ALTERNATIVES IDENTIFICATION AND SCREENING

Workshop No. 8 was held on February 6, 2017, at NSWWTP to present a list of electrical alternatives, including alternatives for a backup power supply to the Headworks backup power (HBP), and screen the alternatives down to a shorter list to evaluate in detail. Based on discussion at the workshop, the following alternatives were selected to be evaluated further:

- Alternative HBP No. 0—No Change (Null Alternative)
- Alternative HBP No. 1—Stationary Diesel Generator for Headworks Facility
- Alternative HBP No. 2—Stationary Natural Gas Generator for Headworks Facility

Each of these alternatives are evaluated further in the following sections.
8.03 DESCRIPTION OF HBP ALTERNATIVES

This section includes a detailed evaluation of each short-listed Headworks Facility Backup Power Supply Alternatives.

For all the electrical reliability evaluations included herein, the null alternative was defined as the “do nothing” alternative and assumes the existing equipment will last throughout the planning horizon. While this may not be viable for all of these evaluations (e.g., East Blower Controls), the null alternative was defined as such to maintain consistency within this portion of the facilities plan.

A. Alternative HBP No. 0–No Change (Null Alternative)

Alternative HBP No. 0 would maintain the existing redundant power feeds to the Headworks facility MCCs as the only sources of power to the facility. With only a single power outage recorded over the past 20 years lasting about 45 minutes, the electrical utility and distribution system have proven to be robust and reliable. Electrical distribution system equipment is also routinely inspected and serviced to improve reliability. Electrical distribution equipment at the Headworks Facility and upstream unit substation (U15) is less than 20 years old, and will not need to be replaced for about another 10 years. However, electrical equipment at the main NSWWTP unit substation (H1) and main switchgear (S1), while still functioning properly, was brought online in 1985 and has been in operation for about 32 years. The expected service life for this type of equipment is 30 years, so the equipment should be considered for replacement in the near future.

If the Headworks facility experiences a power outage event, it is likely that wastewater will bypass the mechanical screening equipment. A total loss of power to the Headworks Facility can be caused by a catastrophic event at main unit substation H1, main switchgear S1, or unit substation U15, or due to the configuration of equipment cutting of redundant distribution paths. Based on the current configuration, both MCCs in the Headworks Facility are powered from a single unit substation U15, which would result in the entire facility losing power in U15 were to fail. The District should consider powering the MCCs independently from each of the two incoming power feeds from unit substation U15 so that some equipment would remain energized if only the power feed from substation U15 were to fail.

B. Alternative HBP No. 1–Stationary Diesel Generator for Headworks Facility

Alternative HBP No. 1 would provide a stationary diesel generator dedicated to powering the Headworks Facility during a power outage. This Alternative includes a 300-kW, Tier 3-rated generator, based on a peak recorded electrical demand of approximately 200 kW. A 480-volt, 300-kW generator would be sufficient to power the entire Headworks Facility during a power outage with about 30 percent spare capacity for future electrical loads at the Headworks Facility. The proposed installation location for this generator is the east storage room in Storage Building No. 3 because it has space to accommodate the new generator, and intake/outlet ventilation louvers can be installed in the east and north walls. Minor structural and heating, ventilation, and air conditioning (HVAC) modifications to this building to accommodate the generator and 300-gallon fuel tank are also included in this alternative.

A power transfer control system that automatically transfers the supply of power to the Headworks Facility MCCs from a failed incoming feeder from unit substation U15 to an available U15 feeder, or to the new
standby generator is also included in this alternative. This control system includes new electronically controlled circuit breakers and voltage monitors and could be installed as a dedicated control panel or incorporated into the existing programmable logic controller (PLC) control panel in the Headworks Facility.

Opinions of probable construction cost were developed for two scenarios in the alternative. In one scenario, four new circuit breakers are installed and the power feed from the new generator is fed into MCC-HF2 while both power feeds from unit substation U15 remain. In the second option, the new generator is wired directly into a new circuit breaker in the Headworks Facility MCC, which would reduce the number of new circuit breakers but would require one of the redundant power feeds from unit substation U15 to be removed.

C. Alternative HBP No. 2—Stationary Natural Gas Generator for Headworks Facility

Similar to Alternative HBP No. 1, Alternative HBP No. 2 would provide a stationary generator dedicated to powering the Headworks Facility during a power outage. However, a natural gas generator would be installed instead of a diesel generator. Based on the average Headworks Facility electrical loading previously discussed under Alternative HBP No. 1, a 300-kW natural gas generator would also be appropriate to power current and future Headworks facility electrical loads. Natural gas generators require a gas utility line for fuel and do not require any on-site fuel storage.

Maintaining power to the Headworks facility MCCs for this alternative would require the same power transfer control system, MCC voltage monitors, and electrically-controlled MCC circuit breakers previously described under Alternative HBP No. 1. The same generator location and HVAC modifications for the east storage bay in Storage Building No. 3 previously described under Alternative HBP No. 1 are also included in this alternative.

Natural gas piping would need to be extended to the new generator in Storage Building No. 3. Based on recorded natural gas usage by MG&E, there appears to be adequate capacity on the existing gas service line to accommodate a tap to feed a new 300-kW generator. Actual gas service capacity available for the new generator would need to be verified during detailed design.

8.04 HBP ALTERNATIVES COST EVALUATION

Table 8.04-1 presents a summary of the opinion of probable construction costs for each of the Headworks Facility Backup Power alternatives.

There are no upfront costs associated with this Alternative HBP No. 0. However, District staff estimates that it would cost at least $1,000 to clean the process equipment if influent wastewater bypasses the mechanical screens because of a power outage.

The budgetary opinions of probable construction costs for Alternatives HBP No.1 and No. 2 assume that the District would perform all PLC and Human-Machine Interface (HMI) programming updates and does not include estimated fees for engineering design and construction-related services. These two alternatives are presented both with four new circuit breakers (with one accepting the new generator power feed) and with three new circuit breakers. In the three circuit break alternatives, one of the main circuit breakers would be used to accept the new generator power feed.
Nonmonetary considerations for each alternative were evaluated and are summarized in Table 8.05-1.

8.06 HBP ALTERNATIVE RECOMMENDATION

The maintenance expense required to clean processes affected by influent wastewater bypassing the mechanical screens is insignificant when compared to the upfront expense required to install a generator, so project costs alone will not justify the installation of a new standby generator. In addition, because of the very infrequent power failures at the headworks, we recommend the null alternative (Alternative HBP No. 0) be continued.

If the District would still like to install a generator to avoid the potential of cleaning process equipment and managing a temporary increase in biosolids debris, we recommend installing a diesel generator at the Headworks Facility (Alternative HBP No. 1). This option not only provides a backup power source for the entire Headworks Facility, but upgrading to electrically-controlled breakers would improve the speed at which power to the Headworks Facility is switched between the two existing feeders from unit substation U15.

- The new electrically-controlled circuit breakers would significantly reduce future electrical outage durations at the Headworks Facility. The electrically-controlled circuit breakers could also be installed by themselves without the generator to eliminate concerns with a single substation U15 power source to both Headworks MCCs (i.e., tie breaker closed) failing and requiring manual transfer to the other U15 power source. This concern could also be eliminated by simply committing to always powering the Headworks Facility independently from U15 (i.e., tie breaker open).
- The diesel engine generator would be able to supply standby power to the facility during an electric utility outage for about 20 hours before needing to be refueled. Immediate generator operation would not rely on any off-site fuel sources.
- The upfront cost to install a diesel engine generator would be significantly lower than the cost required to install a natural gas engine generator, and would not require any NSWWTP utilities to be modified.
Table 8.05-1  HBP Alternative Nonmonetary Considerations Summary

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
</table>
| Alternative HBP No. 0–No Change (Null Alternative)| • The Headworks Facility currently has power distribution system redundancy back to the main NSWWTP unit substation, and most of the equipment is operating within its anticipated service life.  
  • There is a limited history of power outages at NSWWTP; only one 45-minute outage over the past 20 years.  
  • The MG&E Nine Springs substation has been upgraded to improve reliability since the previously-recorded, 45-minute outage. | • It’s possible for the Headworks facility MCC circuit breakers to be configured so that the entire facility would lose power if a single incoming power feed from unit substation U15 fails.  
  • Electrical equipment at the main NSWWTP unit substation H1 and main switchgear S1 has been operating for about 32 years, which is beyond its expected service life of 30 years.  
  • If an outage does occur and the screens are bypassed, there could be a negative impact on downstream processes and the biosolids product. |
| Alternative HBP No. 1–Stationary Diesel Generator for Headworks Facility | • The generator control system would be able to energize the Headworks facility as quickly as 10 seconds after a loss of power on one or both of the MCC incoming power feeds from unit substation U15.  
  • Diesel fuel is stored in a tank underneath the generator, so the fuel source, while limited to 12 to 24 hours before requiring a refill, is not dependent on an off-site source.  
  • No additional utility services (gas, water, etc.) are required for the generator installation. | • The generator would require regular maintenance.  
  • Outages lasting longer than 12 to 24 hours, depending on the fuel tank size, would require refueling.  
  • Diesel fuel must be stored on-site, and given that the NSWWTP power distribution system is so reliable, it is likely that most of the fuel would not be used before it degrades and has to be replaced. |
| Alternative HBP No. 2–Stationary Natural Gas Generator for Headworks Facility | • The generator control system would be able to energize the Headworks facility as quickly as 10 seconds after a loss of power on one or both of the MCC incoming power feeders.  
  • No on-site fuel storage or fuel maintenance. | • The generator would require regular maintenance.  
  • A natural gas utility service outage would render the generator inoperable.  
  • NSWWTP natural gas utility piping needs to be extended to Storage Building No. 3. |
8.07 EXISTING EAST AERATION SYSTEM CONTROL PANEL

There are two blower buildings at the NSWWTP, the East Blower Building (Blower Building 1) and the West Blower Building (Blower Building 2). Each blower building houses several 4.16-kV motor-driven blowers, and the East Blower Building also houses an engine-driven blower.

