Insensitivity of the North Branch Root River, Milwaukee County, Wisconsin: Implications for Restoration

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THE ISSUES

The North Branch of the Root River (NBRR) watershed and its mainstem and tributary channels has undergone significant anthropogenically-induced changes since the 1830's (Figure 1). These include:

- conversion of hardwood forests to farmland (1834-1870)
- drainage of the valley-bottom marshes
- elimination of riparian vegetation
- urbanization of about 45 percent of the watershed
- in-channel sand-and-gravel mining
- construction of small dams and reservoirs on some of the tributaries
- channelization and straightening of 81 percent of the meandering NBRR, and
- installation of infrastructure (bed and bank protection structures as well as bridges and culverts)

Under most circumstances, watershed and channel changes that involved increasing channel slope by a factor of about 1.5, as well as increasing the magnitude of the 2-(970 cfs), 5-(1,650 cfs) 10-(2,210 cfs) and 100-year (4,660 cfs) peak discharges by factors of 1.6, 2.6, 2.8 and 4.1, respectively would cause significant channel instability, including bed degradation and channel widening (Wolman, 1967; Knox, 1977; Schumm et al., 1984).

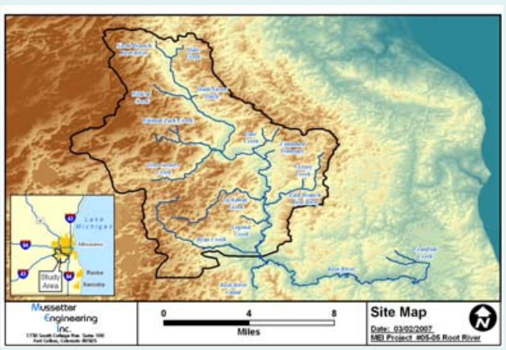


Figure 1. North Branch Root River watershed showing the locations of the mainstem and major tributaries.

OBJECTIVES

Currently, the NBRR is remarkably stable and shows limited evidence of channel degradation or widening. Projected future development in the watershed (2020 condition) is expected to increase the magnitude of the annual runoff volume by a further 10 percent and the 2- and 100-year flood peaks by 15 and 5 percent, respectively.

The objectives of this investigation of the NBRR that was conducted for the Milwaukee Metropolitan Sewerage District (MMSD) were to:

1. Determine likely future channel adjustments
2. Identify future channel and floodplain management requirements

WHY IS THE NBRR INSENSITIVE TO CHANGES ?

Geologic, geomorphic, hydrologic, hydraulic and sediment transport modeling and analyses of the NBRR and its tributaries were used to develop an understanding of why the NBRR is insensitive to forced changes in watershed hydrology and channel morphology. For the purposes of the project, the NBRR was divided into 10 subreaches (SR) on the basis of hydrologic and geomorphic criteria. The NBRR flows through the Root River Parkway in SR 1-7 and through undeveloped floodplain in SR 8-10.

Geologic Controls: The general north-south orientation of the end moraines controls the locations of the stream channels within the NBRR watershed. (Figure 2). Lateral erosion of the end moraines by the tributaries is the source of most of the coarser sediments (sands and gravels) that are delivered to the NBRR. The NBRR flows on the very low gradient valley floor that is composed of fine-grained, consolidated, and erosion-resistant ground moraine and is generally incapable of transporting the coarser sediments.

Figure 2. Geologic map (USGS, 2004).

Figure 4. Till in bed of NBRR.

Figure 5. Root-reinforced tills.

Vertical Stability: Comparative thalweg data indicate that there has been little bed degradation since 1966 except in SR 1 (due to downstream channelization), SR 4 (due to removal of LWD jams) and SR 10 (due to downstream channelization) (Figure 3). Vertical stability is due to consolidated tills in the bed of NBRR (Figure 4).

