8 Recommended Plan to Meet 2050 Foundational Goals

8.1 Introduction and Plan Summary

This chapter presents the recommended plan to help meet MMSD's 2050 Foundational Goals, which address non-permit requirements and include projects that address Commission policy and rules established by MMSD, projects that help to improve regional water quality and reduce energy usage, and projects that are designed to save MMSD money in the long term.[1] The recommended plan outlines the new projects that are recommended to be implemented to address potential risks to meeting 2050 Foundational Goals under Baseline, Future, and Buildout Conditions. [2]

While predicting the needs of MMSD for the year 2050 is difficult, MMSD outlined the following overarching drivers and 2050 Foundational Goals to help guide the 2050 Facilities Plan (2050 FP) development:

Drivers

D1. Regulatory oversight: Regulation of the District is expected to intensify during the planning period of this facilities plan. Regulations on nutrient discharges, air emissions, and non-point discharges could be more stringent. The District is fortunate to be at a strong starting point for this driver with excellent permit compliance and the initial steps towards watershed water management.

D2. Limited financial resources: Financial resources will continue to be a limiting factor in District efforts. Fluctuations in the federal investment in clean water and the continued pressures locally to keep rates and taxes low will not go away. Sustainable long-range funding, efficient operations, partnerships, new technologies, and good planning are solutions that will help to combat this driver.

D3. Public participation: The public is anticipated to be more involved in how the District moves forward than ever before. As the drivers to water quality become more external to the District, such as non-point pollution, the public may turn to the District for solutions. Effective, regular communication and clarification of expectations and responsibilities will dictate the outcome of this driver.

D4. Climate adaptation and mitigation: The climate is changing. Adapting to and mitigating these changes will be the most important driver for the District because it affects all other drivers. Further expanding green infrastructure (adaptation example) and renewable energy (mitigation example) places the District well along the path towards resiliency.

[1] *This recommended plan reflects public input. For details regarding public comments and resultant changes, see Section 9.10 in Chapter 9, Implementation Plan.*

[2] *Baseline, Future, and Buildout Conditions are defined in Chapter 5, but generally are defined as follows: Baseline – existing as of the time of the 2050 FP, approximately 2010 to 2019 depending on the analysis; Future – projected conditions to the year 2040; Buildout – projected full development plus projected climate change impacts.*

D5. Cost of Energy: The cost of energy is a significant District cost.[3] Through cost-effective investments and energy management, it is possible to reduce the District's energy costs, which will benefit ratepayers.

It is anticipated that some of these drivers may evolve over time to include additional considerations such as:

- Some pollutant regulations (e.g., for arsenic and mercury) could become more stringent in the future
- Emerging contaminants like perfluoroalkyl substances (also referred to as PFAS), microplastics, and other yet-to-be identified compounds may become regulated in the future
- Effective asset management may help better allocate financial resources
- Effective, regular communication and clarification of expectations and responsibilities will support public involvement

Goals

G1. Change the District from an organization that impacts the environment to an organization that benefits the environment

G2. Incorporate new technologies and operational improvements to minimize the District's financial burden on ratepayers

G3. Integrate green infrastructure into all facets of development and redevelopment

G4. Support urban biodiversity activities within the region

G5. Provide adaptive leadership to climate change

The recommended projects presented in this chapter are included in the implementation plan in Chapter 9. Refer to Figure 8-1 for a flow diagram of the content for Chapters 6, 7, 8, and 9.

[3] *Energy costs are a large component of MMSD's annual O&M budget.*

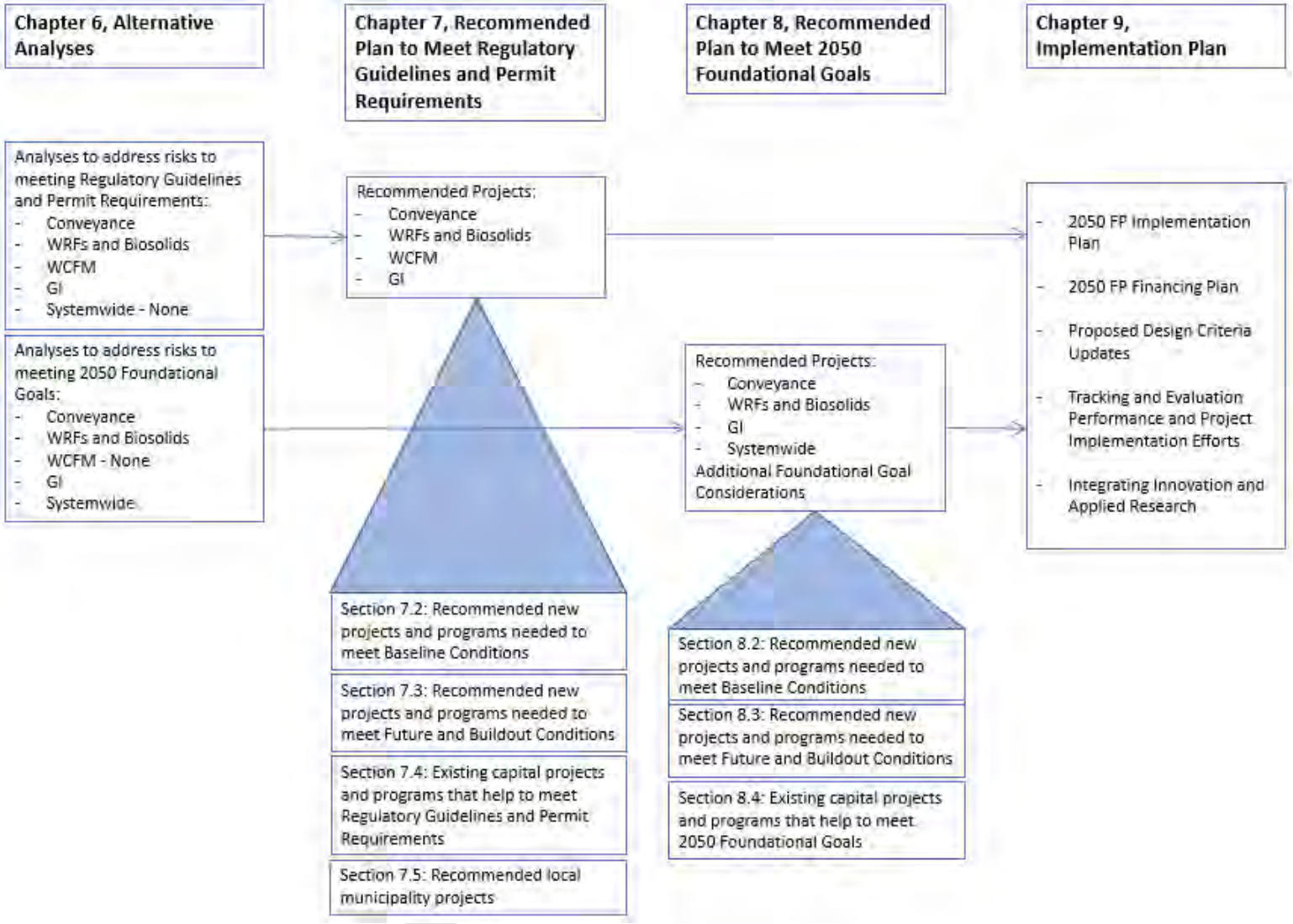

FIGURE 8-1: ORGANIZATIONAL FLOW CHART FROM CHAPTER 6 THROUGH CHAPTER 9

Recommended Plan

The recommended new projects and programs fall into two categories:

1. **Recommended new MMSD projects and programs needed to meet Baseline Conditions (Section 7.2).** These new projects and programs are recommended to address identified risks under Baseline Conditions, such as risks to meeting 2035 Vision targets. It is assumed that the projects listed in Table 8-1 will be implemented starting in 2021 following Wisconsin Department of Natural Resources (WDNR) approval of the 2050 FP. Estimated capital and annual O&M costs for these recommendations are provided. The implementation plan and financing plan for these projects and programs are presented in Chapter 9, Implementation Plan.
2. **Recommended new MMSD projects and programs to meet Future and Buildout Conditions (Section 7.3).** These projects and programs are recommended to address risks due to growth, such as risks to meeting 2035 Vision targets under Future and Buildout Conditions. These recommendations are summarized in Table 8-2 and have more flexible implementation dates based on actual growth or changes in assumptions. Estimated costs for these recommendations are provided so they can be incorporated into future budgets, if and when appropriate. The implementation plan for these projects and programs is presented in Chapter 9, Implementation Plan.

Budgetary Planning

These recommended projects will impact MMSD's capital cost long-range finance plan, which is updated annually and presents planned capital costs for the upcoming six years, as well as impacting future annual O&M budgets as outlined below:

- New projects to meet Baseline Conditions are recommended to be added to MMSD's 2020 to 2025 long-range finance plan per the suggested schedule provided in this chapter.
- Recommended projects to meet Future and Buildout Conditions are recommended to be added to future long-range finance plans only if and when projected growth is realized, which will trigger the need for the project.
- The estimated incremental changes in annual O&M costs after each project is implemented is also provided so that the costs can be added to future annual budgets.

Existing Projects that support the 2050 FP

In addition to the recommended new projects, a number of projects and programs included in existing budgets will support the 2050 FP by addressing some of the identified potential risks. These existing projects and programs, which are discussed in Section 8.4, are all committed MMSD activities (activities in construction, contracts in place, and other programs already funded). Because these costs are already included in MMSD budgets, they do not represent new costs; therefore, they are not included in the recommended plan. They are listed to show that they address risks identified in Chapter 5; therefore, a new project or program does not need to be recommended as discussed in Chapter 6.

Additional Information

Identified projects are organized by the following asset systems, as applicable: Conveyance and Storage, Water Reclamation Facilities (WRFs) and Biosolids, GI, and Systemwide.[4]

Additional information about the estimated costs for the recommended projects:

- The costs are estimated at a projected Engineering News-Record Construction Cost Index (ENR-CCI) of 14,700 in December 2019 for Milwaukee (Milwaukee ENR). The ENR-CCI represents the cost of a common base of construction labor and materials (including concrete, steel, and lumber). The Milwaukee ENR is calculated as the average between Chicago and Minneapolis Construction Cost Index values published monthly by ENR. Milwaukee ENR December 2019 is a projected value from May 2019 based on average historical monthly increase in value from 2007 (2020 Facilities Plan published June 2007) to May 2019.
- These costs represent facilities planning-level estimates that have a range of accuracy from +50 percent to -30 percent, as established by the Association for the Advancement of Cost Engineering (AACE) International for Class 4 (study or feasibility) estimates. [1] All estimated project costs will be refined over time as preliminary engineering analyses are completed. Thus, the final total projected cost could vary significantly from these estimates.

As part of the implementation of some of the recommended projects, updates will need to be made to the design criteria presented in the Jones Island Water Reclamation Facility (JIWRF) and South Shore Water Reclamation Facility (SSWRF) Operation and Maintenance (O&M) manuals. The recommended projects that will require updates to the design criteria are identified this chapter; the specific proposed design criteria updates are presented in Chapter 9.

8.2 RECOMMENDED NEW PROJECTS AND PROGRAMS TO MEET BASELINE CONDITIONS

Chapter 6 recommends projects to address risks under Baseline Conditions that should be added to MMSD's budgets. These projects are recommended even if there is no growth in the MMSD planning area.[5]

- WRFs and Biosolids Asset System:
    - Three projects are recommended to address level of service risks in the alternative biosolids processing disposal systems and SSWRF's renewable energy usage.
        - WRF FG2: Alternative Biosolids Processing Disposal Systems. The recommended project includes new dryers at JIWRF and additional upgrades. This project also addresses permit requirement to "properly operate and maintain all facilities and systems" (2019 WPDES Permit Section 9.2.10) by addressing the physical mortality risks identified in Chapter 5. Findings from existing project M03102, Biosolids Advanced Facility Planning (see Section 8.3) may identify additional facilities needed to address future capacity risks, but these costs are not included in the recommendations in the 2050 FP. The

[4] *All Watercourse and Flood Management (WCFM) projects are listed in Chapter 7. There are no additional recommended WCFM projects to address 2050 Foundational Goals. For purposes of the 2050 FP, systemwide is defined as a project that applies to more than one asset system.*

[5] *All recommended projects for the Conveyance Asset System are already included in the 2020 to 2025 long-range finance plan (refer to Section 8.2). There are no recommended WCFM or GI Asset System projects to meet Baseline Conditions.*

starting year presented in the 2020 to 2025 long-range finance plan column of Table 8-1 is assumed to be 2024 because the project scope will be adjusted based on the results of project M03102. Because this is a complicated project, the schedule assumes a long design and construction schedule. See SW FG4, Energy 2035 Vision discussion below regarding impacts on energy by implementing this recommendation.

