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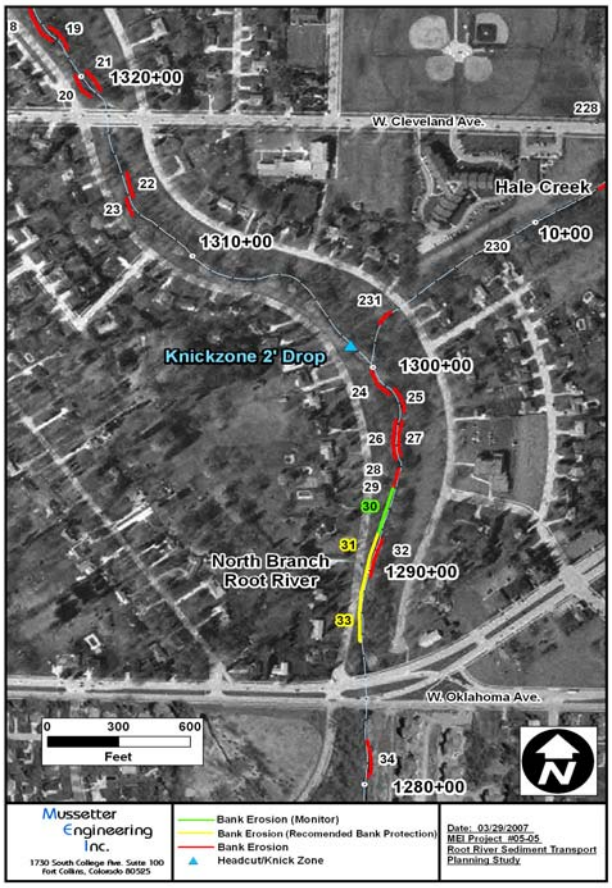
TECHNICAL MEMORANDUM

Management Recommendations

Root River Sediment-transport Planning Study
Contract No. W30003P01



Submitted to: **Milwaukee Metropolitan Sewerage District**
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Milwaukee, Wisconsin 53204

MMSD
Preserving The Environment • Improving Water Quality

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September 7, 2007

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1. INTRODUCTION

The primary purpose of the Root River Sediment Transport Planning Study is to provide the Milwaukee Metropolitan Sewerage District (MMSD) with a tool to predict the impacts of future proposed work for flood management purposes on the vertical and horizontal stability of stream channels within the District's jurisdiction. To this end, Mussetter Engineering, Inc. (MEI) has evaluated the historical and existing conditions within the North Branch Root River and its primary tributaries that are the basis for future predictions (Schumm, 1991). The following Technical Memoranda have been prepared by MEI to document, analyze and predict, the existing and future (2020) conditions, respectively for the North Branch Root River from the South 124th Street Bridge to the confluence of the North and South Branches, as well as the primary tributaries, Hale Creek, Wildcat Creek, 104th Street Ditch, Whitnall Park Creek, Tess Corners Creek, Dale Creek, East Branch Root River, Tuckaway Creek, Legend Creek and Ryan Creek:

- Root River Sediment-transport Planning Study -Surveys
- Root River Sediment-transport Planning Study- Hydrology
- Root River Sediment-transport Planning Study - Hydraulics
- Root River Sediment-transport Planning Study - Geomorphology
- Root River Sediment-transport Planning Study - Sediment Transport

During the course of the field investigation of the North Branch Root River and the primary tributaries, observations were made of vertical and lateral instability of the channel, the presence of large woody debris obstructions in the channels, the presence and performance of bank protection and grade-control measures, and the presence and performance of various infrastructure elements (bridges, stormwater outfalls, utility crossings). These observations, and the results of the quantitative analyses (hydrology, hydraulics, sediment transport), were used to develop a set of management recommendations for the ten identified subreaches of the North Branch Root River as well as the primary tributaries.

In general, the North Branch Root River is relatively insensitive to changes in water and sediment supply (Schumm, 1991). The insensitivity is due primarily to the combined effects of the erosion resistance of the channel boundary materials, relatively flat channel gradients and the presence of a functioning floodplain that dissipates flood energy. The erosion resistance is due to the presence of consolidated and clay-rich till deposits, root reinforcement of the relatively shallow channel banks and the relatively high frequency in many of the subreaches of large woody debris jams that cause backwater conditions and lateral accretion of fine-grained sediments to the banks. Vertical instability is present in the uppermost subreach of the North Branch Root River, the result of direct channelization, channelization-induced baselevel lowering and steeper slopes.

The primary tributaries to the North Branch Root River tend to exhibit more lateral erosion because the slopes are steeper as they traverse the end moraines, the tills that comprise the moraines are more heterogeneous, and for some of the tributaries, the floodplain has been encroached. The coarser bed materials derived from the end moraines tend to armor the bed of the tributary channels, but a number of boulder grade-control structures have been emplaced, primarily in the East Branch Root River, to counter the effects of channelization and straightening of the channel. The lower reaches of Whitnall Park Creek, Tess Corners Creek, Tuckaway Creek and Legend Creek are laterally eroding their relatively coarse-grained alluvial fans due to clear-water scour in response to the upstream presence of ponds and other small detention structures that effectively trap all the upstream-supplied bed material.

2. GENERAL RECOMMENDATIONS

Existing issues that require addressing on the North Branch Root River and the primary tributaries are:

- lateral and vertical channel stability
- performance of existing bed and bank protection structures
- performance of existing stormwater outlets
- performance of existing bridges and culverts
- management of large woody debris jams, and
- management of the existing impoundments and the associated downstream channel erosion.

Criteria for addressing the risk associated with lateral and vertical instability and damage to existing bed and bank protection were developed from the knowledge gained from the various technical analyses conducted for this study and observations of system behavior over about a 50-year time frame.

2.1. Channel Instability

A total of 26,182 lineal feet of bank erosion was mapped on the North Branch Root River (19,933 feet) and its primary tributaries (6,249 feet). Based on the historical behavior of the river and tributaries, it is apparent that both lateral and vertical erosion rates are low, and therefore, neither forms of channel instability are likely to cause catastrophic problems during a single flood event. Based on the historic system behavior, algorithms for assessing erosion risk and prioritizing sites for remediation were developed.

2.1.1. Bank Erosion and Lateral Instability

The risk of lateral erosion affecting infrastructure (roads, bridges, houses) was assessed on the basis of the distance between the eroding bank and the infrastructure element expressed as multiples of the channel width. If the distance from the eroding bank is equal to, or less than, 1 channel width, the Proximity Rating (PR) is 1. If the distance is between 1 and 2 channel widths the PR is 2, and if the distance is greater than two channel widths, the PR is 3. If the PR is 1, the risk of erosion damage is considered to be high enough to warrant action. If the PR is 2, the risk is such that monitoring of the site will suffice, and if the PR is 3, the risk is low enough to warrant no action. Category 1 sites were further prioritized based on the nature of the bank

materials, with a higher rating being assigned to non-cohesive soils and a lower rating being assigned to the cohesive soils.

Table 2.1 provides a summary of the risk assessments and the prioritizations for the North Branch Root River and the primary tributaries. Based on the risk assessment, about 1.450 lineal feet of bank erosion at 10 locations on the North Branch Root River is rated as Category 1 and of this, about 380 lineal feet has the higher priority rating based on the potential erodibility of the bank materials. All of the Category 1 sites are located in Subreaches 1, 2, 3 and 10, but the higher priority locations are located in Subreaches 2 and 10. Approximately 2,110 lineal feet of eroding bank were rated as Category 2, and because of the lower level of risk, they should be monitored. The remainder of the observed erosion (16,510 lineal feet) is rated as Category 3, and as such, poses so little risk to infrastructure that no action is required.

Table 2.1. Summary of bank erosion lengths and instances, by subreach, and the length and priority for bank protection.

Subreach	Total Length of Bank Erosion (ft)	Number of Bank Erosion Sites	Total Length of Bank Erosion to Monitor (ft)	Number of Bank Erosion Sites to Monitor	Total Length of Bank Erosion to Protect (ft)	Number of Bank Erosion Sites to Protect	Total Length Designated High Priority (ft)	Number of Bank Erosion Sites Designated High Priority
North Branch Root River								
1	2,200	23	70	2	380	3	0	0
2	4,990	43	410	2	510	2	280	1
3	6,060	51	1130	6	100	1	0	0
4	940	11	0	0	0	0	0	0
5	60	2	20	1	0	0	0	0
6	220	3	0	0	0	0	0	0
7	190	2	0	0	0	0	0	0
8	2,380	32	330	0	100	1	0	0
9	560	9	150	1	0	0	0	0
10	2,850	41	0	0	360	3	100	1
Tributaries								
Hale Creek	290	5	0	0	0	0	0	0
104th Street Ditch	160	3	0	0	0	0	0	0
Wildcat Creek	290	6	0	0	0	0	0	0
Whitnall Park Creek	1,170	23	0	0	0	0	0	0
Tess Corners Creek	310	6	0	0	0	0	0	0
Dale Creek	0	0	0	0	0	0	0	0
Unnamed Tributary	0	0	0	0	0	0	0	0
Legend Creek	70	1	0	0	0	0	0	0
East Branch Root Rive	4,540	82	140	2	80	2	0	0
Tuckaway Creek	60	1	0	0	0	0	0	0
Ryan Creek	0	0	0	0	0	0	0	0

Table 2.1 also provides an erosion assessment summary for the primary tributaries to the North Branch Root River. Approximately 6,720 lineal feet of eroding bank was observed in the tributary channels, but only 2 locations (80 lineal feet) in the East Branch Root River were rated as Category 1 risks. Category 2 risks were assessed at twp locations (in the East Branch Root River), and these have a combined length of 170 lineal feet. Monitoring of the Category 2 locations is recommended. The remainder of the observed erosion (6,500 lineal feet) is rated as Category 3, and as such, poses so little risk to infrastructure that no action is required.

Bank protection is the appropriate course of action at the Category 1 locations in both the North Branch Root River and the primary tributaries. Composite forms of bank protection that have an armored toe with bio-technical upper bank protection will provide bank stabilization while also improving the aesthetics of the sites. Where site conditions permit, a rock toe and a fully bio-

technical upper bank treatment can be used (**Figure 2.1**). If site conditions are more limited, the mid-bank region can be protected with backfilled and planted geocells that permit a steeper mid-slope segment between the armored toe and the planted upper bank (**Figure 2.2**).

2.1.2. Bed Erosion and Vertical Instability

Most probably as a result of downstream channelization in Subreach 2 and 3 that caused baselevel lowering for Subreach 1, the bed of the North Branch Root River has degraded into the till deposits that comprise the bed of the channel in Subreach 1. Headcuts (2) and knickzones (2) with about 2 to 3 feet of drop across them were observed in the bed of the channel between West Oklahoma Avenue and West Lincoln Avenue. Cumulatively, the knickpoints and headcuts located between West Cleveland Avenue and West Lincoln Avenue could lower the bed of the channel by up to 7 feet. Degradation of this magnitude would most likely cause the bank height to exceed the critical height (Harvey and Watson, 1986), thereby leading to mass failure of the banks and general destabilization of the channel (Schumm et al., 1984). Where the channel is located adjacent to South 124th Street, degradation-induced mass failure is likely to have an adverse impact on road stability, and thus, public safety. Additionally, the integrity of the historic WPA wall located on the east bank of the channel between Sta 1303+20 and Sta1305+60 is threatened by a 3-foot high knickzone at the downstream end of the wall. Stabilization of the knickpoints and headcuts can be accomplished with suitably designed and sized constructed riffles that have the advantages of being adjustable and more aesthetically pleasing (**Figure 2.3**).

Based on the comparative thalweg profiles (Figure 4.3, Geomorphology Technical Memorandum), field observations and the results of the sediment transport modeling, it appears as though Subreach 10 of the North Branch Root River is also degradational. However, since the West Oakwood Road culverts are likely to be replaced with a span bridge, and recent bridge replacements have included riprap placement on the bed and banks, it is unlikely that further grade control will be required in the subreach.

2.2. Infrastructure

Field inspections identified the status of existing locations of bank-protection and grade-control structures, in the North Branch Root River and the primary tributaries.

2.2.1. Bank-protection Structures

Two levels of assessment were applied to the existing bank-protection structures. First, an assessment was made as to whether the structure was functioning or not, or was damaged but still functioning. Second, the proximity to other infrastructure elements was assessed with a channel width-based metric. Risk was evaluated as a combination of damage and proximity to other infrastructure elements. If the failed or damaged structure was less than 1 channel width away from an adjacent infrastructure element (e.g., road, bike path or bridge), it was placed in Category 1. If the failed or damaged structure was between 1 and 2 channel widths away from an infrastructure element, it was placed in Category 2, and if the distance was greater than 2 channel widths it was placed in Category 3. Category 1 sites require replacement or rehabilitation, Category 2 sites should be monitored, and no action is required at Category 3 sites.

On the banks of the North Branch Root River, about 3,740 lineal feet of bank protection has been installed over time, mainly in Subreaches 1, 2 and 3 (**Table 2.2**). Based on the risk assessment, no sites were rated in Categories 1 and 2, and therefore, there is no need to either replace or rehabilitate failed or damaged sites, nor monitor any of the failed or damaged sites.

Table 2.2. Summary of lengths and numbers of bank protection sites, by subreach, and the locations where monitoring or replacement are recommended.

Subreach	Total Length of Bank Protection (ft)	Number of Bank Protection Sites	Total Length of Bank Protection to Monitor (ft)	Number of Bank Protection Sites to Monitor	Total Length of Bank Protection to Replace (ft)	Number of Bank Protection Sites to Replace
North Branch Root River						
1	1,500	12	0	0	0	0
2	1,460	12	0	0	0	0
3	310	5	0	0	0	0
4	0	0	0	0	0	0
5	10	1	0	0	0	0
6	70	1	0	0	0	0
7	0	0	0	0	0	0
8	70	1	0	0	0	0
9	240	4	0	0	0	0
10	80	2	0	0	0	0
Tributaries						
Hale Cr	340	3	0	0	0	0
104th Street Ditch	240	4	0	0	0	0
Wildcat Cr	320	2	0	0	0	0
Whitnall Park Cr	3,030	23	0	0	40	2
Tess Corners Cr	390	2	260	1	0	0
Dale Cr	0	0	0	0	0	0
Unnamed Trib	0	0	0	0	0	0
Legend Cr	0	0	0	0	0	0
East Branch Root River	1,210	26	0	0	60	1
Tuckaway Cr	0	0	0	0	0	0
Ryan Cr	50	1	0	0	0	0

On the banks of the primary tributaries, about 5,580 lineal feet of bank protection has been installed over time (Table 2.2). Based on the risk assessment, 50 lineal feet of a single Category 1 site requires replacement or rehabilitation on Whitnall Park Creek, and a further 57 lineal feet of a single Category 2 requires monitoring on Tess Corners Creek.

