Chapter 9: Alternatives Development

9.1 Introduction

This chapter evaluates the various capacity enhancement alternatives within the Milwaukee Metropolitan Sewerage District (MMSD) conveyance system. This chapter also provides recommendations for conveyance enhancements, as well as recommendations for other conveyance-related improvements. Project sites are identified based on a hydraulic study that identified areas of concern. Alternative solutions are presented for each site to obtain five-year and 10-year sanitary sewer overflow (SSO) levels of protection (LOP) in the sanitary sewer service area.

The information presented in this chapter should be considered preliminary, based on several limitations inherent in a facilities planning level of evaluation. Specific limitations include the following:

♦ The MMSD flow monitoring network does not provide accurate flow levels for some of the metropolitan interceptor sewer (MIS) segments identified as having hydraulic restrictions. The density of the flow monitoring network is sufficient for planning purposes, but more focused monitoring is needed to verify flows in specific segments.

♦ The accuracy of the flow data for many of the monitors is limited by the use of level-only meters and rating curves to derive values for flow. This technique for flow measurement is reasonably accurate where wastewater flows near normal depth in the pipe. However, the accuracy diminishes at locations subject to backwater or surcharging, which is the case for many areas of the MIS. [Note: Surcharging of the MIS is acceptable depending upon the location and other factors. However, surcharging does affect level only measurements.]

♦ The population and development projections provided by the Southeastern Wisconsin Regional Planning Commission (SEWRPC) for 2020 Baseline conditions appear to be very optimistic in some locations. Consequently, projected flows may not be realized until late in the planning period, if at all. In all cases, it is not known when the projected future flows will actually occur.

In light of these limitations, the hydraulic restrictions identified in this chapter should be viewed as areas of the MIS that are potentially vulnerable to hydraulic problems if the projected growth occurs. Recommendations for the specific projects presented were developed for the purpose of estimating the costs of potential conveyance enhancements. However, the actual need for a conveyance enhancement should be verified by focused flow monitoring in the areas of concern before proceeding with any improvements. If flow monitoring confirms that flows are increasing, the projected growth should be verified with the municipalities. This additional growth may cause flows to approach levels that will result in hydraulic restrictions. Detailed preliminary engineering should be performed to identify the most appropriate conveyance system enhancement.
9.2 **Approach and Identification of Potential Conveyance Improvement Projects**

Computer modeling of the identified alternatives was completed using flows based on the 2020 Baseline population and land use estimates developed by SEWRPC. The conveyance system was represented using the Model of Urban Sewers (MOUSE) computer program with the Streamline-MOUSE model. Flow development and calibration are discussed in Chapter 3. The Streamline-MOUSE model was simulated using a system-wide five-/seven-year LOP configuration as discussed in Chapter 9 of the 2020 Facilities Plan Report.

The inline storage system (ISS) was set to stay open for the duration of the simulations to identify the conveyance needs related to capacity restrictions in the MIS, rather than restrictions related to closures of ISS gates. This is a modeled condition; in practice, the ISS provides storage capacity up to the seven-year excess wastewater event recurrence interval. This is called the seven-year LOP; see Chapter 9 of the Facilities Plan Report for further discussion.

The MMSD conveyance system was modeled to assess its hydraulic performance. The hydraulic analysis determined the ability of the conveyance system to provide a free outlet for local sewers connected to the MIS system. To determine if the MIS provides a free outlet to local sewer connections, critical elevations were identified throughout the conveyance system. A critical elevation is defined as the elevation of the invert of a local sewer connection. It is not possible to provide a free outlet for all conditions. Some of the connections are influence by the operations of the ISS. When the ISS fills and closes, water levels in many parts of the MIS rise above critical elevations. Other connections are influenced by the conveyance capacity of the MIS. The MIS therefore provides a free outlet to local communities. An MIS was determined to have a conveyance restriction if the MIS segment resulted in a conveyance-related SSO or the hydraulic grade line (HGL) reached or exceeded critical elevations while the ISS was open. Exceeding a critical elevation while the ISS is closed does not necessarily indicate a hydraulic restriction in the MIS. The frequency of exceeding a critical elevation is specific to each connection. It is not possible to make a general statement for the frequency of exceeding critical elevations at all connections to the MIS system.

Sites with potential conveyance restrictions in the MIS were identified from at least one of three of the largest events in the 64.5-year period of record (January 1940 through June 2004), which included the event with the largest combined sewer overflow (CSO) volume (August 1986), the event with the largest SSO volume (March 1960), and an event in which the HGL exceeded critical elevations in large reaches of the MIS (May 1990).

Once the potential conveyance restriction sites were identified, it was determined whether a capacity enhancement is needed to provide a free outlet for the local sewers under two flow conditions: a five-year recurrence interval event and a 10-year recurrence interval event. The five- and 10-year events were identified at each location based on the HGL along the MIS segment or the volume of a conveyance-related SSO. Seventeen of the largest events in the 64.5-year period of record were ranked by HGL to determine the five- and 10-year recurrence interval events. Table 9-1 lists the dates for the 17 events simulated for hydraulic modeling.

An MIS was determined to require capacity enhancement for the five- and 10-year recurrence interval events if a conveyance restriction resulted in a conveyance related SSO or the HGL reached or exceeded critical elevations for the five- and 10-year recurrence interval events, respectively. Table 9-2 identifies the five- and 10-year recurrence events for each project.
<table>
<thead>
<tr>
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<th>Simulated Events</th>
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<tbody>
<tr>
<td>1</td>
<td>June 20-30, 1940</td>
</tr>
<tr>
<td>2</td>
<td>September 7-13, 1941</td>
</tr>
<tr>
<td>3</td>
<td>July 19-23, 1950</td>
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<td>4</td>
<td>June 2-6, 1954</td>
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<tr>
<td>5</td>
<td>July 17-21, 1959</td>
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<td>March 26 - April 5, 1960</td>
</tr>
<tr>
<td>7</td>
<td>April 23-28, 1976</td>
</tr>
<tr>
<td>8</td>
<td>July 16-22, 1977</td>
</tr>
<tr>
<td>9</td>
<td>May 12-17, 1978</td>
</tr>
<tr>
<td>10</td>
<td>April 1-7, 1983</td>
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<td>August 6-10, 1986</td>
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<td>12</td>
<td>July 18-22, 1989</td>
</tr>
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<td>13</td>
<td>May 8-15, 1990</td>
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<tr>
<td>14</td>
<td>April 18-24, 1993</td>
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<tr>
<td>15</td>
<td>June 20-24, 1997</td>
</tr>
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<td>16</td>
<td>April 20-28, 1999</td>
</tr>
<tr>
<td>17</td>
<td>May 16-24, 2000</td>
</tr>
<tr>
<td>Project #</td>
<td>Project Name</td>
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<tr>
<td>----------</td>
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<tr>
<td>1</td>
<td>North 91st Street MIS</td>
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<tr>
<td>2</td>
<td>Milwaukee River MIS</td>
</tr>
<tr>
<td>3</td>
<td>North Range Line Road MIS</td>
</tr>
<tr>
<td>5</td>
<td>Green Bay Avenue/Mill Road MIS</td>
</tr>
<tr>
<td>6</td>
<td>North Santa Monica Boulevard MIS</td>
</tr>
<tr>
<td>7</td>
<td>Menomonee River MIS</td>
</tr>
<tr>
<td>8</td>
<td>South 35th Street MIS</td>
</tr>
<tr>
<td>9</td>
<td>South 81st Street MIS</td>
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<tr>
<td>10</td>
<td>South Howell Avenue MIS</td>
</tr>
<tr>
<td>11</td>
<td>South Sheridan Drive MIS</td>
</tr>
<tr>
<td>12</td>
<td>Ryan Road MIS</td>
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<tr>
<td>13</td>
<td>Franklin/Muskego Interceptor</td>
</tr>
</tbody>
</table>

Two alternatives were analyzed for each project site: relief and replacement. The relief alternative provides a second sewer so that the total conveyance capacity of both the relief sewer and the existing sewer is sufficient to convey the peak flow. The sewer replacement alternative replaces the existing MIS with a larger sewer to convey the 2020 Baseline flow tributary to the MIS segment.

The decision to recommend the relief or the replacement alternative was based on cost and age of the existing sewer. If the cost of replacement was approximately the same as relief (no more than 10% greater than the relief cost) then the replacement alternative was recommended. With respect to age, if the existing sewer was built prior to 1955, (sewers older than 65 years by the year 2020) then replacement was recommended without regard to the cost. Ages of sewers were determined to estimate the approximate physical conditions of the sewers for the purpose of determining a cost estimate. In some locations, both relief and replacement alternatives were costly; therefore, other alternatives were included if they were determined to be more cost effective. In cases where the cost of the other alternative was at least 10% less than the cost of relief, it was recommended regardless of the age of the existing MIS.

Infiltration and Inflow (I/I) reduction was evaluated for each MIS segment, but was found to be cost effective in only one project location, Project 11. Infiltration and inflow reduction includes sewer rehabilitation in the local municipality sewers tributary to the MIS segments that require capacity enhancement. The amount of I/I reduction analyzed for conveyance relief is discussed in Appendix 9A. Near surface storage also was considered for project sites in which a small amount of volume could be diverted to avoid activating a SSO and/or avoid the HGL from reaching a local connection or “critical” elevation. The required storage volumes in these
instances were found to be large, which would not be cost effective; therefore near surface storage is not listed as a recommended alternative for any of the project locations.

Construction costs for relief and replacement sewers were developed from unit costs that included different levels of utility conflicts. Land uses were categorized into three categories: residential, commercial/industrial and mixed use. Unit costs were developed without consideration for utility conflicts and were increased by 15%, 20%, and 25% for residential, mixed use, and commercial/industrial land use types, respectively, to approximate potential costs that might be incurred for potential conflicts.

Construction costs include costs for sewers, manholes, and related appurtenances, including excavation and the restoration of the local street surfaces. Two unit costs were developed, one for open-cut construction and one for tunneled construction. Open-cut construction costs were applied for sewers with a maximum depth of 30 feet. Tunneled construction costs were applied for sewer segments that are below 30 feet at any point along the existing MIS segment.

All costs are escalated using the Engineering News Record Construction Cost Index (ENR-CCI), which was projected to be 10,000 in 2007. Total costs were determined by adding 25% for contingencies and then adding 35% of the cost plus contingencies for technical services and administration costs.

There are 10 potential project sites for the five-year LOP, and four more potential project sites for the 10-year LOP. Figure 9-1 shows the potential recommended projects for a five-year LOP, and Figure 9-2 shows the potential recommended projects for a 10-year LOP. The recommendation and cost for each potential project for a five-year LOP is summarized in Table 9-3. The recommendation and cost for each potential project for a 10-year LOP is summarized in Table 9-4.

A total cost of $59.8 million is estimated for the potential MIS system improvements for a five-year LOP, and $153 million is estimated for a 10-year LOP.

In addition to the MIS conveyance enhancement projects, two policies are recommended by the 2020 FP. First, there are a number of potential projects that will relieve or replace MIS segments that may meet the definition of “local” sewers; i.e., they serve only one community. Second, potential conveyance project segments may have direct property connections to the MIS. The 2020 FP recommends that the MMSD Commission adopt policies to clarify the ownership of these types of sewers and to address direct property connections to the MIS.

Alternatives and recommendations have been developed based on the hydraulic modeling study performed for the 2020 Baseline estimated flows. Prior to implementation of any of the projects, it is recommended that flow monitoring be performed to verify that the estimated flows occur and that capacity enhancements are truly needed for the MIS segments. Additionally, preliminary engineering should be performed to verify sewer alignments, explore alternate relief sewer routes, and to investigate the possibility of compromising the free outlet condition by allowing the MIS and local sewers to surcharge, with the condition that they do not impact local basements or cause SSOs.
FIGURE 9-1
POTENTIAL MIS RELIEF PROJECTS FOR 5-YEAR LOP
2020 BASELINE
2020 CONVEYANCE REPORT
5/2/07
CR_9.0001.07.05.02.cdr
<table>
<thead>
<tr>
<th>Project #</th>
<th>Project Name</th>
<th>5-Year Recommendations</th>
<th>Capital Cost ($ M)</th>
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</thead>
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<tr>
<td>1</td>
<td>North 91st Street MIS</td>
<td>DC0308 Modification and New Local Sewer and Pump Station</td>
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<td>2</td>
<td>Milwaukee River MIS</td>
<td>Sewer Replacement</td>
<td>18.1</td>
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<tr>
<td>3</td>
<td>North Range Line Road MIS</td>
<td>Sewer Replacement</td>
<td>1.1</td>
</tr>
<tr>
<td>4</td>
<td>River Hills MIS</td>
<td>Sewer Replacement</td>
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</tr>
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<td>5</td>
<td>Green Bay Ave/Mill Road MIS</td>
<td>Green Tree Pump Station Modification and New Force Main</td>
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</tr>
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<td>7</td>
<td>Menomonee River MIS</td>
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<td>9</td>
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<td>10</td>
<td>South Howell Ave MIS</td>
<td>Relief Sewer</td>
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</tr>
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<td>13</td>
<td>Franklin-Muskego MIS¹</td>
<td>Parallel Force Main</td>
<td>4.7</td>
</tr>
<tr>
<td>14</td>
<td>DC0103 Modifications</td>
<td>Structural Modification and RTC Strategy Improvements</td>
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</tr>
</tbody>
</table>

**Total Cost** $59.8

RTC = Real Time Control

Notes:

All projects, except the RTC Strategy Improvements, are potential enhancements, the need for which will only be known during the implementation phase of the 2020 FP after MIS flows and population projections have been verified.

All costs are escalated using the Engineering News Record Construction Cost Index (ENR-CCI), which was projected to be 10,000 in 2007.

Capital cost includes construction cost plus 25% for engineering and 35% for technical services and administration.

These costs do not include O&M and salvage values.

1) Project 13 is subject to refinement or change based on a project-specific facilities plan to evaluate options for the Ryan Creek Interceptor and the upgrade to the existing Franklin-Muskego MIS.
<table>
<thead>
<tr>
<th>Project #</th>
<th>Project Name</th>
<th>10-Year Recommendations</th>
<th>Capital Cost ($ M)</th>
</tr>
</thead>
<tbody>
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<td>DC0308 Modification and New Local Sewer and Pump Station</td>
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<td>Milwaukee River MIS</td>
<td>Sewer Replacement</td>
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<td>3</td>
<td>North Range Line Road MIS</td>
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<td>4</td>
<td>River Hills MIS</td>
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<td>Green Bay Ave/Mill Road MIS</td>
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<td>North Santa Monica Blvd MIS</td>
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<td>7</td>
<td>Menomonee River MIS</td>
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<td>1.3</td>
</tr>
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<td>8</td>
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<td>10</td>
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<tr>
<td>13</td>
<td>Franklin-Muskego MIS¹</td>
<td>Parallel Force Main</td>
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<tr>
<td>14</td>
<td>DC0103 Modifications</td>
<td>Structural Modification and RTC Strategy Improvements</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Total Cost $153.0

RTC = Real Time Control

Notes:
All projects, except the DC0103 Modifications, are potential enhancements, the need for which will only be known during the implementation phase of the 2020 FP after MIS flows and population projections have been verified.
All costs are escalated using the Engineering News Record Construction Cost Index (ENR-CCI), which was projected to be 10,000 in 2007.
Capital cost includes construction cost plus 25% for engineering and 35% for technical services and administration.
These costs do not include O&M and salvage values.

1) Project 13 is subject to refinement or change based on a project-specific facilities plan to evaluate options for the Ryan Creek Interceptor and the upgrade to the existing Franklin-Muskego MIS.
9.3 Metropolitan Interceptor Potential Sewer Capacity Enhancement Alternatives

9.3.1 Project 1 – North 91st Street MIS

Existing System and Area Description

Project 1 provides capacity enhancement to a portion of the MIS that generally runs along North 107th Street and North 91st Street between West County Line Road on the north and West Green Tree Road on the south. The MIS ranges from 25-50 feet below the ground surface and was constructed between 1957 and 1962. The land use along the North 91st Street MIS is residential, commercial, and industrial. Flow tributary to the North 91st Street MIS is from Germantown, Menomonee Falls, the southwest portion of Mequon, and the northwest portion of Milwaukee.

The North 91st Street MIS conveyance enhancement is intended to prevent high water levels from occurring in an existing 57-inch special section (SS) MIS. The MIS segment starts at West County Line Road as a 57-inch special section MIS that runs south along North 107th Street and then southeast along the Little Menomonee River. The 57-inch SS MIS increases to a 72-inch SS MIS at North 91st Street, near West Good Hope Road. The 72-inch SS MIS continues south along North 91st Street to West Green Tree Road where it heads southwest to West Mill Road.

The full pipe capacity of the 57-inch SS MIS and the 72-inch SS MIS from MMSD manhole (MH) 19702 (West Brown Deer Road) to diversion chamber DC0308 (near Daphne Street) is exceeded during five-year and 10-year recurrence interval events with 2020 Baseline flows. The conveyance restriction in the MIS causes flow to back up and critical elevations to be reached or exceeded at MMSD MHs 19716 (West County Line Road) and 19509 (West Bradley Road) for the five-year and 10-year recurrence interval events and at 19702 for the 10-year recurrence interval event. Additionally the present crest elevation of the weir to the Northwest Side Relief Sewer (NWSRS) is eight feet above the crown of the MIS. When the MIS becomes surcharged, the HGL reaches eight feet above the crown of the MIS before the MIS is relieved. Flow to the MIS for the five-year and 10-year recurrence interval events is greater than the capacity, causing additional surcharge of the MIS.

5-Year List of Alternatives

Three alternatives were considered for the capacity enhancement of the North 91st Street MIS for the five-year recurrence interval event as follows:

A. Alternative A: Relief and Modification to DC0308
B. Alternative B: Replacement and Modification to DC0308
C. Alternative C: Modification to DC0308 and Local Pump Station

10-Year List of Alternatives

Three alternatives were considered for the capacity enhancement of the North 91st Street MIS for the 10-year recurrence interval event as follows:

A. Alternative A: Relief with Modification to DC0308
B. Alternative B: Replacement with Modification to DC0308
C. Alternative C: Modification of DC0308 and Local Pump Station
Evaluation of Alternatives

5-Year Alternative A: Relief and Modification to DC0308

Alternative A consists of construction of 9,027 lineal feet (LF) of 24-inch diameter relief sewer along North 91st Street from MMSD MH 19702 to MMSD MH 19505, construction of 7,023 LF of 30-inch diameter relief sewer along North 91st Street from MMSD MH 19505 to diversion chamber DC0308, and lowering the weir in diversion chamber DC0308 by eight feet. The relief sewers would generally be routed parallel to the existing 57-inch SS MIS and 72-inch SS MIS with approximately the same slope and depth of 25-50 feet.

The relief sewer would be sized to convey flow above the capacity of the existing 57-inch SS MIS and 72-inch SS MIS to DC0308. The relief sewer alone, however, does not decrease the HGL enough to provide a free outlet to connections along North 107th Street between West County Line Road and West Glenbrook Court. Therefore, the diversion weir crest elevation in DC0308 must be lowered (by removing concrete) to divert flow into the NWSRS when the HGL reaches the crown of the MIS. With the relief sewer in place and the modification to DC0308, the HGL will be reduced and critical elevations will no longer be reached along the MIS segment for the five-year recurrence interval event.

The cost for the North 91st Street MIS 5-Year Relief Sewer and Modification to DC0308 project is estimated to be $37.3 million. Because the proposed relief sewer depth ranges from 25-50 feet, it is assumed that this sewer would be constructed using tunneling methods.

5-Year Alternative B: Replacement and Modification to DC0308

Alternative B consists of construction of 16,050 LF of 54-inch diameter replacement sewer along North 91st Street from MMSD MH 19702 to diversion chamber DC0308 and lowering the weir in diversion chamber DC0308 by eight feet. The replacement sewer replaces the existing 57-inch SS MIS and 72-inch SS MIS at approximately the same slope and depth of 25-50 feet.

The replaced sewer would have the capacity to convey the five-year recurrence interval event. The sewer replacement alone however, does not decrease the HGL enough to provide a free outlet to connections along North 107th Street between West County Line Road and West Glenbrook Court. Therefore the diversion weir crest elevation in DC0308 must be lowered (by removing concrete) to divert flow into the NWSRS when the HGL reaches the crown of the MIS.

The cost for the North 91st Street MIS 5-Year Replacement Sewer and Modification of structure DC0308 is estimated to be $45.5 million. Because the proposed replacement sewer depth ranges from 25-50 feet, it is assumed that this sewer would be constructed using tunneling methods.

5-Year Alternative C: Modification to DC0308 and Local Pump Station

Alternative C consists of the construction of 1,874 LF of 10-inch diameter local relief sewer along North 107th Street, construction of a local pump station at the intersection of North 107th Street and West County Line Road, and lowering the weir in diversion chamber DC0308 by eight feet. The relief sewer will capture the flow from four local connections between West County Line Road and West Glenbrook Court along North 107th Street and convey them north to a pump station that will pump the flow into the 57-inch SS MIS. The approximate depth of the local relief sewer is 30-40 feet below the ground surface.
Lowering the weir in DC0308 will provide relief of the North 91st Street MIS by lowering the diversion elevation for flow to enter the NWSRS. With the diversion elevation to the NWSRS lowered, the HGL in the MIS decreases; however, the MIS remains surcharged upstream and is above local connections along North 107th Street from West County Line Road to Glenbrook Court. The proposed local relief sewer and pump station convey the tributary flow from the local connections for the five-year recurrence interval event to the 57-inch SS MIS at North 107th Street at West County Line Road. The local relief sewer and pump station provide a free outlet for the connections along North 107th Street between West County Line Road and West Glenbrook Court. With the modification to structure DC0308 and the local relief and pump station, all local connections along the MIS segment will have free outlet conditions for the five-year recurrence interval event.