- WRF FG4: Increase SSWRF Renewable Energy Use. The recommended project, a 3.2 MW solar grid with battery storage at SSWRF, assists MMSD in reaching the KPI[6] target of 80 percent of energy needs provided by renewable energy generated by MMSD. When factoring in the incremental reduction in annual O&M costs, the total present worth for Alternative 2 is $4.7 million. The estimated annual O&M savings should be verified during preliminary engineering to confirm that this project should proceed.
- WRF FG9: SSWRF Wet Weather Capacity (Implement Blending). Blending is recommended to reduce combined sewer overflow (CSO) volumes at CSO locations BS0405 and DC0103. Because MMSD has already identified a capital project, no additional capital cost is recommended. An additional annual O&M cost of $30,000 is anticipated when this project is implemented.

o The following recommended new projects to meet Baseline Conditions are anticipated to require updates to the design criteria in the JIWRF and SSWRF O&M Manuals when the projects are implemented (proposed design criteria updates are presented in Chapter 9):

- WRF FG2, Alternative Biosolids Processing Disposal Systems (new drying systems at JIWRF Dewatering and Drying [D&D] Facility)
- WRF FG9, SSWRF Wet Weather Capacity (implement blending)

- Systemwide:

o The following two projects are recommended to address level of service risks:

- SW FG1: JIWRF and SSWRF Reutilization. The analysis evaluated methods to address the risks associated with anticipated increases in costs to maintain JIWRF and those associated with not using the various available treatment and transport reutilization options at JIWRF, SSWRF, and the conveyance system in the most effective manner. The recommended project includes further assessment of the conveyance system to determine which facilities are needed to divert flow from the JIWRF service area to the SSWRF service area in the event the WRFs might be reutilized in the future, including the potential expansion of SSWRF.
- SW FG4: Energy 2035 Vision. The findings and recommendation of the analysis are as follows:
  - The WRF Baseline renewable energy use as percentage of total energy demand was determined to be 33 percent in Chapter 5. The analysis determined that the energy KPI targets of 100 percent renewable energy and 80 percent of the renewables from internal sources cannot be met with the existing drying system at JIWRF due to the high energy demand of the dryers and lack of renewable options to meet the demand. The 2035 Vision energy recommendations include

[6] *KPIs are discussed in Chapter 3, including the source for setting targets – energy KPI targets were set in the 2035 Vision.*

new dryers at JIWRF as recommended in WRF FG2 and solar energy as recommended in WRF FG4. After those projects are implemented, renewable energy as a percentage of total energy demand is projected to increase to 60 percent.

- The recommendation is to update the 2015 Energy Plan, which evaluates the recommendations from SW FG4 to investigate the feasibility of generating renewable natural gas at SSWRF, contracting for additional landfill gas (LFG), purchasing electricity at the renewable energy rate from We Energies, and researching other renewable energy sources to supplement LFG sources. The project also includes advanced planning/preliminary engineering to implement feasible alternatives.

Summary

Table 8-1 lists the recommended new projects to address risks identified under Baseline Conditions, organized by asset system. The table includes the initial recommended timeframe for implementing the projects as identified in Chapter 6, along with an updated recommended schedule for inclusion in MMSD's budgets. The implementation plan and financing plan for these projects is presented in Chapter 9, Implementation Plan. The vast majority of these costs – $214.6 million – is to replace the dryers at JIWRF, which also addresses the permit requirement to "properly operate and maintain all facilities and systems" (2019 WPDES Permit Section 9.2.10).

TABLE 8-1: RECOMMENDED NEW PROJECTS TO MEET 2050 FOUNDATIONAL GOALS UNDER BASELINE CONDITIONS

Name of Recommended Project	More Research/ Effort Recommended Prior to Project?	Recommended Timeframe of Project[1]	2020–2025 Long-Range Finance Plan Schedule (start-end) [2]	Capital Cost ($ millions) [3,4]	Incremental Change in Annual O&M Cost ($ thousands) [3,5]	Present Worth ($ millions) [3,6]
WRFs and Biosolids						
WRF FG2, Alternative Biosolids Processing Disposal Systems (new drying systems at JIWRF Dewatering and Drying [D&D] Facility)[7]	Y – a sensitivity analysis as part of the Biosolids Advanced Facility Planning project, include biosolids processing assumptions, energy costs and biosolids revenue, and future capacity of JIWRF MP08, MP13, SSWRF MP09	2020–2024	2024–2040[8]	$214.6	($8,200.0)[8]	$94.6[8]
WRF FG4, Increase SSWRF Renewable Energy Use (3.2 MW Solar with battery storage)	N	2020–2024	2024–2029	$19.5	($880.0)[9]	$4.7[9]
WRF FG9, SSWRF Wet Weather Capacity (Implement Blending)[7]	Y – see details in WRF FG9 analysis	2020–2024	2021–2025	$0.0	$30.0[10]	$0.4
WRFs and Biosolids TOTAL				**$234.1**	**($9,050.0)**	**$99.7**
Systemwide						
SW FG1, JIWRF and SSWRF Reutilization (Assessment of Conveyance system – diversion of flow from JIWRF service area to SSWRF service area)	N – recommendation is research	2020–2024	2021–2023	$0.1	$0.0	$0.1

TABLE 8-1: RECOMMENDED NEW PROJECTS TO MEET 2050 FOUNDATIONAL GOALS UNDER BASELINE CONDITIONS

Name of Recommended Project	More Research/ Effort Recommended Prior to Project?	Recommended Timeframe of Project[1]	2020–2025 Long-Range Finance Plan Schedule (start-end) [2]	Capital Cost ($ millions) [3,4]	Incremental Change in Annual O&M Cost ($ thousands) [3,5]	Present Worth ($ millions) [3,6]
SW FG4, Energy 2035 Vision (update to 2015 Energy Plan)[11]	N - recommendation is research	2020–2024	2021–2022	$1.6	$0.0	$1.6
Systemwide TOTAL				**$1.7**	**$0.0**	**$1.7**

1) This is the anticipated timeframe of the identified risk as presented in Chapter 5/6 and is intended to provide a general timeframe of when a project should start.
2) Represents the anticipated start and completion dates for the recommended project to be incorporated into the 2020 to 2025 long-range plan. Note that some of the end dates are anticipated to end after 2025.
3) These costs represent December 2019 dollars at a projected Milwaukee ENR of 14,700. Costs presented are facilities planning-level estimates that have a range of accuracy from +50 percent to -30 percent, as established AACE International for Class 4 (study or feasibility) estimates.
4) Costs represent capital costs recommended to be added to the 2020 to 2025 long-range finance plan.
5) Costs represent an incremental change in operation, maintenance and other annual costs (such as labor) recommended to be added to MMSD Annual Budget once a project is implemented.
6) Costs represent annual O&M costs, equipment replacement costs, and salvage value as appropriate over 20 years discounted, by 3.375 percent, plus capital costs.
7) As part of the implementation of this project, the design criteria presented in the JIWRF and SSWRF O&M manuals will need to be updated. The specific proposed design criteria updates are presented in Chapter 9.
8) The new dryer project recommended for WRF FG2, Alternative Biosolids Processing Disposal Systems will be complex to design and construct – the 15-year timeframe, which will start after the completion of the Biosolids Advanced Facility Plan, represents 2 years for preliminary engineering, 3 years for design, and 10 years for construction. The annual O&M costs represent the savings in annual O&M costs from the dryer systems in place as of 2019 by installing newer, more efficient dryers. The present worth costs also include salvage value savings. As noted in Note 11 regarding SW FG4 findings, new dryers are needed to assist in meeting MMSD energy KPI targets.
9) The annual O&M costs represent the incremental savings calculated by comparing the 2016 electrical bill at SSWRF to the estimated bill if a 3.2MW solar system were installed, along with additional O&M costs. Only 1 year of detailed analysis was performed; additional analysis is recommended in preliminary engineering to verify the assumptions and determine the cost savings, which may be even more significant, to confirm that this project should proceed.
10) Capital costs for project S03003 are present in Table 8-3. The annual O&M costs presented in this table represent the estimated additional annual electrical and chemical costs to treat the additional 75 MGD of blending flow once the project is implemented.
11) The SW FG4 analysis is tied to the WRF FG2 analysis in that findings in SW FG4 found that energy KPIs cannot be met with the existing drying system at JIWRF due to the high energy demand of the dryers and lack of renewable options to meet the demand. The SW FG4 recommendations assume implementation of new dryers at JIWRF in the WRF FG2 project and the recommended update to the 2015 Energy Plan should include the energy demands with new dryers.

8.3 RECOMMENDED NEW PROJECTS AND PROGRAMS TO MEET FUTURE AND BUILDOUT CONDITIONS

Chapter 6 also recommends new projects to address risks under Future and Buildout Conditions to be added to future MMSD budgets. These projects are recommended to be implemented only if the projected flow and wasteload growth in the MMSD planning area is realized or because they address risks in the year 2026 or later, and are presented by asset system.[7]

- WRFs and Biosolids Asset System:
    - One project is recommended to address the capacity risks outlined in the WRF FG8, JIWRF Wet Weather Capacity Analysis in Chapter 6. This project entails the expansion of the JIWRF blending capacity by modifying the bypass channel and disinfection system to maintain the baseline CSO frequency of 3.25 CSO events per year. This project also includes effluent filtration to remove total suspended solids (TSS) from the bypassed flow to address the increased risk of not meeting WPDES mass limits with the increase in blending capacity.
    - This recommended new project is anticipated to require updates to the design criteria in the JIWRF O&M Manual when the project is implemented (proposed updates are presented in Chapter 9).
- GI Asset System:
    - Projects are recommended for each of the six analyses presented in Chapter 6. Most of these projects address level of service risks regarding an insufficient number of GI assets being built to address the KPI target of 740 MG of GI storage by 2035. Some of these projects, just by their nature, will also address physical mortality and economic efficiency risks. The following information should be kept in mind when considering recommended GI projects:
        - The large ramp up in 2020 from community-based GI (CBGI) will potentially change the way MMSD implements GI; therefore, MMSD needs to review the current program strategy to determine if resources need to be shifted into more CBGI-type programs.
        - Chapter 5 identifies the MMSD portion of ongoing costs to maintain GI assets, with the expectation that regional partners, including municipalities, businesses, and private homeowners, would take on the remaining operation and maintenance costs. Since these costs would not be incurred by MMSD and because some of the costs would (absent GI) otherwise be included in grey stormwater management infrastructure projects by regional partners and would not fully be new costs, they are not included in the discussion in this chapter.
        - Revisions of GI programs and operations may happen as MMSD evolves in this field; therefore, recommendations are conservative—not to overstate GI costs, but to leave the door open to appropriate increases or shifts in funding of these endeavors.
        - MMSD is refining hydraulic modeling efforts under project C98056, Conveyance System Modeling Software Improvements to get a better understanding of how GI can help to

[7] *All recommended projects for the Conveyance Asset System are already included in the 2020–2025 long-range finance plan (refer to Section 8.3). There are no recommended WCFM Asset System projects to meet Future and Buildout Conditions.*

achieve the 2035 Vision, with the understanding that findings may require MMSD to subsequently update the 2035 Vision and revise the Regional GI Plan as appropriate to make the most of limited financial resources.

- This is an emerging field and there may be technological advancements or policy changes that will shape how MMSD moves forward. The 2050 FP is not pre-determining the future, but rather, investigating what is coming up on the horizon and making the best recommendations based on the assumptions made at the time of the 2050 FP.

- Systemwide:
  - One project is recommended to address level of service risks outlined in the SW FG2, Zero Overflows Analysis in Chapter 6. The SW FG2 analysis assumes other 2050 FP recommendations will contribute to reaching the goal of zero overflows, including CS R9, GI R1, WRF FG8, WRF FG9, GI FG1 to FG6, and projects that address capacity and flows within the Conveyance system and at the WRFs. Specific to GI R1 and GI FG3, the SW FG2 analysis assumes that 200 MG of the GI recommendations made in Chapter 7 and in Table 8-2 to achieve the internal KPI target of 740 MG of GI will be implemented in the combined sewer service area. Over and above these recommendations, SW FG2 recommends an additional phased project approach, all of which falls after the year 2026 and are therefore considered "future" recommendations per MMSD's capital planning efforts. Note that the goal of achieving zero overflows will not be fully achieved by following this phased approach, but it allows for a controlled implementation to begin to close the gap while also measuring the impacts of recommended projects and reassessing the recommendations with new information after projects are implemented. This project also helps to address the permit requirement to have a maximum of six CSOs per year. The following projects are recommended to be implemented in a phased approach through the year 2050:
    - Assess the system through hydraulic model analysis after the implementation of the recommended projects to be implemented by 2026 that are outlined in this chapter and in Chapter 7 to determine if annual average overflows have been reduced from Conveyance Baseline Conditions as was assumed for the baseline scenario in SW FG2.
    - If an additional reduction in overflows is still needed, implement overflow reduction projects that include high rate treatment (HRT) at JIWRF, system modifications to eliminate conveyance-related SSOs estimated to occur under Conveyance Future Conditions, and HRT at select CSO sites in the system.

Summary

Table 8-2 lists the recommended new projects to address risks identified under Future and/or Buildout Conditions, organized by asset system. The implementation plan for these projects is discussed in Chapter 9, Implementation Plan. The vast majority of these costs – $992.4 million – is to reduce CSOs through the use of high rate treatment, which also helps to address the permit requirement to have a maximum of six CSOs per year.