Controls for the west blowers were upgraded by the District engineering staff about 16 years ago, including PLC control panels and motor control relays in each blower motor starter. Since then, the west blower control systems have operated reliably and, therefore, have not been evaluated for replacement at this time.

The east blower control system, which controls Blower Nos. 2, 3, 4, 5, includes a common control panel using hardwired relay logic and legacy panel-mounted digital controllers. Blower No. 1 is an engine-driven blower that has a separate control panel. The east blower control panel has been in use since the original blowers were installed in the 1960s, and several undocumented modifications and adjustments have been performed over the years to keep the blowers in operation. As a result, the control panel wiring is unorganized and no reliable documentation exists to help District maintenance staff troubleshoot and correct problems that occasionally arise. District staff indicate that problems with this control panel often require several days to diagnose and correct. Since the original controls installation, a newer Allen-Bradley CompactLogix PLC and network switch have been installed, but only to monitor the engine-driven blower (Blower No. 1) temperatures. Replacing the existing east blower control panel with a PLC-based control system similar to what was provided for the west blowers would improve reliability and allow the control system to easily adapt to future blower equipment upgrades.

8.08 EAST AERATION SYSTEM CONTROL PANEL UPGRADE ALTERNATIVES IDENTIFICATION AND SCREENING

Based on discussion at Workshop No. 8, the following alternatives for the east aeration system control panel upgrades (EBC) were selected to be evaluated further:

- Alternative EBC No. 0—No Change (Null Alternative)
- Alternative EBC No. 1—Replace East Blower Control Panel

Each of these alternatives are evaluated further in the following sections.

8.09 DESCRIPTION OF EBC ALTERNATIVES

This section includes a detailed evaluation of each short-listed EBC Alternatives.

A. Alternative EBC No. 0—No Change (Null Alternative)

Alternative EBC No. 0 would leave the existing hardwired control panel for Blower Nos. 2, 3, 4, and 5 in the East Blower Building in operation. The control panel would be replaced during future blower equipment upgrades. The control panel is currently located in the center of the blower room, which is a relatively noisy and dirty environment.
B. Alternative EBC No. 1—Replace East Blower Control Panel

Alternative EBC No. 1 would replace the existing hardwired control panel for Blower Nos. 2, 3, 4, and 5 in the East Blower Building with new dedicated PLC-based control panels for each of these blowers located in Aeration Control Building No. 2. These PLC-based controls include a new remote input/output (I/O) enclosure in the East Blower Building that communicates with the new blower control panel in the Aeration Control Building No. 2 using NSWWTP’s recently upgraded fiber optic cabling and would allow most of the existing field wiring to be reused.

The District is currently considering blower equipment upgrades including a change from blowers powered by medium-voltage motors to blowers powered by 480-volt motors. While upgrading the control system prior to the blower equipment upgrades would require the new control panels to be modified slightly to accommodate the new equipment, new PLC-based control panels would easily be able to adapt and interface with any type of upgraded blower equipment.

8.10 EBC ALTERNATIVES COST EVALUATION

Table 8.10-1 presents a summary of the opinion of probable construction costs for each of the EBC Alternatives.

There are no upfront costs associated with Alternative EBC No. 0. However, there will likely be future costs associated with the time and materials required for NSWWTP maintenance staff to troubleshoot and repair blower control panel problems, which are not able to be reliably estimated. The budgetary opinion of probable construction cost for Alternative EBC No. 1 assume that the District would perform all PLC and HMI programming updates.

<table>
<thead>
<tr>
<th></th>
<th>Alternative EBC No. 0—No Change (Null Alternative)</th>
<th>Alternative EBC No. 1—Replace East Blower Control Panel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Opinion of Capital Cost</td>
<td>$0</td>
<td>$390,000</td>
</tr>
</tbody>
</table>

Table 8.10-1 EBC Alternatives Opinion of Probable Construction Cost Summary

8.11 EBC ALTERNATIVES NONMONETARY CONSIDERATIONS

Nonmonetary considerations for each alternative were evaluated and are summarized in Table 8.11-1.
### Table 8.11-1 EBC Alternative Nonmonetary Considerations Summary

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative EBC No. 0–No Change (Null Alternative)</td>
<td>• None</td>
<td>• The existing control panel components are very old, difficult to troubleshoot, and some replacement parts are difficult to find.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Future control panel problems due to aging equipment will likely require several days to troubleshoot and repair.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The existing control panel location in the blower building is not ideal for control equipment because it is a somewhat dirty environment, which can lead to premature equipment failure. The loud noise levels in the East Blower Building also require occupants to wear hearing protection, which complicates maintenance and troubleshooting efforts.</td>
</tr>
<tr>
<td>Alternative EBC No. 1–Replace East Blower Control Panel</td>
<td>• Replacing aging equipment would reduce the likelihood of control system problems that affect blower operation.</td>
<td>• Maintenance staff would lose the convenience of having the control panel, blower equipment, and motor starters in the same room.</td>
</tr>
<tr>
<td></td>
<td>• New and well-documented control panels would simplify maintenance and reduce the time required to diagnose and correct problems.</td>
<td>• Control system modifications, while not a significant effort or expense, would be required to interface the new control panel with future blower equipment upgrades.</td>
</tr>
<tr>
<td></td>
<td>• Relocating controls to Aeration Building No. 2 would provide a cleaner and less noisy environment, which would improve equipment longevity and provide a worker-friendly environment for control system maintenance and upgrades.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The new remote I/O enclosure in the East Blower Building would provide a point of local control via a touchscreen OIT and access to all I/O signal wiring.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The new control equipment would match current NSWWTP standards and maintenance staff would have easy access to replacement parts.</td>
<td></td>
</tr>
</tbody>
</table>
8.12 EBC ALTERNATIVE RECOMMENDATION

The recommended alternative for the east blower controls replacement is Alternative EBC No. 1. The east blower control panel is very old and replacement parts are hard to locate. In addition, the control panel wiring is undocumented and requires several days to troubleshoot and correct control system problems. Replacing the control system would greatly improve the east blower system reliability and use control equipment consistent with recent NSWWTP control system upgrades.

If the District chooses to upgrade the blowers within the next 5 years, the District could reasonably consider delaying the blower control panel upgrade until the blower equipment is upgraded with the understanding that there is an increased risk for extended control system outages as existing control panel equipment continues to age.

8.13 EXISTING EAST AND WEST BLOWER MEDIUM-VOLTAGE SWITCHGEAR

The East Blower Building and the West Blower Building each house medium-voltage (4.16 kV) switchgear lineups with starters for each blower motor, except for Blower No. 1 in the East Blower Building, which is powered with a digester gas-fueled engine. The East Blower Building has a main switchgear lineup with the main and tie switches and starters for Blowers No. 4 and No. 5, as well as a remote switchgear lineup with starters for Blowers No. 2 and 3. The remote lineup is powered from the main switchgear lineup with redundant power feeds. All motor starters in the West Blower Building switchgear are part of one continuous lineup. The switchgear in both buildings are powered with redundant 4.16-kV power feeds from either side of the main switchgear S1 bus-tie circuit breaker.

Both of the medium-voltage switchgear lineups are regularly inspected and maintained, but are operating beyond their expected service life of 30 years. The East Blower Building’s switchgear was installed in 1963 and the West Blower Building's switchgear was installed in 1985.

The East Blower Building’s medium-voltage switchgear (S141 & S142) powers the following equipment:

- Blower No. 2: 600 horsepower (HP)
- Blower No. 3: 600 HP
- Blower No. 4: 375/500 HP (two-speed, two-winding motor)
- Blower No. 5: 315/450 HP (two-speed, two winding motor)

The West Blower Building’s medium-voltage switchgear (M51) powers the following equipment:

- Blower No. 1: 1,250 HP
- Blower No. 2: 1,250 HP
- Blower No. 3: 1,250 HP

8.14 EAST AND WEST BLOWERS MEDIUM-VOLTAGE SWITCHGEAR REPLACEMENT ALTERNATIVES IDENTIFICATION AND SCREENING

Based on discussion at Workshop No. 8, the following alternatives for the east and west blower medium-voltage switchgear replacement (BMC) were selected to be evaluated further:
Each of these alternatives are evaluated further in the following sections.

