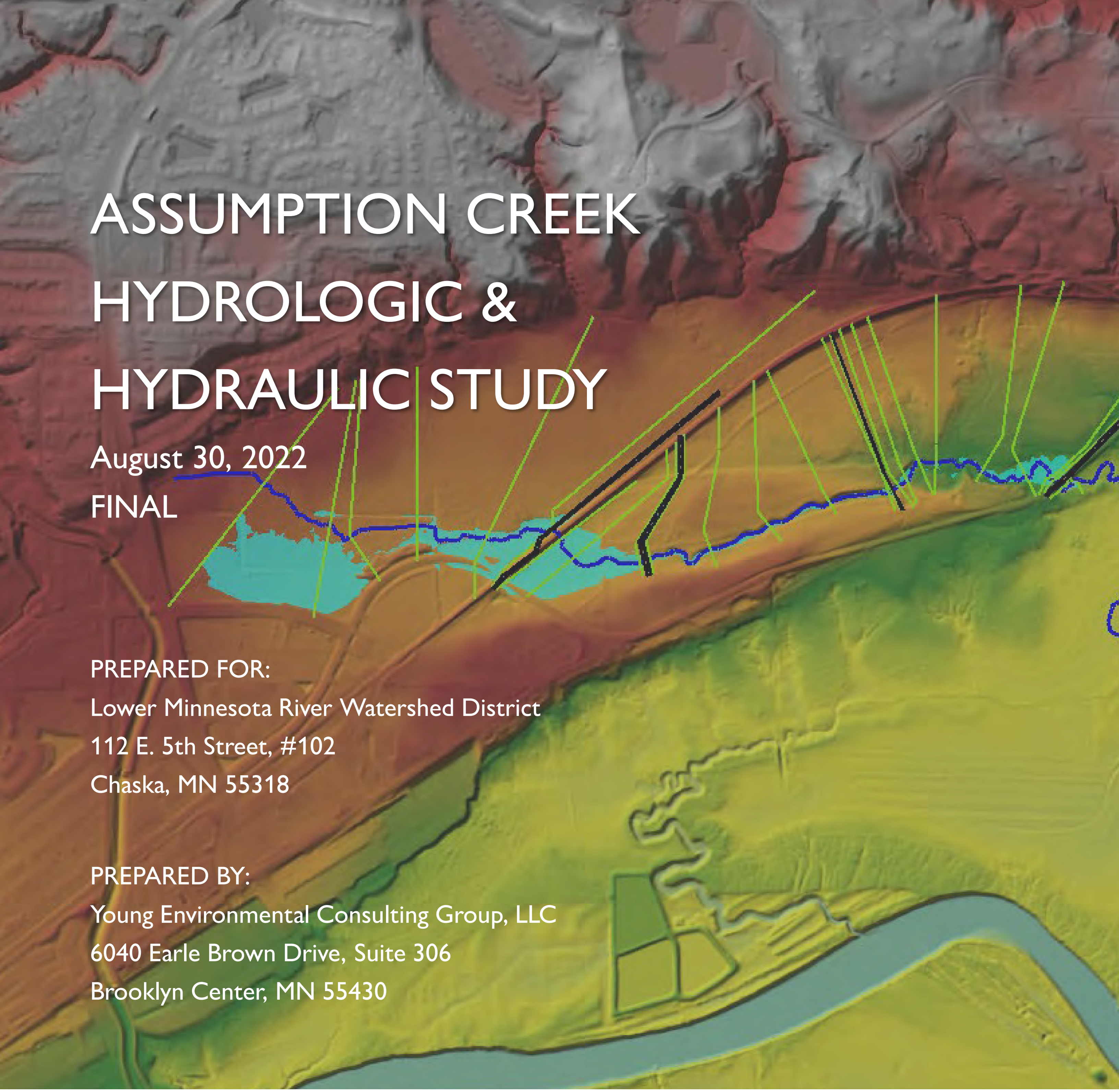

ASSUMPTION CREEK HYDROLOGIC & HYDRAULIC STUDY

August 30, 2022

FINAL

PREPARED FOR:

Lower Minnesota River Watershed District

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LOWER MINNESOTA RIVER
WATERSHED DISTRICT

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LIST OF ABBREVIATIONS

Abbreviation	Term, Phrase, or Name
DEM	Digital Elevation Map
HSG	Hydrologic Soil Group
HECRAS	Hydrologic Engineering Centers River Analysis System
LiDAR	Light Detection and Ranging
LMRWD	Lower Minnesota River Watershed District
MCES	Minnesota Council Environmental Services
MDH	Minnesota Department of Health
MnDNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
MSL	Mean Sea Level
NRCS	Natural Resources Conservation Service
SFWC	Seminary Fen Wetland Complex
USGS	United States Geological Survey
Young Environmental	Young Environmental Consulting Group, LLC

EXECUTIVE SUMMARY

Assumption Creek is a designated trout stream located in the Lower Minnesota River Watershed District (LMRWD). The hydrology of Assumption Creek is closely connected to the Seminary Fen Wetland Complex (SFWC) that surrounds and provides cold-water discharge to the upper reaches of the creek. As part of the LMRWD's 2018–2027 Watershed Management Plan, LMRWD identified the Assumption Creek Hydrology Restoration Project as a capital improvement project aimed at evaluating the opportunities available to resupply the groundwater hydrology to the creek (LMRWD, 2018). This report is a summary of the surface water hydrologic analysis completed for Assumption Creek and supplements several other management and monitoring efforts the watershed district has completed. Barr Engineering completed a complementary hydrogeology analysis in April 2022 to accompany this report (Wuolo, Evenocheck, & Christianson, 2022).

Assumption Creek is a small tributary to the Minnesota River and is unique because it lies entirely within the LMRWD's boundary. The Minnesota Department of Natural Resources (MnDNR) has identified it as a fishable trout stream; however, no trout have been found in the creek since 2002 (Berg, 2019). The drainage area is relatively small. The upper portions of the watershed are located on the bluffs of the Minnesota River, and the southern portions are nestled within the floodplain of the Minnesota River. Wetlands dominate the floodplain of the creek between the base of the bluffs and the abandoned railroad (Southwest Regional Trail). Downstream of the railroad, the banks of the creek are lined with wooded areas and some agricultural land. Hydrologic Soil Group (HSG) B is the primary soil type within the watershed, although HSG A, C, and D are also present.

Altered hydrology has played a significant role in the degradation of the creek. The first major development in this watershed was the construction of the Minneapolis and St. Louis Railway in 1870. Agriculture had become the dominant land use for fields within the watershed by 1937. Residential development began after the 1960s, primarily in the northwestern corner of the watershed. Currently, large tracts of land remain undeveloped; however, it is predicted that these open spaces will be developed as low-density residential areas. Agricultural fields that once dominated the landscape will make up less than 10% of the land use by 2050. Additionally, climate change in the form of intense, heavy precipitation events will continue to impact the watershed.

The viability of Assumption Creek as a trout stream is highly dependent on the quality of the water and habitat. Although the creek has not been designated as severely degraded in terms of water quality or geomorphology, there are indications of the steady degradation of the creek's ecosystem. These include loss of trout species within the creek, formation of mid-channel bars, heavy sedimentation in the upper reaches, and slight entrenchment.

Young Environmental Consulting Group LLC (Young Environmental) conducted hydraulic and hydrologic modeling to provide a quantitative perspective on the hydrologic changes that are occurring within the watershed. We used HydroCAD for the hydrologic modeling and HECRAS for the hydraulic modeling. We modeled three scenarios —presettlement, existing, and future conditions—and adjusted rainfall depths and curve numbers to account for the differences among these three conditions. The results showed an increase in the volume and rate of surface water runoff. Although the creek appears to be drying up in places, this is most likely caused by the rerouting of the drainage rather than the lack of runoff volume. The upper reaches of the creek may be losing inflow, but downstream of the Southwest Regional Trail, higher discharges are predicted to enter the creek. The stability of the creek is at risk, and, without mitigation, Assumption Creek will likely see continued degradation, particularly downstream of the railroad.

Further investigation and collaboration are needed to gain a better understanding of the interactions between surface water hydrology and hydrogeology of the Assumption Creek watershed. More data are required before we can make a recommendation on how to restore Assumption Creek as a viable trout stream. Our current recommendations include:

1. We recommend a completing a sediment transport analysis to help inform sediment competence and capacity of the creek and to determine stability.
2. We recommend developing hydrologic and hydraulic models near High Value Resource Areas (HVRAs) to improve the LMRWD's understanding of the interconnection of natural resources within the district, and aid in the monitoring and management of HVRAs.

1.0 INTRODUCTION

Assumption Creek, a designated trout stream, is a tributary of the Minnesota River and encompasses a drainage area of approximately two square miles within the southwestern suburbs of Minneapolis. The western portion of the watershed is in the city of Chaska, and the eastern portion is in the city of Chanhassen. The first 0.7 miles of the creek flow through the SFWC before passing under the abandoned Minneapolis and St. Louis railroad that has been repurposed as part of the Southwest Regional Trail system. The creek continues easterly until it crosses Flying Cloud Drive and enters the Minnesota River floodplain. A map of the creek's watershed is shown in Figure 1. Identified by the Minnesota Department of Natural Resources (MnDNR) as M–55–17, and the Minnesota Pollution Control Agency (MPCA) as Assessment Unit 07020012–582, the creek is an important cold-water resource of the LMRWD.

This hydrology study is part of a larger effort by the LMRWD to understand and guide the management of natural resources in the lower Minnesota River watershed. Related publications are the Fens Sustainability Gaps Analysis–Carver, Dakota, and Scott Counties, Minnesota (Young, 2021); Geomorphic and Habitat Assessments of Trout Streams in the Lower Minnesota River Watershed District Technical Memorandum (Berg, 2019); Trout Streams Gaps Analysis and Management Plan (Young, 2022); and a companion gaps analysis that Young Environmental is preparing that evaluates a management plan for the Assumption Creek watershed. The management and protection of Assumption Creek will likely be coordinated with the management plan for SFWC.

1.1 Purpose and Scope

The purpose of this report is to review the hydrology of Assumption Creek as it relates to The Assumption Creek Hydrology Restoration Project that was included in the LMRWD's 2018–2027 Watershed Management Plan as a capital improvement project. Although Assumption Creek is part of a larger hydrologic system that is largely dependent on the sustained discharge of cold groundwater, the primary focus of this report will be on surface water hydrology and its effects on the creek. This report will complement a hydrogeology analysis conducted by Barr Engineering in April 2022.

1.2 Data Available

Data and other information used in this report were obtained from a variety of sources. Spatial data such as light detection and ranging (LiDAR), land use, and aerial imagery were available publicly through the state of Minnesota. HydroCAD models were requested from the cities of Chanhassen and Chaska. A significant amount of background information was collected from the companion gaps analysis for the Assumption Creek watershed that is being completed by Young Environmental. A data matrix that compiles all the data and resources collected for this report is included as Attachment 1.

2.0 ASSUMPTION CREEK WATERSHED

Several watershed characteristics affect surface runoff, including drainage area size, topography, vegetation, land use, and soil type (Water Science School, 2018). Depressional areas such as ponds, lakes, reservoirs, and wetlands can also alter the rate and volume of runoff within a watershed. Section 2 describes the current characteristics of the Assumption Creek watershed.

2.1 Drainage Area

The existing drainage area for Assumption Creek is approximately two square miles, located mainly in the city of Chaska and partially in the city of Chanhassen. The northern part of the drainage area is situated on the bluffs of the Minnesota River. The land quickly transitions to the Minnesota River floodplain through steep slopes and ravines that carry runoff south. A digital elevation map (DEM) of the drainage area, created from LiDAR collected in 2011, is shown in Figure 2 (NRCS, 2011). Runoff from the northern part of the watershed most likely infiltrates in the wetlands at the base of the bluffs, which are covered by shrub wetland, hardwood wetland, and shallow marsh (MnDNR, 2022). Given that Assumption Creek flows from west to east, most of the runoff (surface and subsurface) will be intercepted by the creek as it flows to the Minnesota River. A wetland map in relation to the creek is shown in Figure 3. The SFWC is designated as a calcareous fen and is protected as a high value resource area by the LMRWD.

2.2 Land Use

A large portion of the Assumption Creek watershed is affected by urban development. Much of the area on the bluff has been developed as residential property. Based on the most recent land use data provided by the Metropolitan Council in 2016, the western side is dominated by typical suburban residential lots, whereas the eastern side is dominated by large rural residential lots. The land use transitions to agriculture and recreational parkland, as well as undeveloped land, in the southern half of the watershed. Table 1 summarizes the current land use, and Figure 4 shows the current land use in a map of the Assumption Creek watershed.

