ENGINEER'S REPORT

MEEKER COUNTY DITCH 47 / MIDDLE FORK CROW RIVER RESTORATION PROJECT #2017-01

Prepared for:
Middle Fork Crow River Watershed District
189 County Road 8 NE
Spicer, MN 56288

Prepared by:
Wenck Associates, Inc.
1800 Pioneer Creek Center
Maple Plain, MN 55359-0249

The Middle Fork Crow River Watershed District received a Clean Water Fund Accelerated Implementation Grant from the Board of Soil and Water Resources in 2015 to do an assessment of the current conditions of river banks on County Ditch 47 also a public water Middle Fork of the Crow River in Meeker County.

WENCK
Responsive partner.
Exceptional outcomes.

MIDDLE FORK CROW RIVER
WATERSHED DISTRICT

County Meeker
MINNESOTA

CLEAN WATER LAND & LEGACY AMENDMENT

Meeker County Ditch 47 / Middle Fork Crow River Restoration Project #2017-01

Engineer's Report

Prepared For: Middle Fork Crow River Watershed District

Prepared By: WENCK ASSOCIATES, INC.
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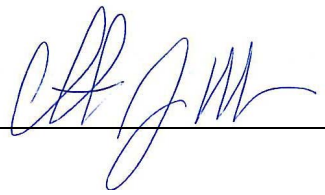
Wenck File: 1979-08

July 2017

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I, a duly Licensed Professional Engineer under the laws of Minnesota.

Print Name Christopher J. Meehan

Signature 

Date 07/26/2017 License No. 43066

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PURPOSE

The founding petition of the Middle Fork Crow River Watershed District stated that the formation of the District was necessary because of the degradation of water resources in recent decades and the need to address issues including erosion, sedimentation, and best management practices.

The 11-mile stretch of the Middle Fork Crow River downstream of Lake Calhoun has been a straightened and degraded portion of the river. That portion which is located in Meeker County is designated as County Ditch (47).

Ditching has reduced the connectivity of the stream to its floodplain as well as physically altered the stream. Ditching (dredging and straightening) reduced channel roughness by reducing pools and riffles, increased the channel slope by shortening the length of stream flow and has separated flood flows from the floodplain through the buildup of dredge spoils wasted on the streambank. All of these factors serve to contain more flow in the channel, increase the velocity of river flow and creates the potential for increased erosion problems both on the channel banks and the channel bottom (degradation and channel incision).

Ditching and draintiling has likely changed the hydraulics and hydrology of the Middle Fork Crow River from its pre-settlement conditions to a system that sends more water to the river system faster. This increased runoff volume and flow rate also increases the potential for erosion problems.

Combining the factors of ditching and hydrology modifications puts more water in the channel, makes the water move through the straight channel faster and has increased bank erosion.

As a result of the erosion noted along this section the Middle Fork Crow River Watershed District received a Clean Water Fund Accelerated Implementation Grant from the Board of Soil and Water Resources in 2015 to do an assessment of the current conditions of river banks on County Ditch 47 in Meeker County.

The objective of the study was to identify the eroding portions of the river bank to determine sources and sediment loading. Through the assessment practices would be identified which stabilize the stream and limit erosion improving the water quality of the river.

In June of 2017 The Middle Fork Crow River Watershed District Board of Managers ordered Project 2017-01 to implement Best Management Practices which will address excess erosion which is occurring on the stream (Appendix 1).

BACKGROUND

The Middle Fork Crow River Watershed District (MFCRWD) was formed by order of the Minnesota Board of Water and Soil Resources (BWSR) on April 27, 2005, in accordance with Minnesota Statutes Chapter 103D (Watershed Law). The action concluded a process that began with an establishment petition that was signed by more than 350 concerned citizens. The petition stated that the formation of the District was necessary because of the degradation of water resources in recent decades and the need to address issues including erosion, sedimentation, and best management practices. The organizational structure of the MFCRWD consists of a Board of Managers and an Advisory Committee. The Board, which is comprised of five members, is responsible for the oversight of all District-related business. Board representation is based upon the relative area of each county within the District; three managers represent Kandiyohi County, while Meeker and Stearns County each have one manager. District is required to prepare and adopt a watershed management plan for the purposes for which it was established. The intent of this Plan is to fulfill this requirement and provide a "vision" for water resource management for the next ten years (April 2007-April 2017). The Plan consists of an introduction and five chapters (Appendix 2).

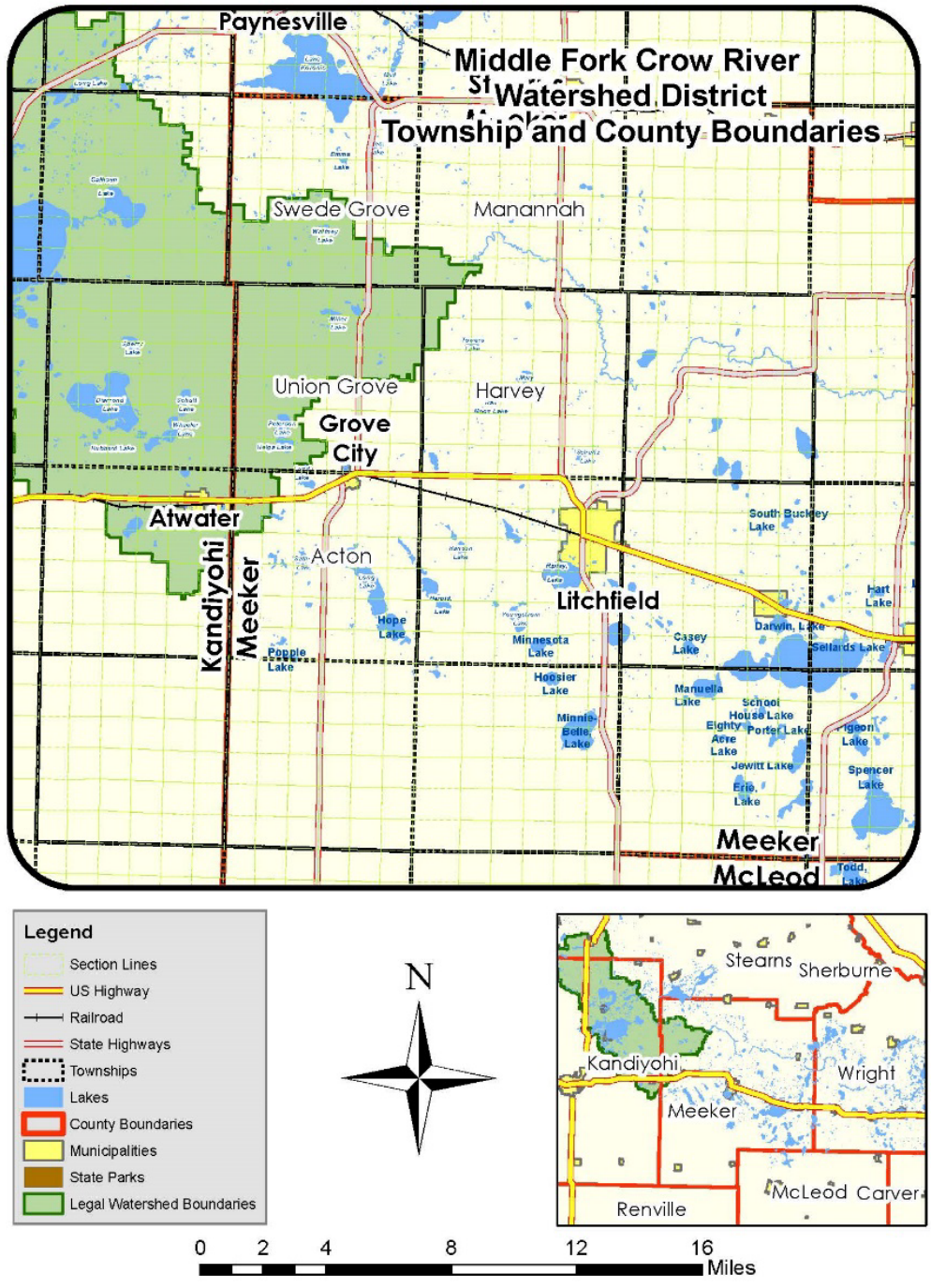


Figure 1 – Project Location Map.

Location and Size

The general location of the MFCRWD is displayed in Figure 1. Notice that political boundary of the District closely resembles the hydrological boundary of the Middle Fork Crow River Watershed. The Watershed is part of the much larger Upper Mississippi River Watershed; the Middle Fork of the Crow River outlets to the North Fork of the Crow River near Manannah, which eventually outlets to the Mississippi River near Dayton. The District encompasses 270.7 square miles (173,220 acres) across portions of four counties. The overwhelming majority of the District is located within Kandiyohi County (72.1%), with lesser percentages in Meeker (16.2%), Stearns (11.3%), and Pope (0.5%) Counties. In addition, the cities of Atwater, Belgrade, New London, and Spicer are all entirely located within the District.

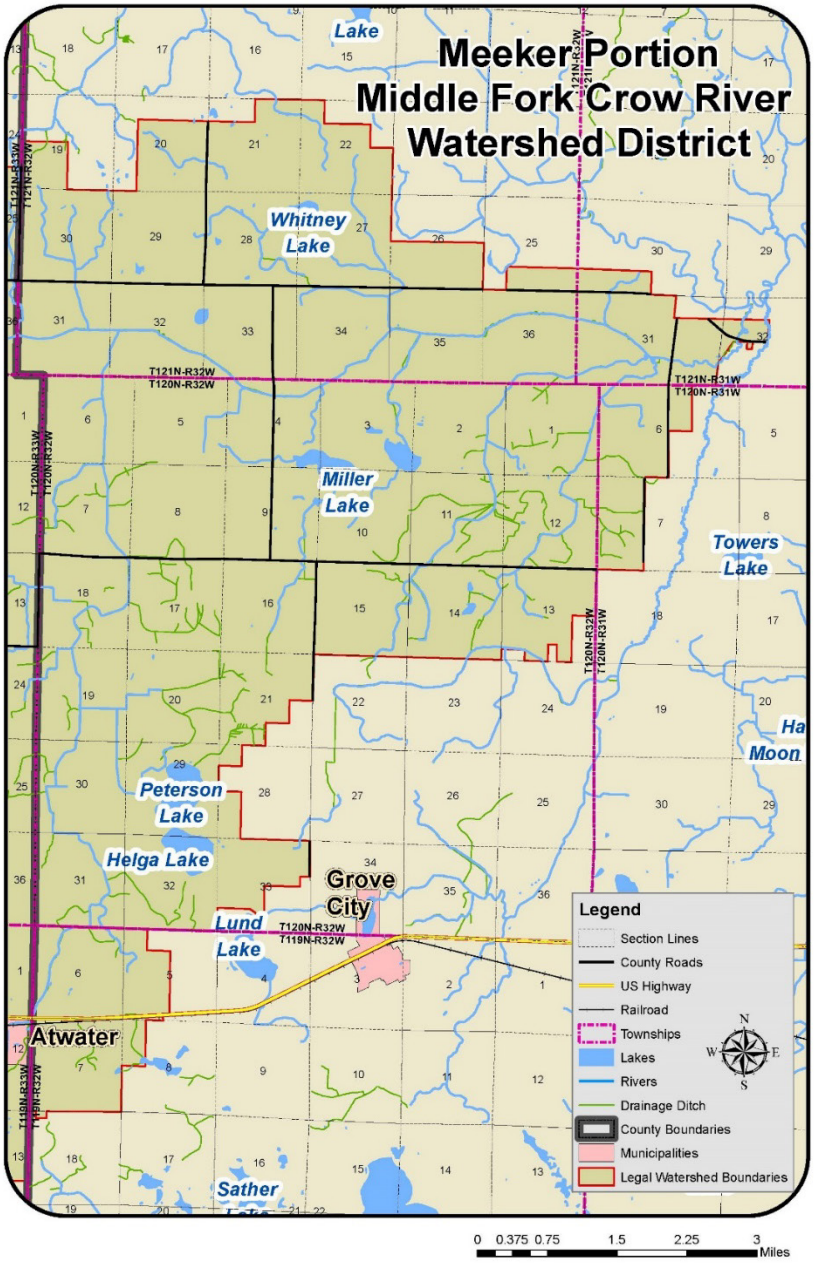


Figure 2 – Meeker County Portion of the Middle Fork Crow River Watershed District

Rivers and Streams

The stream network of the District primarily consists of the Middle Fork of the Crow River, which extends approximately 48.8 miles through the District. The River originates near Crow Lake in Stearns County and outlets to the North Fork of the Crow River near Manannah in Meeker County. Many sections of the River have been channelized for drainage purposes. In fact, only two extensive segments of the River remain relatively unaltered by human activity. The first segment extends from the New London Dam to Nest Lake, while the second is found upstream of Monongalia Lake. It is important to note that while these sections resemble the state of the River prior to settlement, flows have been anthropogenically modified.

Project Area

The stretch of Middle Fork Crow River in Meeker county to the confluence with the North Fork of the Crow River in Manannah is also designated as Meeker County Ditch 47 and was the area of study for this project. This area was noted as part of subwatershed #10 in the District's Overall Management Plan. The physical characteristics of the subwatershed are described below.

Subwatershed #10 - Middle Fork Crow River

Area: 20,704 ac

Minor Subwatersheds:

1805300 (12,533 ac)

1805301 (1,792 ac)

1805302 (3,248 ac)

1805303 (161 ac)

1802800 (2,970 ac)

Land Use Characteristic	Subwatershed		
	Total	Percent	Ranking
Agriculture	16,325	79%	1
Urban/Developed	1,015 ac	5%	9
Water	275 ac	1%	6
Wetlands	2,966 ac	14%	9
Restorable Wetlands	--	--	7
Erodible Land (HEL/PHEL)	545 ac	3%	8
Public Drainage Ditches	20 mi	--	2
Feedlots	10	--	8

Surface Water Resources:

Middle Fork of the Crow River

Local Governmental Units:

Counties: Kandiyohi and Meeker

Townships: Harrison, Irving, Union Grove, Manannah, Harvey, and Swede Grove

Priority Issues and Recommendation Identified in the Overall Management Plan were:

- ***Agricultural Drainage.*** There is an extensive network of public drainage systems in the subwatershed. The District should cooperatively work with the drainage authority and other partners to minimize the impact of these systems on water resources through the enforcement of existing regulations (MN Statutes Ch. 103E) and promotion of BMPs.

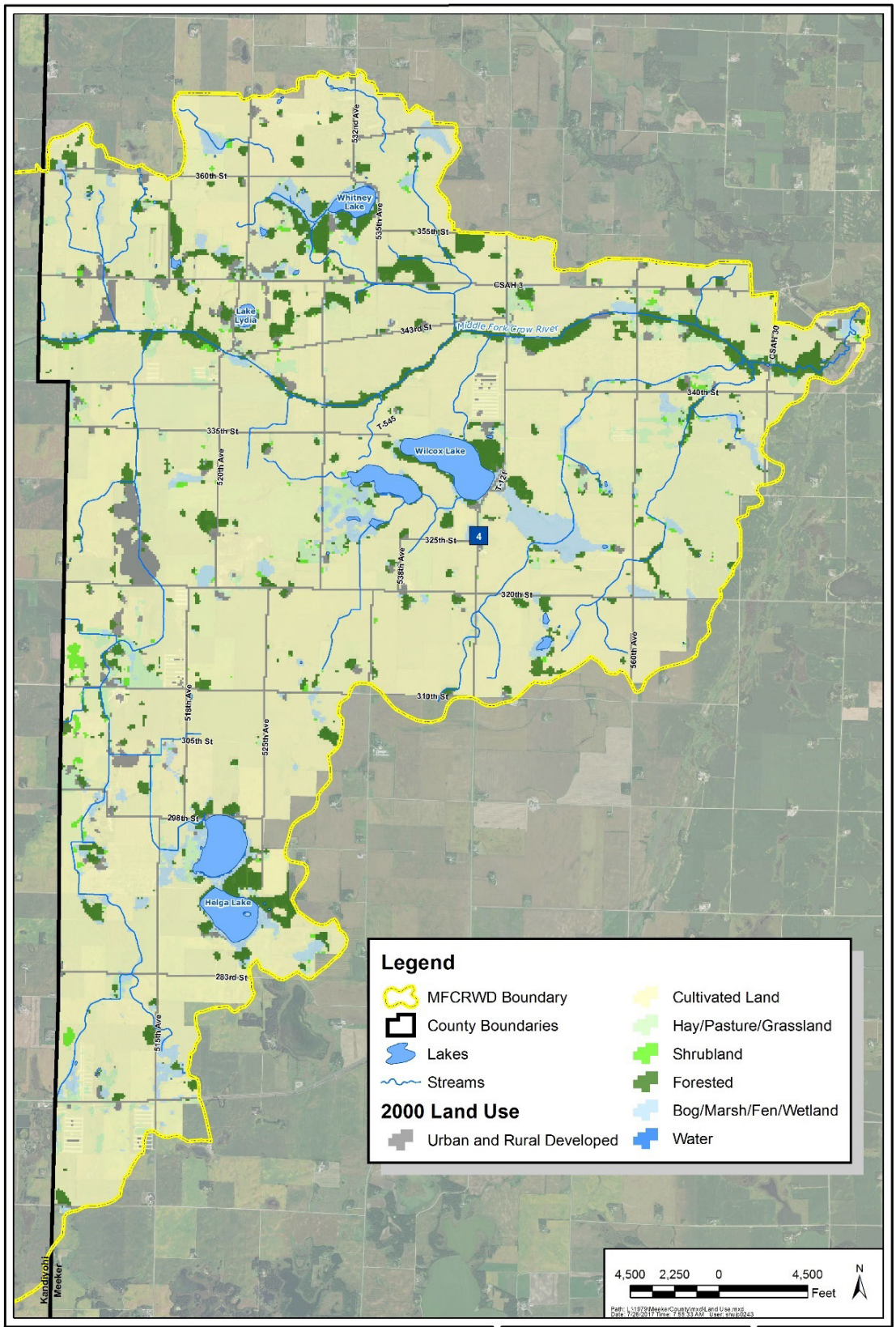
Figure 3 – Middle Fork Crow River Watershed District Subwatershed Boundaries – Subwatershed #10 is highlighted

- ***Erosion and Sediment Control.*** Cultivated agricultural land is the primary contributor of sediment to the River. The District should reduce erosion and sedimentation associated with agricultural land by promoting the implementation of BMPs, including riparian buffer strips and crop residue management.

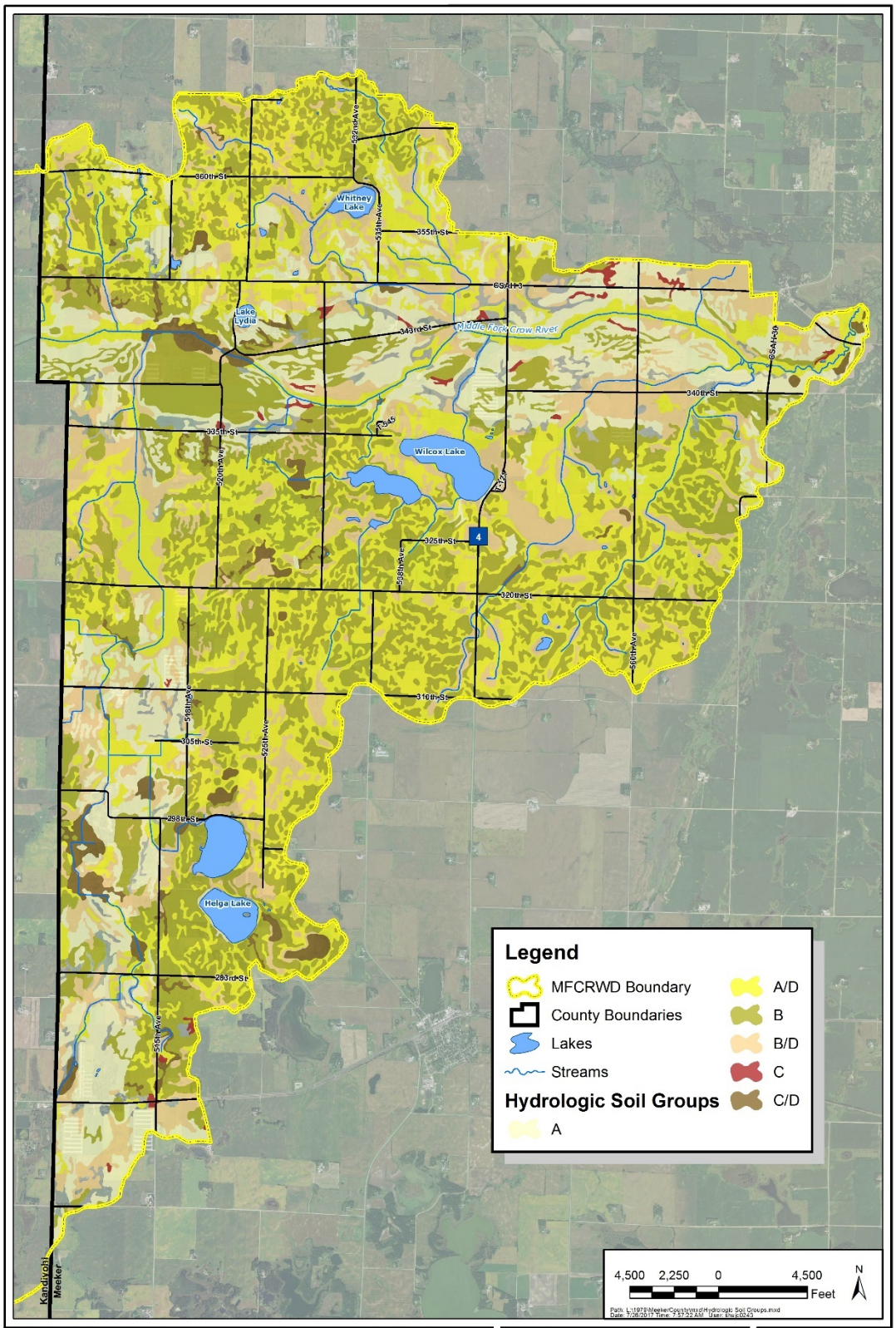
- ***River Restoration.*** The majority of the River in the subwatershed has been channelized, resulting in downcutting of the streambed in many areas. The District should work with the DNR and other partners to restore segments of the River to a more natural state.

- ***Wetland Preservation/Restoration.*** There are many existing and restorable wetlands in the subwatershed. The District should cooperatively work with partnering agencies to preserve and restore these areas through the enforcement of existing regulations and promotion of various conservation programs.

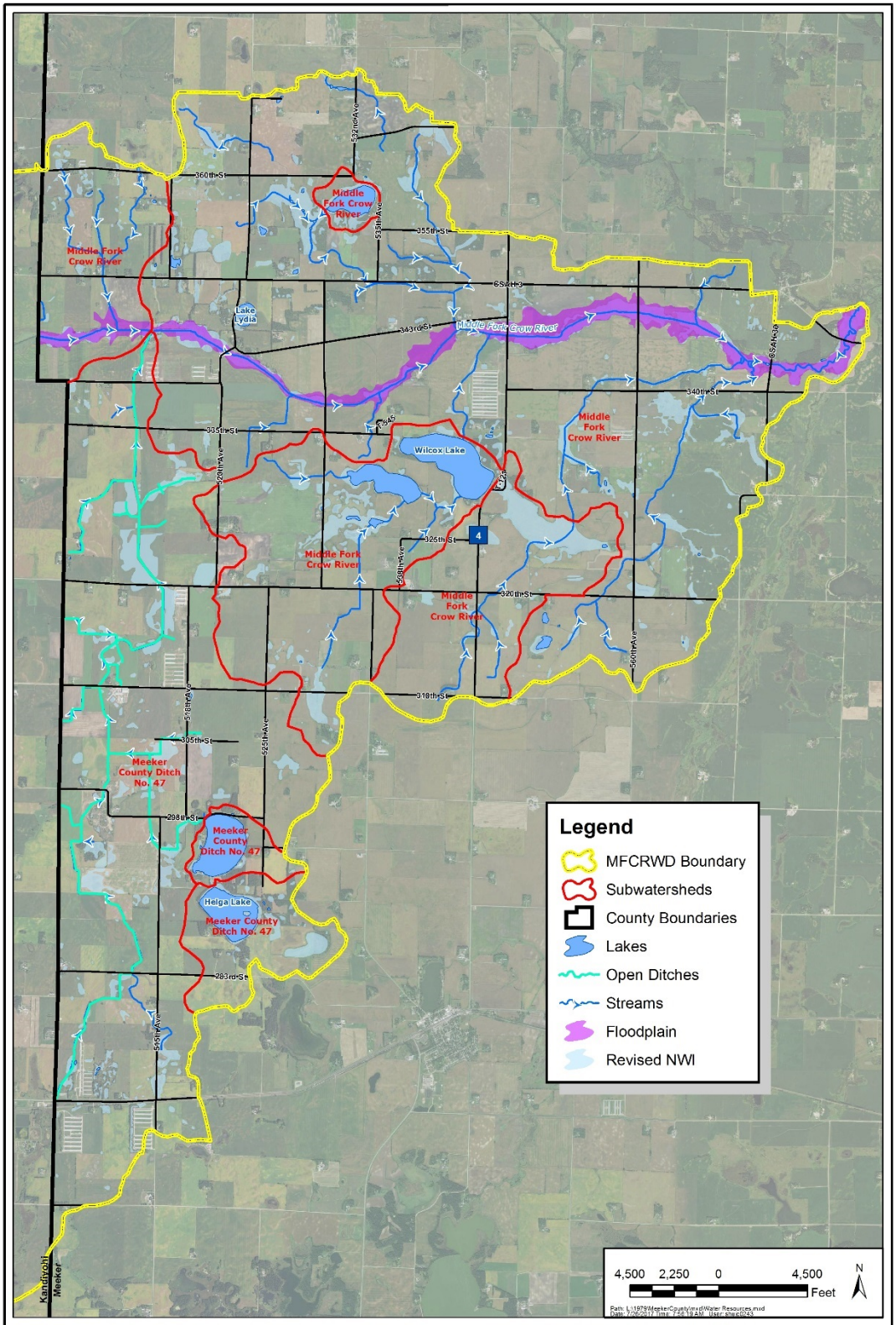
A summary of additional physical characteristics in the watershed are shown in the following figures.