2.2.2. Grade-control Structures

Two riprap grade-control structures are located within Subreach 1 between West Cleveland Avenue and West Lincoln Avenue. Both of the structures show some signs of rock loss and rock displacement, but they are still functional. Addition of constructed riffles in Subreach 1 will provide the required level of bed stabilization, and therefore, there is no need for replacement or rehabilitation of the existing riprap structures. Existing grade control in the remainder of the subreaches in the North Branch Root River does not require monitoring, replacement or rehabilitation.

Because of the generally coarser nature of the bed material derived from the end moraines, and the existing presence of a number of rock riprap grade-control structures and concrete bridge sills, there were no identified requirements for additional grade control in the primary tributaries.

2.3. Large Woody Debris Management

The riparian corridor along the North Branch Root River has expanded over the last several decades as adjacent land use has shifted from agriculture to parkland (Harza, 1966; see Geomorphology Technical Memorandum). This expansion will likely continue over time given the regulatory objectives of watercourse protection. As a consequence, the size and quantity of LWD that enters the river will likely increase, as will the number of woody debris obstructions in the channel. Woody debris obstructions may increase the frequency of overbank flooding and the rate of channel shifting adjacent to debris jams. In general, however, the obstructions will continue to contribute to the functional geomorphic character and biologic health of the river and floodplain.

From a land management perspective, the LWD processes of recruitment, transport, and storage should be considered appropriate and beneficial to the health and function of the Root River system. Most bridges on the North Branch Root River (with the exception of West Drexel Avenue and West Oakwood Road) are capable of passing wood transported by the river. Large trees that do collect on bridges should be removed as needed. Where not located immediately upstream of a bridge, it is recommended that trees leaning toward the river, and LWD obstructions in the channel, be left intact. It is further recommended that mowing to the edge of the river banks cease, and that an unmanaged vegetation buffer be maintained; a buffer width equal to the channel top width would be appropriate. Development and maintenance of a woody riparian strip will increase root reinforcement of the channel bank materials, thereby reducing the risk of lateral erosion.

It is recommended that the North Branch Root River floodplain be managed to prevent or strictly limit encroachment and inundation-sensitive development. In other words, uses such as athletic fields may be appropriate in the floodplain, while occupied structures may not. In all cases, the riparian vegetation corridor should be preserved and, where lacking, expanded. Although the floodplain is fairly broad, the water-surface elevations of floods may increase with the gradual accumulation of LWD in the channel over the next several decades. As such, flood managers should account for these potential future flood elevation increases as part of land use planning.

2.4. Impoundments

Water impoundments are present in the lower reaches of a number of the primary tributaries to the North Branch Root River, including Whitnall Park Creek, Tess Corners Creek, Legend Creek

and Tuckaway Creek. In general, the ponds and dams have high trap efficiencies for the bed material sediments supplied from the upstream watershed and channels, and consequently the channels downstream of the structures exhibit bank erosion due to clear-water scour. Most of the downstream bank erosion takes place as the tributary channels traverse their relatively coarse grained alluvial fans, but there is no evidence of vertical instability because of the coarseness of the bed material. Since the fans are undeveloped, there is little point in preventing the bank erosion which compensates to some extent for the sediment trapped in the impoundments. Removal of the impoundments and restoration of the channels is unlikely to be very successful because the upstream watersheds have been developed, or are in the process of being developed, and thus the sediment-water ratios have already changed, or will change, to the point where channel equilibrium is unlikely to be achieved. Consequently, the water impoundments, which provide recreational and other benefits, may as well be maintained. Mechanical removal of deposited sediments from the impoundments may be required periodically.

3. SUBREACH-SPECIFIC RECOMMENDATIONS

The North Branch Root River was subdivided into 10 subreaches on the basis of watershed hydrology, the locations of significant hydraulic controls, and geomorphic characteristics (**Table 3.1**) (see Technical Memorandum: Geomorphology).

Table 3.1. Location of the geomorphic subreaches in the North Branch Root River.

Subreach	Upstream Limit	Downstream Limit	Upstream Station (ft)	Downstream Station (ft)	Subreach Length (mi)
1	S 124th Street (Milwaukee-Waukesha County Line)	Hale Creek	1357+48	1300+00	1.1
2	Hale Creek	Wildcat Creek	1300+00	1182+00	2.2
3	Wildcat Creek	West Grange Avenue	1182+00	1061+58	2.3
4	West Grange Avenue	Whitnall Park Creek	1061+58	993+00	1.3
5	Whitnall Park Creek	West Loomis Rd (Hwy 36)	993+00	901+04	1.7
6	West Loomis Rd (Hwy 36)	West Rawson Avenue	901+04	827+85	1.4
7	West Rawson Avenue	Below Gravel Pits	827+85	770+00	1.1
8	Below Gravel Pits	West Puetz Road	770+00	672+26	1.9
9	West Puetz Road	West Ryan Rd (Hwy 100)	672+26	593+69	1.5
10	West Ryan Rd (Hwy 100)	South 60th Street	593+69	460+68	2.5

3.1. North Branch Root River, Subreach 1

3.1.1. Channel Stability

3.1.1.1. Bank Erosion

Twenty-three sites with active bank erosion were identified in Subreach 1, with a total length of 2,200 lineal feet (**Table 3.2**). About 430 lineal feet of bank protection is recommended at four locations where the eroding bank is less than one channel width away from infrastructure

(Category 1). If left unprotected, erosion of the right bank at these locations (Sta 1349+50, Sta 1348+50, Sta 1347+30, and Sta 1343+60) could affect South 124th Street (**Appendix A**). Because the bank erosion at these locations is caused by weathering of the cohesive bank material and the erosion rates are low, the priority for installation of bank protection is lower.

Table 3.2. Summary of sites with bank erosion in Subreach 1 of the North Branch Root River and the recommended course of action for each site.

Bank Erosion Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Bank Material	Failure Mechanism [1]	Proximity to Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [2]	Course of Action	Priority [3]
1	1355+60	1355+10	1355+40	50	Cohesive	W	20	14	2	Monitor	-
2	1354+90	1353+80	1354+40	110	Cohesive	W	33	14	3	None	-
3	1353+80	1353+50	1353+70	30	Cohesive	W	208	14	3	None	-
4	1353+30	1352+80	1353+10	50	Cohesive	W	43	14	3	None	-
5	1353+30	1352+70	1353+00	60	Cohesive	W	203	14	3	None	-
6	1352+70	1352+10	1352+40	60	Cohesive	W	187	14	3	None	-
7	1352+70	1352+10	1352+40	60	Cohesive	W	50	14	3	None	-
8	1351+30	1350+70	1351+00	60	Cohesive	W	54	14	3	None	-
9	1350+50	1349+90	1350+20	60	Cohesive	W	100	14	3	None	-
10	1350+10	1349+90	1350+00	20	Cohesive	W	20	14	2	Monitor	-
11	1349+70	1349+20	1349+50	50	Cohesive	W	30	14	3	None	-
12	1348+80	1348+20	1348+50	60	Cohesive	W	12	14	1	Protect	Low
13	1348+70	1348+10	1348+40	60	Cohesive	W	89	14	3	None	-
14	1347+90	1346+60	1347+30	130	Cohesive	W	12	14	1	Protect	Low
15	1346+40	1345+00	1345+70	140	Cohesive	W	32	14	3	None	-
16	1344+50	1342+60	1343+60	190	Cohesive	W	11	14	1	Protect	Low
17	1328+20	1325+60	1326+90	260	Noncohesive	G/G	89	14	3	None	-
18	1324+00	1322+10	1323+10	190	Cohesive	W	42	14	3	None	-
19	1322+70	1321+40	1322+10	130	Cohesive	W	213	14	3	None	-
20	1320+20	1319+10	1319+70	110	Noncohesive	G/G	34	14	3	None	-
21	1320+10	1318+90	1319+50	120	Noncohesive	G/G	40	14	3	None	-
22	1315+00	1313+80	1314+40	120	Cohesive	W	30	14	3	None	-
23	1313+90	1313+10	1313+50	80	Cohesive	W	40	14	3	None	-

[1] W = weathering, G/G = grain by grain, MF = mass failure

[2] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[3] Low protection priority for weathering, high priority for grain by grain erosion.

The bank erosion should be monitored at the Category 2 sites (Sta 1355+40 and Sta 1350+00), since the eroding bank at these locations is between 1 and 2 channel widths away from South 124th Street.

3.1.1.2. Vertical Stability

Numerous headcuts and knickzones were identified in Subreach 1, as well as areas of general channel downcutting (Appendix A). Three constructed rock riffle grade-control structures are recommended in Subreach 1. To prevent further lateral instability that could affect South 124th Street, a constructed rock riffle grade-control structure is recommended at the upstream headcut above the Root River Parkway Bridge (Sta 1341+70). A second grade-control structure is recommended at the existing headcut at Sta 1326+90. The third grade-control structure is recommended at the headcut at Sta 1301+30 to limit upstream migration that could undermine the Works Progress Administration (WPA) rock wall.

3.1.2. Infrastructure

3.1.2.1. Bank Protection

Twelve sites with existing bank protection were identified in Subreach 1 with a total length of 1,500 lineal feet (**Table 3.3, Appendix B**). All of the existing bank protection, including the damaged portion of the WPA rock wall at Sta 1303+40, is functioning and, therefore, does not require replacement. However, given the historical significance of the WPA rock wall, installation of riprap through the scour hole that is undermining the wall foundation is recommended to avoid further damage to the wall.

Table 3.3. Summary sites with existing bank protection in Subreach 1 of the North Branch Root River and the recommended course of action for each site.

Bank Protection Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Damaged	Functioning	Proximity to Other Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [1]	Course of Action [2,3]
1	1320+60	1320+40	1320+50	20	No	Yes	170	14	3	None
2	1318+80	1318+20	1318+50	60	No	Yes	73	14	3	None
3	1318+70	1318+20	1318+50	50	No	Yes	99	14	3	None
4	1317+20	1315+40	1316+30	180	No	Yes	35	14	3	None
5	1317+10	1315+30	1316+20	180	No	Yes	91	14	3	None
6	1310+60	1306+80	1308+70	380	No	Yes	33	14	3	None
7	1306+40	1306+10	1306+30	30	No	Yes	59	14	3	None
8	1305+60	1304+20	1304+90	140	No	Yes	74	14	3	None
8.1	1303+70	1303+20	1303+50	50	No	Yes	74	14	3	None
9	1304+20	1303+70	1304+00	50	Yes	Yes	134	14	3	None
10	1302+50	1300+60	1301+60	190	No	Yes	218	14	3	None
11	1302+50	1300+80	1301+70	170	No	Yes	34	14	3	None

[1] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[2] Replace if damaged and not functioning with Proximity Rating of 1.
Monitor if damaged and not functioning with Proximity Rating of 2 or 3 or damaged and functioning with Proximity Rating of 1.
Otherwise, no course of action is recommended.

[3] Replace with hard toe and a soft upper. See text for explanation.

3.1.2.2. Grade Control

Grade control in Subreach 1 (Appendix B) is provided by two sections of rock-lined channel below South 124th Street and below West Cleveland Avenue, two rock sills (Sta 1319+28 and Sta 1336+14), and the concrete sill below West Lincoln Avenue. Except for the rock sill at Sta 1336+14, the features are not damaged and provide grade control. Since three rock riffle grade-control structures are recommended in the vicinity of the damaged rock sill (Sta 1336+14), this structure does not require replacement, but it should be monitored to ensure that local incision does not result in increased erosion of the right bank that could affect the South Root River Parkway.

3.1.2.3. Storm Drain Outfalls

Eight storm drain outfalls were identified in Subreach 1 (Appendix B). The failed portion of the 12-inch concrete culvert outlet at Sta 1318+70 should be removed to prevent further local scour, if possible.

3.1.2.4. Bridge and Culvert Crossings

Publicly owned bridge crossings in Subreach 1 include the corrugated metal pipe (CMP) culvert crossing at South 124th Street, the reinforced concrete box culvert (RCBC) at West Lincoln Avenue, the RCBC at the South Root River Parkway Bridge, and the RCBCs at West Cleveland Avenue. Each of the structures is functioning (hydraulically), and as such, no action is required.

3.2. North Branch Root River, Subreach 2

3.2.1. Channel Stability

3.2.1.1. Bank Erosion

Forty-three sites with active bank erosion were identified in Subreach 2, with a total length of 4,990 lineal feet (**Table 3.4**). About 510 lineal feet of bank protection is recommended at two locations where the eroding bank is less than one channel width away from infrastructure (Category 1). If left unprotected, erosion of the right bank at these locations (Sta 1290+40 and Sta 1289+00) could affect South Root River Parkway (Appendix A). Installation of bank protection along the right bank at Sta 1290+40 is higher priority, since the bank materials are non-cohesive and the erosion rates associated with grain-by-grain erosion are relatively high. Because the bank erosion at Sta 1289+00 is caused by weathering of the cohesive bank material and the erosion rates are low, the priority for installation of bank protection is lower at this location. The bank erosion should be monitored at the Category 2 sites, since the eroding bank at these locations is between 1 and 2 channel widths away from South Root River Parkway (Sta 1292+90) and the bike path near Sta 1203+80.

3.2.1.2. Vertical Stability

In Subreach 2, there is little evidence of vertical instability of the channel.

3.2.2. Infrastructure

3.2.2.1. Bank Protection

Twelve sites with existing bank protection were identified in Subreach 2 with a total length of 1,460 lineal feet (**Table 3.5**, Appendix B). The existing bank protection sites are not damaged and are functioning, and as such, no action is required.

3.2.2.2. Grade Control

Grade control in Subreach 2 (Appendix B) is provided by two rock sills that protect utility crossings (Sta 1205+70 and Sta 1275+90), and rock riprap in the channel bed to protect against contraction scour at the S 116th Street Bridge and the Beloit Road Bridge. The features do not require replacement since they are not damaged and are functioning. In addition, remnants of rock sills were identified at old (broken) metal pipeline crossings at Sta 1236+40 and Sta 1238+30 that do not provide sufficient grade control, but should be monitored for future local scour.

3.2.2.3. Storm Drain Outfalls

Five storm drain outfalls were identified in Subreach 2 (Appendix B). None of the storm drain outfalls are damaged and do not require any course of action.

