Young Environmental Consulting Group, LLC

Technical Memorandum

To: Linda Loomis, Administrator
Lower Minnesota River Watershed District

From: Katy Thompson, PE, CFM
Della Schall Young, CPESC, PMP

Date: October 16, 2020

Re: Area 3 Slope Stability Project Update

Approved by the Lower Minnesota River Watershed District (LMRWD or District) at the May 20, 2020, board meeting, this memo summarizes the outcomes of the following authorized tasks:

1. Install a vibrating wire in the existing piezometer to record groundwater levels within the Area 3 embankment.
2. Increase the frequency of data collection from the inclinometers to a minimum of twice per year: first, after snowmelt in the spring; second, after sustained high water levels in the late summer or early fall.
3. Update river cross sections to determine if the river channel has moved or scoured since the previous survey in 2009.
4. Collect and review available data to determine causes of gully erosion along Riverview Road:
    a. Review electronic storm sewer maps of the area from the City of Eden Prairie.
    b. Overlay inclinometer locations, lidar topography, storm sewer outfalls, available photos, and historic aerials to identify possible concentrated flow locations that could exacerbate the erosion processes.
    c. Evaluate options for a team to view the site from the Minnesota River in the fall.
    d. Contact the Freshwater Society to find out if it has identified potential areas of erosion.
    e. Review the Federal Emergency Management Agency (FEMA) “hot spots” report.

Inclinometers and Monitoring

Braun Intertec Corporation (Braun) has been responsible for maintaining the piezometer and inclinometers and collecting data since 2010. Throughout the summer, Young Environmental emailed and called Braun multiple times to obtain the monitoring data and coordinates of the inclinometers and to determine whether the vibrating wires had been installed. Braun was unresponsive; no information was obtained—leading to Braun's removal from the project. Barr Engineering Co. (Barr) has now been charged with completing an initial field review, re-initializing the piezometers and inclinometers, and completing the biannual monitoring. We expect to have preliminary data from Barr in mid-to-late November. We will provide an updated map with the inclinometer locations at that time.

River Cross Sections

Barr conducted a bathymetric survey of the six cross sections surveyed in 2009 on September 3, 2020 (**Figure 1**). The cross-sectional data was compared to the 2009 data by aligning the horizontal stations and elevations at the survey (**Figure 2**).

Cross sections 1–2 are upstream of Area 3 and show evidence of scouring and continuing erosion since 2009; the channel has deepened, and the right bank significantly eroded. Cross section 3 is also upstream of Area 3 but shows some deposition evidence in the channel. Still, the overall shape and extent of the cross section appear to be only minorly changed.

Cross sections 4 through 6 are within the Area 3 project area and all show evidence of channel movement and scour. Cross section 5 clearly shows the channel has moved toward the left bank—closer to the Area 3 embankment—and has deepened since 2009. This movement is consistent with the 2009 Wenck assumptions and historical aerial photo analysis, which showed the river has been migrating north at an average of 2 feet per year between 1937 and 2008.

Compared to the 2009 cross sections, Joel Toso from Barr concluded that the 2020 data show the river has continued to move toward the Area 3 embankment and will continue to threaten private properties, the City of Eden Prairie stormwater pond, and Riverview Road. He also estimated that the continued erosion contributes approximately 5,000 tons of sediment into the river each year.

Data Review

Four primary data sources were reviewed for additional information on the Area 3 embankment: the *Hennepin County Landslide Inventory* (also referred to as the Freshwater Society and FEMA's "hot spots" report), the LMRWD *2020 Gully Inventory Updates and Condition Assessment*, the Minnesota Department of Natural Resources (MnDNR) *Springs Inventory*, and a simple hydrologic model. These data were reviewed to determine if additional factors at play could be causing the gully erosion and slope

movement in the Area 3 embankment that should be addressed with the Area 3 Slope Stabilization project. From the previous work completed with the *2020 Gully Inventory Updates and Condition Assessment*, within the LMRWD, the following were determined to be the primary drivers in gully erosion and slope instability:

- Steep slopes
- Susceptible soils
- Changes in hydrology

Area 3 is located within the District's Steep Slopes Overlay District (SSOD), which encompasses all three slope instability drivers. It includes the Minnesota River bluffs, where slopes exceed 30 percent, and elsewhere within the District where slopes exceed 18 percent. The SSOD is intended to maintain the stability of the bluffs, steep slopes, and other areas prone to erosion. The SSOD is also a good indicator of the presence of gullies and active erosion within the LMRWD.

The soils within the SSOD tend to be susceptible to erosion, especially when saturated. Excessive rainfall can saturate the soil, leading to landslides and slumping of slopes in addition to the development of gullies. Rainfall, including the erosive power of intense rainstorms and stormwater discharges from pipes, can also lead to the development of gullies within the LMRWD. Because of the fragile nature of the soils and slopes, changes in natural hydrology, including new pipe outfalls, stormwater discharges, and increased impervious surface area within the watershed, could destabilize these slopes.

Groundwater can also destabilize slopes within the SSOD when it flows to the surface at springs and seeps, saturating the slopes, like rainfall with similar effects on the hillside gully formation, landslides, and slumping.

Historical Landslide Inventory

The MnDNR, the University of Minnesota, the National Weather Service, and Hennepin County developed the *Historical Landslide Inventory of the Twin Cities Metropolitan Area* in response to the June 2014 rainfall and subsequent landslides. The report states that within the LMRWD, the glacial sediment terraces along the Minnesota River valley are prone to landslides and tend to fail when stormwater is not well-controlled. Slopes can become destabilized when excess rainfall saturates the soil and can create gully erosion and induce landslides. Groundwater springs in these areas can also saturate the soil and contribute to gully development, erosion, and slope movement[1].

Hennepin County provided locations of historic landslides derived from an analysis of LiDAR topography. The Area 3 embankment has been subject to several historical landslides, which have deposited material along the slope's left toe and within the

[1] *Historical Landslide Inventory for the Twin Cities Metropolitan Area*, https://files.dnr.state.mn.us/waters/watermgmt_section/shoreland/landslide-inventory.pdf

Minnesota River (**Figure 3**). The inventory lends additional credibility for the continued slope movement monitoring of the embankment.

2020 Gully Inventory Updates and Condition Assessment

Several sites were surveyed over the summer and are shown in **Figure 4**. The area was identified as High-Priority Region (HPR) 14 in the *2020 Gully Inventory* due to the cluster of high-priority gullies found. This area contains several gullies rated as having high erosion potential, meaning they may be actively eroding and transporting sediment downstream. Most of the sites surveyed in HPR 14 noted evidence of slope movement, including curved or leaning trees and hillside slumps.

Many of the sites surveyed also noted seeps or groundwater and listed it as a potential cause for erosion and gully development (see individual datasheets attached). These sites correlate well with the MnDNR *Springs Inventory* (**Figure 5**) and provide additional confirmation that groundwater baseflow will need to be considered as part of any future stabilization designs.