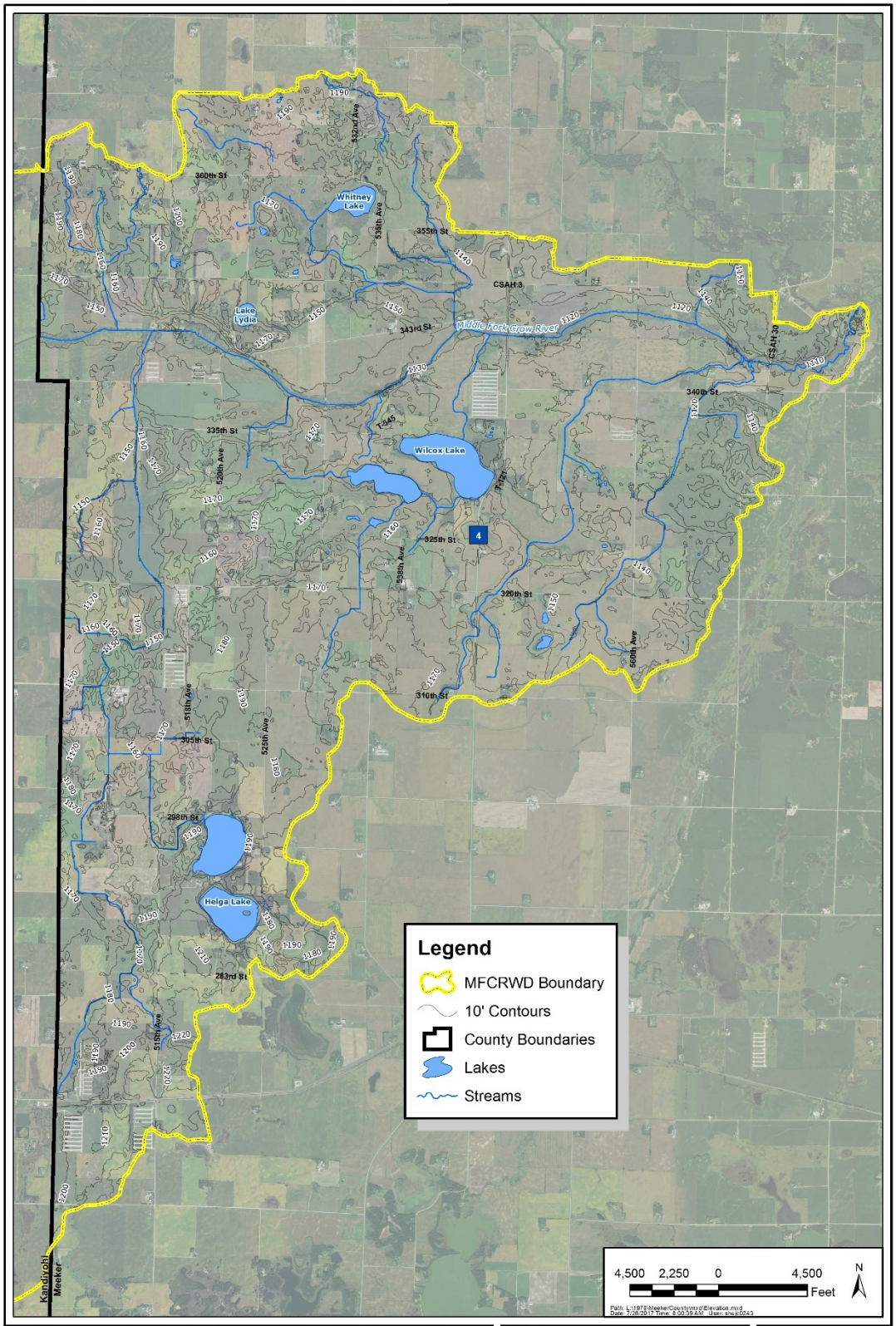
MFCRWD Land Use	WENCK Responsive partner. Exceptional outcomes.	JULY 2017



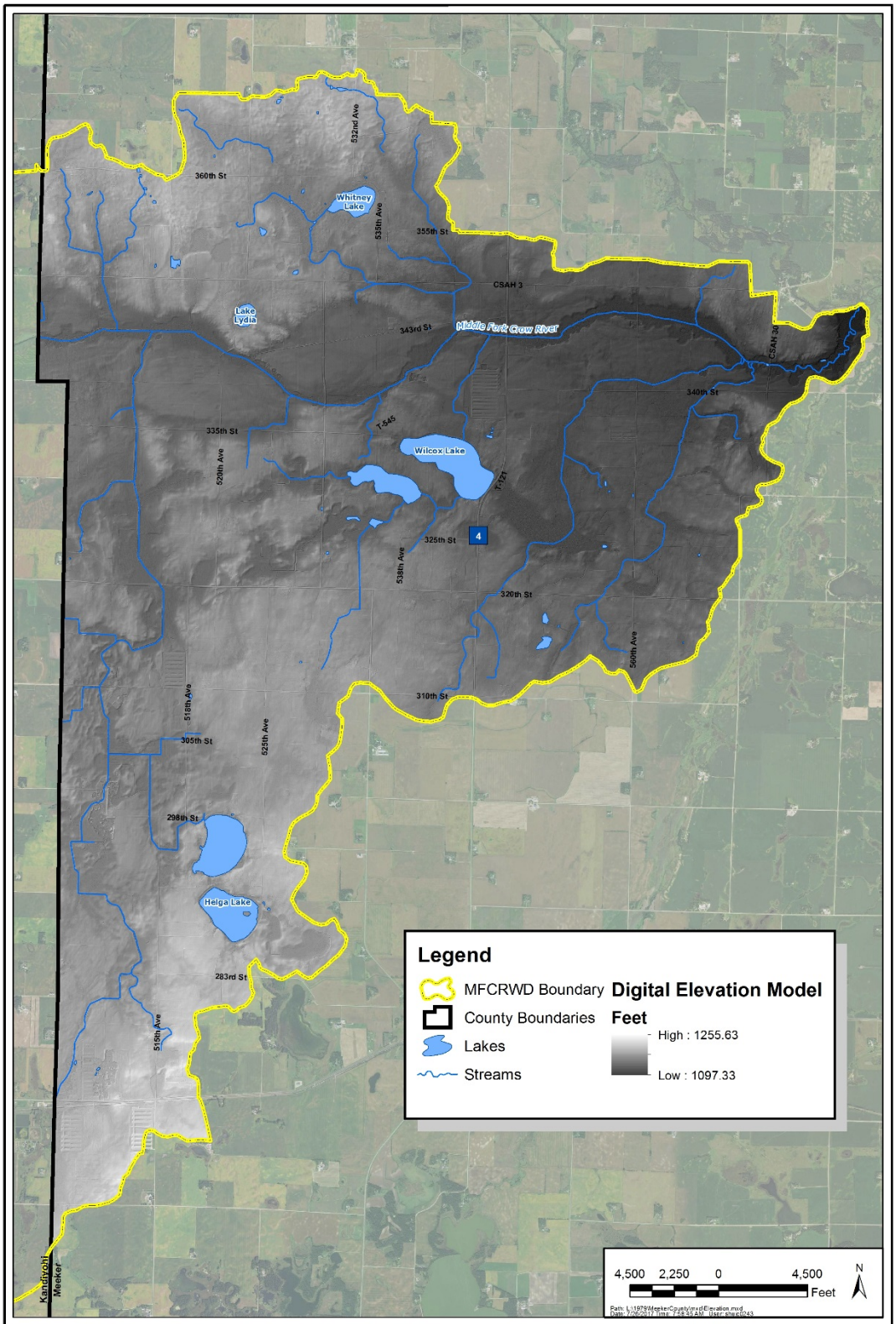
MFCRWD Hydrologic Soil Groups	WENCK Responsive partner. Exceptional outcomes.	JULY 2017



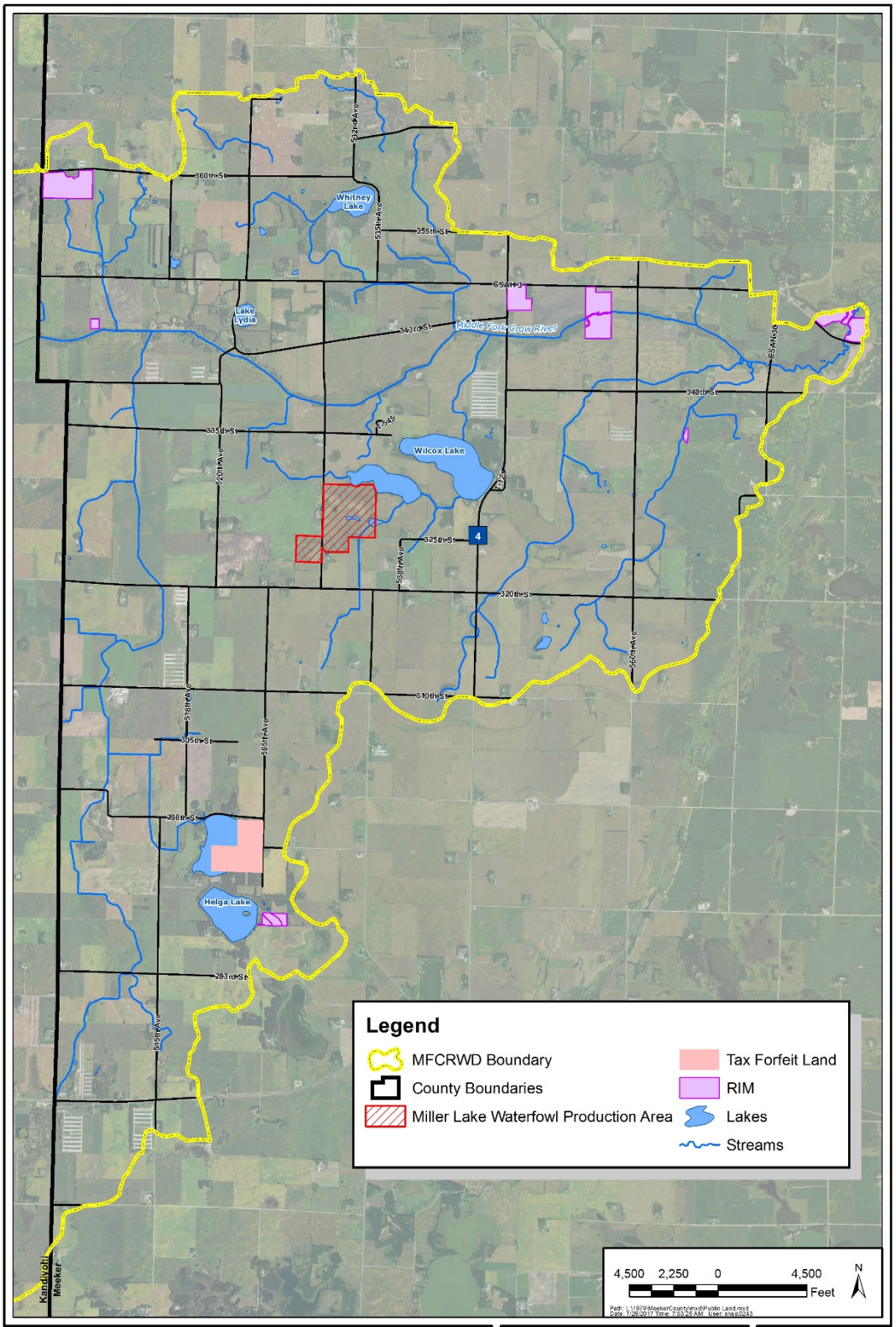
MFCRWD	WENCK	JULY 2017
Water Resources	Responsive partner. Exceptional outcomes.	



MFCRWD 10' LiDAR Contours	WENCK Responsive partner. Exceptional outcomes.	JULY 2017



MFCRWD	WENCK	JULY 2017
Digital Elevation Model	Responsive partner. Exceptional outcomes.	



MFCRWD Public Land	WENCK Responsive partner. Exceptional outcomes.	JULY 2017

APPROACH

The Middle Fork Crow River Watershed District received an Accelerated Implementation Grant in 2015 to do an assessment of the current conditions of river banks. The river was evaluated from Lake Calhoun to the confluence with the North Fork of the Crow River near Mannanah (Figure 4). These areas were chosen due to past practices of straightening the Middle Fork Crow River in this section along with several noted severe erosion problems had been identified along this segment.

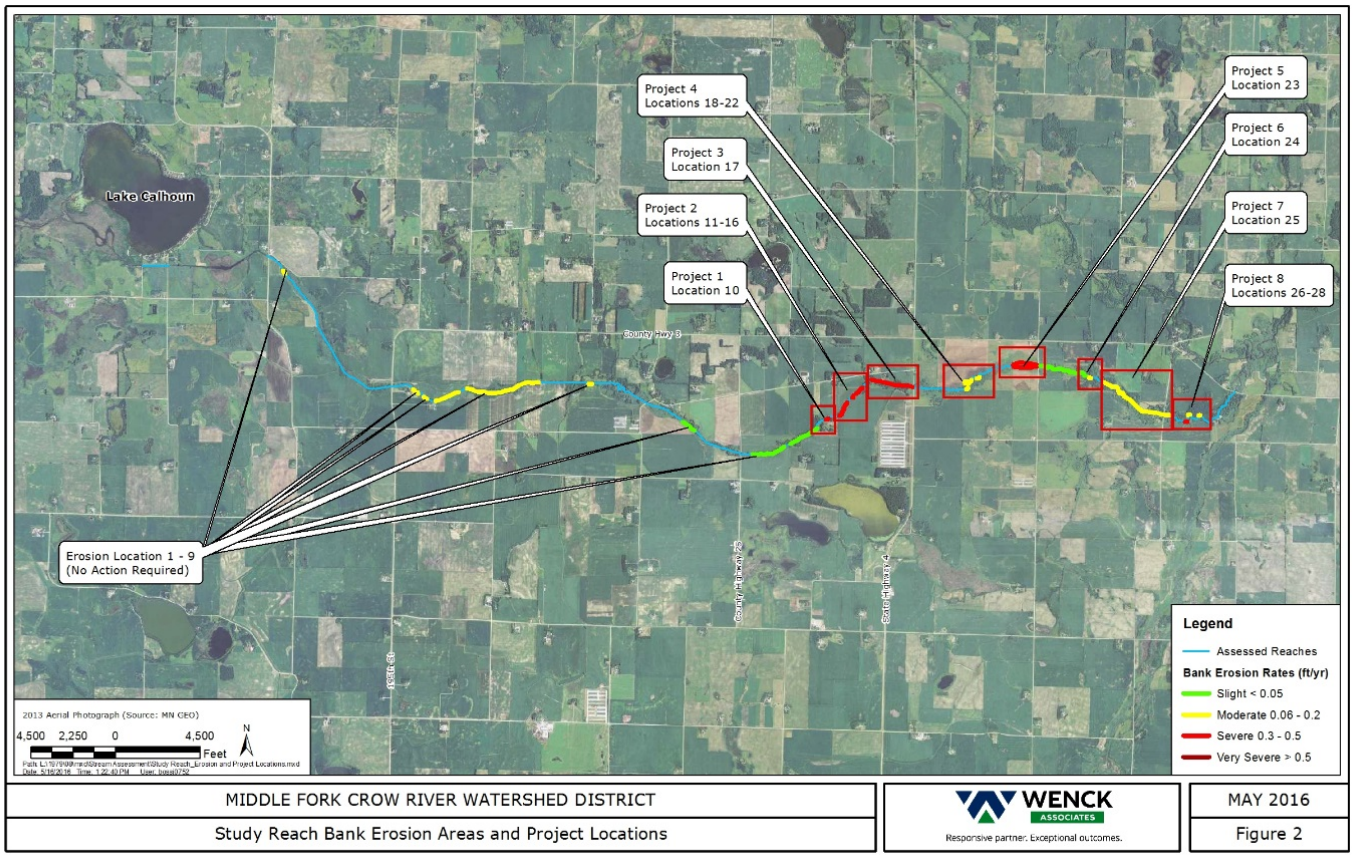


Figure 4 – 2015 Middle Fork Crow River Watershed District Accelerated Implementation Grant Project Study Area

On October 14th and 15th of 2015, Wenck and District staff floated down the Middle Fork of the Crow River from Lake Calhoun to the confluence with the North Fork Crow River to do an assessment of the current conditions of river banks. Locations of erosion were logged with survey equipment, measurements were taken, and photographs were taken.

Following the field work, Wenck reviewed the data to estimate erosion rates and amounts at each location and attributed severity based upon erosion rates (ft/yr). The WI NRCS recession severity classification was used to identify severity of erosion.

It was observed during the field evaluation where straightened sections of the river return to more natural meandering sections, that those locations are where the biggest erosion problems are occurring. Flow accelerates in the straightened sections (increased slope) and dissipates the increased energy through bank erosion in the meandering sections (natural or lower slope) as the flow slows back down (because the slope decreases). Returning the straightened sections to a more natural meandering pattern would remove the flow acceleration and reduce the active erosion (Appendix 3).

The solution to reducing the erosion occurring in the reach is to stabilize the active erosion areas and protect them from future erosion. Each of the marked erosion features can be consolidated into several Best Management Practice (BMP) projects to reduce the amount of sediment being contributed to the river.

After evaluating the erosion features, causes and potential stabilization techniques, eight projects were identified that combined 18 erosion locations into 8 groups that minimize access, disturbance, and construction costs (Appendix 4)

Conceptual designs were prepared for the erosion locations with moderately-high to severe erosion features were identified and combined locations into projects 1 – 8 based on proximity to one another, access, and number of landowners. All the projects identified were in Meeker County along County Ditch 47 which became the focus of the Engineer's Report and the Petition.

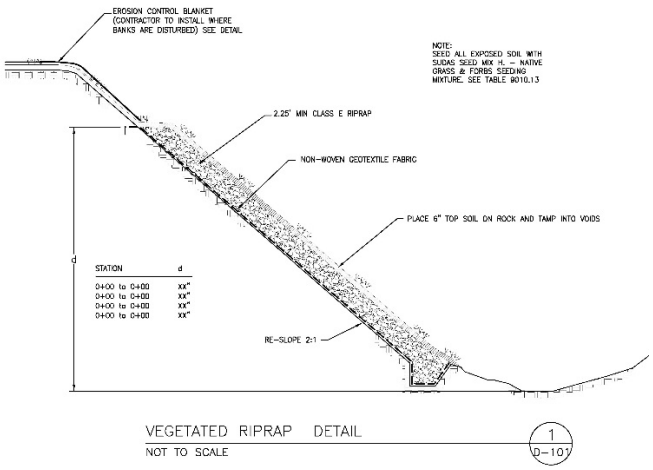
Through the assessment it was identified annual sediment and phosphorus loading could be reduced by 798 tons and 160 lbs respectively through the implementation of streambank stabilization techniques. A construction cost estimate was prepared for each concept project design and compared to the estimated reductions of erosion to rank the projects based on the dollars per pounds of sediment and phosphorous removed annually from lowest to highest.

Each streambank stabilization concept design recommends specific stabilization techniques for mitigating erosion and creating long-term solutions to the current issues. Each stabilization practice will be briefly explained and accompanied with images and/or typical construction details. *All figures and details were created by Wenck unless otherwise noted.*

VEGETATED RIPRAP

Vegetated riprap is a slope stabilization technique to be used in instances where flow velocity (5 – 20 CFS) requires hard armoring (rock) instead of bioengineered techniques. Vegetation adds a more natural aesthetic by camouflaging the rock.

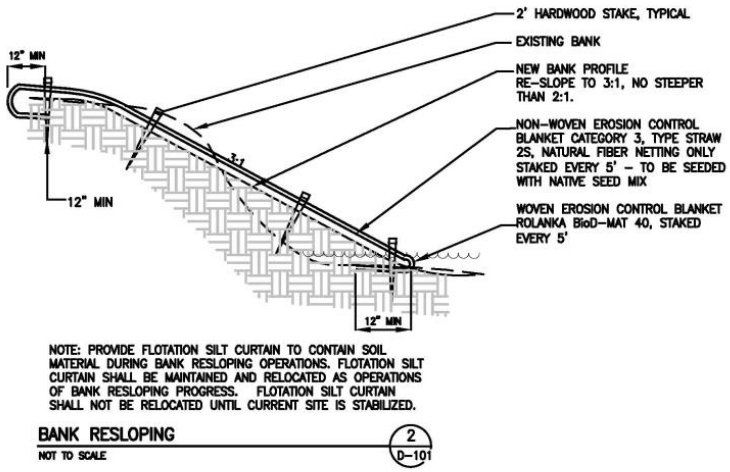
Vegetated riprap is intended to provide toe protection on taller (> 4'), vertical, eroding stream banks. Riprap would be installed at the existing toe line of the side slopes and be keyed in slightly below the stream bed. Some bank disturbance would be required to make the vertical bank less steep (ideally, 2:1 H:V or less) by grading from the top of the bank to the new riprap toe. Final stabilization of the riprap toe areas would include revegetation with native seed and either erosion control blanket along the channel where high flows are expected and straw mulch or hydro-mulch in the upland areas. Riprap toe would follow the existing bank, would balance cut and fill on site and would not alter the channel cross section.



Description. Vegetated Riprap Channel, 1 year after construction.

BANK RESLOPING WITH SEED & EROSION CONTROL BLANKET

Bank resloping is a bioengineering stabilization technique to be used in instances where flow velocity allows (<6 FPS) and/or for the portions of the bank above the normal high water level of a channel. Bank resloping is intended to establish native vegetation and provide toe protection on shorter (<3'), steep stream banks. Resloping the bank ranges from 3:1(H:V) or less (preferred), to no steeper than 2:1. It is intended to provide a stable slope for new vegetation to establish. The roots of the vegetation hold the slope during periods of inundation and reduce soil migration.



Description. Resloped Banks Constructed During Winter Work on Elm Creek.

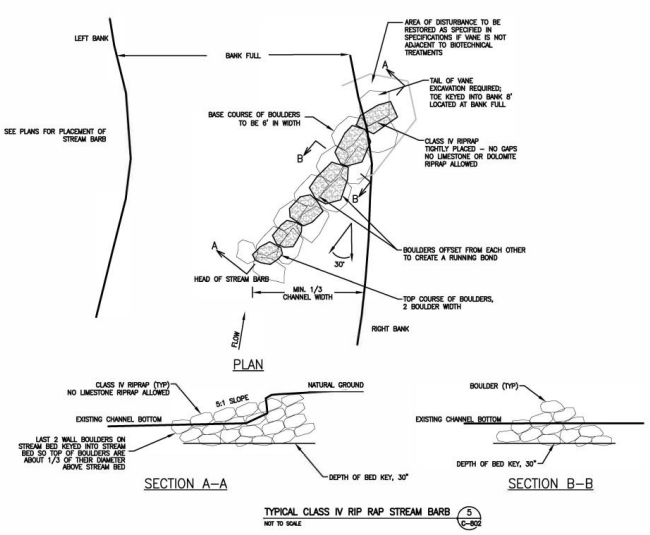
Tree Thinning/Tree Removal

Thinning existing trees to presettlement vegetation densities of 5 – 10 trees per acres, allows for more sunlight to reach the soil. Increased sunlight encourages the amount and vigor of ground plane grasses thus mitigating soil movement into adjacent waterbody's.

Description. One year after clearing trees, the existing seed bank grew into a healthy grass buffer on Coon Creek

Stream Barbs

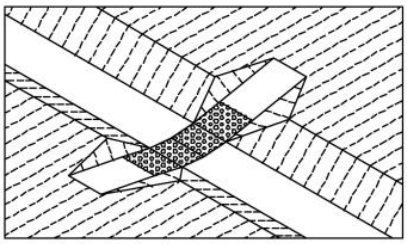
Stream barbs are a descending trapezoidal mass of rock, pointed upstream extending from the center of the channel back into the adjacent bank. Stream barbs serve to redirect erosive force within the stream channel back toward the center of the channel and away from the banks. On the downstream side, at approximately 5 times the length of the barb, water flow experiences reduced velocity and erosive action allowing sedimentation to occur.



Description. Three stream barbs to turn the flow of Purgatory Creek away from sharp outside bend.

CATTLE CROSSING & EXCLUSION FENCING

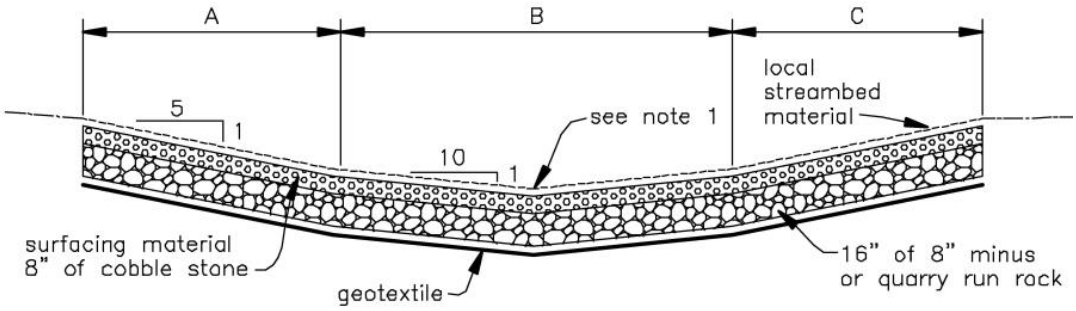
Cattle crossing and exclusion fencing serves to prevent the overgrazing of bank vegetation and trampling of stream banks while still allowing livestock access to water and pastures on the opposite side. Disturbance and erosion of the stream bed and banks is minimized by only allowing access and crossing of the stream in select locations that have been designed and constructed to be stable under cattle and equipment traffic.



ISOMETRIC

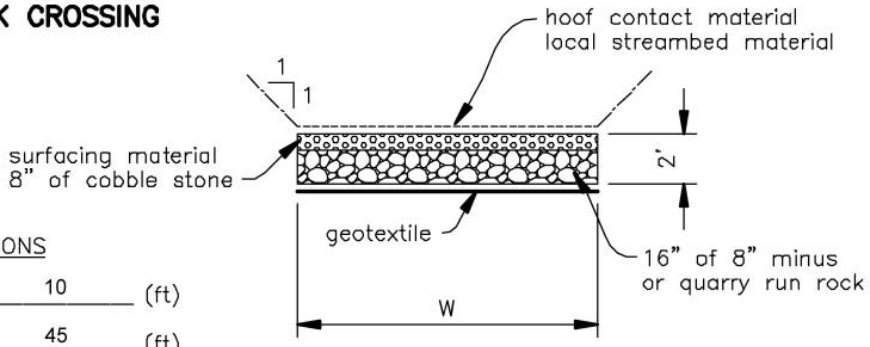
CONSTRUCTION NOTES

1. Crossing surface shall be a minimum of 0.2 ft below channel invert.
2. Surfacing material shall be compacted as per method (4) of CS–15.6.