Table 3.4. Summary of sites with bank erosion in Subreach 2 of the North Branch Root River and the recommended course of action for each site.

Bank Erosion Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Bank Material	Failure Mechanism [1]	Proximity to Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [2]	Course of Action	Priority [3]
24	1299+90	1298+60	1299+30	130	Cohesive	W	82	36	3	None	-
25	1298+60	1297+60	1298+10	100	Cohesive	W	162	36	3	None	-
26	1297+20	1295+40	1296+30	180	Cohesive	W	92	36	3	None	-
27	1297+10	1295+50	1296+30	160	Cohesive	W	187	36	3	None	-
28	1294+90	1294+30	1294+60	60	Cohesive	W	95	36	3	None	-
29	1294+10	1294+00	1294+10	10	Cohesive	W	167	36	3	None	-
30	1293+90	1291+80	1292+90	210	Cohesive	W	37	36	2	Monitor	-
31	1291+80	1289+00	1290+40	280	Noncohesive	G/G	5	36	1	Protect	High
32	1289+70	1291+50	1290+60	180	Noncohesive	G/G	153	36	3	None	-
33	1289+00	1286+70	1287+90	230	Cohesive	W	7	36	1	Protect	Low
34	1282+00	1280+40	1281+20	160	Cohesive	W	103	36	3	None	-
35	1273+40	1271+50	1272+50	190	Noncohesive	G/G	80	36	3	None	-
36	1270+90	1268+60	1269+80	230	Cohesive	W	258	36	3	None	-
37	1264+70	1263+70	1264+20	100	Cohesive	W	110	36	3	None	-
38	1264+10	1263+50	1263+80	60	Cohesive	W	210	36	3	None	-
39	1263+20	1262+70	1263+00	50	Cohesive	W	239	36	3	None	-
40	1262+50	1261+90	1262+20	60	Cohesive	W	81	36	3	None	-
41	1261+20	1262+20	1261+70	100	Cohesive	W	239	36	3	None	-
42	1261+10	1260+50	1260+80	60	Cohesive	W	200	36	3	None	-
43	1259+60	1259+30	1259+50	30	Cohesive	W	92	36	3	None	-
44	1256+70	1256+10	1256+40	60	Cohesive	W	83	36	3	None	-
45	1256+60	1256+10	1256+40	50	Cohesive	W	117	36	3	None	-
46	1253+00	1252+20	1252+60	80	Cohesive	W	169	36	3	None	-
47	1251+60	1251+00	1251+30	60	Cohesive	W	94	36	3	None	-
48	1249+70	1249+10	1249+40	60	Cohesive	W	169	36	3	None	-
49	1247+80	1247+10	1247+50	70	Cohesive	W	164	36	3	None	-
50	1244+00	1242+30	1243+20	170	Cohesive	W	76	36	3	None	-
51	1242+00	1241+50	1241+80	50	Cohesive	W	82	36	3	None	-
52	1237+90	1236+70	1237+30	120	Cohesive	W	101	36	3	None	-
53	1234+50	1232+50	1233+50	200	Cohesive	W	158	36	3	None	-
54	1222+20	1221+40	1221+80	80	Cohesive	W	77	36	3	None	-
55	1220+80	1220+40	1220+60	40	Cohesive	W	144	36	3	None	-
56	1209+80	1209+40	1209+60	40	Cohesive	W	90	36	3	None	-
57	1208+60	1208+10	1208+40	50	Cohesive	W	74	36	3	None	-
58	1207+50	1206+40	1207+00	110	Noncohesive	G/G	258	36	3	None	-
59	1204+80	1202+90	1203+90	190	Noncohesive	G/G	126	36	3	None	-
60	1204+80	1202+80	1203+80	200	Noncohesive	G/G	60	36	2	Monitor	-
61	1201+60	1201+40	1201+50	20	Cohesive	W	187	36	3	None	-
62	1200+30	1198+30	1199+30	200	Cohesive	W	117	36	3	None	-
63	1200+30	1199+50	1199+90	80	Cohesive	W	95	36	3	None	-
64	1195+90	1193+90	1194+90	200	Cohesive	W	101	36	3	None	-
65	1192+80	1193+50	1193+20	70	Cohesive	W	105	36	3	None	-
66	1191+30	1189+20	1190+30	210	Cohesive	W	105	36	3	None	-

[1] W = weathering, G/G = grain by grain, MF = mass failure

[2] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[3] Low protection priority for weathering, high priority for grain by grain erosion.

Table 3.5. Summary of sites with existing bank protection in Subreach 2 of the North Branch Root River and the recommended course of action for each site.

Bank Protection Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Damaged	Functioning	Proximity to Other Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [1]	Course of Action [2,3]
12	1268+30	1266+30	1267+30	200	No	Yes	100	36	3	None
13	1268+20	1266+40	1267+30	180	No	Yes	101	36	3	None
14	1254+90	1253+60	1254+30	130	No	Yes	324	36	3	None
15	1254+80	1253+60	1254+20	120	No	Yes	394	36	3	None
17	1223+30	1222+10	1222+70	120	No	Yes	248	36	3	None
18	1223+20	1222+10	1222+70	110	No	Yes	405	36	3	None
19	1213+30	1211+80	1212+60	150	No	Yes	33	36	1	None
20	1213+20	1211+70	1212+50	150	No	Yes	29	36	1	None
21	1205+70	1205+00	1205+40	70	No	Yes	59	36	2	None
22	1205+70	1205+00	1205+40	70	No	Yes	279	36	3	None
23	1188+60	1187+80	1188+20	80	No	Yes	41	36	2	None
24	1188+50	1187+70	1188+10	80	No	Yes	84	36	3	None

[1] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[2] Replace if damaged and not functioning with Proximity Rating of 1.

[3] Replace with hard toe and a soft upper. See text for explanation.

3.2.2.4. Bridge and Culvert Crossings

Publicly owned bridge crossings in Subreach 2 include the RCBCs at West National Avenue and the bridges at South 116th Street, West Morgan Avenue, West Beloit Road, South 108th Street (State Highway 100), West Cold Spring Road, and a pedestrian bridge is located at Sta 1204+20. Each of the structures is functioning (hydraulically), and as such, no action is required.

3.3. North Branch Root River, Subreach 3

3.3.1. Channel Stability

3.3.1.1. Bank Erosion

Fifty-one sites with active bank erosion were identified in Subreach 3, with a total length of 6,060 lineal feet (**Table 3.6**). About 100 lineal feet of bank protection is recommended where the eroding bank is less than one channel width away from infrastructure (Category 1). If left unprotected, erosion of the left bank at Sta 1153+80 could affect South Root River Parkway (Appendix A). Because the bank erosion at this location is caused by weathering of the cohesive bank material and the erosion rates are low, the priority for installation of bank protection is lower. The bank erosion should be monitored at the six Category 2 sites, since the eroding bank at these locations is between 1 and 2 channel widths away from Root River Parkway (Sta 1152+30, Sta 1125+50, Sta 1099+50, Sta 1097+20, Sta 1091+20 and Sta 1068+90).

3.3.1.2. Vertical Stability

In Subreach 3, there is little evidence of vertical instability of the channel.

Table 3.6. Summary of sites with bank erosion in Subreach 3 of the North Branch Root River and the recommended course of action for each site.

Bank Erosion Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Bank Material	Failure Mechanism [1]	Proximity to Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [2]	Course of Action	Priority [3]
68	1180+50	1178+30	1179+40	220	Cohesive	W	115	52	3	None	-
69	1178+30	1177+60	1178+00	70	Noncohesive	G/G	112	52	3	None	-
70	1177+40	1176+70	1177+10	70	Cohesive	W	118	52	3	None	-
71	1176+10	1176+00	1176+10	10	Cohesive	W	280	52	3	None	-
72	1176+00	1175+40	1175+70	60	Cohesive	W	290	52	3	None	-
73	1174+60	1174+20	1174+40	40	Cohesive	W	270	52	3	None	-
74	1174+10	1173+70	1173+90	40	Cohesive	W	250	52	3	None	-
75	1172+50	1172+20	1172+40	30	Cohesive	W	220	52	3	None	-
76	1172+00	1171+60	1171+80	40	Cohesive	W	226	52	3	None	-
77	1171+90	1171+50	1171+70	40	Cohesive	W	208	52	3	None	-
78	1167+80	1166+80	1167+30	100	Cohesive	W	400	52	3	None	-
79	1166+80	1166+20	1166+50	60	Cohesive	W	181	52	3	None	-
80	1158+10	1157+10	1157+60	100	Cohesive	W	396	52	3	None	-
81	1155+60	1154+40	1155+00	120	Cohesive	W	530	52	3	None	-
82	1154+30	1153+30	1153+80	100	Cohesive	W	20	52	1	Protect	Low
83	1153+20	1152+90	1153+10	30	Cohesive	W	311	52	3	None	-
84	1152+60	1152+00	1152+30	60	Cohesive	W	79	52	2	Monitor	Low
85	1151+90	1150+70	1151+30	120	Cohesive	W	387	52	3	None	-
86	1150+70	1150+00	1150+40	70	Cohesive	W	147	52	3	None	-
87	1150+00	1149+40	1149+70	60	Cohesive	W	498	52	3	None	-
88	1149+50	1148+80	1149+20	70	Cohesive	W	231	52	3	None	-
89	1148+90	1148+20	1148+60	70	Cohesive	W	347	52	3	None	-
90	1147+50	1147+10	1147+30	40	Cohesive	W	275	52	3	None	-
91	1145+40	1146+60	1146+00	120	Cohesive	W	188	52	3	None	-
92	1145+10	1144+70	1144+90	40	Cohesive	W	238	52	3	None	-
93	1142+50	1141+80	1142+20	70	Cohesive	W	240	52	3	None	-
94	1138+90	1136+90	1137+90	200	Cohesive	W	125	52	3	None	-
95	1136+90	1136+30	1136+60	60	Cohesive	W	324	52	3	None	-
96	1127+60	1123+30	1125+50	430	Noncohesive	G/G	83	52	2	Monitor	-
97	1124+60	1123+20	1123+90	140	Noncohesive	G/G	333	52	3	None	-
98	1117+90	1123+10	1120+50	520	Cohesive	W	174	52	3	None	-
99	1114+60	1114+50	1114+60	10	Noncohesive	G/G	106	52	3	None	-
100	1113+10	1114+30	1113+70	120	Cohesive	W	124	52	3	None	-
102	1112+10	1110+90	1111+50	120	Cohesive	W	281	52	3	None	-
101	1111+50	1113+00	1112+30	150	Cohesive	W	145	52	3	None	-
103	1107+50	1106+20	1106+90	130	Cohesive	W	223	52	3	None	-
104	1104+70	1103+20	1104+00	150	Cohesive	W	141	52	3	None	-
105	1102+90	1101+00	1102+00	190	Cohesive	W	135	52	3	None	-
106	1097+90	1101+00	1099+50	310	Cohesive	W	92	52	2	Monitor	-
107	1096+80	1097+50	1097+20	70	Cohesive	W	91	52	2	Monitor	-
108	1090+60	1091+80	1091+20	120	Noncohesive	G/G	92	52	2	Monitor	-
109	1088+30	1088+10	1088+20	20	Cohesive	W	138	52	3	None	-
110	1086+50	1085+50	1086+00	100	Noncohesive	G/G	230	52	3	None	-
111	1082+00	1084+10	1083+10	210	Noncohesive	G/G	109	52	3	None	-
112	1082+00	1080+60	1081+30	140	Cohesive	W	125	52	3	None	-
113	1075+70	1078+90	1077+30	320	Cohesive	W	212	52	3	None	-
114	1075+00	1073+00	1074+00	200	Noncohesive	G/G	330	52	3	None	-
115	1069+90	1069+80	1069+90	10	Noncohesive	G/G	512	52	3	None	-
116	1067+90	1069+90	1068+90	200	Cohesive	W	103	52	2	Monitor	-
117	1063+80	1065+30	1064+60	150	Cohesive	W	145	52	3	None	-
118	1062+20	1063+60	1062+90	140	Cohesive	W	223	52	3	None	-

[1] W = weathering, G/G = grain by grain, MF = mass failure

[2] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[3] Low protection priority for weathering, high priority for grain by grain erosion.

3.3.2. Infrastructure

3.3.2.1. Bank Protection

Five sites with existing bank protection were identified in Subreach 3 with a total length of 310 lineal feet (**Table 3.7,** Appendix B). No action is required at the existing bank protection sites since the sites are not damaged and are functioning.

Table 3.7. Summary of existing bank protection in Subreach 3 of the North Branch Root River and the recommended course of action for each site.

Bank Protection Number	Start Station (ft)	Stop Station (ft)	Mipoint Station (ft)	Length (ft)	Damaged	Functioning	Proximity to Other Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [1]	Course of Action [2,3]
25	1173+50	1172+80	1173+15	70	No	Yes	228	52	3	None
27	1159+10	1158+60	1158+85	50	No	Yes	19	52	1	None
27.1	1159+10	1158+60	1158+85	50	No	Yes	19	52	1	None
28	1086+40	1086+90	1086+65	50	No	Yes	34	52	1	None
29	1078+60	1079+50	1079+05	90	No	Yes	143	52	3	None

[1] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[2] Replace if damaged and not functioning with Proximity Rating of 1.
Monitor if damaged and not functioning with Proximity Rating of 2 or 3 or damaged and functioning with Proximity Rating of 1.
Otherwise, no course of action is recommended.

[3] Replace with hard toe and a soft upper. See text for explanation.

3.3.2.2. Grade Control

Grade control in Subreach 3 (Appendix B) is provided by a rock sill at Sta 1081+85 and rock riprap in the channel bed to protect against contraction scour at the pedestrian bridge at Sta 1083+00 and at the West Grange Avenue Bridge. The features do not require replacement since they are not damaged and are functioning.

3.3.2.3. Storm Drain Outfalls

Fifteen storm drain outfalls were identified in Subreach 3 (Appendix B). The failed portion of the concrete culvert outlets at Sta 1138+30, Sta 1089+50 and Sta 1077+70 should be removed to prevent further local scour, if possible.

3.3.2.4. Bridge and Culvert Crossings

Publicly owned bridge crossings in Subreach 3 include the bridges at Interstate 43, West Layton Avenue, West Forest Home Avenue (State Highway 24), South 84th Street, West Grange Avenue, and the pedestrian bridges at Sta 1094+00 and Sta 1086+70. In addition, the concrete arch bridge for the abandoned MHL&T Railroad bridge is located at Sta 1147+90. Each of the structures is functioning (hydraulically), and as such, no action is required.

