# Kinnickinnic River: Rehabilitation in an Urban Watershed

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MMSD PARTNERS FOR A CLEANER ENVIRONMENT

TETRA TECH

## The Issues

The Kinnickinnic River (KKR) watershed and its mainstem and tributary channels have undergone significant man-induced changes since the 1830's (Figure 1). These include:

- Urbanization of about 97 percent of the watershed;
- Conversion of hardwood forests to farmland (1858-1870);
- Drainage of the valley-bottom marshes ;
- Elimination of riparian vegetation;
- Construction of small dams and reservoirs on some of the tributaries;
- Channelization, straightening, concrete lining (38 percent; 9.6 miles) and enclosure (25 percent; 6.4 miles) of watershed channels (Figure 2); and
- Installation of infrastructure (bed and bank protection structures as well as bridges and culverts) (Figure 3).

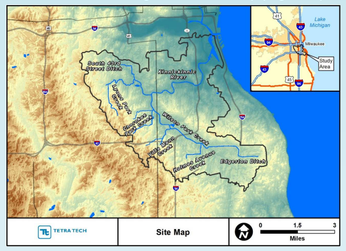



Figure 1. Kinnickinnic River Watershed showing the location of the mainstem and major tributaries.

The urbanization resulted in an approximately 10-fold increase in the magnitude of the peak flows. Much of the existing concrete lining (installed between the late 1950's and early 1970's) is aged and deteriorating (Figure 4) and the channels no longer convey the design flows. The Milwaukee Metropolitan Sewerage District (MMSD) is exploring options for removing the concrete and rehabilitating the channels. MMSD's goals include improved aquatic and riparian habitat and enhanced recreational opportunities while providing increased public safety and reduced impacts from flooding. In the channels that are not concrete-lined, MMSD is concerned with bank erosion (Figure 5) and vertical downcutting, as well as resulting sedimentation in the Lake Michigan estuary.

Figure 2. 1961 photograph of the recently lined KKR.

Figure 3. 1960 photograph of riprap along the KKR.

## Objectives

The objective of the study conducted by Tetra Tech was to provide a supplementary planning tool for flood management, channel stabilization, and rehabilitation activities within the KKR watershed, primarily within MMSD's jurisdiction. Specific objectives included:

- Collecting and evaluating relevant sediment and geomorphic data in the context of channel stability, flood management, and overall watershed management;
- Identifying existing problem areas and opportunities for improvement of watershed condition, to be integrated with flood management initiatives;
- Providing a comprehensive database of geomorphic and sediment-transport characteristics to enable effective watershed management and decision making;
- Providing guidance and prioritization of identified projects within MMSD jurisdiction.

Figure 4. Damaged concrete lining in Holmes Avenue Creek.

Figure 5. Bank erosion in the unlined portion of the KKR.

## Analytical Methods

### Field Reconnaissance

An extensive field reconnaissance was carried to evaluate the existing morphology of the unlined channels, assess the condition of the channel infrastructure, identify geomorphic and hydraulic controls, and characterize the channel boundary materials (Figure 6). During the field reconnaissance, areas exhibiting bed or bank erosion were mapped to identify potential sites for rehabilitation. Representative cross sections were surveyed as part of the this study to facilitate development of the hydraulic model.

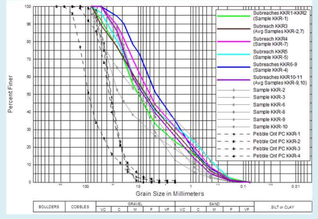
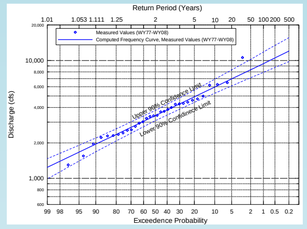



Figure 6. Bed material gradation curves for the 10 bulk samples and 4 pebble counts collected along the KKR, and the representative curves for each subreach.

## Analytical Methods (cont.)

Figure 7. Flood frequency curve at the S. 11th Street Gage.




### Hydrology

USGS gage information was used in conjunction with HSPF hydrologic modeling to assess the more frequently occurring flows that will be the basis for the design of the rehabilitated low flow channels and the extreme flood events that are the basis for the design of the overall flood conveyance channels under existing and future (2020 planned land use) conditions. The existing conditions analyses indicate that 10 percent mean daily flow exceedence level ranges from about 4.4 cfs in the upstream portion of the KKR to about 48 cfs at the downstream limit of the study reach, while the 100-year peak flow ranges from 1,960 cfs to 8,050 cfs at these two locations (Figure 7).