CENTERLINE PROFILE

LIVESTOCK CROSSING



SECTION

DIMENSIONS

A = 10 (ft)

B = 45 (ft)

C = 10 (ft)

W = 15 (ft)

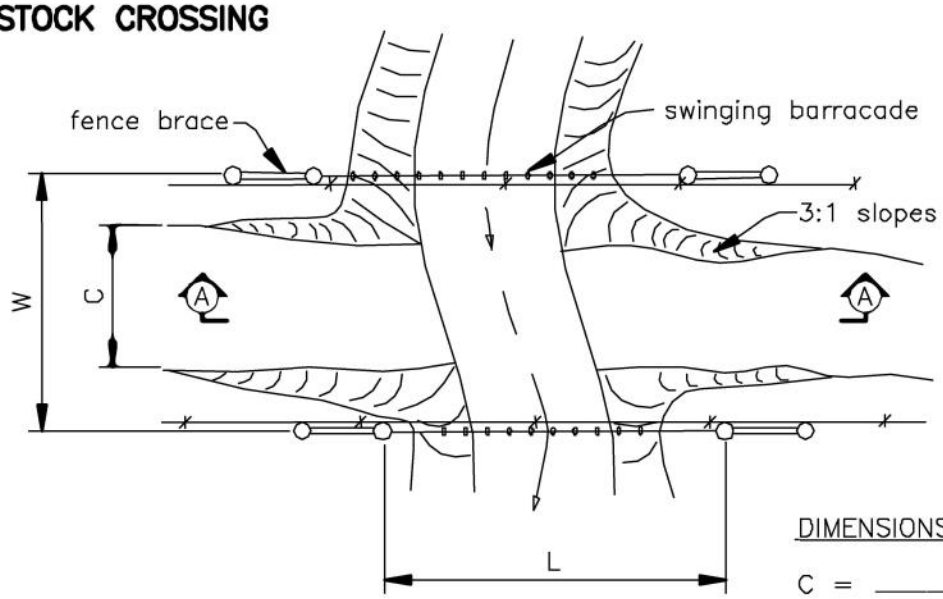
Station _____

Drawing not to scale.

NOTE:
This standard drawing requires supporting technical documentation prior to use and must be adapted to the specific site.

Description. Note: Construction Details by NRCS

LIVESTOCK CROSSING



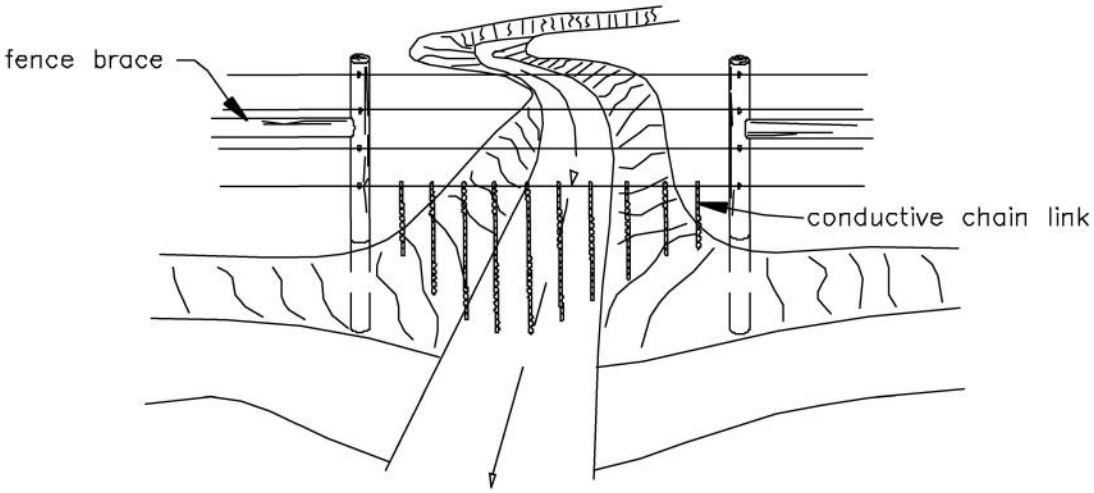
PLAN VIEW

DIMENSIONS

C = _____ (ft)

W = _____ (ft)

L = _____ (ft)



SECTION

Fence must meet Practice Standard No. 382.

Drawing not to scale. Standardized drawing must be adapted to the specific site.

Description. Note: Construction Details by NRCS

1 Rod Buffer

1 rod = 16.5 ft. Buffers stabilize the ground surface near waterways from overland flow, as well as, filter sediments out of stormwater runoff from surrounding areas by reducing flow velocity. Bare farm fields and paved surfaces in particular can contribute sediment into adjacent waterways. Implementation of the new MN Buffer Law will help stabilize the banks and improve water quality and habitat of the Middle Fork Crow River.

Description. An established grassed buffer. Photo by MN DNR.

FINDINGS

Each of the erosion locations with a moderate-high to severe erosion rates along County Ditch 47 in Meeker County were grouped into conceptual designs based on location, proximity to other features, access and number of homeowners for construction. Refer to the Project Location Overview (Figure 5) map for the locations of each project within the project area. Each design was considered feasible based on the ability to access the site, construct, and permit the improvement.

PROJECT LOCATION OVERVIEW

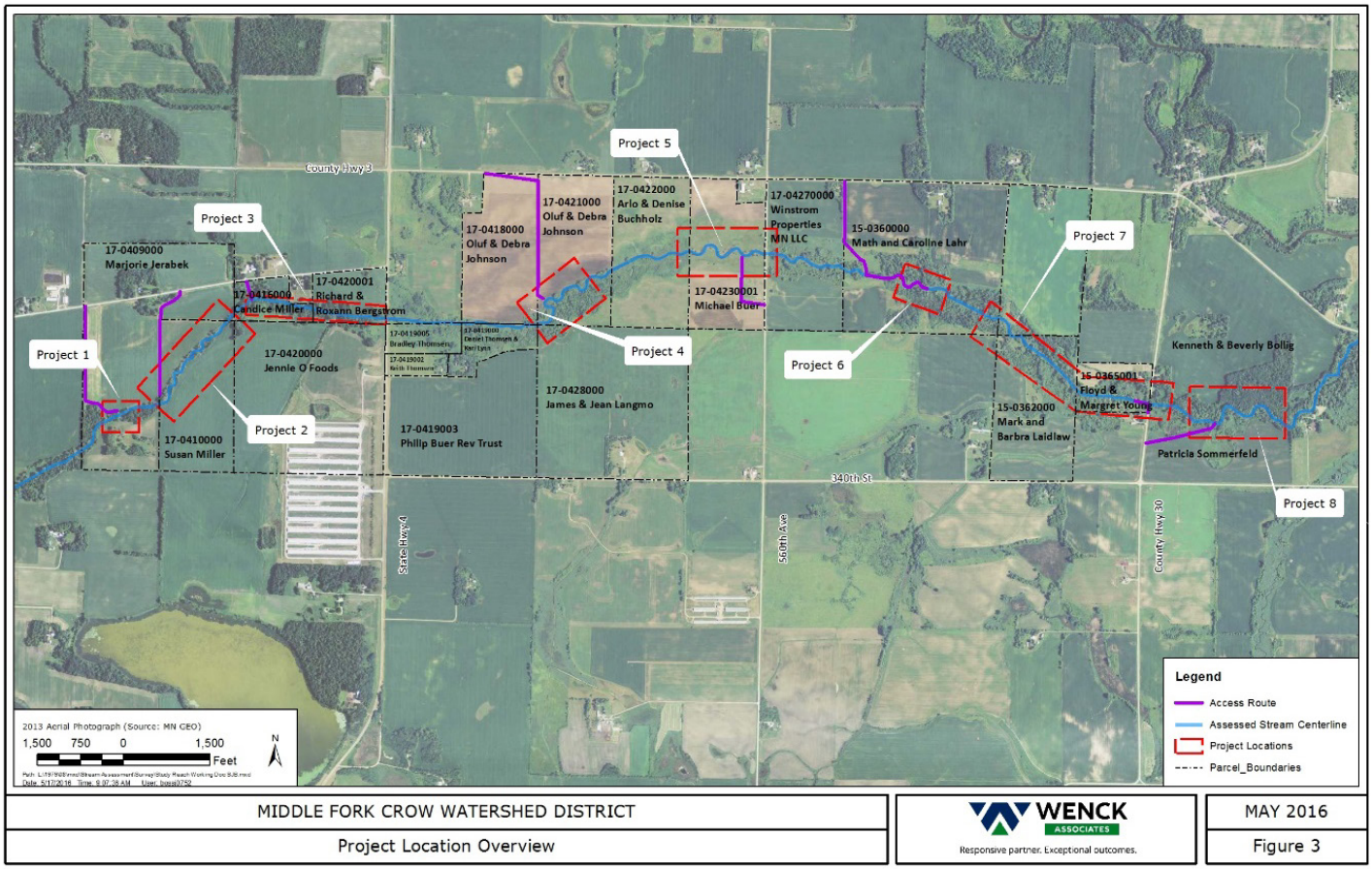
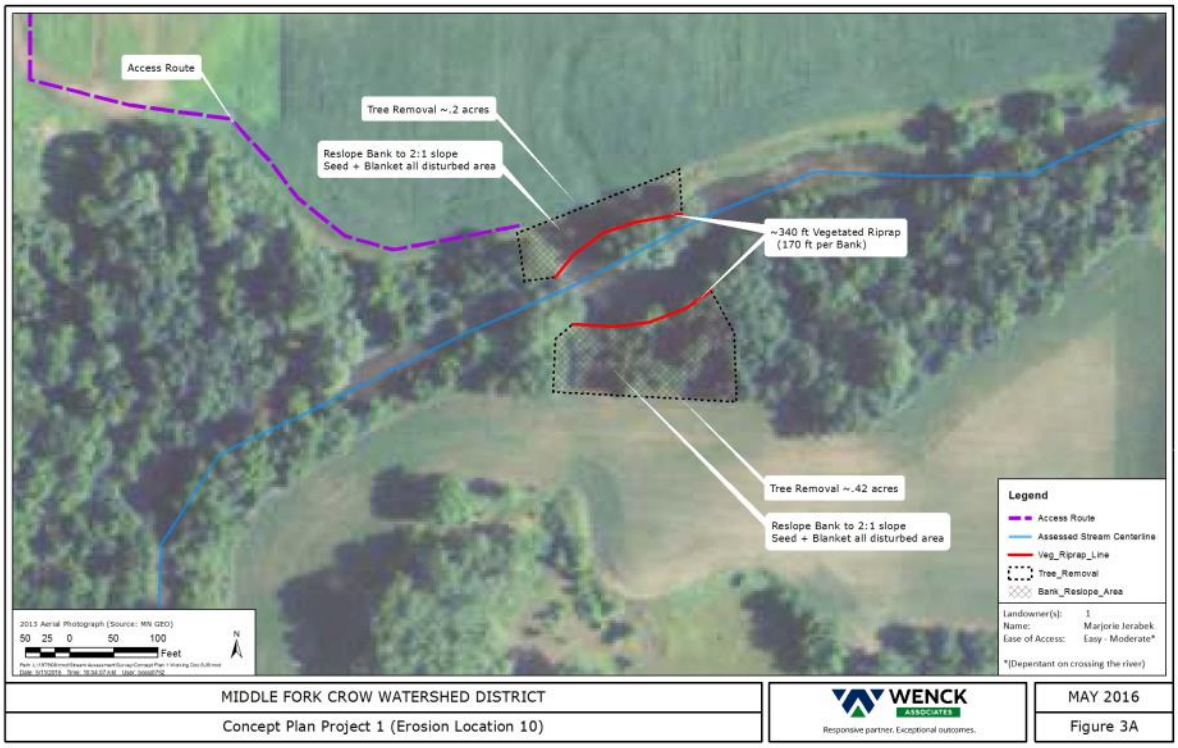


Figure 5 – Project Location Map

The following section provides a summary for each of the eight identified project areas.

PROJECT AREA 1: TOE PROTECTION WITH VEGETATED RIPRAP



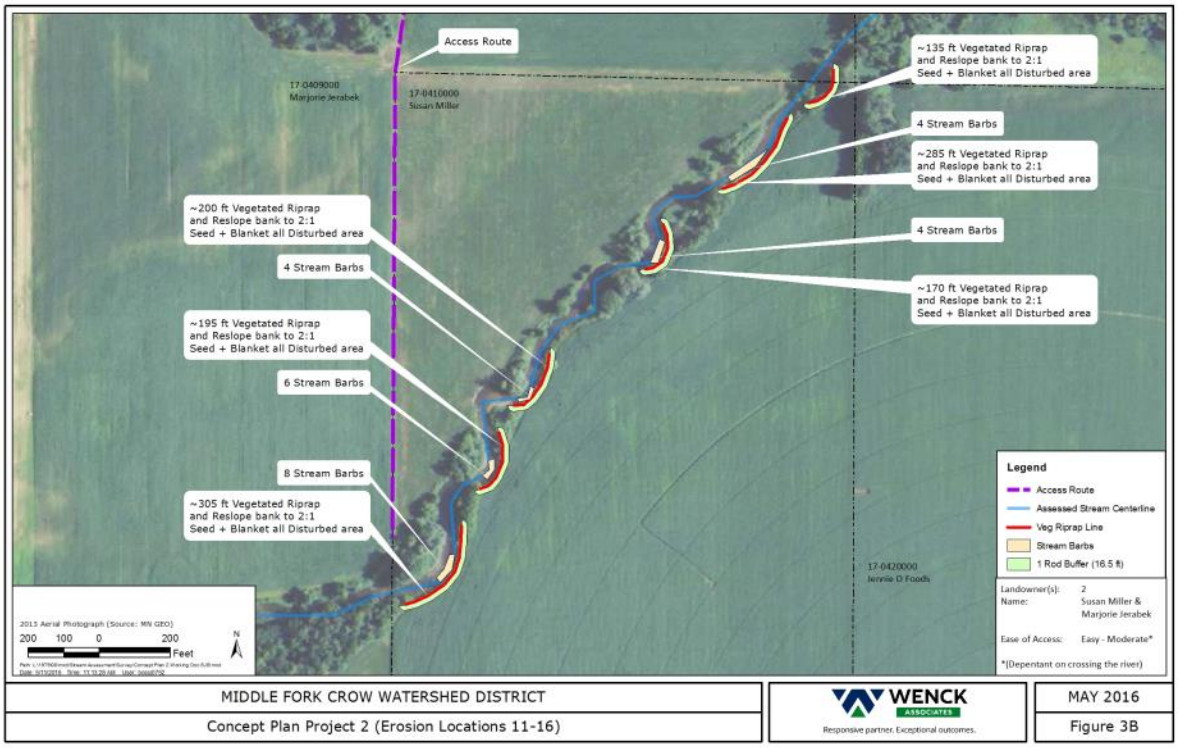
At Project Area 1, river banks are severely eroding for approximately 170 ft. on both sides and have an eroded vertical face of 4 ft. The erosion is due to do a bridge located directly upstream that creates a restriction in flow, a hydraulic jump and circulating eddies coming off the downstream flow onto the embankments. To minimize the current scour, collapse and erosion, both banks will need the toe protected in with vegetated riprap and regraded to a slope of 2:1 (3:1 if possible). In order to accomplish the regrading and allow sunlight to penetrate the new grade trees will need to be removed directly upslope from the affected area.

Project Area 1 would require 0.8 acres for temporary construction easement assuming a 15ft width easement.

	BID TABULATION				
No.	**Item**	**Units**	**Qty**	**Unit Price**	**Total**
1	Mobilization/Demobilization	LS	1	$ 2,000.00	$ 2,000.00
2	Site Access & Restoration	LS	1	$ 5,000.00	$ 5,000.00
3	Tree Removal	LS	1	$ 7,500.00	$ 7,500.00
4	Bank Resloping	LF	340	$ 10.00	$ 3,400.00
5	Class II Rip Rap (Veg. Riprap)	TON	150	$ 120.00	$ 18,000.00
6	Geotextile (MnDOT typ. 5)	SY	420	$ 5.00	$ 2,100.00
7	Floating silt curtin	LF	100	$ 20.00	$ 2,000.00
8	Erosion Control Blanket	SY	490	$ 3.00	$ 1,470.00
9	Seeding (MN state mix 34-261)	SY	490	$ 2.00	$ 980.00
				SUBTOTAL	$ 42,450.00
	25% ENGINEERING, OVERSIGHT, ADMINISTRATION				$ 10,612.50
		TOTAL CONSTRUCTION COST			$ 53,062.50
				20% CONTINGENCY	$ 10,612.50
				TOTAL	**$53,062.50**

Cost Estimate for Project Area 1

PROJECT AREA 2: STREAM BARBS



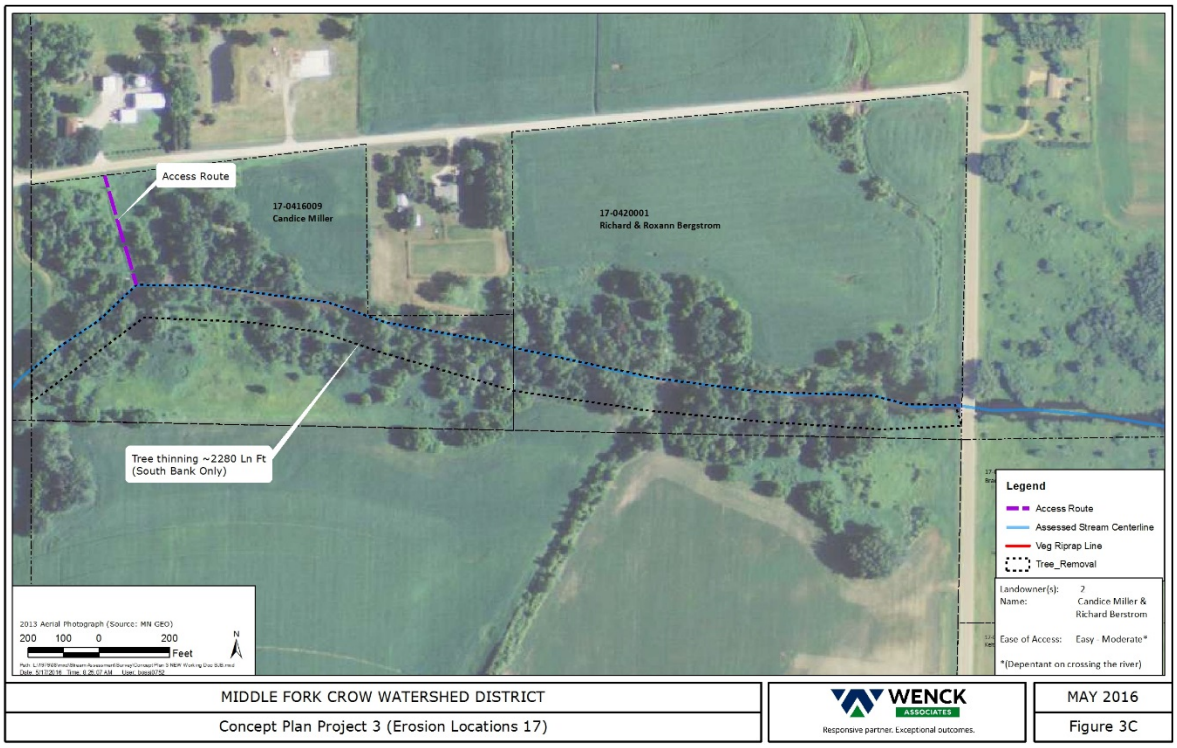
At Project Area 2, river banks are severely eroding on the outside bends for approximately 1290 ft. and have an eroded vertical face from 4 - 12 ft. To stabilize the erosion, banks will need to be regraded to a slope of 2:1 with the toe protected with vegetated riprap. If the landowner isn't willing to loose land for the 2:1 slope a steeper slope will need to be explored. In addition to the vegetated riprap, 26 stream barbs are proposed to redirect erosive force within the stream channel back toward the center of the channel and away from the banks. In order to mitigate the runoff coming off of the adjacent farm field upslope enforcement of the 1 rod buffer should also be invoked.

Project Area 2 would require 0.7 acres for temporary construction easement assuming a 15ft width easement.

No.	Item	Units	Qty	Unit Price	Total
	BID TABULATION				
1	Mobilization/Demobilization	LS	1	$ 13,000.00	$ 13,000.00
2	Site Access & Restoration	LS	1	$ 10,000.00	$ 10,000.00
3	Bank Resloping	LF	1290	$ 10.00	$ 12,900.00
4	Class II Rip Rap (Veg. Riprap)	TON	535	$ 120.00	$ 64,200.00
5	Class III Rip Rap (Stream Barbs)	TON	400	$ 130.00	$ 52,000.00
6	Geotextile (mnDOT typ. 5)	SY	1615	$ 5.00	$ 8,075.00
7	Floating silt curtin	LF	50	$ 20.00	$ 1,000.00
8	Erosion Control Blanket	SY	2315	$ 3.00	$ 6,945.00
9	Seeding (MN state mix 34-261)	SY	2315	$ 2.00	$ 4,630.00
				SUBTOTAL	$ 172,750.00
	25% ENGINEERING, OVERSIGHT, ADMINISTRATION				$ 43,187.50
	TOTAL CONSTRUCTION COST				$ 215,937.50
				20% CONTINGENCY	$ 43,187.50
				TOTAL	**$ 259,125.00**

Cost Estimate for Project Area 2

PROJECT AREA 3: CANOPY THINNING AND VEGETATION ESTABLISHMENT



At Project Area 3, the river has been straightened and the channel is over-widened, incised or confined by flood and spoil deposition on the banks. River banks are severely eroding for approximately 2,280 ft. while the channel runs through the floodplain forest. Erosion is noticeably worse in this reach compared to the next reach that is also straightened but has much less tree density and more extensive grass ground cover. To minimize the current erosion, and mimic the more stable reference reach downstream, the existing tree canopy should be thinned on the southern bank to allow sunlight to penetrate the areas on both banks for stabilizing grasses to germinate and grow. This project could be accomplished by a crew of Conservation Corps employees over approximately a three-week period.

Two options exist for Conservation Corps workers:

1. Hire crew for full price of $1,500.00 per day plus the cost of the seed and herbicide associated with the project.

2. Apply for a project grant which the labor cost is 25% of the estimated cost. The district would have to supply the seed and the herbicide (Garlon 4)

Project Area 3 would require 1.1 acres for temporary construction easement assuming a 15ft width easement.

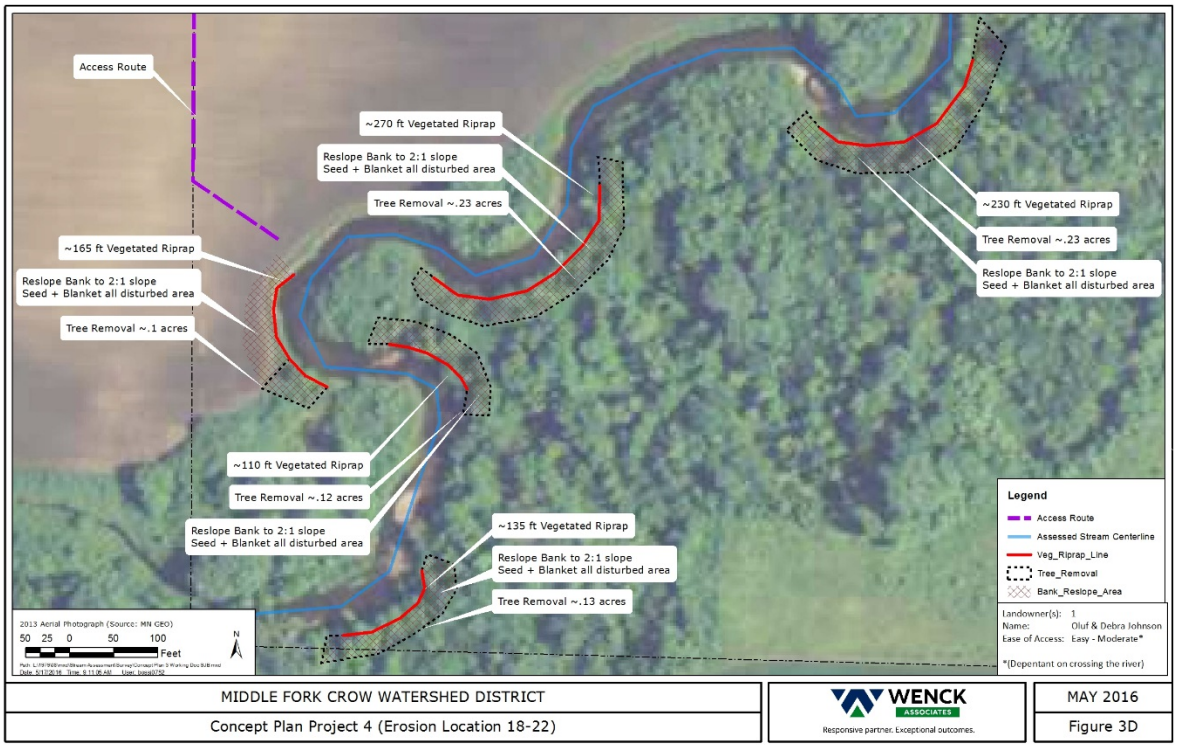
Lack of groundcover vegetation and eroding banks on Project Area 3 (on right). Downstream reach with less tree canopy and more extensive grass ground cover.