TABLE 8-2: RECOMMENDED NEW PROJECTS TO MEET 2050 FOUNDATIONAL GOALS UNDER FUTURE/BUILDOUT CONDITIONS

Name of Recommended Project	More Research/ Effort Recommended Prior to Project?	Recommended Timeframe of Project[1]	Capital Cost ($ millions) [2,3]	Incremental Change in Annual O&M Cost ($ thousands) [2,4]	Present Worth ($ millions) [2,5]
WRFs and Biosolids					
WRF FG8, JIWRF Wet Weather Capacity (expand blending)[6,7]	Y – recommendations should be incorporated when implementing changes for WRF R4	Depends on flow and growth	$0.1 for just bypass channel and disinfection upgrades $48.5 for all	$30.0 for just bypass channel and disinfection upgrades $1,120.0 for all	$0.6 for just bypass channel and disinfection upgrades $64.6 for all
WRFs and Biosolids TOTAL			**$48.5**	**$1,120.0**	**$64.6**
Green Infrastructure[8]					
GI FG1, Education Initiative (Learn, share, adapt, and expand collaboration)	N – recommendation includes research	By 2035	$0.0	$326.1	$4.4
GI FG2, Improve Effectiveness (Standardize and optimize approach to GI design, review, and installation)	N – recommendation includes research	By 2035	$0.0	$308.0	$2.7
GI FG3, Foundational Goal Financial Needs (GI funding projects and initiatives)[9]	N- recommendation includes research	By 2035	$225.4[10]	$600.0	$234.0
GI FG4, Tracking and Goals (Expand ongoing tracking activities)	N – recommendation includes research	By 2035	$0.0	$100.0	$1.4
GI FG5, Optimize Impact of Regulations (Eliminate barriers and standardize regulations)	N – recommendation includes research	By 2035	$0.0	$100.0	$0.5

TABLE 8-2: RECOMMENDED NEW PROJECTS TO MEET 2050 FOUNDATIONAL GOALS UNDER FUTURE/BUILDOUT CONDITIONS

Name of Recommended Project	More Research/ Effort Recommended Prior to Project?	Recommended Timeframe of Project[1]	Capital Cost ($ millions) [2,3]	Incremental Change in Annual O&M Cost ($ thousands) [2,4]	Present Worth ($ millions) [2,5]
GI FG6, Operations and Maintenance (Enhance fresh coast resource center services, training, and develop specialized maintenance services)	N – recommendation includes research	By 2035	$0.0	$3,165.0	$45.5
Green Infrastructure TOTAL			**$225.4**	**$4,599.1[6]**	**$288.5**
Systemwide					
SW FG2, Zero Overflows (Phase 2: Assessment of system through modeling analysis and research)	N – recommendation includes research	2026–2050	$10.0	$0.0	$10.0
SW FG2, Zero Overflows (Phase 3: JIWRF HRT, conveyance-related SSOs, select CSO HRT)[11]	Y - Phase 2 assessment	2030–2039	$982.4	$0.0	$982.4
Systemwide TOTAL			**$992.4**	**$0.0**	**$992.4**

1) This is the timeframe that is identified in Chapter 5/6 regarding the projected timing of the identified risk. Chapters 6 and 9 indicate the specific trigger for each recommended project that needs to be tracked to determine when a project needs to be implemented.
2) These costs represent December 2019 dollars at a projected Milwaukee ENR of 14,700. Costs presented are facilities planning-level estimates that have a range of accuracy from +50 percent to -30 percent, as established AACE International for Class 4 (study or feasibility) estimates.
3) Represents capital costs recommended to be added to future long-range finance plans.
4) Costs represent operation, maintenance, and other annual costs (such as labor) to be added to MMSD Annual Budget once a project is implemented.
5) Costs represent annual O&M costs, equipment replacement costs and salvage value as appropriate over 20 years, discounted by 3.375 percent, plus capital costs.
6) The expansion of blending at JIWRF, which is included in the recommendation for WRF R6, JIWRF TMDL Management, is recommended to be implemented under Future/Buildout Conditions to allow MMSD time to confirm that operational procedures can manage weekly mass TSS limits under the 2019 WPDES permit. If weekly TSS mass limits can be met by operational procedures, then the capital costs to expand blending are estimated to be $0.1 million. If operational procedures alone are not sufficient, effluent filtration for the blending flow is also recommended, represented by the $48.6 million

7) As part of the implementation of this project, the design criteria presented in the JIWRF O&M manual will need to be updated. The specific proposed design criteria updates are presented in Chapter 9.
8) Each of the GI projects listed represent multiple projects and programs grouped together under an overarching area of focus. Details of the recommended projects and programs for each GI project are presented in Appendix 6D, GI Alternative Analyses.
9) Capital cost listed for GI FG3 is the present worth of the future annual payments for constructing and replacing 500 MG GI to achieve the MMSD internal KPI target of 740 MG over and above the 200 MG goal presented in Chapter 7 and the 40 MG assumed to already be installed as of the end of 2019.
10) Costs represent an estimated $15.7 million per year of capital costs; however, some of the estimated cost may fall under O&M as research.
11) SW FG2, Zero Overflows also recommended Phase 4: SSWRF HRT at an estimated capital cost of $355.8 million. Because the recommendation was to not implement this system until after the year 2050, and therefore is outside of the time period of the 2050 FP, the SSWRF HRT system recommended in Phase 4 was not included in the recommendations in this chapter.

8.4 EXISTING CAPITAL PROJECTS AND PROGRAMS THAT HELP TO MEET 2050 FOUNDATIONAL GOALS

The 2050 FP project team reviewed the 2020 to 2025 long-range finance plan to identify existing projects that address potential risks identified in Chapter 5. Because these existing projects will also help to address identified risks, no additional projects are recommended in the 2050 FP. [8]

These projects are summarized as follows:

- Conveyance and Storage Asset System:
    - One project—project C02009, H_2S and Odor Mitigation Planning Study—addresses the risks associated with hydrogen sulfide (H_2S) in the sewer system, which has caused odor complaints, makes access to some MMSD facilities very difficult and hazardous, and causes corrosion throughout the collection system.
    - Three projects address level of service risks to meeting 2050 Foundational Goals. Two of these projects are anticipated to be active in 2020: project C05051, Edgewood MIS Extension and project I06001, NS 12 Collector System Improvements. The third project—project C02013, Oak Creek Southwest MIS Extension—is scheduled to start in 2026 to provide service to Caledonia and Raymond and potentially Oak Creek and Franklin as needed.
- WRFs and Biosolids Asset System:
    - One project—project J04074, Milorganite® Packaging Facility—addresses the risk of not being able to contract with a Milorganite packaging / bagging vendor due to the limited number of potential vendors.[9] The WRF FG3, JIWRF Milorganite Bagging Analysis in Chapter 6 provides guidance for this project.
    - One project—project S03003, Post-Secondary Capacity Improvements—addresses the risk of conveyance system overflows at BS0405 and DC0103 by not utilizing the potential to blend at SSWRF. The WRF FG9, SSWRF Wet Weather Capacity Analysis in Chapter 6 provides guidance for this project.
    - One project—project S04031, Digester Gas Treatment—addresses risk of not meeting energy key performance indicator (KPI) targets of 100 percent renewable energy and 80 percent of the renewables from internal sources.
    - The following existing project is anticipated to require updates to the design criteria in the SSWRF O&M Manual when the project is implemented (proposed updates are presented in Chapter 9):
        - S03003, Post-Secondary Capacity Improvements

[8] Many of the existing projects included in the 2020 to 2025 long-range finance plan are driven by MMSD's organizational financial goals and outside factors (political, social, and economic) that influence the financial resources available for both short-term asset needs and long-term planning purposes. The only projects that are listed here are those that specifically address potential risks outlined in Chapter 5 as discussed in Chapter 6.

[9] Only one vendor, Kinder Morgan, bid on the 10-year packaging contract awarded in 2014.

- GI:
    - The four projects listed in Table 8-3 for GI not only help to address the risk of not meeting the goal of 50 MG of GI as identified in the 2019 Wisconsin Pollutant Discharge Elimination System (WPDES) permit, they also help address the risk of not meeting the projected 200 MG GI goal within the regulatory period (2020 to 2040) and the broader KPI target of 740 MG of GI storage by 2035. The costs to address the additional recommendations over and above those presented in Chapter 7 are discussed in Section 8.4.

Summary

Table 8-3 lists the projects identified in Chapter 6, Alternative Analyses that are already included in MMSD's 2020 to 2025 long-range finance plan that help to meet 2050 Foundational Goals. The costs and implementation schedules for these projects and programs are included in MMSD's 2020 Operations and Maintenance and Capital Budgets (2020 Annual Budgets). [2] Therefore, the costs for these projects are not included in the recommended plan, which only represents additional costs for recommended new projects.

TABLE 8-3: EXISTING CAPITAL PROJECTS AND PROGRAMS THAT HELP TO MEET 2050 FOUNDATIONAL GOALS[1]

Name of Existing Project
Conveyance and Storage
C02009, H2S and Odor Mitigation Planning Study[2]
C02013, Oak Creek Southwest MIS Extension (sewer extension)
C05051, Edgewood MIS Extension (relief near surface collector [NSC] sewer)[3]
I06001, NS 12 Collector System Improvements (relief NSC sewer)
WRFs and Biosolids
J04074, Milorganite Packaging Facility[4]
M03102, Biosolids Advanced Facility Planning[5]
S03003, Post-Secondary Capacity Improvements[6,7]
S04031, Digester Gas Treatment System[8]
Green Infrastructure[9]
G98002, Fresh Coast Green Solutions Phase 2
G98004, Fresh Coast Implementation Phase 2
G98005, Green Solutions Phase 2 (formerly M10002)
G98011, Alternative Project Delivery / Community-Based GI

1) Table presents projects in the 2020 to 2025 long-range finance plan that support 2050 Foundational Goals.
2) Project is anticipated to address the risks analyzed in CS FG1, Programmatic Approach to H_2S.
3) The official name for project C05051 is different than the name listed in Appendix 6A (Edgewood Avenue MIS Extension), which was from preliminary engineering report information.
4) Project is anticipated to address the risks analyzed in WRF FG3, JIWRF Milorganite Bagging.
5) This project will refine the recommendations in the 2050 FP and determine what facilities or capital improvements are needed for biosolids management. It is anticipated that the recommendations from the WRF FG2, Alternative Biosolids Processing Disposal Systems Analysis and other biosolids-related evaluations noted in Chapter 7 will be further analyzed under this project.
6) Project is anticipated to address the risks analyzed in WRF FG9, SSWRF Wet Weather Capacity.
7) As part of the implementation of this project, the design criteria presented in the SSWRF O&M manual will need to be updated. The specific proposed design criteria updates are presented in Chapter 9.
8) This digester gas treatment project is presented as Alternative 1 in WRF FG4, Increase SSWRF Renewable Energy Use for comparison to other alternatives.
9) The GI projects listed are needed not only to meet the 50 MG goal in the 2019 WPDES permit as noted in Chapter 7, but also to assist in meeting the MMSD's internal KPI target of 740 MG. With approximately 40 MG assumed to be installed as of the end of 2019 as stated in Chapter 5 and Appendix 5D, the recommended projects identified in Table 8-2 are for an additional 500 MG over and above the 200 MG assumed to be achieved after implementing all the projects in Chapter 7.

8.5 SUMMARY OF RECOMMENDED PROJECTS

The implementation of the recommended projects in this chapter is anticipated to reduce the likelihood of failing to meet 2050 Foundational Goals due to identified capacity, physical mortality, level of service, and economic efficiency risks.

Chapter 9 presents the implementation plan for all new recommended projects presented in this chapter as well as the new recommended projects to meet regulatory guidelines and permit requirements outlined in Chapter 7.

Table 8-4 presents a summary of the costs per asset system identified in Tables 8-1 and 8-2. The vast majority of these costs is to implement two projects that will also address permit requirements: reduce CSOs through the use of high rate treatment ($992.4 million) and replace the dryers at JIWRF ($214.6 million).

The recommended plan to meet 2050 Foundational Goals will achieve the following:

- Increase green infrastructure (GI) from 40 million gallons (MG) to 740 MG by 2035
- Increase renewable energy use from 33 percent to 60 percent
- Maintain combined sewer overflow (CSO) frequency at 3.25 events per year with future projected increase in flows

TABLE 8-4: SUMMARY OF RECOMMENDED PLAN COSTS TO MEET 2050 FOUNDATIONAL GOALS

Asset System Summary[1]	Capital Cost ($ millions)	Incremental Change in Annual O&M Cost ($ thousands)
Conveyance and Storage		
Table 8-1, Projects Recommended to Meet Baseline Conditions[2]	$0.0	$0.0
Table 8-2, Projects Recommended to Meet Future/Buildout Conditions[3]	$0.0	$0.0
Conveyance and Storage TOTAL	**$0.0**	**$0.0**
WRFs and Biosolids		
Table 8-1, Projects Recommended under Baseline Conditions[2]	$234.1	($9,050.0)
Table 8-2, Projects Recommended under Future/Buildout Conditions[3]	$48.5	$1,120.0
WRFs and Biosolids TOTAL	**$282.6**	**($7,930.0)**
Watercourse and Flood Management[4]	**$0.0**	**$0.0**
Green Infrastructure		
Table 8-1, Projects Recommended to Meet Baseline Conditions[2]	$0.0	$0.0
Table 8-2, Projects Recommended to Meet Future/Buildout Conditions[3]	$225.4	$4,599.1
Green Infrastructure TOTAL	**$225.4**	**$4,599.1**
Systemwide		
Table 8-1, Projects Recommended to Meet Baseline Conditions[2]	$1.7	$0.0
Table 8-2, Projects Recommended to Meet Future/Buildout Conditions[3]	$992.4	$0.0
Systemwide TOTAL	**$994.1**	**$0.0**

1) There are no additional WCFM recommended projects over and above those in Chapter 7.
2) Capital costs and incremental changes in annual O&M costs due to projects recommended to meet Baseline Conditions. These projects are recommended for inclusion in the 2020 to 2025 long-range finance plan and MMSD Annual Budget.
3) Capital costs and incremental changes in annual O&M costs due to projects recommended to meet Future/Buildout Conditions. These projects are recommended for consideration in future long-range finance plans and MMSD Annual Budgets if and when they are determined to be necessary based on growth and other future needs.

8.6 ADDITIONAL OPPORTUNITIES TO HELP MEET 2050 FOUNDATIONAL GOALS

In addition to the recommended projects outlined above, MMSD has identified several priority areas to help meet its 2050 Foundational Goals. These include issues that MMSD may need to consider in future facilities plans as well as regulatory guidelines, permit requirements, goal changes, and programs that MMSD may consider implementing in the future. While the 2050 FP does not include any recommended projects for these areas, this section is included to document background information on each topic and provide initial guidance in terms of state of industry best practices that can be referred to when and if

MMSD needs to implement additional projects to address a specific issue. Priority areas of support include the following:

- Information technology integration
- Climate change impacts
- Emerging technologies
- Tree replacement
- Integrating energy and GI KPIs into Conveyance and WCFM
- Resilience Plan regional integration
- Further green all County parks and public spaces
- Support TMDL implementation
- Watershed-based permitting program considerations
- Carbon sequestration
- Emerging contaminants

In addition to the specific issues discussed in this section, all recommended projects outlined in the 2050 FP should be considered in light of general sustainability principles that cover triple bottom line (environment, economic, and social) considerations. Frameworks such as the Institute for Sustainable Infrastructure's ENVISION and the United Nations' Sustainable Development Goals can help guide MMSD to optimize projects for sustainability considerations.