Table 1. Land Use Classification Based on Metropolitan Council Data from 2016

Land use	Area (Acres)	Percentage
Agriculture	121	10.5%
Park, recreational, preserve	337	29.2%
Single family detached	264	22.9%
Undeveloped	376	32.6%
Other*	57	4.9%

*Includes industrial, institutional, open water, commercial, farmstead, and golf course

2.3 Soils

Soil type directly affects surface runoff potential. Sandy soils have high infiltration rates and effectively capture rainfall before it can flow downstream over the surface. Clay soils, however, have extremely low infiltration rates and are unable to reduce surface runoff as efficiently. The NRCS developed four hydrologic soil groups (HSG)—A, B, C, and D—to help characterize the infiltration rates of soils based on their minimum infiltration rate, which is obtained for bare soil after prolonged wetting (NRCS, 1986). Soils with an HSG of A generally have low runoff potential and high infiltration capacity (sandy soils). Soils with an HSG of D have the highest runoff potential and lowest infiltration capacity (clay soils). Table 2 summarizes the soil types that are found in the Assumption Creek watershed and their corresponding HSG classification.

Table 2. Assumption Creek Watershed Soil Types

Map Unit Name	Map Unit Symbol	HSG	Percentage of the Watershed
Alluvial land, frequent overflow, 0 to 6 percent slopes	Ab	A	17.5%
Hawick loamy sand, 20 to 40 percent slopes	AE	A	
Estherville sandy loam, 2 to 6 percent slopes	EB	A	
Estherville-Hawick sandy loams, 6 to 12 percent slopes	HC	A	
Estherville-Hawick sandy loams, 6 to 12 percent slopes, eroded	HC2	A	
Estherville-Hawick sandy loams, 12 to 18 percent slopes	HD	A	
Sparta loamy sand, 0 to 2 percent slopes	PA	A	
Sparta loamy sand, 2 to 6 percent slopes	PB	A	
Sparta loamy sand, 6 to 12 percent slopes	PC	A	
Rasset-Lester-Kilkenny complex, 12 to 18 percent slopes	YD	A	
Rasset-Lester-Kilkenny complex, 18 to 25 percent slopes	YE	A	
Lester-Kilkenny loams, 2 to 6 percent slopes, eroded	KB2	B	39.7%
Lester-Kilkenny loams, 6 to 12 percent slopes	KC	B	
Lester-Kilkenny loams, 12 to 18 percent slopes	KD	B	
Minneiska-Kalmarville complex, frequently flooded	KM	B	
Minneiska loam	MN	B	
Terril loam, 2 to 6 percent slopes	TB	B	
Terril loam, 6 to 12 percent slopes	TC	B	
Aastad clay loam, 1 to 3 percent slopes	AaA	C	16.6%
Lester-Kilkenny complex, 6 to 10 percent slopes, moderately eroded	KC2	C	
Lester-Kilkenny complex, 10 to 16 percent slopes, moderately eroded	KD2	C	
Lester-Kilkenny complex, 16 to 22 percent slopes	KE2	C	
Lester-Kilkenny complex, 22 to 40 percent slopes	KF	C	
Blue Earth mucky silt loam	BH	D	26.2%
Chaska loam, occasionally flooded	CH	D	
Glencoe clay loam, 0 to 1 percent slopes	GL	D	
Hamel loam, 0 to 2 percent slopes	HM	D	
Kilkenny-Lester loams, 2 to 6 percent slopes	KB	D	
Oshawa silty clay loam	OS	D	
Klossner muck, 0 to 1 percent slopes	PM	D	

Figure 5 shows the watershed symbolized by HSG. It is important to note that soil type only plays a role in runoff potential for pervious areas, and the runoff potential of a subcatchment cannot be determined solely from the hydrologic soil group. For example, the northwestern corner of the watershed is largely classified as HSG A. However, this corner has been developed into residential neighborhoods and has a significant amount of impervious area that will lead to an increase in runoff. Similarly, a large portion of the Minnesota River floodplain is classified as HSG D. However, this area is dominated by wetlands with depressions and thick vegetation that may lead to a decrease in runoff because of its higher storage capacity.

3.0 ALTERED HYDROLOGY

Altered hydrology is a term used to describe a change or deviation in the hydrologic conditions of a watershed from a preferred or benchmark condition (Houston Engineering, Inc., 2017). The benchmark condition for the Assumption Creek watershed is defined as presettlement conditions, or before human activities began affecting the interactions between the surface water and the groundwater and ultimately the ecosystem of the creek. The Assumption Creek Gaps Analysis report provides a detailed history and analysis of the watershed setting, land use, and water quality. This section highlights the watershed changes in terms of their altered hydrology.

3.1 Land Use Changes

3.1.1 Historic Land Use

Presettlement, the Assumption Creek watershed was dominated by Big woods—hardwoods, river bottom forest, and wet prairie—according to data collected by the MnDNR. Presettlement land use is shown in Figure 6, and the breakdown of area is summarized in Table 3.

Table 3. Historic Land Use Based on Marschner's Vegetation Analysis

Land Use	Area (Acres)	Percentage
Big woods—hardwoods (oak, maple, basswood, hickory)	953	68.0%
Oak openings and barrens	24	1.7%
River bottom forest	208	14.8%
Wet prairie	216	15.4%

This data is based on vegetation mapping completed by Francis J. Marschner using the Public Land Survey bearing tree data. It provides valuable information about how this area looked at the time of European settlement between 1848 and 1907 (MnDNR, 2022). By 1907, there was evidence of development in this area, including the construction of the Minneapolis and St. Louis railroad, which cuts directly through the Assumption Creek watershed. A road aligned much like today's Flying Cloud Drive is also present by 1907, adding a second crossing of Assumption Creek.

Construction of the railroad and agricultural expansion were the first anthropogenic alterations to the landscape that potentially influenced the rate of runoff and erosion of Assumption Creek. Aerial photos from the University of Minnesota's Minnesota Historic Aerial Photographs Online (MHAPO) website show that in 1937, agricultural fields dominated the bluffs area, with some forested areas concentrated along the ravines at the transition between the bluffs and the floodplain (Figure 7; University of Minnesota, 2015). The location of agricultural land seems to correlate with the areas with well-drained soils (HSG A and B). The aerial photos show minimal change between 1937, 1951, and 1963; however, drainage swales are more evident in the 1951 and 1963 imagery shown in Figure 8, indicating that a concentration of flows was occurring in the watershed. This concentration was most likely caused by increased runoff from the agricultural land. Evidence of drain tile in the landscape is most noticeable in the 1951 imagery. Residential and urban development did not occur until after 1963. The next available imagery in 1997 shows development of the residential area in the northwestern corner of the watershed as well as large residential lots scattered across other parts of the watershed.

In summary, land use within the Assumption Creek watershed has shifted from hardwood forests and wet prairie to agriculture and finally to residential development, causing an increase in surface water runoff. Based on our review of the data, we made several assumptions regarding surface water runoff within the watershed. An increase in impervious area prevents precipitation from infiltrating. Historically, according to land use, it appears that runoff coming from the bluffs would recharge the groundwater table at the base of the bluffs in the wetlands and then discharge to Assumption Creek as cold groundwater. Currently, surface runoff from impervious areas on the bluffs is now routed via storm sewers away from the upper reaches of Assumption Creek. When the runoff does reach the creek, it carries excessive sediment and other pollutants with it. Without its steady inflow of groundwater, the creek does not have sufficient discharge to transport larger sediment particles, and it eventually aggrades in the channel. Although this report is primarily focused on surface water, it is important to note that without the ability to recharge groundwater through infiltration, the hydrology of this system will remain unstable and continue to cause degradation of the creek. Solutions should account for disturbances to the surface water as well as the groundwater.

3.1.2 Future Land Use

Figure 9 shows the Metropolitan Council's planned (2050) land use for the Assumption Creek watershed, and Table 4 summarizes the areas.

Table 4. Future Land Use Based on Metropolitan Council's Planned Land Use (2050)

Land Use	Area (Acres)	Percentage
Low-density residential	493	42.7%
Medium-density residential	91	7.9%
Park and open space	358	31.0%
Agriculture	98	8.5%
Other*	115	10.0%

*Includes right-of-way, public, industrial, commercial, and office

Most of the area that is considered undeveloped will be converted to low- and medium-density residential properties. Parks and preserve areas will remain unchanged. Most of the development is planned to occur within areas dominated by HSG B soils, which means there will be fewer opportunities for precipitation to infiltrate. Although commercial and retail development usually go hand in hand with urbanization, only a very small percentage of the watershed is designated for that use. With the addition of impervious areas, the Assumption Creek watershed can expect another increase in surface water runoff if not mitigated appropriately.

3.2 Climate

Climate encompasses a range of factors, but precipitation is the most important in terms of hydrology. Appendix D of the Fens Sustainability Gaps Analysis (Young, 2020) provides a detailed review of the past, present, and projected climate trends in the LMRWD. In summary, it is projected that intense and heavy precipitation events (which are occurring more frequently in the LMRWD) are expected to increase in the future. Additionally, annual precipitation volumes are increasing, and spring snowmelt is occurring earlier. Volume of runoff and intensity of precipitation play a significant role in altered hydrology. When rain or spring runoff occurs at a rate that is higher than the capacity of the stormwater management systems or the infiltration capacity of the pervious areas, the result is an increase in untreated overland flow. Although Assumption Creek is periodically drying up, the creek requires a constant inflow of cold groundwater in contrast to quick, intense bursts of contaminated overland flow.

The Minnesota River is experiencing higher flood levels caused by altered hydrology within its own watershed. More frequent flooding of the downstream reach of Assumption Creek is likely to occur, disturbing the geomorphology and habitat of the creek and shortening the viable length of restorable trout stream. Changes in the projected climate will play an important role in determining a resilient solution for Assumption Creek.

3.3 Creek Geomorphic Characteristics

A geomorphological assessment conducted during the summer of 2019 identified the western reaches of the creek as Type A5/6 and E5/6 because of the entrenchment and the large amount of silt and sand observed in the creek bottom (Berg, 2019). The assessment indicated that the creek was often dry and not hydraulically connected to the eastern reach that crosses Flying Cloud Drive. In the uppermost reaches of the creek, the sinuosity decreases, and there is a buildup of sand and heavy silt or muck. The assessment identified the eastern reaches as Type E4/5 because of the entrenchment and low width-to-depth ratio. Midchannel bars were observed in this reach. Most of the eastern reach downstream of Flying Cloud Drive was inaccessible because of flooding from the Minnesota River.

Currently, there are no indicators of severe geomorphic degradation within Assumption Creek; however, the health of the watershed is not headed in the right direction to once again support a cold-water fishery. The western reaches are drying up due to a lack of groundwater inflow, whereas the eastern reaches are more frequently inundated by the Minnesota River due to increased surface water runoff. As the watershed continues to be developed, the increase in impervious area will lead to a concentration of surface runoff. That runoff, combined with more intense and heavy precipitation, has the potential to disrupt the balance of Assumption Creek and lead to more severe entrenchment, predominantly in the upper reaches where there is a lack of sinuosity. Simultaneously, there is evidence of sedimentation caused by an increase in overland surface runoff bringing sediment with it from the upstream watershed. Sedimentation reduces the diversity of substrate, particularly gravel substrate. The temperature of overland surface water inflow is higher than groundwater, potentially raising the water temperature of the creek beyond what is considered healthy for a designated trout stream.

Although the immediate condition of Assumption Creek is not currently classified as severely degraded, the predicted land use and climate changes will continue to negatively affect the ecological and geomorphological health of the creek.

4.0 MODELING

Hydraulic and hydrologic modeling of Assumption Creek and its watershed provides a quantitative perspective on the hydrologic changes that are occurring. We made several assumptions throughout the modeling effort and discuss them in this section. The current modeling exclusively considers surface water hydrology; however, we know that groundwater hydrology has a significant impact on the creek as well. The surface water hydrologic analysis should be supplemented with a groundwater analysis to draw the most accurate conclusions and to provide feasible solutions to the LMRWD.

4.1 Hydrology

As part of their surface water management plans, the cities of Chaska and Chanhassen developed HydroCAD models that include portions of the watershed. Chaska contains the watershed upstream of the Southwest Regional Trail, while Chanhassen's model contains the eastern portions of the watershed as well as the area downstream of the railroad. These model outputs were analyzed together to describe the flows discharging to Assumption Creek. There were discrepancies between the subcatchments used in the two models. We addressed these discrepancies by choosing the subcatchments from each model that best represented the current delineated watershed. We verified drainage areas for the chosen subcatchments. We reviewed time of concentrations at a high level and determined that they did not require modifications for this level of analysis because the major land use changes that will occur between existing and future conditions will not significantly affect time of concentration values. However, for consistency with our hydrologic analysis, we modified the subcatchment curve numbers to align with the land use and soil analysis that we completed for the watershed (as discussed in Section 3.1).

We modeled presettlement, existing, and future conditions and used the Soil Conservation Service (SCS) Curve Number (CN) method to estimate runoff as a function of cumulative precipitation, soil cover, and land use (NRCS, 2019). We estimated precipitation depths for presettlement conditions by using Technical Paper 40 (TP-40) developed by the National Oceanic and Atmospheric Administration (NOAA) in 1961. In 2014, NOAA released Atlas 14 precipitation frequency estimates based on more comprehensive data and analysis. Volume 8 Version 2.0 is for Midwestern States, including Minnesota (Perica, et al., 2013). Future precipitation depths were estimated based on a study completed by the University of Minnesota. The study utilized global climate change projections and NOAA Atlas 14 estimation methods to predict precipitation depths at the end of the century (2080–2099) assuming high emissions. Grid-level data for the entire state of Minnesota were produced, providing the percent change from modeled historic depths to modeled future depths. These precent changes were applied to the current NOAA Atlas 14 rainfall depths to estimate future conditions rainfall depths. Table 5 summarizes the precipitation frequency estimates used for all three scenarios for the 2-year, 10-year, and 100-year return periods.