	BID TABULATION (NO GRANT)				
No.	**Item**	**Units**	**Qty**	**Unit Price**	**Total**
1	Tree Removal (CC-MN)	DAYS	12	$ 1,500.00	$ 18,000.00
2	Seeding (MN state mix 34-261)	LBS	180	$ 20.00	$ 3,600.00
3	Herbicide Treatment	Gallon	35	$ 111.00	$ 3,885.00
				SUBTOTAL	$ 25,485.00
			25% ENGINEERING, OVERSIGHT, ADMINISTRATION		$ 6,371.25
			TOTAL CONSTRUCTION COST		$ 31,856.25
				20% CONTINGENCY	$ 6,371.25
				TOTAL	**$38,227.50**

	BID TABULATION (WITH GRANT)				
No.	**Item**	**Units**	**Qty**	**Unit Price**	**Total**
1	Tree Removal (CC-MN)*	DAYS	12	$ 1,500.00	$ 4,500.00
2	Seeding (MN state mix 34-261)**	LBS	180	$ 20.00	$ 3,600.00
3	Herbicide Treatment***	Gallon	35	$ 111.00	$ 3,885.00
	* With Grant labor rate is 25% of total cost			SUBTOTAL	$ 11,985.00
	* (30 lbs/Acre x 6 Acres)		25% ENGINEERING, OVERSIGHT, ADMINISTRATION		$ 2,996.25
	** (6 Quarts/Acre x 6 Acres)		TOTAL CONSTRUCTION COST		$ 14,981.25
				20% CONTINGENCY	$ 2,996.25
				TOTAL	**$17,977.50**

Cost Estimate for Project Area 3

PROJECT AREA 4: TREE REMOVAL AND RESLOPE WITH VEGETATIVE RIPRAP



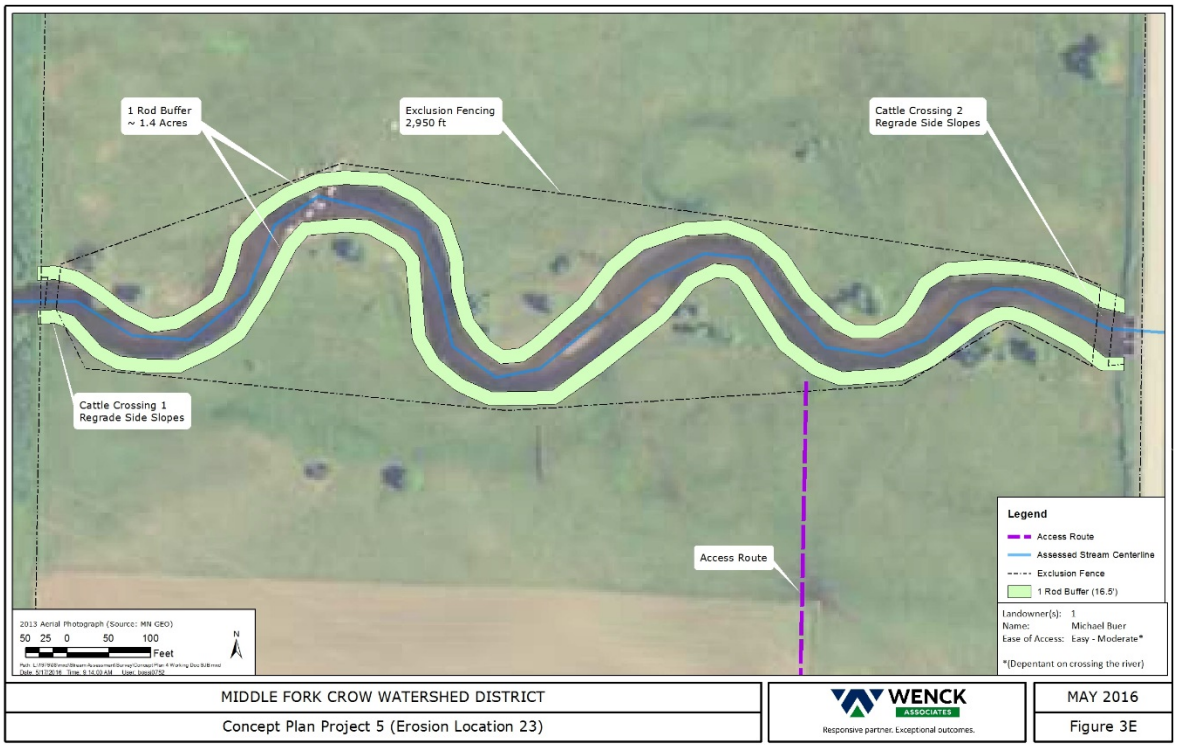
At Project Area 4, river banks are moderately eroding on the outside bends for approximately 910 ft. and have an eroded vertical face of 4 ft. To minimize the current erosion, banks will need to be regraded to a slope of 2:1 with the toe protected with vegetated riprap. In order to accomplish the regrading and allow sunlight to penetrate the new grade trees will need to be removed directly upslope from the affected area for stabilizing grasses.

Project Area 4 would require 0.4 acres for temporary construction easement assuming a 15ft width easement.

	BID TABULATION				
No.	**Item**	**Units**	**Qty**	**Unit Price**	**Total**
1	Mobilization/Demobilization	LS	1	$ 4,000.00	$ 4,000.00
2	Site Access & Restoration	LS	1	$ 2,000.00	$ 2,000.00
3	Tree Removal (CC-MN)	LS	1	$ 8,500.00	$ 8,500.00
4	Bank Resloping	LF	910	$ 10.00	$ 9,100.00
5	Class II Rip Rap (Veg. Riprap)	TON	380	$ 120.00	$ 45,600.00
6	Geotextile (mnDOT typ. 5)	SY	1140	$ 5.00	$ 5,700.00
7	Floating silt curtin	LF	50	$ 20.00	$ 1,000.00
8	Erosion Control Blanket	SY	1315	$ 3.00	$ 3,945.00
9	Seeding (MN state mix 34-261)	SY	1315	$ 2.00	$ 2,630.00
				SUBTOTAL	$ 82,475.00
	25% ENGINEERING, OVERSIGHT, ADMINISTRATION				$ 20,618.75
			TOTAL CONSTRUCTION COST		$ 103,093.75
				20% CONTINGENCY	$ 20,618.75
				TOTAL	**$ 123,712.50**

Cost Estimate for Project Area 4

PROJECT AREA 5: ANIMAL EXCLUSION FENCING



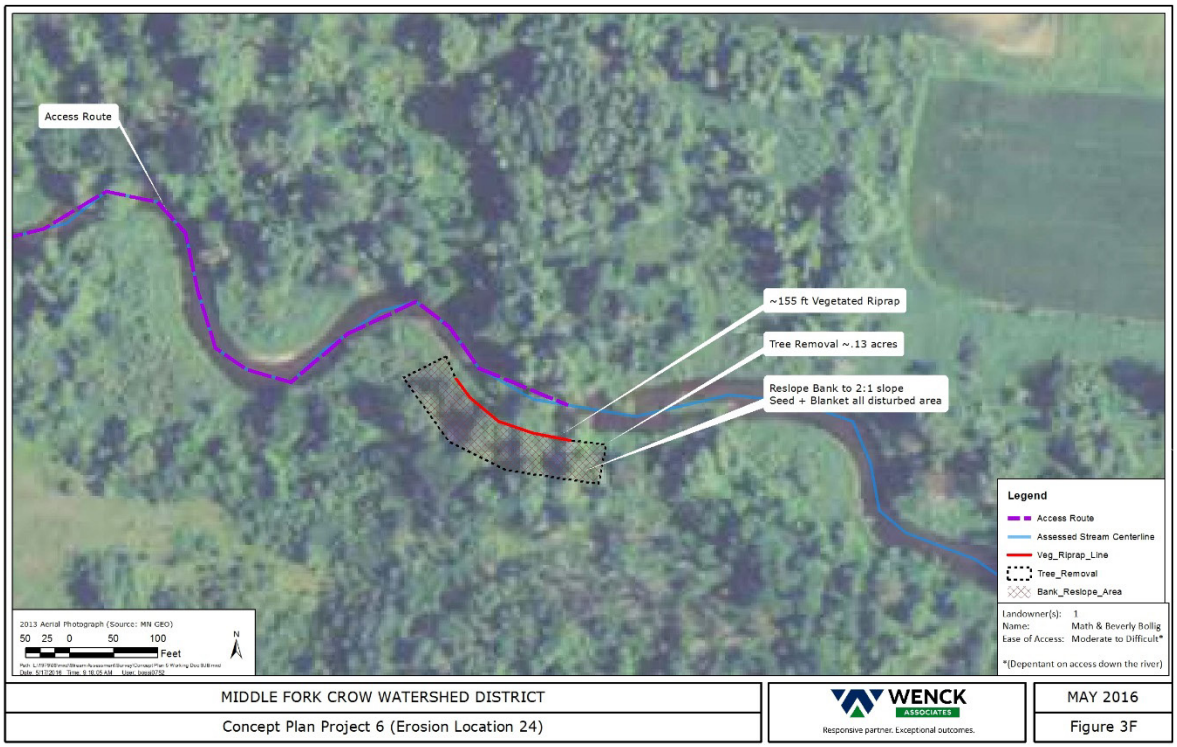
At Project Area 5, river banks are severely eroding for approximately 3,400 ft. on both sides and have an eroded vertical face up to 3 ft. The erosion is due to do cattle watering and crossing the river. To minimize the current erosion, we recommend adding 2 specific cattle crossing/watering points with reinforcement gravel on the property and installing exclusion fencing in all other areas along the river. Enforcement of the 1 rod buffer should also be invoked to increase the vegetation height and rooting depth of grasses to secure the river banks.

Project Area 5 would require 1.1 acres for temporary construction easement assuming a 15ft width easement.

	BID TABULATION				
No.	**Item**	**Units**	**Qty**	**Unit Price**	**Total**
1	Mobilization/Demobilization	LS	1	$ 2,500.00	$ 2,500.00
2	Grading	CY	40	$ 40.00	$ 1,600.00
3	Fencing (3 lines w conductive chain over stream)	LF	3600	$ 5.00	$ 18,000.00
4	Filter Agregate	TON	70	$ 80.00	$ 5,600.00
5	Class II Rip Rap	TON	130	$ 120.00	$ 15,600.00
6	Geotextile (mnDOT typ. 5)	SY	75	$ 5.00	$ 375.00
7	Floating silt curtin	LF	100	$ 20.00	$ 2,000.00
8	Erosion Control Blanket	SY	435	$ 3.00	$ 1,305.00
9	Seeding (MN state mix 34-261)	SY	435	$ 2.00	$ 870.00
				SUBTOTAL	$ 47,850.00
	25% ENGINEERING, OVERSIGHT, ADMINISTRATION				$ 11,962.50
				TOTAL CONSTRUCTION COST	$ 59,812.50
				20% CONTINGENCY	$ 11,962.50
				TOTAL	**$ 71,775.00**

Cost Estimate for Project Area 5

PROJECT AREA 6: TREE REMOVAL AND RESLOPE



At Project Area 6, river bank is moderately eroding on the outside bend for approximately 155 ft. and have an eroded vertical face of 4 ft. To minimize the current erosion, banks will need the toe protected with vegetated riprap. In order to allow sunlight to penetrate, trees will need to be removed directly upslope from the affected area for stabilizing grasses to germinate and grow.

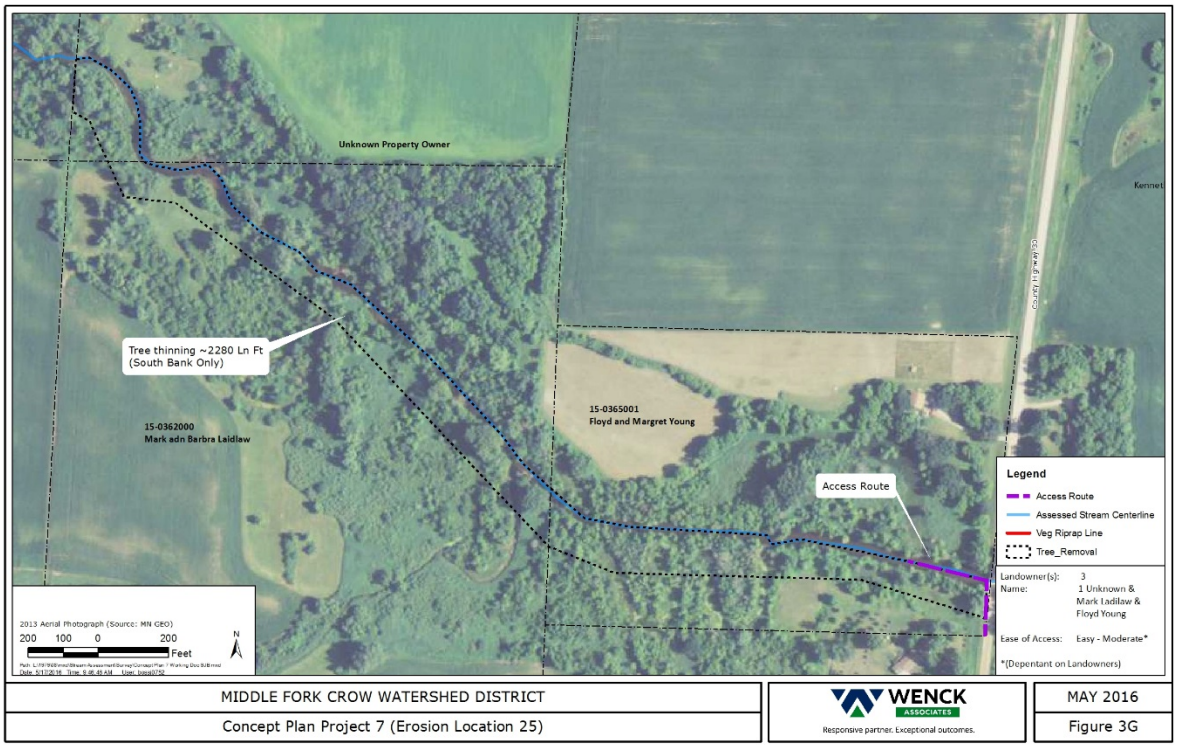
Project Area 6 would require 0.4 acres for temporary construction easement assuming a 15ft width easement.

BID TABULATION

No.	Item	Units	Qty	Unit Price	Total
1	Mobilization/Demobilization	LS	1	$ 1,000.00	$ 1,000.00
2	Site Access & Restoration	LS	1	$ 4,000.00	$ 4,000.00
3	Tree Removal	LS	1	$ 2,000.00	$ 2,000.00
4	Bank Resloping	LF	155	$ 10.00	$ 1,550.00
5	Class II Rip Rap (Veg. Riprap)	TON	65	$ 120.00	$ 7,800.00
6	Geotextile (mnDOT typ. 5)	SY	195	$ 5.00	$ 975.00
7	Floating silt curtin	LF	50	$ 20.00	$ 1,000.00
8	Erosion Control Blanket	SY	225	$ 3.00	$ 675.00
9	Seeding (MN state mix 34-261)	SY	225	$ 2.00	$ 450.00
				SUBTOTAL	$ 19,450.00
	25% ENGINEERING, OVERSIGHT, ADMINISTRATION				$ 4,862.50
				TOTAL CONSTRUCTION COST	$ 24,312.50
				20% CONTINGENCY	$ 4,862.50
				TOTAL	**$29,175.00**

Cost Estimate for Project Area 6

PROJECT AREA 7: TREE THINNING



At Project Area 7, the river has been straightened and the channel is over-widened, incised or confined by flood and spoil deposition on the banks. River banks are moderately eroding for approximately 8,600 ft. while the channel runs through the floodplain forest. To minimize the current erosion, the existing tree canopy should be thinned on the southern bank to allow sunlight to penetrate the areas on both banks for stabilizing grasses to germinate and grow. This project could be accomplished by a crew of Conservation Corps employees over approximately a four-week period.

Two options exist for Conservation Corps workers:

1. Hire crew for full price of $1,500.00 per day plus the cost of the seed and herbicide associated with the project.

2. Apply for a project grant which the labor cost is 25% of the estimated cost. The district would have to supply the seed and the herbicide (Garlon 4)

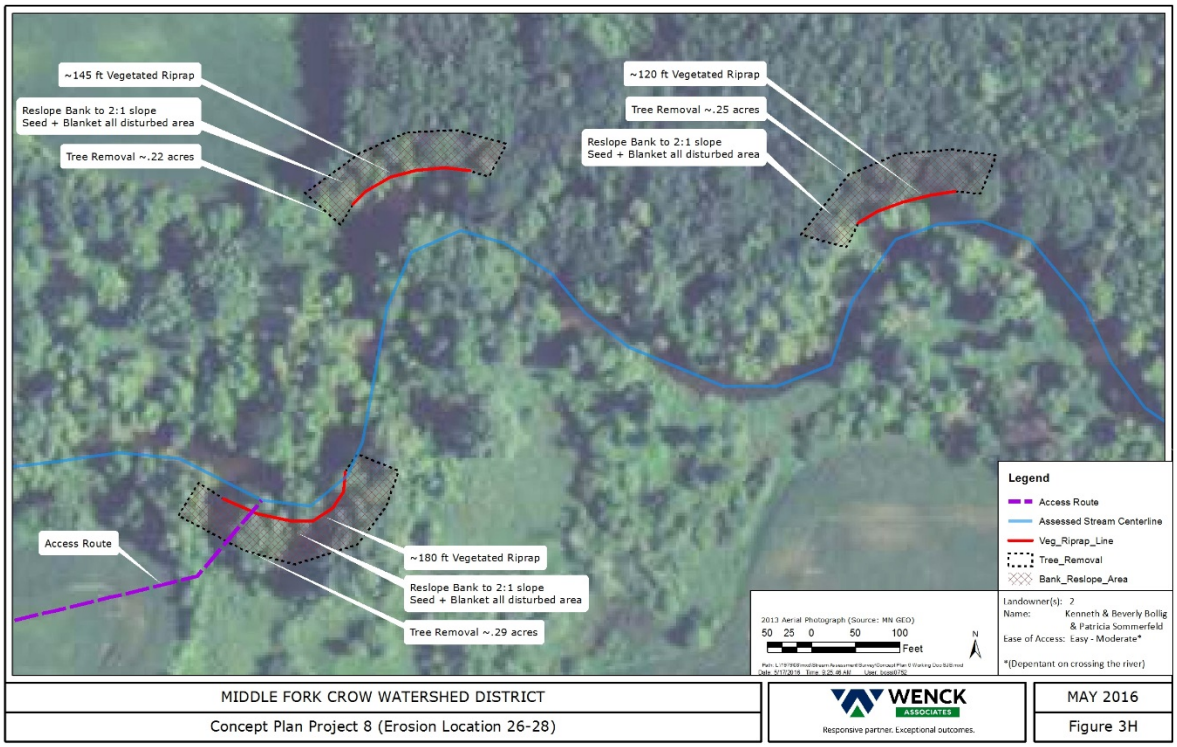
Project Area 7 would require 0.1 acres for temporary construction easement assuming a 15ft width easement.

	BID TABULATION (NO GRANT)				
No.	**Item**	**Units**	**Qty**	**Unit Price**	**Total**
1	Tree Removal (CC-MN)	DAYS	16	$ 1,500.00	$ 24,000.00
2	Seeding (MN state mix 34-261)	LBS	180	$ 20.00	$ 3,600.00
3	Herbicide Treatment	Gallon	35	$ 11.00	$ 385.00
	*Seeding & Herbicide included in price/day			SUBTOTAL	$ 27,985.00
				25% ENGINEERING, OVERSIGHT, ADMINISTRATION	$ 6,996.25
				TOTAL CONSTRUCTION COST	$ 34,981.25
				20% CONTINGENCY	$ 6,996.25
				TOTAL	**$41,977.50**

	BID TABULATION (WITH GRANT)				
No.	**Item**	**Units**	**Qty**	**Unit Price**	**Total**
1	Tree Removal (CC-MN)*	DAYS	16	$ 1,500.00	$ 6,000.00
2	Seeding (MN state mix 34-261)**	LBS	240	$ 20.00	$ 4,800.00
3	Herbicide Treatment***	Gallon	48	$ 111.00	$ 5,328.00
	* With Grant labor rate is 25% of total cost			SUBTOTAL	$ 16,128.00
	* (30 lbs/Acre x 6 Acres)			25% ENGINEERING, OVERSIGHT, ADMINISTRATION	$ 4,032.00
	** (6 Quarts/Acre x 8 Acres)			TOTAL CONSTRUCTION COST	$ 20,160.00
				20% CONTINGENCY	$ 4,032.00
				TOTAL	**$24,192.00**

Cost Estimate for Project Area 7

PROJECT AREA 8: TREE REMOVAL, RESLOPE, & VEGETATED RIPRAP



At Project Area 8, river banks are moderately to severely eroding on the outside bends for approximately 445 ft. and have an eroded vertical faces from 4 – 8 ft. To minimize the current erosion, banks will need to be regraded to a slope of 2:1 with the toe protected with vegetated riprap. In order to accomplish the regrading and allow sunlight to penetrate the new grade, trees will need to be removed directly upslope from the affected area for stabilizing grasses to germinate and grow.

Project Area 8 would require 0.1 acres for temporary construction easement assuming a 15ft width easement.

	BID TABULATION				
No.	**Item**	**Units**	**Qty**	**Unit Price**	**Total**
1	Mobilization/Demobilization	LS	1	$ 3,500.00	$ 3,500.00
2	Site Access & Restoration	LS	1	$ 2,000.00	$ 2,000.00
3	Tree Removal (CC-MN)	LS	1	$ 8,000.00	$ 8,000.00
4	Bank Resloping	LF	445	$ 10.00	$ 4,450.00
5	Class II Rip Rap (Veg. Riprap)	TON	300	$ 120.00	$ 36,000.00
6	Geotextile (mnDOT typ. 5)	SY	560	$ 5.00	$ 2,800.00
7	Floating silt curtin	LF	150	$ 20.00	$ 3,000.00
8	Erosion Control Blanket	SY	1030	$ 3.00	$ 3,090.00
9	Seeding (MN state mix 34-261)	SY	1030	$ 2.00	$ 2,060.00
				SUBTOTAL	$ 64,900.00
	25% ENGINEERING, OVERSIGHT, ADMINISTRATION				$ 16,225.00
				TOTAL CONSTRUCTION COST	$ 81,125.00
				20% CONTINGENCY	$ 16,225.00
				TOTAL	**$ 97,350.00**

Cost Estimate for Project Area 8

COST BENEFIT ANALYSIS

All of the proposed projects are effective at reducing total suspended solids and phosphorous contributions to the Middle Fork Crow River and a described in various way in the local water plans and drainage policy. A 20-yr lifecycle was assumed when evaluating the cost effectiveness of each of the proposed projects.

If all projects were built, 797 tons of sediment and 160 lbs. of phosphorous would be reduced, and the project cost would be $ 714,405.00.

Engineering, construction oversight and administrative costs would be $178,600.

To help prioritize the order in which projects should be pursued, the following table summarizes each project and ranks them from lowest to highest in dollars per pound of phosphorous.

Project Rank	Project #	Tons/Year of TSS	lbs/year P	Project Estimate	$/TON TSS	$/lbs P
1	**3**	205	41	$ 38,228	$ 9	$ 46
2	**7**	172	34	$ 41,978	$ 12	$ 61
3	**5**	153	31	$ 71,775	$ 23	$ 117
4	**2**	188	38	$ 259,125	$ 69	$ 343
5	**1**	20	4	$ 53,063	$ 132	$ 661
6	**8**	25	5	$ 97,350	$ 196	$ 978
7	**4**	31	6	$ 123,713	$ 197	$ 985
8	**6**	3	1	$ 29,175	$ 474	$ 2,363
TOTAL		**798**	**160**	**$ 714,405**		

RECOMMENDATION

Following the Middle Fork Crow River Stream assessment erosion features, causes and potential stabilization techniques for long term protection, eight projects were identified that combined 18 erosion locations into 8 groups that minimize access, disturbance and construction costs while achieving the goal of reducing streambank erosion by 798 tons of sediment and 160 lbs. of phosphorous each year. Each design was considered feasible based on the ability to access the site, construct, and permit the improvement. A cost benefit analysis was completed to help prioritize projects based on maximum reduction of erosion for the lowest cost per pound of pollutants reduced.

Appendix 1: Order of the Board Initiating Project #2017-01

STATE OF MINNESOTA
MIDDLE FORK CROW RIVER WATERSHED DISTRICT

The Matter of the Initiation of the Middle Fork Crow River/Meeker County Ditch 47 Restoration Project (Project #2017-01)	**ORDER OF THE BOARD INITIATING PROJECT (MINN. STAT. §103D.605)**

At its regular meeting on June 6, 2017, the Board of Managers of the Middle Fork Crow River Watershed District considered the following findings and order related to the initiation of a basic water management project as identified in its watershed management plan. Manager Wing moved, seconded by Manager Schaefer adoption of the following:

Findings

1. In 2013 the MFCRWD applied for Accelerated Implementation Grant to analyze the condition of the channel of a portion on the Middle Fork of the Crow River in Meeker County. The designated portion of river channel to be analyzed was an 11 mile reach of the Middle Fork Crow River downstream of Lake Calhoun. The Purpose of the analysis was to determine the scope of eroding riverbanks.

2. The State awarded the grant to the MFCRWD in April of 2015, under its Clean Water Fund grant program.

3. After public hearing, the MFCRWD establish project 15-03, the "Middle Fork Crow River Watershed Integrated Water Quality Analysis for Targeted Priority Practices Project"

4. Under project 15-03, the MRCRWD analyzed the designated portion of river channel to identify eroding portions of the river bank, determine conditions and sources of pollutant and sediment loading, and to identify both practices and locations of practices that would benefit water quality and stability in the designated portion of river channel.

5. In March 2017, the consulting engineer for project 15-03 filed its Streambank Assessment Technical Memo related to the project.

6. The Streambank Assessment Technical Memo identified specific deterioration conditions on the river channel contributing to sediment and pollutant loading on the designated portion of river.

7. In response to the Study, the MFCRWD applied for and received approval for a Clean Water Partnership (CWP) loan with the intent of using proceeds from the loan to implement one or more of the recommendations from the Streambank Assessment Technical Memo. Specifically, the CWP loan proceeds may be used to reduce the impacts of stormwater runoff and sediment and nutrient loading into the Middle Fork Crow River by implementing a variety of best management practices including stormwater management, streambank and channel restorations, and conservation agricultural projects.

8. The portion of river channel analyzed is also part of the legal alignment of Meeker County Ditch (CD) 47.

9. The establishment of CD 47 modified/improved the channel of the river. However, since establishment of CD 47, much of the river channel analyzed has deteriorated as the river attempted to re-establish a more natural channel.

10. It is important to note that the deteriorated channel of the river is not impacting the hydraulic efficiency of CD 47.

11. Because the Meeker County Board of Commissioners is the drainage authority for CD 47, the MFCRWD staff presented the Streambank Assessment to the Board of Commissioners on May 16, 2017.

12. The project proposed herein is intended to implement one or more of the recommendations contained in the Streambank Assessment Technical Memo.

13. The actions proposed by the project can be implemented in a manner consistent with the concurrent status of the designated portion of river channel as a public drainage system.

14. The project is initiated in furtherance of the Basic Water Management Project priorities contained in the MFCRWD's Comprehensive Watershed Management Plan, 2007-2017 (Plan) and implements the Plan Implementation Goals, Objectives and Initiatives as found in chapter 4 if the Plan. (see Chapter 4: Goal 1, Objective B, Initiatives 6, 9, 10 and 11; Objective C, Initiative 16; Objective D, Initiative 21; and Goal 6, Objective B, Initiative 68).

15. The proposed project is conducive to the public health, promotes the general welfare, and is identified in and in compliance with the Plan.

Order

A. Pursuant to Minnesota Statutes Section 103D.605, the Middle Fork Crow River Watershed District (MFCRWD) Board of Managers (Board) initiates the Middle Fork Crow River/Meeker County Ditch 47 Restoration Project, Project # 2017- 01.

B. The Board appoints the engineering firm of Wenck Associates to work with the MFCRWD staff to prepare a project plan for the various actions proposed by the project.

After discussion, the President called the question. The question was on the adoption of the foregoing findings and order and there were 4 yeas and 0 nays as follows:

	Yea	Nay	Absent	Abstain
BEHM	☐	☐	☒	☐
HEDTKE	☒	☐	☐	☐
SCHAEFER	☒	☐	☐	☐
WING	☒	☐	☐	☐
HODAPP	☒	☐	☐	☐

Upon vote, the President declared the Resolution 2017-01.