Information Technology Integration

Purpose

MMSD uses information technology and data integration throughout its organization. Continuing to maintain these systems is important, as is considering how best to enhance them. Information technology is a rapidly changing landscape and it is critical to remain positioned to know how best to leverage existing investments in this area. Development and monitoring of new information technologies must be followed and incorporated when deemed beneficial and practicable.

Approach

A listing of current MMSD initiatives in information technology and geographic information systems is presented below. Ongoing consideration of long-term goals for MMSD along with a systematic way of keeping abreast of innovations in information technology will help to identify the types of technologies that could be considered into the future.

Topic Evaluation

MMSD information technology efforts include initiatives that improve asset management and overall knowledge management. This is being done through parallel and related efforts, including, but not limited to, reviewing and continuously upgrading the following information technologies:

- Hydraulic Modeling – Hydraulic modeling software is used to understand, predict, and manage water resources and is the key element to managing the flows in the conveyance system.
- AssetView – AssetView improves MMSD's ability to track assets and define their value, criticality, and service life. Currently, there is some level of integration of maintenance activity with modeling capability (for scenarios). MMSD is also integrating Microsoft Power BI, which offers data visualization tools, for better assessment of the AssetWise database.
- Geographic Information System (GIS) – MMSD invests in a mature enterprise GIS and existing records management solution (OnBase). There are continued opportunities for expansion and integration into all functional areas of MMSD, including plant and conveyance live operational data as well as O&M manuals.
- Building Information Modeling (BIM) – MMSD is engaged in a pilot program based on years of planning. Previous phases helped to build standards and an approach to building 3D data for WRFs incrementally over time and integrating it with the other systems (GIS, e-Builder, AssetWise and OnBase). This includes the use of Lidar scanning to capture existing facilities as well as new standards to enable future consulting/contractor work to help feed this critical enterprise BIM model. MMSD is interested in expanding the use of BIM in conjunction with GIS to integrate with as many systems as possible, including the same examples provided for GIS.
- e-Builder – MMSD is working towards a transition from Oracle to this new solution for overall program and project management of all capital projects. Includes budget, schedule management, and collaboration tools for projects. This also can present an opportunity for MMSD to incorporate interactive methods for managing technical specifications and contract documents.
- SCADA – SCADA (supervisory control and data acquisition) is a computer system for gathering and analyzing real time data. MMSD uses SCADA along with information and control (I&C) to communicate and control the system.

In addition to the MMSD initiatives mentioned above, data brokering software was reviewed for the 2050 FP. Data brokering software gathers data across multiple data sources and databases to create a simple, user-friendly system that allows departments to access data and easily generate reports for evaluation. Many utilities are challenged with finding a "system" that can take information and data from the various data programs, such as Water Information Management System (WIMS), AssetView, supervisory control and data acquisition (SCADA), Maintenance, Records, Finance, and others, and provide a "combined" reporting system. An example of data brokering software is e.RIS. Because it is a newer technology, utilities, such as the City of Fort Wayne, Indiana, are still evaluating it to determine how user-friendly the system is.

Information technology can help to measure the achievement of MMSD's long-range goals. Therefore, continued support and advancement of these and other information technologies can help document how well goals are being addressed.

TABLE 8-5: FOUNDATIONAL GOALS REVIEW - INFORMATION TECHNOLOGY INTEGRATION

Foundational Goals	Topic – does this topic address foundational goals?
G1. Change the District from an organization that impacts the environment to an organization that benefits the environment.	Indirectly. Technology integration can support district efforts in this area.
G2. Incorporate new technologies and operational improvements to minimize the District's financial burden on ratepayers.	Yes
G3. Integrate green infrastructure into all facets of development and redevelopment.	Indirectly. Technology integration can help identify and quantify benefits of GI
G4. Support urban biodiversity activities within the region.	Indirectly. Technology integration can support district efforts in this area.
G5. Provide adaptive leadership to increased regulatory oversight, limited financial resources, increased public participation, climate change, and management of energy costs.	Yes. Technology integration can help identify and quantify benefits as well as enable sharing such data with decision makers and rate payers.

Recommendations

It is important to continue to support and enhance mature enterprise GIS including the mature integration with AssetWise or other information technology. Continuing to support existing information technologies while considering how best to implement emerging information technologies will allow MMSD to be able to continue to measure its progress on various goals and evaluate its effectiveness.

One recommendation is that MMSD integrate data sources for a particular asset based upon the MMSD asset management system that will allow the asset to be searchable by either the asset system or by GIS. Some of this is already done, but other elements could to be added (e.g., electronic editable O&M manuals).

MMSD should consider investing in ways to better leverage data through data science/analytics for the ability to obtain a deep learning/understanding of operations through business intelligence (BI) as well as predictive analytics and smart controls. The ability to implement this and move an enterprise to the

ability to leverage machine learning (ML) and artificial intelligence (AI) takes strategic thought into data governance and data/systems architecture.

- BI connects structures, systems, services and management within a single analytics platform. MMSD has started to use one tool, Microsoft Power BI, to assess collected AssetView data. Other powerful platforms on the market enable natural speech query across enterprise systems as well as enable many data science abilities, including predictive capabilities. Leveraging data shifts an agency from descriptive and diagnostic information collection to predictive and prescriptive action, with the goal of having automated prescriptive responses to what is coming. For example, advancements in sensing technology and deployment in conveyance could help operators adjust and prepare to handle a septic waste slug before it enters the plant. In addition, BI could be used to analyze sensor data to build a model that forecasts influent flow based on weather patterns and historical plant data. The results could then be used to plan pump runtimes and speeds, adjust staffing needs, and proactively divert flow to storage.
- AI, and more specifically machine learning, is the ability of systems to learn from data patterns; an example is real-time monitoring of plant equipment. The data trends exposed by a machine learning solution could help predict equipment failure and allow for savings in labor/equipment costs by avoiding an emergency repair. For instance, monitoring of pump vibration can help an operator take corrective action to restore operations within the specified best efficiency point, thereby reducing wear on the asset and improving its efficiency. Artificial intelligence is the next big step of having computers act upon data without human intervention. An example is real-time water flow trends and analytics that define a certain chemical level and automatically alert the SCADA system to activate a valve. AI applications can be applied across the full spectrum of water/wastewater operational tools, from asset investment planning, pipe replacement and risk analysis, event management, and predictive leak detection to asset performance monitoring.
- Smart controls include the integration of emerging and advancing technology of hardware and communications to better manage flows and slug loads. For example, faster computer processing and network speeds combined with low-cost storage of large quantities of data and smaller, more accurate, and less expensive sensors can result in better information for managing flows, optimizing energy use and improving treatment performance. The concept of the “internet of things” (IoT) is to connect every device to the Internet. Widespread deployment of sensing technologies coupled with investment in machine learning provide an increased opportunity for improvement at the asset and system levels by mining data for complex correlations to KPIs. Using smaller, higher-capacity batteries and photovoltaics reduces dependence on permanent hard-wired power sources. Wireless transmittal of acquired data reduces the need for continuous or dial-up hard-wired communications systems. MMSD could utilize advances in technology to implement “smart data infrastructure” for wet weather control—that is, use advanced monitoring data to support wet weather control and decision-making, energy use optimization, and treatment performance in real time or near real time. MMSD previously developed real time control systems for wet weather control but found that no additional improvements could be made to the ability of the conveyance system to capture flow volumes without the ability to accurately predict rainfall. However, MMSD may find that more recent advances in technology could make additional applications for real time control more feasible. Case studies about communities that have done this across the country are included in the U.S. EPA document listed as a reference below.

These and other emerging technologies could address how much blending would be possible without exceeding mass limits. The use of artificial emerging technologies such as artificial neuro networking (ANN), industrial internet of things (IIOT), and AI is becoming common practice in various industries. MMSD could investigate how these technologies could optimize plant performance in the following ways:

- Implement predictive analytics for mitigation process upsets and root cause analysis.
- Upgrade existing ANN to incorporate newer IIOT and AI technology to improve real-time process control measures to optimize plant performance and minimize costs (e.g., real-time calculation of TSS mass limits against weather forecast probability to optimize blending and corresponding chlorination/dechlorination). Note that MMSD is already investigating the implementation of this effort.
- Optimize operations and maintenance cycles to allocate resources most effectively in the system (e.g., targeted deployment of sensors coupled with machine learning can lead to development of asset utilization profiles that assist operations staff in a more efficient allocation of resources, potentially eliminating unnecessary preventative maintenance or identifying needed corrective actions). This strategy needs to consider warranty requirements.

Potential data brokering systems should be evaluated, including a review of the experiences of other utilities that have implemented these systems to determine the feasibility for application by MMSD.

The recommendation to address 2050 Foundational Goal G2—incorporate new technologies and operational improvements to minimize the District's financial burden on ratepayers—involves continued emphasis on information technology development by the MMSD. Establishing a working group or committee dedicated to this topic could track progress on this foundational goal.

This working group or committee can be comprised of people representing multiple functional areas and could be accountable for the information technology vision for MMSD. It could include IT staff as well as environmental and financial leadership to help guide investment in effective information technology. This group could be charged with articulating and defining specific outcomes that are desired from information technology investment. Having a dedicated group taking ownership of this process could identify which information technology enhancements and updates may be the most effective.

Bibliography

J. Roof, *A Digital Governance Framework is key component for successful transformations*, CIO Review. Accessed on April 6, 2020. [Online]. Available: https://utilities.cioreview.com/cioviewpoint/A-Digital-Governance-Framework-is-a-key-component-for-successful-transformations-nid-30205-cid-41.html

U.S. Environmental Protection Agency, Smart Data Infrastructure for Wet Weather Control and Decision Support, U.S. Environmental Protection Agency Office of Wastewater Management, August 2018. Accessed on April 6, 2020. [Online]. Available: https://www.epa.gov/sites/production/files/2018-08/documents/smart_data_infrastructure_for_wet_weather_control_and_decision_support_-_final_-_august_2018.pdf

Climate Change Impacts

Purpose

The requirement and benefit of an interim qualitative assessment of climate change aligns directly with 2050 Foundational Goal G5—provide adaptive leadership to climate change. The 2014 Climate Change Vulnerability Analysis (CCVA) report was based upon climate change projections applied to the period 1940 to 2004. Almost 13 years of additional meteorological data was available in 2019, which may provide valuable insights into the impacts and risks identified in the CCVA. The impacts of climate change and the timing of those impacts must be addressed using a risk management approach based upon the best and most recent and relevant data available. The periodic assessment of the models that will guide actions regarding climate change for MMSD is also an important aspect to meeting 2050 Foundational Goal G5.

Approach

An analysis of the impacts of climate change should be based upon the framework developed in the CCVA, which graphically is shown in Figure ES-1 from the report:

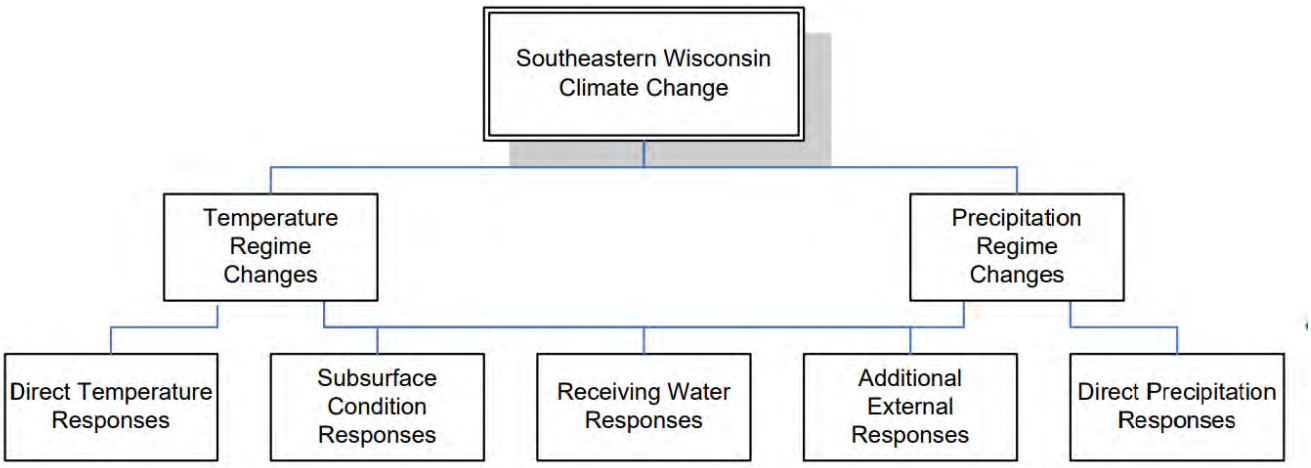

Figure ES-1. Projected Southeastern Wisconsin Climate Change Responses

This graphic shows the principal climate data required to assess the long-term climate change impacts: temperature and precipitation regime changes. The long-term actions of MMSD need to be based upon the study of these two regimes and the use of this data in the modeling effort that projects the impacts on MMSD facilities.

