

RAVINE MANAGEMENT

October 2020



Prepared by: The City of North Mankato

Public Works Department

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Ravine Management Report

June 2020



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I. Introduction

In 2018 The City of North Mankato began a ravine inspection program with the aid of a GPS collector, and a predetermined inspection checklist. Each ravine is evaluated on eight criteria to assess the conditions within the ravine from the condition of the bottom channel to vegetation on the hillsides. This data collection will occur during the fall of each year to provide a yearly snapshot of the condition of the ravines. Along with GPS points and evaluations, photos are also taken within the ravine to document conditions.

II. Existing Systems:

The ravine system in North Mankato is comprised of twenty-one identified ravines or hillsides that aid in the management of storm water from Upper North Mankato. Ten of these twenty-one identified areas have partially installed or fully installed (from top of ravine to bottom), storm sewer piping

III. Ravine Inspection and Evaluation:

During the creation of the inspection program criteria were established for evaluation of the ravines. This creates a standard across the years and gives a consistent inspection from year to year within each ravine. Criteria is based both on office collection and field collection.

Inspection criteria are as follows:

A. Office Verified Criteria

1. Segment Name: Identifies the ravine number and which segment within each ravine.
2. Physical Description: Physical description is based upon the closest road to the ravine.
3. Streets Adjacent: based upon additional roads along the ravine section to help identify exact location of the segment.
4. Ravine/Adjacent Areas within City Limits: Identifies if the adjacent area is within city limits.
5. Adjacent Areas Developed: Identifies if the adjacent area is developed.
6. Ownership: Identifies who owns the ravine.
7. Ravine Access: Identifies if and where direct access to the ravine is. Also is the access an outlot, utility easement or off a road section.
8. Storm Sewer: Identifies if storm sewer is piped within the ravine. Includes material type, size and if piping runs the entire length of ravine or not.

B. Field data collection

1. Extent of foundation/sump pump drain lines extended to bottom: Identifies the number of drain lines that run to the bottom of the ravine.
2. Condition of ravine/channel bottom: Identifies if the bottom channel of the ravine is eroding or stabilized.
3. Degree of vegetation: Identifies how much vegetation is established on the hillsides of the ravine.
4. Slides/sloughs and location: Identifies how many slides are within a section and at what location.
5. Photos: Photo documentation

IV. 2019 Inspection Report Findings:

Ravines South of Highway 14

- A. Segment Name:** North Ridge Ravine
Sections: S1-1 through S-21
Adjacent Streets: North Ridge Dr, Abbeywood Lane, Pleasant View Drive, Lehigh Ave, Marie Lane, Staley Lane, and Aspen Lane
Within City Limits: Yes
Access: Pleasant View Dr, Marie Lane, Lehigh Ave, Aspen Lane and Camden Ct
Storm Sewer: 13 of the 21 sections within this ravine have storm sewer piping within them.
Foundation/Sump Drains: During inspections it was found that 50 to 75% of the visible drains are extended to the bottom of the ravine.
Bottom Condition: The bottom channel of the ravine is in good condition in the 13 sections that are stabilized with storm sewer. The sections that are not stabilized with storm sewer are showing signs of erosion of the bottom channel due to high water flows.
Vegetation: In general, there is moderate vegetation on all side slopes within the ravine. The areas that are not stabilized with storm sewer are seeing sloughs and sliding that are disrupting the vegetation growth. Areas that are stabilized with piping have good growth on the sides as well as the bottom of the ravine.
Sliding/Sloughs: Sections that are not stabilized with storm sewer have severe sliding and sloughs that are caused by high volumes of water eroding the toe of the slope. This is particularly evident in sections S1-9 through S1-15 which is the sections between North Ridge Dr and Abbywood Lane.
Recommendation: Continue annual inspections and address issues as they arise in areas that are stabilized by pipe. Continue to extend the 72" piping project from sections 1-21 down through section 1-9.
- A. Segment Name:** Cliff Court Ravine
Sections: S2-1 through S2-5
Adjacent Streets: Carol CT, Marquette Ave
Within City Limits: Yes
Access: No
Storm Sewer: None in bottom channel, storm sewer from adjacent roads is piped to the bottom.
Foundation/Sump Drains: During inspections it was found that 50% of the visible drains are extended to the bottom of the ravine.
Bottom Condition: The bottom channel of this section is showing signs of erosion due to high water volumes from adjacent storm water piping.
Vegetation: In general, there is moderate vegetation on all side slopes within the ravine except the bottom channel.
Sliding/Sloughs: There is several smaller sloughs and slides in this ravine, most observed in areas where the bottom channel changes direction.

Recommendation: Continue annual inspections to document and address any issues. Install storm water pipe through bottom channel to carry water passed the developed area. A project of this magnitude would require work outside of city limits.

- B. **Segment Name:** Oak Terrace Court Ravine
Sections: S3-1
Adjacent Streets: Oak Terrace, Lookout Dr, Marvin
Within City Limits: Yes
Access: Yes, Lookout Drive.
Storm Sewer: Yes, in bottom channel and storm sewer from adjacent roads is piped to the bottom.
Foundation/Sump Drains: During inspections it was found that 75% of the visible drains are extended to the bottom of the ravine.
Bottom Condition: The bottom channel of this section is in good shape. Small areas of erosion due to overland water but nothing of concern.
Vegetation: In general, there is moderate to heavy vegetation on all side slopes within this section of ravine.
Sliding/Sloughs: There is some smaller several smaller sloughs and slides in this ravine but no major ones of concern.
Recommendation: Continue annual inspections to document and address any issues.
- C. **Segment Name:** Oak Terrace Drive Ravine
Sections: S4-1
Adjacent Streets: Oak Terrace Dr, Roe Crest Dr
Within City Limits: Yes
Access: Yes, Lookout Drive.
Storm Sewer: Yes, in bottom channel and storm sewer from adjacent roads is piped to the bottom.
Foundation/Sump Drains: During inspections it was found that 75% of the visible drains are extended to the bottom of the ravine.
Bottom Condition: The bottom channel of this section is in good shape. Small areas of erosion due to overland water but nothing of concern.
Vegetation: In general, there is moderate to heavy vegetation on all side slopes within this section of ravine.
Sliding/Sloughs: There is some smaller several smaller sloughs and slides in this ravine but no major ones of concern.
Recommendation: Continue annual inspections to document and address any issues.
- D. **Segment Name:** Roe Crest Drive Ravine
Sections: S5-1
Adjacent Streets: Oak Terrace Dr, Roe Crest Dr
Within City Limits: Yes
Access: Yes, Lookout Drive.
Storm Sewer: Partial, storm sewer from Roe Crest is piped into the top portion of the ravine.

Foundation/Sump Drains: During inspections it was found that 75% of the visible drains are extended to the bottom of the ravine.

Bottom Condition: The bottom channel of this section is in good shape. Small areas of erosion due to water from the storm sewer pipe.

Vegetation: In general, there is moderate to heavy vegetation on all side slopes within this section of ravine.

Sliding/Sloughs: There is some smaller several smaller sloughs and slides in this ravine but no major ones of concern.

Recommendation: Continue annual inspections to document and address any issues.

E. **Segment Name:** Roe Crest Drive Ravine

Sections: S6-1

Adjacent Streets: Roe Crest Dr, Lookout Dr

Within City Limits: Yes

Access: Yes, Lookout Drive.

Storm Sewer: No

Foundation/Sump Drains: During inspections it was found that 50% of the visible drains are extended to the bottom of the ravine.

Bottom Condition: The bottom channel of this section is in good shape.

Vegetation: In general, there is moderate to heavy vegetation on all side slopes within this section of ravine.

Sliding/Sloughs: There is some smaller several smaller sloughs and slides in this ravine but no major ones of concern.

Recommendation: Continue annual inspections to document and address any issues.

F. **Segment Name:** Roe Crest Drive Ravine

Sections: S7-1

Adjacent Streets: Roe Crest Dr, Lookout Dr

Within City Limits: Yes

Access: Yes, Lookout Drive.

Storm Sewer: No

Foundation/Sump Drains: During inspections it was found that 50% of the visible drains are extended to the bottom of the ravine.

Bottom Condition: The bottom channel of this section is in good shape.

