TECHNICAL MEMORANDUM

To: Greg Johnson, PE, MCES
From: Ron Leaf, PE, Kimley-Horn
Mat Cox, PE, Kimley-Horn
CC: Uma Vempati, PE, Kimley-Horn
Date: October 14, 2025
Subject: White Bear Lake Comprehensive Plan: Study No. 9B
Model and Evaluate Raising White Bear Lake Outlet Elevation - Update

INTRODUCTION

The purpose of this technical memorandum is to detail the modeling and data gathering efforts completed to analyze the impacts of raising the outlet of White Bear Lake. Previously, Study 9A was completed to summarize the potential impacts and risks associated with raising the existing outlet elevation of White Bear Lake. The benefits of raising the outlet would be to collect and store additional rainfall and runoff following wet weather events and therefore delay and/or reduce the impacts of low water level conditions on White Bear Lake. This work is part of Metropolitan Council's (Met Council) White Bear Lake Area Comprehensive Plan Work Group efforts to ensure communities in the White Bear Lake area have access to sufficient drinking water to allow for municipal growth while ensuring the sustainability of surface and groundwater resources.

The scope of work for Study No. 9B includes:

1. Data collection and screening-level GIS assessment for areas at risk of high-water level changes, identify where LOMAs are needed, conduct field review of critical structures, and survey lake outlets.
2. Develop 1D/2D model of White Bear Lake and its outlet system for the 100-yr, 24-hr event, 100-yr, 24-hr back-to-back event, and wet periods between 2018 and 2020, evaluate different outlet types, and evaluate hydraulic conditions downstream.
3. Assess infrastructure risks from Study 9A, determine if 100-yr high water level changes, and assess impact of high-water level changes.
4. Determine estimated costs, including capital costs, land and easement acquisition costs, if necessary, and annual operation and maintenance costs.
5. Address the method or alternative's potential to improve or maintain surface water elevations in White Bear Lake and the potential to provide long-term sustainability for the underlying aquifer for the White Bear Lake area communities (e.g. resiliency)
6. Address and compare the advantages and disadvantages of the method or alternative with respect to its technical, financial, regulatory, and sustainability components.

The extents of White Bear Lake, contributing drainage area, and overall model development boundary is shown on Exhibit 1.

DATA COLLECTION AND REVIEW

The following section describes the data collection and review process for the sources of data used to assess the issues and risks of raising the outlet elevation of White Bear Lake.

OUTLET SURVEY

Survey of the outlet of White Bear Lake to Bald Eagle Lake was completed by Sambatek to support the model development. A total of 14 existing culverts were surveyed with the following information reported: material, upstream invert, downstream invert, pipe height, and pipe width. The culverts ranged in size from 15 inches to 48 inches, with most being made of reinforced concrete.

Additionally, a topographic survey was completed of the overflow area at White Bear Lake County Park to better understand the overflow elevations and overland flow paths in the event of high-water levels on White Bear Lake. Exhibit 5 details the survey information that was collected as part of this project.

The topographic survey revealed that the overflow elevation in the park is 926.37 feet and is located between the park and the boat launch area. The overflow discharges into a stormwater basin which is then routed through piping to discharge into the existing wetland area northwest of the park parking lot. Exhibit 6 includes the detailed topographic survey data.

CRITICAL STRUCTURES REVIEW

As the various projects aimed at raising the water level on White Bear Lake progress forward, there should be discussions with individual landowners to communicate risks as well as discuss historical construction and flooding occurrences around the lake. It is unlikely that an existing structure would be impacted by an increase in the normal water level on White Bear Lake, as of result of these projects, as the structure would likely have been built prior to 1977 (initial FIS study in Washington County) when the outlet from White Bear Lake was above 925 feet. More recently construction near the lake would have to abide by local shoreland management zoning and floodplain regulations. The Minnesota DNR setback regulations were last updated as part of a revision in 1989 (MN Regulations Parts 6120.2500-6120.3900). The setbacks limited residential construction of structures in terms of their placement, height, orientation, and overall parcel lot size. As a result of the Shoreland Management setbacks and the Flood Insurance Study, limited development at the shore’s edge has been completed recently.

1D/2D MODEL DEVELOPMENT

ICM was selected as the software to use for its many advantages when analyzing a large and complex area. The software combines 1D and 2D model components (storm pipe network and land surface), and it discretizes the 2D area into elements of various sizes to accurately capture topography changes, depressional storage, and overland flow paths. Other advantages of ICM include efficient simulation run times, integration of bridges and culverts, and multi-user capabilities. For this project, the model development included roughness zones, infiltration zones, a ground model, 2D mesh (level zones and breaklines), a level event 2D boundary, initial hydraulic condition, nodes, and conduits. Through these model components, the model incorporates rainfall and surface hydrology, hydraulics for surface and subsurface (pipe) flows, as well as 1D/2D element connections. These components will be discussed in greater detail in the remaining subsections.

RAINFALL

The rainfall method selected for this model is the rain-on-grid methodology. This precipitation methodology applies a rainfall curve (incremental depth) to the entire 2D model area. As rain falls on each cell, the model calculates runoff and hydrologic losses at each cell, water is then routed across cells based on assessment of flow velocities and inundation depths of neighboring cells. Runoff can continue to infiltrate based upon the CNSWMM parameters and the underlying land use and hydrologic soil group classification.