Topic Evaluation

MMSD must periodically update the analyses completed for CCVA to assess actual impacts to MMSD facilities and to revise future predicted impacts as applicable. To achieve accurate findings, the update should follow the process in the original CCVA, including:

1. Overall assessment of potential vulnerabilities to MMSD facilities and operations
2. Evaluation of changes in the frequency and volume of CSOs and sanitary sewer overflows (SSOs) as a result of different climate change scenarios

3. Evaluation of changes in high and low flows in the two CCVA selected reaches (most downstream reaches for the Kinnickinnic and Menomonee Rivers) as a result of different climate change scenarios
4. Evaluation of the effectiveness of GI assets with changes in rainfall patterns (changes in intensity and frequency) as a result of climate change
5. Identification of facilities at JIWRF and SSWRF that may be at risk of deterioration, inundation, or loss of performance as a result of lower or higher than average water levels in Lake Michigan

This can only be done by implementing the recommendations of the CCVA, including:

1. Implement "no-regrets" actions that will be beneficial to MMSD even if climate change predictions may not fully represent future conditions.
    - This can be done by including an assessment of climate change in each MMSD project much like how energy and sustainability are now assessed.
2. Monitor trends in local factors that are indicators of climate change.
    - This can only be done in a cooperative effort with many local and state resources and experts, with the continuation of the group that provided input to the CCVA.
3. Monitor climate change research on changes in precipitation and temperature and update evaluations of impacts on MMSD facilities if research indicates significant changes from the assumptions used in this study.
    - Using the data and resources from items 1-2 should provide the basis for when to update the impact evaluation.
4. Consider the use of corrosion resistant materials and linings when replacing or rehabilitating sewers and pump stations and evaluate the need for odor control measures if an increasing trend in H_2S is observed.
    - This element must be done on a case-by-case basis in terms of the impacts of reduced sewer flows in dry weather in MMSD systems that already exhibit these issues.
5. Investigate impacts of decreased watercourse low flows on aquatic habitat, water quality, and aquatic species viability.
    - Expanding on the *Using Green Infrastructure to Enhance Urban Biodiversity in the MMSD Planning Area* report, baseline conditions should be developed, including developing a biologic inventory and habitat assessments. [2]
6. As GI is implemented, evaluate its effectiveness with regards to different rainfall distributions to assess how changes in distributions with climate change may impact the effectiveness of GI.
    - Potential new technologies should be considered as a part of overall research on the effectiveness of GI, also tying into 2050 Foundation Goal G2.
7. Continue to perform physical inspection of selected wood piles, particularly when lake levels are low. A periodic inspection of JIWRF facilities that may have been exposed to drying during the low Lake Michigan water level/low ground water period in 2012 would assess whether deterioration has occurred over time, which could be indicative of potential deterioration if climate change results in more frequent periods of low ground water levels.

- This effort has already been initiated with the Jones Island Structural Evaluation (MMSD project J06032) in 2016.

TABLE 8-6: FOUNDATIONAL GOALS REVIEW - CLIMATE CHANGE IMPACTS

Foundational Goals	Topic – does this topic address foundational goals?
G1. Change the District from an organization that impacts the environment to an organization that benefits the environment.	Yes. GI assets and other planning efforts can offset climate change impact. Ongoing conveyance and water reclamation facilities efforts also benefit the environment.
G2. Incorporate new technologies and operational improvements to minimize the District's financial burden on ratepayers.	Yes. GI assets and other technologies can reduce the financial burden on rate payers, as would community-based GI, where efficiencies may be realized. Also, changes to operations and energy improvements could lower costs.
G3. Integrate green infrastructure into all facets of development and redevelopment.	Yes. GI assets can assist in the management of impacts from climate change
G4. Support urban biodiversity activities within the region.	Yes. Activities supported by continued investigation of the impacts of decreased watercourse low flows on aquatic habitat, water quality, and aquatic species viability.
G5. Provide adaptive leadership to increased regulatory oversight, limited financial resources, increased public participation, climate change, and management of energy costs.	Yes. Recommendations include how to adapt to manage impacts to climate change.

Recommendations

Implement the recommendations of the CCVA as noted in in the Topic Evaluation section, above. Successful long-term attainment of Foundational Goal G5 requires diligence each year to adapt by addressing the various aspects of the impacts of climate change. The CCVA was last updated in 2019.

Bibliography

There are many references for strategies to address climate change. The CCVA is certainly the base reference for this effort. Among many other references, these may be useful:

Brown and Caldwell, Climate Change Vulnerability Analysis, MMSD Contract No. M03054P01, MMSD, Milwaukee, WI, 2014. Accessed on: April 6, 2020. [Online]. Available: https://www.mmsd.com/application/files/2814/8416/3477/Climate_Change_Vulnerability_Analysis_Report_Without_Appendices.pdf

Wisconsin Initiative on Climate Change Impacts, Slideshow - Maps of Recent and Projected Climate Change in Wisconsin, Wisconsin Initiative on Climate Change Impacts, Madison, WI. Accessed on: April 6, 2020. [Online]. Available: https://www.wicci.wisc.edu/climate-change.php

Emerging Technologies

Purpose

The benefits of incorporating new technologies as identified in the foundational goals is very important. Technology is changing so quickly and the technologies that will influence MMSD into the future may not even be developed as of the completion of the 2050 FP. Development and monitoring of new technologies – especially those that impact the far-reaching future goals of MMSD – must be followed and brought into MMSD as soon as they are practicable. The identification of these technologies must be systematic and integrated into MMSD's long-term system solutions.

Approach

MMSD is currently monitoring emerging technologies. It is expected that findings from this ongoing effort will help to identify the types of technologies that need to be followed and considered into the future. It is impossible to identify the exact technologies at this point but a method of identifying, documenting, and initiating consideration of these new technologies should be developed. Information from the Water Environment Federation and the Water Research Foundation (which MMSD is a member of), including Water Research Foundation: Leading Water and Wastewater Utility Innovation (WRF 4907), was reviewed for information on managing the use of emerging technologies and threats. Water Research Foundation: Leading Water and Wastewater Utility Innovation (WRF 4907) helps the process from defining the innovation program through improvement implementation progress and metrics.

Topic Evaluation

The use of new technologies will be critical to the achievement of the long-range goals of MMSD, including key performance indicator targets related to achieving zero overflows, full implementation of GI, and renewable energy. Therefore, the technologies to be monitored must be technologies that address each of these significant goals and hopefully technologies that address all three simultaneously.

For the achievement of zero overflows, technologies that reduce, store, or treat wet weather flows must be monitored. A key area in this technology assessment is the use of GI to reduce infiltration and inflow in the separate sewer service area. Another key technology development area is in the control of infiltration and inflow in sanitary sewers in terms of lining and other methods to eliminate the wet weather flows. Additionally, technologies may be developed that will allow for effective satellite treatment of overflows to render them the same quality as fully treated wastewater. Specifically, cloth media technology, which is being installed in Hammond, Indiana, and CEPT in-pipe treatment being piloted by MMSD, discussed as part of SW FG2, Zero Overflows in Chapter 6, should be investigated further.

For the full implementation of GI and to achieve the direct and indirect benefits of GI, more cost effective and easily maintained technologies must be developed that can be effectively applied in the entire MMSD service area. Full implementation will also be dependent upon innovative technology delivery such as public-private partnership (also referred to as P3) delivery of GI. While this is not necessarily a technology development, it is a technology implementation development that should be studied and improved upon in the future.

In terms of the energy goals, although no recommendations to reduce energy are made in the 2050 FP over and above the recommendations in the Energy Plan, future emerging methods to improve the energy efficiency of all aspects of MMSD operations must be explored as well as methods to achieve

zero net energy use by MMSD facilities. A key technology in this area is biosolids drying in terms of energy consumption and overall energy balance. Technology development in this area has been somewhat limited but the long-term need to produce viable recyclable biosolids must be met using technologies that are energy neutral. None exist today and the technology development in this area must proceed for MMSD to meet its future energy goals.

TABLE 8-7: FOUNDATIONAL GOALS REVIEW – EMERGING TECHNOLOGIES

Foundational Goals	Topic – does this topic address foundational goals?
G1. Change the District from an organization that impacts the environment to an organization that benefits the environment.	Yes. New technologies can assist MMSD in this goal
G2. Incorporate new technologies and operational improvements to minimize the District's financial burden on ratepayers.	Yes. This topic specifically addresses this goal.
G3. Integrate green infrastructure into all facets of development and redevelopment.	Yes. More cost effective and easily maintained GI technologies must be developed that can be effectively applied in the entire MMSD service area
G4. Support urban biodiversity activities within the region.	Yes – indirectly through GI.
G5. Provide adaptive leadership to increased regulatory oversight, limited financial resources, increased public participation, climate change, and management of energy costs.	Yes. New technologies can allow MMSD to be more adaptive.

Recommendations

The recommendation involves an increased emphasis on exploring, testing, and implementing new technology to achieve foundational goals (as well as regulatory guidelines). This increased emphasis can be achieved by leveraging all available funding and knowledge resources, including MMSD staff, consultants, operations contractor, and the other vital assets that are in the Milwaukee area, including the universities and the Global Water Center. Participation in Water Environment Federation research is also crucial to achieving this goal. The establishment of a larger MMSD research effort will also help achieve these goals by possibly providing additional staff and/or additional efforts, including the establishment of an outside scientific advisory board, offering opportunities for consultants and inventors to present new technologies to MMSD, and support of research and development activities both locally and nationally.

All this work will carry a cost. In private industry, typically up to 10 percent of a company's overall effort is on new product development. Certainly, MMSD cannot afford to dedicate 10 percent of its budget to this area, but 1 to 3 percent of the budget to support the development of new technologies to address the foundational goals is justified, which is in alignment with the budget being spent by MMSD as of 2019. An innovation planning tool, using information from Water Research Foundation: Leading Water and Wastewater Utility Innovation (WRF 4907) as a guide, should be developed and deployed, and staff training should be provided to set guidelines and metrics for success in evaluating emerging technologies.

Bibliography

Arcadis, *Leading Water and Wastewater Utility Innovation*, presentation at Ohio Water Environment Associate annual conference, June 27, 2019. Accessed on: April 6, 2020. [Online]. Available: https://www.ohiowea.org/docs/OWEA2019-Leading_Wastewater_Utility_Innovation.pdf

There are numerous documents related to emerging technologies available on these two websites:

Water Environment Federation website. Accessed on: April 6, 2020. [Online]. Available: https://www.wef.org

Water Research Foundation website. Accessed on: April 6, 2020. [Online]. Available: https://www.waterrf.org/

Tree Replacement

Purpose

MMSD has an opportunity to remove and replace trees during construction of certain conveyance and watercourse projects. A focused tree replacement policy can provide benefits and help MMSD work towards meeting multiple foundational goals by:

- Promoting good site design
- Mitigating impacts to neighborhoods and wildlife as a result of construction and project implementation
- Reducing stormwater runoff
- Increasing carbon sequestration
- Remove invasive species

Approach

A brief Internet search for tree replacement initiatives was conducted during July and August 2019 to prepare this document.

Topic Evaluation

Trees can be used to reduce stormwater runoff by capturing and storing rainfall in the canopy and releasing water into the atmosphere through evapotranspiration. Additionally, tree roots and leaf litter create soil conditions that promote the infiltration of rainwater into the soil. Trees also reduce erosion by capturing rain in the leaf canopy and tree roots bind the soil and absorb water from the soil.

Trees also provide other economic, social, and environmental benefits, ranging from improved aesthetics, biodiversity, increased property values, shade provision, and noise reduction. Trees can also capture and store carbon dioxide (carbon sequestration). Carbon dioxide is the most commonly produced greenhouse gas, so increased carbon sequestration can contribute to the goal of reducing climate change.

On the other hand, it should be noted that trees can increase the risk of damage if they are placed too close to private laterals, where their roots may cause pipe damage and corresponding leaks.

TABLE 8-8: FOUNDATIONAL GOALS REVIEW – TREE REPLACEMENT

Foundational Goals	Topic – does this topic address foundational goals?
G1. Change the District from an organization that impacts the environment to an organization that benefits the environment.	Yes. Replacement of trees can have multiple environmental benefits.
G2. Incorporate new technologies and operational improvements to minimize the District's financial burden on ratepayers.	No new technologies were identified at this time.
G3. Integrate green infrastructure into all facets of development and redevelopment.	Yes. Trees are a defined GI strategy.
G4. Support urban biodiversity activities within the region.	Yes. Trees can provide broader biodiversity.
G5. Provide adaptive leadership to increased regulatory oversight, limited financial resources, increased public participation, climate change, and management of energy costs.	Yes. Tree replacement is an adaptive approach to challenges MMSD faces.

Recommendations

Continue to include trees in WCFM projects and pursue community GI tree projects. Develop a policy to address tree replacement and targeted tree removal on conveyance and watercourse projects.

Bibliography

Trees and Stormwater website. Accessed on: April 6, 2020. [Online]. Available: http://treesandstormwater.org/

Trees and Stormwater is a website of the Ohio Kentucky Indiana Regional Council of Governments (OKI) and its team of national partners. This group is developing a guide for local decision makers to integrate trees into stormwater management design and policy that is applicable across the nation. It is funded in part by the USDA Forest Service's National Urban and Community Forestry Challenge Cost Share Grant Program.

Minnesota Pollution Control Agency, *Minnesota Stormwater Manual: Calculating credits for tree trenches and tree boxes*, Minnesota Pollution Control Agency, Minnesota, August 13, 2019. Accessed on: April 6, 2020. [Online]. Available: https://stormwater.pca.state.mn.us/index.php/Calculating_credits_for_tree_trenches_and_tree_boxes

In Minnesota, in recognition that trees can be an important tool for retention and detention of stormwater runoff, the Minnesota Pollution Control Agency has established a methodology for calculating credits for tree trenches and tree boxes. Trees benefits identified include: cleaner air, reduction of heat island effects, carbon sequestration, reduced noise pollution, reduced pavement maintenance needs, and cooler cars in shaded parking lots. The credits incentivize developers to encourage preservation and enhancement of natural areas.