MnDNR Springs Inventory

The MnDNR has been crowdsourcing, collecting new data, and digitizing historic spring data through the Minnesota Spring Inventory Recording Application. The inventory contains both potential and verified springs. In Area 3, there are three springs shown: the Upper Red Spring, the Red Spring to the west, and an unnamed spring (once known as “Mrs. Leigh’s Spring”) to the east (**Figure 5**).

Surface Hydrology

At the May 2020 meeting, it was discussed that the surface hydrology should be reviewed to determine if any concentrated flow locations may be acerbating erosion or causing gully development on the hillside. The City of Eden Prairie provided its storm sewer network data for Area 3 for review, and it was determined that no municipal stormwater outfalls are located in the Area 3 hillside. From field observation in May, no roof or sump pump discharges were observed in the area either. The development along Riverview Road collects stormwater runoff away from the bluff. It directs it to a stormwater pond north of Riverview Road and to the City stormwater pond in the southeast corner of the Area 3 site.

Using the City’s storm sewer network and the MnDNR LiDAR data, three sub-catchments were delineated to the locations where gullies flow into the Minnesota River from the Area 3 embankment (**Figure 6**). This delineation confirmed that there are no major storm sewer outfalls into the gullies from Riverview Road. The gully drainage areas appear to be limited to the areas directly connected to the gullies. The sub-catchments are relatively small (3.3–16.2 acres) and predominately open space, with a small amount of single-family residential development at the top of each subcatchment.

Soils within these sub-catchments are well-drained and classified as Hydrologic Soil Group A, indicating a high rainfall infiltration capacity. Despite the small size of these drainage areas, the runoff from several design events was calculated to determine each gully's rainfall-runoff relationship.

To determine the amount of runoff each gully can generate, we modeled the system using HEC-HMS, a hydrologic model, with the NOAA Atlas 14 rainfall depths for the standard design storms required for LMRWD project permits (**Table 1**).

Table 1. NOAA Atlas 14 Design Storm Rainfall Depths

Design Event	Precipitation (in)
2-yr., 24-hr.	2.86
10-yr., 24-hr.	4.25
100-yr., 24-hr.	7.43

The HEC–HMS modeling results confirmed that the underlying Area 3 soils absorb most of the rainfall for these design storms, and little to no runoff occurs in most events. Rainfall-runoff does not occur for events less than 4" in depth, suggesting that in general, surface hydrology may have a minimal impact on the development of gullies and slope movement in Area 3. **Table 2** presents the results from the modeling.

Table 2. Area 3 HEC-HMS Model Results

Subbasin	Drainage Area (ac)	2-yr. Q_{peak} (cfs)	2-yr. Volume (ac-ft)	10-yr. Q_{peak} (cfs)	10-yr. Volume (ac-ft)	100-yr. Q_{peak} (cfs)	100-yr. Volume (ac-ft)
1	3.812	0	0	0	0	1.1	0.2
2	10.80	0	0	0	0	3	0.7
3	16.24	0	0	0.8	0.3	13.9	2

It should be noted that this analysis only considers design events typically used for permitting and design of stormwater management features. As discussed in the Hennepin County Historical Landslide Inventory, the soils are susceptible to failure during extreme rainfall events or saturated by excessive rainfall or groundwater. While the design storms indicate the soil can infiltrate large amounts of water, this is only possible when the groundwater table is sufficiently below the ground surface to allow this infiltration to occur. Monitoring groundwater will be especially crucial for future stabilization designs because surface water runoff does not appear to be a main driver of erosion or instability.

Recommendations

Based on the work completed over the summer, we are confident in recommending the Board move forward with the development of preliminary and final engineering design of the 2009 alternative, which included rock vanes to protect the embankment and direct river flows away from the slope (to mitigate the movement of the river toward Area 3). The estimated cost to complete the design is $210,000, based on the escalated construction costs from 2009 to 2020. Without intervention, the embankment is likely to continue to erode due to several factors:

1. The bend in the Minnesota River at this location has been and will continue to direct flows at the Area 3 slope and erode the embankment's toe.
2. Groundwater is a concern in this area. The baseflow from these seeps and springs may continue to cause gully development and erosion, further destabilizing the slope. Future slope stabilization designs will need to include a groundwater management system to prevent the stabilized slope from becoming saturated by groundwater.
3. The surface water likely does not play a significant role because most of the surface runoff has already been directed away from the bluff slopes. However, because of the fragile nature of the underlying soils, continued rainfall or substantial rainfall events, such as the June 2014 floods, suggest the embankment has the potential to catastrophically fail if the soils become saturated. Any future slope stabilization will need to ensure that adequate drainage exists to prevent extended soil saturation.

Attachments

Figure 1: River Cross Section Locations

Figure 2: Cross Section Comparisons 2009–2020

Figure 3: Area 3 Historic Landslides

Figure 4: Area 3 2020 *Gully Inventory* Locations

Figure 5: Area 3 Groundwater Observations

Figure 6: Sub-catchment Delineation and Storm Sewer Map

Area 3 Surveys from *Gully Inventory and Condition Assessment (2020).*

Figure 1:
River Cross-Sections

LEGEND

- Area 3 Study Area
- River Cross-Sections
- Hennepin & Scott Co. 2-ft Contours
- Public Waters
- Public Waterbodies

LMRWD Overlay Districts

- Steep Slopes Overlay District [SSOD]

Political Boundaries

- Eden Prairie
- LMRWD Boundary
- Cities, Townships, Unincorporated Areas
- County Boundaries