Vegetation: In general, there is moderate to heavy vegetation on all side slopes within this section of ravine.

Sliding/Sloughs: There is some smaller several smaller sloughs and slides in this ravine but no major ones of concern.

Recommendation: Continue annual inspections to document and address any issues.

G. **Segment Name:** Old Belgrade Hill Ravine

Sections: S8-1 through S8-13

Adjacent Streets: Roe Crest Dr, Roe Crest Ct, Lor Ray Dr, Clare Ct, Sunrise Dr

Within City Limits: Yes

Access: Yes, Clare Court, Belgrade Ave.

Storm Sewer: Yes

Foundation/Sump Drains: During inspections it was found that 75% of the visible drains are extended to the bottom of the ravine.

Bottom Condition: The bottom channel of this section is in excellent shape

Vegetation: In general, there is moderate to heavy vegetation on all side slopes within this section of ravine.

Sliding/Sloughs: There is some smaller several smaller sloughs and slides in this ravine but no major ones of concern.

Recommendation: Continue annual inspections to document and address any issues.

H. **Segment Name:** Lee Hill Ravine

Sections: S9-1 through S9-8

Adjacent Streets: Lee Blvd

Within City Limits: Yes

Access: Yes, Lee Blvd.

Storm Sewer: Yes

Foundation/Sump Drains: During inspections it was found that 75% of the visible drains are extended to the bottom of the ravine.

Bottom Condition: The bottom channel of this section is in good shape.

Vegetation: In general, there is moderate to heavy vegetation on all side slopes within this section of ravine.

Sliding/Sloughs: There is some smaller several smaller sloughs and slides in this ravine.

Recommendation: Continue annual inspections to document and address any issues.

I. **Segment Name:** Lake Street Ravine

Sections: S10-1 through S10-3

Adjacent Streets: Lake Street, Kings Ct

Within City Limits: Yes

Access: No

Storm Sewer: Yes

Foundation/Sump Drains: During inspections it was found that all sump drains run to the bottom however some roof gutters channel water right to the edge of the ravine.

Bottom Condition: The bottom channel of this section is mostly stable.

Vegetation: In general, there is moderate to heavy vegetation on all side slopes within this section of ravine.

Sliding/Sloughs: There is one larger slump about halfway up the bluff, staff are trying to establish vegetation in this area.

Recommendation: Continue annual inspections to document and address any issues.

J. **Segment Name:** Bluff Park Ravines

Sections: S11-1, S11-2, S11-3

Adjacent Streets: Lake Street, Highway 14, Mary Circle

Within City Limits: Yes

Access: Yes, Mary Circle and Collette Dr

Storm Sewer: Yes

Foundation/Sump Drains: During inspections it was found that 75% of the visible drains are extended to the bottom of the ravine.

Bottom Condition: The bottom channel of this section is in good shape.

Vegetation: In general, there is moderate to heavy vegetation on all side slopes within this section of ravine.

Sliding/Sloughs: There is some smaller several smaller sloughs and slides in this ravine.

Recommendation: Continue annual inspections to document and address any issues.

Ravines North of Highway 14

- A. **Segment Name:** Howard Drive Ravines
Sections: N1-1 through N1-5, N2-1, N3-1, N4-1
Adjacent Streets: Howard Dr, Valley View Ct
Within City Limits: Yes
Access: No
Storm Sewer: Yes in Sections N2-1 and N4-1
Foundation/Sump Drains: During inspections it was found that 75% of sump drains run to the bottom.
Bottom Condition: The bottom channel of this section is mostly stable. There is some erosion at the areas where the storm sewer piping ends and water is overland.
Vegetation: In general, there is moderate to heavy vegetation on all side slopes within this section of ravine.
Sliding/Sloughs: There is some small to moderate slumping in areas where water is over land and has eroded the bottom channel.
Recommendation: Continue annual inspections to document and address any issues.
- B. **Segment Name:** Coventry Lane Ravines
Sections: N5-1, N6-1 through N6-3
Adjacent Streets: Coventry Lane
Within City Limits: Yes
Access: Yes, Coventry Lane
Storm Sewer: Yes in Sections N5-1.
Foundation/Sump Drains: No adjacent development
Bottom Condition: The bottom channel of this section is mostly stable. There is some erosion at the areas where the ravine changes direction.
Vegetation: In general, there is moderate to heavy vegetation on all side slopes within this section of ravine.
Sliding/Sloughs: There is some small to moderate slumping in areas and has eroded the bottom channel.
Recommendation: Continue annual inspections to document and address any issues.

- C. **Segment Name:** Howard Ct Ravines
 Sections: N7-1 through N7-3
 Adjacent Streets: Coventry Lane
 Within City Limits: Partial
 Access: No
 Storm Sewer: No
 Foundation/Sump Drains: All observed foundation drain lines run to the bottom.
 Bottom Condition: There
 Vegetation: In general, there is moderate to heavy vegetation on all side slopes within this section of ravine.
 Sliding/Sloughs: There is some small to moderate slumping in areas and has eroded the bottom channel.
 Recommendation: Continue annual inspections to document and address any issues.
- D. **Segment Name:** Prairie/Reserve Ravines
 Sections: N8-1 through N8-28
 Adjacent Streets: Coventry Lane, Deerwood Ct, Simon Ct, Lor Ray Dr
 Within City Limits: Partial
 Access: Yes, Sarah Circle, Countryside Dr, Simon Ct, Lexington Lane
 Storm Sewer: Partial
 Foundation/Sump Drains: 50% of observed foundation drain lines run to the bottom.
 Bottom Condition: Moderate to severe erosion on toe of slope
 Vegetation: In general, there is moderate to heavy vegetation on all side slopes within this section of ravine.
 Sliding/Sloughs: There is moderate to heavy slumping in areas that have eroded toe conditions. Slumping is present in areas that do not have any storm water directed to them.
 Recommendation: Continue annual inspections to document and address any issues. Plan for storm water piping extension in capitol improvements plan.

V. Recommendations

The inspections conducted within the ravines provided three observations. They are:

- A. Ravines that have storm sewer piping through the bottom channel have minimal erosion and heavy vegetation.
- B. Ravines that allow water to flow overland through the bottom channel have moderate to severe bottom channel and side sloughing.
- C. Ravines that have storm water piping to the bottom, but not continued into the bottom channel, have moderate erosion along the bottom channel and moderate to heavy vegetation along the side slopes.

The inspection documentation shows that the North Ridge ravine and Prairie/Reserve ravines have the most bottom and side slope erosion. This is likely to these two ravines carrying the two largest volumes of storm water from upper North Mankato to lower North Mankato. These two ravines also have many turns within them which water will erode the toe of the slope on and create a slough. Based upon these findings, this report recommends extending the storm water piping within these two ravines as far down the ravine as possible to get passed the developed areas along these ravines.

RAVINE CAPITAL IMPROVEMENT PLAN				
Ravine Name	Section	Type	Estimated Cost	Order of Importance
North Ridge Ravine	S1-19	72" Storm Pipe Extension	\$ 995,000.00	1
North Ridge Ravine	S1-17	72" Storm Pipe Extension	\$ 1,007,000.00	2
North Ridge Ravine	S1-15	72" Storm Pipe Extension	\$ 400,000.00	3
North Ridge Ravine	S1-13	72" Storm Pipe Extension	\$ 325,000.00	4
North Ridge Ravine	S1-11	72" Storm Pipe Extension	\$ 1,500,000.00	9
North Ridge Ravine	S1-9	72" Storm Pipe Extension	\$ 300,000.00	10
North Ridge Ravine	S1-1	72" Storm Pipe Extension	\$ 1,200,000.00	11
Prairie/Reserve Ravine	N8-29	27" Storm Pipe Extension	\$ 800,000.00	5
Prairie/Reserve Ravine	N8-28	27" Storm Pipe Extension	\$ 500,000.00	6
Prairie/Reserve Ravine	N8-27	54" Storm Pipe Extension	\$ 300,000.00	7
Prairie/Reserve Ravine	N8-23	54" Storm Pipe Extension	\$ 850,000.00	8
Prairie/Reserve Ravine	N8-22	27" Storm Pipe Extension	\$ 250,000.00	12
Prairie/Reserve Ravine	N8-21	54" Storm Pipe Extension	\$ 100,000.00	13
Prairie/Reserve Ravine	N8-19	54" Storm Pipe Extension	\$ 1,500,000.00	14
Prairie/Reserve Ravine	N8-7	54" Storm Pipe Extension	\$ 820,000.00	15
Prairie/Reserve Ravine	N8-3	54" Storm Pipe Extension	\$ 2,100,000.00	16
		Reconstruct Total:	\$ 12,947,000.00	

Currently, the 2020 City budget for storm water materials and rental equipment is \$8,000. Based upon the amount of storm water piping, storm water structures and access challenges to get within the ravines, this plan recommends allocating \$20,000 per year to storm water materials and rental equipment.