U.S. Environmental Protection Agency, *Soak Up the Rain: Trees Help Reduce Runoff*, U.S. Environmental Protection Agency, Boston, MA. Accessed on: April 6, 2020. [Online]. Available: https://www.epa.gov/soakuptherain/soak-rain-trees-help-reduce-runoff

University of Minnesota Northland NEMO website. Accessed on: April 6, 2020. [Online]. Available: http://www.northlandnemo.org/resources.html

The University of Minnesota, through its Northland Nonpoint Education for Municipal Officials (NEMO), has several resources related to nonpoint pollution, including an interactive "watershed game" and information about use of trees to help manage stormwater.

Breland, A, et al, The role of trees in urban stormwater management, U.S. National Library of Medicine, National Institutes of Health, September 12, 2018. Accessed on: April 6, 2020. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6134866/

A study by the National Institutes of Health documented the many ancillary benefits of trees, such as aesthetics, shade provision, increased property values, and noise reduction.

Unites States Department of Agriculture Forest Service, Carbon Sequestration, Unites States Department of Agriculture, October 7, 2016. Accessed on: April 6, 2020. [Online]. Available: https://www.fs.fed.us/ecosystemservices/carbon.shtmlThe USDA Forest Service notes that sustainable forestry practices can increase the "ability of forests to sequester atmospheric carbon while enhancing other ecosystem services, such as improved soil and water quality. Planting new trees and improving forest health through thinning and prescribed burning are some of the ways to increase forest carbon in the long run. Harvesting and regenerating forests can also result in net carbon sequestration in wood products and new forest growth."

Integrating Energy and GI KPIs into Conveyance and WCFM

Recommended policy changes include the requirement that renewable energy and GI opportunities be evaluated as part of planning or preliminary engineering phases of all applicable conveyance and WCFM projects. This is typically done now, and memorializing it as a policy would ensure it is accomplished.

Specific to energy, the WRFs, and specifically biosolids heat demand, are such a large part of total energy demand that even if all the non-process electricity[10] used were converted to renewable, it would only increase the total percent renewable from 33 to 34 percent. However, because only 3.5 percent of total non-process electricity in 2017 was provided using renewable power, consideration of upgrades to solar power should be reviewed as part of all conveyance facility replacement projects. MMSD's policy on climate change, adopted by the MMSD Commission in July 2019, provides a framework for this integration.

[10] *Non-process electricity for MMSD buildings and conveyance operations, such as pump stations, is categorized as non-process energy in the energy analysis developed in SW FG4, Energy 2035 Vision (Appendix 6E).*

Resilience Plan Regional Integration

Purpose

In 2019, MMSD collaborated with multiple municipalities, agencies, and community organizations to address risks that are impacting the 28 southeastern Wisconsin municipalities served by MMSD. Through a collaborative process, risks and recommendations were identified collectively by stakeholders, and the stakeholders discussed working towards a future based on three visions:

1. Make the Milwaukee region a better place to live by improving the public's participation in decision making and their environment
2. Boost the region's economic vitality through innovative job creation and access to equal opportunities
3. Adapt infrastructure to the challenges of the 21st century by preparing critical infrastructure for tomorrow and innovating to preserve natural resources

Approach

The Resilience Plan declares that "A healthy environment, strong schools, robust economy, and collaborative governments are the foundational elements of this Resilience Plan." Twenty specific recommendations or actions were identified to work towards the three visions, some of which may be implemented individually or integrated into projects. Topics covered a range of initiatives, including several that are not typically tasks of a wastewater agency. As such, the Resilience Plan sets a good framework for externally-focused actions while the 2050 FP makes recommendations for internally-focused actions.

The action steps or recommendations may be implemented by many partners over many years, and MMSD is identified as the lead on several, which are listed below.

- Engage stakeholders in collaborative decision making and implementation of watershed restoration and water quality plans
- Accelerate local efforts to improve municipalities by replacing grey impervious surfaces with green spaces
- Support the creation of and training for jobs related to sustainability in specific industries and trades
- Develop and implement sustainable practices through bids and businesses across the region
- Assess the reliability of critical infrastructure by performing a criticality analysis
- Establish a policy review and response mechanism
- Increase GI in the region
- Develop and implement a plan to make critical infrastructure around water systems cyber resistant

Topic Evaluation

As shown in Table 8-9, the Resilience Plan and its visions align well with the foundational goals of the 2050 FP.

TABLE 8-9: FOUNDATIONAL GOALS REVIEW - RESILIENCE PLAN REGIONAL INTEGRATION

Foundational Goals	Topic – does this topic address foundational goals?
G1. Change the District from an organization that impacts the environment to an organization that benefits the environment.	Yes. Collaborating with Resilience Plan stakeholders may be a proactive way to identify areas where MMSD can continue to be an organization that benefits the environment.
G2. Incorporate new technologies and operational improvements to minimize the District's financial burden on ratepayers.	Yes. Vision 2 of the Resilience Plan specifically identifies boosting the economy with innovative job creation and Vision 3 considers adapting infrastructure to the challenges of the 21st century.
G3. Integrate green infrastructure into all facets of development and redevelopment.	Yes. Vision 3 includes Integrating sustainability in bid practices and specifically identifies increasing GI in the region.
G4. Support urban biodiversity activities within the region.	Yes. Several actions in the Resilience Plan would improve biodiversity such as replacing grey impervious surfaces with green spaces and increasing GI in the region.
G5. Provide adaptive leadership to increased regulatory oversight, limited financial resources, increased public participation, climate change, and management of energy costs.	Yes. Vision 1 of the Resilience Plan focuses on improving public participation in decision making.

Recommendations

The importance of addressing resiliency in the context of climate change and regional socio-economic conditions is vital to the long-term effectiveness of MMSD and its systems. While MMSD plans for replacement of equipment and maintenance of the system through the facilities planning process, there are factors external to MMSD such as climate change, population changes, and changes in land use that will continue to impact the demand for MMSD services.

While the Resilience Plan has components that go beyond typical duties of a regional wastewater agency, MMSD expenditures have an impact on social, environmental, and economic components of the region. The aspirational visions of the Resilience Plan align with the foundational goals of the 2050 FP and the consideration of these areas will help make regional resilience an element of any planning process.

To work towards the visions presented in the Resilience Plan, continued and structured collaboration and commitment of the stakeholders is critical. This should be achieved by a continued working group of the stakeholders that worked on the plan, or at least an annual convergence of this group that could serve as a "report back" function to ensure continued progress. Ad hoc groups related to each of the actions could work collaboratively to impact change in each action area.

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Further Green all County Parks and Public Spaces

Purpose

In the 2019 Resilience Plan, the topic of replacing grey impervious spaces with green spaces was identified as an action. The 2019 Resilience Plan identified "Reduce stormwater runoff, energy costs, impacts of climate change, and urban heat island effects" as the objective of this action. One way to help achieve this action item is to implement the greening of county parks, municipal parks, and other public spaces, which could help reduce stormwater runoff, increase biodiversity, lessen energy costs, and reduce the impacts of climate change while providing aesthetic and municipal benefits.

Approach

Further greening of parks and public spaces could manifest as various initiatives, such as removing impervious surfaces and replacing them with green spaces, providing additional trees or other vegetation, amending soil or adding compost wherever possible, or implementing other green initiatives in public spaces. Evaluating locations where stormwater could be directed to green spaces (such as parks with or surrounded by large roadways) rather than having water run off into combined or storm sewers could provide additional benefits.

In addition to county and municipal parks, municipal public spaces (such as municipal properties and school properties) could benefit from efforts to add compost or soil to green spaces, replace grey impervious surfaces with green spaces, and increase the number of trees.

Costs are undetermined for these initiatives, but there could be opportunities for joint funding and grants. Funding opportunities to explore include the Great Lakes Restoration Initiative, Fund for Lake Michigan, local funders, and others. Several municipalities in the MMSD service area participate in Tree City USA, a program that supports municipalities in increasing tree canopies.

In Portland, Oregon a non-profit organization called *depave* specifically transforms over-paved places while engaging municipalities and reconnecting urban landscapes to nature through education, advocacy, and stewardship.

Topic Evaluation

Milwaukee County alone has 15,338 acres of County-owned parkland. In addition, there are 3,363 acres of parkland owned by municipalities and school districts in Milwaukee County. While this includes all park areas, not just greenspace, a substantial amount is area that could receive compost soil amendments and could increase the amount of stormwater captured on parkland. In addition, there are other municipal properties that could be considered, though areas were not identified for these spaces.

The review of this topic against the foundational goals is presented in Table 8-10.

TABLE 8-10: FOUNDATIONAL GOALS REVIEW - GREEN ALL COUNTY PARKS AND PUBLIC SPACES

Foundational Goals	Topic – does this topic address foundational goals?
G1. Change the District from an organization that impacts the environment to an organization that benefits the environment.	Yes. Greening Milwaukee County parks. Municipal parks and public spaces will contribute to MMSD's positive impact on the environment.
G2. Incorporate new technologies and operational improvements to minimize the District's financial burden on ratepayers.	Yes. Creative use of new green technologies could absorb more stormwater on public property, and in turn lessen energy and treatment costs during heavy rains.
G3. Integrate green infrastructure into all facets of development and redevelopment.	Yes. Greening the parks and public spaces is directly related to this goal.
G4. Support urban biodiversity activities within the region.	Yes. Replacing grey impervious surfaces with green spaces or adding trees or other vegetation would increase biodiversity. Soil amendments could make for healthier plant life, which in turn could support additional flora and fauna.
G5. Provide adaptive leadership to increased regulatory oversight, limited financial resources, increased public participation, climate change, and management of energy costs.	Yes. This initiative could be an opportunity to collaborate with local leaders to be creative with implementation and even funding. People tend to be passionate about public spaces and collaborative public participation processes could result in unique outcomes in the parks and public spaces, all while having environmental benefits.

Recommendations

Further greening of county parks, municipal parks, and public spaces should be pursued to provide benefits to the environment and assist in meeting the action of the 2019 Resilience Plan to replacing grey impervious spaces with green spaces. Scaling up the greening of the parks and public spaces would be a collaborative effort among municipalities, counties, non-profit or business partners, and MMSD.

Further greening of the parks and public spaces could result in a substantial amount of additional stormwater managed during major rain events, to help get to the MMSD internal KPI target of 740 MG of GI assets.

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depave website. Accessed on: April 6, 2020. [Online]. Available: https://depave.org/

Support TMDL Implementation

Purpose

A comprehensive total maximum daily load (TMDL) implementation plan outlines management goals, projects, partners, priorities, schedule, and findings along with tracking, monitoring, and reevaluation processes. A TMDL is one step in the water regulatory or restoration process. While the TMDL calculates numeric targets for attainment of water quality standards, a plan and subsequent actions are key to meeting these targets.

U.S. Environmental Protection Agency (U.S. EPA) regulations and the Clean Water Act require states to identify waterbodies that do not meet U.S. EPA-established water quality standards and to develop TMDLs for those impaired waters. When funding became available, MMSD commissioned a third-party TMDL study and developed TMDLs for phosphorus, TSS, and bacteria (fecal coliform) in the Milwaukee River Basin (MRB, defined as the Milwaukee River, Menomonee River, and Kinnickinnic River watersheds). The TMDL was approved by U.S. EPA in March 2018. MMSD developed the Water Quality Improvement Plan (WQIP), which will begin the integrated watershed management approach process and will address the greater Milwaukee watersheds (GMW). The GMW include the MRB as well as the Oak Creek and Root River watersheds within the MMSD planning area. The WQIP for the GMW within or tributary to MMSD's planning area was submitted to the WDNR by March 1, 2020, as was required by the 2019 WPDES permit.

In an overall management plan, distinct objectives typically are identified to determine which practices to use in critical areas to achieve needed reductions. Throughout the planning and implementation process the objectives may be refined and adjusted to meet specific needs. TMDL implementation plans can also invoke a wide array of monitoring, tracking, and logistical measures.

Approach

A brief review of the U.S. EPA website regarding effectively implementing TMDLs and a review of Southeastern Wisconsin Watersheds Trust, Inc.'s (Sweet Water's) summary of the WQIP was used for this analysis.

Topic Evaluation

The WQIP for the GMW is a holistic plan that provides a framework for integrated watershed management and helps to focus efforts at meeting TMDLs. It uses a collaborative approach, explores and facilitates cost-effective collaboration opportunities between and across watershed stakeholders for project implementation and establishes a monitoring strategy to help assess the progress of impairment removal from reaches of waterbodies listed in the WDNR Section 303(d) list of impaired waterbodies. The plan provides a framework for coordinating among MMSD's regional flood management projects, water quality improvement initiatives of partners, and TMDL implementation. The plan development process included stakeholder engagement throughout 2019. It includes proposed funding arrangements for GI, community-based GI, watershed-wide price supports, expanding watercourse projects to watershed projects, and partnering with private sector development.

TABLE 8-11: FOUNDATIONAL GOALS REVIEW – SUPPORT TMDL IMPLEMENTATION

Foundational Goals	Topic – does this topic address foundational goals?
G1. Change the District from an organization that impacts the environment to an organization that benefits the environment.	Yes. One intent of TMDL implementation is to meet this goal.
G2. Incorporate new technologies and operational improvements to minimize the District's financial burden on ratepayers.	Yes. New technologies can assist achieving this goal, especially in GI projects completed as part of TMDL implementation.
G3. Integrate green infrastructure into all facets of development and redevelopment.	Yes. GI is a key component of TMDL Implementation.
G4. Support urban biodiversity activities within the region.	Yes. Water quality improvement projects and stream restoration projects increase biodiversity.
G5. Provide adaptive leadership to increased regulatory oversight, limited financial resources, increased public participation, climate change, and management of energy costs.	Yes. Flexibility is at the core of the Water Quality Improvement Plan.