Ruth Schaefer
Ruth Schaefer, Secretary

Dated: June 6, 2017

* * * * * * * * * * * *

I, Ruth Schaefer, Secretary of the Middle Fork Crow River Watershed District, do hereby certify that I have compared the above resolution with the original thereof as the same appears of record and on file with the District and find the same to be a true and correct transcript thereof.

IN TESTIMONY WHEREOF, I hereunto set my hand this 6 day of June, 2017.

Ruth Schaefer
Ruth Schaefer, Secretary

APPENDIX 2: WATER MANAGEMENT AND PLANNING

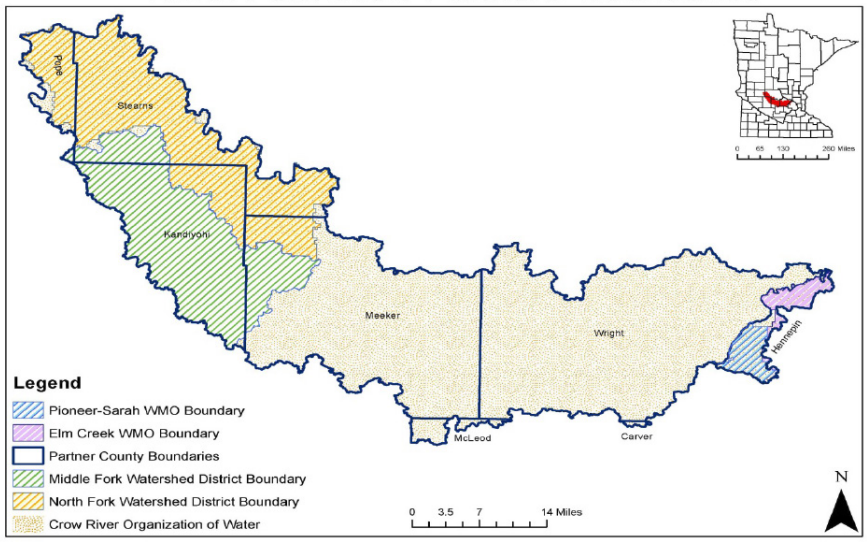
According to Minnesota Statute 103B, each county is encouraging to develop and implement a local water management plan. The Meeker County Soil and Water Conservation District and Meeker County have both adopted *The 2013 – 2023 Meeker County Comprehensive Local Water Plan; with a Five-Year Implementation Program Serving the Years of 2013 – 2018.*

In Minnesota Statutes 103D (section .401) the Managers [of the watershed district] must adopt a watershed management plan for any or all of the purposed for which a watershed district was established. The Middle Fork Crow River Watershed District adopted the *Middle Fork Crow River Watershed District; Watershed Management Plan* on April 27, 2005.

In early 2014, planning partners in this watershed joined together to submit a nomination to pilot One Watershed, One Plan. After their selection, partners started the plan development process in early 2015. Stakeholders include local governments, state agencies, and community members as partners in the planning process. The plan will identify the priority resources and the issues affecting them and describe projects and programs to address those issues in a targeted, measureable way.

Draft sections of the plan are contained in this Engineer's Report below.

North Fork Crow Partners' Boundaries



One Watershed, One Plan is rooted in Minnesota's long history of water management by local government. Planning for the program began with the Local Government Water Roundtable (Association of Minnesota Counties, Minnesota Association of Watershed Districts, and Minnesota Association of Soil and Water Conservation Districts). Roundtable members recommended that local governments charged with water management should develop focused implementation plans on a watershed scale. In 2012, the Minnesota State Legislature, through the One Watershed, One Plan legislation, authorized BWSR to develop and implement a comprehensive watershed management plan approach. The resulting approach coordinates and consolidates water plans on a watershed basis instead of political boundaries.

BWSR, One Watershed, One Plan

Below are the implementation initiatives listed:

Goal 1: Protect and improve surface water quality.

OBJECTIVE B: REDUCE EROSION AND SEDIMENT LOADING.

6. Riparian Buffer Strip Incentive Program. Provide financial incentives to landowners for establishing and maintaining riparian buffer strips.
8. Erosion and Sediment Control Ordinances. Provide technical assistance to local governmental units for the development of erosion and sediment control ordinances.
9. Highly Erodible Land. Identify and target highly erodible land for enrollment in conservation easement programs, such as CRP and RIM.
10. Stream Stabilization/Debris Removal. Implement and/or provide technical and financial assistance, as available, to landowners for stream stabilization and debris removal projects to maintain stream integrity.
11. BMP Program. Provide technical and financial assistance, as available to local governmental units and landowners for the implementation of erosion and sediment control BMPs.

OBJECTIVE C: REDUCE EXTERNAL AND INTERNAL NUTRIENT/CONTAMINANT LOADING.

16. Sourcewater Protection. Actively participate in the Upper Mississippi River Sourcewater Protection Program.

OBJECTIVE D: MANAGE PUBLIC DRAINAGE SYSTEMS TO PROVIDE BOTH CONVEYANCE AND ECOLOGICAL BENEFITS.

18. Drainage System Management. Ensure that public drainage systems are operated and maintained in accordance with State Drainage Law (M.S. Chapter 103E) and other applicable regulations.
20. Alternative Drainage Practices. Provide financial incentives to landowners for the implementation of alternative drainage practices, such as blind tile inlets, that have the potentials to improve water quality.
21. River Restoration. Cooperatively work with stateholders to restore channelized segments of the River to a more natural state.

Goal 5: Promote Wise Land Use Management.

OBJECTIVE A: PARTICIPATE IN LAND USE PLANNING.

43. Ordinance Review. Review and provide comments to local governmental units when they adopt or amend ordinances relating to water resources.

Goal 6: Expand Our Knowledge and Understanding of the Watershed.

OBJECTIVE A: COORDINATE AND IMPROVE WATER RESOURCES MONITORING AND ANALYSIS EFFORT.

49. Water Resources Monitoring. Coordinate a comprehensive monitoring program within the District to assess the condition of surface and groundwater resources and identity pollution sources.
51. Subwatershed Water Quality Goals. Utilize available data to identify specific water quality goals for water resources.

THE 2013-2023 MEEKER COUNTY COMPREHENSIVE LOCAL WATER PLAN

WITH A FIVE-YEAR IMPLEMENTATION PROGRAM SERVING THE YEAR 2013-2018

In 1990, the Meeker County Board of Commissioners adopted a resolution to develop a Comprehensive Local Water Plan, according to Minnesota Statutes 110B. The plan was to serve two purposes. The first was to identify existing and potential problems and opportunities for the protection, management and development of water and related land resources. The second purpose was to develop goals, objectives and a work plan to implement programs and strategies to promote the sound management of water and land resources for effective environmental protection. The plan focused on surface water, groundwater, related land resources and land use. The original Comprehensive Local Water Plan was approved by the Board of Soil and Water Resources (BWSR) and officially adopted by the Meeker County Board of Commissioners in 1991. Since then, Meeker County has revised its Water Plan in 1996, 2002, and 2007 (which expires in December 2012). The Meeker County Planning and Zoning Department and the Meeker County Administrator's Office are jointly responsible for administering the County's Water Plan. According to Minnesota Statute 103B, each county is encouraged to develop and implement a local water management plan with the authority to:

1. Prepare and adopt a local water management plan that meets the requirements of this section and section 103B.315;
2. Review water and related land resources plans and official controls submitted by local units of government to assure consistency with the local water management plan; and
3. Exercise any and all powers necessary to assure implementation of local water management plans.

Pursuant to the requirements of the law, this Meeker County Water Plan:

- Covers the entire area of Meeker County;
- Addresses water problems in the context of watershed units and groundwater systems;
- Is based upon principles of sound hydrologic management of water, effective environmental protection and efficient management;
- Is consistent with comprehensive water plans prepared by local watershed management organizations and neighboring counties; and
- Will serve as a 10-year water plan (2013-2023), with a 5-year implementation plan (2013-2018). In 2018, the implementation plan will be updated.

To address the priority concerns identified in the scoping process, the Meeker County Water Plan Task Force met and developed four goal areas. These four goal areas are further broken down into interrelated objectives that deal with each of the priority concerns. Most importantly, each objective has a series of action steps identified which are designed to help achieve the goal area if implemented properly. A summary of the County's Water Plan Goals, Objectives and Action Steps are provided below. Collectively they form the County's Water Implementation Plan. In addition, a summary of their annual estimated costs is provided (separated into Overall Costs and County Only Costs, which includes funds spent by the Meeker County SWCD). Please keep in mind that not all of the identified Action Items will be accomplished over the course of the Water Plan, but it is the intent to attempt to accomplish as much as money and time allows. A better detailed description of the County's Goals, Objectives, and Action Steps is contained in Chapter Three of this Water Plan. Likewise, Chapter Four provides more details on administering the Water Plan.

Where are Meeker County's Erosion Prone Soils Located? The beginning of this section provided a generalized description of the 10 soil associations found in Meeker County. The following section analyzes the erosion potential of those soil associations. Meeker County is adversely affected by both wind and water erosion. Water Erosion - Water erosion results from soil being moved from its original location by the force of water to the convex lower slopes and flats. Average tolerable soil loss for the County is three to five tons per acre per year. Erosion types are classified as sheet, rill, ephemeral and gully. Soil erosion affects cropland, urban areas, roadsides, lakeshores, streambanks and drainage systems. Meeker County Water Plan (2013-2023) 30 Water erosion impacts the water quality of the County's waterbodies, as well as develops detrimental

conditions in the uplands and steeper slopes of the soil associations with erosion prone characteristics. Water erosion in Meeker County generally occurs most often between the months of April and June, when fields have been tilled and planted, but a crop canopy has not developed to protect the soil surface.

Section Four: Meeker County Ongoing Water Plan Activities

Meeker County has numerous ongoing programs and land use controls that are directly linked to the County's Water Plan. These ongoing activities include educational efforts on key water planning issues, stream monitoring, and Best Management Practices (BMPs) implementation. In addition, County staff regularly attends water management meetings, educational conferences, and promotes water protection projects. The County also annually provides cost-share to fund various watershed groups (i.e., Crow River Joint Powers and MN River Joint Powers Boards) and similar organizations. All of these activities directly are related to implementing the Local Water Management Program (i.e., Water Plan). In addition to implementing the County's Water Plan, the County also accomplishes numerous water plan initiatives through implementing the following County programs. Table 3 shows that Meeker County has spent nearly $1.5 million in funds on all of these ongoing activities between the five-year period of 2007 and 2011.

Shoreland Management Program –Meeker County assists the Minnesota Department of Natural Resources (DNR) with administering the Shoreland Management Act. This Act regulates land use development within 1,000 feet of a lake and 300 feet of a river and its designated floodplain.

Goal 2: Promote Erosion and Sediment Control Activities.

OBJECTIVE F: IMPLEMENT BMPS TO REDUCE EROSION AND SEDIMENT LOADING OF SURFACE WATER RESOURCES.

25. Erodible land. Target 75 acres of highly erodible land annually for enrollment in conservation easement programs, such as CRP, and easements as part of upland buffers under RIM and USFWS programs.
26. BMP Program. Provide educational, technical, and financial assistance, as available, to landowners for the implementation of water quality-related BMPs. Target impaired subwatersheds and implement five (5) projects annually.
27. Cost-Share. Seek funding in the form of State cost-share, Federal EQIP, and Clean Water Funds for the installation of BMPs. Prioritize impaired subwatersheds.
33. CROW BMP Implementation and Education Initiatives. Cooperatively work with the Crow River Organization of Waters (CROW) to implement BMP implementation and education initiatives to reduce Fecal coliform, E.coli, turbidity, dissolved oxygen and chloride in North and South Fork Crow River Watersheds. Projects include: Lakeshore/Streambank Stabilization, Wetland Restorations, Rain Gardens, Lakeshore Naturalizations, Filterstrip/Grass/Riparian Buffers, Windbreaks, Sediment Basins, Grass Waterways, CRP/RIM Incentive Payments, Social Media, Newsletters and workshops – Implement six projects annually, create quarterly electronic newsletters, update website/facebook page weekly and provide annual workshop.

OBJECTIVE G: ENSURE LONG-TERM AGRICULTURAL PRODUCTION BY MAINTAINING AND IMPROVING THE PUBLIC DRAINAGE SYSTEM

34. Public Drainage Systems. Ensure that public drainage systems are operated and maintained in accordance with the State Drainage Law (M.S. Chapter 103E) and other applicable regulations, such as WCA.
37. Conservation Drainage Practices. Provide educational, technical, and financial assistance, as available, to landowners for the demonstration of conservation drainage practices. Establish two (2) demonstrations sites.
39. Two-Stage Ditch Systems. Examine the use of two-stage ditch systems. Apply for funding to assist with problem areas. Establish a research/demonstration site (2014).

Goal 3: Enhance surface water management.

OBJECTIVE H: MANAGE SURFACE WATERS TO MINIMIZE STORMWATER POLLUTION AND RUNOFF.

44. Drainage Plans. Continue to require surface water drainage plans on development in rural areas (i.e., feedlots, gravel pits, etc.). Annually review ordinance provisions.

DRAINAGE REPAIR POLICY FOR COUNTY DRAINAGE SYSTEMS

Most of the drainage systems in the County were established with the aid of federal wetlands grant monies, starting in 1890 and ending in 1925. Minnesota adopted its' drainage laws in the late 1800's, and with the exception of a few changes, most of these laws are still read as originally worded. Most of the original drainage work was done to add value to the land for agricultural purpose or to prevent diseases caused by mosquitoes.

2. Vegetation Control:

Tree Removal: Tress that need to be removed form a drainage system will be removed in a manner that will reduce erosion. Trees will be piled, burned and buried when dry. Landowners may remove tree themselves for wood before the repair is started, at their own expense.

5. Drop Inlet Pipe Structures:

The Drainage Authority will actively promote erosion control measures within its County Drainage System to prevent future costly ditch clean outs. Since the most common cause of erosion in ditches is a lack of adequate structures to control side inlet water slow into the ditch, the Drainage Authority will have drop inlet pipe structures installed in area where it determines the erosion is a problem as a maintenance procedure. The Drainage System shall be responsible for paying for the following expenses, which are necessary to install a drop inlet tile structure:

a. Forty- (40) foot pipe; dual wall plastic pip preferred, the first twenty (20) feet being non-perforated.
b. The blind tee.
c. The marker flag.
d. Five (5) foot perforated riser, which must extend one (1) foot above ground level.
e. All necessary digging and dirt moving to install the drop inlet pipe structure.
   All expenses associated with extending the horizontal pipe beyond forty- (40) feet will be paid by the landowner of the person requesting the extension.

Sites will be selected based on the requests by property owners and inspections of the ditches by the County Engineer or Drainage Authority representative. Drop inlet pipe installation authorization will rest with the Ditch Authority Representative. The design of a drop inlet structure must be approved by the County Engineer and Drainage Authority Representative. If the installation of drop inlet pipe within a ditch is expected to exceed $5,000.00, or a combination of a drop inlet pipe and dip out is expected to exceed $10,000.00, the project, in order to proceed, shall be brought to the full Drainage Authority for their approval.

Attached to this Policy is a diagram of what a typical drop inlet pipe structure would look like.

A property owner who has a tile system that brings sub-surface water drainage into the Drainage System shall be solely responsible for installing and payment for an adequate inlet into the System.

6. Beaver Control:

Trapping: When beaver dams are reported or discovered when inspecting drainage systems, a trapper will be retained by the County Engineer or Drainage Authority Representative to remove the problem beaver. In order to be compensated, trappers will be responsible for providing the County Engineer with the number of beaver trapped along with their tails and where they were trapped. It is the trapper's responsibility to contact the DNR for appropriate approval for trapping beavers out-of-season. The Drainage Authority will annual set the rate of payment for the removal of beaver.

7. Grass Buffer Strips:

Requirements: A permanent grass buffer strip shall, whenever possible, be maintained between the top edges of the channel or ditch and the drainage system right of way boundary, line for those systems not required to comply with Minn. Stat. 103E.021, up to the maximums required for Minn. Stat. 103E.021 compliance. For all other systems, Minn. Stat. 103E.021 shall be complied with including a permanent grass buffer strip being maintained on the banks and on a strip of land 16 ½ feet in width or the crown of the leveled spoil bank, whichever is greater, on each side of the channel or ditch. Grass buffer strips will be required on all systems when repairs are done that require re-sloping of the ditch banks within the system. All landowners are encouraged to contact the Farm Service Agency concerning the installation of grass buffer strips.

Violations: Landowners will be notified by the Drainage Authority if a violation of the buffer strip requirement is found. The landowner will be given 60 days to bring the area of non-compliance into compliance. If the area is not brought into compliance during this period, the Drainage Authority will proceed in a manner described in Minnesota Statue 103E.21 subd. 4 and 5.

Agricultural Practices: Agricultural practices such as plowing, tilling, pasturing cattle or other practices, which are not consistent with the purpose of the grass buffer strip, are not permitted. The grass buffer strip may be cut from time to time, but the cut hay must be removed. Grasses used to seed slopes and grass buffer strips will need to be resistant to sprays and chemicals used to control brush. Alfalfa seeding will not be allowed on the slopes or grass buffer strips.

14. Miscellaneous Drainage System Issues:

Cattle: Cattle will not be allowed to be in a drainage ditch except to cross at approved location. If cattle must cross a ditch, the preferred method is to have them cross at an installed crossing to prevent cattle from entering the water. Cattle may be watered from the ditch but the access to the amount of ditch must be controlled. Cattle will be allowed to graze along a ditch for short periods of time to remove vegetation and them must be removed. No trampling of the ditch banks will be allowed. Owner wishing to graze the spoils and slopes must contact the County Engineer to work out a rotation for the cattle to be allowed to graze.

Feedlot Runoff: Feedlot runoff should be prevented from entering the ditch system either by direct or indirect methods.

Fences: No fence may be installed closer than 50 feet from the crown of the spoils. When ditch repair is performed, gates may be installed in the property line fences next to each side of the ditch allow for the access of equipment used for repairing the ditch.

Obstructions: Any obstruction to be installed in a system must have proper engineering, have a hearing as provided by State Statute and be permitted by the Drainage Authority.

Rock and Debris: Rocks or debris will not be allowed to be dumped into or next to a drainage ditch. Landowners should be encouraged to stockpile rock when removing from fields for later use as riprap.

Adopted this 20th day of May, 2003. Revised this 18th day of September, 2007.

ONE WATERSHED ONE PLAN – NORTH FORK CROW RIVER WATERSHED (2018 – 2028)

The North Fork Crow River (NFCR) One Watershed One Plan (1W1P) boundary follows the boundary of the North Fork Crow River Watershed (HUC 07010204). The NFCR watershed is located in an agricultural region of south-central Minnesota, draining an area of 1,483 square miles (950,000 acres). The watershed is located in the Upper Mississippi River Basin and encompasses parts of Pope (3.7%), Stearns (16.0%), Kandiyohi (16.0%), Meeker (28.4%), Wright (31.7%), Hennepin (3.0%), Carver (0.1%), and McLeod (1.0%) counties. There are 31 municipalities located completely or partially within the boundaries of the watershed.

The vast majority of the watershed is within the North Central Hardwood Forest Ecoregion, with a small portion lying within the Western Cornbelt Plains Ecoregion, meaning the watershed was originally a mixture of hardwood trees and prairie. The watershed's surface waters are abundant with 679 lakes and 233 streams segments, or assessment units (AUIDs) throughout the watershed. From its source at Grove Lake in Pope County, the North Fork Crow River runs east-southeast for a total length of 157 miles, flowing through Rice Lake and Lake Koronis until it meets the South Fork Crow River, where the confluence of the two rivers at Rockford forms the Crow River. The Crow River flows northeast until it meets the Mississippi River near the cities of Otsego and Dayton (MPCA, 2014). The watershed elevation ranges from approximately 800 to 1400 feet above sea level, decreasing from west to east.

Stream and Lake Condition Status

Of the 679 lakes and 233 stream segments (AUIDs) in the watershed, 90 lakes and 74 streams have been assessed and their impairment status is presented in the NFCR Watershed WRAPS report. Although there are many other lakes and stream resources within the watershed, not all have been assessed as some may be too small (lakes under four (4) hectares) or they are limited resource waters (ditches or heavily channelized streams). The 90 lakes have been evaluated for aquatic recreation, which are assessed using total phosphorus (nutrient) criteria. The 74 streams have been assessed for aquatic life parameters including dissolved oxygen (DO), index of biotic integrity (IBI), and turbidity; in addition, aquatic recreation parameters include bacteria (fecal coliform or *E. coli*) were also used to assess streams. Some of the waterbodies in the NFCR watershed are impaired by mercury; however, the WRAPS report does not cover toxic pollutants.

The NFCR watershed is mainly agricultural and has numerous public and private drainage ditches. Public drainage systems are managed by the North Fork Crow River Watershed District, or other drainage authority on behalf of the benefitted landowners. For locations of drainage systems within the watershed, see **Figure 11**.

Section 5: Implementation Program

Capital Improvements

A capital improvement is defined as a major non-recurring expenditure for the construction, repair, retrofit, or increased utility or function of physical facilities, infrastructure, or environmental features. Capital improvements are beyond the "normal" financial means of the NFCR 1W1P planning participants, and therefore require external state and federal funding. Capital projects normally exceed the amount of financial support which can be provided through the BMP Cost Share Initiative.

Capital Improvement Project	Description	Information Source	Years (Start & End)	Status	Estimated Cost*
MFCR Stream Bank Stabilization Projects	Conceptual designs for the erosion locations with moderately-high to severe erosion features	Middle Fork Crow Watershed District	Clean Water Fund: Accelerated Implementation Subwatershed Assessment Study	2018	Planning Level Analysis

Regulatory Administration

Many of the issues affecting priority concerns can be addressed in part through the administration of statutory responsibilities and ordinances. **Table 5-3** shows the relationship between statutory obligations and ordinances administered by the counties and watershed districts within the NFCR Watershed. Additional descriptions of the administration of statutory responsibilities and local ordinances is described within this section of the plan.

ADMINISTRATION OF STATUTORY RESPONSIBILITIES

The state statutes administered by the counties and watershed districts involved in this plan are described below. In many cases, local regulations and ordinances have been adopted to conform to the standards and requirements of the state statutes (table 5-3). The responsibility for implementing these programs will remain with the respective counties.

BUFFER AND SOIL LOSS LEGISLATION

During the 2015 legislative session, the state of Minnesota passed the buffer and soil loss legislation (Minnesota statue 2014, section 103b.101), commonly referred to as the Minnesota buffer law. The legislation requires a 50-foot average continuous buffer of perennial vegetation with a 30-foot minimum width around all public waters and a 16.5-foot minimum width continuous buffer of perennial vegetation along all public drainage systems. The swcds will be relied upon for implementation and assessing compliance of the buffer legislation. Swcds are also likely to provide technical assistance and provide guidance about financial assistance options. Landowners also have the option of working with their swcd to determine if other alternative practices aimed at protecting water quality can be used, rather than a buffer.

SHORELAND MANAGEMENT

The Minnesota Legislature has delegated responsibility to LGUs to regulate the subdivision, use, and development of shorelands along public waters to preserve and enhance the quality of surface waters, conserve the economic and natural environmental values of shorelands, and provide for the wise use of waters and related land resources. This statute is administered and enforced as a zoning ordinance requiring a 50-foot buffer around public waters.

FLOODPLAIN MANAGEMENT

Floodplain zoning regulations are intended to guide development in the flood plain consistent with the magnitude of the flood threat, in order to minimize loss of life and property, disruption of commerce and governmental services, extraordinary public expenditure for public protection and relief, and interruption of transportation and communication, all of which adversely affect the public health, safety, and general welfare.

Local Ordinances

Local ordinances are used by all of the counties in the NFCR Watershed to address issues specific to their county. **Table 5-3** shows the counties which have ordinances related to managing water and resources. The responsibility for implementing these ordinances will remain with the respective counties.

SOIL EROSION

Some counties participating in this plan have erosion control regulations within their zoning ordinances that address construction and storm water plans. The State of Minnesota also requires permits through the National Pollutant Discharge Elimination System (NPDES) for all construction on development sites of one acre or more in size.

Rules

There are two watershed districts within the NFCR Watershed: the North Fork Crow River Watershed District and the Middle Fork Crow River Watershed District. Both the NFCRWD and MFCRWD have a system of rules and regulations for the management of water within their respective watershed districts. No new rules or regulations specific to water management will be implemented by the watershed districts within the NFCR Watershed. Rather the need for new and implementation of existing rules and regulations will continue through the NFCRWD and MFCRWD. **Table 5-3** shows existing rules and regulations within the NFCRWD and MFCRWD, as they relate to statutory responsibilities and local county ordinances. Existing rules and regulations for the NFCRWD and MFCRWD.

PUBLIC DRAINAGE SYSTEMS: ESTABLISHMENT, IMPROVEMENT, REROUTING, REPAIRS, IMPOUNDMENTS, BUFFER COMPLIANCE

Actions impacting public drainage systems are regulated by rules within the NFCRWD. The following actions require a permit from the NFCRWD to proceed:

- Work in any water course or water basin, whether or not open water is present at the time of the work--including but not limited to excavation, filling, dredging, and the placement of structures. In the case of agriculture drainage, a permit is required for: a. Surface or open ditch drainage of a drainage area greater than 160 A.'s b. Tile drainage of a drainage area greater than 320 A.'s (NFCRWD Rules 3.1A);
- Work in the right of way of any legal drainage system within the jurisdiction of the District (NFCRWD Rules 3.1C);
- Diversion of water into a public drainage system from land not assessed for the public system (NFCRWD Rules 3.1D);
- Cultivating any area that is closer than one rod from the top edge of any water course that is part of a public drainage system (NFCRWD Rules 3.1F).

PRESERVATION OF NATURAL DRAINAGEWAYS

The NFCRWD has a rule in place requiring a permit for any work to restrict the normal or natural drainage of land or to enlarge wetlands that will cause flooding of adjacent land or public or private roadways. This rule is in place to help ensure wise development and conservation of the NFCRWD's water resources.

TILE DRAINAGE

Tile drainage is regulated by rules within the NFCRWD and MFCRWD to preserve drainage capacity, prevent flooding, and improve water quality. Within these rules, permits are required for certain new or expanded tile drainage systems. Permits may also be required for the repair or preplacement of existing private drainage facilities.

STREAM HYDRAULIC CAPACITY

Actions impacting stream hydraulic capacity are regulated by rules within the NFCRWD. The following actions require a permit from the NFCRWD to proceed:

- Construction, installation or alteration of any water control structure in any water course or water basin that is of greater or lesser capacity then is reasonable considering the upstream and water control structures (NFCRWD Rules 3.1B).

