System-Wide Evaluation of Flood-Risk Mitigation Options

Beltline Resiliency Study

Prepared for
Ramsey-Washington Metro Watershed District

December 2019

4300 MarketPointe Drive, Suite 200
Minneapolis, MN 55435
952.832.2600
www.barr.com

System-Wide Evaluation of Flood-Risk Mitigation Options

December 2019

Contents

List of Tables

List of Figures

List of Appendices

Certifications

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

	date
Name	Date
PE #: add PE number	

Abbreviations

LiDAR	Light Detection and Ranging
MDNR	Minnesota Department of Natural Resources
MnDOT	Minnesota Department of Transportation
NOAA	National Oceanic and Atmospheric Administration
RWMWD	Ramsey-Washington Metro Watershed District
TP40	Technical Paper 40

1 Introduction

The Ramsey-Washington Metro Watershed District (RWMWD or District) has a long history of planning and managing water resources to mitigate flood risk. The District was formed in 1975 in response to concerns about severe erosion and flooding on Battle Creek. Since then the District has continued to work closely with the 12 cities and two counties in the watershed to identify and mitigate flood risk throughout the watershed.

Recently, the District completed an evaluation to identify potentially flood-prone structures based on updated rainfall depths published in Atlas 14 (Reference [1]). As a result, numerous structures were identified in flood-risk areas upstream of the Beltline. This study evaluates potential system modifications that could be implemented in the Beltline watershed to reduce flood risk to those habitable structures in those areas. While not the primary focus, a cursory benefit would be also protecting some non-habitable structures and low-lying lands. Much of this study is centered on evaluating ways to optimize the use of the Beltline to lower flood levels upstream. For the purposes of the is study we assumed 1) the size and/or the peak capacity would not be increased and 2) flood prone homes upstream of the Beltline were not purchased and removed from the flood plain.

1.1 Identification of Potentially Flood-Prone Structures

In 2013, the National Oceanic and Atmospheric Administration (NOAA) released updated precipitation frequency estimates for the Midwestern states (NOAA Atlas 14, Volume 8) (Reference [1]). These estimates, which serve as an update to the U.S. Weather Bureau's Technical Paper 40 (TP 40) (Reference [2]), published in 1961, reflect the results of statistical analyses performed for a much longer period of recorded precipitation data. The results show significant increases in rainfall amounts in the Twin Cities area; for example, the 100-year, 4-day rainfall depth increased by approximately 23% when compared to TP 40. Following the release of Atlas 14, the District updated the hydrologic and hydraulic model of the stormwater system to incorporate the updated precipitation estimates to calculate the 100-year floodplain.

Floodplain extents were intersected with available building structure outlines to identify habitable structures. RWMWD defines the term "habitable" as *Any enclosed space usable for living or business purposes, which includes but is not limited to: working, sleeping, eating, cooking, recreation, office, office storage, or any combination thereof. An area used only for storage incidental to a residential use is not included in the definition of Habitable* (reference [3]).

Auxiliary structures such as detached garages, sheds, park pavilions, etc. are not considered habitable, and potential system modifications to mitigate flood risk for auxiliary structures were not evaluated. There were 785 structures identified as potentially flood prone throughout the District; these are shown on Figure 1-1.

1.2 Beltline Background

The Beltline Stormwater Interceptor (Beltline) is a critical part of the District's stormwater infrastructure; it not only collects a large percentage of stormwater runoff from Saint Paul's east side, but also conveys runoff from the entire Phalen Chain of Lakes and Beaver Lake to the Mississippi River, as shown on Figure 1-2. The total drainage area to the Beltline Interceptor is over 17,800 acres (27.8 square miles). There are 652 potentially flood-prone structures upstream of the Beltline; these are shown in Figure 1-1.

The Beltline is approximately 6.4miles long, extending from the outlets of Lake Phalen and Beaver Lake to the Mississippi River. Constructed in 1920, large sections are cast-in-place concrete horseshoe-shaped pipe buried up to 30 feet underground, with heights varying from 7 to 12 feet. During flood events, the size of the Beltline creates a restriction in stormwater flow to the river. This restriction has resulted in pipe pressurization and above-ground surcharges of water in the downstream reaches. In 2001 modifications to the Beltline were constructed to relief pressure near the outfall, and more recently extensive repair work was complete in 2018.As a result, there is no additional capacity for an increase in peak flow rate into the Beltline to lower upstream flood levels.

Due to the large number of potentially flood-prone structures upstream of the Beltline, and its lack of additional capacity, this study evaluates whether real-time mechanical operation of Lake Phalen and Keller Lake channel outlet structures, as well as other critical system infrastructure, could provide flood damage reduction by manipulating the time at which the peak flows arrived at those structures. The theory is that active real time management of flows throughout control points upstream may allow the district to optimize the use of the Beltline during times in a flood event where the pipe is not flowing at full capacity. Further, if successful, this optimization would result in lower flood levels and, in turn, fewer homes impacted by flooding.

This study considers a variety of operating conditions at each critical control point in the upstream watershed independently and in concert with other points and areas in an attempt to discover if the real time operation will work to lower flood levels in areas without raising flood levels in other areas, and, if so, what operating conditions will have the most positive impact toward reducing flood risk to existing habitable structures.

Subwatershed	Impacted Structures
Battle Creek	33
Battle Creek Lake	25
Beaver Lake	22
Blufflands	3
Carver Lake	49
Fish Creek	2
Gervais Creek	113
Gervais Lake	6
Grass Lake	60
Keller Lake	32
Kohlman Creek	50
Kohlman Lake	11
Lake Owasso	99
Lake Phalen	48
Lake Wabasso	3
Snail Lake	34
Snake Creek	0
St. Paul Beltline	75
Tanners Lake	20
Twin Lake	0
Willow Creek	47
Vadnais Lake	5

- Potentially Impacted Structures
- Major Subwatersheds
- Saint Paul Beltline Interceptor
- Municipal Boundary

0 2 Miles

POTENTIALLY FLOOD-PRONE STRUCTURES IN RWMWD

Beltline Resiliency Study
Ramsey-Washington
Metro Watershed District

FIGURE 1-1

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Arden Hills
North Oaks
Vadnais Heights
White Bear Lake
Gem Lake
Shoreview
Roseville
Little Canada
Maplewood
North Saint Paul
Oakdale
Saint Paul
Newport
Woodbury
Landfall

Snail Lake
Snail Lake
Grass Lake
West Vadnais Lake
Shoreview Lake
Wabasso Lake
Lake Wabasso
Lake Emily
Owasso Lake
Lake Owasso
Bennet Lake
Twin Lake
Twin Lake
Willow Creek
Willow Lake
Gervais Creek
Round Lake (LC)
Kohlman Lake
Kohlman Lake
Lake Gervais
Kohlman Creek
Gervais Lake
Keller Lake
Keller Lake
Lake Phalen
Round Lake (M)
Lake Phalen
Wakefield Lake
Beaver Lake
Beaver Lake
St. Paul Beltline
Tanners Lake
Tanners Lake
Battle Creek
Battle Creek Lake
Battle Creek Lake
Blufflands
Carver Lake
Carver Lake
Eagle Lake
Fish Creek
Snake Creek

Mississippi River

35E
694
94
494

DRAFT

Major Subwatersheds
Saint Paul Beltline Interceptor
Tributary Area to Beltline
Municipal Boundary

0 2
Miles

DRAINAGE AREA
TO THE BELTLINE

Beltline Resiliency Study
Ramsey-Washington
Metro Watershed District

FIGURE 1-2

BARR
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

2 Methodology

The goal of this study is to evaluate potential system-level flood-damage-reduction options, including real-time operation of Lake Phalen and Keller Lake channel outlet structures, to actively manage stormwater runoff from flood-prone areas tributary to the Beltline to reduce flood levels that would otherwise impact habitable structures.

Systems modifications summarized in this report are one option for mitigating flood risk that does not include purchasing flood-prone property. There may be other flood-risk-reduction options that could be considered, and prior to implementation of any modification additional feasibility studies may be required to verify that the optimal, most cost-effective modification has been identified.

In general, the study was phased so that flood-prone areas in the upstream portion of the watershed were addressed first, working downstream. This approach was followed to ensure that we were reasonably confident there are no adverse impacts (e.g., increased flood levels) downstream as a result of upstream system modifications and/or operations. In this manner, the drainage area upstream of the Beltline was divided into five phases:

- Phase 1: Gervais Creek
- Phase 2: Grass Lake
- Phase 3: Kohlman Creek and Willow Creek
- Phase 4: Phalen Chain of Lakes
- Phase 5: Beaver Lake

The one exception was the Grass Lake subwatershed. The District Managers requested that this subwatershed be included in the evaluation at the February 2019 board meeting, after modifications in Gervais Creek had already been evaluated. The five study area phases are shown in Figure 2-1.

The following sections describe the methodology for identifying potentially flood-prone structures and evaluating system modifications. Study limitations or items that are not addressed by the methodology are also described.

Arden Hills
North Oaks
Vadnais Heights
White Bear Lake
Gem Lake
Shoreview
Little Canada
Roseville
Maplewood
North Saint Paul
Oakdale
Saint Paul
Landfall
Woodbury
Newport
Mississippi River
35E
694
94
494

Snail Lake
Snail Lake
Grass Lake
West Vadnais Lake
Shoreview Lake
Wabasso Lake
Lake Wabasso
Lake Emily
Owasso Lake
Lake Owasso
Bennet Lake
Twin Lake
Twin Lake
Gervais Creek
Round Lake (LC)
Lake Gervais
Gervais Lake
Willow Creek
Willow Lake
Kohlman Lake
Kohlman Lake
Kohlman Creek
Keller Lake
Keller Lake
Lake Phalen
Round Lake (M)
Lake Phalen
Wakefield Lake
St. Paul Beltline
Beaver Lake
Beaver Lake
Tanners Lake
Tanners Lake
Battle Creek
Battle Creek Lake
Battle Creek Lake
Blufflands
Carver Lake
Carver Lake
Eagle Lake
Fish Creek
Snake Creek

Major Subwatersheds
Saint Paul Beltline Interceptor
Municipal Boundary

Phases

Phase 1: Gervais Creek
Phase 2: Grass Lake
Phase 3: Willow Creek & Kohlman Creek
Phase 4: Phalen Chain of Lakes
Phase 5: Beaver Lake

0 2
Miles

BELTLINE RESILIENCY STUDY PHASES

Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 2-1

BARR
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

2.1 Identification of Potentially Flood-Prone Structures

In 2017, RWMWD collected stage data at 11 ponds, wetlands, and lakes and flow-rate data at five streams. The monitoring data was used to validate the results of the District stormwater models (Reference [4]). After validating the models to measured stage data, the 100-year, 4-day Atlas 14 rainfall event (8.3 inches) was simulated and floodplain elevations were calculated.

For the purposes of this study, the 100-year floodplain elevation represents the elevation that each water body has a 1-percent chance of exceeding as a result of a storm that has a 1-percent chance of occurring in in any given year. This elevation is called the annual-exceedance elevation. In this case, it is assumed that the waterbody is at the control elevation (the invert of an outlet, or the crest of an overflow weir, for example) when this storm occurs (in other words, prior to these large storm events, the water body has had adequate time to drain down to its control elevation.) Outlet control structures for water bodies are also assumed to be free of debris and sediment and functioning as designed.

In recent years, several water bodies in RWMWD have experienced high elevations as a result of several consecutive years of very wet weather. Certain RWMWD water bodies in particular have stayed high because they are landlocked (have no outlet or overflow structure that is regularly used, such as Snail Lake or Twin Lake) or have very restricted outlets that have not drawn down to their outlet elevations for several years (Grass Lake/West Vadnais Lake). Recent high elevations in these areas were not used as the starting elevations for the purposes of calculating the annual exceedance elevation to identify flood prone structures. The reason is the way practitioners typically look at hydrologic probability. Combining the already unlikely (though existing) high water levels that have been experienced recently with a coincident (and rare) storm event that has a 1 percent chance of happening in any given year compounds risk in a way that is typically not evaluated. This type of evaluation uses what is called "conditional probability".

While this study does not look at the conditional probability of certain flood levels in the landlocked or highly restricted portions of RWMWD, RWMWD has acknowledged the vulnerability of these areas and has prioritized efforts to minimize flood risks to habitable structures.

For this reason, RWMWD regularly uses the stormwater model to estimate resulting water levels assuming a 100-year rainfall event occurs when starting water levels are high to help plan flood response strategies undertaken by both RWMWD and its member cities. For example, in March 2019 a series of snowmelt scenarios were modeled to estimate potential flood elevations in April 2019, if the starting elevation of the waterbodies was an estimate of existing conditions. Also, although Twin Lake's lowest home does not appear on Figure 1, it is below the outlet from Twin Lake, RWMWD is currently evaluating flood risk reduction options for Twin Lake (and Grass Lake) outside of the scope of this Beltline Resiliency Study.

Floodplain extents were intersected with building structure outlines in Ramsey and Washington Counties. The building outlines in Ramsey County are based on the footprint derived from the Minnesota Department of Natural Resources' (MDNR) light detection and ranging (LiDAR) data, (Reference [5])corrected by Ramsey County in 2015 (Reference [6]). Building outlines in Washington County were based on the nationwide Microsoft Building Footprints dataset (Reference [7]). Habitable structures (e.g., residences, office and commercial buildings, apartments, etc.) that intersected the

floodplain were identified as potentially flood-prone. Within the Ramsey County dataset structures identified as "residential," "non-residential," and "mobile home" were considered habitable structures. Because similar data categories do not exist in the Washington County dataset, structures greater than 550 square feet in area were considered to be habitable structures. Auxiliary structures such as detached garages, sheds, park pavilions, etc. were not considered.

A desktop planning-level identification of potentially flood-prone structures was completed using best available information. Unless noted in Section 3, field survey of the low adjacent grade or low-entry elevation was not completed as part of the analysis. Field survey, as part of future feasibility studies, may change the number of structures identified within the floodplain or elevations of structures identified.

A high-level evaluation of each potentially flood-prone structure, shown in Figure 1-1, upstream of the Beltline, was completed to estimate if flooding was caused by:

- Proximity to District-managed water bodies or facilities (e.g., high water level of a District-managed water body, capacity through a District-managed culvert, etc.). These structures were classified as "District."
- Local flooding potentially not related to District-managed water bodies or facilities (e.g., high water level of municipal pond, capacity through municipal storm sewer infrastructure, etc.). These structures were classified as "Local."

There were 612 structures upstream of the Beltline identified as potentially flood-prone; 197 structures were classified as "District" and 415 were classified as "Local." These two types of flood-risk areas are shown on Figure 2-2.

Although potentially flood-prone structures classified as both "Local" and "District" are shown on Figure 2-2, only system modifications to reduce flood levels adjacent to structures classified as "District" were considered for this evaluation. These areas typically require system modifications that affect peak discharge rates or water levels across municipal boundaries. However, the District should continue to work cooperatively with the cities to address localized flooding concerns and manage inflows to District water bodies.

Arden Hills
North Oaks
Vadnais Heights
White Bear Lake
Gem Lake
Shoreview
Little Canada
Maplewood
North Saint Paul
Roseville
Oakdale
Saint Paul
Newport
Woodbury
Landfall

Snail Lake
Snail Lake
Grass Lake
West Vadnais Lake
Shoreview Lake
Wabasso Lake
Lake Emily
Owasso Lake
Lake Owasso
Bennet Lake
Twin Lake
Twin Lake
Gervais Creek
Round Lake (LC)
Gervais Lake
Lake Gervais
Kohlman Lake
Kohlman Lake
Keller Lake
Keller Lake
Willow Lake
Willow Creek
Kohlman Creek
Wakefield Lake
Round Lake (M)
Lake Phalen
Lake Phalen
St. Paul Beltline
Beaver Lake
Beaver Lake
Tanners Lake
Tanners Lake
Battle Creek
Battle Creek Lake
Battle Creek Lake
Blufflands
Carver Lake
Carver Lake
Eagle Lake
Fish Creek
Snake Creek

35E
694
94
494

Mississippi River

Potentially Impacted Structures:

- District
- Local
- Major Subwatersheds
- Saint Paul Beltline Interceptor
- Tributary Area to Beltline
- Municipal Boundary

0 2
Miles

POTENTIALLY FLOOD-PRONE STRUCTURES UPSTREAM OF THE BELTLINE

Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 2-2

BARR
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

2.2 System Modifications Considered and Evaluated

The District stormwater model was used to evaluate possible modifications to the stormwater system within the watershed. Several types of modifications were considered and evaluated as part of this analysis to determine which, if any, implementation recommendations for future feasibility study could be made. In general, potential system modifications can be classified by the following general categories:

- **Decrease conveyance capacity** – Reducing the conveyance capacity through culverts and lake outlet structures was considered and evaluated in locations upstream of potentially flood-prone structures where the 100-year water level was more than 2 feet lower than the low adjacent grade of existing structures in the upstream location.

- **Flood storage volume** – Providing additional flood storage volume either above-ground (e.g., excavating stormwater ponds to increase surface area, or to create new stormwater ponds) or underground (e.g., storage chambers) was considered and evaluated.

- **Modification of overflow** – Modifications to existing overflows were considered and evaluated to either redirect runoff or provide additional upstream storage volume. Overflow modifications evaluated included raising roads and/or trails.

- **Modification to storm sewer system** – Storm sewer modifications considered and evaluated that redirected drainage from flood-prone areas to downstream locations with available storage volume.

- **Mechanical operation of outlet structures** – Operation of the Lake Phalen and Keller Lake outlet structures was considered and evaluated to optimize floodplain storage in the Phalen Chain of Lakes and control discharge into Beltline. Mechanical operation was not considered for outlet structures from smaller stormwater ponds and wetlands.

- **Increase conveyance capacity** – Increasing the conveyance capacity of culverts, storm sewer, or lake outlets were considered. In general, increasing conveyance capacity was considered and evaluated in locations where options for providing additional floodplain storage volume was limited. In locations where conveyance capacity was increased as a part of the evaluations, downstream system modifications then also needed to be considered and evaluated to mitigate increases in 100-year water elevations in those areas.

- **Site specific flood-proofing** – In a few locations, site-specific flood proofing (i.e., localized grading or structural modifications) were considered as a part of the evaluation. Typically, these modifications were considered for locations where the 100-year water level was within the accuracy of the LiDAR data and further system modifications did not appear feasible.

The goal of each system modification being evaluated was to lower the 100-year floodplain elevation below the low adjacent grade of the lowest habitable structure. System modifications were not evaluated to provide freeboard above the flood elevation generated by the 100-year event. And, potential future increases to the 100-year floodplain as a result of climate change were not considered in this evaluation.

Finally, the evaluation did not consider any system modifications that conveyed water to adjacent watershed districts, increased the capacity of the Beltline (i.e., replacing the existing pipe with a larger pipe or conveyance system), or purchasing of flood-prone structures. These options may need to be considered as part of future feasibility studies if the evaluated alternatives are ultimately considered to be ineffective or not feasible.

2.3 Study Limitations

The system modifications being considered and evaluated represent an approach for possible mitigation of flood risk for habitable structures within the District. However, as with any study and model of natural systems, there are limitations. There are practical limits on the level of detail used to achieve the study objectives. Although data sets for model inputs are frequently updated, they are not always complete or error free. Nonetheless, the data is useful and appropriate for the purpose of this study. Acknowledgement of study limitations is important so that the findings and recommendations can be used with professional judgment in developing recommendations that are consistent with the intent of the study. Understanding the limitations also makes it easier for future evaluations to build on the results of this study.

Major assumptions for this study are listed below:

- Possible system modifications presented are intended to demonstrate one possible option for mitigating flood risk. There may be other options that may be considered to reduce flood risk during future feasibility studies.
- Possible system modifications may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other local permitting jurisdictions to determine permit requirements. It is possible that permit requirements may change the configuration or function of system modifications.
- Potentially flood-prone structures were identified based on topographic information and aerial photographs available at the time of the evaluation. Only limited survey information was available in many parts of RWMWD. Additional field survey work may change the number and location of potentially flood-prone structures.
- The District stormwater model was developed and calibrated to District-managed lakes, creeks, and facilities. It is important to note that the models developed do not simulate all of the local storm sewer systems within the watershed. As a result, each city may identify separate, localized flooding areas that are not discussed in this report. The District should continue to work cooperatively with the cities to address localized flooding concerns and manage inflows to District water bodies.
- Data sets used for model development are not always complete or error free. In general, the RWMWD stormwater model was developed using a combination of survey information, as-built plans, LiDAR, and GIS information publicly accessible and/or provided by municipalities and other public agencies within the District. As additional information is collected or provided by the

municipalities and public agencies, the number of potential flood-prone structures may change and the potential system modifications necessary to mitigate flood risk may change accordingly.

3 Resiliency Study Phases

The Beltline resiliency study represents a nontraditional approach to optimizing a regional urban stormwater system. In general, the study is phased so that flood-prone areas in the upstream portion of the watershed were evaluated first, working downstream. In general, the study was phased so that flood-prone areas in the upstream portion of the watershed were addressed first, working downstream. This approach was followed to ensure that we were reasonably confident there are no adverse impacts (e.g., increased flood levels) downstream as a result of upstream system modifications and/or operations. The following sections describe the current flooding concerns, system modifications, and post-modification flood concerns for each of the five phases:

- Phase 1: Gervais Creek
- Phase 2: Grass Lake
- Phase 3: Kohlman Creek and Willow Creek
- Phase 4: Phalen Chain of Lakes
- Phase 5: Beaver Lake

3.1 Phase 1 – Gervais Creek

The Gervais Creek subwatershed is in Ramsey County. It is approximately 1,800 acres and includes portions of Vadnais Heights and Little Canada. There are several flood-prone areas within Gervais Creek, including North Star Estates, a manufactured housing development south of the Owasso Basin, where many homes are located within the 100-year floodplain.

3.1.1 Current Condition Flooding Concerns

There are 116 potentially flood-prone habitable structures within the Gervais Creek subwatershed. The 101 structures classified as "District" are near District-managed facilities, lakes, or creeks, or are in locations where addressing flooding may change downstream peak flow rates and water levels in multiple municipalities. Sixteen structures are classified as "Local," which indicates that the structure is likely not adjacent to District-managed facilities, lakes, or creeks, and that flooding may be a result of the local storm drainage system. Potentially flood-prone structures within the Gervais Creek subwatershed are shown in Figure 3-1.

Most of the potentially flood-prone structures in the Gervais Creek subwatershed are in the North Star Estates development south of Owasso Basin. There are also four structures near Gervais Mill Pond.

There have been several reports of flooding within this subwatershed. More recently, two properties north of Owasso Basin (200 and 209 Ryan Drive) were flooded in 2011. During the same event, the water level in Owasso Basin extended into the North Star Estates development.

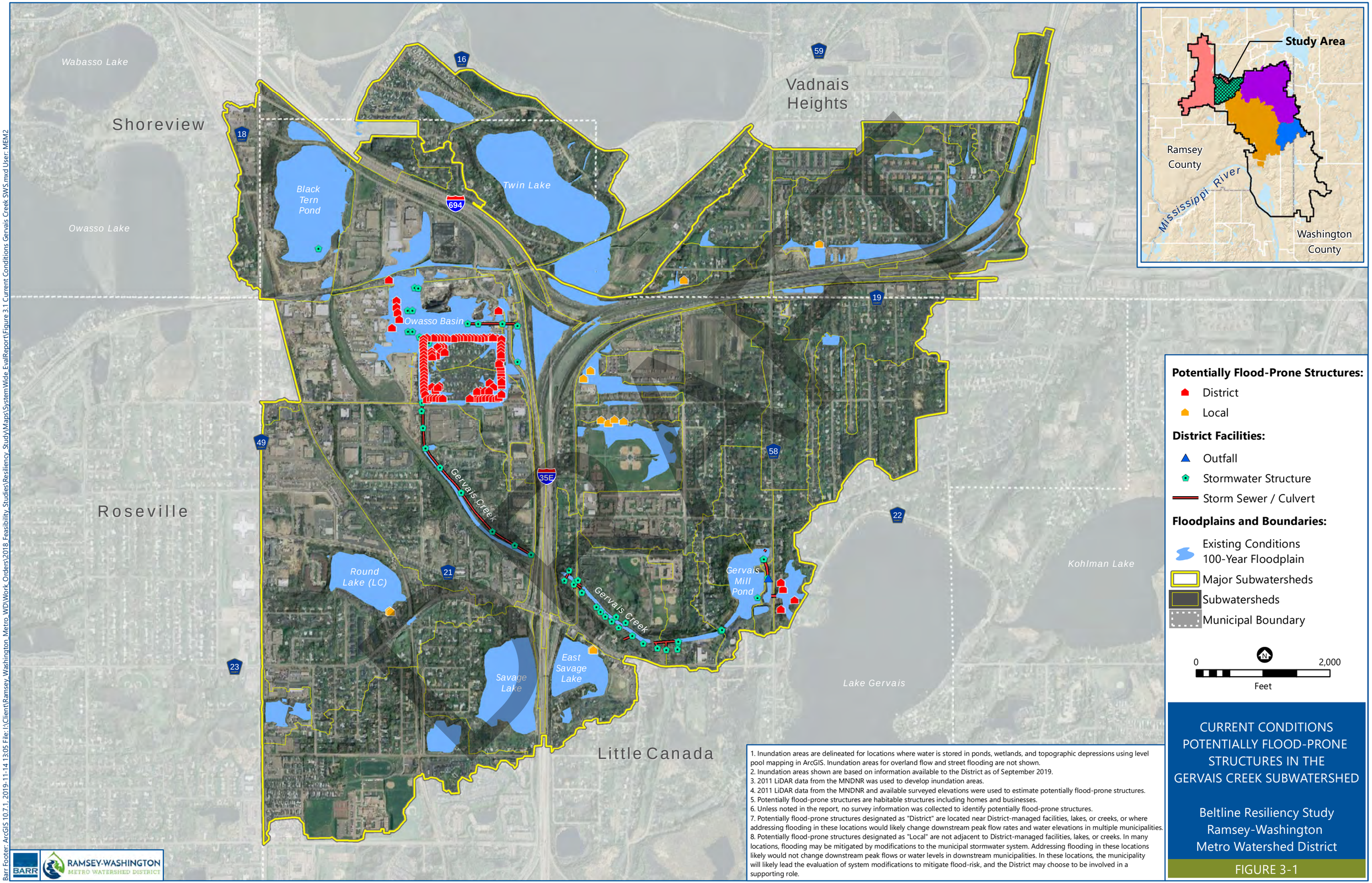
The District also has a long history of implementing flood-risk-reduction projects within the subwatershed. Previous District projects include construction of Owasso Basin in 1990, Gervais Mill Pond and County Ditch 16 improvements in 1992, South Gervais Area drainage improvements in 1999, Black Tern Pond outlet construction in 2002, and Owasso Basin performance improvement in 2005.

Table 3-1 lists the potentially flood-prone structures in the Gervais Creek subwatershed classified as "District." System modifications discussed in Section 3.1.2 were evaluated to remove structures listed in Table 3-1 from the floodplain.

Table 3-1 Potentially Flood-Prone Structures in the Gervais Creek Subwatershed

Parcel ID	Address	Lowest Adjacent Grade[2]	Source for Lowest Adjacent Grade	Existing 100-YYear Water Surface Elevation
062922120005	3001 Country Dr, Little Canada 55117[1]	872.1	LiDAR[4]	875.9
062922210037	3164 Ryan Ln, Little Canada 55117	874.7	LiDAR[4]	875.9
062922210038	3168 Ryan Ln, Little Canada 55117	874.6	LiDAR[4]	875.9
062922210019	3101 Country Dr, Little Canada 55117	875.8	LiDAR[4]	875.9
062922120003	3172 Ryan Ln, Little Canada 55117	874.0	LiDAR[4]	875.9
062922210018	3176 Ryan Ln, Little Canada 55117	874.1	LiDAR[4]	875.9
062922120004	196 Ryan Ln, Little Canada 55117	875.3	LiDAR[4]	875.9
313022340017	200 Ryan Dr, Little Canada 55117	876876.6	Survey[3]	873.9
062922210017	193 Ryan Dr, Little Canada 55117	875.8	LiDAR[4]	875.9
052922430036	627 Keller Pkwy, Little Canada 55117	864.2	LiDAR[4]	864.4
052922430024	2746 Edgerton St, Little Canada 55117	862.6	LiDAR[4]	864.4
052922430025	2756 Edgerton St, Little Canada 55117	864.3	LiDAR[4]	864.4
052922430032	2718 Edgerton St, Little Canada 55117	864.3	LiDAR[4]	864.4

(1) 3001 Country Dr, Little Canada 55117 is North Star Estates, which includes two adjacent parcels (123-062922120005 and 123-062922120004). There are 89 buildings which are individual mobile homes; the lowest adjacent grade listed is the lowest among all 89 buildings.
(2) Limited survey is available in this area; therefore, LiDAR is the primary source for the lowest adjacent grade analysis. The mobile homes' building outline could change over the time; the estimated elevations listed are based on 2019's high-resolution aerial image provided by Near Map.
(3) The original low adjacent grade was 873.7 feet (Reference [8]); this building was rebuilt in 2016 and the current low adjacent grade has been raised by 2.9 feet.
(4) Reference [5]



1. Inundation areas are delineated for locations where water is stored in ponds, wetlands, and topographic depressions using level pool mapping in ArcGIS. Inundation areas for overland flow and street flooding are not shown.
2. Inundation areas shown are based on information available to the District as of September 2019.
3. 2011 LiDAR data from the MNDNR was used to develop inundation areas.
4. 2011 LiDAR data from the MNDNR and available surveyed elevations were used to estimate potentially flood-prone structures.
5. Potentially flood-prone structures are habitable structures including homes and businesses.
6. Unless noted in the report, no survey information was collected to identify potentially flood-prone structures.
7. Potentially flood-prone structures designated as "District" are located near District-managed facilities, lakes, or creeks, or where addressing flooding in these locations would likely change downstream peak flow rates and water elevations in multiple municipalities.
8. Potentially flood-prone structures designated as "Local" are not adjacent to District-managed facilities, lakes, or creeks. In many locations, flooding may be mitigated by modifications to the municipal stormwater system. Addressing flooding in these locations likely would not change downstream peak flows or water levels in downstream municipalities. In these locations, the municipality will likely lead the evaluation of system modifications to mitigate flood-risk, and the District may choose to be involved in a supporting role.

CURRENT CONDITIONS POTENTIALLY FLOOD-PRONE STRUCTURES IN THE GERVAIS CREEK SUBWATERSHED

Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-1

BARR | RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.7.1, 2019-11-14 13:05 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2018_Feasibility_Studies\Resiliency_Study\Maps\SystemWide_EvalReport\Figure 3.1 Current Conditions Gervais Creek SWS.mxd User: MEM2

3.1.2 Evaluation of Potential System Modifications

The District stormwater model was used to evaluate potential system modifications within the Gervais Creek subwatershed. The stormwater model was modified to evaluate the impact that potential system modifications would have on the 100-year floodplain. The goal for each system modification was to prevent the 100-year flood level from inundating habitable structures

Evaluation of potential system modifications did not include discussions with property owners, permitting agencies, or other stakeholders. Additional evaluation for system modifications, including detailed feasibility studies that further evaluate economic and social considerations, is necessary prior to modifying the drainage system.

Based on available topographic information (reference [5]), the lowest adjacent grade to the low home within the North Star Estates development was estimated to be 872.1 feet, and the low structure west of Owasso Basin was estimated to be 872.6 feet. The low structure in the industrial area north of Owasso Basin is 877.2 feet.

There are four single-family residential buildings potentially impacted by the 100-year flood level in the Gervais Mill Pond area. The lowest adjacent grade of these four homes is 862.6 feet, estimated from available topographic information (reference [5]).

Flood-risk mitigation near North Star Estates includes a combination of modifications near Owasso Basin and diversion of flow around Owasso Basin. System modifications near Owasso Basin are based on previous District feasibility studies that explored diverting flow from the Minnesota Department of Transportation (MnDOT) system around Owasso Basin (Reference [8]). System modifications near Gervais Mill Pond improve conveyance to Gervais Lake.

Potential system modifications to mitigate flood risk in the Gervais Creek subwatershed are divided into four steps (step 1A through 1D) and are described in the following sections.

1A Ryan Drive and North Star Estates

Potential system modifications near Owasso Basin and Ryan Drive are shown in Figure 3-2. Those possible system modifications would be intended to improve the conveyance capacity below Ryan Drive into Owasso Basin, improve the existing berm west of Owasso Basin, add a berm northwest of North Star Estates, and increase the outlet capacity from Owasso Basin. System modifications shown in Figure 3-2 include:

- Raising a portion of Ryan Drive to 877 feet.
- Increasing culvert capacity at Ryan Drive by adding a box culvert 6 feet high and 10 feet wide, or equivalent.
- Increasing the capacity of the weir south of Owasso Basin by expanding the weir length

- Increasing culvert capacity through the berm west of Owasso Basin by adding eight additional 36 inch or equivalent drainpipes.
- Constructing a berm along the northwestern corner of the mobile home development; the berm will be approximately 1500 feet, an increase of approximately 4 feet.
- Raising the berm west of Owasso Basin from 874 to 875 feet to prevent the existing berm from overtopping.
- Performing minor site grading at 3176 and 3164 Ryan Lane.

1B MnDOT Diversion

Potential system modifications east of Owasso Basin are shown in Figure 3-3. Possible modifications include diverting drainage from the MnDOT storm sewer system within the I-35E and I-694 interchange to the south. Modifications shown in Figure 3-3 include:

- Diverting MnDOT flow through an approximately 3,000-foot-long, 60-inch concrete culvert (or pipe with equivalent capacity) along I-35E. The potential diversion outlets in Gervais Creek downstream of the I-35E crossing.
- Blocking three existing 30-inch pipes conveying water from Larry Pond to Porky Pond.

1C West Industrial Diversion

Potential system modifications west of Owasso Basin are shown in Figure 3-4. Possible modifications include diverting stormwater runoff from the industrial area south to the existing storm sewer along South Owasso Boulevard. Modifications shown in Figure 3-4 include:

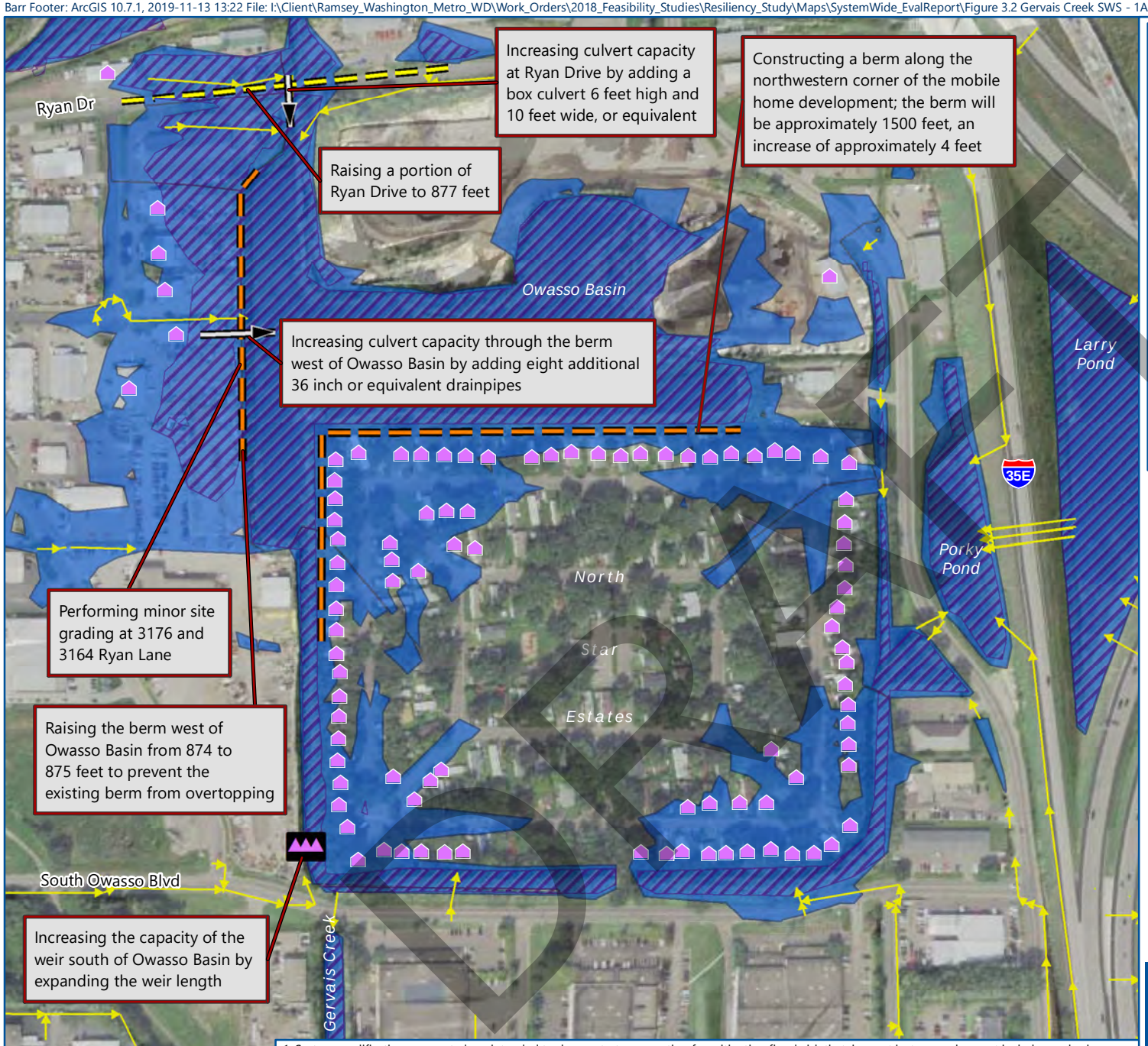
- Rerouting stormwater runoff from the area west of Owasso Basin to Gervais Creek, south of South Owasso Boulevard.
- Grading west of Spruce Street to divert stormwater runoff to the south; the berm is approximately 1,800 feet long and approximately 2.5-feet high.

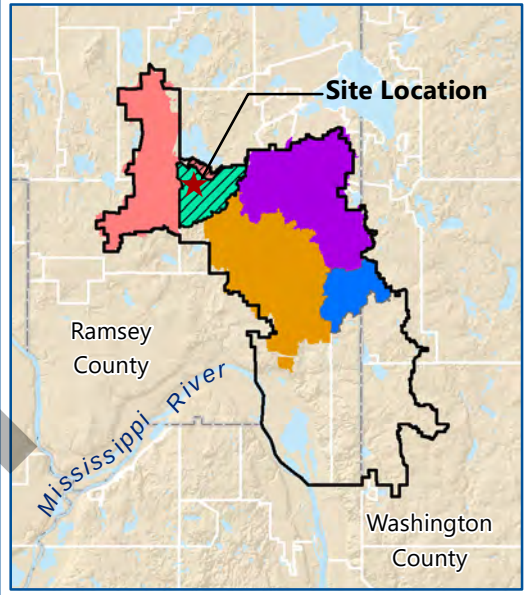
1D Gervais Creek

Potential system modifications along Gervais Creek from South Owasso Boulevard to Gervais Lake are shown in Figure 3-5. Possible modifications include restoring the hydraulic capacity of Gervais Creek and increasing culvert capacity at five creek crossings. Gervais Creek has a nearly flat slope in this portion of the subwatershed, and improvements to conveyance capacity that lower the water surface profile along the creek also lower the Owasso Basin floodplain. Possible modifications shown in Figure 3-5 include:

- Restoring the hydraulic capacity of Gervais Creek between Owasso Boulevard and Gervais Mill Ponds through selective excavation of sediment deposits.

- Increasing culvert capacity along Gervais Creek at Highway I-35E by adding two additional 84-inch concrete pipes (or equivalent size) at the invert of the existing 84-inch pipe.
- Increasing culvert capacity along Gervais Creek at the trail between Centerville Road and Noel Drive by adding two additional 84-inch concrete pipes or equivalent at the invert of the existing 84-inch pipe.
- Increasing culvert capacity along Gervais Creek at Noel Drive by adding two 84-inch equivalent arch pipes or equivalent) at the invert of the existing pipe.
- Increasing culvert capacity along Gervais Creek at Edgerton Street by adding two 84-inch equivalent arch pipes or equivalent at the invert of the existing pipe.
- Increasing culvert capacity along Gervais Creek at Keller Parkway by adding two 120-inch equivalent arch pipes or equivalent at the invert of the existing pipe.