### 8.15 DESCRIPTION OF BMC ALTERNATIVES

This section includes a detailed evaluation of the East and West Blowers Medium-Voltage Switchgear Replacement Alternatives.

**A. Alternative BMC No. 0–No Change (Null Alternative)**

Alternative BMC No. 0 would leave both the existing East Blower Building and West Blower Building medium-voltage switchgear in place and powering the blower motors.

The West Blower Building switchgear has been in service for about 32 years and the East Blower Building switchgear has been in service for over 50 years, but have maintained consistent, reliable operation thus far. While there are many examples of switchgear equipment operating for more than 50 years, the expected service life for medium-voltage switchgear is about 30 years. Operating beyond 30 years introduces a greater chance for arc-fault events due to failed insulation, failed switch mechanisms, failed bus hardware, and other potential causes. Operating switchgear beyond its expected service life is possible with proper routine maintenance and testing, but the risk of equipment failure will still increase as equipment ages. Risks can be minimized by reconditioning switchgear with new components, but reconditioning efforts would still not account for the improved reliability and safety that could be provided with modern switchgear.

Since the original switchgear installations, advancements have been made in switchgear insulating technologies, switch mechanism reliability, and enclosure safety. New arc-resistant switchgear is also available to redirect the massive expansion of gas and molten conductor metal out of ducted passages and away from personnel in front of the switchgear. Photo-sensors and high-speed relays can now be used to quickly detect and clear arc-faults. Draw-out motor controller construction can also be used to improve equipment access and improve safety when maintaining equipment.

In addition to failures resulting from equipment aging, equipment grounding systems must also be considered for regular replacement. It is not uncommon for below-grade ground rods and conductors to corrode beyond the point where it can successfully transmit ground-fault currents.

**B. Alternative BMC No. 1–Replace East Blower Building Switchgear**

This alternative includes replacing the East Blower Building switchgear with a new switchgear to power the existing blower motors. A switchgear would be installed in the same location as the existing switchgear and existing below-grade, concrete-encased duct bank could be reused to refeed the new switchgear with new medium-voltage cables from main switchgear S1 in the Effluent Building. The existing switchgear configuration allows switchgear replacement on one side of the tie while Blower Nos. 2, 3, and 5 remain energized and replacement on the other side once Blower No. 4 is energized from the new switchgear.
Future blower equipment upgrades could potentially include a change from blowers using medium-voltage motors to blowers using multiple 480-volt motors. If 480-volt blower motors are selected for the upgrade, new 480-volt variable frequency drives or reduced-voltage solid-state starters, and potentially a new unit substation, would have to be installed. As a result, the new medium-voltage motor starters proposed as part of this alternative would no longer be used to power the blowers.

C. Alternative BMC No. 2—Replace West Blower Building Switchgear

This alternative includes replacing the West Blower Building switchgear with new switchgear to power the existing blower motors. Switchgear would be installed in the same location as the existing switchgear and existing below-grade, concrete-encased duct bank could be reused to refeed the new switchgear with new medium-voltage cables from main switchgear S1 in the Effluent Building. The existing switchgear configuration allows switchgear replacement on one side of the tie while Blowers Nos. 2 and 3 remain energized and replacement on the other side once Blower No. 1 is energized from the new switchgear.

Future blower equipment upgrades could potentially include a change from blowers using medium-voltage motors to blowers using multiple 480-volt motors. If 480-volt blower motors are selected for the upgrade, new 480-volt variable frequency drives or reduced-voltage solid-state starters, and potentially a new unit substation, would have to be installed. As a result, the new medium-voltage motor starters proposed as part of this alternative would no longer be used to power the blowers.

8.16 BMC ALTERNATIVES COST EVALUATION

Table 8.16-1 presents a summary of the opinion of probable construction costs for each of the East and West Blowers Medium-Voltage Switchgear Replacement alternatives.

There are no upfront costs associated with Alternative BMC No. 0. There would be future costs associated with the time and materials required for District maintenance staff to troubleshoot and repair switchgear equipment as it fails, which are not able to be reliably estimated. The budgetary opinions of probable construction cost for Alternative BMC No. 1 and No. 2 are based on non-fused main and tie switches and draw-out style motor controllers.

<table>
<thead>
<tr>
<th>Alternative BMC No. 0—No Change (Null Alternative)</th>
<th>Alternative BMC No. 1—Replace East Blower Building Switchgear</th>
<th>Alternative BMC No. 2—Replace West Blower Building Switchgear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Opinion of Capital Cost</td>
<td>$0</td>
<td>$1,136,000</td>
</tr>
</tbody>
</table>

Table 8.16-1 BMC Alternatives Opinion of Probable Construction Cost Summary
8.17 BMC ALTERNATIVES NONMONETARY CONSIDERATIONS

Nonmonetary considerations for each alternative were evaluated and are summarized in Table 8.17-1.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative BMC No. 0–No Change (Null Alternative)</td>
<td>• If the blowers are eventually replaced with blowers using 480-volt motors, the District would avoid buying new switchgear that could not be reused to power the new 480-volt blower motors.</td>
<td>• The switchgear equipment is operating beyond its expected service life and the potential for equipment failures will increase as equipment ages. • Switchgear reliability and safety could be improved if replaced with new equipment using improved operating mechanisms and draw-out motor controller construction. • Newer draw-out style motor starters would improve access to equipment and simplify maintenance.</td>
</tr>
<tr>
<td>Alternative BMC No. 1–Replace East Blower Building Switchgear</td>
<td>• Switchgear reliability and safety would be improved. • Replacing aging medium-voltage cables would address concerns with the increasing potential for arc-fault events. • Newer draw-out style motor starters would improve access to equipment and simplify maintenance.</td>
<td>• If new blower equipment uses 480-volt motors, this new switchgear would need to be replaced with 480-volt VFDs and motor controls.</td>
</tr>
<tr>
<td>Alternative BMC No. 2–Replace West Blower Building Switchgear</td>
<td>• Switchgear reliability and safety would be improved. • Replacing aging medium-voltage cables would address concerns with the increasing potential for arc-fault events. • Newer draw-out style motor starters would improve access to equipment and simplify maintenance.</td>
<td>• If new blower equipment uses 480-volt motors, this new switchgear would need to be replaced with 480-volt VFDs and motor controls.</td>
</tr>
</tbody>
</table>

Table 8.17-1 BMC Alternative Nonmonetary Considerations Summary

8.18 BMC ALTERNATIVE RECOMMENDATION

We recommend that the District first decide on what type of future blower equipment will be installed before deciding on which medium-voltage switchgear to replace. If future blower equipment upgrades will also use 4.16-kV motors, then both Alternatives BMC No. 1 and BMC No. 2 should be prioritized in
order to upgrade all of the existing blower building switchgear lineups with new switchgear. The existing switchgear and associated medium-voltage conductors are operating beyond their expected service life, and new equipment would address reliability concerns and introduce equipment with enhanced operating and safety features.

8.19 EXISTING UNIT SUBSTATIONS U11, U12, AND U13

Unit substations at the NSWWTP are used to interface with underground 4.16-kV distribution lines powered from main switchgear S1 in the Effluent Building. The unit substation transformers step the distribution system voltage down from 4.16 kV to 480 volts and then distribute 480-volt power to the various motor control centers and distribution panels in each building.

Unit substations U11, U12, and U13 were originally installed in 1984 and brought online in 1985. Outdoor unit substations should be replaced every 25 to 30 years, and these three unit substations have been operating for about 32 years. The unit substation equipment enclosures are significantly corroded, which increases the likelihood of damage to equipment from rain, snow, and rodent intrusion. The District regularly maintains major electrical distribution equipment and also hires a consultant to periodically inspect the equipment every three years. A detailed report of the latest evaluation performed by A.C. Engineering Company, dated May 11, 2015, noted that unit substations U11, U12, and U13 are “very rusted and deteriorated,” and recommends that all equipment at these unit substations “be replaced as soon as possible.”

Unit substation U11 is located directly west of the West Blower Building and serves two MCCs in the West Blower Building and two MCCs in Storage Building No. 3. The unit is located along a NSWWTP roadway and parking lot and does not have any physical barriers protecting it from vehicle traffic.

Unit substation U12 is located at the northwest corner of the Effluent Building and serves the two MCCs in the Effluent Building and two MCCs in Aeration Control Building No. 4. The unit substation is located in a damp/wet area that is often shaded from sunlight, and as a result, equipment enclosures at this unit substation retain moisture longer than equipment at other unit substations that have more exposure to sunlight.

Unit substation U13 is located directly west of Shop Building No. 1 and serves a disconnect switch at the Service Building, an MCC in Shop Building No. 1, and a fused disconnect switch in Shop Building No. 2. The unit substation is located along a NSWWTP roadway and has four bollards protecting it from vehicle traffic. The load on this unit substation has been significantly reduced since maintenance operations and staff moved to the recently-constructed Maintenance Building. This unit substation is unique to the others in that it has only a single transformer, but a redundant 480-volt power feed is supplied to it from unit substation U2.