STORMWATER RUNOFF

Through District rules, the MFCRWD manages storm water runoff within the watershed to protect surface water and groundwater resources, promote infiltration, encourage pretreatment, and minimize peak flows after storm events and spring snow melt. Included in this rule are permit requirements for certain development and redevelopment and standards for stormwater permit application.

Incentive Based Initiatives

Incentive based initiatives are a key component of the targeted implementation schedule presented in **Section 4**. Incentive based initiatives are used as the funding mechanism to implement the strategies and actions to make progress toward achieving the measurable goals. Incentive based initiatives used by plan participants across the NFCR Watershed, but lack commonality. This plan establishes common incentive based initiatives within the plan area. The implementation of the actions and funding of initiatives will be done at the local level. The incentive based initiatives are described conceptually in this section. Specific details for execution may be needed prior to program use.

As introduced in **Section 3**, each action is categorized as an implementation program component. Six different implementation program components are included in the targeted implementation schedule: i.e., 1) Structural BMP; 2) Management Practice; 3) Education and Outreach; 4) Data Gaps and Research; 5) Regulatory and 6) Capital Improvement.

Implementation program components relate to the incentive based initiative which will be used to fund the action. These initiatives are defined and discussed in this plan section. As local approvals and ordinances are already a component of local government budgets, actions in the Regulatory implementation program component are not assigned a specific initiative, and are instead discussed in **Section 5.5**. Likewise, Capital Improvements represent larger projects not associated with general local funding, and are also not associated with a specific initiative. These projects are discussed in **Section 5.2**.

APPENDIX 3: STREAM ASSESSMENT TECHNICAL MEMORANDUM

Technical Memo

WENCK ASSOCIATES

Responsive partner.
Exceptional outcomes.

To: Margaret Johnson, Middle Fork Crow River Watershed District

From: Lucius Jonett, Wenck Associates, Inc.

Copy: Jon Morales, Middle Fork Crow River Watershed District

Date: January 14, 2016

Subject: Middle Fork Crow River Stream Assessment

This memo summarizes the streambank erosion and condition assessment completed along the Middle Fork Crow River from Lake Calhoun to the Middle Fork's confluence with the North Fork Crow River. This portion of the Middle Fork Crow River was listed in 2012 as impaired on the Minnesota Pollution Control Agency's 303(d) list for E. Coli. While there is an E. Coli impairment, the focus of this assessment was on locating and documenting eroding streambanks, areas with little or no buffer zone, side inlets, damaged or outdated tiling methods and any other notable features that may cause increased erosion. The result of the assessment will highlight, document and pin-point problems where Best Management Practices could help eliminate significant sources of pollution to the Middle Fork Crow River.

Stream Channel Assessment

Wenck and the Middle Fork Crow River Watershed District (MFCRWD) staff completed a stream assessment of the Middle Fork Crow River on October 14 and 15, 2015. The Middle Fork Crow River from Lake Calhoun to the confluence with the North Fork Crow River was the focus of the stream assessment; the study reach. From aerial photographs, the study reach has been visibly altered (channel straightening) and is in a watershed of modified hydrology (agricultural ditching and draintiling).

To provide a basis for comparison, a reference reach of the Middle Fork Crow River was found that has minor channel and watershed hydrology modifications in comparison to the study reach. An equivalent assessment of the reference reach of the Middle Fork Crow River from County Road 40 NE to Nest Lake was completed.

The following table summarizes the portions of the Middle Fork Crow River assessed:

Reference Reach (3.2 miles)		**Study Reach (12.2 miles)**	
Upstream Station	Downstream Station	Upstream Station	Downstream Station
County Rd 40 NE	161st Ave NE	150th St NE	160th St NE
		175th St NE	195th St NE
		195th St NE	520th Ave
		520th Ave	Hwy 25
		Hwy 25	Hwy 4
		Hwy 4	560th Ave
		560th Ave	Hwy 30
		Hwy 30	Hwy 3

Some portions of the study reach (from 160th St NE to 175th St NE and from Hwy 3 to the confluence with the North Fork Crow River) were skipped to save time as they were visibly similar to portions that were assessed and not likely to have active erosion features. From aerial photographs there is outer bank erosion on the Middle Fork Crow River where it joins the North Fork Crow River. But that erosion is considered part of the natural meandering process that rivers undergo and should be left alone instead of fighting it as long as there is minimal threat to structures and property.

The stream assessment included traversing the length of the reference reach, 3.2 miles, and the length of the study reach, approximately 12.2 miles. During the assessment, slope, depth, typical cross-sections, streambed particle size distribution data, survey points of erosion and photographs were gathered.

See Figure 1 for photo locations and areas of stream bank erosion along the reference reach.

See Figure 1A for draintile locations and cross-section locations along the reference reach.

Reference Reach Pebble Count

Reference Reach Pebble Count			
Cross-Section	XS-1	XS-2	XS-3
Units	mm	mm	mm
D_{16}	2	0.08	0.075
D_{35}	5	2.00	3
D_{50}	7	2.00	5.5
D_{84}	14.16	5.00	13
D_{95}	20	7.05	16

See Figure 2 for photo locations and areas of stream bank erosion along the study reach.

See Figure 2A, 2B, 2C, 2D, 2E for draintile locations and cross-section locations along the study reach.

Study Reach Pebble Count

Study Reach Pebble Count				
Cross-Section	XS-1	XS-6	XS-7	XS-8
Units	mm	mm	mm	mm
D_{16}	0.075	0.04	15.84	0.075
D_{35}	0.67625	0.075	28	0.075
D_{50}	2	0.075	34	0.075
D_{84}	12.16	2	62	0.383
D_{95}	16.05	10	117.45	10.05

Sediment Contributed from Streambank Erosion

During the stream assessment, areas of active erosion were marked with GPS and measured for length and height of the erosion. Streambank erosion can occur for many different reasons. Landcover changes in the riparian zone may have weakened the streambanks by reducing or eliminating long-rooted native vegetation that strengthens and stabilizes the banks. Changes in flow regime may have destabilized streambanks that are exposed to prolonged periods of wetting or wet-dry cycles. Animals grazing on the stream bank may denude the riparian area, and may physically break down the banks as they access the stream. Straightened or ditched sections of streams increases the channel slope and stream velocity increasing the shear stress or erosive power of the water.

To understand if the erosion features observed on the study reach were contributing a proportionally larger amount of sediment when compared to the reference reach, the annual soil loss for both the reference and the study reach was estimated using field collected data and a method developed by the Natural Resources Conservation Service referred to as the "NRCS Direct Volume Method," or the "Wisconsin method," (Wisconsin NRCS 2003). Soil loss is calculated by:

1. measuring the amount of exposed stream bank in a known length of stream;
2. multiplying that by a rate of loss per year;
3. multiplying that volume by soil density to obtain the annual mass for that stream length; and then
4. converting that mass into a mass per stream mile.

The Direct Volume Method is summarized in the following equation:

$$\frac{\text{(eroding area) (lateral recession rate) (density)}}{\text{2,000 lbs/ton}} = \text{erosion in tons/year}$$

Comparing the results from the two reaches, the difference between the amount of "typical" erosion for the reference reach and the amount of streambank erosion of the study reach is considered the "excess" erosion volume.

The erosion reduction target for the study reach is:
(Excess or eroding erosion volume – stable erosion volume = reduction in erosion required)

	Estimated erosion (tons/year)	Reach length (miles)	Average Erosion Per Mile (tons/year)
Reference Reach	45	3.2	14.1
Study Reach	1050	12.2	86.1
Reduction Required	1095		72.0

The excess erosion volume of 1,000 tons per year is the reduction goal of bank stabilization projects to reduce the excessive erosion of the study reach and make it similar to a natural, non-eroding channel (the study reach).

Sediment Delivery and Transport

In undisturbed watersheds there is some minor soil lost every year and delivered to nearby streams. Sediment loss from stream bank erosion also occurs in undisturbed streams as channels undergo natural migration and change as the stream meanders (moves) within its meander belt. Channels are made and unmade; streams in equilibrium will neither on average aggrade, or experience deposition, nor degrade, or scour. Changes in sediment delivery, particle size, stream flow, or stream slope (Lane 1955) may cause the stream to aggrade or degrade, impacting channel type and morphology. An aggrading stream does not have the power to effectively mobilize and flush streambed particles either by bed load or suspended load. Whereas a degrading stream is disconnected from the floodplain as the channel gets deeper and more and more flow is contained within the channel increasing the power to mobilize and move larger amounts of bedload. The observed, probable incision on the straightened sections of the Middle Fork Crow River where levees are forming, either artificially from spoils of ditch cleaning or naturally from frequent flooding and deposition, is suggestive of a degrading stream reach.

The Shields Threshold of Motion Equation (Shields 1936) can be used to determine D_s, the particle size at the threshold of motion, when individual particles on a stream bed are on the verge of motion by stream flow. For a sand-gravel stream in equilibrium at bankfull flow the D_s value is close to the D_{50} value, which is the median particle size.

$$D_s = \tau / ((\rho_s - \rho)\, g\, 0.06)(304.8)$$

D_s=diameter sediment particle (mm)
τ=shear stress=(ρg)(depth)(slope) (lb/ft^2) (N/m^2)
ρ_s=density of sediment (5.15 slugs/ft^3) (2560 kg/m^3)
ρ=density of water (1.94 slugs/ft^3) (1000 kg/m^3)
g=gravitational acceleration (32.2 ft/s^2) (9.81 m/s^2)
0.06 = Shield's parameter typically in the range of 0.04 to 0.07
Conversion constant 304.8 mm/ft or 1000 mm/m

Einstein (1950) developed a method of using the Shields Equation to estimate bedload transport in a way that accounts for the probability that any sediment particle would be mobilized by flow. This method assumes that the streambed material is not uniformly sized and uses channel depth, slope, and sediment size characteristics to estimate the particle size at the threshold of motion. These equations can be used to estimate the rate of bedload transport per unit channel width.

To estimate stable (reference) bedload volume per foot width and compare to the eroding (study) bedload, Wenck completed Einstein's bedload equations using slope, depth, and D50 particle size data gathered during the stream assessment.

Threshold of motion parameters for the reference reach are as follows:

Parameter	Cross Section 1	Cross Section 2	Cross Section 3
Depth (ft)	1.962	2.01	2.28
Slope (ft/ft)	0.002	0.002	0.003
Sediment D_{50} (mm)	7.0	2.0	5.5
Shear Stress (lb/ft^2)	0.103	0.037	0.229
Particle at Threshold of Motion (mm)	12.0	12.0	21.0
% Particles Smaller	78%	97%	99%
Unit Bedload Transport (ft^2/s unit width)	0.00255	0.00774	0.01481

Cross section 3 has a greater bedload than cross sections 1 and 2 mainly because of increased channel slope.

Threshold of motion parameters for the study reach are as follows:

Parameter	Cross Section 1	Cross Section 6	Cross Section 7	Cross Section 8
Depth (ft)	3.94	3.17	2.34	1.63
Slope (ft/ft)	0.0004	0.0006	0.0006	0.0008
Sediment D_{50} (mm)	2.0	0.075	34.0	0.075
Shear Stress (lb/ft^2)	0.145	7.67	0.008	3.213
Particle at Threshold of Motion (mm)	5.0	6	4	4.0
% Particles Smaller	68%	92%	5%	85%
Unit Bedload Transport (ft^2/s unit width)	0.00104	0*	0[1]	0*

*Cross section 1 was the only reach with notable bedload, cross sections 6 and 8 were silt dominated and do not have large enough particle diameters. Particle sizes greater than 0.5 millimeters (mm) or medium sand are needed to calculate stream bedload.

[1]Cross section 6 contains the greatest D_{50} distribution among the cross sections sampled in the study reach; however, a low slope of 0.0006 ft/ft does not provide enough energy to move sediment through the reach. The slope through cross section 7 should be verified by collecting additional streambed elevation values upstream at 560th Ave and downstream at County Road 30.

Based on the current calculations, bedload in the study reach does not exceed values in the reference reach meaning both reaches are in similar states of equilibrium (neither aggrading nor degrading) passing fine sands and silts through the reaches. Generally, the size of particle at the threshold of motion is larger than the D_{50} particle size, which is the median particle size, in the reference reach. The low slopes through cross sections 1, 6, and 8 do not provide enough energy to move sediment through the reach. Fine sands and silts will mobilize as total suspended solids rather than bedload and will entrain in the water column. The motion of threshold value for cross section 7 is less than the D_{50} particle size. Fine particles will mobilize under normal flow conditions and gravel to cobble sized materials will not be transported.

From observation during the field investigation, and supporting the calculation results, the channel morphology and sediment composition is such that the stream is mobilizing finer particles on the streambed. Except for downstream of the active erosion and straightened sections of the reference reach where the equations look like the channel is aggrading when really the channel is more near equilibrium and the mass wasting or erosion of the streambanks is depositing so much sediment into the channel that natural flows aren't able to mobilize all the deposits. In such areas where fine sediment deposition has occurred in the reference reach of the Middle Fork Crow River, pebble, cobble and larger bed material maybe present under the layer of fine sands and silts. While the stream naturally is trying

to mobilize these fine sediments, they are constantly being replenished from the banks and watershed.

Loss of Watershed Connectivity and Flow Alteration Due to Ditching/Straightening

Ditching has reduced the connectivity of the stream to its floodplain as well as physically altered the stream. Ditching (dredging and straightening) reduced channel roughness by reducing pools and riffles, increased the channel slope by shortening the length of stream flow and has separated flood flows from the floodplain through the buildup of dredge spoils wasted on the streambank. All of these factors serve to contain more flow in the channel, increase the velocity of river flow and creates the potential for increased erosion problems both on the channel banks and the channel bottom (degradation and channel incision).

Ditching and draintiling has likely changed the hydraulics and hydrology of the Middle Fork Crow River from its pre-settlement conditions to a system that sends more water to the river system faster. This increased runoff volume and flow rate also increases the potential for erosion problems. During the stream assessment, visible draintile outlet locations were recorded with the GPS.

Erosion can occur around draintile outlets from the flow of water coming out of the draintile as well as from the flow in the river interacting with the draintile pipe. Active erosion was not observed around the few (7) draintile outlets found during the field assessment.

Combining the factors of ditching and hydrology modifications on the study reach puts more water in the channel, makes the water move through the straight channel faster and has increased bank instability when compared to the reference reach that is more naturally meandering and has less draintile input.

It was observed during the field evaluation where straightened sections of the river return to more natural meandering sections, that those locations are where the biggest erosion problems are occurring. Flow accelerates in the straightened sections (increased slope) and dissipates the increased energy through bank erosion in the meandering sections (natural or lower slope) as the flow slows back down (because the slope decreases). Returning the straightened sections to a more natural meandering pattern would remove the flow acceleration and reduce the active erosion.

Conclusion

Comparing the representative or natural, not-modified reference reach to the study reach of the Middle Fork Crow River, there is "excess" erosion in the study reach being caused by streambank erosion and mass wasting. Observations made during the stream channel assessment show that the study reach has several straightened reaches and where the straightened reaches return to natural meandering channels is where the significant erosion is occurring. Channel characteristics, typical cross-sections and streambed particle size distribution data collected during the assessment supports that there is more erosion happening on the study reach. The study reach of the Middle Fork Crow River is actively eroding 1,000 tons per year more than the reference reach.

Analysis of the streambed particles measured during the assessment shows that bedload in the study reach and the reference reach is similar. Fine particles (fine sands and silts) will

mobilize under normal flow conditions. In the reference reach, the results suggest that the channel is aggrading especially downstream of the active erosion and straightened sections. Really the channel is more near equilibrium and the mass wasting or erosion of the streambanks is depositing so much sediment into the channel in these areas that natural flows aren't able to mobilize all the deposits away. If these deposits were flushed downstream, underneath there is pebble, cobble, maybe even larger bed material. It was observed during the field assessment that pebble size bed material does lay several inches under the sand and silt deposits on the river bed. While the stream is naturally trying to mobilize these fine sediments, they are being replenished from the bank erosion.

Based on the field assessment and the analysis of data collected, the reference reach of the Middle Fork Crow River is eroding more and contributing more sediment annually than the reference reach. The major contribution to the increased degradation of the streambanks in the reference reach is predominantly a result of the ditching and straightening that has been done to the reference reach. Several moderate to severe erosion features were observed in areas of little to no buffer and there was one area where cattle was not excluded from trampling the streambanks. The short-term solution to reducing the extra 1,000 tons of erosion occurring in the reference reach is to stabilize the active erosion areas and protect them from future erosion. Each of the marked erosion features can be consolidated into several Best Management Practice (BMP) projects to reduce the amount of sediment being contributed to the river. The long-term solution to minimize the potential for new accelerated erosion features is to consider remeandering ditched segments to lower channel slope, lower flow velocity and reconnect the channel with the floodplain.

Following this assessment, Wenck will recommend and conceptually design Best Management Practice (BMP) projects and develop construction estimates. Through a cost benefit analysis, we will help the District prioritize future implementation of the recommended BMPs both short-term and potentially long-term.

Literature Cited

Einstein, H.A. 1950. The Bed-Load Function for Sediment Transportation in Open Channel Flows. U.S. Department of Agriculture, Soil Conservation Service, Technical Bulletin No. 1026.

Lane, E.W. 1955. The Importance of Fluvial Morphology in Hydraulic Engineering. American Society of Civil Engineering, Proceedings, 81, paper 745: 1-17.

Shields, A. 1936. Application of Similarity Principles and Turbulence Research to Bed Load Movement. Versuchsant fur Wasserbau und Schiffbau, Berlin, No. 26.

Wisconsin NRCS. 2003. Field Office Technical Guide: Streambank Erosion.

APPENDIX 4: STREAM STABILIZATION TECHNICAL MEMORANDUM

Technical Memo

WENCK ASSOCIATES

Responsive partner.
Exceptional outcomes.

To: Margaret Johnson, Middle Fork Crow River Watershed District

From: Lucius Jonett, Wenck Associates, Inc.

Copy: Jon Morales, Middle Fork Crow River Watershed District

Date: May 20th, 2016

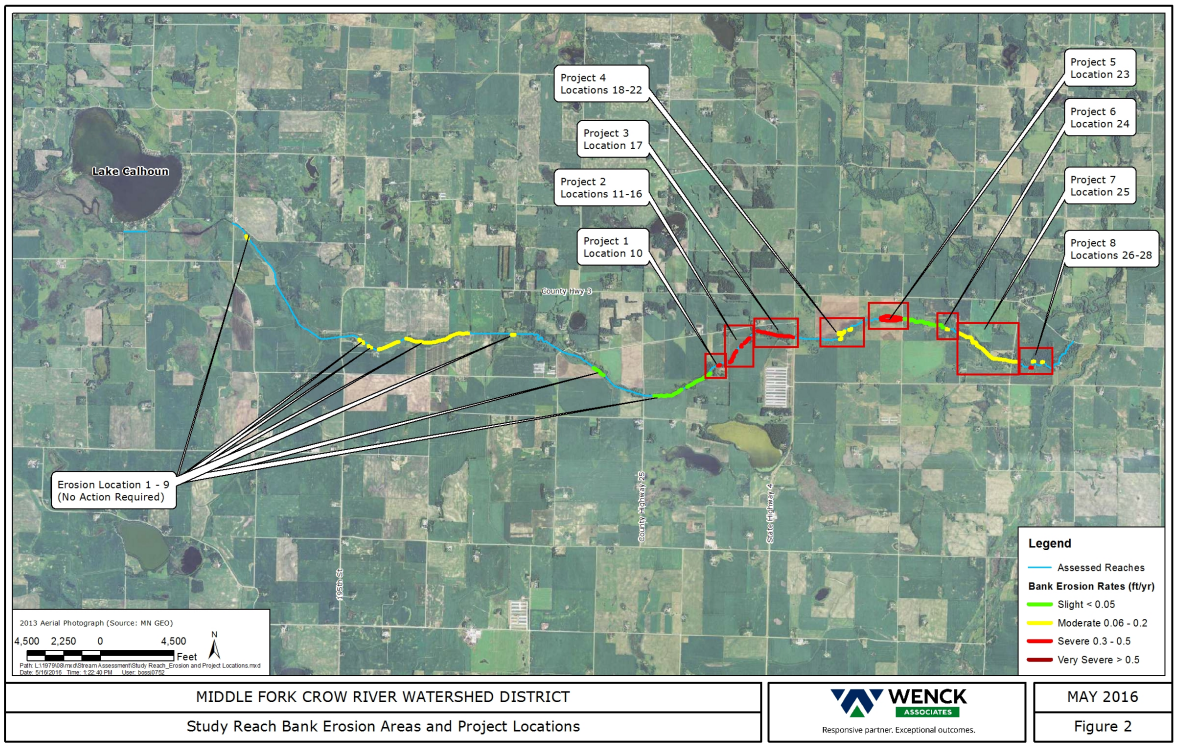
Subject: Middle Fork Crow River Stream Bank Stabilization Projects

Introduction

On October 14th and 15th of 2015, Wenck staff and district staff floated down the Middle Fork of the Crow River from Lake Calhoun to the confluence with the North Fork Crow River to do an assessment of the current conditions of river banks. Locations of erosion were logged with survey equipment, measurements were taken, and photographs were taken. Full sized maps of figures shown are attached at the end of this memo.

Following the field work, Wenck reviewed the data to estimate erosion rates and amounts at each location and attributed severity based upon erosion rates (ft/yr). We then prepared conceptual designs for the erosion locations with moderately-high to severe erosion features and combined locations into projects 1 – 8 based on proximity to one another, access, and number of landowners. A construction cost estimate was prepared for each concept project design and compared to the estimated reductions of erosion to rank the projects based on the dollars per pounds of sediment and phosphorous removed annually from lowest to highest.

Margaret Johnson
Administrator
Middle Fork Crow River Watershed District
May 20th, 2016



MIDDLE FORK CROW RIVER WATERSHED DISTRICT	WENCK ASSOCIATES Responsive partner. Exceptional outcomes.	MAY 2016
Study Reach Bank Erosion Areas and Project Locations		Figure 2

Streambank Stabilization Practices

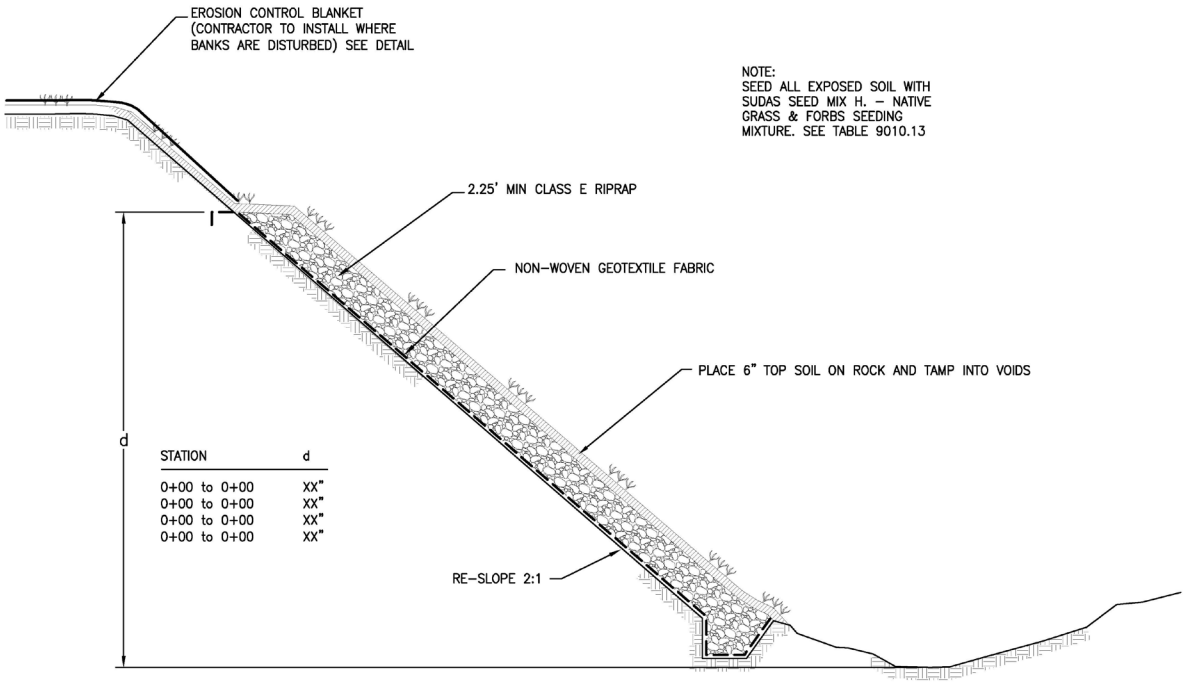
Each streambank stabilization concept design recommends specific stabilization techniques for mitigating erosion and creating long-term solutions to the current issues. Each stabilization practice will be briefly explained and accompanied with images and/or typical construction details. *All figures and details created by Wenck unless otherwise noted.*

Vegetated Riprap

Vegetated riprap is a slope stabilization technique to be used in instances where flow velocity (5 – 20 CFS) requires hard armoring (rock) instead of bioengineered techniques. Vegetation adds a more natural aesthetic by camouflaging the rock.

Vegetated riprap is intended to provide toe protection on taller (> 4’), vertical, eroding stream banks. Riprap would be installed at the existing toe line of the side slopes and be keyed in slightly below the stream bed. Some bank disturbance would be required to make the vertical bank less steep (ideally, 2:1 H:V or less) by grading from the top of the bank to the new riprap toe. Final stabilization of the riprap toe areas would include revegetation with native seed and either erosion control blanket along the channel where high flows are expected and straw mulch or hydro-mulch in the upland areas. Riprap toe would follow the existing bank, would balance cut and fill on site and would not alter the channel cross section.

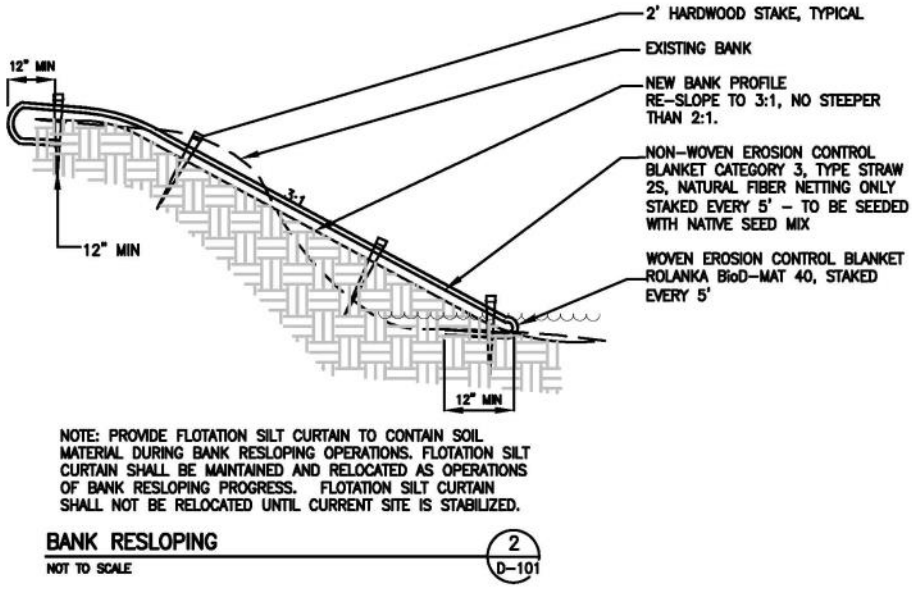
Figure 1: Vegetated Riprap Channel, 1 year after construction.