3.4. North Branch Root River, Subreach 4

3.4.1. Channel Stability

3.4.1.1. Bank Erosion

Eleven sites with active bank erosion were identified in Subreach 4, with a total length of 940 lineal feet (**Table 3.8**). Because the bank erosion at these locations is located more the 2 channel widths from infrastructure (Category 3), no action is required.

Table 3.8. Summary of sites with bank erosion in Subreach 4 of the North Branch Root River and the recommended course of action for each site.

Bank Erosion Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Bank Material	Failure Mechanism [1]	Proximity to Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [2]	Course of Action	Priority [3]
119	1058+40	1058+80	1058+60	40	Cohesive	W	188	31	3	None	-
120	1055+00	1054+50	1054+80	50	Cohesive	W	155	31	3	None	-
121	1036+50	1037+50	1037+00	100	Cohesive	W	90	31	3	None	-
122	1035+90	1035+40	1035+70	50	Cohesive	W	112	31	3	None	-
123	1031+80	1031+30	1031+60	50	Cohesive	W	169	31	3	None	-
124	1027+40	1027+20	1027+30	20	Cohesive	W	449	31	3	None	-
125	1024+10	1025+10	1024+60	100	Cohesive	W	79	31	3	None	-
126	1023+50	1024+00	1023+80	50	Cohesive	W	173	31	3	None	-
127	1022+60	1024+10	1023+40	150	Cohesive	W	114	31	3	None	-
128	1012+70	1010+00	1011+40	270	Cohesive	W	85	31	3	None	-
129	996+70	997+30	997+00	60	Cohesive	W	73	31	3	None	-

[1] W = weathering, G/G = grain by grain, MF = mass failure

[2] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[3] Low protection priority for weathering, high priority for grain by grain erosion.

3.4.1.2. Vertical Stability

In Subreach 4, there is little evidence of vertical instability of the channel.

3.4.2. Infrastructure

3.4.2.1. Bank Protection

No bank protection was identified in Subreach 4.

3.4.2.2. Grade Control

No grade-control structures were identified in Subreach 4.

3.4.2.3. Storm Drain Outfalls

Eighteen storm drain outfalls were identified in Subreach 4 (Appendix B). The failed portion of the concrete culvert outlets at Sta 1061+00, Sta 1058+00, Sta 1024+00 and Sta 1023+20 should be removed to prevent further local scour, if possible.

3.4.2.4. Bridge and Culvert Crossings

No bridge structures were identified in Subreach 4.

3.5. North Branch Root River, Subreach 5

3.5.1. Channel Stability

3.5.1.1. Bank Erosion

Two sites with active bank erosion were identified in Subreach 5, with a total length of 60 lineal feet (**Table 3.9**). The bank erosion should be monitored at the Category 2 site (Sta 902+40), since the eroding right bank at this location is between 1 and 2 channel widths away from the Root River Parkway.

Table 3.9. Summary of sites with bank erosion in Subreach 5 of the North Branch Root River and the recommended course of action for each site.

Bank Erosion Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Bank Material	Failure Mechanism [1]	Proximity to Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [2]	Course of Action	Priority [3]
130	975+50	975+10	975+30	40	Cohesive	W	278	51	3	None	-
131	902+50	902+30	902+40	20	Cohesive	W	65	51	2	Monitor	-

[1] W = weathering, G/G = grain by grain, MF = mass failure

[2] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[3] Low protection priority for weathering, high priority for grain by grain erosion.

3.5.1.2. Vertical Stability

In Subreach 5, there is little evidence of vertical instability of the channel.

3.5.2. Infrastructure

3.5.2.1. Bank Protection

One site with existing bank protection is located in Subreach 5 at Sta 920+70 with a total length of 10 lineal feet (Appendix B). No action is required at the existing bank protection sites since the site is not damaged and is functioning.

3.5.2.2. Grade Control

Grade control in Subreach 5 (Appendix B) is provided by a rock sill at Sta 904+00. In addition, a rock grade-control structure is located at the mouth of a small tributary at Sta 920+70. The structures do not require replacement since they are not damaged and are functioning.

3.5.2.3. Storm Drain Outfalls

Four storm drain outfalls were identified in Subreach 5 (Appendix B). The failed portion of the concrete culvert outlets at Sta 975+50 and Sta 974+80 should be removed to prevent further local scour, if possible.

3.5.2.4. Bridge and Culvert Crossings

Publicly owned bridge crossings in Subreach 5 include the bridges at South 76th Street, Root River Parkway, and West Loomis Road (State Highway 36). Each of the structures is functioning (hydraulically), and as such, no action is required.

3.6. North Branch Root River, Subreach 6

3.6.1. Channel Stability

3.6.1.1. Bank Erosion

Three sites with active bank erosion were identified in Subreach 6, with a total length of 220 lineal feet (**Table 3.10**). Because the bank erosion at these locations is located more the two channel widths from infrastructure (Category 3), no action is required.

Table 3.10. Summary of sites with bank erosion in Subreach 6 of the North Branch Root River and the recommended course of action for each site.

Bank Erosion Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Bank Material	Failure Mechanism [1]	Proximity to Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [2]	Course of Action	Priority [3]
132	857+80	857+10	857+50	70	Cohesive	W	262	63	3	None	-
133	853+00	854+00	853+50	100	Cohesive	W	189	63	3	None	-
134	844+70	845+20	845+00	50	Cohesive	W	485	63	3	None	-

[1] W = weathering, G/G = grain by grain, MF = mass failure

[2] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[3] Low protection priority for weathering, high priority for grain by grain erosion.

3.6.1.2. Vertical Stability

In Subreach 6, there is little evidence of vertical instability of the channel.

3.6.2. Infrastructure

3.6.2.1. Bank Protection

One site with existing bank protection is located in Subreach 6 at Sta 849+30 with a total length of 70 lineal feet (Appendix B). No action is required at the existing bank protection site since the site is not damaged and is functioning.

3.6.2.2. Grade Control

No grade-control structures were identified in Subreach 6.

3.6.2.3. Storm Drain Outfalls

No storm drain outfalls were identified in Subreach 6.

3.6.2.4. Bridge and Culvert Crossings

The bridge at West Rawson Avenue is the only bridge crossing in Subreach 6. The structure is functioning (hydraulically), and as such, no action is required.

3.7. North Branch Root River, Subreach 7

3.7.1. Channel Stability

3.7.1.1. Bank Erosion

Two sites with active bank erosion were identified in Subreach 7, with a total length of 190 lineal feet (**Table 3.11**). Because the bank erosion at these locations are located more the two channel widths from infrastructure (Category 3), no action is required.

Table 3.11. Summary of sites with bank erosion in Subreach 7 of the North Branch Root River and the recommended course of action for each site.

Bank Erosion Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Bank Material	Failure Mechanism [1]	Proximity to Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [2]	Course of Action	Priority [3]
135	783+80	782+30	783+10	150	Cohesive	W	281	60	3	None	-
136	780+60	781+00	780+80	40	Cohesive	W	803	60	3	None	-

[1] W = weathering, G/G = grain by grain, MF = mass failure

[2] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[3] Low protection priority for weathering, high priority for grain by grain erosion.

3.7.1.2. Vertical Stability

In Subreach 7, there is little evidence of vertical instability of the channel.

3.7.2. Infrastructure

3.7.2.1. Bank Protection

No existing bank protection is located in Subreach 7.

3.7.2.2. Grade Control

Grade control in Subreach 5 (Appendix B) is provided by a rock sill at Sta 787+60. The structure does not require replacement since it is not damaged and is functioning.

3.7.2.3. Storm Drain Outfalls

One undamaged storm drain outfall was identified in Subreach 7.

3.7.2.4. Bridge and Culvert Crossings

No bridge crossings are present in Subreach 7.

3.8. North Branch Root River, Subreach 8

3.8.1. Channel Stability

3.8.1.1. Bank Erosion

Thirty-two sites with active bank erosion were identified in Subreach 8, with a total length of 2,380 lineal feet (**Table 3.12**). About 100 lineal feet of bank protection is recommended where the eroding bank is less than one channel width away from infrastructure (Category 1). If left unprotected, erosion of the left bank at Sta 750+50 could affect West Drexel Avenue (Appendix A). Because the bank erosion at the remainder of the sites is located more the two channel widths from infrastructure (Category 3), no action is required.

Table 3.12. Summary of sites with bank erosion in Subreach 8 of the North Branch Root River and the recommended course of action for each site.

Bank Erosion Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Bank Material	Failure Mechanism [1]	Proximity to Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [2]	Course of Action	Priority [3]
137	764+80	762+80	763+80	200	Cohesive	W	195	54	3	None	-
138	757+90	757+40	757+70	50	Cohesive	W	187	54	3	None	-
139	755+80	755+60	755+70	20	Cohesive	W	410	54	3	None	-
140	751+00	750+00	750+50	100	Cohesive	W	12	54	1	Protect	Low
142	747+90	747+40	747+70	50	Cohesive	W	324	54	3	None	-
143	747+80	747+30	747+60	50	Cohesive	W	147	54	3	None	-
144	746+30	745+70	746+00	60	Cohesive	W	185	54	3	None	-
145	746+10	745+10	745+60	100	Noncohesive	G/G	243	54	3	None	-
146	745+20	744+90	745+10	30	Cohesive	W	290	54	3	None	-
147	740+00	739+40	739+70	60	Cohesive	W	131	54	3	None	-
148	736+60	735+60	736+10	100	Cohesive	W	196	54	3	None	-
149	735+00	734+00	734+50	100	Cohesive	W	300	54	3	None	-
150	733+90	733+10	733+50	80	Cohesive	W	118	54	3	None	-
151	731+60	731+20	731+40	40	Cohesive	W	145	54	3	None	-
152	731+20	730+80	731+00	40	Cohesive	W	485	54	3	None	-
153	730+90	730+50	730+70	40	Cohesive	W	379	54	3	None	-
154	729+90	729+50	729+70	40	Cohesive	W	389	54	3	None	-
155	727+80	726+30	727+10	150	Noncohesive	W	210	54	3	None	-
156	726+90	726+40	726+70	50	Cohesive	W	469	54	3	None	-
157	724+30	723+80	724+10	50	Non-cohesive	G/G	157	54	3	None	-
158	722+10	721+60	721+90	50	Cohesive	W	120	54	3	None	-
159	721+70	721+20	721+50	50	Noncohesive	G/G	397	54	3	None	-
160	720+90	720+40	720+70	50	Cohesive	W	547	54	3	None	-
161	706+50	705+00	705+80	150	Cohesive	W	258	54	3	None	-
162	703+90	703+40	703+70	50	Cohesive	W	172	54	3	None	-
163	703+00	702+60	702+80	40	Cohesive	W	176	54	3	None	-
164	702+30	701+80	702+10	50	Cohesive	W	170	54	3	None	-
165	700+60	700+10	700+40	50	Cohesive	W	195	54	3	None	-
167	698+10	697+60	697+90	50	Cohesive	W	307	54	3	None	-
168	687+50	685+50	686+50	200	Cohesive	W	265	54	3	None	-
169	685+30	684+30	684+80	100	Cohesive	W	109	54	3	None	-
170	681+70	680+40	681+10	130	Cohesive	W	132	54	3	None	-

[1] W = weathering, G/G = grain by grain, MF = mass failure

[2] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[3] Low protection priority for weathering, high priority for grain by grain erosion.

3.8.1.2. Vertical Stability

In Subreach 8, there is little evidence of vertical instability of the channel.

3.8.2. Infrastructure

3.8.2.1. Bank Protection

One site with existing bank protection is located in Subreach 8 at Sta 674+20 with a total length of 70 lineal feet (Appendix B). No action is required at the existing bank protection site since the site is not damaged and is functioning.

3.8.2.2. Grade Control

Grade control in Subreach 8 is provided for the rock sill under the pedestrian bridge at Sta 696+10 and rock riprap in the channel bed to protect against contraction scour at the West Puetz Road Bridge. The structures do not require replacement since they are not damaged and are functioning. Grade control is also provided by the CMP culverts at West Drexel Avenue, and is discussed later in Section 3.8.2.4, Bridge and Culvert Crossings.

3.8.2.3. Storm Drain Outfalls

Two undamaged storm drain outfalls were identified in Subreach 8.

3.8.2.4. Bridge and Culvert Crossings

Publicly owned bridge crossings in Subreach 8 include the CMP culverts at West Drexel Avenue, the recently constructed (1999) bridge at West Puetz Road, and the pedestrian bridge at Sta 706+10. The bridge at West Puetz Road and the pedestrian bridge structure are functioning (hydraulically), and as such, no action is required. The CMP culverts at West Drexel Avenue are partially blocked on the right bank by floodplain accretion caused by backwater effects, and therefore do not efficiently convey large flows. However, the backwater caused by the culverts does not have an adverse impact on sediment transport; thus, the priority for replacement of the West Drexel Avenue culverts is lower. When the District or the Wisconsin Department of Transportation (WDOT) deems it necessary to replace the culverts, the structure should include a bridge span with appropriate hydraulic conveyance and sufficient bank and bed protection. It may also be necessary to adjust the alignment of the channel upstream from the bridge entrance to enhance conveyance through the bridge.

3.9. North Branch Root River, Subreach 9

3.9.1. Channel Stability

3.9.1.1. Bank Erosion

Nine sites with active bank erosion were identified in Subreach 9, with a total length of 560 lineal feet (**Table 3.13**). The bank erosion should be monitored at Sta 597+70 (Category 2), since the eroding right bank is between one and two channel widths away from West Ryan Road (State

Highway 100) (Appendix A). Because the bank erosion at the remainder of the sites is located more the two channel widths from infrastructure (Category 3), no action is required.

Table 3.13. Summary of sites with bank erosion in Subreach 9 of the North Branch Root River and the recommended course of action for each site.

Bank Erosion Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Bank Material	Failure Mechanism [1]	Proximity to Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [2]	Course of Action	Priority [3]
171	646+50	646+90	646+70	40	Non-cohesive	G/G	255	72	3	None	-
172	641+40	641+30	641+40	10	Non-cohesive	MF	324	72	3	None	-
173	634+40	634+80	634+60	40	Cohesive	W	250	72	3	None	-
174	628+70	628+30	628+50	40	Cohesive	W	227	72	3	None	-
175	625+70	625+30	625+50	40	Cohesive	W	205	72	3	None	-
176	624+90	625+30	625+10	40	Cohesive	W	320	72	3	None	-
177	613+60	615+10	614+40	150	Cohesive	W	219	72	3	None	-
178	608+90	609+40	609+20	50	Cohesive	W	294	72	3	None	-
179	596+90	598+40	597+70	150	Cohesive	W	105	72	2	Monitor	-

[1] W = weathering, G/G = grain by grain, MF = mass failure

[2] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[3] Low protection priority for weathering, high priority for grain by grain erosion.