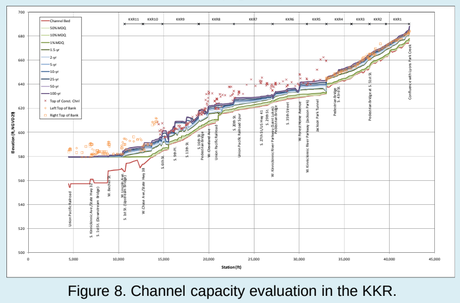



Figure 8. Channel capacity evaluation in the KKR.

### Hydraulics

HEC-RAS modeling was used to identify the channel capacity along the KKR (Figure 8), and to provide input to the sediment-transport analysis. The HEC-RAS model was initially developed by the Southeast Wisconsin Regional Planning Committee (SWERPC), and was updated for this study using the most recent topographic mapping and survey data. In the unlined portions of the KKR, the channel capacity ranges from the 2- to 10-yr RI peak flows. In the concrete-lined portions of the KKR, the channel capacity is generally greater than the 100-yr RI peak flow, except in areas that are affected by localized backwater zones created by bridges and in one reach with heavy residential encroachment where the channel capacity is less than the 25-yr RI peak flow.

## Analytical Methods (cont.)

### Sediment-transport

For purposes of this analysis, the KKR and its tributaries were divided into 47 subreaches. Reach-averaged hydraulics from the HEC-RAS model and bed material gradations for the individual subreaches were used to conduct a sediment continuity analysis of the KKR for existing and future conditions. The results indicate that the most significant erosion will occur in the unlined reaches of the KKR and Lyons Park Creek, and that aggradation in the lined reaches is unlikely (Figure 9).

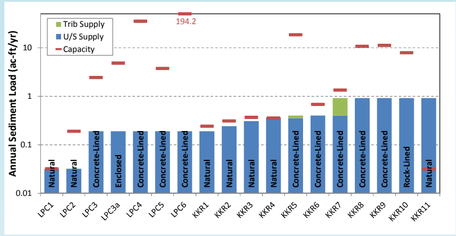



Figure 9. Results of the sediment-continuity analysis in Lyons Park Creek and the KKR.

## Rehabilitation Opportunities

The primary problems identified within the KKR and tributaries by this study and the identified opportunities for rehabilitation are:

- **Problem:** Lack of hydraulic capacity (<100-year peak flow), primarily in the concrete-lined subreaches of the KKR between South 43rd Street and South 6th Avenue.
- ✓ **Rehabilitation Opportunity:** Replacement of the existing, concrete-lined channel with a larger channel geometry to provide increased flood conveyance. Successful replacement could be achieved with a compound channel, sized to convey the 100-yr RI design flow without eroding, including a low-flow, rock-lined channel sized to convey about the 0.1-percent mean daily exceedence flow (Figures 10 and 11). Appropriate vertical and lateral variability could be incorporated to provide fish passage and resting areas.

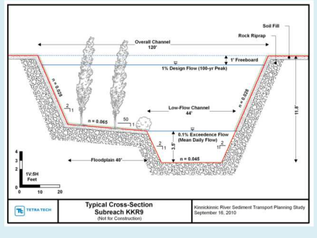



Figure 10. Conceptual design for the replaced channel in the Kinnickinnic River.

## Rehabilitation Opportunities (cont.)

Figure 11. Photgraph of the existing KKR and conceptual rendering of the rehabilitated channel.

- **Problem:** Failed and poor-condition, open-channel concrete lining, primarily in the KKR that was constructed in the early 1960s and is coincident with the impaired hydraulic capacity.
- ✓ **Rehabilitation Opportunity:** Given the coincidence between the poor state of the concrete and the impaired hydraulic capacity, the compound channel identified to mitigate problems with channel capacity would also remedy the problems with the concrete lining.

- **Problem:** Eroding unlined channel segments in the KKR and tributaries that both threaten streamside infrastructure and supply sediment to the downstream estuary of the KKR where it is deposited.
- ✓ **Rehabilitation Opportunity:** Stabilization of the eroding banks that are currently threatening infrastructure could be achieved by installing a rock toe designed to withstand movement at the 100-yr RI flow with bio-engineered upper banks (Figure 12). Rock riffle grade control structures will be necessary in areas of downcutting, and will also enhance habitat (Figure 13).

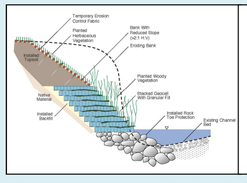



Figure 12. Conceptual design of combination rock-toe and bio-engineered bank stabilization.

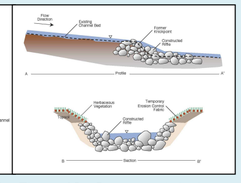



Figure 13. Conceptual design of rock riffle grade control structure.

- **Problem:** Sedimentation in the Lake Michigan estuary.
- ✓ **Rehabilitation Opportunity:** Stabilization of the currently eroding banks and installation of grade control structures would reduce sediment loads delivered to the estuary by about 50 percent.