Reliable unit substations are critical to maintaining consistent NSWWTP operation. Unit substations U11 and U12 serve critical process buildings with redundant 480-volt feeders, and a critical failure in the 480-volt distribution section of these unit substations would result in an extended power outage to one or more buildings.
8.20 UNIT SUBSTATIONS U11, U12, and U13 REPLACEMENT ALTERNATIVES IDENTIFICATION AND SCREENING

Based on discussion at Workshop No. 8, the following alternatives for the unit substations U11, U12, and U13 replacement were selected to be evaluated further:

- Alternative USUB No. 0–No Change (Null Alternative)
- Alternative USUB No. 2–Replace Unit Substations U11 and U12 with One New Indoor Unit Substation and Eliminate Unit Substation U13
- Alternative USUB No. 3–Replace Unit Substation U12 with One New Indoor Unit Substation and Eliminate Unit Substations U11 and U13

Each of these alternatives are evaluated further in the following sections.

8.21 DESCRIPTION OF USUB ALTERNATIVES

This section includes a detailed evaluation of each short-listed unit substations U11, U12, and U13 Replacement Alternative.

A. Alternative USUB No. 0–No Change (Null Alternative)

Alternative USUB No. 0 would leave existing unit substations U11, U12, and U13 in operation. Unit substation U13 now serves non-critical loads and its electrical load has been significantly reduced since maintenance operations and staff moved to the recently-constructed Maintenance Building. However, unit substations U11 and U12 serve critical processes loads that could significantly affect NSWWTP operation if unit substation equipment fails.

B. Alternative USUB No. 2–Replace Unit Substations U11 and U12 with One New Indoor Unit Substation and Eliminate Unit Substation U13

Alternative USUB No. 2 would replace unit substations U11 and U12 with one new large, indoor unit substation located approximately equidistant from both existing unit substations to serve all of the existing unit substations U11 and U12 electrical loads, except for two MCCs in Storage Building No. 3, which are currently fed from unit substation U11 but could be refed more economically from nearby unit substation U15. Unit substation U13 would be removed entirely and its existing loads would be refed from existing unit substation U2 and a new 480-volt MCC in Shop Building No. 1.

This alternative includes one new large unit substation to feed the existing 480-volt loads currently fed from unit substations U11 and U12. The unit substation would also include additional capacity to serve future equipment associated with NSWWTP process expansion on the west side of the NSWWTP. This substation would be housed in a building with a below-grade cable vault, heating and mechanical cooling, and a new concrete-encased duct bank to reroute fiber optic cabling to the building.

This alternative also includes power meters each 480-volt main circuit, a new 480-volt MCC in the new unit substation building to serve miscellaneous building and HVAC loads, new concrete-encased duct bank from the existing manhole southeast of the Effluent Building to the new substation building, and the
replacement of MCCs in Storage Building No. 3 and Shop Building No. 1. Redundant 2,000 kVA transformers with fused, medium-voltage primary switches are assumed in this alternative.

C. Alternative USUB No. 3—Replace Unit Substation U12 with One New Indoor Unit Substation and Eliminate Unit Substations U11 and U13

Alternative USUB No. 3 would replace unit substation U12 with one new indoor unit substation located near the Effluent Building, and unit substations U11 and U13 would be removed entirely. Unit substation U11 loads would be refed from unit substation U14 located in the Metrogro Pump Station. The two MCCs in Storage Building No. 3 that are currently fed from unit substation U11 and would be replaced with one new MCC that could be powered from nearby unit substation U15. Unit substation U13 would be removed entirely and its existing loads would be refed from existing unit substation U2 and a new 480-volt MCC in Shop Building No. 1.

This alternative includes one new unit substation to feed the existing 480-volt loads currently fed from unit substation U12. The unit substation would also include additional capacity to serve potential future equipment associated with NSWWTP process expansion west of the Effluent Building. This substation would be housed in an extension of the existing Effluent Building with a below-grade cable vault and heating and mechanical cooling. New concrete-encased duct bank with new power feeds to the MCCs in the Aeration Control Building No. 4, from U14 to the West Blower Building, and from the existing U12 location to the new U12 location are also provided in this alternative.

This alternative also includes power meters each 480-volt main circuit, a new 480-volt MCC in the new unit substation building to serve miscellaneous building and HVAC loads, and the replacement of MCCs in Storage Building No. 3 and Shop Building No. 1. Redundant 1,500 kVA transformers with fused, medium-voltage primary switches are assumed in this alternative.

This alternative would provide the District with an opportunity to upgrade the existing unit substation U14 480-volt distribution switchboards with draw-out switchgear construction. This switchgear installation is included in the opinion of probable construction cost for this alternative.

8.22 USUB ALTERNATIVES COST EVALUATION

Table 8.22-1 presents a summary of the opinion of probable construction costs for each of Unit Substations U11, U12, and U13 replacement alternatives.

There are no upfront costs associated with Alternative USUB No. 0. There would be future costs associated with the time and materials required for District maintenance staff to troubleshoot and repair unit substation equipment as it fails, which are not able to be reliably estimated.

The budgetary opinions of probable construction cost for Alternative USUB No. 2 and No. 3 are based on the use of indoor, dry-type unit substation transformers. An upfront-cost evaluation associated with the use of indoor, dry-type or outdoor, liquid-filled transformers is included later in this memorandum in alternatives USUB-XFMR No. 1 and USUB-XFMR No. 2. The long-term operating costs of these alternatives would increase because outdoor unit substations are being replaced with a new unit substation building and the additional energy consumed by building electrical and HVAC loads. However,
replacing old unit substation equipment and wiring would improve the power distribution system reliability and reduce the likelihood of conductor faults.

The OPCC for Alternative USUB No. 3 also includes the cost to upgrade the 480-volt distribution sections in unit substation U14 to draw-out switchgear construction, including new circuit breakers for all existing loads and the new power feeds to the West Blower Building MCCs. Installing new circuit breakers in the existing unit substation U14 480-volt distribution sections instead of replacing the sections with draw-out switchgear could reduce the OPCC by approximately $90,000.

<table>
<thead>
<tr>
<th>Alternative USUB No. 0– No Change (Null Alternative)</th>
<th>Alternative USUB No. 2– Replace Unit Substations U11 and U12 with One New Indoor Unit Substation and Eliminate Unit Substation U13</th>
<th>Alternative USUB No. 3– Replace Unit Substation U12 with One New Indoor Unit Substation and Eliminate Unit Substations U11 and U13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Opinion of Capital Cost</td>
<td>$0</td>
<td>$3,227,000</td>
</tr>
</tbody>
</table>

Table 8.22-1 USUB Alternatives Opinion of Probable Construction Cost Summary

8.23 USUB ALTERNATIVES NONMONETARY CONSIDERATIONS

Nonmonetary considerations for each alternative were evaluated and are summarized in Table 8.23-1.
### Table 8.23-1 USUB Alternative Nonmonetary Considerations Summary

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative USUB No. 0—No Change (Null Alternative)</td>
<td>▪ None</td>
<td>▪ Unit substation equipment is operating beyond its expected service life and the potential for equipment failure will increase as equipment ages.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Unit substation equipment enclosures are severely rusted, which increases the likelihood of damage to equipment from rain, snow, and rodent intrusion.</td>
</tr>
<tr>
<td>Alternative USUB No. 2—Replace Unit Substations U11 and U12 with One New Indoor Unit Substation and Eliminate Unit Substation U13</td>
<td>▪ Replacing aging unit substation equipment would address concerns with the potential for increased equipment failures. ▪ One new unit substation is being installed while three unit substations are being removed, two of which are currently located near roadways/parking lots. ▪ New equipment would be located inside of a building, which helps equipment last longer and provides a safer environment for operating and maintaining the equipment. ▪ Replacing aging medium-voltage cables would address concerns with the increasing potential for arc-fault events.</td>
<td>▪ The only location central to the loads served by the new unit substation impedes on an existing storage lot area and might require earthwork to avoid restricting the drainage swale.</td>
</tr>
<tr>
<td>Alternative USUB No. 3—Replace Unit Substation U12 with One New Indoor Unit Substation and Eliminate Unit Substations U11 and U13</td>
<td>▪ Replacing aging unit substation equipment would address concerns with the potential for increased equipment failures. ▪ One new unit substation is being installed while three unit substations are being removed, two of which are currently located near roadways/parking lots. ▪ This alternative takes advantage of spare capacity in existing unit substations U2, U14, and U15 to feed loads currently served by existing unit substations U11 and U13. ▪ New unit substation U12 equipment would be located inside of a building, which helps equipment last longer and provides a safer environment for operating and maintaining the equipment. ▪ Replacing aging medium-voltage cable would address concerns with aging conductor insulation that could lead to future arc-fault events.</td>
<td>▪ Any NSWWTP process expansion to the west would require longer power feeds from unit substation U12 and/or unit substation U14.</td>
</tr>
</tbody>
</table>
8.24 USUB ALTERNATIVES RECOMMENDATION

The recommended unit substations U11, U12, and U13 Replacement alternative is Alternative USUB No. 3. This alternative replaces three existing unit substations with one unit substation and takes advantage of existing electrical capacity in unit substations U2, U14, and U15 to power existing loads currently served by unit substations U11 and U13.