The cost for the North 91st Street MIS 5-Year Modification to DC0308 and Local Pump Station is estimated to be $5.9 million. Because the proposed local relief sewer depth ranges from 30-40 feet, it is assumed that this sewer would be constructed using tunneling methods.

10-Year Alternative A: Relief with Modification to DC0308

Alternative A consists of construction of 2,671 LF of 21-inch diameter relief sewer along West Brown Deer Road from MMSD MH 19707 to MMSD MH 19702, construction of 16,050 LF of 36-inch diameter relief sewer along North 91st Street from MMSD MH 19702 to diversion chamber DC0308, and lowering the weir in diversion chamber DC0308 by eight feet. The relief sewers would generally be routed parallel to the existing 57-inch SS MIS and 72-inch SS MIS with approximately the same slope and depth of 25-50 feet.

The cost for the North 91st Street MIS 10-Year Relief Sewer and Modification to DC0308 project is estimated to be $44.9 million.

10-Year Alternative B: Replacement with Modification to DC0308

Alternative B consists of construction of 15,419 LF of 54-inch diameter replacement sewer along West Brown Deer Road and North 91st Street from MMSD MH 19707 to MMSD MH 19407, construction of 3,302 LF of 72-inch diameter sewer replacement along North 91st Street from MMSD MH 19407 to diversion chamber DC0308, and lowering the weir in diversion chamber DC0308 by eight feet. The replacement sewers replace the existing 57-inch SS MIS and 72-inch SS MIS at approximately the same slope and depth of 25-50 feet.

The cost for the North 91st Street MIS 10-Year Replacement Sewer and Modification of structure DC0308 is estimated to be $55.8 million.

10-Year Alternative C: Modification of DC0308 and Local Pump Station

Alternative C consists of the construction of 1,874 LF of 10-inch diameter local relief sewer along North 107th Street to intercept the local sewers prior to connection with the MIS, construction of a local pump station at the intersection of North 107th Street and West County Line Road, and lowering the weir in diversion chamber DC0308 by eight feet. The relief sewer will capture the flow from four local connections between West County Line Road and Glenbrook Court along North 107th Street and convey them to a pump station that will pump the flow into the MIS. The approximate depth of the local relief sewer is 30-40 feet below the ground surface.
The cost for the North 91st Street MIS 10-Year Modification to DC0308 and Local Pump Station is estimated to be $6.0 million. The 10-year Alternative C is almost the same as the five-year Alternative C listed above; the larger local pump station capacity increases the cost slightly.

Recommendation

5-Year

The costs of Alternatives A and B are several millions of dollars more than the cost of Alternative C. Therefore, if conveyance enhancement is required, Alternative C is recommended to provide a conveyance LOP of five years. Alternative C will provide free outlet conditions for the conveyance of 2020 Baseline flows up to the five-year recurrence interval event. Additionally, the MMSD Commission should develop and adopt a policy regarding the costs and ownership of the local relief sewer and lift station prior to any design or construction contract. The recommended local relief route and facilities are shown in Figure 9-3.

10-Year

The costs of Alternatives A and B are several millions of dollars more than the cost of Alternative C. Therefore, if conveyance enhancement is required, Alternative C is recommended to provide a conveyance LOP of 10 years. Alternative C will provide free outlet conditions for the conveyance of 2020 Baseline flows up to the 10-year recurrence interval event. Additionally, the MMSD Commission should develop and adopt a policy regarding the costs and ownership of the local relief sewer and lift station prior to any design or construction contract. The recommended local relief route and facilities are shown in Figure 9-4.
FIGURE 9-3
PROJECT 1 –
NORTH 91ST STREET MIS
5-YEAR RECOMMENDED ALTERNATIVE MODIFICATION TO DC0308 AND LIFT STATION
2020 CONVEYANCE REPORT
5/2/07
CR_9.0003.07.05.02.cdr
FIGURE 9-4
PROJECT 1 –
NORTH 91ST STREET MIS
10-YEAR RECOMMENDED ALTERNATIVE
MODIFICATION TO DC0308 AND LIFT STATION
2020 CONVEYANCE REPORT

5/2/07

CR_9.0004.07.05.02.cdr
9.3.2 Project 2 – Milwaukee River MIS

Existing System and Area Description

Project 2 provides capacity enhancement to a portion of the MIS on the north central side of the MMSD sewer service area that runs along the Milwaukee River between West Bradley Road on the north and West Green Tree Road on the south. The MIS ranges from 25-50 feet below the ground surface and was constructed in 1932 and 1933. The land use along the Milwaukee River MIS is residential and commercial. Most of the Milwaukee River MIS runs below private residential property. Flow tributary to the Milwaukee River MIS includes River Hills, a northeast portion of Brown Deer, a northeast portion of Milwaukee (Brown Deer Park), and a northern portion of Glendale.

The Milwaukee River MIS conveyance enhancement is intended to prevent potential high water levels from occurring in an existing 39-inch SS MIS. The MIS segment starts at MMSD MH 14817 (West Fairy Chasm Road extended) as a 39-inch SS MIS that runs east along Dean Road, then turns southeast and runs along the Milwaukee River to the diversion chamber DC70509 at West Green Tree Road and West River Road, which is just upstream of MMSD’s Green Tree Road Pump Station PS0502.

The full pipe capacity of the 39-inch SS MIS from MMSD MH 14603 (West Bradley Road) to diversion chamber DC70509 is exceeded during five-year and 10-year recurrence interval events with 2020 Baseline flows. The conveyance restriction in the 39-inch SS MIS causes the HGL to rise and reach or exceed critical elevations at MMSD manholes along the MIS to West Dean Road including MMSD MH 14817, 14809 (West Brown Deer Road), and 14503 (West Greenwood Road extended) for the five-year recurrence interval event and MMSD MH 14817, 14809, 14603, 14601, and 14503 for the 10-year recurrence interval event. Additionally, during the 10-year recurrence interval event, the flow restriction in the 39-inch SS MIS hinders flow from the 30-inch diameter MIS connecting into the 39-inch SS MIS at North Range Line Road and West Dean Road. The high HGL causes the bypass pump station BS0506 on North Range Line Road to activate, resulting in a simulated 0.18 million gallons (MG) of sanitary sewer overflow at WPDES 231. The bypass pump station BS0506 is not activated for a five-year recurrence interval event.

5-Year List of Alternatives

Two alternatives were considered for the capacity enhancement of the Milwaukee River MIS for the five-year recurrence interval event as follows:

A. Alternative A: Relief Sewer
B. Alternative B: Sewer Replacement

10-Year List of Alternatives

Two alternatives were considered for the capacity enhancement of the Milwaukee River MIS for the 10-year recurrence interval event as follows:

A. Alternative A: Relief Sewer
B. Alternative B: Sewer Replacement
Evaluation of Alternatives

5-Year Alternative A: Relief Sewer

Alternative A consists of construction of 4,250 LF of 30-inch diameter relief sewer along the Milwaukee River from MMSD MH 14603 to MH 14503 and construction of 3,480 LF of 36-inch diameter relief sewer along the Milwaukee River from MH 14503 to diversion chamber DC70509. For the purpose of estimating the cost of the alternatives, the relief and replacement sewer alternatives in this analysis are assumed to be routed parallel to the existing 39-inch SS MIS with approximately the same slope and depth of 25-50 feet. Because much of the existing MIS is routed through private property, it is undesirable to build a relief or replacement sewer along the same route. Preliminary engineering should include alternatives along other alignments that would have better access in the future. The alternatives of this analysis assume a route parallel to the existing sewer as a means of estimating the cost using an approach that is consistent with the other projects.

The relief sewer would be sized to convey flow above the capacity of the existing 39-inch SS MIS to diversion chamber DC70509 on West Green Tree Road. With the relief sewer in place, the HGL will be reduced and critical elevations will no longer be reached.

The cost for the Milwaukee River MIS Relief Sewer project is estimated to be $17.4 million. Because the proposed relief sewer depth ranges from 25-50 feet, it is assumed that this sewer would be constructed using tunneling methods.

5-Year Alternative B: Sewer Replacement

Alternative B consists of construction of 7,734 LF of 42-inch diameter replacement sewer along the Milwaukee River from MMSD MH 14603 to diversion chamber DC70509. This sewer replaces the existing 39-inch SS MIS at approximately the same slope and depth of 25-50 feet.

The cost for the Milwaukee River MIS Replacement Sewer project is estimated to be $18.1 million. Because the proposed replacement sewer depth ranges from 25-50 feet, it is assumed that this sewer would be constructed using tunneling methods.

10-Year Alternative A: Relief Sewer

The size of the relief sewer to convey the excess flow from the 39-inch SS MIS is the same for both a five-year and 10-year recurrence interval event. Therefore, Alternative A for the 10-Year Relief Sewer is the same as the 5-Year Relief Sewer.

10-Year Alternative B: Sewer Replacement

The size of the sewer replacement to convey in the Milwaukee River MIS is the same for both a five-year and 10-year recurrence interval event. Therefore, Alternative B for the 10-Year Sewer Replacement is the same as the 5-Year Sewer Replacement.

Recommendation

5-Year

The cost of Alternative B (replacement) is only 4% more than Alternative A (relief) and the existing sewer will be approximately 95 years of age by the year 2020. Therefore, if conveyance enhancement is required, Alternative B is recommended for the purpose of establishing the project cost. The recommended replacement route is shown in Figure 9-5. Alternative B
recommends replacement along the existing sewer route, which may be difficult due to existing land use conditions.

10-Year

The sewer replacement pipe is the same size as that for the five-year LOP; therefore, the recommendation for the 10-year LOP is the same as the five-year recommendation. The recommended replacement route is shown in Figure 9-5. (Note the same figure represents the five-year and 10-year LOP option).
FIGURE 9-5
PROJECT 2 – MILWAUKEE RIVER MIS 5-YEAR AND 10-YEAR RECOMMENDED ALTERNATIVE SEWER REPLACEMENT
2020 CONVEYANCE REPORT
5/2/07 CR_9.0005.07.05.02.cdr

Legend
- M.S. - SEWER REPLACEMENT
- CRITICAL ELEVATION EXCEEDED
- DIVERSION CHAMBER
- PUMP STATION
- FLOW DIRECTION

Village of RIVER HILLS

City of GLENDALE

42" Sewer Replacement
9.3.3 Project 3 – North Range Line Road MIS

Existing System and Area Description

Project 3 provides capacity enhancement for a segment of MIS on North Range Line Road bounded by West Dean Road on the north and West Bradley Road on the south. The 10-inch diameter MIS ranges from 15-30 feet below the ground surface and was constructed in 1932-1933. The land use on North Range Line Road is residential. Flow tributary to the North Range Line Road MIS includes a northwest portion of River Hills, a southeast portion of Brown Deer, a northwest portion of Glendale, and a northeast portion of Milwaukee.

The North Range Line Road MIS begins as a 10-inch diameter sewer at MMSD MH 14912 and runs along North Range Line Road to the bypass pump station BS0506, WPDES 231. From BS0506, the MIS is a 30-inch diameter sewer that runs along North Range Line Road and connects into MMSD MH 14706 where the flow from the North Range Line Road MIS goes into a 39-inch SS MIS in West Dean Road.

The full pipe capacity of the 10-inch diameter MIS from MH 14909 (West Bradley Road) to MH 14907 is exceeded during the five-year recurrence interval event with 2020 Baseline flows. The 10-inch diameter MIS downstream of MMSD MH 14907 is not under capacity for the five-year recurrence interval event because the slope of the 10-inch diameter sewer from MH 14907 to BS0506 is steeper than the 10-inch diameter sewer from MH 14909 to MH 14907. The conveyance restriction causes the HGL to rise and reach or exceed critical elevations at MMSD MH 14912 and 14909. The bypass pump station BS0506 is not activated during the five-year recurrence interval event.

The full pipe capacity of the 10-inch diameter MIS from MH 14909 to bypass pump station BS0506 is exceeded during the 10-year recurrence interval event. The conveyance restriction causes the HGL to rise and reach or exceed critical elevations at MMSD MH 14912 and 14909. The bypass pump station BS0506 is not activated during the 10-year recurrence interval event for the Range Line Road MIS.

5-Year List of Alternatives

Two alternatives were considered for the capacity enhancement of the Range Line Road MIS for the five-year recurrence interval event as follows:

A. Alternative A: Relief Sewer
B. Alternative B: Sewer Replacement

10-Year List of Alternatives

Two alternatives were considered for the capacity enhancement of the Range Line Road MIS for the 10-year recurrence interval event as follows:

A. Alternative A: Relief Sewer
B. Alternative B: Sewer Replacement
Evaluation of Alternatives

5-Year Alternative A: Relief Sewer

Alternative A consists of construction of 1,244 LF of 12-inch diameter relief sewer along North Range Line Road from MMSD MH 14909 to 14907. The relief sewer would generally be routed parallel to the existing 10-inch diameter MIS with approximately the same slope and depth of 15-30 feet.

The relief sewer would be sized to convey flow above the capacity of the existing 10-inch diameter MIS for a five-year recurrence interval event. The cost for the North Range Line Road MIS 5-Year Relief Sewer is estimated to be $1.1 million. Because the proposed relief sewer depth ranges from 15-30 feet, it is assumed that this sewer would be constructed using open cut methods.

5-Year Alternative B: Sewer Replacement

Alternative B consists of construction of 1,244 LF of 15-inch diameter replacement sewer along North Range Line Road from MMSD MH 14909 to 14907. This replaces the existing 10-inch diameter MIS at approximately the same slope and depth of 15-30 feet.

The cost for the North Range Line Road MIS 5-Year Replacement Sewer is estimated to be $1.1 million. Because the proposed replacement sewer depth ranges from 15-30 feet, it is assumed that this sewer would be constructed using open cut methods.

10-Year Alternative A: Relief Sewer

Alternative A consists of construction of 2,895 LF of 12-inch diameter relief sewer along North Range Line Road from MMSD MH 14909 to bypass pump station BS0506. The relief sewer would generally be routed parallel to the existing 10-inch diameter MIS with approximately the same slope and depth of 15-30 feet.

The cost for the North Range Line Road MIS 10-Year Relief Sewer is estimated to be $2.1 million. Because the proposed relief sewer depth ranges from 15-30 feet, it is assumed that this sewer would be constructed using open cut methods.

10-Year Alternative B: Sewer Replacement

Alternative B consists of construction of 2,895 LF of 15-inch diameter replacement sewer along North Range Line Road from MMSD MH 14909 to bypass pump station BS0506. The replacement sewer replaces the existing 10-inch diameter MIS at approximately the same slope and depth of 15-30 feet. The replacement sewer has the capacity to convey the 10-year recurrence interval event.

The cost for the North Range Line Road MIS 10-Year Replacement Sewer is estimated to be $2.1 million. Because the proposed replacement sewer depth ranges from 15-30 feet, it is assumed that this sewer would be constructed using open cut methods.

Recommendation

5-Year

The costs of Alternative A and B are nearly the same. If conveyance enhancement is required, Alternative B is recommended to provide a conveyance LOP of 5 years for the purpose of establishing a project cost. The replacement sewer will have the required capacity to convey
2020 Baseline flows up to the five-year recurrence interval event. The recommended replacement route is shown in Figure 9-6.

**10-Year**

The costs of Alternative A and B are nearly the same. If conveyance enhancement is required, Alternative B is recommended to provide a conveyance LOP of 10 years for the purpose of establishing a project cost. The replacement sewer will have the required capacity to convey 2020 Baseline flows up to the 10-year recurrence interval event. The recommended replacement route is shown in Figure 9-7.
FIGURE 9-6
PROJECT 3 – RANGE LINE ROAD MIS
5-YEAR RECOMMENDED ALTERNATIVE
SEWER REPLACEMENT
2020 CONVEYANCE REPORT
5/2/07
FIGURE 9-7
PROJECT 3 – RANGE LINE ROAD MIS
10-YEAR RECOMMENDED ALTERNATIVE SEWER REPLACEMENT

2020 CONVEYANCE REPORT
5/2/07
9.3.4 Project 4 – River Hills MIS

Existing System and Area Description

Project 4 provides capacity enhancement for a short segment of 8-inch diameter MIS that crosses under the Milwaukee River to connect to the 39-inch SS MIS that follows along the west bank of the Milwaukee River. The River Hills MIS is near West Calumet Court at MH 14509 on the east side of the Milwaukee River and runs southwest where it connects into the existing 39-inch SS Milwaukee River MIS at MMSD MH 14503 at the intersection of West Greenwood Road and North Pierron Avenue on the west side of the Milwaukee River. MMSD MH 14503 is also along the Milwaukee River MIS, which is part of Project 2. Construction on the River Hills MIS should be performed in conjunction with the Milwaukee River MIS Project. The 8-inch diameter MIS ranges from 17-25 feet below the ground surface and was constructed in 1932. The land use in the vicinity of the River Hills MIS is residential. Flow tributary to the River Hills MIS is from a portion of the southwest side of River Hills.

The full pipe capacity of the 8-inch diameter MIS from MH 14509 to MH 14503 is exceeded during five-year and 10-year recurrence interval events. The conveyance restriction causes the HGL to rise and reach or exceed critical elevations at MMSD MH 14509.

5-Year List of Alternatives

Two alternatives were considered for the capacity enhancement of the River Hills MIS for the five-year recurrence interval event as follows:

A. Alternative A: Relief Sewer
B. Alternative B: Sewer Replacement

10-Year List of Alternatives

Two alternatives were considered for the capacity enhancement of the River Hills MIS for the 10-year recurrence interval event as follows:

A. Alternative A: Relief Sewer
B. Alternative B: Sewer Replacement

Evaluation of Alternatives

5-Year Alternative A: Relief Sewer

Alternative A consists of construction of 267 LF of 15-inch diameter relief sewer from MMSD MH 14509 to 14503. The relief sewer would generally be routed parallel to the existing 8-inch diameter MIS with approximately the same slope and depth of 17-25 feet.

The relief sewer will convey flow above the capacity of the existing 8-inch diameter MIS to the existing 39-inch SS MIS at MMSD MH 14503. With the relief sewer in place, the HGL will be reduced and critical elevations will no longer be reached.

The cost for the River Hills MIS Relief Sewer project is estimated to be $520,000. Because the proposed relief sewer runs under the Milwaukee River, it is assumed that this sewer would be constructed using tunneling methods.
5-Year Alternative B: Sewer Replacement

Alternative B consists of construction of 267 LF of 15-inch diameter replacement sewer from MMSD MH 14509 to 14503. This replaces the existing 8-inch diameter MIS at approximately the same slope and depth of 17-25 feet. With the replacement sewer in place, the HGL will be reduced and critical elevations will no longer be reached for five-year recurrence interval events.

The cost for the River Hills MIS 5-Year Replacement Sewer is estimated to be $520,000. Because the proposed replacement sewer runs under the Milwaukee River, it is assumed that this sewer would be constructed using tunneling methods.

10-Year Alternative A: Relief Sewer

The size of the relief sewer to convey the excess flow from the 39-inch SS MIS is the same for both a five-year and 10-year recurrence interval event. Therefore, Alternative A for the 10-Year Relief Sewer is the same as the 5-Year Relief Sewer.

10-Year Alternative B: Sewer Replacement

Alternative B consists of construction of 267 LF of 18-inch diameter replacement sewer from MMSD MH 14509 to 14503. This replaces the existing 8-inch diameter MIS at approximately the same slope and depth of 17-25 feet. With the replacement sewer in place, the HGL will be reduced and critical elevations will no longer be reached for 10-year recurrence interval events.

The cost for the River Hills MIS 10-Year Replacement Sewer is estimated to be $520,000. Because the proposed replacement sewer runs under the Milwaukee River, it is assumed that this sewer would be constructed using tunneling methods.

Recommendation

5-Year

The costs for Alternatives A and B are the same. Because the River Hills MIS will be approximately 90 years old by 2020, if conveyance enhancement is necessary, Alternative B is recommended to provide a conveyance LOP of 5 years. The replacement sewer will have the required capacity to convey 2020 Baseline flows up to the five-year recurrence interval event. Additionally, the MMSD Commission should develop and adopt a policy regarding costs and ownership of the River Hills MIS prior to any design or construction contract. The recommended replacement route is shown in Figure 9-8. Because the River Hills MIS connects to the Milwaukee River MIS, it is recommended that the District perform construction on this sewer in conjunction with the construction of the Milwaukee River MIS.