Table 5. Precipitation Frequency Estimates for Modeling

Return Period (24-hr)	TP-40 Rainfall Depths (inches)	Percent Change from TP40 to Atlas 14	NOAA Atlas 14 Rainfall Depths (inches)	Percent Change from Atlas 14 to Future	Future Conditions Rainfall Depths (inches)
2-year	2.8	+2.1%	2.86	19%	3.40
10-year	4.2	+1.1%	4.25	12%	4.77
100-year	6	+22.8%	7.37	10%	8.10

The SCS CN method utilizes CNs to characterize the runoff properties for a particular ground cover and HSG soil type. Attachment 2 summarizes CN's associated with various combinations of land use and soil type used to determine the CNs of each watershed for the three modeling scenarios. Tables 6–8 summarize the CNs used for the three modeling scenarios. The curve numbers are weighted for each watershed and include the impervious areas. There is no direct comparison for the presettlement to existing and future conditions because of the drastic changes in subcatchment boundaries. However, when comparing the weighted curve number for the entire Assumption Creek watershed, there is a 16% increase from presettlement conditions to existing conditions and a 5% increase from existing to proposed conditions.

Table 6. Presettlement Curve Numbers for HydroCAD Subcatchments

Subcatchment	Area (acres)	Presettlement CN
6S	70.2	46
7S	562.1	64
8S	367.6	60
9S	402.4	68
Assumption Creek watershed	**1402.3**	**63**

Table 7. Existing Curve Numbers for HydroCAD Subcatchments

Subcatchment	Area (acres)	Existing CN
1.20.3	1.8	65
10	46.5	57
10.1	14.2	60
11.1	93.4	72
11.2	7.9	80
11.3a	10.4	55
11.3b	26.1	56
8	10.5	80
8.1	8.4	77
8.2	10.8	77
8.3	17.4	70
LOM 1	117.6	73
LOM 1-1	157.9	66
LOM 2	82.9	80
LOM 2-1	143	84
LOM 3-4	4.2	69
LOM 4-1	29.8	70
Seminary	384.4	74
Assumption Creek watershed	**1167.1**	**73**

Table 8. Future Curve Numbers for HydroCAD Subcatchments

Subcatchment	Area (acres)	Future CN
1.20.3	1.8	86
10	46.5	57
10.1	14.2	60
11.1	93.4	78
11.2	7.9	80
11.3a	10.4	55
11.3b	26.1	56
8	10.5	80
8.1	8.4	77
8.2	10.8	77
8.3	17.4	70
LOM 1-1	117.6	77
LOM 1-2	157.9	77
LOM 1-3	82.9	81
LOM 1-5	143	86
LOM 1-6	4.2	70

Subcatchment	Area (acres)	Future CN
LOM 1-7	29.8	78
LOM 2-2	384.4	77
LOM 2-3	1.8	86
Seminary	46.5	57
Assumption Creek watershed	**1167.1**	**77**

As mentioned, climate change is causing increases in not only the volume of precipitation but also the intensity of rainfall. This increase is modeled as a synthetic rainfall distribution, which includes maximum rainfall intensities arranged in a sequence that produces peak discharges (NRCS, 1986). The SCS Type II distribution is used for the presettlement scenario. The NRCS developed design rainfall distributions for the Midwest and Southeast United States, referred to as Midwest and Southeast (MSE) 1 through MSE 6 (Merkel & Moody, 2015). MSE 3 is widely accepted around the state of Minnesota. The MSE 3 is more intense than SCS Type II in that it concentrates a larger volume of precipitation toward the middle of the storm. The existing and future conditions HydroCAD models use the MSE 3 rainfall distribution.

4.2 Hydraulics

For this study, we used Hydraulic Engineering Center–River Analysis System (HEC–RAS) modeling software, package version 6.2. We incorporated bathymetry data from the 2019 geomorphic assessment and 2022 survey collection to develop the 1D HEC–RAS model. The channel of the creek is represented by survey data, while the overbanks are represented by LiDAR. We surveyed 11 cross sections as part of the geomorphic assessment project: five in the western reach and six in the eastern reach. In 2022, Young Environmental partnered with Barr Engineering to survey 13 additional cross sections along with three culvert crossings. A degraded historic dam was also surveyed and included in the model. The outlet of the model is located just downstream of Flying Cloud Drive. The model extends upstream for approximately 1.5 river miles. We delineated the centerline of the creek based on LiDAR collected in 2009 and aerial imagery from 2016. We used Manning's *N* values to represent the roughness coefficients of the channel. A typical Manning's *N* for channels is 0.035, which is used for the creek channel. A typical Manning's *N* for overbank areas dominated by grassland and agriculture is 0.05. The Manning's *N* values were adjusted for the presettlement conditions by assuming the vegetation, sinuosity, and substrate diversity would be greater. We used a channel Manning's *N* value of 0.055. We also assumed the overbanks would consist of thicker vegetation and forested wetland characteristics and increased the Manning's N value to 0.085. For future conditions, we reduced the Manning's N value of the channel to 0.03 to simulate continued erosion of the channel but maintained the Manning's N value of the overbanks because the land use surrounding the HEC–RAS cross sections is park area and will not change in the future.

Figure 10 shows the HEC–RAS geometry, inflow locations, and the model subcatchments. The inflow locations in Figure 10 represent the approximate locations in the creek where all the runoff from the corresponding subcatchment has drained to the creek. We chose to use a normal depth boundary condition on the Minnesota River, assuming there would be no coincident peak. The Assumption Creek watershed is relatively small and likely peaks long before the Minnesota River does, particularly for synthetic summer events like the ones we are modeling.

4.3 Results

4.3.1 Hydrology

The peak discharge results for the three scenarios are presented in Tables 9–11. It should be noted that the peak discharges shown do not account for routing in the river and are not cumulative.

Table 9. Assumption Creek Presettlement Conditions Peak Discharges

Discharge Location	2-Year (cfs)	10-Year (cfs)	100-Year (cfs)
Upper reaches of Assumption Creek	1	3	15
Assumption Creek between Southwest Regional Trail and Historic Dam	78	157	269
At Flying Cloud Drive	29	175	291

Table 10. Assumption Creek Existing Conditions Peak Discharges

Discharge Location	2-Year (cfs)	10-Year (cfs)	100-Year (cfs)
Upper reaches of Assumption Creek	3	18	62
Assumption Creek between Southwest Regional Trail and Historic Dam	294	350	482
At Flying Cloud Drive	152	384	518

Table 11. Assumption Creek Future Conditions Peak Discharges

Discharge Location	2-Year (cfs)	10-Year (cfs)	100-Year (cfs)
Upper reaches of Assumption Creek	21	87	244
Assumption Creek between Southwest Regional Trail and Historic Dam	682	874	1071
At Flying Cloud Drive	399	919	1110

Figure 11 shows the increasing trend of discharge within the watershed from presettlement to future conditions.

4.3.2 Hydraulics and Geomorphology

Based on preliminary modeling results, the maximum permissible shear stress and velocity for different channel materials is presented in Table 12 (Fischenich, 2001).

Table 12. Permissible Shear Stress and Velocity

Channel Material Type	Permissible Shear Stress (lb/sq.ft.)	Permissible Velocity (ft/sec)
Silty loam	0.02–0.03	1.5
Long native grasses	1.2 –1.7	4 - 6
Short native and bunch grass	0.7–0.95	3 - 4
Hardwood tree plantings	0.41–2.5	NA

Table 13 summarizes the velocity and shear stress of one western cross section and one eastern cross section for all three scenarios and indicates whether the channel would be stable given the assumed channel material.

Table 13. Channel Stability Based on Velocity and Shear Stress

		Presettlement Conditions			
		Western Cross Section (Long Native Grasses)		Eastern Cross Section (Hardwood Trees)	
Velocity	Return Period	Total Velocity	Stable	Total Velocity	Stable
	2-year	1.17	yes	2.91	yes
	10-year	1.19	yes	3.84	yes
	100-year	1.41	yes	4.59	yes
Shear Stress	Return Period	Total Shear	Stable	Total Shear	Stable
	2-year	0.14	yes	0.81	yes
	10-year	0.14	yes	1.21	yes
	100-year	0.19	yes	1.59	yes
		Existing Conditions			
		Western Cross Section (Short Native Grasses)		Eastern Cross Section (Short Native Grasses)	
Velocity	Return Period	Total Velocity	Stable	Total Velocity	Stable
	2-year	1.71	yes	5.38	no
	10-year	1.76	yes	5.71	no
	100-year	2.33	yes	6.21	no
Shear Stress	Return Period	Total Shear	Stable	Total Shear	Stable
	2-year	0.10	yes	0.79	yes
	10-year	0.13	yes	1.10	no
	100-year	0.20	yes	1.01	no
		Future Conditions			
		Western Cross Section (Silty Loam)		Eastern Cross Section (Silty Loam)	
Velocity	Return Period	Total Velocity	Stable	Total Velocity	Stable
	2-year	1.91	no	5.80	no
	10-year	2.46	no	7.29	no
	100-year	2.34	no	7.17	no
Shear Stress	Return Period	Total Shear	Stable	Total Shear	Stable
	2-year	0.11	no	0.88	no
	10-year	0.17	no	1.25	no
	100-year	0.17	no	0.99	no

The western (upstream) portion of the creek appears to be moderately stable according to the current hydraulic analysis. This may be due to the limited flow that the channel sees in this portion of the creek. The eastern (downstream) portions of the creek however are currently unstable and are expected to become less stable in the future due to the changing land use and increasing precipitation.

Hydrologic analysis indicates that surface runoff from the watershed is increasing; however, field observations indicate that portions of the creek dry up completely. According to current data, urban development in the northwestern part of the watershed has rerouted a large portion of the watershed that historically flowed down from the bluffs and slowly seeped into the SFWC. The runoff would flow toward Assumption Creek and enter the channel at several locations, providing a steady baseflow along the entire length of the creek from its headwaters to the railroad crossing. Storm sewers within the residential developments and a trail at the base of the bluffs have likely affected this. Runoff is rerouted to the east and then south toward Assumption Creek through two drainage paths where it ultimately enters the creek right before it crosses under the Southwest Regional Trail. Figure 12 outlines the assumed historic and existing drainage routes.

The 2019 geomorphic assessment identified the majority of Assumption Creek as a Type E stream. Stream stability is defined as "the ability of a stream to transport the water and sediment of its watershed in such a manner as to maintain its dimension, pattern, and profile, over time, without either aggrading or degrading" (Rosgen, 1996). Although Assumption Creek does not appear to be experiencing any significant degradation or erosion right now, several less obvious indicators, such as mid-channel bars and slight entrenchment, point to an unstable system. These developments combined with altered hydrology will inevitably cause instability within Assumption Creek, particularly downstream of the railroad. Photos taken during the 2022 survey collection provide a visual representation of the creek's geomorphic characteristics. The photos and a map showing the location of the photos are included in Figure 13.

5.0 RECOMMENDATIONS

Assumption Creek is a valuable natural resource in the LMRWD. Our hydrologic analysis is only a small portion of the overall investigation into the future of Assumption Creek as a viable trout stream. Based on the data we reviewed, we recommend the following management strategies for Assumption Creek:

1. Past investigations of the creek have noted the formation of midchannel bars and significant sediment aggradation in the creek, particularly in the upstream reaches. Thus, we recommend completing a sediment transport analysis to further our understanding of the movement of sediment within the watershed and the creek. Additional data are required to determine the sediment competence and capacity of the creek, including the size of bed and bar material, bed-load sediment transport, suspended sediment transport, and bankfull discharge measurements (NRCS, 2007).

2. The LMRWD has prioritized monitoring and protecting HVRAs within the district such as Seminary Fen and Assumption Creek. We recommend developing hydrologic and hydraulic models near HVRAs within the LMRWD to improve the LMRWD's understanding of the interconnection of natural resources within the district. Developing these models will provide the necessary data to make informed decisions regarding the management of HVRAs for future projects and permit reviews.

Table 12 summarizes these recommendations with an associated implementation year and estimated cost. The cost is a ballpark estimate that may need to be refined in the future depending on the workplan and the implementation plan.