VI. Conclusion

The ravine system in North Mankato is an asset for development and storm water management. Continuation of the yearly inspection process and feedback from the community is vital in assessing the ravines. Secondly a capital improvement plan and implementation are vital to maintaining the ravines in such a way that they continue to remain an asset.

Legend

- City Limits
- Ravine
- Manhole Box
- Manholes
- Culverts
- Back Yard Drains
- Catch Basins
- Storm Pipe
- Subsurface Basin
- Medians
- Roadways
- Roads
- US TRUNK HWY
- COUNTY STATE AID HWY
- MUNICIPAL STATE AID STREET
- LOCAL STREET
- RAMP
- PRIVATE STREET
- Lakes & Ponds
- Minnesota River
- Nman_city19_3inch.sxd
- Red_Band_1
- Green_Band_2
- Blue_Band_3



Map Name

Scale:

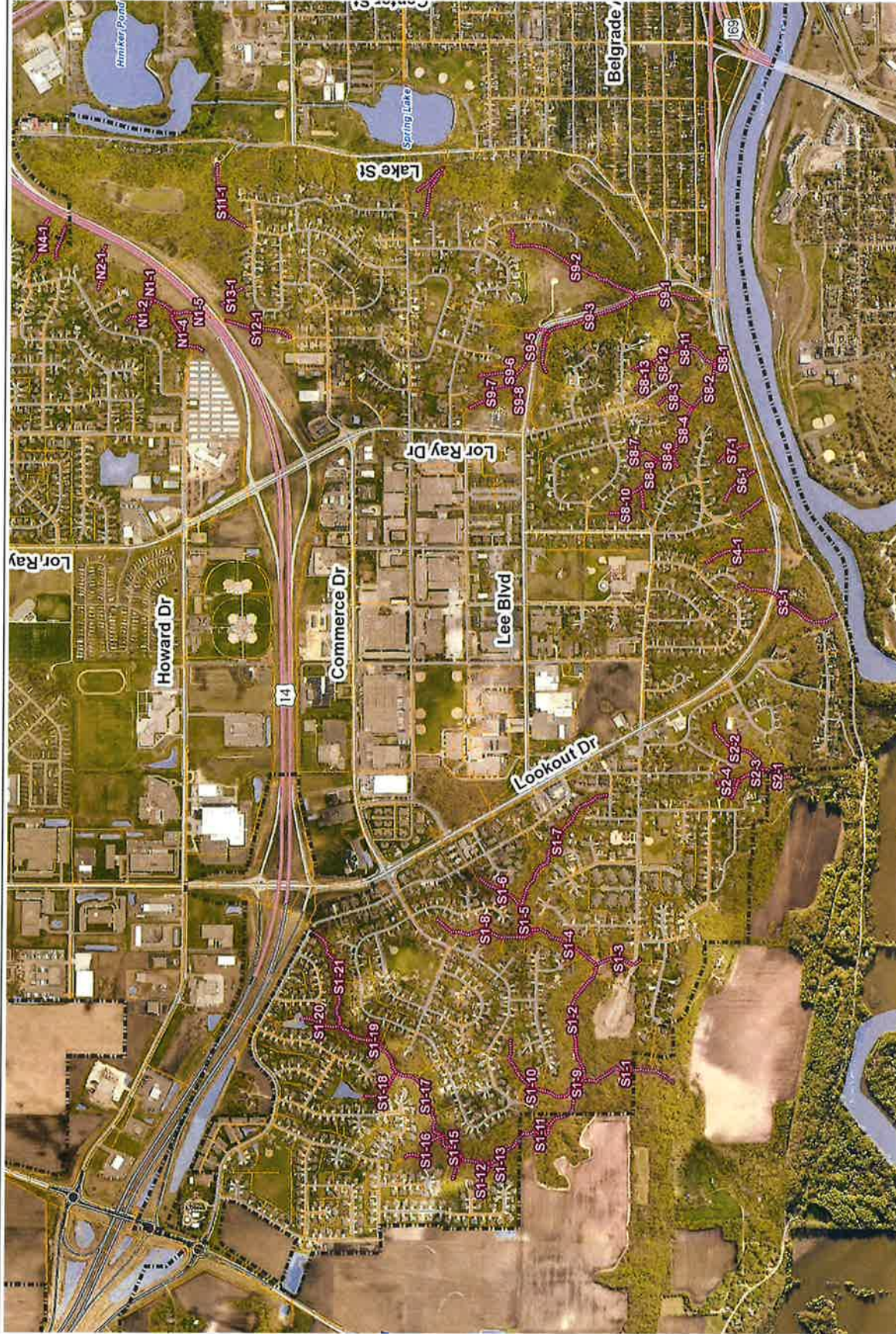
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South Ravines

0 1,053 Feet

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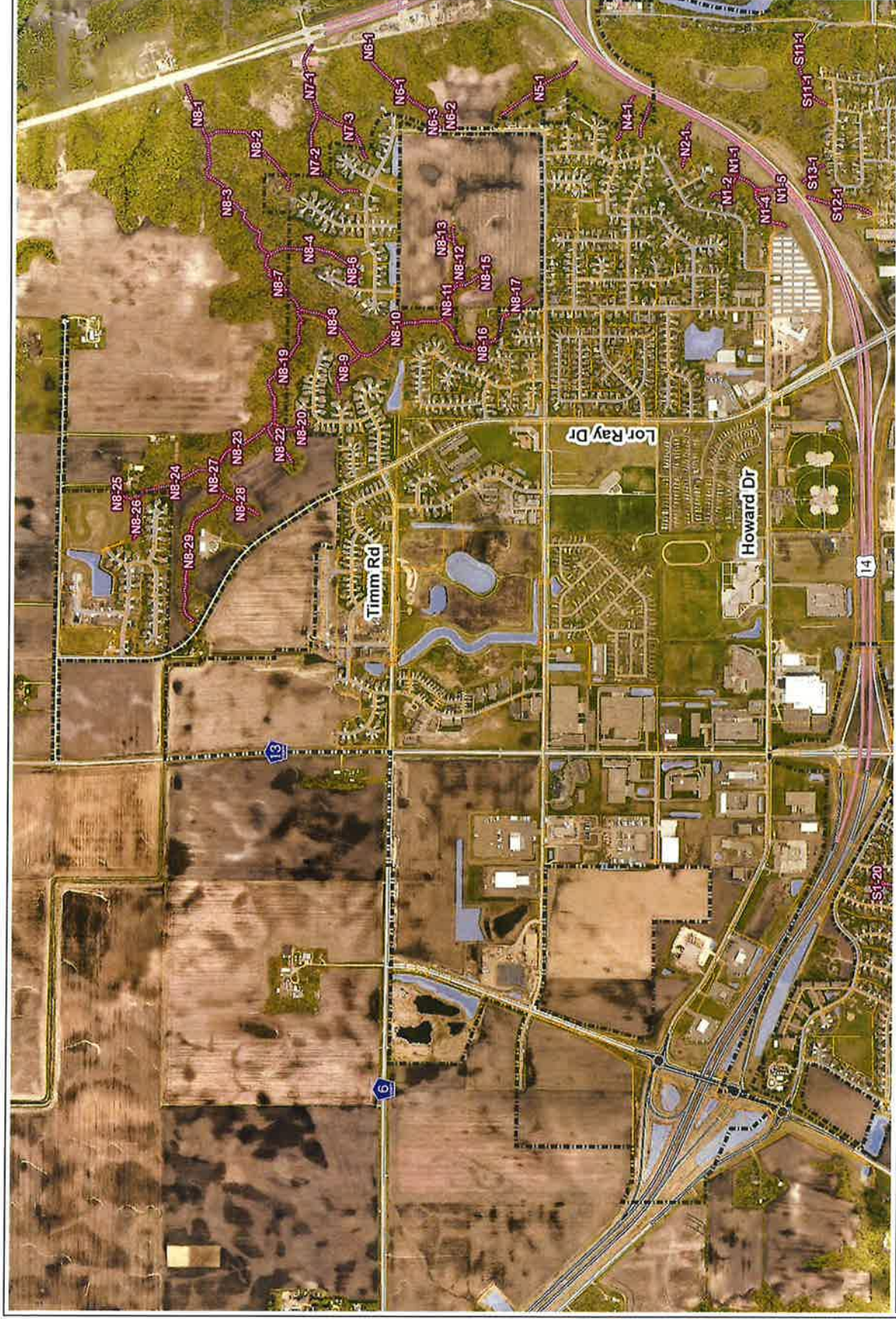