Recommendations

Continue funding and support watershed recommendations by funding various activities in the MMSD planning area that focus on TMDL goals and delisting of watershed segments.

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Sweet Water, Water Quality Improvement Plan, Sweet Water, March 2020. Accessed on: April 6, 2020. [Online]. Available: https://www.swwtwater.org/wqip

Watershed-based Permitting Program Considerations

Purpose

The U.S. EPA has delegated the authority to administer the NPDES permitting within Wisconsin to the WDNR. MMSD and the municipalities in MMSD's service area operate under permits issued by the WDNR, including WPDES permits. Each WPDES permit, which incorporates requirements from the Federal National Pollutant Discharge Elimination System (NPDES), regulates sanitary sewer, combined sewer and treatment plant discharges, the disposal of biosolids, and industrial pretreatment. Construction or maintenance activities in the vicinity of watercourses may trigger requirements to obtain federal or state permits.

Approach

Permitting information documented in the previous 2020 Facilities Plan and WDNR's website regarding water quality trading was referenced for this analysis. Sweet Water's summary of the WQIP and workgroup discussions that occurred as part of the WQIP development was also used to research this topic.

Topic Evaluation

Water quality trading (WQT) may be used by WPDES permit holders to demonstrate compliance with water quality-based effluent limitations. During development of the 2020 Facilities Plan, which focused on water

quality and a watershed approach, it was thought that WQT would be a viable option for meeting future permit limits. Since the 2020 Facilities Plan focused on a watershed approach for facilities planning, MMSD developed a TMDL for the Milwaukee River Basin and to tie together water quality improvement plans and projects being developed by municipalities throughout the GMW through the WQIP. The focus of the WQIP is integrated watershed management (IWM), which is similar to WQT but is a more holistic way of looking at water quality improvement on a watershed scale. This thought process is very similar to what was imagined in the 2020 Facilities Plan, although more is known about the watersheds and what needs to be done to achieve water quality improvements.

MMSD implements many projects that improve water quality in the watercourses. The municipalities served by MMSD contribute financially to these projects, and therefore are contributing to greater water quality in receiving streams and Lake Michigan. The municipalities will face TMDLs in their upcoming Municipal Separate Storm Sewer System (MS4) permits and would like to be able to acknowledge their part in MMSD projects that improve stream water quality. To streamline the connection between MMSD projects and the municipalities' MS4 permit requirements, MMSD has developed an Intergovernmental Cooperation Agreement (ICA). As of the end of 2019, 18 of the 28 municipalities have signed the ICA. All the municipalities are expecting TMDL requirements in their next WPDES permits. More municipalities may sign the ICA as the requirements are adopted.

The TMDL and the related ICA are key drivers of the WQIP, and WQIP recommendations should provide clear guidance in reference to both. However, at the same time, the scope of WQIP recommendations is not constrained to the TMDL or the ICA but can also reach beyond to include other mechanisms and processes for effective collaboration. The intent is to restore watershed health and delist impaired waters in the GMW in accordance with the needs, interests, and opportunities identified through stakeholder discussions with municipal staffs, MMSD, and other watershed stakeholders. Some municipalities have entered into group MS4 permits in the time since the 2020 Facilities Plan, including two groups in our region: the Menomonee River Watershed MS4 Group and the North Shore MS4 Group. These two groups each have an MS4 permit that covers all entities in the group. The intention is that each of these groups will determine and fund projects that will result in the best water quality improvements for the group. This arrangement allows all the municipalities covered by the group permit to show progress toward TMDL permit goals and do so in an efficient way. Many of the strategies discussed in the WQIP follow this type of reasoning but on a larger scale. By working on the watershed together, MMSD and municipalities can make a larger impact on improving water quality.

The WQIP sets up a framework that shows how expanding from one project to other projects can multiply the positive effects on a watershed. An example of how the framework operates is to start with an MMSD watercourse project. Then, MMSD looks to the municipalities in the watershed for projects for which they planned in their TMDL implementation plans. Water quality improvements projects upstream of watercourse rehabilitation projects can go a long way toward significantly improving watercourse water quality, leading toward TMDL compliance, and eventually stream delisting.

TABLE 8-12: FOUNDATIONAL GOALS REVIEW - WATERSHED-BASED PERMITTING PROGRAM CONSIDERATIONS

Foundational Goals	Topic – does this topic address foundational goals?
G1. Change the District from an organization that impacts the environment to an organization that benefits the environment.	Yes. The goal of the program is that stakeholders collaborate to improve water quality throughout the planning area and region.
G2. Incorporate new technologies and operational improvements to minimize the District's financial burden on ratepayers.	Possibly. In implementation of the program, opportunities to achieve this goal should be considered.
G3. Integrate green infrastructure into all facets of development and redevelopment.	Yes. GI is a key component in achieving water quality improvements through the WQIP and associated programs.
G4. Support urban biodiversity activities within the region.	Yes. Watershed-based permitting allows for larger projects that should have more chance to establish habitat, encouraging biodiversity.
G5. Provide adaptive leadership to increased regulatory oversight, limited financial resources, increased public participation, climate change, and management of energy costs.	Yes. Achievement of this goal is one intent of this program.

Recommendations

Continue support of a watershed-based permitting program and integrated watershed management working with WDNR, U.S. EPA, and municipalities/others to develop watershed permits that include agricultural impacts and impacts from areas outside of the MMSD planning area.

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Carbon Sequestration

Purpose

The purpose of this topic is to address reduction in carbon emissions from MMSD operations.

Carbon dioxide (CO_2) and methane are two carbon compounds with greenhouse gas potential. A greenhouse gas is a gas that is released into the atmosphere and contributes to the heat trapping effect of the atmosphere whereby high energy radiation such as ultraviolet radiation passes through the atmosphere and is absorbed. Heat generated on earth is radiated as infrared radiation and does not pass through the atmosphere; therefore, it is retained. Because the largest source of greenhouses gases is carbon compounds associated with the production and combustion of fossil fuel, it is desirable to identify ways to retain carbon in liquid and solid media to limit the release of carbon into the atmosphere.

Approach

The approach for this issue is the review of state of the industry information regarding carbon sequestration and how that could be applied to MMSD facilities.

Topic Evaluation

SSWRF and JIWRF are also carbon recycling facilities where the carbon contained in wastewater is converted to biosolids and biogas. Biosolids are beneficially used as Milorganite® fertilizer, which returns carbon to the soil. Biogas is used as renewable fuel, thereby displacing fossil fuel use.

The Energy Information Administration (EIA) identifies four approaches to reducing CO_2 emissions from power generation (1):

1. Reduce carbon intensity
2. Increase efficiency
3. Develop new power production technologies
4. Develop carbon capture technologies

The US Department of Energy (DOE) has a carbon capture program and a carbon storage program, both of which are administered by the Office of Fossil Energy. These programs are primarily focused on carbon emissions from coal combustion. The programs, while not applicable to MMSD, do identify the two ways to reduce carbon emissions through capture and storage (2):

- Post-combustion capture
- Pre-combustion capture

Post-combustion capture is primarily applicable to fossil fuel-based systems where the CO_2 is captured from the flue gas after fuel combustion. (2)

“Pre-combustion capture is applicable to integrated gasification combined cycle (IGCC) power plants, where solid fuel is converted into gaseous components ("syngas") by applying heat under pressure in the presence of steam and oxygen. In this case, the carbon is captured from the syngas before completing the combustion process.” (2)

Carbon storage is underground storage of CO_2 in brine formations. (1) This concept applies to large coal-burning power plants and is not applicable to MMSD.

MMSD is already meeting the first approach to CO_2 reduction by employing low-carbon digester gas and landfill gas for power production. Post-combustion carbon capture technologies are typically used at large fuel generation facilities and are not considered applicable to the engine generators and combustion turbines that MMSD employs.

Similarly, small point sources like the Milorganite dryers would not be feasible for implementation of post-combustion technologies because of the high degree of dilution in the dryer exhaust making CO_2 capture difficult.

The approach in this analysis is to look at two pre-combustion concepts that could capture CO_2. As noted in the 2035 Energy Vision analysis, digester gas at SSWRF can be converted to renewable natural gas (RNG) by removing CO_2. Using membrane separation or amine scrubbing technology would allow the CO_2 removed to be captured and recovered for use in industrial processes, including food and beverages. (3) In this way, the release of CO_2 in the tail gas from the upgrading process is reduced.

Landfill gas (LFG) is currently used at JIWRF for producing electricity in the gas combustion turbines and the dryers are being retrofitted to use LFG. Converting LFG to renewable natural gas can also provide benefits similar to those of digester gas upgrading, such as allowing CO_2 to be recovered and improving the quality of fuel to the dryers. LFG upgrading would be a larger scale application of the gas treatment technology and would benefit from the economy of scale it offers.

Pyrolysis and gasification are thermal processes that convert the carbon in biosolids to gas, liquid, and solids residuals. The gas produced contains hydrogen, CO_2, and carbon monoxide (CO). Hydrogen and CO both have fuel value and the CO_2 can be removed and captured similar to the digester gas process. If the CO can be separated to produce a hydrogen fuel, hydrogen can be used in fuel cells to generate electricity. The liquid fraction may be amenable to anaerobic digestion and the solid fraction, called char, is a valuable soil amendment or potential feedstock for activated carbon production. The pyrolysis and gasification technologies are in a pre-commercial phase but represent an active area of research.

At this time, it appears that a viable pathway for MMSD to increase carbon sequestration would be to upgrade digester gas at SSWRF. Pentair-Haffmans has a commercially available biogas upgrading system that includes CO_2 recovery. (3) An interesting feature of this system is that the CO_2 recovery process also recovers methane that is returned to main process feed such that the recovery of incoming methane into the biogas as RNG approaches 100 percent. This process is illustrated below in Figure 8-1 courtesy of Pentair-Haffmans.

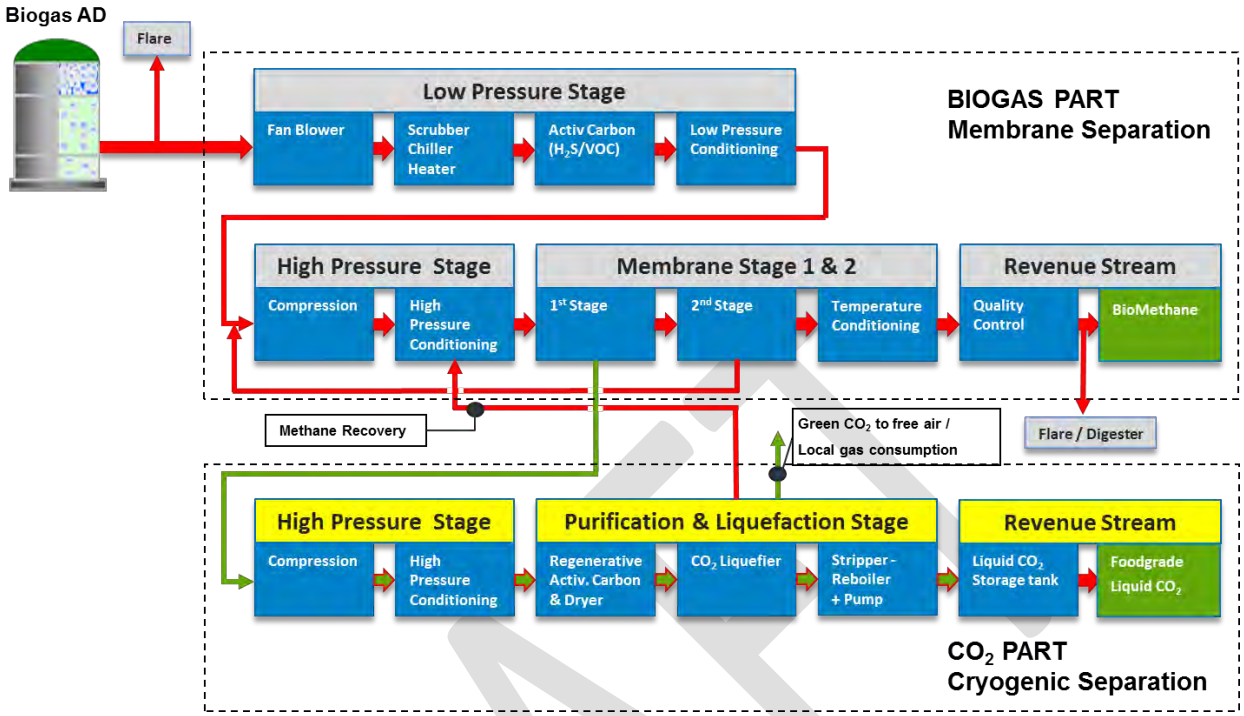

FIGURE 8-2: BIOGAS UPGRADING AND CO_2 RECOVERY PROCESS

TABLE 8-13: FOUNDATIONAL GOALS REVIEW – CARBON SEQUESTRATION

Foundational Goals	Topic - does this topic address foundational goals?
G1. Change the District from an organization that impacts the environment to an organization that benefits the environment.	Yes. Carbon capture reduces greenhouse gas emission which is consistent with MMSD 2035 Vision and this Foundational Goal
G2. Incorporate new technologies and operational improvements to minimize the District's financial burden on ratepayers.	Yes. Implementation of gas upgrading with CO_2 capture needs to be evaluated for cost effectiveness.
G3. Integrate green infrastructure into all facets of development and redevelopment.	Yes. GI initiatives, including stormwater trees and biochar, can be used to provide carbon sequestration.
G4. Support urban biodiversity activities within the region.	No. Goal is not applicable to this alternative.
G5. Provide adaptive leadership to increased regulatory oversight, limited financial resources, increased public participation, climate change, and management of energy costs.	Yes. Carbon capture and renewable energy will reduce greenhouse gas emissions.