Potentially Flood-Prone Structures:

- Structures Removed from Floodplain

Design Elements:

- Weir
- Pipe
- Site Grading
- Road Raise
- Existing Storm Sewer Pipe

100-Year Floodplain:

- Following System Modifications
- Existing Atlas 14 Inundation

0 500

Feet

GERVAIS CREEK SUBWATERSHED SYSTEM MODIFICATIONS 1A

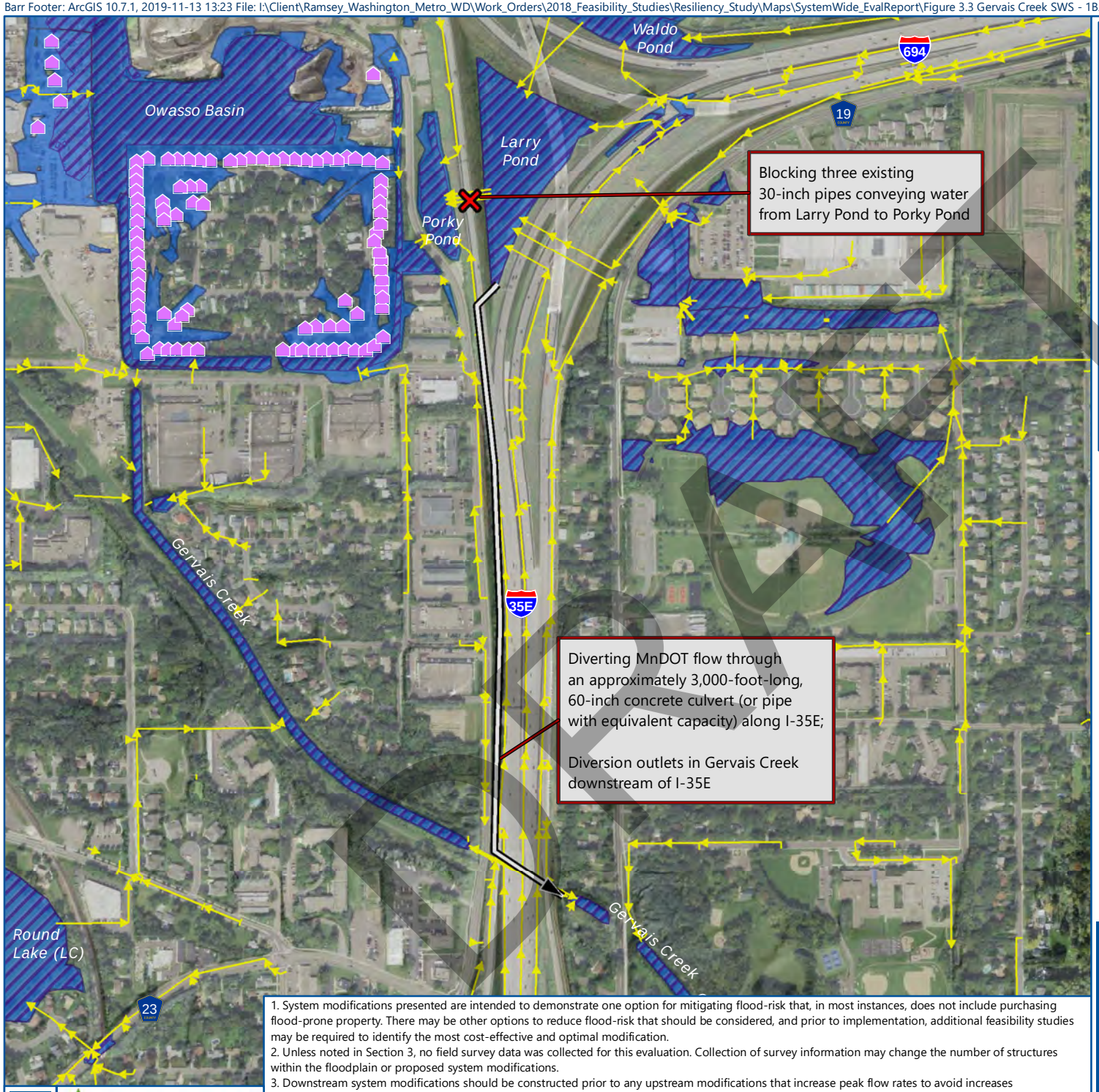
Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

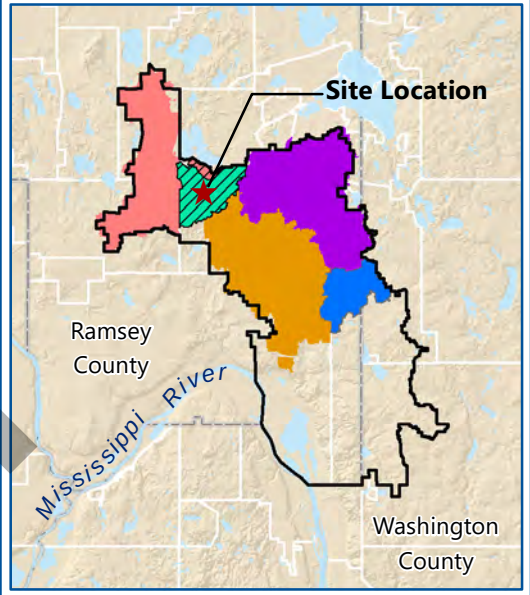
FIGURE 3-2

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT





Potentially Flood-Prone Structures:

Structures Removed from Floodplain

Design Elements:

Block / Restrict Outlet

Pipe

Existing Storm Sewer Pipe

100-Year Floodplain:

Following System Modifications

Existing Atlas 14 Inundation

0 1,000

Feet

GERVAIS CREEK SUBWATERSHED SYSTEM MODIFICATIONS 1B

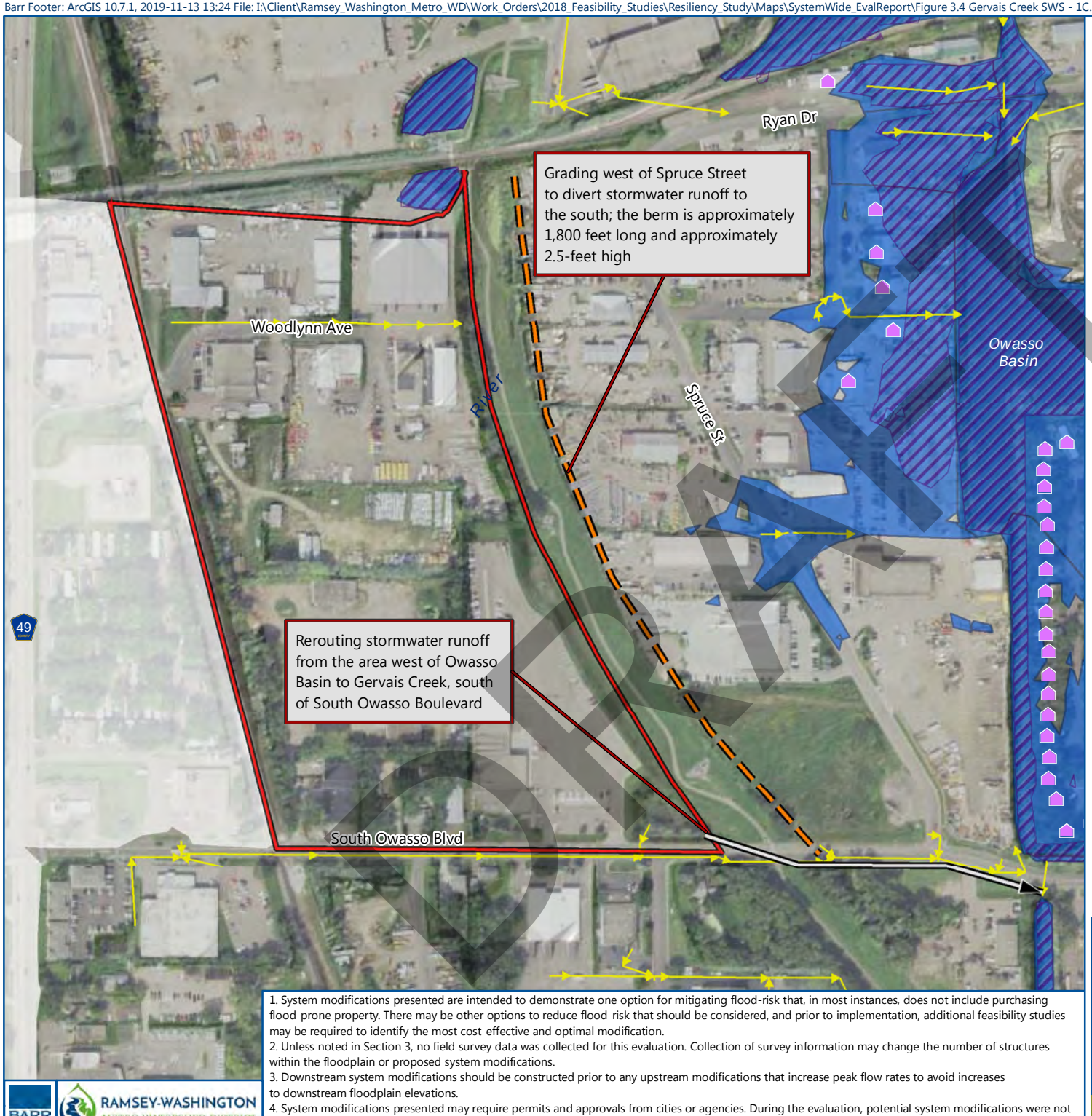
Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

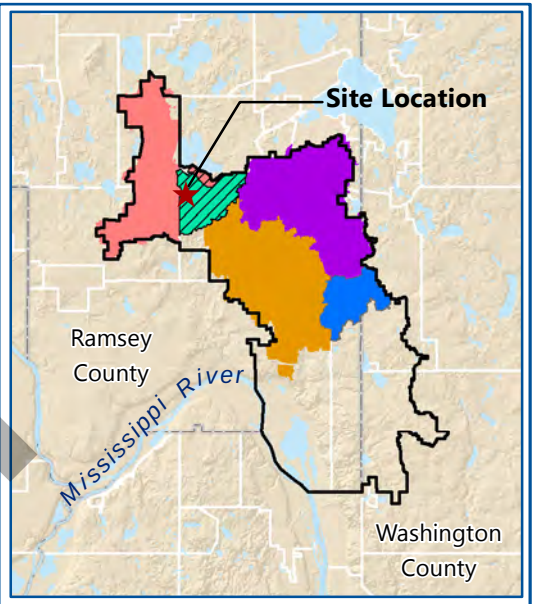
FIGURE 3-3

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT





Potentially Flood-Prone Structures:

- Structures Removed from Floodplain

Design Elements:

- Pipe
- Site Grading
- Redirect Runoff
- Existing Storm Sewer Pipe

100-Year Floodplain:

- Following System Modifications
- Existing Atlas 14 Inundation

0 — 500 Feet

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

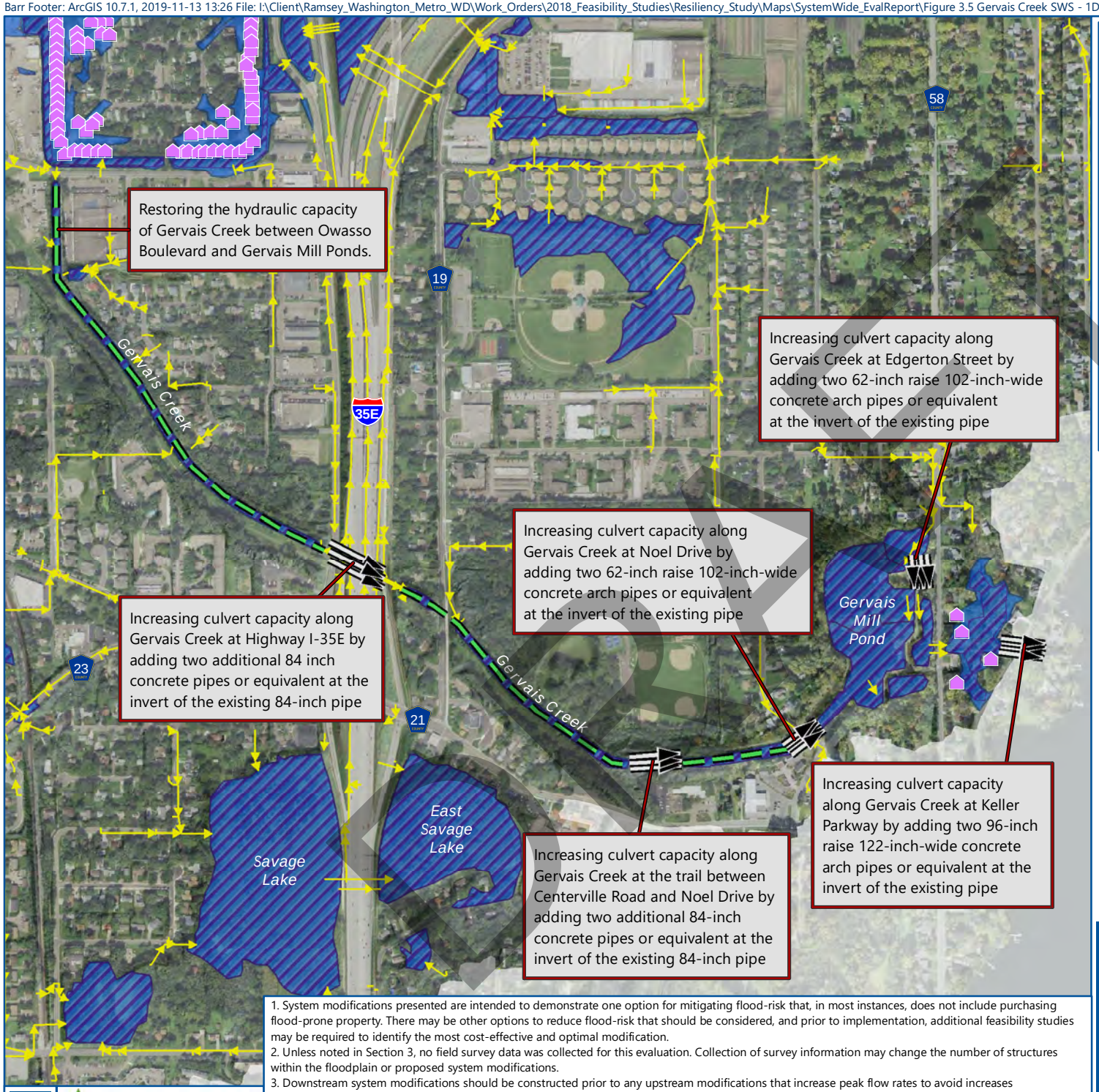
BARR

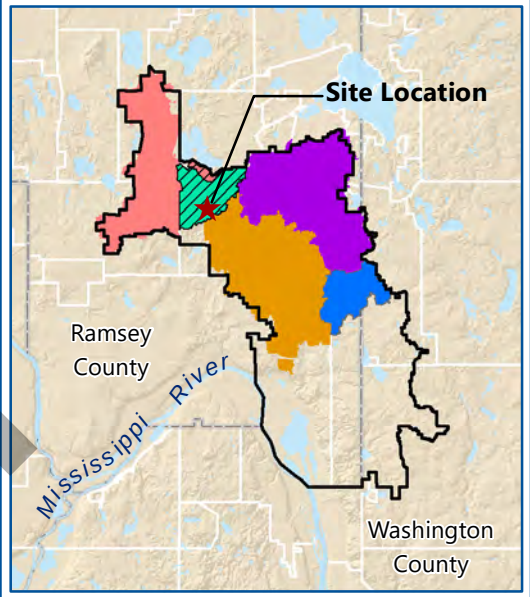
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

GERVAIS CREEK SUBWATERSHED SYSTEM MODIFICATIONS 1 C

Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-4





Potentially Flood-Prone Structures:

- Structures Removed from Floodplain

Design Elements:

- Pipe
- Restore Ditch Capacity
- Existing Storm Sewer Pipe

100-Year Floodplain:

- Following System Modifications
- Existing Atlas 14 Inundation

0 1,000 Feet

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

GERVAIS CREEK SUBWATERSHED SYSTEM MODIFICATIONS 1D

Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-5

3.1.3 Flooding Concerns following System Modifications

The potential system modifications result in lowering the 100-year floodplain below the low adjacent grade of habitable structures within the Gervais Creek subwatershed. The 100-year floodplain following system modifications is shown in Figure 3-6.

With these modifications, the 100-year water surface elevation in Owasso Basin could be reduced by 1.7 feet. The resulting floodplain would still extend into the North Star Estates development but would not reach existing habitable structures in that area. During the next phase of evaluation, additional information, including collection of survey information, would be required. Model simulations indicate that the 100-year water level in Gervais Lake would not increase as a result of the system modifications discussed in Section 3.1.2. The peak discharge from Gervais Creek reaches Gervais Lake before the peak water level in Gervais Lake occurs. The modifications evaluated, do not significantly change the timing of inflows to Gervais Lake, and as a result, the peak water level in Gervais Lake does not increase. If the configuration or function of system modifications change during subsequent phases of feasibility study or design, the impact to downstream water levels should be re-evaluated.

Table 3-2 lists the existing 100-year water surface elevation and the elevation following modifications to the drainage system.

Table 3-2 also includes planning-level considerations related to project sequencing to avoid increases to downstream water levels. Project sequencing refers to the order that system modifications should be constructed to prevent adverse downstream impacts. For this evaluation, sequencing does not refer to prioritization, which refers to which area should be addressed first. For example, improvements to the downstream portion of the system should be constructed prior to increasing the discharge conveyed from upstream areas. Prerequisite system modifications listed in Table 3-2 refer to modifications that should be constructed prior to the system modification to mitigate flood risk for each parcel. For example, the sizing of system modifications presented in step 1A (Figure 3-2) assumes that system modifications presented in steps 1B (Figure 3-3) and 1C (Figure 3-4), diverting stormwater around Owasso Basin, and step 1D (Figure 3-5), downstream improvements to Gervais Creek, have already been constructed. If these system modifications are not in place, then the sizing, function, or configuration of system modifications included in step 1A may change or impact downstream water levels. A planning-level schematic for sequencing of potential system modifications is included in Appendix A.

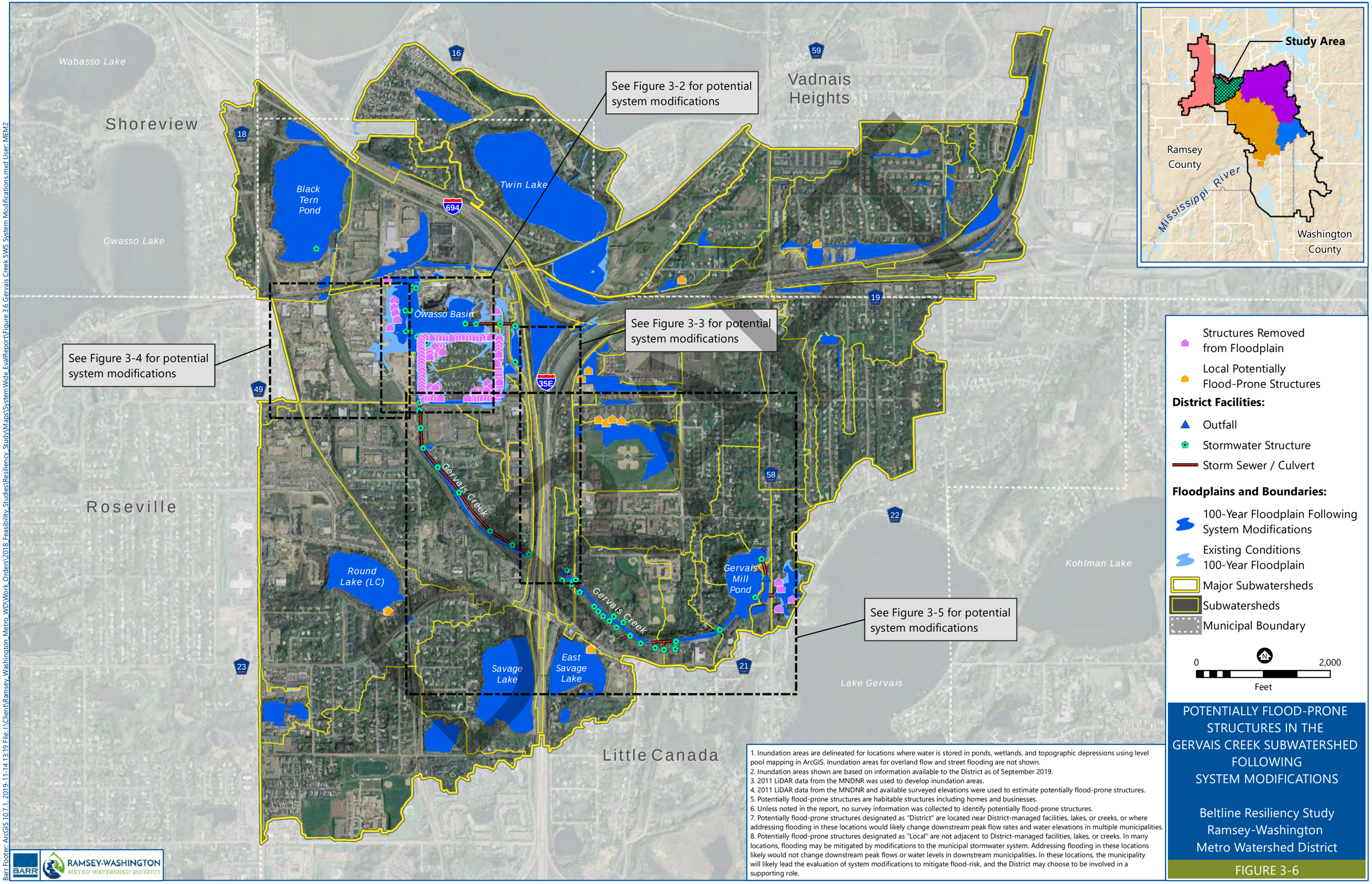
Table 3-2 Potentially Flood-Prone Structures in the Gervais Creek Subwatershed

Parcel ID	Address	Lowest Adjacent Grade[2]	Existing 100-Year Water Surface Elevation	100-Year Water Surface Elevation following System Modifications	System Modification to Reduce Flood Risk	Prerequisite System Modifications
062922120005	3001 Country Dr, Little Canada 55117[1]	872.1	875.9	873.9	1A	1B, 1C, 1D
062922210037	3164 Ryan Ln, Little Canada 55117	874.7	875.9	873.9	1A	1B, 1C, 1D
062922210038	3168 Ryan Ln, Little Canada 55117	874.6	875.9	873.9	1A	1B, 1C, 1D
062922210019	3101 Country Dr, Little Canada 55117	875.8	875.9	873.9	1A	1B, 1C, 1D
062922120003	3172 Ryan Ln, Little Canada 55117	874.0	875.9	873.9	1A	1B, 1C, 1D
062922210018	3176 Ryan Ln, Little Canada 55117	874.1	875.9	873.9	1A	1B, 1C, 1D
062922120004	196 Ryan Ln, Little Canada 55117	875.3	875.9	873.9	1A	1B, 1C, 1D
313022340017	200 Ryan Dr, Little Canada 55117	873.7	873.9	876.6[3]	1A	1B, 1C, 1D
062922210017	193 Ryan Dr, Little Canada 55117	875.8	875.9	875.7	1A	1B, 1C, 1D
052922430036	627 Keller Pkwy, Little Canada 55117	864.2	864.4	862.5	1D	N/A
052922430024	2746 Edgerton St, Little Canada 55117	862.6	864.4	862.5	1D	N/A
052922430025	2756 Edgerton St, Little Canada 55117	864.3	864.4	862.5	1D	N/A
052922430032	2718 Edgerton St, Little Canada 55117	864.3	864.4	862.5	1D	N/A

(1) 3001 Country Dr., Little Canada 55117 is North Star Estates, which includes 89 individual mobile homes. Seventy-five of these have a low adjacent grade above 873.9 feet; 14 of them are lower but will be protected by the site grading.

(2) Limited survey is available in this area; therefore, LiDAR is the primary source for the lowest adjacent grade analysis. The building outline for the mobile homes could change over the time. The estimated elevations are based on 2019 aerial imagery provided by Microsoft.

(3) The lowest adjacent grade for 200 Ryan Drive was surveyed in 2012 (Reference [8]). The building was rebuilt in 2016, and the new lowest adjacent grade was raised by 2.9 feet to 876.6 feet.



1. Inundation areas are delineated for locations where water is stored in ponds, wetlands, and topographic depressions using level pool mapping in ArcGIS. Inundation areas for overland flow and street flooding are not shown.
2. Inundation areas shown are based on information available to the District as of September 2019.
3. 2011 LiDAR data from the MNDNR was used to develop inundation areas.
4. 2011 LiDAR data from the MNDNR and available surveyed elevations were used to estimate potentially flood-prone structures.
5. Potentially flood-prone structures are habitable structures including homes and businesses.
6. Unless noted in the report, no survey information was collected to identify potentially flood-prone structures.
7. Potentially flood-prone structures designated as "District" are located near District-managed facilities, lakes, or creeks, or where addressing flooding in these locations would likely change downstream peak flow rates and water elevations in multiple municipalities.
8. Potentially flood-prone structures designated as "Local" are not adjacent to District-managed facilities, lakes, or creeks. In many locations, flooding may be mitigated by modifications to the municipal stormwater system. Addressing flooding in these locations likely would not change downstream peak flows or water levels in downstream municipalities. In these locations, the municipality will likely lead the evaluation of system modifications to mitigate flood-risk, and the District may choose to be involved in a supporting role.

POTENTIALLY FLOOD-PRONE STRUCTURES IN THE GERVAIS CREEK SUBWATERSHED FOLLOWING SYSTEM MODIFICATIONS

Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-6

BARR | RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

3.2 Phase 2 – Grass Lake

The Grass Lake subwatershed is approximately 5,688 acres and includes portions of Shoreview and Roseville. There are four structures on Lake Owasso within the 100-year floodplain. However, since there are limited options to store flood water within the Lake Owasso subwatershed, potential watershed system modifications focus on evaluating potential changes to outlet control structures. However, immediately downstream of the Grass Lake subwatershed is the Gervais Creek system. And, as mentioned earlier, there are several flood-prone areas within the Gervais Creek subwatershed, including North Star Estates, a manufactured housing development south of Owasso Basin where many homes are located within the 100-year floodplain. Currently, a peak flow of approximately 4 cubic feet per second flows from the Grass Lake subwatershed to the Gervais Creek system. Increasing this flow rate, without other system modifications, results in increases to downstream water levels.

3.2.1 Current Condition Flooding Concerns

There are 205 potentially flood-prone habitable structures within the drainage area tributary to Grass Lake, Snail Lake, Wetland "A" and Twin Lake, as shown in Figure 3-8. There are 10 structures upstream of Grass Lake that are classified as "District," which indicates that they are near District-managed facilities, lakes, or creeks, or located where system modifications may change downstream peak flow rates and water levels in multiple municipalities. The remaining structures within the subwatershed are classified as "Local."

There are six potentially flood-prone, habitable structures classified as "District" near Victoria Street North and four structures on the eastern shore of Lake Owasso. The lowest home in this watershed, 313 S. Owasso Boulevard, is located on Lake Owasso and has a low adjacent grade elevation of 888.5 feet. Figure 3-7 shows this home and illustrates how the low adjacent grade was estimated when survey information was available. The current 100-year water level on Lake Owasso is 889.3, meaning the lowest home is approximately 0.8 ft below the floodplain.

In 2017, the District staff began coordination with municipalities to develop an Emergency Response Plan for Lake Owasso. The Emergency Response Plan (Reference [9]) includes contact information for local officials, temporary sandbag embankment alignments and details, and information regarding the 100-year floodplain. The Emergency Response Plan was developed to provide information to help the City respond to high water levels in Lake Owasso.

There are several homes within the subwatersheds with basements. For these structures, the elevation of the low adjacent grade was used to evaluate system modifications to mitigate flood risk. In other words, system modifications were evaluated to remove the ground adjacent to the structure from the floodplain; system modifications to lower the floodplain below a basement elevation were not considered.

There are several auxiliary structures such as sheds and garages that are also below the 100-year floodplain. As discussed in Section 2.1, potential system modifications to remove these structures from the floodplain were not considered as part of the evaluation.

Figure 3-7 Low Adjacent Grade for 313 S. Owasso Boulevard

Table 3-3 Potentially Flood-Prone Structures in the Grass Lake Subwatershed

Parcel ID	Address	Lowest Adjacent Grade	Source for Lowest Adjacent Grade	Existing 100-Year Water Surface Elevation
112923120009	2581 Fisk St, Roseville 55113	891.3	LiDAR[1]	892.3
112923120036	2575 Fisk St, Roseville 55113	890.5	LiDAR[1]	892.3
112923120037	2569 Fisk St, Roseville 55113	890.2	LiDAR[1]	892.3
112923120038	2561 Fisk St, Roseville 55113	890.3	LiDAR[1]	892.3
112923120080	778 Oakcrest Ave, Roseville 55113	891.5	LiDAR[1]	892.3
112923120079	768 Oakcrest Ave, Roseville 55113	891.5	LiDAR[1]	892.3
012923120001	313 S Owasso Blvd W, Roseville 55113	888.5	Barr 2017 Survey[2]	889.3
012923120006	341 South Owasso Blvd, Roseville 55113	888.7	Barr 2017 Survey[2]	889.3
012923120002	317 South Owasso Blvd, Roseville 55113	888.9	Barr 2017Survey[2]	889.3
012923220006	3115 Sandy Hook Dr, Roseville 55113	889.0	Barr 2017 Survey[2]	889.3

(1) Reference [5]
(2) Reference [9]

Since 2016, there has been significant concern about flooding in other areas near Grass Lake as well. These areas have been a focus of many studies and discussions by RWMWD staff. Some of these areas

may benefit from the potential system modifications evaluated, even though the modifications themselves are focused on mitigating flood-risk for low homes within the floodplain surrounding, and just upstream of Lake Owasso.

Suzanne Pond

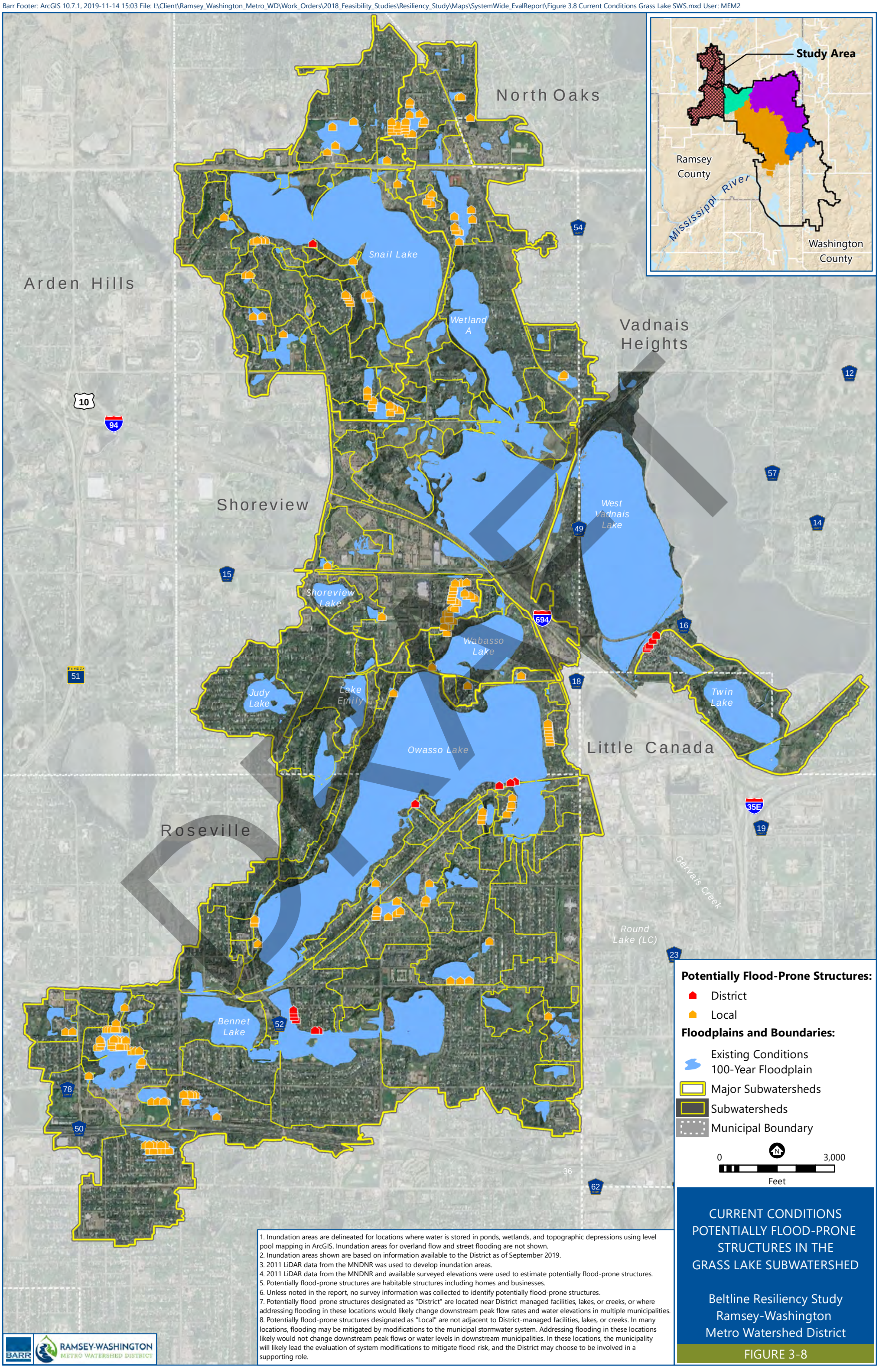
The water level in Suzanne Pond is controlled by a lift station that is operated and maintained by the City of Shoreview. Based on available information, the 100-year floodplain does not inundate low homes adjacent to Suzanne Pond. The most effective flood management strategy in this area is the maintenance of the City lift station and the reinforcement and raising of berms surrounding the pond, both of which are currently being evaluated by the City of Shoreview. Without the City lift station, the homes surrounding Suzanne Pond would be at risk of flooding during the 100-year storm event.

Snail Lake

The low home on Snail Lake 4380 Reiland Ln (elevation 886.0) lies below the overflow elevation of the lake (which is at 887.9) This home has been recently abandoned (due to vacancy- not due to flood damage) and is up for resale. District staff have been in communication with the property owner and even a prospective buyer of the property, explaining the risk of flooding to the home. Recent water levels in Snail Lake have nearly approached the home's low entry elevation (886.0). Other District studies have looked at several alternatives for mitigating flood-risk for structures on Snail Lake, however, the most viable option (implementing an outlet that connects Snail to Grass Lake) relies on the management of downstream flood levels in Grass Lake, and even then, would have to be shut off during flood events until water can gravity flow from Snail Lake to Grass Lake (and not in the opposite direction). At present, the most effective flood management strategy in this area is flood proofing the low home (dependent on coordination with the current property owners) and informing the current (already done) and prospective future buyers (already done once) about the flood risk on the property.

Vadnais-Snail Lake Regional Park System

Since 2016, trails in this park have been inundated and are inaccessible to park patrons. While not a focus of this Beltline Resiliency Study (the focus is protection of habitable structures) some of the options discussed here may provide some flood relief in this area.



1. Inundation areas are delineated for locations where water is stored in ponds, wetlands, and topographic depressions using level pool mapping in ArcGIS. Inundation areas for overland flow and street flooding are not shown.
2. Inundation areas shown are based on information available to the District as of September 2019.
3. 2011 LiDAR data from the MNDNR was used to develop inundation areas.
4. 2011 LiDAR data from the MNDNR and available surveyed elevations were used to estimate potentially flood-prone structures.
5. Potentially flood-prone structures are habitable structures including homes and businesses.
6. Unless noted in the report, no survey information was collected to identify potentially flood-prone structures.
7. Potentially flood-prone structures designated as "District" are located near District-managed facilities, lakes, or creeks, or where addressing flooding in these locations would likely change downstream peak flow rates and water elevations in multiple municipalities.
8. Potentially flood-prone structures designated as "Local" are not adjacent to District-managed facilities, lakes, or creeks. In many locations, flooding may be mitigated by modifications to the municipal stormwater system. Addressing flooding in these locations likely would not change downstream peak flows or water levels in downstream municipalities. In these locations, the municipality will likely lead the evaluation of system modifications to mitigate flood-risk, and the District may choose to be involved in a supporting role.

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

CURRENT CONDITIONS POTENTIALLY FLOOD-PRONE STRUCTURES IN THE GRASS LAKE SUBWATERSHED

Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-8

3.2.2 Evaluation of Potential System Modifications

As described in Section 3.1.2, the District stormwater model was used to evaluate potential system modifications within the Grass Lake subwatershed. The stormwater model was modified to evaluate the impact that potential system modifications would have on the 100-year floodplain. The goal for each system modification was to lower the 100-year flood level below habitable structures.

Evaluation of potential system modifications did not include discussions with property owners, permitting agencies, or other stakeholders. Additional evaluation for system modifications, including detailed feasibility studies that further evaluate economic and social considerations, is necessary prior to modifying the drainage system.

Based on available topographic information (Reference [5]), the lowest adjacent grade to the low home on Lake Owasso is 888.5 feet; the low structure upstream of Victoria Street is 890.2 feet. Flooding within these areas is primarily a result of runoff volume. In other words, flooding typically occurs as a result of longer rainfall events with higher rainfall depths and not for short, intense rainfall events. Since there are no significant locations where large retention projects could be considered, system modifications considered were generally limited changes to outlet control structures and conveyance systems.

Potential system modifications to mitigate flood risk in the Grass Lake subwatershed are divided into three steps (step 2A through 2CD) and are described in the following sections.

2A Victoria Street

Potential system modifications near Victoria Street are shown in Figure 3-9. Possible system modifications include improving conveyance between the wetland and Lake Owasso with culvert improvements at County Road C and the railroad. Potential system modifications shown in Figure 3-9 include:

- An additional 48-inch equivalent arch pipe or culvert with equivalent capacity at the same invert of existing arch pipes to route water from this area more quickly into Lake Owasso.

2B Lake Owasso

Potential system modifications to the Lake Owasso outlet are shown in Figure 3-10. System modifications include increasing the outlet capacity of Lake Owasso without changing the outlet elevation of the lake. System modifications shown in Figure 3-10 include:

- Three additional 42-inch equivalent arch pipes or pipes with an equivalent capacity.

2C Wabasso, Grass Lake and West Vadnais Lake

Potential system modifications downstream of Lake Owasso are shown in Figure 3-11 and Figure 3-12. Possible system modifications include increasing the outlet capacity of Lake Wabasso, Grass Lake, and West Vadnais Lake without changing the outlet elevations of each lake. Capacity modifications to all of these outlet control structures would be necessary to mitigate impacts to the 100-year water levels in

each of the lakes. The outlet from West Vadnais Lake, sized to prevent an increase in the 100-year water surface elevation, is assumed to connect to the MnDOT diversion discussed in Section 3.1.2. Other necessary modifications near the lake include improvements that would create a more stable, engineered berm (the current feature is an overgrown earthen embankment and not an engineered flood-risk mitigation feature) along the southeast side, just upstream of Five Star Estates. With this improvement and other modifications within the watershed a smaller outlet may be possible; a detailed feasibility study would be required to optimize the outlet configuration.

In addition, the District is evaluating modifications to the West Vadnais Lake outlet that would lower the invert of the existing 15-inch outlet by approximately 0.8-feet. If the outlet of West Vadnais Lake is lowered, further evaluation of potential system modifications described below would be required, as a smaller outlet from West Vadnais maybe possible. Potential system modifications shown in Figure 3-11 and Figure 3-12 include the following:

Lake Wabasso

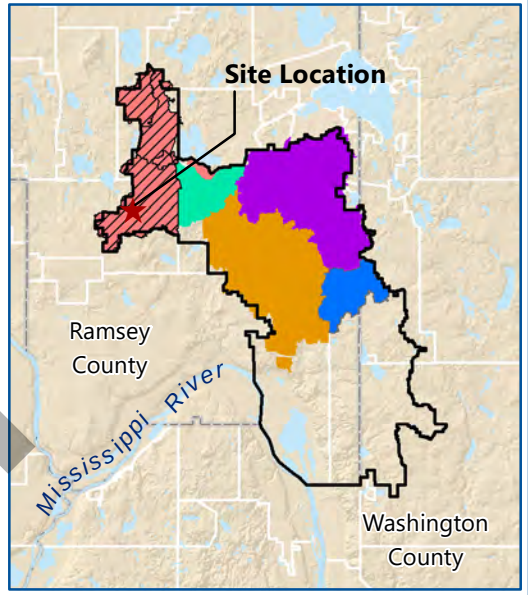
- Evaluate an increased weir length to a total of 20 feet for both weirs and maintain the existing natural channel (Figure 3-11).
- Evaluate adding three 54-inch equivalent arch pipes or pipes with equivalent capacity (Figure 3-11).
- Maintain and cleanout natural channels (Figure 3-11).

Grass Lake

- Evaluate adding two 30-inch equivalent arch pipes or pipes with equivalent capacity (Figure 3-11).
- Evaluate adding 60-inch equivalent arch pipe or pipes with equivalent capacity below railroad (Figure 3-11).
- Evaluate adding 36-inch-diameter outlet or pipes with equivalent capacity at existing Rice Street outlet elevation (Figure 3-11).

West Vadnais Lake

- Evaluate adding three 60-inch equivalent arch pipes or pipes with equivalent capacity through Vadnais Boulevard (Figure 3-12).
- Evaluating adding two 48-inch equivalent arch pipes or pipes with equivalent capacity for West Vadnais outlet (Figure 3-12).
- Construct an engineered berm along the southeast side of the lake upstream of Five Star Estates and Twin Lake (Figure 3-12).