Bank Resloping with seed & erosion control blanket

Bank resloping is a bioengineering stabilization technique to be used in instances where flow velocity allows (<6 CFS) and/or for the portions of the bank above the normal high water level of a channel. Bank resloping is intended to establish native vegetation and provide toe protection on shorter (<3'), steep stream banks. Resloping the bank ranges from 3:1(H:V) or less (preferred), to no steeper than 2:1. It is intended to provide a stable slope for new vegetation to establish. The roots of the vegetation hold the slope during periods of inundation and reduce soil migration.

Figure 2: Resloped Banks Constructed During Winter Work on Elm Creek.



Tree Thinning/Tree Removal

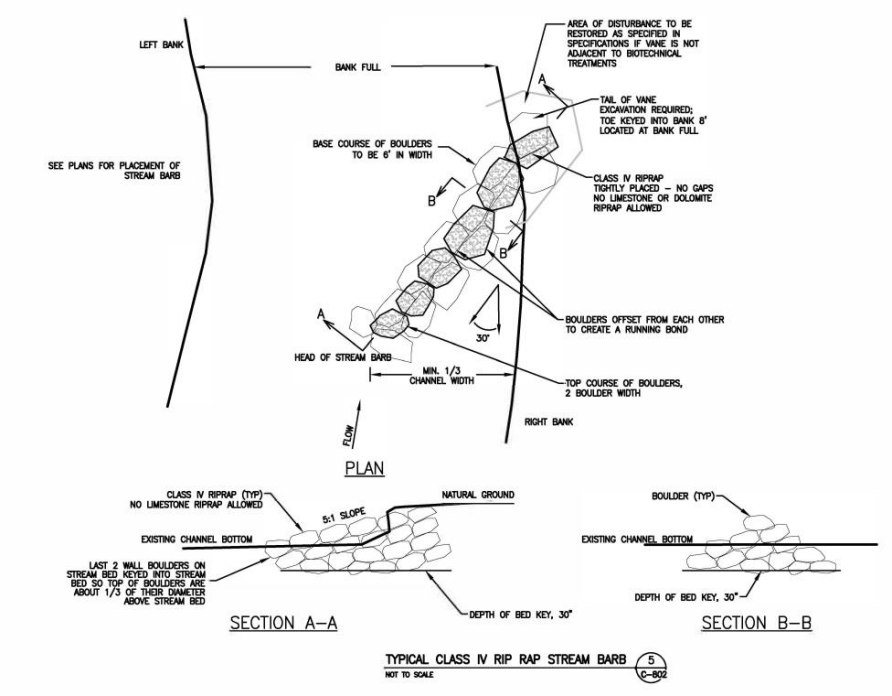
Thinning existing trees to presettlement vegetation densities of 5 – 10 trees per acres, allows for more sunlight to reach the soil. Increased sunlight encourages the amount and vigor of ground plane grasses thus mitigating soil movement into adjacent waterbody's.

Figure 3: One year after clearing trees, the existing seed bank grew into a healthy grass buffer on Coon Creek

Stream Barbs

Stream barbs are a descending trapezoidal mass of rock, pointed upstream extending from the center of the channel back into the adjacent bank. Stream barbs serve to redirect erosive force within the stream channel back toward the center of the channel and away from the banks. On the downstream side, at approximately 5 times the length of the barb, water flow experiences reduced velocity and erosive action allowing sedimentation to occur.

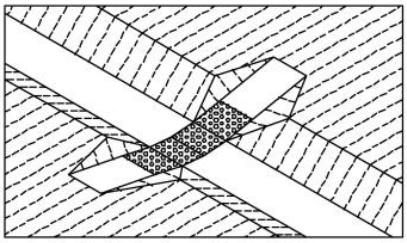
Figure 4: Three stream barbs to turn the flow of Purgatory Creek away from sharp outside bend.



Margaret Johnson
Administrator
Middle Fork Crow River Watershed District
May 20th, 2016

Cattle Crossing & Exclusion Fencing

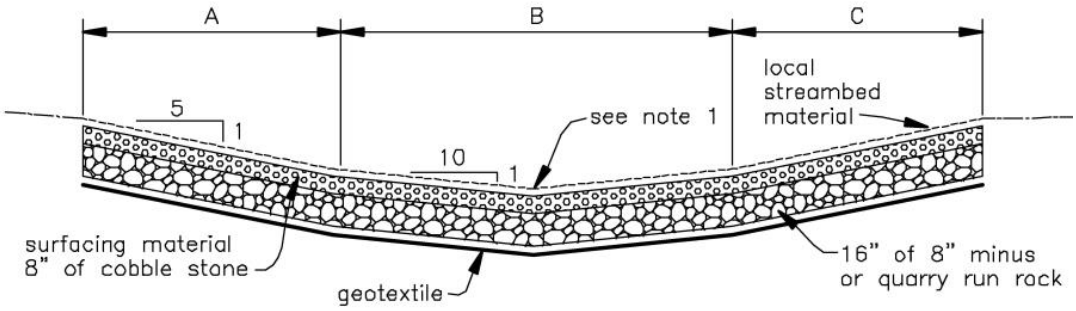
Cattle crossing and exclusion fencing serves to prevent the overgrazing of bank vegetation and trampling of stream banks while still allowing livestock access to water and pastures on the opposite side. Disturbance and erosion of the stream bed and banks is minimized by only allowing access and crossing of the stream in select locations that have been designed and constructed to be stable under cattle and equipment traffic.



ISOMETRIC

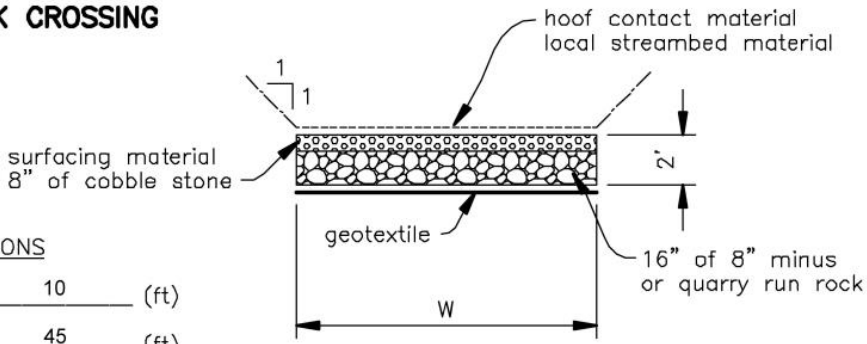
CONSTRUCTION NOTES

1. Crossing surface shall be a minimum of 0.2 ft below channel invert.
2. Surfacing material shall be compacted as per method (4) of CS–15.6.



CENTERLINE PROFILE

LIVESTOCK CROSSING



SECTION

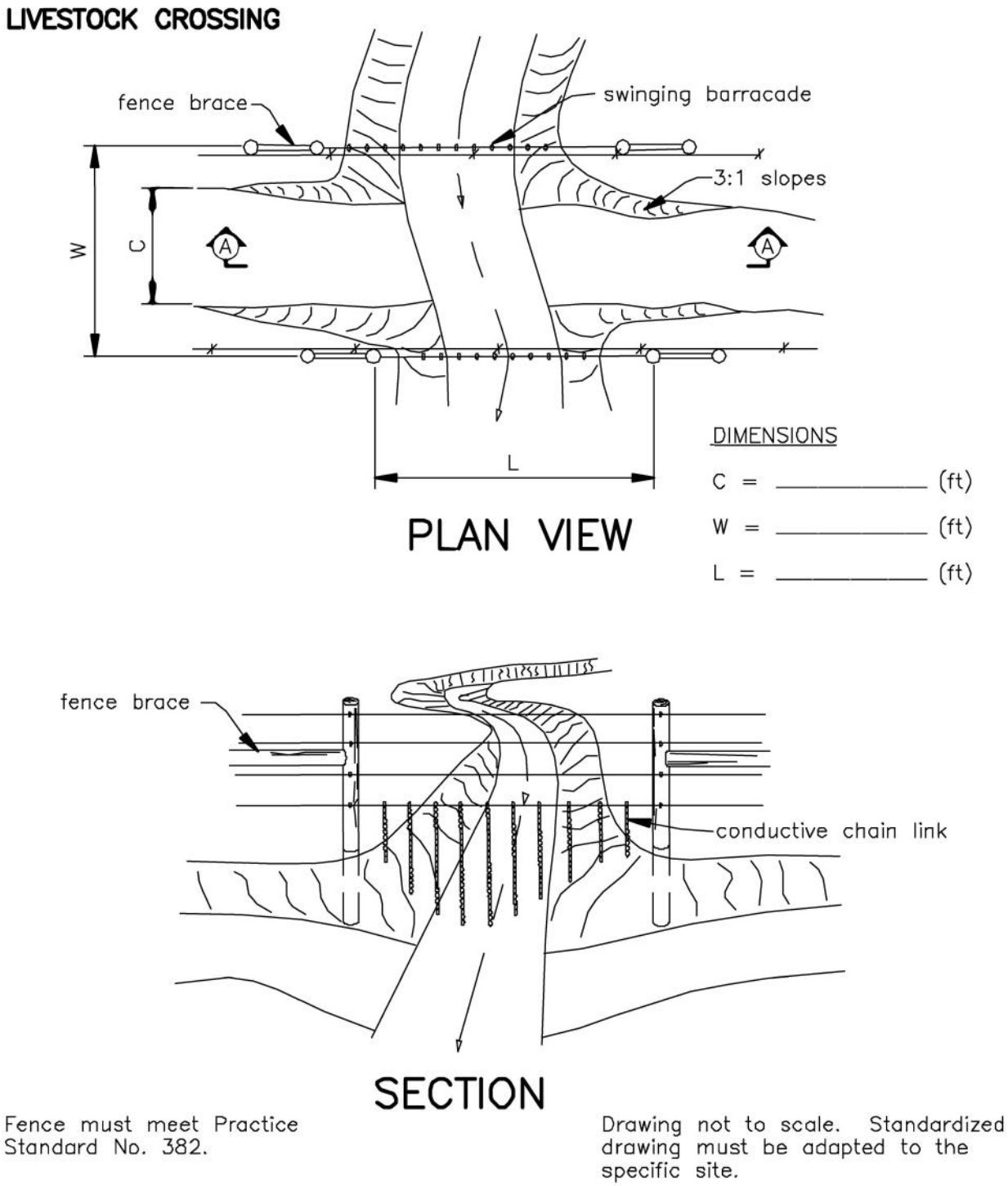
DIMENSIONS

A = 10 (ft)
B = 45 (ft)
C = 10 (ft)
W = 15 (ft)
Station _____

Drawing not to scale.

NOTE:
This standard drawing requires supporting technical documentation prior to use and must be adapted to the specific site.

Note: Construction Details by NRCS



Note: Construction Details by NRCS

1 Rod Buffer

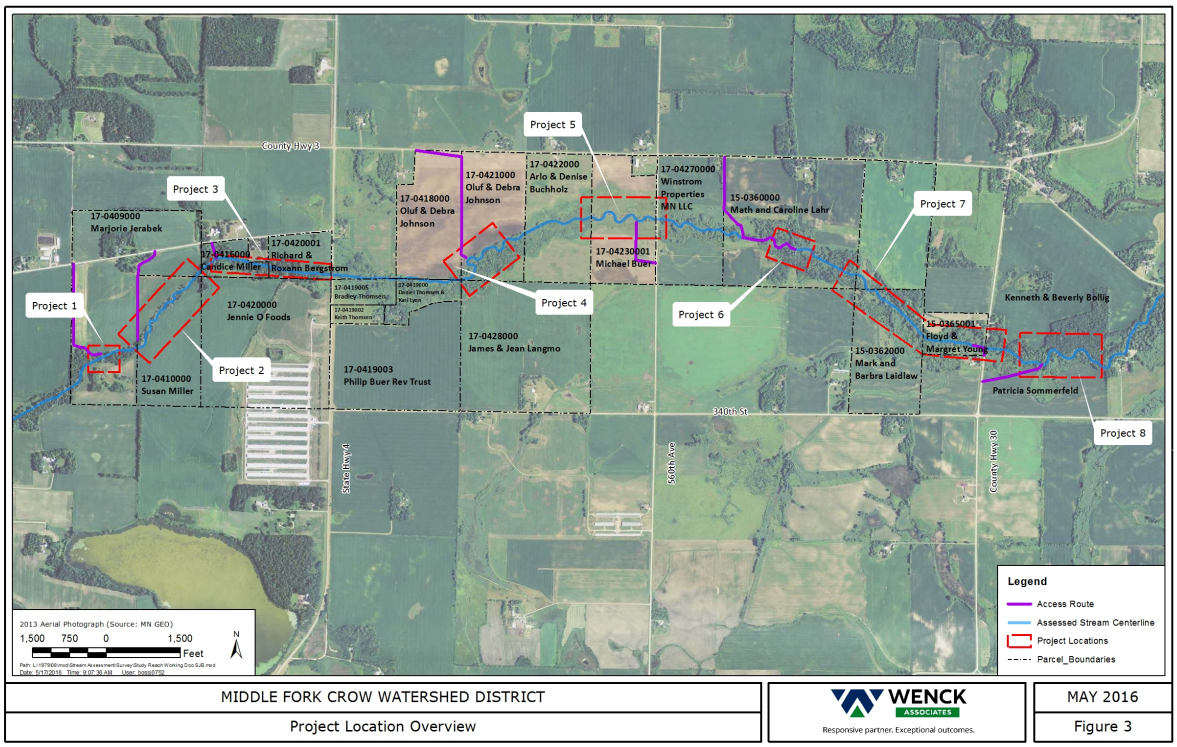
1 rod = 16.5 ft. Buffers stabilize the ground surface near waterways from overland flow, as well as, filter sediments out of stormwater runoff from surrounding areas by reducing flow velocity. Bare farm fields and paved surfaces in particular can contribute sediment into adjacent waterways. Implementation of the new MN Buffer Law will help stabilize the banks and improve water quality and habitat of the Middle Fork Crow River.

Figure 5: An established grassed buffer. Photo by MN DNR.

Streambank Stabilization Concept Plans

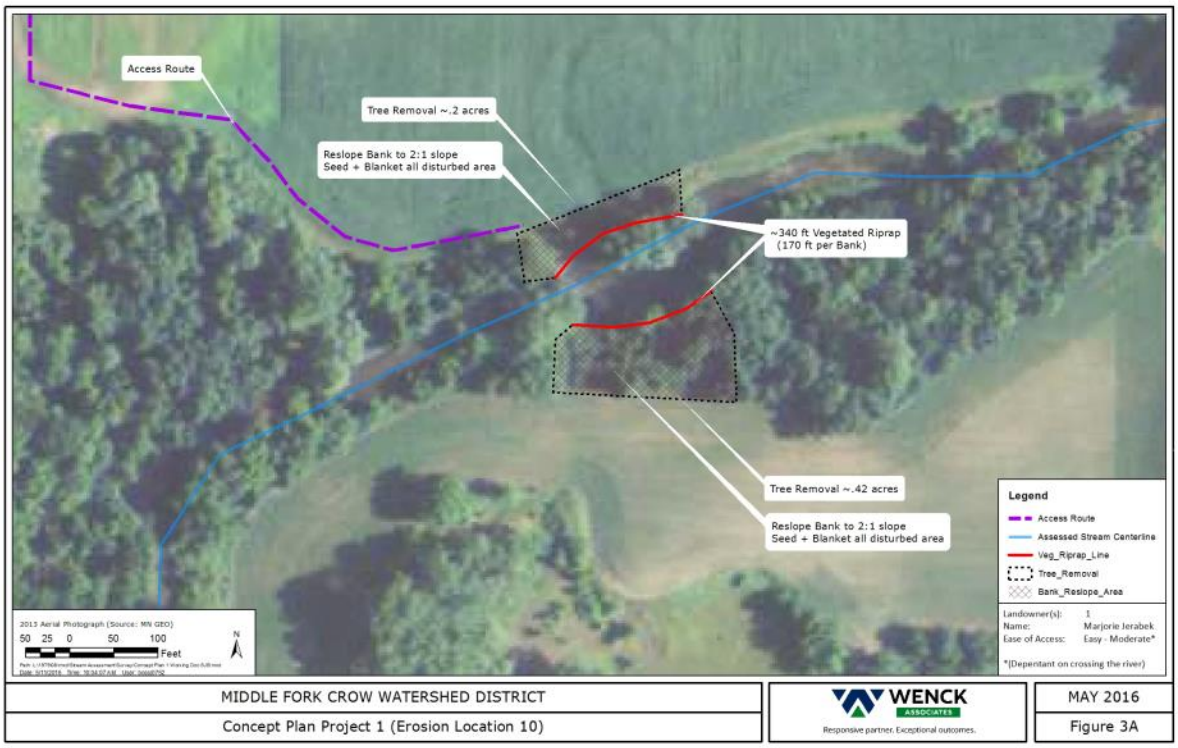
Each of the erosion locations identified from the field visit with a moderate-high to severe erosion rates were grouped into conceptual designs based on location, proximity to other features, access and number of homeowners into feasible construction projects. Refer to the Project Location Overview (Figure 3) map for the locations of each project within the assessed length of the Middle Fork Crow River.

Project Location Overview (Figure 3)



Erosion locations 1 through 9 were assessed using the WI NRCS recession severity classification and fell below the threshold of this document, thus no corrective action is needed at this time. These areas were not included in the project location overview. See table 1, at the end of the document for more detailed information of the erosion locations: Length, Height, Rescission rate, Volume in ft3, and recommended stabilization technique.

Concept Plan 1 (Figure 3A)

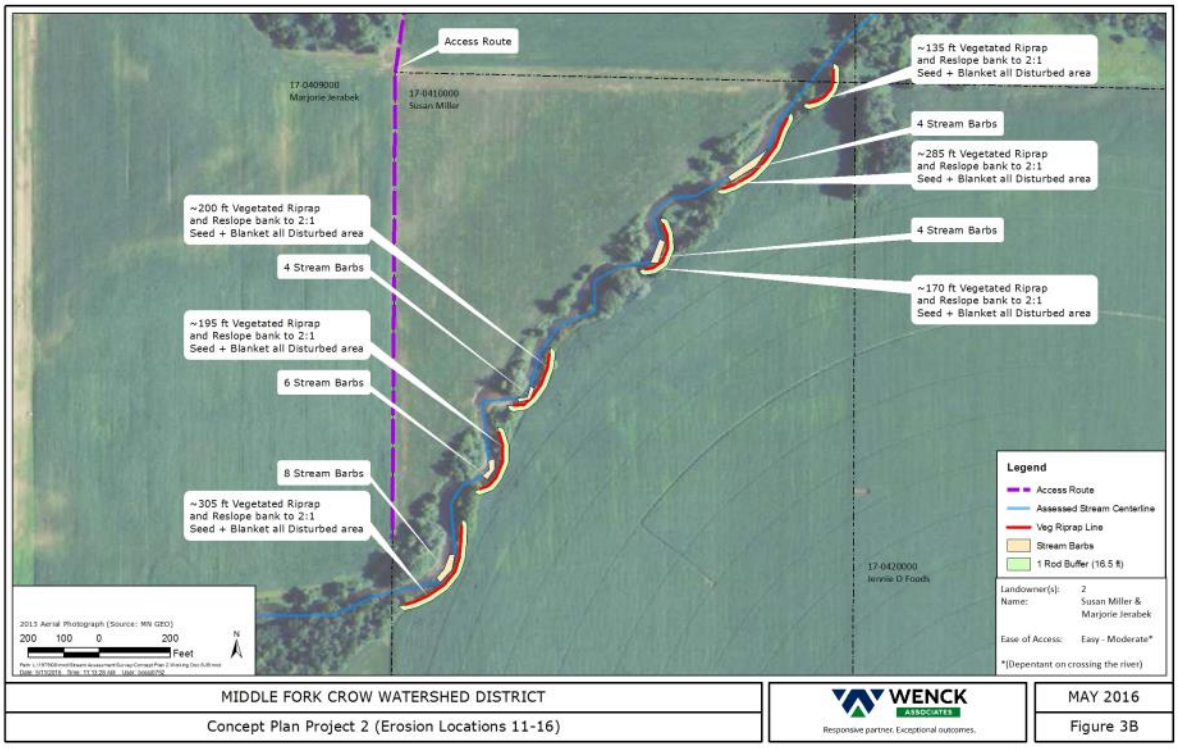


At erosion location 10, river banks are severely eroding for approximately 170 ft. on both sides and have an eroded vertical face of 4 ft. The erosion is due to do a bridge located directly upstream that creates a restriction in flow, a hydraulic jump and circulating eddies coming off the downstream flow onto the embankments. To minimize the current scour, collapse and erosion, both banks will need the toe protected in with vegetated riprap and regraded to a slope of 2:1 (3:1 if possible). In order to accomplish the regrading and allow sunlight to penetrate the new grade trees will need to be removed directly upslope from the affected area.

No.	Item	Units	Qty	Unit Price	Total
	BID TABULATION				
1	Mobilization/Demobilization	LS	1	$ 2,000.00	$ 2,000.00
2	Site Access & Restoration	LS	1	$ 5,000.00	$ 5,000.00
3	Tree Removal	LS	1	$ 7,500.00	$ 7,500.00
4	Bank Resloping	LF	340	$ 10.00	$ 3,400.00
5	Class II Rip Rap (Veg. Riprap)	TON	150	$ 120.00	$ 18,000.00
6	Geotextile (MnDOT typ. 5)	SY	420	$ 5.00	$ 2,100.00
7	Floating silt curtin	LF	100	$ 20.00	$ 2,000.00
8	Erosion Control Blanket	SY	490	$ 3.00	$ 1,470.00
9	Seeding (MN state mix 34-261)	SY	490	$ 2.00	$ 980.00
				SUBTOTAL	$ 42,450.00
				20% CONTINGENCY	$ 8,490.00
				TOTAL	$ 50,940.00

Cost Estimate for Concept Plan 1

Concept Plan 2 (Figure 3B)



At erosion locations 11 – 16, river banks are severely eroding on the outside bends for approximately 1290 ft. and have an eroded vertical face from 4 - 12 ft. To stabilize the

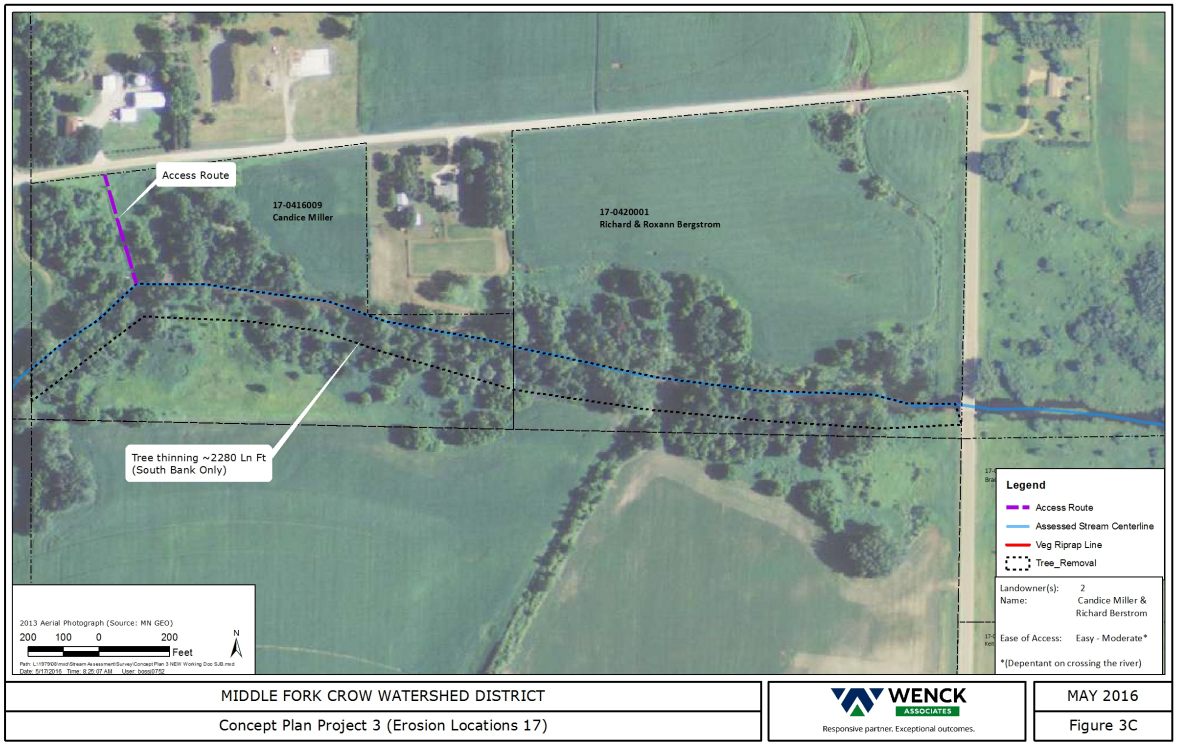
erosion, banks will need to be regraded to a slope of 2:1 with the toe protected with vegetated riprap. If the landowner isn't willing to loose land for the 2:1 slope a steeper slope will need to be explored. In addition to the vegetated riprap, 26 stream barbs are proposed to redirect erosive force within the stream channel back toward the center of the channel and away from the banks. In order to mitigate the runoff coming off of the adjacent farm field upslope enforcement of the 1 rod buffer should also be invoked.