LMRWD Watershed Location Map

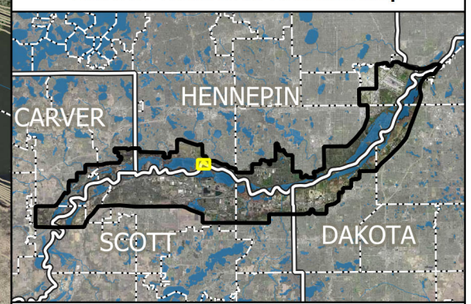

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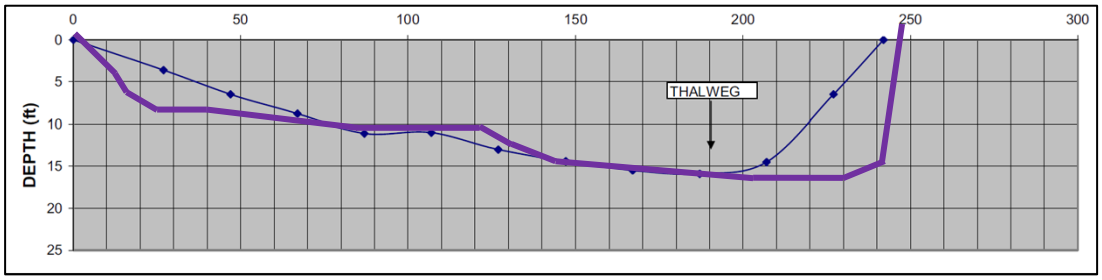
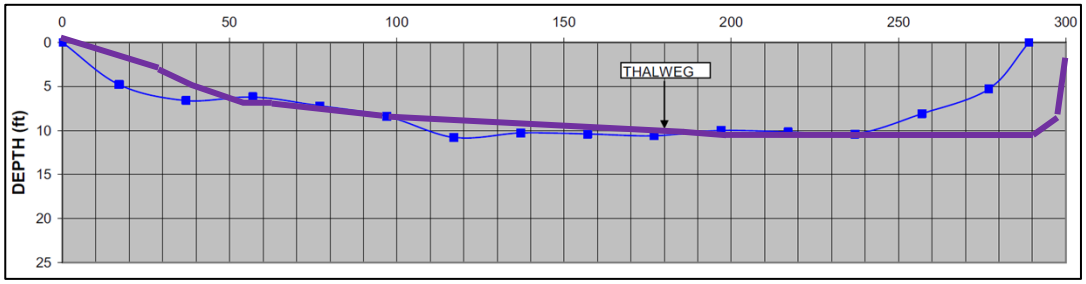
Figure 2. 2009 and 2020 River Cross-Sections (2020 in purple, left-to-right looking downstream)

