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Pentagon Park/Border Basin Regional Stormwater Management Plan

Prepared for

Nine Mile Creek Watershed District, City of Edina, and City of Bloomington

April 6, 2018

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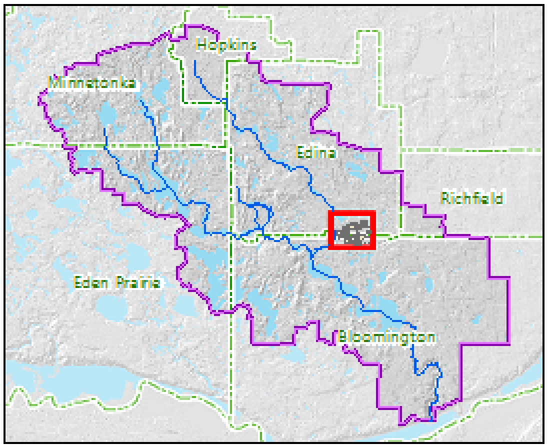
Executive Summary

Background

The Pentagon Park/Border Basin Area (study area) is a commercial, office and industrial park area located just north of Interstate 494 and east of Trunk Highway 100 within the cities of Edina and Bloomington. The study area and its tributary watershed is approximately 700 acres, with runoff from about 190 acres flowing through the ponds on the former Fred Richards Golf Course on the north side of the Pentagon Park area and runoff from approximately 410 acres, including the Centennial Lakes watershed, flowing through the Border Basin located west of the intersection of West 77th Street and Minnesota Drive, along the Edina/Bloomington border. Stormwater from most of the study area and its tributary watershed is conveyed under Trunk Highway 100 via a 97-inch x 154-inch reinforced concrete arch pipe and discharges to the North Fork of Nine Mile Creek.



The red box shows the Pentagon Park/Border Basin area in relation to the Nine Mile Creek watershed.

Much of the study area is low-lying and becomes inundated during large storm events. The ponds and low areas on the former Fred Richards Golf Course store runoff from the golf course and tributary watershed. In the 100-year, 24-hour rainfall event, the flood storage capacity in the former golf course is exceeded and approximately 67 acre-feet of runoff flows south toward West 77th Street, contributing to high flood elevations in the West 77th Street and adjacent flood storage areas. The Border Basin, a constructed stormwater pond along the Edina/Bloomington border, receives runoff from portions of the study are and a large tributary upstream watershed. In the 10-year and 100-year, 24-hour rainfall events, the inflow greatly exceeds the discharge capacity of the relatively small basin, causing flood elevations to inundate significant portions of the adjacent private properties. Other low areas throughout the study area also become inundated in the 10- and/or 100-year, 24-hour rainfall event.

The flooding problems throughout the study area are primarily due to the interconnection with Nine Mile Creek and the influence of high creek surface water elevations during large storm events. The peak elevation in Nine Mile Creek at the arch pipe outfall is 819.0 MSL during the 10-year, 24-hour rainfall event. During the 100-year, 24-hour rainfall event simulation, the elevation of Nine Mile Creek at the arch pipe outfall peaks at elevation 821.6 MSL, and remains above 820.0 MSL for more than 12 hours. These 10-year and 100-year peak surface water elevations in the creek exceed the natural ground surface elevation of many low-lying areas throughout the study area, including the Border Basin (control elevation of 814.7 MSL) and the ponds on the former Fred Richards Golf Course (control elevation of approximately 818.2 MSL). The high tailwater elevations and the minimal difference in surface water elevation between the study area and the creek result in significantly restricted discharge from the area.

Study Objectives

Given the flood risks and anticipated redevelopment within the study area, the cities of Edina and Bloomington requested assistance from the NMCWD to develop a planning-level regional flood and stormwater management approach for this area to 1) identify and evaluate options to alleviate flood risk, and 2) guide stormwater management for future redevelopment. The planning-level analysis was to include consideration of flood reduction options, identification and evaluation of regional stormwater management opportunities, and development of potential stormwater management guidelines and/or best practices for consideration as redevelopment occurs in the study area. This report summarizes the analyses performed and options for consideration with regard to regional stormwater management and potential area-specific stormwater management guidelines for redevelopment within the study area.

Flood Risk Reduction Evaluation

One of the primary objectives of this study was to identify options to alleviate flood risk within the study area. Several flood risk reduction alternatives were evaluated, including (1) expanding storage in the former Fred Richards Golf Course, (2) expanding storage in the Border Basin, (3) providing additional upstream storage, (4) increasing conveyance capacity to Nine Mile Creek, and (5) diversion of stormwater to Normandale Lake. While several of the evaluated alternatives provide minor reductions in flood elevations, none resulted in significant reductions in 100-year flood elevations, primarily due to the influence of high surface water elevations in Nine Mile Creek. Given the circumstances, the following recommendations for consideration are for managing or reducing flood risk within the study area and tributary watershed:

- Flood storage volumes within the study area and upstream watershed should be maintained to prevent increased flood risk within the study area. Where effective, opportunities to provide additional flood storage in the study area or upstream watershed should be pursued.
- Flood storage volume within the former Fred Richards Golf Course and Lake Edina Park should be maintained as it is redeveloped, and expanded if feasible such that surface overflows to the south from the former golf course property will be eliminated for the 100-year, 24-hour rainfall event.
- A regional approach to coordinating and facilitating flood storage creation and mitigation should be considered by the stakeholders, to better identify and take advantage of opportunities.
- The development of a master land use plan should be considered which would evaluate the study area and propose the dedication of some land to public purposes (e.g., flood storage and/or stormwater management) in a coherent fashion that creates an amenity, promotes stronger property values and redevelopment potential, and improves community open space and natural resource value.
- As redevelopment occurs, the cities of Bloomington and Edina should continue to work closely with developers to understand and communicate drainage patterns and restrictions within the study area. This includes sharing information regarding available storm sewer capacity under various design events and surface overflow patterns between neighboring properties.

- As redevelopment occurs, low floor elevation requirements should continue to be implemented to reduce flood risk for property owners.
- Existing stormwater infrastructure should continue to be inspected and maintained.
- Agreements between Bloomington and Edina that govern operation and maintenance of the stormwater infrastructure within the study area should be memorialized and maintenance activities should be coordinated, when appropriate.

Potential Stormwater Management Guidelines for Redevelopment

Significant portions of the study area will be undergoing redevelopment in the near future. Results of the flood risk reduction evaluation confirmed that flood improvement alternatives within the study area will not result in substantial reductions in flood elevations, primarily due to the influence of high surface water elevations in Nine Mile Creek, and properties within the study area will continue to be impacted by flood waters in large storm events.

The extent of both 10-year and 100-year frequency flood inundation throughout the study area will pose a challenge to redevelopment efforts, with significant site building constraints and onsite stormwater management and flood storage requirements that may, in some cases, hinder redevelopment potential. Maintaining existing flood storage volumes to prevent transfer of flood risk to neighboring properties will be a significant design constraint on many parcels. Flood storage volumes for the 1% annual chance flood event (also known as the 100-year flood event), in terms of average depth of flood storage across the entire parcel, range from 0 to 3.4 feet, with nine privately-owned parcels having greater than two feet of average floodwater depth and an additional ten parcels having greater than one foot average floodwater depth across the parcel.

Other site constraints within the study area will pose additional stormwater management challenges, including the widespread presence of soils with low infiltration capacity (hydrologic soil group "D" soils) and the occurrence of shallow groundwater. These site constraints, which impact the feasibility of meeting the NMCWD's volume retention criteria, coupled with the onsite flood storage requirements, will make compliance with the NMCWD rules difficult. In the absence of an approved alternative stormwater management approach for the study area, redevelopment of many individual sites within the study area will likely require requests for variances from the NMCWD's current rules.

To assist in addressing this challenge, an objective of this study was to develop guidelines for an alternative approach to managing stormwater within the area as redevelopment occurs. The guidelines presented in this report provide information and ideas regarding potential stormwater management options and approaches that property owners can consider, either on individual sites or on a regional basis.

Potential Alternative Stormwater Management Approach

Recognizing that it may not be reasonably feasible to comply with the NMCWD's rules within the study area, a potential alternative stormwater management approach has been identified for the Pentagon Park/Border Basin study area to optimize stormwater management benefits with consideration of site and cost constraints. The potential alternative regional stormwater management approach requires redeveloping sites to provide additional runoff rate control, *beyond limiting peak flowrates to that of existing conditions,* in lieu of volume retention, to mimic the rate control benefits typically achieved from implementing BMPs to achieve the NMCWD's volume retention criteria. An advantage of using extended detention within the study area is that most (or all) of the storage volume provided as part of an extended detention and rate control system can also serve as flood storage, assuming the drawdown time of an extended detention system is within a reasonable timeframe and the extended detention system is installed at elevations that correspond to the desired elevations for flood storage.

Under the potential alternative regional stormwater management approach, each redeveloping parcel would be required to implement "highly restrictive" extended detention, which significantly restricts site discharge for all rainfall events up to the 1-year frequency, 24-hour event. The suggested level of additional rate control is dependent upon the extent of flood storage required on each redeveloping parcel, with parcels highly impacted by flood storage requirements required to provide less additional rate control than sites that are not impacted by flood storage requirements. This approach is intended to reflect the inherent rate control that occurs on parcels within the study area that are highly impacted by floodwaters during large storm events and the high financial burden of maintaining flood storage onsite, especially when the flood storage volume exceeds the runoff generated on a given site. The potential alternative stormwater management approach also requires that runoff be treated to at least 60 percent annual removal efficiency for total phosphorus and 90 percent annual removal efficiency for total suspended solids, consistent with the current NMCWD stormwater management rules.

The potential alternative stormwater management approach presented in Section 4.3 of this report represents one possible framework for a region-specific stormwater management plan. Upon further refinement, a more detailed stormwater management plan for the Pentagon Park/Border Basin region could be submitted by the City of Edina and/or the City of Bloomington for consideration by the NMCWD managers.[1]

Potential Need for Additional Design Flexibility to Promote Redevelopment

The Pentagon Park/Border Basin study area was primarily developed in the late 1960s and early 1970s, prior to the era of stormwater management regulation. Much of the area receives little or no rate control or water quality treatment prior to discharging to Nine Mile Creek. Redevelopment of the study area will result in a benefit to the Nine Mile Creek system, assuming stormwater management practices are

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[1] The NMCWD rules do not presently provide a mechanism whereby a regional stormwater management plan can take the place of compliance with NMCWD rules for individual properties. (The NMCWD Stormwater Management Rule currently does allow regional treatment to meet water quality standards.) The NMCWD is currently undergoing a rule revision process, in which draft rule revisions include the addition of a provision to allow approval of a stormwater management plan for a defined region that demonstrates that degradation of downstream receiving waters will be prevented and that benefits that would be achieved by a plan in compliance with the NMCWD criteria will be achieved to the maximum extent practicable, recognizing the site or regional constraints that prevent full compliance. In the meantime, a region-specific alternative stormwater management plan would have to be proposed to the NMCWD as a regional variance.

implemented to reduce runoff rates and pollutant contributions to the creek. As such, efforts to promote redevelopment in this area should be considered as beneficial to downstream resources.

Under existing conditions, flood storage occurs on the surface, primarily in parking lots, roadways, and green space. As redevelopment occurs, property owners may need to fill portions of some sites so new structures can be built at elevations high enough to meet the District's and/or cities' low floor elevation requirements (i.e., minimum of two feet above the 1% annual chance flood elevation). Filling portions of the parcel will require that compensatory flood storage be provided to offset the lost storage capacity, which will be a significant challenge due to the high cost of installing underground storage facilities (approximately $10-$20 per cubic foot), high land costs, and/or the high opportunity cost of dedicating a portion of a site for surface flood storage.

Maintaining flood storage may impact the redevelopment potential of many parcels within the study area, due to the large amount of flood storage volume necessary, high land costs, and the limited availability of land for flood storage (i.e., much of the area is already storing floodwaters). Given this significant design challenge, offering flexibility toward zoning and other site design constraints may be necessary to improve the economic achievability of redevelopment. Flexibility toward zoning requirements such as building set-backs, building height restrictions, and parking requirements should be considered. Storage of floodwaters in surface parking lots or lower levels of above-ground parking structures should also be considered. Depending on the degree of onsite flood storage required, an applicant for a specific redevelopment project likely would need to request a variance from the two-foot freeboard requirement. This would require that property owners accept the burden of additional risk solely.

Regional Stormwater Systems Opportunity Evaluation

The potential alternative regional stormwater management approach presented in Section 4.3 allows developing or redeveloping sites to meet the stormwater management criteria and/or flood storage requirements either onsite or through regional systems. For portions of the study area, it may be more cost-effective to utilize regional stormwater systems to meet some or all of the potential management criteria and flood storage requirements. As part of this study, several opportunities for implementing or improving regional stormwater treatment systems were evaluated. While the focus of the evaluation was toward potential regional water quality treatment systems, several of these systems could be designed to also incorporate additional rate control and/or flood storage measures.

Given the extent of flood storage that will be required on many parcels within the study area, availability of a regional system to achieve the NMCWD water quality criteria would help promote redevelopment efforts within the study area. Several specific regional water quality treatment alternatives were evaluated, including (1) expansion of the Border Basin, (2) construction of a new regional water quality pond located southeast of the intersection of West 77th Street and Computer Avenue, and (3) stormwater capture and reuse via irrigation. Based on the evaluation, the following recommendations should be considered to provide regional water quality treatment:

- Construction of a new regional water quality pond located southeast of the intersection of West 77th Street and Computer Avenue could provide water quality treatment for approximately

20 parcels within the study area (about 53 acres). While the cost of this alternative is high, primarily due to land acquisition costs, the cost per acre of tributary developable land ($89,000) is within the typical range for onsite stormwater management costs.

- Stormwater capture and reuse at the former Fred Richards Golf Course could provide regional treatment. Review of conceptual plans developed as part of the Fred Richards Master Plan process indicates the potential for approximately 20-30 acres of green space that could be utilized for reuse of stormwater.
- Expansion of the Border Basin or construction of additional smaller-scale ponds directly upstream of the Border Basin could also be considered to provide additional flood storage and water quality treatment within the study area.

In addition, it is recommended that the water quality treatment benefits provided by the former Fred Richards Golf Course under existing conditions should be maintained, or improved, as redevelopment of the park occurs.

Next Steps

The results of this regional stormwater management analysis have helped to understand the cause and extent of the flooding problem within the Pentagon Park/Border Basin study area, assess the effectiveness of potential flood risk reduction efforts, provide stormwater management guidelines including development of a potential alternative stormwater management approach for the study area, and evaluate the potential for regional stormwater management systems to assist in compliance with the stormwater requirements. The potential alternative stormwater management approach has been designed to optimize stormwater management benefits given the significant site constraints and offer flexibility to promote redevelopment within the area. The evaluation of flood storage requirements within the study area has provided parcel-based information, including runoff generation (10- and 100-year), flood storage volumes and depths (10- and 100-year), extent of inundation, and taxable market values. The evaluation of potential regional stormwater management systems has provided useful planning-level information, including quantification of costs and benefits.

The next steps with regard to moving forward with a region-specific stormwater management plan will be for the participating cities and stakeholders to make some important decisions regarding approach for regional stormwater management, including potential land acquisition(s) for regional stormwater management system(s), funding mechanisms, and sources, and then prepare a more detailed region-specific plan proposal for submittal to the NMCWD.

While this regional stormwater management analysis included modeling of the benefits of additional rate control (in comparison to volume retention practices), it did not include a detailed, site-by-site modeling analysis of the impacts of the potential regional stormwater management approach, as this level of detailed modeling was outside of the existing scope of work. The detailed region-specific stormwater management plan proposal would need to include a more detailed modeling analysis that reflects the proposed alternative stormwater management approach (including detailed assumptions about onsite versus regional treatment) to better evaluate the impacts to Nine Mile Creek. Additional requirements of the detailed region-specific stormwater management plan proposal would need to be determined in consultation with NMCWD staff.

Funding for a regional stormwater management system in the Pentagon Park/Border Basin study area would likely be a public-private partnership, including contributions from one or both cities and private property owners that plan to utilize the regional system for compliance with NMCWD rules. The NMCWD would consider financial participation in projects that provide beyond-compliance water-resources protection benefits, such as wetlands restoration or projects that provide flood storage or water quality treatment capacity beyond what is required to meet NMCWD rules.

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1.0 Background and Study Area Description

1.1 Introduction

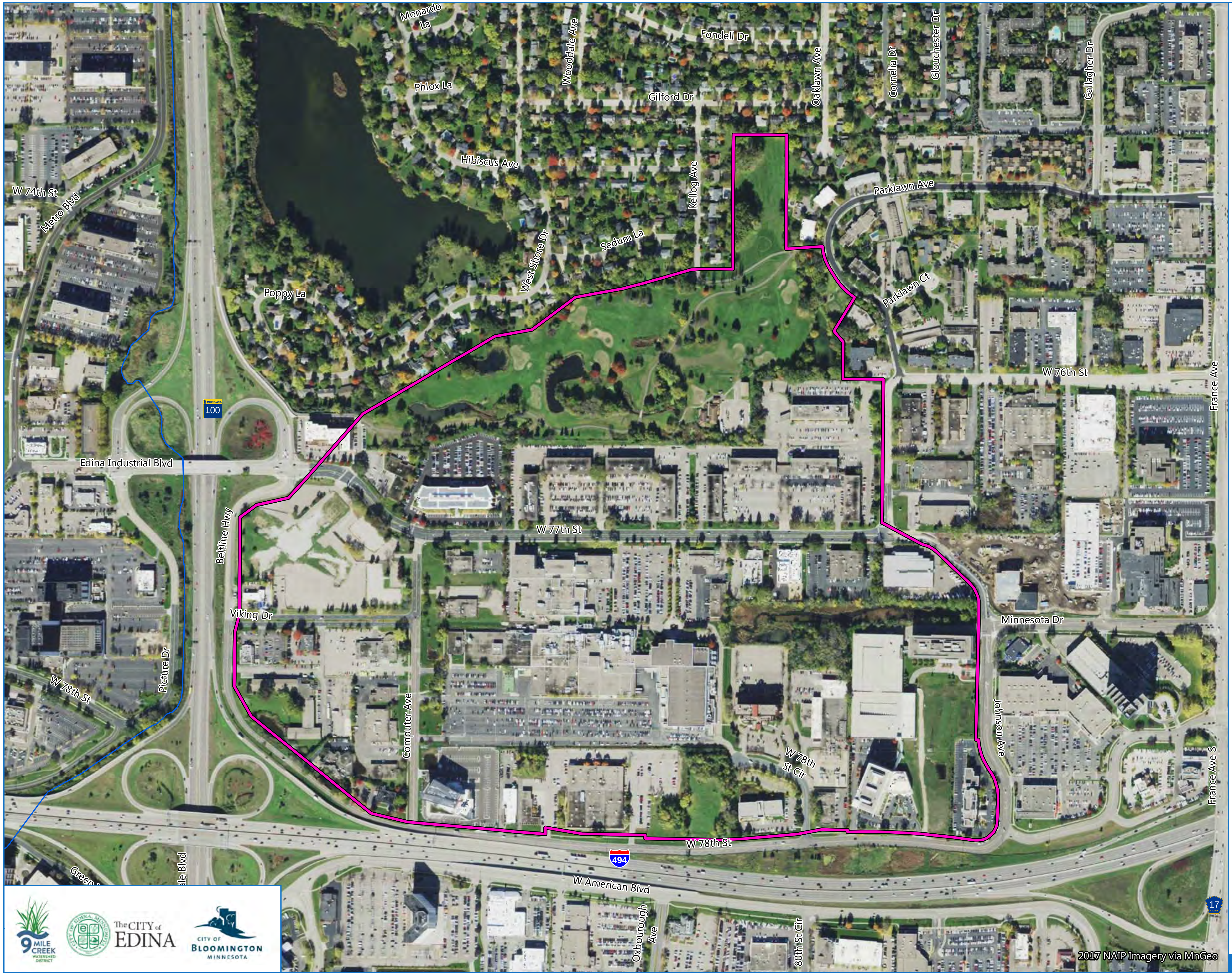
The Pentagon Park/Border Basin Area (study area) is a commercial, office and industrial park area located just north of Interstate 494 and east of Trunk Highway 100 within the cities of Edina and Bloomington. Much of the study area is low-lying and becomes inundated during large storm events. Results from recent hydrologic and hydraulic model revisions completed by the Nine Mile Creek Watershed District (NMCWD) in response to updated regional precipitation frequency estimates indicate that 100-year flood management elevations in the Pentagon Park/Border Basin area are considerably higher than previously established flood elevations (ranging from 0.4 to 2.2 feet higher).

Significant portions of the study area are undergoing redevelopment and the study area will continue to redevelop in the near future. The recent increase in flood management will pose a challenge to redevelopment efforts, including significant site building constraints and challenges in meeting regulatory requirements that could, in some cases, hinder redevelopment potential.

Given the increased flood management elevations and active redevelopment within the study area, the cities of Edina and Bloomington requested assistance from the NMCWD to conduct a regional flood risk reduction analysis to evaluate options to alleviate flood risk and develop a planning-level stormwater management approach to guide stormwater management for future redevelopment. The stormwater management plan, described herein, includes consideration of storing additional stormwater upstream and/or on the former Fred Richards golf course, planning for regional stormwater management opportunities, and developing site development best practices to guide stormwater management as redevelopment occurs.

1.2 Study Area Location

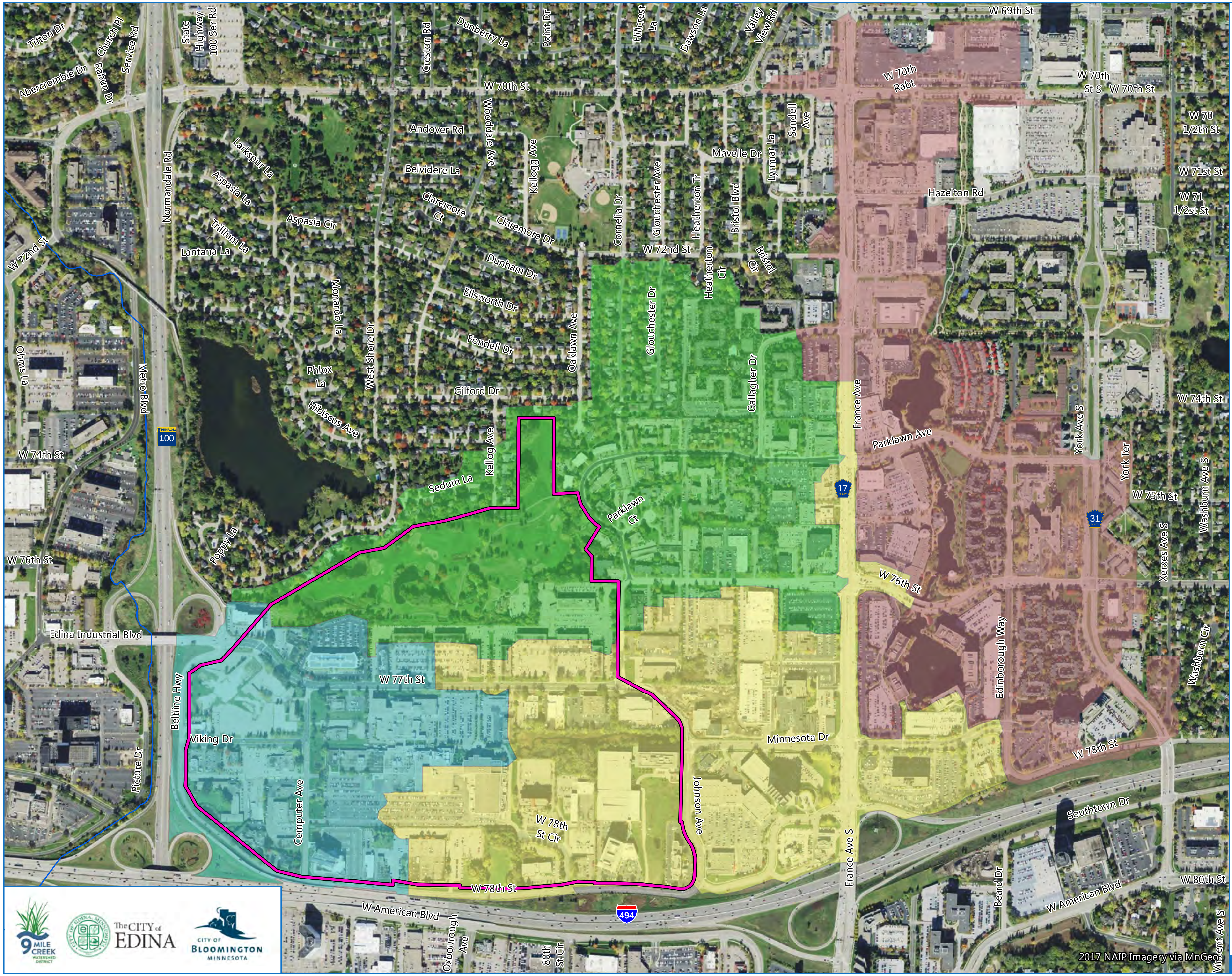
The study area is bounded on the north by a residential neighborhood on the north side of the former Fred Richards Golf Course, on the west by Trunk Highway 100 (TH 100), on the south by Interstate Highway 494 (I-494), and on the east by Johnson Avenue and Parklawn Avenue (Figure 1-1). The watershed tributary to the study area is approximately 700 acres, including the Centennial Lakes watershed (Figure 1-2). There are three primary stormwater flow paths through the area. Approximately 190 acres are tributary to the ponds on the former Fred Richards Golf Course on the north side of the Pentagon Park area; approximately 410 acres, including the Centennial Lakes watershed, are tributary to the Border Basin (South Pond) located west of the intersection of West 77th Street and Minnesota Drive, along the Edina/Bloomington border; and approximately 100 acres drain directly to the storm sewer system within the Pentagon Park/Border Basin area. Most of the stormwater from the ponding areas and from the direct Pentagon Park/Border Basin watershed is conveyed via a 10-ft x 7-ft box culvert to a 97-inch x 154-inch reinforced concrete arch pipe that passes under TH 100 and discharges to Nine Mile Creek approximately 900 feet south of West 77th Street.



STUDY AREA
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure 1-1

Barr Footer: ArcGIS 10.4.1, 2018-04-06 08:37 File: I:\Client\Nine_Mile_Creek_WD\Work_Orders\Pentagon_Park_Updates\Maps\Reports\Report\Figure 1-1 Study Area.mxd User: rcs2



Nine Mile Creek

NMCWD Legal Boundary

Study Area

Contributing Area

Border Basin

Centennial Lakes

Golf Course

Nine Mile Creek

BARR

N

0 500 1,000

Feet

CONTRIBUTING WATERSHEDS
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure 1-2

1.3 Land Use

1.3.1 Historic Land Use

A 1901 USGS map (Figure 1-3) shows that prior to urban development, the study area was a low-lying marshy area that was hydrologically connected to Nine Mile Creek to the west and to a wetland complex that now encompasses Normandale Lake to the south. As the area became urbanized, road construction cut off the study area from the surrounding water bodies, and parts of the area were drained and filled to accommodate building construction. For some time a landfill waste disposal site known as the France Avenue Dump was operated just east of the area, near the present-day northwest corner of France Avenue and I-494. Later, a drive-in movie theater was constructed on the former landfill site. By 1972, the area had essentially reached its present developed condition (Figure 1-4). Appendix A contains a series of figures showing the available historic aerial imagery of the study area.

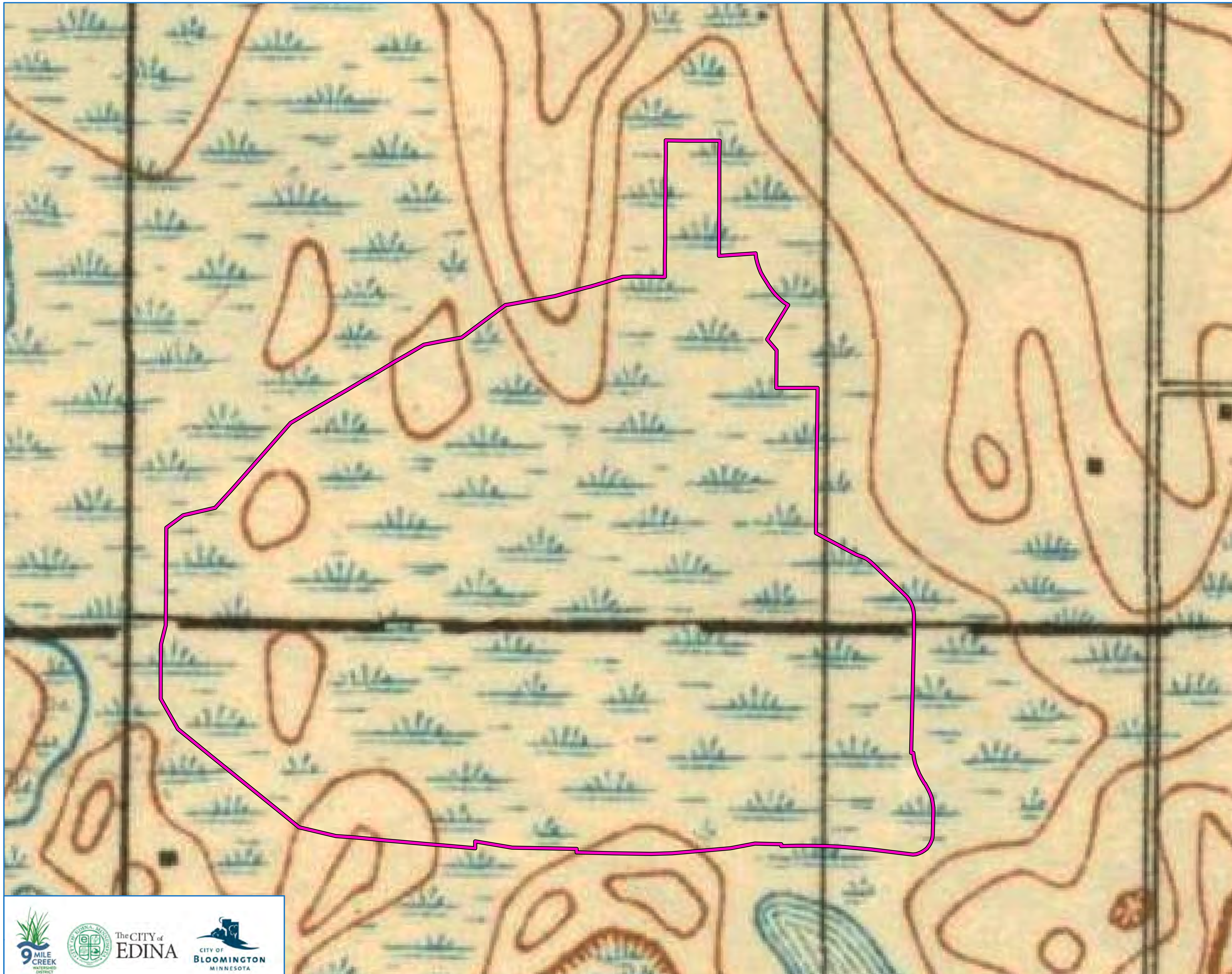
1.3.2 Recent Land Use

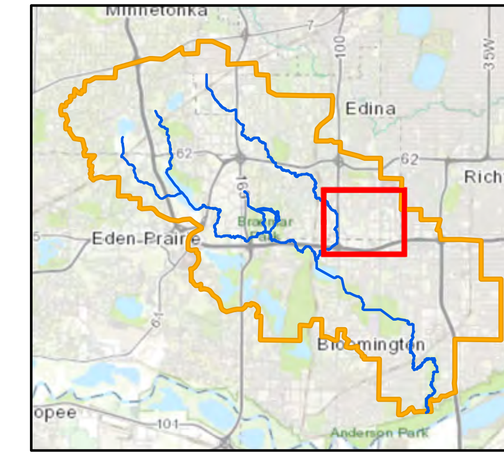
The Pentagon Park office complex that gives the area its name was constructed in the late 1960s and early 1970s. Pentagon Park was one of the first suburban office parks in the state, but over the years the buildings were viewed as dated and suffered from disuse. In 2014 the city of Edina announced that it was seeking partners to raze the old buildings and redevelop the Pentagon Park area. Between 2014 and 2015 several buildings on the west side of the study area were demolished.

The Fred Richards Golf Course was opened by the mid-1960s as the Normandale Executive Golf Course and was purchased by the City of Edina in 1992. Operation of the golf course was ended in fall 2014. The City is currently evaluating potential plans for repurposing the golf course property, with the intention of preserving its greenspace as playfields and parkland. Renderings of conceptual redesigns developed by the City of Edina Parks & Recreation are included as Appendix B.

Seagate Technology owns and operates a manufacturing plant and associated parking lots on approximately 34 acres located southeast of the intersection of Computer Avenue and West 77th Street. Large portions of the Seagate parking areas are low-lying and are prone to inundation during flood events.

The remainder of the study area is made up of smaller private parcels developed for a variety of uses, including office buildings, mini-storage facilities, parking ramps, restaurants, apartments, and hotels. Figure 1-5 shows the most recent publicly available aerial imagery for the study area.





Nine Mile Creek
NMCWD Legal Boundary
Study Area

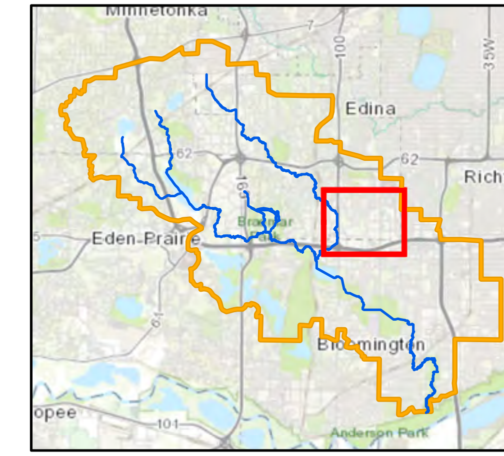
BARR

N

0 500 1,000
Feet

HISTORICAL LAND USE
1901 USGS QUAD
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure 1-3



Nine Mile Creek

NMCWD Legal Boundary

Study Area

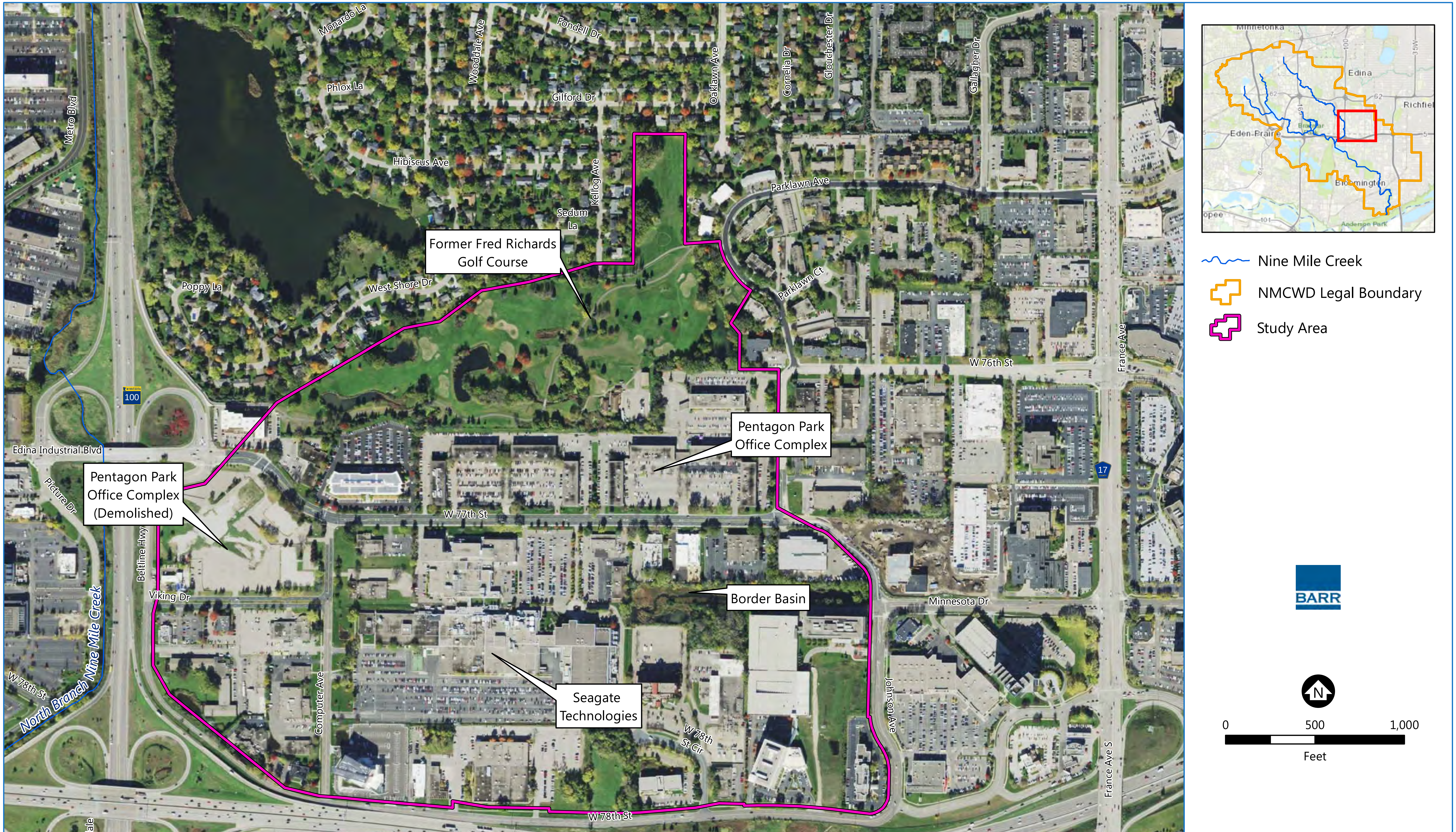
BARR

0 500 1,000
Feet

HISTORICAL LAND USE
1972 USGS AERIAL IMAGERY
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure 1-4

Barr Footer: ArcGIS 10.4.1, 2018-04-06 08:44 File: I:\Client\Nine_Mile_Creek_WD\Work_Orders\Pentagon_Park_Updates\Maps\Reports\Report\Figure 1-4 1972 Aerial Imagery.mxd User: rcs2



PRESENT-DAY AERIAL IMAGERY
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure 1-5

Barr Footer: ArcGIS 10.4.1, 2018-04-06 08:44 File: I:\Client\Nine_Mile_Creek_WD\Work_Orders\Pentagon_Park_Updates\Maps\Reports\Report\Figure 1-5 Present-Day Aerial Imagery.mxd User: rcs2

1.4 Topography

The study area topography is roughly bowl-shaped. Much of the area lies between elevation 814 and 824 feet (National Geodetic Vertical Datum of 1929 or NGVD 29), and the study area is surrounded by higher land of greater than elevation 830 feet (Figure 1-6). Buildings are typically constructed on pads of fill to prevent flooding and are surrounded by lower-lying parking lots that typically become inundated to varying extents during high intensity rainfall events.

In the northern part of the study area, the normal water elevation of the ponds on the former golf course is approximately 818.2 feet. The golf course area is separated from the rest of the area to the south by a small berm at an elevation of approximately 822 feet to 823 feet.

The Border Basin, located on the eastern side of the study area, is a linear pond that runs from east to west, providing stormwater runoff storage for the area. A shallow ditch running through parking lots in the far southern part of the area provides a limited amount of additional stormwater storage. Three small stormwater ponds also provide limited amounts of additional flood storage (Figure 1-6).

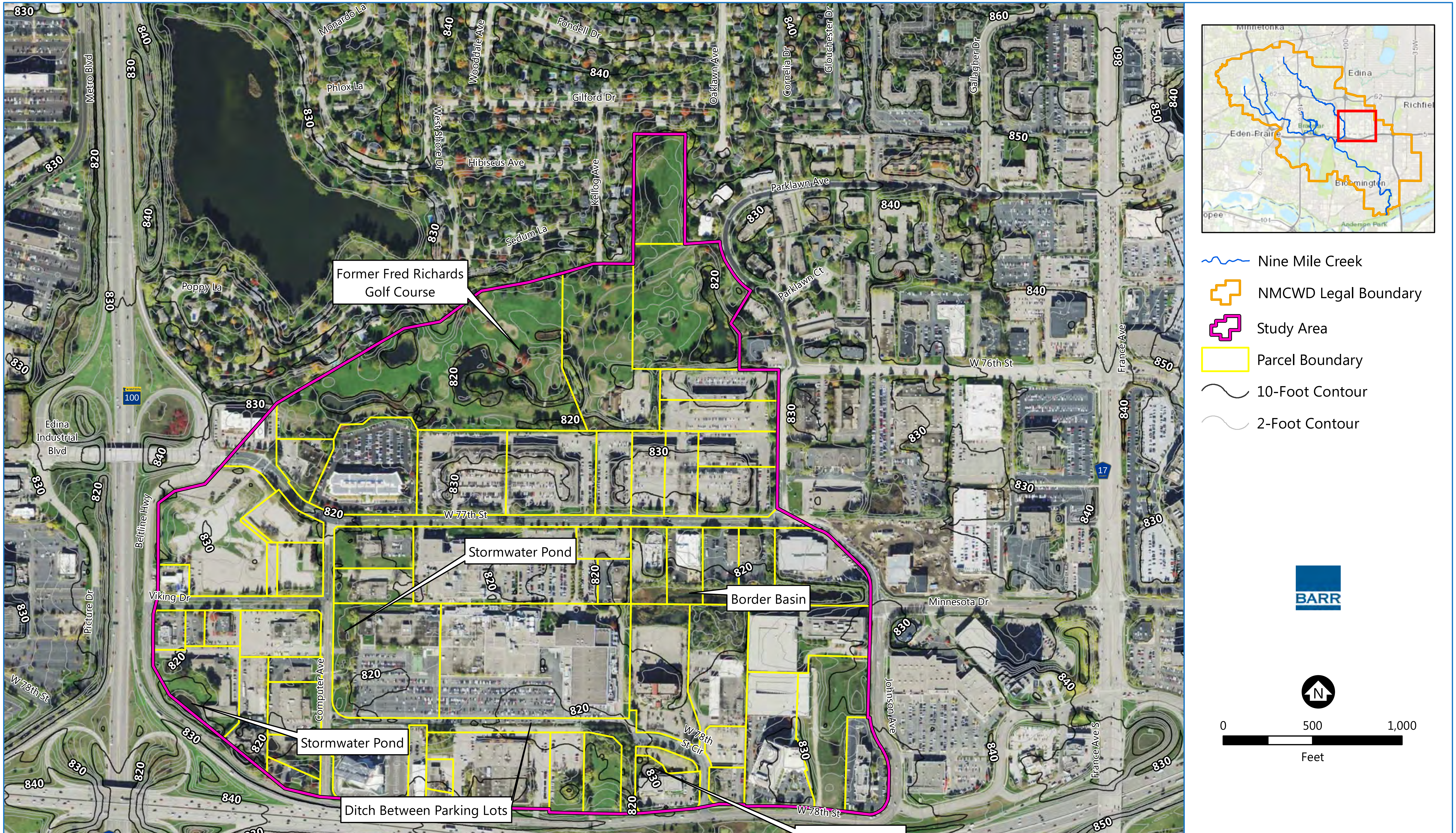
Elevation data collected by the Minnesota Department of Natural Resources in 2011 using Light Detection and Ranging (LiDAR) was used for this study.

1.5 Soils

The underlying soils of the study area are classified as hydrologic soil group D (HSG D) with very slow infiltration rates and high runoff potential (Figure 1-7). Soil investigations for a recent construction project on the Seagate property in the southern part of the area encountered a surficial water table at approximately elevation 814.

1.6 Groundwater

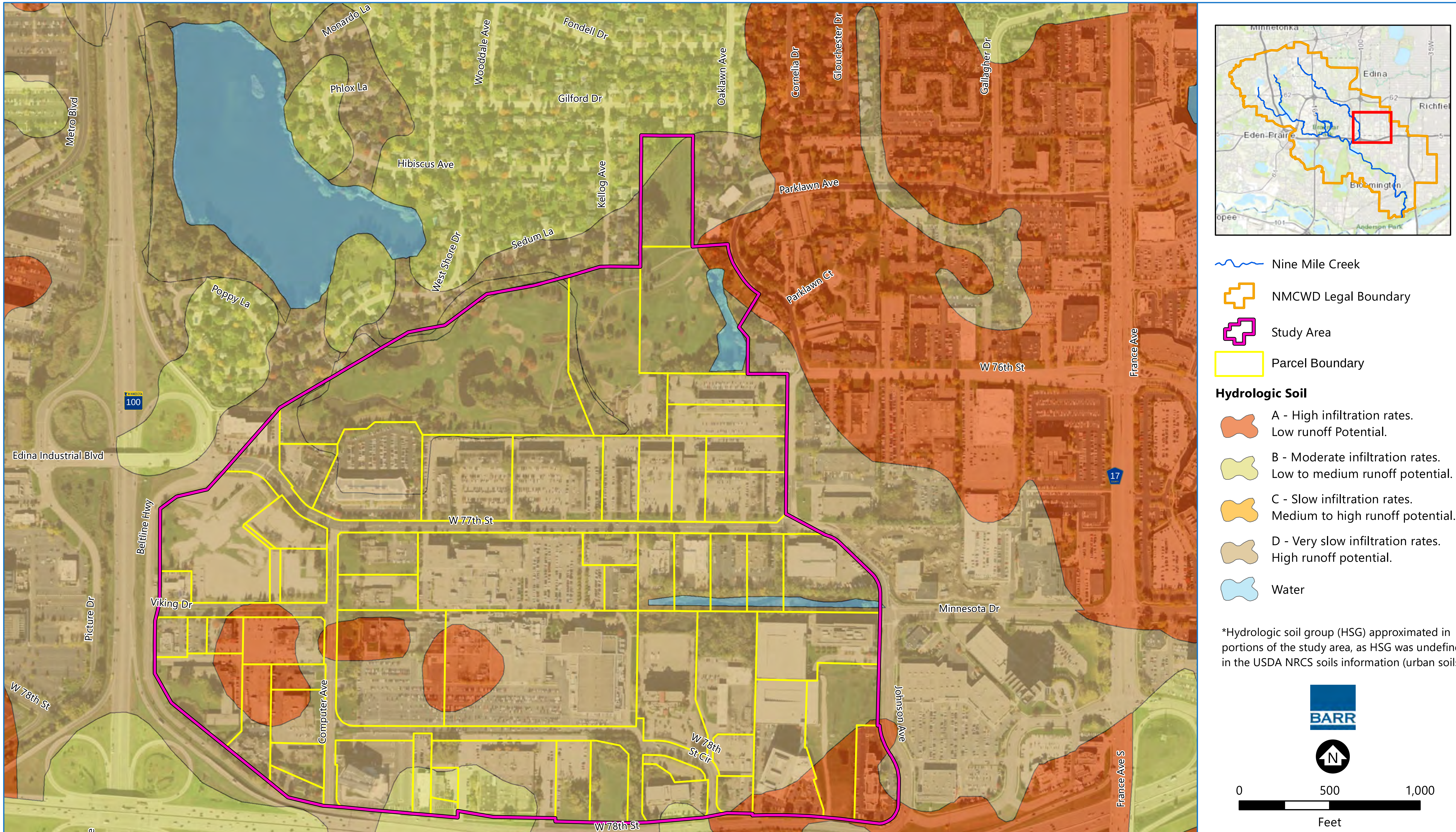
Groundwater elevations throughout the study area vary. Review of soil boring logs from six properties submitted as part of NMCWD permit applications in recent years indicates that groundwater levels range from 806 feet to 816 feet M.S.L within the study area.