- Legend**
- City Limits
 - Ravine
 - Manhole Box
 - Manholes
 - Culverts
 - Back Yard Drains
 - Catch Basins
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 - Red_Band_1
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Map Name

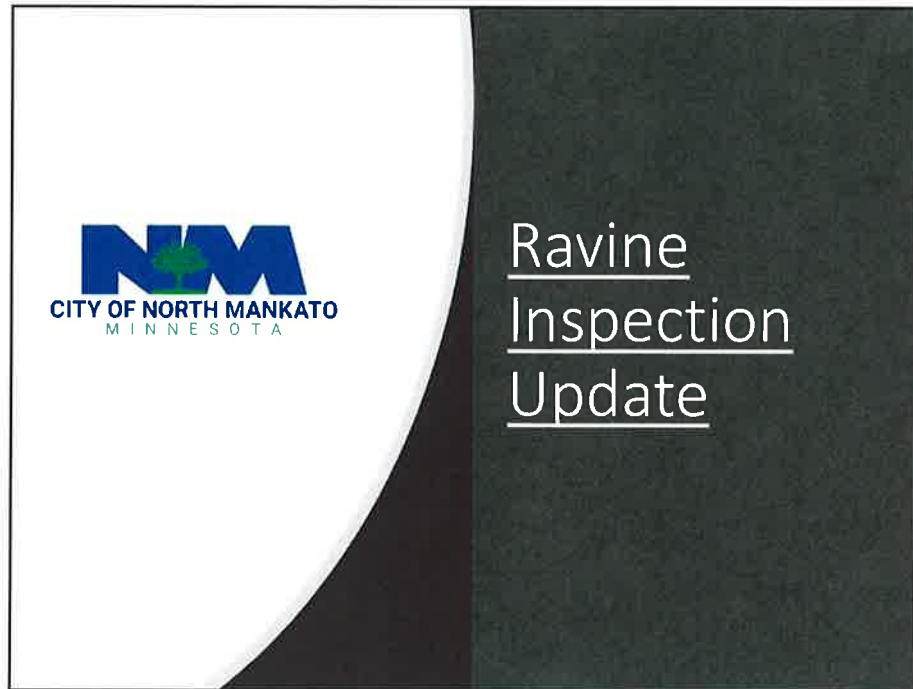
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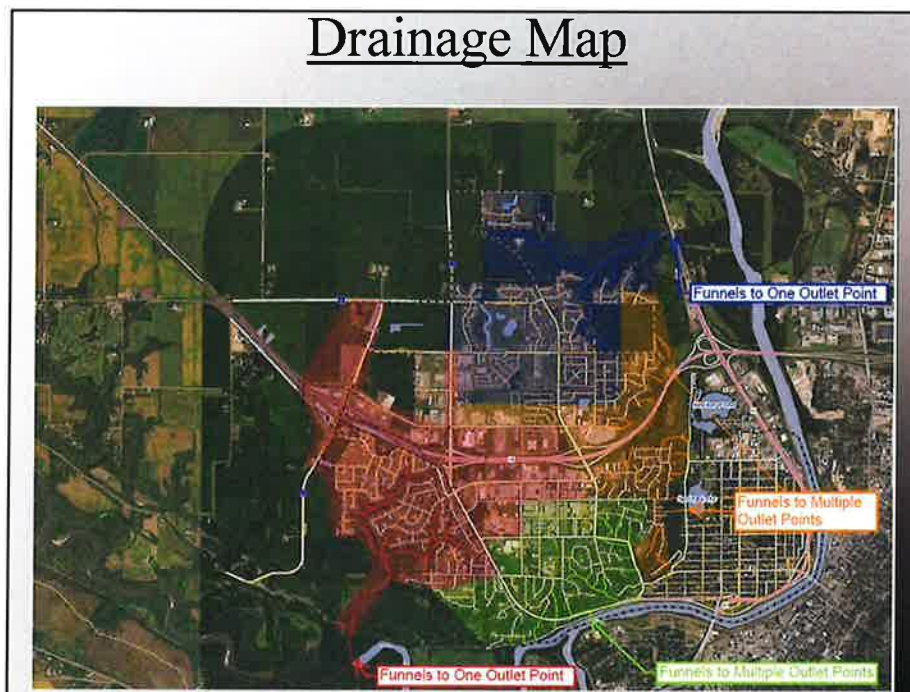
North Ravines

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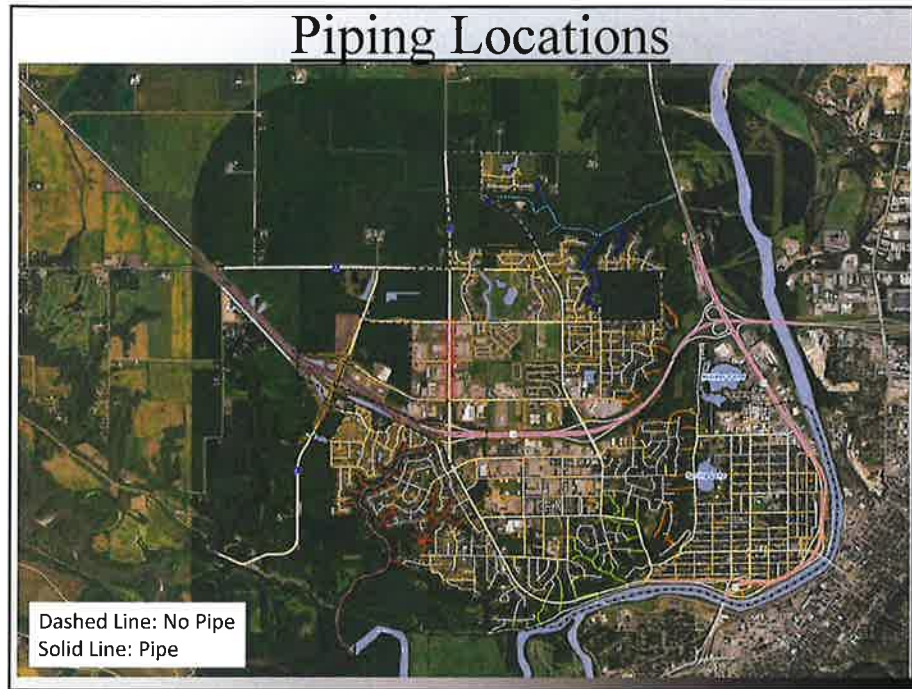
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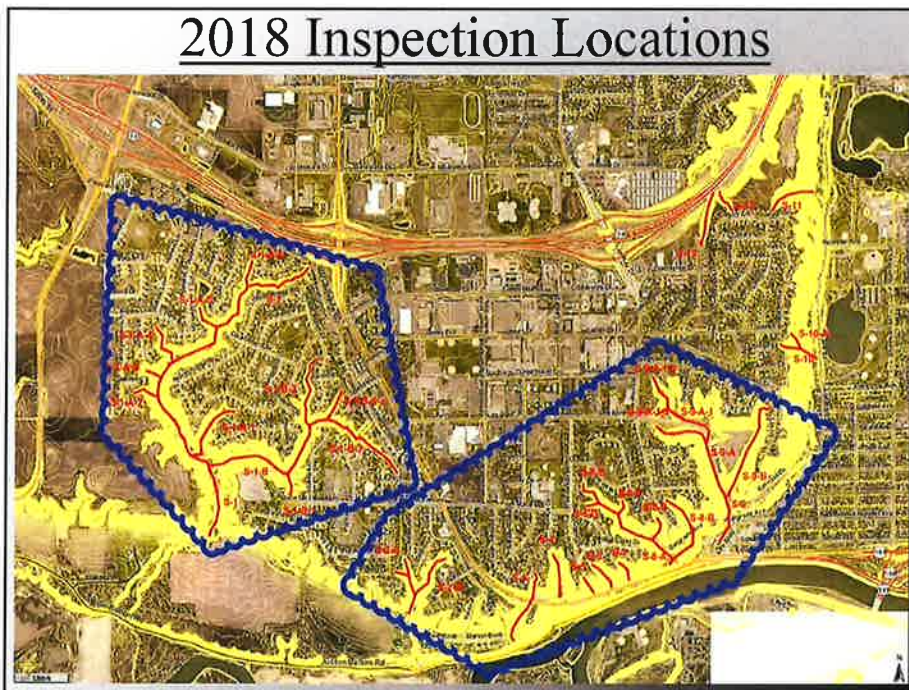
1



