MENOMONEE RIVER, WAUWATOSA, WISCONSIN

Low Flow Barriers Concept Plan: Swan Boulevard to Harmonee Drive

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PREPARED FOR:

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Introduction

Connecting Great Lakes with their tributary streams has been identified as an important priority at local, regional and national scales (NOAA, 2012). Southeast Wisconsin organizations have been leaders in putting the studies and plans into action to achieve fish passage in critical reaches of Lake Michigan tributaries.

The Milwaukee Riverkeeper has contracted with Inter-Fluve, Inc. to develop a concept plan to illustrate options for modifying five structures that hamper fish movement in the stretch of river between Harmonee Avenue and Swan Boulevard in the City of Wauwatosa. For the sake of this document, it is assumed that the sewer lines are operational and will not be removed in the foreseeable future. Three of the structures are concrete encased sanitary sewer lines, and two are pedestrian/road crossings. The distance between the most upstream structure and the downstream structure is 3,380 feet. The last remaining barrier to fish movement in the Menomonee River between these structures and Lake Michigan is the concrete lining that extends upstream from the Highway I-94 crossing at River Mile 3.62. Fish passage is limited in this stretch due to the occurrence of supercritical flows at high velocities in combination with the lack of resting areas. (SEWRPC, 2010). The US Fish and Wildlife Service has committed funding to restore fish passage in that concrete lined stretch of the river, opening up fish access to the Harmonee-Swan barriers that are under consideration.

Figure 1 Old Stone Road viewing from left bank

Background and Justification

The Milwaukee Metropolitan Sewerage District (MMSD), the Milwaukee Riverkeeper, Southeastern Wisconsin Watershed Trust, Inc , the Southeast Wisconsin Regional Planning Commission (SEWRPC) and the Wisconsin Department of Natural Resources (DNR) have identified eliminating fish passage barriers at these five structures as a high priority in their stream planning and management efforts.

MMSD recognized the benefits of removing these fish barriers in the *Sediment Transport Study of the Menomonee River Watershed* (MMSD, 2001):

"There are three main activities, which the District can implement to support a native fishery:

- Removal of barriers (velocity or physical) within the watercourse which impede fish passage…
- In-stream activities to mitigate the impacts of development include the rehabilitation of floodplain connections and channel diversity. Several reaches within the Menomonee River system have been straightened and/or separated from their floodplain. Rehabilitation of the connection with the floodplain (especially for more frequent events) will provide needed spawning sites for northern pike and provide other benefits to the system. Additional in-stream activities may include the creation of pools or other measure to reduce the impact of increased temperature associated with development at lower flows.
- Off-stream activities to mitigate the impact of development."

SEWRPC has suggested a three-tiered approach, focused on the reconnection of waterways that have been historically isolated from the Lake Michigan stream system through construction of dams, roadways, and flow control structures, or modified through construction of single-purpose systems, such as stormwater conveyances (SEWPPC, 2010).

The three components of this strategy are:

- Tier 1–Restoring connectivity and habitat quality between the mainstem waterways and the Lake Michigan endpoint.
- Tier 2–Restoring connectivity and habitat quality between the tributary streams and the mainstems of the Menomonee and Kinnickinnic Rivers.
- Tier 3–Expanding connection of highest-quality fish, invertebrate, and habitat sites within each of the watersheds.

The report goes further by recommending specific management actions to carry out the strategy: "Removal and/or retrofitting of five low-head structures along the Menomonee River between Swan Boulevard and Harmonee Avenue (within Reach MN-17A). These structures consist of three sewer crossings, one abandoned road, and one grade control structure. Rehabilitation of riparian and instream habitat should also be undertaken as part of this removal. It is recommended that concrete associated with these structures be removed from the stream channel or floodplain where possible."