BID TABULATION

No.	Item	Units	Qty	Unit Price	Total
1	Mobilization/Demobilization	LS	1	$ 13,000.00	$ 13,000.00
2	Site Access & Restoration	LS	1	$ 10,000.00	$ 10,000.00
3	Bank Resloping	LF	1290	$ 10.00	$ 12,900.00
4	Class II Rip Rap (Veg. Riprap)	TON	535	$ 120.00	$ 64,200.00
5	Class III Rip Rap (Stream Barbs)	TON	400	$ 130.00	$ 52,000.00
6	Geotextile (mnDOT typ. 5)	SY	1615	$ 5.00	$ 8,075.00
7	Floating silt curtin	LF	50	$ 20.00	$ 1,000.00
8	Erosion Control Blanket	SY	2315	$ 3.00	$ 6,945.00
9	Seeding (MN state mix 34-261)	SY	2315	$ 2.00	$ 4,630.00
				SUBTOTAL	$ 172,750.00
				20% CONTINGENCY	$ 34,550.00
				TOTAL	$ 207,300.00

Cost Estimate for Concept Plan 2

Concept Plan 3 (Figure 3C)



At erosion location 17, the river has been straightened and the channel is over-widened, incised or confined by flood and spoil deposition on the banks. River banks are severely eroding for approximately 2280 ft. while the channel runs through the floodplain forest. Erosion is noticeably worse in this reach compared to the next reach that is also straightened but has much less tree density and more extensive grass ground cover. To minimize the current erosion, and mimic the more stable reference reach downstream, the existing tree canopy should be thinned on the southern bank to allow sunlight to penetrate the areas on both banks for stabilizing grasses to germinate and grow. This project could be accomplished by a crew of Conservation Corps employees over approximately a three week period.

Two options exist for Conservation Corps workers:

1. Hire crew for full price of $1,500.00 per day plus the cost of the seed and herbicide associated with the project.

2. Apply for a project grant which the labor cost is 25% of the estimated cost. The district would have to supply the seed and the herbicide (Garlon 4)

	BID TABULATION (NO GRANT)				
No.	**Item**	**Units**	**Qty**	**Unit Price**	**Total**
1	Tree Removal (CC-MN)	DAYS	12	$ 1,500.00	$ 18,000.00
2	Seeding (MN state mix 34-261)	LBS	180	$ 20.00	$ 3,600.00
3	Herbicide Treatment	Gallon	35	$ 111.00	$ 3,885.00
				SUBTOTAL	$ 25,485.00
				20% CONTINGENCY	$ 5,097.00
				TOTAL	$ 30,582.00

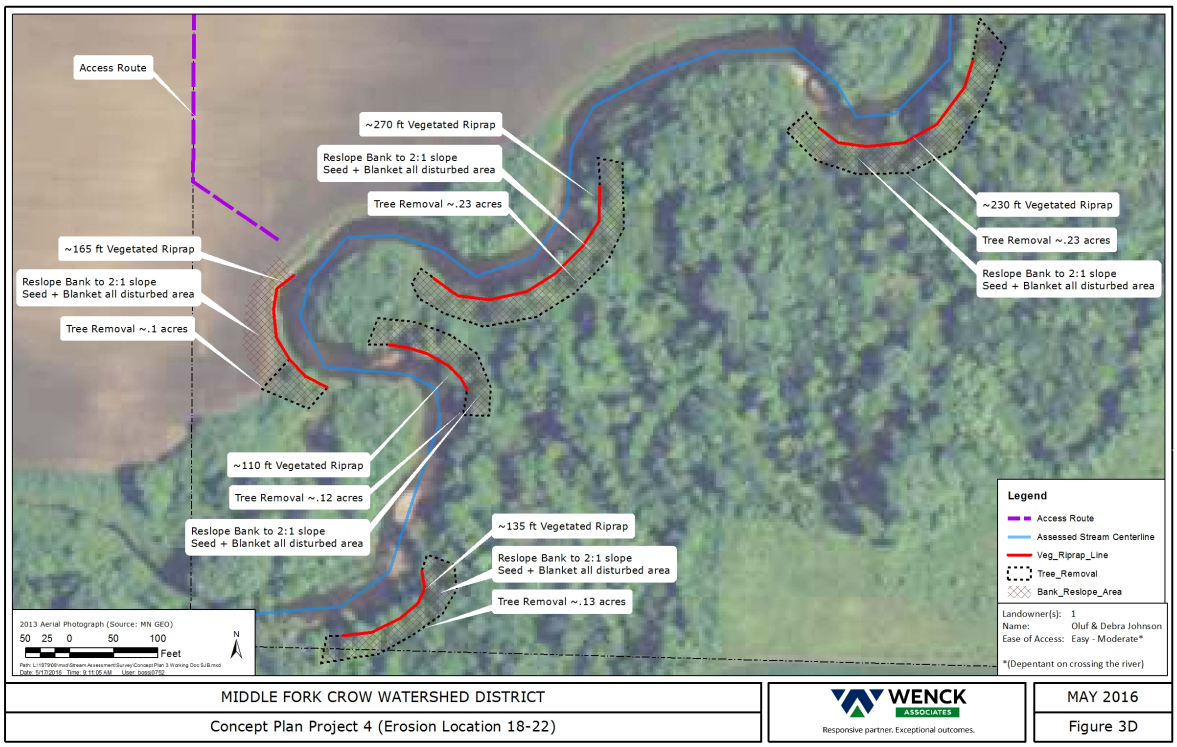
	BID TABULATION (WITH GRANT)				
No.	**Item**	**Units**	**Qty**	**Unit Price**	**Total**
1	Tree Removal (CC-MN)*	DAYS	12	$ 1,500.00	$ 4,500.00
2	Seeding (MN state mix 34-261)**	LBS	180	$ 20.00	$ 3,600.00
3	Herbicide Treatment***	Gallon	35	$ 111.00	$ 3,885.00
	* With Grant labor rate is 25% of total cost			SUBTOTAL	$ 11,985.00
	* (30 lbs/Acre x 6 Acres)			20% CONTINGENCY	$ 2,397.00
	** (6 Quarts/Acre x 6 Acres)			TOTAL	$ 14,382.00

Cost Estimate for Concept Plan 3

Lack of groundcover vegetation and eroding banks on erosion location 17.

Downstream reach with less tree canopy and more extensive grass ground cover.

Concept Plan 4 (Figure 3D)

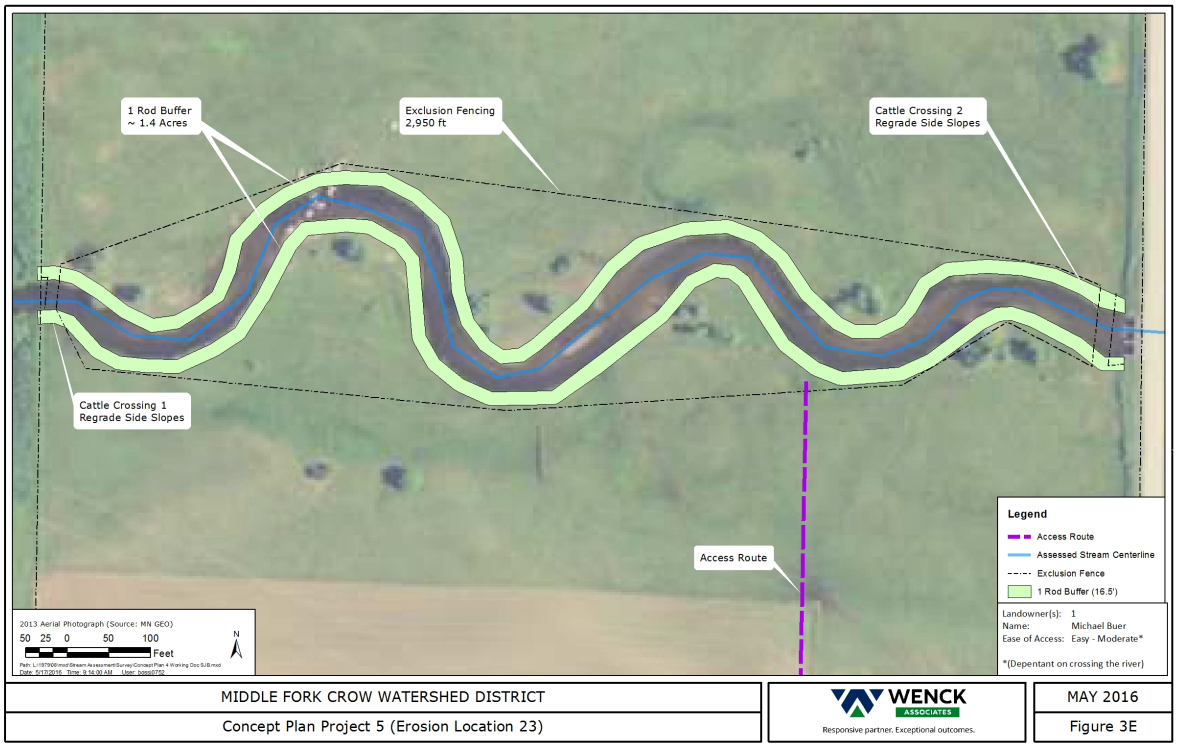


At erosion locations 18 - 22, river banks are moderately eroding on the outside bends for approximately 910 ft. and have an eroded vertical face of 4 ft. To minimize the current erosion, banks will need to be regraded to a slope of 2:1 with the toe protected with vegetated riprap. In order to accomplish the regrading and allow sunlight to penetrate the new grade trees will need to be removed directly upslope from the affected area for stabilizing grasses.

No.	Item	Units	Qty	Unit Price	Total
	BID TABULATION				
1	Mobilization/Demobilization	LS	1	$ 4,000.00	$ 4,000.00
2	Site Access & Restoration	LS	1	$ 2,000.00	$ 2,000.00
3	Tree Removal (CC-MN)	LS	1	$ 8,500.00	$ 8,500.00
4	Bank Resloping	LF	910	$ 10.00	$ 9,100.00
5	Class II Rip Rap (Veg. Riprap)	TON	380	$ 120.00	$ 45,600.00
6	Geotextile (mnDOT typ. 5)	SY	1140	$ 5.00	$ 5,700.00
7	Floating silt curtin	LF	50	$ 20.00	$ 1,000.00
8	Erosion Control Blanket	SY	1315	$ 3.00	$ 3,945.00
9	Seeding (MN state mix 34-261)	SY	1315	$ 2.00	$ 2,630.00
				SUBTOTAL	$ 82,475.00
				20% CONTINGENCY	$ 16,495.00
				TOTAL	$ 98,970.00

Cost Estimate for Concept Plan 4

Concept Plan 5 (Figure 3E)



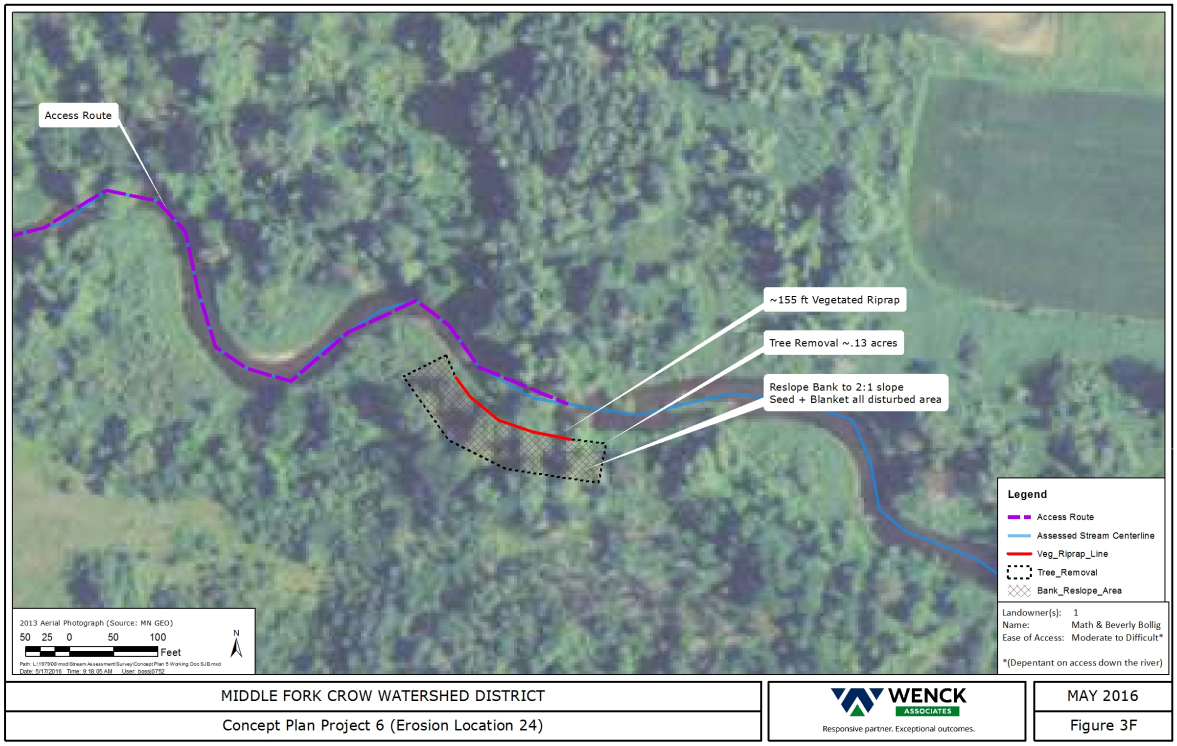
At erosion location 23, river banks are severely eroding for approximately 3400 ft. on both sides and have an eroded vertical face up to 3 ft. The erosion is due to do cattle watering and crossing the river. To minimize the current erosion, we recommend adding 2 specific

cattle crossing/watering points with reinforcement gravel on the property and installing exclusion fencing in all other areas along the river. Enforcement of the 1 rod buffer should also be invoked to increase the vegetation height and rooting depth of grasses to secure the river banks.

	BID TABULATION				
No.	**Item**	**Units**	**Qty**	**Unit Price**	**Total**
1	Mobilization/Demobilization	LS	1	$ 2,500.00	$ 2,500.00
2	Grading	CY	40	$ 40.00	$ 1,600.00
3	Fencing (3 lines w conductive chain over stream)	LF	3600	$ 5.00	$ 18,000.00
4	Filter Agregate	TON	70	$ 80.00	$ 5,600.00
5	Class II Rip Rap	TON	130	$ 120.00	$ 15,600.00
6	Geotextile (mnDOT typ. 5)	SY	75	$ 5.00	$ 375.00
7	Floating silt curtin	LF	100	$ 20.00	$ 2,000.00
8	Erosion Control Blanket	SY	435	$ 3.00	$ 1,305.00
9	Seeding (MN state mix 34-261)	SY	435	$ 2.00	$ 870.00
				SUBTOTAL	$ 47,850.00
				20% CONTINGENCY	$ 9,570.00
				TOTAL	$ 57,420.00

Cost Estimate for Concept Plan 5

Concept Plan 6 (Figure 3F)



At erosion location 24, river bank is moderately eroding on the outside bend for approximately 155 ft. and have an eroded vertical face of 4 ft. To minimize the current erosion, banks will need the toe protected with vegetated riprap. In order to allow sunlight to penetrate, trees will need to be removed directly upslope from the affected area for stabilizing grasses to germinate and grow.

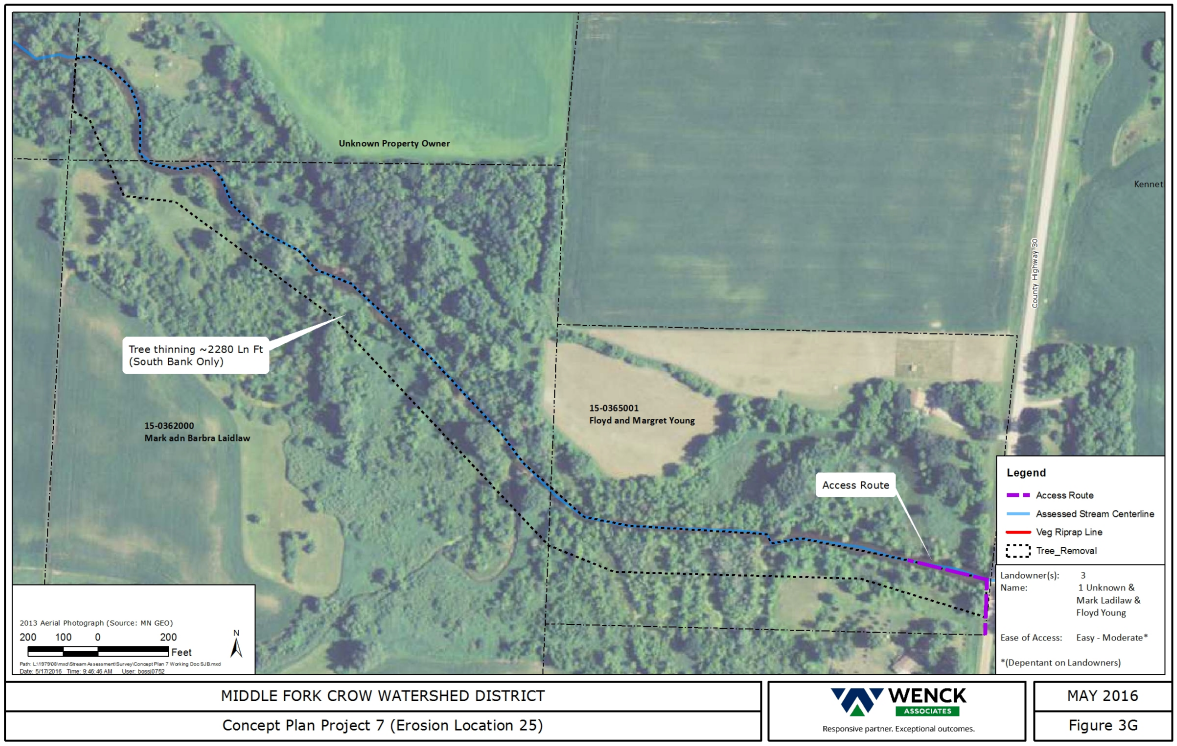
Responsive partner.
Exceptional outcomes.

BID TABULATION

No.	Item	Units	Qty	Unit Price	Total
1	Mobilization/Demobilization	LS	1	$ 1,000.00	$ 1,000.00
2	Site Access & Restoration	LS	1	$ 4,000.00	$ 4,000.00
3	Tree Removal	LS	1	$ 2,000.00	$ 2,000.00
4	Bank Resloping	LF	155	$ 10.00	$ 1,550.00
5	Class II Rip Rap (Veg. Riprap)	TON	65	$ 120.00	$ 7,800.00
6	Geotextile (mnDOT typ. 5)	SY	195	$ 5.00	$ 975.00
7	Floating silt curtin	LF	50	$ 20.00	$ 1,000.00
8	Erosion Control Blanket	SY	225	$ 3.00	$ 675.00
9	Seeding (MN state mix 34-261)	SY	225	$ 2.00	$ 450.00
				SUBTOTAL	$ 19,450.00
				20% CONTINGENCY	$ 3,890.00
				TOTAL	$ 23,340.00

Cost Estimate for Concept Plan 6

Concept Plan 7 (Figure 3G)



At erosion locations 25, the river has been straightened and the channel is over-widened, incised or confined by flood and spoil deposition on the banks. River banks are moderately eroding for approximately 8600 ft. while the channel runs through the floodplain forest. To minimize the current erosion, the existing tree canopy should be thinned on the southern bank to allow sunlight to penetrate the areas on both banks for stabilizing grasses to germinate and grow. This project could be accomplished by a crew of Conservation Corps employees over approximately a four week period.

Two options exist for Conservation Corps workers:

1. Hire crew for full price of $1,500.00 per day plus the cost of the seed and herbicide associated with the project.

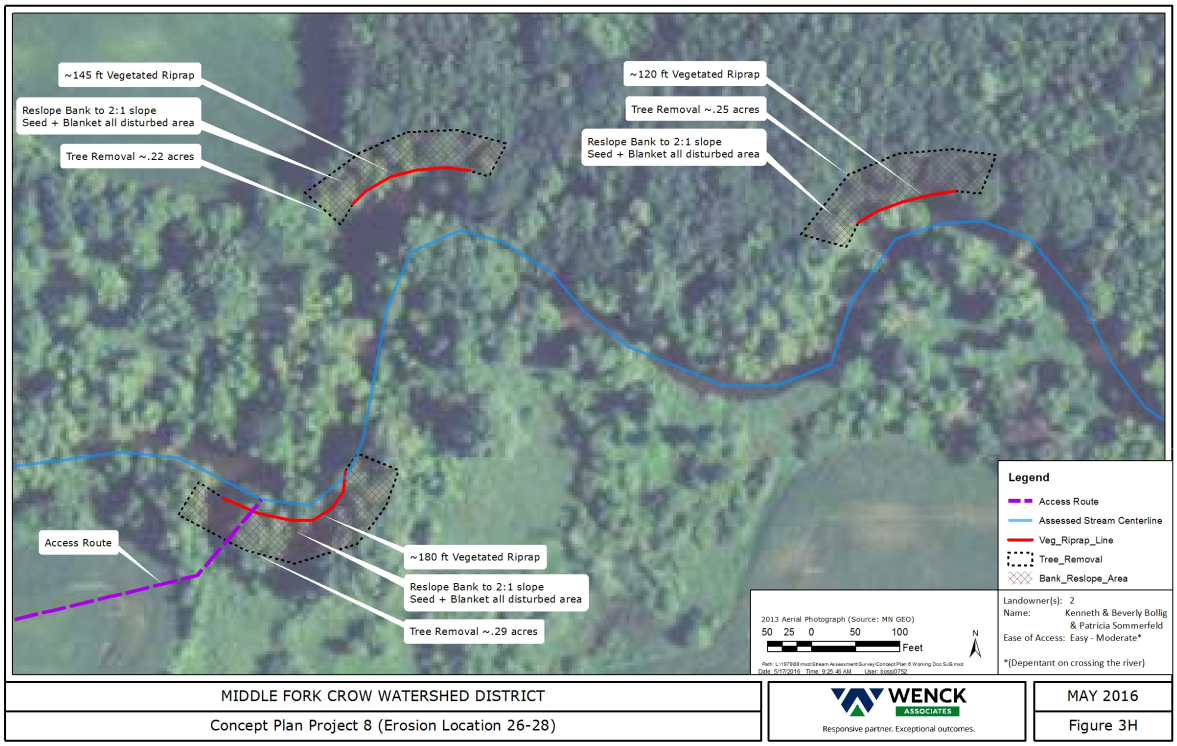
2. Apply for a project grant which the labor cost is 25% of the estimated cost. The district would have to supply the seed and the herbicide (Garlon 4)

	BID TABULATION (NO GRANT)				
No.	**Item**	**Units**	**Qty**	**Unit Price**	**Total**
1	Tree Removal (CC-MN)	DAYS	16	$ 1,500.00	$ 24,000.00
2	Seeding (MN state mix 34-261)	LBS	180	$ 20.00	$ 3,600.00
3	Herbicide Treatment	Gallon	35	$ 11.00	$ 385.00
				SUBTOTAL	$ 27,985.00
	*Seeding & Herbicide included in price/day			20% CONTINGENCY	$ 5,597.00
				TOTAL	$ 33,582.00

	BID TABULATION (WITH GRANT)				
No.	**Item**	**Units**	**Qty**	**Unit Price**	**Total**
1	Tree Removal (CC-MN)*	DAYS	16	$ 1,500.00	$ 6,000.00
2	Seeding (MN state mix 34-261)**	LBS	240	$ 20.00	$ 4,800.00
3	Herbicide Treatment***	Gallon	48	$ 111.00	$ 5,328.00
	* With Grant labor rate is 25% of total cost			SUBTOTAL	$ 16,128.00
	* (30 lbs/Acre x 6 Acres)			20% CONTINGENCY	$ 3,225.60
	** (6 Quarts/Acre x 8 Acres)			TOTAL	$ 19,353.60

Cost Estimate for Concept Plan 7

Concept Plan 8 (Figure 3H)



At erosion locations 26 - 28, river banks are moderately to severely eroding on the outside bends for approximately 445 ft. and have an eroded vertical faces from 4 – 8 ft. To minimize the current erosion, banks will need to be regraded to a slope of 2:1 with the toe protected with vegetated riprap. In order to accomplish the regrading and allow sunlight to penetrate the new grade, trees will need to be removed directly upslope from the affected area for stabilizing grasses to germinate and grow.

	BID TABULATION				
No.	**Item**	**Units**	**Qty**	**Unit Price**	**Total**
1	Mobilization/Demobilization	LS	1	$ 3,500.00	$ 3,500.00
2	Site Access & Restoration	LS	1	$ 2,000.00	$ 2,000.00
3	Tree Removal (CC-MN)	LS	1	$ 8,000.00	$ 8,000.00
4	Bank Resloping	LF	445	$ 10.00	$ 4,450.00
5	Class II Rip Rap (Veg. Riprap)	TON	300	$ 120.00	$ 36,000.00
6	Geotextile (mnDOT typ. 5)	SY	560	$ 5.00	$ 2,800.00
7	Floating silt curtin	LF	150	$ 20.00	$ 3,000.00
8	Erosion Control Blanket	SY	1030	$ 3.00	$ 3,090.00
9	Seeding (MN state mix 34-261)	SY	1030	$ 2.00	$ 2,060.00
				SUBTOTAL	$ 64,900.00
				20% CONTINGENCY	$ 12,980.00
				TOTAL	$ 77,880.00

Cost Estimate for Concept Plan 8

Cost Benefit Analysis

All of the proposed projects are effective at reducing total suspended solids and phosphorous contributions to the Middle Fork Crow River. If all projects were built, 797 tons of sediment and 160 lbs. of phosphorous would be reduced, but the project cost would be $ 562,050.00. The target reduction of the sediment from the study reach to the reference reach identified in the streambank assessment was 1000 tons of sediment annually. To help prioritize the order in which projects should be pursued, the following table summarizes each project and ranks them from lowest to highest in dollars per pound of phosphorous.

Project Rank	Project #	Tons/Year of TSS	lbs/year P	Project Estimate	$/TON TSS	$/lbs P
1	**3**	205.2	41.13	$ 30,582.00	$ 149.04	$ 743.61
2	**7**	172	34.47	$ 33,582.00	$ 195.24	$ 974.17
3	**5**	153	30.66	$ 57,420.00	$ 375.29	$ 1,872.53
4	**2**	188.49	37.78	$ 207,300.00	$ 1,099.79	$ 5,487.43
5	**1**	20.04	4.02	$ 50,940.00	$ 2,541.92	$12,682.92
6	**8**	24.84	4.98	$ 77,880.00	$ 3,135.27	$15,643.45
7	**4**	31.32	6.28	$ 98,970.00	$ 3,159.96	$15,766.67
8	**6**	3.08	0.62	$ 23,340.00	$ 7,577.92	$37,810.00

Conclusion

Following the Middle Fork Crow River Stream assessment an annual reduction of 1000 tons per year of sediment was identified for the study reach of the river. After evaluating the erosion features, causes and potential stabilization techniques for long term protection, eight projects were identified that combined 18 erosion locations into 8 groups that minimize access, disturbance and construction costs while achieving the goal of reducing streambank erosion by 798 tons of sediment and 160 lbs. of phosphorous each year. A cost benefit analysis was completed to help prioritize projects based on maximum reduction of erosion for the lowest cost per pound of pollutants reduced. Through the analysis, the top 3 most effective projects include vegetation maintenance and cattle exclusion only. No hard armoring is required until the fourth project and beyond.