10-Year

The costs for Alternatives A and B are the same. Because the River Hills MIS will be approximately 90 years old by 2020, if conveyance enhancement is necessary, Alternative B is recommended to provide a conveyance LOP of 10 years. The replacement sewer will have the required capacity to convey 2020 Baseline flows up to the 10-year recurrence interval event. Additionally, the MMSD Commission should develop and adopt a policy regarding costs and ownership of the River Hills MIS prior to any design or construction contract. The recommended replacement route is shown in Figure 9-9.
FIGURE 9-8
PROJECT 4 –
RIVER HILLS MIS
5-YEAR RECOMMENDED
ALTERNATIVE
SEWER REPLACEMENT
2020 CONVEYANCE REPORT
5/2/07
CR_9_0008.07.05.02.cdr
9.3.5  Project 5 – Green Bay Avenue/Mill Road MIS

Existing System and Area Description

Project 5 provides capacity enhancement for a 72-inch diameter segment of MIS on West Mill Road and North Green Bay Avenue that is generally bounded by West Green Tree Road on the north and North Sidney Place on the west. A conveyance restriction in this 72-inch diameter MIS segment results in a surcharged condition in the farthest upstream segments of the MIS at West County Line Road. Figure 9-10 shows the segments of the MIS that exceed critical elevations due to the conveyance restriction in the downstream 72-inch diameter MIS segment.

The 72-inch diameter MIS was constructed in 1981-1982 and is part of the Northeast Side Relief Sewer. The 72-inch diameter MIS ranges from 30-50 feet below the ground surface. The land use in the vicinity of the Green Bay Avenue/Mill Road MIS is residential, commercial, and industrial. Flow tributary to the Green Bay Avenue/Mill Road MIS is from River Hills, Fox Point, Bayside, Mequon, a northern portion of Glendale and a northeast portion of Brown Deer.

The Green Bay Avenue/Mill Road MIS conveyance enhancement is intended to prevent a potential sanitary sewer overflow (WPDES 206) near East Ravine Baye Road (near the Ozaukee County line) and to prevent high water levels from occurring upstream of the 72-inch diameter MIS along two legs of tributary MIS that are located in the Village of Fox Point, the Village of Bayside, and the Village of River Hills. The Green Bay Avenue/Mill Road MIS has two tributary MIS legs upstream: a 39-inch SS MIS and a 48-inch diameter MIS. The 39-inch SS MIS and the 48-inch MIS join together at North Sleepy Hollow Lane in River Hills. Flow from both segments is conveyed downstream in a 48-inch diameter MIS.

The 39-inch SS MIS begins at MMSD MH 18904 on North Pheasant Lane (in River Hills on the west side of I-43 near Spruce Court extended). The 39-inch SS MIS runs east, under I-43, to North Port Washington Road and then along West Laramie Lane to North Sleepy Hollow Lane at MMSD MH 15614. The 48-inch diameter MIS begins at MH 20306 on West County Line Road and North Sleepy Hollow Lane extended. The 48-inch diameter MIS runs south to join the 39-inch SS MIS at MMSD MH 15614. The 48-inch diameter MIS then generally runs southeast along North Santa Monica Boulevard to MMSD MH 34504 on North Regent Road and West Brown Deer Road. From West Brown Deer Road, the MIS is a 72-inch diameter sewer that generally runs southwest to West Green Tree Road and North Green Bay Avenue at MMSD MH 34005. Wet weather flow from the Green Tree Pump Station enters the 72-inch diameter MIS at MMSD MH 34005. From West Green Tree Road and North Green Bay Avenue, the 72-inch diameter MIS runs south to West Mill Road and then west along West Mill Road to diversion chamber DC0409 where flow can either continue westward through the 72-inch diameter MIS or be diverted southward into the 72-inch diameter North Side High Level Relief Sewer.

The surcharged MIS in Bayside has the potential for causing sanitary sewer bypasses at WPDES 206, which is a gravity overflow that is located in the northern section of the 48-inch diameter MIS near the Milwaukee-Ozaukee County Line Road. The second overflow in the project area is the Green Tree overflow manholes at MMSD MH 34004 and 34003 near Green Tree Road on the east and west banks of the Milwaukee River. Overflows occur at these manholes when the HGL reaches the ground elevation. When the ISS is open, the HGL does not reach the ground elevation. Consequently, SSO from the bypass manholes occurs only when the ISS is closed and therefore, they are not conveyance related.
The full pipe capacity of the 72-inch diameter MIS from MMSD MH 34003 to diversion chamber DC0409 is exceeded during five-year and 10-year recurrence interval events with 2020 Baseline flows. The conveyance restriction causes the HGL to rise and reach or exceed critical elevations at MMSD MHs 20306, 20304, 15619, 15616, 15611 and 34501 for the five-year recurrence interval event and at MMSD MHs 20306, 20304, 15619, 15616, 15611, 34501 and 34401 for the 10-year recurrence interval event. The SSO WPDES 206 does not activate during the five-year recurrence interval event. However, the HGL reaches the SSO elevation at WPDES 206 for the 10-year recurrence interval event, which results in 0.28 MG of simulated sanitary sewer overflow.

Hydraulic analysis indicates that the full pipe capacity of the 72-inch diameter MIS is relatively small due to the flat slope of the MIS. Further investigation reveals that, due to the terrain in the northeast side of the sanitary sewer service area, replacement or relief sewers would have to be constructed at basically the same slope. Consequently, to achieve free outlet conditions, both the sewer replacement and the relief sewer would have to be much larger than the size of the existing MIS and would require nearly 24,000 LF of sewer, resulting in high cost for achieving free outlet conditions for the 48-inch diameter MIS in Bayside.

Bayside connections located at MMSD MH 20304 and on East Ravine Baye Road were investigated and it was found that the local sewers connecting into the MIS are 20 to 25 feet below the ground surface. The local Bayside sewer along East Ravine Baye Road is about 15 feet below the ground surface at the connection to the MIS. Because the local sewer is 20 to 25 feet deep, lateral connections are several feet higher than the local sewer. The nearest connection for the East Ravine Baye Road local sewer is about 3-4 feet above the maximum HGL for the five-year recurrence interval event. Likewise, the local Bayside sewer connecting into the MIS at MMSD MH 20304 from North Waverly Road is close to 20 feet below the ground surface at the connection. The maximum HGL for the five-year recurrence interval event is about 5-6 feet below this elevation.

The investigation into the Bayside connections and the high cost of relief or replacement required to achieve free outlet conditions led to the investigation of an alternative (Alternative C) that will provide adequate relief to prevent basement backups from occurring in the local communities, but will not provide a free outlet at the two Bayside connections. The alternative reduces the likelihood of an SSO at WPDES 206 and will provide free outlet conditions for all other connections along the Northeast Side Relief Sewer System.

5-Year List of Alternatives

Three alternatives were considered for the capacity enhancement of the Green Bay Avenue/Mill Road MIS for the five-year recurrence interval event as follows:

- A. Alternative A: Relief Sewer
- B. Alternative B: Sewer Replacement
- C. Alternative C: Green Tree Pump Station Modification and New Force Main

10-Year List of Alternatives

Two alternatives were considered for the capacity enhancement of the Green Bay Avenue/Mill Road MIS for the 10-year recurrence interval event as follows:
A. Alternative A: Relief Sewer

B. Alternative B: Sewer Replacement

C. Alternative C: Green Tree Pump Station Modification and New Force Main

Evaluation of Alternatives

5-Year Alternative A: Relief Sewer

Alternative A consists of construction of 8,300 LF of 96-inch diameter relief sewer along North Green Bay Avenue and West Mill Road from MMSD MH 34003 to diversion chamber DC0409. The relief sewer on the downstream portion of the MIS will draw the HGL down in the upstream portion of the MIS. The relief sewer would generally be routed parallel to the existing 72-inch diameter MIS with approximately the same slope and depth of 30-50 feet. An alternate route would run west along West Green Tree Road, then south along North Range Line Road, and then west along West Mill Road to diversion chamber DC0409, with approximately the same slope, depth of 30-50 feet, and length as the proposed route.

The cost for the Green Bay Avenue/Mill Road MIS 5-Year Relief Sewer is estimated to be $37.6 million. Because the proposed relief sewer depth ranges from 30-50 feet, it is assumed that this sewer would be constructed using tunneling methods.

5-Year Alternative B: Sewer Replacement

Alternative B consists of construction of 8,300 LF of 108-inch diameter replacement sewer along North Green Bay Avenue and West Mill Road, from MMSD MH 34003 to diversion chamber DC0409. This replaces the existing 72-inch diameter MIS at approximately the same slope and depth of 30-50 feet. The replacement sewer has the capacity to convey the five-year recurrence interval event.

The cost for the Green Bay Avenue/Mill Road MIS 5-Year Replacement Sewer is estimated to be $43.9 million. Because the proposed replacement sewer depth ranges from 30-50 feet, it is assumed that this sewer would be constructed using tunneling methods.

5-Year Alternative C: Green Tree Pump Station Modification and New Force Main

Alternative C consists of construction of 8,566 LF of 30-inch diameter force main and modifications to the Green Tree Pump Station. The modifications to the Green Tree Pump Station will provide the required head to pump flow from West Green Tree Road to West Mill Road. The modifications include a new wet well, new piping, larger pumps and motors with variable frequency drives, complete rewiring of the electrical supply including a self contained standby engine generator, and a new ventilation system. The upgraded pump station and force main convey the wet weather flow from the Green Tree Pump Station to diversion chamber DC0409 near West Mill Road at North Sidney Place, which reduces the peak flow in the Green Bay Avenue/Mill Road MIS. An alternate route would run west along West Green Tree Road then south along North Range Line Road, and then west along West Mill Road to diversion chamber DC0409.

The force main is considered as an alternative to relief or replacement for the Green Bay Avenue/Mill Road MIS because the relief and replacement sewers are very large. The size of the force main is smaller and can be shallow in the ground, following the grade of the ground surface. The force main would be sized to convey the flow tributary to the Green Tree Pump
Station for a five-year recurrence interval event. The cost for the West Green Tree force main and related pump station upgrades is estimated to be $16.0 million.

10-Year Alternative A: Relief Sewer

Alternative A consists of construction of 8,300 LF of 108-inch diameter relief sewer along North Green Bay Avenue and West Mill Road from MMSD MH 34003 to diversion chamber DC0409. The relief sewer would generally be routed parallel to the existing 72-inch diameter MIS with approximately the same slope and depth of 30-50 feet. An alternate route could be considered for the relief sewer to run west along West Green Tree Road then south along North Range Line Road, and then west along West Mill Road to diversion chamber DC0409, with approximately the same slope, depth of 30-50 feet, and close to the same length as the proposed route.

The cost for the Green Bay Avenue/Mill Road MIS 10-Year Relief Sewer is estimated to be $44.0 million. Because the proposed relief sewer depth ranges from 30-50 feet, it is assumed that this sewer would be constructed using tunneling methods.

10-Year Alternative B: Sewer Replacement

Alternative B consists of construction of 8,300 LF of 120-inch diameter replacement sewer along North Green Bay Avenue and West Mill Road from MMSD MH 34003 to diversion chamber DC0409. This replaces the existing 72-inch diameter MIS at approximately the same slope and depth of 30-50 feet. The replacement sewer has the capacity to convey the flow tributary to the Green Bay Avenue/Mill Road MIS 10-year recurrence interval event.

The cost for the Green Bay Avenue/Mill Road MIS 10-Year Replacement Sewer is estimated to be $51.9 million. Because the proposed replacement sewer depth ranges from 30-50 feet, it is assumed that this sewer would be constructed using tunneling methods.

10-Year Alternative C: Green Tree Pump Station Modification and New Force Main

Alternative C was considered for the 10-year recurrence interval event. However, even with the Green Tree Pump Station modification and new force main, the flow in the 72-inch diameter MIS was still large enough to create conveyance restrictions so that the HGL exceeded critical elevations at MHs 20306, 20304, 15616, and 34501. Therefore, Alternative C is not considered for capacity enhancement recommendation of a 10-year recurrence interval event.

Recommendation

5-Year

The cost of Alternative C is 57% less than Alternative A and 64% less than Alternative B. Therefore, if conveyance capacity enhancement is required, Alternative C is recommended to provide a conveyance LOP of 5 years. The recommended force main route is shown in Figure 9-11.

10-Year

The cost of Alternative A is approximately 18% less than Alternative B. Therefore, if conveyance capacity enhancement is required, Alternative A is recommended to provide a conveyance LOP of 10 years. The recommended relief sewer route is shown in Figure 9-12.
FIGURE 9-11
PROJECT 5 – GREEN BAY AVENUE/MILL ROAD MIS 5-YEAR RECOMMENDED ALTERNATIVE
GREEN TREE PUMP STATION FORCE MAIN
2020 CONVEYANCE REPORT
5/2/07
FIGURE 9-12
PROJECT 5 –
GREEN BAY AVENUE/MILL ROAD MIS
10-YEAR RECOMMENDED ALTERNATIVE
RELIEF SEWER
2020 CONVEYANCE REPORT
5/2/07

Legend

MIS
- FORCE MAIN
- DIVERSION CHAMBER
- BYPASS STRUCTURE OR OVERFLOW CHAMBER
- PUMP STATION
- FLOW DIRECTION

City of MILWAUKEE
City of GLENDALE
Village of RIVER HILLS
9.3.6 Project 6 – North Santa Monica Boulevard MIS

Existing System and Area Description

Project 6 provides capacity enhancement for a short segment of 10-inch diameter MIS that is on North Santa Monica Boulevard just north of East Bradley Road. The 10-inch diameter MIS ranges from 20-25 feet below the ground surface and was constructed in 1987-1988. The land use on North Santa Monica Boulevard is residential and commercial. Flow tributary to the North Santa Monica Boulevard MIS includes a western portion of Fox Point.

The North Santa Monica Boulevard MIS conveyance enhancement is intended to prevent potential high water levels from occurring in an existing 10-inch diameter MIS on North Santa Monica Boulevard. The North Santa Monica Boulevard MIS is a 10-inch diameter sewer that begins at MMSD MH 15517 and connects into a 30-inch diameter MIS at MMSD MH 34310 on East Bradley Road.

The full pipe capacity of the 10-inch diameter MIS is adequate to convey 2020 Baseline flows for the five-year recurrence interval event. Hence, capacity enhancements are only needed for a 10-year LOP. The conveyance restriction causes the HGL to rise and exceed a critical elevation at MMSD MH 15517.

List of Alternatives

Two alternatives were considered for the capacity enhancement of the North Santa Monica Boulevard MIS for the 10-year recurrence interval event as follows:

A. Alternative A: Relief Sewer
B. Alternative B: Sewer Replacement

Evaluation of Alternatives

Alternative A: Relief Sewer

Alternative A consists of construction of 360 LF of 12-inch diameter relief sewer along North Santa Monica Boulevard, from MMSD MH 15517 to MMSD MH 34310. The relief sewer would generally be routed parallel to the existing 10-inch diameter MIS with approximately the same slope and depth of 20-25 feet. The relief sewer would be sized to convey flow above the capacity of the existing 10-inch diameter MIS for a 10-year recurrence interval event.

The cost for the North Santa Monica Boulevard 10-Year Relief Sewer is estimated to be $350,000. Because the proposed relief sewer depth ranges from 20-25 feet, it is assumed that this sewer would be constructed using open cut methods.

Alternative B: Sewer Replacement

Alternative B consists of construction of 360 LF of 12-inch diameter replacement sewer along North Santa Monica Boulevard from MMSD MH 15517 to MMSD MH 34310. The replacement sewer replaces the existing 10-inch diameter MIS at approximately the same slope and depth of 20-25 feet. The replacement sewer has the capacity to convey the flow tributary to the North Santa Monica Boulevard MIS for a 10-year recurrence interval event. With the replacement sewer in place, the HGL will be reduced and the critical elevation at MMSD MH 15517 will no longer be reached.
The cost for the North Santa Monica Boulevard MIS 10-Year Replacement Sewer is estimated to be $350,000. Because the proposed replacement sewer depth ranges from 20-25 feet, it is assumed that this sewer would be constructed using open cut methods.

**Recommendation**

Because the sizes of the North Santa Monica Boulevard 10-year Relief Sewer and the North Santa Monica Boulevard 10-year Replacement Sewer are the same, the costs are the same for both alternatives. In 2020, the North Santa Monica Boulevard MIS will be approximately 95 years old. Therefore, if conveyance enhancement is required, Alternative B is recommended to provide a conveyance LOP of 10 years. Additionally, the MMSD Commission should develop and adopt a policy regarding costs and ownership of the North Santa Monica Boulevard MIS prior to any design or construction contract. The recommended replacement route is shown in Figure 9-13.
9.3.7 Project 7 – Menomonee River MIS

Existing System and Area Description

Project 7 provides capacity enhancement for a segment of MIS that runs along the Menomonee River just south of Interstate-94. The 21-inch diameter MIS ranges from 15-20 feet below the ground surface and was constructed in 1926. The land use along the Menomonee River MIS is commercial and industrial. Flow tributary to the Menomonee River MIS includes Miller Park, the Clement J. Zablocki Veterans Administration Medical Center, a northern portion of West Milwaukee and a small portion of residential area in Milwaukee.

The Menomonee River MIS conveyance enhancement is intended to prevent high water levels from occurring in an existing 21-inch diameter MIS along the Menomonee River. The Menomonee River MIS begins as a 15-inch diameter sewer at MMSD MH 04716 that runs north along the Menomonee River. The MIS then increases to a 21-inch diameter sewer at MMSD MH 04712 and runs north along the Menomonee River to MMSD MH 04605, where the 21-inch diameter MIS turns east to MMSD MH 04604B, which then connects into an existing siphon that runs underneath the Menomonee River.

The full pipe capacity of the 21-inch diameter MIS from MMSD MH 04705 to 04604B is exceeded during five-year and 10-year recurrence interval events with 2020 Baseline flows. The conveyance restriction causes the HGL to rise and reach or exceed critical elevations at MMSD MH 04705. Additionally during the 10-year recurrence interval event, the HGL is above the local connection elevation at MMSD MH 04705 due to the downstream boundary condition of the Menomonee Special MIS project. The HGL in the Menomonee River MIS exceeds the local connection elevation prior to filling the downstream 84-inch Menomonee Special MIS. Preliminary engineering should be performed to verify the surcharging caused by the downstream boundary condition in the 84-inch Menomonee Special MIS is acceptable.

5-Year List of Alternatives

Two alternatives were considered for the capacity enhancement of the Menomonee River MIS for the five-year recurrence interval event as follows:

A. Alternative A: Relief Sewer
B. Alternative B: Sewer Replacement

10-Year List of Alternatives

Two alternatives were considered for the capacity enhancement of the Menomonee River MIS for the 10-year recurrence interval event as follows:

A. Alternative A: Relief Sewer
B. Alternative B: Sewer Replacement

Evaluation of Alternatives

5-Year Alternative A: Relief Sewer

Alternative A consists of construction of 1,170 LF of 21-inch diameter relief sewer along the Menomonee River from MH 04705 to MH 04604B. The relief sewer would generally be routed parallel to the existing 21-inch diameter MIS with approximately the same slope and depth of 15-20 feet.
The cost for the Menomonee River MIS 5-Year Relief Sewer is estimated to be $1.1 million. Because the proposed relief sewer depth ranges from 15-20 feet, it is assumed that this sewer would be constructed using open cut methods.

5-Year Alternative B: Sewer Replacement

Alternative B consists of construction of 1,170 LF of 30-inch diameter replacement sewer along the Menomonee River from MH 04705 to MH 04604B. This replaces the existing 21-inch diameter MIS at approximately the same slope and depth of 15-20 feet. The replacement sewer has the capacity to convey both the five-year and 10-year recurrence interval events. With the replacement sewer in place the HGL will be reduced.

The cost for the Menomonee River MIS Replacement Sewer is estimated to be $1.3 million. Because the proposed replacement sewer depth ranges from 15-20 feet, it is assumed that this sewer would be constructed using open cut methods.

10-Year Alternative A: Relief Sewer

Alternative A consists of construction of 1,170 LF of 24-inch diameter relief sewer along the Menomonee River from MMSD MH 04705 to MMSD MH 04604B. The relief sewer would generally be routed parallel to the existing 21-inch diameter MIS with approximately the same slope and depth of 15-20 feet.

The cost for the Menomonee River MIS 10-Year Relief Sewer is estimated to be $1.1 million. Because the proposed relief sewer depth ranges from 15-20 feet, it is assumed that this sewer would be constructed using open cut methods.

10-Year Alternative B: Sewer Replacement

The size of the sewer replacement to convey flow in the Menomonee River MIS is the same for both a five-year and 10-year recurrence interval event. Therefore, Alternative B for the 10-Year Sewer Replacement is the same as the 5-Year Sewer Replacement.

Recommendation

5-Year

The cost of Alternative A is approximately 25% less than Alternative B. Although the cost for relief is significantly less, the existing sewer will be approximately 95 years old by 2020; therefore, sewer replacement is recommended for the purpose of establishing a project cost. Therefore, if conveyance enhancement is required, Alternative B is recommended to provide a conveyance LOP of 5 years. The recommended replacement route is shown in Figure 9-14.

10-Year

The cost of Alternative A is approximately 22% less than Alternative B. Although the cost for relief is significantly less, the existing sewer will be approximately 95 years old by 2020; therefore, sewer replacement is recommended for the purpose of establishing a project cost. Therefore, if conveyance enhancement is required, Alternative B is recommended to provide a conveyance LOP of 10 years. The recommended replacement route is shown in Figure 9-15.
9.3.8 Project 8 – South 35th Street MIS

Existing System and Area Description

Project 8 provides capacity enhancement for a segment of MIS on South 35th Street generally bounded by West Lincoln Avenue on the north and West Forest Home Avenue on the south. The 36-inch diameter MIS ranges from 27-34 feet below the ground surface and was constructed in 1924-1926. The land use on South 35th Street is residential, commercial, and industrial. Flow tributary to the South 35th Street MIS is from a southeast portion of West Allis, a southern portion of West Milwaukee, and a western portion of Milwaukee.