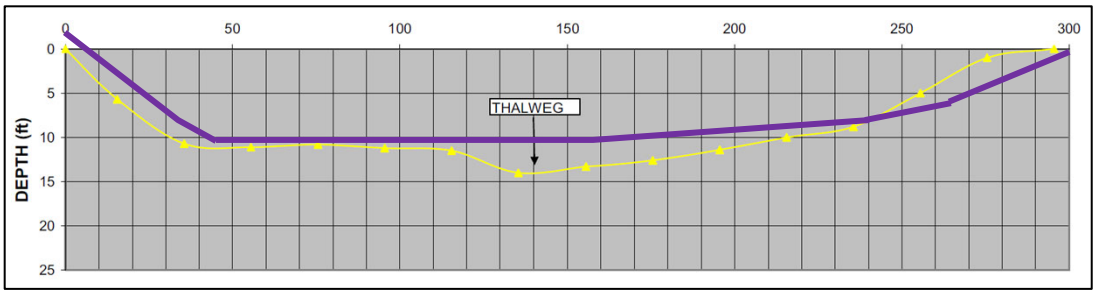
Cross-Section 1



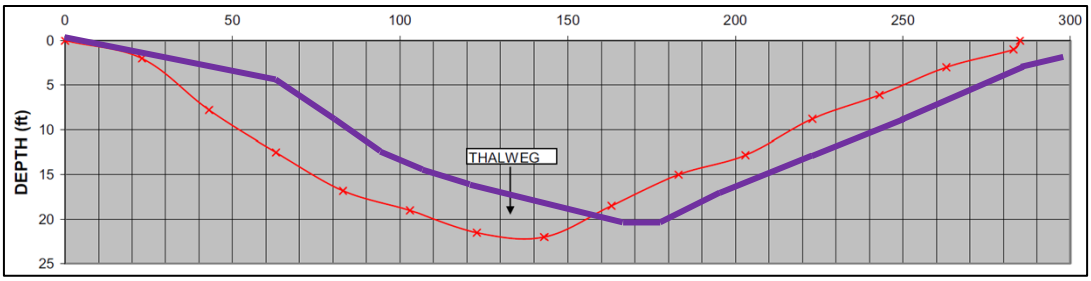
Cross-Section 2



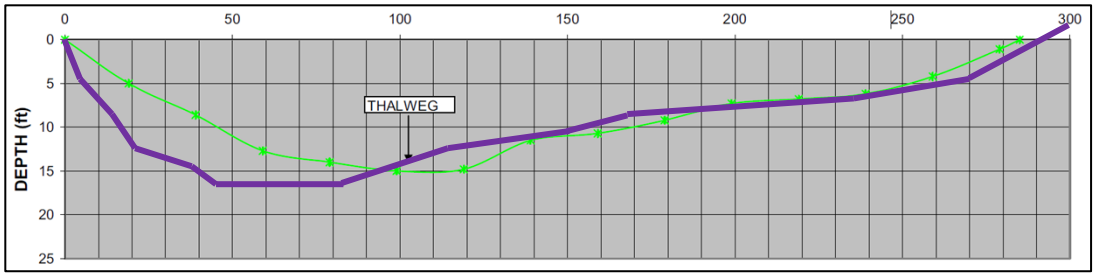
Cross-Section 3



Cross-Section 4



Cross-Section 5



Cross-Section 6

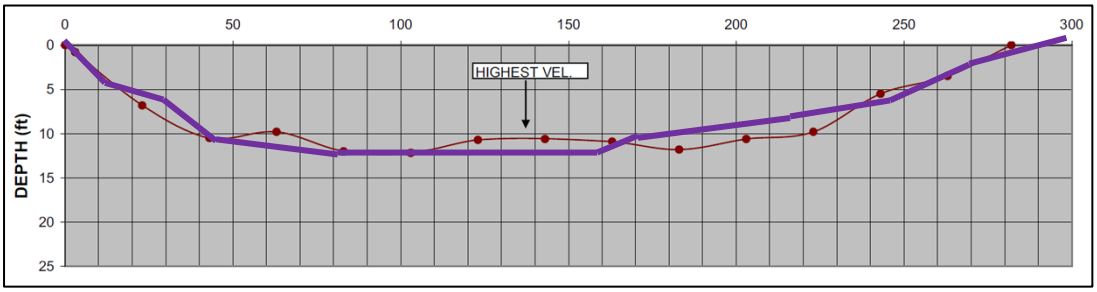
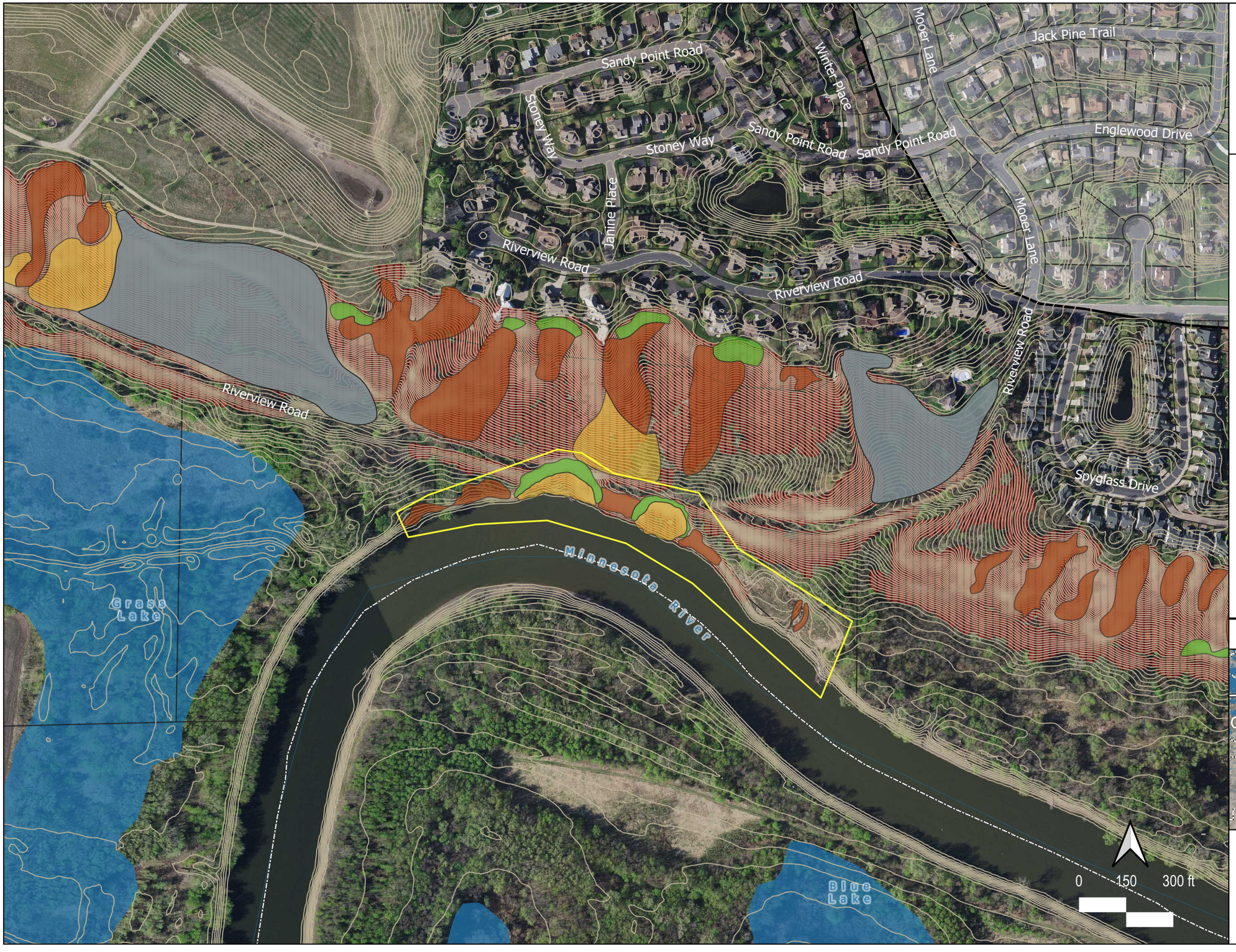


Figure 3: Area 3 Historic Landslides



LEGEND

- Area 3 Study Area

Hennepin Co. Landslide Inventory

- Historic Landslides
- Scarp and Flank
- Small Slides
- Modified Slopes
- Deposits
- Hennepin & Scott Co. 2-ft Contours
- Public Waters
- Public Waterbodies

LMRWD Overlay Districts

- Steep Slopes Overlay District [SSOD]

Political Boundaries

- Eden Prairie
- LMRWD Boundary
- Cities, Townships, Unincorporated Areas
- County Boundaries

LMRWD Watershed Location Map

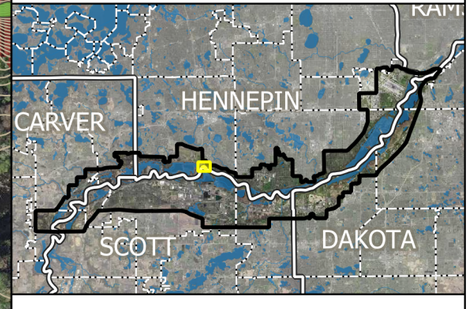


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Figure 4:
Area 3 2020 Gully Inventory Sites

LEGEND

- High Priority Region 14

High Priority Sites

- Low --> High
- Moderate --> High
- High --> High
- New Site High
- Other 2020 Gully Inventory Sites
- Area 3 Study Area
- Hennepin & Scott Co. 2-ft Contours
- Public Waters
- Public Waterbodies

LMRWD Overlay Districts

- Steep Slopes Overlay District [SSOD]

Political Boundaries

- Eden Prairie
- LMRWD Boundary
- Cities, Townships, Unincorporated Areas
- County Boundaries

LMRWD Watershed Location Map

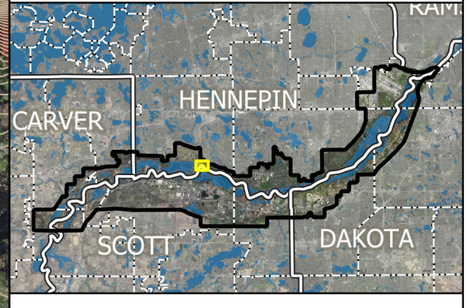

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Figure 5: Area 3 Groundwater Observations

LEGEND

- Area 3 Study Area
- MnDNR Spring Inventory

2020 Gully Surveys

- No Groundwater/Seep Noted
- 2020 Survey Noted Groundwater or Seeps
- Hennepin & Scott Co. 2-ft Contours
- Public Waters
- Public Waterbodies

LMRWD Overlay Districts

- Steep Slopes Overlay District [SSOD]

Political Boundaries

- Eden Prairie
- LMRWD Boundary
- Cities, Townships, Unincorporated Areas
- County Boundaries