TOPOGRAPHY
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure 1-6

Barr Footer: ArcGIS 10.4.1, 2018-04-06 08:47 File: I:\Client\Nine_Mile_Creek_WD\Work_Orders\Pentagon_Park_Updates\Maps\Reports\Report\Figure 1-6 Topography.mxd User: rcs2



HYDROLOGIC SOIL GROUPS
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

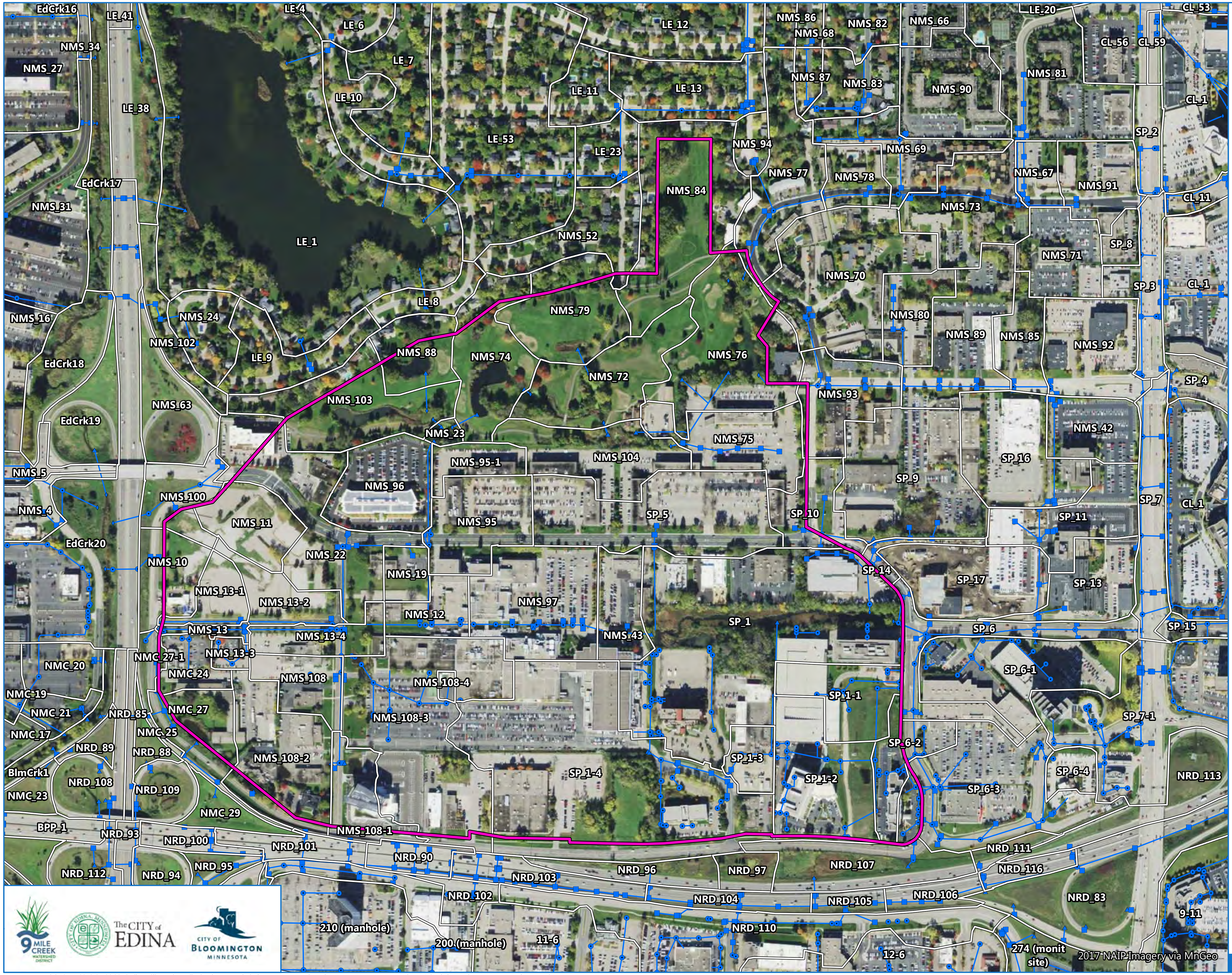
Figure 1-7

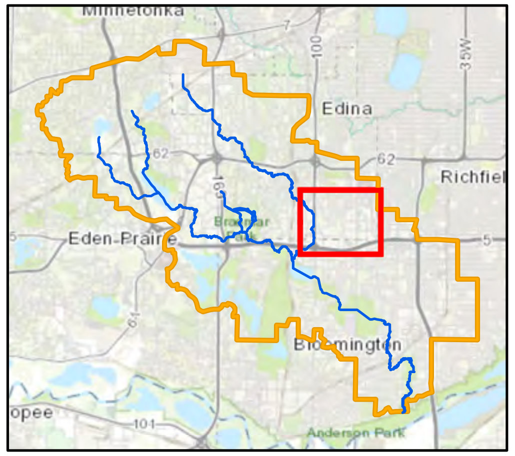
1.7 Drainage Patterns

The study area drains west through storm sewer pipes to the North Fork of Nine Mile Creek, which runs from north to south along the west side of TH 100. Figure 1-8 shows the storm sewer utilities within the study area. The main stormwater conveyances to Nine Mile Creek are a 7 feet high x 9.7 feet wide concrete box culvert that flows from the Border Basin to TH 100, and a 48-inch corrugated metal pipe (CMP) that flows parallel and just south of the box culvert from Computer Avenue to TH 100. These two pipes converge at a junction just east of TH 100. From this junction a 97-inch x 154-inch reinforced concrete arch pipe (RCPA) conveys water west, passing under TH 100 before discharging to Nine Mile Creek. Within the study area, a network of municipal and private storm sewer systems drain stormwater from catch basins and ponds to the main conveyances.

In addition to the main outlet, three other pipes convey stormwater to Nine Mile Creek from smaller drainage areas located near TH 100. These include a 66-inch reinforced concrete pipe (RCP) located approximately 250 feet south of West 77th Street; an 18-inch RCP located approximately 500 feet south of West 77th Street, and a 36-inch RCP located just north of the TH 100/I-494 interchange.

The study area receives stormwater inflows from drainage areas located to the north and the east. These inflows include a 60-inch RCP that discharges to a pond on the east side of the golf course near Parklawn Avenue (NMS_76); a 45-inch x 73-inch RCPA that discharges to the same pond near 76th Street; and a 78-inch RCP that collects the combined drainage from France Avenue, Centennial Lakes, and areas between France Avenue and Minnesota Drive before discharging to the Border Basin. During large events, the former golf course area also receives stormwater surface overflows from Kellogg Avenue and Oaklawn Avenue.





- Nine Mile Creek
- NMCWD Legal Boundary
- Study Area
- Subwatersheds

Storm Sewer

- Manhole
- Catch Basin
- Inlet
- Outlet
- Other
- Collector

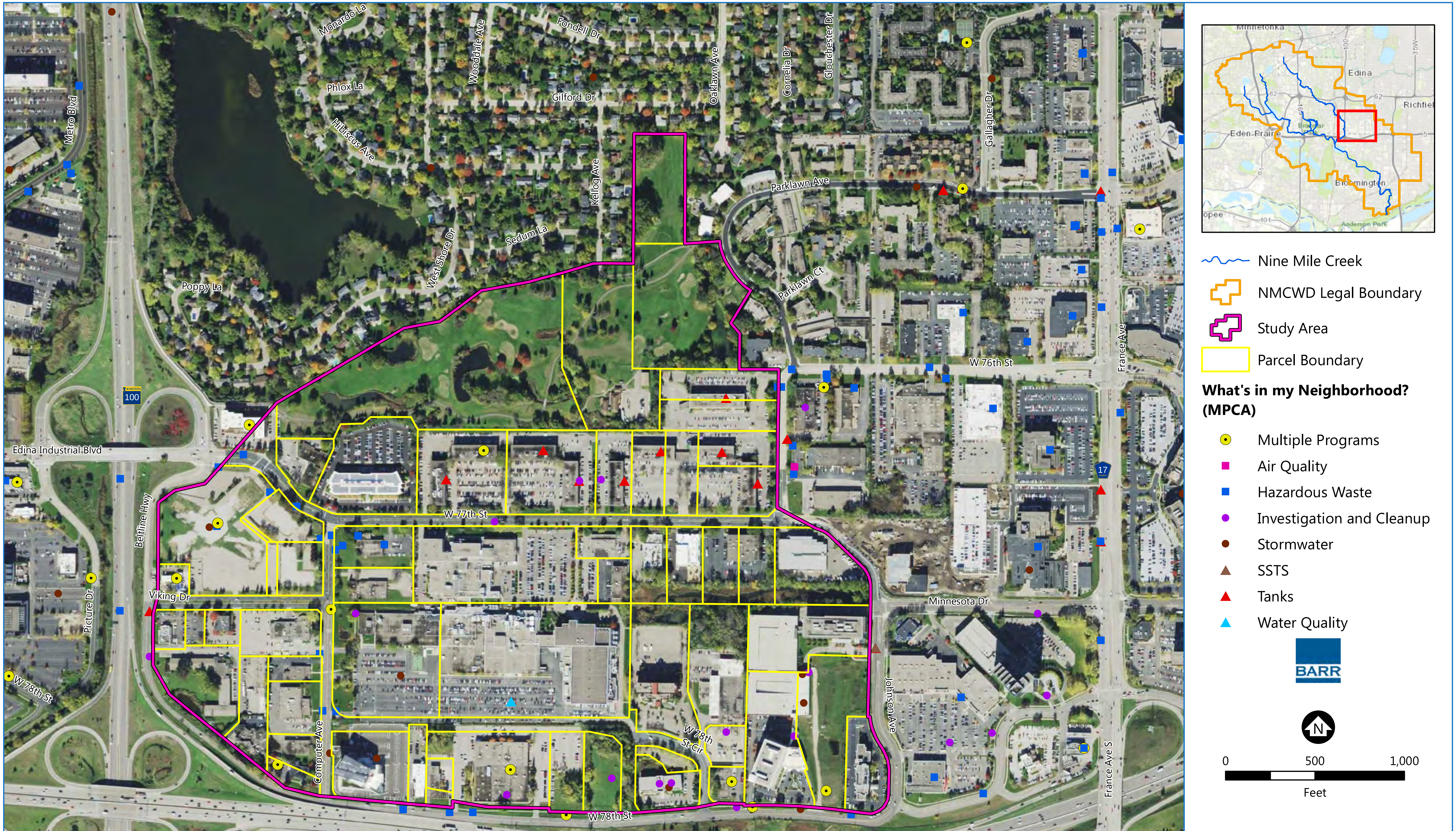
BARR

0 500 1,000
Feet

EXISTING DRAINAGE PATTERNS
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure 1-8

9 MILE CREEK WATERSHED DISTRICT — The CITY of EDINA — CITY OF BLOOMINGTON MINNESOTA



ENVIRONMENTAL HAZARDS
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure 1-9

Barr Footer: ArcGIS 10.4.1, 2018-04-06 08:55 File: I:\Client\Nine_Mile_Creek_WD\Work_Orders\Pentagon_Park_Updates\Maps\Reports\Report\Figure 1-9 Environmental Hazards.mxd User: rcs2

2.0 Existing Stormwater Management

2.1 Existing Flood Conditions

2.1.1 Modeling Methodology

The existing flood conditions for the study area were simulated using XP-SWMM modeling software. The model used for this study was based on models developed previously for the NMCWD and cities of Edina and Bloomington. Modeled areas within the City of Edina were updated during work to support the City of Edina 2017 Comprehensive Water Resource Management Plan (CWRMP). Modeled areas within the City of Bloomington were updated to include additional detail reflecting existing surface drainage patterns and recent storm sewer projects. To facilitate faster run-times, the model was "clipped" to those elements that were necessary and sufficient to generate results matching the full length model. Boundary conditions for Nine Mile Creek inflows and storm sewer outfalls were based on hydrographs extracted from full model runs for the corresponding storm events.

The XP-SWMM modeling software simulates precipitation falling on a watershed area, where it can either be stored (depression storage), infiltrate (soak into the ground) or become runoff. Runoff can be routed into storm sewer pipes, surface channels, or storage areas representing lakes, ponds or depressions. Infiltrated water does not contribute to downstream water bodies or storm sewer. During a simulation, the modeling software tracks the water surface elevations, flow rates, and storage volumes for each modeled element (e.g. manhole locations, ponds, pipes, and surface channels).

Storage areas are represented in XP-SWMM using stage-area tables computed using ArcGIS and the DNR LiDAR elevation data. Prior to performing this analysis, building footprints were subtracted from the subwatershed polygons to avoid over-estimating the available storage.

Rainfall depths and intensities from the *Atlas 14, Volume 8 Precipitation-Frequency Atlas of the United States* (Atlas 14), published by NOAA in 2013, were used for the analysis. Atlas 14 provides estimates of precipitation depth (i.e., total rainfall in inches) and intensity (i.e., depth of rainfall over a specified period) for storm event durations from 5 minutes up to 60 days, over a range of recurrence intervals. Atlas 14 supersedes publications Technical Paper 40 (TP-40) and Technical Paper 49 (TP-49) issued by the National Weather Bureau (now the National Weather Service) in 1961 and 1964, respectively. Improvements in Atlas 14 precipitation estimates include denser data networks, longer and more recent periods of record, application of regional frequency analysis, and new techniques in spatial interpolation and mapping. Comparison of precipitation depths and intensity between TP-40 and Atlas 14 indicates increased precipitation depths and intensity for more extreme (i.e., less frequent) events. The Pentagon Park/Border Basin model was used to simulate the 10- and 100-year recurrence interval, 24-hour Atlas 14 rainfall events of approximately 4.3 inches and 7.5 inches, respectively.

2.1.2 Flood Storage in the Study Area

The simulated peak flood elevations and peak storage volumes for subwatersheds within the study area are shown in Table 2-1. Peak flood elevations for the 10- and 100-year, 24-hour rainfall events were mapped on a LiDAR surface using ArcGIS; approximate inundation areas corresponding to the 100-year and 10-year events are shown in Figure 2-1 and Figure 2-2, respectively. The simulation results and inundation mapping show that during the 10-year and 100-year flood events, the study area can be divided into eight major flood storage areas, interconnected by the existing storm sewer network and surface flow paths. Three of these flood storage areas are located in the northern part of the study area, in and around the former Fred Richards Golf Course, while five lie in the southern portion of the study area. The eight major storage areas, shown in Figure 2-3, are described in more detail below.

2.1.2.1 Northern Storage Areas

Lake Edina Park Storage Area

The Lake Edina Park storage area lies within subwatershed NMS_84 (as identified in the City of Edina Comprehensive Water Resource Management Plan (Edina CWRMP)), in the northernmost part of the study area (Figure 1-8). The direct subwatershed for Lake Edina Park is approximately 12 acres, but the simulations show that during the 10-year and 100-year events, Lake Edina Park also receives surface overflows from Oaklawn Avenue. The Lake Edina Park storage area is landlocked for more-frequent rainfall events, but during the 10-year and 100-year events it overflows to the Western Golf Course storage area at elevation 825.1 MSL.

Eastern Golf Course Storage Area

The Eastern Golf Course storage area lies south of Lake Edina Park, within subwatershed NMS_76 (Edina CWRMP). Stormwater runoff from storm sewer systems draining areas of 76th Street and Parklawn Avenue discharges to a pond located in the center of this storage area. This pond discharges to the Western Golf Course area through a storm sewer outlet and, during the 10-year and 100-year events, through a surface overflow at elevation 824.1 MSL.

Western Golf Course Storage Area

The Western Golf Course storage area contains eight subwatersheds that make up the majority of the former Fred Richards Golf Course. The area receives runoff originating from the direct contributing area and from storm sewer inflows from adjacent subwatersheds. Surface water is detained in several ponds that are interconnected by storm sewer and surface flow paths, allowing the ponds' water surface elevations to equalize during flood events. A weir structure located in subwatershed NMS_23 (Edina CWRMP) controls the normal water elevation of the ponds at elevation 818.2 MSL. Water discharging over the weir is conveyed south by storm sewer pipe that connects to the box culvert outlet pipe from the Border Basin. During the 10-year and 100-year events, the Western Golf Course storage area surface overflows to the south at elevation 821.8 MSL to the Edina Corporate Center (4700 West 77th Street) parking lot, eventually reaching West 77th Street.

2.1.2.2 Southern Storage Areas

Border Basin Storage Area

The Border Basin stormwater pond is the primary flood storage area within the southern part of the study area. The Border Basin is a linear pond that is located between Minnesota Drive and the eastern edge of the Seagate property at One Disc Drive. An outlet control weir structure at the western end of the pond maintains the pond's normal water elevation at 814.7 MSL.

Altogether, approximately 410 acres contribute stormwater runoff to the Border Basin. This includes storm sewer inflows from the Centennial Lakes area, from the area between France Avenue and Johnson Avenue, and from areas located to the north and south of the basin, as well as runoff from its direct subwatershed. The eastern end of West 77th Street also drains directly to the Border Basin and is therefore included in this storage area. During the 100-year event, the storage within the Border Basin inundates the Park Plaza Hotel parking lot to the south and the Seagate parking lots to the northwest and southwest, ultimately impacting areas west of Computer Avenue. During the 10-year event the peak flood inundation is limited to the parking areas located north and south of the basin, and to the easternmost Seagate parking lot on the north side of the basin.

Seagate Parking Lot Storage Area

The Seagate parking lots lie west of the Border Basin between West 77th Street and West 78th Street, north and south of the main Seagate buildings. Parking lots on the north side of the buildings receive stormwater runoff from their local subwatersheds and drain through storm sewer to the 10-foot by 10-foot Border Basin outlet box culvert. Parking lots on the south side of the building and adjacent parcels to the south of Seagate are inundated from the detention of the 100-year storm event within the Border Basin.

The southeast Seagate parking lots and parking lots on adjacent properties located south of Seagate drain to a shallow drainageway that flows to a 60-inch RCP that discharges to the Border Basin. A backflow of surface water in the pipe during flood events causes water surface elevations in the ditch and parking lot to equalize with the Border Basin. The southeast parking lots overflow to the west during the 100-year event at elevation 821.3 MSL.

The southwest Seagate parking lots drain through storm sewer to the 48-inch CMP at Computer Avenue and Viking Drive, which drains to the main study area outlet at TH 100. The southwest parking lots during the 100-year event are inundated from the surface water overflow from the southeast parking lots. Water from the southwest parking lots during the 100-year event overtops Computer Avenue at elevation 820.6 MSL and flows to the west toward TH 100.

West 77th Street Storage Area

The storage area on and around West 77th Street, between Computer Avenue and TH 100 frontage road (labelled as "TH 100 Frontage Road" on Figure 2-3), receives runoff from its local subwatershed and surface overflows from the former Fred Richards Golf Course. Catch basins at the intersection of 77th Street and Computer Avenue drain to the 48-inch CMP at Viking Drive, while catch basins on West 77th Street west of Computer Avenue drain to the Border Basin outlet box culvert. The 48-inch CMP and the 10-foot by 10-foot box culvert are connected to the 154-inch span RCPA that conveys water beneath TH 100 and discharges to Nine Mile Creek. During the 10-year and 100-year events, water ponding on West 77th Street flows south towards Viking Drive at elevation 820.5 MSL.

Computer Avenue/West 78th Street Storage Area

The storage area between Computer Avenue and West 78th Street south of Viking Drive receives stormwater runoff from the local subwatershed and from the upstream areas that overflow from West 77th Street and Computer Avenue. Most of this area drains to a small stormwater pond located along West 78th Street southwest of the Days Inn. This pond discharges through an 18-inch RCP outlet to a 36-inch RCP that conveys water under TH 100 to Nine Mile Creek.

TH 100 Frontage Road Storage Area

A portion of the TH 100 frontage road right-of-way located in the northwest corner of the study area provides a small amount of flood storage. The frontage road is drained by two storm sewer pipes under TH 100 to Nine Mile Creek.

2.1.3 Peak Discharge Rates and Runoff Volumes within the Study Area

Simulation results from the existing conditions study area XP-SWMM model were used to identify and quantify significant peak discharge rates and runoff volumes within the study area. Figure 2-4 and Figure 2-5 show the peak flow rates and the total flow volumes for significant flow paths during the 100-year and 10-year, 24-hour rainfall event simulations, respectively.

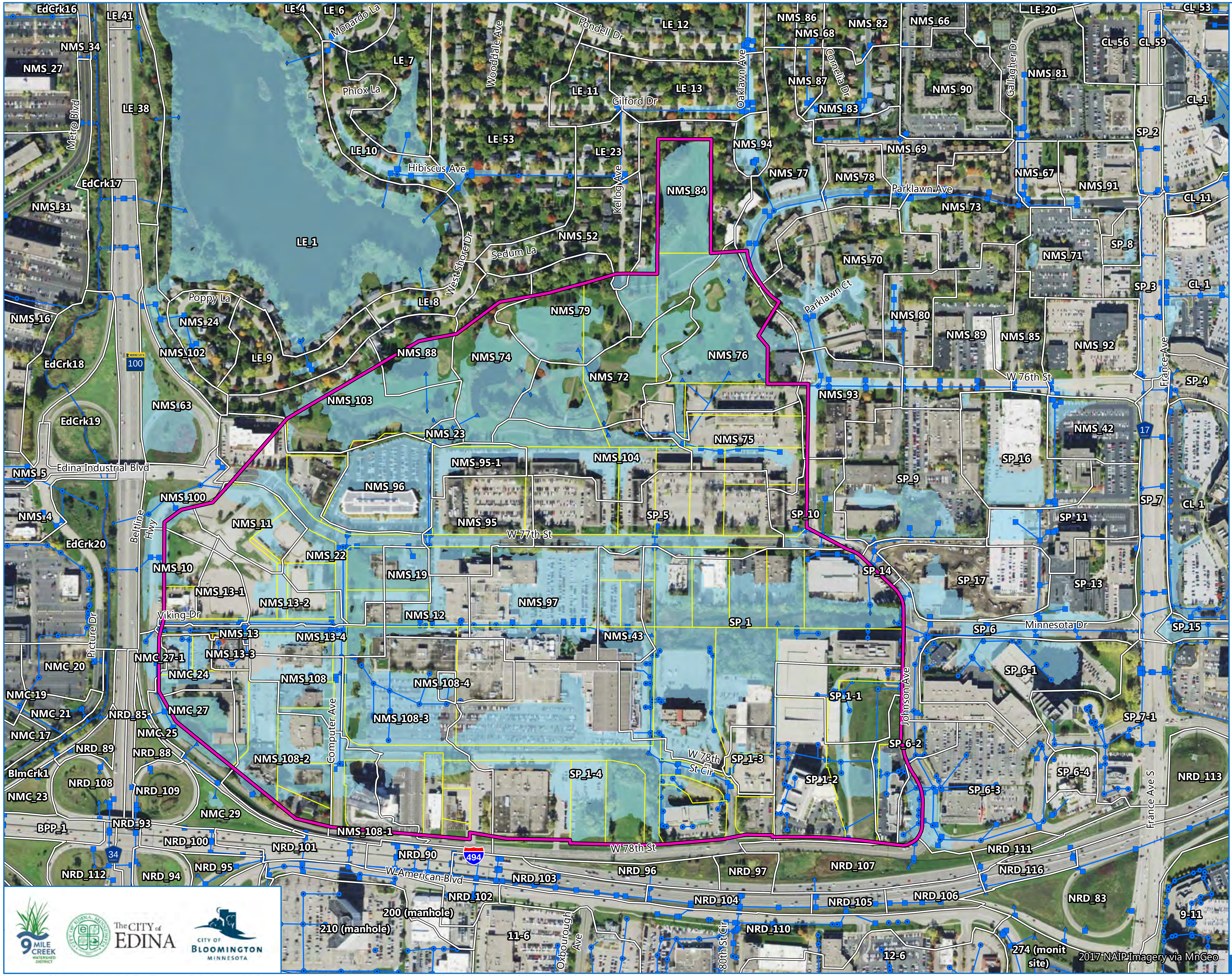
During the 100-year rainfall event simulation, an overflow volume of approximately 16.5 acre-feet flows into Lake Edina Park via the surface flow paths at Kellogg Avenue and Oaklawn Avenue. Stormwater from these areas is conveyed to Lake Edina by storm sewer during smaller rainfall events. Approximately 52 acre-feet of additional volume flows into the eastern side of the former Fred Richards Golf Course through storm sewer and surface flow paths. The combined volume of these inflows, added to the runoff volume of the local golf course subwatersheds (45.5 acre-feet), exceeds the available flood storage in Lake Edina Park and the former Fred Richards golf course of approximately 47 acre-feet. As a result, during the 100-year event approximately 67 acre-feet overflow south from the golf course area and add to flooding in downstream areas (Figure 2-4).

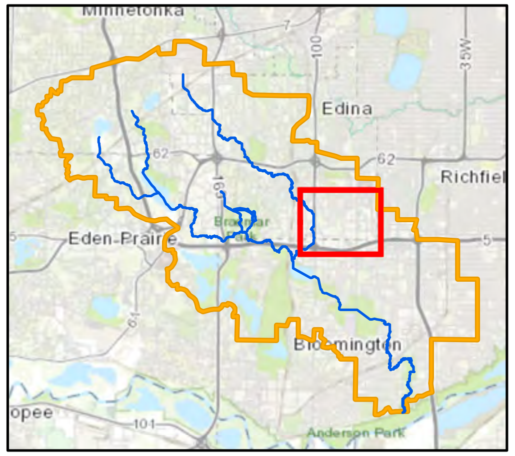
The Border Basin also receives stormwater runoff exceeding its capacity from upstream areas. As shown in Figure 2-4, the Centennial Lakes storm sewer outlet carries a volume of approximately 216 acre-feet with a peak discharge rate of 394 cfs into the Border Basin. Approximately 417 acre-feet of stormwater are discharged from the study area via the 154-inch span arch pipe under TH 100. Due to high tailwater conditions in Nine Mile Creek, during the 100-year storm event the peak discharge rate of the arch pipe is limited to 295 cfs. Because the combined discharge rates into the study area exceed the discharge rate out of the study area, the excess stormwater is stored within the study area, causing flood elevations to rise above the elevations that would be reached due to local runoff from the study area alone.

Table 2-1 10-year and 100-year Peak Flood Elevations and Storage Volumes for Subwatersheds within the Study Area

Subwatershed (as identified in the Edina CWRMP)	100-year Peak Flood Elevation (feet NGVD29)	100-year Peak Storage Volume (acre-feet)	10-year Peak Flood Elevation (feet NGVD29)	10-year Peak Storage Volume (acre-feet)
NMC_24	822.6	1.5	819.8	0.0
NMC_27	822.6	7.8	818.8	1.8
NMC_27-1	822.6	0.4	820.7	0.0
NMS_10	821.9	1.3	820.8	0.3
NMS_100	821.9	1.4	819.4	0.0
NMS_103	822.9	9.9	822.1	6.5
NMS_104	822.9	8.2	822.1	5.4
NMS_108	822.7	2.5	820.1	0.0
NMS_108-1	822.6	1.4	820.6	0.1
NMS_108-2	822.6	7.6	820.6	2.2
NMS_108-3	822.6	10.9	820.4	1.9
NMS_108-4	822.6	0.4	820.4	0.0
NMS_11	822.6	1.7	820.8	0.2
NMS_12	822.6	2.5	820.7	0.6
NMS_13	822.6	0.1	819.4	0.0
NMS_13-1	822.6	0.0	819.3	0.0
NMS_13-2	822.6	2.1	819.5	0.0
NMS_13-3	822.6	0.0	819.5	0.0
NMS_13-4	822.6	2.0	819.6	0.0
NMS_19	822.6	4.4	820.7	1.8
NMS_22	822.6	10.0	820.7	1.9
NMS_23	822.9	1.2	822.1	0.8
NMS_43	822.7	5.3	820.5	1.3
NMS_52	827.2	0.0	825.9	0.0
NMS_70	826.2	1.9	825.1	0.4
NMS_72	822.9	7.3	822.1	5.0
NMS_74	822.9	9.2	822.1	6.4
NMS_75	824.6	0.6	822.5	0.0
NMS_76	826.2	15.9	824.8	10.3

Subwatershed (as identified in the Edina CWRMP)	100-year Peak Flood Elevation (feet NGVD29)	100-year Peak Storage Volume (acre-feet)	10-year Peak Flood Elevation (feet NGVD29)	10-year Peak Storage Volume (acre-feet)
NMS_77	827.8	1.5	827.0	0.6
NMS_79	823.0	3.4	822.1	1.6
NMS_84	826.8	13.8	825.3	6.3
NMS_88	822.9	5.8	822.1	4.0
NMS_93	826.2	0.8	824.9	0.0
NMS_95	822.6	1.1	820.8	0.0
NMS_95-1	822.9	1.3	822.1	0.5
NMS_96	822.9	1.5	822.1	0.2
NMS_97	822.7	10.4	820.1	1.6
SP_1	822.7	72.4	820.5	41.1
SP_10	824.7	0.0	824.5	0.0
SP_1-1	824.4	0.6	823.0	0.2
SP_1-2	824.4	0.9	822.9	0.1
SP_1-3	822.9	0.1	820.9	0.0
SP_1-4	822.7	35.3	820.5	12.8
SP_5	822.7	1.6	821.4	0.2
SP_6	827.5	0.9	825.7	0.0
SP_6-2	824.4	1.0	823.6	0.6
SP_6-3	826.8	1.4	825.5	0.2





Nine Mile Creek

NMCWD Legal Boundary

Study Area

Parcel Boundary

100-year, 24-hour Flood Inundation

Subwatersheds

Storm Sewer

Manhole

Catch Basin

Inlet

Outlet

Other

Collector

BARR

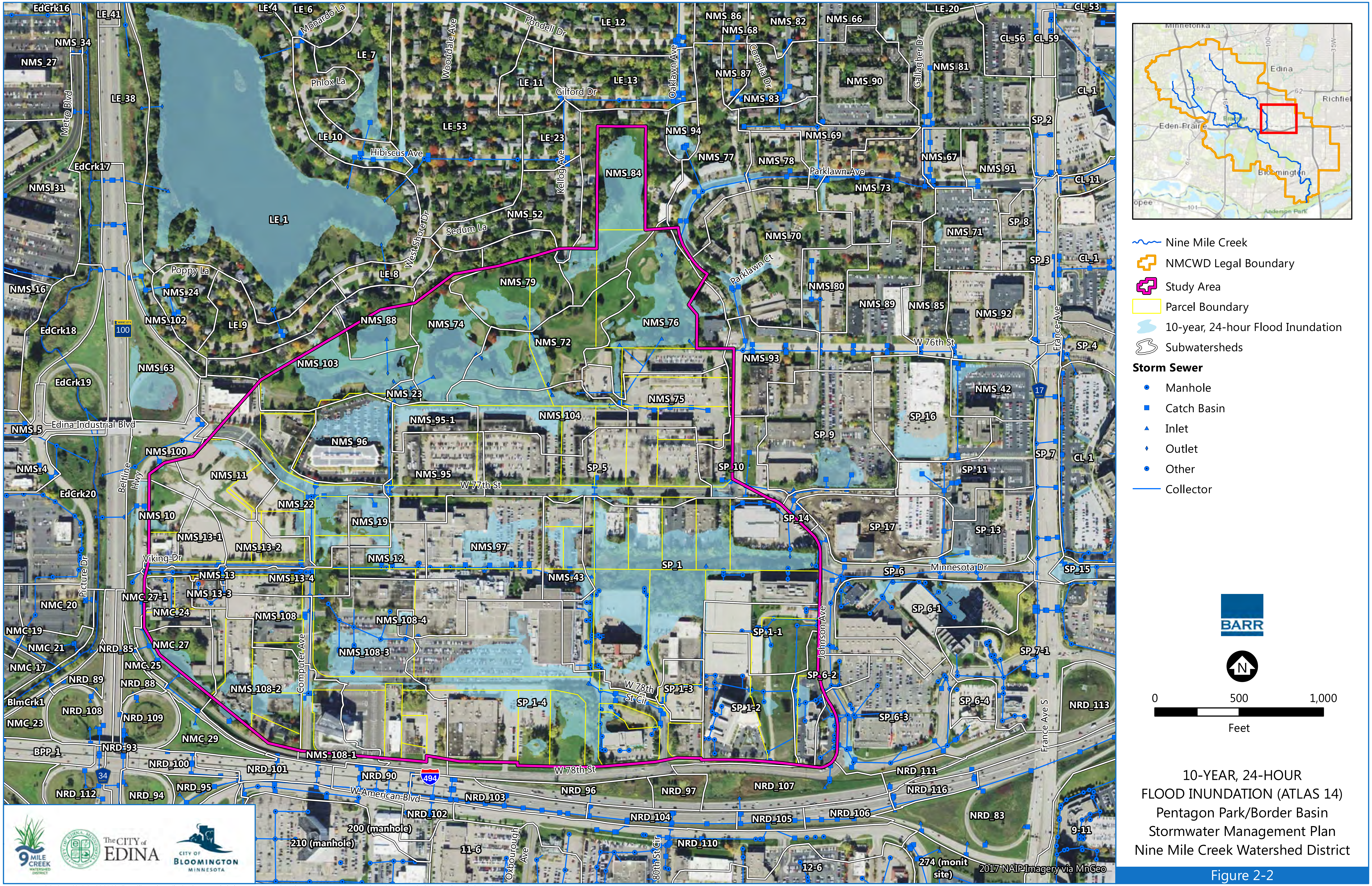
N

0 500 1,000

Feet

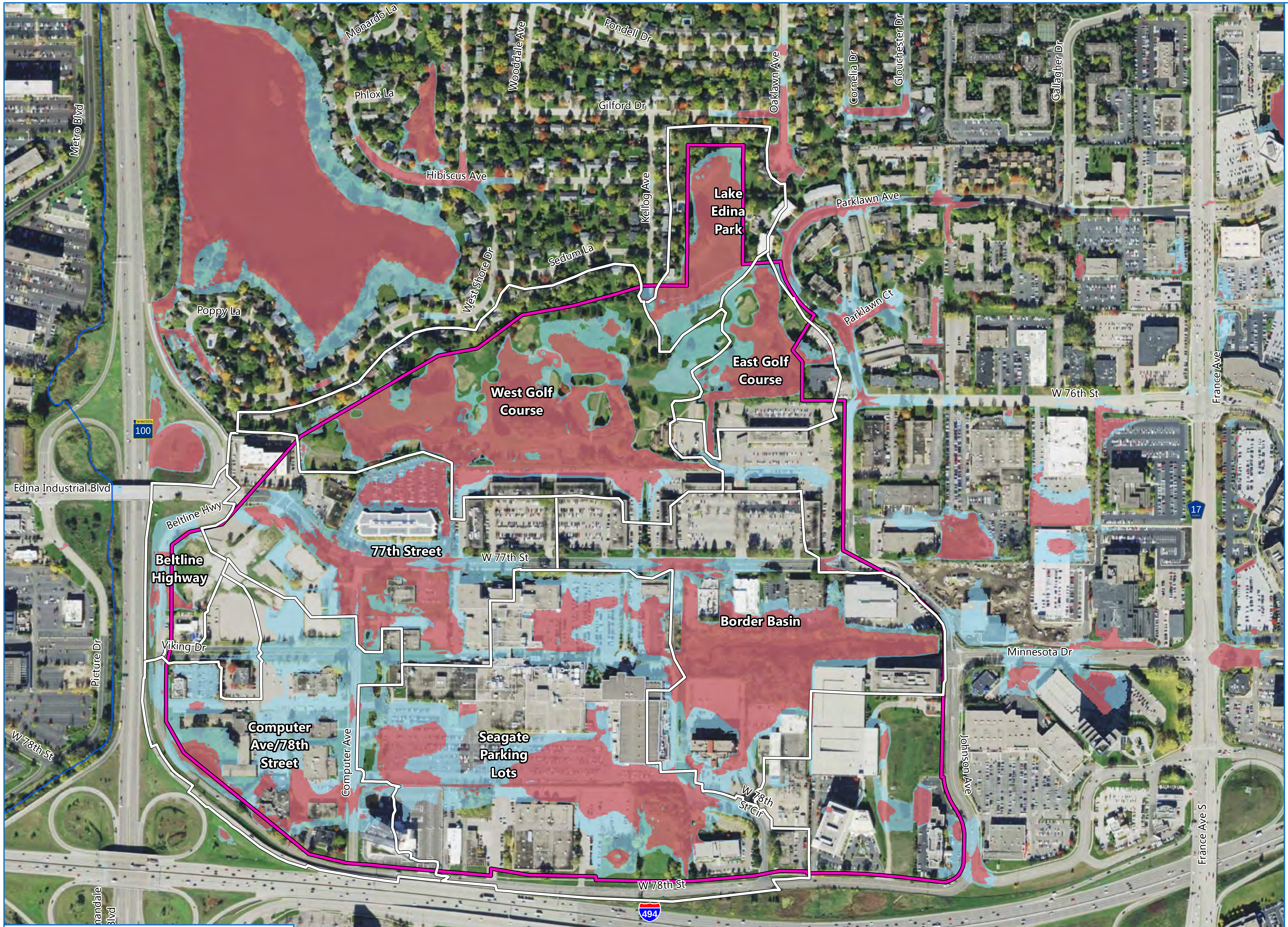
100-YEAR, 24-HOUR
FLOOD INUNDATION (ATLAS 14)
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

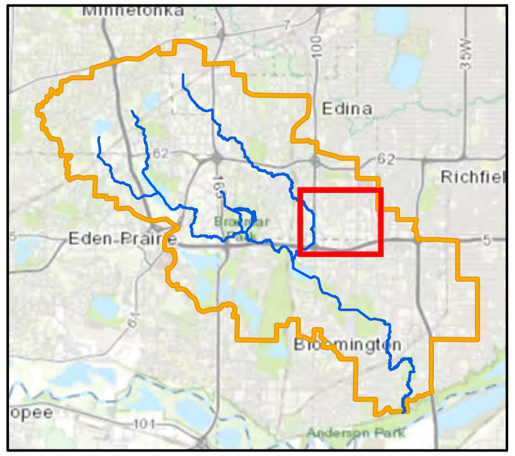
Figure 2-1



10-YEAR, 24-HOUR FLOOD INUNDATION (ATLAS 14)
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure 2-2





- Nine Mile Creek
- NMCWD Legal Boundary
- Study Area
- 10-year, 24-hour Flood Inundation
- 100-year, 24-hour Flood Inundation
- Major Flood Storage Areas

BARR

N

0 500 1,000

Feet

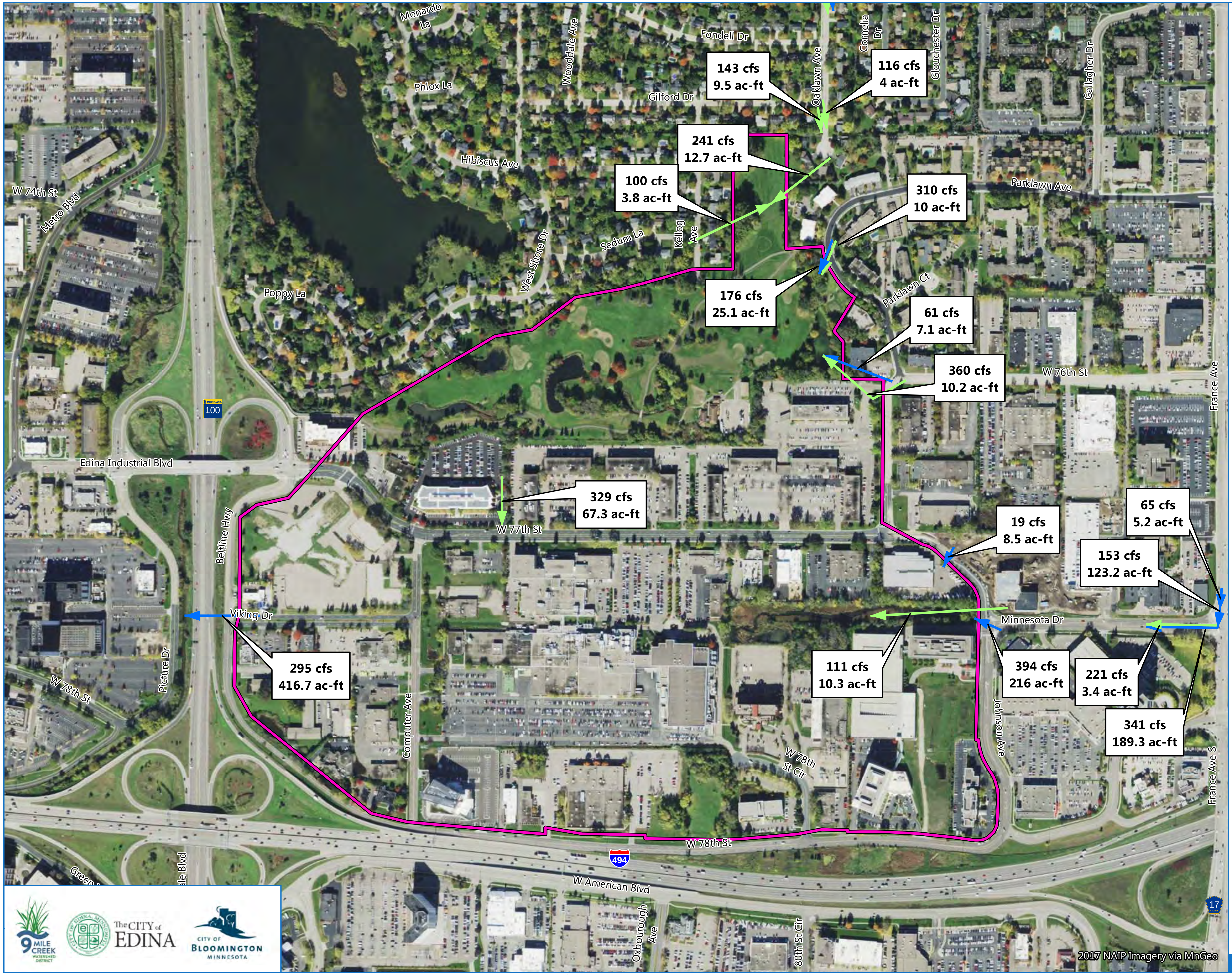
SIGNIFICANT FLOOD STORAGE AREAS
WITHIN THE STUDY AREA
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

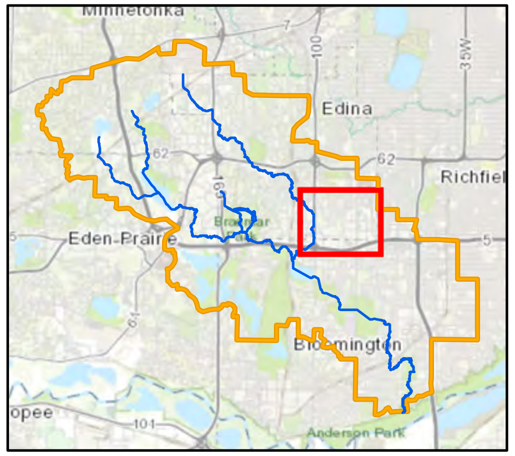
Figure 2-3

9 MILE CREEK WATERSHED DISTRICT

The CITY of EDINA

CITY OF BLOOMINGTON MINNESOTA





Nine Mile Creek

NMCWD Legal Boundary

Study Area

Contributing Conduits 100yr

Storm Sewer

Surface Channel

0 500 1,000

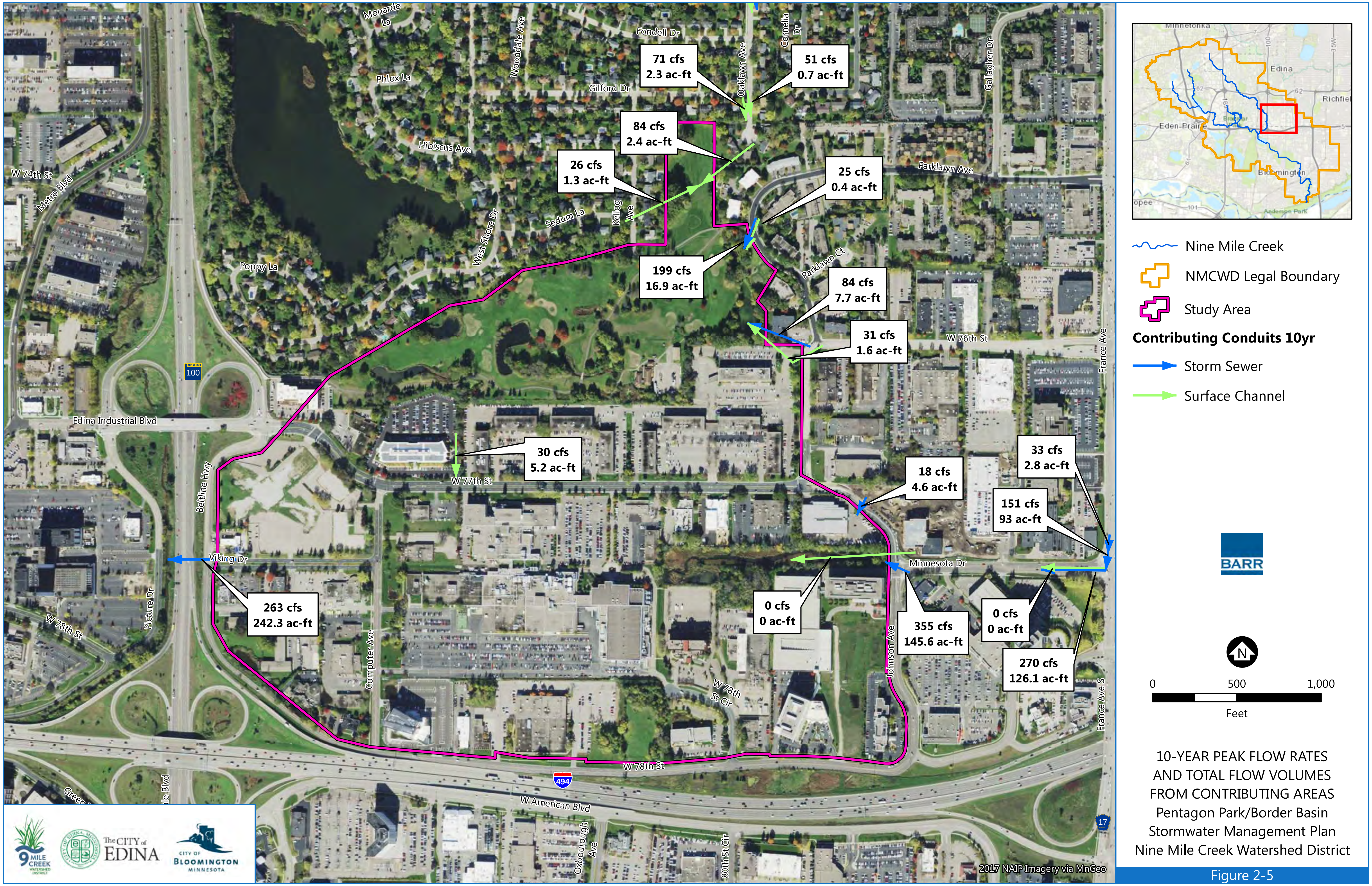
Feet

100-YEAR PEAK DISCHARGE RATES AND TOTAL FLOW FROM CONTRIBUTING AREAS

Pentagon Park/Border Basin Stormwater Management Plan

Nine Mile Creek Watershed District

Figure 2-4



10-YEAR PEAK FLOW RATES AND TOTAL FLOW VOLUMES FROM CONTRIBUTING AREAS
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure 2-5

2.2 Existing Regional Stormwater Treatment

The Border Basin and ponds within the former Fred Richards Golf Course provide water quality treatment to stormwater runoff from portions of the study area, as well as the upstream contributing drainage areas. The extent of phosphorus and total suspended solids removal that occurs under existing conditions was estimated using a P8 (Program for Predicting Polluting Particle Passage through Pits, Puddles, and Ponds, 2000) model originally developed as part of the 2003 City of Edina Comprehensive Water Resource Management Plan (Barr, 2003) and later calibrated as part of the Nine Mile Creek Watershed District Normandale Lake Use Attainability Analysis (Barr, 2005). The P8 model simulates the hydrology, phosphorus, and sediment loads (among other pollutants) introduced from the subwatersheds and the transport of these pollutants throughout the stormwater system.