The South 35th Street MIS conveyance enhancement is intended to prevent high water levels from occurring in an existing 36-inch diameter MIS on South 35th Street. The South 35th Street MIS is a 36-inch diameter sewer that begins in West Lincoln Avenue at MMSD MH 07802 and runs south along South 35th Street to MMSD MH 07711. At MMSD MH 07711, excess flow can be diverted into the South 35th Street 18-inch diameter relief sewer proposed by the 2010 Facilities Plan project. (The 2010 FP recommends the 18-inch diameter relief sewer; however, preliminary engineering report for the South 35th Street Relief Sewer recommends another 4,000 feet of supplemental sewer replacement.) Upstream of the South 35th Street MIS at West Lincoln Avenue and near South 43rd Street is the WPDES 243 gravity bypass. Downstream of MH 07711 at South 35th Street and West Manitoba Street is bypass pump station BS0601, WPDES 225.

The full pipe capacity of the 36-inch diameter MIS is adequate to convey 2020 Baseline flows for the five-year recurrence interval event. Hence, capacity enhancements are only needed for a 10-year LOP. The full pipe capacity of the 36-inch diameter MIS from MMSD MH 07802 to 07711 is exceeded during the 10-year recurrence interval event with 2020 Baseline flows. The conveyance restriction causes the HGL to rise and exceed a critical elevation upstream on the 36-inch diameter MIS at MMSD MH 07901 and 07902. The rise in the HGL for the 10-year recurrence interval event does not activate the sanitary sewer overflows at either WPDES 225 or WPDES 243.

List of Alternatives

Two alternatives were considered for the capacity enhancement of the South 35th Street MIS for the 10-year recurrence interval event as follows:

A. Alternative A: Relief Sewer

B. Alternative B: Sewer Replacement

Evaluation of Alternatives

Alternative A: Relief Sewer

Alternative A consists of construction of 2,875 LF of 36-inch diameter relief sewer along South 35th Street from MMSD MH 07802 to 07711. The relief sewer would generally be routed parallel to the existing 36-inch diameter MIS with approximately the same slope and depth of 27-34 feet. The relief sewer would be sized to convey flow above the capacity of the existing 36-inch diameter MIS for a 10-year recurrence interval event.
The cost for the South 35th Street 10-Year Relief Sewer is estimated to be $6.7 million. Because the proposed relief sewer depth ranges from 27-34 feet, it is assumed that this sewer would be constructed using tunneling methods.

Alternative B: Sewer Replacement

Alternative B consists of construction of 2,875 LF of 48-inch diameter replacement sewer along South 35th Street from MMSD MH 07802 to MMSD MH 07711. The replacement sewer replaces the existing 36-inch diameter MIS at approximately the same slope and depth of 27-34 feet. The replacement sewer has the capacity to convey the flow tributary to the South 35th Street MIS for a 10-year recurrence interval event. With the replacement sewer in place, the HGL will be reduced and the critical elevation at MMSD MH 07901 and 07902 will no longer be reached.

The cost for the South 35th Street MIS 10-Year Replacement Sewer is estimated to be $7.1 million. Because the proposed replacement sewer depth ranges from 27-34 feet, it is assumed that this sewer would be constructed using tunneling methods.

Recommendation

The difference between the cost for relief and replacement is approximately 6% and the existing sewer will be almost 95 years old by 2020. Therefore, if conveyance capacity enhancement is required, Alternative B is recommended to provide a conveyance LOP of 10 years for the purpose of establishing a project cost. The recommended replacement route is shown in Figure 9-16. The South 35th Street MIS should be incorporated with the Proposed South 35th Street Relief Sewer Project to save on project costs if the 10-year LOP is implemented.
FIGURE 9-16
PROJECT 8 – SOUTH 35TH STREET MIS 10-YEAR RECOMMENDED ALTERNATIVE SEWER REPLACEMENT
2020 CONVEYANCE REPORT
5/2/07
CR_9.0016.07.05.02.cdr
9.3.9 Project 9 – South 81st Street MIS

Existing System and Area Description

Project 9 provides capacity enhancement for a segment of MIS that runs along South 84th Street, West Rogers Street and South 81st Street. The 18-inch diameter MIS ranges from 20-25 feet below the ground surface and was constructed in 1926. The land use along the South 81st Street MIS is residential, commercial, and industrial. Flow tributary to the South 81st Street MIS includes a central portion of West Allis.

The South 81st Street MIS conveyance enhancement is intended to prevent high water levels from occurring in an existing 18-inch diameter MIS in South 81st Street. The South 81st Street MIS begins near South 84th Street at West National Avenue. At MMSD MH 08310 flow can either go south through an 18-inch diameter MIS or be diverted to the north by gravity to a 27-inch diameter MIS. The 18-inch diameter MIS runs south along South 84th Street to West Rogers Street where it turns and runs east along West Rogers Street to South 81st Street. The 18-inch diameter sewer then runs south along South 81st Street to West Grant Street at MMSD MH 08302. From MMSD MH 08302 flow either continues south through an 18-inch diameter MIS or is diverted east to a 27-inch diameter MIS and then to a 96-inch diameter MIS.

The full pipe capacity of the 18-inch diameter MIS from MMSD MH 08310 to MMSD MH 08302 is exceeded during five-year and 10-year recurrence interval events with 2020 Baseline flows. The conveyance restriction causes the HGL to rise and exceed the critical elevation and the ground surface elevation at MMSD MH 08307. Some of the flow from upstream of MMSD MH 08310 is diverted by gravity to the 27-inch diameter MIS. Additionally, flow from West Allis connecting to MMSD MH 08307 either flows south through the 18-inch diameter sewer or backs-up through the 18-inch diameter sewer into the 27-inch diameter MIS.

5-Year List of Alternatives

Two alternatives were considered for the capacity enhancement of the South 81st Street MIS for the five-year recurrence interval event as follows:

A. Alternative A: Relief Sewer
B. Alternative B: Sewer Replacement

10-Year List of Alternatives

Two alternatives were considered for the capacity enhancement of the South 81st Street MIS for the 10-year recurrence interval event as follows:

A. Alternative A: Relief Sewer
B. Alternative B: Sewer Replacement

Evaluation of Alternatives

5-Year Alternative A: Relief Sewer

Alternative A consists of construction of 2,890 LF of 21-inch diameter relief sewer along South 81st Street and West Rogers Street from MMSD MH 08310 to 08302. The relief sewer would generally be routed parallel to the existing 18-inch diameter MIS with approximately the same slope and depth of 20-25 feet.
The relief sewer would be sized to convey flow above the capacity of the existing 18-inch diameter MIS for a five-year recurrence interval event. The cost for the South 81st Street MIS 5-Year Relief Sewer is estimated to be $3.4 million. Because the proposed relief sewer depth ranges from 20-25 feet, it is assumed that this sewer would be constructed using open cut methods.

**5-Year Alternative B: Sewer Replacement**

Alternative B consists of construction of 2,890 LF of 24-inch diameter replacement sewer along South 81st Street and West Rogers Street from MMSD MH 08310 to 08302. This replaces the existing 18-inch diameter MIS at approximately the same slope and depth of 20-25 feet. The replacement sewer has the capacity to convey the flow tributary to the South 81st Street MIS for a five-year recurrence interval event. With the replacement sewer in place the HGL will be reduced and the critical elevation will no longer be reached.

The cost for the South 81st Street MIS Replacement Sewer is estimated to be $3.5 million. Because the proposed replacement sewer depth ranges from 20-25 feet, it is assumed that this sewer would be constructed using open cut methods.

**10-Year Alternative A: Relief Sewer**

Alternative A consists of construction of 2,890 LF of 24-inch diameter relief sewer along South 81st Street and West Rogers Street from MMSD MH 08310 to 08302. The relief sewer would generally be routed parallel to the existing 18-inch diameter MIS with approximately the same slope and depth of 20-25 feet. The relief sewer would be sized to convey flow above the capacity of the existing 18-inch diameter MIS for a 10-year recurrence interval event.

The cost for the South 81st Street MIS 10-Year Relief Sewer is estimated to be $3.5 million. Because the proposed relief sewer depth ranges from 20-25 feet, it is assumed that this sewer would be constructed using open cut methods.

**10-Year Alternative B: Sewer Replacement**

Alternative B consists of construction of 2,890 LF of 30-inch diameter replacement sewer along South 81st Street and West Rogers Street from MMSD MH 08310 to 08302. This replaces the existing 18-inch diameter MIS at approximately the same slope and depth of 20-25 feet. The replacement sewer has the capacity to convey the flow tributary to the South 81st Street MIS for a 10-year recurrence interval event. With the replacement sewer in place, the HGL will be reduced and the critical elevation will no longer be reached.

The cost for the South 81st Street MIS Replacement Sewer is estimated to be $4.1 million. Because the proposed replacement sewer depth ranges from 20-25 feet, it is assumed that this sewer would be constructed using open cut methods.

**Recommendation**

**5-Year**

The difference in cost between Alternative A and B is about 2% and the existing sewer will be approximately 95 years old by 2020. Therefore, if conveyance capacity enhancement is required, Alternative B is recommended to provide a conveyance LOP of 5 years for the purpose of establishing a project cost. Additionally, the MMSD Commission should develop and adopt a policy regarding the costs and ownership of the South 81st Street MIS and other MIS segments in
this area that serve West Allis alone prior to any design or construction contract. The recommended replacement route is shown in Figure 9-17.

Because modeled flows in this area appear to be high, the actual need for a conveyance enhancement should be verified by focused flow monitoring before proceeding with any improvements.

10-Year

The difference in cost between Alternative A and B is approximately 15%. Although the cost for relief is significantly less, the existing sewer will be approximately 95 years old by 2020; therefore, Alternative B is recommended to provide a conveyance LOP of 10 years for the purpose of establishing a project cost. Additionally, the MMSD Commission should develop and adopt a policy regarding the costs and ownership of the South 81st Street MIS and other MIS segments in this area that serve West Allis alone prior to any design or construction contract. The recommended replacement route is shown in Figure 9-18.
FIGURE 9-17
PROJECT 9 – SOUTHERN 81ST STREET MIS
5-YEAR RECOMMENDED ALTERNATIVE SEWER REPLACEMENT
2020 CONVEYANCE REPORT
5/3/07
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FIGURE 9-18
PROJECT 9 – SOUTH 81ST STREET MIS 10-YEAR RECOMMENDED ALTERNATIVE SEWER REPLACEMENT
2020 CONVEYANCE REPORT
5/2/07
CR_9.0018.07.05.02.cdr
9.3.10 Project 10 – South Howell Avenue MIS

Existing System and Area Description

Project 10 provides capacity enhancement for a segment of MIS that runs along South Howell Avenue from West Ramsey Avenue extended to West Layton Avenue. The capacity enhancement will improve the performance of the MIS that is generally bounded by South 27th Street on the west, West College Avenue on the south, South Howell Avenue on the east, and West Layton Avenue on the north. The 27-inch diameter MIS ranges from 25-35 feet below the ground surface and was constructed in 1956-1961. The land use along the South Howell Avenue MIS is residential, commercial, and industrial. Flow tributary to the South Howell Avenue MIS is from a northeastern portion of Franklin, a southeastern portion of Greenfield, a southeastern portion of Milwaukee, including General Mitchell International Airport, and a northeastern portion of Oak Creek.

The South Howell Avenue MIS conveyance enhancement is intended to prevent high water levels from occurring in an existing 27-inch diameter MIS on South Howell Avenue and upstream along two legs of tributary MIS and to prevent the WPDES 220 sanitary sewer overflow at South Howell Avenue just south of the airport spur freeway from activating. The South Howell Avenue MIS has two tributary MIS legs upstream. The first MIS leg begins as a 24-inch diameter MIS at South 27th Street and West Ramsey Avenue that runs south along South 27th Street to West College Avenue where it then runs east to South 13th Street. At 13th Street, the 24-inch diameter sewer increases to a 39-inch SS MIS and runs north along South 13th Street and connects into the second MIS leg. The second MIS leg also begins at South 27th Street and West Ramsey Avenue as a 30-inch diameter MIS that runs east along West Ramsey Avenue to MMSD MH 20006 where the MIS increases to a 39-inch SS MIS which then runs southeast and connects into the first MIS leg. From the connection of the two MIS legs, the 39-inch SS MIS runs northeast to West Ramsey Avenue extended, then runs east along West Ramsey Avenue extended to South Howell Avenue. At South Howell Avenue the MIS is a 27-inch diameter sewer that travels north to West Layton Avenue at MMSD diversion chamber DC0102. Some of the flow from the 39-inch SS MIS is diverted at West Ramsey Avenue extended and South Howell Avenue via the Howell Avenue Pump Station.

The full pipe capacity of the 27-inch diameter MIS from MMSD MH 17618 to diversion chamber DC0102 is exceeded during the five-year recurrence interval event with 2020 Baseline flows. The conveyance restriction causes the HGL to rise and exceed the critical elevations and/or the ground surface elevations at several locations upstream including MMSD MHs 10752, 10709, 10702, and 17604. Additionally, the HGL elevation reaches the bypass elevation at WPDES 220 along South Howell Avenue which results in a simulated sanitary sewer overflow volume of 0.01 MG.

The full pipe capacity of a short section of the 39-inch special section MIS upstream of the Howell Avenue Pump Station and the 27-inch diameter MIS from MMSD MH 10702 to diversion chamber DC0102 is exceeded during a 10-year recurrence interval event with 2020 Baseline flows. The conveyance restriction causes the HGL to rise and exceed the critical elevations and/or the ground surface elevations at several locations upstream including MMSD MHs 10752, 10716, 10709, 10706, 10702 and 17604. Additionally, the HGL elevation reaches the bypass elevation at East Grange Avenue and South Howell Avenue, which results in a simulated sanitary sewer overflow volume of 0.30 MG.
5-Year List of Alternatives

Two alternatives were considered for the capacity enhancement of the South Howell Avenue MIS for the five-year recurrence interval event as follows:

A. Alternative A: Relief Sewer
B. Alternative B: Sewer Replacement

10-Year List of Alternatives

Two alternatives were considered for the capacity enhancement of the South Howell Avenue MIS for the 10-year recurrence interval event as follows:

A. Alternative A: Relief Sewer
B. Alternative B: Sewer Replacement

Evaluation of Alternatives

5-Year Alternative A: Relief Sewer

Alternative A consists of construction of 5,254 LF of 24-inch diameter relief sewer along South Howell Avenue from MMSD MH 17618 to 17604 and construction of 1,427 LF of 30-inch diameter relief sewer along South Howell Avenue from MMSD MH 17604 to diversion chamber DC0102. The relief sewer would generally be routed parallel to the existing 27-inch diameter MIS with approximately the same slope and depth of 25-35 feet. The relief sewer would be sized to convey flow above the capacity of the existing 27-inch diameter MIS for a five-year recurrence interval event.

The cost for the South Howell Avenue MIS 5-Year Relief Sewer is estimated to be $8.3 million. Because the proposed relief sewer depth ranges from 25-35 feet, it is assumed that this sewer would be constructed using tunneling methods.

5-Year Alternative B: Sewer Replacement

Alternative B consists of construction of 5,254 LF of 36-inch diameter sewer replacement along South Howell Avenue from MMSD MH 17618 to 17604 and construction of 1,427 LF of 42-inch diameter sewer replacement along South Howell Avenue from MMSD MH 17604 to diversion chamber DC0102. This replaces the existing 27-inch diameter MIS at approximately the same slope and depth of 25-35 feet. The replacement sewer has the capacity to convey both the five-year and 10-year recurrence interval events. With this replacement sewer, the HGL will be reduced, the critical elevations will no longer be reached, and the sanitary sewer bypass will not be activated.

The replacement sewer would be sized to convey the flow tributary to the South Howell Avenue MIS for a five-year recurrence interval event. The cost for the South Howell Avenue MIS Replacement Sewer is estimated to be $10.4 million. Because the proposed replacement sewer depth ranges from 25-35 feet, it is assumed that this sewer would be constructed using tunneling methods.

10-Year Alternative A: Relief Sewer

Alternative A consists of construction of 7,609 LF of 30-inch diameter relief sewer along West Ramsey Avenue extended and along South Howell Avenue from MMSD MH 10702 to diversion...
chamber DC0102. The relief sewer would generally be routed parallel to the existing 39-inch SS MIS and 27-inch diameter MIS with approximately the same slope and depth of 25-35 feet.

The relief sewer would be sized to convey flow above the capacity of the existing 39-inch SS MIS and 27-inch diameter MIS for a 10-year recurrence interval event. The cost for the South Howell Avenue MIS 10-Year Relief Sewer is estimated to be $10.6 million. Because the proposed relief sewer depth ranges from 25-35 feet, it is assumed that this sewer would be constructed using tunneling methods.

10-Year Alternative B: Sewer Replacement

Alternative B consists of construction of 6,182 LF of 36-inch diameter sewer replacement along West Ramsey Avenue extended and South Howell Avenue from MMSD MH 10702 to MMSD MH 17604 and construction of 1,427 LF of 42-inch diameter sewer replacement along South Howell Avenue from MMSD MH 17604 to diversion chamber DC0102. This replaces the existing 39-inch SS MIS and 27-inch diameter MIS at approximately the same slope and depth of 25-35 feet. The replacement sewer has the capacity to convey the flow tributary to the South Howell Avenue MIS for a 10-year recurrence interval event. With the replacement sewer in place the HGL will be reduced, the critical elevations will no longer be reached, and the sanitary sewer bypass will not be activated.

The cost for the South Howell Avenue MIS Replacement Sewer is estimated to be $11.7 million. Because the proposed replacement sewer depth ranges from 25-35 feet, it is assumed that this sewer would be constructed using tunneling methods.

Recommendation

5-Year

Because modeled flows in this area appear to be high, the actual need for a conveyance enhancement should be verified by focused flow monitoring before proceeding with any improvements.

Alternative A costs approximately 20-25% less than Alternative B. Therefore, if conveyance capacity enhancement is required, Alternative A is recommended to provide a conveyance LOP of 5 years. The recommended relief sewer route is shown in Figure 9-19.

10-Year

The difference in cost between Alternative A and B is approximately 10%. Therefore, if conveyance capacity is required, Alternative A is recommended to provide a conveyance LOP of 10 years. The recommended relief sewer route is shown in Figure 9-20.
FIGURE 9-19
PROJECT 10 – SOUTH HOWELL AVENUE MIS 5-YEAR RECOMMENDED ALTERNATIVE RELIEF SEWER
2020 CONVEYANCE REPORT
5/3/07
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FIGURE 9-20
PROJECT 10 – SOUTH HOWELL AVENUE MIS
10-YEAR RECOMMENDED ALTERNATIVE RELIEF SEWER
2020 CONVEYANCE REPORT
5/3/07
CR_9.0020.07.05.03.cdr
9.3.11 Project 11 – South Sheridan Drive MIS

Existing System and Area Description

Project 11 provides capacity enhancement for a segment of MIS that is along South Sheridan Drive from Warnimont Park to East Allerton Avenue. The 18-inch diameter MIS ranges from 20-25 feet below the ground surface and was constructed in 1934. The land use on South Sheridan Drive is residential, commercial, and industrial. Flow tributary to the South Sheridan Drive MIS is from a northeast portion of Cudahy.

The South Sheridan Drive MIS conveyance enhancement is intended to prevent potential high water levels from occurring in the existing 18-inch diameter MIS on South Sheridan Drive. The South Sheridan Drive MIS is an 18-inch diameter sewer that begins at MMSD MH 11605 and runs north along South Sheridan Avenue to East Allerton Avenue at MMSD MH 11417.

The full pipe capacity of the 18-inch diameter MIS during the five-year recurrence interval event is adequate to convey 2020 Baseline flows. Hence, capacity enhancements are only needed for a 10-year LOP. The full pipe capacity of the 18-inch diameter MIS from MMSD MH 11605 to 11417 is exceeded during the 10-year recurrence interval event with 2020 Baseline flows. The conveyance restriction causes the HGL to rise and the critical elevation to be reached at MMSD MH 11604.

List of Alternatives

The South Sheridan Drive MIS has the potential to benefit from I/I reduction by eliminating the need for relief or replacement. The three alternatives considered for the capacity enhancement of the South Sheridan Drive MIS for the 10-year recurrence interval event are as follows:

A. Alternative A: Relief Sewer
B. Alternative B: Sewer Replacement
C. Alternative C: I/I Reduction

Evaluation of Alternatives

Alternative A: Relief Sewer

Alternative A consists of construction of 5,510 LF of 18-inch diameter relief sewer along South Sheridan Drive from MMSD MH 11605 to 11417. The relief sewer would generally be routed parallel to the existing 18-inch diameter MIS with approximately the same slope and depth of 20-25 feet. The relief sewer would be sized to convey flow above the capacity of the existing 18-inch diameter MIS for a 10-year recurrence interval event.