2



3



4

Findings

- Erosion at locations where piping stopped
- Erosion at areas without pipe
- Satisfactory conditions above piped areas
- Pipe capacity challenges at pipped areas
- Sump Drain Lines

5

Findings



Upstream of 72" Pipe at Northridge Ravine

6

Findings



Downstream of 72" Pipe at Northridge Ravine

7

Findings



Large Scarping of Side slopes

8

Findings



Large Scarping of Side slope

9

Findings



Outlet That Needs Correction

10

Findings



Correct Outlet Piping

11

Findings



Howard Drive and Valley View CT

12

2019 Planned Maintenance



13

Where Do We Go From Here?

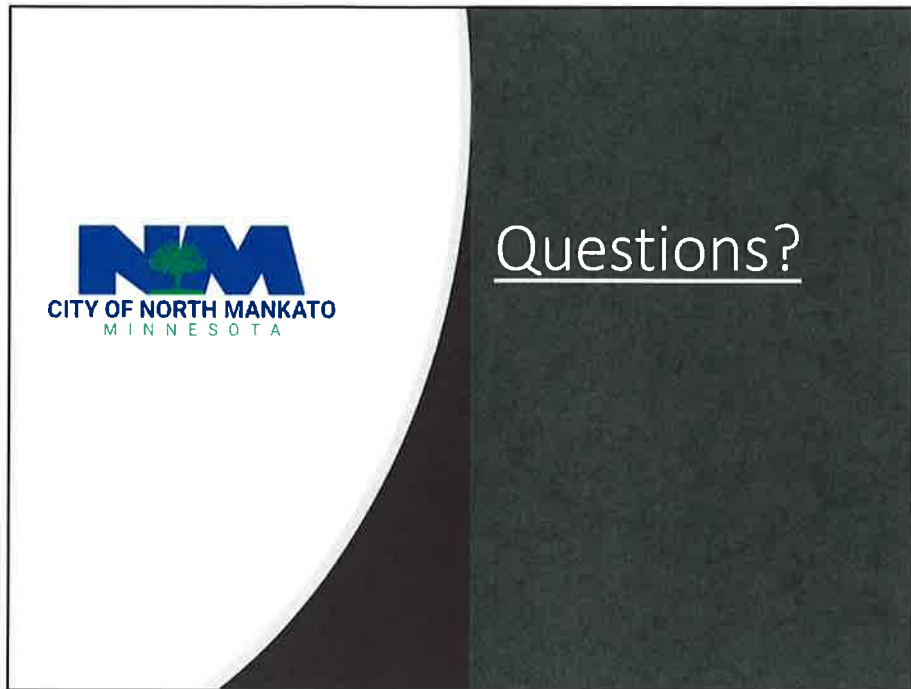
Short Term

- Continue Yearly Inspections
 - Build Historical Database
 - Ensure Corrective Measures are Working
 - Identify and Fix Deficiencies

Long Term

- Build a Program to Incrementally Add Pipe Segments
- Evaluate Storm Sewer Sizing
- Continue to Enforce Sump Line Drainage Code
- Continue to Add Underdrainage

14



15



Real People. Real Solutions.

1960 Premier Drive
Mankato, MN 56001-5900

Ph: (507) 625-4171
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Bolton-Menk.com

MEMORANDUM

Date: September 23, 2020
To: John Harrenstein, City Administrator
From: Daniel R. Sarff, P.E., City Engineer
CC: Nate Host, Public Works Director
Subject: Lake Street Bluff Drainage and Erosion Issues
BMI Project No. OM1.122664

BACKGROUND INFORMATION:

This report addresses drainage and erosion issues in several locations along the bluff located just west of Lake Street. This bluff is the transition from the "upper" portion of North Mankato to the "lower" North Mankato. Lake Street extends along most of the length of the bluff in lower North Mankato and several streets and cul-de-sacs (Sherwood Drive, Queens Court, Kings Court, and Mary Lane) are located adjacent the upper edge of the bluff. The difference in elevation from Lake Street to the upper edge of the bluff is approximately 210 to 220 feet. The bluff was created by erosion due to the meandering of the Minnesota River over thousands of years well prior to the development of the area of lower North Mankato and the construction of the flood control improvements. Most of the bluff is heavily wooded and mostly vegetated. Over the years prior to and after development of the upper area, the storm water runoff from the bluff itself and any areas in the upper area that drain toward the bluff have concentrated in certain locations to create ravines. Many of the ravines are wooded and vegetated but some have eroded and sloughed. It should be noted that the ravines along the Lake Street bluff and in other areas of North Mankato are products of erosion and are natural phenomenon that existed well before any development took place.

Between Page Avenue to the north end of Spring Lake, 22 single family homes are located between Lake Street and the bluff. Some of these homes are located directly at the base of the bluff and some were constructed into the hillside. North of Webster Avenue, there are 17 houses located between Lake Street and the bluff. In the area from the north end of Spring Lake to Webster Avenue, Lake Street is located at the base of the bluff with no houses between the street and the bluff.

The entire bluff area is shown on Exhibit No. 1. Exhibit No. 2 shows photos of a ravine that has limited erosion and a photo of a portion of a ravine segment that has eroded and sloughed.

In general, there have been isolated locations along the length of the bluff where drainage and/or erosion problems occurred. The primary focus of this report is to address the drainage and erosion problems at three specific locations:

- Garfield Avenue/806 Garfield Avenue (Hardwick property)
- 919 Lake Street (Mutch property)
- 927 Lake Street (Hagen property)

Ravines within the bluff converge to concentrate the storm water runoff at these locations resulting on more serious drainage and erosion issues that in other areas along the bluff. Each of these areas is addressed individually in the following paragraphs.

EVALUATION/ANALYSIS

Garfield Avenue/806 Garfield Avenue (Hardwick property):

A drainage area of approximately 6.4 acres drains to the segment of Garfield Avenue that extends west of Lake Street. Approximately 4.7 acres of the overall drainage area (73%) consists of the bluff and approximately 1.7 acres (27%) consist of roofs and back yards from 9 homes on Sherwood Drive. Approximately 1.8 acres of the 4.7-acre bluff area is within an outlot owned by the City. The remainder of the drainage area is privately-owned property.

Of the 6.4 total drainage area that discharges to Garfield Avenue, approximately 3.5 acres, or about 55% flows to a ravine that ends directly above 806 Garfield Avenue (Hardwick property). This property is nestled into the base of the bluff on the north side of Garfield Avenue. The drainage area the discharges to this location flows into a ravine that concentrates the flow at one location directly above the 806 Garfield Avenue property. This area has experienced excess overland stormwater flows and sediment discharge numerous times over the years during which water and sediment flowed over the retaining wall and across the driveway at 809 Garfield Avenue.

The stormwater runoff from the remaining 2.9 acres flows into a ravine that discharges directly onto the dead-end segment of Garfield Avenue west of Lake Street.

Exhibit 3 shows the drainage area and sub drainage areas for which stormwater outlets at Garfield Avenue.