Under existing conditions, the series of ponds within the former Fred Richards Golf Course collectively achieve an approximate 74% average annual total phosphorus removal and 95% total suspended solids removal from the contributing watershed, based on a P8 model simulation for a 50-year time period.

The Border Basin achieves an approximate 31% average annual total phosphorus removal and 64% total suspended solids removal. The moderate removal effectiveness in the Border Basin is due to several factors, including the shallow nature of the existing pond, its small size in comparison with the large contributing drainage area, and the significant proportion of inflow from Centennial Lakes, which has a large fraction of soluble phosphorus since much of the solids and associated phosphorus has already settled out. The cumulative percent removal of total phosphorus and total suspended solids achieved through the Border Basin and upstream Centennial Lakes is better – 48% and 78%, respectively.

3.0 Flood Risk Reduction Evaluation

3.1 Flood Risk Reduction Alternatives

Five concept-level flood risk reduction alternatives were evaluated by simulating them with the Pentagon Park/Border Basin XP-SWMM model. Due to the large volume of flood water moving through the area during major events, the primary criteria for the alternatives evaluated was the ability to provide a large increase in storage volume or a large increase in conveyance out of the area. Alternatives selected for evaluation included:

1) Storage expansion in the former Fred Richards Golf Course area
2) Storage expansion in the Border Basin
3) Upstream storage along France Avenue
4) Increased conveyance to Nine Mile Creek
5) Diversion of stormwater to Normandale Lake

The five flood risk reduction alternatives were evaluated by comparing the peak flood elevations and peak storage volumes of the previously-described storage areas to the existing conditions model for the 10- and 100-year, 24-hour rainfall events.

3.1.1 Storage expansion in former Fred Richards Golf Course area

The Western Golf Course storage area in the former Fred Richards Golf Course is approximately 46 acres of mostly open space, encompassing subwatersheds NMS_23, NMS_72, NMS_74, NMS_79, NMS_88, NMS_95-1, NMS_103, and NMS_104 (as identified in the Edina CWRMP). During the 10-year and 100-year events, the storage capacity of the storage area is exceeded, resulting in overflow to the south through the Edina Corporate Center (4700 West 77th Street) parking lot. The simulated peak flow rates of the overflow are 30 cfs for the 10-year, 24-hour rainfall event and 329 cfs for the 100-year, 24-hour rainfall event. This water then flows south through the parking lot, eventually reaching West 77th Street. The overflow volumes from the Western Golf Course storage area are 67 acre-feet for the 100-year, 24-hour rainfall event and 5 acre-feet for the 10-year, 24-hour rainfall event.

Two different storage expansion alternatives were simulated to reduce the surface overflows from the former Fred Richards Golf Course: 1) construction of a berm around the area to increase flood storage by permitting additional bounce, and 2) excavation of areas that will result in an increase in flood storage volume below the existing overflow elevation of 821.8 MSL. The simulated storage expansion area footprint is shown in Figure 3-1.

Construction of a 4,200 foot long berm surrounding the western golf course area to a minimum elevation of 825.2 MSL was simulated by raising the surface overflow elevation from NMS_23 to elevation 825.2 MSL. The simulated peak 100-year flood elevation within the area increased from 823.0 feet to 824.2 feet as a result of this modeling change. This alternative would contain the floodwaters within the park, preventing surface overflows to the south and extension of the flood storage areas onto adjacent residential properties to the north (Figure 3-1).

Excavation within western golf course area could result in an additional 81 acre-feet of flood storage by removing approximately 132,000 cubic yards of soil, lowering the ground surface to elevation 818.0 MSL, which is approximately equal to the normal water elevation of the existing ponds in subwatersheds NMS_23 and NMS_74 (Edina CWRMP).

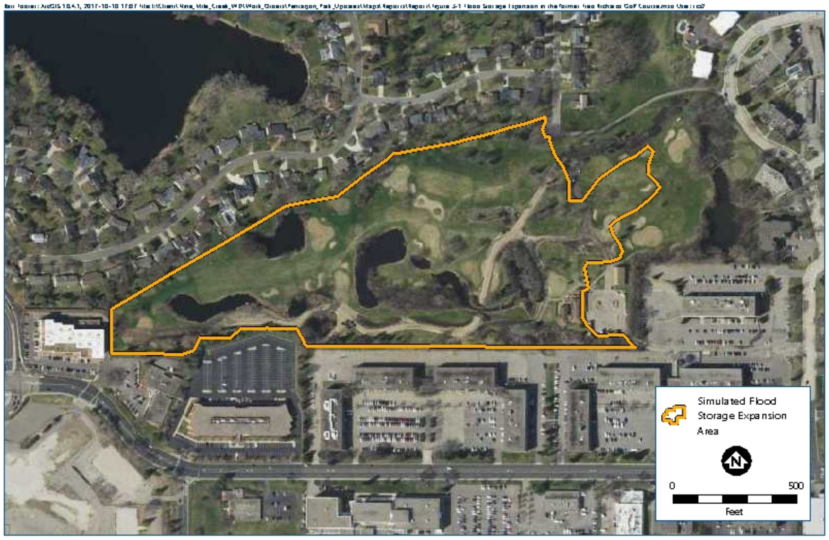


Figure 3-1 Flood Storage Expansion in the former Fred Richards Golf Course

The 100-year peak flood elevation in the West Golf Course was increased by 1.2 feet in the ‘berm’ simulation, and decreased by 0.8 feet in the ‘excavation’ simulation. Both of the scenarios eliminated surface overflows to the south during both the 100-year and 10-year rainfall events. As a result, the 100-year peak flood elevations decreased by between 0.2 and 0.5 feet in other storage areas (Table 3-1).

Table 3-1 Existing Conditions 100-year Peak Flood Elevation and Simulated Changes in Peak Flood Elevation Due to Golf Course Flood Risk Reduction Alternatives

Simulation	Location (Subwatershed)							
	Lake Edina Park (NMS_84)	East Golf Course (NMS_76)	West Golf Course (NMS_103)	Border Basin (SP_1)	Seagate Parking Lots (NMS_108-3)	Computer Avenue and West 78th Street (NMS_108)	West 77th Street (NMS_22)	TH 100 Frontage Road (NMS_10)
Existing Conditions	826.4	826.2	823.0	822.7	822.7	822.7	822.6	821.9
Storage expansion in former golf course (berm)	0.0	0.0	+1.2	-0.4	-0.5	-0.5	-0.5	-0.2
Storage expansion in former golf course (excavation)	+0.4	0.0	-0.8	-0.4	-0.5	-0.5	-0.5	-0.2

3.1.2 Storage expansion in Border Basin

At present the Border Basin ponding area has a peak 100-year flood storage volume of 72 acre-feet at elevation 822.7 MSL. This alternative would increase the footprint of the Border Basin by approximately 6 acres, increasing the available flood storage by approximately 36 acre-feet (Figure 3-2) with a resulting flood elevation of 822.4 MSL.

Figure 3-2 Flood Storage Expansion in the Border Basin

The simulated 100-year peak elevation changes at flood storage areas are shown in Table 3-2. The 100-year peak flood elevations in the golf course storage areas were unchanged. The 100-year peak flood elevations decreased by between 0.1 and 0.3 feet in the other storage areas.

Table 3-2 Existing Conditions 100-year Peak Flood Elevation and Simulated Changes in Peak Flood Elevation Due to Border Basin Flood Risk Alternative

Simulation	Location (Subwatershed)							
	Lake Edina Park (NMS_84)	East Golf Course (NMS_76)	West Golf Course (NMS_103)	Border Basin (SP_1)	Seagate Parking Lots (NMS_108-3)	Computer Avenue and West 78th Street (NMS_108)	West 77th Street (NMS_22)	TH 100 Frontage Road (NMS_10)
Existing Conditions	826.4	826.2	823.0	822.7	822.7	822.7	822.6	821.9
Storage expansion in Border Basin	0.0	0.0	0.0	-0.3	-0.3	-0.3	-0.3	-0.1

3.1.3 Upstream storage expansion along France Avenue

The Centennial Lakes contributing area represents a significant portion of the total floodwater volume flowing into the Border Basin. This alternative simulated construction of a 10 acre-foot flood storage area within a hypothetical potential redevelopment area along France Avenue, upstream of Centennial Lakes.

The simulated 100-year peak elevation changes at flood storage areas are shown in Table 3-3. The 100-year peak flood elevations in all storage areas were unchanged by this simulation.

Table 3-3 Existing Conditions 100-year Peak Flood Elevation and Simulated Changes in Peak Flood Elevation Due to Upstream Storage Flood Risk Reduction Alternative

Simulation	Location (Subwatershed)							
	Lake Edina Park (NMS_84)	East Golf Course (NMS_76)	West Golf Course (NMS_103)	Border Basin (SP_1)	Seagate Parking Lots (NMS_108-3)	Computer Avenue and West 78th Street (NMS_108)	West 77th Street (NMS_22)	TH 100 Frontage Road (NMS_10)
Existing Conditions	826.4	826.2	823.0	822.7	822.7	822.7	822.6	821.9
Upstream storage expansion along France Avenue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

3.1.4 Increased conveyance to Nine Mile Creek

This alternative simulated increasing the conveyance to Nine Mile Creek by doubling the capacity of the existing box culvert and the arch pipe from the Border Basin to Nine Mile Creek. This alternative would require the construction of approximately 2,700 feet of 10-ft by 7-ft box culvert and 380 feet of arch pipe under TH 100 (Figure 3-3).

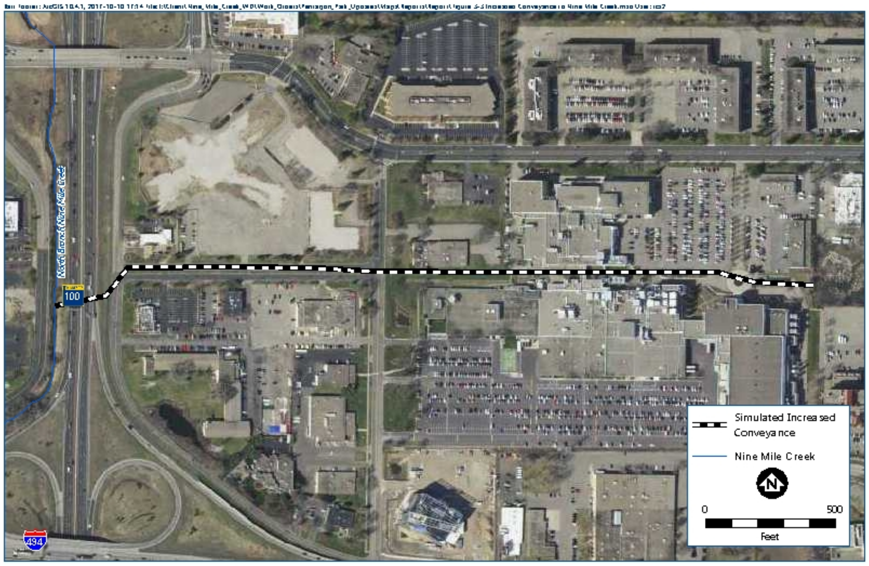


Figure 3-3 Increased Conveyance to Nine Mile Creek

This alternative caused the simulated 100-year peak water surface elevation of Nine Mile Creek to increase by approximately 0.5 feet between West 77th Street and I-494, and by less than 0.1 feet at Normandale Lake. The simulated 100-year peak elevation changes at flood storage areas are shown in Table 3-2. The peak flood elevations in the golf course storage areas were unchanged. The 100-year peak flood elevations of most storage areas decreased by 0.2 feet, while the 100-year peak flood elevation of the TH 100 Frontage Road storage area increased by 0.4 feet, due to the increase in the Nine Mile Creek elevation.

Table 3-4 Existing Conditions 100-year Peak Flood Elevation and Simulated Changes in Peak Flood Elevation Due to Increased Conveyance to Nine Mile Creek Flood Risk Reduction Alternative

Simulation	Location (Subwatershed)							
	Lake Edina Park (NMS_84)	East Golf Course (NMS_76)	West Golf Course (NMS_103)	Border Basin (SP_1)	Seagate Parking Lots (NMS_108-3)	Computer Avenue and West 78th Street (NMS_108)	West 77th Street (NMS_22)	TH 100 Frontage Road (NMS_10)
Existing Conditions	826.4	826.2	823.0	822.7	822.7	822.7	822.6	821.9
Increased conveyance to Nine Mile Creek	0.0	0.0	0.0	-0.2	-0.2	-0.2	-0.2	+0.4

3.1.5 Diversion of stormwater to Normandale Lake

This alternative simulated the construction of a 72-inch diameter pipe to divert water from the Border Basin outlet box culvert at Computer Avenue to Normandale Lake. This alternative would require the construction of approximately 6,300 feet of pipe that would convey water under I-494 and follow existing street right-of-way to Normandale Lake. Figure 3-4 shows the potential pipe alignment that was assumed to simulate impacts from installation of the pipe.

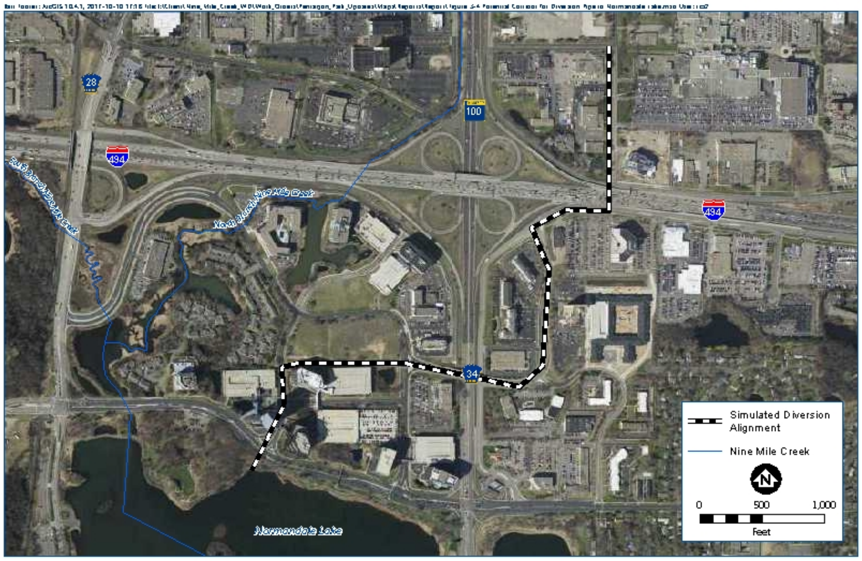


Figure 3-4 Potential Corridor for Diversion Pipe to Normandale Lake

The simulated 100-year peak elevation changes at flood storage areas are shown in Table 3-2. The peak flood elevations in the golf course storage areas were unchanged. The 100-year peak flood elevations in the other storage areas decreased by between 0.2 and 0.6 feet. Figure 3-5 compares the discharge hydrograph from the study area under existing conditions and under the diversion scenario. As shown in the figure, installation of the 72-inch diversion pipe to Normandale Lake increases the peak discharge rate from the study area overall (arch pipe + diversion—Figure 3-5). However, the diversion of runoff from the study area lowers the flood elevations in the study area such that water from Nine Mile Creek backflows into the study area (see negative flows in the arch pipe- Figure 3-5), whereas backflow does not occur during the 100-year, 24-hour rainfall event under existing conditions. This alternative results in a 0.1 foot increase in the 100-year peak water surface elevation of Normandale Lake.

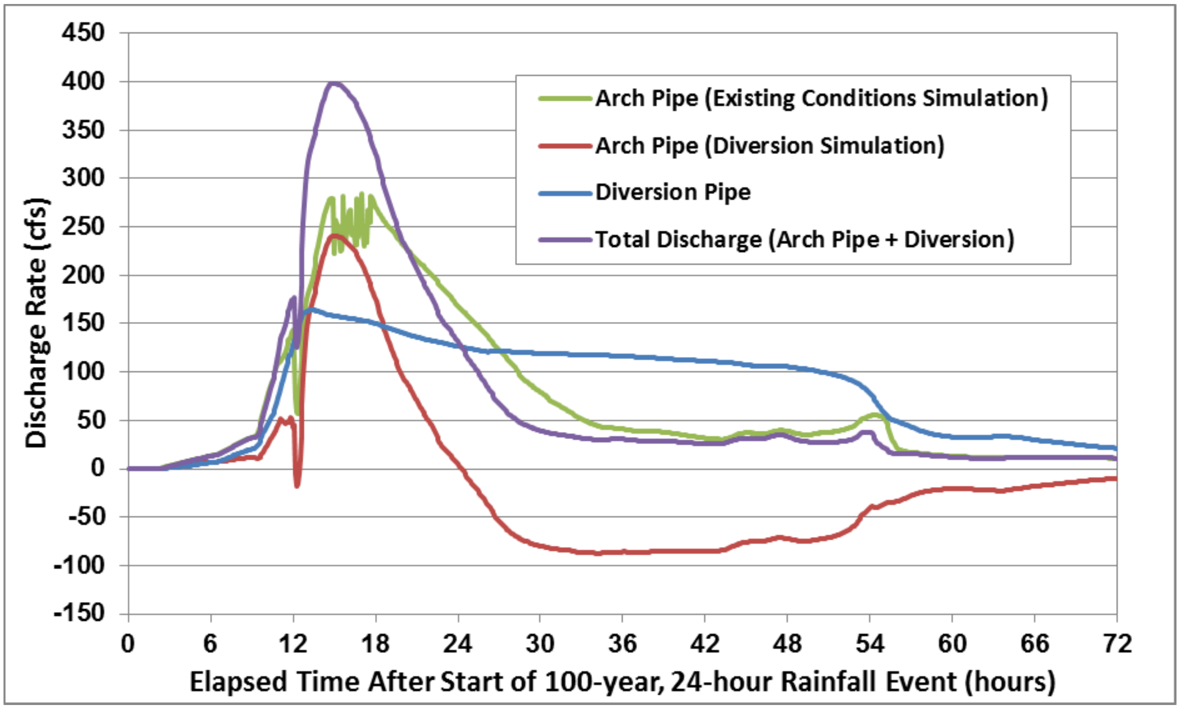


Figure 3-5 **Discharge Rate from Study Site to Nine Mile Creek with and without Simulated Diversion Pipe**

Table 3-5 **Existing Conditions 100-year Peak Flood Elevation and Simulated Changes in Peak Flood Elevation Due to Diversion to Normandale Lake Flood Risk Reduction Alternative**

Simulation	Location (Subwatershed)							
	Lake Edina Park (NMS_84)	East Golf Course (NMS_76)	West Golf Course (NMS_103)	Border Basin (SP_1)	Seagate Parking Lots (NMS_108-3)	Computer Avenue and West 78th Street (NMS_108)	West 77th Street (NMS_22)	TH 100 Frontage Road (NMS_10)
Existing Conditions	826.4	826.2	823.0	822.7	822.7	822.7	822.6	821.9
Diversion to Normandale Lake	0.0	0.0	0.0	-0.4	-0.6	-0.6	-0.6	-0.2

3.1.6 Summary

Results of the flood risk reduction alternative analysis are summarized below. Table 3-6 and Table 3-7 compare the peak elevation changes and flood storage volume changes for the 100-year, 24-hour rainfall event, while Table 3-8 and Table 3-9 summarize the peak elevation changes and peak flood storage volume changes for the 10-year, 24-hour rainfall event.

Table 3-6 Existing Conditions 100-year Peak Flood Elevation and Simulated Changes in Peak Flood Elevation Due to Flood Risk Reduction Alternatives

Simulation	Location (Subwatershed)							
	Lake Edina Park (NMS_84)	East Golf Course (NMS_76)	West Golf Course (NMS_103)	Border Basin (SP_1)	Seagate Parking Lots (NMS_108-3)	Computer Avenue and West 78th Street (NMS_108)	West 77th Street (NMS_22)	TH 100 Frontage Road (NMS_10)
Existing Conditions	826.4	826.2	823.0	822.7	822.7	822.7	822.6	821.9
Storage expansion in former golf course (berm)	0.0	0.0	+1.2	-0.4	-0.5	-0.5	-0.5	-0.2
Storage expansion in former golf course (excavation)	+0.4	0.0	-0.8	-0.4	-0.5	-0.5	-0.5	-0.2
Storage expansion in Border Basin	0.0	0.0	0.0	-0.3	-0.3	-0.3	-0.3	-0.1
Upstream storage expansion along France Avenue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Increased conveyance to Nine Mile Creek	0.0	0.0	0.0	-0.2	-0.2	-0.2	-0.2	+0.4
Diversion to Normandale Lake	0.0	0.0	0.0	-0.4	-0.6	-0.6	-0.6	-0.2

Table 3-7 Existing Conditions 100-year Peak Flood Storage and Simulated Changes in Peak Flood Storage Due to Flood Risk Reduction Alternatives (acre-feet)

Simulation	Location (Subwatershed)							
	Lake Edina Park	East Golf Course	West Golf Course	Border Basin	Seagate Parking Lots	Computer Avenue and West 78th Street	West 77th Street	TH 100 Frontage Road
Existing Conditions	11.8	15.9	48.0	74.3	62.7	25.4	19.8	2.7
Storage expansion in former golf course (berm)	-0.1	0.0	+27.6	-7.6	-11.6	-7.3	-0.2	-1.4
Storage expansion in former golf course (grading)	+2.0	-0.1	+36.0	-7.3	-11.1	-6.9	-4.6	-0.3
Storage expansion in Border Basin	0.0	0.0	0.0	+36.0	-6.8	-4.2	-1.4	-0.2
Storage expansion along France Avenue	0.0	0.0	0.0	-0.5	-0.8	-0.4	+1.4	0.0
Increased conveyance to Nine Mile Creek	0.0	0.0	0.0	-4.1	-5.8	-2.9	-0.3	+0.9
Diversion to Normandale Lake	0.0	0.0	0.0	-7.1	-11.3	-7.8	-4.1	-0.4

Table 3-8 Existing Conditions 10-year Peak Flood Elevation and Simulated Changes in 10-year Peak Flood Elevation Due to Flood Risk Reduction Alternatives

Simulation	Location (Subwatershed)							
	Lake Edina Park (NMS_84)	East Golf Course (NMS_76)	West Golf Course (NMS_103)	Border Basin (SP_1)	Seagate Parking Lots (NMS_108-3)	Computer Avenue and West 78th Street (NMS_108)	West 77th Street (NMS_22)	TH 100 Frontage Road (NMS_10)
Existing Conditions	825.2	824.8	822.1	820.5	820.4	820.1	820.7	820.8
Storage expansion in former golf course (berm)	0.0	0.0	+0.1	0.0	0.0	0.0	-0.3	0.0
Storage expansion in former golf course (grading)	0.0	0.0	-2.0	0.0	0.0	0.0	-0.5	0.0
Storage expansion in Border Basin	0.0	0.0	0.0	-0.6	-0.1	-0.1	0.0	0.0
Storage expansion along France Avenue	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0
Increased conveyance to Nine Mile Creek	0.0	0.0	0.0	-0.4	0.0	0.0	0.0	0.0
Diversion to Normandale Lake	0.0	0.0	0.0	-0.6	-0.1	-0.2	-0.1	0.0

Table 3-9 Existing Conditions 10-year Peak Flood Storage and Simulated Changes in 10-year Peak Flood Storage Due to Flood Risk Reduction Alternatives (acre-feet)

Simulation	Location (Subwatershed)							
	Lake Edina Park	East Golf Course	West Golf Course	Border Basin	Seagate Parking Lots	Computer Avenue and West 78th Street	West 77th Street	TH 100 Frontage Road
Existing Conditions	6.3	10.3	30.2	41.3	17.6	4.0	4.5	0.4
Storage expansion in former golf course (berm)	0.0	0.0	+1.8	0.0	0.0	0.0	-1.2	-0.3
Storage expansion in former golf course (grading)	0.0	-0.1	+7.9	-0.5	-0.5	0.0	-2.6	0.0
Storage expansion in Border Basin	0.0	0.0	0.0	+21.4	-5.6	-0.3	0.0	0.0
Storage expansion along France Avenue	0.0	0.0	0.0	-0.6	-0.5	0.0	+0.2	0.0
Increased conveyance to Nine Mile Creek	0.0	0.0	0.0	-4.6	-3.3	+0.2	+0.2	0.0
Diversion to Normandale Lake	0.0	0.0	0.0	-6.9	-6.0	-0.4	-0.4	0.0

3.2 Flood Risk Reduction Conclusions and Recommendations

3.2.1 Conclusions

The evaluated alternatives all have limited effectiveness in reducing flood elevations within the study area, primarily due to the low ground elevation of the study area as compared to the 100-year and 10-year flood elevations of Nine Mile Creek and the restricted discharge from the area, as compared to the inflows. As shown in Figure 1-6, there are several locations within the developed portion of the study area where the ground surface is especially low, with elevations of 820.0 MSL and lower. During the 10-year, 24-hour event simulation, the peak elevation in Nine Mile Creek is 819.0 MSL at the arch pipe outfall, resulting in restricted discharge from the study area and inundation of the low areas. During the 100-year, 24-hour rainfall event simulation, the water surface elevation of Nine Mile Creek at the arch pipe outfall peaks at elevation 821.6 MSL, and remains above 820.0 MSL for more than 12 hours. Due to the high tailwater elevations in the creek, the peak flood elevations within the study area will remain equal to or slightly higher than the corresponding peak flood elevation in the creek.

The Normandale Lake diversion alternative and storage expansion in the former Fred Richards Golf Course alternative resulted in the greatest flood elevation changes within the Border Basin and other storage areas south of the former Fred Richards Golf Course. The Normandale Lake diversion alternative provides increased discharge capacity from the study area, lowering the peak flood elevation(s) in the storage areas south of the former Fred Richards Golf Course. However, the diversion of runoff from the study area lowers the flood elevations in the study area such that water from Nine Mile Creek backflows into the study area. Although this alternative results in somewhat lower flood elevations, it was determined to be cost prohibitive due to the long length of storm pipe and numerous road crossings (including I-494). The highly-developed nature of the proposed alignment, likelihood of utility conflicts, and minimal elevation difference between the Border Basin (elevation 814.7 MSL) and Normandale Lake (elevation 808.0 MSL) make the constructability of this alternative challenging. This alternative results in a 0.1 foot increase in the 100-year peak water surface elevation of Normandale Lake.

The former Fred Richards Golf Course serves as an important flood storage area, storing approximately 64 acre-feet of stormwater in the 100-year, 24-hour event under existing conditions. Most of the floodwater originates from the 190-acre watershed upstream of the golf course, which is comprised of single- and multi-family residential, commercial, and industrial land uses. In the 100-year, 24-hour rainfall event, the flood storage capacity in the former golf course is exceeded and approximately 67 acre-feet of runoff flows south toward West 77th Street, contributing to high flood elevations in the 77th Street and adjacent flood storage areas.

Aside from the Normandale Lake diversion alternative, expansion of storage in the former Fred Richards Golf Course results in the greatest reductions in flood elevations within the Border Basin and other storage areas south of the former Fred Richards Golf Course. The golf course storage expansion alternatives (construction of a berm or excavation, or a combination of both) benefit downstream areas by holding back and storing water that would overflow south to West 77th Street under existing conditions. Prevention of surface overflows from the former golf course directly decreases peak flood elevations in the West 77th Street storage area, and indirectly decreases peak flood elevations in other areas by increasing the available conveyance capacity of the box culvert and arch pipe that serve as the main outlet for the study area.

Providing additional temporary detention in the watershed upstream of the study area provides minimal reduction in flood elevations within the study area. While the temporary storage attenuates peak flows from the tributary area, the flow ultimately reaches the downstream receiving waters and/or low areas within the study area before flood elevations have receded. To maximize effectiveness, efforts to provide upstream flood storage should be focused on volume retention (permanent storage and infiltration) or detention with highly restricted outflow that minimizes contributions of flow while floodwaters remain high within the study area.

Expansion of the Border Basin provides some flood reduction benefits, decreasing the 100-year flood elevation(s) in the Border Basin, West 77th Street, Computer Ave/West 78th Street, and Seagate Parking Lot flood storage areas by 0.3 feet. This flood reduction alternative would require acquisition of several parcels, including 4445 West 77th Street and 4425 West 77th Street. The planning-level engineer's opinion of probable cost to expand the Border Basin is $14.3 Million, with $4.1 Million in construction costs (including demolition and removal of the existing structures, pavement, and utilities on the acquired parcels) and $10.2 Million for acquisition of 4445 and 4425 West 77th Street parcels, based on 2017 Hennepin County taxable market values. Given the high cost and moderate reduction in flood elevation, this alternative is not recommended unless conducted in conjunction with expansion of the Border Basin for water quality treatment purposes.

Doubling the conveyance capacity to Nine Mile Creek provides minor flood reduction benefits, decreasing the 100-year flood elevation(s) in the Border Basin, West 77th Street, Computer Ave/West 78th Street, and Seagate Parking Lot flood storage areas by only 0.2 feet. The planning-level engineer's opinion of probable cost to double the capacity of the existing box culvert and the arch pipe from the Border Basin to Nine Mile Creek is $7.7 Million. Given the high cost and minor reduction in flood elevation(s), this alternative is not recommended.

3.2.2 Recommendations

The former Fred Richards Golf Course serves as an important regional flood storage area, storing runoff and attenuating flows from the 190-acre tributary watershed. However, in a 100-year event, the flood storage capacity of the former golf course is exceeded and significant surface overflows (approximately 67 acre-feet) contribute to high flood elevations in the West 77th Street and adjacent flood storage areas. Given the importance of the existing flood storage within the former Fred Richards Golf Course and the potential benefits of providing additional storage, **the following recommendations should be considered as the former golf course is redeveloped**:

- At a minimum, the flood storage volume within the former Fred Richards Golf Course and Lake Edina Park should be maintained, and
- The flood storage volume within the former Fred Richards Golf Course and Lake Edina Park should be expanded, through construction of a berm and/or excavation of upland areas, such that

surface overflows from the former golf course property will be eliminated for the 100-year, 24-hour rainfall event.

While several other flood risk reduction alternatives evaluated as part of this study provide minor reductions in flood elevations, no alternative resulted in significant reductions in 100-year flood elevations. This is primarily due to the high tailwater elevations in Nine Mile Creek, which restrict discharge from the study area, due to the minimal difference in upstream and downstream water surface elevations. Efforts to provide additional flood storage in the study area below the peak tailwater elevation in Nine Mile Creek will be ineffective in substantially reducing flood elevations, as additional storage in the study area below the peak creek elevation will reduce the differential in water surface elevation, thereby reducing the flow to the creek. In extreme scenarios, if a significant amount of additional flood storage were provided in the study area below the peak tailwater elevation, flows from Nine Mile Creek would backflow into the study area.

With the high tailwater elevations in the creek, the peak flood elevations within the study area will remain equal to or slightly higher than the corresponding peak flood elevation in the creek. The limited effectiveness of regional flood risk reduction alternatives indicates that properties within the study area will continue to be burdened with floodwater in the 10-year and/or 100-year frequency events**. Beyond providing additional storage at the former Fred Richards Golf Course, investments made in the Study Area for flood mitigation should be focused on maintaining flood storage (versus providing additional flood storage) and reducing flood risk to properties**. Providing additional flood storage lowers flood elevations due to additional storage, in turn reducing the amount of water discharged to Nine Mile Creek from the study area due to high tailwater conditions and resulting in only a marginal flood reduction benefit. In some portions of the study area, the substantial addition of flood storage would result in backflow conditions from Nine Mile Creek. Flood mitigation investments may include filling some portions of the study area to raise buildings and reduce impacts to private property, while providing compensatory flood storage elsewhere within the study area to maintain existing flood storage volumes.

4.0 Stormwater Management Guidelines for Redevelopment

Significant portions of the study area will be undergoing redevelopment in the near future. Results of the flood risk reduction evaluation confirmed that flood improvement alternatives within the study area will not result in substantial reductions in flood elevations, primarily due to the influence of high surface water elevations in Nine Mile Creek, and properties within the study area will continue to be impacted by flood waters in large storm events.

The extent of both 10-year and 100-year frequency flood inundation throughout the study area will pose a challenge to redevelopment efforts. Other site constraints within the study area will pose additional stormwater management challenges, including the widespread presence of soils with low infiltration capacity (hydrologic soil group "D" soils) and the occurrence of shallow groundwater. These site constraints, which impact the feasibility of meeting the NMCWD's volume retention criteria, coupled with the onsite flood storage requirements, will make compliance with the NMCWD rules difficult. In the absence of an approved alternative stormwater management approach for the study area, redevelopment of many individual sites within the study area will likely require requests for variances from the NMCWD's current rules.

To assist in addressing this challenge, an objective of this study was to develop guidelines for an alternative approach to managing stormwater within the area as redevelopment occurs. The guidelines presented in this section provide information and ideas regarding potential stormwater management options and approaches that property owners can consider, either on individual sites or on a regional basis.

4.1 Existing Stormwater Regulation

4.1.1 Stormwater Management

The management of stormwater within the study area is regulated by the NMCWD's stormwater management rule (Rule 4.0—included as Appendix C). The stormwater management regulation is guided by the NMCWD's policy to require that onsite retention and regional water quality treatment systems operate together to provide complete and effective runoff management, through the following principles:

- Manage peak runoff rates to achieve rates equal to or below existing rates;
- Manage runoff volume to achieve a net reduction from existing conditions;
- Provide effective water quality treatment to remove sediment, pollutants, and nutrients from stormwater and snowmelt before discharge to surface water bodies and wetlands; and
- Provide for nondegradation of surface water bodies in the watershed.

NMCWD Rule 4.0 establishes the following standards as part of its criteria for implementing the stormwater management rule:

Runoff Volume Retention: Provide for onsite retention of one inch of runoff from all impervious surface of the parcel. If site constraints prevent full compliance with the retention requirement, the NMCWD's volume banking system can be utilized.

Runoff Rate Control: Limit peak runoff flow rates to that from existing conditions for the 2-, 10- and 100-year storm events for all points where stormwater discharge leaves the parcel.

Water Quality Treatment: Provide for all runoff to be treated to at least 60 percent annual removal efficiency for total phosphorus and 90 percent annual removal efficiency for total suspended solids. Pollutant removal efficiencies can be achieved through onsite or offsite detention/retention designed to treat the 2.5-inch storm event (NURP criteria) or through use of alternative practices providing equivalent or better treatment. The onsite retention of runoff may be included in demonstrating compliance with the total suspended solids and phosphorus removal requirements.

If site constraints prevent full compliance with the runoff volume retention criteria, permit applicants must provide for onsite retention of ½-inch of runoff from all impervious surface of the parcel, and then utilize credits from the NMCWD's volume bank to fulfill the remainder of the one-inch retention requirement. If no qualifying credits are available, an applicant may contribute funds to the District's Stormwater Facilities Fund to cover the cost of implementing offsetting volume retention projects elsewhere in the watershed.

NMCWD Rule 4.0 also includes criteria prohibiting construction or reconstruction of structures with a lowest floor elevation less than two feet above the 100-year flood elevation and requiring stormwater management structures and facilities be designed for maintenance access and property maintained in perpetuity to assure that they continue to function as designed.

4.1.1.1 Benefits- Volume Retention

Developed sites without stormwater management practices, similar to existing conditions throughout much of the Pentagon Park/Border Basin study area, produce significantly more stormwater runoff volume as compared with undeveloped (or natural) sites. Depending on the soil type, the average annual runoff from an 80% impervious developed site (similar to conditions within the study area) is about three to five times that of native undeveloped conditions (MPCA, 2011). Implementation of BMPs to meet the NMCWD's "1-inch" volume retention standard significantly reduces the stormwater runoff volume from developed sites, resulting in average annual runoff that is similar to runoff from native conditions (MPCA, 2011). Implementation of BMPs to meet a ½-inch volume retention criteria on an 80% impervious site with Hydrologic Soil Group C soils results in an estimated average annual runoff volume reduction of approximately 67%, as compared to 88% runoff reduction from the 1-inch retention criteria (MPCA, 2011).

4.1.1.2 Benefits- Runoff Rate Control

The current NMCWD stormwater rules require that peak runoff flow rates be limited to that from existing conditions for the 2-, 10- and 100-year storm events for all points where stormwater discharge leaves the site. For undeveloped sites, the NMCWD's rate control criteria will limit flow rates to those similar to a natural or "native" condition. For redevelopment areas such as Pentagon Park, where development primarily occurred prior to the requirement for rate control practices, the NMCWD rate control rules likely will not require reductions from existing peak flow rates.

While the NMCWD rate control criteria do not require peak flows be reduced beyond existing levels, the stormwater volume retention standard provides some rate control benefits. The extent of the rate control benefit is primarily dependent on the volume of the BMP; the larger the BMP volume, the more frequently runoff rate is restricted to levels below natural conditions. Modeling conducted as part of the MPCA MIDS project concluded that implementation of BMPs that achieve the 1-inch volume retention criteria generally reduces the 1-year, 24-hour peak flow rates from a site to less than or equal to that of native conditions for most scenarios (MPCA, 2011).

4.1.1.3 Benefits- Water Quality

In addition to volume reduction, stormwater volume retention BMPs provide significant pollutant removal benefits. While strongly correlated with the amount of runoff captured and infiltrated, the overall pollutant removal efficiency is also dependent on other factors such as the varying concentration of pollutants in runoff (such as the "first flush effect") and pollutant removal that occurs through sedimentation or other mechanisms.

BMPs that meet the 1-inch volume retention criteria significantly reduce the loading of total phosphorus and suspended sediment from developed sites. Modeling conducted as part of the MPCA MIDS project concluded that BMPs that achieve the 1-inch volume retention criteria on 80% impervious sites with hydrologic soil group B soils reduce the average annual phosphorus and total suspended solids removals by 95% and 99%, respectively (MPCA, 2011). This performance well exceeds the NMCWD's water quality criteria for all runoff to be treated to at least 60 percent annual removal efficiency for total phosphorus and 90 percent annual removal efficiency for total suspended solids.

The average annual runoff volume captured onsite and associated pollutant removal varies depending on the volume retention criteria and resulting BMP volume. Figure 4-1, based on modeling conducted as part of the MPCA's MIDS project, shows how the total phosphorus removal varies for an 80% impervious site with B soils, depending on the volume retention criteria. The modeling analysis showed that retaining one inch of runoff from an 80% impervious site with B soils results in 95% total phosphorus removal, whereas retaining ½-inch of runoff results in 83% total phosphorus removal. While the MIDS analysis did not include evaluation for volume retention on sites with D soils, it is expected that the phosphorus removal effectiveness would be slightly lower than that of sites with B soils.

BMPs that meet the volume retention criteria are especially beneficial because they remove both particulate and dissolved phosphorus from stormwater runoff. Particulate phosphorus is the phosphorus that attaches to sediment particles and can generally be removed through sedimentation. Dissolved phosphorus is the phosphorus that is in solution within the stormwater, and it difficult to remove through conventional stormwater treatment mechanisms such as sedimentation or filtration.

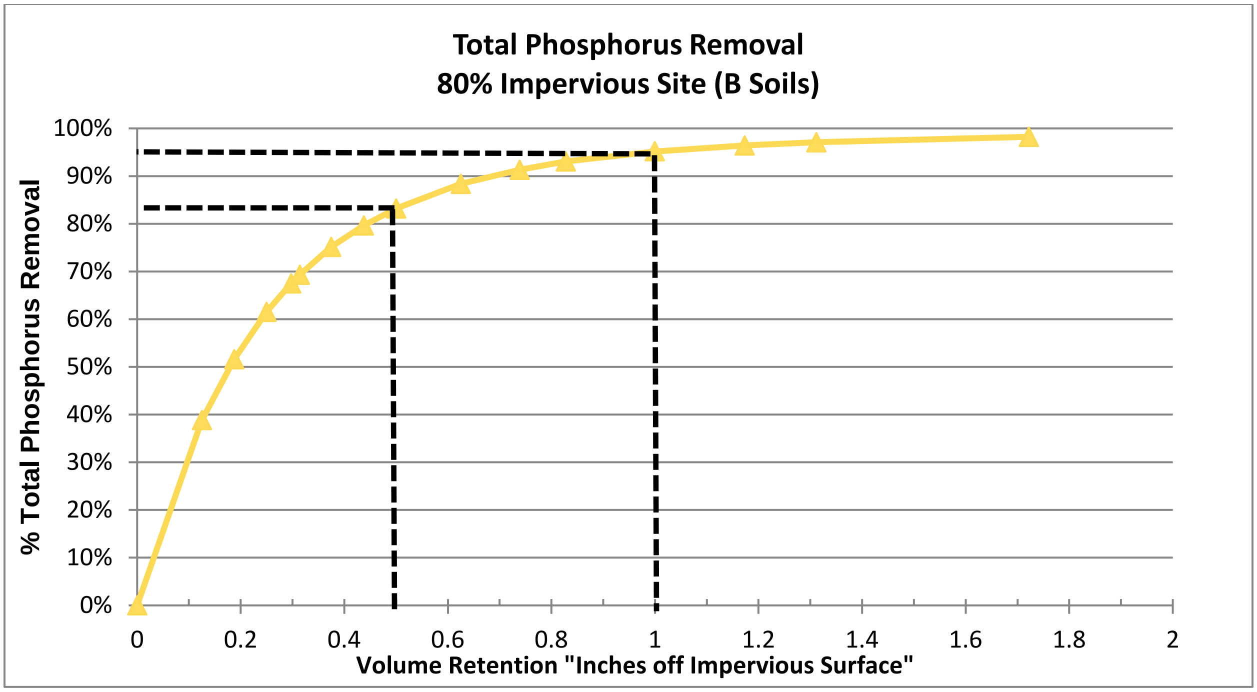


Figure 4-1 **Total phosphorus removal from compliance with a range of volume retention criteria for an 80% impervious site on B soils**

4.1.2 Floodplain Management and Drainage Alterations

The management and preservation of floodplain and floodwater storage within the study area is regulated by the NMCWD's Floodplain Management and Drainage Alteration Rule (Rule 2.0—included as Appendix D). The rule contributes to the implementation of NMCWD's policies to ensure the preservation of the natural function of floodplains as floodwater storage areas and to maintain no net loss of floodplain storage in order to accommodate 100-year storage volumes. The NMCWD's policy also seeks to maximize upstream storage and infiltration of floodwaters.