The cost for the South Sheridan Drive 10-Year Relief Sewer is estimated to be $5.7 million. Because the proposed relief sewer depth ranges from 20-25 feet, it is assumed that this sewer would be constructed using open cut methods.

Alternative B: Sewer Replacement

Alternative B consists of construction of 5,510 LF of 24-inch diameter replacement sewer along South Sheridan Drive from MMSD MH 11605 to MMSD MH 11417. This replaces the existing 18-inch diameter MIS at approximately the same slope and depth of 20-25 feet. The replacement sewer has the capacity to convey flow tributary to the South Sheridan Drive MIS for a 10-year recurrence interval event. With the replacement sewer in place the HGL will be reduced.
The cost for the South Sheridan Drive MIS 10-Year Replacement Sewer is estimated to be $7.2 million. Because the proposed replacement sewer depth ranges from 20-25 feet, it is assumed that this sewer would be constructed using open cut methods.

**Alternative C: I/I Reduction**

Alternative C consists of reducing I/I for the area tributary to the Sheridan Drive MIS to reduce peak flows to the capacity of the South Sheridan Drive MIS. Flow tributary to the South Sheridan Drive MIS is from sewersheds CU6009 and CU6019. It was determined that if the I/I generated from sewersheds CU6009 and CU6019 was reduced approximately 18%, the HGL would be less than the critical elevation, even though the MIS would still be surcharged. A general discussion of the I/I reduction analysis method and specific details on Project 11 are provided in Appendix 9A. The cost for the South Sheridan Drive MIS I/I Reduction alternative is estimated to be $1.9 million.

**Recommendation**

The difference between the cost for relief and replacement is approximately 25%. The cost of the I/I reduction is approximately 66% less than the cost for the relief sewer alternative. Therefore, Alternative C is recommended to provide a conveyance LOP of 10 years. Additionally, the MMSD Commission should develop and adopt a policy regarding costs and ownership of the South Sheridan Drive MIS prior to any design or construction contract. The recommended sewershed area for reduction in I/I is shown in Figure 9-21.
9.3.12 Project 12 – Ryan Road MIS

Existing System and Area Description

Project 12 provides capacity enhancement for a segment of MIS that is on East and West Ryan Road and South Pennsylvania Avenue generally bounded by South 10th Street extended on the west and East Puetz Road on the north. The 84-inch diameter MIS ranges from 40-70 feet below the ground surface and was constructed in 1964-1966. The land use on East and West Ryan Road and South Pennsylvania Avenue is residential, commercial, and industrial. Flow tributary to the Ryan Road MIS is from Franklin, Muskego, Greendale, Hales Corners, and a southern portion of Oak Creek, a southwestern portion of West Allis, a southern portion of Milwaukee, a western portion of Greenfield, and a southeastern portion of New Berlin. The 84-inch diameter MIS serves 96 sewersheds, in all or part of 10 communities. The tributary area is 75,471 acres (31% of the sanitary sewer area).

The Ryan Road MIS conveyance enhancement is intended to prevent high water levels from occurring in an existing 84-inch diameter MIS on East and West Ryan Road and in upstream legs of the Ryan Road MIS. Figure 9-22 shows the critical elevation exceedences upstream of the Ryan Road MIS. The MIS section requiring relief begins at MMSD MH 40401 on West Ryan Road near the point where Oak Creek passes under West Ryan Road and runs east along West Ryan Road and East Ryan Road to South Pennsylvania Avenue to MMSD MH 40103. The 84-inch diameter MIS then runs north along South Pennsylvania Avenue to East Puetz Road at MMSD MH 30202.

The full pipe capacity of the 84-inch diameter MIS is slightly exceeded during the five-year recurrence interval event with 2020 Baseline flows; however, critical elevations are not reached. For this reason, capacity enhancements would potentially be needed for a 10-year LOP only if growth is fully realized. The full pipe capacity of the 84-inch diameter MIS from MMSD MH 40401 to 30202 is exceeded during the 10-year recurrence interval event with 2020 Baseline flows. The conveyance restriction causes the HGL to rise and reach or exceed critical elevations at many upstream locations including MMSD MH 42005, 42003, 41906, 41905, 41302, 41301, 41102, and 40903.

List of Alternatives

Two alternatives were considered for the potential capacity enhancement of the Ryan Road MIS for the 10-year recurrence interval event as follows:

A. Alternative A: Relief Sewer
B. Alternative B: Sewer Replacement

Evaluation of Alternatives

Alternative A: Relief Sewer

Alternative A consists of construction of 16,315 LF of 54-inch diameter relief sewer along East and West Ryan Road and South Pennsylvania Avenue from MMSD MH 40401 to 30202. The relief sewer would generally be routed parallel to the existing 84-inch diameter MIS with approximately the same slope and depth of 60-70 feet. The relief sewer would be sized to convey flow above the capacity of the existing 84-inch diameter MIS for a 10-year recurrence interval event.
The cost for the Ryan Road 10-Year Relief Sewer is estimated to be $51.8 million. Because the potential proposed relief sewer depth ranges from 60-70 feet, it is assumed that this sewer would be constructed using tunneling methods.

**Alternative B: Sewer Replacement**

Alternative B consists of construction of 16,315 LF of 96-inch diameter replacement sewer along East and West Ryan Road and South Pennsylvania Avenue from MMSD MH 40401 to 30202. This replaces the existing 84-inch diameter MIS at approximately the same slope and depth of 60-70 feet. The replacement sewer has the capacity to convey flow tributary to the Ryan Road MIS for a 10-year recurrence interval event. With the replacement sewer in place, the HGL will be reduced and critical elevations will no longer be reached for up to a 10-year recurrence interval event.

The cost for the potential Ryan Road MIS 10-Year Replacement Sewer is estimated to be $80.9 million. Because the potential replacement sewer depth ranges from 60-70 feet, it is assumed that this sewer would be constructed using tunneling methods.

**Recommendation**

The difference between the cost for relief and replacement is approximately 50%. Therefore, if conveyance capacity enhancement is required, Alternative A is recommended to provide a conveyance LOP of 10 years. The recommended relief sewer route is shown in Figure 9-23.

Project 12 is relatively far downstream in the conveyance system and it is near the South Shore Wastewater Treatment Plant (SSWWTP); consequently, it functions as a “downstream” facility much like the treatment plant. This analysis of the capacity enhancement for the Ryan Road MIS is based on flows generated by the 2020 Baseline population and land use.

In subsequent preliminary engineering studies, it would be appropriate to also evaluate the need for this project using the Revised 2020 Baseline population and land use values. This is because the performance of the Ryan Road MIS is related to the treatment capacity of the SSWWTP. The recommended sizing of treatment capacity upgrades at the SSWWTP are based on the Revised 2020 Baseline population and land use because it is a downstream facility. Therefore, preliminary engineering of Project 12 may need to evaluate the facility needs from both sets of population and land use values. For the purposes of the 2020 FP, only the original 2020 Baseline population and land use values were used to evaluate Project 12.
FIGURE 9-23
PROJECT 12 – RYAN ROAD MIS
10-YEAR RECOMMENDED ALTERNATIVE RELIEF SEWER
2020 CONVEYANCE REPORT
5/4/07
CR_9.0023.07.05.04.cdr
9.3.13 Project 13 – Franklin-Muskego MIS

Introduction

The existing conveyance system was analyzed to identify hydraulic restrictions. Project 13 is a conveyance upgrade project to increase the conveyance capacity of the existing Franklin-Muskego MIS to provide adequate capacity for future growth. Project 13, however, is not the only option available; this section also discusses several options that have been proposed for serving Muskego and parts of Franklin and New Berlin in the future. A potential Ryan Creek Interceptor (in various forms) is an alternative option to upgrading the existing Franklin-Muskego Interceptor. The potential Ryan Creek Interceptor option will be further subdivided and defined below.

This section will begin with a discussion of the options that are in various degrees of conceptual development. Due to the preliminary nature of the available data, these options (and the associated preliminary cost estimates) are presented here for discussion without recommendation.

Conveyance enhancement for the Franklin-Muskego MIS has been evaluated for the 2020 FP conveyance system analysis. Therefore, the details of this analysis are presented after a general discussion of the potential Ryan Creek Interceptor options.

Ryan Creek Interceptor Options compared to the Franklin-Muskego Interceptor Upgrade Option

The Ryan Creek Interceptor is a possible interceptor concept, named as it is because it would generally follow the west to east alignment of Ryan Creek in Franklin. Various options for the Ryan Creek Interceptor would provide sanitary sewer service to the southwest portion of the city of Franklin, to part of the city of Muskego, and to a part of the city of New Berlin. The options for the Ryan Creek Interceptor include both gravity and pressure sewer options. A gravity sewer option would need to be relatively deep while a pressure sewer option would involve the construction of two parallel force main pipes in the same trench at a depth of approximately six to 12 feet.

The areas that would be served by the Ryan Creek Interceptor vary between options. In all of the options listed below, two sewersheds in southwestern Franklin would be served; the extent of service in Muskego varies between the options. For example, one of the options below would serve most of Muskego (areas not served by the existing Franklin-Muskego force main) and a small part of New Berlin, while another option would only serve the southern half of Muskego.

The evaluation compares three main options with two sub-options. The three main options were evaluated in a Technical Memorandum dated Sept. 1, 2006. Two sub-options, using force mains instead of gravity sewers, were proposed recently by the three communities. These five options are defined below:

Option A: The MMSD would upgrade the existing Franklin-Muskego Interceptor to accommodate growth in Muskego. Muskego would construct local systems to convey future growth to the existing MIS. Franklin would construct a local collection system to serve the growth in the southwest part of Franklin; this local system from Franklin would have a connection to the MMSD 84-inch diameter
MIS at South 60th Street and West Ryan Road. The MMSD would not construct the Ryan Creek Interceptor in this option and would only be responsible for the expansion of the Franklin-Muskego Interceptor.

**Option B – Gravity Sewer:** This option involves the construction of a new Ryan Creek Interceptor to serve parts of Franklin and the majority of Muskego (including a part of New Berlin). The Ryan Creek Interceptor would be a gravity sewer line to the MIS at South 60th Street and West Ryan Road. The route of this gravity sewer would generally follow Ryan Creek.

**Option B – Force Main:** The area served by this option is the same as the above option. Instead of a gravity sewer, this option would use pump stations and shallow force mains to convey the flows from Muskego and Franklin to the MIS at South 60th Street and West Ryan Road. The route of the collector force main would be along West Ryan Road.

**Option C – Gravity Sewer:** This option involves the construction of a smaller Ryan Creek Interceptor that would serve parts of Franklin and only two sewersheds in the southern part of Muskego. This would be a gravity sewer line to the MIS at South 60th Street and West Ryan Road. The route of this gravity sewer would generally follow Ryan Creek.

**Option C – Force Main:** The area served by this option is the same as the above option. Instead of a gravity sewer, this option would use pump stations and shallow force mains to convey the flows from Muskego and Franklin to the MIS at South 60th Street and West Ryan Road. The route of the collector force main would be along West Ryan Road.

Table 9-5 summarizes the costs for the five options by dividing the preliminary cost estimates into possible components for MMSD, the city of Muskego, and the city of Franklin. The MMSD force main costs in the table are for ductile iron pipe (costs for PVC pipe are given in footnotes). It is uncertain whether the cost for Muskego and Franklin include the cost of pump stations because Ruekert and Mielke, Inc., prepared these values and need further clarification. These options and the associated costs are presented for comparison; however, the uncertainties in the bases and assumptions used to develop the estimates make the values tentative, based on the available data at this time.
TABLE 9-5
OPTIONS FOR FUTURE POTENTIAL SERVICE TO MUSKEGO
AND PARTS OF FRANKLIN AND NEW BERLIN
PRELIMINARY COST ESTIMATES ($ MILLIONS)

<table>
<thead>
<tr>
<th>Option</th>
<th>MMSD Costs</th>
<th>Muskego Costs</th>
<th>Franklin Costs</th>
<th>Total Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option A</td>
<td>$4.7²</td>
<td>$15¹</td>
<td>$41¹</td>
<td>$63</td>
</tr>
<tr>
<td>Option B Gravity¹</td>
<td>69</td>
<td>16</td>
<td>16</td>
<td>101</td>
</tr>
<tr>
<td>Option B Force main</td>
<td>29²³</td>
<td>15²⁴</td>
<td>32</td>
<td>76</td>
</tr>
<tr>
<td>Option C Gravity¹</td>
<td>54</td>
<td>10</td>
<td>16</td>
<td>80</td>
</tr>
<tr>
<td>Option C Force main</td>
<td>15²⁵</td>
<td>18²⁶</td>
<td>32</td>
<td>66</td>
</tr>
</tbody>
</table>

1) Cost estimates from Ryan Creek Interceptor analysis (see endnote number 2 at the end of this chapter).
2) Cost estimate determined by 2020 Facilities Plan using ductile iron pipe.
3) Cost for Option B Force main for MMSD with PVC: $21 million.
4) Cost of Option B Force main for Muskego with PVC: $11 million.
5) Cost for Option C Force main for MMSD with PVC: $11 million.
6) Cost of Option C Force main for Muskego with PVC: $13 million.

The costs of Option A and Option C force main are within 10% of each other; however, due the accuracy of these preliminary cost estimates it is not possible to identify the least costly option based upon this preliminary analysis. Therefore, the 2020 FP team recommends a project specific facilities plan to review all of these options in greater detail. The values require further evaluation and review before they are a suitable basis for decision-making.

A project specific facilities plan is necessary to clarify the population and land use conditions to be used for analysis. It is also necessary for estimating sewershed flows that will be the basis of further analysis and refinement of the recommendations for facilities sizing. A project specific facilities plan would be required by Wisconsin Administrative Code (NR110.10).

Project 13 is the MMSD part of Option A. This project was evaluated as part of the MMSD conveyance system evaluation for the five- and 10-year LOPs. Therefore, the rest of this section is a discussion of Project 13 only.

Existing Franklin-Muskego Interceptor Potential Upgrade Evaluation

The existing Franklin-Muskego Interceptor currently serves the northeast part of Franklin and all of Muskego. Local pump stations convey flows from the areas served to the existing MIS, which is a pressure sewer.

The Franklin-Muskego Interceptor begins as a 24-inch diameter pressure sewer on South 124th Street, near West McShane Drive, where it connects to the force main from Muskego. The 24-inch diameter pressure sewer runs east to West Forest Home Avenue where a 20-inch diameter pressure sewer from the Franklin Pump Station connects at MMSD MH 44208. Manhole MH 44208 is on the 20-inch pipe from Franklin and is adjacent to the junction point with the 24-inch pipe from Muskego. At the junction point, (labeled 44202 on the as-built drawings, sheet 442B), the pressure sewer size increases to 30 inches. The pressure sewer continues northeast along West Forest Home Avenue to Carroll Circle where it connects into a 36-inch diameter gravity flow MIS at MH 44008. The 24 to 30-inch diameter MIS ranges from 10-25 feet below the
ground surface and was constructed in 1984. The land use along the alignment is residential and commercial.

Project 13 increases the capacity of the Franklin-Muskego Interceptor; it represents the MMSD part of Option A. Option A also includes other projects related to the communities that are not a part of the MMSD MIS system, and therefore, are not included in the cost estimate for Project 13.

5-Year List of Alternatives

Two alternatives were considered for the capacity enhancement of the Franklin-Muskego Interceptor for the five-year recurrence interval event as follows:

A. Alternative A: Parallel Force Main
B. Alternative B: Force Main Replacement

10-Year List of Alternatives

Two alternatives were considered for the capacity enhancement of the Franklin-Muskego Interceptor for the 10-year recurrence interval event as follows:

A. Alternative A: Parallel Force Main
B. Alternative B: Force Main Replacement

Evaluation of Alternatives

5-Year Alternative A: Parallel Force Main

Alternative A consists of construction of 10,626 LF of 30-inch diameter force main from MMSD MH 44302 to 44008. The force main would generally be routed parallel to the existing 24-inch and 30-inch diameter force mains with approximately the same slope and depth of 10-25 feet.

The parallel force main would be sized so that the conveyance capacity of the new parallel force main together with the existing 24-inch and 30-inch diameter force mains would be adequate for a 5-year peak wastewater flow recurrence interval event. The parallel force main would be sized to maintain a velocity in both the existing and proposed force mains of 8 feet per second. The cost for the parallel force main is estimated to be $4.7 million. It is assumed that this force main would be constructed using open cut methods.

5-Year Alternative B: Force Main Replacement

Alternative B consists of construction of 10,626 LF of 36-inch diameter replacement force main from MMSD MH 44302 to 44008. This replaces the existing 24-inch and 30-inch diameter force mains at approximately the same slope and depth of 10-25 feet. The cost for the replacement force main is estimated to be $6.4 million.

10-Year Alternative A: Parallel Force Main

The size of a parallel force main to convey a 10-year event is the same as the size needed to convey the five-year event.
10-Year Alternative B: Force Main Replacement

Alternative B consists of construction of 3,504 LF of 36-inch diameter replacement force main from MMSD MH 44302 to junction point 44202 and construction of 7,122 LF of 42-inch diameter replacement force main from junction point 44202 to MH 44008. This replaces the existing 24- and 30-inch diameter force mains at approximately the same slope and depth of 10-25 feet. The replacement force main has the capacity to convey the 10-year recurrence interval event. The cost for a replacement force main is estimated to be $7.6 million.

Recommended Alternative for Project 13

5-Year

The cost for the parallel force main for the five-year recurrence interval event is less than the cost for replacing the existing pressure sewers. Therefore, if conveyance capacity enhancement is required, Alternative A is recommended. The recommended force main route is shown in Figure 9-24.

10-Year

The parallel force main is the same size as the five-year; therefore, the 10-year recommendation is the same as the five-year recommendation. The recommended replacement route is shown in Figure 9-24. (Note the same figure represents the five- and 10-year LOP options).

Recommendation

A project specific advanced facilities plan is recommended to refine the options for potential future service to Muskego and parts of Franklin and New Berlin. The definition of the options and the estimated costs presented in this section are intended to support the ongoing discussion related to the Ryan Creek Interceptor concept. They are not sufficiently refined to recommend a specific project at this time.

The details for potentially upgrading the existing Franklin-Muskego Interceptor are presented in this chapter because they were developed in the hydraulic evaluation of the existing MIS conveyance system.
FIGURE 9-24
PROJECT 13 – FRANKLIN-MUSKEGO MIS
5-YEAR AND 10-YEAR RECOMMENDED ALTERNATIVE PARALLEL FORCE MAIN
2020 CONVEYANCE REPORT
5/4/07
CR_9.0024.07.05.04.cdr
9.3.14 Project 14 – Real-Time Control Strategy Improvements to DC0103

The 2020 FP proposes new strategies to increase the treatment capacity at SSWWTP. If the treatment capacity at SSWWTP is increased, the conveyance system capacity will become the limiting factor on the peak flow delivered to SSWWTP. A change in the real-time control (RTC) strategy at diversion chamber DC0103, located at South 6th Street and West Oklahoma Avenue, is recommended to increase the conveyance capacity of the 144-inch diameter MIS to SSWWTP during wet weather.

The existing operational strategy for diversion chamber DC0103 is to divert flow from the MIS to the ISS during wet weather. When the flow to SSWWTP in the MIS is greater than the treatment capacity, the MIS becomes surcharged. The wet weather flow diversion into the ISS at diversion chamber DC0103 controls the surcharging in the MIS to SSWWTP. The proposed enhancements to SSWWTP will increase treatment capacity. The full pipe capacity of the MIS will then be less than the available treatment capacity at SSWWTP. To convey more flow in the MIS than the full pipe capacity, the MIS must be surcharged. The slope of the HGL in the MIS must be increased to maximize flow to the SSWWTP. Consequently, the operational strategy at DC0103 must be modified to maximize the slope of the HGL in the MIS.

There are two gates at DC0103 that control sanitary sewer inflow to the ISS through the KK-01 dropshaft. The gate operation is presently controlled by the HGL at three locations or “control points” located at MS0301 on South 84th Street near West Adler Street, MS0102 on West Howard Avenue near South 5th Street, and in DC0103. Both gates throttle open and throttle closed, meaning they can partially open and close in a stepwise fashion. The HGL at the control points determines how far the gates open or close, in turn, the throttling of the gates controls the amount of flow into the ISS.

With the present operation; if the gates were controlled only on the depth in DC0103, they would begin to open when the depth in DC0103 reaches 9.49 feet (depth in chamber based on the invert elevation in DC0103 of 23.58 feet); both gates would be completely open when the depth in DC0103 reaches or exceeds 11.00 feet and would begin to close when the depth recedes below 11.00 feet. However, because the depths at MS0102 and MS0301 also control the movement of the gates, the depth in DC0103 rarely reaches 11.00 feet. Based on modeling, the typical maximum depth in DC0103 when Gate 1 begins to open is about 9.00 feet.