Potentially Flood-Prone Structures:

Structures Removed from Floodplain

Design Elements:

Pipe

Existing Storm Sewer Pipe

100-Year Floodplain:

Following System Modifications

Existing Atlas 14 Inundation

0 500

Feet

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

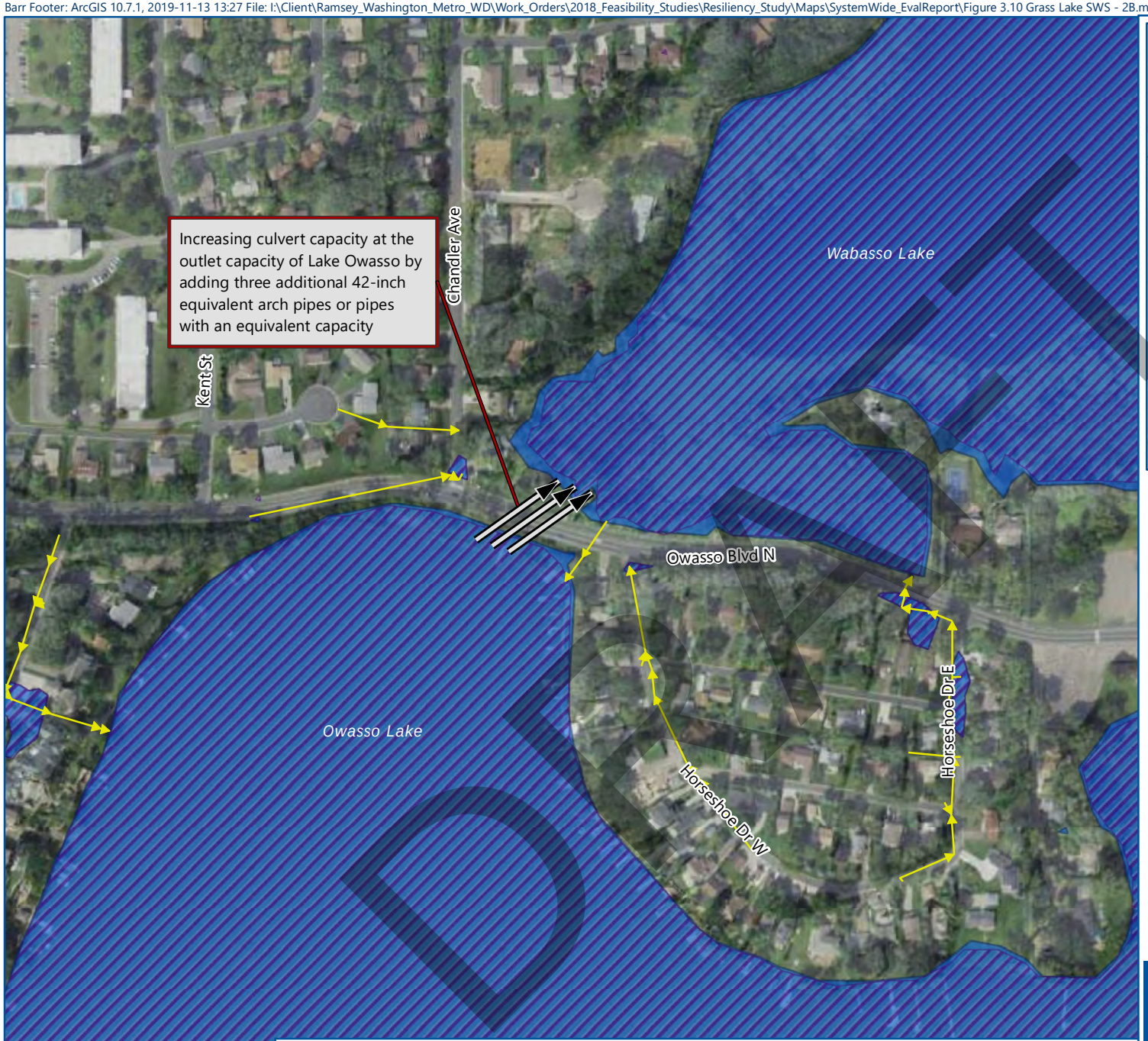
BARR

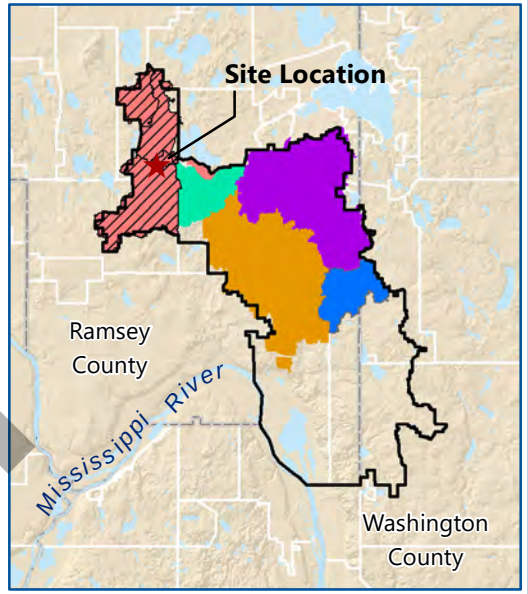
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

GRASS LAKE SUBWATERSHED SYSTEM MODIFICATIONS 2A

Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-9





Potentially Flood-Prone Structures:

Structures Removed from Floodplain

Design Elements:

Pipe

Existing Storm Sewer Pipe

100-Year Floodplain:

Following System Modifications

Existing Atlas 14 Inundation

0 500

Feet

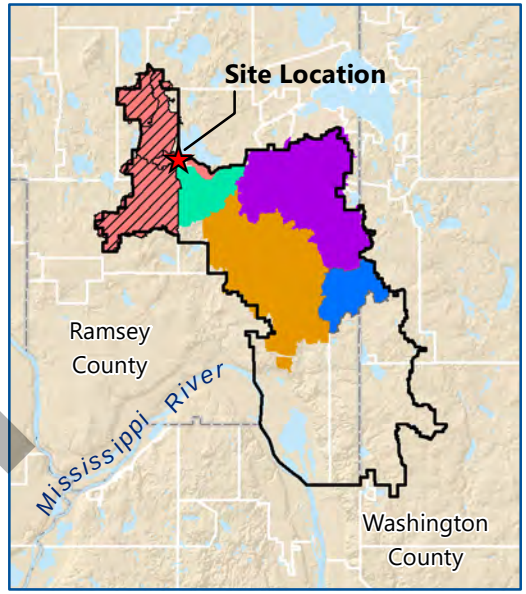
1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

GRASS LAKE SUBWATERSHED
SYSTEM MODIFICATIONS
2B
Beltline Resiliency Study
Ramsey-Washington
Metro Watershed District

FIGURE 3-10



Potentially Flood-Prone Structures:

- Structures Removed from Floodplain

Design Elements:

- Increase Weir Length
- Pipe
- Restore Ditch Capacity
- Existing Storm Sewer Pipe

100-Year Floodplain:

- Following System Modifications
- Existing Atlas 14 Inundation

0 1,000 Feet

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

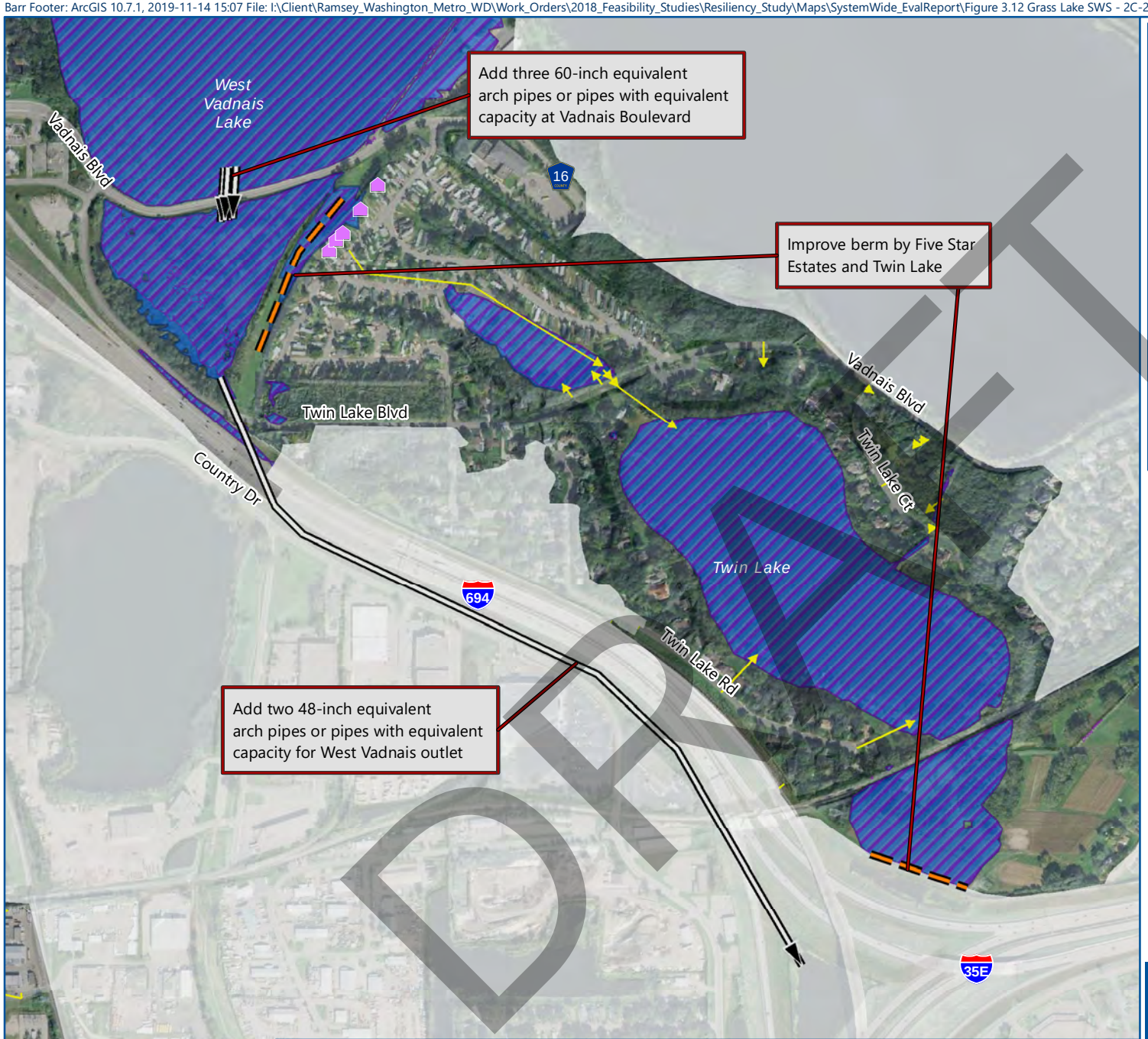
BARR

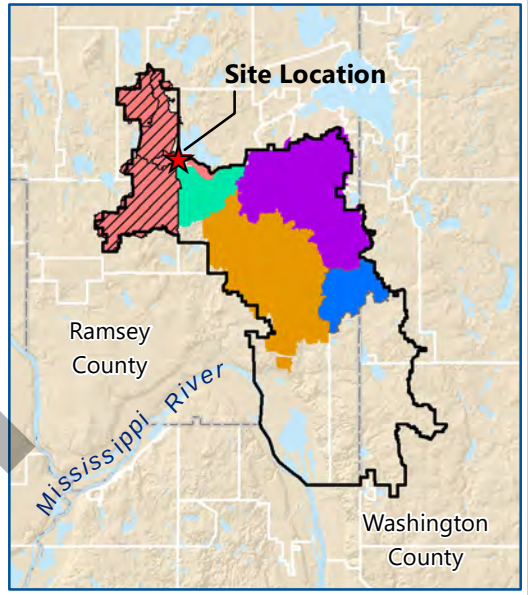
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

GRASS LAKE SUBWATERSHED SYSTEM MODIFICATIONS 2C-1

Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-11





Potentially Flood-Prone Structures:

- Structures Removed from Floodplain

Design Elements:

- Increase Weir Length
- Pipe
- Site Grading
- Existing Storm Sewer Pipe

100-Year Floodplain:

- Following System Modifications
- Existing Atlas 14 Inundation

0 1,000
Feet

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

BARR
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

GRASS LAKE SUBWATERSHED SYSTEM MODIFICATIONS 2C-2

Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-12

3.2.3 Flooding Concerns following System Modifications

The potential system modifications result in lowering the 100-year floodplain below the low adjacent grade of habitable structures within the Grass Lake subwatershed. The 100-year floodplain following system modifications is shown in Figure 3-13.

The potential system modifications evaluated include changes to the Lake Wabasso, Grass Lake, and West Vadnais Lake outlets. Outlet modifications for these lakes were evaluated to prevent increases to the 100-year floodplain. Modifications were not evaluated to lower the floodplain in these areas where there have been no habitable structures identified below the 100-year floodplain.

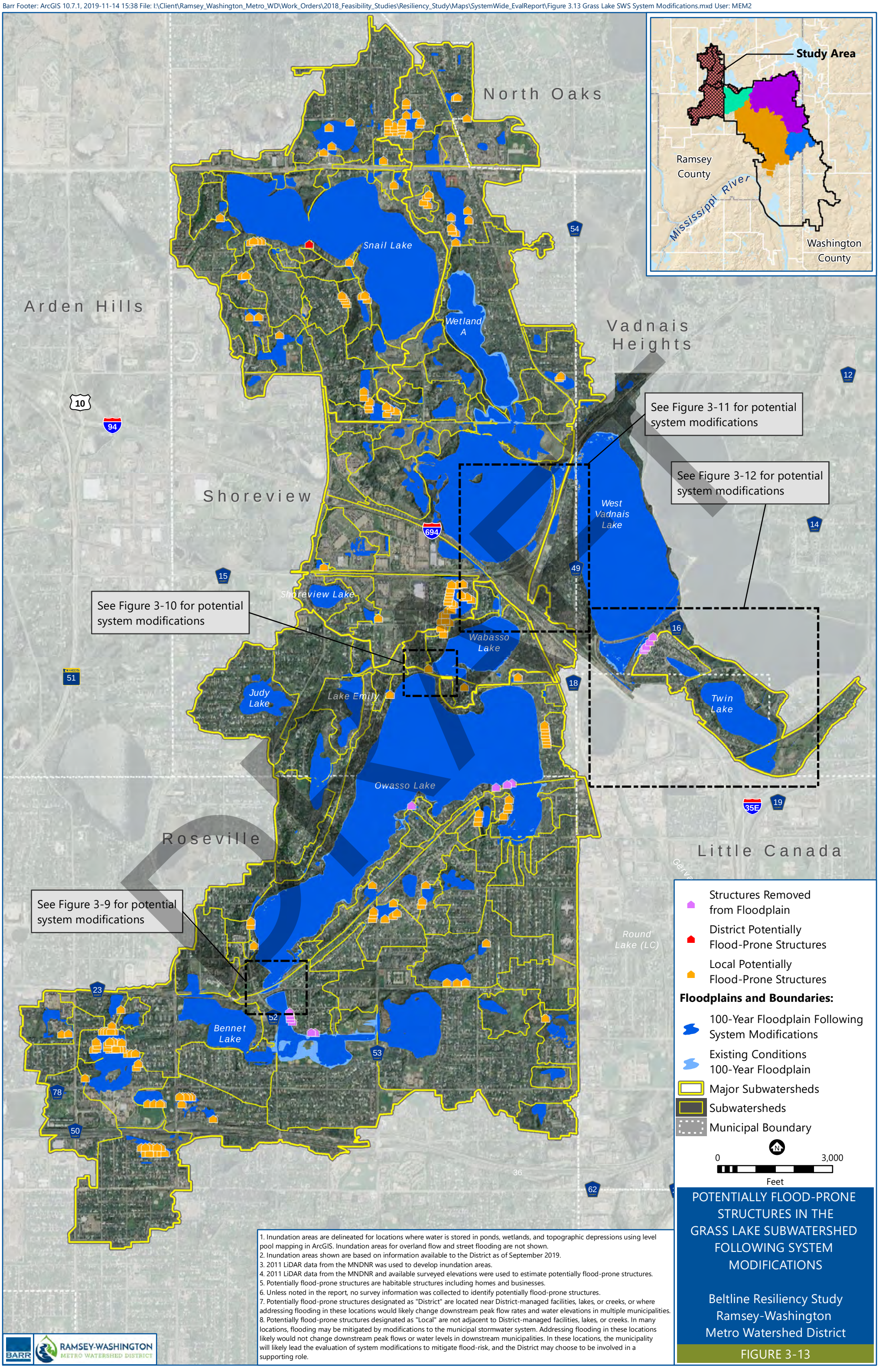
Table 3-3 lists the existing 100-year water surface elevation and the elevation following modifications to the drainage system.

Table 3-3 also includes planning-level considerations related to project sequencing to avoid increases to downstream water levels. Project sequencing refers to the order that system modifications should be constructed to prevent adverse downstream impacts. For this evaluation, sequencing does not refer to prioritization, which refers to which area should be addressed first. For example, improvements to the downstream portion of the system should be constructed prior to increasing the discharge conveyed from upstream areas. Prerequisite system modifications listed in Table 3-2 refer to modifications that should be constructed prior to the system modification to mitigate flood risk for each parcel. System modifications in the Grass Lake subwatershed assume that system modifications in the Gervais Creek subwatershed (Section 3.1) and modification of the Keller Creek and Lake Phalen control structures (Section 3.4) have already been constructed. If these system modifications are not in place, then the sizing, function, or configuration of system modifications presented may change or impact downstream water levels. A planning-level schematic for sequencing of potential system modifications is included in Appendix A.

Table 3-4 Potentially Flood-Prone Structures in the Grass Lake Subwatershed

Parcel ID	Address	Lowest Adjacent Grade	Existing 100-year Water Surface Elevation	100-year Water Surface Elevation following System Modifications	System Modification to Reduce Flood Risk	Prerequisite System Modifications [3]
112923120009	2581 Fisk St, Roseville 55113	891.34[1]	892.3	890.0	2A	2B, 2C
112923120036	2575 Fisk St, Roseville 55113	890.5[1]	892.3	890.0	2A	2B, 2C
112923120037	2569 Fisk St, Roseville 55113	890.2[1]	892.3	890.0	2A	2B, 2C
112923120038	2561 Fisk St, Roseville 55113	890.7[1]	892.3	890.0	2A	2B, 2C
112923120080	778 Oakcrest Ave, Roseville 55113	891.5[1]	892.3	890.0	2A	2B, 2C
112923120079	768 Oakcrest Ave, Roseville 55113	891.5[1]	892.3	890.0	2A	2B, 2C
012923120001	313 S Owasso Blvd W, Roseville 55113	888.5[2]	889.3	888.5	2B	2C
012923120006	341 South Owasso Blvd, Roseville 55113	888.7[2]	889.3	888.5	2B	2C
012923120002	317 South Owasso Blvd, Roseville 55113	888.9[2]	889.3	888.5	2B	2C
012923220006	3115 Sandy Hook Dr, Roseville 55113	889.0[2]	889.3	888.5	2B	2C

(1) Reference [5]
(2) Reference [9]
(3) See Appendix A for planning-level sequencing schematic. Grass Lake system modifications assume that system modifications described in Phase 1 – Gervais Creek, and Phase 4 – Phalen Chain of Lakes related to the Keller Creek and Lake Phalen control structures have been constructed.



1. Inundation areas are delineated for locations where water is stored in ponds, wetlands, and topographic depressions using level pool mapping in ArcGIS. Inundation areas for overland flow and street flooding are not shown.
2. Inundation areas shown are based on information available to the District as of September 2019.
3. 2011 LiDAR data from the MNDNR was used to develop inundation areas.
4. 2011 LiDAR data from the MNDNR and available surveyed elevations were used to estimate potentially flood-prone structures.
5. Potentially flood-prone structures are habitable structures including homes and businesses.
6. Unless noted in the report, no survey information was collected to identify potentially flood-prone structures.
7. Potentially flood-prone structures designated as "District" are located near District-managed facilities, lakes, or creeks, or where addressing flooding in these locations would likely change downstream peak flow rates and water elevations in multiple municipalities.
8. Potentially flood-prone structures designated as "Local" are not adjacent to District-managed facilities, lakes, or creeks. In many locations, flooding may be mitigated by modifications to the municipal stormwater system. Addressing flooding in these locations likely would not change downstream peak flows or water levels in downstream municipalities. In these locations, the municipality will likely lead the evaluation of system modifications to mitigate flood-risk, and the District may choose to be involved in a supporting role.

POTENTIALLY FLOOD-PRONE STRUCTURES IN THE GRASS LAKE SUBWATERSHED FOLLOWING SYSTEM MODIFICATIONS

Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-13

BARR
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

3.2.4 Alternative Evaluations

During the evaluation, two additional alternatives were evaluated to mitigate flood risk upstream of West Vadnais Lake. The first consisted of constructing a new outlet from Lake Owasso to convey stormwater to the east, (bypassing Lake Wabasso, Grass Lake and West Vadnais Lake) and the second was a seasonal drawdown of West Vadnais Lake. Each alternative is described in the following sections.

3.2.4.1 Lake Owasso Outlet

The first alternative evaluated is a second outlet from Lake Owasso. During discussions with the Board and residents, this alternative has been referred to by RWMWD staff and managers as the "Lake Owasso Shunt". The alternative consists of constructing a second outlet on the east side of Lake Owasso that discharges to the east, connecting to either Black Tern Pond and then Owasso Basin, or directly to Gervais Creek downstream of Owasso Basin. Schematics for the Lake Owasso outlet configurations are shown in Figure 3-14.

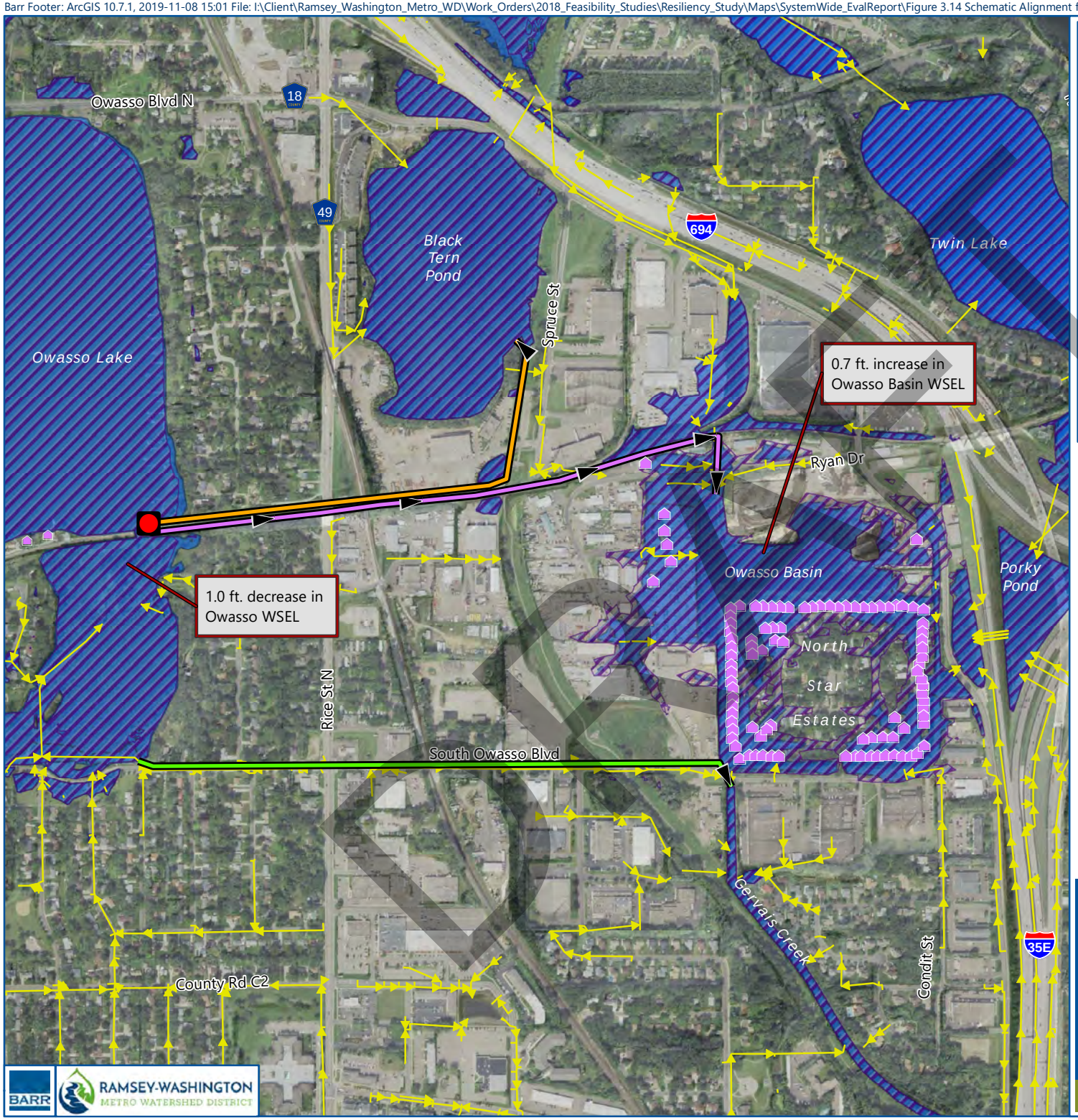
The evaluation of the second outlet from Lake Owasso showed that it was not as effective at reducing flood risk for habitable structures on Lake Owasso or for lowering the water levels in West Vadnais Lake as system modifications included in Step 2C.

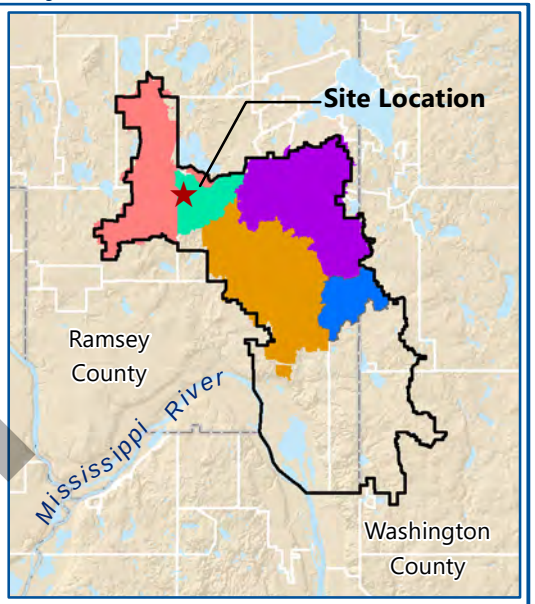
To reduce the floodplain in Lake Owasso and mitigate flood risk for existing habitable structures a large volume of stormwater needs to be conveyed to the Gervais Creek system. The Gervais Creek system is currently undersized and does not have capacity to safely convey additional flow downstream. System modifications for the Gervais Creek system, discussed in Section 3.1.2, would divert stormwater around Owasso Basin and lower the 100-year water level, but would not provide freeboard for the low homes. A new outlet from Lake Owasso would increase the stormwater that is conveyed to (or near) Owasso Basin. Additional system modifications in the Gervais Creek subwatershed could be evaluated, but the flat slope of Gervais Creek will likely limit the effectiveness of improvements to add conveyance capacity.

In addition, a second outlet from Lake Owasso increases the rate at which flow reaches Gervais Creek. In other words, flow would reach Gervais Creek faster, because water is not routed through Lake Wabasso, Grass Lake, and West Vadnais Lake. The increase in flow rate results in increases to the 100-year water levels along Gervais Creek and the Phalen Chain of Lakes, even if the outlet structures on the Phalen Chain are actively managed during a flood event.

To mitigate flood risk to habitable structures on Lake Owasso, flow would only be diverted during periods when water levels on Lake Owasso are high. This would have limited effect on recent high water levels in Grass Lake and West Vadnais Lake. This is because high water-levels on Grass Lake and West Vadnais Lake are generally volume driven. In other words, long wet periods of steady rainfall can result in high water levels in Grass Lake and West Vadnais. Typically, these types of rainfall events do not pose a flood risk for homes on Lake Owasso. Flood risk for Lake Owasso is more likely a result of rainfall events with higher intensity, which don't necessarily result in higher water levels in Grass Lake and West Vadnais Lake. By comparison, the system modifications presented in Section 3.2.2 mitigate flood risk for habitable

structures on Lake Owasso and address recent prolonged periods of high water levels in Grass Lake and West Vadnais Lake.





Potentially Flood-Prone Structures:

- Structures Removed from Floodplain

Design Elements:

- Outlet
- Flow to Black Tern Pond
- Flow to Gervais Creek
- Flow to Owasso Basin
- Existing Storm Sewer Pipe

100-Year Floodplain:

- Following System Modifications
- Existing Atlas 14 Inundation

N

0 1,000

Feet

SCHEMATIC ALIGNMENT FOR HIGH-FLOW OUTLET FROM LAKE OWASSO

Beltline Resiliency Study
Ramsey-Washington
Metro Watershed District

FIGURE 3-14

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

3.2.4.2 Seasonal Drawdown for West Vadnais Lake

The effect of a potential seasonal (late fall through winter) drawdown of West Vadnais Lake was evaluated. A seasonal drawdown could lower water levels below Rice Street temporarily. However, a seasonal drawdown does not mitigate flood risk for habitable structures below the 100-year floodplain.

The effect of a seasonal drawdown was evaluated by using the District stormwater model. The past four years of rainfall were simulated to develop a time series of water levels for West Vadnais Lake. The seasonal operation assumed that West Vadnais Lake would be drawn down during the late fall when water elevations in the Phalen Chain of Lakes are typically low. This operational plan was selected to avoid increases to water levels during the spring and summer months when flooding typically occurs. It was assumed that West Vadnais Lake could be drawn down to elevation 881.0 as shown in Figure 3-15.

The seasonal drawdown simulations indicate that water levels could be lowered during the fall and winter months without significant increases in flood risk downstream. Based on recent rainfall patterns, seasonal drawdown may not result in a significant reduction to the peak water level in West Vadnais Lake, but would reduce the duration high water levels. If a seasonal drawdown is pursued, additional design and analysis of the outlet configuration and operation would be required.

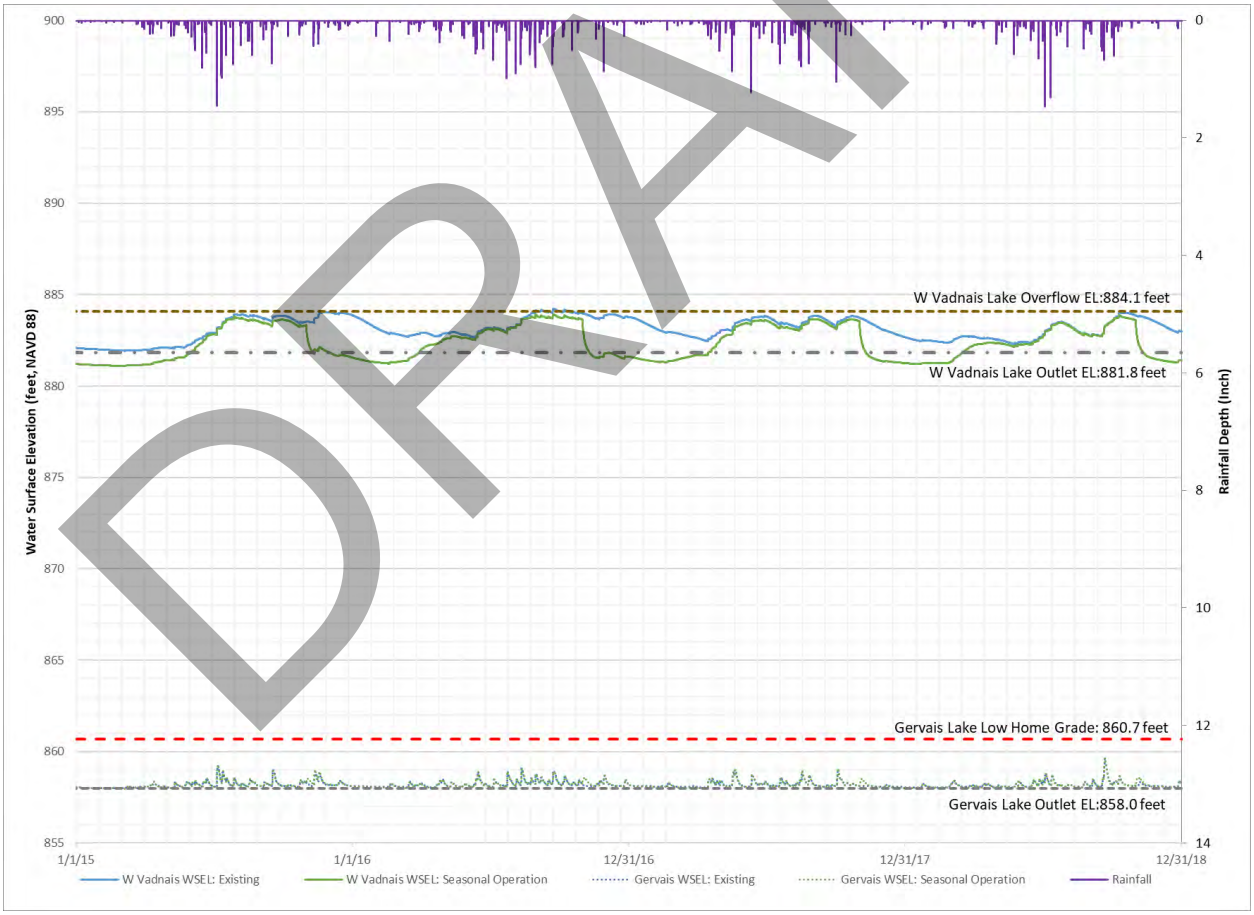


Figure 3-15 West Vadnais Lake and Gervais Lake Water Levels following Seasonal Drawdown

3.3 Phase 3 – Kohlman Creek and Willow Creek

The Willow Creek subwatershed is approximately 2,923 acres and includes portions of White Bear Lake, Vadnais Heights, Gem Lake, and Maplewood. The Kohlman Creek subwatershed is approximately 3,563 acres and includes portions of North Saint Paul, Maplewood, and Oakdale. There are 106 structures within the 100-year floodplain.

3.3.1 Current Condition Flooding Concerns

There are 106 potentially flood-prone structures in the Willow Creek and Kohlman Creek subwatersheds. Potentially flood-prone structures are shown in Figure 3-16 and Figure 3-17. There are 40 habitable structures classified as "District" and 66 classified as "Local."

The majority of potentially flood-prone structures in the Willow Creek subwatershed are near Burke Road Pond and the upstream wetland. These structures are located near the Willow Creek drainage improvement project that the District completed in 2003.

Table 3-5 lists the potentially flood-prone structures in the Willow Creek subwatershed classified as "District." System modifications discussed in Section 3.3.2 were evaluated to remove structures listed in Table 3-5 from the floodplain.

Table 3-5 Potentially Flood-Prone Structures in the Willow Creek Subwatersheds

Parcel ID	Address	Lowest Adjacent Grade	Source for Lowest Adjacent Grade	Existing 100-Year Water Surface Elevation
343022420021	1803 Buerkle Rd, White Bear Lake 55110	914.6	LiDAR[1]	914.5
343022410009	1851 Buerkle Rd, White Bear Lake 55110	913.3	LiDAR[1]	914.5
343022410013	1825 Buerkle Rd, White Bear Lake 55110	913.2	LiDAR[1]	914.5
343022410007	1805 Buerkle Rd, White Bear Lake 55110	913.4	LiDAR[1]	914.5
343022420018	1791 Buerkle Cir, White Bear Lake 55110	913.0	LiDAR[1]	914.5
353022320025	3200 Orchard Ct, White Bear Lake 55110	913.5	LiDAR[1]	914.5
353022320024	3210 Orchard Ct, White Bear Lake 55110	913.8	LiDAR[1]	914.5
353022320026	3215 Orchard Ct, White Bear Lake 55110	914.3	LiDAR[1]	914.5
353022320022	3230 Orchard Ct, White Bear Lake 55110	914.2	LiDAR[1]	914.5
353022320021	3240 Orchard Ct, White Bear Lake 55110	914.0	LiDAR[1]	914.5
353022320030	3255 Orchard Ct, White Bear Lake 55110	914.4	LiDAR[1]	914.5
353022320032	1790 Orchard Ln, White Bear Lake 55110	912.9	LiDAR[1]	914.5

(1) Reference [5]

Kohlman Creek Current Flooding Concerns

Potentially flood-prone structures are distributed throughout the Kohlman Creek subwatershed. Near the upstream end of the watershed there are flood-prone structures near the North Saint Paul Ecology Center. Moving downstream there are flood-prone structures near PCU Pond, east of White Bear Avenue North, Markham Pond, and Kohlman Basin.

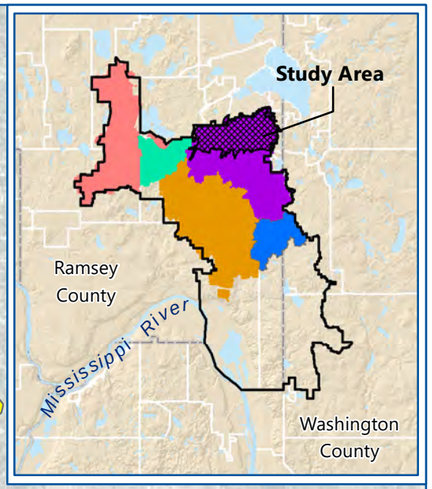
The District has completed several drainage improvement and flood-risk-reduction projects in the Kohlman Creek subwatershed. Previous projects include the Casey Lake outlet in 1991, Target Pond (now known as PCU Pond) and the White Bear road control in 1994, and the Kohlman Basin pipeline in 1996.

Table 3-6 lists the potentially flood-prone structures in the Kohlman Creek subwatershed classified as "District." System modifications, discussed in Section 3.3.2, were evaluated to remove structures listed in Table 3-6 from the floodplain.

Table 3-6 Potentially Flood-Prone Structures in the Kohlman Creek Subwatersheds

Parcel ID	Address	Lowest Adjacent Grade	Source for Lowest Adjacent Grade	Existing 100-year Water Surface Elevation
142922110010	2145 5th St, North St. Paul 55109	945.7	LiDAR[1]	946.2
112922410013	2220 Hwy 36, North St. Paul 55109	938.6	LiDAR[1]	940.8
112922410014	2204 Hwy 36, North St. Paul 55109	939.4	LiDAR[1]	940.8
112922210053	2600 White Bear Ave, Maplewood 55109	920.1	LiDAR[1]	922.7
042922410013	2806 Maplewood Dr, Maplewood 55109	867.6	LiDAR[1]	870.3
032922420009	1570 Beam Ave, Maplewood 55109	885.7	LiDAR[1]	886.3
032922410011	1670 Beam Ave, Maplewood 55109	890.0	LiDAR[1]	890.1
112922440015	2157 South Ave, North St. Paul 55109	940.7	LiDAR[1]	940.8
112922440014	2159 South Ave, North St. Paul 55109	939.3	LiDAR[1]	940.8
112922440014	2159 South Ave, North St. Paul 55109	939.5	LiDAR[1]	940.8
112922430108	2187 6th St, North St. Paul 55109	940.3	LiDAR[1]	941.0
112922440029	2172 6th St, North St. Paul 55109	940.3	LiDAR[1]	940.8
112922430105	2205 6th St, North St. Paul 55109	940.4	LiDAR[1]	941.0
112922230007	1807 Gervais Ct, Maplewood 55109	910.9	LiDAR[1]	913.6
112922230006	1801 Gervais Ave, Maplewood 55109	913.5	LiDAR[1]	913.6
112922230006	1801 Gervais Ave, Maplewood 55109	913.6	LiDAR[1]	913.6
112922230006	1801 Gervais Ave, Maplewood 55109	912.8	LiDAR[1]	913.6
122922230017	2268 13th Ave, North St. Paul 55109	936.9	LiDAR[1]	937.0
112922120078	2133 13th Ave, North St. Paul 55109	935.8	LiDAR[1]	936.6
112922110071	2139 13th Ave, North St. Paul 55109	937.7	LiDAR[1]	936.6
112922120079	2127 13th Ave, North St. Paul 55109	934.5	LiDAR[1]	936.6
112922120100	2119 13th Ave, North St. Paul 55109	934.8	LiDAR[1]	936.6
112922120077	2138 14th Ave, North St. Paul 55109	936.4	LiDAR[1]	936.6
112922120076	2132 14th Ave, North St. Paul 55109	935.2	LiDAR[1]	936.6
112922120111	2570 Seans Way, North St. Paul 55109	932.6	LiDAR[1]	936.6
112922120102	2576 Seans Way, North St. Paul 55109	935.0	LiDAR[1]	936.6
112922210025	2599 Ariel St, Maplewood 55109	922.5	LiDAR[1]	922.7
112922220022	1876 County Rd C, Maplewood 55109	911.6	LiDAR[1]	913.6
112922220017	1862 County Rd C, Maplewood 55109	911.9	LiDAR[1]	913.6

(1) Reference [5]



Gem Lake

White
Bear Lake

Vadnais
Heights

Mahtomedi

Little
Canada

Maplewood

Willow Lake

Willow Creek

Pepper
Tree
Pond

Varney
Pond

Heiner's
Lake

Handlo's
Lake

14
59
35E
15
70
68
694
65
61
19
20
244

Potentially Flood-Prone Structures:

- District
- Local

District Facilities:

- Stormwater Structure
- Storm Sewer / Culvert

Floodplains and Boundaries:

- Existing Conditions 100-Year Floodplain
- Major Subwatersheds
- Subwatersheds
- Municipal Boundary

0 2,500
Feet

1. Inundation areas are delineated for locations where water is stored in ponds, wetlands, and topographic depressions using level pool mapping in ArcGIS. Inundation areas for overland flow and street flooding are not shown.
2. Inundation areas shown are based on information available to the District as of September 2019.
3. 2011 LiDAR data from the MNDNR was used to develop inundation areas.
4. 2011 LiDAR data from the MNDNR and available surveyed elevations were used to estimate potentially flood-prone structures.
5. Potentially flood-prone structures are habitable structures including homes and businesses.
6. Unless noted in the report, no survey information was collected to identify potentially flood-prone structures.
7. Potentially flood-prone structures designated as "District" are located near District-managed facilities, lakes, or creeks, or where addressing flooding in these locations would likely change downstream peak flow rates and water elevations in multiple municipalities.
8. Potentially flood-prone structures designated as "Local" are not adjacent to District-managed facilities, lakes, or creeks. In many locations, flooding may be mitigated by modifications to the municipal stormwater system. Addressing flooding in these locations likely would not change downstream peak flows or water levels in downstream municipalities. In these locations, the municipality will likely lead the evaluation of system modifications to mitigate flood-risk, and the District may choose to be involved in a supporting role.