NMCWD Rule 2.0 establishes the following criteria for floodplain and drainage alterations:

Low Floor Elevations. The low floor elevation of all new and reconstructed structures shall be constructed at a minimum of two feet above the 100-year flood elevation for the creek or water body.

Prohibition of Fill. Placement of fill below the 100-year flood elevation is prohibited unless fully compensatory storage at the same elevation (+/- 1 foot) and within the floodplain of the same water body is provided. Creation of floodplain storage capacity to offset fill must occur within the original permit term. If offsetting storage capacity will be provided off site, it shall be created before any floodplain filling for the project will be allowed.

Surface Flow Alterations. The District shall issue a permit to alter surface flows only if it finds that the alteration will not have an adverse impact on any upstream or downstream landowner and will not adversely affect flood risk, basin or channel stability, groundwater hydrology, stream base flow, water quality or aquatic or riparian habitat.

Structure Placement. No structure may be placed, constructed or reconstructed and no surface may be paved within 50 feet of the centerline of any water course, with exception of bridges, culverts and other structures and associated impervious surface regulated under NMCWD Rule 6.0, and trails 10 feet wide or less, designed primarily for nonmotorized use.

Maintaining flood storage is also required by the cities of Edina and Bloomington to prevent transfer of flood risk to neighboring properties. Currently, the City of Edina manages for no net increase in flood risk to structures or neighboring/downstream properties in the 1% probability ("100-year") event. The City of Bloomington manages to a "net zero fill" standard in the 1% probability event.

4.2 Stormwater Management Challenges in Pentagon Park/Border Basin Study Area

The NMCWD's stormwater management criteria are imposed to achieve nondegradation of surface water bodies in the watershed, at a minimum, and maintain or reduce stormwater runoff rates, reduce stormwater runoff volume, and provide effective pollutant removal before discharge to surface water bodies and wetlands.

Implementation of the NMCWD's stormwater management criteria typically occurs on each individual property that requires a stormwater permit. Onsite implementation of BMPs to meet the criteria (specifically the volume retention criteria) will be challenging within the Pentagon Park/Border Basin study area, due to soils with limited infiltration capacity, potentially high groundwater conditions, and onsite flood storage requirements within the study area. These challenges are discussed in more detail in the following sections.

4.2.1 Volume Retention

While the NMCWD volume retention criteria can achieve significant reductions in stormwater runoff from developed sites, implementing BMPs within the Pentagon Park/Border Basin study area will be challenging due to site constraints such as soils with low permeability and potentially shallow groundwater. The sections below discuss these specific site challenges in further detail.

4.2.1.1 Soils with Low Infiltration Capacity

Soils with low infiltration capacity, typically categorized as Hydrologic Soil Group D, are a site constraint that can impact the feasibility of implementing infiltration-based BMPS. The Minnesota NPDES Construction Stormwater General Permit (CGP) indicates that infiltration-based BMPs must drain within 48 hours. Meeting this drawdown timeframe on D soils with very slow infiltration (0.06 inches/hour per the Minnesota Stormwater Manual) requires that the depth of the infiltration BMPs be very shallow (approximately 3 inches). The shallow nature of infiltration BMPs on D soils often translates to BMPs with large surface footprints, in comparison with BMPs on other soil types. Figure 4-2 shows the footprint of an infiltration-based BMP, in terms of percentage of development site area, for an 80% impervious site using the 1-inch and ½-inch volume retention criteria, assuming a 48-hour drawdown time. As shown in Figure 4-2, implementation of BMPs to meet the volume retention criteria on A, B, and C soils requires much less space than on D soils. For example, meeting the 1-inch criteria via infiltration on A, B, and C soils requires a BMP footprint spanning 2%-8% of the site, versus 28% of a site with D soils, which is not feasible given the 80% impervious surface coverage of the site. While compliance with the ½-inch volume retention criteria via infiltration techniques on D soils requires 14% of the site area, less than the available 20%, the

½-inch criteria still utilizes most of the pervious surface available on the site for stormwater management purposes.

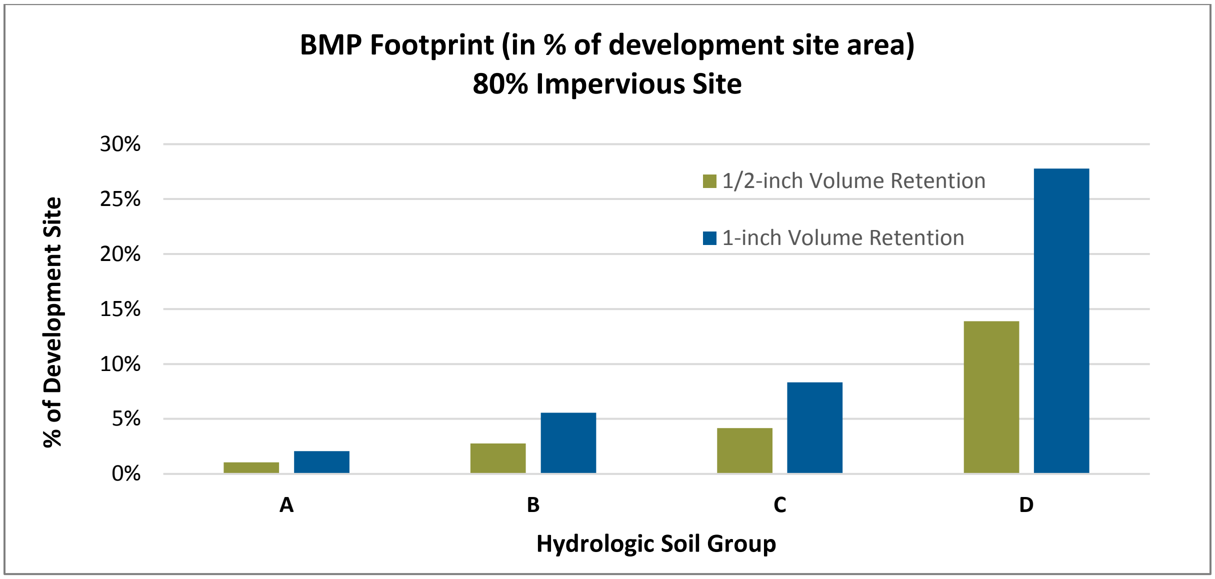


Figure 4-2 Footprint of infiltration-based BMPs, in terms of percentage of development site area, for an 80% impervious site using the 1-inch and ½-inch volume retention criteria

The significant BMP footprint required for infiltration-based BMPs on D soils increases the likelihood that property owners will install underground systems to comply with the District's volume retention standard. While underground infiltration-based systems can be effective in some situations, the high silt and clay content of soils within the study area may increase the likelihood that infiltration BMPs plug or have significantly reduced infiltration rates over time, therefore reducing the effectiveness. Assessing whether underground systems are functioning properly or if maintenance or repair is needed can be challenging due to access limitations or restrictions. If significant maintenance and/or repairs are required to sustain the infiltration capacity of the underground BMPs long-term, it may be necessary to dig up the underground system, which is costly and disruptive.

4.2.1.2 Potential High Groundwater Conditions

The presence of shallow groundwater is another site constraint that impacts the feasibility of infiltration BMPs in portions of the Pentagon Park/Border Basin study area. The Minnesota Stormwater Manual defines shallow groundwater as a condition where the seasonal high groundwater table, or saturated soil, is less than 3 feet from the ground surface. The Minnesota CGP requires 3 feet of separation from the bottom of an infiltration practice to the seasonal high water table. Detailed information on seasonal high water table elevations within the study area is limited. Review of soil boring logs submitted as part of NMCWD permit applications for six properties within the study area in recent years indicates that groundwater levels range from 806 feet to 816 feet M.S.L. With numerous parcels in the study area characterized by low elevations less than three feet above 816 feet M.S.L., there is potential for there to be less than 3 feet of available separation between the potential bottom on an infiltration practice and the seasonal high water table.

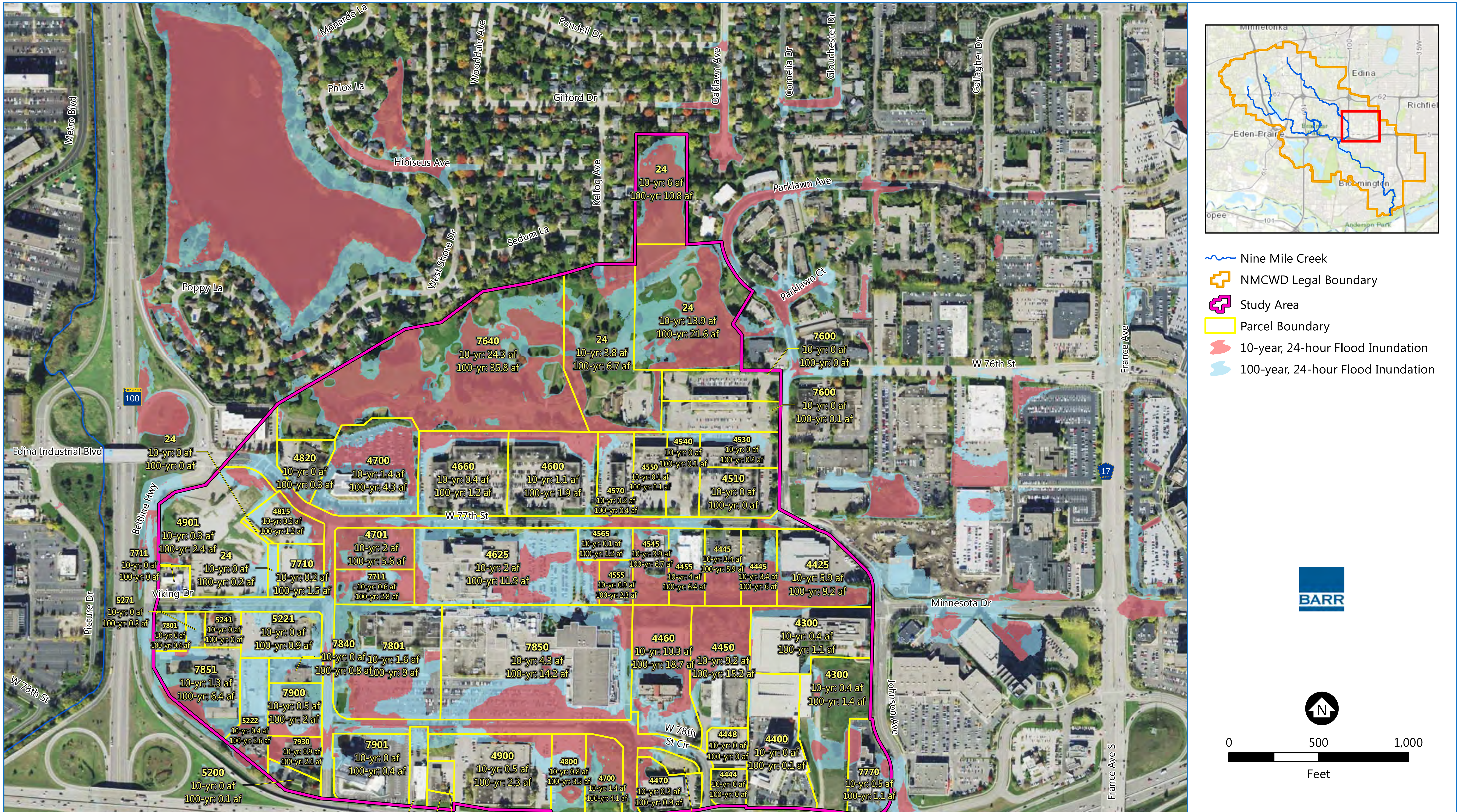
The presence of shallow groundwater can also reduce the pollutant removal effectiveness of infiltration BMPs. Some pollutants such as bacteria are removed in the unsaturated zone beneath the bottom of the BMP via biological activity, chemical degradation, adsorption of pollutants to soil, and plant uptake. The Minnesota Stormwater Manual indicates that shallow groundwater reduces the depth of the unsaturated soil available for treatment, leading to an increased likelihood of groundwater contamination. The manual also indicates that non-infiltration BMPs, such as lined filtration or settling practices, should be considered in areas with shallow groundwater.

4.2.2 Onsite Flood Storage Requirements

Much of the Pentagon Park/Border Basin study area is low-lying, with significant portions of the study area being inundated in the 1% annual chance flood event and some areas being inundated in the 10% annual chance flood event. While several flood risk reduction alternatives were evaluated as part of this study, only minor reductions in flood elevations were achievable during the 1% annual chance flood event due to high tailwater conditions in downstream Nine Mile Creek. The limited effectiveness of regional flood risk reduction scenarios indicates that properties within the study area will continue to be burdened with periodic inundation.

As redevelopment occurs within the Pentagon Park/Border Basin study area, property owners or developers will be required to maintain existing flood storage volumes on their sites to comply with rules and prevent transfer of flood risk to neighboring properties. Figure 4-3 shows the approximate flood storage volumes being stored on each parcel within the study area for the 1% annual chance and 10% annual chance flood events. Figure 4-4 also shows the approximate flood storage volumes being stored on each parcel within the study area for the 1% annual chance and 10% annual chance flood events, but in terms of average depth of flood storage across the entire parcel. For example, if an entirely flat parcel is storing one acre-foot of floodwater, the average across the entire parcel is one foot of depth of flood storage. In reality, a parcel that is storing one acre-foot of floodwater will have water depths that vary throughout the parcel based on the topography of the parcel. As shown in Figure 4-4, the average flood storage depths within the study area for the 1% annual chance flood event range from 0 to 3.4 feet. The approximate flood storage volumes and average depths stored on each parcel within the study area for the 1% annual chance and 10% annual chance flood events are also summarized in Table 4-1.

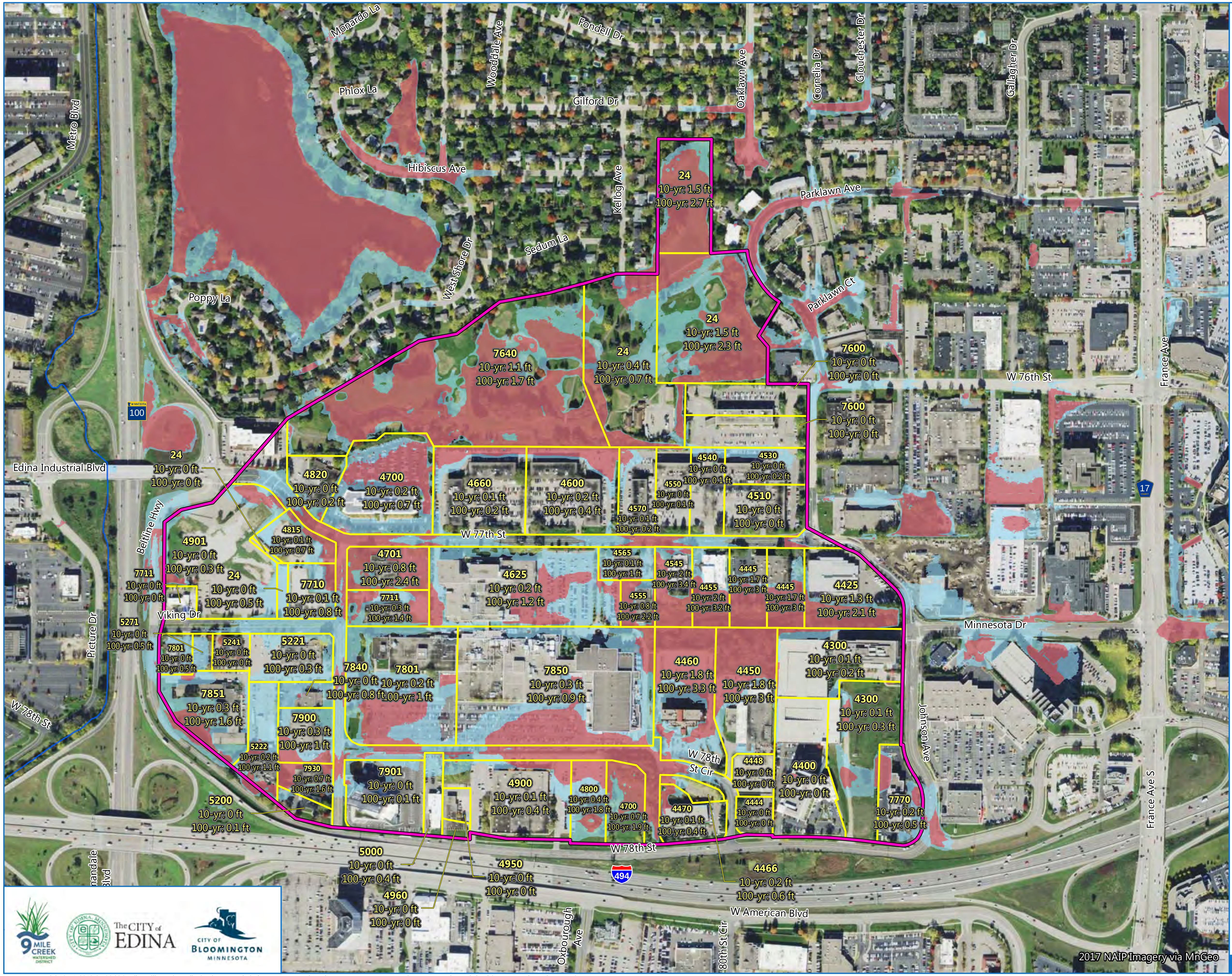
Flood storage will pose a significant site design challenge for many of the redeveloping properties within the Pentagon Park/Border Basin study area. Under existing conditions, flood storage occurs on the surface, primarily in parking lots, roadways, and green space. As redevelopment occurs, property owners will likely need to fill portions of the sites so new structures can be built at elevations high enough to meet the District's and/or cities' low floor elevation requirements (i.e., minimum of two feet above the 1% annual chance flood elevation). Filling portions of the parcel will require that compensatory flood storage be provided on other portions of the parcel, or at alternate flood storage sites within the study area, to offset the lost storage capacity. Flood storage can be provided on the ground surface or underground, depending on site layout and available space. However, providing flood storage (onsite or regionally) will be a significant challenge due to the high cost of installing underground storage facilities (approximately $10-$20 per cubic foot), high land costs, and/or the high opportunity cost of dedicating a portion of a site for surface flood storage.

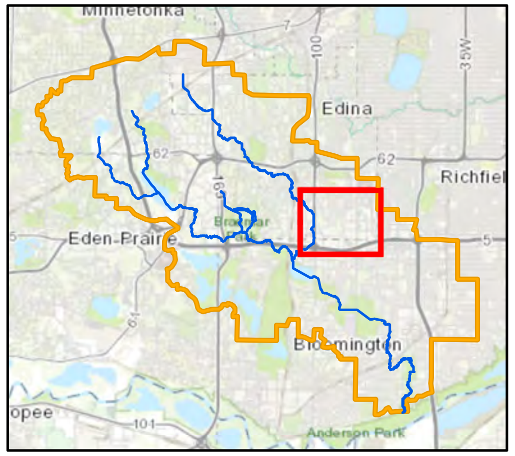


PARCEL-BASED FLOOD STORAGE VOLUMES
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure 4-3

Barr Footer: ArcGIS 10.4.1, 2018-04-06 09:07 File: I:\Client\Nine_Mile_Creek_WD\Work_Orders\Pentagon_Park_Updates\Maps\Reports\Report\Figure 4-3 Parcel-Based Flood Storage Volumes.mxd User: rcs2





- Nine Mile Creek
- NMCWD Legal Boundary
- Study Area
- Parcel Boundary
- 10-year, 24-hour Flood Inundation
- 100-year, 24-hour Flood Inundation

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Feet

PARCEL-BASED FLOOD STORAGE DEPTHS
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure 4-4

Table 4-1. Parcel-based runoff generation, flood storage volumes and average depths, and taxable market values

Street Address	Parcel ID	Parcel Area (acres)	10-Year Max Floodwater Stored on Parcel (ac-ft)	100-Year Max Floodwater Stored on Parcel (ac-ft)	10-Year Runoff Volume Generated from Parcel (ac-ft)	100-Year Runoff Volume Generated from Parcel (ac-ft)	10-Year Average Depth of Floodwater Stored on Parcel (feet)	100-Year Average Depth of Floodwater Stored on Parcel (feet)	Taxable Market Value (2017) ($)	Taxable Market Value Per Square Foot (2017) ($/sq ft)	Percent of Parcel Covered by 10-year Inundation (%)	Percent of Parcel Covered by 100-year Inundation (%)
4400 78TH ST W	0602724120023	5.4	0.03	0.13	1.8	3.3	0.00	0.02	$47,191,000	$200	1	3
4300 78TH ST W	0602724120024	5.7	0.35	1.44	1.3	2.8	0.06	0.25	$3,343,100	$13	7	21
7711 COMPUTER AVE	3102824330016	2.0	0.59	2.75	0.6	1.1	0.29	1.38	$1,422,600	$16	38	74
4555 77TH ST W	3102824340013	1.1	0.89	2.30	0.4	0.6	0.84	2.16	$773,700	$17	54	68
4815 77TH ST W	3102824330014	1.8	0.22	1.24	0.6	1.1	0.12	0.69	$1,326,700	$17	20	56
4540 77TH ST W	3102824430002	2.0	0.00	0.11	0.7	1.2	0.00	0.05	$970,400	$11	0	12
7710 COMPUTER AVE	3102824330015	1.8	0.18	1.49	0.5	1.0	0.10	0.84	$1,310,600	$17	11	57
4565 77TH ST W	3102824340014	1.2	0.08	1.19	0.4	0.7	0.07	0.96	$608,200	$11	12	71
4510 77TH ST W	3102824430003	2.8	0.00	0.01	0.9	1.7	0.00	0.00	$2,701,600	$22	1	1
4660 77TH ST W	3102824340007	5.4	0.42	1.18	1.8	3.3	0.08	0.22	$2,607,200	$11	13	23
4600 77TH ST W	3102824340008	5.4	1.14	1.94	1.8	3.3	0.21	0.36	$2,910,400	$12	16	22
4570 77TH ST W	3102824340009	2.2	0.17	0.41	0.7	1.3	0.08	0.19	$2,929,400	$31	8	21
4530 77TH ST W	3102824430004	2.0	0.00	0.32	0.7	1.2	0.00	0.16	$2,678,600	$31	0	27
4701 77TH ST W	3102824330017	2.4	1.99	5.57	0.7	1.3	0.84	2.35	$0	$0	68	84
4820 77TH ST W	3102824330018	1.7	0.02	0.30	0.6	1.0	0.01	0.17	$1,296,900	$17	2	21
4625 77TH ST W	3102824340017	9.7	2.00	11.93	3.2	5.8	0.21	1.23	$9,045,800	$21	24	59
4901 77TH ST W	3102824330010	8.1	0.33	2.35	2.7	4.9	0.04	0.29	$3,862,400	$11	7	23
4550 77TH ST W	3102824430001	2.0	0.07	0.12	0.7	1.2	0.04	0.06	$969,600	$11	2	4
4700 77TH ST W	3102824330025	6.2	1.40	4.29	2.0	3.7	0.23	0.69	$11,900,000	$44	31	68
4455 77TH ST W	3102824430015	2.0	3.98	6.38	0.6	1.1	2.00	3.21	$1,500,600	$17	52	65
4445 77TH ST W	3102824430014	2.0	3.44	5.88	0.6	1.1	1.73	2.96	$890,600	$10	51	63
4445 77TH ST W	3102824430013	2.0	3.41	5.96	0.6	1.1	1.72	3.00	$964,300	$11	55	67
4545 77TH ST W	3102824430016	2.0	3.93	6.73	0.6	1.1	1.98	3.39	$473,500	$5	60	73
4425 77TH ST W	3102824430018	4.5	5.86	9.21	1.3	2.5	1.31	2.06	$7,736,800	$40	31	40
5000 78TH ST W	0602724210006	1.0	0.01	0.38	0.3	0.6	0.01	0.37	$715,400	$16	2	28
7901 COMPUTER AVE S	0602724220016	3.8	0.00	0.36	1.3	2.3	0.00	0.10	$10,719,000	$66	0	15
7600 PARKLAWN AVE	3102824430005	2.6	0.00	0.07	0.8	1.5	0.00	0.03	$2,509,400	$22	0	5
7930 COMPUTER AVE S	0602724220009	1.3	0.87	2.09	0.4	0.7	0.68	1.64	$0	$0	40	59
5200 78TH ST W	0602724220010	0.8	0.01	0.10	0.2	0.4	0.01	0.13	$820,000	$24	2	13
4466 78TH STREET CIR W	0602724120014	0.6	0.14	0.40	0.2	0.3	0.22	0.65	$321,200	$12	14	31
4448 78TH STREET CIR W	0602724120015	1.1	0.00	0.00	0.4	0.7	0.00	0.00	$2,945,200	$59	0	1
7770 JOHNSON AVE S	0602724120019	2.5	0.54	1.14	0.9	1.5	0.21	0.45	$8,690,000	$79	15	34
4900 78TH ST W	0602724210013	5.7	0.51	2.30	1.9	3.4	0.09	0.40	$4,664,000	$19	9	21
4700 78TH ST W	0602724210011	2.1	1.39	4.06	0.7	1.3	0.67	1.94	$1,046,600	$12	46	69
7851 NORMANDALE BLVD	0602724220004	4.0	1.26	6.37	1.1	2.1	0.31	1.58	$3,414,000	$19	16	58
7801 NORMANDALE BLVD	0602724220002	0.9	0.00	0.42	0.3	0.5	0.00	0.46	$1,343,000	$34	1	55
5271 VIKING DR	0602724220003	0.5	0.00	0.25	0.1	0.3	0.00	0.52	$320,000	$15	0	71
5221 VIKING DR	0602724220001	2.7	0.00	0.91	0.8	1.5	0.00	0.34	$1,187,100	$10	0	53
5241 VIKING DR	0602724220013	0.9	0.00	0.00	0.3	0.5	0.00	0.00	$1,049,600	$26	0	2
5222 78TH ST W	0602724220005	2.3	0.36	2.59	0.8	1.4	0.15	1.12	$1,200,000	$12	16	80
7840 COMPUTER AVE S	0602724220007	1.0	0.01	0.75	0.3	0.5	0.01	0.78	$738,900	$18	1	69
4300 MARKETPOINTE DR	0602724120020	5.1	0.37	1.12	1.7	3.0	0.07	0.22	$33,171,000	$148	4	12
7850 NORD AVE S	0602724210019	15.6	4.31	14.21	5.2	9.3	0.28	0.91	$12,195,000	$18	20	41
4460 78TH STREET CIR W	0602724120011	5.7	10.26	18.73	1.9	3.5	1.80	3.28	$7,368,800	$30	52	79
4470 78TH STREET CIR W	0602724120008	2.1	0.27	0.86	0.6	1.2	0.13	0.42	$3,479,000	$39	10	18
4800 78TH ST W	0602724210012	2.0	0.80	3.51	0.6	1.1	0.41	1.80	$852,700	$10	34	93
7900 COMPUTER AVE S	0602724220008	2.0	0.51	2.03	0.6	1.2	0.25	0.99	$1,078,000	$12	22	66
7801 COMPUTER AVE S	0602724220015	8.7	1.59	8.95	2.6	4.9	0.18	1.02	$4,346,000	$11	20	64
4450 78TH STREET CIR W	0602724120012	5.1	9.25	15.24	1.5	2.9	1.82	2.99	$2,441,000	$11	50	60
7600 PARKLAWN AVE	3102824430006	2.6	0.00	0.00	0.9	1.6	0.00	0.00	$2,506,800	$22	0	1

Table 4-1. Parcel-based runoff generation, flood storage volumes and average depths, and taxable market values

Street Address	Parcel ID	Parcel Area (acres)	10-Year Max Floodwater Stored on Parcel (ac-ft)	100-Year Max Floodwater Stored on Parcel (ac-ft)	10-Year Runoff Volume Generated from Parcel (ac-ft)	100-Year Runoff Volume Generated from Parcel (ac-ft)	10-Year Average Depth of Floodwater Stored on Parcel (feet)	100-Year Average Depth of Floodwater Stored on Parcel (feet)	Taxable Market Value (2017) ($)	Taxable Market Value Per Square Foot (2017) ($/sq ft)	Percent of Parcel Covered by 10-year Inundation (%)	Percent of Parcel Covered by 100-year Inundation (%)
7640 PARKLAWN AVE	3102824310058	21.2	24.27	35.75	7.0	12.6	1.14	1.68	$0	$0	61	76
7711 NORMANDALE RD	3102824330011	0.7	0.00	0.00	0.2	0.4	0.00	0.00	$601,500	$20	0	0
4444 78TH ST W	0602724120016	0.9	0.00	0.00	0.3	0.5	0.00	0.00	$823,800	$20	0	0
4950 78TH ST W	0602724210014	0.6	0.00	0.00	0.2	0.4	0.00	0.00	$585,300	$22	0	0
4960 78TH ST W	0602724210015	0.3	0.00	0.00	0.1	0.1	0.00	0.00	$138,700	$10	0	0

4.3 Potential Alternative Stormwater Management Framework

Implementation of stormwater management practices to comply with the NMCWD volume retention criteria achieves several benefits, including reduced runoff volume, decreased runoff rates for more frequent rainfall events, and pollutant removal (including particulate and dissolved phosphorus). Redeveloping properties in the Pentagon Park/Border Basin study area, however, will likely have difficulty siting and designing infiltration practices due to soils with low permeability and potential for shallow groundwater, as well as significant onsite flood storage requirements. Recognizing that it may not be reasonably feasible to comply with the NMCWD's volume retention criteria within the study area, a potential alternative stormwater management approach has been identified for the Pentagon Park/Border Basin study area to optimize stormwater management benefits with consideration of site and cost constraints. A schematic summarizing the potential alternative stormwater management approach is provided in Figure 4-5.

The potential alternative stormwater management approach presented in Figure 4-5 represents one possible framework for a region-specific stormwater management plan. Upon further refinement, a more detailed stormwater management plan for the Pentagon Park/Border Basin region would be submitted by the City of Edina and/or the City of Bloomington for consideration by the NMCWD managers.[2]

4.3.1 Provide Additional Runoff Rate Control

The potential alternative regional stormwater management approach would require developing or redeveloping sites to provide additional runoff rate control, *beyond limiting peak flowrates to that of existing conditions,* in lieu of volume retention. Additional runoff rate control can be provided through the technique of extended detention. An extended detention system, typically in the form of a pond or underground storage structure with a multi-stage outlet structure, temporarily detains a portion of the stormwater runoff and releases the runoff slowly, resulting in an extended drawdown of the stormwater volume from high frequency storms. While extended detention systems do not permanently retain stormwater volume (as volume retention BMPs do), the reduced discharge rate from a site can help reduce erosion in downstream waterbodies.

4.3.1.1 Modeling Analysis of Extended Detention and Rate Control

Providing additional runoff rate control is intended to mimic the rate control benefits achieved from implementing the volume retention criteria. A site-based hydrologic and hydraulic modeling analysis was conducted as part of this study to evaluate the use of extended detention in lieu of volume retention for a

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[2] The NMCWD rules do not presently provide a mechanism whereby a regional stormwater-management plan can take the place of compliance with NMCWD rules for individual properties. (The NMCWD Stormwater Management Rule currently does allow regional treatment to meet water quality standards.) The NMCWD is currently undergoing a rule revision process, in which draft rule revisions include the addition of a provision to allow approval of a stormwater management plan for a defined region that demonstrates that degradation of downstream receiving waters will be prevented and that benefits that would be achieved by a plan in compliance with the NMCWD criteria will be achieved to the maximum extent practicable, recognizing the site or regional constraints that prevent full compliance. In the meantime, a region-specific alternative stormwater management plan would have to be proposed to the NMCWD as a regional variance.

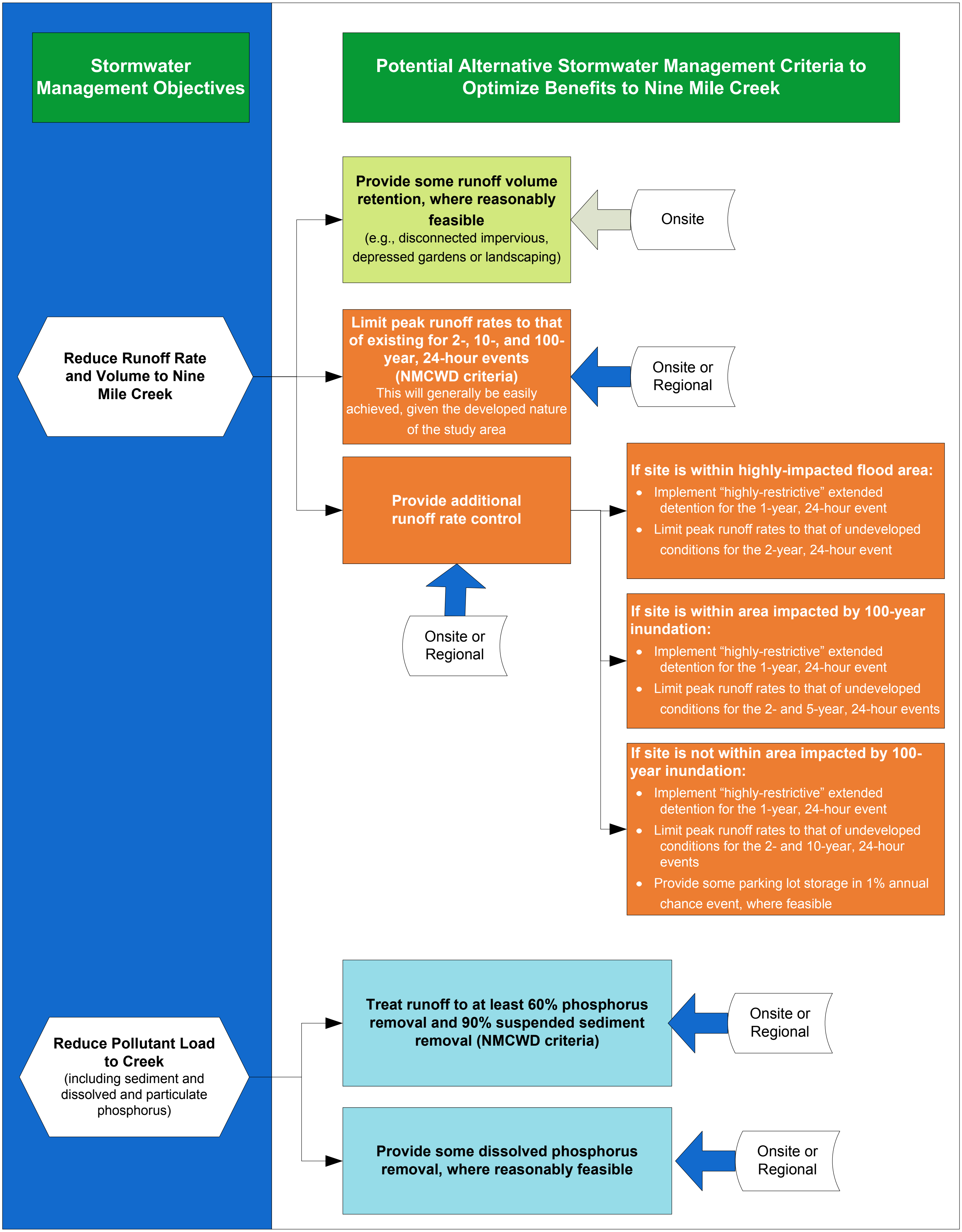
hypothetical redevelopment site. Two extended detention scenarios were simulated for a hypothetical 10-acre redevelopment site with 80% imperviousness and D soils. The modeled extended detention scenarios included:

Rate Control Only (2-, 10-, and 100-year)- Developed site (80% impervious, D soils) with extended detention to limit peak runoff rates to that from undeveloped, native conditions for the 2-, 10-, and 100-year storm events.

Highly-restrictive Extended Detention- Developed site (80% impervious, D soils) with highly-restrictive extended detention to significantly reduce flows from up to the 2-year, 24-hour storm (lowest stage controlled by a 6-inch orifice), then limit peak runoff rates to at or below those from undeveloped, native conditions for the 10- and 100-year storm events.

Results of the modeling analysis indicated that extended detention can reduce peak runoff rates to at or below the flow rates achieved through compliance with the 1-inch or ½-inch volume retention criteria, depending on the extent of flow restriction implemented. Extended detention can also effectively reduce runoff rates to those similar to native, undeveloped conditions for medium- and high-intensity rainfall events. A detailed summary of the modeling analysis and results is provided in the August 15, 2017 memo, included as Appendix E.

Figure 4-5. Potential Alternative Regional Stormwater Management Approach



4.3.1.2 Suggested Levels of Additional Rate Control

The level of additional runoff rate control suggested in the alternative stormwater management approach (beyond what is required by NMCWD's current rate control criteria) is dependent upon the extent that a property is impacted by flood inundation. The three categories and corresponding rate control requirements are described below.

Highly-impacted Flood Areas

For parcels within the highly-impacted flood areas in the study area, the suggested runoff rate control requirements include:

- Implement "highly-restrictive" extended detention (e.g., lowest stage controlled by a 6-inch orifice) for the 1-year, 24-hour event
- Limit peak runoff rates to that of undeveloped conditions for the 2-year, 24-hour event
- Limit peak runoff rates to that of existing conditions for the 10- and 100-year, 24-hour events

Highly-impacted flood areas are defined as those areas within the study area where a portion of a parcel is inundated by the 10- and 100-year storm event ***and*** the amount of runoff stored on a parcel in the 100-year event exceeds the amount of runoff generated from that parcel. Figure 4-6 shows the parcels within the study area that are considered to be within highly-impacted flood areas.

100-Year Flood Areas

For parcels within the study area that are not considered "highly-impacted", but are impacted by inundation from the 100-year, 24-hour storm event (see Figure 4-6), the potential runoff rate control requirements could include:

- Implement "highly-restrictive" extended detention (e.g., lowest stage controlled by a 6-inch orifice) for the 1-year, 24-hour event
- Limit peak runoff rates to that of undeveloped conditions for the 2- and 5-year, 24-hour events
- Limit peak runoff rates to that of existing conditions for the 10- and 100-year, 24-hour events

Minimally- or Non-impacted Areas

For parcels within the study area that are not significantly impacted by the 100-year, 24-hour storm event (see Figure 4-6), the potential runoff rate control requirements could include:

- Implement "highly-restrictive" extended detention for the 1-year, 24-hour event
- Limit peak runoff rates to that of undeveloped conditions for the 2- and 10-year, 24-hour events
- Limit peak runoff rates to that of existing conditions for the 100-year, 24-hour event
- Provide some parking lot storage in the 100-year, 24-hour event, where feasible.

4.3.1.3 Design Considerations

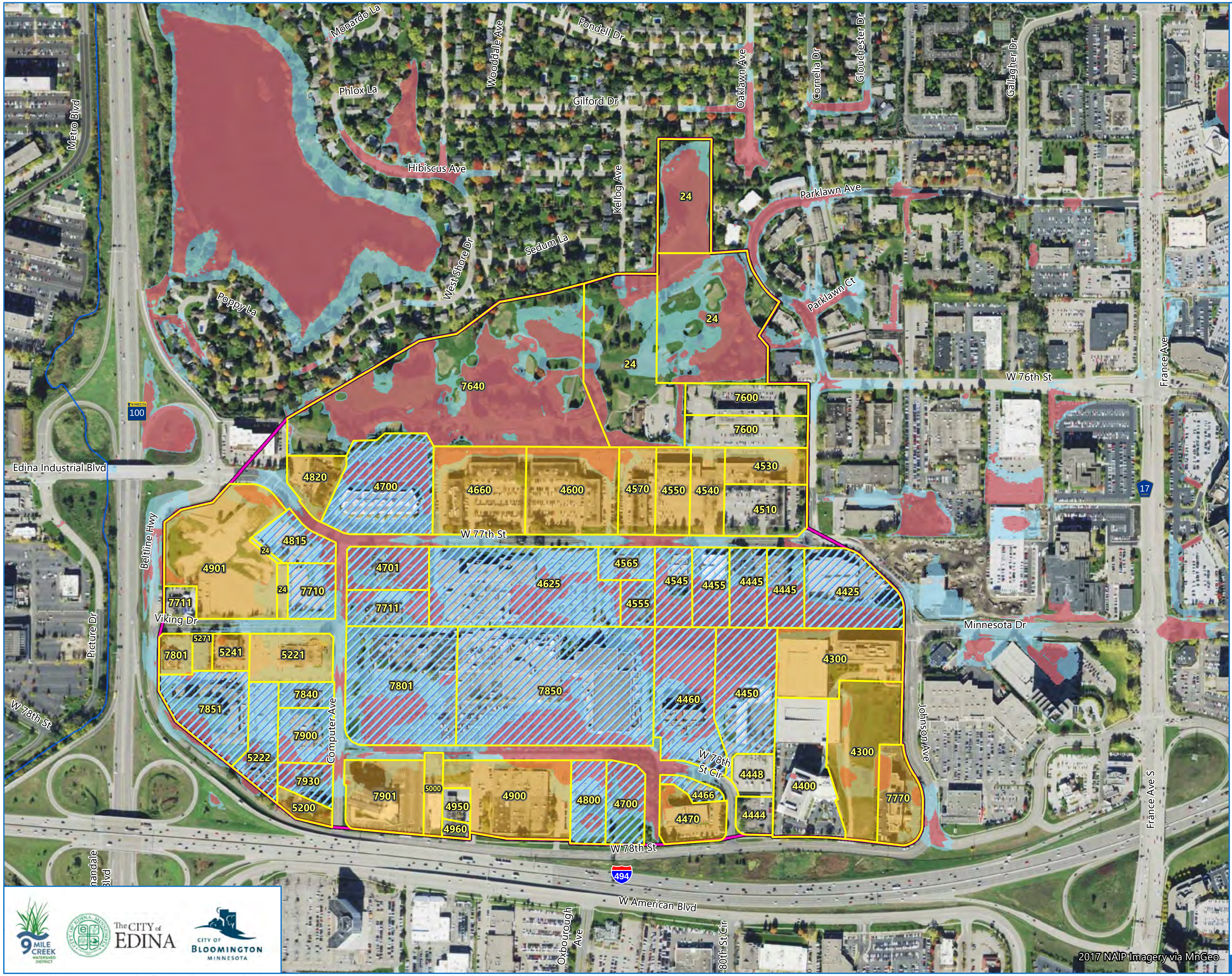
Extended detention and rate control systems are typically in the form of ponds or underground storage structures with a multi-stage, or tiered outlet. The lowest stage is typically designed to temporarily store and slowly release runoff from smaller, more frequent storm events. Higher stages of the outlet structure are often designed to meet specified rate control criteria (e.g., not exceeding prescribed peak discharge rates for the 10-, and 100-year events).

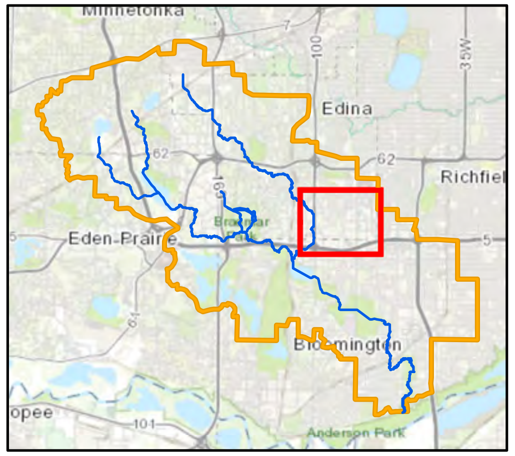
Extended detention and rate control systems require sufficient storage capacity to store and slowly release water at rates that conform to the specified peak flowrate restrictions. A storage capacity sizing exercise was conducted as part of the modeling analysis, in which storage capacity volumes were determined to correspond with the modeled scenarios. Based on the results of the exercise, the following planning-level sizing guidelines were developed:

- If limiting peak flows to that of native, undeveloped conditions for the 100-year event, approximately 10,500 cubic feet of storage is required per acre of developed land (assuming 80% imperviousness)
- If limiting peak flows to that of native, undeveloped conditions for the 10-year event, approximately 7,000 cubic feet of storage is required per acre of developed land (assuming 80% imperviousness)
- If limiting peak flows to that of native, undeveloped conditions for the 5-year event, approximately 6,000 cubic feet of storage is required per acre of developed land (assuming 80% imperviousness)

For comparison purposes, if one inch of volume retention is required from an 80% impervious site, approximately 3,000 cubic feet of storage volume is required per acre of developed land.

Costs for underground storage systems can range considerably, depending on numerous factors including system volume, footprint (area), depth, soils, and necessary storm sewer connections; A general planning-level cost estimate for underground storage in the Twin Cities regional area is $10-$20 per cubic foot, depending on site and design conditions. In general, systems that are deeper, with a smaller surface area to volume ratio, tend to be more cost efficient. Soil conditions can also have a significant effect on cost, with systems on poor soils requiring more substantial foundations. Given the shallow groundwater and limited elevation difference between the ground surface and downstream storm sewer elevation in portions of the study area, underground storage systems within the study area are likely to be relatively shallow. The soils within the study area will also likely require installation of substantial piling and foundations. These factors will likely lead to costs for underground storage systems toward the higher end of the planning-level cost range.





- Nine Mile Creek
- NMCWD Legal Boundary
- Study Area
- Parcel Boundary
- 10-year, 24-hour Flood Inundation
- 100-year, 24-hour Flood Inundation
- Highly-impacted Parcels
- 100-year Impacted Parcels
- Non-impacted Parcels

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HIGHLY-IMPACTED FLOOD AREAS
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure 4-6

An advantage of using extended detention within the study area in lieu of volume retention is that the extended detention and rate control basins or underground structures also provide flood storage, which will be required on many properties within the study area. Most (or all) of the storage volume provided as part of an extended detention and rate control system can also serve as flood storage, assuming the drawdown time of an extended detention system is within a reasonable timeframe (likely 48 hours) and the extended detention system is installed at elevations that correspond to the desired elevations for flood storage.