The potential modification of the operation of Gates 1 and 2 in diversion chamber DC0103 is to control the gate operation based solely on the depth in DC0103. With the potential change of the operation, the gates begin to open when the depth in DC0103 reaches 10.1 feet, both gates are completely open when the depth in DC0103 reaches or exceeds 10.6 feet, and they begin to close when the depth recedes below 10.6 feet. Based on the simulated hydraulic analysis, the modification to the operational strategy will result in the necessary HGL to maximize flow to SSWWTP via the MIS. Table 9-6 summarizes the existing operational strategy for the ISS gates at DC0103 and Table 9-7 summarizes a potential operational strategy for the ISS gates at DC0103 and also includes the existing control strategy for the SSO gate at DC0103.
<table>
<thead>
<tr>
<th>Gate Description</th>
<th>Reference Structure</th>
<th>Operand</th>
<th>HGL (ft)</th>
<th>Depth (ft)</th>
<th>Logical Condition</th>
<th>Gate Move to Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate to Bypass</td>
<td>DC0103 ISS</td>
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<tr>
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<td>ISS Closed</td>
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<td></td>
<td></td>
<td></td>
<td>9.49</td>
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<tr>
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<td>15.22</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11.00</td>
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HGL = Hydraulic Grade Line  
ISS = Inline Storage System  
DC = Diversion Chamber  
MS = Monitoring Station
TABLE 9-7
POTENTIAL REAL TIME CONTROL STRATEGY AT DC0103

<table>
<thead>
<tr>
<th>Setpoints</th>
<th>Reference Structure</th>
<th>Operand</th>
<th>HGL (ft)</th>
<th>Depth (ft)</th>
<th>Logical Condition</th>
<th>Gate Move to Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate to Bypass</td>
<td>SAME AS EXISTING STRATEGY</td>
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<tr>
<td>Gate 1 to ISS</td>
<td>DC0103</td>
<td>&gt;</td>
<td>33.68</td>
<td>10.10</td>
<td>--</td>
<td>Start Opening</td>
</tr>
<tr>
<td></td>
<td>DC0103</td>
<td>&gt;</td>
<td>34.18</td>
<td>10.60</td>
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<td>DC0103</td>
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<td>10.60</td>
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</tr>
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<td>Closed</td>
<td>--</td>
<td>--</td>
<td></td>
<td></td>
</tr>
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<td>10.90</td>
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<td>Closed</td>
<td>--</td>
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<td>OR</td>
<td>Closed</td>
</tr>
</tbody>
</table>

HGL = Hydraulic Grade Line  ISS = Inline Storage System  DC = Diversion Chamber  MS = Monitoring Station

The potential change to the operational strategy for the overflow gate in DC0103 is to open when the ISS is closed and when the depth in DC0103 reaches or exceeds 11.1 feet. With the potential operational change there is a 0.50-foot difference in depth between the depth to completely open the ISS gates and the depth to open the overflow gate. This small difference may result in cycling of gate movement within DC0103. The cycling of gate movement may occur because the sluice gates are located at the bottom of the diversion chamber. When the depth in the chamber reaches 11.1 feet, the sluice gate to the overflow will open, resulting in a drop of the depth in the chamber. The depth change may prompt the overflow gate to close or may prompt one of the ISS gates to close, thereby increasing the depth in the chamber and reopening the overflow sluice gate. The gate movements would then be cycling and causing depth changes within the chamber in short intervals. Therefore, with a change to the operational strategy at DC0103, it may be necessary to modify the configuration of the overflow in the diversion chamber. This could be done by removing the sluice gate and replacing it with a downward acting weir gate. The downward acting weir gate would reduce the potential for gate cycling within the diversion chamber.

The cost of the diversion chamber modification as described is estimated to be $400,000. Preliminary engineering and further study of the RTC operation of DC0103 is recommended to determine the affects on the gate movement and verify that replacement of the controlled sluice gate is necessary.
With the potential change to the operational strategy at DC0103, the flow to SSWWTP will be maximized and the flow diverted into the ISS will be minimized. The future modification of the operational strategy at DC0103 is essential for establishing a five-year SSO LOP with increased treatment capacity at SSWWTP. The hydraulic modeling study did not find adverse impacts to the MIS system with the described operational changes at DC0103.

### 9.4 Other Possible Conveyance Recommendations

Two other policies related to the conveyance system should be considered. These are clearly defined policies for new sewer construction, but are not implemented consistently in the existing collection system due to the historical development of the sewer system.\(^3\) The policies are:

1) **Transfer of ownership:** For MIS segments that serve one municipality and are smaller than 24 inches in diameter, transfer of ownership from MMSD to the municipality should be considered. Often these are small sections of pipe that are currently owned by MMSD, but would not meet the definition of an MIS. If the sewer were to be built today, policy would be very clear that the municipality take ownership of the sewer. When appropriate, ownership should be transferred to the municipality. This policy would result in a small reduction in the operations and maintenance cost for MMSD. This policy would also improve equity among satellite municipalities. This general policy would need to accommodate case-by-case issues.

2) **Direct lateral disconnection from the MIS:** Due to the historical development of the sewer systems (owned by MMSD and the municipalities), there are many laterals that are directly connected to the MIS. This type of connection is, in many cases, the best way to provide sewer service for these customers. In general, laterals should be connected to sewers owned by the municipalities and not directly connected to the MIS. On a case-by-case basis, when possible, laterals should be disconnected from the MIS. This will reduce the number of connections to the MIS, which will reduce maintenance costs.
References

(1) Philip Evenson, Southeastern Wisconsin Regional Planning Commission, *01-23-03 Land Use Request* data, correspondence with Patrick Marchese, HNTB (July 1, 2004)

(2) Draft Technical Memorandum, Ryan Creek Interceptor Analysis – MMSD 2020 Facilities Plan, from William Krill (HNTB) to Tim Bate (MMSD) (September 10, 2006)

Appendix 9A
Infiltration and Inflow Reduction
Appendix 9A: Infiltration and Inflow Reduction

9A.1 Overview of Approach

Infiltration and Inflow (I/I) cause the wastewater flow rates in the collection system to increase during wet weather significantly above the dry weather flow rates. Excessive peak flows and greater wastewater volumes result in sanitary sewer overflows (SSOs) when the conveyance, storage, and treatment capacities of the system are exceeded.

Rehabilitation of the collection systems to reduce the I/I component of the wastewater flow is a potential technology to improve the level of protection (LOP) against SSOs. The LOP for SSOs can be defined for the conveyance system as the likelihood of wastewater flow rates exceeding the conveyance capacity of the metropolitan interceptor sewer (MIS). The LOP for SSOs can be defined for the overall system as the likelihood of exceeding the treatment, pumping, and storage capacities of the inline storage system (ISS) and treatment plants. Reduction in I/I can improve the LOP for both the conveyance system and the overall system response.

This analysis uses a calibrated sewershed flow model to characterize the current I/I response at the sewershed-scale. Conceptual reductions in I/I are then analyzed to predict the effectiveness and the cost of I/I reduction efforts.

The goal of this analysis is to determine if it is cost effective to pursue I/I reduction to meet LOP objectives or if it is more cost effective to use additional end-of-pipe facilities to achieve the same outcome without reducing I/I rates. The analysis method is applied on a system-wide basis to determine the potential benefits and cost of I/I reduction. The system-wide analysis compares the cost of I/I reduction to the cost of additional treatment and pumping upgrades to determine the cost effective combination of technologies that satisfy the LOP goals.

The methodology is also used to estimate the cost of ongoing conveyance system maintenance to sustain the current I/I rates into the future so that the LOP achieved is not compromised by unplanned growth of I/I. The cost of ongoing I/I maintenance applies to all of the sewersheds in the separate sewer area, whether or not these sewersheds receive rehabilitation work to reduce the initial rate of I/I.

In addition to the system-wide analysis of I/I reduction, the same method is used to investigate I/I reduction in specific sub-areas tributary to sections of the MIS system with hydraulic restrictions. In these cases, the method is applied to determine whether I/I reduction in the tributary sewersheds can avoid the need to relieve or replace an MIS section with a hydraulic restriction.

Figure 9A-1 presents a flow chart that illustrates implementation of I/I reduction system-wide and the relationship to sizing facilities and specific MIS upgrades.
FIGURE 9A-1
OVERVIEW OF I/I REDUCTION ANALYSIS
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9A.2 Sewershed Scale Analysis: Performance-Based Approach

The I/I reduction analysis is applied on the sewershed scale; this means that I/I rates and potential reductions in I/I are estimated for individual sewersheds. No analysis is performed for subareas smaller than a sewershed. Each sewershed contains sewer pipes and other collection facilities that are potential sources of I/I. These pipes and facilities may be owned by the Milwaukee Metropolitan Sewerage District (MMSD) (interceptor sewers), satellite municipalities (sewer mains and trunk sewers), or private property owners (laterals and private interceptors mains). The analysis does not partition the costs to the various ownership categories; instead, the cost is estimated for a sewershed as a whole, no matter who the owner may be.

Because the costs are estimated at the sewershed scale, the method does not assume a particular type of I/I reduction technology. Common I/I reduction technologies include rehabilitation of private property laterals, replacement of or relining sewer mains, sealing manholes, and prevention of stormwater cross connections with the sanitary sewer system. This analysis does not assume the application of specific technologies; instead, it uses a performance-based approach that focuses on the outcome of the I/I reduction efforts. The performance-based approach uses a unit cost function that is derived from several demonstration projects and real-life rehabilitation projects that have been carefully monitored and evaluated for effectiveness and cost.

The Flow Forecasting System (FFS) was used to characterize the I/I rates for each sewershed including the I/I increase due to anticipated developments (Revised 2020 Baseline population and land use estimates). A series of assumed levels of I/I reduction were then analyzed to estimate the percent reduction in the system-wide peak flow and the number of sewersheds that require I/I rehabilitation.

The MACRO model is a useful screening tool to predict the overall system response using the period of January 1940 through June 2004 (the “period of record”). As a screening tool, the model is useful to simulate the approximate response to various levels of I/I reduction, but it is not intended to be an in-depth analysis. The MACRO screening simulations were used to estimate the reduction in SSOs achieved by various levels of I/I reduction.

The results should be viewed as a guide to the relative cause-and-effect or the system-wide benefits that may be achieved by I/I reduction; they should not be viewed as highly accurate predictions suitable for design decisions.

Where more detailed results are needed, the MOUSE model is used. For example, the investigation of MIS hydraulic restrictions requires detailed simulations of the hydraulic grade line in specific MIS pipes. For this type of analysis the MOUSE model results (rather than the MACRO model results) were used. The MOUSE model simulation results assumed no I/I reduction; they were used as the baseline from which the I/I reduction needs were estimated by hand calculations.

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\[a\] See Chapter 1, 2 and 3 of this report for a detailed explanation of the term sewershed.

\[b\] See Chapter 3 of this report for a description of the FFS

\[c\] Revised 2020 Baseline estimates = revisions of the 2020 estimates of population and land use based upon SEWRPC’s estimated 2035 population and land use estimates for each community.
9A.3 Baseline Infiltration and Inflow in Sewersheds (Pre-rehabilitation rates)

Sewershed flows are computed by the FFS model based on calibration to MMSD flow meters using data during the period of 1998-2001. The calibration process and results are summarized in Appendix 3A, Sewershed Modifications – Separate Sewer Area. Planned growth in I/I rates was also accounted for in the FFS model using the Revised 2020 Baseline population and land use estimates.

The I/I rate of each sewershed is based on the FFS simulation of sewersheds flows. The I/I flow is the peak hourly flow rate less the base sanitary flow (accounting for the diurnal variations at the time of the peak flow). The separate sewer service area (244,288 acres) is subdivided in the model into 533 sewersheds of various sizes. Most sewersheds are in the 100 to 1,000 acre size range; however, the largest sewershed is over 6,900 acres while the smallest is just 4 acres. Therefore the sewershed I/I rates are compared on a flow per unit area basis using the units of gallons per acre per day (gpad).

Figure 9A-2 shows the range of sewershed I/I rates. These I/I rates are the simulated rates for the selected wet weather event (April 23, 1999), which has an approximate peak wastewater flow recurrence interval of 5 years. The rates of this event are reference values to characterize the distribution of I/I rates. A few sewersheds have I/I rates over 30,000 gpad but most sewersheds are less than 10,000 gpad (the median is approximately 6,500 gpad). The overall average I/I rate (based on the sum of the peak I/I flows divided by the sum of the separate area served) is 4,460 gpad.

In the computation of future flow additions, the uniform I/I rate is approximately 3,000 to 3,500 gpad. This rate was selected to represent typical I/I rates for new construction using common construction techniques.

The FFS flow generation model simulates sewershed flows using a continuous hydrologic process; consequently, the I/I rates vary with the magnitude of each wet weather event.

Figure 9A-3 shows the relative distribution of the source of I/I flow as a percent of the separate sewer service area served. Half of the peak wet weather flow rate is generated in 15% of the separate sewer service area (based on the sum of the sewershed peak flow rates). The other half of the peak wet weather flow rate is from the remaining 85% of area. This implies that I/I reduction efforts must be focused on those sewersheds that make the largest relative contribution to the I/I flow.

It is important to remember that this analysis is a screening tool to estimate the change in the overall system response due to I/I reduction. This analysis estimates the number of sewersheds that are potential candidates for I/I reduction work. The analysis is not intended to be used to draw conclusions about the I/I behavior of a specific sewershed. Sewershed specific flow monitoring is needed to support or refine these initial screening estimates. This approach estimates the fraction of the overall system that may be involved in I/I reduction and it estimates overall reduction in peak flow if the assumed reduction levels are actually achieved. Further monitoring is recommended before specific engineering and design work can define the I/I reduction projects in greater detail.
I/I rates for a hydrologic event with a 5-yr SSO recurrence interval

Median 6500 gpad

Percent of Separate Sewer Area Served with I/I Greater than Value on Vertical Axis

FIGURE 9A-2
DISTRIBUTION OF SEWERSHED I/I RATES PER UNIT AREA
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9A.4 Infiltration and Inflow Reduction – Performance Based Unit Cost Function

To conform to the approach used throughout the 2020 Facilities Plan (2020 FP) to evaluate the cost-benefit of SSO reduction technologies, an approach was developed for I/I reduction that would predict SSO reductions for a given capital investment. Rather than using traditional facility planning approaches that rely on significant amounts of sewer system condition data (which were not available), the 2020 FP approach used actual I/I reduction project results that have been documented in a number of relevant studies and technical publications (discussed below).

A key component to this approach is the unit cost curve, which is used to determine the investment required to achieve the target I/I level for each sewershed. Figure 9A-4 provides the curve developed for the 2020 FP. The curve represents a conservative fit to data from over twenty individual I/I reduction projects that were analyzed for cost and I/I reduction in a fashion compatible with a Water Environment Research Foundation (WERF) protocol.(1) This protocol detailed the information that should be provided when documenting an I/I reduction project and how to perform an analysis of I/I reduction effectiveness. By using proper documentation and protocols, the results of an I/I reduction project can be compared and used by others who are preparing to do similar work.

The supporting documentation for these projects provided I/I reduction results in a number of different contexts. For use in the 2020 FP, the unit cost used to compare projects was the pre-rehabilitation I/I rate per unit area (gpad) using a wet weather event with a 5-year peak wastewater flow recurrence interval. Each of the documented projects provided results in this format. A variety of I/I reduction technologies deployed both on public and private systems were included in the data set.

Three specific sources were used for developing the I/I project data set:

- MMSD I/I Reduction Demonstration Projects (2)
- King County I/I Reduction Pilot Projects (3)
- WERF I/I Reduction Projects (4)

**MMSD I/I Reduction Demonstration Projects.** From 2000 to 2005, MMSD selected, provided grant money for, and oversaw the implementation of I/I reduction demonstration projects to demonstrate different combinations of I/I reduction technology and local conditions. The MMSD recognized that these applications would be relevant to other similar conditions in the MMSD service area. As a result, MMSD only selected projects that had existing significant I/I in the basin – resulting in the elimination of one of the projects initially chosen. Even so, the projects had a range of pre-rehabilitation I/I rates. These factors are important for understanding the results of the demonstration projects. The project evaluations were conducted so that these projects could be compared to other similar demonstration projects. Results were presented such that MMSD could use them in future planning efforts that consider the cost effectiveness of I/I reduction. The report, published in 2006, provided local results to support the general theory that it is more cost effective to remove I/I in basins that have higher I/I to start with.
Figure 9A-4: Performance-Based Unit Cost of I/I Removal

Unit Cost = 1760 Q^{-0.7}

Legend:
- King County Pilot Projects
- WERF Case Studies
- MMSD Demonstration Projects
- Proposed Cost Curve

ENR = 10,000

Unit Cost of I/I Removal ($/gpd of 5-Year Peak Hour Flow Removed)

Pre-Rehabilitation 5-Year, Peak Hour I/I Flow (gpad)
King County I/I Reduction Pilot Projects. As part of a larger Regional I/I Control Program, King County (Washington) Wastewater Treatment Division (WTD) conducted ten I/I reduction pilot projects, with a combined investment of $7.8 million. The projects evaluated a range of technologies and applied to both private and public sewers. King County WTD documented its results so that additional studies on the costs and benefits of I/I control measures could be performed locally and nationally. Analysis of flow reduction was performed consistent with the WERF protocol.

WERF I/I Reduction Projects. This study, described previously in this chapter, evaluated past I/I reduction projects with the goal of establishing a link between sewer rehabilitation applications and I/I reduction. The study identified and evaluated nine projects and documented the results. The work also resulted in a protocol for evaluating and documenting I/I reduction projects.

The unit cost curve presented in Figure 9A-4 represents a power curve that fits an upper trend of data. This approach was chosen as it conformed to a basic premise of the pilot project reports mentioned above – that the unit cost of I/I reduction is less for the conditions that start with higher I/I levels. Also, as pre-rehabilitation I/I rates decrease, the unit cost of I/I reduction increases. The upper trend of the data was chosen as the project team concluded this was a better basis to project system-wide costs at a planning level.

9A.5 Infiltration and Inflow Reduction – Calculation Method

The pre-rehabilitation I/I rate of a nominal 5-year event was derived from a simulation of the April 23, 1999 event in the FFS model. The simulation used the Revised 2020 Baseline population and land use conditions and the meteorological conditions at the General Mitchell International Airport rain gauge applied uniformly to all sewersheds.

The first level of I/I reduction identified all sewersheds with I/I rates greater than 30,000 gpad; at this level, 18 sewersheds, which is 1% of the separate sewer service area, were affected. The I/I rehabilitation efforts are assumed to successfully reduce the I/I rates in these sewersheds to 30,000 gpad while the I/I rates in the remainder of the separate sewer area are unchanged.

Take, for example, a sewershed with a pre-rehabilitation rate of 36,000 gpad. In this first level, the I/I rate would be reduced to 30,000 gpad. A real I/I reduction project may only rehabilitate a fraction of the sewers in the sewershed. While the I/I reduction in the project area may be large, the net flow reduction on the sewershed scale may be relatively small. Similarly, the change in the system-wide peak flow may be small because only a small fraction of the entire separate sewer area is rehabilitated. In this first level, the system-wide peak flow reduction is 1%.

The second level of I/I reduction reduced I/I rates to 25,000 gpad. This level assumes additional work in the 18 sewersheds identified in the first level to bring those rates from 30,000 gpad to 25,000 gpad and new rehabilitation in ten other sewersheds that had initial rates between 25,000 and 30,000 gpad. The 28 sewersheds affected at this level represent 2% of the separate sewer area. The system-wide peak flow reduction is approximately 2%.

Figure 9A-5 illustrates how the process was repeated for I/I levels of 20,000, 15,000, and 10,000 gpad. Table 9A-1 summarizes the number of sewersheds, percent of area, and the percent reduction in system-wide peak flow of each I/I reduction level.
FIGURE 9A-5
PROGRESSIVE LEVELS OF I/I REDUCTION
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Reduce to 30,000 gpad level
Reduce to 25,000 gpad level
Reduce to 20,000 gpad level
Reduce to 15,000 gpad level
Reduce to 10,000 gpad level
Median 6,500 gpad

Sewershed I/I Rate per Unit Area (gpad)

Percent of Separate Sewer Area Served with I/I Greater than Value on Vertical Axis

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
TABLE 9A-1
NUMBER OF SEWERSHEDS AFFECTED BY INFILTRATION AND INFLOW REDUCTION LEVELS

<table>
<thead>
<tr>
<th>I/I Reduction Level</th>
<th>Number of Sewersheds Affected by I/I Rehabilitation</th>
<th>% of Separate Sewer Service Area</th>
<th>% Reduction in Peak I/I Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>30,000 gpad</td>
<td>18</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>25,000 gpad</td>
<td>28</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>20,000 gpad</td>
<td>49</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>15,000 gpad</td>
<td>68</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>10,000 gpad</td>
<td>140</td>
<td>11</td>
<td>19</td>
</tr>
</tbody>
</table>

gpad = Gallons per Acre per Day
I/I = Infiltration and Inflow

The incremental construction cost is the cost of I/I reduction to get from one I/I level to the next level. The unit cost of the I/I reduction is based on the pre-rehabilitation I/I rate. When progressing through the I/I levels, the former I/I level is used as the pre-rehabilitation rate for the next level.

The cumulative construction cost is the sum of the incremental costs to reach a desired I/I reduction goal. The construction cost includes a 25% contingency.

The capital cost includes 35% of the construction cost for technical services (engineering and administration). Figure 9A-6 shows the cumulative capital cost as a function of the percent reduction in system-wide peak I/I flow. The cost to achieve a 19% peak flow reduction (by limiting the I/I rates to 10,000 gpad in 140 sewersheds) is approximately $600 million.