Table 14. Implementation Cost Estimates

No.	Recommendation	Type	Year	Estimated Cost
1	Sediment transport analysis	Study	2023–2025	$200,000
2	Develop hydrologic and hydraulic models near HVRAs	Study/Modeling	2022–2024	$400,000

6.0 REFERENCES

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7.0 FIGURES

Figure 1: Assumption Creek Watershed Location

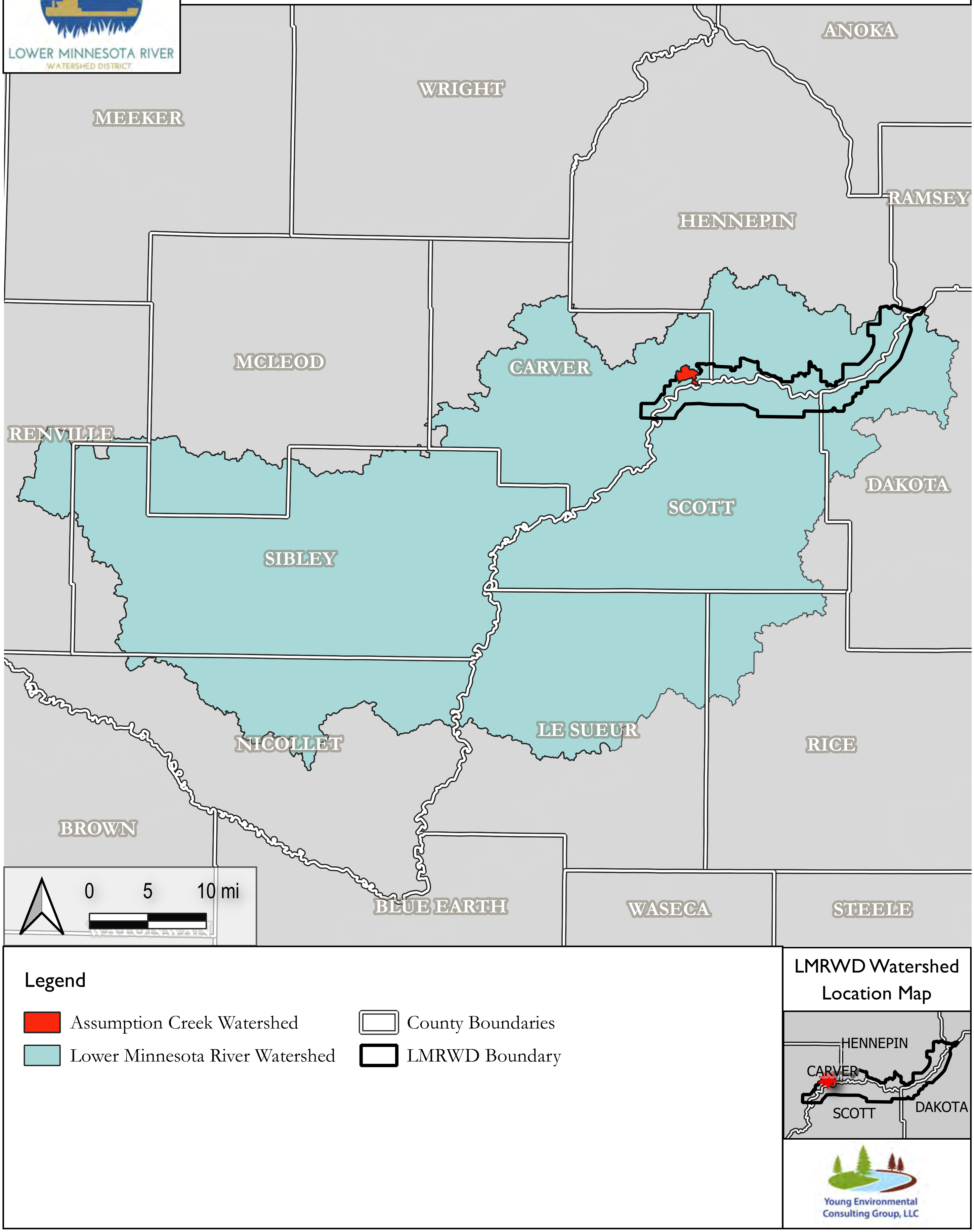


Figure 2: Watershed Digital Elevation Map

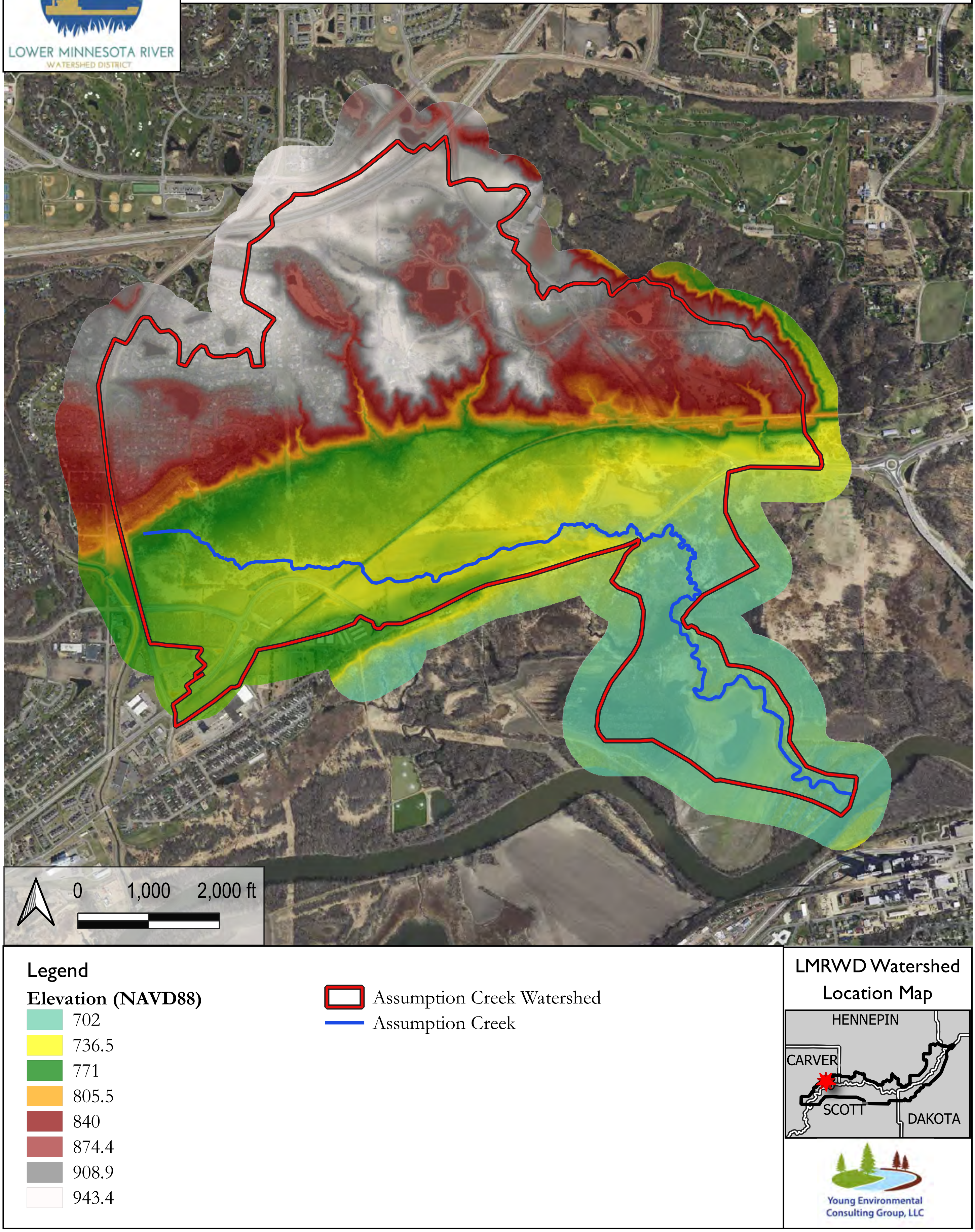
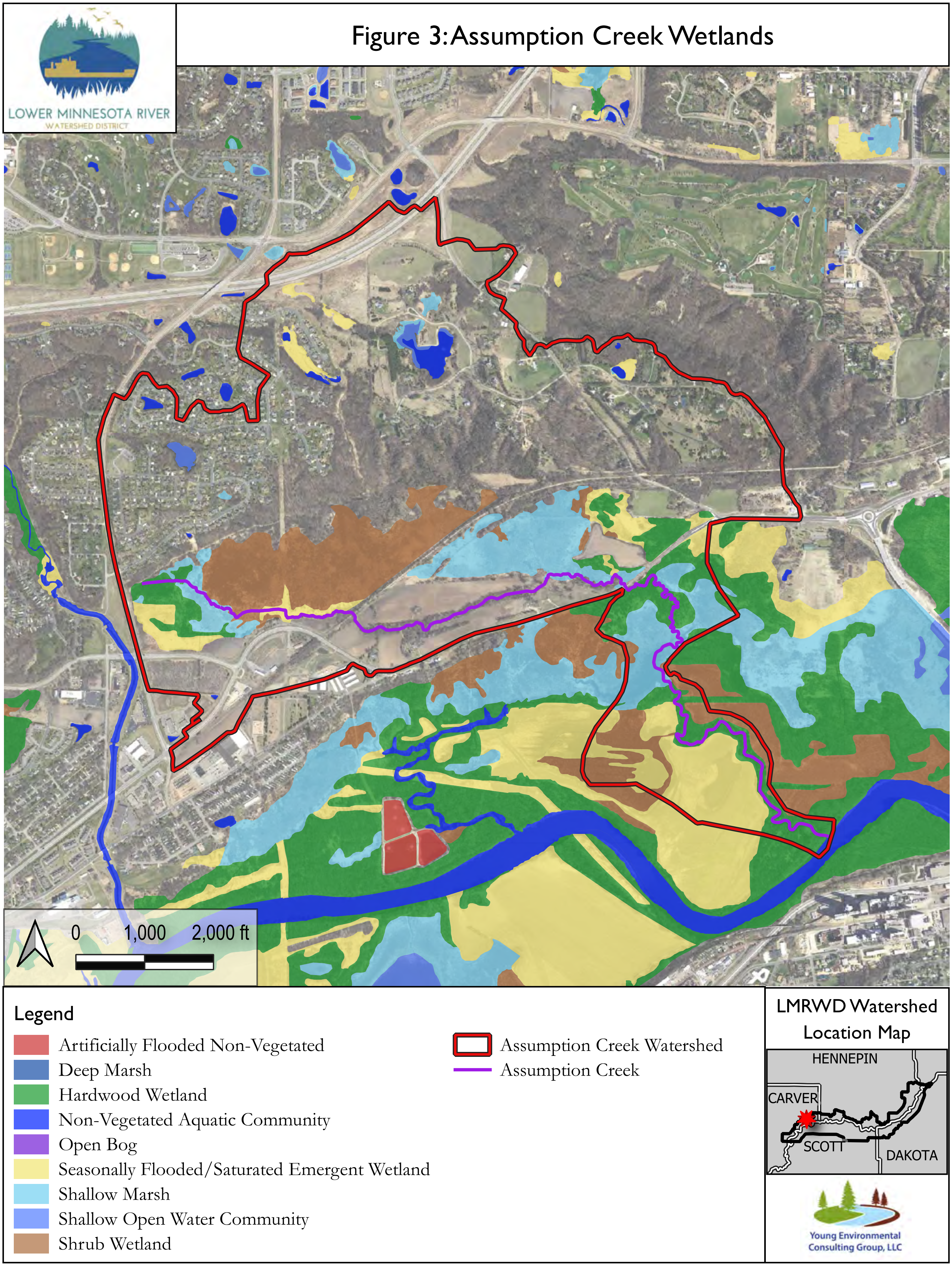
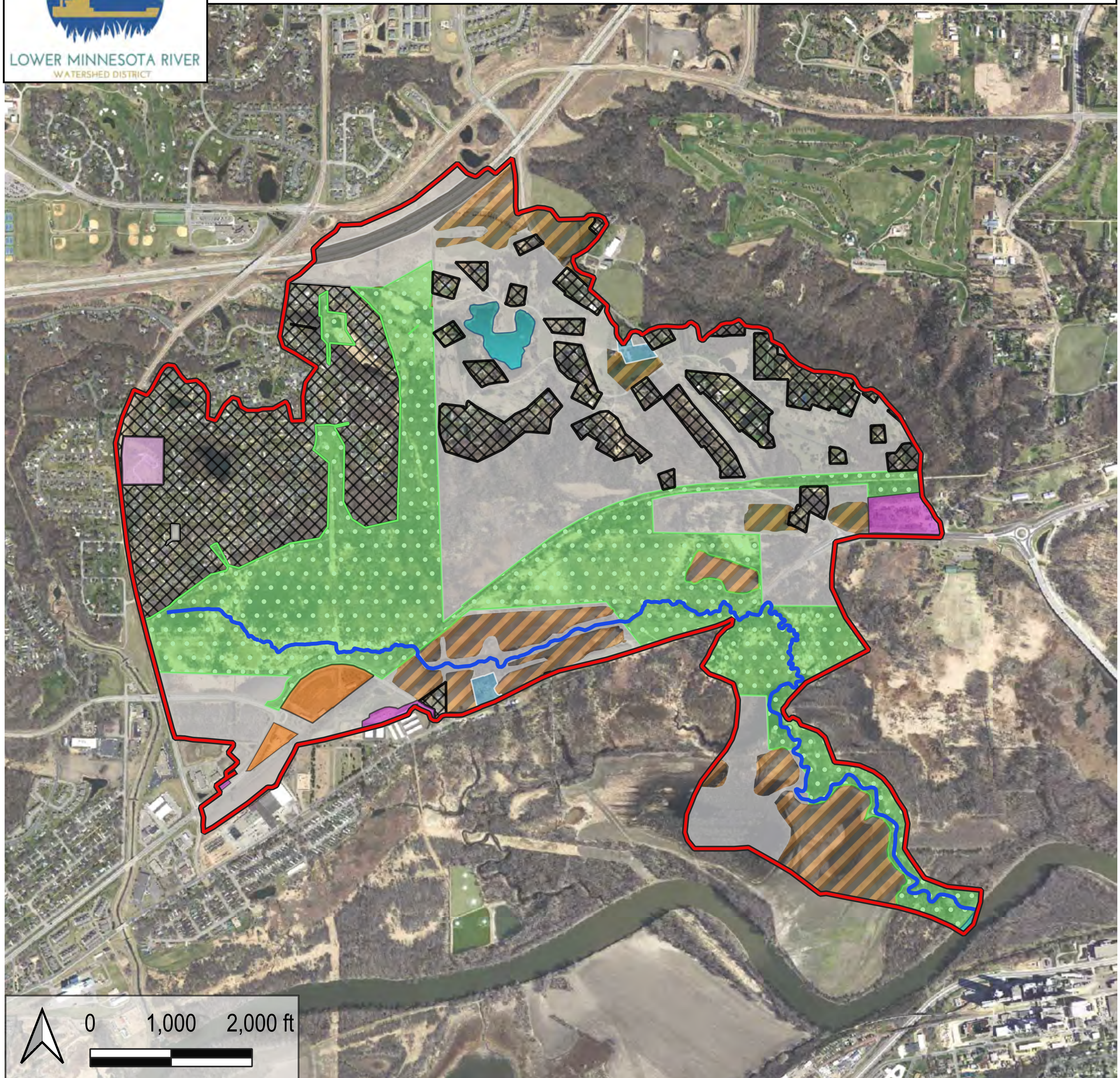