Under the potential alternative stormwater management approach, complying with the runoff rate control requirements identified in Figure 4-5 could be done onsite or through regional basins or flood storage areas. Under the current NMCWD rules, regional compliance with rate control criteria would require a variance.

4.3.1.4 Consideration of Potential Cumulative Impacts

An evaluation of the cumulative impacts of implementing extended detention practices within the Pentagon Park/Border Basin study area on Nine Mile Creek, in lieu of volume retention practices, has not been conducted as part of this study, but would be necessary as part of the more detailed stormwater management plan proposal. This evaluation would include modeling of the Nine Mile Creek system upstream and downstream of the study area to assess the impacts of changes in discharge volume and timing resulting from implementation of various extended detention scenarios within the study area based on a redevelopment scenario.

4.3.2 Water Quality Treatment

The NMCWD's stormwater management criteria require that all runoff be treated to at least 60 percent annual removal efficiency for total phosphorus and 90 percent annual removal efficiency for total suspended solids. The potential alternative regional stormwater management approach allows developing or redeveloping sites to meet this criteria either onsite or through regional management (consistent with current NMCWD rules). On-site practices to achieve the water quality treatment criteria could include stormwater ponds or surface filtration systems, among other BMPs. Ponds and surface filtration systems can be designed to remove pollutants and restrict discharge flowrates to meet the additional runoff rate control requirements suggested in the potential alternative regional stormwater management approach. For portions of the study area, it may be more cost-effective to utilize regional stormwater treatment to meet the water quality treatment criteria, if it is feasible to direct runoff to an existing or future regional treatment facility and if sufficient treatment capacity in one of these systems is available.

4.3.3 Maintain Flood Storage

As discussed in Sections 4.1.2 and 4.2.2, redeveloping properties within the Pentagon Park/Border Basin study area will be required to maintain 100-year flood storage volumes. If grading and/or filling is necessary on the redevelopment sites, compensatory flood storage must be provided either onsite or within the study area. Compensatory storage can be provided on the ground surface or underground, but should be provided at the same (or similar) elevation to maintain flood elevations. If replacement flood storage is provided at a lower elevation that the existing flood storage, high water elevations within the study area will be slower to increase, reducing the positive head differential between the flood areas and Nine Mile Creek and decreasing the flowrate and volume conveyed from the study area.

4.3.3.1 Design Considerations- Onsite or Offsite Flood Storage

As redevelopment occurs, property owners will likely need to fill portions of the sites so new structures can meet the low floor elevation requirements (i.e., minimum of two feet above the 100-year flood elevation). Compensatory flood storage can be provided on the ground surface or underground, depending on site layout and available space. Underground storage is a common approach which allows the land above the storage to be utilized for parking or other uses. However, underground storage facilities can be costly to install (approximately $10-$20 per cubic foot), especially in locations with soils that require significant foundations. It may also be difficult to provide underground storage at elevations that are compensatory with existing conditions.

In some cases, it may be more economical and/or feasible to utilize above-ground flood storage on a portion of the redevelopment site or an adjacent property, depending on land value and available flood storage at the desired elevations. Figure 4-7 shows an example of a redevelopment site requiring fill for building construction. Development Scenario 1 utilizes underground storage to provide compensatory flood storage volume at an estimated cost of $15 per cubic foot, whereas Development Scenario 2 utilizes above-ground storage on an adjacent parcel. The "per cubic foot" cost of flood storage on the adjacent parcel will be dependent on the market value of the land and the amount of available flood storage volume (i.e., amount of land on the parcel that isn't already being used for flood storage at a given elevation). Figure 4-8 shows the approximate land values within the study area on a 'per parcel' and 'per square foot' basis, based on 2017 Hennepin County taxable market values (established by the assessor as of January 2, 2016).

If expansion of the Border Basin is pursued, some additional flood storage will be provided. Given that the overall reduction in flood elevation from this flood risk reduction alternative is minor, the additional flood storage provided could be utilized as compensatory storage for adjacent parcels that are desiring to fill portions of their site for improved use and/or redevelopment. For example, if the Border Basin was expanded to extend south to 4450 78th Street Circle (requiring acquisition), the additional flood storage volume could be utilized by the adjacent property to the west (4460 78th Street Circle).

4.3.3.2 Other Design Considerations

Providing compensatory flood storage will be a significant challenge for many of the redeveloping properties within the study area due to the potential large amount of flood storage volume being required, high land costs, and the limited availability of land for flood storage (i.e., much of the area is already storing floodwaters). Given this significant design challenge, flexibility toward other zoning and design constraints in portions of the study area would help the potential for redevelopment. Flexibility toward zoning requirements such as building set-backs, building height restrictions, and parking requirements should be considered. Storage of floodwaters in surface parking lots or lower levels of above-ground parking structures should also be considered. Depending on the degree of onsite flood storage required, an applicant for a specific redevelopment project likely would need to request a variance from the two-foot freeboard requirement. However, this would likely require that property owners accept the burden of additional risk solely.

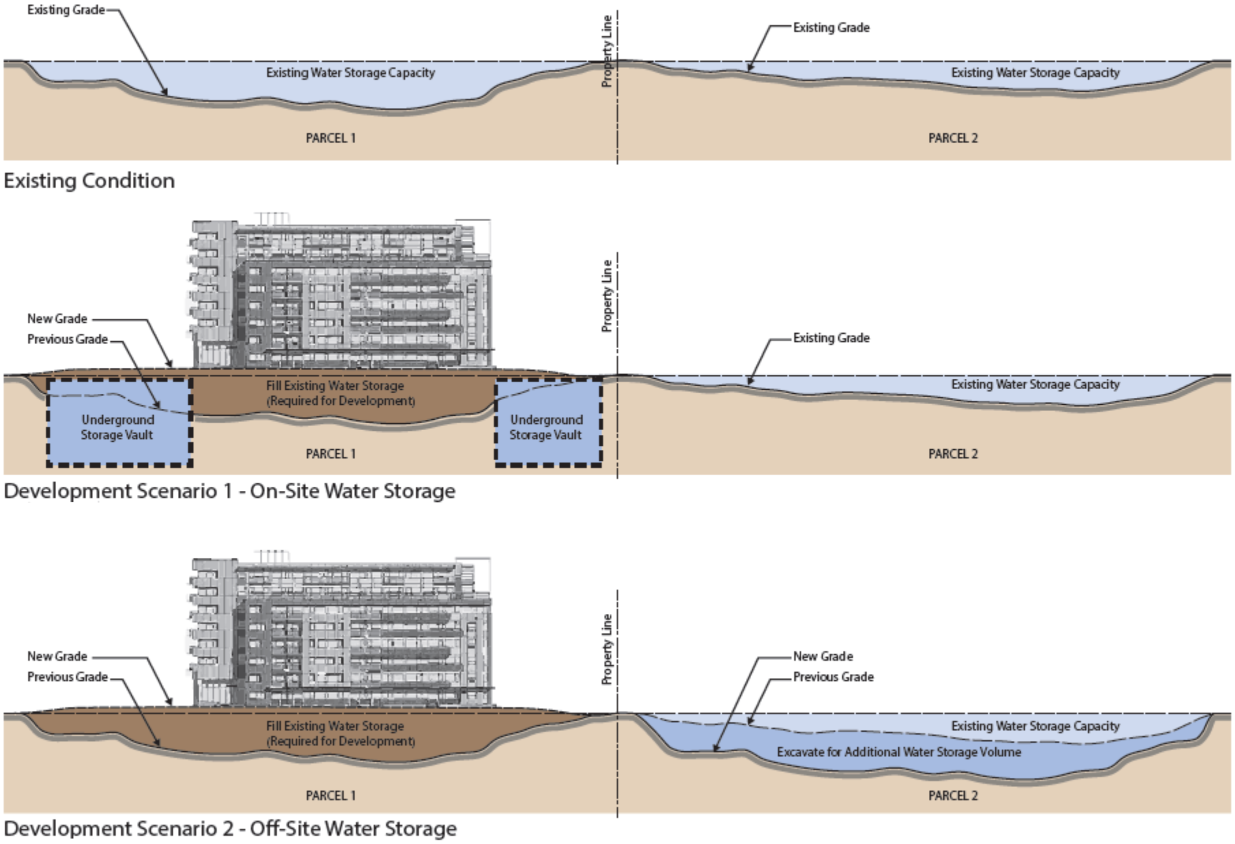
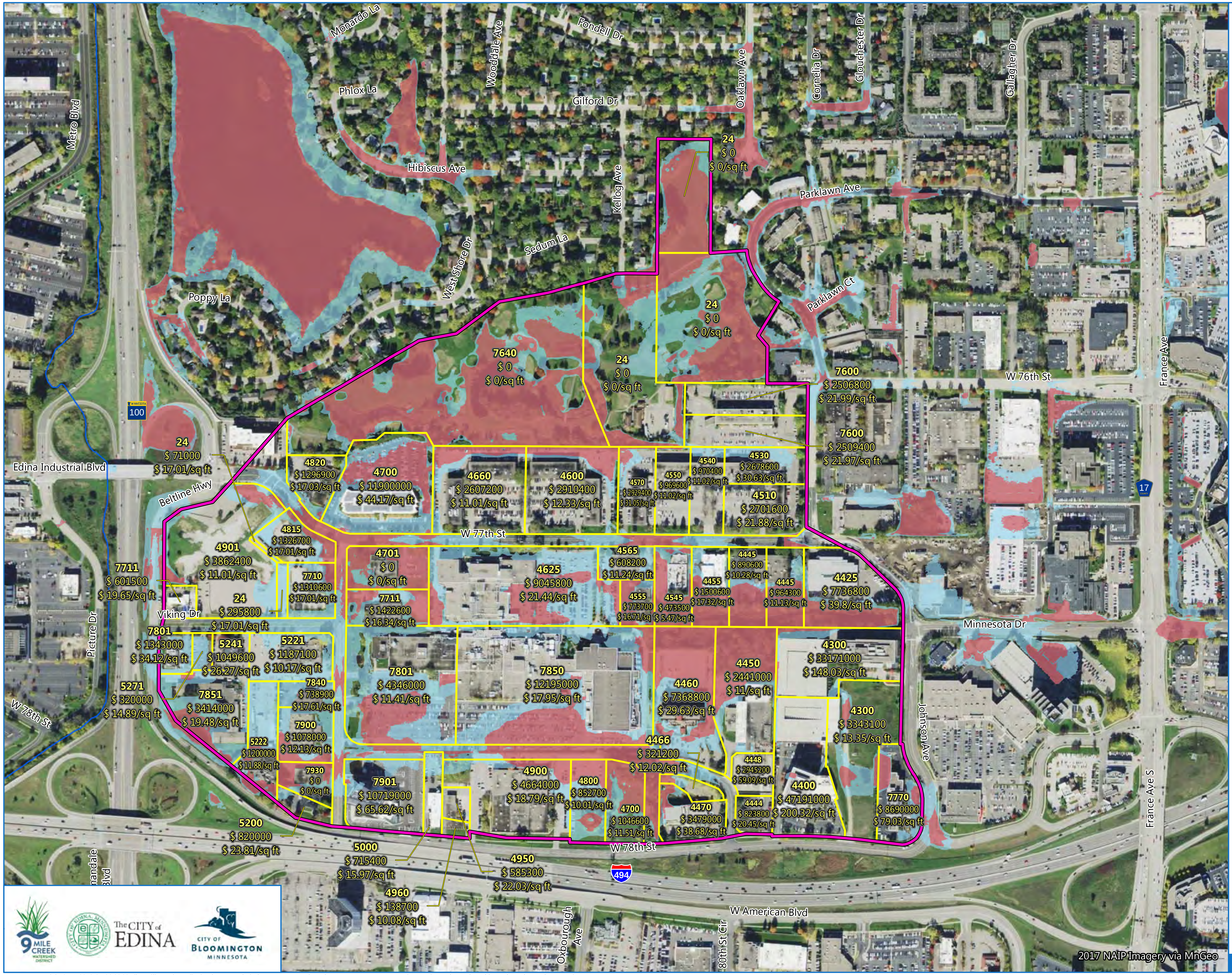
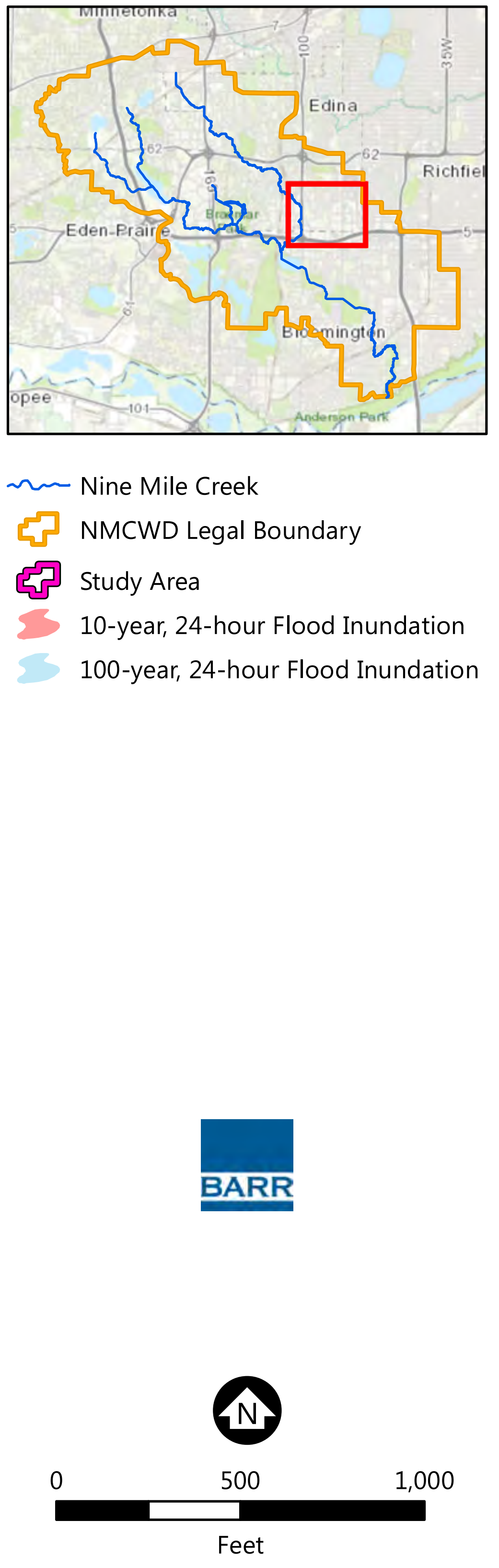


Figure 4-7 Example of a redevelopment site requiring fill for building construction.





PARCEL-BASED TAXABLE MARKET VALUE
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure 4-8

Barr Footer: ArcGIS 10.4.1, 2018-04-06 09:09 File: I:\Client\Nine_Mile_Creek_WD\Work_Orders\Pentagon_Park_Updates\Maps\Reports\Report\Figure 4-8 Parcel-Based Taxable Market Value.mxd User: rcs2

5.0 Regional Water Quality Treatment

The potential alternative stormwater management approach for the Pentagon Park/Border Basin study area identifies achievement of the NMCWD's pollutant removal criteria through either onsite or regional water quality treatment practices. Several opportunities for implementing or improving regional stormwater treatment systems were evaluated as part of this study; these opportunities are described in further detail below.

5.1 Expansion of the Border Basin

The existing Border Basin receives flows from Centennial Lakes, as well as stormwater runoff directly from a 200-acre watershed. Expansion of the existing Border Basin was evaluated to increase the water quality treatment capacity of the pond. For modeling purposes, it was assumed that the Border Basin was expanded to approximately 7.6 acres, with 39 acre-feet of additional dead storage volume (below the outlet elevation) and approximately 40 acre-feet of additional flood storage volume. Figure 5-1 shows the extent of the Border Basin expansion that was simulated, as well as the potential tributary drainage area to the Border Basin, which is larger than the tributary area under existing conditions.

5.1.1 Pollutant Removal Performance

Under existing conditions, the basin achieves approximately 31% total phosphorus removal and 64% total suspended solids removal on an average annual basis. With the expanded basin size and increased direct tributary drainage area, the basin achieves approximately 50% annual TP removal and 83% annual TSS removal overall, based on a model originally developed as part of the 2003 City of Edina Comprehensive Water Resource Management Plan (Barr, 2003) and modified as part of this study. The average annual pollutant removal effectiveness from the direct watershed is greater, with 61% removal of TP and 84% removal of TSS. The pollutant removal achieved from the direct watershed under the expanded Border Basin scenario meets the NMCWD's phosphorus removal requirement (60%), but does not quite meet the NMCWD's TSS removal criteria of 90%. The lower TSS removal is likely due to the large amount of inflow to the Border Basin from the Centennial Lakes watershed, resulting in a shorter residence time for settling out sediment particles.

To better understand the relationship between the size (volume and depth) of the Border Basin and the pollutant removal effectiveness, several additional expansion scenarios with reduced pond depths and areas were evaluated. Table 5-1 summarizes the pollutant removal effectiveness, in terms of average annual percent removal and average annual pounds of removal, in comparison with the effectiveness of the basin expansion scenario summarized above (Figure 5-1).

Table 5-1. TP and TSS Removal Effectiveness of Expanded Border Basin in Treating Runoff from the Direct Watershed

Scenario	Average Annual TP Removal (%)	Average Annual TP Removal (lbs)	Average Annual TSS Removal (%)	Average Annual TSS Removal (lbs)
Expand Border Basin- 7.6 acre surface area, ~10 feet depth	61	82	84	79,000
Expand Border Basin- 7.6 acre surface area, ~7 feet depth	58	78	82	77,000
Expand Border Basin- 5.7 acre surface area, ~7 feet depth	53	71	78	73,000

5.1.2 Engineer's Opinion of Probable Cost

Expansion of the Border Basin will require acquisition of several parcels. The expanded Border Basin footprint used for modeling and preparing the planning-level cost estimate assumed acquisition of 4445 West 77th Street and 4425 West 77th Street (see Figure 5-1). The planning-level engineer's opinion of probable cost to expand the Border Basin for improved regional water quality treatment is $16.7 Million, with $6.5 Million in construction costs (including demolition and removal of the existing structures, pavement, and utilities on the acquired parcels) and $10.2 Million for acquisition of 4445 and 4425 West 77th Street parcels, based on 2017 Hennepin County taxable market values (established by the assessor as of January 2, 2016). Note that the estimated cost to expand the Border Basin for improved regional water quality treatment is higher than the estimated cost for providing additional flood storage (Section 3.2) due to the additional dead storage excavation for the water quality improvement scenario.

Although the modeling and cost estimate for the Border Basin expansion is based on the pond footprint identified in Figure 5-1, the overall cost could be reduced by expanding the pond footprint to the south (4450 78th Street Circle) instead of expanding northeast to 4425 West 77th Street. The 4450 78th Street Circle property has a lower taxable market value ($2.4 Million, or $11.0/square foot) than 4425 West 77th Street ($7.7 Million, or $39.8/square foot).

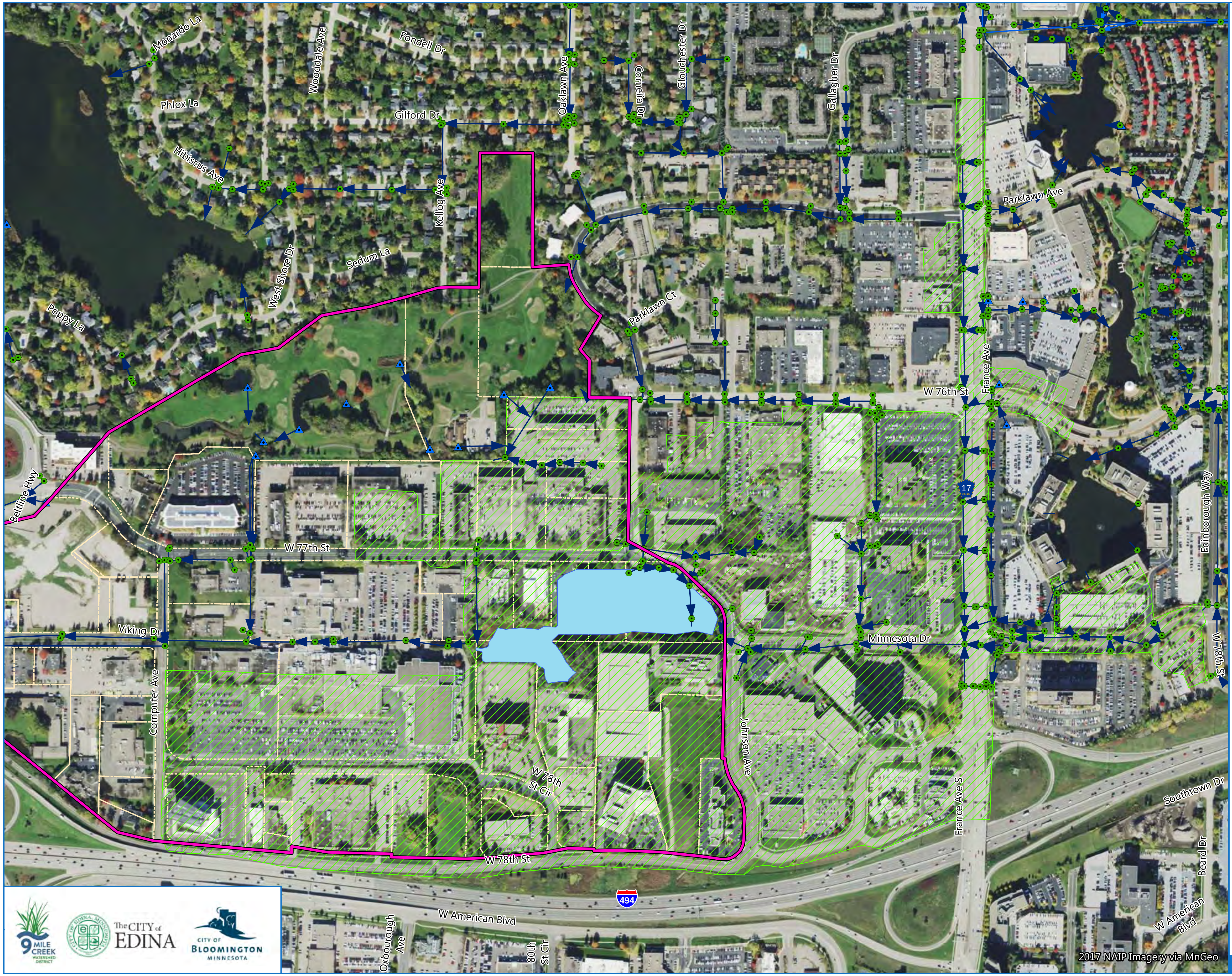
Comparison of the estimated TP and TSS removal benefits with estimated costs of expanding the Border Basin indicates a very high cost/benefit ratio for this option ($200,000 per pound of phosphorus removal from the direct watershed).

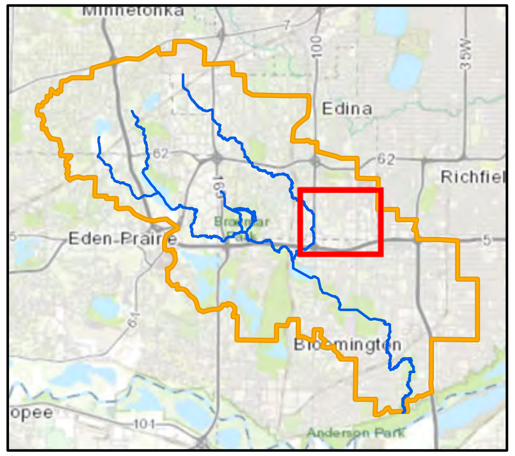
5.1.3 Other Considerations

Although the feasibility of expanding the basin has not been evaluated in detail, anecdotal information indicates that soil conditions may create challenging construction conditions.

Alternatives for providing regional water quality treatment for redeveloping parcels tributary to the Border Basin were also considered. Options could include construction of smaller-scale pond(s) directly upstream of the existing Border Basin to avoid the flushing effect. For example, a pond could be constructed at 4450 78th Street Circle to treat runoff from the redeveloping parcels southwest of the Border Basin, or at

4445 West 77th Street to treat runoff from redeveloping parcels adjacent to the Border Basin (north side) or the parcels northeast of the Basin. Both of these options would also provide some additional flood storage that could be used as compensatory storage for neighboring redeveloping parcels. Another option is to acquire land in (or near) the drainage area tributary to the Border Basin that has good infiltration potential, and construct a regional infiltration system to provide volume retention and water quality credits. For example, several parcels south of West 76th Street have soils that are well suited for infiltration, based on the NRCS Hennepin County soil survey (e.g., 4175 and 4401 West 76th Street). These sites could also be used to provide mitigating flood storage, assuming the system is designed as a retention system (versus temporary storage).





- Nine Mile Creek
- NMCWD Legal Boundary
- Study Area
- Existing Manhole
- Existing Inlet
- Existing Storm Sewer
- Study Area Parcels
- Potential Border Basin Expansion
- Potential Direct Tributary Area

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BORDER BASIN EXPANSION
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure 5-1

9 MILE CREEK WATERSHED DISTRICT
The CITY of EDINA
CITY OF BLOOMINGTON MINNESOTA

5.2 Construction of a New Regional Pond

Under existing conditions, stormwater from the portion of the study area generally west of the Border Basin and south of Fred Richards Park receives little or no stormwater treatment prior to conveyance to Nine Mile Creek via the trunk storm sewer system. Construction of a regional stormwater pond located southeast of the intersection of West 77th Street and Computer Avenue was evaluated to provide regional water quality treatment for this portion of the study area. Figure 5-2 shows the potential pond location and the parcels that could be tributary to the pond upon redevelopment, based on topography (approximately 53 acres). For modeling and cost estimating purposes, the potential pond was assumed to have a normal water elevation of 817 MSL, surface area of approximately 2 acres, and depth of approximately 10 feet.

5.2.1 Pollutant Removal Performance

Results from a P8 model originally developed as part of the 2003 City of Edina Comprehensive Water Resource Management Plan (Barr, 2003) and modified as part of this study indicate that the potential pond achieves approximately 70% annual TP removal and 90% annual TSS removal overall. Table 5-2 summarizes the pollutant removal effectiveness, in terms of average annual percent removal and average annual pounds of removal. This indicates that redevelopment parcels that are tributary to the potential pond could meet the NMCWD's water quality criteria by routing site runoff through the basin.

Table 5-2. TP and TSS Removal Effectiveness of New Regional Pond

Scenario	Average Annual TP Removal (%)	Average Annual TP Removal (lbs)	Average Annual TSS Removal (%)	Average Annual TSS Removal (lbs)
Construct New Regional Pond	70	23.5	90	21,500

5.2.2 Engineer's Opinion of Probable Cost

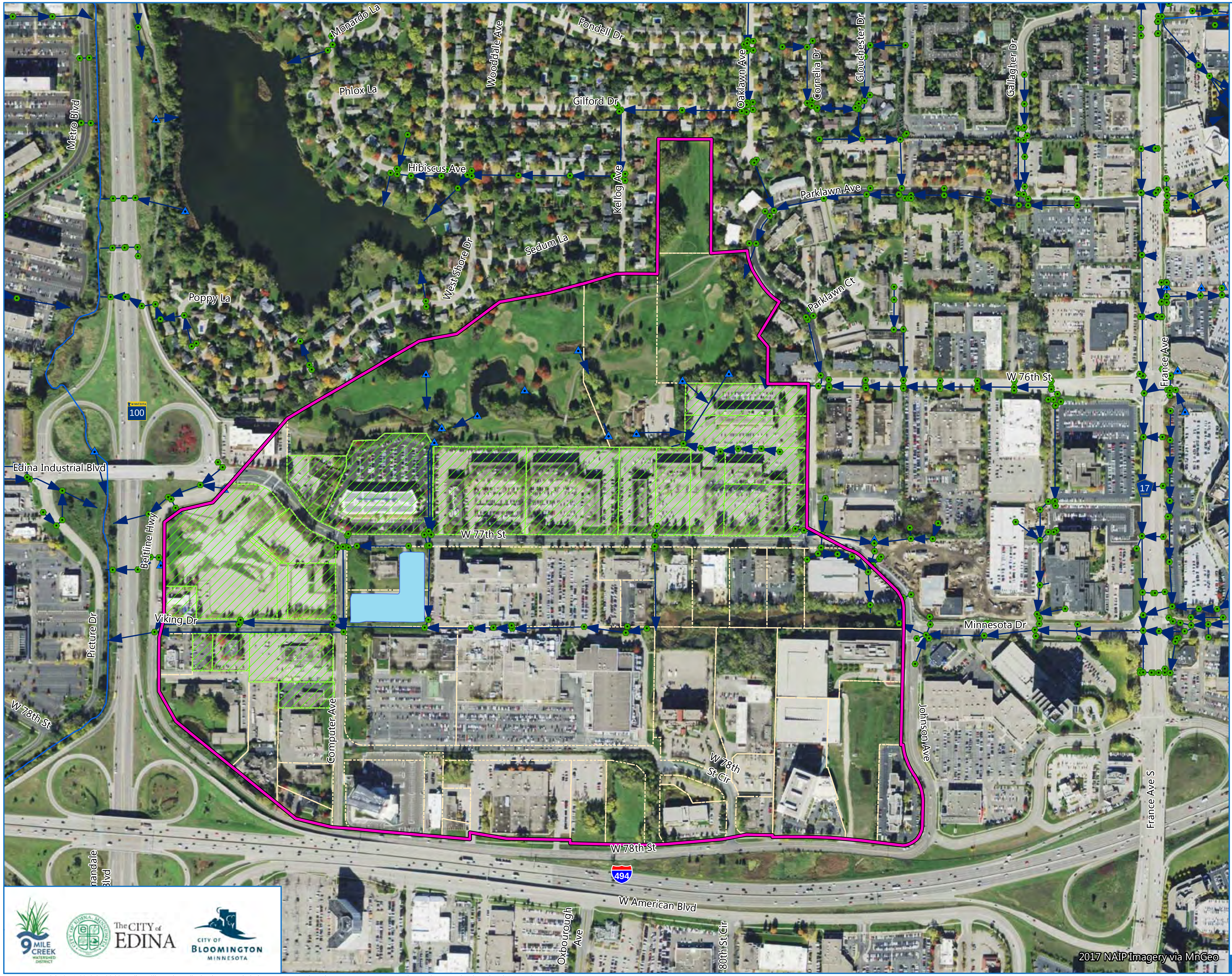
Construction of a regional pond southeast of the intersection of West 77th Street and Computer Avenue would require acquisition of two parcels-- 7711 Computer Avenue and 4701 West 77th Street. The planning-level engineer's opinion of probable cost to construct the new regional water quality treatment pond is $4.7 Million, with $1.3 Million in construction costs (including demolition and removal of the existing structures, pavement, and utilities on the acquired parcels) and $3.4 Million for acquisition of 7711 Computer Avenue and 4701 West 77th Street parcels, based on 2017 Hennepin County taxable market values (approximated for 4701 West 77th Street).

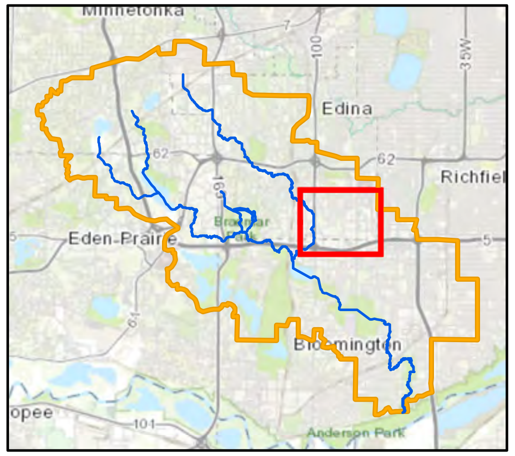
Comparison of the estimated TP and TSS removal benefits with estimated costs of expanding the Border Basin indicates a high cost/benefit ratio for this option (e.g., $200,000 per pound of phosphorus removal from the direct watershed). However, with a potential tributary area of approximately 53 acres, the cost is approximately $89,000 per acre of tributary developable land (i.e., property owners would contribute $89,000 per acre to utilize the regional pond for compliance with the potential regional stormwater management framework), which is within, but at the upper end of the typical range for onsite stormwater management costs.

The engineer's opinion of probable cost includes the cost for acquisition of the two parcels. However, it may be feasible to design the pond on the lower portions of the two parcels, and resell the higher portion of the 4701 West 77th Street parcel for redevelopment, which would reduce the overall cost.

5.2.3 Other Considerations

The potential regional pond would serve primarily as a water quality treatment facility, offering minimal additional flood storage benefit. Because such significant portions of the two parcels are inundated in the 10- and 100-year rainfall events under existing conditions, only minor increases in flood storage would be provided with construction of the water quality pond.





- Nine Mile Creek
- NMCWD Legal Boundary
- Study Area
- Existing Manhole
- Existing Inlet
- Existing Storm Sewer
- Study Area Parcels
- Potential WQ Pond Site
- Parcels Potentially Treated By New Pond

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9 MILE CREEK WATERSHED DISTRICT

The CITY of EDINA

CITY OF BLOOMINGTON MINNESOTA

NEW REGIONAL POND
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure 5-2

5.3 Regional Stormwater Capture and Reuse

Stormwater capture and reuse via irrigation was evaluated as a potential onsite or regional option to provide runoff volume retention and water quality treatment within the study area. With the former Fred Richards Golf Course being repurposed as a multi-use park, there may be opportunities to implement stormwater reuse via irrigation, using the ponds for stormwater storage and green space for irrigation.

The effectiveness of irrigation as a stormwater reuse alternative is based on several key factors, including the amount of impervious surface tributary to the storage system, the storage volume capacity, the rate and duration of irrigation, and the amount of available land for irrigation.

The Stormwater Reuse Credit Calculator developed for the Mississippi Water Management Organization by Barr Engineering Co. was used to estimate the potential volume retention benefits from capturing and reusing stormwater runoff within the Pentagon Park/Border Basin study area. Several storage and irrigation scenarios were evaluated based on a hypothetical 10-acre redevelopment site with D soils (the reuse calculator was modified slightly to account for sites with D soils). Figure 5-3 shows the percent average annual runoff volume retained and reused for the evaluated storage capacity and irrigation area scenarios.

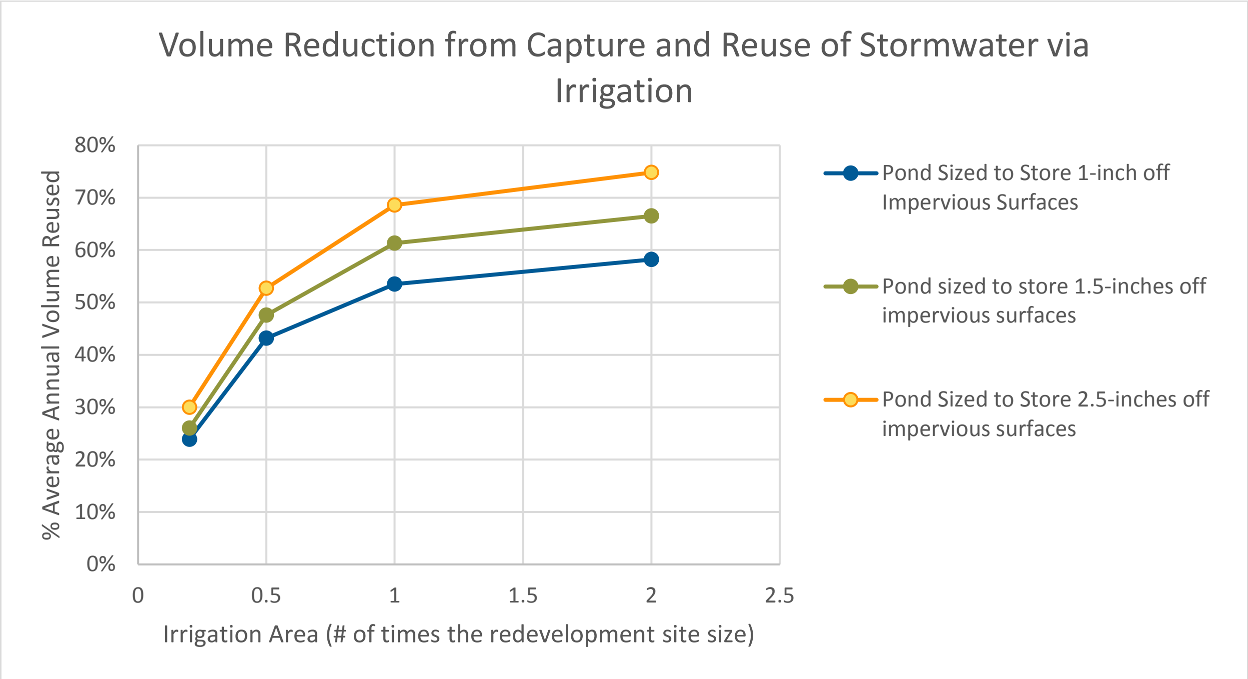

Figure 5-3 Volume Retention Effectiveness of Stormwater Capture and Reuse from a 10-acre, 80% Impervious Site for a Range of Storage Capacities and Irrigation Areas

Results of the analysis showed that while capture and reuse of stormwater via irrigation provides some volume reduction (and associated pollutant removal), quite a large amount of storage capacity and/or green space is required to achieve substantial volume reduction. For example, if capturing and storing

1-inch of runoff from an 80% impervious site, an irrigation area equivalent to the size of the redevelopment site would be necessary to achieve at least 50% average annual volume reduction. Given the large amount of storage volume and irrigation area required to achieve significant runoff volume reduction, it appears that use of regional stormwater reuse sites such as Fred Richards Park will be more economical and feasible than onsite reuse. While plans for Fred Richards Park have not been finalized, review of conceptual plans indicates the potential for approximately 20-30 acres of green space that could be irrigated.

An estimate of probable cost was not prepared for this alternative due to the uncertainty in size and scope of a potential stormwater capture and reuse system within the study area.

6.0 Conclusions and Recommendations

6.1 Flood Risk Management

The flooding problems throughout the study area are primarily due to the proximity to Nine Mile Creek and the influence of high surface water elevations in the creek during large storm events. The peak elevation in Nine Mile Creek at the arch pipe outfall (the primary discharge point from the study area) is 819.0 MSL during the 10-year, 24-hour rainfall event. During the 100-year, 24-hour rainfall event simulation, the elevation of Nine Mile Creek at the arch pipe outfall peaks at elevation 821.6 MSL, and remains above 820.0 MSL for more than 12 hours. The 10-year and 100-year peak surface water elevations in the creek exceed the ground surface elevation of many low-lying areas throughout the study area, including the Border Basin (control elevation of 814.7 MSL) and the ponds on the former Fred Richards Golf Course (control elevation of approximately 818.2 MSL). The high tailwater elevations and the minimal difference in surface water elevation between the study area and the creek result in significantly restricted discharge from the area.

Several flood risk reduction alternatives were evaluated, including expanding storage in the former Fred Richards Golf Course, expanding storage in the Border Basin, providing additional upstream storage, increasing conveyance capacity to Nine Mile Creek, and diversion of stormwater to Normandale Lake. While several of the evaluated alternatives provide minor reductions in flood elevations, none resulted in significant reductions in 100-year flood elevations, primarily due to the influence of high surface water elevations in Nine Mile Creek.

The limited effectiveness of regional flood risk reduction alternatives in reducing flood elevations within the study area indicates that many property owners will need to continue managing floodwaters on-site during large rainfall events**.** The following sections discuss recommendations for managing or reducing flood risk within the study area and tributary watershed.

6.1.1 Further Assess Flood Risk

Flood elevations throughout the study area are reported and mapped as part of this study, based on available elevation data. However, information regarding whether the predicted flood elevations have the potential to impact existing structures within the study area was not available. It is recommended that topographic surveys be conducted to identify low entry elevations of existing structures within the 100-year inundation areas for comparison purposes. This information will help further evaluate the cost effectiveness of the evaluated flood risk reduction alternatives. For example, flood inundation mapping indicate that 10- and 100-year flood elevations may impact structures within the Seagate property. However, it is uncertain whether the predicted flood elevations are actually higher than the low entry elevations of the structures. A topographic survey of this site (and others within the study area) will help better define the flood risk and weigh the cost effectiveness of the flood risk reduction alternatives evaluated as part of this study.

6.1.2 Maintain or Increase Flood Storage

Flood storage volumes within the study area and upstream watershed must be maintained to prevent increased flood risk within the study area. Where effective, opportunities to provide additional flood storage in the study area or upstream watershed should be pursued. However, providing additional storage volume will not be effective in portions of the study area, as additional flood storage results in lower flood elevations, in turn reducing the amount of water discharged to Nine Mile Creek from the study area due to high tailwater conditions and resulting in only a marginal flood reduction benefit. And in some portions of the study area, the substantial addition of flood storage would result in backflow conditions from Nine Mile Creek. The NMCWD's XP-SWMM model for this study area can serve as a useful tool to help evaluate the effectiveness of potential storage locations.

Former Fred Richards Golf Course

The former Fred Richards Golf Course serves as an important regional flood storage area, storing runoff and attenuating flows from the 190-acre tributary watershed. However, in a 100-year event, the flood storage capacity of the former golf course is exceeded and significant surface overflows (approximately 67 acre-feet) contribute to high flood elevations in the West 77th Street and adjacent flood storage areas. Given the importance of the existing flood storage within the former Fred Richards Golf Course and the potential benefits of providing additional storage, the following recommendations should be considered as the former golf course is redeveloped:

- At a minimum, the flood storage volume within the former Fred Richards Golf Course and Lake Edina Park should be maintained, and
- The flood storage volume within the former Fred Richards Golf Course and Lake Edina Park should be expanded, through construction of a berm and/or excavation of upland areas, such that surface overflows from the former golf course property will be eliminated for the 100-year, 24-hour rainfall event.

Redevelopment

The limited effectiveness of regional flood risk reduction scenarios indicates that properties within the study area will continue to be burdened with periodic inundation. As redevelopment occurs within the Pentagon Park/Border Basin study area, property owners or developers will generally be required to maintain existing flood storage volumes on their sites to comply with NMCWD and city rules and policies. This will prevent the transfer of flood risk to neighboring properties, which will pose significant site design challenges. Property owners may have to fill portions of their sites to meet the District's and/or cities' low floor elevation requirements, requiring that compensatory flood storage be provided on other portions of the parcel or at alternate flood storage sites within the study area. It is recommended that the cities of Bloomington and Edina, along with other stakeholders, consider a regional approach to coordinating and facilitating flood storage creation and mitigation, to better identify and take advantage of available opportunities. Opportunities could include, but are not limited to, acquisition of property, requiring additional rate control (extended detention to hold back more runoff) on sites within the study area and upstream watershed that are not impacted by flooding, and encouraging redeveloping properties to provide "extra" storage in parking lots and other areas.

With the anticipated redevelopment in the study area, it is also recommended that the cities of Bloomington and Edina, potentially in conjunction with the NMCWD, consider developing a master land use plan for the area. Given the significant site design challenges throughout the area, it may become necessary for some parcels to be acquired and dedicated to stormwater management and/or flood storage. Without a master planning process, there is a risk that isolated parcels may be acquired as they become available, creating a haphazard and less than ideal situation for stormwater management, property values, and community value. A master planning process could evaluate the study area and propose the dedication of some land to public purposes (e.g., stormwater management, flood storage, recreation) in a coherent fashion that creates an amenity, generating both stronger surrounding property values and redevelopment potential, as well as improved community open space and natural resource value.

6.1.3 Manage for System Capacity Restrictions

As discussed in this report, high tailwater elevations and minimal difference in surface water elevation between the study area and the creek result in significantly restricted discharge from the area. As redevelopment occurs, the cities of Bloomington and Edina should continue to work closely with developers to understand and communicate drainage patterns and restrictions within the study area. This includes sharing information regarding available storm sewer capacity under various design events and surface overflow patterns between neighboring properties.

6.1.4 Implement Building Low Floor Elevation Requirements

The NMCWD rules require that low floor elevations of all new and reconstructed structures be constructed at a minimum of two feet above the 100-year flood elevation for the creek or water body. Proposed NMCWD rule revisions (still draft at the time of this report completion) seek to expand this rule to also require at least two feet of freeboard above the 100-year high water elevation of an open stormwater conveyance or constructed stormwater facility, or one foot above the natural overflow of a water body.

Providing compensatory flood storage and sufficient freeboard will be a significant challenge for many of the redeveloping properties within the study area. Given this significant design challenge, the cities of Bloomington and Edina may wish to consider flexibility toward other zoning and design constraints in portions of the study area, such as building set-backs, building height restrictions, and parking requirements.

6.1.5 Maintain Existing Stormwater Management Infrastructure

Continued inspection and maintenance of existing stormwater infrastructure is recommended. Given the flood risk within the study area, it is especially important to monitor the function of the existing system and identify potential drainage issues early. With the study area including portions of both Bloomington and Edina, it is recommended that the cities of Bloomington and Edina understand and memorialize the agreements that govern operation and maintenance of the stormwater infrastructure within the study area and coordinate maintenance activities, when appropriate.

6.2 Alternative Regional Stormwater Management Approach

Redevelopment of significant portions of the study area is anticipated in the near future. The extent of both 10-year and 100-year frequency flood inundation throughout the study area will pose a challenge to redevelopment efforts. Other site constraints within the study area will pose additional stormwater management challenges, including the widespread presence of soils with low infiltration capacity (hydrologic soil group "D" soils) and the occurrence of shallow groundwater. These site constraints, coupled with the onsite flood storage requirements, will make compliance with the NMCWD stormwater rules especially difficult.

To assist in addressing this challenge, an alternative regional stormwater management framework for the study area was developed for consideration by the cities and stakeholders. If a regional stormwater management approach within the study area is pursued, a more detailed stormwater management plan for the Pentagon Park/Border Basin region would need to be undertaken and submitted by the City of Edina and/or the City of Bloomington for consideration by the NMCWD managers.[3] In the absence of an approved regional alternative stormwater management approach for the study area, redevelopment of individual sites within the study area may require requests for variances from the NMCWD's current rules.