This alternative does require some NSWWTP roadway reconstruction associated with new concrete-encased duct bank conduits that would need to be routed from unit substation U14 to the West Blower Building. However, reusing existing unit substation capacity would reduce the size of the new unit substation building and electrical equipment, which would reduce upfront equipment and installation costs.

8.25 EVALUATION OF INDOOR AND OUTDOOR UNIT SUBSTATION TRANSFORMERS

An evaluation of using indoor dry-type unit transformers versus liquid filled transformers was conducted that corresponds with the unit substation evaluation presented earlier in this section. Dry-type unit substation transformers are commonly used for indoor unit substations instead of liquid-filled transformers because they do not use oil for cooling, which eliminates the need for spill containment, they are non-flammable, and they can be located directly in line with the unit substation medium-voltage and low-voltage switchgear. Liquid-filled transformers are commonly used for outdoor unit substations because they are sealed and use oil-filled heat-sinks to radiate heat. While locating transformers outdoors allows for a smaller unit substation building to be constructed and removes significant heat load from the building, there is a slight increase in risk of damage due to water leaks, corrosion, and rodent intrusion.

8.26 NEW UNIT SUBSTATION TRANSFORMER ALTERNATIVES IDENTIFICATION AND SCREENING

Based on discussion at Workshop No. 8, the following alternatives for the new unit substation transformer were selected to be evaluated further:

- Alternative USUB-XFMR No. 1–Indoor, Dry-Type Unit Substation Transformers
- Alternative USUB-XFMR No. 2–Outdoor, Liquid-Filled Unit Substation Transformers

Each of these alternatives are evaluated further in the following sections.

8.27 DESCRIPTION OF USUB-XFMR ALTERNATIVES

This section includes a detailed evaluation of both short-listed Unit Substation Transformer Alternatives.

A. Alternative USUB-XFMR No. 1–Indoor, Dry-Type Unit Substation Transformers

Alternative USUB-XFMR No. 1 would use indoor, dry-type transformers for the new NSWWTP unit substations previously identified under Alternatives USUB No. 2 and USUB No. 3.

Dry-type unit substation transformers are commonly used for indoor unit substations instead of liquid-filled transformers because they do not require oil spill containment, are non-flammable, and can be located directly in line with the unit substation medium-voltage and low-voltage switchgear. Existing indoor unit substations at the NSWWTP currently use indoor, dry-type transformers and outdoor unit substations use liquid-filled transformers.
Dry-type transformers require less maintenance than liquid-filled transformers, although the additional maintenance required for liquid-filled transformers is relatively minor. Indoor, dry-type transformers require a larger building size to house them and also add a significant heat load inside the building, which increases cooling demand during the summer months but supplements heating equipment during the winter months. Indoor transformers are also difficult to remove and replace relative to how easily outdoor transformers can be accessed and replaced.

B. Alternative USUB-XFMR No. 2—Outdoor, Liquid-Filled Unit Substation Transformers

Alternative USUB-XFMR No. 2 would use outdoor, liquid-filled transformers for the new NSWWTP substations previously identified under Alternatives USUB No. 2 and USUB No. 3.

Liquid-filled transformers are commonly used for outdoor unit substations because they are sealed and use heat-sink fins to radiate heat instead of open ventilation louvers and fans. The sealed construction fully protects the transformer windings from environmental damage. Locating unit substation transformers outdoors allows for a smaller unit substation building to be constructed and provides easier access to the transformers for replacement. Liquid-filled transformers are also slightly more efficient than dry-type transformers.

Liquid-filled transformers require slightly more maintenance than dry-type transformers and introduce a potential fire hazard from the use of cooling/insulating oil, although the risk of fire can be significantly reduced with the use of new less-flammable fluids. Due to the use of cooling/insulating oil, liquid spill containment structures or below-grade geo-synthetic barriers are also required to contain transformer oil leaks.

Locating transformers outdoors also provides a slight increase in risk of damage from water ingress and rodent intrusion, although this type of damage is rarely experienced. However, if paint on an outdoor transformer’s enclosure is scratched, the enclosure could begin to rust and increase the likelihood of premature failure.

8.28 USUB-XFMR COST EVALUATION

Table 8.28-1 compares opinions of probable construction costs associated with using indoor versus outdoor transformers for the unit substation alternatives detailed under Alternatives USUB No. 2 and USUB No. 3. There would be additional costs associated with transformer oil containment structures for outdoor transformers, which are not included in Table 8.28-1. Costs for larger air conditioning equipment and a larger unit substation building when using indoor, dry-type unit substation transformers instead of using outdoor, liquid-filled transformers is included, as well as addition conduit and wiring required to use an outdoor transformer.

While indoor transformers would require additional cooling demand inside the unit substation building during the summer months, the heat output from the transformer would supplement heating equipment operating during the winter months. A detailed analysis during project design would need to be performed to accurately determine the actual expected operating times for heating and cooling equipment to determine the potential operating cost savings associated with using indoor or outdoor transformers.
8.29 USUB-XFMR ALTERNATIVES RECOMMENDATION

The recommended alternative is Unit Substation Transformer Alternative No. 2 because outdoor, liquid-filled transformers will reduce upfront costs for the unit substation building and HVAC equipment, will operate more efficiently, and will fully-protect the transformer windings from corrosive gasses. Based on the District’s consistent maintenance and inspection efforts, it is reasonable to expect that liquid-filled transformers would be properly maintained and could be expected to have a longer operating life than dry-type transformers. The additional transformer maintenance associated with liquid-filled transformers is minor, and transformer failure due to water or rodent ingress is unlikely.
This section presents a summary of additional evaluations and capital upgrades recommended for the NSWWTP that did not fit within the context of the previous evaluations and Facilities Plan sections. Some of these evaluations were developed in the technical memoranda (see Appendices), while others are included herein because of a stated need that was discovered through the various workshops, meetings, and interim deliverables.

Figure 9.01-1 provides a potential location for the metering structures at the plant, as well as other miscellaneous projects highlighted in this section of the Facilities Plan. Table 9.07-1 provides an opinion of probable cost for the structures and related facilities and services.

### 9.01 EAST-WEST PLANT FLOW METERING

All flows to the NSWWTP are measured using venturi flow meters upstream of the screening facilities. Following screening and grit removal, flows are split between the east and west plants but are not directly measured in terms of flow to each side. In the west plant, there are four magnetic flow meters that measure primary effluent flow into each of the four activated sludge trains. However, because of the location of these flow meters, calibration of the meters is not practical and has not been practiced. These flow meters are mainly used for process control to throttle the primary effluent valves into the activated sludge trains. East plant flows are estimated based on the difference between mixed liquor flows and RAS flows.

Based on the review of the flow data provided by the District for the activated sludge technical memorandum (TM-5, Appendix E), it became clear that the flow metering at the west plant was likely not accurate. This was evidenced by the fact that the flow measures at the west plant were less than the calculated flows to the east plant, even though the main flow splitter structure was set up to divert more flow to the west plant under normal flow conditions. Because of this situation, as well as the importance of accurately measuring flows to each plant for process control purposes, we recommend improving flow metering to both the east and west plants.

If new Parshall flumes are preferred for flow metering, the hydraulic grade line appears to have available head for flow metering downstream of the east-west splitter structure based on the plant hydraulic model (TM-4, Appendix D). New Parshall flumes should accommodate nearly all hydraulic conditions for both the east and west plants without surcharging. On the west plant, assuming an equal flow split to each plant, the new flume should be able to be constructed to avoid surcharging under all anticipated flows up to 90 mgd to the west plant. At the east plant, flows above about 80 mgd to the east plant would likely surcharge the new flume to the east plant. While this is not ideal, the main purpose of the flumes is for process control, and potentially inaccurate flow measurement to one-half of the plant under very rare conditions is not a significant concern. The main drawback of using Parshall flumes is the considerable cost of constructing new concrete structures to house the new flumes. The main pipes serving the east and west plants are fairly deep, and the opinion of construction costs for the new structures and metering equipment is approximately $100,000 to $150,000 for each side, or $200,000 to $300,000 total.

One alternative includes a relatively new in-pipe flow metering technology that would not require construction of significant concrete structures. This technology (e.g., Teledyne ISCO accQpulse™ Velocity Profiler) uses a pressure transducer and measures flow velocity at several locations across the pipe/channel cross section, and can be installed within an existing pipe at a manhole or structure location. This technology provides a ± 2 percent accuracy based on the company’s literature, which is adequate
Primary Tanks No. 1 and No. 2 Rehabilitation

54" Primary Influent Pipe Rehabilitation

West Plant Flow Metering Station

East Plant Flow Metering Station

Effluent Pump Station Overflow To Grade
for this application. For the purposes of this Facilities Plan, we have assumed that a new access structure would be required in both the east and west plants, which would include a large-diameter manhole. The opinion of cost for this alternative is approximately $50,000 to 75,000 for each side, or approximately $100,000 to $150,000 total. If an existing structure proves suitable for installation of the meters, these costs could potentially be reduced to about $30,000-$40,000 for each metering location, or $60,000 to $80,000 total.