3.9.1.2. Vertical Stability

In Subreach 9, there is little evidence of vertical instability of the channel.

3.9.2. Infrastructure

3.9.2.1. Bank Protection

Four sites with existing bank protection are located in Subreach 9 with a total length of 240 lineal feet (**Table 3.14**, Appendix B). No action is required at the existing bank protection sites since the sites are not damaged and are functioning.

Table 3.14. Summary of sites with existing bank protection in Subreach 9 of the North Branch Root River and the recommended course of action for each site.

Bank Protection Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Damaged	Functioning	Proximity to Other Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [1]	Course of Action [2,3]
33	656+70	656+00	656+35	70	No	Yes	334	72	3	None
33.1	656+70	656+00	656+35	70	No	Yes	334	72	3	None
34	635+70	636+20	635+95	50	No	Yes	208	72	3	None
35	610+10	609+60	609+85	50	No	Yes	896	72	3	None

[1] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[2] Replace if damaged and not functioning with Proximity Rating of 1.

[3] Replace with hard toe and a soft upper. See text for explanation.

3.9.2.2. Grade Control

Grade control in Subreach 9 is provided by rock riprap in the channel bed to protect against contraction scour at the West Ryan Road (State Highway 100) Bridge. The structure does not require replacement since it is not damaged and is functioning.

3.9.2.3. Storm Drain Outfalls

One undamaged storm drain outfall was identified in Subreach 9 at Sta 635+40.

3.9.2.4. Bridge and Culvert Crossings

The new bridge that is currently being constructed at West Ryan Road (State Highway 100) is the only bridge crossing in Subreach 9. The structure is functioning (hydraulically), and as such, no action is required.

3.10. North Branch Root River, Subreach 10

3.10.1. Channel Stability

3.10.1.1. Bank Erosion

Forty-one sites with active bank erosion were identified in Subreach 10, with a total length of 2,850 lineal feet (**Table 3.15**). About 360 lineal feet of bank protection is recommended where the eroding bank is less than one channel width away from infrastructure (Category 1). If left unprotected, erosion of the right bank could cause failure of the powerline structure at Sta 469+70 (Appendix A). Because the bank erosion at this location is caused by mass slope failures and weathering of the cohesive bank material, the priority for installation of bank protection is higher. Low priority bank protection is recommended for the eroding left bank at Sta 494+30 to protect West Oakwood Road and the eroding right bank at Sta 434+30 to protect South 60th Street, since the erosion rates associated with weathering of the cohesive banks are low. Because the bank erosion at the remainder of the sites is located more the two channel widths from infrastructure (Category 3), no action is required.

3.10.1.2. Vertical Stability

Although some channel incision was identified in Subreach 10, the rate of downcutting is relatively low due to the presence of erosion-resistant clays in the bed material. Therefore, additional grade control is not recommended at this time. The vertical stability of this subreach, however, should be monitored to ensure that further incision does not lead to lateral instability (i.e., mass slope failures) associated with increased bank heights.

3.10.2. Infrastructure

3.10.2.1. Bank Protection

Two sites with existing bank protection are located in Subreach 10 with a total length of 80 lineal feet (**Table 3.16**, Appendix B). No action is required at the existing bank protection sites since both are not damaged and are functioning.

3.10.2.2. Grade Control

Grade control in Subreach 10 is provided by two rock riprap sills at Sta 468+60 and Sta 504+50, and the culverts at the West Oakwood Road Bridge. The rock sills do not require replacement since they are not damaged and are functioning. The culverts at West Oakwood Road are discussed later in the Bridge and Culvert Crossings section.

Table 3.15. Summary of sites with bank erosion in Subreach 10 of the North Branch Root River and the recommended course of action for each site.

Bank Erosion Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Bank Material	Failure Mechanism [1]	Proximity to Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [2]	Course of Action	Priority [3]
180	591+70	592+10	591+90	40	Cohesive	W	505	44	3	None	-
181	577+10	576+80	577+00	30	Cohesive	W	407	44	3	None	-
182	567+00	567+40	567+20	40	Cohesive	W	247	44	3	None	-
183	564+80	565+80	565+30	100	Cohesive	W	392	44	3	None	-
184	560+70	561+70	561+20	100	Cohesive	W	947	44	3	None	-
185	557+30	557+90	557+60	60	Cohesive	W	217	44	3	None	-
186	550+90	550+20	550+60	70	Cohesive	W	620	44	3	None	-
187	549+20	549+70	549+50	50	Cohesive	W	386	44	3	None	-
188	545+90	544+90	545+40	100	Cohesive	W	570	44	3	None	-
189	545+50	546+00	545+80	50	Cohesive	W	607	44	3	None	-
190	540+30	541+10	540+70	80	Cohesive	W	627	44	3	None	-
191	531+80	532+80	532+30	100	Cohesive	W	796	44	3	None	-
192	530+70	531+70	531+20	100	Cohesive	W	729	44	3	None	-
193	525+50	525+40	525+50	10	Cohesive	MF	901	44	3	None	-
194	519+60	519+40	519+50	20	Noncohesive	G/G	200	44	3	None	-
195	518+60	518+50	518+60	10	Cohesive	MF	96	44	3	None	-
196	513+00	514+10	513+60	110	Cohesive	W	263	44	3	None	-
197	512+00	512+60	512+30	60	Cohesive	MF	540	44	3	None	-
199	510+70	511+30	511+00	60	Cohesive	MF	224	44	3	None	-
200	509+10	509+80	509+50	70	Cohesive	MF	488	44	3	None	-
201	506+70	507+60	507+20	90	Cohesive	MF	167	44	3	None	-
202	505+10	505+90	505+50	80	Cohesive	W	431	44	3	None	-
203	505+10	505+90	505+50	80	Cohesive	MF	431	44	3	None	-
204	505+10	505+90	505+50	80	Cohesive	MF	240	44	3	None	-
205	501+30	501+20	501+30	10	Noncohesive	MF	150	44	3	None	-
207	495+90	496+10	496+00	20	Cohesive	W	250	44	3	None	-
208	494+90	493+70	494+30	120	Cohesive	W	36	44	1	Protect	Low
209	492+80	494+00	493+40	120	Cohesive	W	100	44	3	None	-
210	492+80	492+70	492+80	10	Cohesive	MF	1576	44	3	None	-
212	491+50	492+30	491+90	80	Cohesive	W	1400	44	3	None	-
214	489+50	490+70	490+10	120	Cohesive	W	1498	44	3	None	-
215	485+20	485+30	485+30	10	Noncohesive	MF	1855	44	3	None	-
216	485+20	484+20	484+70	100	Cohesive	W	1477	44	3	None	-
217	482+70	482+20	482+50	50	Cohesive	W	529	44	3	None	-
218	477+90	477+60	477+80	30	Cohesive	W	1675	44	3	None	-
220	477+00	477+30	477+20	30	Cohesive	W	955	44	3	None	-
221	475+40	475+80	475+60	40	Cohesive	W	1742	44	3	None	-
222	471+10	472+90	472+00	180	Cohesive	W	592	44	3	None	-
224	469+20	470+20	469+70	100	Cohesive	W/MF	8	44	1	Protect	High
225	466+20	465+20	465+70	100	Cohesive	W	224	44	3	None	-
226	463+60	465+00	464+30	140	Cohesive	W	22	44	1	Protect	Low

[1] W = weathering, G/G = grain by grain, MF = mass failure

[2] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[3] Low protection priority for weathering, high priority for grain by grain and mass failure erosion.

Table 3.16. Summary of sites with existing bank protection in Subreach 10 of the North Branch Root River and the recommended course of action for each site.

Bank Protection Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Damaged	Functioning	Proximity to Other Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [1]	Course of Action [2,3]
36	587+60	588+20	587+90	60	No	Yes	30	44	1	None
37	496+10	495+90	496+00	20	No	Yes	50	44	2	None

[1] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[2] Replace if damaged and not functioning with Proximity Rating of 1.
Monitor if damaged and not functioning with Proximity Rating of 2 or 3 or damaged and functioning with Proximity Rating of 1. Otherwise, no course of action is recommended.

[3] Replace with hard toe and a soft upper. See text for explanation.

3.10.2.3. Storm Drain Outfalls

One undamaged storm drain outfall was identified in Subreach 10 at Sta 587+30.

3.10.2.4. Bridge and Culvert Crossings

The culvert crossing at West Oakwood Road is the only publicly owned bridge crossing in Subreach 10. Although flow conveyance through the culverts is limited, the effect of the culverts is unclear due to downstream backwater effects that are associated with the constriction of the floodplain by the bounding terraces. The backwater effects drown the crossing relatively frequently at flows greater than the 1-percent exceedence discharge. It is therefore likely that the culverts will be replaced with a bridge span in the future. When the District or the WDOT deems it necessary to replace the culverts, the structure should include a bridge span with appropriate hydraulic conveyance and sufficient bank and bed protection. It may also be necessary to adjust the alignment of the channel up- and downstream from the bridge entrance to enhance conveyance through the bridge.

3.11. Hale Creek

3.11.1. Channel Stability

3.11.1.1. Bank Erosion

Five sites with active bank erosion were identified in Hale Creek, with a total length of 290 lineal feet (**Table 3.17**). Because the bank erosion at each of the sites is located more the 2 channel widths from infrastructure (Category 3), no action is required.

Table 3.17. Summary of sites with bank erosion in Hale Creek and the recommended course of action for each site.

Bank Erosion Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Bank Material	Failure Mechanism [1]	Proximity to Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [2]	Course of Action	Priority [3]
227	42+10	42+00	42+10	10	Noncohesive	G/G	67	12	3	None	-
228	16+50	17+50	17+00	100	Cohesive	W	67	12	3	None	-
229	13+70	13+10	13+40	60	Cohesive	W	391	12	3	None	-
230	8+30	7+80	8+10	50	Noncohesive	G/G	80	12	3	None	-
231	2+60	1+90	2+30	70	Cohesive	W	258	12	3	None	-

[1] W = weathering, G/G = grain by grain, MF = mass failure

[2] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[3] Low protection priority for weathering, high priority for grain by grain erosion.

3.11.1.2. Vertical Stability

In Hale Creek, there is little evidence of vertical instability of the channel.

3.11.2. Infrastructure

3.11.2.1. Bank Protection

Three existing bank protection sites are located in Hale Creek with a total length of 340 lineal feet (**Table 3.18**, Appendix B). No action is required at the existing bank protection sites since the sites are not damaged and are functioning.

Table 3.18. Summary of sites with existing bank protection in Hale Creek and the recommended course of action for each site.

Bank Protection Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Damaged	Functioning	Proximity to Other Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [1]	Course of Action [2,3]
38	18+20	17+20	17+70	100	No	Yes	36	12	3	None
39	15+70	14+90	15+30	80	No	Yes	51	12	3	None
40	1+60	+	+80	160	No	Yes	55	12	3	None

[1] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[2] Replace if damaged and not functioning with Proximity Rating of 1.
Monitor if damaged and not functioning with Proximity Rating of 2 or 3 or damaged and functioning with Proximity Rating of 1.
Otherwise, no course of action is recommended.

[3] Replace with hard toe and a soft upper. See text for explanation.

3.11.2.2. Grade Control

Grade control in Hale Creek is provided by the RCBC crossing at the Root River Parkway Bridge (Sta 3+10). In addition, a rock sill grade-control structure is located in the left bank tributary below the West Cleveland Road storm drain outfall. No action is required at the structures since both are not damaged and are functioning.

3.11.2.3. Storm Drain Outfalls

Twenty-one storm drain outfalls were identified in Hale Creek. at Sta 635+40. The failed portion of the 30-inch concrete culvert outlet at Sta 35+20 should be removed to prevent further local scour, if possible.

3.11.2.4. Bridge and Culvert Crossings

Public bridge crossings in Hale Creek include the West Cleveland Road Bridge and the RCBCs at the Root River Parkway crossing. The structures are functioning (hydraulically), and as such, no action is required.

3.12. 104th Street Ditch

3.12.1. Channel Stability

3.12.1.1. Bank Erosion

Five sites with active bank erosion were identified in 104th Street Ditch, with a total length of 160 lineal feet (**Table 3.19**). Because the bank erosion at each of the sites is located more the two channel widths from infrastructure (Category 3), no action is required.

Table 3.19. Summary of sites with bank erosion in 104th Street Ditch and the recommended course of action for each site.

Bank Erosion Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Bank Material	Failure Mechanism [1]	Proximity to Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [2]	Course of Action	Priority [3]
231	7+30	6+30	6+80	100	Noncohesive	G/G	216	19	3	None	-
232	5+40	5+70	5+60	30	Cohesive	W	58	19	3	None	-
234	2+50	2+80	2+70	30	Cohesive	W	60	19	3	None	-

[1] W = weathering, G/G = grain by grain, MF = mass failure

[2] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[3] Low protection priority for weathering, high priority for grain by grain erosion.

3.12.1.2. Vertical Stability

In 104th Street Ditch, there is sufficient grade control that limits channel incision.

3.12.2. Infrastructure

3.12.2.1. Bank Protection

Four sites with existing bank protection are located in 104th Street Ditch with a total length of 240 lineal feet (**Table 3.20**, Appendix B). Additional bank protection may be in place that has been covered by urban landscaping or other vegetation and was therefore not identified. No action is required at the existing bank protection sites since each site is not damaged and is functioning.

Table 3.20. Summary of sites with existing bank protection in 104th Street Ditch, and the recommended course of action for each site.

Bank Protection Number	Start Station (ft)	Stop Station (ft)	Midpint Station (ft)	Length (ft)	Damaged	Functioning	Proximity to Other Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [1]	Course of Action [2,3]
41	12+90	13+10	13+00	20	No	Yes	100	19	3	None
42	14+40	14+60	14+50	20	No	Yes	103	19	3	None
42.1	5+90	6+90	6+40	100	No	Yes	25	19	2	None
42.2	5+90	6+90	6+40	100	No	Yes	120	19	3	None

[1] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[2] Replace if damaged and not functioning with Proximity Rating of 1.
Monitor if damaged and not functioning with Proximity Rating of 2 or 3 or damaged and functioning with Proximity Rating of 1.
Otherwise, no course of action is recommended.

[3] Replace with hard toe and a soft upper. See text for explanation.