9A.6 Cost of Maintenance to Prevent Unplanned Infiltration and Inflow Growth

To prevent unplanned growth in I/I rates, ongoing long-term I/I maintenance is assumed to be successful. This is a fundamental assumption in sizing facilities to provide the planned level of protection. The cost of this maintenance applies to both the sewersheds initially rehabilitated and those that were not. All sewersheds must be maintained so that the I/I rates do not increase.

This cost is difficult to estimate due to insufficient data on the expenditures of communities on their infrastructure, the effectiveness of I/I work, and the fact that this cost only applies to the cost of maintaining the I/I performance and does not include the cost of maintenance for structural or other reasons. Lacking suitable data, this analysis is presented as a rough estimate of maintenance cost using two key assumptions. The first key assumption is that the I/I rates progressively increase 7% per decade without maintenance. This assumption is used as a possible value for unplanned growth that may be likely (but it is not supported by data). (The value of 7% is an intuitive estimate of the likely change in I/I rates over a 10-year period of time. The sensitivity to this assumption is presented later.)
FIGURE 9A-6
CAPITAL COST OF I/I REDUCTION FOR SYSTEMWIDE PEAK FLOW REDUCTION
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The second key assumption is that ongoing maintenance work is successful in preventing unplanned I/I growth and the cost of this maintenance can be estimated using the unit cost of I/I rehabilitation.

**Method of Computing Cost of Maintenance**

The method of computing the maintenance cost is similar to the method of computing the cost of I/I reduction presented above. The costs are evaluated on a sewershed scale. The initial I/I rates are assumed to grow 7% in 10 years. Figure 9A-7 is a conceptual diagram to visualize the growth in the I/I rate and the periodic maintenance to prevent unplanned I/I growth in the long term. (Use of a 10-year period does not imply that sewershed maintenance should take place on a 10 year interval. The 10-year period is simply the assumed increment used for the sake of this computational exercise.) At the end of the period I/I rates are assumed to return to the initial rates due to maintenance work. The unit cost of the maintenance is based the larger I/I rate at the end of the period.

The average annual maintenance cost is 1/10 of the decade cost. It is likely that the maintenance costs will be incurred in various parts of the collection system at various times; it is unlikely that that expenditures will be uniform from year to year. Nevertheless, the cost can be accounted for as an average annual cost.

For the cost effectiveness analysis maintenance costs are presented as the present worth of a 20 year series of maintenance expenditures using a discount rate of 5.125%. The maintenance costs also include 25% for contingencies and 35% for non-construction costs (engineering and administration).

Figure 9A-8 shows the 20-year maintenance costs along with the cost of initial I/I rehabilitation. The magnitude of the maintenance curve is approximately $400 million, but this value is not as significant as the fact that the curve has very little slope. This finding is an outcome of the assumptions of the method and it indicates that the cost of ongoing maintenance is not sensitive to the level of initial I/I reduction.

**9A.7 Sensitivity Analysis for Assumed Infiltration and Inflow Growth Rate**

The analysis assumes that I/I rates will grow 7% per decade and in order to prevent this type of unplanned growth in I/I, some amount of ongoing maintenance is required. Assuming a 7% increase per decade, the 20-year present value maintenance cost is approximately $400 million.

To test the sensitivity of this assumption, the analysis was repeated with 4% and 10% per decade growth rates. The 20-year maintenance costs for these assumed rates of I/I increase are shown in Figure 9A-9. Even though the magnitude of the maintenance cost is directly effected by the assumed percent of I/I growth, the shapes of the curves for various levels of I/I reduction are similar; in each case the cost curve is relatively flat. Therefore, for the purpose of identifying the cost effective level of I/I reduction, the I/I growth rate assumption does not change the identification of the minimum cost point. It does affect the magnitude of the I/I maintenance cost.
Assume 7% increase per decade

FIGURE 9A-7
INCREASE IN I/I PER DECADE REQUIRING MAINTENANCE TO HOLD I/I CONSTANT
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FIGURE 9A-8
COST OF I/I REDUCTION AND COST OF SYSTEMWIDE SEWERSHED MAINTENANCE
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MACRO screening results (July06FFS)

Maintenance to prevent unplanned growth in I/I
20-year present worth cost
(assumed 7% increase per decade)

Cost ($ Millions)

System-wide Percent Reduction in Peak I/I Rate

I/I Reduction

20,000 gpad

15,000 gpad

10,000 gpad

30,000 gpad

25,000 gpad

30,000 gpad
MACRO screening results (July06FFS)

- 10% increase per decade
- 7% increase per decade
- 4% increase per decade

Maintenance to prevent unplanned growth in I/I

I/I Reduction

Cost ($ Millions)

System-wide Percent Reduction in Peak I/I Rate

FIGURE 9A-9
MAINTENANCE COST TO PREVENT UNPLANNED GROWTH IN I/I RATES
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More data are needed to improve the assumption of 7% per decade I/I growth rate. The assumption appears to be reasonable and of the correct order of magnitude. A perspective on the magnitude of the maintenance cost is gained by comparing it to the total asset value of the public and privately owned collection systems. There are approximately 3,000 miles of publicly owned sewers and another 3,000 miles of privately owned sewer laterals. A rough estimate of the total asset value of these public and private sewers is approximately $10 billion.

The estimated 20-year maintenance cost is approximately $400 million (assuming a tendency for I/I to increase 7% per decade). Therefore the 20-year maintenance cost is 4% of the asset value. If a collection system has a life of 100 years then the projected cost for I/I maintenance would be $2 billion (20% of the asset value). This is a reasonable assumption because maintenance for I/I purposes is only a part of the total cost of sewer maintenance. Repairs for structural reasons, or cleaning sediment/grease, or inspections are also components of an ongoing sewer maintenance and renewal program.

Further study to determine a suitable value for I/I growth is needed. For the purpose of this planning effort, however, the assumed 7% per decade is a reasonable assumption.

Note that this $400 million estimate for I/I maintenance has been assumed as the cost for the satellite municipalities of MMSD to hold current I/I levels as noted in the Facilities Plan Report, Chapter 8.

9A.8 Cost Effective Infiltration and Inflow Reduction for Achieving Desired Sanitary Sewer Overflow Level of Protection

An objective of the 2020 FP is to determine the amount of I/I reduction that is cost effective compared to other technologies in order to achieve desired SSO LOP outcomes. Depending on the level of initial I/I reduction, additional conveyance and treatment capacity may be needed to achieve the desired LOP to control SSOs. These technologies are discussed in more detail in Chapter 9 of the Facilities Plan Report, but they specifically include additional physical-chemical treatment methods at South Shore Wastewater Treatment Plant (SSWWTP) and ISS pumping. The 2020 FP analysis has concluded that physical-chemical treatment at SSWWTP is a cost effective technology to improve the LOP and is used in almost all cases considered. Blending at Jones Island Wastewater Treatment Plant (JIWWTP) (equal to 60 MGD) is also assumed to be a viable technology and available at this rate in all cases.

5-Year Level of Protection against Sanitary Sewer Overflows

Figure 9A-10 shows the cost of the upgraded conveyance, pumping, and treatment technologies to satisfy the 5-year LOP objective. The approximate cost values shown in the figure are based on the cost estimates available at the time of the I/I reduction analysis. Refined estimates of the cost of the recommended facilities are presented in Chapter 9, Section 9.6 of the Facilities Plan Report. For the baseline case with no initial I/I reduction, the 5-year LOP is achieved with an additional 150 MGD of physical-chemical treatment at SSWWTP and an additional 100 MGD of additional pumping from the ISS to JIWWTP.
FIGURE 9A-10
TECHNOLOGY COMBINATIONS TO ACHIEVE 5-YEAR LOP
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If rehabilitation work reduces the peak I/I rate, then less additional pumping capacity is needed. If I/I reduction (to 15,000 gpad) is able to reduce the peak flows 9 to 10%, then the 5-year LOP can be achieved with only physical-chemical treatment at SSWWTP (without additional pumping capacity). If a 19% peak I/I flow reduction can be achieved (with I/I limited to 10,000 gpad), then 80 MGD of additional physical-chemical capacity at SSWWTP is required. However, the cost of achieving a 19% reduction in I/I is greater than the cost of the baseline case without I/I reduction. Table 9A-2 summarizes the facilities needed to achieve the 5-year LOP for the various levels of I/I reduction on a system-wide basis.

The cost of achieving the 5-year LOP with conveyance/pumping/treatment upgrades is approximately $480 million assuming no initial reduction in I/I rates. This includes the cost of physical-chemical treatment at SSWWTP, additional pumping to JIWWTP and conveyance system upgrades. These conveyance projects improve the LOP of the MIS so that it matches the system-wide 5-year LOP. Other work to relieve hydraulic restrictions in the local community sewer systems is also included in the cost. Table 9A-3 summarizes the approximate value of the cost components assuming no initial I/I reduction.

### TABLE 9A-2
FACILITIES FOR A 5-YEAR LEVEL OF PROTECTION AGAINST SANITARY SEWER OVERFLOWS

<table>
<thead>
<tr>
<th>I/I Reduction Level (gpad)</th>
<th>SSWWTP Physical-Chemical Treatment (MGD)</th>
<th>JIWWTP Physical-Chemical Treatment (MGD)</th>
<th>Pumping to JIWWTP (MGD)</th>
<th>VRSSI (MG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>150</td>
<td>0</td>
<td>100</td>
<td>197</td>
</tr>
<tr>
<td>30,000</td>
<td>150</td>
<td>0</td>
<td>75</td>
<td>197</td>
</tr>
<tr>
<td>25,000</td>
<td>150</td>
<td>0</td>
<td>52</td>
<td>197</td>
</tr>
<tr>
<td>20,000</td>
<td>150</td>
<td>0</td>
<td>30</td>
<td>197</td>
</tr>
<tr>
<td>15,000</td>
<td>150</td>
<td>0</td>
<td>0</td>
<td>197</td>
</tr>
<tr>
<td>10,000</td>
<td>80</td>
<td>0</td>
<td>0</td>
<td>177</td>
</tr>
</tbody>
</table>

gpad = Gallons per Acre per Day  
JIWWTP = Jones Island Wastewater Treatment Plant  
SSWWTP = South Shore Wastewater Treatment Plant  
I/I = Infiltration and Inflow  
MG / MGD = Million Gallons / Million Gallons per Day  
VRSSI = Volume Reserved for Separate Sewer Inflow
### TABLE 9A-3
**CONVEYANCE/PUMPING/TREATMENT COST COMPONENTS: 5-YEAR LEVEL OF PROTECTION ASSUMING NO INITIAL INFILTRATION AND INFLOW REDUCTION**

<table>
<thead>
<tr>
<th>Component</th>
<th>Approx Cost ($ M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical-Chemical Treatment at SSWWTP</td>
<td>$193</td>
</tr>
<tr>
<td>Additional ISS Pumping to JIWWTP</td>
<td>119</td>
</tr>
<tr>
<td>MIS Conveyance Upgrades</td>
<td>60</td>
</tr>
<tr>
<td>Local Conveyance Upgrades</td>
<td>106</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$478</strong></td>
</tr>
</tbody>
</table>

ISS = Inline Storage System  JIWWTP = Jones Island Wastewater Treatment Plant  
MIS = Metropolitan Interceptor Sewer  SSWWTP = South Shore Wastewater Treatment Plant

Notes:
All costs were escalated using the Engineering News Record Construction Cost Index (ENR-CCI), projected to be 10,000 in 2007.  
Approximate cost values based on the estimates available at the time of the I/I analysis.  See Chapter 9 of the Facilities Plan Report for revised cost estimates.

The total cost for a 5-year LOP is shown in Figure 9A-11. The total cost is the sum of the initial I/I reduction cost, conveyance-pumping-treatment upgrade costs, and the present worth cost for 20-years of maintenance to prevent unplanned growth in I/I. The lowest point along the total cost curve is the cost effective combination of technologies that satisfy the 5-year LOP objective. No initial system-wide I/I reduction is included as part of the most cost effective technology combination to achieve a 5-year LOP. The total cost curve is relatively flat for a small amount of I/I reduction, i.e., 0 to 3% system-wide reduction in peak I/I rate; therefore, some initial I/I reduction is effectively cost equivalent to no initial reduction. The lowest total cost is approximately $900 million based on the approximate cost estimates available at the time of the I/I reduction analysis. These cost values were used to determine the level of I/I reduction that is cost effective relative to the cost of other technologies. Revised cost estimates for the facilities in the Recommended Plan are presented in Chapter 9 of the Facilities Plan Report.

#### 9A.9 10-year Level of Protection against Sanitary Sewer Overflows

The analysis was extended to the 10-year LOP as shown in Figure 9A-12. The key change from the 5-year case is the additional physical-chemical treatment at JIWWTP. The costs of conveyance upgrades and additional pumping also increase for the 10-year LOP. Table 9A-4 summarizes the facilities needed to achieve the 10-year LOP for the various levels of system-wide I/I reduction.
FIGURE 9A-11
COST EFFECTIVENESS:
5-YEAR LOP
2020 CONVEYANCE REPORT
5/4/07
CR_9A.0011.07.05.04.cdr

MACRO Screening Results (July06FFS)

- **Total Cost**
- **Convey, Pump, Treat**
- Maintenance to prevent unplanned growth in I/I (assumed 7% increase per decade)
- **I/I Reduction**

Cost ($ Millions) vs. System-wide Percent Reduction in Peak I/I Rate
MACRO Screening Results (July06FFS)

Total Cost

Convey, Pump, Treat

Maintenance to prevent unplanned growth in I/I (assumed 7% increase per decade)

I/I Reduction

System-wide Percent Reduction in Peak I/I Rate

Cost ($ Millions)

10-yr LOP

FIGURE 9A-12
COST EFFECTIVENESS: 10-YEAR LOP
2020 CONVEYANCE REPORT
5/4/07 CR_9A.0012.07.05.04.cdr
### TABLE 9A-4
**FACILITIES FOR A 10-YEAR LEVEL OF PROTECTION AGAINST SANITARY SEWER OVERFLOWS**

<table>
<thead>
<tr>
<th>I/I Reduction Level (gpad)</th>
<th>SSWWTP Physical-Chemical Treatment (MGD)</th>
<th>JIWWTP Physical-Chemical Treatment (MGD)</th>
<th>Pumping to JIWWTP (MGD)</th>
<th>VRSSI (MG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>150</td>
<td>140</td>
<td>120</td>
<td>197</td>
</tr>
<tr>
<td>30,000</td>
<td>150</td>
<td>125</td>
<td>120</td>
<td>197</td>
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<tr>
<td>25,000</td>
<td>150</td>
<td>105</td>
<td>120</td>
<td>197</td>
</tr>
<tr>
<td>20,000</td>
<td>150</td>
<td>80</td>
<td>120</td>
<td>197</td>
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<tr>
<td>15,000</td>
<td>150</td>
<td>50</td>
<td>120</td>
<td>197</td>
</tr>
<tr>
<td>10,000</td>
<td>150</td>
<td>0</td>
<td>45</td>
<td>197</td>
</tr>
</tbody>
</table>

gpad = Gallons per Acre per Day  
JIWWTP = Jones Island Wastewater Treatment Plant  
SSWWTP = South Shore Wastewater Treatment Plant  
VRSSI = Volume Reserved for Separate Sewer Inflow

The cost effective point is the minimum total cost, which occurs with no system-wide I/I reduction. This case involves 140 MGD of physical-chemical treatment capacity at JIWWTP, 150 MGD of physical-chemical treatment at SSWWTP, and an additional 120 MGD of pumping from the ISS to JIWWTP. The cost of conveyance/pumping/treatment upgrades for the 10-year LOP is approximately $800 million; the components of this cost are summarized in Table 9A-5.

The total cost for the 10-year LOP, including the ongoing I/I maintenance costs, assumed to be $400 million, is approximately $1.2 billion based on the approximate cost estimates available at the time of the I/I reduction analysis.
### TABLE 9A-5
CONVEYANCE/PUMPING/TREATMENT COST COMPONENTS: 10-YEAR LEVEL OF PROTECTION ASSUMING NO INITIAL INFILTRATION AND INFLOW REDUCTION

<table>
<thead>
<tr>
<th>Component</th>
<th>Approx Cost ($ M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical-Chemical Treatment at SSWWTP</td>
<td>$193</td>
</tr>
<tr>
<td>Physical-Chemical Treatment at JIWWTP</td>
<td>152</td>
</tr>
<tr>
<td>Additional ISS Pumping to JIWWTP</td>
<td>130</td>
</tr>
<tr>
<td>MIS Conveyance Upgrades</td>
<td>184</td>
</tr>
<tr>
<td>Local Conveyance Upgrades</td>
<td>106</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$765</strong></td>
</tr>
</tbody>
</table>

ISS = Inline Storage System  
JIWWTP = Jones Island Wastewater Treatment Plant  
MIS = Metropolitan Interceptor Sewer  
SSWWTP = South Shore Wastewater Treatment Plant

Notes:  
All costs were escalated using the Engineering News Record Construction Cost Index (ENR-CCI), projected to be 10,000 in 2007.  
Approximate cost values based on the estimates available at the time of the I/I analysis. See Chapter 9 of the Facilities Plan Report for revised cost estimates.

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**9A.10 Specific Area Infiltration and Inflow Reduction to Reduce or Eliminate Metropolitan Interceptor Sewer Hydraulic Restrictions**

The MIS hydraulic restrictions were identified as those sections of the MIS with insufficient conveyance capacity resulting in water levels rising above critical elevations or causing conveyance related SSOs. A detailed discussion of hydraulic restrictions and recommendations for upgrades is in Chapter 9 of the *Conveyance Report*. Most of the hydraulic restrictions are resolved by the construction of a relief sewer or the replacement of the existing pipe with a larger size. All of the hydraulic restrictions were also evaluated to determine if I/I reduction could be cost effective to resolve the restriction by reducing the peak flow rates. In general the relief/replacement solutions were cost effective and the I/I reduction solutions were not.

One project, Project 11, identified a hydraulic restriction along the Sheridan Drive MIS in Cudahy that may be resolved cost effectively by I/I reduction. Therefore, this project will be discussed as an example of the method by which hydraulic restrictions were evaluated.

**Project 11: South Sheridan Drive Metropolitan Interceptor Sewer (Infiltration and Inflow Reduction to Resolve Hydraulic Restriction)**

Project 11 has a conveyance restriction for the 10-year LOP. The 18” MIS runs parallel to the shore of Lake Michigan along South Sheridan Drive and South Lake Drive. The flow, which originates in Cudahy (sewershed CU6009, with an area of 173.2 acres, and sewershed CU6019, which is a golf course), is measured at meter MS0617. The current modeling system does not accommodate the flow from the golf course accurately because it has no residential population or commercial/industrial area. The simulations assume that the flow from CU6019 is zero. As a consequence, the calibration to meter MS0617 tends to overestimate the flow generated in sewershed CU6009 to make up for flow that is not accounted for from CU6019. This type of
modeling deficiency can be improved by further monitoring and refinement. It is sufficient for the purposes of the facilities plan to simulate the flow in the MIS accurately even if the identification of the source of the flow requires further refinement.

The capacity of the MIS is adequate for the 5-year event but not for the 10-year event. Project 11 seeks to reduce the HGL so that it is less than the critical elevation at manhole 11604, which is not represented explicitly by a node in the MOUSE model. This manhole is located 261 feet downstream of manhole 11605, which is the upstream end of the Sheridan Drive MIS.

The peak flow in the Sheridan Drive MIS is 7.2 cubic feet per second (cfs) for the event that has a 10-year recurrence interval for the frequency of exceeding the critical elevation. The peak flow exceeds the full pipe capacity of 4.2 cfs. An 18” parallel relief sewer is one option to resolve this hydraulic restriction. Another option is I/I reduction in sewersheds CU6009 and CU6019. The analysis proceeds with the assumption that sewershed CU6009 is the source of the I/I and sewershed CU6019 is neglected. This assumption can be refined in the future, but it necessary to estimate the benefit of I/I reduction using the available structure of the model.

The change in peak flow for any event is assumed to be proportional to the change in the peak I/I rate for the 5-year reference event (April 1999). The peak I/I rate in sewershed CU6009 is 24,360 gpad (for the 5-year reference event). If the I/I rate were reduced to 20,000 gpad, the peak I/I rate would be reduced by 18%.

Assuming the peak flow is reduced 18% from 7.2 cfs to 5.9 cfs, the pipe would still be surcharged, but the HGL would be reduced approximately 3 feet below the critical elevation at MH 11604. Thus, I/I reduction is one possible means of relieving the hydraulic restriction.

To compute the cost of I/I reduction, the initial rate of 24,360 gpad is reduced to 20,000 gpad. For the 173.2 acre area, 0.75 MGD of peak I/I is removed. The unit cost for an initial rate of 24,360 gpad is approximately $1.50 per gallon per day removed (based on Figure 9A-4). The cost is the product of the peak I/I flow removed times the unit cost. After increasing the value with a 25% contingency and 35% for technical services, the total cost of the project is approximately $2 million.

The cost to resolve the hydraulic restriction is estimated to be $2 million by I/I reduction. This is one third of the cost of a relief project, which is estimated to be approximately $6 million. Therefore, I/I reduction is the recommended solution to the conveyance restriction for Project 11.