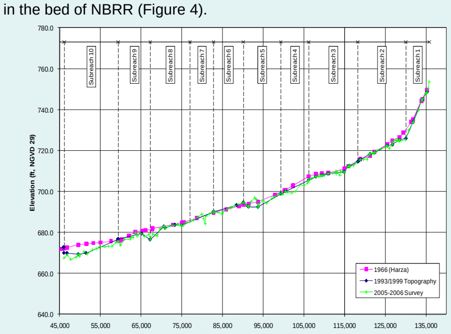


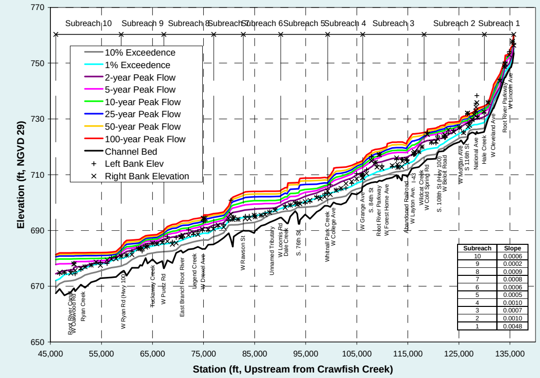
Figure 3. Comparative thalweg profiles for the North Branch Root River.

Lateral Stability: Field mapping indicated that about 9% of the total bank length along the 17 miles of the NBRR is eroding, the bulk of which is located in SR 1 and SR 2 (38%) where there is some bed degradation. General erosion resistance is due to root-reinforced, fine-grained and cohesive banks.

Large Woody Debris: Large woody debris jams have a significant impact on channel capacity and sediment transport. The frequency of LWD jams varies along the NBRR from 2 to 18/mile, with the highest frequency where the riparian vegetation is the densest and most mature (Figure 6).

Figure 6. Large woody debris jam.

Hydraulic Capacity: HEC-RAS modeling was used to identify the channel capacity along the NBRR (Figure 7). Where the NBRR was channelized but not bermed (SR 4-10), the channel capacity is about the 1% exceedence flow which is equal to the pre-development 2-yr RI peak flow. Where the channel was bermed (SR 2-3), the capacity is equal to the present 2-yr peak flow. Channel capacity varies from the 5- to the 100-yr RI peak flow in SR 1 that has incised and is bounded by historic terraces.



Subreach	Slope
10	0.0006
9	0.0002
8	0.0009
7	0.0008
6	0.0006
5	0.0005
4	0.0010
3	0.0007
2	0.0010
1	0.0048

Figure 7. Hydraulic and bed and bank profiles of NBRR.

Sediment Transport: 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 NBRR for existing and future conditions. Where the median size (D_{50}) of the bed material was less than 4 mm, the Yang (1972) equation was used and where the D_{50} exceeded 4mm the Wilcock and Crowe (2003) equation was used (Figure 8). Degradation is predicted in SR 1, SR 9, SR 10 and in SR 3 downstream of historic sand-and-gravel mining pits. Aggradation is predicted downstream of the major tributaries in SR 2, SR 5, and SR 9 where the coarser bed material load delivered by the steeper tributaries is not readily transported by the NBRR. The increased future condition flows generally increase local aggradation in SR 5 and 9 and also increase degradation in SR 3, 9 and 10.

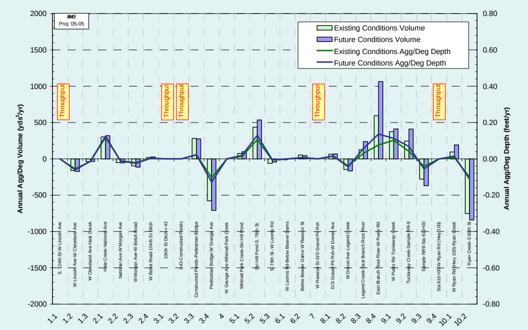


Figure 8. Annual volume of aggradation or degradation under existing and future (2020) hydrologic conditions and corresponding change in bed elevation along NBRR.

CONCLUSIONS & RECOMMENDATIONS

Conclusions: The muted response of the NBRR to extensive anthropogenic changes is due to the combined effects of low channel slopes, erosion-resistant channel boundary materials, low channel capacity and a functioning floodplain. There is no need for large-scale restoration.

Recommendations:

Bank Protection: 26,182 LF of eroding bank

- 2,800 LF (4 sites) that are located < 1 channel width from infrastructure require bio-technical bank protection (Proximity Rating = 1)
- 2,150 LF require monitoring (PR = 2)
- 21,232 LF require no action (PR = 3)

Bed Stabilization: Approx. 7 feet of additional degradation in SR 1

- Three constructed-riffle grade-control structures

Floodplain Protection

- Highly recommended that MMSD continue its open-lands protection policies