3.12.2.2. Grade Control

Numerous grade-control structures are located in 104th Street Ditch, including the grouted rock riprap sill below Interstate 894, the RCBCs that are outfitted with a downstream sill at South 104th Street and West Cold Spring Road Bridge, rock riprap sills at Sta 11+90 and Sta 9+20, and multiple sections of rock-lined channel between West Cold Spring Road and South 104th Street. The structures are not damaged and are functioning, so no action is required.

3.12.2.3. Storm Drain Outfalls

One undamaged lateral storm drain outfall was identified in 104th Street Ditch at Sta 4+00. In addition, numerous undamaged storm drain outfalls enter the ditch at the downstream face of Interstate 894.

3.12.2.4. Bridge and Culvert Crossings

Publicly owned bridge crossings of 104th Street Ditch include the concrete culvert crossing at Interstate 894 and the RCBCs at South 104th Street and West Cold Spring Road. The structures are functioning (hydraulically), and as such, no action is required.

3.13. Wildcat Creek

3.13.1. Channel Stability

3.13.1.1. Bank Erosion

Six sites with active bank erosion were identified in Wildcat Creek, with a total length of 290 lineal feet (**Table 3.21**). Because the bank erosion at each of the sites is located more the 2 channel widths from infrastructure (Category 3), no action is required. However, if the District deems necessary, bank erosion should be monitored in the vicinity of the athletic fields downstream from South 108th Street.

Table 3.21. Summary of sites with bank erosion at Wildcat Creek and the recommended course of action for each site.

Bank Erosion Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Bank Material	Failure Mechanism [1]	Proximity to Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [2]	Course of Action	Priority [3]
235	7+50	7+00	7+30	50	Cohesive	W	39	13	3	None	-
236	8+10	7+70	7+90	40	Cohesive	W	72	13	3	None	-
237	8+30	7+70	8+00	60	Cohesive	W	229	13	3	None	-
238	9+90	9+70	9+80	20	Cohesive	W	153	13	3	None	-
239	10+70	10+10	10+40	60	Cohesive	W	50	13	3	None	-
240	11+30	10+70	11+00	60	Cohesive	W	80	13	3	None	-

[1] W = weathering, G/G = grain by grain, MF = mass failure

[2] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[3] Low protection priority for weathering, high priority for grain by grain erosion.

3.13.1.2. Vertical Stability

There is little evidence of vertical instability in Wildcat Creek.

3.13.2. Infrastructure

3.13.2.1. Bank Protection

Two sites with existing bank protection are located in Wildcat Creek with a total length of 320 lineal feet (**Table 3.22**, Appendix B). No action is required for the bank protection sites since they are not damaged and are functioning.

Table 3.22. Summary of sites with existing bank protection in Wildcat Creek and the recommended course of action for each site.

Bank Protection Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Damaged	Functioning	Proximity to Other Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [1]	Course of Action [2,3]
43	15+90	17+50	16+70	160	No	Yes	20	13	1	None
43.1	15+90	17+50	16+70	160	No	Yes	20	13	1	None

[1] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[2] Replace if damaged and not functioning with Proximity Rating of 1.
Monitor if damaged and not functioning with Proximity Rating of 2 or 3 or damaged and functioning with Proximity Rating of 1.
Otherwise, no course of action is recommended.

[3] Replace with hard toe and a soft upper. See text for explanation.

3.13.2.2. Grade Control

Numerous grade-control structures are located in Wildcat Creek, including rock riprap in the channel bed to protect against contraction scour at the pedestrian bridges at Sta 6+90 and Sta 18+10, sections of rock/gabion-lined channel upstream from South 112th Street (Sta 29+00), and the RCBC at West Beloit Road. The structures are not damaged and are functioning; therefore, no action is required.

3.13.2.3. Storm Drain Outfalls

No storm drain outfalls were identified in Wildcat Creek.

3.13.2.4. Bridge and Culvert Crossing

Downstream from the RCBC at West Beloit Road, publicly-owned bridge crossings of Wildcat Creek include the RCBCs at South 108th Street, West Cold Spring Road, the concrete arch culvert (CAC) at South 112th Street, and two pedestrian bridges at Sta 6+90 and Sta 18+10 The structure is functioning (hydraulically), and as such, no action is required.

3.14. Whitnall Park Creek

3.14.1. Channel Stability

3.14.1.1. Bank Erosion

Twenty-two sites with active bank erosion were identified in Whitnall Park Creek, with a total length of 1,000 lineal feet (**Table 3.23**, Appendix A), including 50 feet of bank erosion in the Northwest Fork of Whitnall Park Creek and 170 feet of bank erosion in the North Fork of Whitnall Park Creek. Because the bank erosion at each of the sites is located more the two channel widths from infrastructure (Category 3), no action is required.

3.14.1.2. Vertical Stability

There is little evidence of vertical instability in Whitnall Park Creek.

Table 3.23. Summary of sites with bank erosion in Whitnall Park Creek, and the recommended course of action for each site.

Bank Erosion Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Bank Material	Failure Mechanism [1]	Proximity to Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [2]	Course of Action	Priority [3]
241	161+20	161+50	161+40	30	Cohesive	W	75	20	3	None	-
242	98+70	98+20	98+50	50	Cohesive	W	65.4	20	3	None	-
243	97+60	97+90	97+80	30	Cohesive	W	120	20	3	None	-
244	29+10	28+70	28+90	40	Cohesive	W	106	20	3	None	-
245	23+10	22+70	22+90	40	Cohesive	W	224	20	3	None	-
246	16+70	17+30	17+00	60	Cohesive	W	338	20	3	None	-
247	13+80	14+00	13+90	20	Cohesive	W	103	20	3	None	-
248	11+20	10+60	10+90	60	Cohesive	W	200	20	3	None	-
249	9+00	9+50	9+30	50	Cohesive	W	119	20	3	None	-
251	8+10	7+60	7+90	50	Cohesive	W	72	20	3	None	-
252	6+30	5+80	6+10	50	Cohesive	W	354	20	3	None	-
253	4+40	5+40	4+90	100	Cohesive	W	675	20	3	None	-
254	3+90	4+30	4+10	40	Cohesive	W	652	20	3	None	-
255	3+60	3+40	3+50	20	Noncohesive	G/G	665	20	3	None	-
256	3+10	2+50	2+80	60	Cohesive	W	113	20	3	None	-
257	2+10	1+30	1+70	80	Cohesive	W	509	20	3	None	-
351*	+80	+40	+60	40	Cohesive	W	100	20	3	None	-
352*	1+20	+80	1+00	40	Cohesive	W	100	20	3	None	-
353*	1+70	1+30	1+50	40	Cohesive	W	200	20	3	None	-
354*	2+50	2+20	2+40	30	Cohesive	W	149	20	3	None	-
258*	3+30	3+10	3+20	20	Cohesive	W	221	20	3	None	-
259**	16+00	15+50	15+80	50	Cohesive	W	66	20	3	None	-

[1] W = weathering, G/G = grain by grain, MF = mass failure

[2] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[3] Low protection priority for weathering, high priority for grain by grain erosion.

*North Fork Whitnall Park Creek

**Northwest Fork Whitnall Park Creek

3.14.2. Infrastructure

3.14.2.1. Bank Protection

Twenty three sites with existing bank protection are located in Whitnall Park Creek with a total length of 3,030 lineal feet (**Table 3.24**, Appendix B), including about 320 lineal feet in the Northwest Fork of Whitnall Park Creek and about 340 feet in the North Fork Whitnall Park Creek. The failing gabions in the Northwest Fork that are located upstream from Janesville Road should be replaced to safeguard the bridge entrance. In the mainstem of Whitnall Park Creek, the rock dikes that protect the eroding left bank (Sta 7+30) adjacent to Whitnall Park should be monitored to ensure flows do not flank the dike and cause further erosion at this location. The remainder of the bank protection sites requires no action since they are not damaged and are functioning.

3.14.2.2. Grade Control

Numerous grade-control structures are located in the mainstem of Whitnall Park Creek, including the concrete-and-rock arch dams on the Whitnall Park ponds, the concrete sill below West Forest Home Avenue, and numerous hard-bottomed culvert crossings for bridges. In addition, a concrete-lined trapezoidal channel provides grade control in the Northwest Fork at Sta 12+10. The concrete-and-rock arch dams are slightly damaged, and should be monitored. The remainder of the grade-control structures are not damaged and are functioning, and as such, no action is required.

Table 3.24. Summary of sites with existing bank protection and the recommended course of action for each site.

Bank Protection Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Damaged	Functioning	Proximity to Other Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [1]	Course of Action [2,3]
44	174+40	168+90	171+65	550	No	Yes	32	20	2	None
44.1	174+40	168+90	171+65	550	No	Yes	32	20	2	None
45	137+30	138+00	137+65	70	No	Yes	14	20	3	None
46	136+90	134+80	135+85	210	No	Yes	15	20	1	None
47	117+30	115+80	116+55	150	No	Yes	59	20	3	None
48	109+10	109+30	109+20	20	No	Yes	30	20	3	None
48.1	109+10	109+30	109+20	20	No	Yes	30	20	3	None
49	105+00	107+40	106+20	240	No	Yes	13	20	3	None
50	96+20	98+20	97+20	200	No	Yes	38	20	3	None
51	90+90	91+60	91+25	70	No	Yes	23	20	3	None
52	48+10	48+80	48+45	70	No	Yes	235	20	3	None
53	30+70	31+60	31+15	90	No	Yes	30	20	2	None
54	21+20	22+20	21+70	100	No	Yes	181	20	3	None
55	7+50	7+20	7+35	30	No	Yes	72	20	3	None
56**	7+30	6+50	6+90	80	No	Yes	94	20	3	None
56**	7+30	6+50	6+90	80	No	Yes	94	20	3	None
57**	3+30	1+80	2+55	150	No	Yes	75	20	3	None
58**	2+20	2+30	2+25	10	No	Yes	47	20	3	None
59*	18+00	17+00	17+50	100	No	Yes	63	20	3	None
60*	16+80	15+80	16+30	100	No	Yes	25	20	3	None
61*	5+60	5+20	5+40	40	Yes	No	7	20	1	Replace
61.1*	5+60	5+20	5+40	40	Yes	No	7	20	1	Replace
61.2*	6+10	6+70	6+40	60	No	Yes	7	20	1	None

[1] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[2] Replace if damaged and not functioning with Proximity Rating of 1.

[3] Replace with hard toe and a soft upper. See text for explanation.

*Northwest Fork of Whitnall Park Creek

**North Fork of Whitnall Park Creek

3.14.2.3. Storm Drain Outfalls

Fourteen storm drain outfalls were identified in Whitnall Park Creek, including three in the North Fork of Whitnall Park Creek and one in the Northwest Fork of Whitnall Park Creek. The failed portion of the 17-inch corrugated metal pipe (CMP) culvert outlet at Sta 27+90 should be removed to prevent further local scour, if possible.

3.14.2.4. Bridge and Culvert Crossings

- Publicly owned bridge crossings of the mainstem of Whitnall Park Creek include:
- Bridge spans at Root River Parkway, South 92nd Street, South 108th Street, West Forest Home Avenue, and Janesville Road,
- Five bridge spans or concrete arch structures for Whitnall Park Drive,
- CMPs at Kurtz Road, Godsell Avenue and South 124th Street, and
- Numerous pedestrian bridges.

Publicly owned bridge crossings of the Northwest Fork of Whitnall Park Creek include the bridge span at West Janesville, and RCBCs at Godsell Avenue, Parnell Avenue, and South 113th Street. No publicly owned bridge crossings are located on the North Fork of Whitnall Park Creek. The structures are functioning (hydraulically), and as such, no action is required.

3.15. Tess Corners Creek

The field reconnaissance in Tess Corners Creek focused on the reach between the dam at the Whitnall Park Golf Course Pond and the confluence with the North Branch Root River, since upstream sediment loading is trapped in this impoundment.

3.15.1. Channel Stability

3.15.1.1. Bank Erosion

Six sites with active bank erosion were identified in Tess Corners Creek downstream from the Whitnall Park Golf Course Pond, with a total length of 310 lineal feet (**Table 3.25**, Appendix A). Because the bank erosion at each of the sites is located more the two channel widths from infrastructure (Category 3), no action is required.

Table 3.25. Summary of sites with bank erosion at Tess Corners and the recommended course of action for each site.

Bank Erosion Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Bank Material	Failure Mechanism [1]	Proximity to Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [2]	Course of Action	Priority [3]
260	16+20	15+20	15+70	100	Cohesive	W	65	12	3	None	-
261	19+40	19+10	19+30	30	Cohesive	W	114	12	3	None	-
262	21+10	20+80	21+00	30	Cohesive	W	129	12	3	None	-
348	9+50	9+80	9+70	30	Cohesive	W	25	12	3	None	-
349	16+10	16+60	16+40	50	Cohesive	W	202	12	3	None	-
350	20+70	21+40	21+10	70	Cohesive	W	500	12	3	None	-

[1] W = weathering, G/G = grain by grain, MF = mass failure

[2] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[3] Low protection priority for weathering, high priority for grain by grain erosion.

3.15.1.2. Vertical Stability

There is little evidence of vertical instability in Tess Corners Creek.

3.15.2. Infrastructure

3.15.2.1. Bank Protection

Two existing bank protection sites are located in Tess Corners Creek downstream from the Whitnall Park Golf Course Pond, with a total length of 390 lineal feet (**Table 3.26**, Appendix B). The riprap located upstream from Whitnall Park Drive (Sta 9+30 to Sta 10+60) includes very large rock but is typically placed at only one rock thickness, and is partially failed in some locations. This riprap should be monitored to ensure further bank erosion does not threaten the downstream bridge crossing. The remainder of the bank protection (Sta 22+30) requires no action since it is not damaged and is functioning.

Table 3.26. Summary of sites with existing bank protection in Tess Corners Creek, and the recommended course of action for each site.

Bank Protection Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Damaged	Functioning	Proximity to Infrastructure (ft)	Channel Top width (ft)	Rating	Course of Action [2,3]
62	22+90	21+60	22+25	130	No	Yes	200	12	3	None
63	11+90	9+30	10+60	260	Yes	Yes	142	12	3	Monitor

[1] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[2] Replace if damaged and not functioning with Proximity Rating of 1.
Monitor if damaged and not functioning with Proximity Rating of 2 or 3 or damaged and functioning with Proximity Rating of 1.
Otherwise, no course of action is recommended.

[3] Replace with hard toe and a soft upper. See text for explanation.

3.15.2.2. Grade Control

Downstream from the Whitnall Park Golf Course Pond in Tess Corners Creek, a rock-sill provides grade control downstream from the South 92nd Street Bridge. The grade-control structure is not damaged and is functioning, and as such, no action is required.