CURRENT CONDITIONS POTENTIALLY FLOOD-PRONE STRUCTURES IN THE WILLOW CREEK SUBWATERSHED

Beltline Resiliency Study
Ramsey-Washington
Metro Watershed District

FIGURE 3-16

BARR
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Vadnais Heights

White Bear Lake

Little Canada

Maplewood

Oakdale

North Saint Paul

Kohlman Lake

Kohlman Basin

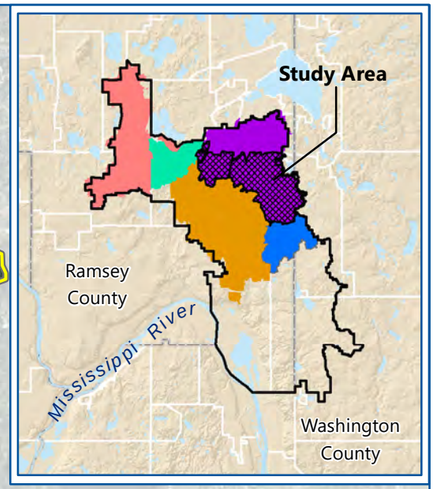
Markham Pond

Kohlman Creek

Casey Lake

PCU Pond

North St. Paul Urban Ecology Center



Potentially Flood-Prone Structures:
- District
- Local

District Facilities:
- CIP
- Outfall
- Stormwater Structure
- Storm Sewer / Culvert

Floodplains and Boundaries:
- Major Subwatersheds
- Existing Conditions 100-Year Floodplain
- Municipal Boundary
- Subwatersheds

0 3,000
Feet

CURRENT CONDITIONS POTENTIALLY FLOOD-PRONE STRUCTURES IN THE KOHLMAN CREEK SUBWATERSHED

Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-17

1. Inundation areas are delineated for locations where water is stored in ponds, wetlands, and topographic depressions using level pool mapping in ArcGIS. Inundation areas for overland flow and street flooding are not shown.
2. Inundation areas shown are based on information available to the District as of September 2019.
3. 2011 LiDAR data from the MNDNR was used to develop inundation areas.
4. 2011 LiDAR data from the MNDNR and available surveyed elevations were used to estimate potentially flood-prone structures.
5. Potentially flood-prone structures are habitable structures including homes and businesses.
6. Unless noted in the report, no survey information was collected to identify potentially flood-prone structures.
7. Potentially flood-prone structures designated as "District" are located near District-managed facilities, lakes, or creeks, or where addressing flooding in these locations would likely change downstream peak flow rates and water elevations in multiple municipalities.
8. Potentially flood-prone structures designated as "Local" are not adjacent to District-managed facilities, lakes, or creeks. In many locations, flooding may be mitigated by modifications to the municipal stormwater system. Addressing flooding in these locations likely would not change downstream peak flows or water levels in downstream municipalities. In these locations, the municipality will likely lead the evaluation of system modifications to mitigate flood-risk, and the District may choose to be involved in a supporting role.

BARR | RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.7.1, 2019-11-08 15:04 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2018_Feasibility_Studies\Resiliency_Study\Maps\SystemWide_EvalReport\Figure 3.17 Current Conditions Kohlman Creek SWS.mxd User: MEM2

3.3.2 Potential System Modifications Evaluated

As described in Section 3.1.2, the District stormwater model was used to evaluate potential system modifications within the Willow Creek and Kohlman Creek subwatersheds. The stormwater model was modified to evaluate the impact that potential system modifications would have on the 100-year floodplain. The goal for each system modification was to prevent the 100-year flood level from inundating habitable structures.

Evaluation of potential system modifications did not include discussions with property owners, permitting agencies, or other stakeholders. Additional evaluation for system modifications, including detailed feasibility studies that further evaluate economic and social considerations, is necessary prior to modifying the drainage system.

There are no potentially flood-prone structures on Willow Lake. Potential system modifications considered improve conveyance through Willow Creek and Willow Lake outlet modifications to provide additional floodplain storage. Potential system modifications to mitigate flood risk in the Willow Creek subwatershed are summarized in steps 3A and 3B.

Flood-prone structures are more distributed in the Kohlman Creek subwatershed. Potential system modifications considered include drainage improvements, floodplain storage, outlet modifications, and diverting the storm sewer. Potential system modifications to mitigate flood risk in the Kohlman Creek subwatershed are summarized in steps 3C through 3G.

3A Willow Creek – Highway 61

Potential modifications to address flood risk upstream of the Buerkle Road embankment are shown on Figure 3-18. Possible modifications include drainage improvements to convey water downstream of Highway 61. Potential system modifications shown in Figure 3-18 include:

- Evaluating adding culvert capacity at the railroad east of the Burke Road Honda.
- Evaluating adding storm sewer capacity between the railroad and existing pipe on Highway 61, bypassing the Burke Road Honda.
- Evaluating adding culvert capacity under the trail west of Highway 61.

3B Willow Creek - Willow Lake

No flood-prone structures were identified near Willow Lake. However, to mitigate increases to the 100-year water levels downstream, additional floodplain storage was provided near the lake. Potential modifications assumed embankment construction and outlet structure modifications. Possible system modifications near Willow Lake are shown in Figure 3-19, and include:

- Evaluating modifying the trail upstream of Willow Lake to provide floodplain storage.
- Evaluating modifying Willow Lake outlet to actively manage downstream discharge.

3C Kohlman Creek – North Saint Paul Urban Ecology Center

Potential system modifications to mitigate flood risk near the North Saint Paul Urban Ecology Center are shown on Figure 3-20 and Figure 3-21. Possible system modifications include a combination of upstream retention and drainage improvements. Figure 3-20 shows potential locations for providing additional flood storage volume. The location of the additional storage volume could be optimized during future evaluations. Above- or below-ground storage BMPs could be provided. Underground BMPs may have less impact on existing parks and open space but are more expensive than above-ground storage. Figure 3-21 shows drainage improvements southwest of the intersection of McKnight Road and Highway 36. Drainage improvements include additional conveyance capacity and localized grading or flood proofing of low structures. System modifications near the North Saint Paul Urban Ecology Center are shown in Figure 3-20 and Figure 3-21, and include:

- Evaluate providing floodplain storage southeast of the intersection of McKnight Road and Holloway Ave East. The outlet from the storage BMP should include extended detention or be actively managed to reduce downstream peak flow (Figure 3-20).
- Evaluate providing floodplain storage to the east of the intersection of 7th Avenue and 6th Street (Figure 3-20).
- Evaluate modifying the storm sewer at 5th Street North to divert stormwater to a depression south of the trail before discharging to the Saint Paul Urban Ecology Center wetland (Figure 3-21).
- Evaluate adding culvert capacity at 6th Street North (Figure 3-21).
- Evaluate adding culvert capacity at Highway 36 (Figure 3-21).
- Evaluate providing localized grading or flood proofing the building edge at 2220 Highway 36 (Figure 3-21).

3D Kohlman Creek – PCU Pond

Potential system modifications to mitigate flood risk near PCU Pond are shown in Figure 3-22 and Figure 3-23. These include a combination of possible modifications to the storm sewer system and drainage improvements near PCU Pond. Figure 3-22 shows potential drainage improvements near PCU Pond, including modifications to 13th Avenue East and underground storage in the Target parking lot. The location of the additional storage volume could be optimized during future evaluations. Above- or below-ground storage options could be considered. Underground BMPs may have less impact on the existing parking lot but are more expensive than above-ground storage. Figure 3-23 shows storm sewer modifications to divert stormwater runoff from PCU Pond to Casey Lake. System modifications near PCU Pond:

- Evaluating installing backflow preventers on the existing pipes below 13th Avenue East (Figure 3-22).

- Evaluate adding culvert capacity and a backflow preventer for the outlet from the depression north of 13th Avenue East. New pipes discharge directly to Kohlman Creek (Figure 3-22).
- Evaluate raising approximately 750 feet of 13th Street East (Figure 3-22).
- Evaluate installing green infrastructure under Target to capture 1 inch of runoff. Green infrastructure may include underground storage chambers, rainwater gardens, etc. (Figure 3-22).
- Evaluate modifying the storm sewer to divert approximately 155 acres to Casey Lake (Figure 3-23).

3E Kohlman Creek – Casey Lake

To mitigate flood-prone areas in Step 3D, approximately 155 acres could be diverted to Casey Lake. Modifications to the Casey Lake outlet and downstream creek crossings to convey the additional volume are shown in Figure 3-24, and include:

- Evaluate modifying the Casey Lake outlet.
- Evaluate adding culvert capacity at White Bear Avenue North (one additional 42-inch culvert, or equivalent).
- Evaluate modifying overflow from the wetland downstream of White Bear Avenue North.

3F Kohlman Creek – West of White Bear Avenue North

Potential modifications downstream of White Bear Avenue North include drainage improvements, constructing additional floodplain storage volume, and floodproofing existing structures. Providing additional floodplain storage in this subwatershed serves two purposes: (1) the additional storage volume mitigates flood risk for structures along Kohlman Creek and (2) the storage volume also reduces the water levels on the Phalen Chain of Lakes.

Flood proofing is proposed for structures when the 100-year floodplain is within 0.2 feet of the structure and significant system modifications would be required to lower the water level an additional 0.2 feet. This methodology was used for planning purposes because 0.2 feet is generally within the accuracy of the topography used to develop the inundation mapping. During the next phase of design a detailed survey of individual structures within a flood-prone area should be completed; this could change the size, configuration, or function of the potential system modifications downstream of White Bear Avenue North shown on Figure 3-25 to Figure 3-28 and described below:

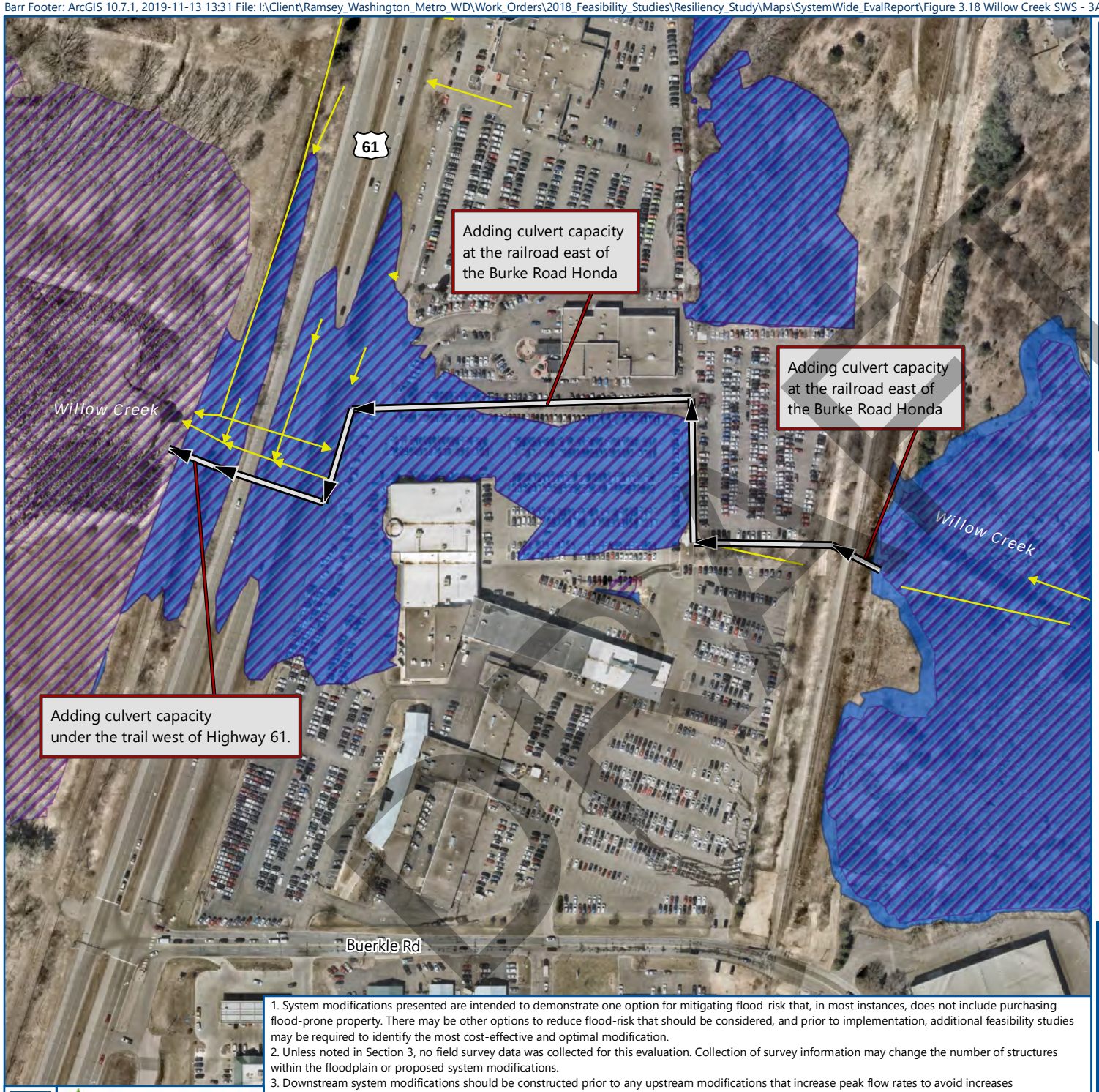
- Provide additional storage volume northeast of the intersection of White Bear Ave and Beam Avenue East (Figure 3-25)
- Modify the outlet from the pond northeast of the intersection of White Bear Ave and Beam Avenue East (Figure 3-25)

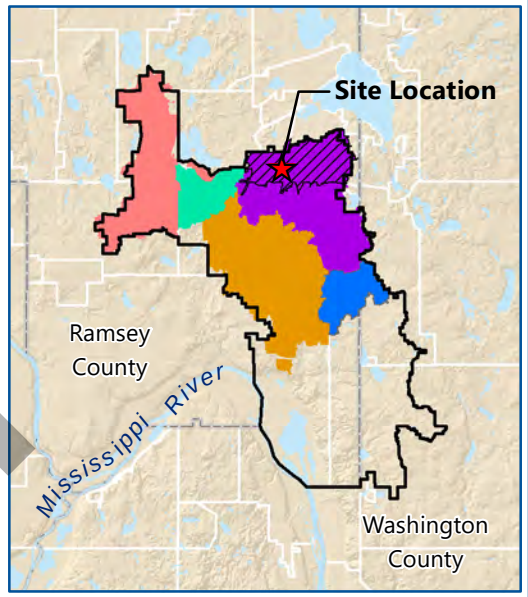
- Providing additional floodplain storage volume under Maplewood Addition to capture additional 1-inch of runoff. Additional floodplain storage could include, underground storage chambers, rainwater gardens, or other green infrastructure type of BMPs (Figure 3-25)
- Floodproof 2599 Ariel Street (Figure 3-26)
- Evaluate performing localized grading at 2600 White Bear Avenue (Figure 3-26)
- Evaluate providing additional culvert capacity at County Road C (Figure 3-26)
- Evaluate constructing embankments along Kohlman Creek to create additional floodplain storage (Figure 3-27 and Figure 3-28)
- Evaluate expanding Markham Pond to provide additional floodplain storage volume (Figure 3-28)
- Evaluate rerouting the existing 72-inch storm sewer under Kennard Street North to Kohlman Creek (Figure 3-28)

3G Kohlman Creek –the Kohlman Basin

Potential modifications near the Kohlman Basin include drainage improvements to reduce the peak discharge conveyed to Kohlman Basin and grading near the low structure adjacent to Kohlman Basin. Potential system modifications are shown in Figure 3-29 and include:

- Evaluate modifying the outlet structure north of County Road D.
- Evaluate performing localized grading around 2806 Maplewood Drive (730 feet for approximately1–3.5 feet) and developing an emergency response plan for low structures.





Potentially Flood-Prone Structures:

Structures Removed from Floodplain

Design Elements:

Pipe

Existing Storm Sewer Pipe

100-Year Floodplain:

Following System Modifications

Existing Atlas 14 Inundation

0 500

Feet

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

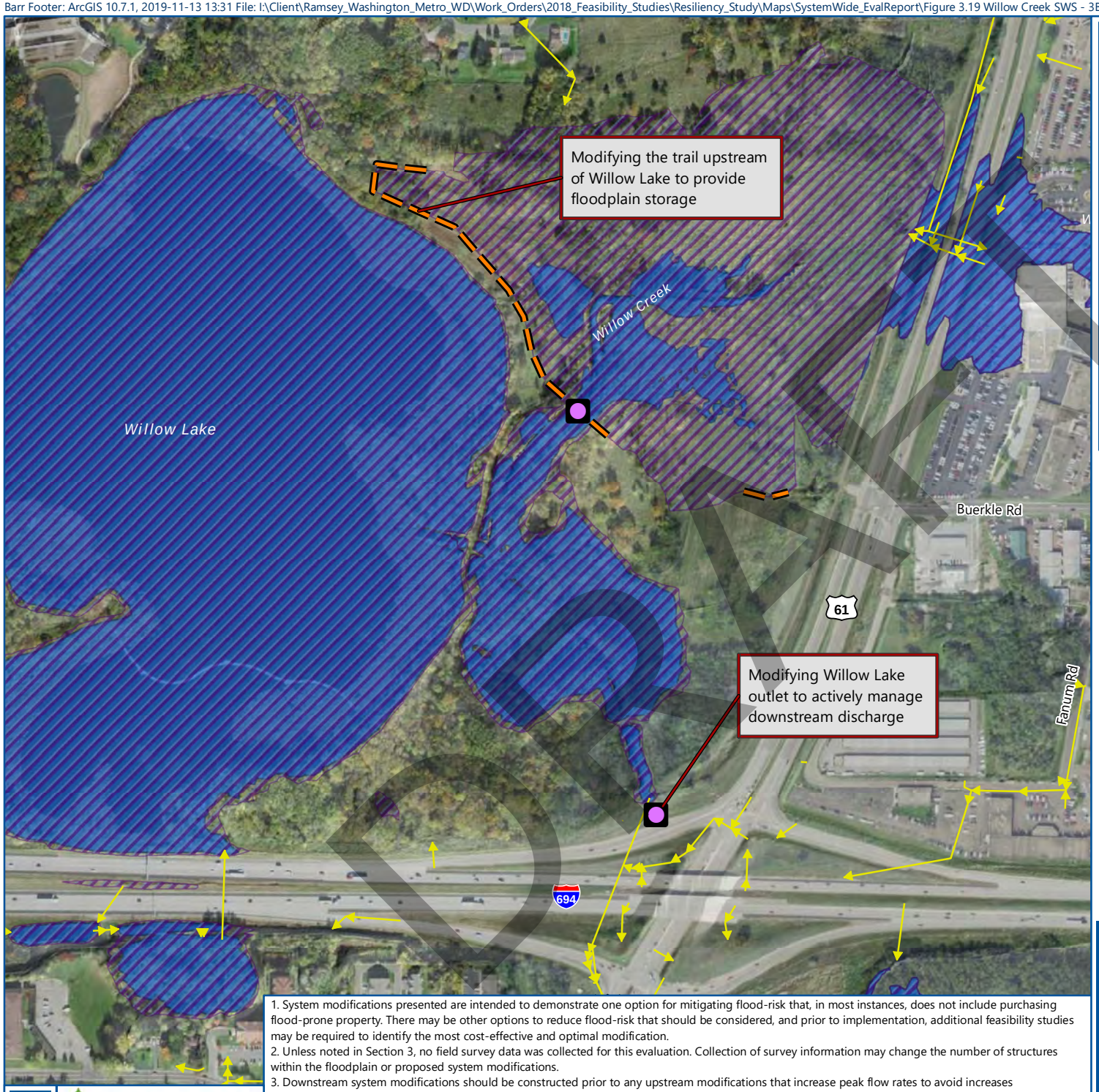
BARR

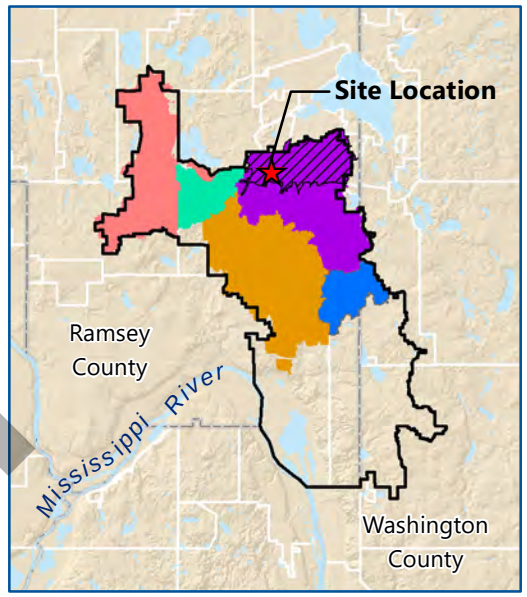
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

WILLOW CREEK SUBWATERSHED SYSTEM MODIFICATIONS 3A

Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-18





Potentially Flood-Prone Structures:

Structures Removed from Floodplain

Design Elements:

Outlet Modification

Site Grading

Existing Storm Sewer Pipe

100-Year Floodplain:

Following System Modifications

Existing Atlas 14 Inundation

N

0 500

Feet

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

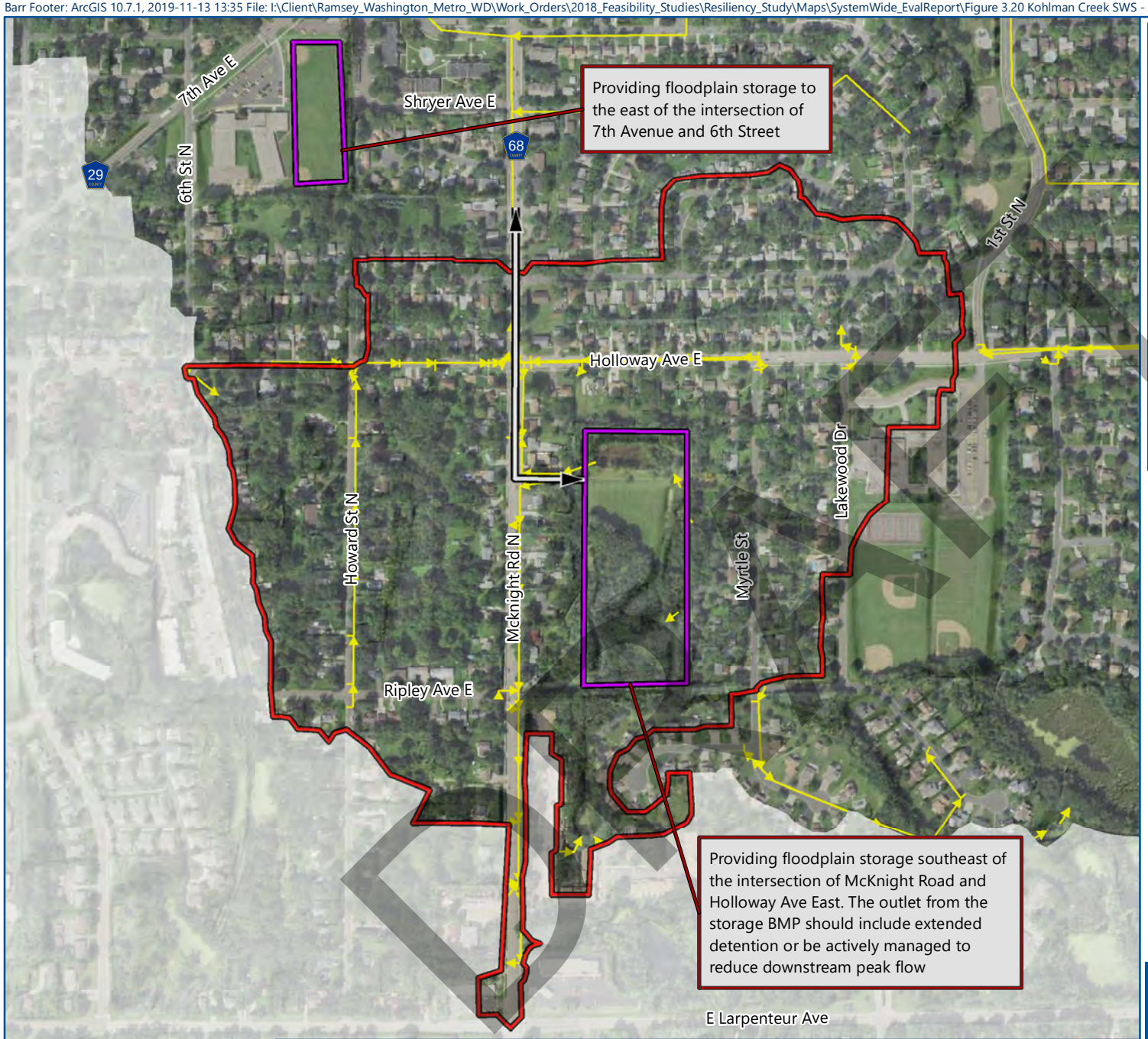
BARR

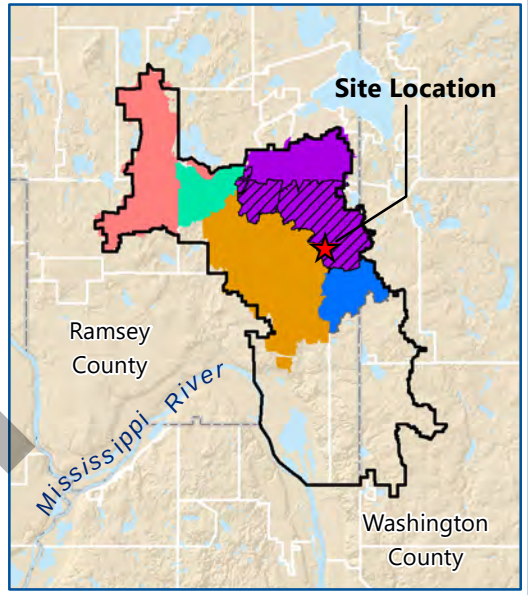
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

WILLOW CREEK SUBWATERSHED SYSTEM MODIFICATIONS 3B

Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-19





Potentially Flood-Prone Structures:

Structures Removed from Floodplain

Design Elements:

Pipe

Surface / Underground Storage

Redirect Runoff

Existing Storm Sewer Pipe

0 1,000

Feet

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

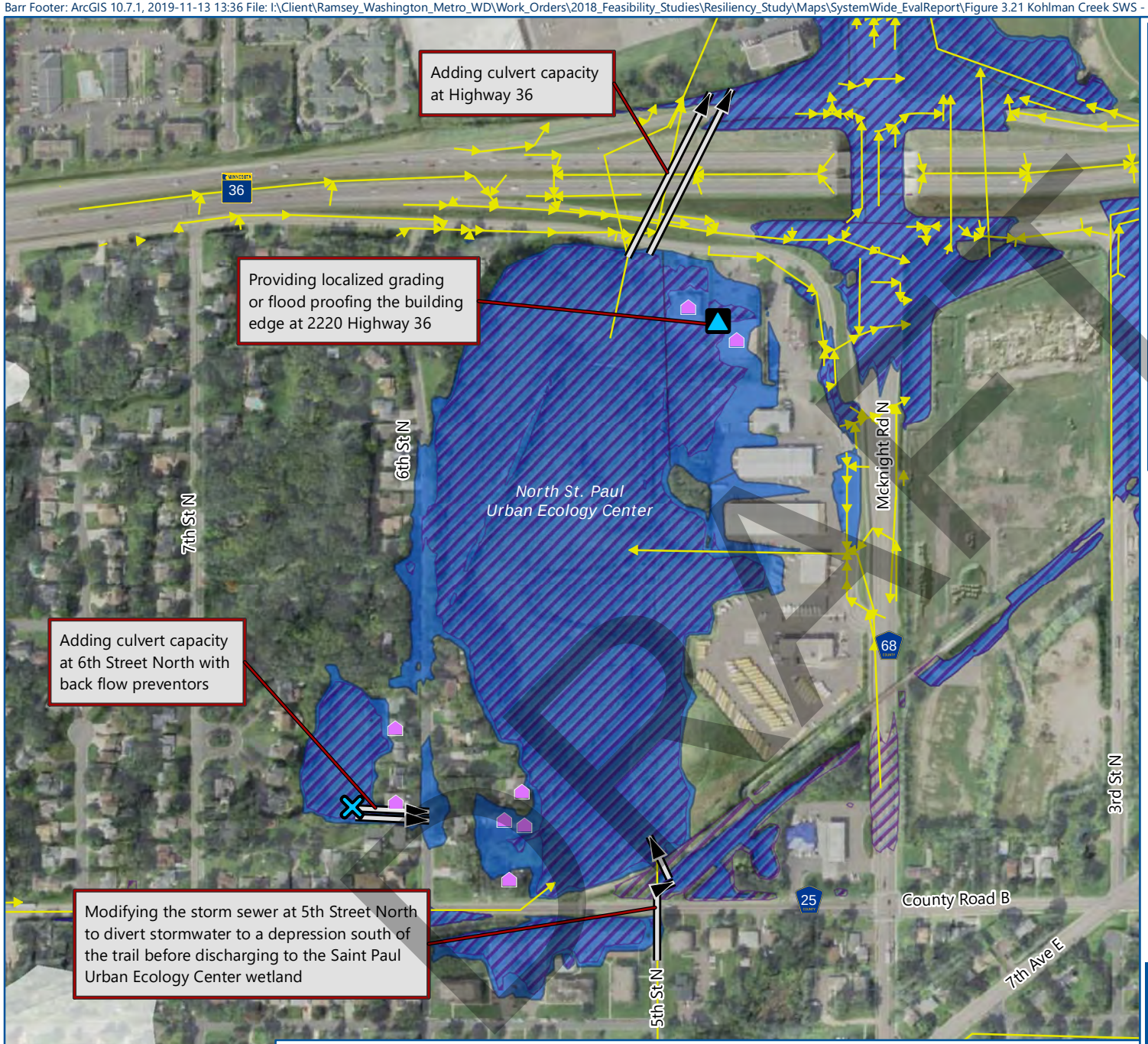
BARR

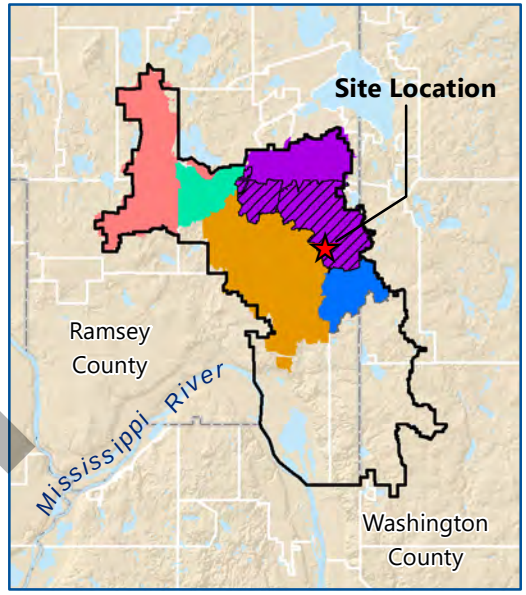
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

KOHLMAN CREEK SUBWATERSHED SYSTEM MODIFICATIONS 3C-1

Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-20





Potentially Flood-Prone Structures:

- Structures Removed from Floodplain

Design Elements:

- Back Flow Preventor
- Flood Proofing
- Pipe
- Existing Storm Sewer Pipe

100-Year Floodplain:

- Following System Modifications
- Existing Atlas 14 Inundation

0 500
Feet

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

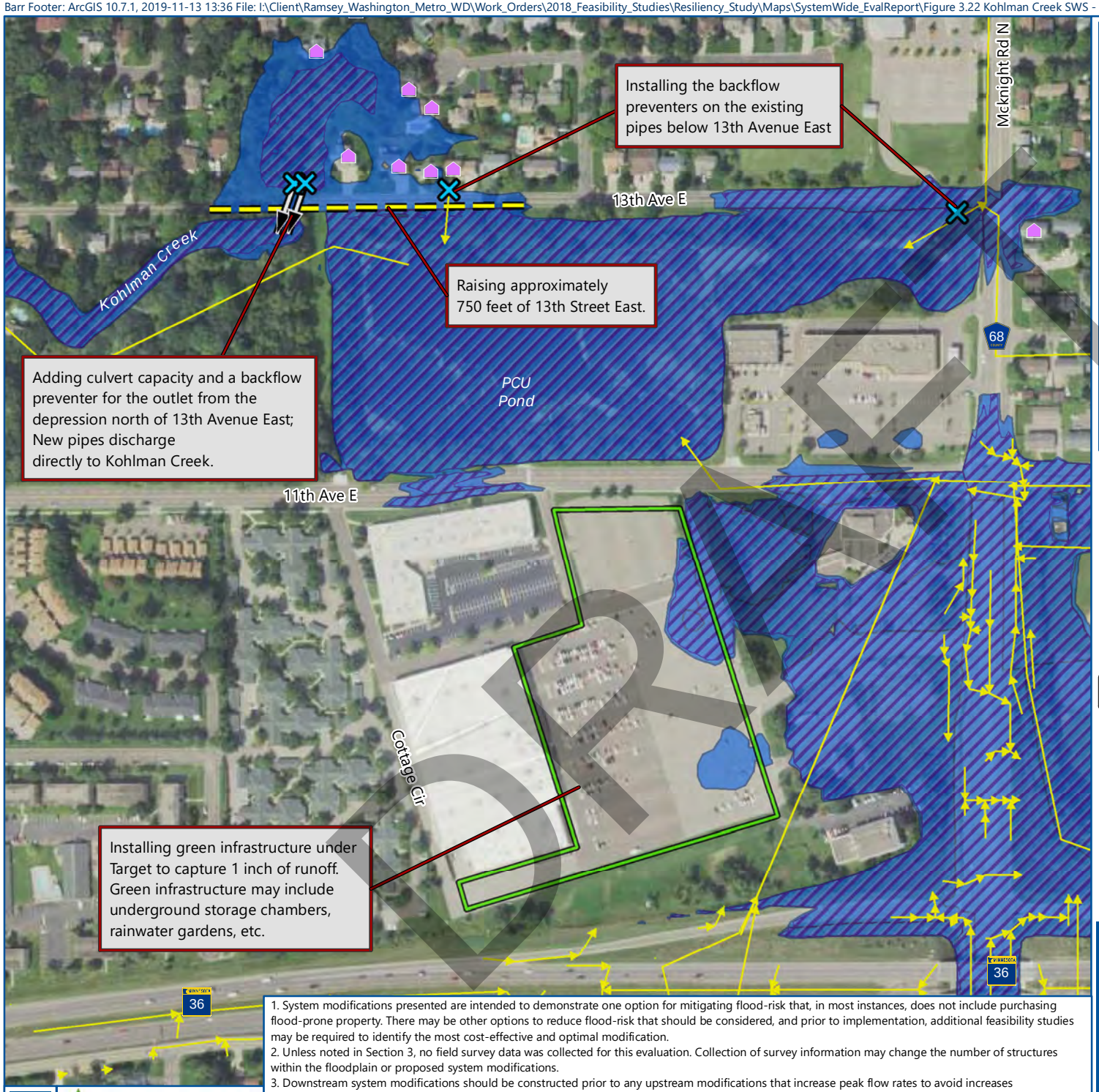
BARR
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

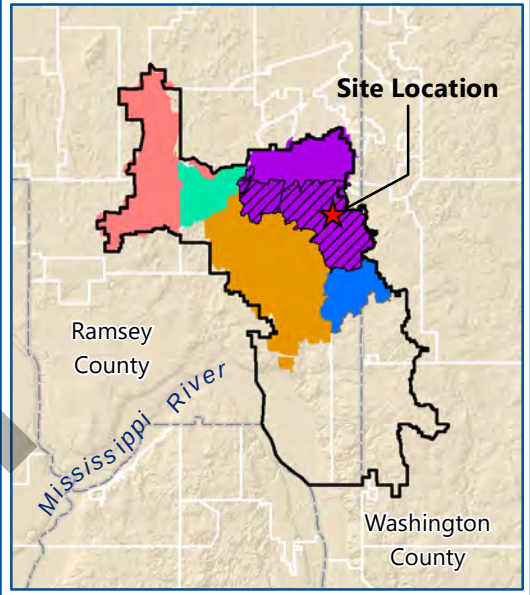
KOHLMAN CREEK SUBWATERSHED SYSTEM MODIFICATIONS

3C-2

Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-21





Potentially Flood-Prone Structures:

- Structures Removed from Floodplain

Design Elements:

- Back Flow Preventor
- Pipe
- Road Raise
- Green Infrastructure
- Existing Storm Sewer Pipe

100-Year Floodplain:

- Following System Modifications
- Existing Atlas 14 Inundation

N

0 500

Feet

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

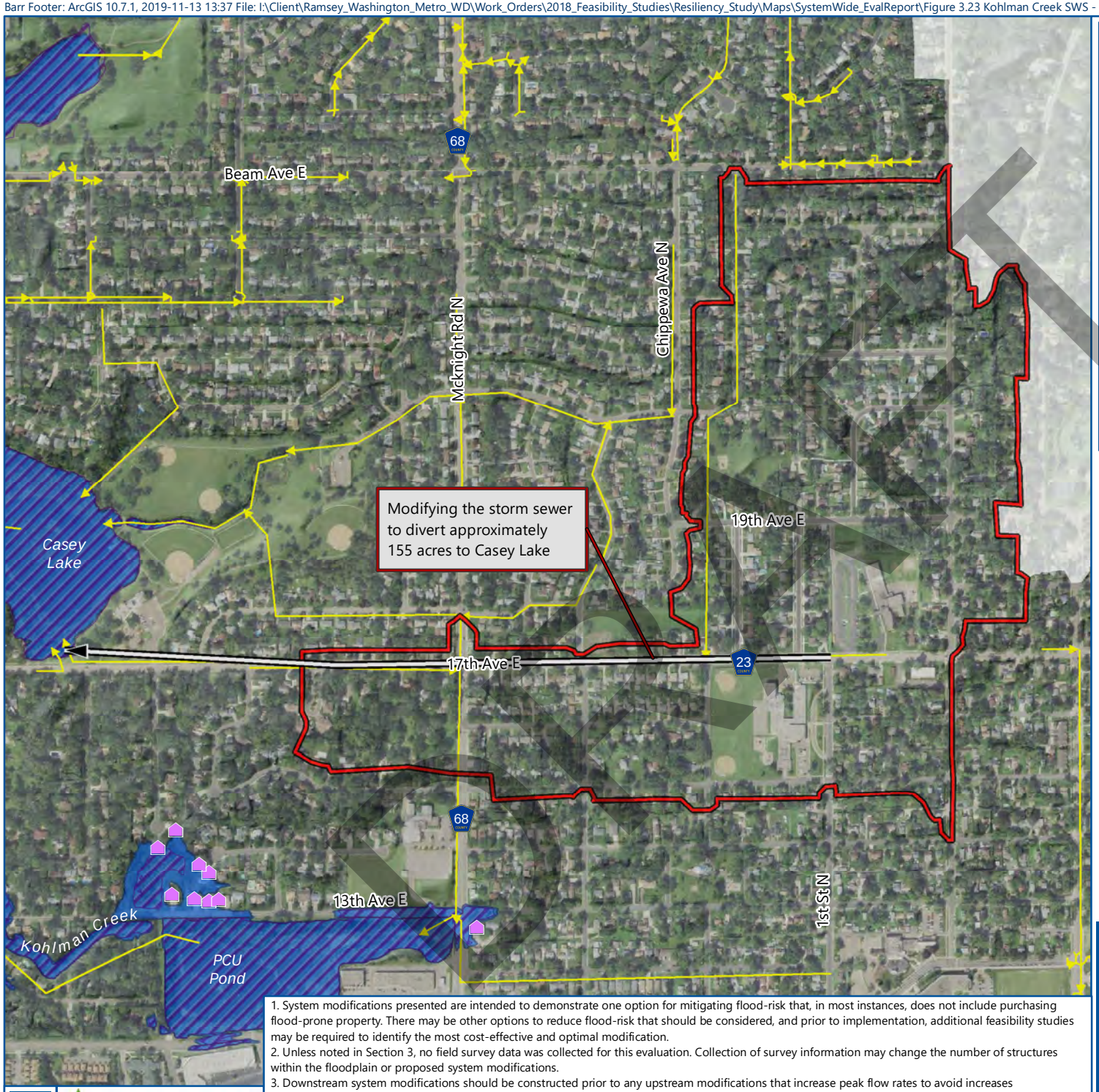
KOHLMAN CREEK SUBWATERSHED SYSTEM MODIFICATIONS

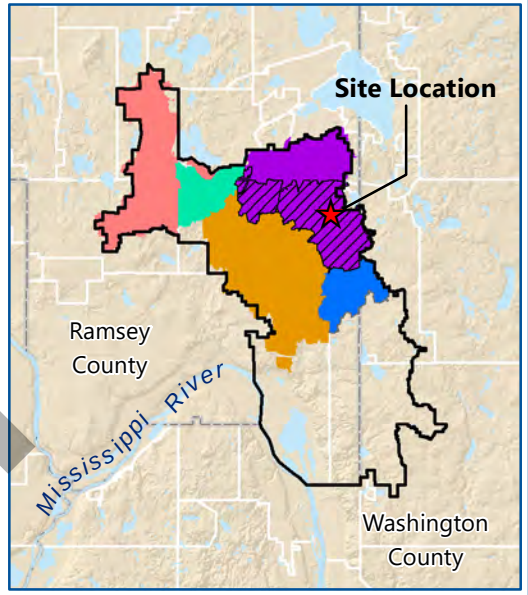
3D-1

Beltline Resiliency Study

Ramsey-Washington Metro Watershed District

FIGURE 3-22





Potentially Flood-Prone Structures:

- Structures Removed from Floodplain

Design Elements:

- Pipe
- Redirect Runoff
- Existing Storm Sewer Pipe

100-Year Floodplain:

- Following System Modifications
- Existing Atlas 14 Inundation

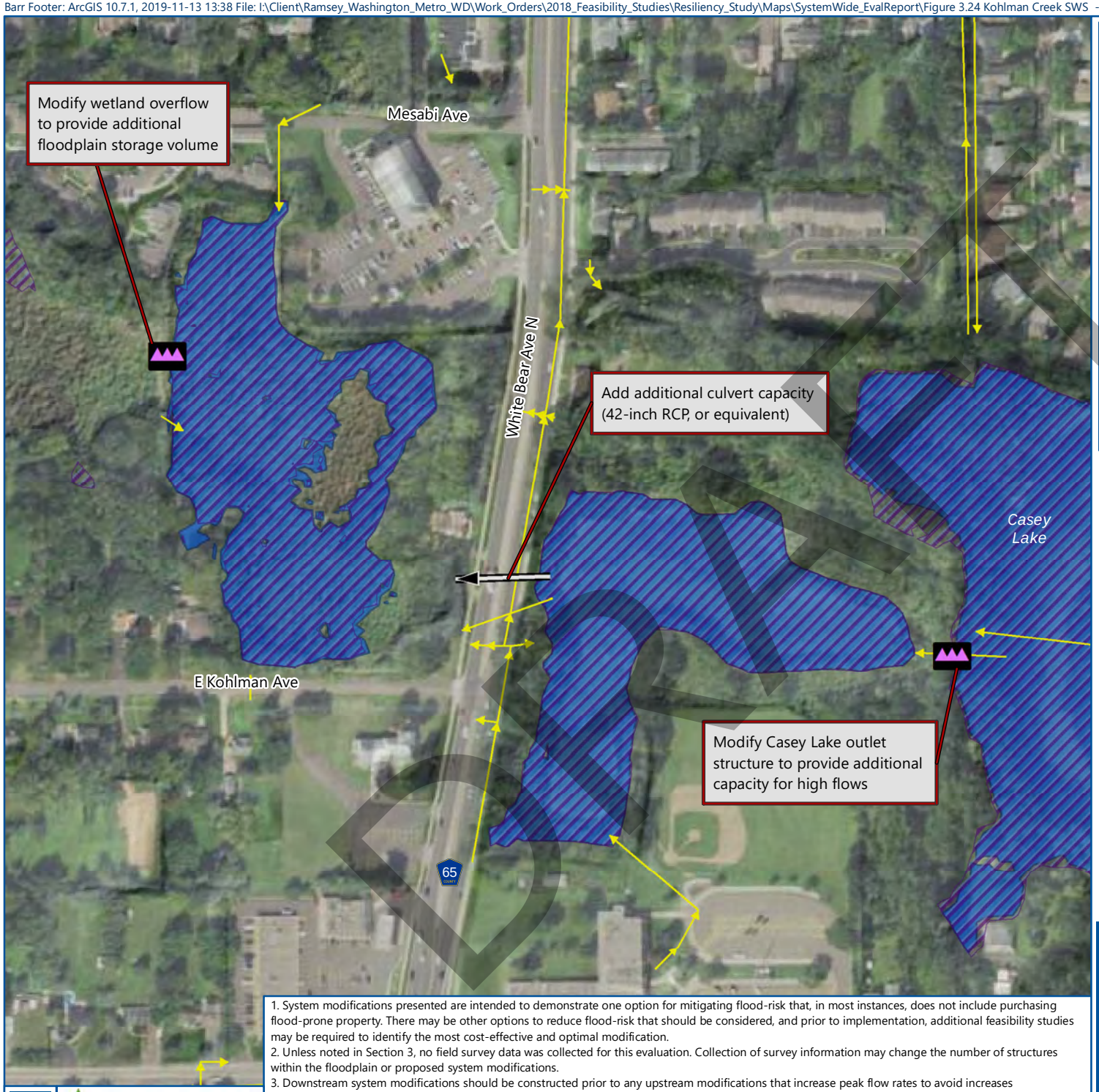
0 1,000
Feet

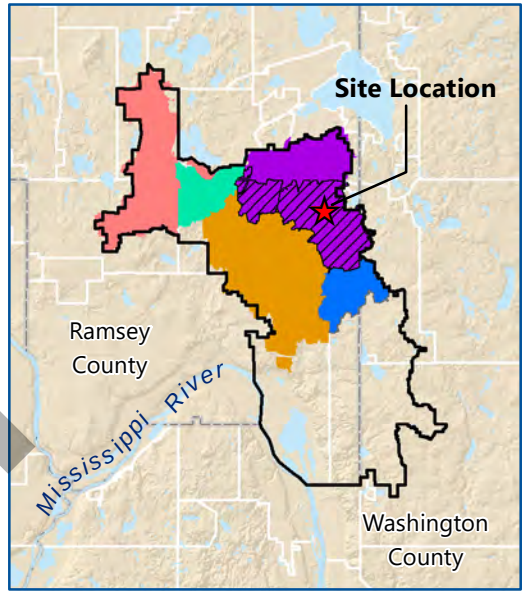
1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

BARR
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

KOHLMAN CREEK SUBWATERSHED SYSTEM MODIFICATIONS
3D-2
Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-23





Potentially Flood-Prone Structures:

Structures Removed from Floodplain

Design Elements:

Weir

Pipe

Existing Storm Sewer Pipe

100-Year Floodplain:

Following System Modifications

Existing Atlas 14 Inundation

0 500

Feet

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

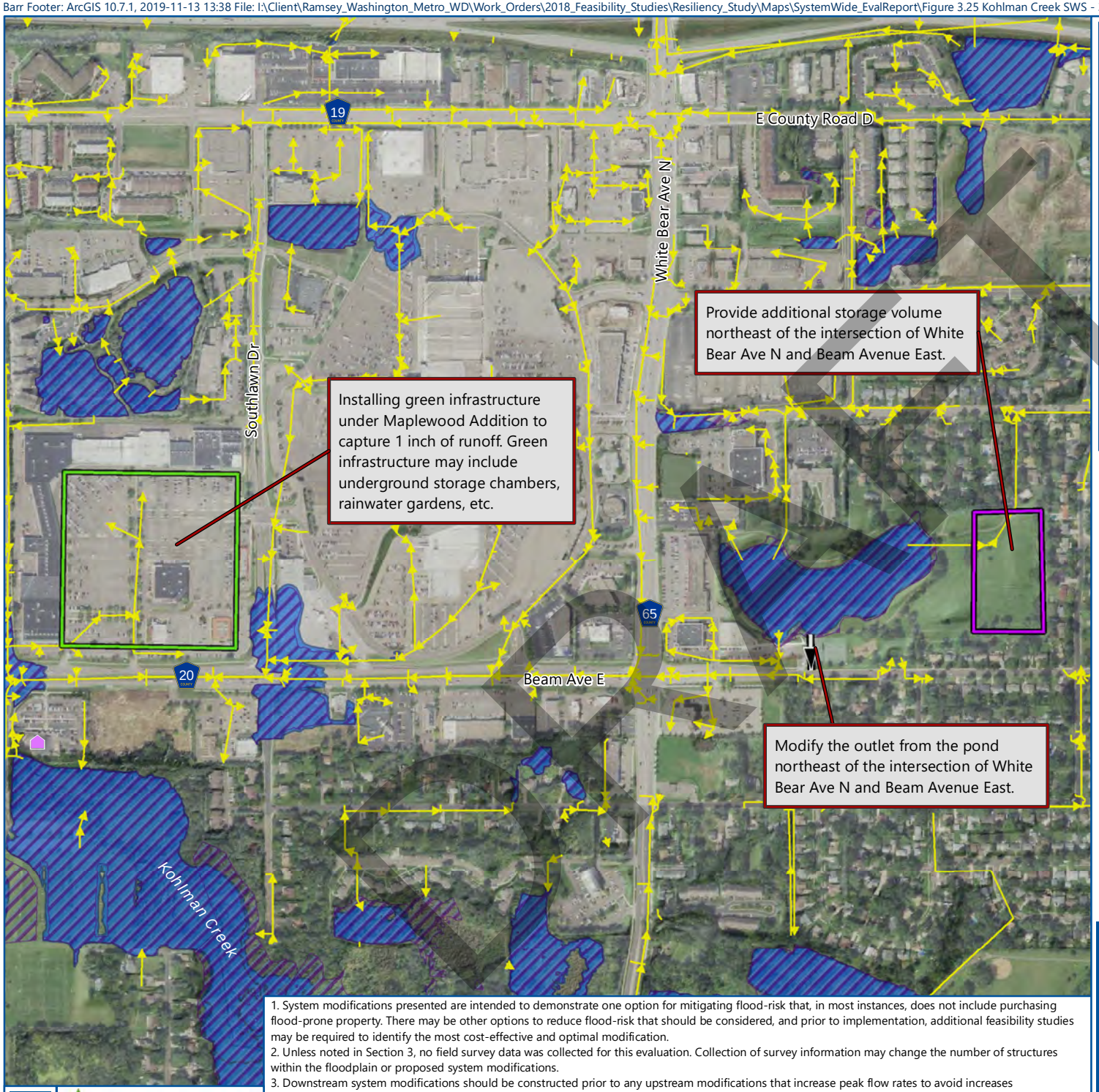
KOHLMAN CREEK SUBWATERSHED SYSTEM MODIFICATIONS

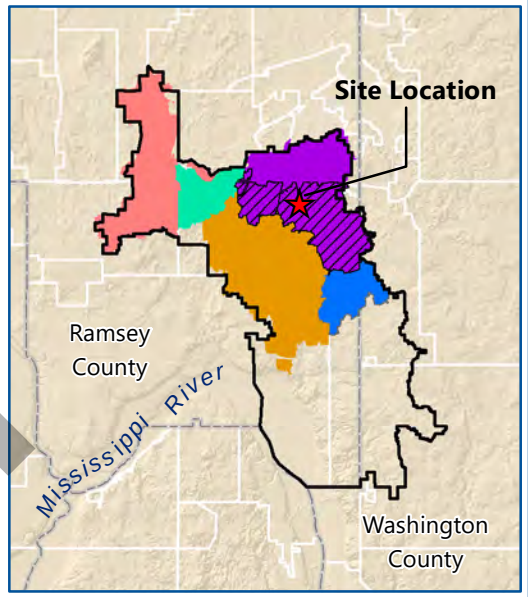
3E

Beltline Resiliency Study

Ramsey-Washington Metro Watershed District

FIGURE 3-24





Potentially Flood-Prone Structures:

- Structures Removed from Floodplain

Design Elements:

- Pipe
- Green Infrastructure
- Surface / Underground Storage
- Existing Storm Sewer Pipe

100-Year Floodplain:

- Following System Modifications
- Existing Atlas 14 Inundation

N

0 1,000

Feet

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

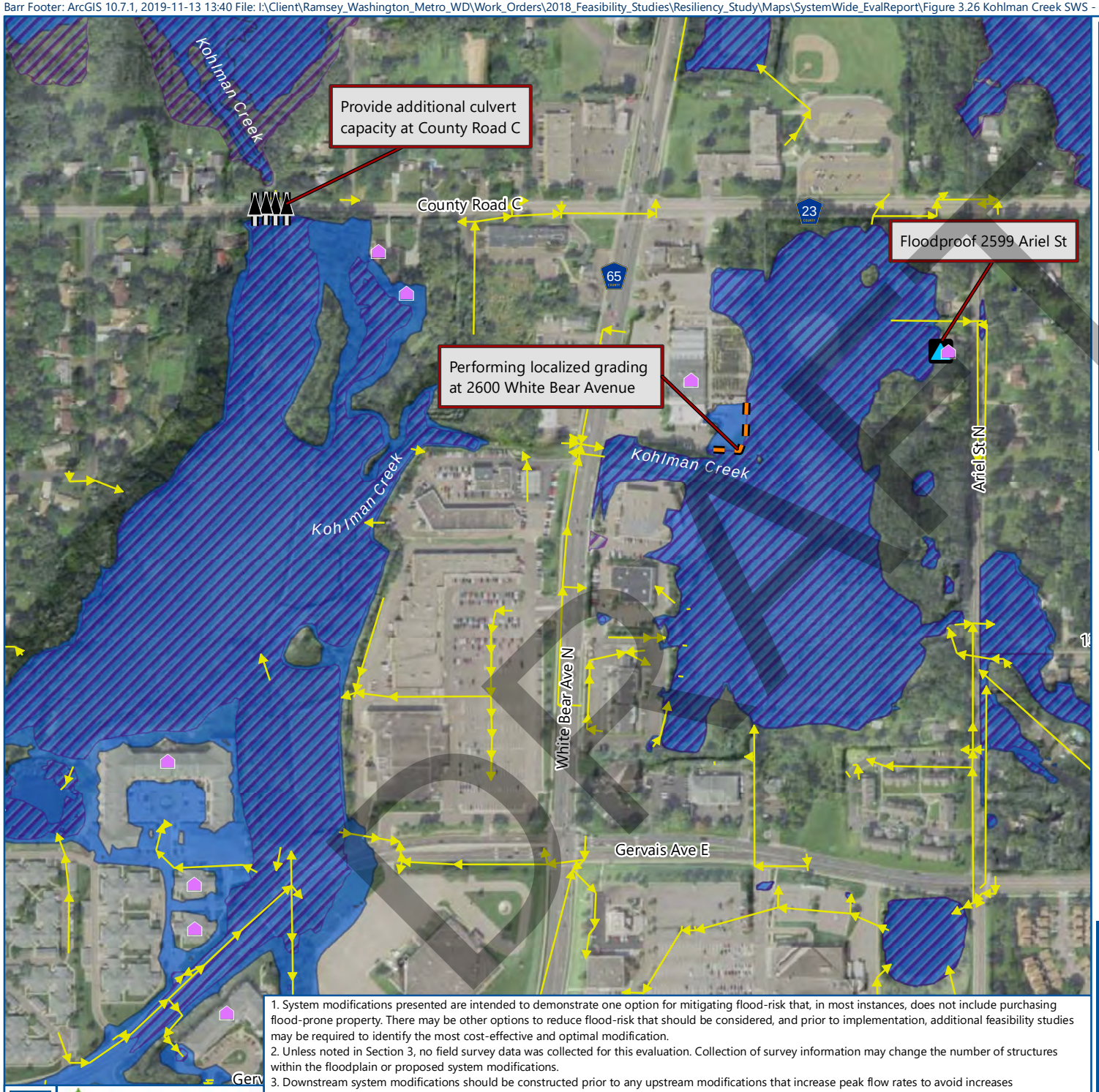
KOHLMAN CREEK SUBWATERSHED SYSTEM MODIFICATIONS

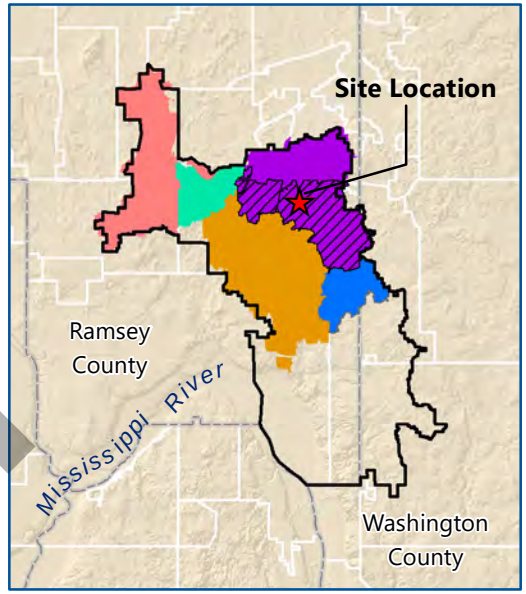
3F-1

Beltline Resiliency Study

Ramsey-Washington Metro Watershed District

FIGURE 3-25





Potentially Flood-Prone Structures:

Structures Removed from Floodplain

Design Elements:

Flood Proofing

Site Grading

Existing Storm Sewer Pipe

100-Year Floodplain:

Following System Modifications

Existing Atlas 14 Inundation

0 500

Feet

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

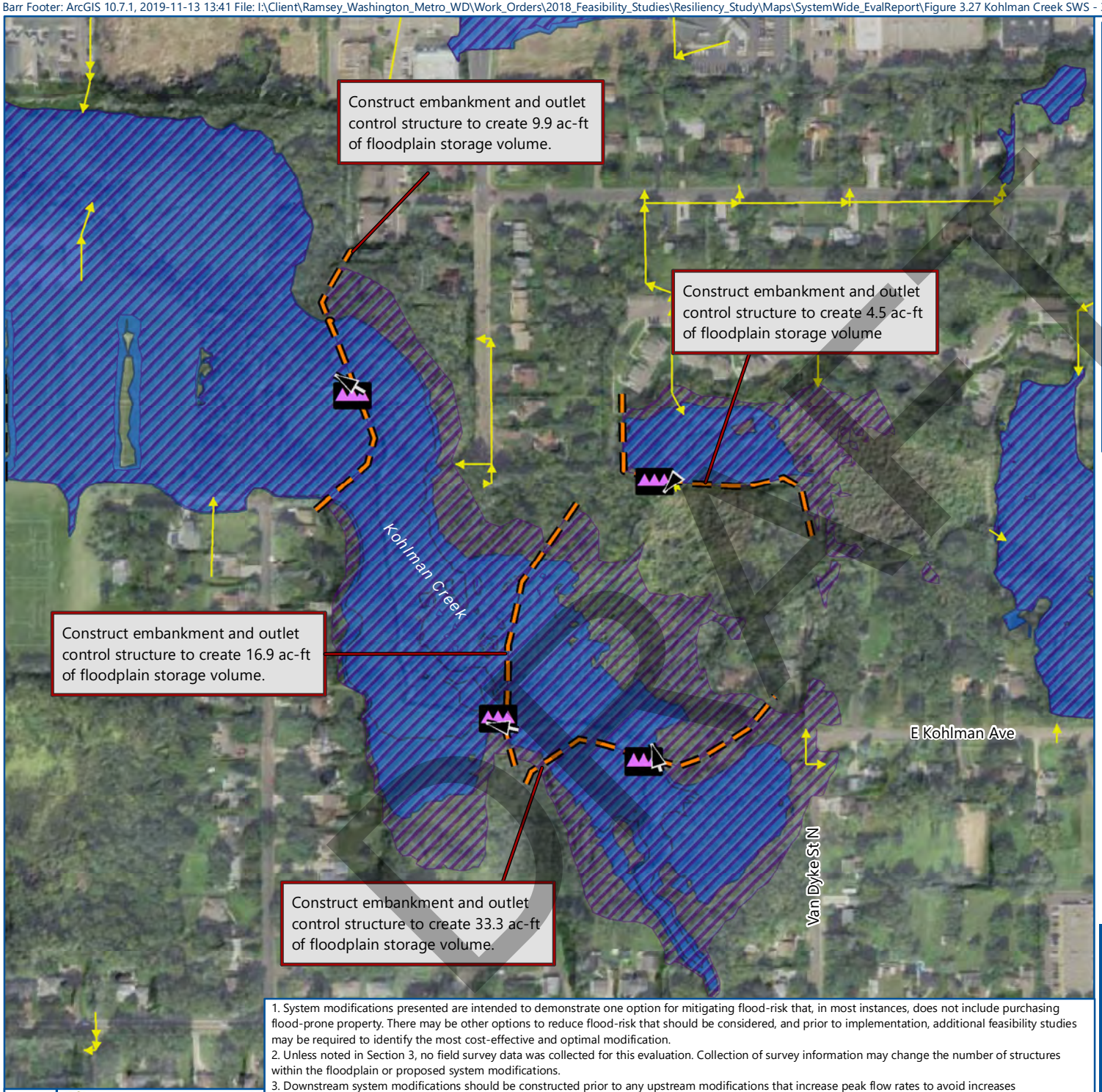
KOHLMAN CREEK SUBWATERSHED SYSTEM MODIFICATIONS

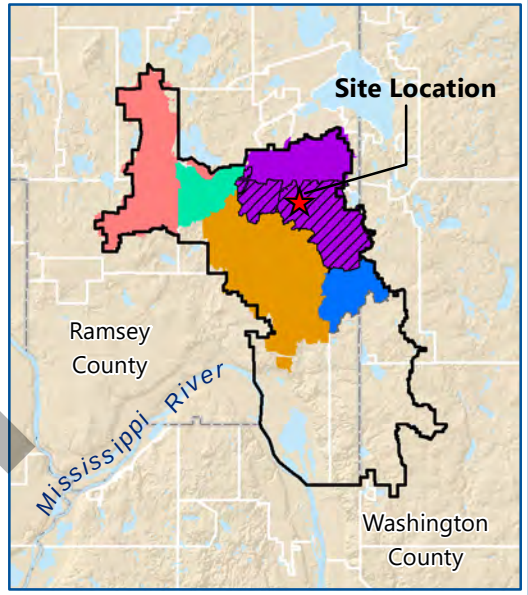
3F-2

Beltline Resiliency Study

Ramsey-Washington Metro Watershed District

FIGURE 3-26





Potentially Flood-Prone Structures:

Structures Removed from Floodplain

Design Elements:

Pipe

Weir

Site Grading

Existing Storm Sewer Pipe

100-Year Floodplain:

Following System Modifications

Existing Atlas 14 Inundation

0 500

Feet

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

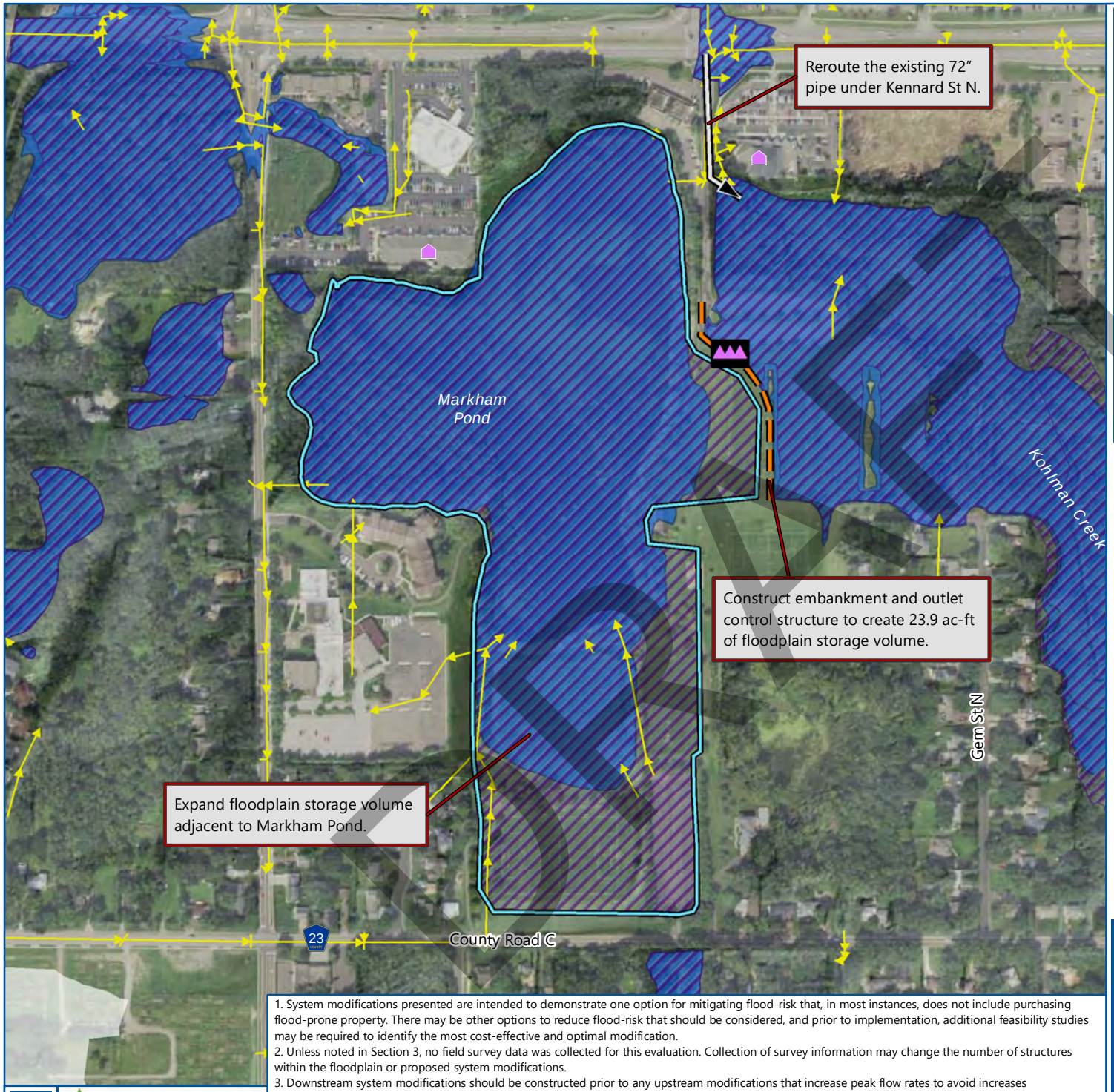
KOHLMAN CREEK SUBWATERSHED SYSTEM MODIFICATIONS

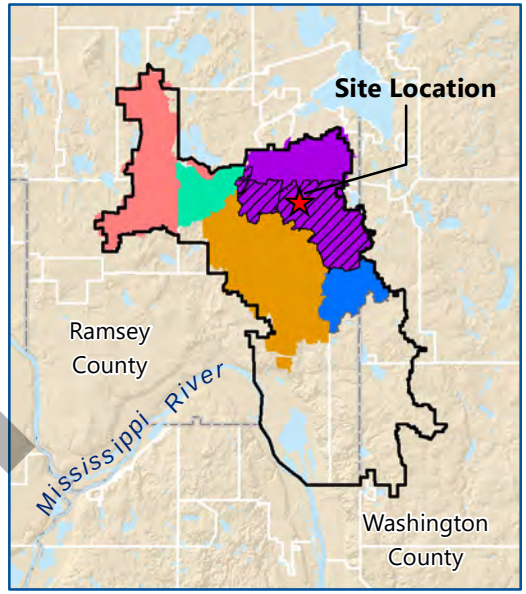
3F-3

Beltline Resiliency Study

Ramsey-Washington Metro Watershed District

FIGURE 3-27





Potentially Flood-Prone Structures:

- Structures Removed from Floodplain

Design Elements:

- Pipe
- Weir
- Site Grading
- Pond Expansion
- Existing Storm Sewer Pipe

100-Year Floodplain:

- Following System Modifications
- Existing Atlas 14 Inundation

0 500 Feet

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

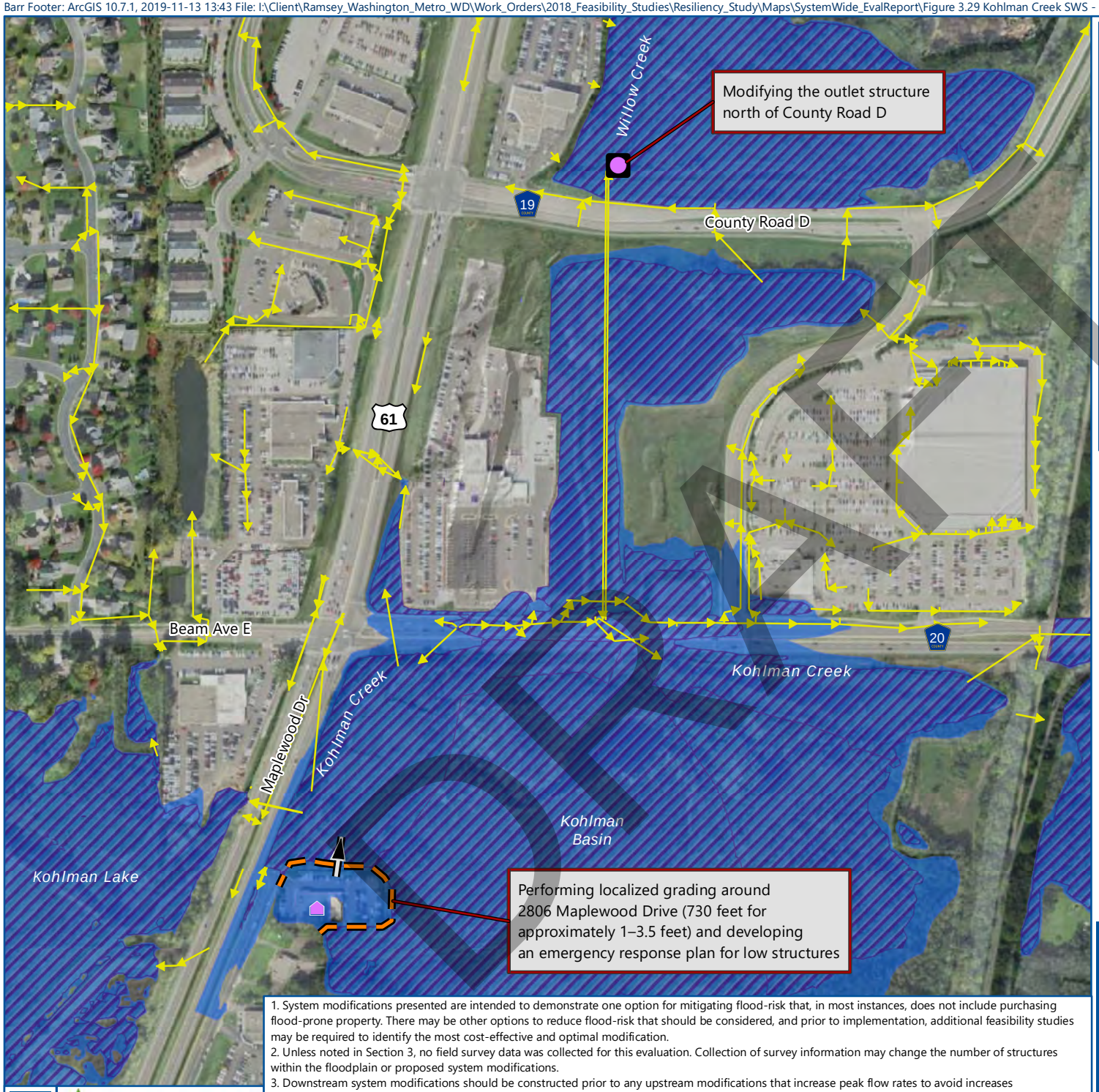
BARR

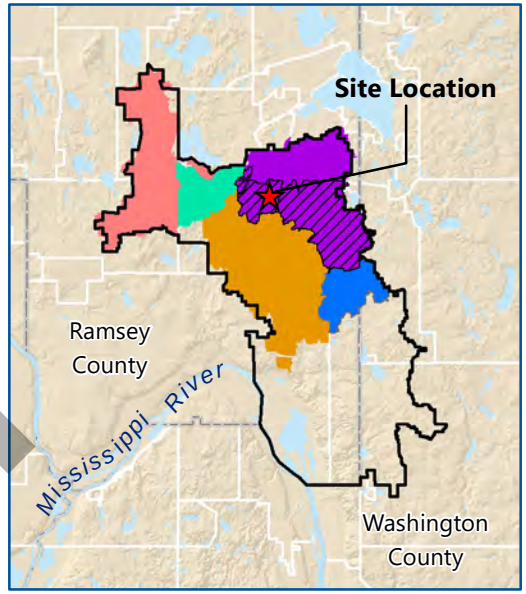
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

KOHLMAN CREEK SUBWATERSHED SYSTEM MODIFICATIONS 3F-4

Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-28





Potentially Flood-Prone Structures:

- Structures Removed from Floodplain

Design Elements:

- Outlet Modification
- Pipe
- Site Grading
- Existing Storm Sewer Pipe

100-Year Floodplain:

- Following System Modifications
- Existing Atlas 14 Inundation

N

0 500

Feet

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

KOHLMAN CREEK SUBWATERSHED SYSTEM MODIFICATIONS

3G

Beltline Resiliency Study

Ramsey-Washington Metro Watershed District

FIGURE 3-29

3.3.3 Flooding Concerns following System Modifications

The potential system modifications result in lowering the 100-year floodplain below the low adjacent grade of habitable structures within the Willow Lake subwatershed, as shown in Figure 3-30. Table 3-7 lists the existing 100-year water surface elevation and the elevation following modifications to the drainage system.

System modifications in the Willow Creek subwatershed include drainage improvements to convey stormwater to Willow Lake. The modifications result in decreases to the floodplain volume in the upstream portion of the subwatershed and increases to the floodplain elevation in Willow Lake. The change in the 100-year water surface elevation is not anticipated to impact habitable structures or I-694.

Table 3-7 also includes planning-level considerations related to project sequencing to avoid increases to downstream water levels. Project sequencing refers to the order that system modifications should be constructed to prevent adverse downstream impacts. For this evaluation, sequencing does not refer to prioritization, which refers to which area should be addressed first. A planning-level schematic for sequencing of potential system modifications is included in Appendix A.

Table 3-7 Potentially Flood-Prone Structures in the Willow Creek Subwatersheds

Parcel ID	Address	Lowest Adjacent Grade[1]	Existing 100-Year Water Surface Elevation	100-Year Water Surface Elevation following System Modifications	System Modification to Reduce Flood Risk	Prerequisite System Modifications
343022420021	1803 Buerkle Rd, White Bear Lake 55110	914.6	914.5	912.9	3A	3B
343022410009	1851 Buerkle Rd, White Bear Lake 55110	913.3	914.5	912.9	3A	3B
343022410013	1825 Buerkle Rd, White Bear Lake 55110	913.2	914.5	912.9	3A	3B
343022410007	1805 Buerkle Rd, White Bear Lake 55110	913.4	914.5	912.9	3A	3B
343022420018	1791 Buerkle Cir, White Bear Lake 55110	913.0	914.5	912.9	3A	3B
353022320025	3200 Orchard Ct, White Bear Lake 55110	913.5	914.5	912.9	3A	3B
353022320024	3210 Orchard Ct, White Bear Lake 55110	913.8	914.5	912.9	3A	3B
353022320026	3215 Orchard Ct, White Bear Lake 55110	914.3	914.5	912.9	3A	3B
353022320022	3230 Orchard Ct, White Bear Lake 55110	914.2	914.5	912.9	3A	3B
353022320021	3240 Orchard Ct, White Bear Lake 55110	914.0	914.5	912.9	3A	3B
353022320030	3255 Orchard Ct, White Bear Lake 55110	914.4	914.5	912.9	3A	3B
353022320032	1790 Orchard Ln, White Bear Lake 55110	912.9	914.5	912.9[2]	3A	3B

1) Reference [5]

Apart from 2599 Ariel Street, the potential system modifications result in lowering the 100-year floodplain below the low adjacent grade of habitable structures within the Kohlman Creek subwatershed. The 100-year floodplain following system modifications is shown in Figure 3-31.

In some areas of the Kohlman Creek subwatershed there is limited information available for the storm sewer system. System modifications are based on information available at this time. If further evaluation is completed within this subwatershed a detailed survey of the storm sewer system and low structure elevations should be completed.

System modifications include additional storage volume at several locations. These locations were selected based on open areas within the watershed. However, the specific location, size, and configuration could change when additional site-specific information is available. The required storage volume was estimated based on the current District stormwater model. After site-specific information is collected, the model should be revised for these locations to include higher resolution of the storm sewer system, which may affect the configuration, size, and function of proposed storage areas.

The 100-year floodplain is within the accuracy of the topographic information for many locations in the watershed. In these areas, local grading, drainage improvements, or floodproofing were assumed rather than additional regional storage BMPs. During the next phase of design site-specific survey information for low structures should be collected prior to further detailed evaluation.

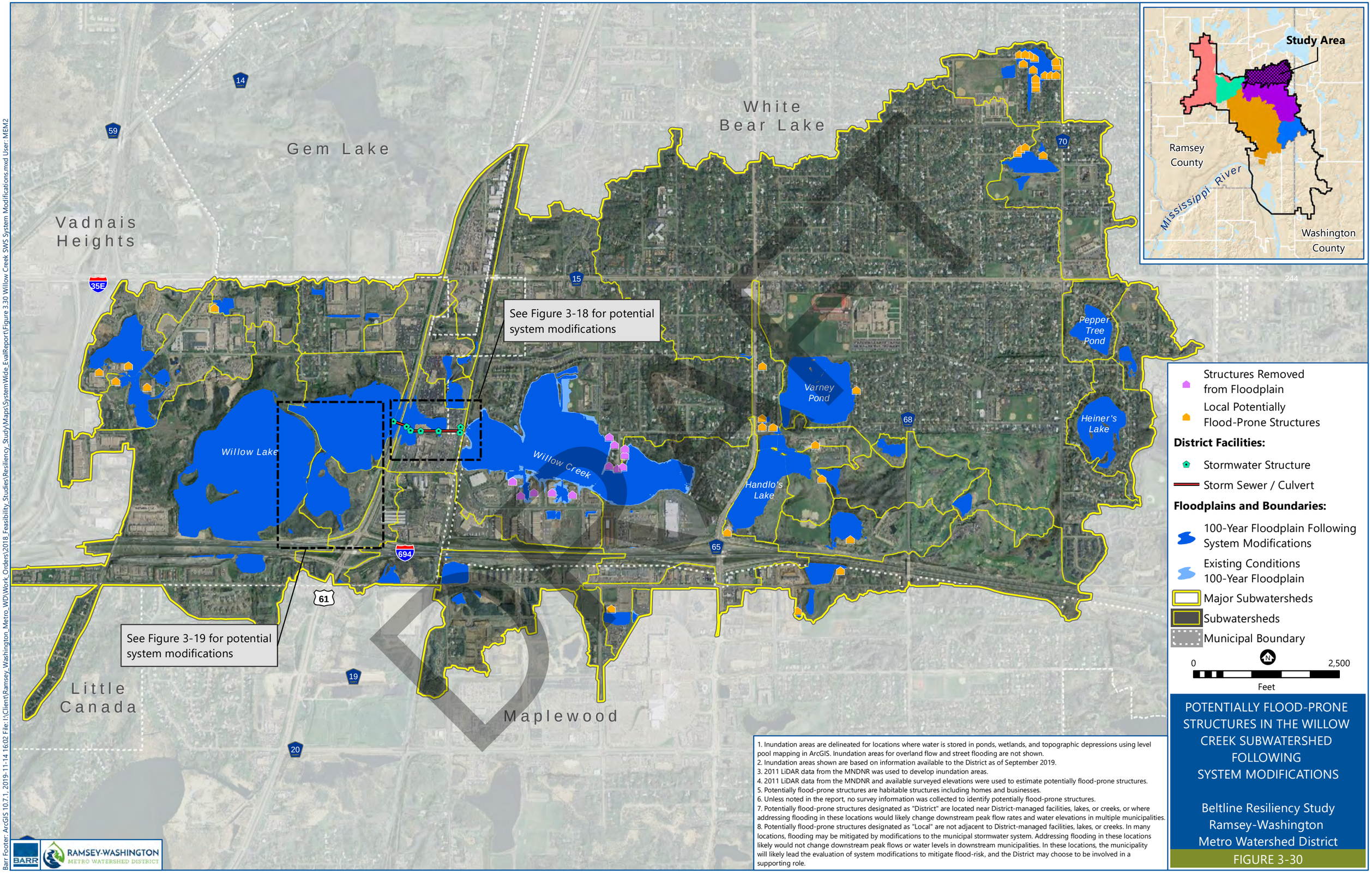
Table 3-8 lists the existing 100-year water surface elevation and elevation following modifications within the Kohlman Creek subwatershed. Table 3-8 also includes planning-level considerations related to project sequencing to avoid increases to downstream water levels. Project sequencing refers to the order that system modifications should be constructed to prevent adverse downstream impacts. System modifications in Willow Creek subwatershed, which reduce the peak discharge to Kohlman Basin, should be completed prior to modifications in the Kohlman Creek subwatershed. A planning-level schematic for sequencing of potential system modifications is included in Appendix A.