Figure 3: Assumption Creek Wetlands



LOWER MINNESOTA RIVER
WATERSHED DISTRICT

Figure 4: Assumption Creek Watershed Current Land Use (2016)



Legend

- Assumption Creek
- Assumption Creek Watershed

Land Use Type

- Agricultural
- Farmstead
- Golf Course
- Industrial and Utility
- Institutional
- Major Highway
- Open Water
- Park, Recreational, or Preserve
- Retail and Other Commercial
- Single Family Detached
- Undeveloped

LMRWD Watershed Location Map

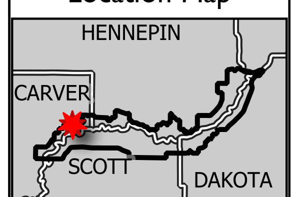


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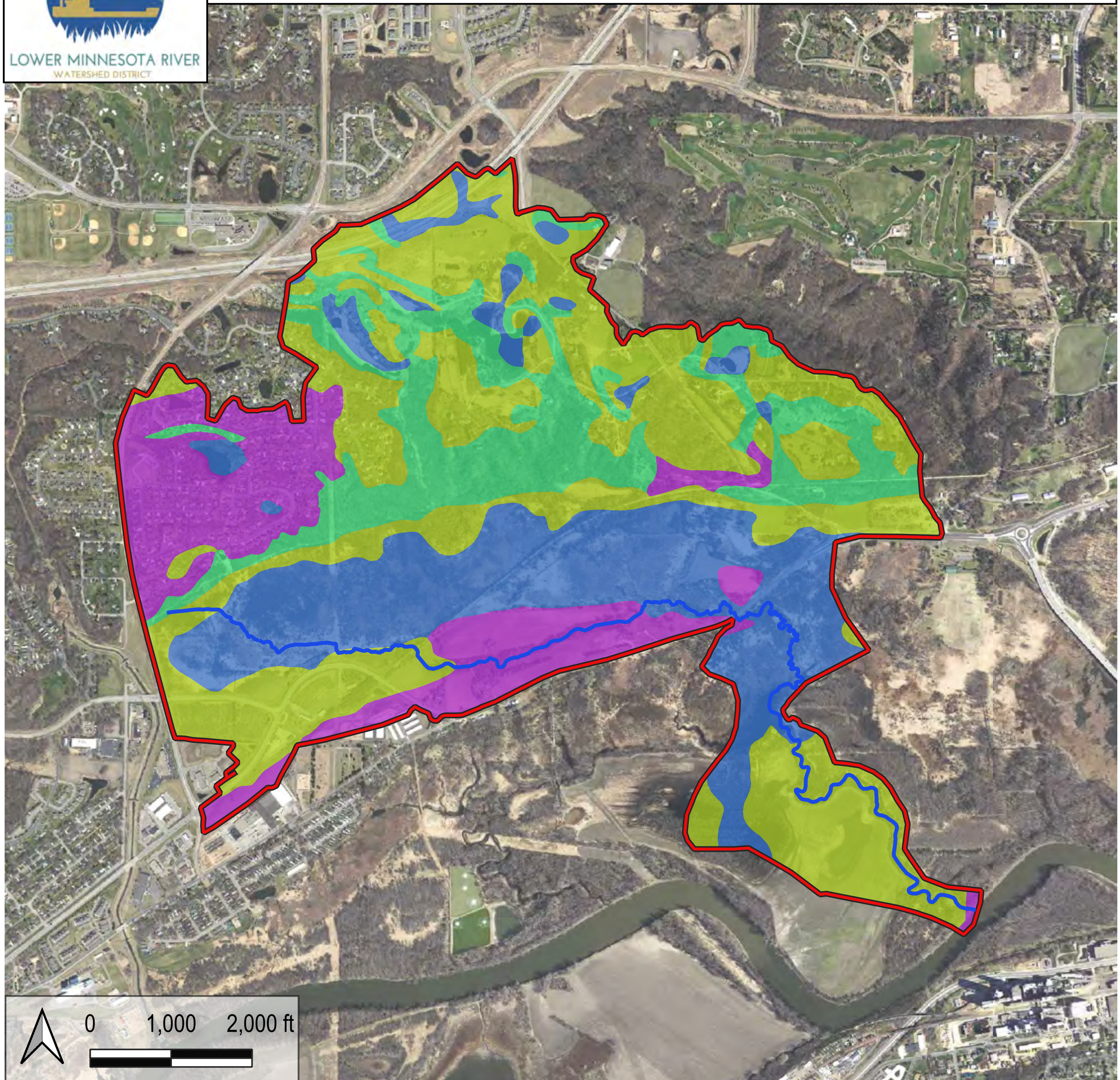
Figure 5: Assumption Creek Watershed Hydrologic Soil Groups



Legend

Hydrologic Soil Groups

- A (17.5%)
- B (39.7%)
- C (16.6%)
- D (26.2%)

Assumption Creek Watershed

Assumption Creek

LMRWD Watershed Location Map

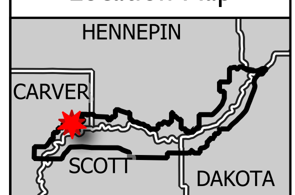


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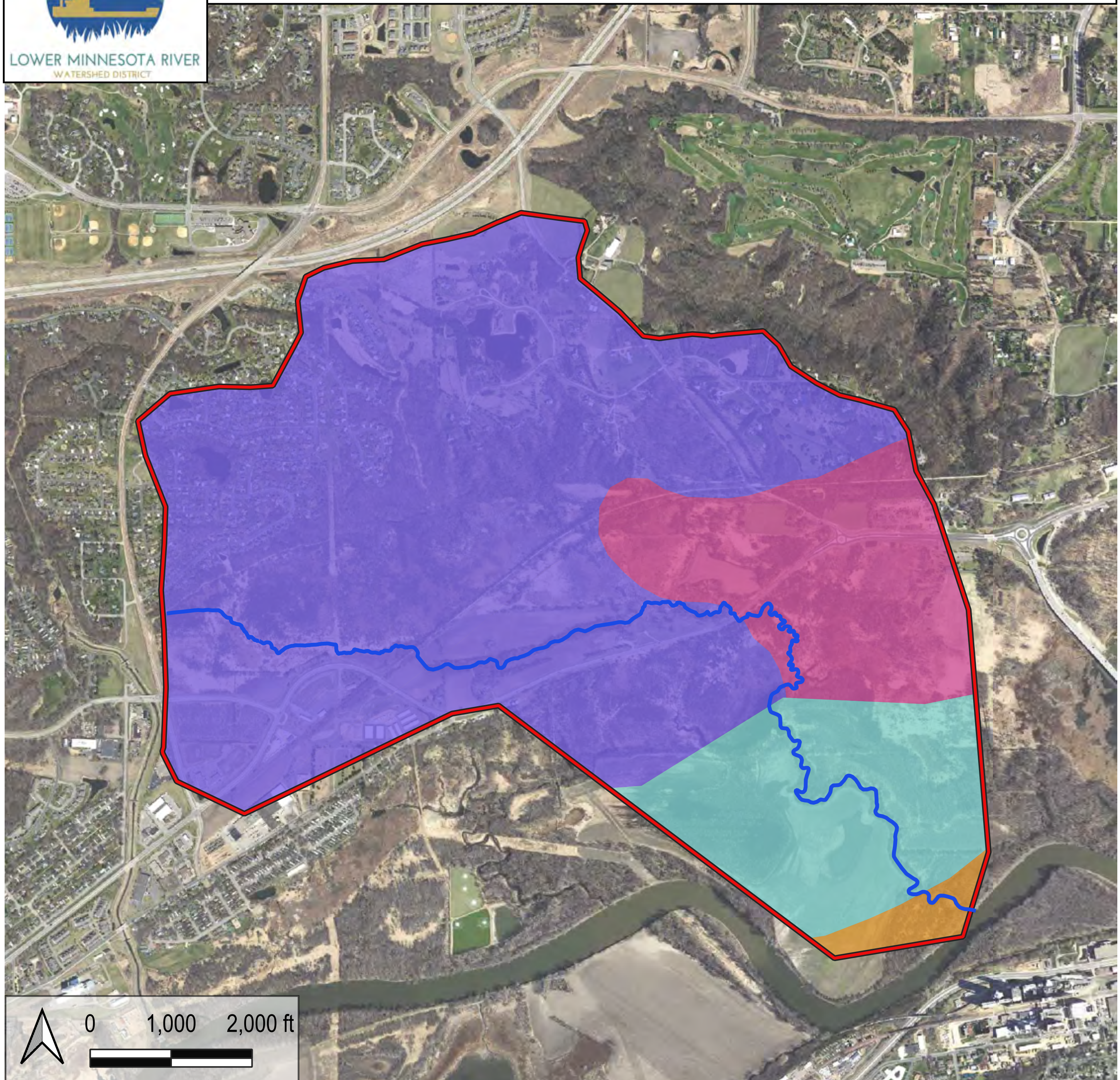
Figure 6: Assumption Creek Watershed Presettlement Land Use



Legend

Presettlement Land Use

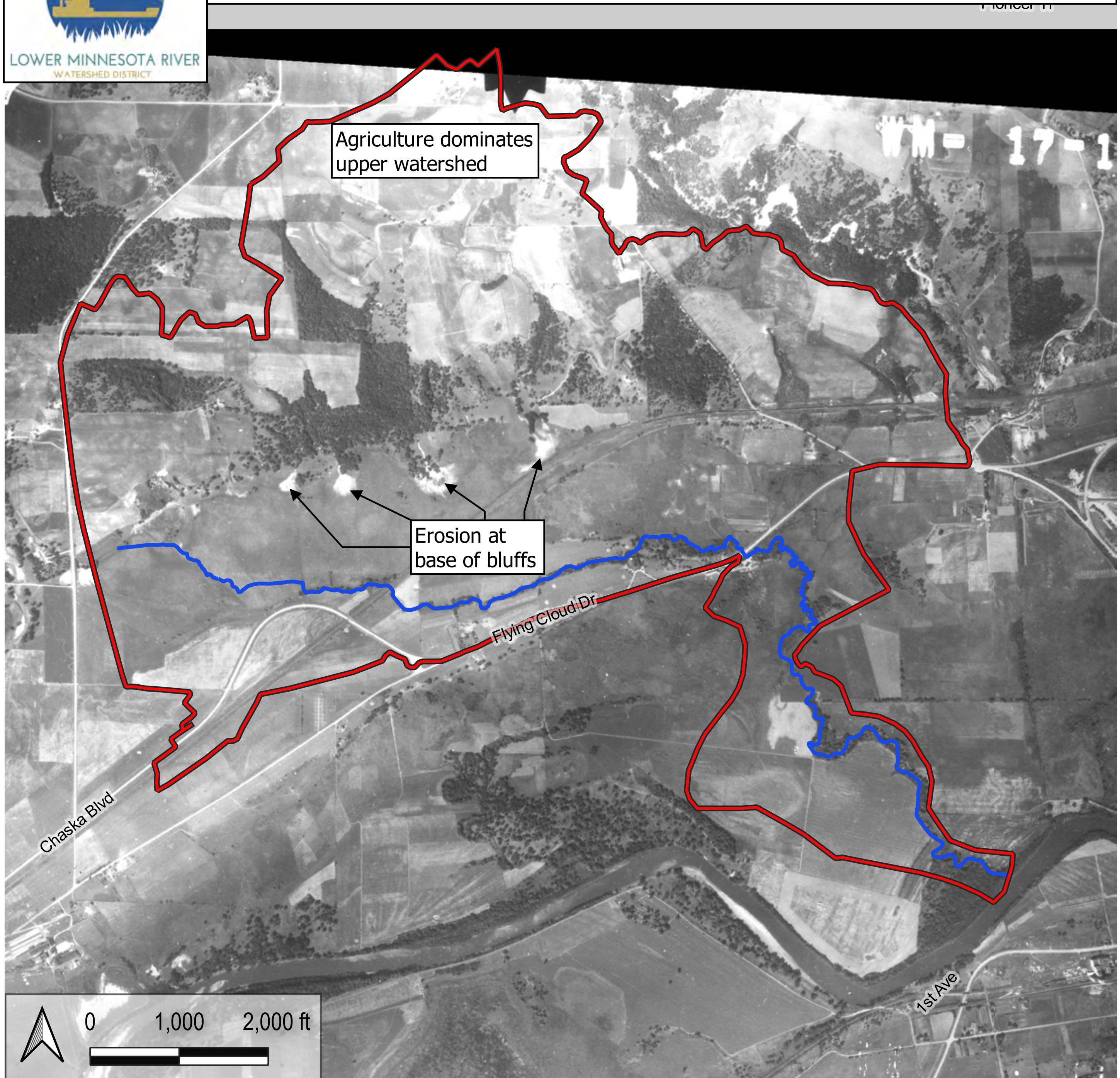
- Big woods - hardwoods
- Oak openings and barrens
- River bottom forest
- Wet prairie