Furthermore the Southeastern Wisconsin Watershed Trust echoes those recommendation in their 2010 report *Implementation Plan and Priority Project List for the Menomonee River Watershed of Southeastern Wisconsin.*

Geomorphic Setting

Past studies have employed different naming conventions for each stretch of stream. The 2001 MMSD Study divided the river and its tributaries into reaches of similar size, slope and shape. Criteria used to establish stream reaches and reach breaks conducive to futrure management activities inlcude:

- Similar geomorphic character, including bed, bank and planform characteristics
- Bed slope, hydraulic and hydrologic character
- Break in channel continuity and grade control resulting from permanent physical features such as culverts, bridges or natural features such as bedrock
- For management purposes, reaches are limited to a length of 3,000 feet.

Menomonee River Physical Characteristics	
Drainage area:	111 square miles
Median flow:	108 cfs
Channel type:	Alluvial
Slope	0.0025
Bed D-50	38 mm
Stability:	Slight degrading
Width:depth:	26:1

Reach MMR13 starts at Harmonee Drive (RM 6.78) and ends at the Old Stone Road

Reach MMR 14 Starts at the the Old Stone Road (RM 7.23) and extends to Sewer Crossing #3

Reach MMR 15 Starts at #3 Sewer Crossing (RM 7.34) and ends at at Swan Blvd (RM 8.00)

Structure Name	River Mile	Geomorphic Reach
Sewer Crossing #1	7.87	14
Stone Walking Path #2	7.82	14
Sewer Crossing #3	7.67	14
Sewer Crossing #4	7.34	15
Old Stone Road #5	7.23	15

Beteween Reach 13 and 42, the 100-year floodplain width is moderately confined and the majority of channel boundary materials are alluvial with stability ratings of 2- to 3+, where 3 is stable, <3 is degrading and >3 is aggrading. Short segments of instability exist but overall ,the dominant geomorphic conditions are stable. The Hoyt Park area has experienced substantial lateral migration and erosion, but has been addressed by the Sewerage Distict in 1999-2000. However, the grade of lower reaches (the mouth to RM 16) is controlled by bedrock, coarse bed material and structures. It is likely that stability is further enhanced by sediment supply from upstream. Results from SAM (Stable Channels in Alluvial Material) analysis indicate degradation in the river's lower reaches between River Mile 2.00 and 10.66.

Figure 2- Typical reach of Menomonee River

The Menomonee River main stem can be divided into two distinct sections for the median grain size (D-50). The D-50 for Reach 01 through Reach 32 ranges from 16-73 mm and the average is 38 mm.

The channel slope for Reaches 13, 14 and 15, tabulated from the HEC-RAS models developed by Tetra Tech, Inc., is 0.0025

Stream Health

Water quality and biological assessments used a different reach numbering system with a total of 19 reaches covering the Menomonee River main stem and tributaries. The study site lies within Reach MN 17A that extends from River Mile 6.7 at the Canadian Pacific Railway crossing to River Mile 8.5 at North Ave. SEWRPC biological assessments (SEWRPC, 2007) summarized that the biological community in the Menomonee River watershed is limited primarily due to 1) periodic stormwater pollutant loads (associated with increased flashiness); 2) decreased base flows and increased water temperatures due to urbanization; and 3) habitat loss and continued fragmentation due to culverts, concrete lined channels, enclosed conduits, drop structures, and past channelization.

Water quality in the study reach ranks in the middle of 14 streams in the greater Milwaukee watersheds that have sufficient data to calculate an aggregate bio-assessment ranking. However, Fish Index of Biotic Integrity for the Harmonee-Swan reach was characterized as ranging from very poor to fair, the Hilsenhoff Biotic Index for invertebrates was fair and habitat quality was not assessed.

Fishery Summary

Despite its challenges, the Menomonee River system's fish populations have remained fairly steady from the beginning of the 20th century to the present. As measured by the number of native and game fish species present, the stretch of river between the Menomonee Falls barrier and the concrete-lined section has declined somewhat from 33 to 28, while the number of native and game fish species in the downstream end has increased from 11 to 38. Most notable are the increased number of pollution intolerant species that have been captured in the downstream end.