A potential alternative stormwater management approach was developed for the Pentagon Park/Border Basin study area as part of this study to optimize stormwater management benefits with consideration of site and cost constraints. The potential alternative regional stormwater management approach requires redeveloping sites to provide additional runoff rate control, *beyond limiting peak flowrates to that of existing conditions,* in lieu of volume retention, to mimic the rate control benefits typically achieved from implementing BMPs to achieve the NMCWD's volume retention criteria. This approach of using extended detention should be relatively cost effective as the extended detention and rate control system can also serve as flood storage, assuming the drawdown time of an extended detention system is within a reasonable timeframe and the extended detention system is installed at elevations that correspond to the desired elevations for flood storage.

The Pentagon Park/Border Basin study area was primarily developed in the late 1960s and early 1970s, prior to the era of stormwater management regulation. Much of the area receives little or no rate control or water quality treatment prior to discharge to Nine Mile Creek. Redevelopment of the study area will result in a benefit to the Nine Mile Creek system, assuming stormwater management practices are implemented to reduce runoff rates and pollutant contributions to the creek. As such, efforts to promote

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[3] The NMCWD rules do not presently provide a mechanism whereby a regional stormwater-management plan can take the place of compliance with NMCWD rules for individual properties. (The NMCWD Stormwater Management Rule currently does allow regional treatment to meet water quality standards.) The NMCWD is currently undergoing a rule revision process, in which draft rule revisions include the addition of a provision to allow approval of a stormwater management plan for a defined region that demonstrates that degradation of downstream receiving waters will be prevented and that benefits that would be achieved by a plan in compliance with the NMCWD criteria will be achieved to the maximum extent practicable, recognizing the site or regional constraints that prevent full compliance. In the meantime, a region-specific alternative stormwater management plan would have to be proposed to the NMCWD as a regional variance.

redevelopment in this area should be considered as beneficial to downstream resources. To this end, it is recommended that the cities of Bloomington and Edina, along with other stakeholders, consider further refining a regional stormwater management plan for the Pentagon Park/Border Basin that would be submitted by for consideration by the NMCWD managers. A regional stormwater management plan would serve as a guide for stormwater management as redevelopment occurs within the study area and could incorporate regional stormwater systems for compliance with NMCWD rules.

6.3 Regional Stormwater Systems Opportunity Evaluation

Regional systems can be a cost effective approach to providing stormwater management, including rate control and water quality treatment (among other potential benefits). The potential alternative regional stormwater management approach identifies achievement of the rate control and pollutant removal criteria through either onsite or regional systems. Several opportunities for implementing or improving regional stormwater treatment systems were evaluated, including expansion of the Border Basin, construction of a new regional water quality pond located southeast of the intersection of West 77th Street and Computer Avenue, and stormwater capture and reuse via irrigation. While the focus of the evaluation was toward potential regional water quality treatment systems, several of these systems could be designed to also incorporate additional rate control measures. Based on the evaluation, the following recommendations should be considered to provide regional water quality treatment:

- Construction of a new regional water quality pond located southeast of the intersection of West 77th Street and Computer Avenue could provide water quality treatment for approximately 20 parcels within the study area (about 53 acres). While the cost of this alternative is high, primarily due to land acquisition costs, the cost per acre of tributary developable land ($89,000 is within the reasonable range for typical onsite stormwater management costs.
- Stormwater capture and reuse at the former Fred Richards Golf Course site should be considered as a regional treatment option as redevelopment of the park occurs. The effectiveness of irrigation as a stormwater reuse alternative is based on several key factors, including the amount of impervious surface tributary to the storage system, the storage volume capacity, the rate and duration of irrigation, and the amount of available land for irrigation. Review of conceptual plans developed as part of the Fred Richards Master Plan process indicates the potential for approximately 20-30 acres of green space that could be utilized for reuse of stormwater.
- The Border Basin achieves only moderate pollutant removal effectiveness under existing conditions due to several factors, including the shallow nature of the existing pond, its small size in comparison with the large contributing drainage area, and the significant proportion of inflow from Centennial Lakes, which has a large fraction of soluble phosphorus. Pollutant removal effectiveness under the Border Basin expansion scenario is improved, but does not quite meet the NMCWD's pollutant removal criteria alone due to the reasons cited above. The cost of the Border Basin expansion is high due to land acquisition costs and the significant excavation volume needed.

  Alternatives for providing regional water quality treatment for redeveloping parcels tributary to the Border Basin include construction of smaller-scale pond(s) directly upstream of the existing Border Basin to avoid the flushing effect. For example, a pond could be constructed at 4450

78th Street Circle to treat runoff from the redeveloping parcels southwest of the Border Basin, or at 4445 West 77th Street to treat runoff from redeveloping parcels adjacent to the Border Basin (north side) or the parcels northeast of the Basin. Both of these options would also provide some additional flood storage that could be used as compensatory storage for neighboring redeveloping parcels. Another option is to acquire land in (or near) the drainage area tributary to the Border Basin that has good infiltration potential, and construct a regional infiltration system to provide volume retention and water quality credits. For example, several parcels south of West 76th Street have soils that are well suited for infiltration, based on the NRCS Hennepin County soil survey (e.g., 4175 and 4401 West 76th Street). These sites could also be used to provide mitigating flood storage, assuming the system is designed as a retention system (versus temporary storage).

In addition, it is recommended that the water quality treatment benefits provided by the former Fred Richards Golf Course under existing conditions (see Section 2.2) should be maintained, or improved, as redevelopment of the park occurs.

Next Steps

The results of this regional stormwater management analysis have helped to understand the cause and extent of the flooding problem within the Pentagon Park/Border Basin study area, assess the effectiveness of potential flood risk reduction efforts, provide stormwater management guidelines including development of a potential alternative stormwater management approach for the study area, and evaluate the potential for regional stormwater management systems to assist in compliance with the stormwater requirements. The potential alternative stormwater management approach has been designed to optimize stormwater management benefits given the significant site constraints and offer flexibility to promote redevelopment within the area. The evaluation of flood storage requirements within the study area has provided parcel-based information, including runoff generation (10- and 100-year), flood storage volumes and depths (10- and 100-year), extent of inundation, and taxable market values. The evaluation of potential regional stormwater management systems has provided useful planning-level information, including quantification of costs and benefits.

The next steps with regard to moving forward with a region-specific stormwater management plan will be for the participating cities and stakeholders to make some important decisions regarding approach for regional stormwater management, including potential land acquisition(s) for regional stormwater management system(s), funding mechanisms, and sources, and then prepare a more detailed region-specific plan proposal for submittal to the NMCWD.

While this regional stormwater management analysis included modeling of the benefits of additional rate control (in comparison to volume retention practices), it did not include a detailed, site-by-site modeling analysis of the impacts of the potential regional stormwater management approach, as this level of detailed modeling was outside of the existing scope of work. The detailed region-specific stormwater management plan proposal would need to include a more detailed modeling analysis that reflects the proposed alternative stormwater management approach (including detailed assumptions about onsite versus regional treatment) to better evaluate the impacts to Nine Mile Creek. Additional requirements of the detailed region-specific stormwater management plan proposal would need to be determined in consultation with NMCWD staff.

Funding for a regional stormwater management system in the Pentagon Park/Border Basin study area would likely be a public-private partnership, including contributions from one or both cities and private property owners that plan to utilize the regional system for compliance with NMCWD rules. The NMCWD would consider financial participation in projects that provide beyond-compliance water-resources protection benefits, such as wetlands restoration or projects that provide additional flood storage or water quality treatment capacity beyond what is required to meet NMCWD rules.

The cities of Bloomington and Edina, potentially in conjunction with NMCWD, may also want to consider developing a master plan for the area to better integrate land use and water resources planning. The master plan would evaluate the study area and develop a cohesive land use plan that helps meet stormwater and flood storage needs, while also generating stronger surrounding property values and redevelopment potential.

7.0 References

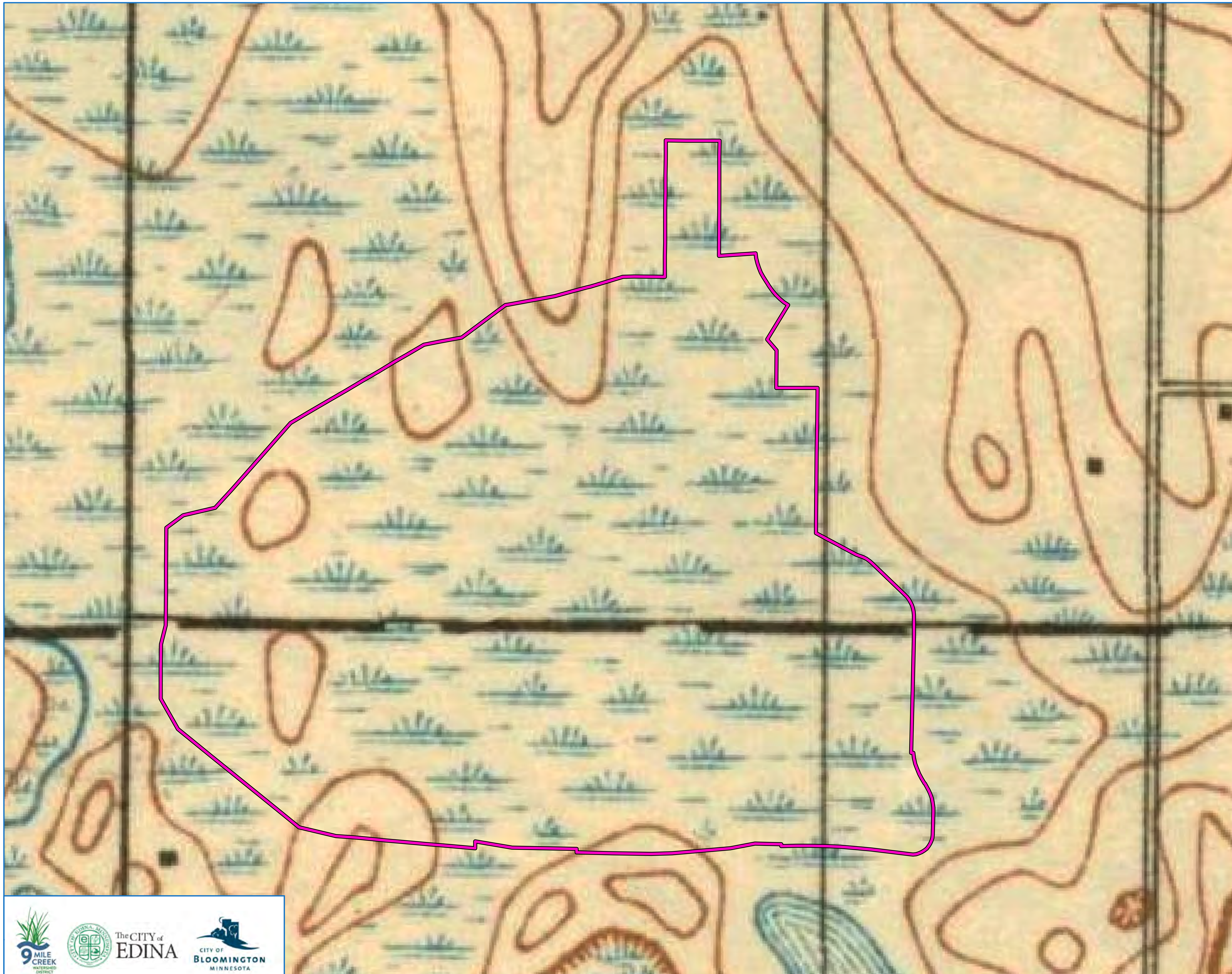
Barr Engineering Co., *City of Edina Comprehensive Water Resources Management Plan*. 2003.

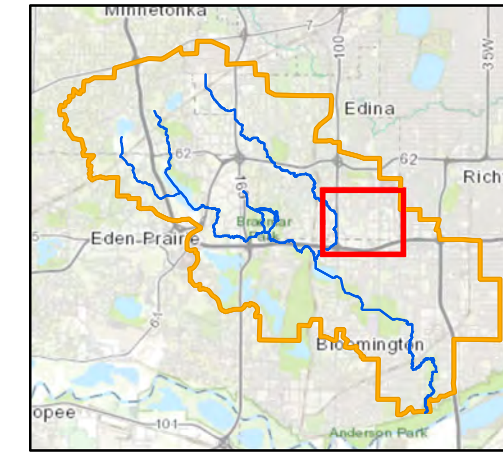
Barr Engineering Co., *Normandale Lake Use Attainability Analysis*. Prepared for Nine Mile Creek Watershed District. 2005.

Minnesota Pollution Control Agency. *Assessment of MIDS Performance Goal Alternatives: Runoff Volumes, Runoff Rates, and Pollutant Removal Efficiencies.* Prepared by Barr Engineering Co. 2011.

Appendix A

Historic Aerial Imagery





Nine Mile Creek

NMCWD Legal Boundary

Study Area

BARR

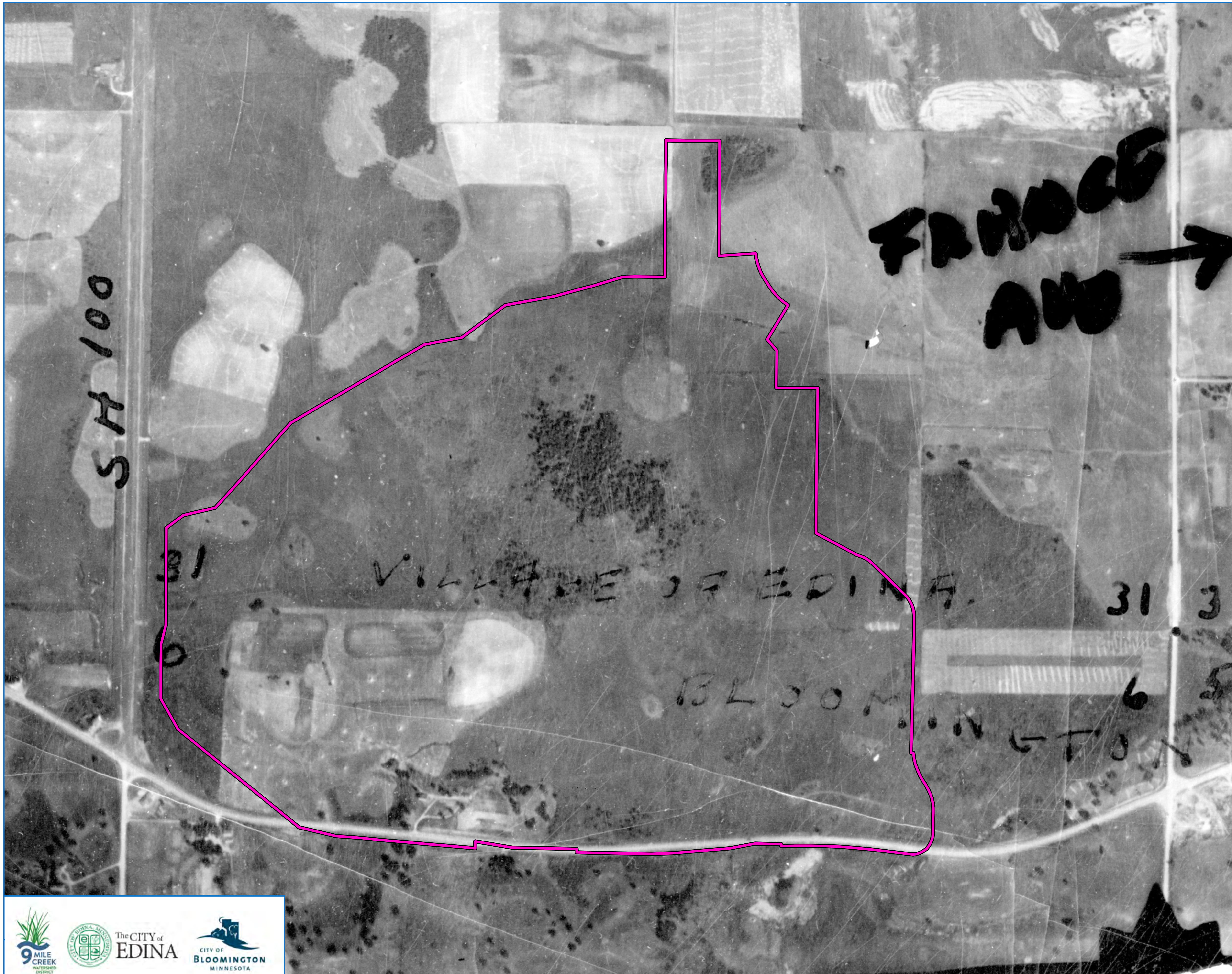
N

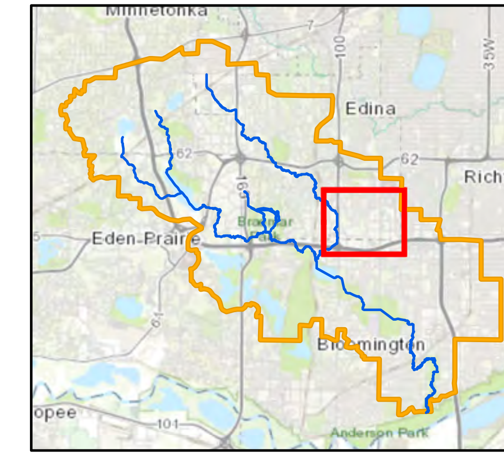
0 500 1,000

Feet

HISTORICAL LAND USE
1901 USGS QUAD
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure A-1





Nine Mile Creek

NMCWD Legal Boundary

Study Area

BARR

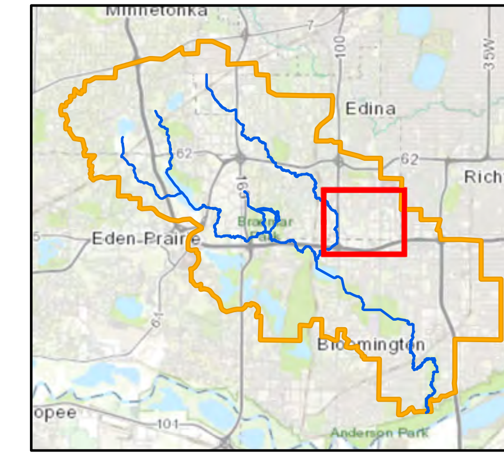
0 500 1,000

Feet

HISTORICAL LAND USE
1937 UNIVERSITY OF MINNESOTA
AERIAL IMAGERY
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure A-2

9 MILE CREEK WATERSHED DISTRICT · The CITY of EDINA · CITY OF BLOOMINGTON MINNESOTA

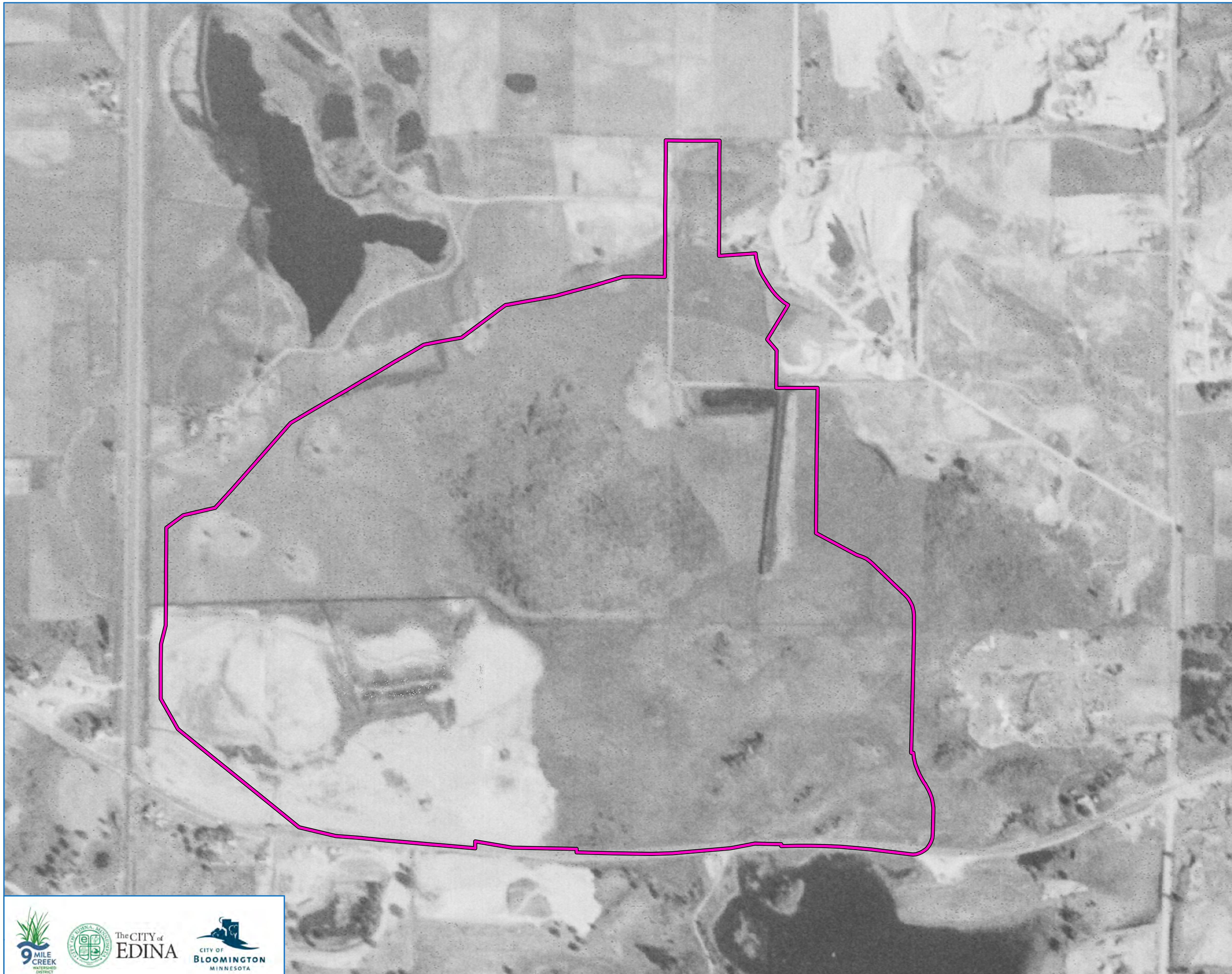


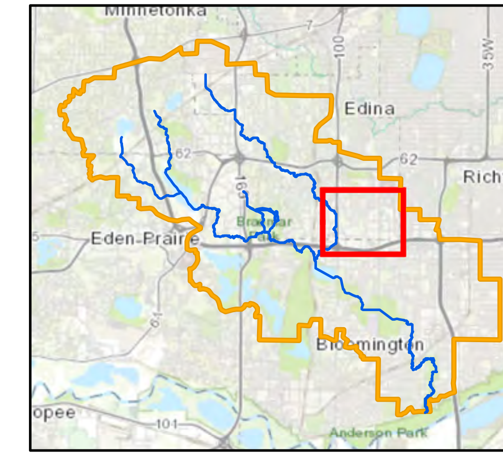
Nine Mile Creek
NMCWD Legal Boundary
Study Area

0 500 1,000
Feet

HISTORICAL LAND USE
1947 USGS AERIAL IMAGERY
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

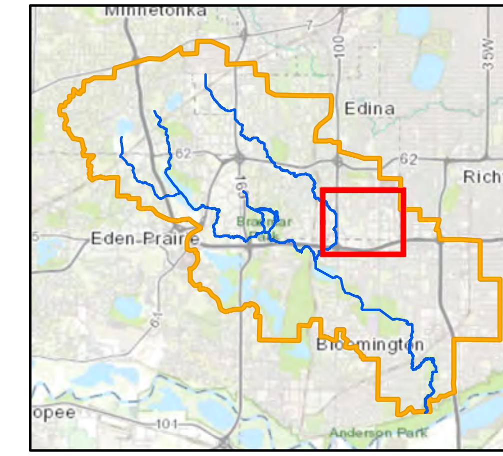
Figure A-3





HISTORICAL LAND USE
1953 USGS AERIAL IMAGERY
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure A-4



Nine Mile Creek

NMCWD Legal Boundary

Study Area

BARR

N

0 500 1,000

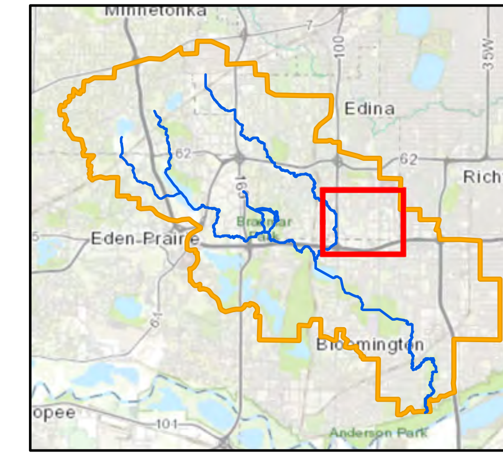
Feet

The CITY of EDINA

CITY OF BLOOMINGTON MINNESOTA

HISTORICAL LAND USE
1966 USGS AERIAL IMAGERY
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure A-5



Nine Mile Creek

NMCWD Legal Boundary

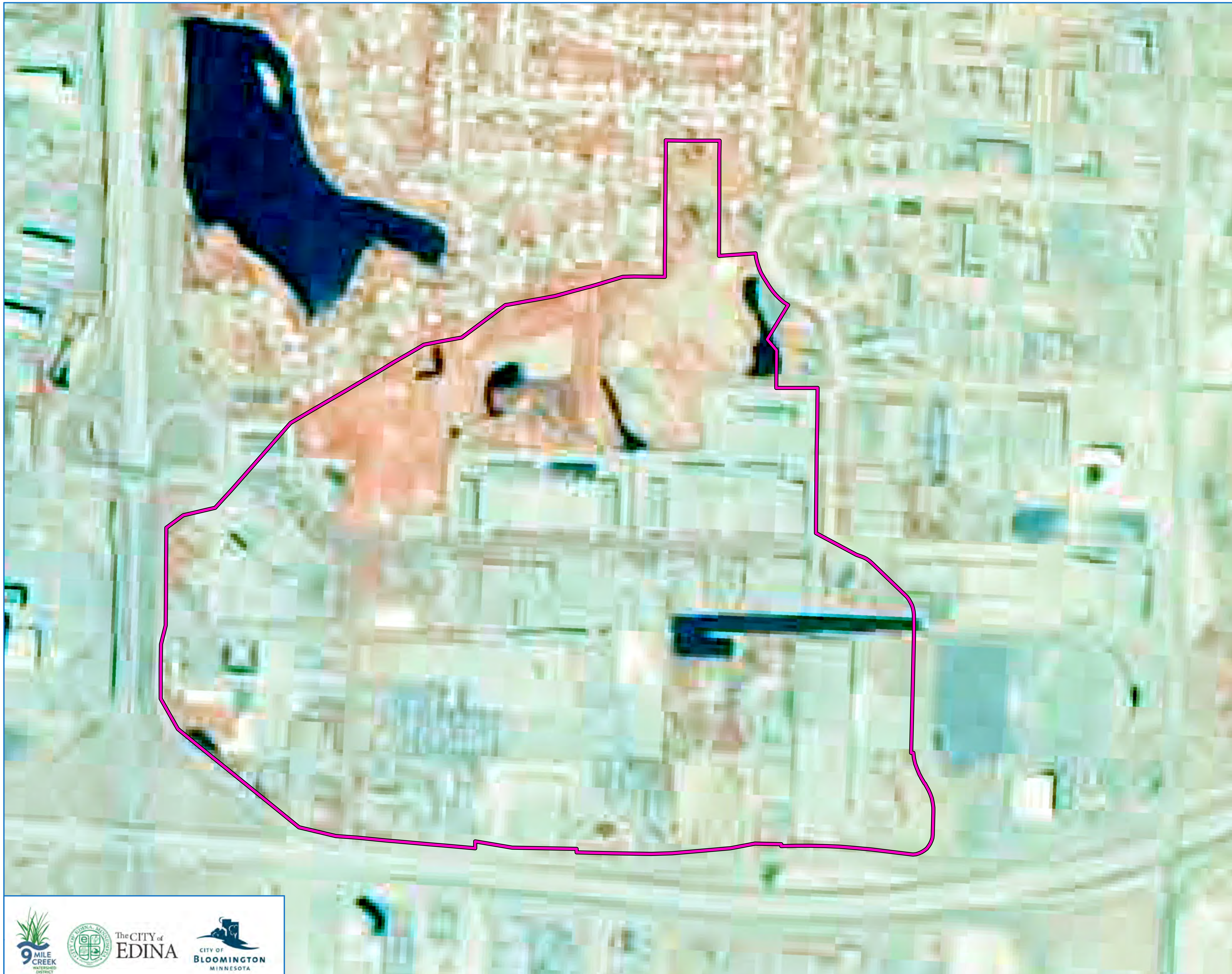
Study Area

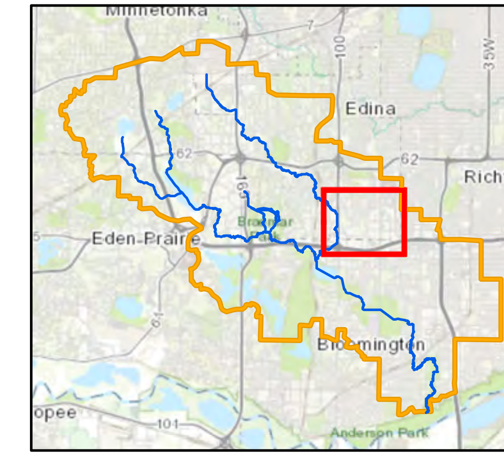
0 500 1,000

Feet

HISTORICAL LAND USE
1972 USGS AERIAL IMAGERY
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure A-6



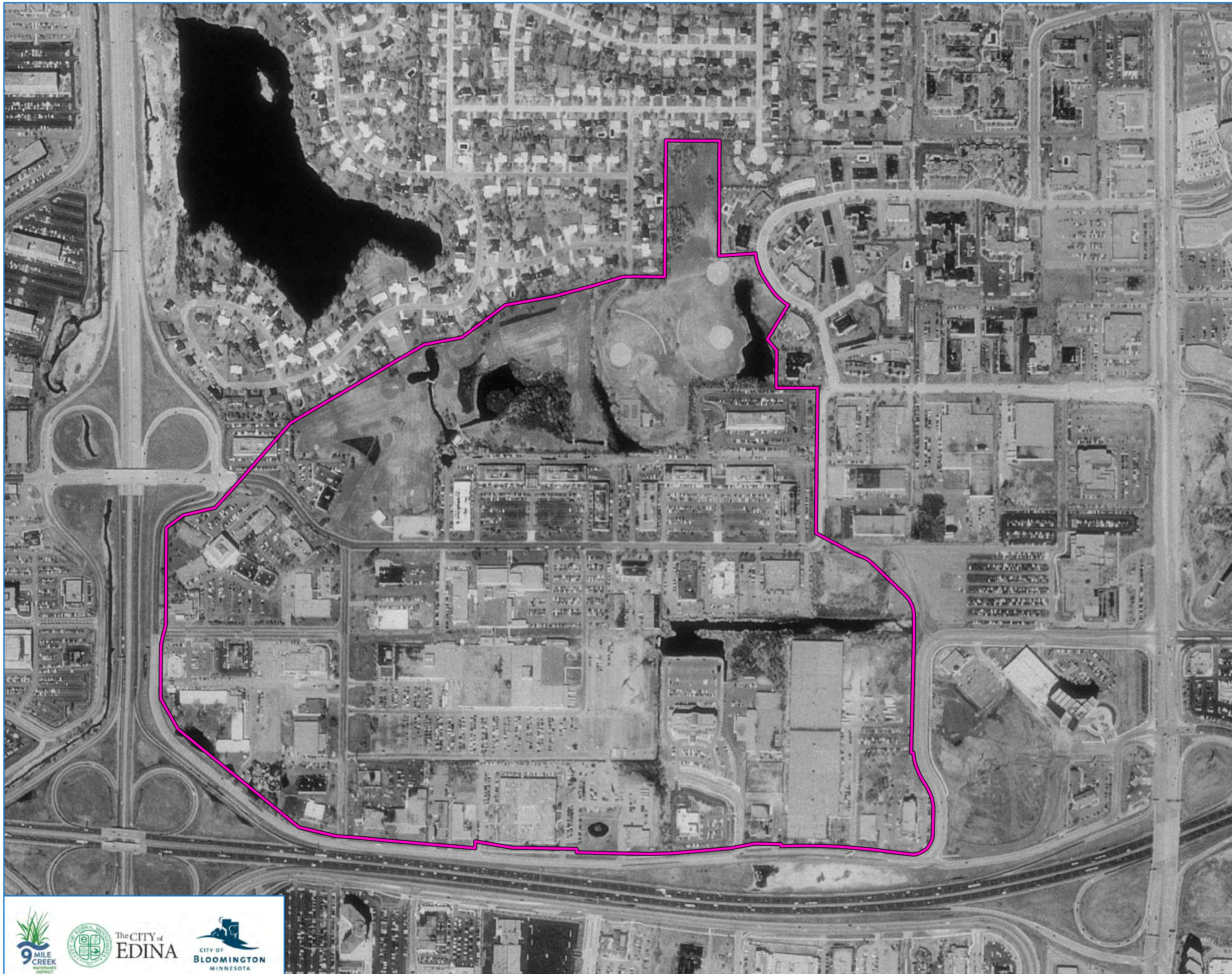


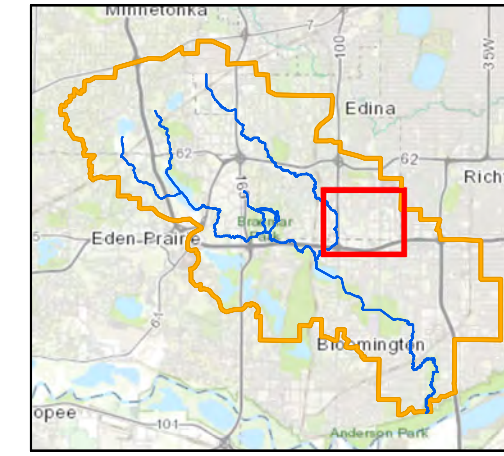
Nine Mile Creek
NMCWD Legal Boundary
Study Area

0 500 1,000
Feet

HISTORICAL LAND USE
1980 USGS INFRARED AERIAL IMAGERY
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure A-7





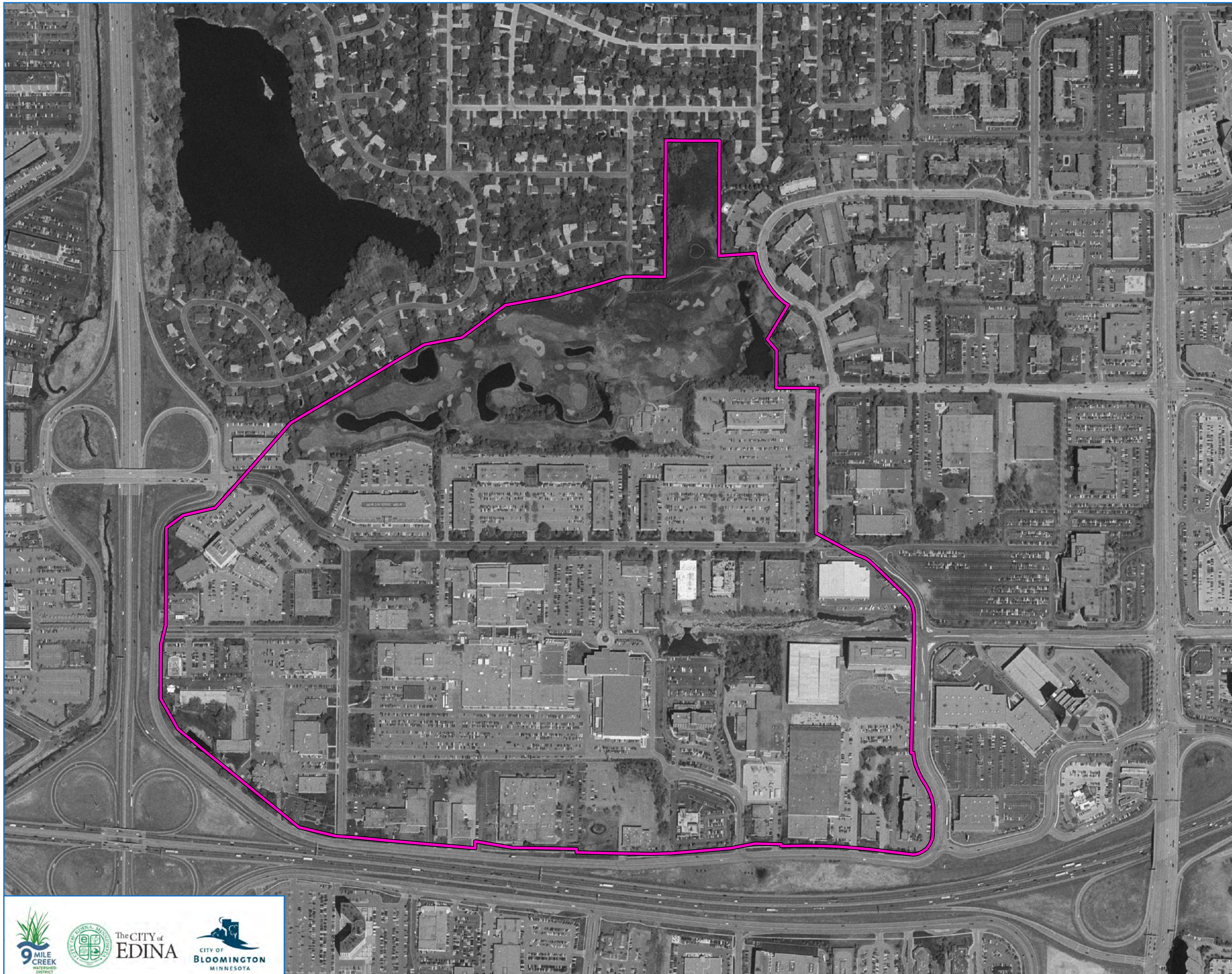
Nine Mile Creek
NMCWD Legal Boundary
Study Area

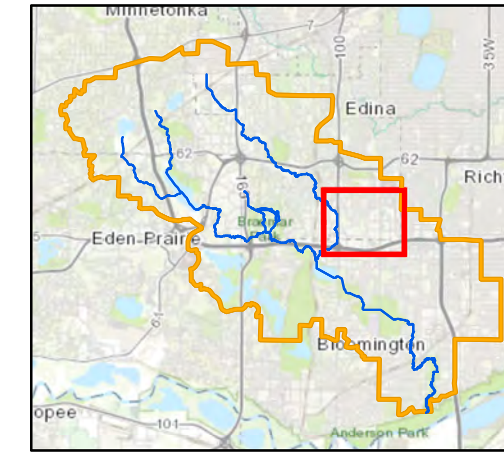
BARR

0 500 1,000
Feet

HISTORICAL LAND USE
1991 USGS AERIAL IMAGERY
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure A-8





Nine Mile Creek

NMCWD Legal Boundary

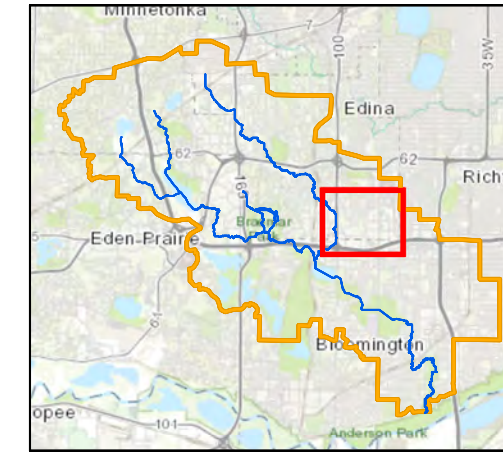
Study Area

0 500 1,000
Feet

HISTORICAL LAND USE
2000 METROPOLITAN COUNCIL
AERIAL IMAGERY
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure A-9

Barr Footer: ArcGIS 10.4.1, 2018-04-06 09:20 File: I:\Client\Nine_Mile_Creek_WD\Work_Orders\Pentagon_Park_Updates\Maps\Reports\Report\Figure A-9 Pentagon Report 2000 Aerial.mxd User: rcs2



Nine Mile Creek

NMCWD Legal Boundary

Study Area

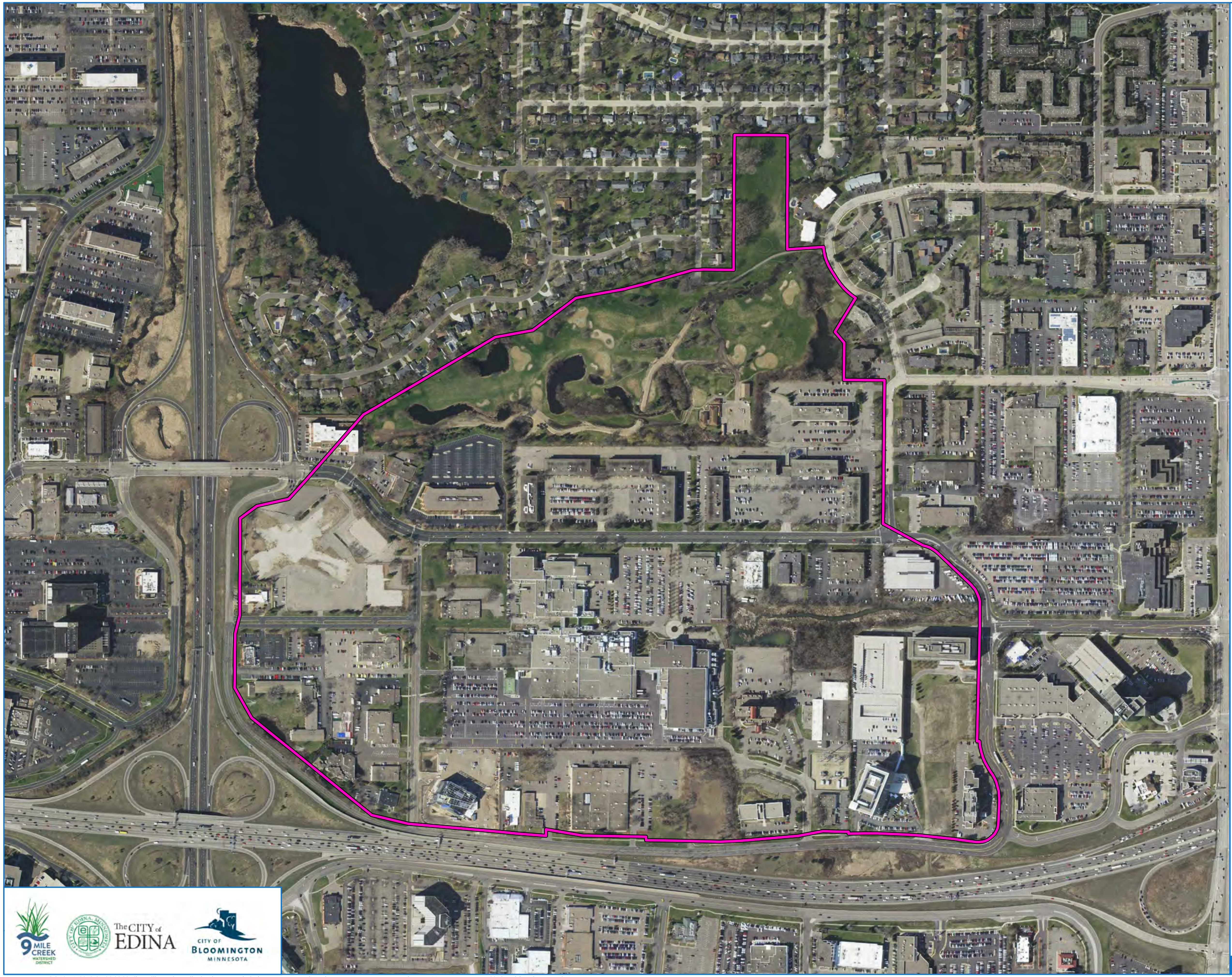
BARR

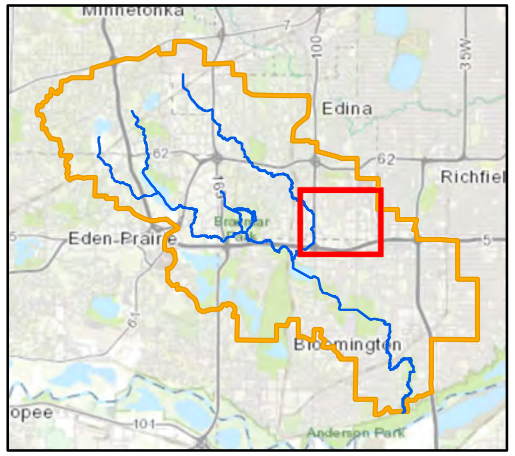
0 500 1,000
Feet

HISTORICAL LAND USE
2010 MINNESOTA DNR
AERIAL IMAGERY
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure A-10

9 MILE CREEK WATERSHED DISTRICT
The CITY of EDINA
CITY OF BLOOMINGTON MINNESOTA





Nine Mile Creek

NMCWD Legal Boundary

Study Area

BARR

0 500 1,000

Feet

HISTORICAL LAND USE
2016 METROPOLITAN COUNCIL
AERIAL IMAGERY
Pentagon Park/Border Basin
Stormwater Management Plan
Nine Mile Creek Watershed District