During these rainfall events, water and sediment also flows onto Garfield Avenue and into Lake Street. Following the events, City crews have removed extensive sediment deposits on Garfield Avenue and have also historically assisted the property owner at 809 Garfield Avenue and possibly other property owners clean the deposited sediment from their property. Excess flows and sediment discharge have been observed at this location on numerous occasions over the years, typically when the rainfall exceeds 1.5".

Many years ago, the City installed a storm sewer inlet just west of the retaining wall on the west side of the driveway at 806 Garfield Avenue. A 6" diameter pipe was constructed from the inlet to an existing 8" diameter pipe that connects to the existing City storm sewer system at the intersection of Lake Street and Garfield Avenue. Exhibit 4 shows the inlet on the 806 Garfield Avenue property. Over the years City crews have also installed riprap around and upstream from the inlet to help control erosion and to direct more of the runoff into the inlet. Exhibit 4 shows the inlet at 806 Garfield Avenue.

The following table shows estimated peak stormwater runoff rates for this location for various rainfall events:

Location	5-Year		10-year		50-Year		100-Year	
	Rainfall (in.)	Flow (cfs)	Rainfall (in.)	Flow (cfs)	Rainfall (in.)	Flow (cfs)	Rainfall (in.)	Flow (cfs)
806 Garfield Avenue	3.60	5.3	4.29	6.6	6.23	11.1	7.20	13.8
Total, Garfield Avenue	3.60	9.6	4.29	12.0	6.23	20.2	7.20	25.2

Approximately 2/3 of the peak flows comes from runoff from the bluff area and approximately 1/3 of the peak flow comes from roofs and back yards at the top of the bluff. It is estimated that less than 15% of the storm water runoff comes from roofs, patios, and other hard surfaced areas.

Based on these calculations the following storm sewer pipe sizes would be required:

Location	Pipe Size Required (in.)			
	5-Year	10-year	50-Year	100-Year
806 Garfield Avenue	12"	15"	18"	18"
Total Garfield Avenue	15"	18"	21"	24"

The pipe sizes shown above assume that all of the storm water runoff arriving at the bottom of the bluff could be captured in the storm sewer system and that the pipes and inlets are clear of dirt and sediment. Due to the steep topography it would be difficult, if not impossible to design a storm water collection system that would capture all the runoff, especially for the larger rainfall events. The calculations show that the existing storm sewer system has capacity to capture the runoff associated with rainfall less than the 5-year recurrence interval. Based on field observations, the runoff exceeds the capacity of the existing storm sewer system with rainfalls of approximately 1.5". It is anticipated that protection for up to the 5-year storm water runoff rate could be accomplished by increasing the storm sewer pipe sizes and improving the storm water inlet system. Due to the steep topography and limited space available for creating a collection area for the storm water runoff, the capacity of the system would be limited by the inlet capacity and it would be difficult to design a system that would provide protection for runoff exceeding the 5-year rainfall event. Even with the improved storm sewer system, rainfall events exceeding the 5-year rainfall event would result in runoff exceeding the capacity of the system and runoff and sediment flowing through the property and onto Garfield Avenue and Lake Street.

919 Lake Street (Mutch property)

A drainage area of approximately 5.5 acres drains to a convergence of ravines that discharge along the south side of 919 Lake Street. Approximately 3.8 acres of the overall drainage area (70%) consists of the bluff and approximately 1.7 acres (30%) consist of roofs and back yards from 9 homes on Queens Court, Kings Court, James Drive and Mary Lane. All of the property within the drainage area is privately-owned property.

Exhibit 5 shows the drainage area and sub drainage areas for which stormwater outlets at 919 Lake Street.

This area has also experienced excess overland stormwater flows and sediment discharge numerous times over the years during which water and sediment flowed through the back yard and along the south property line of 919 Lake Street. During some of these rainfall events, water and sediment also flows onto Lake Street. Following the events, City crews have removed extensive sediment deposits on Garfield Avenue and have also historically assisted the property owner at 809 Garfield Avenue and possibly other property owners clean the deposited sediment from their property. The following are the approximate dates and details of the rainfall events in the past 2 years that caused excessive runoff and sediments deposits at this location:

- September 11&12 2019, approximately 3.6" of rain in less 24-hour period; conditions were already saturated from wet conditions throughout the summer
- July 26, 2020: approximately 7.5" of rain in less than 24 hours
- August 11, 2020: approximately 2.75" of rain in less than 24 hours

There have been other instances that have resulted in similar water and sediment problems at this location in past years, but those listed above are the most recent with more accurate documentation.

In about 2003 or 2004, the City installed a storm sewer system from Lake Street to the west side of the 919 Lake Street property. The storm sewer system consists of a 12" diameter pipe with two inlets at the convergence of several ravines at the base of the bluff. The inlets have been cleaned of sediment and improved a number of times over the years, including following the 7.5" rainfall on July 26th of 2020. At that time, riprap was installed around the inlet to help control erosion and to channel the runoff into the inlet. Grates with increased capacity were also installed on the inlets. City crews also repaired the erosion and re-seeded the area on the south side of the property from the base of the bluff to Lake Street. The area upstream from the inlet was also re-seeded. Some of the seeded areas and eroded with the recent rains. Exhibits 6 and 7 show the inlet at 919 Lake Street with the improvements that were made following the July 2020 rainfall event.

The following table shows estimated peak stormwater runoff rates for this location for various rainfall events

5-Year		10-year		50-Year		100-Year	
Rainfall (in.)	Flow (cfs)	Rainfall (in.)	Flow (cfs)	Rainfall (in.)	Flow (cfs)	Rainfall (in.)	Flow (cfs)
3.60	8.4	4.29	10.4	6.23	17.6	7.20	21.9

Approximately 62% of the peak flows comes from runoff from the bluff area and approximately 38% of the peak flow comes from roofs and back yards at the top of the bluff. It is estimated that less than 10% of the storm water runoff comes from roofs, patios, and other hard surfaced areas.

Based on these calculations the following storm sewer pipe sizes would be required:

Pipe Size Required (in.)			
5-Year	10-year	50-Year	100-Year
15"	18"	21"	24"

As previously discussed, the pipe sizes shown above assume that all of the storm water runoff arriving at the bottom of the bluff could be captured in the storm sewer system and that the pipes and inlets are clear of dirt and sediment. The calculations show that the existing storm sewer system has capacity runoff associated with rainfall slightly less than the 5-year recurrence interval. Based on field observations, the runoff exceeds the capacity of the existing storm sewer system with rainfalls of approximately 3.0. Due to the steep topography and limited space available for creating additional collection areas for the storm water runoff, the capacity of the system would be limited by the inlet capacity and it would be difficult to design a system that would provide protection for runoff exceeding the 5-year rainfall event.

927 Lake Street (Hagen property)

A drainage area of approximately 2.8 acres drains across the property at 927 Lake Street. Approximately 2.4 acres of the overall drainage area (86%) consists of the bluff and approximately 0.4 acres (14%) consist of roofs and back yards from 4 homes on Mary Lane. All of the property within the drainage area is privately-owned property.

Exhibit 8 shows the drainage area for which stormwater outlets across 927 Lake Street.

The runoff from the drainage area upstream from this property is more distributed across the length of the property and, in general, does not converge into one or more ravines upstream. As such, this property only experiences excess overland stormwater flows discharge during the most excessive rainfall events, including the 7.5" rainfall on July 26, 2020, with minimal sedimentation on the property itself or on Lake Street.

RECOMMENDATIONS:

Garfield Avenue/806 Garfield Avenue (Hardwick property):

As stated previously, the existing storm sewer piping system from the inlet above 806 Garfield Avenue to Lake Street appears to handle the runoff from rainfall events of up to approximately 1.5", which is significantly less than a 5-year rainfall event.. The capacity of a storm sewer system is a function of not only pipe size, but also the inlet capacity (ability to capture the peak runoff and get it into the storm sewer pipe). Based on observations of the existing inlet and the surrounding area at 806 Garfield Avenue, it is estimated that the inlet capacity would be sufficient to capture the peak runoff from the 5-year rainfall event, but the system capacity is currently limited by the 6" and 8" pipe sizes. The hydraulic calculation indicate that the capacity of the system could be increased to accommodate the runoff from the 5-year rainfall event by increasing the storm sewer pipe in Garfield Avenue to 12" and 15" pipe. No inlets are currently in place at the west end of Garfield Avenue, and the addition of new inlets in that location would also help capture the runoff from up to a 5-year rainfall event at that location. Due to

the steep topography and limited space, the design of a storm water inlet system that would capture the runoff from more than a 5-year rainfall event is not considered to be feasible.