For the purposes of this Facilities Plan, we have included this alternative “in-pipe” metering equipment and have assumed that new structures would be required. A total project budget of $150,000 is recommended. We also recommend the District pilot test the equipment in an accessible pipe to demonstrate accuracy and viability of the technology.

9.02 PRIMARY CLARIFIERS NO. 1 AND NO. 2 REHABILITATION

Primary Clarifiers No. 1 and No. 2 are part of the east plant battery of primary clarifiers and were constructed in the early 1930s as part of the First Addition to the NSWWTP. These tanks have been in service for more than 80 years, and are still in serviceable condition. The structural condition of these tanks was assessed to identify structural deficiencies and develop rehabilitation costs for these tanks to include in the District’s capital plan.

A summary of the condition assessment conducted on these tanks is included in TM-3 (Appendix C) along with photos of the tanks’ noted deficiencies. The opinion of cost to rehabilitate the tank structures is approximately $450,000.

9.03 EAST PRIMARY INFLUENT PIPE REHABILITATION/REPLACEMENT

The east primary influent pipe is a 54-inch pre-stressed concrete cylinder pipe (PCCP). The pipe was installed in about 1975 as part of the 5th addition to the NSWWTP and conveys wastewater approximately 500 feet from Junction Structure No. 2 to the east primary clarifier influent channel. The District previously videotaped the inside of the pipe in 2007, and the video footage was provided to Strand Associates, Inc.® (Strand) for review. The purpose of this review was to develop rehabilitation costs for this pipe to include in the District’s capital plan.

Based on our hydraulic analysis, the existing 54-inch pipe has adequate capacity to accommodate higher future flows, and, therefore, replacement of the pipe to increase hydraulic capacity is not anticipated to be needed within the planning period. The existing pipe will need to be in serviceable condition throughout the planning horizon of this Facilities Plan, and it will require some form of rehabilitation to restore the overall integrity and reliability of the piping. Strand reviewed the closed circuit television (CCTV) video of the sewer conducted by the District in 2007. Detailed notes related to the CCTV review are included in TM3, which is included at Appendix C.

Rehabilitation options focused on trenchless alternatives (vs. conventional “open cut” techniques). This would involve application of a coating that is applied once the system has been thoroughly cleaned. The coatings evaluated included a corrosion-resistant cementitious lining, a polymer-based spray-on lining system, and epoxy coatings. The costs for coating options range from about $300 to $600 per lineal foot and include the necessary preparation work and access chambers for equipment and personnel. Total budgetary costs, including pipe cleaning, bypass pumping, engineering, and contingencies, are in the range of $300,000 to $600,000. Full replacement of the pipe would be expected to be in the range of $500,000 to $800,000.
Prior to developing a final plan to rehabilitate or replace this pipe, we recommend televising the line again to determine whether its condition has deteriorated significantly in the last 10 years. For the purposes of this planning document, we recommend including a budget of $800,000 in the capital plan as a conservative placeholder.

9.04 EFFLUENT PUMPING STATION HYDRAULIC BACKFLOW PROTECTION

There have been at least two occurrences where the effluent pumps failed and the effluent pumping station wet well surcharged. This caused water to leak onto the floor above the wet well. Electrical controls and gear for the effluent pumps are located in the room above the wet well, and there is concern that future occurrences could structurally damage the floor and/or damage the electrical equipment, resulting in a catastrophic failure and the system being out of service for an extended period of time.

The main concern is during peak flow events, when the effluent storage tanks and the wet well are full, and three large effluent pumps are pumping about 76 mgd. Under an emergency shut down condition, the three pumps will stop pumping and the discharge cone valves will close over a 30-second period. During this time, wastewater in the 54-inch force main will reverse flow and flow back through the pumps and into the wet well. Because the storage tanks are typically full, there is not enough hydraulic head to push flow all the way to the effluent storage tanks at the volumetric rate needed. Therefore, the wet well top slab can become pressurized.

This concern was discussed at both the disinfection workshop as well as the electrical reliability workshop. The following alternatives were considered and are discussed further in the following:

- Relocate the electrical controls and gear.
- Construct an overflow from the wet well to the ground.
- Close the cone check valves more quickly.

A. Relocate the Electrical Controls and Gear

Relocating the electrical control and gear would require construction of an addition to the Effluent Building to house the existing electrical controls. Based on the existing area of approximately 25 feet by 84 feet, a building addition of 2,100 square feet would be required. At an approximate cost of $200 per square foot, the addition would be approximately $400,000 plus the cost of relocating the gear. If the electrical equipment is moved, however, a wet well surcharge could still cause structural damage. Based on discussion with District staff at the technical workshops, this alternative was decided to be too expensive and was not considered further.

B. Construct an Overflow from the Wet Well to the Ground

Constructing an overflow from the wet well to the ground outside of the Effluent Building would provide protection of the structure and electrical gear by installing piping to the exterior of the Effluent Building. Effluent forcemain surge modeling indicated that approximately 5,000 gallons of backflow over a 30-second period is anticipated. This represents an average flow rate of 10,000 gpm, with a peak of approximately 24,000 gpm [53.5 cubic feet per second (cfs)]. Because of the relatively small wet well and the considerable complexity of finding a suitable location for the overflow and route to the exterior, multiple pipes may be required rather than one large diameter pipe. In addition, there is a good likelihood of overflow at any time.
that structural and other building modifications will be required because of the location of the wet well and the surrounding process and building elements. Finally, although overflows would be a rare occurrence, the WDNR will need to approve the proposed overflow concept. This option would need to be evaluated in considerable detail during a preliminary design phase to establish actual routing and construction requirements. A minimum budget of about $100,000 should be included, and based on a preliminary review of the structure and potential conflicts, we recommend budgeting $200,000 for this alternative.

C. **Close Cone Check Valves More Quickly**

If the cone check valves are adjusted to close more rapidly in the event of pump failure, this would reduce the backflow of wastewater into the pumping station wet well. While this may minimize wet well surges, care must be taken not to cause a significant pressure surge in the forcemain and potentially damage the effluent piping through significant negative and positive pressures that would result from a more rapid closing. The existing calculated negative pressures already exceed the nominal specified negative pressure for this pipe. Therefore, we recommend testing of the pipe and additional monitoring of pressures before this alternative is implemented.

The peak flow management recommendations included construction of improvements to better manage the hydraulic profile through the plant, which included the ability to lower the hydraulic grade line through the east plant to divert more volume to the lagoons. This modification will allow the District to better manage the hydraulics through the UV disinfection facilities as well as to the effluent pumping station. The existing wet well has dimensions of about 184 feet long, 10 feet wide, and a total depth of about 17 feet to the bottom of the elevated slab. A weir wall separates the UV disinfection facilities from the wet well, and the top of the weir wall is approximately 13 feet above the floor of the wet well. Given the very long broad crested weir length, the water level over the weir wall would be about 7 inches if the effluent wet well level were at the top of the weir wall at a flow of 80 mgd (122 cfs). The volume available in the wet well under these conditions is in excess of 45,000 gallons before reaching the top slab of the wet well. Therefore, if the hydraulic grade line is maintained at a lower elevation in the effluent wet well under maximum flow conditions, there appears to be ample volume to store the anticipated volume of backflow into the effluent wet well. Based on this analysis, we recommend that a detailed hydraulic analysis be conducted as part of the preliminary design phase of the peak flow management improvements to verify that the proposed overflow structure (with variable weir elevation) will also mitigate the concern with backflow into the effluent pump station wet well under emergency conditions.

**9.05 EFFLUENT FORCE MAIN STANDPIPE MODIFICATIONS**

The 54-inch effluent force main from the effluent pumping station to the Badfish Creek discharge location includes a standpipe that was installed to provide a positive air release location along the force main route. The standpipe includes about 21 feet of 12-inch ductile iron pipe, with a transition to an additional 20 feet of 16-inch ductile iron pipe. Video footage of one event indicates wastewater is pushed up the standpipe because of large volumes of air within the force main. That is, the standpipe does not overflow, but rather wastewater is forcibly lifted in the standpipe and is expelled with large volumes of air. Force main surge modeling confirmed this understanding and indicates the hydraulic grade line elevation at the standpipe location does not exceed the top of the standpipe (TM-3, Appendix C).
The total potential discharge volume of treated effluent wastewater from the standpipe is not known, nor is the quantity predictable. While the volume of discharge is inconsequential in comparison to the total volumes pumped, and while the wastewater is highly treated and likely does not create an environmental concern, the District wishes to eliminate the surge overflow to the extent practical.

Some of the video footage showed wastewater being discharged more than 10 to 20 feet into the air above the current standpipe. If the standpipe diameter was increased by a factor of 2 or 3 about half way up the standpipe, we believe the wastewater carried with the air would not be expelled from the pipe. For budgetary purposes, we recommend the District include a budget of about $100,000 to conduct more detailed investigations and to replace the approximate 45 feet of standpipe with larger diameter pipe and potentially other modifications.