LMRWD Watershed Location Map

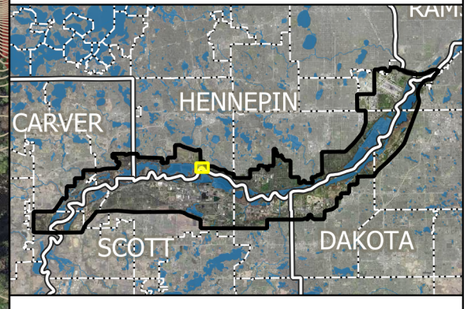

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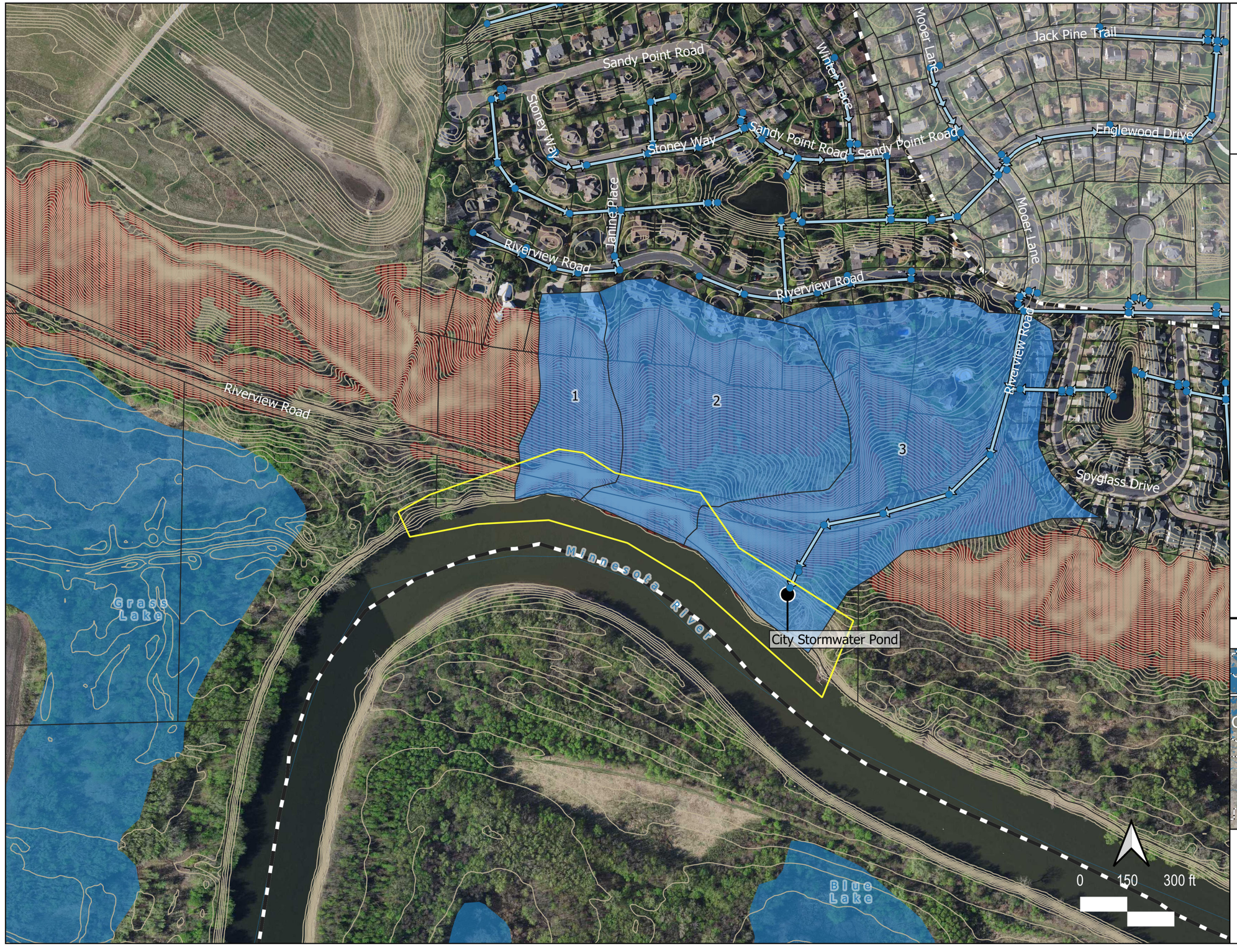
Figure 6: Area 3 Watershed Delineations



LEGEND

- Area 3 Study Area
- Eden Prairie Storm Point
- Eden Prairie Storm Sewer
- Area 3 Subcatchments
- Hennepin & Scott Co. 2-ft Contours
- Public Waters
- Public Waterbodies

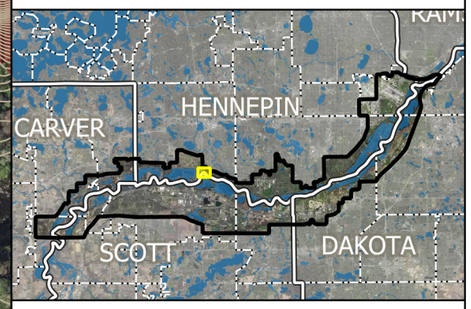
LMRWD Overlay Districts

- Steep Slopes Overlay District [SSOD]

Political Boundaries

- Eden Prairie
- LMRWD Boundary
- Cities, Townships, Unincorporated Areas
- County Boundaries

LMRWD Watershed Location Map



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GULLY ID: 999-166	
PREVIOUS WAYPOINT ID:	
SURVEY DATE: 07/28/2020 1:26 PM	
LOCATION: Eden Prairie	
TYPE OF SITE: Gully	
SITE SUMMARY: Sunny Rain in previous 24 hours: No Walked through a Stream Medium: 50'-100' gully. The problem indicators were: Loss of Bank Vegetation, Vertical and/or bare banks (incision), Flattened and/or slumping banks (widening), undercut or overhanging banks (lateral scouring)	Gully Head UTM Estimation: 4962259N 465688E, Observation Point correction, if applicable: Connections to other points, if applicable: Headcut forming from same groundwater seep as L279

GULLY INFORMATION	
EROSION POTENTIAL:	High
GULLY DEPTH:	Medium: 3'-15'
BOTTOM WIDTH:	Medium: 1'-5'
TOP WIDTH:	Medium: 5'-10'
BANK CONDITION:	Some Vegetation
BOTTOM CONDITION:	Bare Soil
CHANNEL SLOPE:	Steep
GULLY SHAPE:	U-shaped
GULLY MATERIAL:	Gravel/cobble/ boulders
WATER LEVELS	Low, Fast
SEEP	Yes
APPARENT CAUSES:	Seep/groundwater, Slope

ADDITIONAL NOTES:
Rated high erosion potential because there is deep incision from the groundwater seep area and most of the banks are overhanging. Headcut is actively eroding from a large, bare soil groundwater "bowl" Gully widens out after about 20 feet and appears to stabilize, but then quickly incises again due to u stable stream channel

Invasive Species? Low
Type: Common Buckthorn

Debris? None
Existing Stabilization? None
Success: N/A

PICTURES:

Looking d/s from groundwater seep at headcut and channel incision

Looking d/s from right bank at a slump and severely overhanging left banks

Looking u/s at overhanging right banks (d/s from initial slumping)

Looking u/s from large knickpoint (d/s from initial slumping)

Looking u/s from widened section of gully at heavier vegetation. Gully returns to severe erosion shortly d/s (at knickpoint in picture above)

Looking u/s from gully bottom near headcut at slumping along the right bank and a backpack for scale. Headcut visible with groundwater seep above in the background

GULLY ID: L275	
PREVIOUS WAYPOINT ID: 1263	
SURVEY DATE: 07/28/2020 2:04 PM	
LOCATION: Eden Prairie	
TYPE OF SITE: Gully	
SITE SUMMARY: Partly Cloudy Rain in previous 24 hours: No Off of Walking Trail Short: <50' gully. The problem indicators were: Flattened and/or slumping banks (widening), undercut or overhanging banks (lateral scouring), pistol-butted or leaning trees	Gully Head UTM Estimation: 4962322N 465478E, Observation Point correction, if applicable: Connections to other points, if applicable:

GULLY INFORMATION	
EROSION POTENTIAL:	High
GULLY DEPTH:	Deep: >15'
BOTTOM WIDTH:	Wide: >5'
TOP WIDTH:	Wide: >10'
BANK CONDITION:	Bare Soil
BOTTOM CONDITION:	Bare Soil
CHANNEL SLOPE:	Steep
GULLY SHAPE:	Bowl shaped slump
GULLY MATERIAL:	Sand
WATER LEVELS	Low, Slow
SEEP	Yes
APPARENT CAUSES:	Seep/groundwater, Unstable drainage feature entering system , None/Unknown

ADDITIONAL NOTES:
Not really a gully, more of a very large slump along the left bank of the MN River 2007 report noted a spring and a pipe outfall. Spring was located near the river. Pipe outfall located near the left bank of the slump, but unable to assess due to steep slope. All of these features are included in a gully sheet because of the severe erosion and inability to assess pipe.