DNR has recommended that northern pike be used as the target species for passage through over the barriers due to its need to move to its spawning grounds during adverse conditions and its limited swimming and jumping ability. Designing features to accommodate northern pike passage over or around barriers would greatly increase the probability that other fish species with superior swimming and leaping abilities would be able to pass those barriers. Wetland habitats that northern pike could exploit for spawning include those along Underwood Creek, the Little Menomonee River and Lily Creek which support about half of the riparian wetland parcels in the Menomonee River watershed (Wawrzyn, 2013).

Allowing fish passage and creating habitat niches for "emerging" species that have been re-populating the estuary and the lower stretches of the river should also be given attention in the design of the fish barrier mitigation. Some of the fishes that should be looked at for passage are the redhorse species (greater redhorse is state threatened), catfish and small non-game species. Darter species could serve as a good representative of the non-game species because of their intermediate pollution tolerance, their need to reach spawning habitat during low flow conditions and because there is good documentation of their swimming abilities.

Fishway Design

Due to obsolescence of two of the structures (Stone Walking Path #2 and Old Stone Road #5), it is recommended that they be removed from the river instead of retro-fitting. Barring any unknown obstacles, removal would be far less costly than retro-fitting. Both of these structures appear to be easily accessible and straightforward to remove. The sections of the two structures that are buried by floodplain sediment could remain in place to serve as grade control in the event of major channel avulsions. Further sub-surface investigations of the channel would be required to determine the depth and extent of the buried concrete. Cut stone blocks in the core of these two structures could readily be re-used as landscape features in the park.

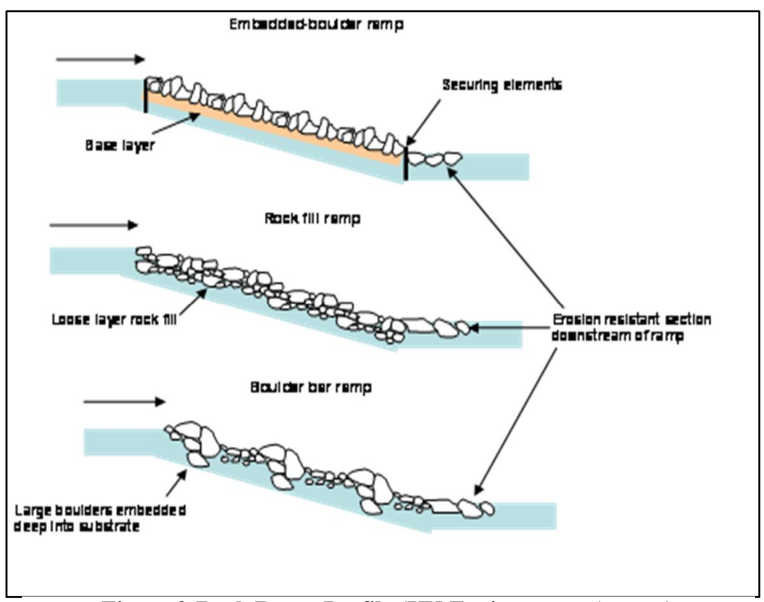

Figure 3-Rock Ramp Profile (UK Environment Agency)

The remaining three barriers, all sewer line crossings, present an opportunity to apply a similar design approach— the rock ramp nature-like fishway. Two basic types of rock ramps can be installed, depending on the barrier characteristics: channel spanning and partial channel spanning ramps. Due to the difference in dimensions and alignment of the sewer lines, slight variations in design will be needed.

Design Considerations

Fish passage structures need to be designed to withstand forces that can be reasonably expected to occur, and they must perform the functions that they are designed for. Types of failure include structural damage as well as performance failure. Geomorphic processes that can impact rock ramps include headcuts/bed degradation, channel migration and sediment deposition. Structural damage will likely result in performance failure as well. Biological performance criteria consist of meeting regulatory or site specific habitat and passage requirements. Biological performance criteria may include low flow depth and velocity, swim distance capability and step height. Structural considerations consist of designing a structure to withstand rolling or sliding during large flows and undermining through piping under the structure. Unless the particle size distribution of the materials is carefully calculated, infiltration of water through the structure could result in dewatering.