Assumption Creek

Assumption Creek Historic Watershed

LMRWD Watershed Location Map

Figure 7: Historic Aerial Imagery - 1937



Legend

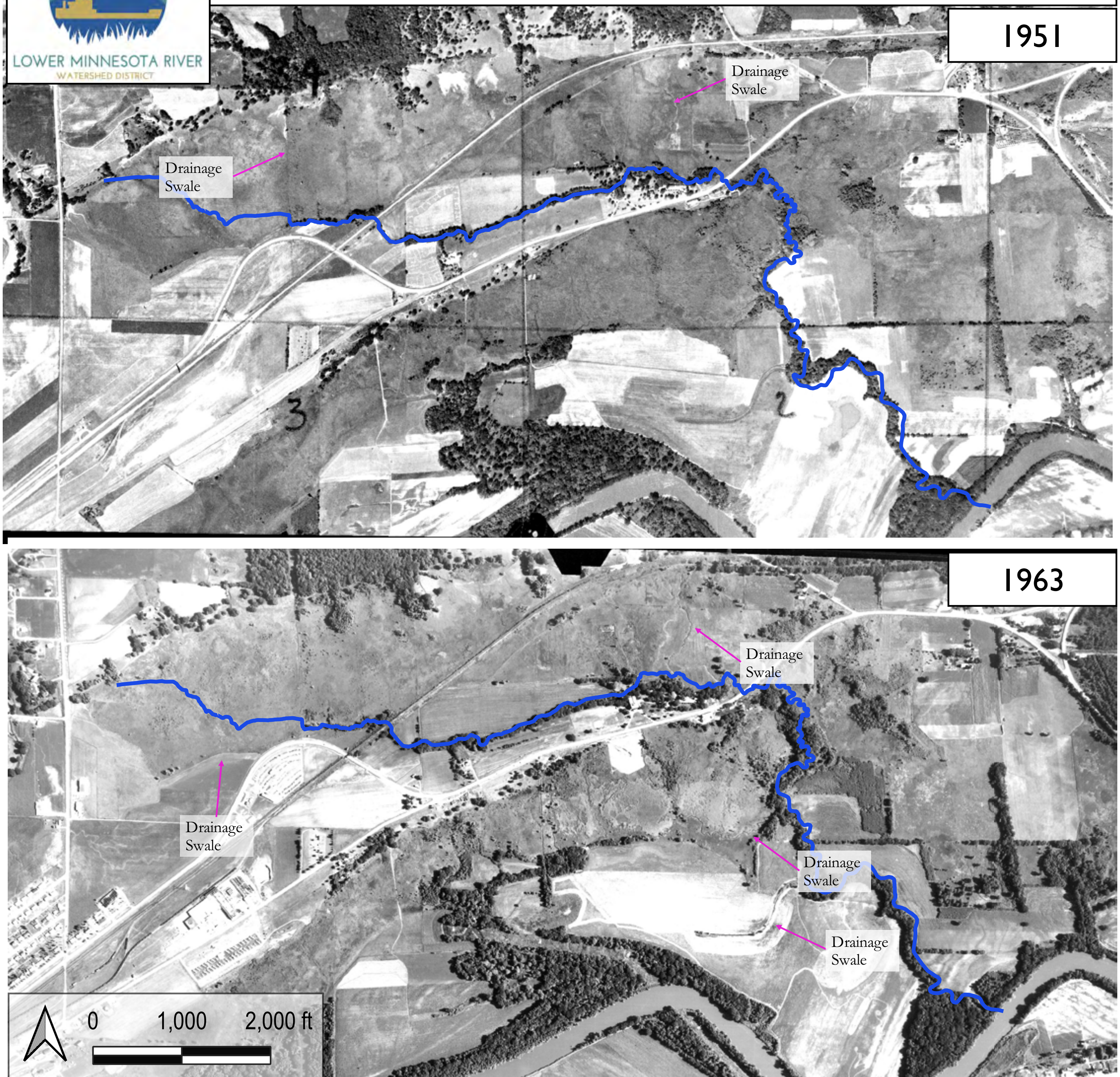
Assumption Creek

Assumption Creek Historic Watershed

LMRWD Watershed Location Map

Young Environmental Consulting Group, LLC

Figure 8: Historic Aerial Imagery



Legend

Assumption Creek

Assumption Creek Historic Watershed

LMRWD Watershed Location Map

Figure 9: Assumption Creek Watershed - Future Land Use (2050)

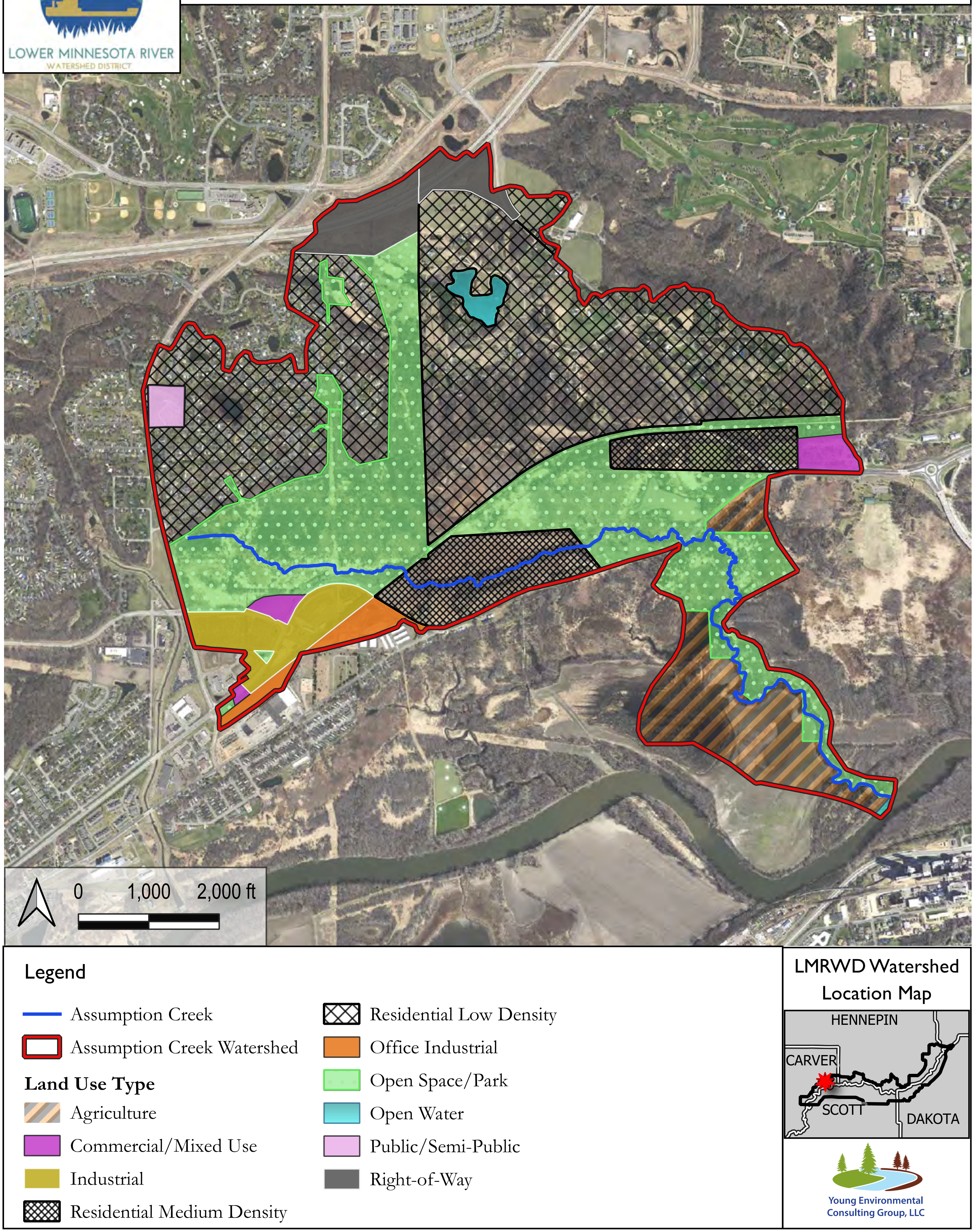
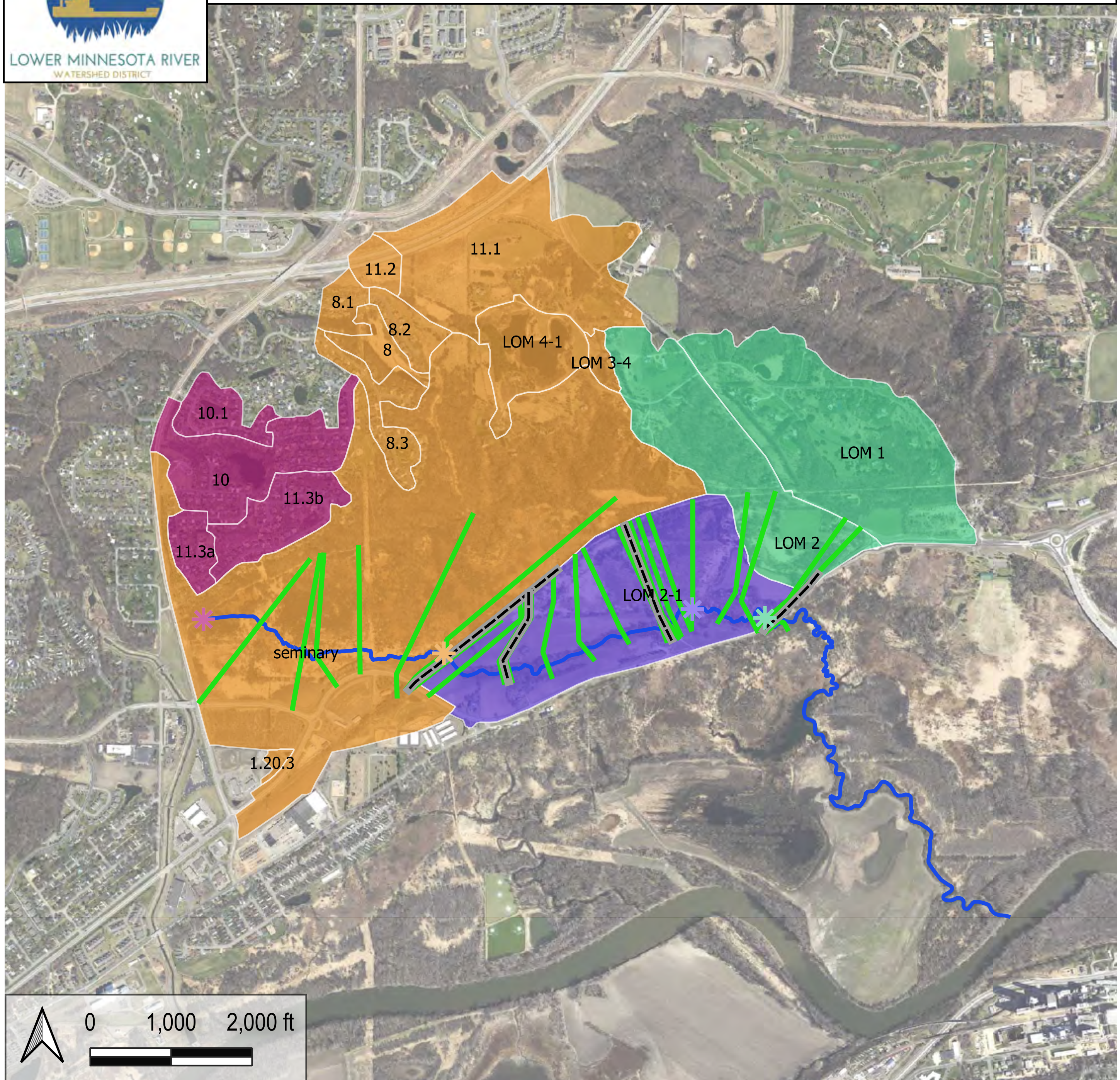


Figure 10: HECRAS Geometry



Legend

Assumption Creek
HEC-RAS Cross Section
HECRAS_Structures

HECRAS Inflow Location*
1
2
3
4

HydoCAD Subcatchments*
1
2
3
4

*The color of the subcatchments corresponds to the color of the inflow location.
For example, runoff from Subcatchment 1 drains to Inflow Location 1.