9.06 PROCESS CONTROL SYSTEM (PCS) PHASE II UPGRADES

The 2012 PCS Facilities Plan was developed to plan the upgrade and replacement of the NSWWTP process control system. The PCS plan is being implemented in two main phases, and Phase I has been completed. Phase II was originally planned to coincide with the upgrades to the east and west blowers, blower controls, and aeration system controls. At the time of the 2012 PCS Facilities Plan development, it was believed that these improvements would be implemented within the next 5 to 7 years (prior to 2020). However, as developed within this current Liquid Processing Facilities Plan, aeration system and blower controls addressed with the PCS Phased II project may not be upgraded until 2024 or later.

The Phase II project will replace the remaining 10 Bristol Babcock distributed control units (DCUs) that were left in place during the Process Control System Upgrade–Phase I. The manufacturer of the DCUs (Bristol Babcock) declared these controllers obsolete as of 2011. Replacement parts for the controllers are no longer available. Configuring the controllers also relies on an operating system that has been obsolete since 2004 (Windows NT). Therefore, the recommendation is to proceed with the PCS Phase II upgrades identified in the 2012 PCS Facilities Plan. District staff and Strand Associates have reviewed the previous facilities plan, and the budget associated with the Phase II project has an opinion of cost of approximately $1,500,000. These upgrades are recommended to be completed as part of the “near term” LPFP upgrade project as provided in Section 10 of this Facilities Plan.

9.07 RECOMMENDATIONS

This section includes a summary of miscellaneous modifications that may be included in future capital projects. Each of the sections provides justification for the various project elements, with a recommendation for implementation and an opinion of cost. These analyses and recommendations are summarized in Table 9.07-1.
## Table 9.07-1 Miscellaneous Modifications Opinion of Cost Summary

<table>
<thead>
<tr>
<th>Project Element/Description</th>
<th>Alternative to Include in Budget</th>
<th>Recommended Budget</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>East-West Flow Metering</td>
<td>In-Pipe Doppler</td>
<td>$150,000</td>
<td>Could potentially be reduced; recommend pilot testing.</td>
</tr>
<tr>
<td>Primary Tanks Nos. 1 and 2</td>
<td>Rehabilitate</td>
<td>$450,000</td>
<td></td>
</tr>
<tr>
<td>East Primary Influent Rehab or Replace</td>
<td></td>
<td>$800,000</td>
<td>Recommend re-inspecting before deciding on a path forward.</td>
</tr>
<tr>
<td>Effluent Pump Station Surge Protection</td>
<td>Do Nothing</td>
<td>$0</td>
<td>Conduct detailed hydraulic analysis of the hydraulic grade line with the proposed new effluent control structure.</td>
</tr>
<tr>
<td>Effluent Force Main Standpipe</td>
<td>Upgrade standpipe and investigate root cause</td>
<td>$100,000</td>
<td>District wishes to eliminate all discharges at the standpipe.</td>
</tr>
<tr>
<td>PCS Phase II Upgrades</td>
<td>Implement upgrades</td>
<td>$1,500,000</td>
<td>Planning was completed in 2012 and Phase I was previously implemented.</td>
</tr>
</tbody>
</table>
This section summarizes the recommended improvements, presents a proposed implementation schedule, evaluates the impact of the project on the environment, and summarizes the impact of the proposed improvements on sewer user charge rates.

10.01 SUMMARY OF CAPITAL IMPROVEMENT RECOMMENDATIONS

Recommendations for capital improvements and future investigations were made in previous sections of this Facilities Plan and the associated technical memoranda. A summary of the recommended upgrades and modifications for the NSWWTP is summarized by process/major facilities planning area in the following:

A. Peak Flow Management

The main focus of the peak flow management evaluations was to provide the ability to manage the anticipated peak flows without overflowing NSWWTP structures and while continuing to meet effluent permit limits. We recommend the District implement Alternative PF10, which includes hydraulic capacity upgrades to the following facilities at the NSWWTP:

1. Construct bypass channel for west primary clarifiers.
2. Raise west final clarifier influent channel walls by 1 foot and modify channel at roadway crossing to prevent overflows.
3. Construct new effluent structure to control diversion to the lagoons and flow conveyed from the east plant to the disinfection building.
4. Construct upgrades to the east and west activated sludge facilities to provide the ability to operate in a biological contact process mode during high flow events.

We also recommended that the District begin evaluating in more detail potential paths forward related to implementing a local permitted discharge to Nine Springs Creek as a first step towards a potential continuous future discharge to Nine Springs Creek at the District.

The District may also consider initiating an aggressive I/I reduction pilot study focused on identifying one or more areas with high I/I rates, and then implementing aggressive I/I reduction measures with the goal of quantifying successes and challenges for future additional measures in other areas.

B. Headworks and Hauled Waste Receiving

The main concern with the existing headworks facilities include a requirement to control the screening channel water depth within a very narrow range, which results in continuous screening equipment operation and significant maintenance concerns. In addition, the hauled waste receiving facilities require considerable operator attention and result in high grit loadings to the screening channels. The recommended headworks and hauled waste receiving improvements consist of the following:

1. IFM5—Relocate Venturi Flow Meters to Lower Elevation
2. S1—Screen Sluiced Screenings or S3—Install New Step Screens and Wash Presses
C. **Activated Sludge and Nutrient Removal**

The existing biological phosphorus removal activated sludge facilities have operated well for many years and continue to serve the near-term needs of the District. The main focus of the facilities planning evaluations was energy efficiency and future upgrades to remove nitrogen. The recommended aeration system capital improvements consist of full-plant implementation of nitrite shunt (Alternative AS4) with high efficiency membrane diffusers, new west blowers and aeration piping cross-connect, and new secondary clarifiers. However, because this process is relatively new and does not have many full-scale operating installations, the District is currently conducting bench-scale pilot testing of the nitrite shunt process. If the bench-scale testing proves to be successful, full-scale pilot testing of nitrite shunt operation is recommended. In addition, final clarifier stress testing is recommended to be conducted to verify clarifier performance and to potentially eliminate the requirement to construct new final clarifiers.

The recommended plan is summarized below (assuming successful bench-scale testing):

1. Conduct clarifier stress testing.
2. Implement Nitrite Shunt Full-Scale Demonstration Study-Install new membrane strip diffusers, polymer feed system, and AVN instrumentation and control system in Plant No. 3 or 4 on the west side.
3. If demonstration testing is successful, implement nitrite shunt operations in the remaining activated sludge plants, including membrane strip diffusers, AVN instrumentation, control valves and flow meters, construction of two new final clarifiers (unless stress testing indicates these are not required), and construction of post-aeration facilities.
4. Construct aeration system efficiency improvements, including interconnecting the east and west aeration systems and installing new west side blowers. These improvements will likely be phased to coincide with nitrite shunt upgrades noted above. The east side blowers may not require replacement if this cross-connection is put into place.
5. Implement miscellaneous activated sludge system improvements noted by District staff during planning, including scum beach icing control, replacement of Plant 2 RAS control valves, and increasing drainage pumping capacity.
6. Improve RAS pump energy efficiency, including new high-efficiency motors for some of the RAS pumps. Alternative improvements include new VFDs or modifying the control of the RAS pumps.
D. Disinfection

The main concern with the existing UV disinfection system is its age. This system was installed in the mid 1990s and is operating beyond the typical useful life for this type of equipment. In addition, the manufacturer of the equipment has not supported this particular system for about 20 years, and replacement parts are becoming more difficult to source or produce. The recommended capital improvements for disinfection include the installation of new UV disinfection equipment within the existing channels (Disinfection Alternative D1 or D2).

E. Electrical Reliability

Electrical improvement alternatives for the NSWWTP included in this facilities planning effort consisted of evaluations related to upgrading or providing the headworks backup power, blower controls, blower medium voltage switchgear, and unit substations U11, U12, and U13. The main goal of these evaluations was to improve systems and overall NSWWTP reliability. The recommended plan consist of the following:

1. No change to the headwork facility backup power situation.
2. Replace the east blower control panel.
3. Replace the east and west blower building switchgear in conjunction with future blower replacements. This may result in no east blower switchgear replacement if the aeration system cross connect is constructed.
4. Construct one new unit substation to replace the existing substations U11, U12, and U13.