Table 3-8 Potentially Flood-Prone Structures in the Kohlman Creek Subwatersheds

Parcel ID	Address	Lowest Adjacent Grade[1]	Existing 100-Year Water Surface Elevation	100-Year Water Surface Elevation following System Modifications	System Modification to Reduce Flood Risk	Prerequisite System Modifications
142922110010	2145 5th St, North St. Paul 55109	945.7	946.2	945.7[2]	3C	3F, 3E, 3D, 3B
112922410013	2220 Hwy 36, North St. Paul 55109	938.6	940.8	938.8 [3]	3C	3F, 3E, 3D, 3B
112922410014	2204 Hwy 36, North St. Paul 55109	939.4	940.8	938.8	3C	3F, 3E, 3D, 3B
112922210053	2600 White Bear Ave, Maplewood 55109	920.1	922.7	922.6[3]	3F	N/A
042922410013	2806 Maplewood Dr, Maplewood 55109	867.6	870.3	864.6[4]	3G	3F
032922420009	1570 Beam Ave, Maplewood 55109	885.7	886.3	885.9	3F	N/A
032922410011	1670 Beam Ave, Maplewood 55109	893.5	889.9	889.7	3F	N/A

Parcel ID	Address	Lowest Adjacent Grade[1]	Existing 100-Year Water Surface Elevation	100-Year Water Surface Elevation following System Modifications	System Modification to Reduce Flood Risk	Prerequisite System Modifications
112922440015	2157 South Ave, North St. Paul 55109	940.7	940.8	938.8	3C	3F, 3E, 3D, 3B
112922440014	2159 South Ave, North St. Paul 55109	939.3	940.8	938.8	3C	3F, 3E, 3D, 3B
112922440014	2159 South Ave, North St. Paul 55109	939.5	940.8	938.8	3C	3F, 3E, 3D, 3B
112922430108	2187 6th St, North St. Paul 55109	940.3	941.0	940.0	3C	3F, 3E, 3D, 3B
112922440029	2172 6th St, North St. Paul 55109	940.3	940.8	938.8	3C	3F, 3E, 3D, 3B
112922430105	2205 6th St, North St. Paul 55109	940.4	941.0	940.0	3C	3F, 3E, 3D, 3B
112922230007	1807 Gervais Ct, Maplewood 55109	910.9	913.6	911.3	3F	N/A
112922230006	1801 Gervais Ave, Maplewood 55109	913.5	913.6	911.3	3F	N/A
112922230006	1801 Gervais Ave, Maplewood 55109	913.6	913.6	911.3	3F	N/A
112922230006	1801 Gervais Ave, Maplewood 55109	912.8	913.6	911.3	3F	N/A
122922230017	2268 13th Ave, North St. Paul 55109	936.9	937.0	936.6	3D	3F, 3E, 3B
112922120078	2133 13th Ave, North St. Paul 55109	935.8	936.6	931.7	3D	3F, 3E, 3B
112922110071	2139 13th Ave, North St. Paul 55109	937.7	936.6	931.7	3D	3F, 3E, 3B
112922120079	2127 13th Ave, North St. Paul 55109	934.5	936.6	931.7	3D	3F, 3E, 3B
112922120100	2119 13th Ave, North St. Paul 55109	934.8	936.6	931.7	3D	3F, 3E, 3B
112922120077	2138 14th Ave, North St. Paul 55109	936.4	936.6	931.7	3D	3F, 3E, 3B
112922120076	2132 14th Ave, North St. Paul 55109	935.2	936.6	931.7	3D	3F, 3E, 3B
112922120111	2570 Seans Way, North St. Paul 55109	932.6	936.6	931.7	3D	3F, 3E, 3B
112922120102	2576 Seans Way, North St. Paul 55109	935.0	936.6	931.7	3D	3F, 3E, 3B
112922210025	2599 Ariel St, Maplewood 55109	922.5	922.7	922.6[2]	3F	N/A
112922220022	1876 County Rd C, Maplewood 55109	911.6	913.6	911.3	3F	N/A
112922220017	1862 County Rd C, Maplewood 55109	911.9	913.6	911.3	3F	N/A

(1) Reference [5]
(2) Minor grading to flood proof this building may be required or development of an emergency response plan. Collection of additional site-specific survey information would be required for further evaluation.
(3) The modeling results assumed that sufficient pump capacity is available during the event.



1. Inundation areas are delineated for locations where water is stored in ponds, wetlands, and topographic depressions using level pool mapping in ArcGIS. Inundation areas for overland flow and street flooding are not shown.
2. Inundation areas shown are based on information available to the District as of September 2019.
3. 2011 LiDAR data from the MNDNR was used to develop inundation areas.
4. 2011 LiDAR data from the MNDNR and available surveyed elevations were used to estimate potentially flood-prone structures.
5. Potentially flood-prone structures are habitable structures including homes and businesses.
6. Unless noted in the report, no survey information was collected to identify potentially flood-prone structures.
7. Potentially flood-prone structures designated as "District" are located near District-managed facilities, lakes, or creeks, or where addressing flooding in these locations would likely change downstream peak flow rates and water elevations in multiple municipalities.
8. Potentially flood-prone structures designated as "Local" are not adjacent to District-managed facilities, lakes, or creeks. In many locations, flooding may be mitigated by modifications to the municipal stormwater system. Addressing flooding in these locations likely would not change downstream peak flows or water levels in downstream municipalities. In these locations, the municipality will likely lead the evaluation of system modifications to mitigate flood-risk, and the District may choose to be involved in a supporting role.

POTENTIALLY FLOOD-PRONE STRUCTURES IN THE WILLOW CREEK SUBWATERSHED FOLLOWING SYSTEM MODIFICATIONS

Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-30

BARR | RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Vadnais Heights

White Bear Lake

Little Canada

Maplewood

Oakdale

North Saint Paul

Kohlman Lake

Kohlman Basin

Markham Pond

Kohlman Creek

Casey Lake

PCU Pond

North St. Paul Urban Ecology Center

See Figure 3-29 for potential system modifications

See Figure 3-25 for potential system modifications

See Figure 3-24 for potential system modifications

See Figure 3-23 for potential system modifications

See Figure 3-22 for potential system modifications

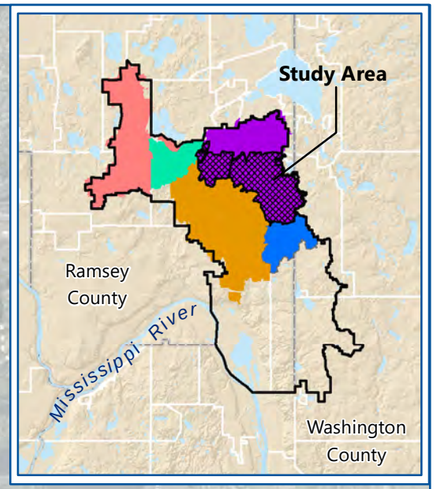
See Figure 3-28 for potential system modifications

See Figure 3-27 for potential system modifications

See Figure 3-26 for potential system modifications

See Figure 3-21 for potential system modifications

See Figure 3-20 for potential system modifications



Structures Removed from Floodplain

Local Potentially Flood-Prone Structures

District Facilities:

CIP

Outfall

Stormwater Structure

Storm Sewer / Culvert

Floodplains and Boundaries:

100-Year Floodplain Following System Modifications

Existing Conditions 100-Year Floodplain

Major Subwatersheds

Subwatersheds

Municipal Boundary

0 3,000

Feet

POTENTIALLY FLOOD-PRONE STRUCTURES IN THE KOHLMAN CREEK SUBWATERSHED FOLLOWING SYSTEM MODIFICATIONS

Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-31

1. Inundation areas are delineated for locations where water is stored in ponds, wetlands, and topographic depressions using level pool mapping in ArcGIS. Inundation areas for overland flow and street flooding are not shown.
2. Inundation areas shown are based on information available to the District as of September 2019.
3. 2011 LiDAR data from the MNDNR was used to develop inundation areas.
4. 2011 LiDAR data from the MNDNR and available surveyed elevations were used to estimate potentially flood-prone structures.
5. Potentially flood-prone structures are habitable structures including homes and businesses.
6. Unless noted in the report, no survey information was collected to identify potentially flood-prone structures.
7. Potentially flood-prone structures designated as "District" are located near District-managed facilities, lakes, or creeks, or where addressing flooding in these locations would likely change downstream peak flow rates and water elevations in multiple municipalities.
8. Potentially flood-prone structures designated as "Local" are not adjacent to District-managed facilities, lakes, or creeks. In many locations, flooding may be mitigated by modifications to the municipal stormwater system. Addressing flooding in these locations likely would not change downstream peak flows or water levels in downstream municipalities. In these locations, the municipality will likely lead the evaluation of system modifications to mitigate flood-risk, and the District may choose to be involved in a supporting role.

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.7.1, 2019-11-14 16:06 File: i:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2018_Feasibility_Studies\Resiliency_Study\Maps\SystemWide_EvalReport\Figure 3-31 Kohlman Creek SWS System Modifications.mxd User: MEM2

3.4 Phase 4 – Phalen Chain of Lakes

The Phalen Chain of Lakes includes Kohlman Lake, Gervais Lake, Keller Lake, and Lake Phalen. The outlet from Lake Phalen is the upstream end of the Beltline. The total tributary area to the Beltline is 25,618 acres. Within the Phalen Chain of Lakes subwatershed there are 161 structures within the 100-year floodplain.

3.4.1 Current Condition Flooding Concerns

There are 161 potentially flood-prone habitable structures within the Phalen Chain of Lakes subwatershed. Forty-six structures are classified as "District" and 115 are classified as "Local." Potentially flood-prone structures are shown on Figure 3-32. In this subwatershed, structures upstream of the Lake Phalen outlet are affected by flood levels on the Chain of Lakes—which are controlled by outlet structures on Keller Creek and Lake Phalen. The District has developed an Emergency Response Plan for structures on Gervais Lake and coordinates with the City of Little Canada during periods of high water levels.

There are also 29 structures classified as "Local" that are downstream of structures classified as "District" located adjacent to District facilities. Potential system modifications considered also considered how to mitigate flood-risk for these additional 29 structures. Table 3-9 lists the potentially flood-prone structures in the Phalen Chain of Lakes subwatershed classified as "District" and the 29 "Local" structures downstream.

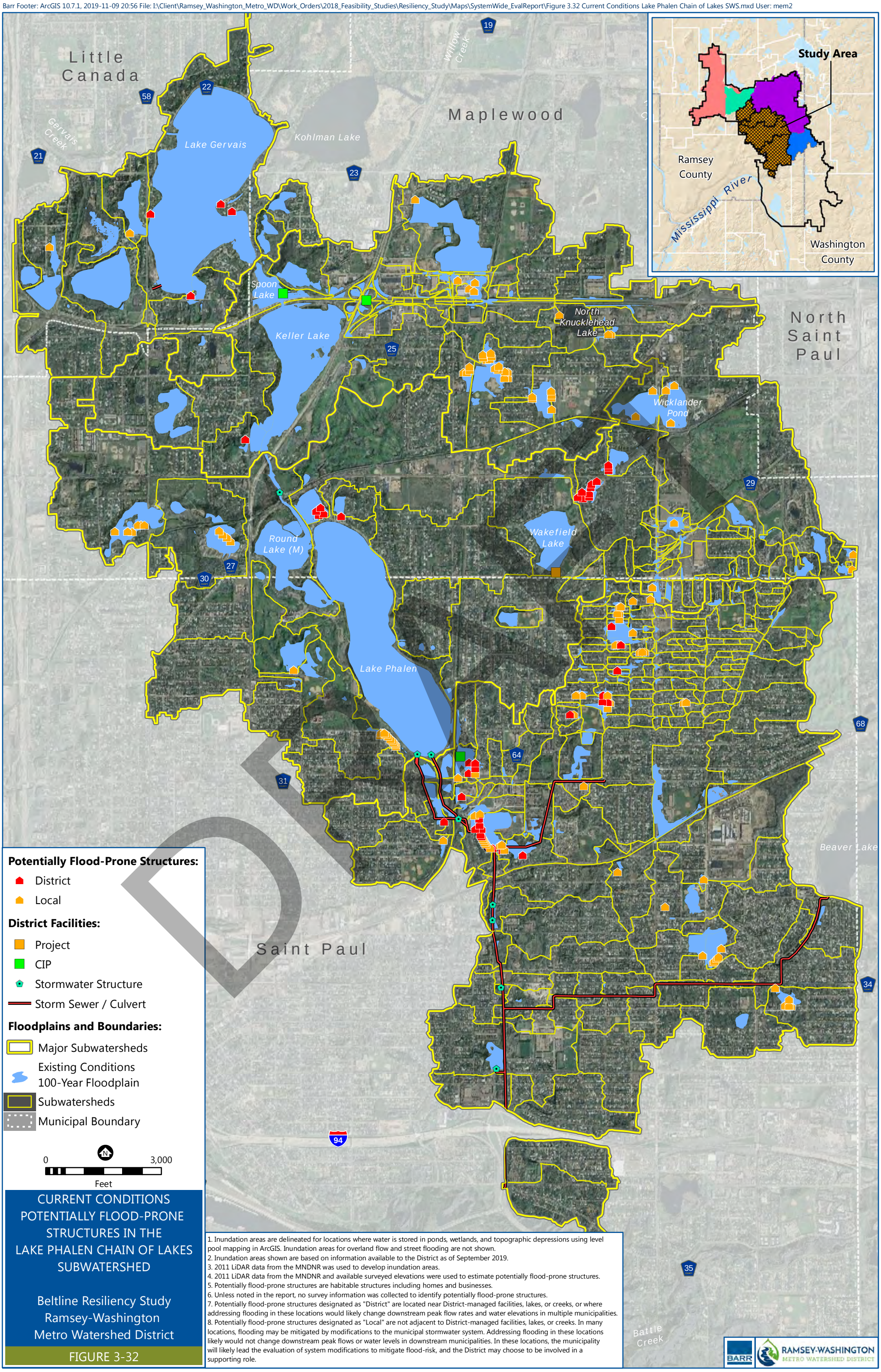
Table 3-9 Potentially Flood-Prone Structures in the Lake Phalen Chain of Lakes Subwatershed

Parcel ID	Address	Lowest Adjacent Grade	Source for Lowest Adjacent Grade	Existing 100-Year Water Surface Elevation
272922220145	1342 Phalen Blvd, St. Paul 55106	855.7	LiDAR[1]	857.9
272922220157	1340 Phalen Blvd, St. Paul 55106	855.8	LiDAR[1]	857.9
272922220140	1350 Phalen Blvd, St. Paul 55106	856.2	LiDAR[1]	857.9
272922230014	1381 Mechanic Ave, St. Paul 55106	856.4	LiDAR[1]	858.4
272922220129	1360 Phalen Blvd, St. Paul 55106	856.6	LiDAR[1]	857.9
272922230013	1389 Mechanic Ave, St. Paul 55106	856.8	LiDAR[1]	858.4
272922220134	1355 Magnolia Ave, St. Paul 55106	857.3	LiDAR[1]	857.9
272922230007	1415 Mechanic Ave, St. Paul 55106	857.6	LiDAR[1]	858.4
272922230011	1397 Mechanic Ave, St. Paul 55106	857.6	LiDAR[1]	858.4
272922230012	1393 Mechanic Ave, St. Paul 55106	857.7	LiDAR[1]	858.4
272922230010	1401 Mechanic Ave E, St. Paul 55106	857.7	LiDAR[1]	858.4
272922220150	1343 Magnolia Ave, St. Paul 55106	857.9	LiDAR[1]	857.9
272922230003	1433 Mechanic Ave, St. Paul 55106	858.0	LiDAR[1]	858.4

Parcel ID	Address	Lowest Adjacent Grade	Source for Lowest Adjacent Grade	Existing 100-Year Water Surface Elevation
222922330167-69 [2]	1251,1253,1255 Clarence St, St. Paul 55106	858.1	LiDAR[1]	860.0
272922230006	1421 Mechanic Ave, St. Paul 55106	858.2	LiDAR[1]	858.4
222922330170-74[2]	1235,1237,1239,1241,1243 Clarence St, St. Paul 55106	858.3	LiDAR[1]	860.0
272922230002	1437 Mechanic Ave, St. Paul 55106	857.4	LiDAR[1]	858.4
222922330175-79[2]	1221,1223,1225,1227,1229 Clarence St, St. Paul 55106	858.6	LiDAR[1]	860.0
282922110118	1275 Magnolia Ave, St. Paul 55106	858.8	LiDAR[1]	860.7
272922230009	1405 Mechanic Ave, St. Paul 55106	857.8	LiDAR[1]	858.4
272922220162	1177 Clarence St, St. Paul 55106	859.5	LiDAR[1]	861.3
222922330180-84[2]	1205,1207,1209,1211,1213 Clarence St, St. Paul 55106	859.8	LiDAR[1]	860.0
222922330192-95[2]	1333,1335,1337,1339 Maryland Ave, St. Paul 55106	859.8	LiDAR[1]	860.0
222922330104	1305 Maryland Ave, St. Paul 55106	859.5	LiDAR[1]	860.0
082922120012	2540 Edgerton St, Little Canada 55117	860.8	LiDAR[1]	861.8
162922310028	1880 East Shore Dr, Maplewood 55109	861.7	LiDAR[1]	863.2
082922420003	681 B2, Little Canada 55117	861.7	LiDAR[1]	861.8
162922310028	1880 East Shore Dr, Maplewood 55109	861.9	LiDAR[1]	863.2
082922110018	750 Carla Ln, Little Canada 55109	861.5	Survey [3]	861.8
172922140072	2009 Arcade St, Maplewood 55109	861.4	LiDAR[1]	861.8
162922310028	1880 East Shore Dr, Maplewood 55109	862.4	LiDAR[1]	863.2
272922240056	1465 Ames Ave, St. Paul 55106	862.7	LiDAR[1]	863.5
162922310010	1858 East Shore Dr, Maplewood 55109	863.0	LiDAR[1]	863.0
282922140007	1267 Cook Ave, St. Paul 55106	863.1	LiDAR[1]	863.2
272922240061	1442 Mechanic Ave, St. Paul 55106	863.2	LiDAR[1]	863.5
162922310028	1880 East Shore Dr, Maplewood 55109	862.5	LiDAR[1]	863.2
272922230042	1438 Mechanic Ave, St. Paul 55106	862.8	LiDAR[1]	863.5
272922120039	1604 Maryland Ave, St. Paul 55106	893.8	LiDAR[1]	894.1
152922420002	1638 Frost Ave, Maplewood 55109	901.5	LiDAR[1]	903.4
152922420006	1880 Maryknoll Ave, Maplewood 55109	901.6	LiDAR[1]	903.4
152922420004	1904 Maryknoll Ave, Maplewood 55109	901.8	LiDAR[1]	903.4
152922420031	1872 Prosperity Rd, Maplewood 55109	901.9	LiDAR[1]	903.4
152922420007	1870 Maryknoll Ave, Maplewood 55109	901.9	LiDAR[1]	903.4
152922420005	1894 Maryknoll Ave, Maplewood 55109	902.7	LiDAR[1]	903.4
152922420032	1871 Maryknoll Ave, Maplewood 55109	903.0	LiDAR[1]	903.4
152922140032	1936 Kennard St, Maplewood 55109	903.3	LiDAR[1]	904.1

Parcel ID	Address	Lowest Adjacent Grade	Source for Lowest Adjacent Grade	Existing 100-Year Water Surface Elevation
152922420033	1885 Maryknoll Ave, Maplewood 55109	903.4	LiDAR[1]	903.4
152922140030	1948 Kennard St, Maplewood 55109	903.9	LiDAR[1]	904.1
152922140031	1944 Kennard St, Maplewood 55109	904.1	LiDAR[1]	904.1
272922140130	1688 Lacrosse St, St. Paul 55106	909.7	LiDAR[1]	909.8
222922420114	1583 Clear Ave, St. Paul 55106	916.4	LiDAR[1]	918.2
222922420113	1577 Clear Ave, St. Paul 55106	916.9	LiDAR[1]	918.2
222922420115	1589 Clear Ave, St. Paul 55106	916.9	LiDAR[1]	918.2
222922420139	1655 Cottage Ave, St. Paul 55106	921.6	LiDAR[1]	923.2
222922410125	1659 Cottage Ave, St. Paul 55106	922.2	LiDAR[1]	923.2
222922410144	1660 Cottage Ave, St. Paul 55106	923.1	LiDAR[1]	923.2
222922420076	1592 Sherwood Ave, St. Paul 55106	923.2	LiDAR[1]	923.3
222922410124	1662 Sherwood Ave, St. Paul 55106	922.9	LiDAR[1]	923.2
222922420075	1598 Sherwood Ave, St. Paul 55106	923.3	LiDAR[1]	923.3
222922420025	1658 Sherwood Ave, St. Paul 55106	923.2	LiDAR[1]	923.2
222922420036	1600 Sherwood Ave, St. Paul 55106	923.3	LiDAR[1]	923.3
222922410126	1665 Cottage Ave, St. Paul 55106	923.2	LiDAR[1]	923.2
222922140108	1696 Montana Ave, St. Paul 55106	927.4	LiDAR[1]	928.0
222922140110	1684 Montana Ave, St. Paul 55106	927.5	LiDAR[1]	928.0
222922110135	1671 Hoyt Ave, St. Paul 55106	927.7	LiDAR[1]	928.0
222922140109	1690 Montana Ave, St. Paul 55106	927.7	LiDAR[1]	928.0
222922140011	1720 Hoyt Ave, St. Paul 55106	928.0	LiDAR[1]	928.0
222922140111	1680 Montana Ave, St. Paul 55106	927.5	LiDAR[1]	928.0
222922110126	1696 Iowa Ave, St. Paul 55106	927.9	LiDAR[1]	928.0
222922140158	1688 Nevada Ave, St. Paul 55106	929.9	LiDAR[1]	929.9
222922140033	1739 Nebraska Ave, St. Paul 55106	931.8	LiDAR[1]	932.5
222922140034	1745 Nebraska Ave, St. Paul 55106	931.8	LiDAR[1]	932.5
222922140033	1739 Nebraska Ave, St. Paul 55106	931.8	LiDAR[1]	932.5
222922140035	1751 Nebraska Ave, St. Paul 55106	932.1	LiDAR[1]	932.5
082922110012	737 Carla Ln, Little Canada 55109	860.7	Survey [3]	861.8

(1) Reference [5]
(2) The parcel ID is for a townhouse. There are multiple parcel IDs and structures that are potentially flood-prone in this location.
(3) Reference [10]



CURRENT CONDITIONS POTENTIALLY FLOOD-PRONE STRUCTURES IN THE LAKE PHALEN CHAIN OF LAKES SUBWATERSHED

Beltline Resiliency Study
Ramsey-Washington
Metro Watershed District

FIGURE 3-32

1. Inundation areas are delineated for locations where water is stored in ponds, wetlands, and topographic depressions using level pool mapping in ArcGIS. Inundation areas for overland flow and street flooding are not shown.
2. Inundation areas shown are based on information available to the District as of September 2019.
3. 2011 LiDAR data from the MNDNR was used to develop inundation areas.
4. 2011 LiDAR data from the MNDNR and available surveyed elevations were used to estimate potentially flood-prone structures.
5. Potentially flood-prone structures are habitable structures including homes and businesses.
6. Unless noted in the report, no survey information was collected to identify potentially flood-prone structures.
7. Potentially flood-prone structures designated as "District" are located near District-managed facilities, lakes, or creeks, or where addressing flooding in these locations would likely change downstream peak flow rates and water elevations in multiple municipalities.
8. Potentially flood-prone structures designated as "Local" are not adjacent to District-managed facilities, lakes, or creeks. In many locations, flooding may be mitigated by modifications to the municipal stormwater system. Addressing flooding in these locations likely would not change downstream peak flows or water levels in downstream municipalities. In these locations, the municipality will likely lead the evaluation of system modifications to mitigate flood-risk, and the District may choose to be involved in a supporting role.

BARR
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

3.4.2 Potential System Modifications Evaluated

Potential system modifications within the Phalen Chain of Lakes subwatershed were evaluated similar to the previous phases. The goal for each system modification was to prevent the 100-year flood level from inundating habitable structures.

Similar to previous phases, evaluation of potential system modifications did not include discussions with property owners, permitting agencies, or other stakeholders. Additional evaluation for system modifications, including detailed feasibility studies that further evaluate economic and social considerations is necessary prior to modifying the drainage system.

Potential system modifications included improvements to and active management of outlet control structures on Keller Creek and Lake Phalen. In areas not directly adjacent to the Phalen Chain, system modifications included drainage improvements, storage areas, and storm sewer system modifications. In some locations, near past District projects, system modifications included items that are typically considered local projects, such as adding a catch basin or inlet capacity. These local system improvements were evaluated as part of this study to avoid adverse impacts as a result of other system modifications. Potential system modifications to mitigate flood risk in the Phalen Chain of Lakes subwatershed are summarized in steps 4A through 4F.

4A Lake Phalen and Keller Creek Outlet Structures

Potential modifications to the control structures on Keller Creek (downstream of Keller Lake) and Lake Phalen included adjustments to actively manage water levels on the chain. Active management allows for adjusting the timing of when water is conveyed into the Beltline, while not lowering the normal water level in the Chain. The general operation of the outlet structures includes: 1) lowering the outlets as water levels increase so more water will be conveyed to the Beltline, and 2) raising the outlets to their existing levels when the Beltline is near its capacity to minimize the downstream impacts. Locations of flood-prone structures on Gervais Lake are shown on Figure 3-33, and the outlet structures are shown in Figure 3-34. System modifications include:

- Evaluate modifying drainage near 737 Carla Lane (Figure 3-33).
- Evaluate modifying the outlet structure on Keller Creek to adjust the weir crest between 856.0 and 858.0 (Figure 3-34).
- Evaluate modifying the outlet structure on Lake Phalen to adjust the weir crest between 857.4 and 856.3 (Figure 3-34).
- Evaluate modifying the outlet structure on Lake Phalen to adjust the weir crest between 857.6 and 855.5 (Figure 3-34).

4B Wakefield Lake

The storm sewer between the intersection of Frost Avenue East and Kennard Street North is undersized to achieve the goals of this study. Additional storm sewer capacity is shown in Figure 3-35. The additional storm sewer capacity will lower the floodplain elevation upstream of Frost Avenue East and increase the water surface elevation in Wakefield Lake by 0.7 feet. The 100-year water level in Wakefield Lake will still be 2 feet lower than adjacent habitable structures. Possible modifications shown in Figure 3-35 include:

- Evaluate increased storm sewer capacity between Frost Avenue North and Wakefield Lake.

4C Phalen Village

Impacts in this area are due to a combination of high water levels in Lake Phalen and local storm sewer capacity. Following improvements to the Phalen Chain outlet structures, discussed in step 4A, additional storm sewer capacity is required to further lower the 100-year levels. Storm sewer modifications are shown in Figure 3-36.

- Evaluate increasing storm sewer capacity. 1 additional 24-inch (or equivalent) outlet.
- Evaluate increasing storm sewer capacity. 1 additional 36-inch (or equivalent) outlet.

4D Duluth Street Recreational Center

Potential system modifications in this area include providing additional storage volume and storm sewer system modifications to convey runoff to the new storage area. System modifications reduce the peak discharge conveyed into the Beltline and are shown in Figure 3-37:

- Evaluate adding storage volume in the park east of Duluth Street
- Evaluate modify existing storm sewer to divert stormwater into the new storage BMP
- Evaluate providing localized grading in multiple locations to reroute overland flow paths
- Evaluate grading the current detention pond in the park southwest of Lake Phalen.

4E Hoyt Pond

Potential System modifications evaluated in this area include providing additional floodplain storage volume and storm sewer system modifications. Potential system modifications are shown in Figure 3-38 through Figure 3-41 and include:

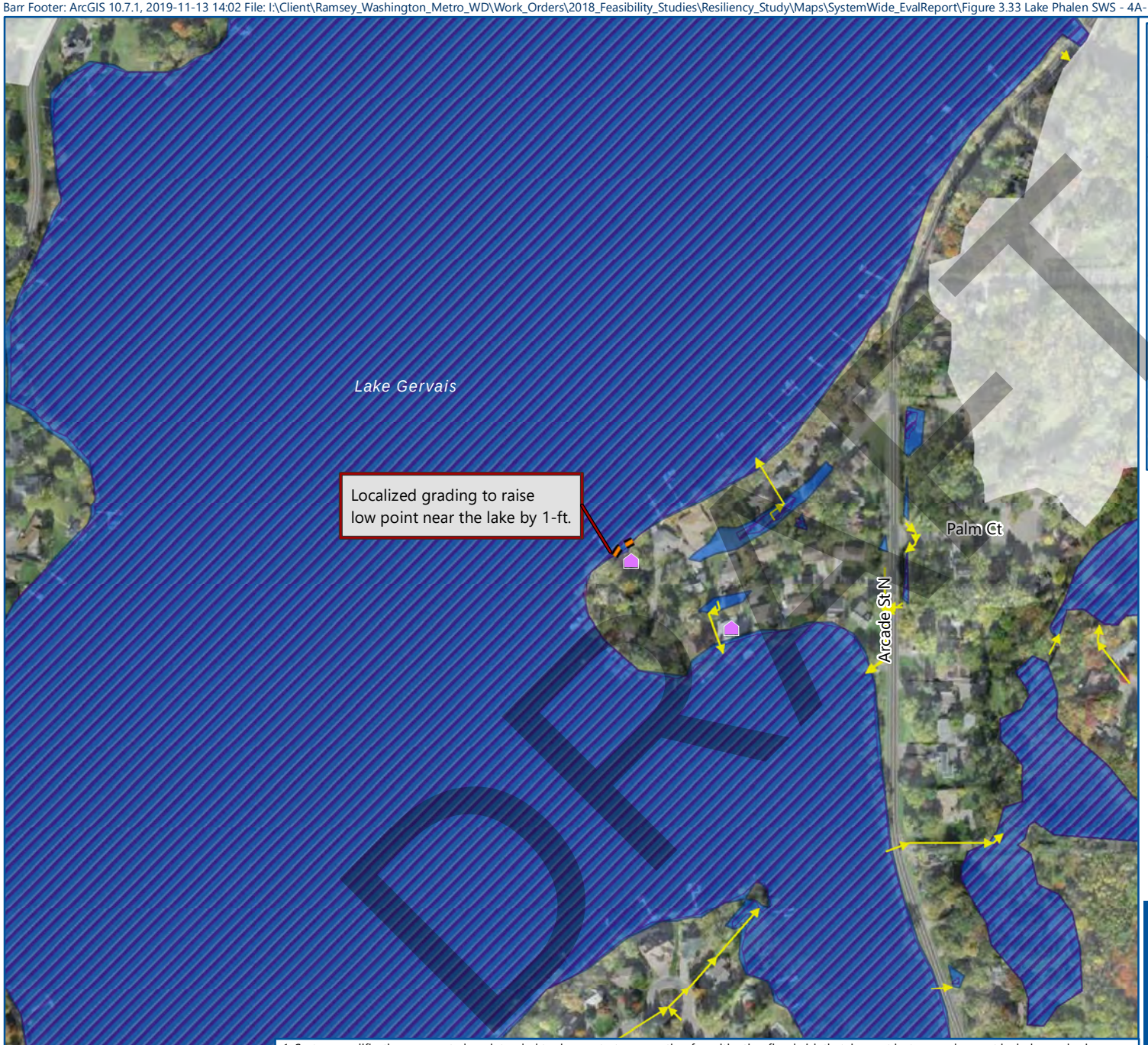
- Providing additional storage volume north of Hoyt Avenue and modifying the storm sewer to connect to the new storage area (Figure 3-38).
- Evaluate adding additional catch basin capacity North of Sherwood Avenue (Figure 3-39).

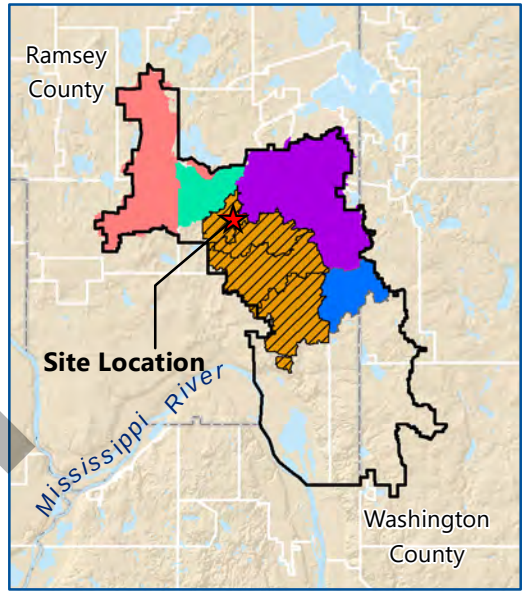
- Evaluate increasing storm sewer capacity along Nebraska Avenue (Figure 3-39).
- Evaluate diverting high flows from Hill Crest Knoll to the pond at 1505 Hoyt Avenue (Figure 3-39).
- Evaluate adding an underground/surface storage BMP in the park (Figure 3-40).
- Evaluate modifying surface overflow paths near the northeast corner of the park to allow overflow into the park (Figure 3-40).
- Evaluate raising Ivy Avenue between Germain Street and Kennard Road (Figure 3-40).
- Evaluate creating a detention pond south of Hoyt Pond (Figure 3-41).

4F AMES LAKE

Ames Lake and the surrounding development are located within a topographic depression. Flooding in this area is a combination of local runoff and overland flow from the upstream watershed. Potential system modifications evaluated to mitigate flood risk in this area include rerouting upstream storm sewer, adding new detention ponds, and expanding existing ponds. Potential modifications are listed below and shown in Figure 3-42 to Figure 3-44:

- Evaluate diverting stormwater runoff from east of White Bear Avenue and the connection to the Beltline (Figure 3-42)
- Evaluate constructing a new detention pond southeast of the intersection of Maryland Avenue and Johnson Parkway (Figure 3-43)
- Evaluate regrading the current detention pond north of Maryland Avenue (Figure 3-43)
- Evaluate increasing the culvert capacity south of Magnolia Avenue (Figure 3-44)— by adding a 36-inch circular concrete pipe, or equivalent
- Evaluate increasing the culvert capacity south of Magnolia Avenue (Figure 3-44)
- Evaluate increasing the culvert capacity at Magnolia Avenue (Figure 3-44)
- Evaluate constructing a new detention pond south of Magnolia Avenue (Figure 3-44)
- Evaluate adding a pond southeast of the intersection of Phalen Boulevard and Johnson Parkway (Figure 3-44)
- Evaluate expanding the stormwater pond south of the intersection of Phalen Boulevard and Johnson Parkway (Figure 3-44)





Potentially Flood-Prone Structures:

- Structures Removed from Floodplain

Design Elements:

- Site Grading
- Existing Storm Sewer Pipe

100-Year Floodplain:

- All Designs Following System Modifications
- Existing Atlas 14 Inundation

0 500

Feet

LAKE PHALEN CHAIN OF LAKES SUBWATERSHED SYSTEM MODIFICATIONS 4A-1

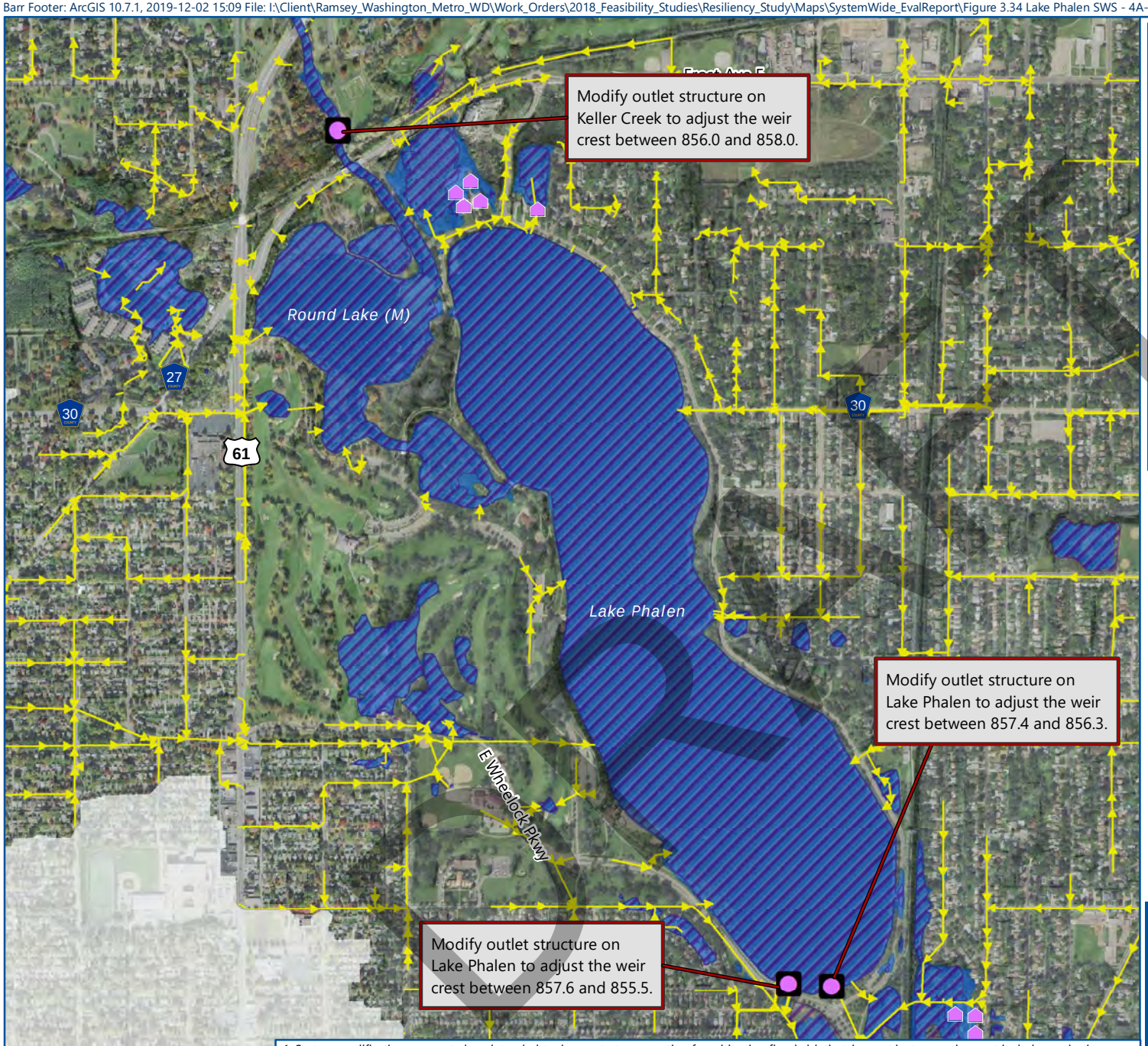
Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

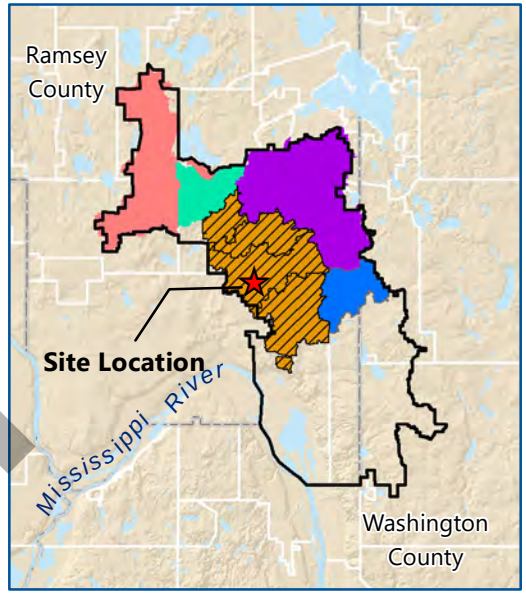
FIGURE 3-33

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT





Potentially Flood-Prone Structures:

Structures Removed from Floodplain

Design Elements:

Outlet Modification

Existing Storm Sewer Pipe

100-Year Floodplain:

All Designs Following System Modifications

Existing Atlas 14 Inundation

0 2,000

Feet

LAKE PHALEN CHAIN OF LAKES SUBWATERSHED SYSTEM MODIFICATIONS 4A-2

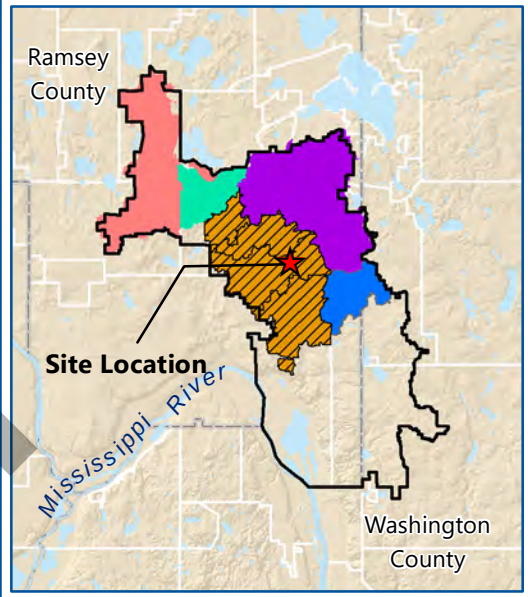
Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-34

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT



Potentially Flood-Prone Structures:

Structures Removed from Floodplain

Design Elements:

Pipe

Existing Storm Sewer Pipe

100-Year Floodplain:

All Designs Following System Modifications

Existing Atlas 14 Inundation

0 500

Feet

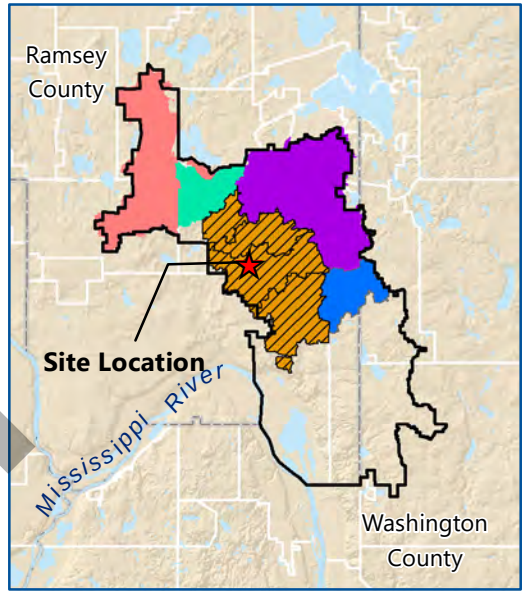
1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

LAKE PHALEN CHAIN OF LAKES
SUBWATERSHED
SYSTEM MODIFICATIONS
4B
Beltline Resiliency Study
Ramsey-Washington
Metro Watershed District

FIGURE 3-35



Potentially Flood-Prone Structures:

Structures Removed from Floodplain

Design Elements:

Pipe

Existing Storm Sewer Pipe

100-Year Floodplain:

All Designs Following System Modifications

Existing Atlas 14 Inundation

0 500

Feet

LAKE PHALEN CHAIN OF LAKES SUBWATERSHED SYSTEM MODIFICATIONS 4C

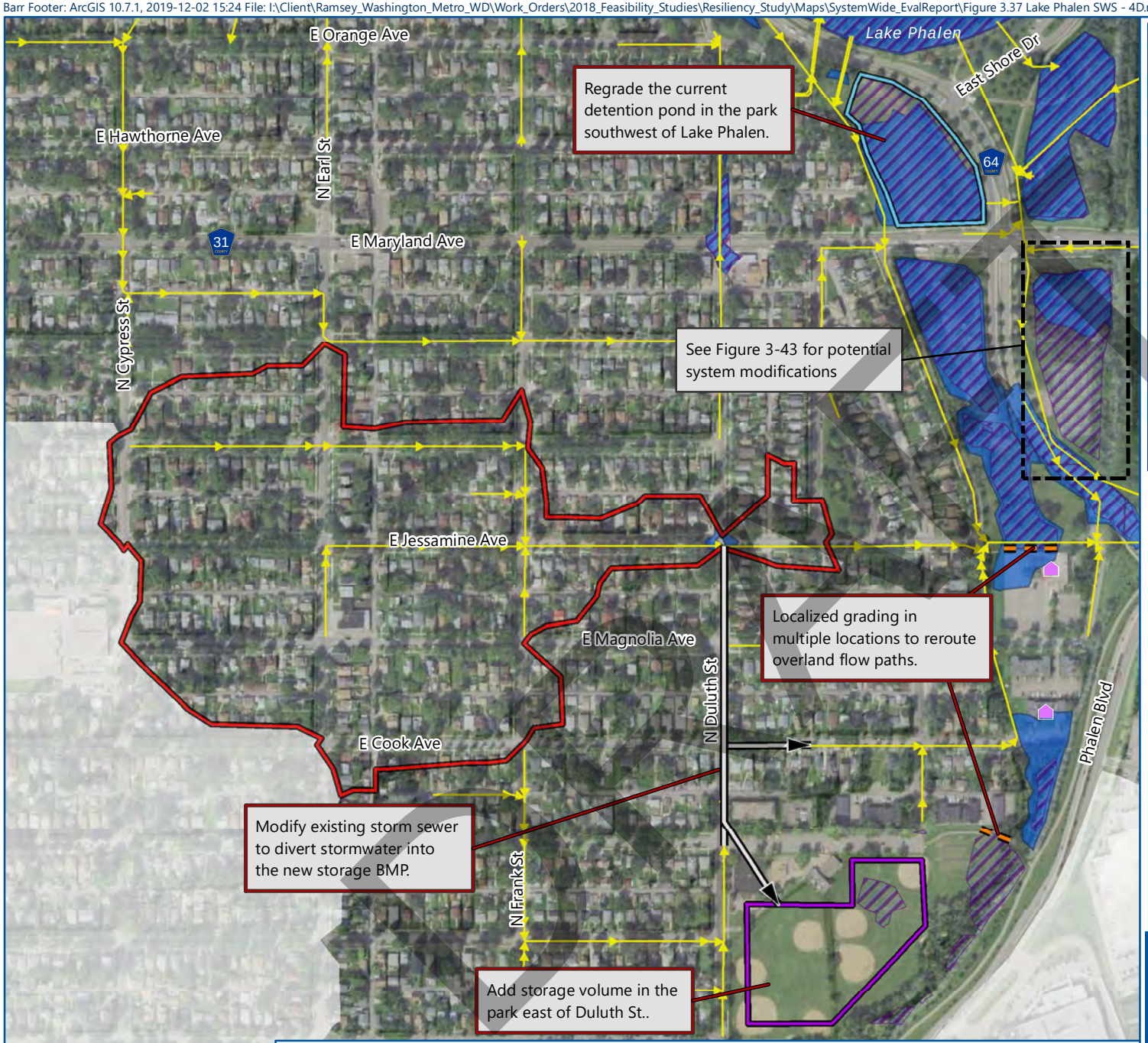
Beltline Resiliency Study
Ramsey-Washington
Metro Watershed District

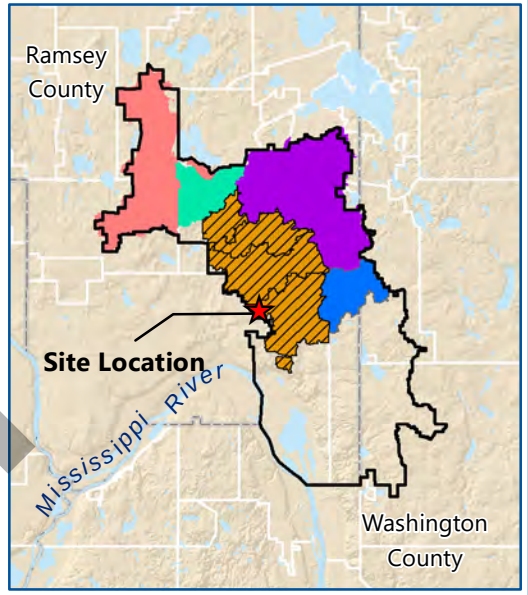
FIGURE 3-36

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT





Potentially Flood-Prone Structures:

- Structures Removed from Floodplain

Design Elements:

- Pipe
- Site Grading
- Detention Pond
- Surface / Underground Storage
- Redirect Runoff
- Existing Storm Sewer Pipe

100-Year Floodplain:

- All Designs Following System Modifications
- Existing Atlas 14 Inundation

0 1,000

Feet

LAKE PHALEN CHAIN OF LAKES SUBWATERSHED SYSTEM MODIFICATIONS 4D

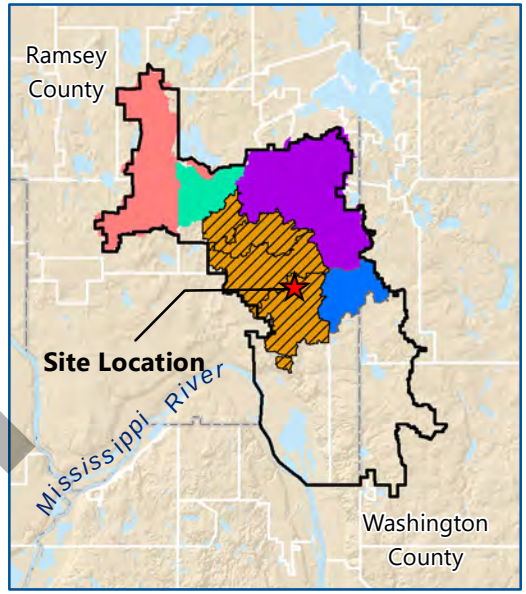
Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-37

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT



Potentially Flood-Prone Structures:

Structures Removed from Floodplain

Design Elements:

Pipe

Surface / Underground Storage

Existing Storm Sewer Pipe

100-Year Floodplain:

All Designs Following System Modifications

Existing Atlas 14 Inundation

0 500

Feet

LAKE PHALEN CHAIN OF LAKES SUBWATERSHED SYSTEM MODIFICATIONS 4E-1

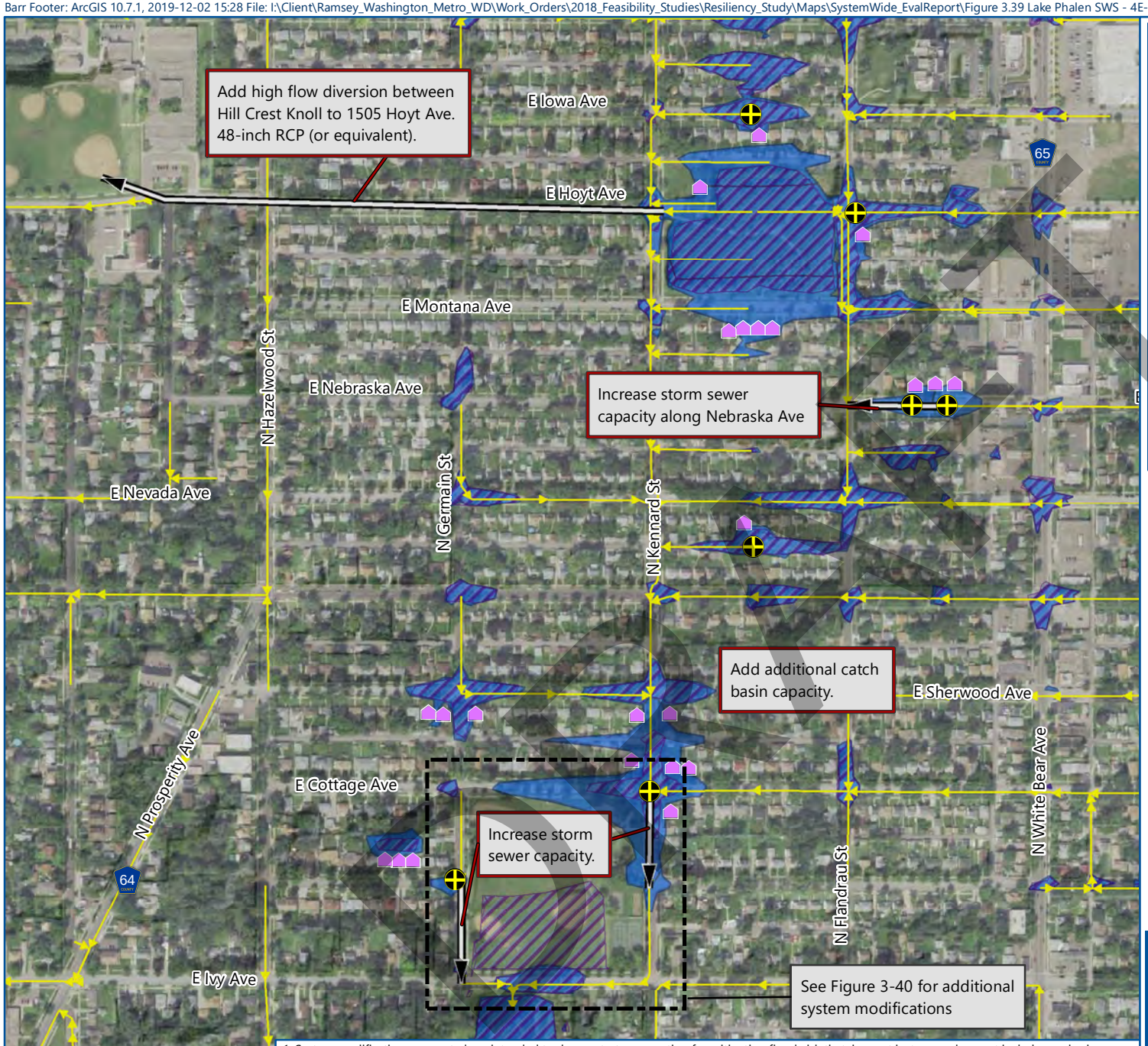
Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

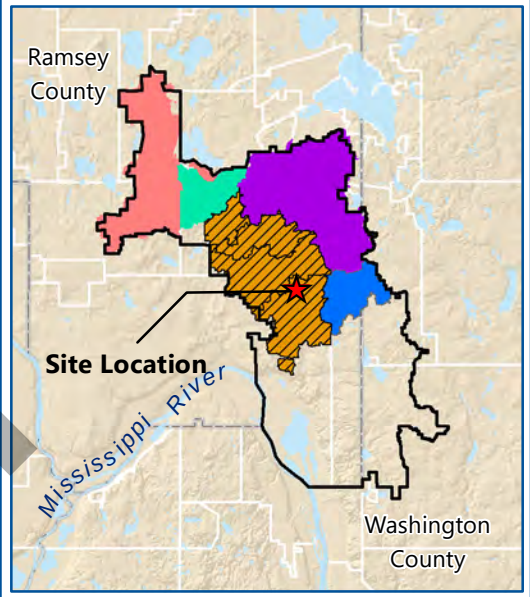
FIGURE 3-38

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT





Potentially Flood-Prone Structures:

Structures Removed from Floodplain

Design Elements:

Add Inlet Capacity

Pipe

Existing Storm Sewer Pipe

100-Year Floodplain:

All Designs Following System Modifications

Existing Atlas 14 Inundation

0 1,000

Feet

LAKE PHALEN CHAIN OF LAKES SUBWATERSHED SYSTEM MODIFICATIONS 4E-2

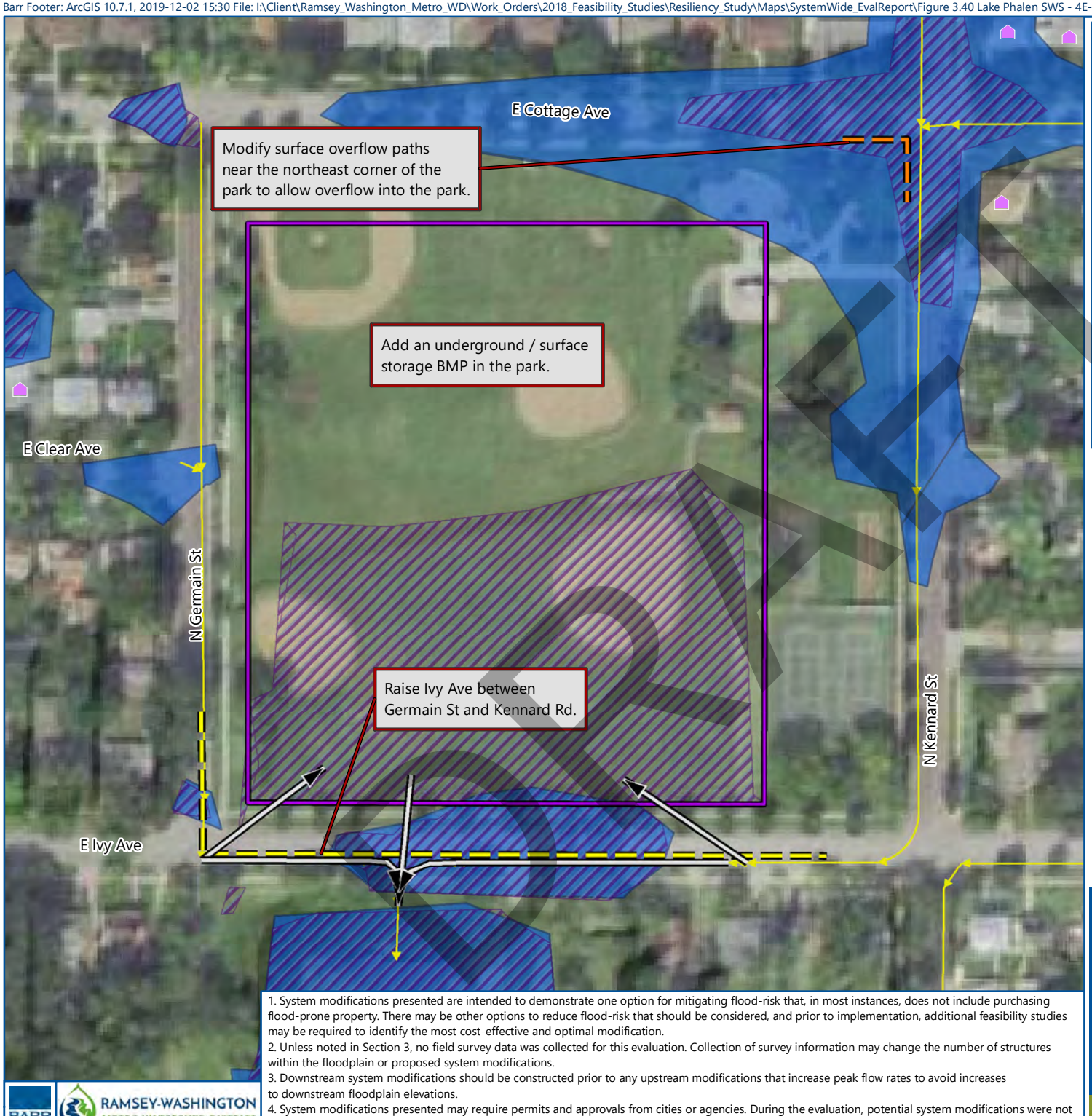
Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

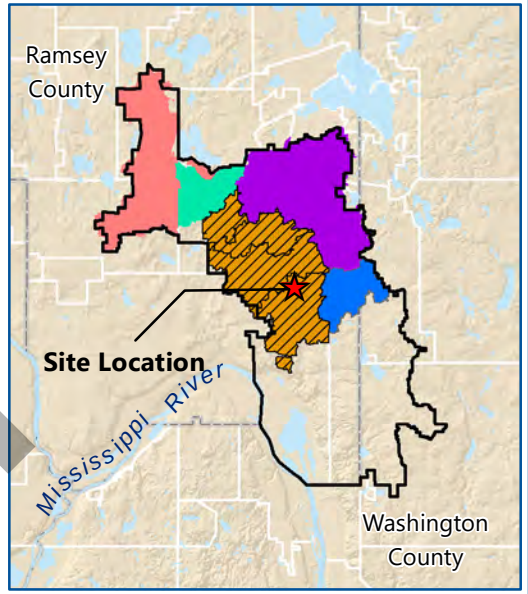
FIGURE 3-39

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT





Potentially Flood-Prone Structures:

- Structures Removed from Floodplain

Design Elements:

- Pipe
- Site Grading
- Road Raise
- Surface / Underground Storage
- Existing Storm Sewer Pipe

100-Year Floodplain:

- All Designs Following System Modifications
- Existing Atlas 14 Inundation

0 200

Feet

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

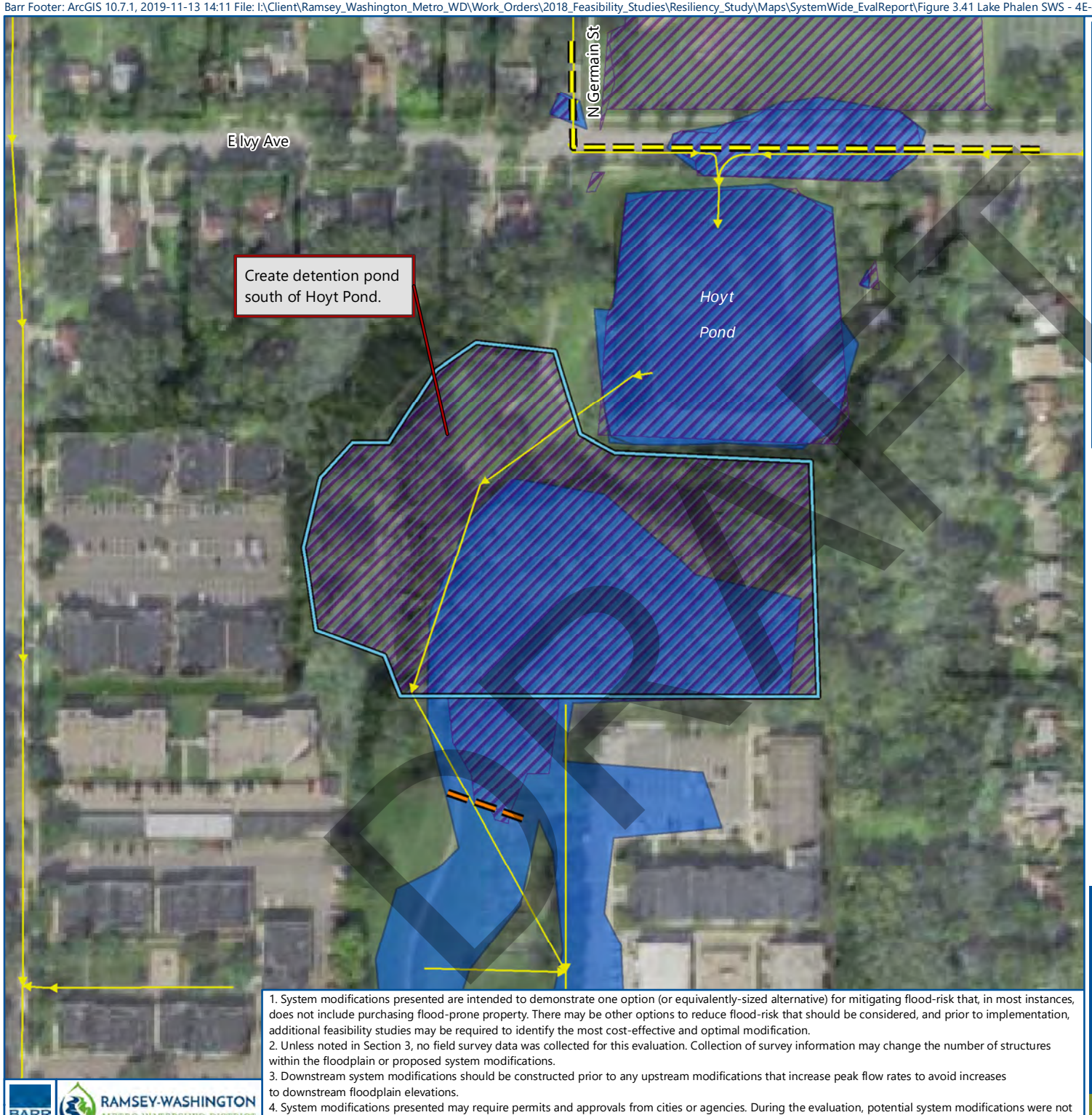
BARR

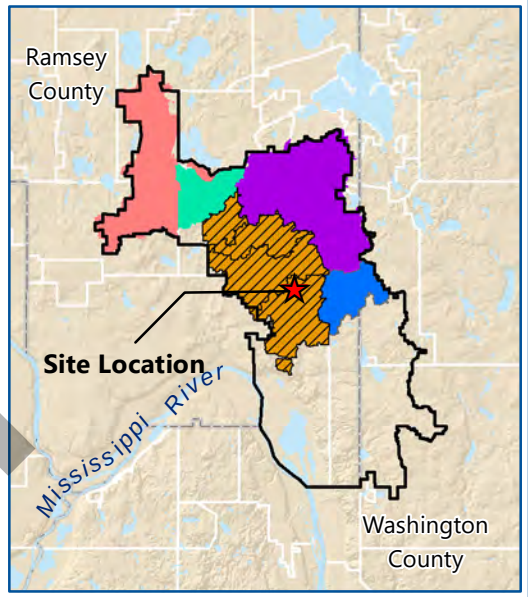
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

LAKE PHALEN CHAIN OF LAKES SUBWATERSHED SYSTEM MODIFICATIONS 4E-3

Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-40





Potentially Flood-Prone Structures:

Structures Removed from Floodplain

Design Elements:

Site Grading

Road Raise

Above Ground Storage

Existing Storm Sewer Pipe

100-Year Floodplain:

All Designs Following System Modifications

Existing Atlas 14 Inundation

0 200

Feet

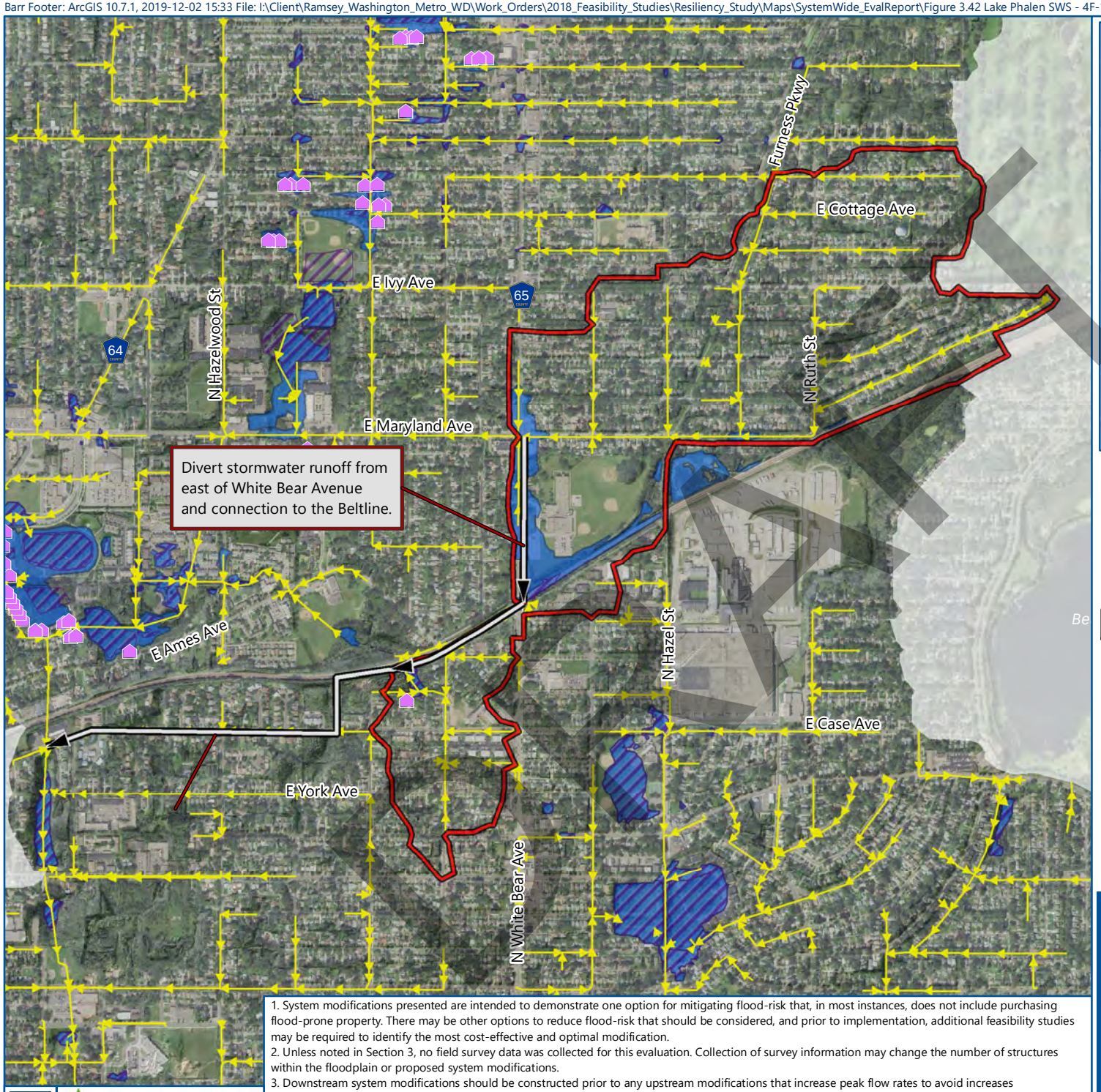
1. System modifications presented are intended to demonstrate one option (or equivalently-sized alternative) for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

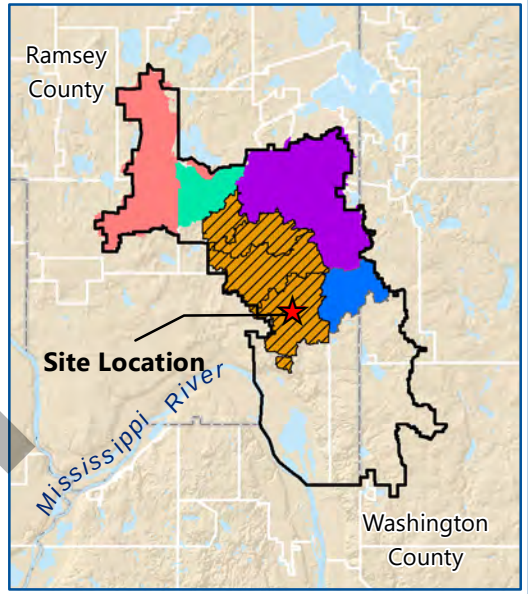
BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

LAKE PHALEN CHAIN OF LAKES SUBWATERSHED
SYSTEM MODIFICATIONS
4E-4
Beltline Resiliency Study
Ramsey-Washington
Metro Watershed District

FIGURE 3-41





Potentially Flood-Prone Structures:

Structures Removed from Floodplain

Design Elements:

Pipe

Redirect Runoff

Existing Storm Sewer Pipe

100-Year Floodplain:

All Designs Following System Modifications

Existing Atlas 14 Inundation

N

0 2,000

Feet

LAKE PHALEN CHAIN OF LAKES SUBWATERSHED SYSTEM MODIFICATIONS 4F-1

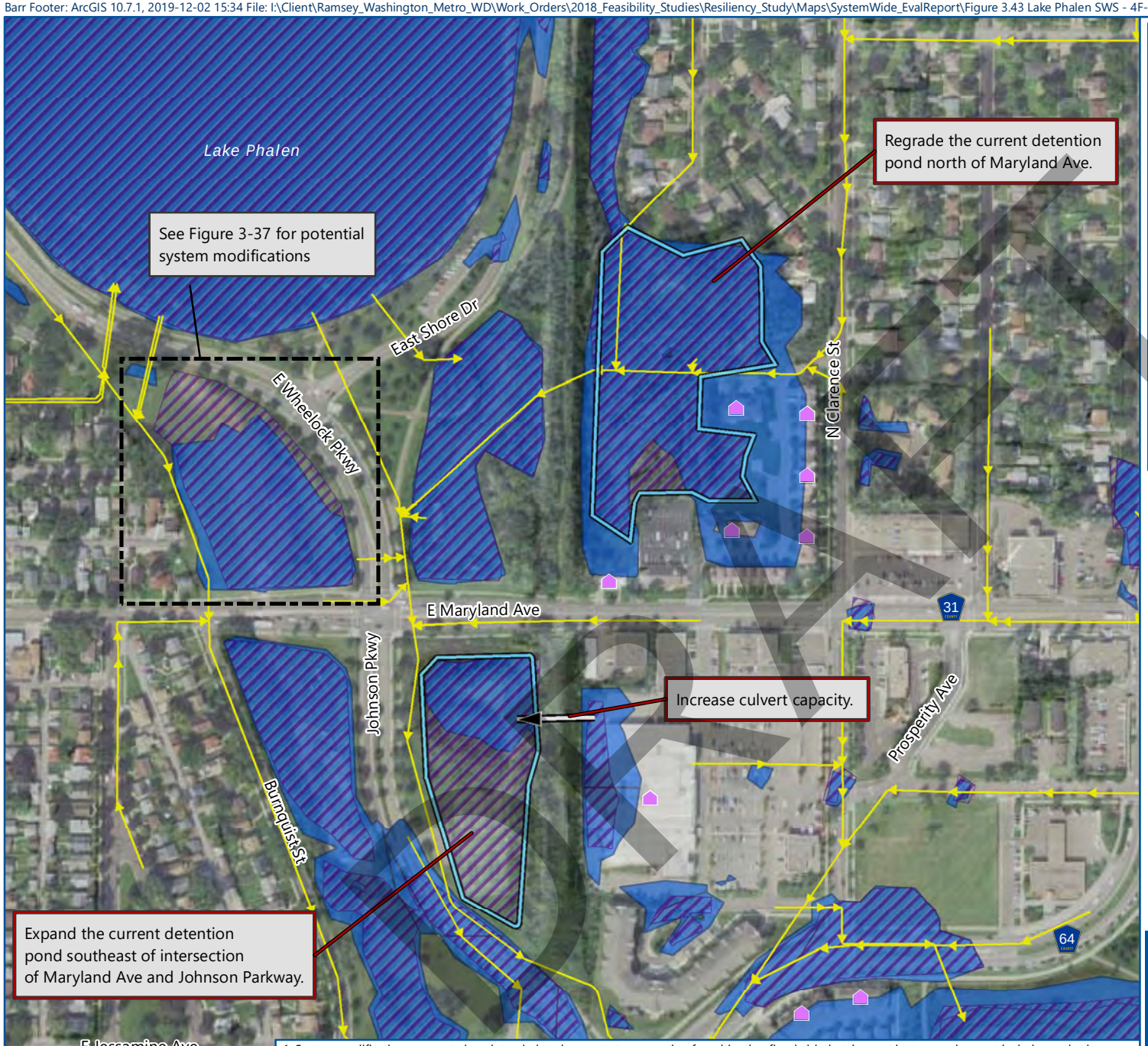
Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

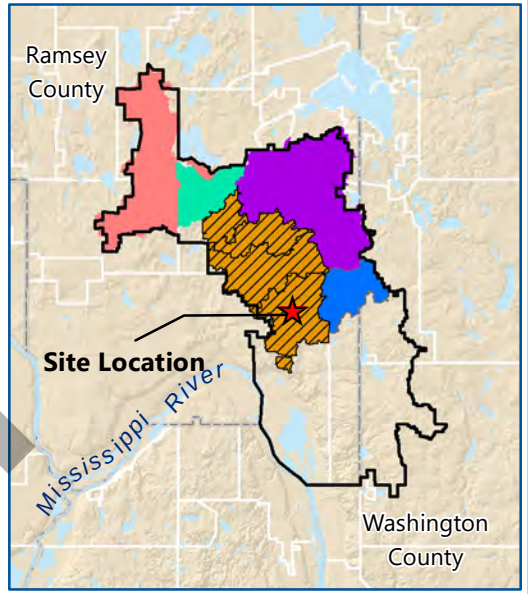
FIGURE 3-42

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT





Potentially Flood-Prone Structures:

Structures Removed from Floodplain

Design Elements:

Pipe

Above Ground Storage

Existing Storm Sewer Pipe

100-Year Floodplain:

All Designs Following System Modifications

Existing Atlas 14 Inundation

0 500

Feet

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

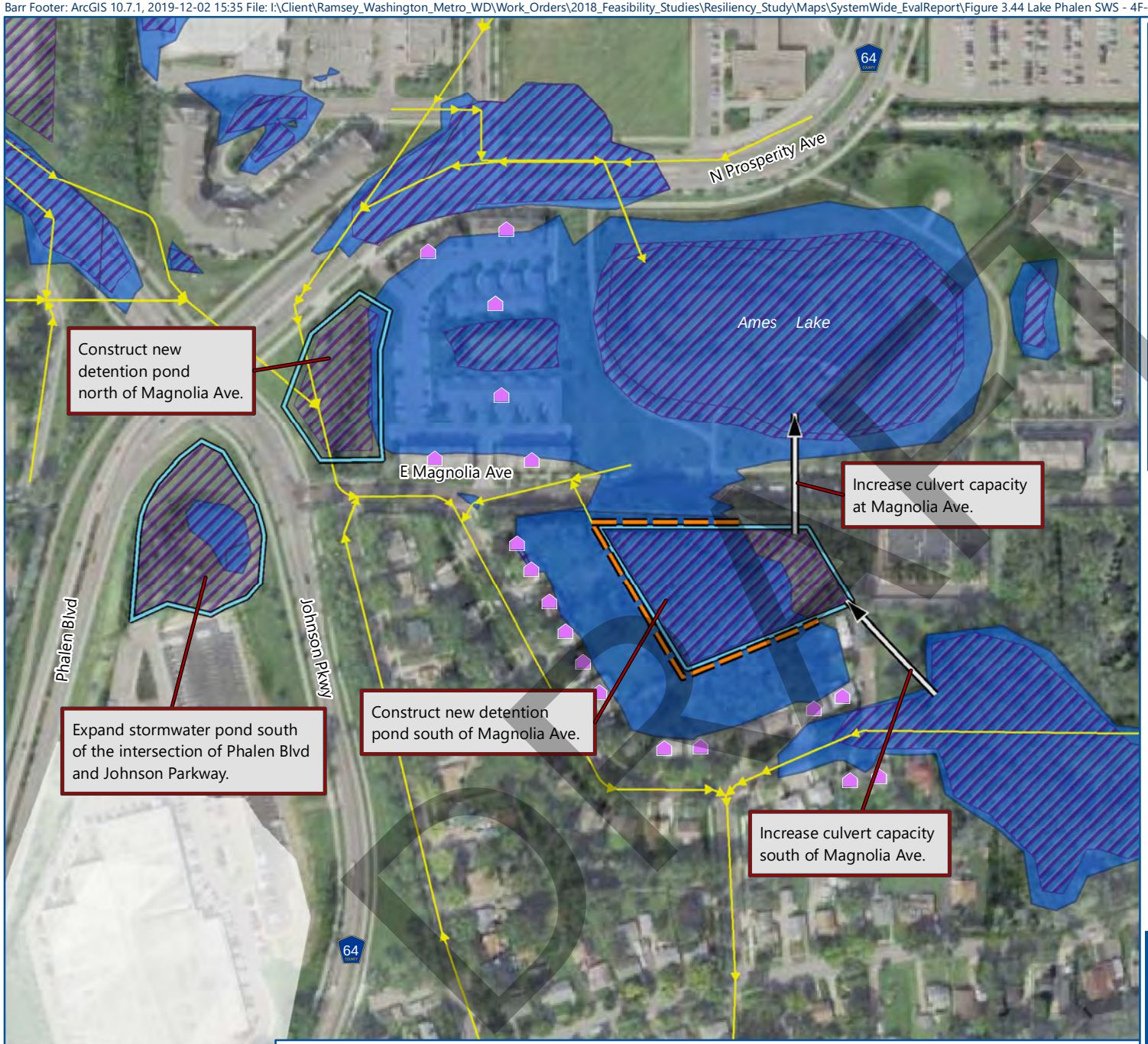
BARR

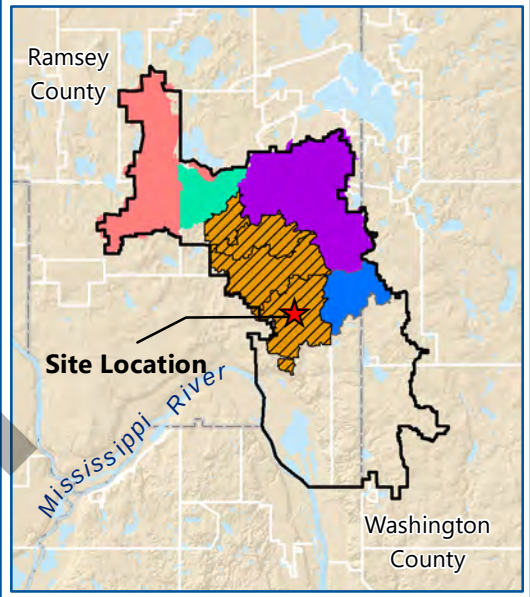
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

LAKE PHALEN CHAIN OF LAKES SUBWATERSHED SYSTEM MODIFICATIONS 4F-2

Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-43





Potentially Flood-Prone Structures:

- Structures Removed from Floodplain

Design Elements:

- Pipe
- Site Grading
- Detention Pond
- Existing Storm Sewer Pipe

100-Year Floodplain:

- All Designs Following System Modifications
- Existing Atlas 14 Inundation

0 500

Feet

1. System modifications presented are intended to demonstrate one option for mitigating flood-risk that, in most instances, does not include purchasing flood-prone property. There may be other options to reduce flood-risk that should be considered, and prior to implementation, additional feasibility studies may be required to identify the most cost-effective and optimal modification.
2. Unless noted in Section 3, no field survey data was collected for this evaluation. Collection of survey information may change the number of structures within the floodplain or proposed system modifications.
3. Downstream system modifications should be constructed prior to any upstream modifications that increase peak flow rates to avoid increases to downstream floodplain elevations.
4. System modifications presented may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other permitting entities. It is possible that permit requirements may change the configuration or function of system modifications.

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

LAKE PHALEN CHAIN OF LAKES SUBWATERSHED SYSTEM MODIFICATIONS 4F-3

Beltline Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-44

3.4.3 Flooding Concerns following System Modifications

The potential system modifications result in lowering the 100-year floodplain below the low adjacent grade of habitable structures within the Phalen Chain of Lakes subwatershed. The 100-year floodplain following system modifications is shown in Figure 3-45. Table 3-10 lists the existing 100-year water surface elevation and elevation following modifications to the drainage system.

System improvements, if implemented, provide flood-risk mitigation for habitable structures adjacent to District-managed waterbodies and also several structures where flooding may be due to the local drainage system. A total of 75 structures are removed from the floodplain, as listed in Table 3-10. Of the 75 structures, 28 had been classified as "Local". A key improvement option is the active management of the Phalen and Keller control structures. An operating plan associated with this active management, along with the modification of these structures, will be necessary with any active management of these control points.

Table 3-11 lists the existing 100-year water surface elevation and the elevation following modifications to the drainage system. Table 3-11 also includes planning-level considerations related to project sequencing to avoid increases to downstream water levels. Project sequencing refers to the order that system modifications should be constructed to prevent adverse downstream impacts. A planning-level schematic for sequencing of potential system modifications is included in Appendix A.