City staff evaluated the possibility of installing a storm sewer system in the back yards of the properties at the top of the bluff to collect roof drainage, sump pump, and back yard drainage. In general, the back yards are at a considerably lower elevation than the streets in the front of the houses and in most areas, there is no storm sewer system in the street. So the only option for an outlet for such a system would be to pipe the system down the bluff. This is not considered feasible due to the very steep topography, and the disruption to the bluff would most likely result in more erosion problems and sloughing. Also, as previously noted, the majority of the runoff is coming from the bluff itself and the reduction of the runoff from the roofs, patios and yards above is not expected to have a significant impact on the runoff at the bottom of the bluff.

City staff has taken efforts to re-establish the vegetation in the eroded areas on the bluff, utilizing special seed mixtures that thrive in shady conditions. These efforts have been successful in several areas and should be continued.

919 Lake Street (Mutch property)

Based on observations of the existing inlet and the surrounding area at 919 Lake Street, it is estimated that the capacity of the two inlets is sufficient to capture the peak runoff from the 5-year rainfall event, and the existing 12" is at a steep enough slope that it, too, has capacity for the runoff from a 5-year event. Due to the steep topography and limited space, the design of a storm water inlet system that would capture the runoff from more than a 5-year rainfall event is not considered to be feasible.

City staff has also evaluated the possibility of installing a storm sewer system in the back yards of the properties at the top of the bluff for this drainage area. The same challenges exist for constructing such a system at this location as was discussed for the Garfield Avenue bluff drainage area. The majority of the runoff from this drainage area is coming from the bluff itself and the reduction of the runoff from the roofs, patios and yards above is not expected to have a significant impact on the runoff at the bottom of the bluff.

City staff has also attempted to re-establish the vegetation in the eroded areas on the bluff at this location and these efforts should be continued.

927 Lake Street (Hagen property)

The storm water runoff coming from the bluff at this location appears to be more distributed and less concentrated in ravines than in the other locations discussed in this report. While this property experienced excess overland flows and some minor erosion and sedimentation during the 7.5" rainfall event in July of 2020, runoff rates and erosion were much less severe in other locations, and problems appear to be limited to extreme rainfall events. There is no storm sewer collection or piping system at this location, and no improvements are recommended at this time.



EXHIBIT 1 - LAKE STREET BLUFF



Example of a ravine with minimal erosion



Example of ravine that has eroded and sloughed



EXHIBIT 3 - 806 GARFIELD AVENUE/GARFIELD AVENUE DRAINAGE AREA



Inlet at 806 Garfield Avenue



Rip-rap installed around inlet and upstream from inlet

EXHIBIT 4 – INLET AT 806 GARFIELD AVENUE



EXHIBIT 5 - 919 LAKE STREET AVENUE DRAINAGE AREA

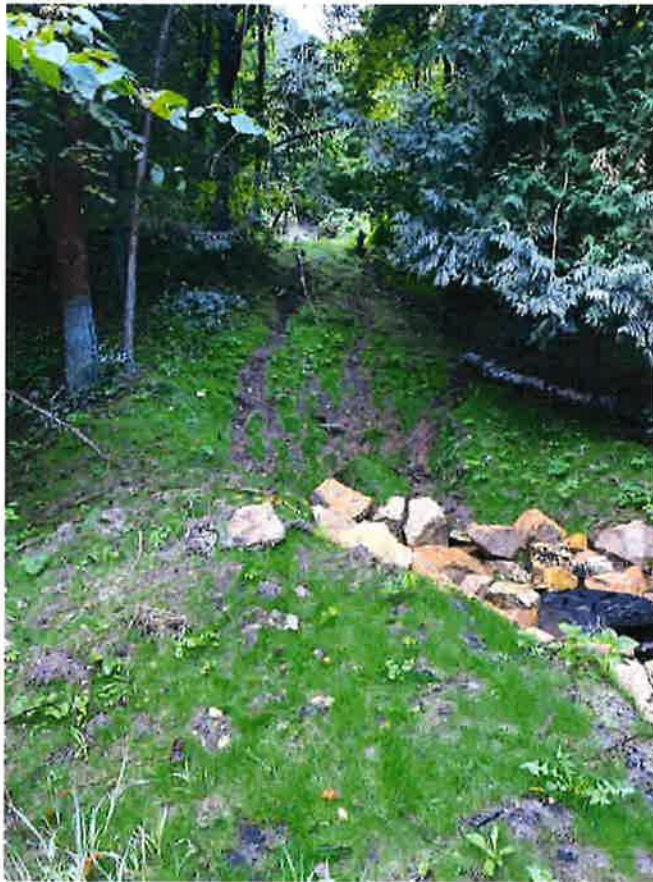


Inlet #1



Inlet #2

EXHIBIT 6 – INLETS AT 919 LAKE STREET



Rip-rap and seeding upstream from inlets



Seeding of area from base of bluff to Lake Street

EXHIBIT 7 – RIP-RAP AND SEEDING AT 919 LAKE STREET



EXHIBIT 7 - 927 LAKE STREET DRAINAGE AREA

Lake Street Bluff Drainage and Erosion Issues

1

Background

- Report addresses drainage and erosion issues in several locations along the bluff located just west of Lake Street
- Bluff is the transition from the "upper" portion of North Mankato to the "lower" North Mankato
- Lake Street extends along most of the length of the bluff in lower North Mankato
- Several streets and cul-de-sacs are located adjacent the upper edge of the bluff
 - Sherwood Drive
 - Queens Court
 - Kings Court
 - Mary Lane)
- Approximately 210 to 220 feet difference in elevation
- Bluff created by erosion due to the meandering of the Minnesota River over thousands of years
- Most of the bluff is heavily wooded and mostly vegetated
- Over the years, ravines have developed:
 - Storm water runoff from the bluff itself
 - Storm water from areas that drain toward the bluff

2

Background



- Many of the ravines are wooded and vegetated but some have eroded and sloughed
- Ravines along the Lake Street bluff and in other areas of North Mankato are results of erosion and are natural phenomenon that existed well before any development took place
- Approximately 37 single family holes are located between Lake Street & bluff
- Some were constructed into the hillside
- In general, there have been isolated locations along the length of the bluff where drainage and/or erosion problems occurred
- This report addresses three specific locations:
 - o Garfield Avenue/806 Garfield Avenue (Hardwick property)
 - o 919 Lake Street (Mutch property)
 - o 927 Lake Street (Hagen property)
- In the first two locations, ravines within the bluff converge to concentrate the storm water runoff at these locations resulting on more serious drainage and erosion issues that in other areas along the bluff



3

Lake Street Bluff



4

Photos of Ravines along Bluff



5

Garfield Avenue/806 Garfield Avenue (Hardwick property)



- Location – segment of Garfield Avenue that extends west of Lake Street
- 806 Garfield (Hardwick property) located on north side at west end of dead-end street
- Overall Drainage area:
 - Total: 6.4 acres
 - Bluff: 4.7 acres (73%)
 - Roofs and back yards on Sherwood Drive: 1.7 acres (27%)
 - Approximately 1.8 acres is within an outlot owned by the City; remainder of the drainage area is privately-owned property.
- 806 Garfield:
 - 3.5 acres (55%) flows to a ravine that ends directly above 806 Garfield Avenue
 - Property is nestled into the base of the bluff on the north side of Garfield Avenue
 - Ravine that concentrates the flow at one location
 - This area has experienced excess overland stormwater flows and sediment discharge numerous times over the years - water and sediment flowed over the retaining wall and across the driveway at 809 Garfield Avenue.
- Garfield Avenue:
 - 2.9 acres (45%)
 - Flows into a ravine that discharges directly onto the dead-end segment of Garfield Avenue west of Lake Street.



6

Garfield Avenue/806 Garfield Avenue (Hardwick property)

NORTH MANKATO
MINNESOTA

1.2 ACRES (POCKET DRAINAGE AREA)

3.5 ACRES (806 GARFIELD)

2.5 ACRES (GARFIELD AVE)

0.2 ACRES (POCKET AND BACK YARD)



TOTAL DRAINAGE AREA - 6.4 ACRES

GARFIELD AVENUE

LAKE STREET

BOLTON & MENK
Real People. Real Solutions.