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\[d\] See Chapter 9.
References


(3) King County, *Pilot Project Report, Regional Infiltration and Inflow Control Program*, King County, Washington (October 2004)

Appendix 9B
Conveyance Project Costs
Appendix 9B: Conveyance Project Costs

9B.1 Introduction
This appendix presents supplementary cost information for the MIS conveyance projects. The information is presented in three tables:

Table 9B-1 Sewer Construction Unit Costs
Table 9B-2 Cost of Recommended Conveyance Projects: 5-year LOP
Table 9B-3 Cost of Recommended Conveyance Projects: 10-year LOP

Chapter 9 defines several potential alternatives to resolve the hydraulic restrictions. For each project, several potential alternatives are presented that meet the 5- and 10-year LOP conditions. This appendix provides supplementary cost information for both the recommended 5-year LOP alternative and the 10-year LOP alternative.

Table 9B-1 is a collection of tables for sewer construction unit costs. These unit costs (given as $/lineal foot) include the costs of excavation, pipe and manholes, installation, pavement, curb, and sidewalk replacement. The costs are estimates for June 2007 assuming a Milwaukee Construction Cost Index ENR equal to 10,000.

The tables contain the unit construction costs of sewers for a range of pipe diameters and a range of sewer depths. Open cut construction costs are given for sewers at 15, 20 and 25 foot depths. Tunnel construction costs are given for sewers 20 to 40 feet deep. These tables assume MIS type construction techniques which typically involve monolithic concrete pipes.

Unit construction costs for local interceptor sewers using open cut construction are also given. Local sewer construction typically involves precast concrete pipe sections.

The basic unit costs assume there are no utility conflicts. The basic unit costs are scaled up 15% in residential areas to account for minor utility conflicts. In commercial and industrial areas, the basic costs are scaled up 25% due to the likelihood of more extensive utility conflicts. If there is a mix of residential and commercial/industrial land use along the proposed alignment, then a 20% adjustment is assumed for utility conflicts.

Table 9B-2 lists the costs for the recommended conveyance projects for a 5-year LOP. The construction costs are scaled with a 25% contingency; then the costs are further scaled up with a 35% margin for engineering and administration to compute the capital cost. Most of the projects are relief or replacement sewers. For those projects that involve other technologies, the details are given in foot notes.

Table 9B-3 is like the previous table, but has the project costs for the 10-year LOP conditions.
### MIS — Tunnel Construction
Pipe Diameter (Inches)

<table>
<thead>
<tr>
<th>Depth</th>
<th>18 inch</th>
<th>21</th>
<th>24</th>
<th>27</th>
<th>30</th>
<th>36</th>
<th>42</th>
<th>48</th>
<th>54</th>
<th>60</th>
<th>72</th>
<th>84</th>
<th>96</th>
<th>108</th>
<th>120</th>
<th>144</th>
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<tbody>
<tr>
<td>20 feet</td>
<td>$969</td>
<td>$977</td>
<td>$985</td>
<td>$1,000</td>
<td>$1,019</td>
<td>$1,047</td>
<td>$1,075</td>
<td>$1,112</td>
<td>$1,240</td>
<td>$1,377</td>
<td>$1,624</td>
<td>$1,876</td>
<td>$2,104</td>
<td>$2,462</td>
<td>$2,917</td>
<td>$3,736</td>
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<tr>
<td>25 feet</td>
<td>$966</td>
<td>$1,004</td>
<td>$1,016</td>
<td>$1,027</td>
<td>$1,046</td>
<td>$1,074</td>
<td>$1,102</td>
<td>$1,139</td>
<td>$1,267</td>
<td>$1,404</td>
<td>$1,651</td>
<td>$1,903</td>
<td>$2,131</td>
<td>$2,469</td>
<td>$2,944</td>
<td>$3,763</td>
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<tr>
<td>30 feet</td>
<td>$1,024</td>
<td>$1,032</td>
<td>$1,044</td>
<td>$1,055</td>
<td>$1,074</td>
<td>$1,102</td>
<td>$1,130</td>
<td>$1,167</td>
<td>$1,295</td>
<td>$1,455</td>
<td>$1,679</td>
<td>$1,931</td>
<td>$2,159</td>
<td>$2,517</td>
<td>$2,972</td>
<td>$3,791</td>
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<tr>
<td>35 feet</td>
<td>$1,052</td>
<td>$1,060</td>
<td>$1,072</td>
<td>$1,083</td>
<td>$1,102</td>
<td>$1,130</td>
<td>$1,158</td>
<td>$1,195</td>
<td>$1,323</td>
<td>$1,483</td>
<td>$1,707</td>
<td>$1,959</td>
<td>$2,187</td>
<td>$2,545</td>
<td>$3,000</td>
<td>$3,819</td>
</tr>
<tr>
<td>40 feet</td>
<td>$1,079</td>
<td>$1,087</td>
<td>$1,099</td>
<td>$1,110</td>
<td>$1,129</td>
<td>$1,157</td>
<td>$1,185</td>
<td>$1,222</td>
<td>$1,360</td>
<td>$1,515</td>
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<td>$2,214</td>
<td>$2,572</td>
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</table>

### MIS — Open Cut Construction
Pipe Diameter (Inches)

<table>
<thead>
<tr>
<th>Depth</th>
<th>8 inch</th>
<th>12</th>
<th>15</th>
<th>18</th>
<th>21</th>
<th>24</th>
<th>27</th>
<th>30</th>
<th>36</th>
<th>42</th>
<th>48</th>
<th>54</th>
<th>60</th>
<th>72</th>
<th>84</th>
<th>96</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 ft depth</td>
<td>$298</td>
<td>$318</td>
<td>$324</td>
<td>$401</td>
<td>$416</td>
<td>$426</td>
<td>$497</td>
<td>$522</td>
<td>$581</td>
<td>$630</td>
<td>$747</td>
<td>$892</td>
<td>$979</td>
<td>$1,249</td>
<td>$2,135</td>
<td>$2,316</td>
</tr>
<tr>
<td>20 ft depth</td>
<td>$381</td>
<td>$401</td>
<td>$407</td>
<td>$501</td>
<td>$518</td>
<td>$526</td>
<td>$559</td>
<td>$622</td>
<td>$681</td>
<td>$730</td>
<td>$847</td>
<td>$1,009</td>
<td>$1,098</td>
<td>$1,366</td>
<td>$2,286</td>
<td>$2,467</td>
</tr>
<tr>
<td>25 ft depth</td>
<td>$459</td>
<td>$479</td>
<td>$486</td>
<td>$596</td>
<td>$611</td>
<td>$621</td>
<td>$692</td>
<td>$717</td>
<td>$776</td>
<td>$825</td>
<td>$942</td>
<td>$1,119</td>
<td>$1,206</td>
<td>$1,476</td>
<td>$2,430</td>
<td>$2,611</td>
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</table>

### Local Interceptors — Open Cut Construction
Pipe Diameter (Inches)

<table>
<thead>
<tr>
<th>Depth</th>
<th>8 inch</th>
<th>12</th>
<th>15</th>
<th>18</th>
<th>21</th>
<th>24</th>
<th>27</th>
<th>30</th>
<th>36</th>
<th>42</th>
<th>48</th>
<th>54</th>
<th>60</th>
<th>72</th>
<th>84</th>
<th>96</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 ft depth</td>
<td>$225</td>
<td>$245</td>
<td>$251</td>
<td>$328</td>
<td>$343</td>
<td>$353</td>
<td>$424</td>
<td>$449</td>
<td>$508</td>
<td>$557</td>
<td>$674</td>
<td>$819</td>
<td>$906</td>
<td>$1,176</td>
<td>$2,062</td>
<td>$2,243</td>
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<tr>
<td>20 ft depth</td>
<td>$263</td>
<td>$283</td>
<td>$289</td>
<td>$363</td>
<td>$398</td>
<td>$408</td>
<td>$479</td>
<td>$504</td>
<td>$563</td>
<td>$612</td>
<td>$729</td>
<td>$891</td>
<td>$978</td>
<td>$1,248</td>
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</tr>
<tr>
<td>25 ft depth</td>
<td>$301</td>
<td>$321</td>
<td>$327</td>
<td>$438</td>
<td>$453</td>
<td>$463</td>
<td>$534</td>
<td>$559</td>
<td>$618</td>
<td>$667</td>
<td>$784</td>
<td>$961</td>
<td>$1,048</td>
<td>$1,318</td>
<td>$2,272</td>
<td>$2,453</td>
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</table>

Sewer Construction Costs: $ per Lineal Foot
### Project 1 — North 91st Street MIS

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Upstream Location</th>
<th>Downstream Location</th>
<th>Land Use</th>
<th>Recommended Size (inches)</th>
<th>Length</th>
<th>Depth</th>
<th>Unit Cost</th>
<th>Construction Cost</th>
<th>Capital Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weir Removal in DC0308</td>
<td>N/A</td>
<td>N/A</td>
<td>Commercial / Industrial</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>$50,000</td>
<td>$84,375</td>
</tr>
<tr>
<td>Local Pump Station*</td>
<td>N/A</td>
<td>N/A</td>
<td>Commercial / Industrial</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>$917,193</td>
<td>$1,547,793</td>
</tr>
<tr>
<td>Relief Sewer</td>
<td>N/A</td>
<td>MH 19716</td>
<td>Commercial / Industrial</td>
<td>10</td>
<td>1.874</td>
<td>40</td>
<td>$1,349</td>
<td>$2,528,026</td>
<td>$4,266,044</td>
</tr>
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</table>

*Total Pumping Capacity: 0.75 MGD. Total Pump Head: 20 ft

### Project 2 — Milwaukee River MIS

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Upstream Location</th>
<th>Downstream Location</th>
<th>Land Use</th>
<th>Recommended Size (inches)</th>
<th>Length</th>
<th>Depth</th>
<th>Unit Cost</th>
<th>Construction Cost</th>
<th>Capital Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replacement Sewer</td>
<td>MH 14603</td>
<td>MH 14503</td>
<td>Mixed</td>
<td>42</td>
<td>4.250</td>
<td>50</td>
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<td>$6,043,500</td>
<td>$10,198,406</td>
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<tr>
<td>Replacement Sewer</td>
<td>MH 14503</td>
<td>MH 14410</td>
<td>Mixed</td>
<td>42</td>
<td>1.646</td>
<td>25</td>
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<td>$3,672,020</td>
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<tr>
<td>Replacement Sewer</td>
<td>MH 14410</td>
<td>DC70509</td>
<td>Mixed</td>
<td>42</td>
<td>1.838</td>
<td>30</td>
<td>$1,356</td>
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### Project 3 — Range Line Road MIS

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<thead>
<tr>
<th>Recommendation</th>
<th>Upstream Location</th>
<th>Downstream Location</th>
<th>Land Use</th>
<th>Recommended Size (inches)</th>
<th>Length</th>
<th>Depth</th>
<th>Unit Cost</th>
<th>Construction Cost</th>
<th>Capital Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replacement Sewer</td>
<td>MH 14909</td>
<td>MH 14908</td>
<td>Residential</td>
<td>15</td>
<td>644</td>
<td>30</td>
<td>$559</td>
<td>$360,136</td>
<td>$607,729</td>
</tr>
<tr>
<td>Replacement Sewer</td>
<td>MH 14908</td>
<td>MH 14907</td>
<td>Residential</td>
<td>15</td>
<td>600</td>
<td>20</td>
<td>$468</td>
<td>$280,833</td>
<td>$473,905</td>
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### Project 4 — River Hills MIS

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Upstream Location</th>
<th>Downstream Location</th>
<th>Land Use</th>
<th>Recommended Size (inches)</th>
<th>Length</th>
<th>Depth</th>
<th>Unit Cost</th>
<th>Construction Cost</th>
<th>Capital Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replacement Sewer</td>
<td>MH 14509</td>
<td>MH 14503</td>
<td>Residential</td>
<td>18</td>
<td>267</td>
<td>25</td>
<td>$1,145</td>
<td>$305,715</td>
<td>$515,894</td>
</tr>
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</table>

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TABLE 9B-2 SHEET 1 OF 3
COST OF RECOMMENDED CONVEYANCE PROJECTS:
5-YEAR LEVEL OF PROTECTION
2020 CONVEYANCE REPORT
3/4/07
CR_08.7002.07.05.04.cdr
## Project 5 — Green Bay Avenue / Mill Road MIS

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Upstream Location</th>
<th>Downstream Location</th>
<th>Land Use</th>
<th>Recommended Size (inches)</th>
<th>Length</th>
<th>Depth</th>
<th>Unit Cost</th>
<th>Construction Cost</th>
<th>Capital Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force Main</td>
<td>Green Tree PS</td>
<td>DC0409</td>
<td>Commercial / Industrial</td>
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<td>8.566</td>
<td>30</td>
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<tr>
<td>Pump Station Modification*</td>
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<td>N/A</td>
<td>N/A</td>
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<td>$12,224,985</td>
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*4 pumps (3 active, 1 redundant) Total Pumping Capacity: 27.6 MGD  Total Pump Head: 125 ft

## Project 7 — Menomonee River MIS

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Upstream Location</th>
<th>Downstream Location</th>
<th>Land Use</th>
<th>Recommended Size (inches)</th>
<th>Length</th>
<th>Depth</th>
<th>Unit Cost</th>
<th>Construction Cost</th>
<th>Capital Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replacement Sewer</td>
<td>MH 04705</td>
<td>MH 04605</td>
<td>Commercial / Industrial</td>
<td>30</td>
<td>200</td>
<td>20</td>
<td>$778</td>
<td>$155,600</td>
<td>$282,575</td>
</tr>
<tr>
<td>Replacement Sewer</td>
<td>MH 04605</td>
<td>MH 04604B</td>
<td>Commercial / Industrial</td>
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<td>971</td>
<td>15</td>
<td>$653</td>
<td>$633,825</td>
<td>$1,069,580</td>
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## Project 9 — South 81st Street MIS

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Upstream Location</th>
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<th>Land Use</th>
<th>Recommended Size (inches)</th>
<th>Length</th>
<th>Depth</th>
<th>Unit Cost</th>
<th>Construction Cost</th>
<th>Capital Cost</th>
</tr>
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<tbody>
<tr>
<td>Replacement Sewer</td>
<td>MH 08310</td>
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$16,000,000

$1,300,000

$3,500,000
### Project 10 — South Howell Avenue MIS

<table>
<thead>
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<th>Recommendation</th>
<th>Upstream Location</th>
<th>Downstream Location</th>
<th>Land Use</th>
<th>Recommended Size (inches)</th>
<th>Length</th>
<th>Depth</th>
<th>Unit Cost</th>
<th>Construction Cost</th>
<th>Capital Cost</th>
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<tbody>
<tr>
<td>Relief Sewer</td>
<td>MH 17018</td>
<td>MH 17511</td>
<td>Commercial / Industrial</td>
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**Total:** $8,300,000

### Project 13 — Franklin-Muskego MIS

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<th>Downstream Location</th>
<th>Land Use</th>
<th>Recommended Size (inches)</th>
<th>Length</th>
<th>Depth</th>
<th>Unit Cost</th>
<th>Construction Cost</th>
<th>Capital Cost</th>
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<tbody>
<tr>
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<td>MH 44302</td>
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**Total:** $4,700,000

### Project 14 — DC0103 Modification

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<thead>
<tr>
<th>Recommendation</th>
<th>Cast-in-Place Concrete Work</th>
<th>Electrical Reconfiguration</th>
<th>Remove / Dispose Existing Sluice Gate</th>
<th>Misc. Concrete Work</th>
<th>Flow Diversion</th>
<th>Installation of Weir</th>
<th>New Weir</th>
<th>Construction Cost</th>
<th>Capital Cost</th>
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<td>$25,000</td>
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<td>$10,000</td>
<td>$50,000</td>
<td>$237,400</td>
<td>$400,613</td>
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**Total:** $400,000
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<thead>
<tr>
<th>Project 1 — North 91st Street MIS</th>
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<tbody>
<tr>
<td><strong>Recommendation</strong></td>
</tr>
<tr>
<td>Weir Removal in DC0208</td>
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<tr>
<td>Local Pump Station*</td>
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<tr>
<td>Relief Sewer</td>
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<tr>
<td>*Total Pumping Capacity: 0.75 MGD  Total Pump Head: 20 ft</td>
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$6,000,000

<table>
<thead>
<tr>
<th>Project 2 — Milwaukee River MIS</th>
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<tr>
<td><strong>Recommendation</strong></td>
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<tr>
<td>Replacement Sewer</td>
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<td>Replacement Sewer</td>
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$18,100,000

<table>
<thead>
<tr>
<th>Project 3 — Range Line Road MIS</th>
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<td>Replacement Sewer</td>
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<tr>
<td>Replacement Sewer</td>
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<td>Replacement Sewer</td>
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$2,100,000

<table>
<thead>
<tr>
<th>Project 4 — River Hills MIS</th>
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<tr>
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$520,000

<table>
<thead>
<tr>
<th>Project 5 — Green Bay Avenue / Mill Road MIS</th>
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<tbody>
<tr>
<td><strong>Recommendation</strong></td>
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<tr>
<td>Relief Sewer</td>
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$44,000,000

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<tr>
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$350,000

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**TABLE 9B-3 SHEET 1 OF 3**

**COST OF RECOMMENDED CONVEYANCE PROJECTS: 10-YEAR LEVEL OF PROTECTION**

2020 CONVEYANCE REPORT

3/4/07

CR_9B.7033.07.05.04.cdr
### Project 7 — Menominee River MIS

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Upstream Location</th>
<th>Downstream Location</th>
<th>Land Use</th>
<th>Recommended Size (inches)</th>
<th>Length</th>
<th>Depth</th>
<th>Unit Cost</th>
<th>Construction Cost</th>
<th>Capital Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replacement Sewer</td>
<td>MH 04705</td>
<td>MH 04605</td>
<td>Commercial / Industrial</td>
<td>30</td>
<td>200</td>
<td>20</td>
<td>$778</td>
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<td>$262,575</td>
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<td>MH 04605</td>
<td>MH 04604B</td>
<td>Commercial / Industrial</td>
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<td>971</td>
<td>15</td>
<td>$653</td>
<td>$633,825</td>
<td>$1,069,580</td>
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$1,300,000

### Project 8 — South 35th Street MIS

<table>
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<th>Downstream Location</th>
<th>Land Use</th>
<th>Recommended Size (inches)</th>
<th>Length</th>
<th>Depth</th>
<th>Unit Cost</th>
<th>Construction Cost</th>
<th>Capital Cost</th>
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</thead>
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<tr>
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<td>MH 07711</td>
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$7,100,000

### Project 9 — South 81st Street MIS

<table>
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<th>Upstream Location</th>
<th>Downstream Location</th>
<th>Land Use</th>
<th>Recommended Size (inches)</th>
<th>Length</th>
<th>Depth</th>
<th>Unit Cost</th>
<th>Construction Cost</th>
<th>Capital Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replacement Sewer</td>
<td>MH 08310</td>
<td>MH 08307</td>
<td>Commercial / Industrial</td>
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$4,100,000

### Project 10 — South Howell Avenue MIS

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<th>Downstream Location</th>
<th>Land Use</th>
<th>Recommended Size (inches)</th>
<th>Length</th>
<th>Depth</th>
<th>Unit Cost</th>
<th>Construction Cost</th>
<th>Capital Cost</th>
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$10,600,000

### Project 11 — Sheridan Drive MIS

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<th>Reduced li (gpad)</th>
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<th>Area (acres)</th>
<th>Flow Reduced (gpad)</th>
<th>Flow Reduced (gpd)</th>
<th>Unit Cost ($/gpd)</th>
<th>Construction Cost</th>
<th>Capital Cost</th>
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<tbody>
<tr>
<td>li Reduction</td>
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$1,900,000

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*TABLE 9B-3 SHEET 2 OF 3*

**COST OF RECOMMENDED CONVEYANCE PROJECTS:
10-YEAR LEVEL OF PROTECTION**

2020 CONVEYANCE REPORT

CR_08.7003.02.05.04.cdr
### Project 12 — Ryan Road MIS

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Upstream Location</th>
<th>Downstream Location</th>
<th>Land Use</th>
<th>Recommended Size (inches)</th>
<th>Length</th>
<th>Depth</th>
<th>Unit Cost</th>
<th>Construction Cost</th>
<th>Capital Cost</th>
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<tbody>
<tr>
<td>Relief Sewer</td>
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<td>MH 30202</td>
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**$51,800,000**

### Project 13 — Franklin-Muskego MIS

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<th>Downstream Location</th>
<th>Land Use</th>
<th>Recommended Size (inches)</th>
<th>Length</th>
<th>Depth</th>
<th>Unit Cost</th>
<th>Construction Cost</th>
<th>Capital Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force Main</td>
<td>MH 44302</td>
<td>MH 44008</td>
<td>Mixed</td>
<td>30</td>
<td>10,626</td>
<td>25</td>
<td>$263</td>
<td>$2,794,638</td>
<td>$4,715,952</td>
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**$4,700,000**

### Project 14 — DC0103 Modification

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Cast-in-Place Concrete Work</th>
<th>Electrical Reconfiguration</th>
<th>Remove / Dispose Existing Sluice Gate</th>
<th>Misc. Concrete Work</th>
<th>Flow Diversion</th>
<th>Installation of Weir</th>
<th>New Weir</th>
<th>Construction Cost</th>
<th>Capital Cost</th>
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<tbody>
<tr>
<td>DC0103 Modification</td>
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<td>$400,613</td>
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**$400,000**