For planning purposes, the rock ramp dimensions should create an incline of 20H:1V or flatter (NOAA, 2012). Rock should consist of a wide variety of particle sizes, with a thickness of 1.5 times the median diameter of the rock size. A wide range of rock sizes reduces the ability of a stream to pull material through the rock layer and undermine the structure through piping. The final gradation represents a compromise between resistance to hydraulic entrainment and resistance to piping. Final surfacing of the ramp can be accomplished by salvaging optimally sized bottom materials and placing them on the rock surface. To meet state and federal floodplain considerations, existing and proposed water surface profiles must not cause an increase in regional flood elevations.

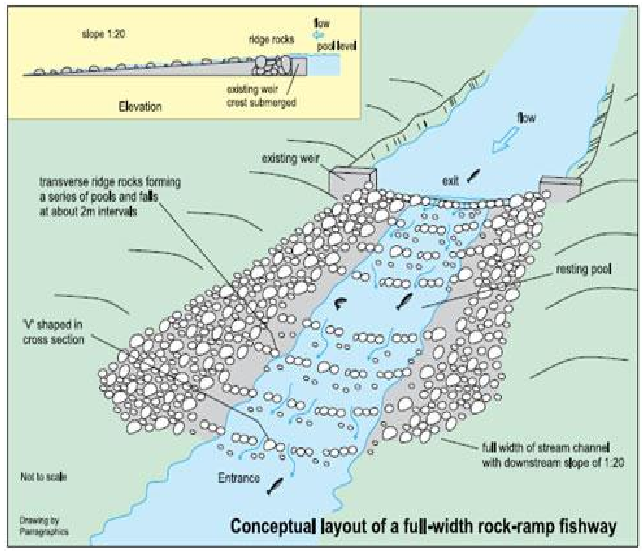

Figure 4- Rock Ramp Schematic (Corps of Engineers)

Sewer Crossing #1

Length:	190 feet
Width:	3-4 feet
Water surface difference:	2.6 feet

This structure is acutely skewed from the perpendicular axis of the river. A cascade with a plunge pool have formed at the left bank of the structure where it deviates the most from perpendicular. Both of these features can be adapted to create a gradual incline that would be suitable for fish passage. The plunge pool that results from the convergence of flows that are "trained" by the structure creates an ideal "staging" pool for fish that are readying to make upstream passage. Because of the slope of the sewer line, flow is concentrated in the cascade section, thereby creating adequate depth for passage of all species.

Sewer Crossing #3

Length:	150 feet
Width:	2-3 feet
Water surface difference:	0.2 feet

The alignment of Sewer Crossing #3 is slightly skewed, and the top slopes downward toward the inside bend on the right bank. The lower surface of the concrete presents an opportunity for installing a partial spanning rock ramp on the right side of the river. While some bed alterations might become necessary on the upstream side to create optimal water depth, there are ample opportunities to incorporate habitat features both upstream and downstream from the structure. Some examples include backwater cuts, coarse woody debris additions and other escape cover.

Figure 5-Overhead cover can complement fish passage

Sewer Crossing #4

Length:	125 feet
Width:	2-3 feet
Water surface difference:	0.79 feet

Because of the alignment and flatness of the top of this sewer line, a channel spanning rock ramp is recommended at this site. Flow will need to be concentrated to compensate for the width of the river and structure in this section. This can be accomplished by shaping the rock ramp into a V shape and constricting the sides of the channel with suitable material. Due to the shallow nature of the river at this site, the addition of habitat features will be important. In this setting, creating pools and installing overhead cover will provide hiding and resting cover for aquatic organisms.