Invasive Species? None
Type: None

Debris? None
Existing Stabilization? None
Success: N/A

PICTURES:

Looking from the left bank of the slump to the right bank

Looking u/s to the headcut area, scale

Looking d/s from left bank viewpoint area at sandy banks and a seep in the middle of the picture

Pipe found along the left bank, but unable to assess due to steep slopes

GULLY ID: L277	
PREVIOUS WAYPOINT ID: 1265	
SURVEY DATE: 07/28/2020 2:54 PM	
LOCATION: Eden Prairie	Gully Head UTM Estimation: 4962444 N 465227 E ,
TYPE OF SITE: Gully	Observation Point correction, if applicable:
SITE SUMMARY: Sunny Rain in previous 24 hours: No Heavily Forested Long: >100' gully. The problem indicators were: Loss of Bank Vegetation, Vertical and/or bare banks (incision), Flattened and/or slumping banks (widening), undercut or overhanging banks (lateral scouring), pistol-butted or leaning trees	Connections to other points, if applicable:

GULLY INFORMATION	
EROSION POTENTIAL:	High
GULLY DEPTH:	Medium: 3'-15'
BOTTOM WIDTH:	Medium: 1'-5'
TOP WIDTH:	Medium: 5'-10'
BANK CONDITION:	Some Vegetation
BOTTOM CONDITION:	Bare Soil
CHANNEL SLOPE:	Steep
GULLY SHAPE:	U-shaped
GULLY MATERIAL:	Sand
WATER LEVELS	Low, Fast
SEEP	Yes
APPARENT CAUSES:	Seep/groundwater, Slope, Channel Incision

ADDITIONAL NOTES:
Gully is very active with signs of recent slumping and erosion through the reach. Steady base flow from seepage at headcut. Significant erosion since 2007. Because of this we conclude it has high erosion potential.

Invasive Species? Medium
Type: Common Buckthorn

Debris? Fallen tree debris
Existing Stabilization? No
Success: N/A

PICTURES:

Upstream view of slumping along left bank and channel incision. View from gully bottom near toe.

Upstream view from gully bottom near toe looking at partial vegetation and overhanging right banks.

Upstream view from gully bottom looking at channel view and tree debris with incision visible.

Upstream view from gully bottom looking at overhanging right banks above slump.

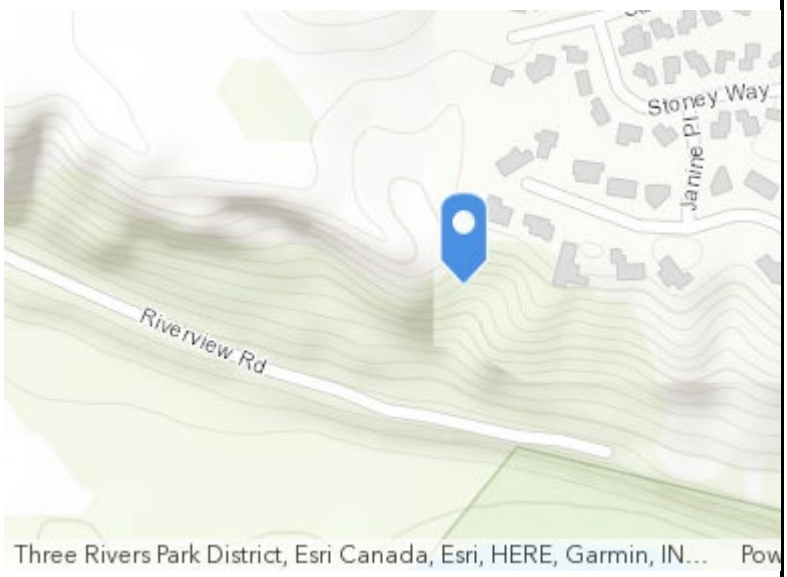
Close up of a tree that recently slumped into gully bottom along right bank. Upstream view from gully bottom.

Upstream view looking at channel view with slumping and bare soil along left bank. View from gully bottom.

Side stream view from left bank looking at slumping and bare soil along right bank near headcut.

Side stream view from left bank at headcut looking at where seepage begins.

Downstream view from right bank of headcut looking at large slump along left bank.

GULLY ID: L278	
PREVIOUS WAYPOINT ID: 1266	
SURVEY DATE: 07/28/2020 3:14 PM	
LOCATION: Eden Prairie	
TYPE OF SITE: Gully	
SITE SUMMARY: Partly Cloudy Rain in previous 24 hours: No Heavily Forested Medium: 50'-100' gully. The problem indicators were: Flattened and/or slumping banks (widening), undercut or overhanging banks (lateral scouring), pistol-butted or leaning trees	Gully Head UTM Estimation: 4962486N 465233E, 1m to the W Observation Point correction, if applicable: Connections to other points, if applicable: L277 is d/s, but has a distinct headcut

GULLY INFORMATION	
EROSION POTENTIAL:	High
GULLY DEPTH:	Deep: >15'
BOTTOM WIDTH:	Narrow/V Ditch
TOP WIDTH:	Wide: >10'
BANK CONDITION:	Bare Soil
BOTTOM CONDITION:	Some Vegetation
CHANNEL SLOPE:	Steep
GULLY SHAPE:	V-shaped
GULLY MATERIAL:	Sand
WATER LEVELS	None, N/A
SEEP	No
APPARENT CAUSES:	Slope, None/Unknown

ADDITIONAL NOTES:
Rated as high erosion potential because of steep bank slopes, narrow bottom width, and an actively eroding headcut with overhanging banks. There is little vegetation holding the soil in place along the banks. However, there were no deep slumps or sections of overhang noted along the banks themselves, so this gully is on the moderate end of high erosion potential.