Recommendations

Foundational Goal G1 directs MMSD to be an organization that benefits the environment as opposed to impacting the environment. To that end, it is important that MMSD reduce greenhouse gas emissions. Carbon capture is one pathway to reduce emissions, which fits with MMSD's renewable energy goal and overall carbon recycling inherent in the effective operation of SSWRF and JIWRF.

Implementing digester gas upgrades at SSWRF is a component of the 2035 Energy Vision and can be coupled with CO_2 recovery for additional greenhouse gas emissions reduction.

In addition, MMSD could consider calculating the carbon sequestration benefits in trees it plants through its Greenseams and GI projects and the soil benefits through its GI projects.

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Emerging Contaminants

Purpose

The management of emerging contaminants in wastewater falls under the following 2050 Foundational Goals:

- Foundational Goal G1 directs MMSD to be an organization that benefits the environment as opposed to negatively impacting the environment.
- Foundational Goal G5 directs MMSD to provide adaptive leadership to increased regulatory oversight, limited financial resources, increased public participation, climate change, and management of energy costs.

To help achieve these goals, it is important that MMSD understand and monitor contaminants of emerging concern (CECs) in plant effluents and biosolids. The purpose of this topic is to provide an overview of CECs that may enter the conveyance system and be discharged to the environment by the WRFs through the plant effluent or biosolids. The concern with CECs in plant effluent or biosolids is that they may reach surface water and have harmful environmental or public health effects.

The term contaminants of emerging concern was developed by the U.S. EPA Office of Water to replace "emerging contaminants." The term refers to chemicals and other substances that have no regulatory standard but have been found in the aquatic environment and may have deleterious effects on aquatic life or have human health effects.

Background

By definition, CECs have no immediate regulatory driver to comply with discharge or monitoring standards. There are several types of CEC chemicals (1), including:

Persistent organic pollutants (POPs): The most notable of these is currently perfluoroalkyl substances (also referred to as PFAS). These are compounds that do not readily break down in the environment and may have environmental or human health effects.

Pharmaceuticals and personal care products (PPCPs): These include prescription and over the counter drugs, bactericides such as triclosan, and sunscreens.

Veterinary medicines: Similar to human drugs, veterinary medicines may be discharged from homes and clinics.

Endocrine-disrupting chemicals (EDCs): Several of note are synthetic estrogens and androgen, naturally occurring estrogens, organochlorine pesticides, and bis-phenol-A (BPA). These compounds may modulate hormonal functions in aquatic organisms.

Nanomaterials: Nanomaterials are very small materials, in the nanoscale (approximately 1-100 nanometers). Understanding the impact of nanotechnology as a contaminant is still truly emerging science. Carbon nanotubes and forms of titanium dioxide are examples of nanomaterials that have been noted as contaminants by U.S. EPA. (1)

Microplastics: Microplastics are being seen throughout the environment and in oceans and fresh surface waters. Microplastics are found in wastewater for sources such as microbeads in personal care products and conventional wastewater treatment is not effective at removing microplastics. (1) The science is developing around human health effects and environmental impacts, especially aquatic life. (1)

MMSD has participated in research with the University of Wisconsin-Milwaukee and the State Lab of Hygiene in studies that have focused on the effectiveness for the WRFs in removing CECs and especially PPCPs and EDCs.

The United States Geological Survey (USGS) has confirmed the presence of many CECs in Milwaukee area waterways (2). These chemicals are thought to enter surface water from a variety of sources. USGS developed domestic wastewater indicators to identify possible leaking sanitary sewers or improperly managed septic systems. (3) Some of these contaminants may also be present in WRF effluent.

Approach

This discussion summarizes the current status of U.S. EPA actions relative to CECs and provides an overview of the CEC issue as it relates to wastewater effluents and biosolids for initial guidance in terms of state of industry best practices, which can be referred to when and if MMSD needs to implement additional projects to address a specific CEC. While there are literally hundreds of CECs that could be investigated, PFAS, PPCPs, and EDCs represent compounds that may impact MMSD's ability to meet Foundational Goal G1—to be an organization that benefits the environment.

The document considers each of these specific CECs in terms of plant effluent and technologies to remove from wastewater and then reviews the impact to biosolids of the CECs as a group.

Topic Evaluation

PFAS appear at this time to be primarily a human health concern whereas PPCPs and EDCs are suspected of having an impact on reproduction in aquatic organisms, including fish. Though not discussed specifically, PFAS precursors should be noted as there are many and they may be evaluated by U.S. EPA for rule making.

The U.S. EPA is looking at aquatic life criteria (ALC) for the contaminants of emerging concern. Criteria using U.S. EPA guidelines do not fit the case of CECs very easily. For example, for conventional toxic pollutants there is the concept that there is little or no risk to aquatic life below a certain concentration, but above that concentration, risks are present and effects are likely to occur. Available research has not confirmed if CECs do or do not follow this model.

Perfluoroalkyl Substances (PFAS)

PFAS are a group of manmade fluorinated compounds that include PFOA (perfluorooctanoic acid), PFOS (perfluorooctanesulfonic acid), and many others. PFAS are used in industry and consumer products for a variety of applications: fire-retardants, non-stick cookware, dental floss, lubricants, and clothing to name a few. PFAS are present at background levels throughout the environment, including homes and businesses. The primary concern raised about PFAS is exposure through drinking water, especially ground water.

MMSD is committed to protecting public health and the environment. A consensus is forming within the wastewater industry about how to address PFAS concerns (4). However, there must be credible science and a consensus of regulators, public utilities and academic researchers on how to move forward on regulating PFAS. MMSD is a receiver of PFAS from various sources, many of which cannot be controlled; most domestic sewage contains at least some PFAS.

PFOA and PFOS are in the process of being phased out of production in the United States. These had been the most common types of PFAS used and sampling has indicated that these compounds are universal in the bloodstream of US residents. (4) The concentration in the blood has decreased since 1999, corresponding to the phase out of production. Even so, PFOA has been found in household dust at levels between 10,000 and 50,000 parts per trillion (ppt) (4). These ambient levels are higher than thresholds discussed for drinking water. Because PFAS can be transported through the air, there are numerous exposure pathways besides drinking water.

Highly concentrated areas such as manufacturing facilities and military bases account for the notable incidences of exposure. The manufacture and routine use of PFAS can be curtailed to reduce exposure and the amount of PFAS entering the environment.

Wastewater does not generate PFAS but merely transports these substances, and conventional wastewater treatment methods are not effective in removing PFAS. PFAS can be removed from drinking water using established drinking treatment technology. Michigan is requiring treatment to remove PFAS. Monitoring revealed the PFAS contamination at a manufacturing site in Michigan. (5) The ground water had been discharged to a publicly-owned treatment works (POTW) while appropriate treatment for surface water discharge was implemented. This ground water was also contaminated with excess phosphorus. In bench scale tests, PFAS were removed to non-detectable limits from the contaminated ground water using the following technologies: granular activated carbon, ion-exchange and a proprietary adsorbent, RemBind®.

Treatment to reduce PFAS is expensive and may not yield any measurable benefits for wastewater treatment (4). A holistic response by legislators, regulators, and public agencies is needed to determine the most effective means to reduce human exposure. Phasing out PFAS use and product substitution with source control is expected to continue to reduce background levels effectively.

Pharmaceuticals and Personal Care Products (PPCPs)

The impacts and control of PPCPs in waterways, including source control and removal from wastewater, have been studied internationally for decades. (6) (7) For PPCPs, source control through drug collection programs appears to be the most cost-effective approach and therefore no removal technologies were reviewed. Another effective way to reduce PPCPs is for companies to eliminate chemicals like triclosan from products that do not specifically require a bactericide, such as toothpaste. In addition, point sources such as hospitals are sometimes required to provide pretreatment for removal of PPCPs.

Endocrine-disrupting Chemicals (EDCs)

Though some EDCs are prescription drugs, such as synthetic estrogen, EDCs are considered a separate contaminant because of the impact to aquatic life. EDCs are a subset of CECs for which source control such as prescription drug collection can be effective, but also for which source control is not possible. Many EDC are excreted from humans and animals and end up in wastewater. However, there are treatment approaches that can be implemented at wastewater treatment plants to reduce the environmental impacts of EDCs.

Conventional secondary wastewater treatment like the activated sludge process employed at JIWRF and SSWRF can remove pharmaceuticals and EDCs, but certain EDCs withstand treatment and may be released into the environment.

MMSD has investigated contaminants found in surface water and the WRF effluent and identified compounds that may have reproductive impacts for fish. (2) MMSD has also quantified the removal of various chemicals in the current WRF treatment processes and identified specific compounds to target for removal. (8)

EDCs can be inactivated by strong oxidation or adsorption with activated carbon. Activated carbon would be more commonly employed for drinking water treatment.

Ozonation is an example of a strong oxidation process that can be used at a wastewater treatment plant. Peracetic acid (PAA) is a chemical that combines acetic acid with hydrogen peroxide and has been demonstrated to be an effective disinfectant, as well as reduce EDCs in wastewater effluents. (9) It was also demonstrated that chlorine increased EDC activity in the plant effluent; thus, PAA has a greater incremental benefit in reducing EDCs compared to chlorine.

Ozone is generated onsite and cannot be stored or piped to the point of application, so ozonation equipment is located at the point of application. PAA is a liquid chemical that can be stored and applied similarly to hypochlorite solution.

Chlorine compounds used for disinfection can create their own CECs in the form of disinfection byproducts, especially trihalomethanes. PAA does not form disinfection byproducts, which offers an additional benefit.

Bench scale and pilot trials can be conducted to assess the effectiveness of PAA in the reduction of EDCs. Any bench scale and pilot trials could also be used to determine the effectiveness of meeting *E. coli* bacteria limits.

Impact from CECs on Biosolids

In addition to returning clean water to Lake Michigan, MMSD also produces Milorganite®, a biosolids product, that is marketed to the public. The concern with CECs in biosolids is the same as that for plant effluents: the contaminants may reach surface water and have harmful environmental or public health effects.

In November 2018, the U.S. EPA's Office of Inspector General (OIG) issued a review critical of the Agency's oversight of biosolids (10). The OIG cited 352 pollutants found in biosolids for which there are insufficient data and risk assessment tools. The U.S. EPA Office of Water has responded to recommendations in the OIG review, but some recommendations remain unresolved.

Essentially the OIG report believes that the U.S. EPA should not state that biosolids are safe because of ongoing risk assessments. The U.S. EPA Office of Water has taken exception to recommendations in the review and a coalition of biosolids industry groups have offered counterpoints to the OIG report, emphasizing the demonstrated safety of biosolids (11).

MMSD is one of few wastewater utilities that successfully markets biosolids to the public. Used as directed, Milorganite has been proven to be a safe and effective fertilizer.

TABLE 8-14: FOUNDATIONAL GOALS REVIEW – EMERGING CONTAMINANTS

Foundational Goals	Topic – does this topic address foundation goals?
G1. Change the District from an organization that impacts the environment to an organization that benefits the environment.	Yes. Addressing contaminants of emerging concern is part of this goal even in the absence of regulatory direction.
G2. Incorporate new technologies and operational improvements to minimize the District's financial burden on ratepayers.	Yes. Switching to peracetic acid for disinfection should be considered to cost-effectively reduce endocrine disrupters and disinfection byproducts.
G3. Integrate green infrastructure into all facets of development and redevelopment.	Goal is not applicable to this alternative.
G4. Support urban biodiversity activities within the region.	Yes. U.S. EPA looks at ALC for the contaminants of emerging concern. Removal of contaminants has an impact on aquatic life, with each species having a different degree of pollution tolerance.
G5. Provide adaptive leadership to increased regulatory oversight, limited financial resources, increased public participation, climate change, and management of energy costs.	Yes. Continue to monitor PFAS issue and implement source controls as appropriate.

Recommendations

As stated in the purpose, Foundational Goal G1 directs MMSD to be an organization that benefits the environment as opposed to negatively impacting the environment. To that end, it is important that MMSD understand and monitor CECs in plant effluents and biosolids, and the technologies available to remove them. By doing so, MMSD will also achieve Foundational Goals FG2 and FG5 related to CEC concerns as well. Below are the recommendations for the three CECs identified for the topic evaluation:

PFAS - More research is needed to understand the best way to test for PFAS in wastewater and biosolids and to fully understand the health effects, actionable concentrations, and exposure routes and risks. In any case, source control will need to be implemented by municipalities and/or manufacturers, as is typically recommended for the many other CECs that may be detected in very low concentrations.

PPCPs – Source control appears at this time to be the most cost-effective method of removing these contaminants from wastewater.

EDCs - There are treatment approaches to EDCs. A promising technique is the use of PAA as a disinfectant instead of chlorine. PAA reduces the toxicity of the plant effluent through reduction of disinfection by-products and has been shown to reduce the estrogenicity of EDCs in plant effluents, especially in comparison to chlorinated effluents. Dechlorination removes chlorine residual but does not remove disinfection by-products of chlorination. Concerns with PAA would be the dosage impact due to partially nitrified effluents on PAA demand and contribution of PAA to effluent biochemical oxygen demand (BOD).

MMSD should consider reaching out to WRFs that have conducted pilot testing of PAA to learn their successes and challenges and ultimately to determine whether it is warranted to conduct bench-scale and pilot trials at each of MMSD's WRFs to assess the effectiveness of PAA in the reduction of EDCs. Bench scale and pilot trials should also consider the effectiveness of meeting *E. coli* bacteria limits as an alternative to the recommendations made in WRF R4, Meeting Future *E. coli* Limits at JIWRF and SSWRF.

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8.7 REFERENCES

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