Figure A-11

9 MILE CREEK WATERSHED DISTRICT | The CITY of EDINA | CITY OF BLOOMINGTON MINNESOTA

Appendix B

Fred Richards Park Master Plan Concept Plans

CONCEPT A

A TRAILHEAD BUILDING FOCUS

B WATER SPORT LEARNING

C NATURE PLAY PODS

D BOARDWALKS

E WILDLIFE BLINDS

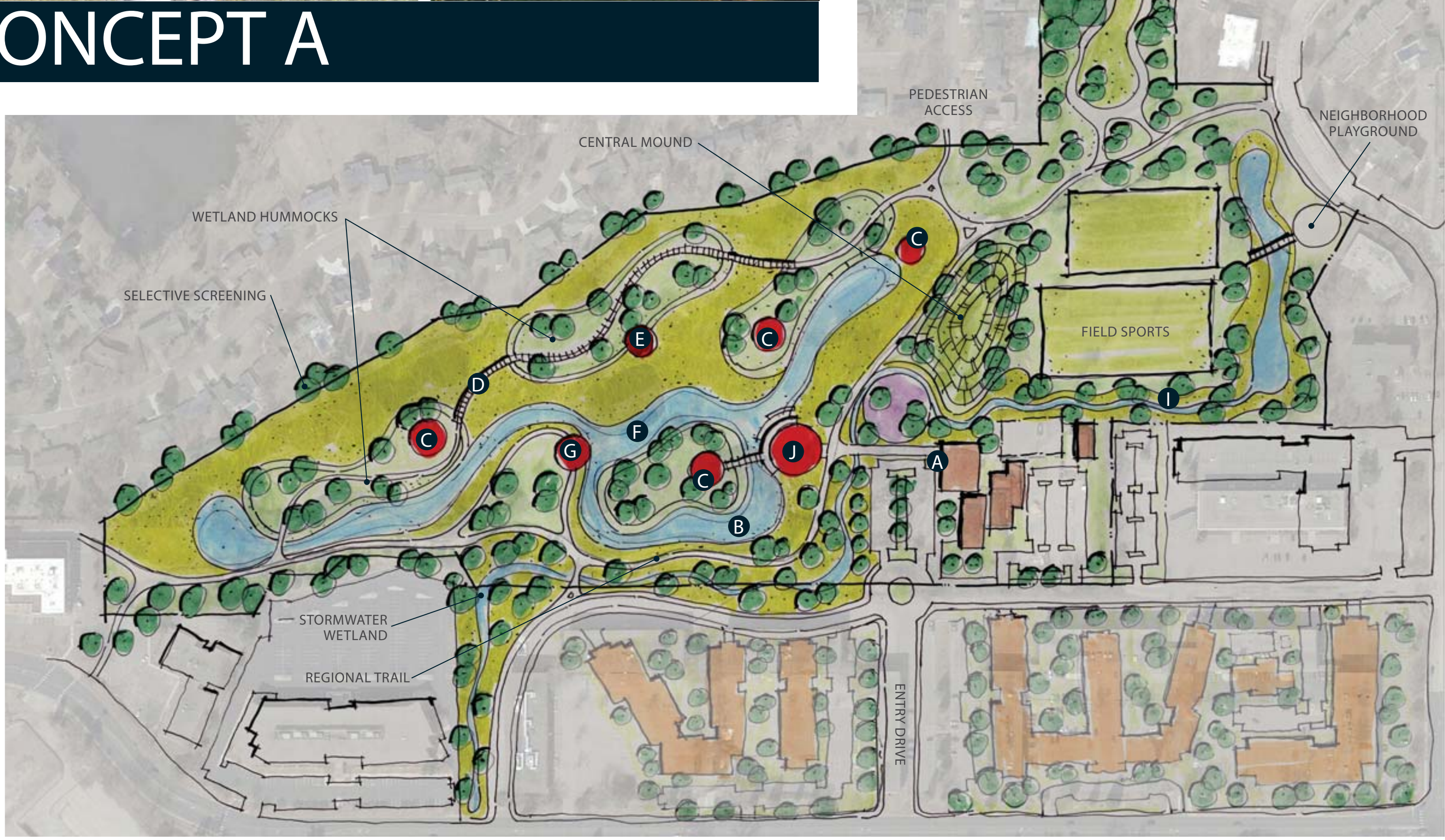
F WINTER ICE SKATING TRAIL

G FITNESS TRAIL - STATIONS

H BIKE SKILLS LOOP - KIDS

I STORMWATER STREAM

J WATER CONNECTIONS



SITE COST	●●●○○	PATHWAYS TO PLAY + REST+ COMMUNITY
BUILDING COSTS	●●●●○	ATHLETIC FIELD + BIKE SKILLS AREA ENCOURAGE MOVEMENT
ENVIRONMENTAL BENEFIT	●●●●○	WATER/ ICE TRAIL PATHWAYS - LEARNING WATER SPORTS & SKATING
FLOOD MITIGATION	●●●●●	NINE MILE CREEK TRAIL HEAD IN BUILDING
TRAFFIC/PARKING NEED	●●●●○	MAXIMIZE ENVIRONMENTAL + HUMAN HEALTH

CONCEPT B


A WETLAND CELLS


B VIEWING TOWER


C PLAY AREA


D GREAT LAWN


E WATER ACCESS

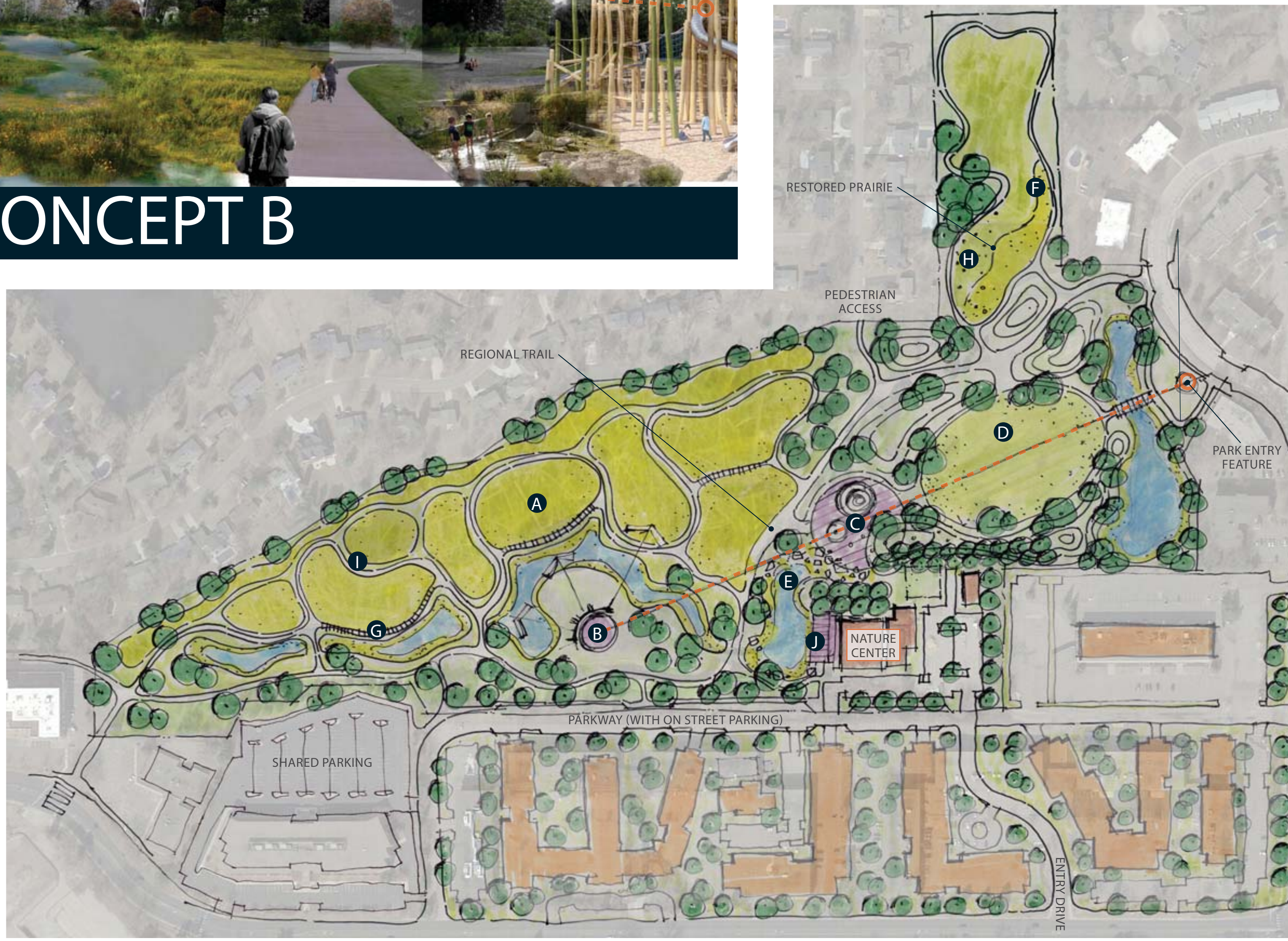

F NATIVE PRAIRIE


G BOARDWALK


H CLIMBING TREE ART


I WILDLIFE OVERLOOK


J OUTDOOR GATHERING AREA



SITE COST	●●●●○
BUILDING COSTS	●●●○○
ENVIRONMENTAL BENEFIT	●●●●●
FLOOD MITIGATION	●●●○○
TRAFFIC/PARKING NEED	●●●○○

ENVIRONMENTAL EXPERIENCE / EDUCATION

MAXIMIZE ECOLOGICAL BENEFITS

INTEGRATE TECHNOLOGY + NATURE

WETLAND AND UPLAND RESTORATION

REUSE THE EXISTING BUILDING AS NATURE CENTER

CONCEPT C

A GEOMETRIC FORMED WETLANDS

B PARK PAVILLION

C PARKWAY

D SLEDDING HILL

E DOG PARK

F ADVENTURE / NATURE PLAY

G CREATIVE LOUNGE

H RESTING/VIEWING AREAS

I SCULPTURE / ART

J INTERACTIVE WATER PLAY

SITE COST	● ● ● ● ●
BUILDING COSTS	● ● ● ● ○
ENVIRONMENTAL BENEFIT	● ● ● ○ ○
FLOOD MITIGATION	● ● ● ● ○
TRAFFIC/PARKING NEED	● ● ● ● ●

VARIETY OF PARK ACTIVITIES

FOCUS ON MORE CENTRALIZED GATHERING

BUILDING SUPPORTS EVENTS

A CENTRALIZED WETLAND FEATURE

STRONG PARKWAY CONNECTION AND ENTRY

FOCUS ON NATURE AND THE RESTORED WETLANDS

Appendix C

Rule 4.0 Stormwater Management

(Excerpt from Nine Mile Creek Watershed District Rules)

4.0 Stormwater Management

4.1 Policy

It is the policy of the District to regulate the management of stormwater runoff to:

4.1.1 Require that onsite retention and regional water quality treatment systems operate together to provide complete and effective runoff management, through the following principles:

- a Manage peak runoff rates to achieve rates equal to or below existing rates;
- b Manage runoff volume to achieve a net reduction from existing conditions;
- c Provide effective water quality treatment to remove sediment, pollutants and nutrients from stormwater and snowmelt before discharge to surface water bodies and wetlands; and
- d Provide for nondegradation of surface water bodies in the watershed.

4.1.2 Encourage the use of Better Site Design, Low Impact Development and other techniques that minimize impervious surfaces or incorporate volume-control practices, such as infiltration, to limit runoff volumes.

4.1.3 Maximize opportunities to improve stormwater and snowmelt management presented by redevelopment of land.

4.2 Regulation

A permit from the District, incorporating an approved stormwater management plan, is required under this rule prior to the commencement of any activities to which this rule applies. The District may review a stormwater management plan at any point in the development of a regulated project and encourages project proposers to seek early review of plans by the District.

4.2.1 The requirements of this rule apply to:

- a Land-disturbing activities that will disturb 50 cubic yards or more of earth,
- b Land-disturbing activities that will disturb 5,000 square feet or more of surface area or vegetation, or
- c Subdivision of a parcel into three or more residential lots.

4.2.2 Notwithstanding the provisions of section 4.2.1, the requirements of this rule do not apply to:

- a Construction or reconstruction on a single-family home site, unless any portion of the parcel is:

1 Within 300 feet of the centerline of and tributary to Nine Mile Creek,

2 Within 500 feet of the ordinary high water level of and tributary to any other public water or protected wetland, or

3 Below the 100-year flood elevation.

b Construction or reconstruction on a single-family home site consistent with a subdivision, development or redevelopment plan that is subject to an active District permit.

c Rehabilitation, including mill and overlay, of paved surfaces.

4.2.3 **Redevelopment.** If a proposed activity will disturb more than 50 percent of the existing impervious surface on the parcel or will increase the imperviousness of the entire parcel by more than 50 percent, the criteria of section 4.3 will apply to the entire project parcel. Otherwise, the criteria of section 4.3 will apply only to the disturbed areas and additional impervious surface on the project parcel. For purposes of this paragraph, disturbed areas are those where underlying soils are exposed in the course of redevelopment.

4.2.4 **Linear projects.** Notwithstanding section 4.2.3, a permit under this rule is not required for a linear project if the project entails construction or reconstruction, including mill and overlay or other maintenance, creating less than 1 acre of new or additional impervious surface. For linear projects creating more than 1 acre of new or additional impervious surface, the criteria of section 4.3 will apply only to the net new or additional impervious surface.

4.2.5 **Common scheme of development.** Activity subject to this rule on a parcel or adjacent parcels under common or related ownership will be considered in the aggregate, and the requirements applicable to the activity under this rule will be determined with respect to all development that has occurred on the site or on adjacent sites under common or related ownership since the date this rule took effect (March 2008).

a For development or redevelopment under common or related ownership, compliance with the criteria of section 4.3 may be achieved through a shared stormwater management facility or facilities as long as the criteria are met on for each contributing drainage area within the common or related ownership.

4.3 Criteria

4.3.1 An applicant for a permit under this rule must demonstrate, using a model acceptable to the District, that the implementation of its stormwater management plan will:

a Provide for the retention onsite of one inch of runoff from all impervious surface of the parcel;

i Where below-ground infiltration facilities, practices or systems are proposed, pretreatment of runoff must be provided.

b Limit peak runoff flow rates to that from existing conditions for the 2-, 10- and 100-year storm events for all points where stormwater discharge leaves a parcel; and

c Provide for all runoff from the parcel from the 2.5-inch storm event to be treated, through onsite or offsite detention, to at least sixty percent (60%) annual removal efficiency for phosphorus, and at least ninety percent (90%) annual removal efficiency for total suspended solids. The onsite retention of runoff may be included in demonstrating compliance with the total suspended solids and phosphorus removal requirements.

4.3.2 **Low floor elevation**

No structure may be constructed or reconstructed such that its lowest floor elevation is less than 2 feet above the 100-year event flood elevation.

a All structures riparian to inundation areas or constructed or natural stormwater management facilities must be located and elevations must be set according to Appendix 4a, "Suggested Low Floor Guidance."

b **Landlocked basins.** Any new or reconstructed structure wholly or partially within a landlocked basin must be constructed such that its lowest floor elevation is:

1 1 ft above the surface overflow of the basin, or

2 2 ft above the elevation resulting from two concurrent 100-year single rainfall events in a 24-hour period or a 100-year, 10-day snowmelt, whichever is higher.

3 The starting elevation of the basin prior to the runoff event shall be established by one of the following:

A Existing ordinary high water elevation established by the Minnesota Department of Natural Resources;

B Annual water balance calculation approved by the District;

C Local observation well records, as approved by the District; or

D Mottled soil.

4.3.3 **Maintenance**

All stormwater management structures and facilities must be designed for maintenance access and properly maintained in perpetuity to assure that they continue to function as designed. Permit applicants must provide a maintenance and inspection plan that identifies and protects the design, capacity and functionality of onsite and offsite stormwater management facilities; specifies the methods, schedule and responsible parties for inspection and maintenance; provides for the inspection and maintenance in perpetuity of the facility, with documentation retained onsite and available to the District upon reasonable notice; and contains at a minimum the requirements in the District's standard maintenance declaration. The plan will be recorded on the deed in a form acceptable to the District. A public entity assuming the maintenance obligation may do so by filing with the District a document signed by an official with authority.

4.4 Volume banking

The District has established and will maintain a bank of available runoff retention and water quality Volume Credits.

4.4.1 Volume reduction or runoff retention achieved onsite in excess of the requirement of Section 4.3.1 may be credited into the District's bank for use on other projects within the District that are unable fully to meet this requirement on parcel.

4.4.2 Stormwater management facilities or practices relied upon to create Volume Credits must be included in the recorded permanent maintenance plan specified in Section 4.3.3.

4.4.3 Volume Credits may be utilized by permit applicants to meet the requirements of Section 4.3.1a and 4.3.1c only after the applicant has demonstrated to the District that:

a One-half inch of runoff from all impervious surface of the parcel will be retained on the parcel; and

b Soil conditions and/or other site constraints prevent retention of additional runoff onsite.

4.4.4 The District will maintain an inventory of all qualified Volume Credits accumulated and sold. Permit applicants are responsible for contacting a seller of Volume Credits and arranging the sale on terms established by the interested parties. The District will certify the sale through a form established by the District and completed by the buyer and seller of the

Volume Credits.

4.4.5 If a project qualifies for use of volume banking credits but applicable credits are not available in the bank for the volume reduction required, the applicant shall pay into the District's Stormwater Facilities Fund to cover the cost of implementing offsetting volume-reduction and water-quality projects elsewhere in the watershed. The required contribution rate shall be set by the Board annually based on the cost of creation of the required retention capacity.

- a Funds contributed to the Stormwater Facilities Fund from a local government unit shall be spent within that local government unit's jurisdiction to the extent possible.
- b Funds contributed to the Stormwater Facilities Fund shall be allocated to volume reduction projects by the District according to the Stormwater Facilities Fund Implementation Plan as approved by the Board.

4.5 Required exhibits

The following exhibits shall accompany the permit application; one set full size (22 inches by 34 inches); one set reduced to maximum size of 11 inches by 17 inches, and one set as electronic files in a format acceptable to the District:

4.5.1 A narrative explaining Better Site Design/Low Impact Development techniques that were evaluated during the development of the design for the project, the results of the evaluation of each and, for any techniques that were deemed infeasible, the reasoning for the determination.

4.5.2 Stormwater management system modeling in a form acceptable to the District.

4.5.3 A site plan showing:

- a Property lines and delineation of lands under ownership of the applicant.
- b Existing and proposed elevation contours.
- c Identification of existing and proposed normal, and ordinary high and 100-year water elevations onsite.

4.5.4 A stormwater management plan including, at a minimum:

- a Proposed and existing stormwater facilities' location, alignment and elevation.
- b Delineation of existing wetlands, marshes, shoreland and/or floodplain areas onsite or to which any portion of the project parcel drains, except that where a project will not alter or change the hydrology of a wetland,

the wetland need only be identified on the plan.

- c Geotechnical analysis including soil borings at all proposed stormwater management facility locations.
- d If infiltration of runoff is proposed, the District engineer may require submission of a phase I environmental site assessment and/or other documentation to facilitate analysis by the District of the suitability of soils for infiltration.
- e Construction plans and specifications for all proposed stormwater management facilities, including design details for outlet control structures.
- f Stormwater runoff volume and rate analyses for the 24-hour, 2-, 10- and 100-year critical events, existing and proposed conditions.
- g All hydrologic, water quality, and hydraulic computations completed to design the proposed stormwater management facilities.
- h Narrative addressing incorporation of retention BMPs.
- i Platting or easement documents showing sufficient drainage and ponding/flowage easements over hydrologic features such as floodplains, storm sewers, ponds, ditches, swales, wetlands and waterways.
- j Documentation as to the status of the project's National Pollutant Discharge Elimination System stormwater permit, if applicable.

4.5.5 An erosion control plan complying with District rule 5.0.

4.5.6 Upon completion of site work, a permittee must submit as-built drawings demonstrating that at the time of final stabilization, stormwater facilities conform to design specifications as approved by the District.

Appendix 4a: Low Floor Elevation Guidance.

See p. 51.

Appendix D

Rule 2.0 Floodplain and Drainage Alteration

(Excerpt from Nine Mile Creek Watershed District Rules)

2.0 Floodplain Management and Drainage Alterations

2.1 Policy

It is the policy of the Board of Managers to ensure the preservation of the natural function of floodplains as floodwater storage areas and to maintain no net loss of floodplain storage in order to accommodate 100-year flood storage volumes. The District will seek to maximize upstream storage and infiltration of floodwaters.

2.2 Regulation

A permit shall be required for:

2.2.1 Any alteration or filling of land below the District's 100-year flood elevation of Nine Mile Creek or another water body in the watershed.

2.2.2 Any alteration of surface water flows below the 100-year flood elevation by changing land contours, diverting or obstructing surface or channel flow, or creating a basin outlet.

2.3 Criteria for floodplain and drainage alterations

2.3.1 The low floor elevation of all new and reconstructed structures shall be constructed at a minimum of two feet above the 100-year flood elevation for the creek or water body. Within landlocked basins, the low floor elevation of all new and reconstructed structures shall be constructed at an elevation one foot above the surface overflow elevation or the calculated high water level from back-to-back 100-year, 24-hour storm events or the 100-year, 10-day snowmelt, whichever is higher. Low floor elevations must also comply with Stormwater Rule 4.3.2.

2.3.2 Placement of fill below the 100-year flood elevation is prohibited unless fully compensatory storage at the same elevation (+/- 1 foot) and within the floodplain of the same water body is provided. Creation of floodplain storage capacity to offset fill must occur within the original permit term. If offsetting storage capacity will be provided off site, it shall be created before any floodplain filling for the project will be allowed.

2.3.3 The District shall issue a permit to alter surface flows only if it finds that the alteration will not have an adverse impact on any upstream or downstream landowner and will not adversely affect flood risk, basin or channel stability, groundwater hydrology, stream base flow, water quality or aquatic or riparian habitat.

2.3.4 No structure may be placed, constructed or reconstructed and no surface may be paved within 50 feet of the centerline of any water course, except that this provision does not apply to:

a Bridges, culverts and other structures and associated impervious surface regulated under Rule 6.0;

b Trails 10 feet wide or less, designed primarily for nonmotorized use.

2.4 Required information and exhibits

The following exhibits shall accompany the permit application; one full-size set (22 inches by 34 inches), one set reduced to a maximum of 11 inches by 17 inches, and one set as electronic files in a format acceptable to the District:

2.4.1 Site plan showing property lines, delineation of the work area, existing elevation contours of the work area, ordinary high water level or normal water elevation and 100-year flood elevation. All elevations must be reduced to NGVD (1929 datum).

2.4.2 Grading plan showing any proposed elevation changes.

2.4.3 Preliminary plat of any proposed land development.

2.4.4 Determination by a licensed civil engineer or registered qualified hydrologist of the 100-year flood elevation for the parcel before and after the project.

2.4.5 Computation by a professional engineer of cut, fill and change in water storage capacity resulting from proposed grading.

2.4.6 Erosion-control plan.

2.4.7 Soil boring results, if requested by the District engineer.

2.4.8 Documentation that drainage and flowage easements over all land below the 100-year flood elevation have been conveyed to the municipality with jurisdiction and recorded. For public entities, this requirement may be satisfied by a written agreement executed with the District in lieu of a recorded document; the agreement shall state that if the land within the 100-year floodplain is conveyed, the public body shall require the buyer to comply with this subsection.

2.5 Exceptions

No floodplain and drainage permit from the District is required:

2.5.1 For construction or reconstruction of a single-family home, unless any portion of the parcel is

a Within 300 feet of the centerline of Nine Mile Creek;

b Within 500 feet of the ordinary high water level of any other water body; or

c Below the 100-year flood elevation.

2.5.2 If all of the following conditions exist:

a The 100-year flood elevation of a waterbasin is entirely within a municipality;

b the waterbasin is landlocked;

c the municipality has adopted a floodplain ordinance regulating floodplain encroachment; and

d the proposed project is entirely within the drainage area of the waterbasin.

Appendix E

August 15, 2017 Memo to Technical Stakeholder Group:

Summary of NMCWD stormwater management rules and alternative approaches within Pentagon Park/Border Basin study area

Technical Memorandum

DRAFT

To: Technical Stakeholder Group
From: Janna Kieffer
Subject: Summary of NMCWD stormwater management rules and alternative approaches within Pentagon Park/Border Basin study area
Date: August 15, 2017
Project: Pentagon Park/Border Basin Regional Stormwater Management Plan

As part of the Pentagon Park/Border Basin Regional Stormwater Management Plan, we are developing regional redevelopment design guidelines to help identify specific stormwater management options for future redevelopment within the Pentagon Park/Border Basin study area. The design guidelines should identify and describe stormwater management options for the study area that meet the existing Nine Mile Creek Watershed District (NMCWD or District) stormwater management rules or an alternative stormwater-management framework that would be submitted for consideration by the NMCWD managers as part of the Pentagon Park/Border Basin stormwater management plan.[1] The purpose of this memo is to provide a technical summary of the District's existing rules and explore preliminary ideas regarding alternative stormwater management within the study area. The memo is structured in the following format:

Section 1.0 Summary of current NMCWD stormwater management criteria, including quantification of benefits from the volume retention, rate control, and water quality treatment criteria

Section 2.0 Discussion of key challenges to implementing BMPs to meet the NMCWD stormwater management criteria in the Pentagon Park/Border Basin study area, including concerns regarding the feasibility and effectiveness of volume retention practices on sites with limited infiltration capacity and onsite flood storage requirements within the study area.

Section 3.0 Analysis of potential alternative stormwater management approaches within the study area, including:

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1 The NMCWD rules do not presently provide a mechanism whereby a regional stormwater-management plan can take the place of compliance with NMCWD rules for individual properties. (The NMCWD Stormwater Management Rule does allow regional treatment to meet water quality standards.) Identification of a proper and viable legal basis for approval of a regional or alternative approach would be necessary for such an approach to become pragmatically viable. Identification of such a framework is beyond the scope of the memo.

a. Regional or onsite stormwater reuse via irrigation of green space to meet the NMCWD volume retention and water quality criteria,

b. Extended detention rate control as an alternative to volume retention in the Pentagon Park/Border Basin study area

c. Regional water quality treatment BMPs to meet NMCWD water quality criteria.

Section 4.0 Conclusions and recommendations

1.0 NMCWD Stormwater Management Criteria

The NMCWD's stormwater management criteria include three primary components: runoff volume retention, runoff rate control, and water quality treatment. The criteria are summarized below:

Runoff Volume Retention: Provide for onsite retention of one inch of runoff from all impervious surface of the parcel. If site constraints prevent full compliance with the retention requirement, the NMCWD's volume banking system can be utilized.

Runoff Rate Control: Limit peak runoff flow rates to that from existing conditions for the 2-, 10- and 100-year storm events for all points where stormwater discharge leaves the parcel.

Water Quality Treatment: Provide for all runoff to be treated to at least 60 percent annual removal efficiency for total phosphorus and 90 percent annual removal efficiency for total suspended solids. Pollutant removal efficiencies can be achieved through onsite or offsite detention/retention designed to treat the 2.5-inch storm event (NURP criteria) or through use of alternative practices providing equivalent or better treatment. The onsite retention of runoff may be included in demonstrating compliance with the total suspended solids and phosphorus removal requirements.

If site constraints prevent full compliance with the runoff volume retention criteria, permit applicants must provide for onsite retention of ½-inch of runoff from all impervious surface of the parcel, and then utilize credits from the NMCWD's volume bank to fulfill the remainder of the one-inch retention requirement. If no qualifying credits are available, an applicant may contribute funds to the District's Stormwater Facilities Fund to cover the cost of implementing offsetting volume retention projects elsewhere in the watershed.

1.1 Benefits of NMCWD Stormwater Management Criteria

The NMCWD's stormwater management criteria provide multiple benefits, including reduced stormwater runoff volume, reduced peak runoff rates, and reduced pollutant loading. The benefits to downstream waterbodies include reduced erosion in streams, less pollutants reaching downstream lakes and streams, and improved downstream water quality. The following sections summarize the benefits of the NMCWD stormwater management criteria with respect to runoff volume, runoff rate control, and pollutant removal, based on modeling analyses conducted as part of the Minnesota Pollution Control Agency (MPCA) Minimal Impact Design Standards (MIDS) project.

1.1.1 Volume Retention

Developed sites without stormwater management practices, similar to the existing conditions within the Pentagon Park/Border Basin study area, produce significantly more stormwater runoff volume as compared with undeveloped sites. As part of the MIDS project, the MPCA evaluated the increase in stormwater runoff from developed sites with imperviousness ranging from 20% to 80%, in comparison with runoff from "native", undeveloped site conditions. Figure 1 shows that the simulated average annual runoff from a hypothetical 10-acre developed site is significantly higher than the runoff generated from the same site under native "meadow" conditions. Depending on the soil type, the average annual runoff from an 80% impervious developed site (similar to development within the Pentagon Park study area) is about three to five times that of native undeveloped conditions.

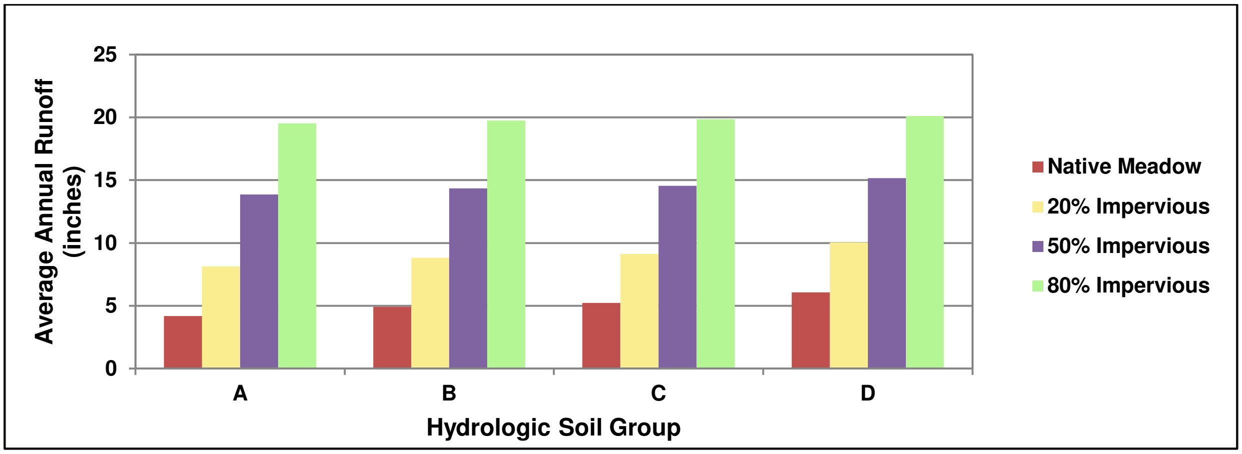

Figure 1. Comparison of average annual stormwater runoff depth over a 10-acre site for native and developed conditions with no site BMPs (Barr, 2011).

"1-inch" Volume Retention Criteria

Implementation of BMPs to meet the NMCWD's "1-inch" retention requirement significantly reduces the stormwater runoff volume from developed sites. As part of the MIDS project, MPCA evaluated the effectiveness of several stormwater volume retention criteria in reducing site runoff, including the NMCWD's 1-inch retention requirement. Figure 2 compares the average annual runoff from a hypothetical 10-acre site under native conditions and developed conditions with and without implementation of BMPs meeting the 1-inch volume retention criteria. As shown in the figure, implementation of BMPs to meet the 1-inch volume retention criteria results in average annual runoff that is similar to runoff from native conditions. Note that Figure 2 summarizes runoff rates from a hypothetical 10-acre site with Hydrologic Soil Group (HSG) C soils (limited infiltration capacity). While much of the Pentagon Park/Border Basin study area is comprised of HSG D soils (e.g., clay soils with poor infiltration capacity), the modeling analysis conducted as part of the MIDS project did not include evaluation of volume retention criteria on D soils, due to the poor infiltration capacity of D soils and the unlikelihood of implementing BMPs to meet equivalent volume retention criteria on these sites.

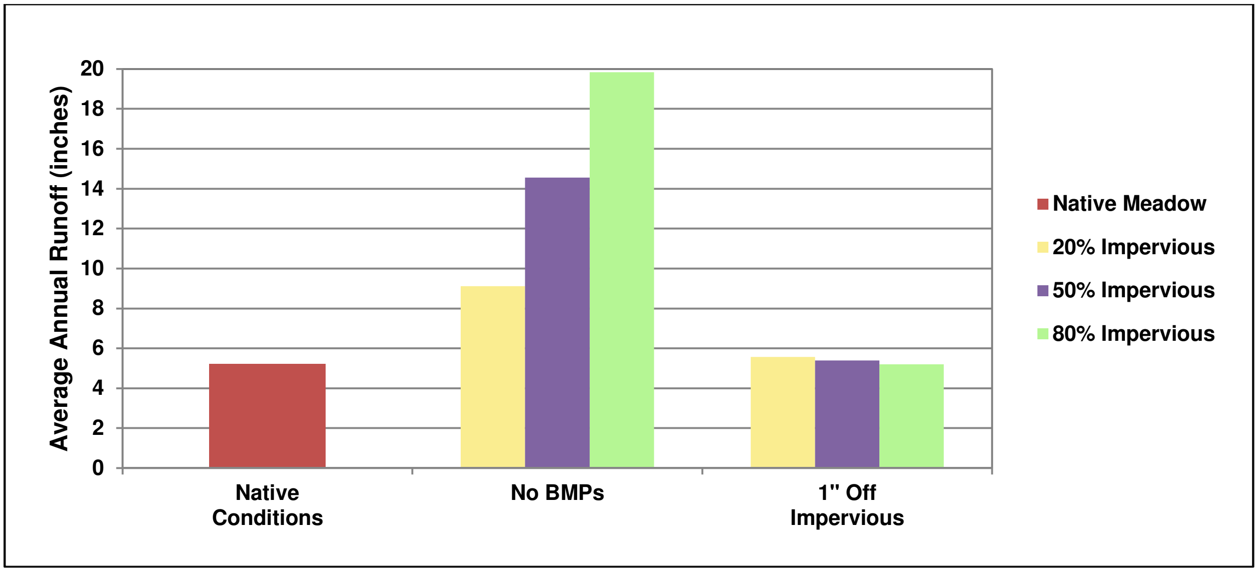

Figure 2 Comparison of average annual stormwater runoff depth over a 10-acre site with Hydrologic Soil Group C soils for native conditions and developed conditions with and without "1-inch" retention requirement (Barr, 2011)

"½-inch" Volume Retention

Site constraints that limit or prohibit infiltration, such as clay soils or contaminated soils, can greatly reduce the feasibility of achieving volume retention criteria on development sites. Under the NMCWD stormwater rules, if site constraints prevent full compliance with the runoff volume retention criteria, permit applicants must provide for onsite retention of ½-inch of runoff from impervious surfaces of the parcel, and then purchase credits through the NMCWD's volume banking program to fulfill the remainder of the 1-inch retention requirement. If credits are not available, an applicant may contribute funds to the District's Stormwater Facilities Fund to cover the cost of implementing offsetting volume retention projects elsewhere in the watershed.

While providing only ½-inch of volume retention allows an increase in the amount of stormwater runoff as compared to implementation of BMPs achieving the 1-inch retention criteria, compliance with the ½-inch criteria still results in a significant reduction in annual runoff from developed sites. Figure 3 shows the estimated average annual runoff volume reduction achieved through a range of volume retention criteria on HSG C soils, based on P8 modeling conducted as part of the MIDS project. As shown in the figure, the ½-inch volume retention criteria results in an estimated average annual runoff volume reduction of approximately 67%, as compared to 88% runoff reduction from the 1-inch retention criteria. Note that Figure 3 summarizes runoff volume retention from a hypothetical site with HSG C soils. The modeling analysis conducted as part of the MIDS project did not include evaluation of volume retention criteria on D soils. If desired by this stakeholder group, we can conduct a similar modeling analysis to quantify the effectiveness of implementation of BMPs to achieve volume retention criteria on D soils.

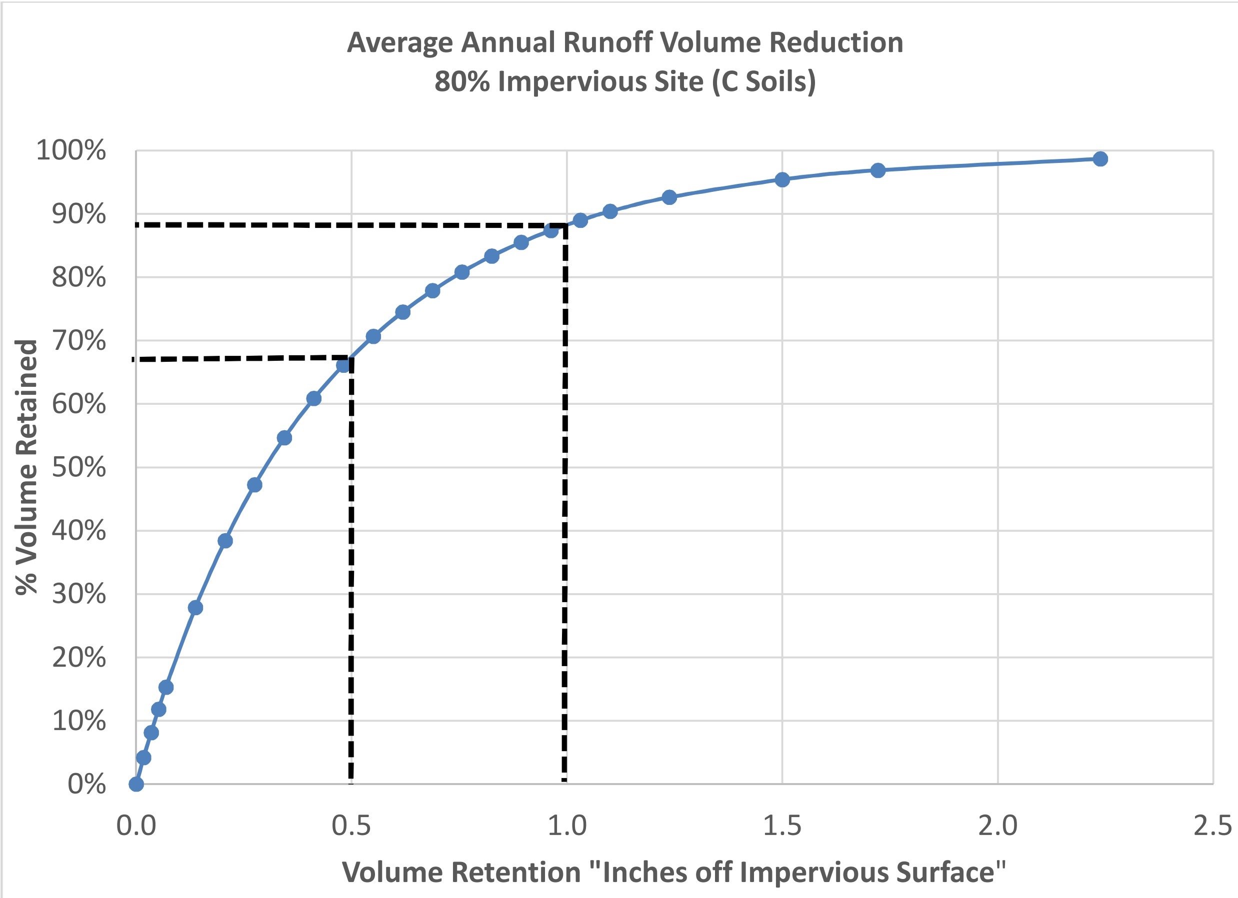

Figure 3. Average annual runoff volume reduction for a range of volume retention "inches off impervious surface" criteria.

1.1.2 Water Quality

In addition to volume reduction, stormwater volume retention BMPs provide significant pollutant removal benefits. While strongly correlated with the amount of runoff captured and infiltrated, the overall pollutant removal efficiency is also dependent on other factors such as the varying concentration of pollutants in runoff (such as the "first flush effect") and pollutant removal that occurs through sedimentation or other mechanisms.

Implementation of BMPs meeting the 1-inch volume retention criteria significantly reduces the loading of total phosphorus and suspended sediment from developed sites. A long-term (50 year) P8 modeling analysis conducted as part of the MIDS project, indicated that implementing BMPs that achieve the 1-inch volume retention criteria on 80% impervious sites with hydrologic soil group B soils results in average annual phosphorus and total suspended solids removals of 95% and 99%, respectively (Barr, 2011). This performance well exceeds the NMCWD's water quality criteria for all runoff to be treated to at least 60 percent annual removal efficiency for total phosphorus and 90 percent annual removal efficiency for total suspended solids.

The average annual runoff volume captured onsite and associated pollutant removal varies depending on the volume retention criteria and resulting BMP volume. Figure 4, based on P8 modeling conducted as part of the MPCA's MIDS project, shows how the total phosphorus removal varies for an 80% impervious site with B soils, depending on the volume retention criteria. The modeling analysis showed that retaining one inch of runoff from an 80% impervious site with B soils results in 95% total phosphorus removal, whereas retaining one-half inch of runoff results in 83% total phosphorus removal. While the MIDS analysis did not include evaluation for volume retention on sites with D soils, it is expected that the phosphorus removal effectiveness would be similar to that of sites with B soils. If desired by this stakeholder group, we can conduct a similar modeling analysis to quantify the phosphorus removal effectiveness of volume retention criteria on D soils.

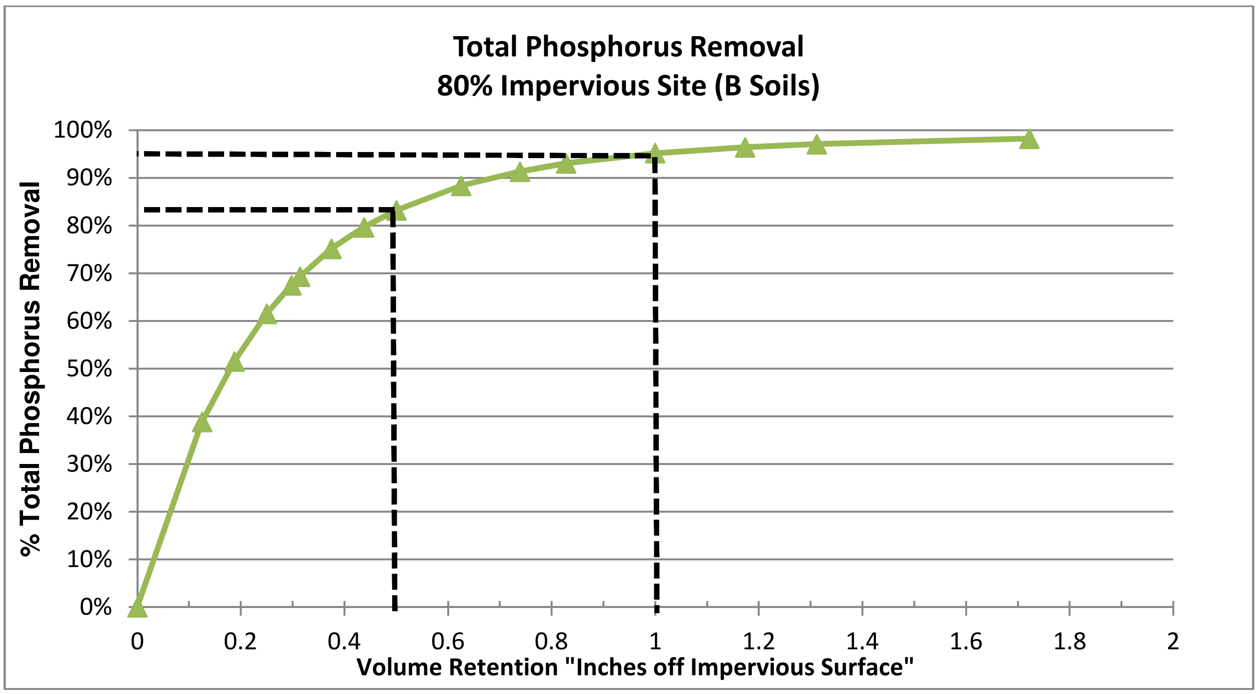

Figure 4. Total phosphorus removal from compliance with a range of volume retention criteria for an 80% impervious site on B soils

1.1.3 Runoff Rate Control

The current NMCWD stormwater rules require that peak runoff flow rates be limited to that from existing conditions for the 2-, 10- and 100-year storm events for all points where stormwater discharge leaves the site. For undeveloped sites, the NMCWD's rate control criteria will limit flow rates to those similar to a natural or "native" condition. For redevelopment areas such as Pentagon Park, where development occurred prior to the requirement for rate control practices, the NMCWD rate control rules do not require reductions from existing peak flow rates.

While the NMCWD rate control criteria do not require peak flows be reduced beyond existing levels, the stormwater volume retention criteria provide some rate control benefits. The extent of the rate control benefit is primarily dependent on the volume of the BMP; the larger the BMP volume, the more frequently runoff rate is restricted to levels below natural conditions. A 35-year continuous modeling analysis conducted as part of the MIDS project concluded that implementation of BMPs that achieve the 1-inch volume retention criteria generally reduces the 1-year, 24-hour peak flow rates from a site to less than or equal to that of native conditions for most scenarios (Barr, 2011).

2.0 Stormwater Management Challenges in Pentagon Park/Border Basin Study Area

2.1 Volume Retention Challenges

2.1.1 Site Constraints

While the NMCWD volume retention criteria can achieve significant reductions in stormwater runoff from developed sites, implementing BMPs within the Pentagon Park/Border Basin study area will be challenging due to site constraints such as soils with low permeability and shallow groundwater.

Soils with low infiltration capacity, typically categorized as Hydrologic Soil Group D, are a site constraint that can impact the feasibility of implementing infiltration-based BMPS. The Minnesota Construction Stormwater General Permit indicates that infiltration-based BMPs must drain within 48 hours. Meeting this drawdown timeframe on D soils with very slow infiltration (0.06 inches/hour per the Minnesota Stormwater Manual) requires that the depth of the infiltration BMPs be very shallow (approximately 3 inches). The shallow nature of infiltration BMPs on D soils often results in BMPs with a large surface footprint, in comparison with BMPs on other soil types. Figure 5 shows the footprint of an infiltration-based BMP, in terms of percentage of development site area, for an 80% impervious site using the 1-inch and ½-inch volume retention criteria, assuming a 48-hour drawdown time. As shown in Figure 5, implementation of BMPs to meet the volume retention criteria on A, B, and C soils requires much less space than on D soils. For example, meeting the 1-inch criteria via infiltration on A, B, and C soils requires a BMP footprint spanning 2%-8% of the site, versus 28% of a site with D soils, which is not feasible given the 80% impervious surface coverage of the site. While compliance with the ½-inch volume retention criteria via infiltration techniques on D soils requires 14% of the site area, less than the available 20%, the ½-inch criteria still utilizes most of the pervious surface available on the site for stormwater management purposes, requiring a permit applicant to explore non-infiltration volume-reduction techniques for compliance (e.g., reuse systems).