7

Garfield Avenue/806 Garfield Avenue (Hardwick property)	
<ul style="list-style-type: none"> Existing storm sewer system: <ul style="list-style-type: none"> City installed a storm sewer inlet just west of the retaining wall on the west side of the 806 Garfield Avenue driveway 6" pipe constructed from the inlet to an 8" pipe in Garfield Avenue 8" pipe connects to City storm sewer system in Lake Street City crews have also installed riprap around and upstream from the inlet to help control erosion and to direct more of the runoff into the inlet Issues at this Location: <ul style="list-style-type: none"> Excess flows and sediment discharge have been observed at this location on numerous occasions over the years, typically when the rainfall exceeds approx. 1.5". Water and sediment also flows onto Garfield Avenue and into Lake Street City crews have removed extensive sediment deposits on Garfield Avenue City crews have also historically assisted the property owner at 809 Garfield Avenue with clean up and repairs 	

8

Garfield Avenue/806 Garfield Avenue (Hardwick property)



9

Garfield Avenue/806 Garfield Avenue (Hardwick property)



- Peak stormwater runoff:

Location	5-Year		10-year		50-Year		100-Year	
	Rainfall (in.)	Flow (cfs)	Rainfall (in.)	Flow (cfs)	Rainfall (in.)	Flow (cfs)	Rainfall (in.)	Flow (cfs)
806 Garfield Avenue	3.60	5.3	4.29	6.6	6.23	11.1	7.20	13.8
Total, Garfield Avenue	3.60	9.6	4.29	12.0	6.23	20.2	7.20	25.2

- Approx. 2/3 of the peak flows comes from runoff from the bluff area and approximately 1/3 of the peak flow comes from roofs and back yards at the top of the bluff
 - Less than 15% of the storm water runoff comes from roofs, patios, and other hard surfaced areas

- Required pipe sizes:

Location	Pipe Size Required (in.)			
	5-Year	10-year	50-Year	100-Year
806 Garfield Avenue	12"	15"	18"	18"
Total Garfield Avenue	15"	18"	21"	24"

- Pipe sizes shown above assume that all of the storm water runoff could be captured in the storm sewer system
 - Due to the steep topography it would be difficult, if not impossible to design a storm water collection system that would capture all the runoff, especially for the larger rainfall events
 - Existing storm sewer system has capacity to capture the runoff associated with rainfall less than the 5-year recurrence interval
 - Based on field observations, capacity is limited to runoff from approx. 1.5" rainfall



10

919 Lake Street (Mutch property)



- Drainage area:
 - Total: 5.5 acres
 - Bluff: 3.8 acres (70%)
 - Roofs and back yards on Queens Court, Kings Court, James Drive and Mary Lane: 1.7 acres (30%)
 - All of the drainage area is privately-owned property.



11

919 Lake Street (Mutch property)



12

919 Lake Street (Mutch property)



- Existing storm sewer system:
 - In 2003 or 2004, City installed a storm sewer system north side of property from Lake Street to base of bluff
 - Two inlets at base of bluff
 - Connects to storm sewer system in Lake Street
 - Inlet grates with increased capacity
 - Riprap around and upstream from the inlet to help control erosion and to direct more of the runoff into the inlet
 - City has seeded area above the inlets
- Issues at this Location:
 - Excess flows and sediment discharge have been observed at this location on numerous occasions over the years, typically when the rainfall exceeds approx. 3".
 - Water and sediment also across the south side of 919 Lake Street and onto Lake Street
 - City crews have removed sediment deposits on Lake Street
 - City crews have also historically assisted the property owner with clean up and repairs



13

919 Lake Street (Mutch property)



14

919 Lake Street (Mutch property)



15

919 Lake Street (Mutch property)



- Peak stormwater runoff:

5-Year		10-year		50-Year		100-Year	
Rainfall (in.)	Flow (cfs)	Rainfall (in.)	Flow (cfs)	Rainfall (in.)	Flow (cfs)	Rainfall (in.)	Flow (cfs)
3.60	8.4	4.29	10.4	6.23	17.6	7.20	21.9

- Approx. 62% of the peak flows comes from runoff from the bluff area and approximately 38% of the peak flow comes from roofs and back yards at the top of the bluff
- Less than 10% of the storm water runoff comes from roofs, patios, and other hard surfaced areas

- Required pipe sizes:

Pipe Size Required (in.)			
5-Year	10-year	50-Year	100-Year
15"	18"	21"	24"

- Pipe sizes shown above assume that all of the storm water runoff could be captured in the storm sewer system
- Due to the steep topography it would be difficult, if not impossible to design a storm water collection system that would capture all the runoff, especially for the larger rainfall events
- Existing storm sewer system has capacity to capture the runoff associated with rainfall slightly less than the 5-year recurrence interval
- Based on field observations, capacity is limited to runoff from approx. 3" rainfall



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927 Lake Street (Hagen property)



- Drainage area:
 - Total: 2.8 acres
 - Bluff: 2.4 acres (86%)
 - Roofs and back yards on Mary Lane: 0.4 acres (14%)
 - All of the drainage area is privately-owned property



17

927 Lake Street (Hagen property)



18

927 Lake Street (Hagen property)



- No existing storm sewer system in this location
- Runoff from is more distributed across the length of the property and less concentrated in ravine systems
- Based in information available, property only experiences excess overland stormwater flows discharge during the most excessive rainfall events
- 7.5" rainfall on July 26, 2020 resulted in overland flows, but minimal sedimentation on the property itself or on Lake Street



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Summary and Recommendations



- Garfield Avenue/806 Garfield Avenue (Hardwick property):
 - Pipe sizes shown in report assume all of the storm water runoff arriving at the bottom of the bluff could be captured in the storm sewer system and that the pipes and inlets are clear of dirt and sediment
 - Calculations show that the existing storm sewer system has capacity for approximately 1.5" rainfall; significantly less than the 5-year recurrence interval
 - Increasing pipe sizes to 12" and 15" pipe is expected to increase capacity of system to approximately 5-year rainfall event
 - Due to the steep topography and limited space available for creating additional collection areas for the storm water runoff, the capacity of the system would be limited by the inlet capacity
 - Not considered feasible to design a system that would provide protection for runoff exceeding the 5-year rainfall event
 - Adding additional inlets at the west end of Garfield Avenue would collect water flowing directly from the bluff onto Garfield Avenue
 - Roofs, patios and hard surfaced areas on homes along Sherwood Drive contribute less than 15% of total runoff
 - Back yards are significantly lower than street and no storm sewer system on Sherwood Drive
 - Not considered feasible to construct collection system along bluff line: no outlet for system, easements would be required, estimated to have limited impact on peak runoff rates
 - Continue attempts to establish turf on eroded portions of the bluff



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Summary and Recommendations



- **919 Lake Street (Mutch property):**

- Pipe sizes shown in report assume all of the storm water runoff arriving at the bottom of the bluff could be captured in the storm sewer system and that the pipes and inlets are clear of dirt and sediment
- Calculations show that the existing storm sewer system has capacity for approximately 3.0" rainfall; slightly less than the 5-year recurrence interval
- Due to the steep topography and limited space available for creating additional collection areas for the storm water runoff, the capacity of the system would be limited by the inlet capacity
- Not considered feasible to design a system that would provide protection for runoff exceeding the 5-year rainfall event
- Roofs, patios and hard surfaced areas on homes along Queens Court, Kings Court, James Drive and Mary Lane contribute less than 10% of total runoff
- Back yards are significantly lower than street and limited storm sewer system in this area
- Not considered feasible to construct collection system along bluff line: no outlet for system, easements would be required, estimated to have limited impact on peak runoff rates
- Continue attempts to establish turf on eroded portions of the bluff



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Summary and Recommendations



- **927 Lake Street (Hagen property)**

- Storm water runoff coming from the bluff at this location is more distributed and less concentrated in ravines than in the other locations discussed in this report
- Based on information provided, it appears that this property experiences excess overland flows and some minor erosion and sedimentation during the most extreme rainfall events
- There is no storm sewer collection or piping system at this location
- No improvements are recommended at this time



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