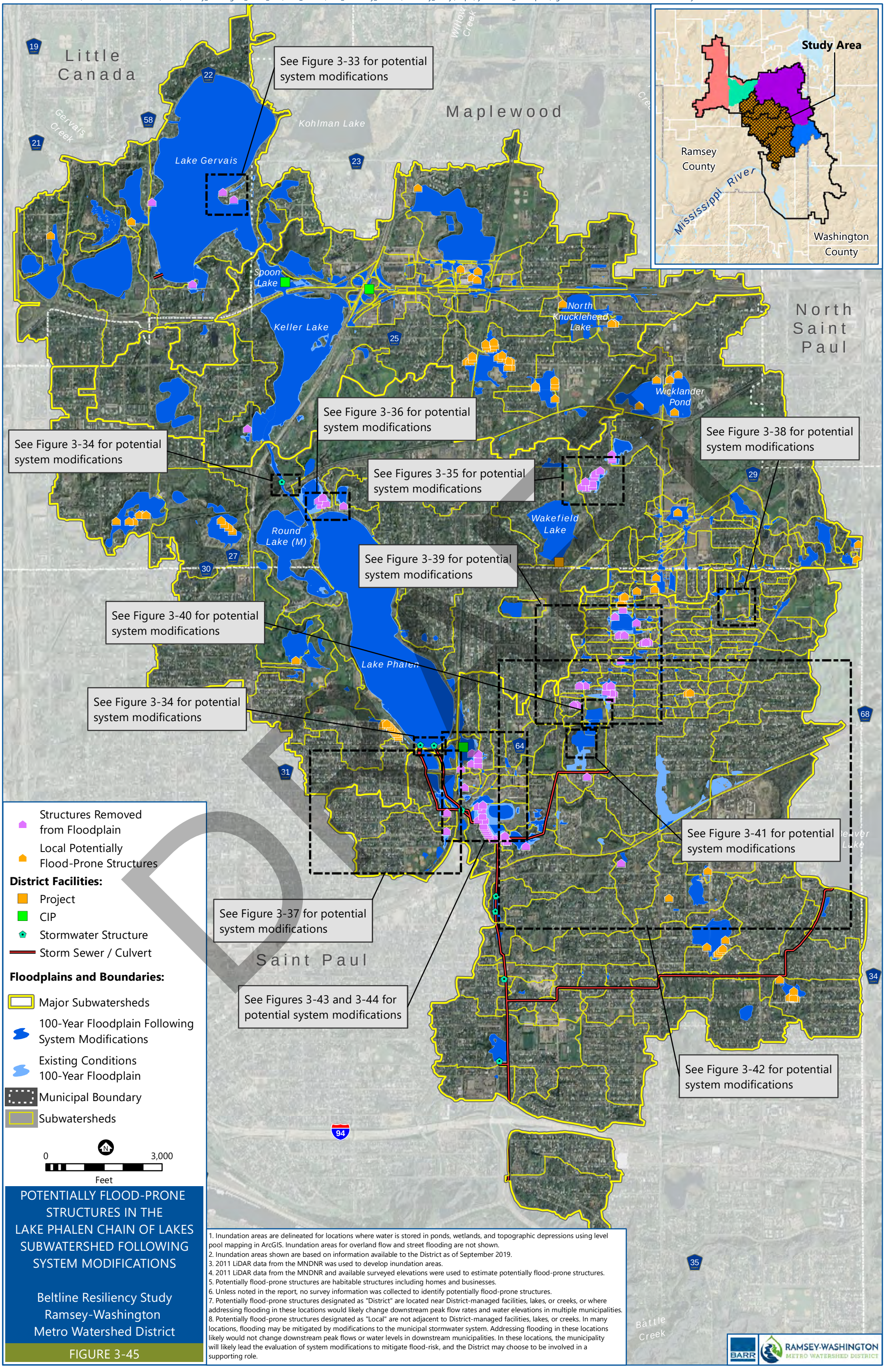
Table 3-10 Potentially Flood-Prone Structures in the Lake Phalen Chain of Lakes Subwatershed

Parcel ID	Address	Lowest Adjacent Grade[1]	Existing 100-year Water Surface Elevation	100-year Water Surface Elevation following System Modifications	System Modification to Reduce Flood Risk	Prerequisite System Modifications
272922220145	1342 Phalen Blvd, St. Paul 55106	855.7	857.9	854.7	4F	N/A
272922220157	1340 Phalen Blvd, St. Paul 55106	855.8	857.9	854.7	4F	N/A
272922220140	1350 Phalen Blvd, St. Paul 55106	856.2	857.9	854.7	4F	N/A
272922230014	1381 Mechanic Ave, St. Paul 55106	856.4	858.4	854.7	4F	N/A
272922220129	1360 Phalen Blvd, St. Paul 55106	856.6	857.9	854.7	4F	N/A
272922230013	1389 Mechanic Ave, St. Paul 55106	856.8	858.4	854.7	4F	N/A
272922220134	1355 Magnolia Ave, St. Paul 55106	857.3	857.9	854.7	4F	N/A
272922230007	1415 Mechanic Ave, St. Paul 55106	857.6	858.4	854.7	4F	N/A
272922230011	1397 Mechanic Ave, St. Paul 55106	857.6	858.4	854.7	4F	N/A
272922230012	1393 Mechanic Ave, St. Paul 55106	857.7	858.4	854.7	4F	N/A
272922230010	1401 Mechanic Ave E, St. Paul 55106	857.7	858.4	854.7	4F	N/A
272922220150	1343 Magnolia Ave, St. Paul 55106	857.9	857.9	854.7	4F	N/A
272922230003	1433 Mechanic Ave, St. Paul 55106	858.0	858.4	854.7	4F	N/A
222922330167-69[2]	1251, 1253, 1255 Clarence St, St. Paul 55106	858.1	860.0	861.3[3]	4F	N/A

Parcel ID	Address	Lowest Adjacent Grade[1]	Existing 100-year Water Surface Elevation	100-year Water Surface Elevation following System Modifications	System Modification to Reduce Flood Risk	Prerequisite System Modifications
272922230006	1421 Mechanic Ave, St. Paul 55106	858.2	858.4	854.7	4F	N/A
222922330170-74[2]	1235,1237,1239,1241,1243 Clarence St, St. Paul 55106	858.3	860.0	861.3[3]	4F	N/A
272922230002	1437 Mechanic Ave, St. Paul 55106	857.4	858.4	854.7	4F	N/A
222922330175-79[2]	1221,1223,1225,1227,1229 Clarence St, St. Paul 55106	858.6	860.0	861.3[3]	4F	N/A
282922110118	1275 Magnolia Ave, St. Paul 55106	858.8	860.7	860.6	4D	N/A
272922230009	1405 Mechanic Ave, St. Paul 55106	857.8	858.4	854.7	4F	N/A
272922220162	1177 Clarence St, St. Paul 55106	859.5	861.3	860.6	4F	N/A
222922330180-84[2]	1205,1207,1209,1211,1213 Clarence St, St. Paul 55106	859.8	860.0	861.3[3]	4F	N/A
222922330192-95[2]	1333, 1335,1337,1339 Maryland Ave, St. Paul 55106	859.8	860.0	861.3[3]	4F	N/A
222922330104	1305 Maryland Ave, St. Paul 55106	859.5	860.0	861.3[3]	4F	N/A
082922120012	2540 Edgerton St, Little Canada 55117	860.8	861.8	861.5[3]	4A	N/A
162922310028	1880 East Shore Dr, Maplewood 55109	861.7	863.2	861.7[4]	4C	4A
082922420003	681 B2, Little Canada 55117	861.7	861.8	861.5	4A	N/A
162922310028	1880 East Shore Dr, Maplewood 55109	861.9	863.2	861.7	4C	4A
082922110018	750 Carla Ln, Little Canada 55109	861.5	861.8	861.5[4]	4A	N/A
172922140072	2009 Arcade St, Maplewood 55109	861.4	861.8	861.4[4]	4A	N/A
162922310028	1880 East Shore Dr, Maplewood 55109	862.4	863.2	861.7	4C	4A
272922240056	1465 Ames Ave, St. Paul 55106	862.7	863.5	861.6	4F	N/A
162922310010	1858 East Shore Dr, Maplewood 55109	863.0	863.0	862.3	4C	4A
282922140007	1267 Cook Ave, St. Paul 55106	863.1	863.2	860.6	4D	N/A
272922240061	1442 Mechanic Ave, St. Paul 55106	863.2	863.5	861.6	4F	N/A
162922310028	1880 East Shore Dr, Maplewood 55109	862.5	863.2	861.7	4C	4A
272922230042	1438 Mechanic Ave, St. Paul 55106	862.8	863.5	861.6	4F	N/A
272922120039	1604 Maryland Ave, St. Paul 55106	893.8	894.1	885.8	4E	N/A
152922420002	1638 Frost Ave, Maplewood 55109	901.5	903.4	901.3	4B	N/A
152922420006	1880 Maryknoll Ave, Maplewood 55109	901.6	903.4	901.3	4B	N/A
152922420004	1904 Maryknoll Ave, Maplewood 55109	901.8	903.4	901.3	4B	N/A
152922420031	1872 Prosperity Rd, Maplewood 55109	901.9	903.4	901.3	4B	N/A
152922420007	1870 Maryknoll Ave, Maplewood 55109	901.9	903.4	901.3	4B	N/A
152922420005	1894 Maryknoll Ave, Maplewood 55109	902.7	903.4	901.3	4B	N/A
152922420032	1871 Maryknoll Ave, Maplewood 55109	903.0	903.4	901.3	4B	N/A
152922140032	1936 Kennard St, Maplewood 55109	903.3	904.1	902.2	4B	N/A
152922420033	1885 Maryknoll Ave, Maplewood 55109	903.4	903.4	901.3	4B	N/A
152922140030	1948 Kennard St, Maplewood 55109	903.9	904.1	902.2	4B	N/A

Parcel ID	Address	Lowest Adjacent Grade[1]	Existing 100-year Water Surface Elevation	100-year Water Surface Elevation following System Modifications	System Modification to Reduce Flood Risk	Prerequisite System Modifications
152922140031	1944 Kennard St, Maplewood 55109	904.1	904.1	902.2	4B	N/A
272922140130	1688 Lacrosse St, St. Paul 55106	909.7	909.8	909.7[4]	4F	N/A
222922420114	1583 Clear Ave, St. Paul 55106	916.4	918.2	916.0	4E	N/A
222922420113	1577 Clear Ave, St. Paul 55106	916.9	918.2	916.0	4E	N/A
222922420115	1589 Clear Ave, St. Paul 55106	916.9	918.2	916.0	4E	N/A
222922420139	1655 Cottage Ave, St. Paul 55106	921.6	923.2	921.3	4E	N/A
222922410125	1659 Cottage Ave, St. Paul 55106	922.2	923.2	921.3	4E	N/A
222922410144	1660 Cottage Ave, St. Paul 55106	923.1	923.2	921.3	4E	N/A
222922420076	1592 Sherwood Ave, St. Paul 55106	923.2	923.3	923.2[4]	4E	N/A
222922410124	1662 Sherwood Ave, St. Paul 55106	922.9	923.2	921.3	4E	N/A
222922420075	1598 Sherwood Ave, St. Paul 55106	923.3	923.3	923.2	4E	N/A
222922420025	1658 Sherwood Ave, St. Paul 55106	923.2	923.2	921.3	4E	N/A
222922420036	1600 Sherwood Ave, St. Paul 55106	923.3	923.3	923.2	4E	N/A
222922410126	1665 Cottage Ave, St. Paul 55106	923.2	923.2	921.3	4E	N/A
222922140108	1696 Montana Ave, St. Paul 55106	927.4	928.0	927.1	4E	N/A
222922140110	1684 Montana Ave, St. Paul 55106	927.5	928.0	924.5	4E	N/A
222922110135	1671 Hoyt Ave, St. Paul 55106	927.7	928.0	924.5	4E	N/A
222922140109	1690 Montana Ave, St. Paul 55106	927.7	928.0	927.1	4E	N/A
222922140011	1720 Hoyt Ave, St. Paul 55106	928.0	928.0	927.7	4E	N/A
222922140111	1680 Montana Ave, St. Paul 55106	927.5	928.0	927.1	4E	N/A
222922110126	1696 Iowa Ave, St. Paul 55106	927.9	928.0	924.5	4E	N/A
222922140158	1688 Nevada Ave, St. Paul 55106	929.9	929.9	929.8	4E	N/A
222922140033	1739 Nebraska Ave, St. Paul 55106	931.8	932.5	930.8	4E	N/A
222922140034	1745 Nebraska Ave, St. Paul 55106	931.8	932.5	929.5	4E	N/A
222922140033	1739 Nebraska Ave, St. Paul 55106	931.8	932.5	930.8	4E	N/A
222922140035	1751 Nebraska Ave, St. Paul 55106	932.1	932.5	929.5	4E	N/A
082922110012	737 Carla Ln, Little Canada 55109	860.7	861.8	861.5[5]	4A	N/A

(1) Reference [5] and [10]
(2) The combined parcel ID is based on the multi-family (townhouse) building type; for each building listed, the combined parcel ID and the addresses listed are all impacted.
(3) This low adjacent grade is lower than the modeling results of the adjacent inundation, but the structures will be protected by the proposed site grading.
(4) The low adjacent grades are rounded to 0.1 foot due to the accuracy of LiDAR; the actual modeling results are lower than the low adjacent grade before rounding.
(5) Minor grading to flood proof this building would be brought in as an alternative to the existing Emergency Response Plan (Reference [10]).


Little Canada
Maplewood
North Saint Paul
Saint Paul
Willow Creek
Gervais Creek
Kohlman Lake
Lake Gervais
Spoon Lake
Keller Lake
North Knuckleheard Lake
Wicklander Pond
Wakefield Lake
Round Lake (M)
Lake Phalen
Battle Creek
Study Area
Ramsey County
Washington County
Mississippi River
See Figure 3-33 for potential system modifications
See Figure 3-34 for potential system modifications
See Figure 3-34 for potential system modifications
See Figure 3-35 for potential system modifications
See Figure 3-36 for potential system modifications
See Figure 3-37 for potential system modifications
See Figure 3-38 for potential system modifications
See Figure 3-39 for potential system modifications
See Figure 3-40 for potential system modifications
See Figure 3-41 for potential system modifications
See Figure 3-42 for potential system modifications
See Figures 3-43 and 3-44 for potential system modifications
Structures Removed from Floodplain
Local Potentially Flood-Prone Structures
District Facilities:
Project
CIP
Stormwater Structure
Storm Sewer / Culvert
Floodplains and Boundaries:
Major Subwatersheds
100-Year Floodplain Following System Modifications
Existing Conditions 100-Year Floodplain
Municipal Boundary
Subwatersheds
0
3,000
Feet
POTENTIALLY FLOOD-PRONE STRUCTURES IN THE LAKE PHALEN CHAIN OF LAKES SUBWATERSHED FOLLOWING SYSTEM MODIFICATIONS
Beltline Resiliency Study
Ramsey-Washington Metro Watershed District
FIGURE 3-45
1. Inundation areas are delineated for locations where water is stored in ponds, wetlands, and topographic depressions using level pool mapping in ArcGIS. Inundation areas for overland flow and street flooding are not shown.
2. Inundation areas shown are based on information available to the District as of September 2019.
3. 2011 LiDAR data from the MNDNR was used to develop inundation areas.
4. 2011 LiDAR data from the MNDNR and available surveyed elevations were used to estimate potentially flood-prone structures.
5. Potentially flood-prone structures are habitable structures including homes and businesses.
6. Unless noted in the report, no survey information was collected to identify potentially flood-prone structures.
7. Potentially flood-prone structures designated as "District" are located near District-managed facilities, lakes, or creeks, or where addressing flooding in these locations would likely change downstream peak flow rates and water elevations in multiple municipalities.
8. Potentially flood-prone structures designated as "Local" are not adjacent to District-managed facilities, lakes, or creeks. In many locations, flooding may be mitigated by modifications to the municipal stormwater system. Addressing flooding in these locations likely would not change downstream peak flows or water levels in downstream municipalities. In these locations, the municipality will likely lead the evaluation of system modifications to mitigate flood-risk, and the District may choose to be involved in a supporting role.
BARR
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

3.5 Phase 5 – Beaver Lake Subwatershed

3.5.1 Current Condition Flooding Concerns

A total of 24 structures were identified as potentially flood prone in the Beaver Lake subwatershed. All of the structures identified are classified as "Local." No flood-prone structures are located on Beaver Lake, but there are two flood-prone structures upstream of Beaver Lake.

3.5.2 Potential System Modifications Evaluated

Beaver Lake is upstream of the Beltline. Active management of the Beaver Lake outlet structure was considered to optimize the timing of water conveyed to the Beltline. The District stormwater model was used to simulate conditions in the Beltline and water levels in Lake Phalen, assuming there was no inflow from Beaver Lake. Simulation results indicated that the water surface elevation in Lake Phalen (and the rest of the Chain) did not change when inflows from Beaver Lake were removed, as shown in Table 3-11.

Table 3-11 Comparison of Water Surface Elevations with and without Beaver Lake Outlet Operation in the 100-Year, 96-Hour Event

	Water Surface Elevation in Lake Phalen	Number of Potentially Impacted Structures near the Lakes
Existing Condition [1]	861.9	3
With Beaver Lake Outlet Operation	861.9	3

[1] The existing condition includes the proposed concept updates from Phase 2, Phase 3, and Phase 4.

The peak discharge downstream of Beaver Lake is only 80 cubic feet per second and occurs before the peak discharge from Lake Phalen, as shown in Figure 3-46**Error! Reference source not found.**. Because the timing of the flows from Beaver Lake and Lake Phalen do not line up, there are no significant benefits to actively managing the outflow from Beaver Lake. In addition, storing water or reducing the peak may increase flood risk to structures upstream of Beaver Lake.

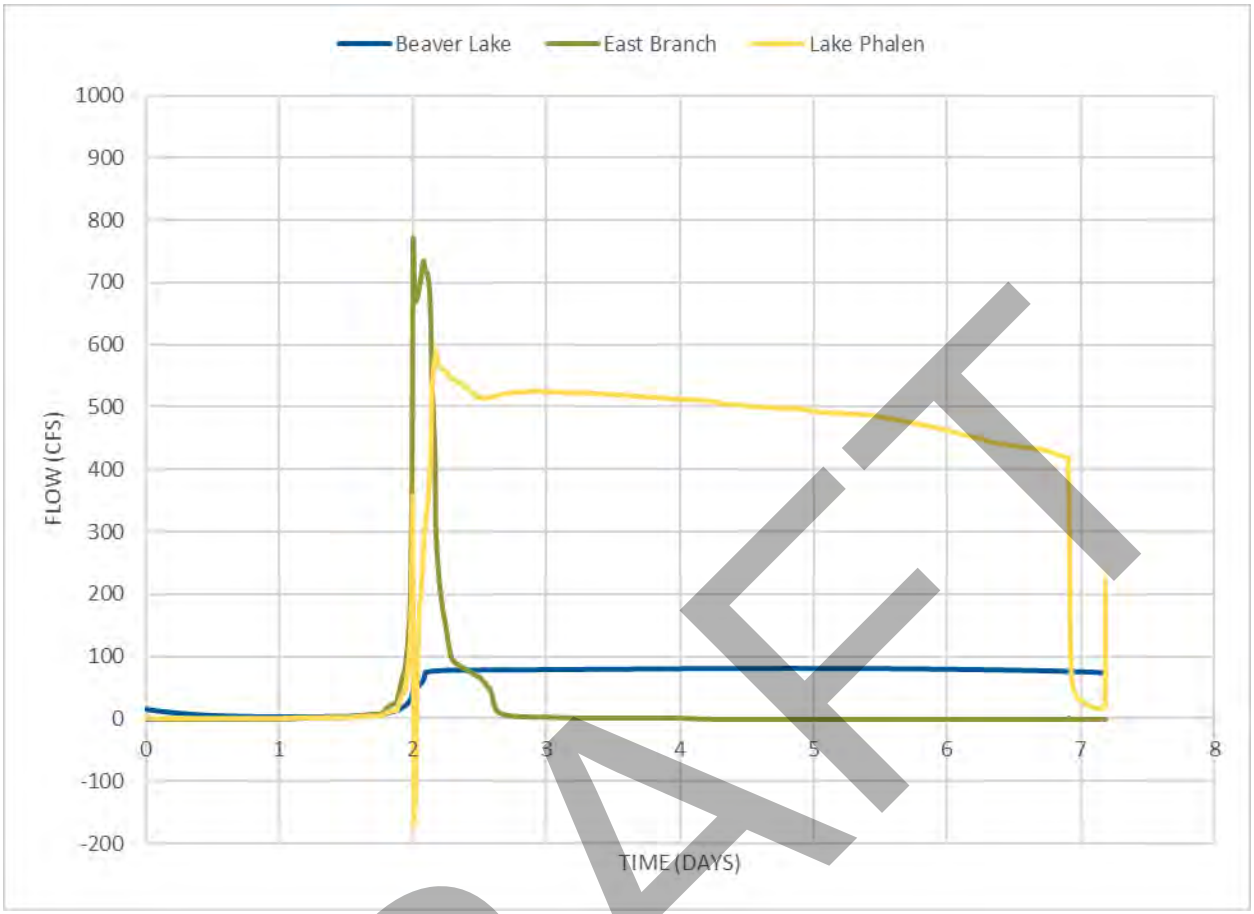


Figure 3-46 Inflow to Saint Paul Beltline

4 Concept Planning-Level Opinion of Probable Construction Cost

There are several factors that affect the cost of implementing a flood-risk-reduction project:

- The volume of stormwater that must be stored within the watershed or conveyed downstream
- The potential to reduce flood risk by retrofitting existing stormwater infrastructure
- The potential to reduce flood risk by constructing new flood-detention facilities
- The potential need to acquire property when other flood-reduction alternatives are not feasible

Evaluating the most cost-efficient flood-reduction project for a given flood-risk area requires (1) review of the source(s) and cause(s) of flooding (requiring detailed hydrologic and hydraulic review), (2) high-level review of available options to mitigate flooding (e.g., Is there sufficient available space for a flood detention project? Is there enough grade to excavate and tie-in to existing storm sewer utilities?, etc.), and (3) preliminary design and cost-comparison analysis of feasible flood-mitigation alternatives. Due to the large number of flood-risk areas identified, it was not practical to perform detailed analysis of multiple flood-mitigation alternatives and develop associated cost estimates for each within the scope of this project.

A planning-level opinion of cost was developed for each system modification. However, more cost-effective modifications may be identified during a detailed feasibility study.

The opinions of cost, project reserves, contingency, documentation, and discussion are intended to provide background information for planning-level alternatives assessment, analysis purposes, and budget consideration by RWMWD. The cost of time escalation is not included in the opinions of probable cost. All costs are presented in 2019 US dollars.

Opinions of costs are primarily based on stochastic estimating methods based on recent bid prices for similar projects within RWMWD and the Twin Cities metropolitan area, published construction cost index resources, and similar stormwater projects. Quantities were estimated with calculations based on available information. Dimensions, areas, and volumes for construction were estimated using Excel, GIS, and available information on the drainage system.

Costs associated with base planning engineering and design (PED) and construction management (CM) are based on percentages of estimated construction cost. Costs associated with construction management are estimated costs to manage the construction process based on Barr's experience with similar projects but may change depending on the type of system modification ultimately selected for a given location.

Due to the limited project definition available at this time, costs associated with mobilization (10%); planning, engineering, and design (10%); construction management (7%); and erosion control (3%) were

estimated as a percentage of the construction cost for each modification. The percentages are based on projects of similar scale to the potential system modification.

The estimates do not include costs associated with permitting and regulatory approvals, easement or land acquisition, wetland mitigation, utility relocation, or regional restoration for disturbed areas outside of the construction extents.

The opinions of cost include tasks and items related to engineering and design and constructing each system modification. The opinions of cost do not include other tasks following construction of each modification presented, such as operations and maintenance or monitoring.

Contingency used in these opinions of probable cost is intended to help identify an estimated construction cost for minor items in the project scope that have not yet been quantified or estimated. Those cost estimates will be refined during site specific feasibility evaluations. Stated another way, contingency is the result of the pluses and minuses that cannot be estimated at the level of project definition that exists. The contingency includes the cost of ancillary items not currently itemized in the quantity summaries but commonly identified in more detailed design and required for completeness of the work. A 50% contingency is applied to the estimated construction cost to account for the costs of these items.

Industry resources for cost estimating (Reference [11], [12]) provide guidance on cost uncertainty, depending on the level of project design developed. The opinion of probable cost for the alternatives evaluated generally corresponds to a Class 5 estimate, characterized by completion of limited engineering and use of stochastic estimating methods. As the level of design detail increases, the level of uncertainty is reduced. Figure 4-1provides a graphic representation of how uncertainty (or accuracy) of cost estimates can be expected to improve as more detailed design is developed.

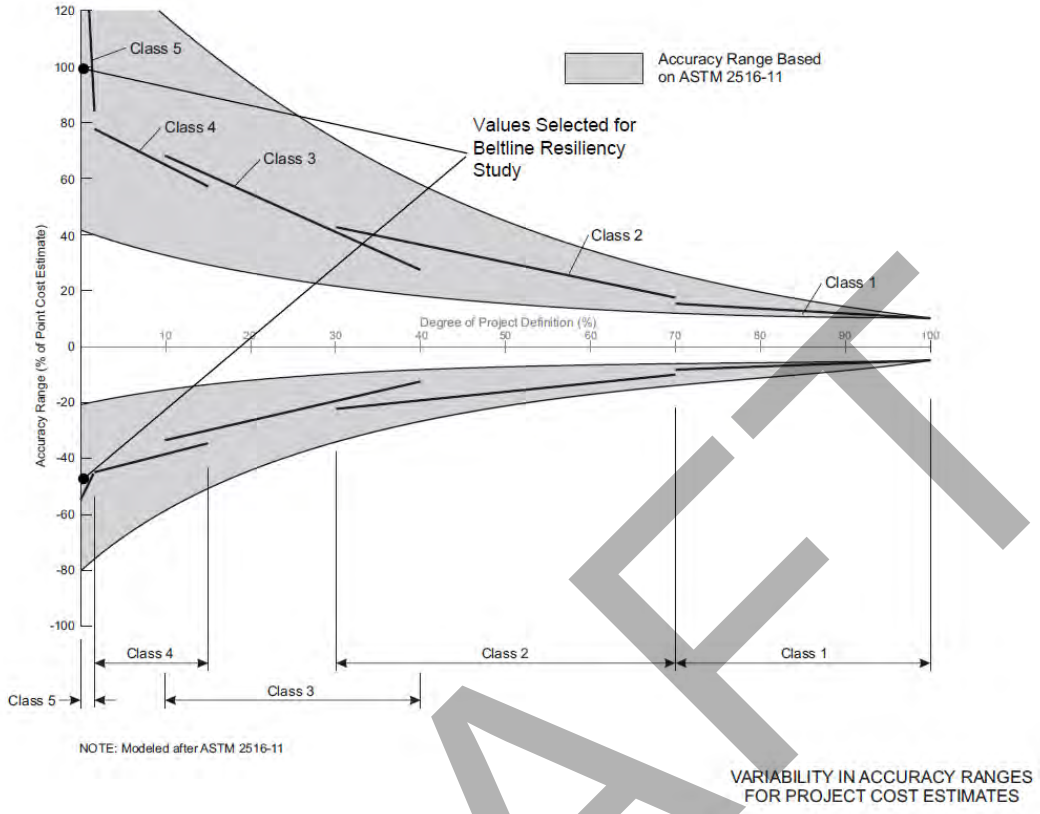


Figure 4-1 Relationship between Cost Accuracy and Degree of Project Definition

At this early stage of project definition, the range of uncertainty of total project cost is high. Due to the early stage of project definition, it is standard practice to place a broad accuracy range around the point cost estimate.

The accuracy range is based on professional judgment considering the level of design completed, the complexity of the project, and the uncertainties in the project scope; the accuracy range does not include costs for future scope changes that are not part of the project as currently defined or risk contingency. The estimated accuracy range for this point estimate is -50% to +100%.

The opinion of probable cost provided is made on the basis of Barr Engineering Co.'s (Barr) experience and qualifications and represents our best judgment as experienced and qualified professionals familiar with the project. It is acknowledged that additional investigations and site-specific information that becomes available in the next stage of evaluation may result in changes to the proposed configuration, cost, and functioning of project features. These opinions are based on project-related information available to Barr at this time and includes a planning-level feasibility design of the project. The opinions of cost may change as more information becomes available and further evaluation is completed. In addition, because we have no control over the eventual cost of labor, materials, equipment, or services furnished by others; over the contractor's methods of determining prices and/or for constructing system modifications;

or over competitive bidding or market conditions, Barr cannot and does not guarantee that proposals, bids, or actual costs will not vary from the opinions of cost presented.

To reduce the uncertainty associated with the opinions of cost, additional evaluation is needed to better define system modifications. In many locations, this may include completion of feasibility studies to identify the optimal type of system modification for the specific location.

Table 4-1 through Table 4-4 include opinions of cost for system modifications for each phase. Table 4-5 includes opinions of cost for all system modifications upstream of the Beltline.

Table 4-1 Opinions of Probable Cost for Gervais Creek System Modifications

System Modification	Description	Low Cost (-50%) ($)	High Cost (+100%) ($)	Figure
Phase 1	**Gervais Creek**	**$10,264,000**	**$41,049,000**	
1A	*Ryan Drive and North Star Estates*	$1,070,000	$4,279,000	Figure 3-2
1B	*MnDOT Diversion*	$5,870,000	$23,478,000	Figure 3-3
1C	*West Industrial Diversion*	$488,000	$1,950,000	Figure 3-4
1D	*Gervais Creek*	$2,836,000	$11,342,000	Figure 3-5

Table 4-2 Opinions of Probable Cost for Grass Lake System Modifications

System Modification	Description	Low Cost (-50%) ($)	High Cost (+100%) ($)	Figure
Phase 2	**Grass Lake**	**$20,584,000**	**$82,332,000**	
2A	*Victoria Street*	$525,000	$2,099,000	Figure 3-9
2B	*Lake Owasso*	$293,000	$1,169,000	Figure 3-10
2C	*Lake Wabasso, Grass Lake, and West Vadnais Lake*	$19,766,000	$79,064,000	Figure 3-11, Figure 3-12

Table 4-3 Opinions of Probable Cost for Kohlman Creek and Willow Creek System Modifications

System Modification	Description	Low Cost (-50%) ($)	High Cost (+100%) ($)	Figure
Phase 3	**Kohlman Creek and Willow Creek**	**$53,102,000**	**$212,400,000**	
3A	*Highway 61N*	$2,125,000	$8,498,000	Figure 3-18
3B	*Willow Lake*	$395,000	$1,578,000	Figure 3-19
3C	*Saint Paul Ecology Center*	$13,974,000	$55,896,000	Figure 3-20, Figure 3-21
3D	*PCU Pond*	$2,997,000	$11,988,000	Figure 3-22, Figure 3-23
3E	*Casey Lake*	$765,000	$3,059,000	Figure 3-24
3F	*West of White Bear Avenue North*	$32,383,000	$129,530,000	Figure 3-25 – Figure 3-28
3G	*Markham Pond and Kohlman Basin*	$463,000	$1,851,000	Figure 3-29

Table 4-4 Opinions of Probable Cost for Phalen Chain of Lakes System Modifications

System Modification	Description	Low Cost (-50%) ($)	High Cost (+100%) ($)	Figure
Phase 4	**Phalen Chain of Lakes**	**$58,030,000**	**$232,111,000**	
4A	*Lake Phalen and Keller Lake Outlet Structures*	$746,000	$2,984,000	Figure 3-33, Figure 3-34
4B	*Wakefield Lake*	$1,528,000	$6,111,000	Figure 3-35
4C	*Phalen Village*	$459,000	$1,836,000	Figure 3-36
4D	*Duluth Street Recreational Center*	$9,209,000	$36,834,000	Figure 3-37
4E	*Hoyt Pond*	$30,789,000	$123,153,000	Figure 3-38 – Figure 3-41
4F	*Ames Lake*	$15,299,000	$61,193,000	Figure 3-42 – Figure 3-44

Table 4-5 Opinions of Probable Cost for System Modifications Upstream of Beltline

System Modification	Description	Removed Structures	Low Cost (-50%) ($)	High Cost (+100%) ($)
Phase 1	Gervais Lake	101	$10,264,000	$41,049,000
Phase 2	Grass Lake	10	$20,584,000	$82,332,000
Phase 3	Willow Creek & Kohlman Creek	41	$53,102,000	$212,400,000
Phase 4	Phalen Chain of Lakes	75	$58,030,000	$232,111,000
TOTAL			**$141,980,000**	**$567,892,000**

The planning-level opinions of cost in Table 4-5 are included to provide an estimate of the potential cost of flood mitigation for 227 potentially flood-prone structures upstream of the Beltline that were classified as "District" and "Local." As additional evaluation is completed and site-specific information is available the final cost of flood-mitigation may be significantly lower or higher than the planning-level opinions of cost included in Table 4-5.

5 Conclusions and Recommended next steps

The study includes several potential system-level flood damage reduction options, including real-time operation of Lake Phalen and Keller Lake channel outlet structures to actively manage stormwater runoff from flood-prone areas tributary to the Beltline. System modifications presented are intended to demonstrate options for mitigating flood risk that do not include purchasing flood-prone properties.

The study was phased such that, in general, upstream system modifications were evaluated prior to downstream modifications. System modifications that result in increased outlet capacity should be sequenced such that downstream modifications are constructed first to avoid increases to the 100-year water level in those areas. Beyond that general recommendation this study does not include further priority recommendations. The study phases were selected to efficiently complete the stormwater modeling required to evaluate system modifications and are not intended to imply prioritization. The general sequencing discussion is intended to illustrate considerations to avoid downstream impacts to the floodplain and not provide a recommendation regarding which flood-risk areas should be prioritized or addressed first.

The following items are recommended as next steps by the District for further evaluation as they are the backbone of the added resiliency:

1. **Active management of Lake Phalen and Keller Lake control structures (Phase 4).** Active management of the control structures on the Phalen Chain of Lakes could optimize the use of live storage volume without adversely impacting downstream water levels. Without optimizing the live storage, additional floodplain storage volume would be needed to mitigate flood risk for structures on the Phalen Chain of Lakes. Preliminary design and permitting discussions with the MDNR could begin regarding potential modifications. Implementation of the control modification must be coupled with operating plans for each structure. These plans should be developed in concert with structure modifications.

2. **MnDOT diversion (Phase 1).** Additional conveyance capacity is needed to mitigate flood risk for structures in North Star Estates. Additional evaluation regarding permitting, MnDOT coordination, utility conflicts, and alignment evaluation is needed to evaluate the feasibility of diverting stormwater around Owasso Basin and North Star Estates. Permitting issues will be significant and should be estimated and quantified through involvement of stakeholders.

3. **Floodplain storage.** Several modifications include additional floodplain storage. In general, retention or floodplain storage projects do not result in increases to downstream discharges and can be implemented independent of downstream projects. Retention projects include the Willow Lake outlet and Casey Lake outlet control structures. Feasibility studies for these locations are needed to define permit requirements, utility conflicts, and optimize the location and storage volume.

4. **Ames Lake.** Several system modifications are necessary to mitigate flood risk near Ames Lake, many of which are projects that the District typically does not implement, including modifications to the local storm sewer system. A detailed feasibility study would be needed to optimize system modifications, coordinate with the City of Saint Paul regarding responsibilities related to flood risk in this area, and document permitting requirements.

5. **Stakeholder review (all phases).** Potential system modifications presented should be reviewed with municipalities, counties, and MnDOT. Many system modifications presented may impact municipal, county, or state drainage systems. Coordination with stakeholders may identify opportunities for partnerships with regards to funding or optimization of system modifications.

The Beltline resiliency study represents a combination of traditional and nontraditional approaches to modifying a regional urban stormwater system to add resiliency and optimize the system's performance under flood conditions. The modifications evaluated and presented represent options for mitigating flood risk to habitable structures without purchasing flood-prone structures. As detailed feasibility studies are completed for individual system modifications or continued coordination with stakeholders, the project definition, cost, and function of system modifications will be updated.

6 References

[1] NOAA, "Precipitation-Frequency Atlas of the United States, Volume 8 Version 2.0," 2013.

[2] U. D. o. Commerce, "Technical Paper No. 40, Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years," 1961.

[3] Ramsey-Washington Metro Watershed District, "Ramsey-Washington Metro Watershed District Rules. Revised 6/5/2019," 2019.

[4] Barr Engineering Co., "RWMWD 2018 Model Update and Validation," Minneapolis, February 2019.

[5] Minnesota Department of Natural Resources, *LiDAR Elevation, Twin Cities Metro Region, Minnesota,* 2011.

[6] Ramsey County, "Building Dataset," 2015. [Online]. Available: http://openramsey-ramseygis.opendata.arcgis.com.

[7] Microsoft, *Microsoft Building Footrprints,* 2019.

[8] Barr Engineering Co., *Beltline Resiliency Study Phase 1 – Owasso Basin Technical Memorandum,* Little Canada, 2018.

[9] Barr Engineering Co., *Low Home Survey in Lake Owasso,* Roseville, 2017.

[10] Barr Engineering Co., *Gervais Lake Emergency Response Plan,* Little Canada, 2014.

[11] American Society for Testing and Materials, ASTM E2516-06 Standard Classification for Cost Estimate Classification System, West Conshohocken, PA: DOI: 10.1520/E2516-06, 2006.

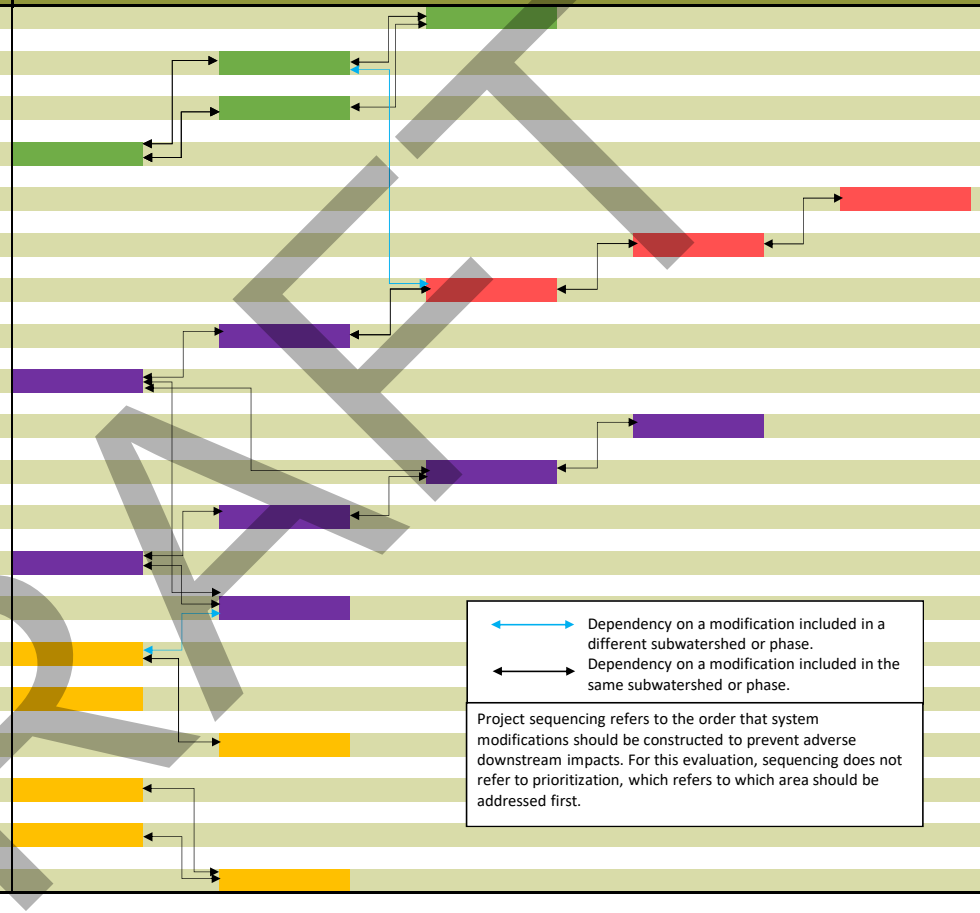
[12] Association for the Advancement of Cost Estimating, AACE International Recommended Practice NO. 18R-97, February 2, 2005.

Appendix A

Planning-Level Sequencing Schematic

Figure A-1. Planning-Level Sequencing Schematic

Step	Description	Prerequisite System Modifications	Planning-Level Sequencing
1A	Ryan Drive & North Star Estates	1B,1C	
1B	Mndot Diversion	1D	
1C	West Industrial Diversion	1D	
1D	Gervais Creek		
2A	Victoria Street	2B	
2B	Lake Owasso	2A	
2C	Wabasso, Grass Lake & West Vadnais Lake	1B	
3A	Highway 61N	3B	
3B	Willow Lake		
3C	Saint Paul Ecology Center	3D	
3D	PCU Pond	3E	
3E	Casey Lake	3F	
3F	West Of White Bear Avenue North		
3G	Kohlman Basin	3B,3F,4A	
4A	Lake Phalen And Keller Lake Outlet Structures		
4B	Wakefield Lake		
4C	Phalen Village	4A	
4D	Duluth Street Recreational Center		
4E	Hoyt Pond		
4F	Ames Lake	4D,4E	



Appendix B

Concept Planning-Level Opinion of Probable Cost Verification

There are several factors that affect the cost of implementing a flood-risk reduction project:

- The volume of stormwater that must be stored within the watershed or conveyed downstream;
- The potential to reduce flood-risk by retrofitting existing stormwater infrastructure;
- The potential to reduce flood-risk by constructing new flood detention facilities; and
- The potential need to acquire property when other flood-reduction alternatives are not feasible.

Evaluating the most cost-efficient flood reduction project for a given flood-risk area requires (1) review of the source(s) and cause(s) of flooding (requiring detailed hydrologic and hydraulic review), (2) high-level review of available options to mitigate flooding (e.g., is there sufficient available space for a flood detention project? Is there sufficient grade to excavate and tie-in to existing storm sewer utilities, etc.), and (3) preliminary design and cost-comparison analysis of feasible flood-mitigation alternatives. Due to the large number of flood-risk areas identified, it was not practical to perform detailed review of flood-mitigation alternatives for each location within the scope of this project.

To verify the opinion of cost estimated for potentially system modifications. The cost for system modifications was compared to the cost of acquiring the flood-prone structures. Cost associated with property acquisition were obtained from the Ramsey County Property Records and Revenue department. This check assumed an estimated acquisition cost of 125% of the estimated market value. The additional 25% is intended to account for the cost of appraisals, removals, and adjustments for market value.

Similar to potential system modifications, and accuracy range of -50% to +100% is applied to the estimate to account for costs that are not currently defined.

An important note is that, based on a more-detailed review of flood-mitigation alternatives, optimization of potential system modifications, and completion of detailed feasibility studies, the final cost of flood-mitigation may be significantly lower or higher than the planning level opinions of cost included in Table B-1. The costs provided in Table B-1 are intended to provide a comparison to the costs presented for potential system modifications that were evaluated.

Table B-1 Opinions of Probable Cost for System Modifications Upstream of Beltline

Description	Low Cost (-50%) ($)	High Cost (+100%) ($)
Potential System Modification	$141,980,000	$567,892,000
Acquire Flood-Prone Property	$58,500,000	$234,100,000