LMRWD Watershed Location Map

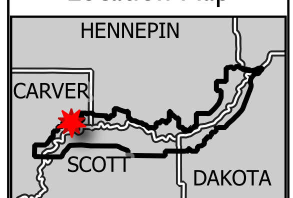


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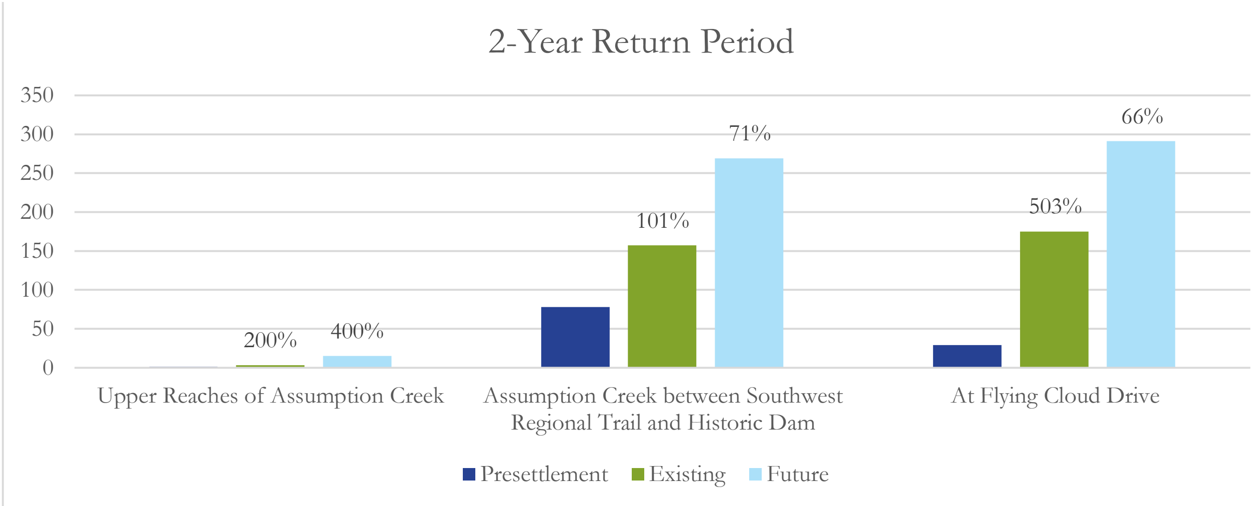
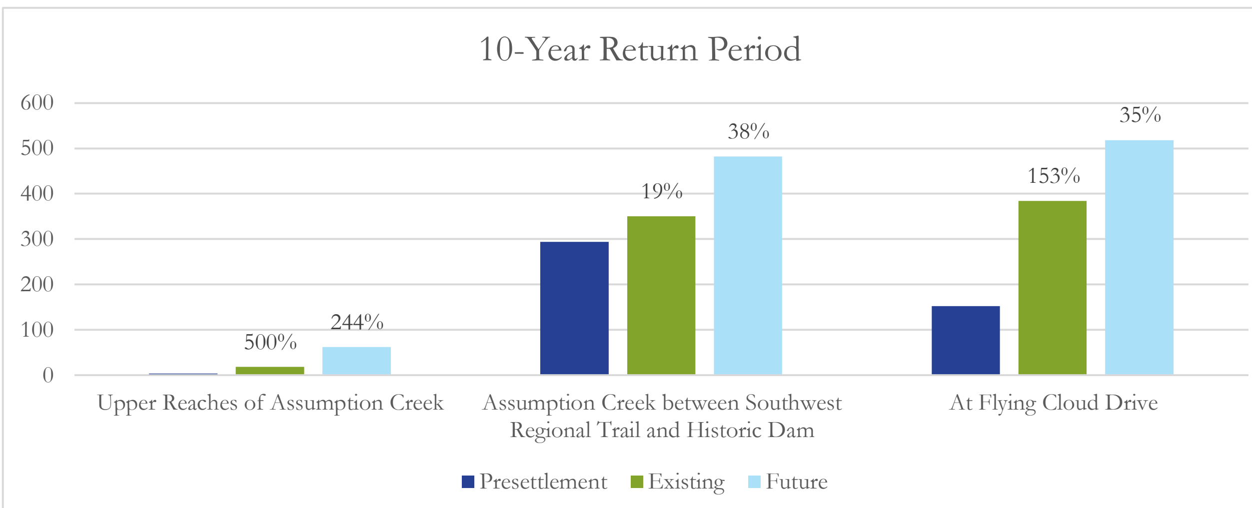
Figure 11: Assumption Creek Discharge Comparison





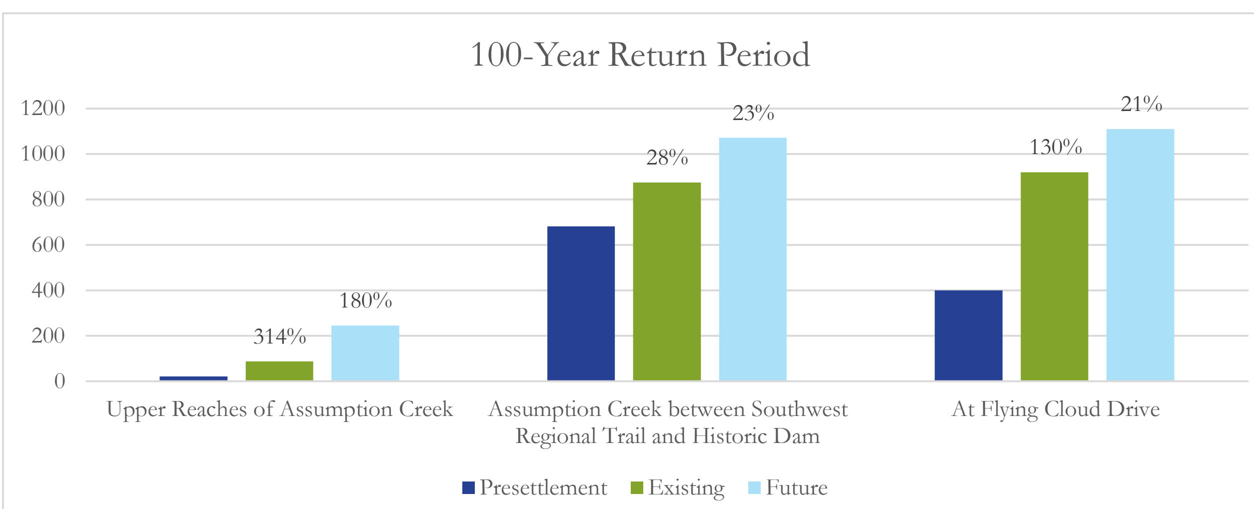
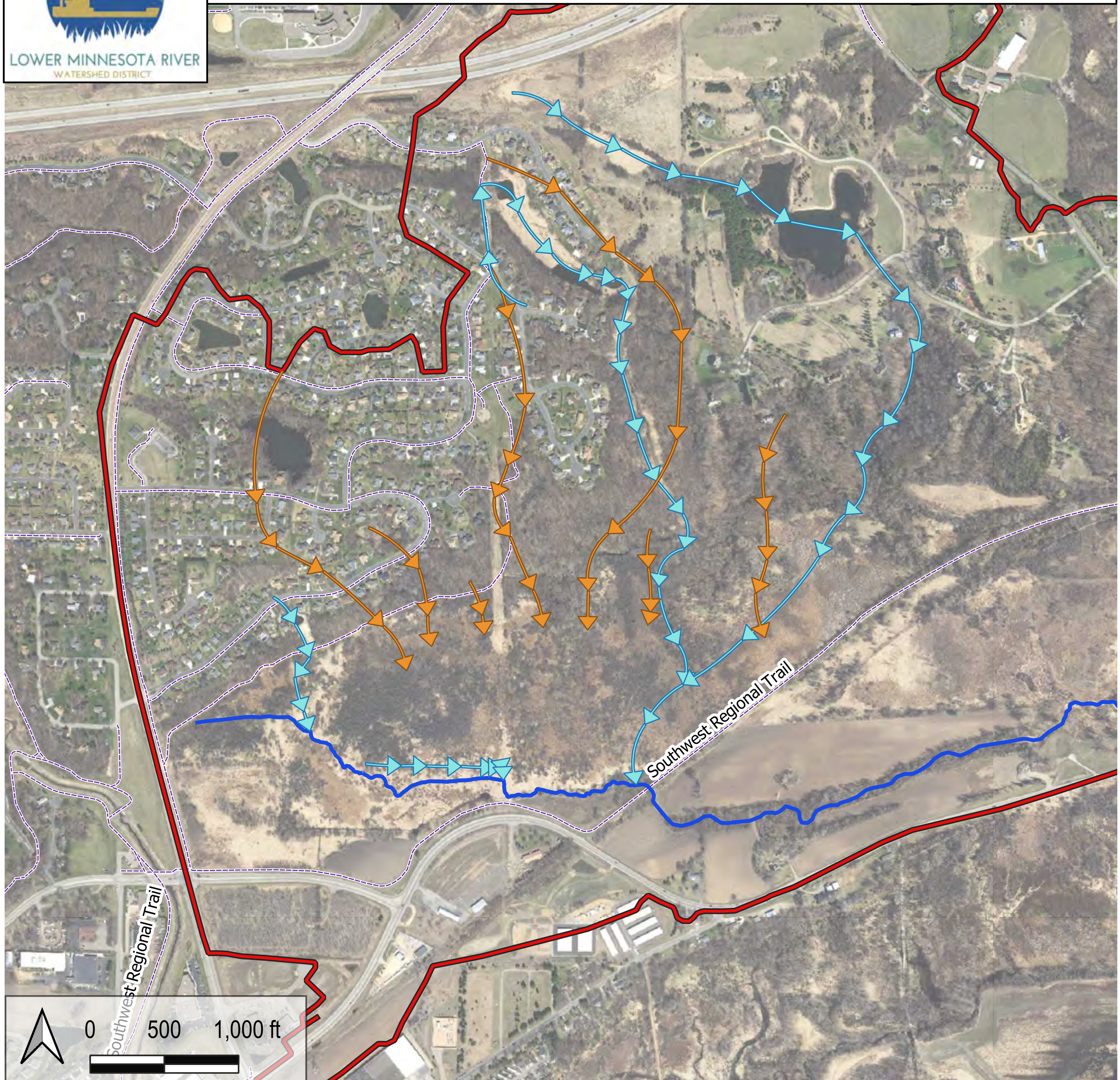


Figure 12: Drainage Path Comparison



Legend

- Assumption Creek Watershed
- Assumption Creek
- Historic Drainage Path
- Current Drainage Path
- Trails