Invasive Species? High
Type: Common Buckthorn
Debris? Tire and some fallen tree

Existing Stabilization? None
Success: N/A

PICTURES:

Looking u/s at gully channel from toe. Leaning tree on right bank and bare soil exhibited

Looking u/s from gully toe towards left bank at exposed tree roots and bare soil

Looking u/s from gully bottom towards headcut at overhanging banks

Looking u/s from gully bottom towards the headcut at the steep slopes and bare soil along the right bank

Looking d/s from gully bottom and bare soil and steep banks

Looking d/s from gully bottom at bare soil and leaning tree along the right bank

GULLY ID: L279	
PREVIOUS WAYPOINT ID: 1272	
SURVEY DATE: 07/28/2020 1:18 PM	
LOCATION: Eden Prairie	
TYPE OF SITE: Gully	
SITE SUMMARY: Sunny Rain in previous 24 hours: No Heavily Forested Medium: 50'-100' gully. The problem indicators were: Degradation, Loss of Bank Vegetation, Vertical and/or bare banks (incision), Flattened and/or slumping banks (widening), undercut or overhanging banks (lateral scouring), pistol-butted or leaning trees	Gully Head UTM Estimation: 4962255 N 465685 E, Observation Point correction, if applicable: Connections to other points, if applicable:

GULLY INFORMATION	
EROSION POTENTIAL:	High
GULLY DEPTH:	Shallow: <3'
BOTTOM WIDTH:	Medium: 1'-5'
TOP WIDTH:	Medium: 5'-10'
BANK CONDITION:	Bare Soil
BOTTOM CONDITION:	Bare Soil
CHANNEL SLOPE:	Steep
GULLY SHAPE:	Trapezoid
GULLY MATERIAL:	Gravel/cobble/ boulders
WATER LEVELS	Low, Fast
SEEP	Yes
APPARENT CAUSES:	Seep/groundwater, Slope, Channel Incision

ADDITIONAL NOTES:
High erosion potential with steady base flow as the erosive force. Lots of signs of active erosion. Off shoot gully 999-166 formed from seepage at headcut formed is becoming a higher erosion potential gully as well.

Invasive Species? None
Type: None

Debris? Fallen tree debris
Existing Stabilization? No
Success: N/A

PICTURES:

Downstream view from mid gully looking at overhang and slumping along both banks and a knick point close to the right bank.

Upstream view of widened section of the gully with slumping along the right bank. View from mid gully bottom.

Downstream view from gully bottom looking at incision and tree debris

Upstream view from gully bottom looking at overhanging banks on both sides and leaning tree on right bank.

Upstream view from left bank looking at deep incision along right bank with person for scale.

Side stream view from left bank looking at section of overhang on right bank.

Downstream view from right bank look at headcut, slumping along left bank.

GULLY ID: L280	
PREVIOUS WAYPOINT ID: 1273	
SURVEY DATE: 07/28/2020 12:51 PM	
LOCATION: Eden Prairie	
TYPE OF SITE: Gully	
SITE SUMMARY: Sunny Rain in previous 24 hours: No Off of Walking Trail Long: >100' gully. The problem indicators were: None	Gully Head UTM Estimation: N/a, 4962325N 465754E Observation Point correction, if applicable: Connections to other points, if applicable:

GULLY INFORMATION	
EROSION POTENTIAL:	Low
GULLY DEPTH:	Shallow: <3'
BOTTOM WIDTH:	Wide: >5'
TOP WIDTH:	Wide: >10'
BANK CONDITION:	Heavy Vegetation
BOTTOM CONDITION:	Armored
CHANNEL SLOPE:	Steep
GULLY SHAPE:	Trapezoid
GULLY MATERIAL:	Gravel/cobble/ boulders
WATER LEVELS	None, N/A
SEEP	No
APPARENT CAUSES:	None/Unknown

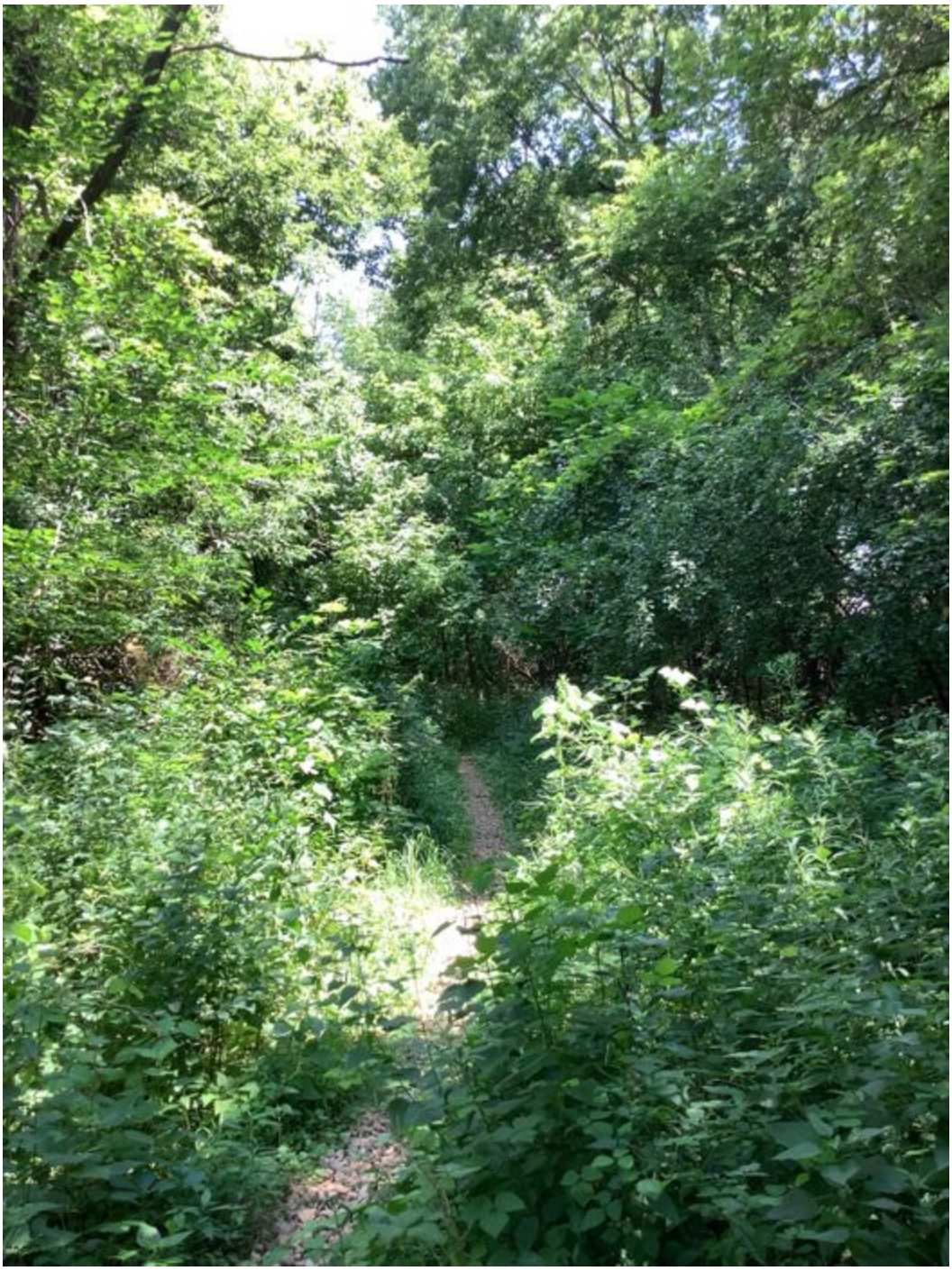
ADDITIONAL NOTES:
2008 Report listed this as a heavily eroded trail, and a small gully was visible. Looks like trail was restored with riprap, it is now a narrow path with heavy vegetation along each side, virtually no banks, and no erosion evident.