3.15.2.3. Storm Drain Outfalls

No storm drain outfalls were identified in Tess Corners Creek downstream from the Whitnall Park Golf Course Pond.

3.15.2.4. Bridge and Culvert Crossings

Publicly owned bridge crossings of Tess Corners Creek downstream from the Whitnall Park Golf Course Pond include bridge spans at South 92nd Street and at Whitnall Park Drive. The structures are functioning (hydraulically), and as such, no action is required.

3.16. Dale Creek

The field reconnaissance in Dale Creek focused on the reach between Southwood Road and the confluence with the North Branch Root River. The bridge crossings between West Grange Avenue and Southwood Road were also evaluated during the site visit.

3.16.1. Channel Stability

3.16.1.1. Bank Erosion

No bank erosion was identified in Dale Creek.

3.16.1.2. Vertical Stability

Vertical instability in Dale Creek is limited to a section of incising channel from Sta 24+00 to Sta 25+50 (Appendix A). A constructed rock riffle grade-control structure should be installed at the upstream limit of this incision at Sta 25+50 to avoid upstream migration of channel downcutting.

3.16.2. Infrastructure

3.16.2.1. Bank Protection

No bank protection was identified in Dale Creek downstream from Southway Road.

3.16.2.2. Grade Control

No grade-control structures were identified in Dale Creek downstream from Southway Road.

3.16.2.3. Storm Drain Outfalls

One undamaged storm drain outfall was identified in Dale Creek downstream from Southway Road at Sta 13+80.

3.16.2.4. Bridge and Culvert Crossings

Publicly owned bridge crossings of Dale Creek downstream from West Grange Avenue include three concrete arch culverts at Southway Road and RCBCs at Schoolway Road and Northway Road. Significant large woody debris and sediment block the two left culverts at the Southway Road crossing, and should be removed to improve the conveyance through the structure. The RCBCs at Schoolway Road and Northway Road are functioning (hydraulically), and as such, no action is required.

3.17. Legend Creek

The field reconnaissance in Legend Creek focused on the reach between South 68th Street and the confluence with the North Branch Root River, since upstream sediment loading is trapped in the Tuckaway Country Club ponds.

3.17.1. Channel Stability

3.17.1.1. Bank Erosion

One bank erosion site was identified in Legend Creek downstream from South 68th Street, with a length of 70 lineal feet (Appendix A). Because the bank erosion is located more the two channel widths from infrastructure (Category 3), no action is required.

3.17.1.2. Vertical Stability

There is little evidence of vertical instability in Legend Creek downstream from South 68th Street.

3.17.2. Infrastructure

3.17.2.1. Bank Protection

No bank protection was identified in Legend Creek downstream from South 68th Street.

3.17.2.2. Grade Control

No grade-control structures were identified in Legend Creek downstream from South 68th Street.

3.17.2.3. Storm Drain Outfalls

No storm drain outfalls were identified in Legend Creek downstream from South 68th Street.

3.17.2.4. Bridge and Culvert Crossings

No publicly owned bridge crossings of Legend Creek occur downstream from the two concrete culverts for the South 68th Street Bridge. The culverts at South 68th Street are functioning (hydraulically), and as such, no action is required.

3.18. East Branch of the Root River

3.18.1. Channel Stability

3.18.1.1. Bank Erosion

Eighty-two sites with active bank erosion were identified in the East Branch of the Root River, with a total length of 4,540 lineal feet (**Table 3.27**). About 80 lineal feet of bank protection is recommended at Sta 251+70 and Sta 249+90 where the eroding right bank is less than one channel width away from mobile homes (Category 1). Because the bank erosion at these locations is caused by weathering of the cohesive bank material and the erosion rates are low, the priority for installation of bank protection is lower at this location. The bank erosion should be monitored at the Category 2 sites, since the eroding bank at these locations is between one and two channel widths away from a private residence (Sta 156+90) and a private driveway (Sta 84+80).

3.18.1.2. Vertical Stability

In the East Branch of the Root River, there is little evidence of vertical instability of the channel.

3.18.2. Infrastructure

3.18.2.1. Bank Protection

Twenty-six sites with existing bank protection were identified in the East Branch of the Root River with a total length of 1,210 lineal feet (**Table 3.28,** Appendix B). The 60-feet of rock wall that is protecting the right bank of the East Branch Root River is unstable and, if not replaced, could affect South 35th Street. No action is required at the remainder of the existing bank protection sites since they are not damaged and are functioning.

Table 3.27. Summary of sites with bank erosion at East Branch of the Root River and the recommended course of action for each site.

Bank Erosion Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Bank Material	Failure Mechanism [1]	Proximity to Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [2]	Course of Action	Priority [3]
264	253+30	252+90	253+10	40	Cohesive	W	32	15	3	None	-
265	252+40	252+10	252+30	30	Cohesive	W	117	15	3	None	-
266	251+90	251+50	251+70	40	Cohesive	W	15	15	1	Protect	Low
267	250+10	249+70	249+90	40	Cohesive	W	11	15	1	Protect	Low
268	248+60	248+90	248+80	30	Cohesive	W	74	15	3	None	-
269	213+20	212+80	213+00	40	Cohesive	MF	638	15	3	None	-
270	212+50	212+40	212+50	10	Cohesive	MF	663	15	3	None	-
271	210+20	210+10	210+20	10	Cohesive	W	219	15	3	None	-
272	209+70	210+00	209+90	30	Cohesive	W	289	15	3	None	-
273	207+20	207+20	207+20	0	Cohesive	W	385	15	3	None	-
274	207+00	207+20	207+10	20	Cohesive	W	448	15	3	None	-
275	206+90	206+90	206+90	0	Cohesive	W	223	15	3	None	-
276	202+10	202+40	202+30	30	Cohesive	W	719	15	3	None	-
277	201+20	201+40	201+30	20	Cohesive	W	757	15	3	None	-
278	199+60	199+90	199+80	30	Cohesive	W	157	15	3	None	-
279	199+10	199+30	199+20	20	Cohesive	W	476	15	3	None	-
280	198+20	197+70	198+00	50	Noncohesive	W	311	15	3	None	-
281	196+50	196+80	196+70	30	Cohesive	W	212	15	3	None	-
282	195+10	194+70	194+90	40	Cohesive	W	127	15	3	None	-
283	194+30	202+60	198+50	830	Noncohesive	W	557	15	3	None	-
284	178+20	178+80	178+50	60	Cohesive	W	38	15	3	None	-
285	176+30	176+20	176+30	10	Cohesive	W	252	15	3	None	-
286	176+00	175+30	175+70	70	Cohesive	W	33	15	3	None	-
287	171+80	172+80	172+30	100	Cohesive	W	213	15	3	None	-
288	170+90	171+20	171+10	30	Cohesive	W	122	15	3	None	-
289	168+50	169+00	168+80	50	Cohesive	W	372	15	3	None	-
290	168+20	168+40	168+30	20	Cohesive	W	97	15	3	None	-
291	167+80	167+40	167+60	40	Cohesive	W	47	15	3	None	-
292	158+80	158+20	158+50	60	Cohesive	W	201	15	3	None	-
293	156+90	156+10	156+50	80	Cohesive	W	27	15	2	Monitor	-
294	154+70	154+20	154+50	50	Noncohesive	G/G	216	15	3	None	-
295	152+90	153+40	153+20	50	Cohesive	W	153	15	3	None	-
297	150+60	151+10	150+90	50	Cohesive	W	133	15	3	None	-
298	147+20	147+90	147+60	70	Cohesive	W	285	15	3	None	-
299	147+00	146+80	146+90	20	Cohesive	W	887	15	3	None	-
300	143+50	143+70	143+60	20	Cohesive	W	798	15	3	None	-
301	143+00	143+50	143+30	50	Cohesive	W	215	15	3	None	-
302	142+20	142+50	142+40	30	Cohesive	W	434	15	3	None	-
303	141+80	142+10	142+00	30	Cohesive	W	216	15	3	None	-
304	140+00	139+20	139+60	80	Cohesive	W	209	15	3	None	-
305	139+50	140+20	139+90	70	Cohesive	W	213	15	3	None	-
306	139+30	139+70	139+50	40	Cohesive	W	129	15	3	None	-
307	138+70	139+00	138+90	30	Cohesive	W	250	15	3	None	-
308	137+50	137+00	137+30	50	Cohesive	W	264	15	3	None	-
309	117+80	118+10	118+00	30	Cohesive	W	176	15	3	None	-
310	111+50	111+80	111+70	30	Cohesive	W	456	15	3	None	-
311	87+20	86+60	86+90	60	Cohesive	W	197	15	3	None	-
312	86+00	86+50	86+30	50	Cohesive	W	132	15	3	None	-
313	84+80	84+20	84+50	60	Cohesive	W	16	15	2	Monitor	-
314	76+10	76+40	76+30	30	Cohesive	W	303	15	3	None	-
315	59+50	59+40	59+50	10	Cohesive	W	50	15	3	None	-
316	59+30	59+10	59+20	20	Cohesive	W	44	15	3	None	-
317	57+50	57+40	57+50	10	Cohesive	W	33	15	3	None	-
318	57+10	56+90	57+00	20	Cohesive	W	45	15	3	None	-
319	36+80	36+30	36+60	50	Cohesive	W	577	15	3	None	-
320	36+30	36+80	36+60	50	Cohesive	W	66	15	3	None	-
321	35+50	34+70	35+10	80	Cohesive	W	516	15	3	None	-
322	33+30	34+10	33+70	80	Cohesive	W	443	15	3	None	-
323	31+40	32+60	32+00	120	Cohesive	W	139	15	3	None	-
324	29+90	31+10	30+50	120	Cohesive	W	144	15	3	None	-
325	28+90	29+70	29+30	80	Cohesive	W	354	15	3	None	-
326	28+10	28+90	28+50	80	Cohesive	W	163	15	3	None	-
327	27+70	28+10	27+90	40	Cohesive	W	312	15	3	None	-
328	26+70	27+40	27+10	70	Cohesive	W	74	15	3	None	-
329	24+40	23+90	24+20	50	Cohesive	W	160	15	3	None	-
330	20+30	20+70	20+50	40	Cohesive	W	383	15	3	None	-
331	19+90	19+50	19+70	40	Cohesive	W	477	15	3	None	-
332	18+20	18+00	18+10	20	Cohesive	W	382	15	3	None	-
333	17+70	18+00	17+90	30	Cohesive	W	352	15	3	None	-
334	12+90	13+30	13+10	40	Cohesive	W	326	15	3	None	-
335	11+40	11+70	11+60	30	Cohesive	W	464	15	3	None	-
336	10+30	10+60	10+50	30	Cohesive	W	69	15	3	None	-
337	9+50	10+10	9+80	60	Cohesive	W	162	15	3	None	-
338	8+80	9+60	9+20	80	Cohesive	W	93	15	3	None	-
339	7+80	8+60	8+20	80	Cohesive	W	159	15	3	None	-
340	7+60	7+50	7+60	10	Noncohesive	G/G	178	15	3	None	-
341	7+50	6+70	7+10	80	Cohesive	W	605	15	3	None	-
342	6+70	7+50	7+10	80	Cohesive	W	177	15	3	None	-
343	5+90	6+90	6+40	100	Cohesive	W	181	15	3	None	-
344	5+40	4+90	5+20	50	Cohesive	W	643	15	3	None	-
345	4+20	4+70	4+50	50	Cohesive	W	80	15	3	None	-
346	1+90	2+70	2+30	80	Cohesive	W	300	15	3	None	-

[1] W = weathering, G/G = grain by grain, MF = mass failure

[2] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[3] Low protection priority for weathering, high priority for grain by grain erosion.

Table 3.28. Summary of sites with existing bank protection at East Branch of the Root River and the recommended course of action for each site.

Bank Protection Number	Start Station (ft)	Stop Station (ft)	Midpoint Station (ft)	Length (ft)	Damaged	Functioning	Proximity to Other Infrastructure (ft)	Subreach Averaged Channel Top width (ft)	Proximity Rating [1]	Course of Action [2,3]
64	207+30	207+00	207+15	30	No	Yes	170	15	3	None
65	206+90	206+80	206+85	10	No	Yes	206	15	3	None
66	200+10	199+90	200+00	20	No	Yes	203	15	3	None
66.1	200+10	199+90	200+00	20	No	Yes	203	15	3	None
67	197+50	197+30	197+40	20	No	Yes	164	15	3	None
68	194+30	194+50	194+40	20	No	Yes	101	15	3	None
69	193+30	193+50	193+40	20	No	Yes	44	15	3	None
70	192+80	193+10	192+95	30	No	Yes	39	15	3	None
71	191+10	190+10	190+60	100	No	Yes	64	15	3	None
72	190+20	190+80	190+50	60	No	Yes	44	15	3	None
73	189+60	189+90	189+75	30	No	Yes	58	15	3	None
74	188+80	188+50	188+65	30	No	Yes	48	15	3	None
75	188+50	188+90	188+70	40	No	Yes	137	15	3	None
76	187+60	187+10	187+35	50	No	Yes	200	15	3	None
77	187+50	187+10	187+30	40	No	Yes	79	15	3	None
78	185+10	184+80	184+95	30	No	Yes	104	15	3	None
78.1	185+10	184+80	184+95	30	No	Yes	104	15	3	None
79	183+40	182+40	182+90	100	No	Yes	148	15	3	None
80	175+50	176+20	175+85	70	No	Yes	33	15	3	None
81	165+20	164+90	165+05	30	No	Yes	23	15	2	None
82	164+30	163+30	163+80	100	No	Yes	33	15	3	None
83	163+60	163+00	163+30	60	Yes	No	11	15	1	Replace
84	95+10	95+00	95+05	10	No	Yes	36	15	3	None
85	89+20	89+80	89+50	60	No	Yes	275	15	3	None
86	78+90	77+90	78+40	100	No	Yes	185	15	3	None
86.1	78+90	77+90	78+40	100	No	Yes	185	15	3	None

[1] 1= Proximity ≤ 1W, 2= 1W < Proximity < 2W, 3= Proximity ≥ 2W

[2] Replace if damaged and not functioning with Proximity Rating of 1.

[3] Replace with hard toe and a soft upper. See text for explanation.