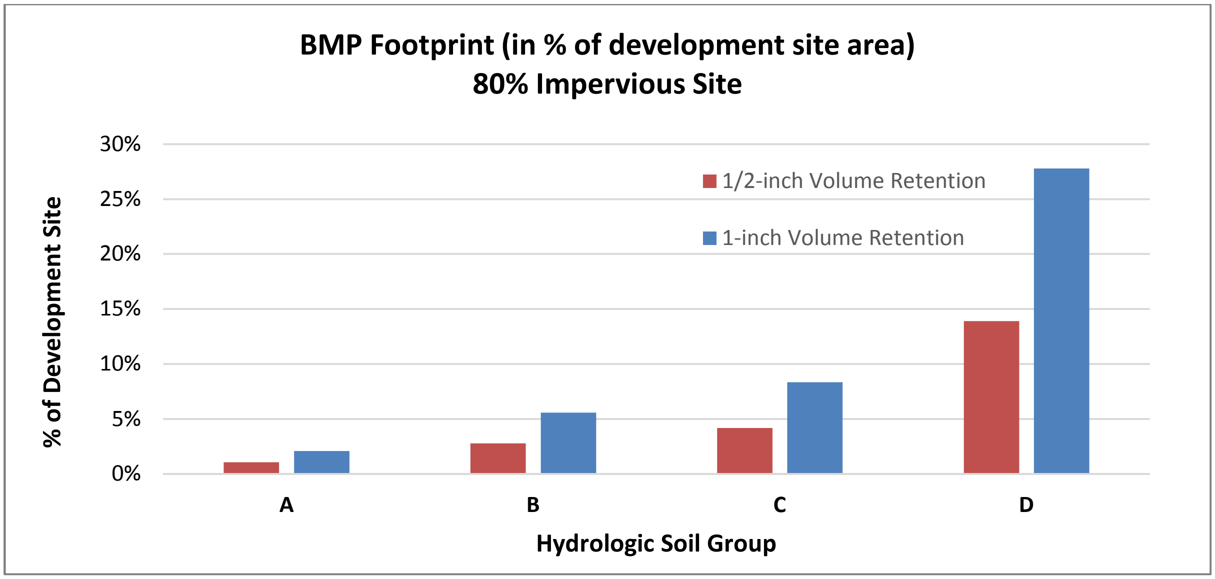

Figure 5. Footprint of infiltration-based BMPs, in terms of percentage of development site area, for an 80% impervious site using the 1-inch and ½-inch volume retention criteria.

The presence of shallow groundwater is another site constraint that impacts feasibility of infiltration BMPs within the Pentagon Park/Border Basin study area. The Minnesota Stormwater Manual defines shallow groundwater as a condition where the seasonal high groundwater table, or saturated soil, is less than 3 feet from the land surface. The Minnesota NPDES Construction General Permit (CGP) requires 3 feet of separation from the bottom of an infiltration practice to the seasonal high water table. Infiltration within the study area may be challenging given the high groundwater table within the area.

2.1.2 BMP Effectiveness

In addition to the low-permeability soils and shallow groundwater conditions making infiltration a challenge within the Pentagon Park/Border Basin study area, the high silt and clay content of soils within the study area will likely cause infiltration BMPs to plug or have significantly reduced infiltration rates over time. The large BMP footprint required for infiltration-based BMPs on D soils increases the likelihood that property owners will install underground systems as redevelopment occurs within the study area It can be difficult to determine if the underground systems are functioning properly or if maintainenace or repair is needed. The Minnesota NPDES CGP prohibits infiltration when an infiltration system will be constructed in areas of predominately Hydrologic Soil Group D soils unless allowed by a local unit of government with a current MS4 permit. (MPCA has not identified NMCWD as a mandatory MS4 owner or operator; the cities of Bloomington and Edina both operate MS4s.)

The presence of shallow groundwater can also reduce the pollutant removal effectiveness of infiltration BMPs. Some pollutants such as bacteria are removed in the unsaturated zone beneath the bottom of the BMP via biological activity, chemical degradation, adsorption of pollutants to soil, and plant uptake. The Minnesota Stormwater Manual indicates that shallow groundwater reduces the depth of the unsaturated soil available for treatment, leading to an increased likelihood of groundwater contamination. The manual also indicates that non-infiltration BMPs, such as lined filtration or settling practices, should be considered in areas with shallow groundwater.

2.1.3 Onsite Flood Storage Requirements

Flood storage will pose an additional site design challenge for many of the property owners within the Pentagon Park/Border Basin study area. Much of the Pentagon Park/Border Basin study area is low-lying; stormwater modeling results indicate that portions of the study area become inundated in the 1% annual chance flood event, based on updated precipitation frequency estimates (published as Atlas 14) developed by the National Oceanic and Atmospheric Administration (NOAA). Several flood reduction scenarios have been evaluated as part of this study. While preliminary results have shown some potential small reductions in flood elevations, properties within the study area would continue to be periodically inundated.

As redevelopment occurs within the Pentagon Park/Border Basin study area, property owners or developers will be required to maintain existing flood storage volumes on their sites to prevent transfer of flood risk to neighboring properties. Currently, the City of Edina manages for no net increase in flood risk to structures or neighboring/downstream properties in the 1% probability ("100-year") event. The City of Bloomington manages to a "net zero fill" standard in the 1% probability event.

Under existing conditions, flood storage occurs on the surface, primarily in parking lots, roadways, and green space. As redevelopment occurs, equivalent flood storage can be provided on the ground surface or underground, depending on site layout and available space.

3.0 Analysis of Alternative Stormwater Management Approaches

Given the challenges discussed above with implementing infiltration practices on redevelopment sites within the Pentagon Park/Border Basin study area, Barr analyzed alternative stormwater management approaches to comply with the current NMCWD retention standard or achieve similar benefits. The alternative stormwater management approaches included:

- Stormwater capture and reuse through irrigation of onsite or regional green space to comply with NMCWD's volume retention and water quality criteria,
- Extended detention rate control as an alternative to volume retention in the Pentagon Park/Border Basin study area, and
- Regional water quality treatment to meet NMCWD water quality criteria, if extended detention system are "dry" and do not provide runoff retention or water quality benefits.

3.1 Stormwater Reuse- Irrigation

Stormwater capture and reuse via irrigation was evaluated as a potential onsite or regional option to meet the NMCWD's volume retention and water quality criteria. The effectiveness of irrigation as a stormwater reuse alternative is based on several key factors, including the amount of impervious surface tributary to the storage system, the rate and duration of irrigation, the storage volume capacity, and the amount of available land for irrigation.

The Stormwater Reuse Credit Calculator developed by Barr for the Mississippi Water Management Organization was used to estimate the potential volume retention/reuse benefits from capturing and reusing stormwater runoff within the Pentagon Park/Border Basin study area. Several storage and irrigation scenarios were evaluated based on a hypothetical 10-acre redevelopment site with D soils (the reuse calculator was modified slightly to account for sites with D soils). These scenarios are described below:

Tributary Impervious Surface- the redevelopment site was assumed to be 80% impervious, which indicates the maximum amount of "onsite" green space would be 2 acres.

Irrigation Rate- 1 inch/week

Irrigation Duration- April through October

Storage Volume Capacity- the evaluated scenarios included storage capacity equivalent to 1 inch, 1.5 inch, and 2.5 inches of runoff from the impervious surfaces of the hypothetical redevelopment site. Runoff could be stored in underground or above-ground tanks or regional ponding basins.

Available Land for Irrigation- the evaluated scenarios included land available for irrigation ranging from 2 acres (the maximum amount of green space available on a hypothetical 10-acre, 80% impervious site) to 20 acres (the approximate amount of available green space within the proposed Fred Richards Park, based on Design Concept A (March 2, 2017).

Figure 6 shows the percent average annual runoff volume retained and reused for the evaluated storage capacity and irrigation area scenarios. Irrigation of 2 acres (20% of redevelopment site) achieves 24% to 30% annual volume retention, depending on the amount of runoff storage capacity, which is well below the annual volume retention achieved through the NMCWD's 1-inch or ½-inch volume retention criteria (see Section 1.1). With runoff storage volume capacity equivalent to 1-inch off of the impervious surfaces, the average annual volume retention ranges from 24% to 58%, depending on the amount of land available for irrigation. Runoff storage capacity equivalent to 1.5 inches off of the impervious surfaces results in average annual volume retention ranging from 26% to 66%, depending on the amount of land for irrigation. With runoff storage capacity of 2.5-inches off of the impervious surfaces, the average annual volume retention through irrigation ranges from 30% to 75%.

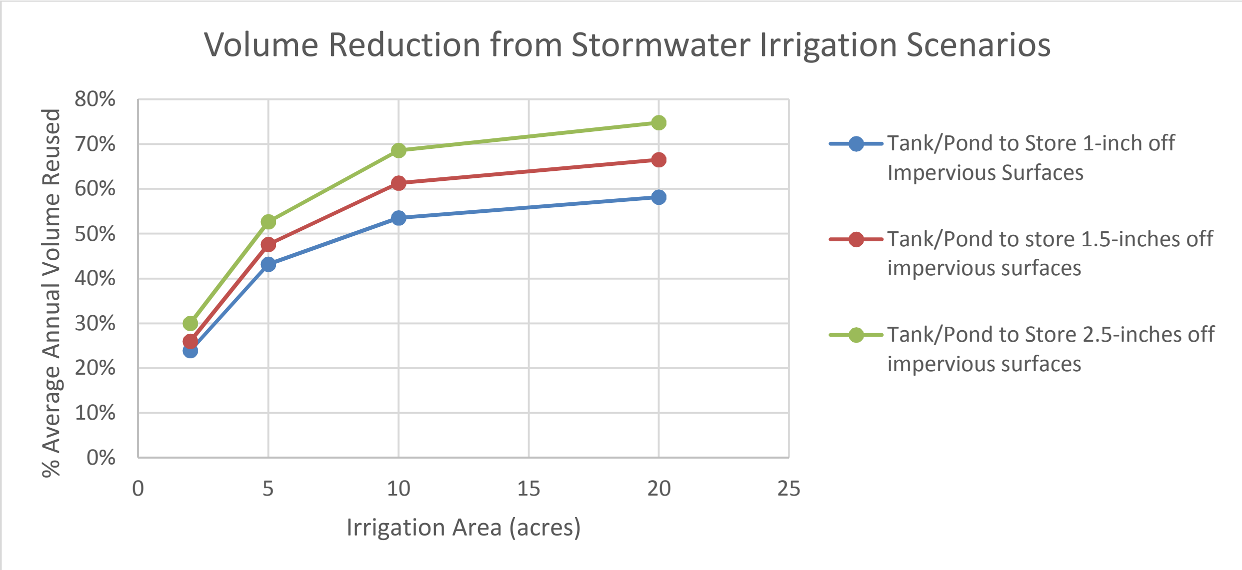

Figure 6. Volume retention effectiveness of stormwater irrigation from a 10-acre, 80% impervious site for a range of storage capacities and size of irrigation areas

Results of the analysis indicate that redevelopment sites would need to capture and store at least 1.5-inches of runoff from the impervious surfaces and have at least 15-20 acres (1.5- to 2 times the redevelopment site size) of available land to irrigate or capture and store around 2.5-inches of runoff from the impervious surfaces and have around 10 acres of land (or 1 times the redevelopment site size) for irrigation to achieve annual volume retention that is similar to that achieved by the NMCWD ½-inch volume retention criteria.

3.2 Extended Detention In Lieu of Volume Retention

Extended detention is a stormwater management technique that was evaluated as an alternative approach to volume retention within the Pentagon Park/Border Basin study area. An extended detention system, typically in the form of a pond or underground storage structure, temporarily detains a portion of the stormwater runoff and releases the runoff slowly, resulting in an extended drawdown of the stormwater volume from high frequency storms. While extended detention systems do not permanently retain stormwater volume, the reduced discharge rate from a site can help reduce erosion in downstream waterbodies. Extended detention of runoff also provides flood control.

Extended detention systems are typically designed with multi-stage outlet structures. The lowest stage is designed to temporarily store and slowly release runoff from smaller, more frequent storm events. Higher stages of the outlet structure are often designed to meet rate control criteria (e.g., not exceeding prescribed peak discharge rates for the 10-, and 100-year events).

3.2.1 Runoff Rate Control

A hydrologic and hydraulic modeling analysis was conducted to evaluate the use of extended detention in lieu of volume retention within the Pentagon Park/Border Basin study area. An XP-SWMM model was developed using historical rainfall records from a 35-year time period to compare runoff rates from a hypothetical redevelopment site under several stormwater management scenarios, including two extended detention scenarios. The hypothetical redevelopment site was 10-acres, with 80% imperviousness and D soils. The modeled stormwater management scenarios are described below:

Native Conditions- Undeveloped site with D soils and native vegetation (meadow)

Developed Site, No BMPs- Developed site (80% impervious, D soils) with no stormwater BMPs

1-inch Volume Retention- Developed site (80% impervious, D soils) with implementation of BMPs that meet the 1-inch volume retention criteria

½-inch Volume Retention- Developed site (80% impervious, D soils) with implementation of BMPs that meet the ½-inch volume retention criteria

Rate Control Only (2-, 10-, and 100-year)- Developed site (80% impervious, D soils) with extended detention to limit peak runoff rates to that from undeveloped, native (meadow) conditions for the 2-, 10-, and 100-year storm events. The lowest stage was controlled by an 18-inch orifice.

Highly-restrictive Extended Detention- Developed site (80% impervious, D soils) with highly-restrictive extended detention to significantly reduce flows from up to the 2-year, 24-hour storm (lowest stage controlled by a 6-inch orifice), then limit peak runoff rates to at or below those from undeveloped, native (meadow) conditions for the 10- and 100-year storm events (10-year peak flow was approximately half of the peak flow under native conditions).

3.2.1.1 Event-based Analysis

Four storm events were evaluated to help assess the effects of extended detention on site runoff flowrates, in comparison with implementation of volume retention BMPs. The four storm events, summarized in Table 1, represent a range of rainfall depths, durations, and intensities. The low- and moderate-intensity storms were selected because the rainfall depth is similar to the NMCWD's current 1-inch volume retention criteria. Note that 1.2 inches of the 1.7-inch, moderate intensity rainfall event occurred within the first 1.5 hours of the storm.

Table 1. Storm events evaluated to compare the effects of extended detention on site runoff rates, in comparison with implementation of volume retention BMPs.

Storm Event	Rainfall Depth (inches)	Rainfall Duration (hours)	Peak Intensity (inches/hour)
Low-intensity, 1.2 inches	1.2	4	0.8
Moderate-intensity, 1.1 inches	1.1	0.75	2.4
Moderate-intensity, 1.7 inches[1]	1.7	6	2.0
High-intensity, 2.5 inches	2.5	2	3.6
[1] While the rainfall event totaled 1.7 inches, 1.2 inches occurred within the first 1.5 hours			

Comparisons of the site runoff rates from the modeled stormwater management scenarios for the four storm events are shown in Figures 7 through 10. The figures help depict the differences in peak flows, as well as the attenuation and duration of flow under the various stormwater management scenarios. The peak flows for each rainfall event and stormwater management scenario are summarized in Table 2.

Table 2. Comparison of peak flowrates from various stormwater management scenarios.

Rainfall Event	Developed Site, No BMPs	Native Conditions	1-inch Volume Retention	½-inch Volume Retention	Rate Control Only (2-, 10-, and 100-year)	Highly-restrictive Extended Detention
Low-intensity, 1.2-inch	6.6	0.2	0.0	3.0	1.9	0.7
Medium-intensity, 1.1-inch	18.0	2.5	0.6	5.2	2.8	0.8
Medium-intensity 1.7-inch	16.0	2.2	1.0	5.4	3.0	0.9
High-intensity, 2.5-inch	34.0	20.0	12.0	25.0	12.0	4.7

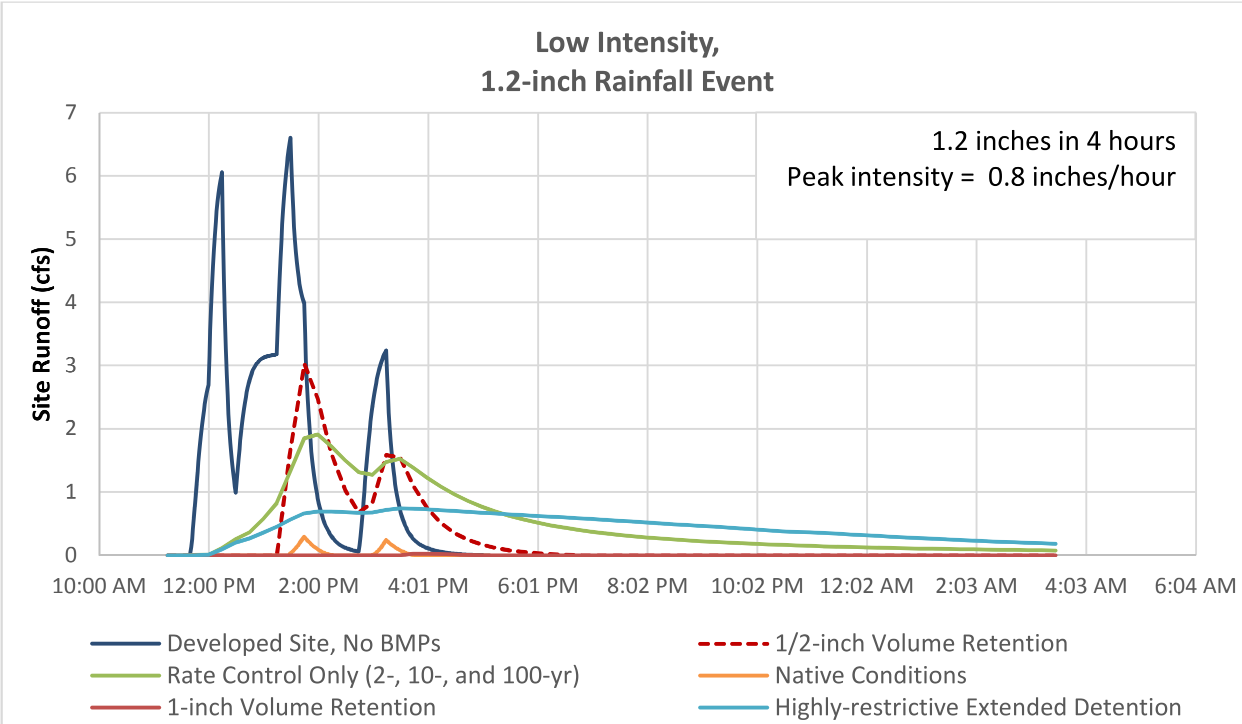

Figure 7. Comparison of site runoff rates for a low intensity, 1.2-inch rainfall event.

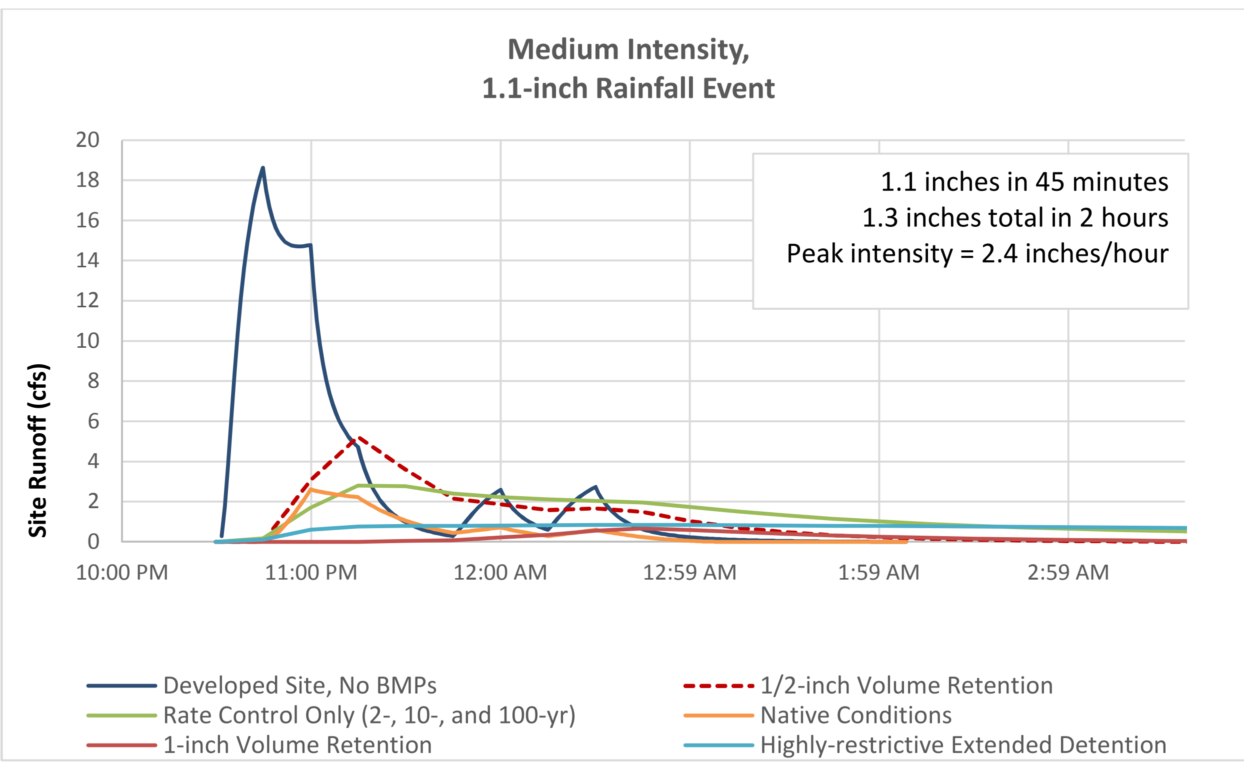

Figure 8. Comparison of site runoff rates for a medium-intensity, 1.1-inch rainfall event.

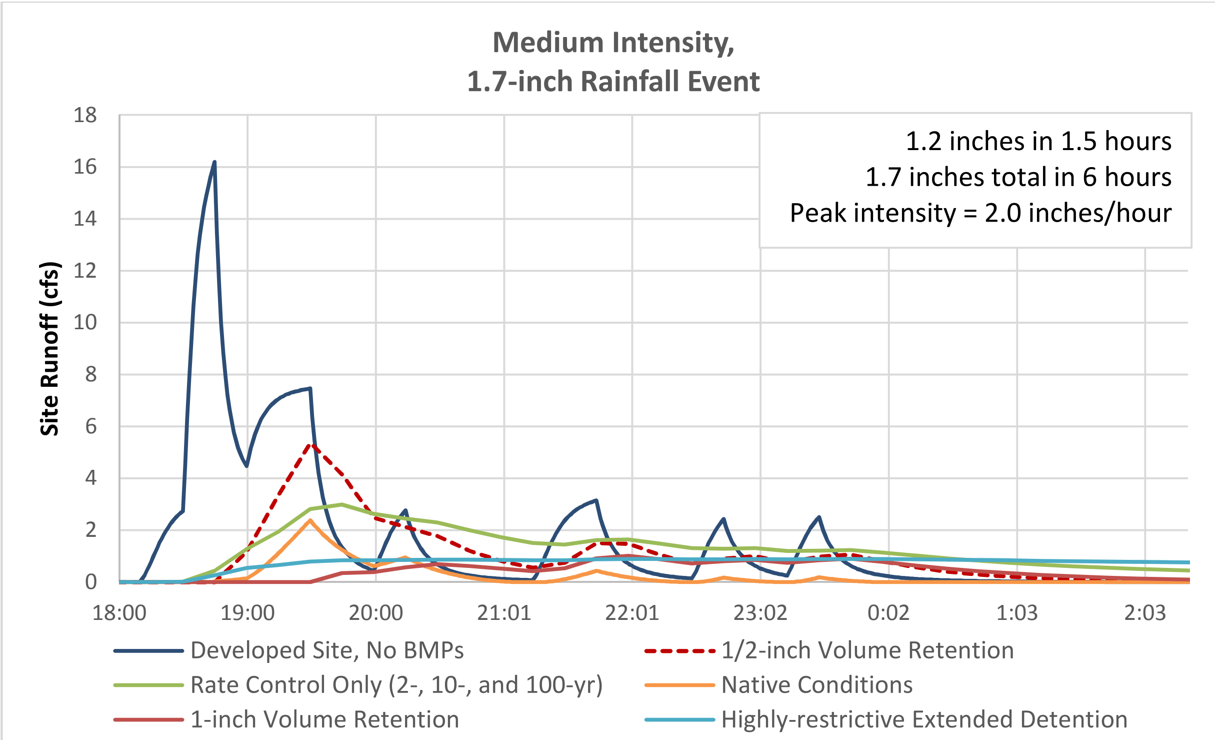

Figure 9. Comparison of site runoff rates for a medium-intensity, 1.7-inch rainfall event.

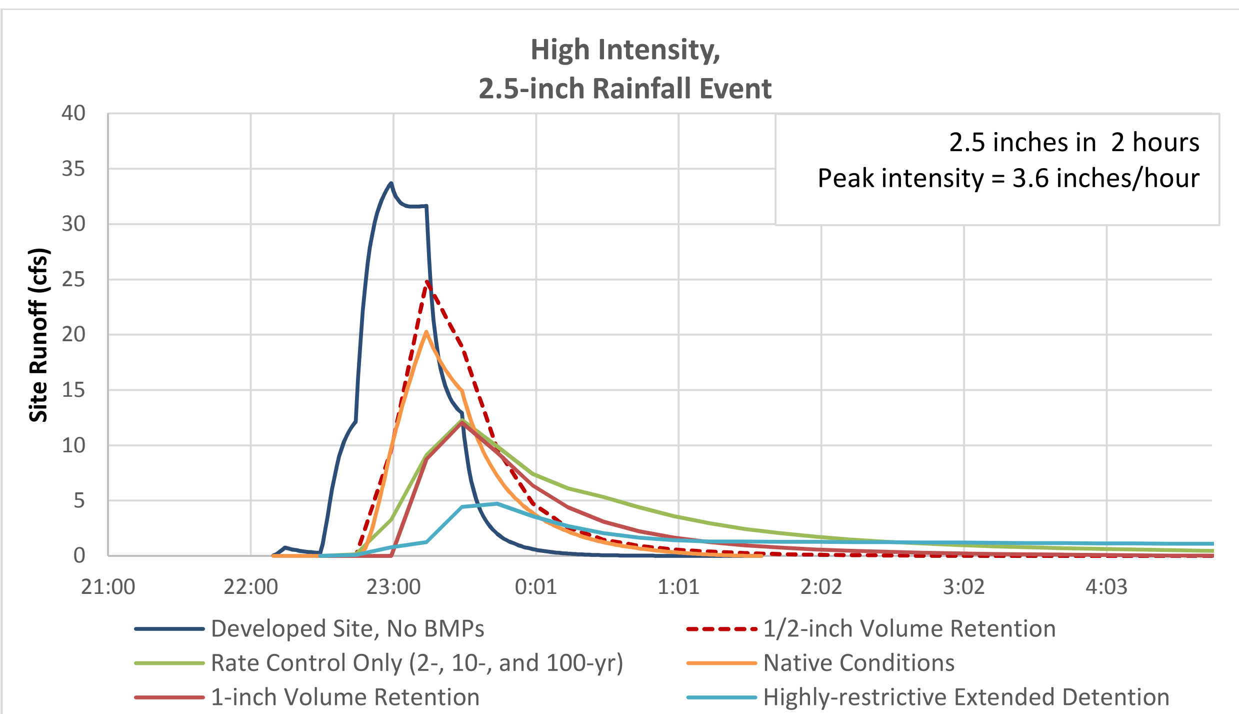

Figure 10. Comparison of site runoff rates for a high-intensity, 2.5-inch rainfall event

Key results and conclusions of the event-based analysis are summarized below:

- All stormwater management scenarios significantly reduce the peak runoff rate from the redevelopment site, as compared with the developed site with no BMPs scenario (which mimics current conditions throughout much of the Pentagon Park/Border Basin study area, with exception of Fred Richards Park).
- The peak flows from the Rate Control Only (2-, 10-, and 100-year) extended detention scenario were well below the peak flows from the ½-inch Volume Retention scenario, ranging from approximately one-third to one-half lower, for all four rainfall events evaluated.
- The peak flows from the Rate Control Only extended detention scenario were higher than the peak flows from the 1-inch Volume Retention Scenario for all four rainfall events, with the exception of the high-intensity, 2.5-inch rainfall event, where peak flows of the two scenarios were very similar.
- Peak flows from the Rate Control Only scenario were similar to the peak flows from the Native Conditions scenario for the moderate-intensity events. For the low-intensity event, the peak flow from the Rate Control Only scenario well exceeded that of the Native Conditions scenario; runoff flow rates and volume from the native, undisturbed site were very low due to the low-intensity nature of the rainfall event and the infiltration capacity of the soils on the undeveloped site. For the high-intensity, 2.5-inch event, the peak flowrate from the Rate Control Only scenario was well below that of the Native Conditions scenario and the same as the peak flow from the 1-inch Volume Retention scenario.
- The Highly-restrictive Extended Detention scenario results in peak flows that are significantly lower than native conditions for the medium- and high-intensity rainfall events and similar to the peak flows from the 1-inch Volume Retention scenario for the medium-intensity events.
- For the high-intensity rainfall event, the Highly-restrictive Extended Detention scenario results in a peak flow that is significantly lower (approximately 50%) than the peak flow under the 1-inch Volume Retention scenario.
- Both extended detention scenarios result in longer durations of flow, as compared with the other stormwater management scenarios. This is evident by comparing the falling limb of the flow hydrographs.

The analysis showed that extended detention can effectively reduce runoff rates from developed sites to those similar to native, undeveloped conditions for medium- and high-intensity rainfall events. By providing rate control to limit peak runoff rates to that from undeveloped, native conditions for the 2-, 10-, and 100-year storm events, runoff from redevelopment sites can be reduced to flowrates well below those achieved through implementation of BMPs that achieve the ½-inch volume retention criteria. By providing highly-restrictive extended detention, not only are flows attenuated for the more frequent storms, but peak flow rates are significantly lower than flows from native conditions and similar or lower than peak flows achieved through implementation of BMPs that meet the 1-inch volume retention criteria for medium- and high-intensity storms. The negative side of the highly-restricted extended detention scenario is that the falling limb of the flow hydrograph is significantly extended in duration, which may be problematic if the attenuated runoff is stored too long, and there is not sufficient capacity to store the next rainfall event.

3.2.1.2 Flow Duration Curves

Flow duration curves were also used to compare stormwater runoff rates under the various stormwater management scenarios. Flow duration curves plot the percentage of time that flows exceed a given flow rate. Figure 11 compares the flow duration curves for the six stormwater management scenarios, including native conditions, fully developed with no BMPs, two volume retention scenarios (1/2-inch and 1-inch), and two extended detention scenarios (rate control only and highly-restricted). Figure 11 shows that for a given flow rate, a developed site without BMPs exceeds that flow rate more frequently than under native conditions. For example, runoff from a developed site without BMPs is equal to or greater than 0.1 cfs/acre approximately 1% of the 35 years modeled, whereas runoff from a native conditions site is equal to or greater than 0.1 cfs/acre only approximately 0.1% of the time. As shown in Figure 11, implementation of volume retention or extended detention stormwater management scenarios shifts the flow duration curves toward that of native conditions. The flow exceedance durations for the extended detention scenarios are less than those of native conditions for all flowrates greater than 0.001 cfs/acre, indicating that extended detention is effective in reducing flow rates to at or below native conditions flow rates.

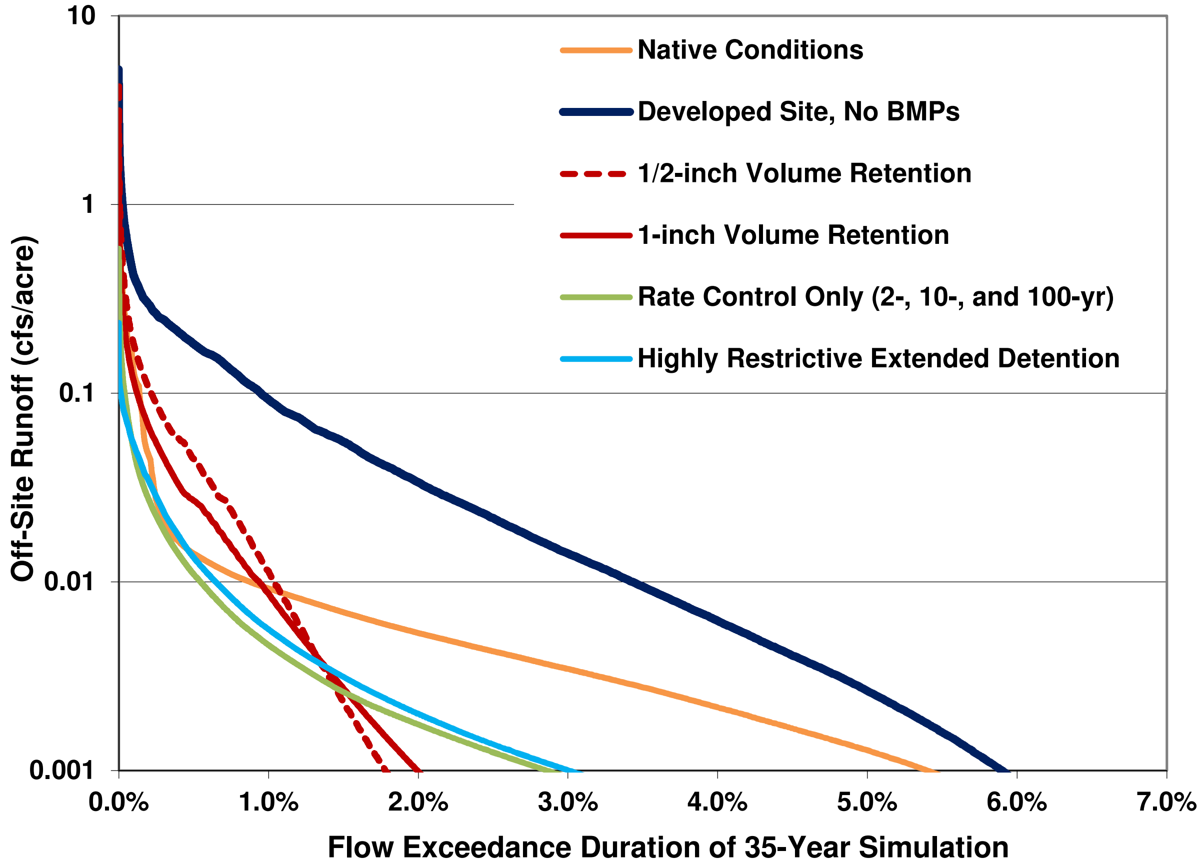

Figure 11. Flow duration curve: comparison of flows from a native conditions site and an 80% impervious developed site, with volume retention and extended detention BMPs

3.2.2 Flood Control

In addition to providing rate control, extended detention systems can also provide flood storage. Much of the Pentagon Park/Border Basin study area is low-lying, with large portions of the study area expected to be inundated in the 1% annual chance flood event. As redevelopment occurs within the Pentagon Park/Border Basin study area, property owners or developers will be required to maintain existing flood storage volumes on their sites to prevent transfer of flood risk to neighboring properties. Most of the storage provided as part of an extended detention and rate control system can also serve as flood storage for the redevelopment site, assuming the drawdown time is within a reasonable timeframe (likely 48 hours).

3.2.3 Water Quality

Extended detention systems rely on the process of sedimentation for removal of pollutants from stormwater. The temporary detention of a portion of runoff allows time for settling of particulate fractions, including sediment and attached phosphorus; the longer stormwater runoff remains in the system, the more settling will occur. The extent of pollutant removal will depend upon whether the extended detention system has a permanent pool. Constructed ponds or wetlands with an extended detention outlet have a permanent pool, which increases the amount of settling time, provides storage and protection from sediment re-suspension when additional runoff enters the system, and promotes biological and chemical processes to remove additional pollutants (e.g., uptake of phosphorus by algae and aquatic plants). Extended detention systems designed as "dry" basins (no permanent pool) are highly susceptible to sediment resuspension and therefore are generally only used for rate control and flood control (limited water quality benefits). Extended detention BMPs do not provide effective soluble pollutant removal.

3.3 Regional Water Quality Treatment Options

The NMCWD Stormwater Management Rule requires that all runoff be treated to achieve at least 60% annual total phosphorus removal and 90% annual total suspended solids removal. The NMCWD's water quality criteria are often met through implementation of volume retention BMPs. If extended detention were to be implemented in lieu of volume retention on redevelopment sites within the study area, it may be necessary to achieve the water quality criteria through regional treatment options, versus onsite. Several opportunities for implementing regional stormwater treatment systems were evaluated; these opportunities are described in further detail below.

3.3.1 Expansion of the Border Basin Pond

The existing Border Basin receives flows from Centennial Lakes, as well as stormwater runoff directly from a 200-acre watershed. Under existing conditions, the basin achieves approximately 44% total phosphorus removal and 76% total suspended solids removal on average. Expansion of the existing Border Basin was evaluated to increase the water quality treatment capacity of the pond. Figure 12 shows the proposed Border Basin expansion, as well as potential tributary drainage area to the Border Basin. With the expanded basin size and increased direct tributary drainage area, the basin achieves approximately 50% annual TP removal and 83% annual TSS removal overall, based on a P8 model developed for the study area. The average annual pollutant removal effectiveness from the direct watershed is somewhat better, with 61% removal of TP and 84% removal of TSS, but does not meet the NMCWD's TSS removal criteria of 90%. The TSS removal lower than the NMCWD criteria is likely due to the large amount of inflow to the Border Basin from the Centennial Lakes watershed, resulting in a shorter residence time for settling out sediment particles.

The expanded Border Basin would also provide additional flood storage capacity for the area. Expansion of the basin would require acquisition of additional parcels. Although the feasibility of expanding the basin has not been evaluated in detail, anecdotal information indicates that soil conditions may create challenging construction conditions.

3.3.2 Construction of a New Regional Pond

Under existing conditions, stormwater from the portion of the study area generally west of the Border Basin and south of Fred Richards Park receives little or no stormwater treatment prior to conveyance to Nine Mile Creek via the trunk storm sewer system. Construction of a regional stormwater pond was evaluated to provide water quality treatment for this portion of the study area. Figure 13 shows the proposed pond location and parcels that could be tributary to the pond upon redevelopment, based on topography. Results from a P8 model developed for the study area indicate that the proposed pond achieves approximately 70% annual TP removal and 90% annual TSS removal overall. This indicates that redevelopment parcels that are tributary to the proposed pond could meet the NMCWD's water quality criteria by routing site runoff through the basin.

Construction of the proposed pond would also provide additional flood storage capacity to the area. Construction of the pond would require acquisition of one or two parcels (7711 Computer Avenue and 4701 West 77th Street). However, it may be feasible to design the pond on the lower portions of the parcels, and resell the higher portion of the 4701 West 77th Street parcel for redevelopment. A pond at this location could be designed as an extension (or at least appear as an extension) of the proposed water features at the Fred Richards Park.

4.0 Conclusions and Recommendations

Redevelopment in compliance with the NMCWD volume retention criteria can achieve significant reductions in stormwater runoff volume and rate from existing conditions. Projects in the Pentagon Park/Border Basin study area, however, may have difficulty siting and designing infiltration practices due to soils with low permeability (Hydrologic Soil Group D soils) and shallow groundwater. In addition, these site conditions may diminish the long-term effectiveness of infiltration-based BMPs. The high silt and clay content of soils within the study area increases the likelihood that infiltration BMPS will plug or have significantly reduced infiltration over time. The large BMP footprint required for infiltration-based BMPs on D soils increases the likelihood that property owners will install underground systems as redevelopment occurs within the study area. It can be difficult to determine if the underground systems are functioning properly or if maintainenace or repair is needed. The Minnesota NPDES Construction General Permit (CGP) prohibits infiltration when an infiltration system will be constructed in areas of predominately Hydrologic Soil Group D soils unless allowed by a local unit of government with a current MS4 permit.

4.1 Stormwater Reuse- Irrigation

Stormwater capture and reuse via irrigation was evaluated as a potential onsite or regional option to meet the NMCWD's volume retention and water quality criteria. The effectiveness of irrigation as a stormwater reuse alternative is based on several key factors, including the amount of impervious surface tributary to the storage system, the rate and duration of irrigation, the storage volume capacity, and the amount of available land for irrigation. Results of the analysis indicate that redevelopment sites would need to capture and store at least 1.5-inches of runoff from the impervious surfaces and have at least 1.5- to 2-times the size of the redevelopment site of available land to irrigate, or capture and store around 2.5-inches of runoff from the impervious surfaces and have a land area available for irrigation that is an equivalent size to the redevelopment site (assuming 80% imperviousness) to achieve annual volume retention that is similar to that achieved by the NMCWD ½-inch volume retention criteria.

4.2 Extended Detention In Lieu of Volume Retention

Using extended detention to reduce peak flows from developed sites in lieu of implementing BMPs that provide the NMCWD's volume retention criteria was considered for sites with D soils in the Pentagon Park/Border Basin study area. While extended detention does not reduce runoff volumes, the technique can effectively reduce runoff rates to those similar to native conditions for medium- and high-intensity rainfall events. Extended detention can also reduce peak runoff rates to at or below the flowrates achieved through compliance with the 1-inch or ½-inch volume retention criteria, depending on the extent of flow restriction implemented.

An advantage of using extended detention within the study area in lieu of implementing volume retention is that the extended detention basins or underground structures can also be used to provide flood storage. Much of the Pentagon Park/Border Basin study area is low-lying, with large portions of the study area expected to be inundated in the 1% annual chance flood event. As redevelopment occurs within the Pentagon Park/Border Basin study area, property owners or developers will be required to maintain existing flood storage volumes on their sites to prevent transfer of flood risk to neighboring properties. Most of the storage provided as part of an extended detention and rate control system can also serve as flood storage for the redevelopment site, assuming the drawdown time is within a reasonable timeframe (likely 48 hours).

Given the uncertainty regarding the long-term effectiveness of infiltration-based BMPs on D soils, the ability of extended detention to effectively reduce runoff rates, and the co-benefit of providing flood storage, extended detention seems to be a reasonable alternative to volume retention on sites within the study area that are not conducive to infiltration. An evaluation of the cumulative impacts of implementing extended detention practices within the study area on Nine Mile Creek, in lieu of volume retention practices, is recommended for your consideration. This evaluation would include modeling of the Nine Mile Creek system upstream of the study area to assess the impacts of changes in discharge volume and timing resulting from implementation of various extended detention scenarios within the study area as redevelopment occurs.

4.3 Regional Water Quality Treatment

While extended detention systems can provide effective rate control and flood storage, they typically provide limited water quality benefits as they are highly susceptible to sediment and pollutant resuspension and do not provide effective soluble pollutant removal. If extended detention is used in lieu of volume retention BMPs to reduce runoff rates, it will be necessary to achieve the NMCWD's water quality treatment criteria through other onsite or regional water quality BMPs. Given that the extended detention and flood storage basin or underground structure would likely be onsite and space for additional onsite water quality BMPs may not be feasible, it is recommended that construction of a regional water quality treatment system be considered as an option to provide a means to meet, at least in part, the NMCWD water quality criteria.

4.4 Recommendations

The information and analyses summarized in this memo suggests that extended detention may be the most viable alternative stormwater management technique to volume retention within the study area, due to the soils with low permeability and shallow groundwater conditions. Extended detention can reduce site runoff to flow rates similar to or lower than those of native conditions, and lower than the construction of BMPs to meeting NMCWD's volume retention criteria. While extended detention does not provide volume retention benefits, the reduced benefit may outweigh the risk of infiltration-based BMPs not property functioning in the long-term due to soil conditions and/or shallow groundwater. Most of the storage provided as part of an extended detention system can also serve as flood storage for the redevelopment site, assuming the drawdown time is within a reasonable timeframe.

An evaluation of the cumulative impacts on Nine Mile Creek resulting from implementing extended detention practices within the study area, in lieu of volume retention practices, is recommended for your consideration. This evaluation would include modeling of the Nine Mile Creek system upstream of the study area to assess the impacts of changes in discharge volume and timing resulting from implementation of various extended detention scenarios within the study area as redevelopment occurs.

If extended detention were to be implemented in lieu of volume retention on redevelopment sites within the study area, it may be necessary to achieve the water quality criteria through regional treatment options, versus onsite. Construction of a regional stormwater pond at 7711 Computer Avenue and 4701 West 77th Street would provide pollutant removal opportunity for much of the study area that is currently untreated. Model results indicate the pond would achieve approximately 70% annual TP removal and 90% annual TSS removal, allowing redevelopment parcels that are tributary to the proposed pond to meet the NMCWD's water quality criteria by routing site runoff through the basin. Construction of the proposed pond, which would require acquisition of one or two parcels, would also provide additional flood storage capacity to the area. To minimize cost, it may be feasible to design the pond using only a portion of the 4701 West 77th Street parcel, and resell the remaining portion for redevelopment. A pond at this location could be design as an extension (or at least appear as an extension) of the proposed water features at the Fred Richards Park.

Stormwater capture and reuse via irrigation is another potential option for meeting the NMCWD's volume retention criteria. However, the technique will require a significant runoff capture and storage volume (at least 1.5-inches of runoff from the impervious surfaces) and a significant amount of land for irrigation (at least one to two times the size of the redevelopment site) to achieve annual volume retention that is similar to that achieved by the NMCWD ½-inch volume retention criteria. Given this, stormwater capture and reuse isn't likely to be a compliance option for a large number of redevelopment sites within the study area.

5.0 References

Barr Engineering Co. *Assessment of MIDS Performance Goal Alternatives: Runoff Volumes, Runoff Rates, and Pollutant Removal Efficiencies.* Prepared for the Minnesota Pollution Control Agency. June 2011.