Invasive Species? None
Type: None
Debris? None
Existing Stabilization? Riprap
Success: Yes

PICTURES:

Looking u/s from 2008 waypoint location (site correction listed above). Unsure if this area was also revegetated

Looking d/s at stable path and heavy vegetation along the sides



Looking u/s at stabilized path

GULLY ID: L485	
PREVIOUS WAYPOINT ID: 1267	
SURVEY DATE: 07/28/2020 4:13 PM	
LOCATION: Eden Prairie	
TYPE OF SITE: Gully	
SITE SUMMARY: Sunny Rain in previous 24 hours: No Heavily Forested Medium: 50'-100' gully. The problem indicators were: Loss of Bank Vegetation, Vertical and/or bare banks (incision), pistol-butted or leaning trees	Gully Head UTM Estimation: 4962433 N 465167 E , Observation Point correction, if applicable: Connections to other points, if applicable:

GULLY INFORMATION	
EROSION POTENTIAL:	Moderate
GULLY DEPTH:	Deep: >15'
BOTTOM WIDTH:	Narrow/V Ditch
TOP WIDTH:	Wide: >10'
BANK CONDITION:	Bare Soil
BOTTOM CONDITION:	Bare Soil
CHANNEL SLOPE:	Flat
GULLY SHAPE:	V-shaped
GULLY MATERIAL:	Sand
WATER LEVELS	None, N/A
SEEP	No
APPARENT CAUSES:	Channel Incision, Dense Canopy

ADDITIONAL NOTES:
Gully is just a flow path that is down cutting on a steep slope. Headcut just is portion of channel where it becomes gradually less incised. Tons of leaning trees and patches of bare soil. Gully appears to be a long term moderate issue.

Invasive Species? Low
Type: Common Buckthorn
Debris? Fallen tree debris
Existing Stabilization? No
Success: N/A

PICTURES:

Upstream view from right bank looking at gully channel and fallen tree debris and bare soil along the banks.

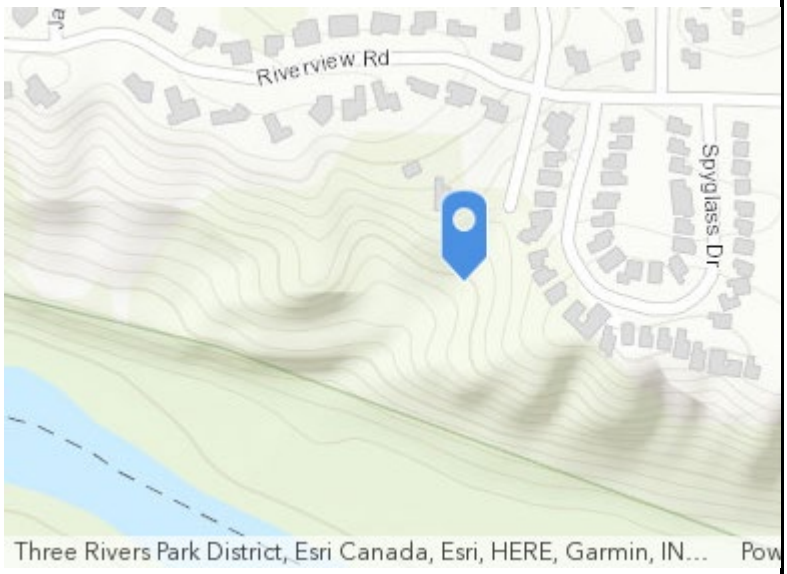
Upstream view from right bank looking at gully channel and fallen tree debris and bare soil along the banks.

Upstream view from gully bottom looking towards headcut. View of bare soil, channel incision, and abundance of dead trees.

Upstream view from gully bottom looking at bare soil along right bank of channel.

Downstream view from gully channel looking at bare soil along the banks and the V-shape of the channel.

Downstream view of left bank of channel which is mostly obstructed by trees. View of partial vegetation on left bank and steep bank slope. View from gully bottom.

GULLY ID: L490	
PREVIOUS WAYPOINT ID: 1274	
SURVEY DATE: 07/28/2020 12:27 PM	
LOCATION: Eden Prairie	
TYPE OF SITE: Gully	
SITE SUMMARY: Sunny Rain in previous 24 hours: No Off of Walking Trail Long: >100' gully. The problem indicators were: Flattened and/or slumping banks (widening), pistol-butted or leaning trees	Gully Head UTM Estimation: 4962343 N 465802 E , Observation Point correction, if applicable: Connections to other points, if applicable:

GULLY INFORMATION	
EROSION POTENTIAL:	Low
GULLY DEPTH:	Medium: 3'-15'
BOTTOM WIDTH:	Wide: >5'
TOP WIDTH:	Wide: >10'
BANK CONDITION:	Heavy Vegetation
BOTTOM CONDITION:	Heavy Vegetation
CHANNEL SLOPE:	Steep
GULLY SHAPE:	Trapezoid
GULLY MATERIAL:	Sand
WATER LEVELS	None, N/A
SEEP	No
APPARENT CAUSES:	Slope, Channel Incision, Game Trails

ADDITIONAL NOTES:
Some leaning trees and old signs of slumpage but no distinct signs of active erosion. Gully appears to be relatively stable.

Invasive Species? Medium
Type: Common Buckthorn
Debris? Fallen tree debris
Existing Stabilization? Fallen tree debris thrown in headcut channel and possible revegetation of gully.
Success: Unknown

PICTURES:

Downstream view from headcut looking at bare soil around headcut area but no signs of active slumping and tree debris piled in headcut channel.

Downstream view from right bank looking at bare soil and tree debris near headcut.

Downstream view from right bank looking at scale and vegetation in the channel.

Downstream view from gully channel lookoking at historic slump on left bank that has revegetated.

Downstream view from gully bottom looking at channel widening, leaning trees along left bank, and heavy vegetation.

Side stream view of patch of bare soil and pistol butted tree along right bank. View from left bank looking right.