Description of Physical and Monetary Constraints

Construction access would require disturbance of park land and loss of trees. The route and location of staging areas should be chosen to avoid desirable and mature trees. Trees greater than a foot in diameter should be salvaged and used as woody cover near the structures. In addition, the structural aspects of the sewer lines would need to be assessed during the design process.

Basis for the Suggested Solutions

While fish swimming ability is the primary factor in whether a given species can pass a barrier, the type and amount of flow interruptions is also critical. Small fishes have proportionately slower burst speeds but have the advantage of moving closer to or within the substrates where velocities are slower. Some small riffle oriented species like the rainbow darter, *Etheostoma caeruleum*, prefer fast moving water and cope by using refugia formed by rocks and other in-stream cover.

One of the major challenges in fish passage structure design in this stretch of the Menomonee River is the considerable width of the stream compared to its depth. With the variable flows common in the river, low flow conditions will spread out the flow, resulting in water too shallow for fish to move and leaving them vulnerable to predation. Concentrating flow by configuring the rock ramps in a V-shape is one way of compensating for the lack of water depth.

Material re-use presents an opportunity to lessen costs and landscape disturbance. Re-use of the cut stone from the stone walking path and the old stone road in the park's landscape would create attractive "hardscape" while recognizing the historical linkage between the park's historic and present uses. Possibilities for re-use of the stone include slope control, benches, steps or simply landscape "sculpture" elements.

No major construction access hurdles have been identified. Trees will need to be cut to gain construction access at all of the sites. When installed correctly, tree trunks and root wads can provide valuable in-stream cover for fish and other aquatic organisms, particularly where hiding and resting cover is needed after traversing a barrier. Salvaging cut trees and incorporating them into woody cover in the design of the fish passage structures would be beneficial to all species of aquatic organisms.

Ballpark Estimate of Costs Based on Similar Projects

Construction costs for a single channel-spanning ramp at either sewer crossing #4 are estimated to be $68,625, not including design and construction oversight, permitting and dewatering costs. Costs for a partial channel spanning ramp at Sewer Crossing #3, and a modified "cascade" at Sewer Crossing #1, would be proportionally less. Variables in the cost include whether work would be bid for all of the structures at once, whether bank protection would need to be added and uncertainties due to unknown subsurface conditions and structural condition of the sewer lines.

Alternatives

Partial removal or notching both the stone walking path and stone road structures could be accomplished at less cost than removal. If limited funding is available, the drop caused by the structures could be reduced, and flow could be concentrated, to provide more favorable passage conditions for fish. Without thorough analysis of flow duration and velocities, it cannot be assured that fish will be able to pass over a partially removed structure.

The river channel could be realigned on the right bank to take advantage of the downward slope of Sewer Crossing #3. This option would need further investigation of the vertical and horizontal alignment of the sewer line under the floodplain. Beside cost considerations, the loss of mature trees and inherent instability resulting from disturbance make this option somewhat risky.

The Design Process Next Steps *adapted from Katopodis, 1992*

- Perform a flow frequency analysis for the passage structures and estimate low, average, and high flows (e.g. flows at 98-95% probability of being equalled or exceeded, mean annual flood, bankfull discharge, flows at 10% and 2% probability).
- Structure design flow (e.g. 1-50 year flood) and fishway design flow (e.g. 3-day delay for 1-10 year flood).
- Prepare stage-discharge relationships for the headwater and tailwater of the existing and proposed structures.
- Prepare a discharge rating curve and characteristic velocity profiles for low, average and high flows for each feasible option.
- Prepare preliminary engineering report, drawings, and estimate costs. Show fishway dimensions, inverts and elevations, provide plan, side and cross-sectional views, stream bed and bank protection measures and fish passage devices.
- Obtain funding.

- Prepare final report and drawings.
- Develop a monitoring and evaluation program including both biological and hydraulic parameters.
- Provide a regular maintenance program, particularly to alleviate ice and debris problems.

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