3.18.2.2. Grade Control

Numerous grade-control structures were identified in the East Branch of the Root River (Appendix B), including:

- The concrete-lined trapezoidal channel upstream from West Ramsey Avenue,
- The underground culvert near Honey Creek Drive,
- RCBCs at 31st Street, Alvina Avenue and West College Avenue,
- The concrete rubble sill at Sta 210+00,
- The rock sill over the gas pipeline crossing at Sta 205+60,
- The rock-lined channel at Sta 186+80,
- The concrete rubble sill at Sta 177+00,
- The rock riprap sill for the pipeline crossing at Sta 106+00,
- The rock riprap sill at Sta 100+20,
- The rock-lined channel to protect against contraction scour at South 51st Street (Sta 73+70), and
- The rock sill at Sta 14+80.

No action is required at the structures, since they are not damaged and are functioning.

3.18.2.3. Storm Drain Outfalls

Thirty Four storm drain outfalls were identified in the East Branch of the Root River (Appendix B). The failed portion of the culvert outlets at Sta 59+90 should be removed to prevent further local scour, if possible.

3.18.2.4. Bridge and Culvert Crossings

Downstream from West Ramsey Avenue, publicly owned bridge crossings in the East Branch of the Root River include:

- The underground concrete pipe below Honey Creek Drive,
- The concrete slab crossing for the private drive in the mobile home park south of West College Avenue,
- The RCBCs at 31st Street, Alvina Avenue and West College Avenue,
- Bridge spans at West Rawson Avenue, West Drexel Avenue, and South 51st Street.

The bridge structures are functioning (hydraulically), and as such, no action is required.

3.19. Tuckaway Creek

The field reconnaissance in Tuckaway Creek focused on the reach between the Milwaukee County House of Corrections pond and the confluence with the North Branch Root River, since upstream sediment loading is trapped in the House of Corrections impoundment.

3.19.1. Channel Stability

3.19.1.1. Bank Erosion

One bank erosion site was identified in Tuckaway Creek downstream from the Milwaukee County House of Corrections (MCHC) pond with a length of 60 lineal feet (Appendix A). Because the bank erosion is located more the two channel widths from infrastructure (Category 3), no action is required. Since the outlet works of the MCHC pond appear to be damaged as a result of overtopping of flows and undercutting from beneath, the structure should be monitored.

3.19.1.2. Vertical Stability

There is little evidence of vertical instability in Tuckaway Creek downstream from the MCHC pond.

3.19.2. Infrastructure

3.19.2.1. Bank Protection

No bank protection was identified in Tuckaway Creek downstream from the MCHC pond.

3.19.2.2. Grade Control

No grade-control structures were identified in Tuckaway Creek downstream from the MCHC pond.

3.19.2.3. Storm Drain Outfalls

No storm drain outfalls were identified in Tuckaway Creek downstream from the MCHC pond.

3.19.2.4. Bridge and Culvert Crossings

No publicly owned bridge crossings of Tuckaway Creek are located downstream from the MCHC pond.

3.20. Ryan Creek

The field reconnaissance in Ryan Creek focused on the reach between South 92nd Street and the confluence with the North Branch Root River, since sediment delivery from upstream sources is limited by the numerous beaver dams in the channelized portion of Ryan Creek.

3.20.1. Channel Stability

3.20.1.1. Bank Erosion

No bank erosion was identified in Ryan Creek downstream from South 92nd Street.

3.20.1.2. Vertical Stability

There is little evidence of vertical instability in Ryan Creek downstream from South 92nd Street.

3.20.2. Infrastructure

3.20.2.1. Bank Protection

One existing bank protection site was identified in Ryan Creek downstream from South 92nd Street at Sta 31+30, with a total length of 50 lineal feet (Appendix B). The existing bank protection site is not damaged and is functioning, and as such, no action is required.

3.20.2.2. Grade Control

No grade-control structures were identified in Ryan Creek downstream from South the 92nd Street culvert.

3.20.2.3. Storm Drain Outfalls

No storm drain outfalls were identified in Ryan Creek downstream from South 92nd Street.

3.20.2.4. Bridge and Culvert Crossings

Downstream from the concrete box culvert at South 92nd Street, the only publicly owned bridge crossing of Ryan Creek is the RCBC at South 76th Street. The bridge crossing is functioning (hydraulically), and as such, no action is required.

Summary sheets for the individual subreaches of the North Branch Root River and tributaries are provided in **Appendix C**.

4. REFERENCES

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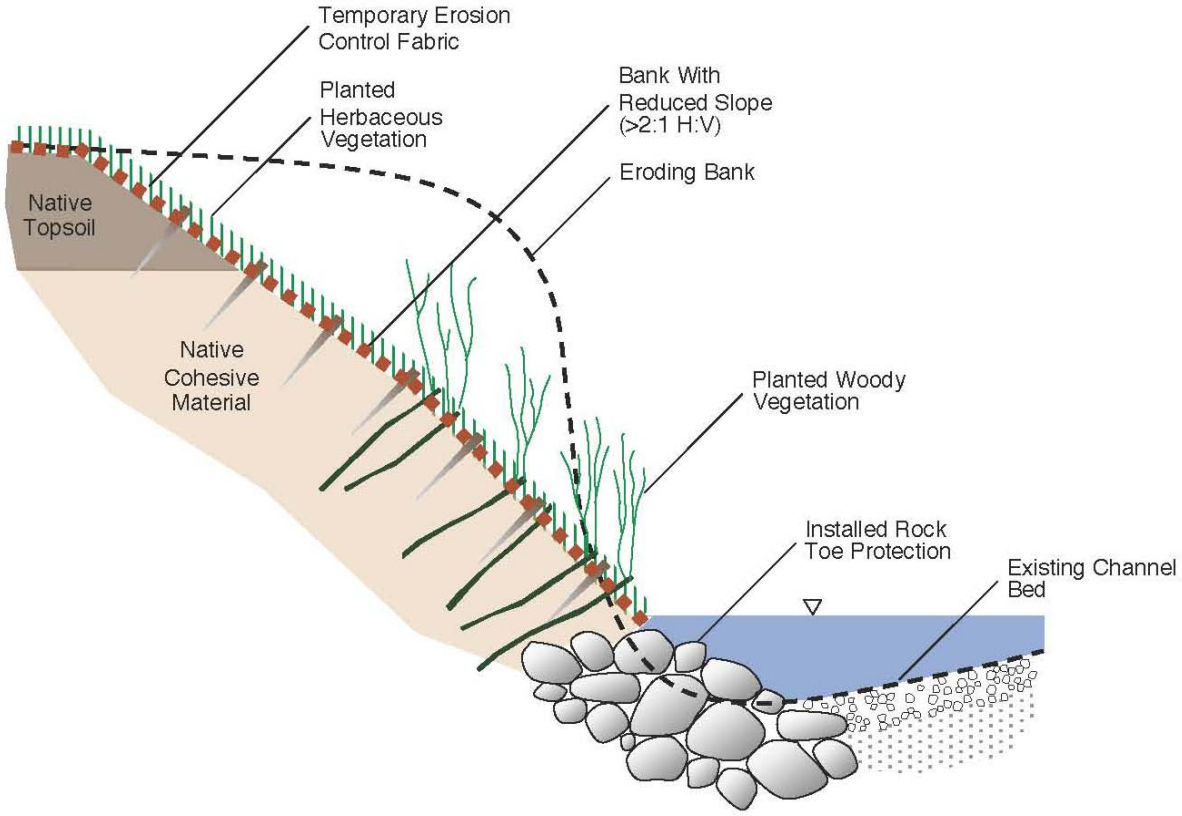

Figure 2.1. Typical bank protection schematic that provides a rock toe armor with a vegetated upper bank (Source: Mainstream Restoration).

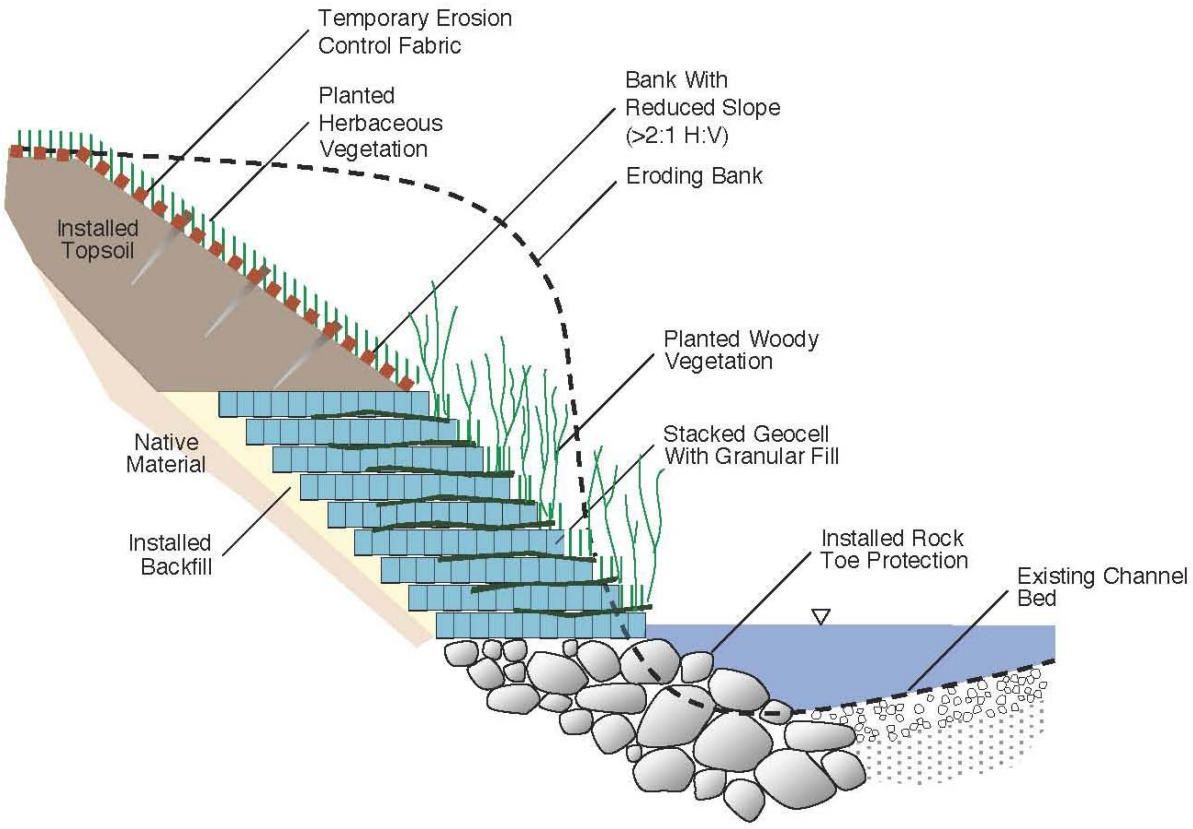

Figure 2.2. Typical bank protection schematic that provides a rock toe armor, a mid-bank reinforcement to allow for a steeper slope and upper bank vegetation (Source: Mainstream Restoration).

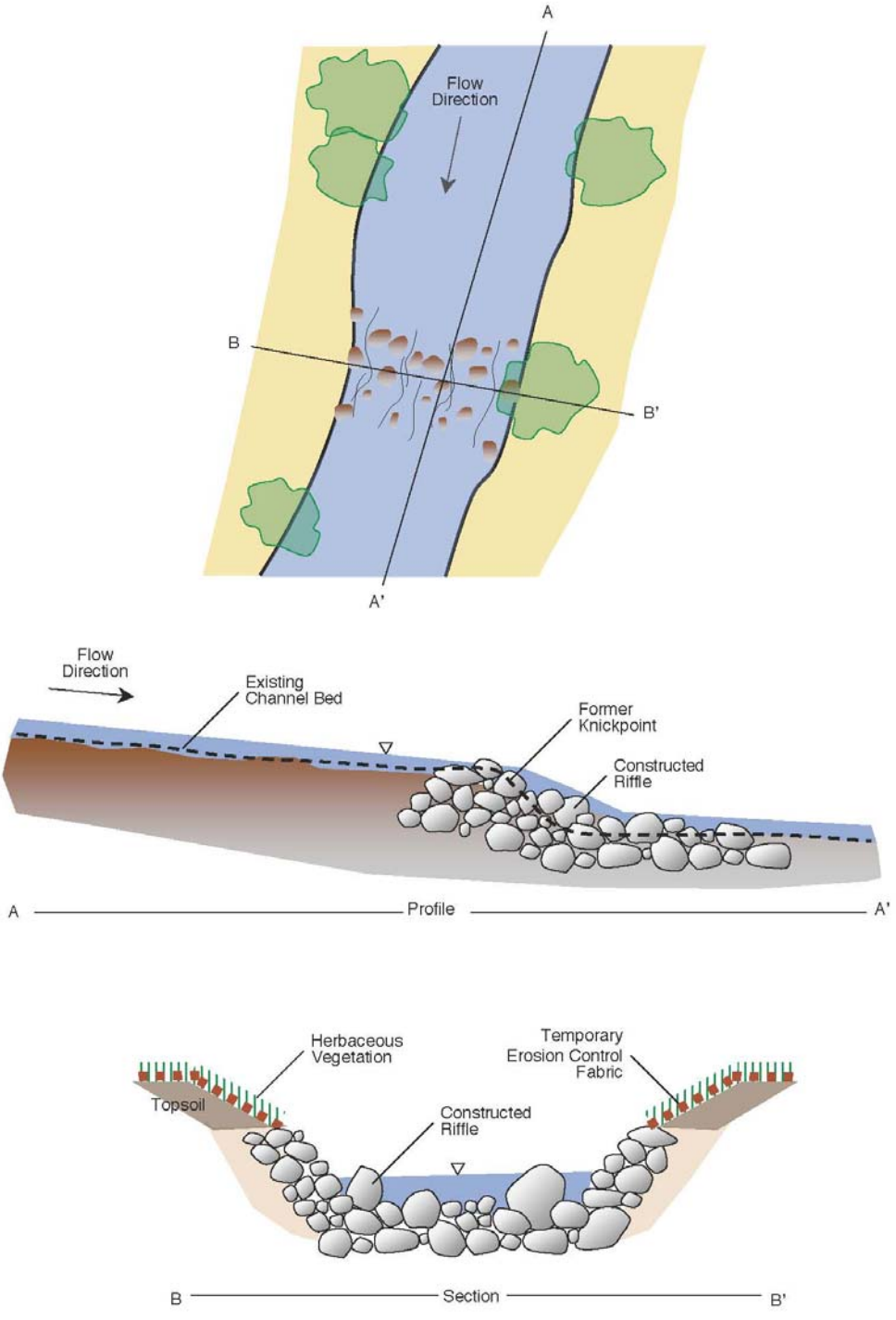

Figure 2.3. Typical grade-control schematic showing a constructed riffle that can be used to stabilize both headcuts and knickpoints (Source: Mainstream Restoration).