F. Miscellaneous Improvements

Miscellaneous improvements were included in the overall scope of the facility plan to evaluate upgrades to some of the aging infrastructure. The following improvements are recommended:

1. Rehabilitate primary clarifier Tanks 1 and 2–These tanks date back to the original construction of the NSWWTP and are in need of some concrete restoration.
2. Replace or rehabilitate the 54-inch primary influent pipe from the east primary junction chamber to the east primary clarifiers. The most recent inspection is from 2007 and showed that the pipe had deteriorated. We recommended an additional inspection before proceeding with replacement or rehabilitation.
3. Install flow metering equipment to measure flows to the east and west plants. This will provide improved process monitoring and control.
4. Conduct further effluent force main standpipe investigations and construct a new, wider effluent force main standpipe to eliminate effluent wastewater from spilling to the ground.
5. Proceed with the PCS Phase II upgrades identified in the 2012 PCS Facilities Plan. This will replace obsolete DCUs and improve overall system control and reliability.
10.02 IMPLEMENTATION PLAN AND SCHEDULE

Since none of the recommended improvements require immediate implementation because of regulatory drivers or because of concerns with imminent failure, the District has flexibility to phase the recommended improvements to best fit its Capital Improvements Plan and future budgets. A preliminary implementation plan for the proposed improvements is presented in Table 10.02-1. This plan is based on discussions with the District and includes three main project phases for near term, mid-term, and longer term construction. All the projects identified are currently scheduled to be completed within about 10 years. However, since there are no immediate regulatory drivers, the District may decide to implement these projects on an alternate schedule.
## Table 10.02-1 Recommended Improvements and Phasing

<table>
<thead>
<tr>
<th>Component</th>
<th>Near Term (2017-2022)</th>
<th>Mid Term (2020-2025)</th>
<th>Future (2024+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEAK FLOW</td>
<td>Alternative PF10–Biological Contact</td>
<td>$5,200,000</td>
<td></td>
</tr>
<tr>
<td>HEADWORKS</td>
<td>Alternative IFM5–Relocate Venturis to Lower Elevation</td>
<td>$2,100,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alternative S3–New Step Screens and Wash Presses</td>
<td>$3,400,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alternative G1–New Grit Washers</td>
<td></td>
<td>$2,000,000</td>
</tr>
<tr>
<td></td>
<td>Alternative HW1–Drive-Through Hauled Waste Station</td>
<td>$2,900,000</td>
<td></td>
</tr>
<tr>
<td>ACTIVATED SLUDGE</td>
<td>Nitrite Shunt Pilot Test and Polymer Feed System</td>
<td></td>
<td>$2,260,000</td>
</tr>
<tr>
<td></td>
<td>Other BNR System Maintenance Issues</td>
<td></td>
<td>$420,000</td>
</tr>
<tr>
<td></td>
<td>Full Plant Nitrite Shunt</td>
<td></td>
<td>$17,860,000</td>
</tr>
<tr>
<td></td>
<td>Aeration Cross-connect Piping</td>
<td></td>
<td>$2,160,000</td>
</tr>
<tr>
<td></td>
<td>Two new west blowers</td>
<td></td>
<td>$4,200,000</td>
</tr>
<tr>
<td></td>
<td>One new west blower</td>
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<td>$2,100,000</td>
</tr>
<tr>
<td></td>
<td>RAS Pump Energy Efficiency Improvements</td>
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<td></td>
<td>Clarifier Stress Testing</td>
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<td>$130,000</td>
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<td>DISINFECTION</td>
<td>Alternative D1/D2–Replace UV Equipment</td>
<td></td>
<td>$3,800,000</td>
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<td>ELECTRICAL</td>
<td>Alternative EBC No. 1–Replace East Blower Control Panel</td>
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<td></td>
<td>Alternative BMC No. 1–Replace East Blower Building Switchgear</td>
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<td>$1,140,000</td>
</tr>
<tr>
<td></td>
<td>Alternative BMC No. 2–Replace West Blower Building Switchgear</td>
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<td>$900,000</td>
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<tr>
<td></td>
<td>Alternative USUB No. 3–Replace Unit Substation U12 with One New Indoor Unit Substation and Eliminate Unit Substations U11 and U13 with Alternative USUB-XFMR No. 2–Outdoor, Liquid-Filled Unit Substation Transformers</td>
<td></td>
<td>$3,100,000</td>
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<td>MISCELLANEOUS</td>
<td>Primary Tanks 1 and 2 Rehabilitation</td>
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<td>East-West Plant Flow Metering</td>
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<tr>
<td></td>
<td>Effluent Force Main Standpipe Revisions</td>
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<tr>
<td></td>
<td>PCS Phase II Upgrades</td>
<td></td>
<td>$1,500,000</td>
</tr>
<tr>
<td>TOTALS</td>
<td></td>
<td>$20,620,000</td>
<td>$12,540,000</td>
</tr>
</tbody>
</table>

Note: All costs are in 2nd quarter 2017 values.
10.03 RESOURCE IMPACT ANALYSES

The recommended improvements will improve effluent quality and the ability of the NSWWTP to manage and treat wastewater in during flow events, resulting in an overall positive impact on the surrounding environment.

A. Water Quality

The recommended improvements improve treatment performance, including nutrient removal and peak flow treatment capacities, as well as electrical and disinfection equipment reliability. These improvements should result in a higher quality effluent and fewer disturbances in treatment during power or equipment related outages and peak flow events.

B. Air Quality

A reduction in energy use associated with the recommended activated sludge improvements is anticipated to have a positive impact on air quality through a reduction in the burning of fossil fuels. As discussed in Section 6, GHG emissions from activated sludge processes is an area of current research, but treatment processes that include nitrogen removal, such as the recommended plan, emit less N₂O than those that do not.

C. Historic and Archeological Sites

All the recommended improvements are located at the existing NSWWTP site. The site has been disturbed in several previous construction projects and no significant historic or archeological sites are known to be present that would be impacted by the recommended improvements.

D. Floodplains and Other Sensitive Environmental Areas

All the recommended improvements are located at the existing NSWWTP site and are outside of the 100-year floodplain. There are no sensitive environmental areas on-site that would be impacted by the recommended improvements. These considerations should be reevaluated if the District chooses to pursue a local Nine Springs Creek discharge.

E. Public Health

The recommended plan will improve the treatment capacity, efficiency and reliability of the NSWWTP, which should have a net positive impact on public health.

10.04 PROJECT FUNDING

The District intends to use the Clean Water Fund program to finance future construction projects. The DNR Bureau of Environmental Loans administers the Clean Water Fund program that provides reduced interest rate loans for eligible wastewater projects. The interest rate for eligible projects is 2.38 percent (70 percent of market rate), as of July 1, 2017. The Wisconsin Department of Administration sets the current market interest rate quarterly, and the percent of market rate the Clean Water Fund charges for loans (currently at 70 percent), is set as part of the state budget process. In the next fiscal year, the subsidize interest rate is expected to be 55 percent of the market rate, though this has not been finalized yet. Flows from industrial dischargers and reserve capacity at the treatment plant for flows beyond 10 years from the time of the project completion are not eligible for the low interest rate financing, and the costs associated with facilities to treat these flows would be financed at the market interest rate.
This facilities plan covers numerous projects over approximately 10 years. The effects on user charges depend on the actual timing and cost of the projects, the CWF interest rate, the growth in district loadings, and the allocation of the annual revenue requirement for capital and annual operating costs over the District’s billing parameters. The long time period covered by the projects in this facilities plan further complicates the analysis, and a detailed user charge study is outside the scope of this report. As a general guideline, based on the District’s analysis, $1.0 million in debt service equates to $6 to $7 for a typical residential household’s annual bill.

Table 10.02-1 shows phasing for the recommended projects in several time periods: Near term (2017 to 2022), Mid term (2020 to 2025) and Future (2024+). The costs in Table 10.02-1 are on a 2017 cost basis. Table 10.04-1 summarizes the effects of the proposed projects on the typical residential customer. It includes the following assumptions:

- Annual construction inflation of 3 percent.
- A 4 percent CWF interest rate on project loans, 20 year loans with 19 years of principal payments on each loan.
- $6 to $7 cost to a typical residential households annual bill per $1 million of debt service.
- A 5 percent annual average increase of residential rates including both MMSD and community charges.

The estimated annual residential service charge for MMSD-provided services in 2017 is $170, or $14.20 per month. The estimated annual typical residential charge including both MMSD and local community charges in 2017 is $313. In 2020, the typical residential service charge is estimated to be $360. The cost of the first phase projects is estimated to be $10.50 to $12.00 of the $360 total charge. The second phase projects are estimated to account for $6.50 to $7.50 of a total annual charge of $400 in 2022. The third phase projects are estimated to account for $13 to $15.50 of a total annual charge of $460 in 2025. In total, the projects included in this plan are estimated to account for $14 to $16 of the estimated typical residential charge of $460 in the year 2025.

<table>
<thead>
<tr>
<th>Phase</th>
<th>2017 to 2022</th>
<th>2020 to 2025</th>
<th>2024+</th>
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</thead>
<tbody>
<tr>
<td>Table 10-02-1 Costs</td>
<td>$20,620,000</td>
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<td>Estimated Cost in</td>
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<tr>
<td>Year of Construction</td>
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<td>Estimated Annual</td>
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<tr>
<td>Debt Service</td>
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<td>$1,100,000</td>
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<td>Residential Rate</td>
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<tr>
<td>Impact, per year</td>
<td>$10.50 to $12.00</td>
<td>$6.50 to $7.50</td>
<td>$14.00 to $16.00</td>
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<tr>
<td>Year of Rate Analysis</td>
<td>2020</td>
<td>2022</td>
<td>2025</td>
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<tr>
<td>Estimated Total</td>
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<tr>
<td>Annual Residential</td>
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<td>$400</td>
<td>$460</td>
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<tr>
<td>Charge</td>
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</table>

Table 10.04-1 Sewer User Charge Impacts