LMRWD Watershed Location Map

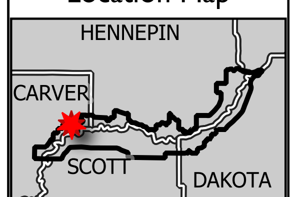


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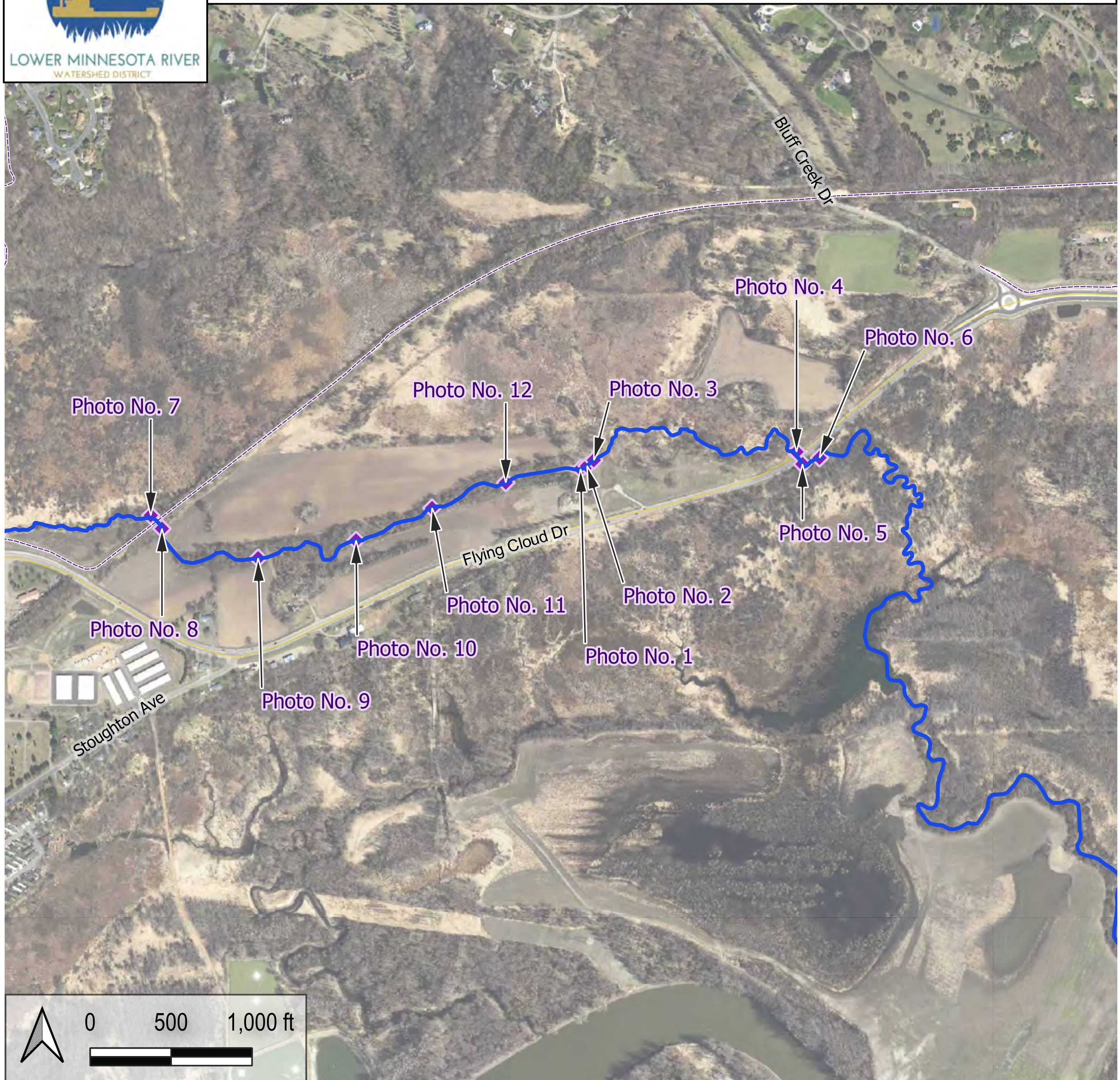
Figure 13: Survey Photos of Assumption Creek



Legend

- Assumption Creek
- Photo Locations

LMRWD Watershed Location Map

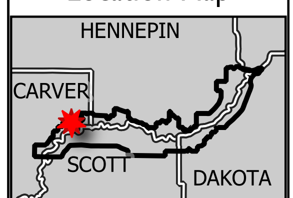


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Photo 1: Looking downstream at the Dam


Photo 2: Looking upstream at the Dam

Photo 3: Looking Downstream

Photo 4: Looking downstream through the culvert

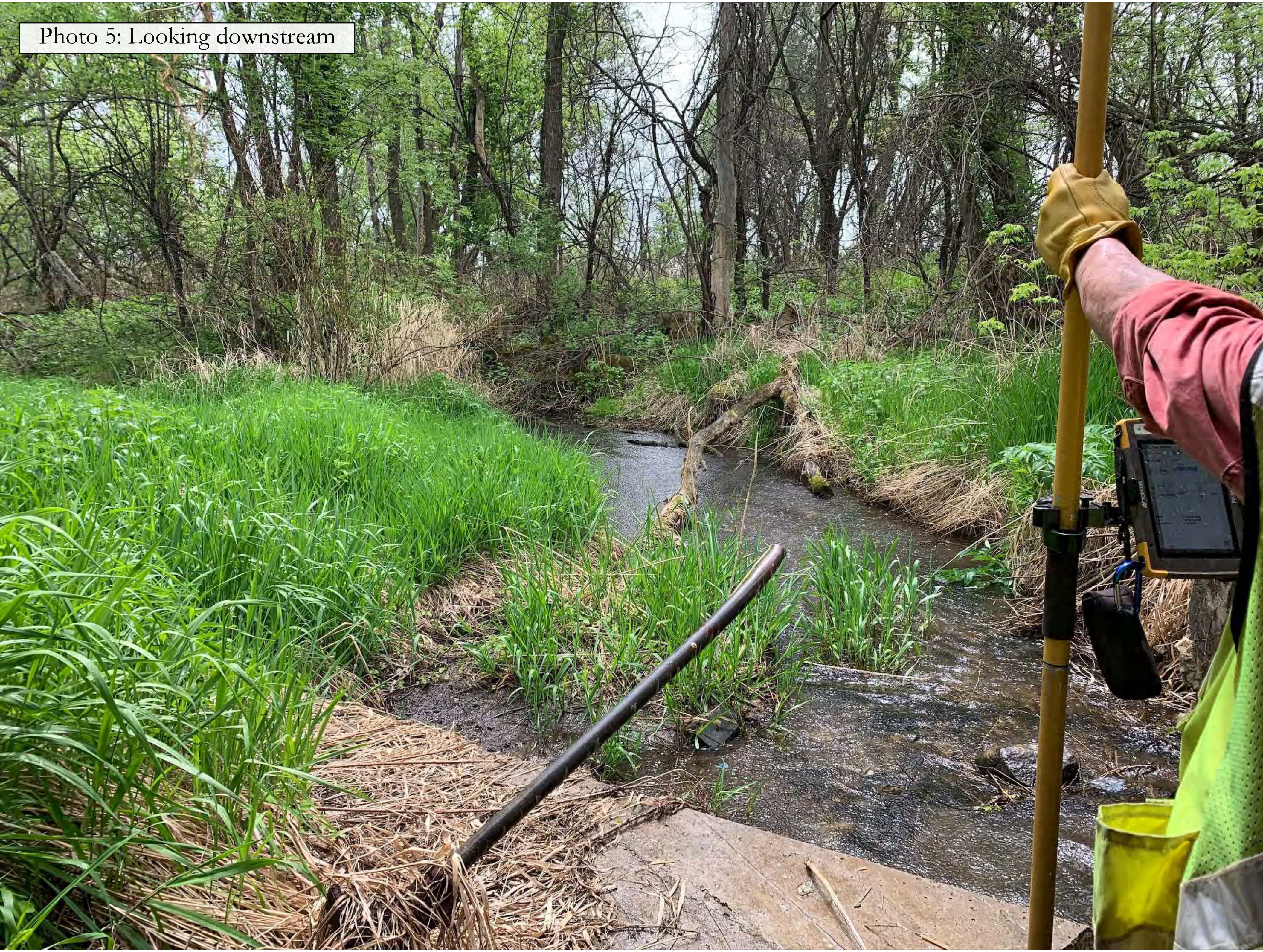

Photo 5: Looking downstream

Photo 6: Looking downstream

Photo 7: Looking downstream at culvert through the trail

Photo 8: Looking upstream at the culvert through the trail


Photo 9: Looking upstream at the culvert through the field crossing

Photo 10: Looking downstream

Photo 11: Looking downstream


Photo 12: Looking downstream

8.0 ATTACHMENTS

Attachment 1: Data Matrix

LMRWD Assumption Creek Data Matrix									
ID	Date Entered	Entered By	Date Accessed	Data Title	File Name/Path	File Type	Author	Data Date	Data Type
1	3/4/2022	HRL	2/11/2022	Spring Creek Hydrology Review Technical Memo	Memo_Spring Creek Hydrau	PDF	Young ECG	1/15/2022	Technical Memo
2	3/4/2022	HRL	2/10/2022	Strategic Resources Evaluation of the LMRW	Microsoft Word - Strategic I	PDF	HDR	1/1/2014	Report
3	3/4/2022	HRL	2/16/2022	Evaluation of Trout Habitat Potential in the Streams of the Lower Minn	Draft Report for LMRWD.pd	PDF	Christina Berg	8/1/2019	Report
4	3/4/2022	HRL	2/16/2022	Fens Sustainability Gaps Analysis for Carver, Dakota, and Scott Countie	2. LMRWD_FensGapsAnaly	PDF	Young ECG	5/3/2020	Report
5	3/4/2022	HRL	2/16/2022	2018 Fen Well Monitoring Report	Fen Well Monitoring Report	PDF	Dakota SWCD	1/1/2018	Report
6	3/4/2022	HRL	2/16/2022	Groundwater and Fen Evaluation Summary Report	Microsoft Word - Groundwa	PDF	Burns & McDo	12/16/2015	Report
7	3/4/2022	HRL	2/16/2022	Environmental Monitoring of Nicols Fen	Microsoft Word - 1_TitlePag	PDF	WSB	6/30/2008	Report
8	3/4/2022	HRL	2/16/2022	Seminary Fen/Chaska Revine Restoration Project	Seminary_Fen_Ravine_Stab	PDF		7/1/2016	Report
9	3/4/2022	HRL	2/16/2022	2018-2027 Watershed Management Plan	1. LMRWD_Complete_Plan	PDF	LMRWD	10/24/2018	Report
10	3/4/2022	HRL	3/4/2022	Assumption Creek Watershed Gaps Analysis and Long-Term Managem	https://youngecg.sharepoir	Word Docum	LMRWD	12/29/2021	Draft Report
11	3/24/2022	HRL	3/24/2022	Stability Thresholds for Stream Restoration Materials	Stability_Thresholds_for_St	PDF	Craig Fischeni	5/1/2001	Report
12	3/24/2022	HRL	3/24/2022	Chapter 11 Rosgen Geomoprhic Channel Design	Chapter 11--Rosgen Geomo	PDF	NRCS	8/1/2007	Chapter of NEH
13	3/24/2022	HRL	3/24/2022	Applied River Morphology		Book	Dave Rosgen	1/1/1996	Book
14	3/24/2022	HRL	3/24/2022	Minnesota Historical Aerial Photographs Online	MHAPO (umn.edu)	website	University of M	2/16/2015	Data Viewer
15	3/24/2022	HRL	3/24/2022	NWI Wetland Finder	NWI Wetland Finder: Minne	website	MnDNR	3/24/2022	Data Viewer
16	3/24/2022	HRL	3/24/2022	LiDAR Elevation Dataset - Bare Earth DEM	USDA:NRCS:Geospatial Data	website	NRCS	4/1/2011	LiDAR
17	3/24/2022	HRL	3/24/2022	Runoff: Surface and Overland Water Runoff	Runoff: Surface and Overlan	website	Water Science	6/6/2018	Article
18	3/24/2022	HRL	3/24/2022	NOAA Atlas 14 Precipitation-Frequency Atlas of the United States Volu	NOAA Atlas 14 Vol 8 (weath	PDF	NOAA	1/1/2013	Report
19	3/24/2022	HRL	3/24/2022	Chapter 4 Storm Rainfall Depth and Distribution	NEH Part 640, Chapter 4, St	PDF	NRCS	8/1/2019	Report
20	3/24/2022	HRL	3/24/2022	Urban Hydrology for Small Watersheds	TR-55 Cover (usda.gov)	PDF	NRCS	6/1/1986	Technical Release
	3/24/2022	HRL	3/24/2022	Altered Hydrology within the Crow Watershed	Crow-Altered-Hydro-Frame	PDF	HEI	3/3/2017	Report
	3/24/2022	HRL	3/24/2022	Vegetation - Presettlement	Vegetation – Pre-Settlemen	website	MnDNR	3/15/2022	GIS shapefile

Attachment 2: HydroCAD Curve Number Index

Land Use	HSG A	HSG B	HSG C	HSG D
Big Woods - Hardwoods (oak, maple, basswood, hickory)	30	55	70	77
Oak openings and barrens	32	58	72	79
River Bottom Forest	32	58	72	79
Wet Prairie	39	61	74	80

Land Use	HSG A	HSG B	HSG C	HSG D
Agricultural	72	81	88	91
Industrial and Utility	81	88	91	93
Institutional	46	65	77	82
Park, Recreation, Preserve	49	69	79	84
Retail and Other Commercial	89	92	94	95
Single Family Detached	54	70	80	85
Undeveloped	43	65	76	82
Major Highway	98	98	98	98
Farmstead	59	74	82	86
Open Water	98	98	98	98
Golf Course	39	61	74	80

Land Use	HSG A	HSG B	HSG C	HSG D
Agriculture	72	81	88	91
Commercial	89	92	94	95
Industrial	81	88	91	93
Low Density Residential	54	70	80	85
Mixed Use	89	92	94	95
Office	81	88	91	93
Office Industrial	81	88	91	93
Open Space	49	69	79	84
Open Water	98	98	98	98
Park	49	69	79	84
Park / Open Space	49	69	79	84
Public / Semi-Public	46	65	77	82
Public Right-of-Way	43	65	76	82
Residential - Large Lot	54	70	80	85
Residential Low Density	54	70	80	85
Residential Medium Density	57	72	81	86
Vehicular Right-of-Way	98	98	98	98