Analysis of the system included five primary storm events of varying recurrence interval and precipitation depth to capture a range of conditions as outlined in Table 1. Wet periods were determined by finding peak storm events in 2018, 2019, and 2020. Precipitation for the wet periods were sourced from MN DNR.

Table 1. Modeled Rainfall and Runoff Events

Storm Recurrence Interval, Duration	Depth of Precipitation (inches)	Description
100-year, 24-hour[1]	7.38	NOAA Atlas 14
100-year, 24-hour back-to-back[1]	14.76	NOAA Atlas 14
2018 Wet Period	3.63	September 19th – 21st
2019 Wet Period	4.68	May 8th – May 29th
2020 Wet Period	2.22	May 16th – May 18th

[1] 24-hr Rainfall Storm Events – MSE Type 3 Rainfall Distribution

2D ZONE (MODEL BOUNDARY)

The 2D Zone is the component within ICM which defines the 2D boundary. The 2D Zone contains the mesh elements and all components therein (discussed in greater detail in the remaining subsections). The 2D Zone allows the user to define a boundary condition, which affects hydraulic behavior of water as it reaches the model's edge. The boundary condition was set to "normal depth" which assumes slope and friction forces remain the same at the boundary, allowing water to leave the model without energy losses.

INFILTRATION ZONE

The infiltration zone parameter in ICM allows the user to incorporate varying infiltration capacity to the model. Soil data from the USDA's Web Soil Survey was downloaded and processed in ArcGIS Pro to develop a relationship between soil type and the infiltration parameters of the area included in the model. The soils layer was intersected with a 2024 USGS National Land Cover Database (NLCD) layer, and Curve Number values were associated with an associated hydrologic soil group and land cover. As shown in **Table 2**, each hydrologic soil group and land cover was mapped to a Curve Number in the ICM model. Exhibit 2 details the spatial variability of the infiltration zones across the model area.

Table 2. Land Use Curve Number Values

Land Use	Hydrologic Soil Group			
	A	B	C	D
Barren Land	63	77	85	88
Cultivated Crops	67	78	85	89
Deciduous Forest	30	55	70	77
Developed, High Intensity	89	92	94	95
Developed, Low Intensity	51	68	79	84
Developed, Medium Intensity	57	72	81	86
Developed, Open Space	39	61	74	80
Emergent Herbaceous Wetlands	98	98	98	98
Evergreen Forest	36	60	73	79
Hay-Pasture	39	61	74	80
Herbaceous	30	62	74	85
Mixed Forest	32	58	72	79
Open Water	98	98	98	98
Scrub/Shrub	30	35	47	55
Woody Wetlands	98	98	98	98

ROUGHNESS ZONE

The roughness zone parameter in ICM allows the user to apply frictional properties to the 2D surface to represent flow conditions. The 2024 USGS National Land Cover Database (NLCD) was used to develop roughness zones. This land cover data was clipped to the model boundary and processed in ArcGIS Pro to be included in the ICM model. Manning's equation for open channel flow was used to model the flow potential for each land classification. The equation estimates average flow velocity for water in an open channel using slope and a roughness parameter (Manning's n). Each land use classification was assigned a Manning's n value based upon the expected resistance to flow that water would encounter within the land use. For instance, buildings, trees, fences, etc. were not included in the model terrain but were taken into account through the use of Manning's n values. These Manning's n values were taken from the USDA's TR-55 manual on urban hydrology.

Table 3. Roughness Zone Parameters

Land Use Classification	Manning's n
Barren Land	0.05
Cultivated Crops	0.06
Deciduous Forest	0.12
Developed, High Intensity	0.03
Developed, Low Intensity	0.07
Developed, Medium Intensity	0.065
Developed, Open Space	0.07
Emergent Herbaceous Wetlands	0.03
Evergreen Forest	0.11
Hay-Pasture	0.08
Herbaceous	0.065
Mixed Forest	0.1
Open Water	0.045
Scrub/Shrub	0.085
Woody Wetlands	0.12

TOPOGRAPHY (GROUND MODEL)

ICM uses the ground model to develop the 2D mesh. Each mesh element has a calculated elevation that is an average of the sample points taken from within the elements. The 1D network also extensively relies on the topography (discussed in greater detail in the remaining subsections). Lidar elevation data, published in January of 2024, was downloaded from the USGS National Map. The lidar data was converted to a digital elevation model (DEM) in ArcGIS Pro, where all non-ground points were filtered out. The DEM was then imported into ICM. Bathymetry data sourced from MN DNR published in October 2021 was incorporated into the topography. The elevation for the bathymetric contours was determined to be the elevation of the lake on the day the bathymetry data was taken (923.5') subtracted by the contour depth provided.

2D MESH

ICM subdivides the 2D Zone into finite elements called the 2D mesh. Within this model, the 2D mesh is comprised over 500,000 elements which range in area from 500 to 50,0000 square feet in size. Each mesh element incorporates data from the ground model (elevation), roughness zone, and infiltration zone. The elevation, roughness, and infiltration parameters all remain constant within each element, but they change from element to element due to the varied nature of the underlying land parameters. ICM applies hydrologic and hydraulic calculations to each mesh elements to create flow patterns and inundation depths throughout the model area.

The “Terrain sensitive meshing” was used in the model development to increase the level of detail in the model without being required to hand edit the 2D mesh. This function allows the software to automatically adjust the level of detail (size of mesh elements) according to the degree of elevation changes in specific areas throughout the model during the mesh generation process. Areas with higher degree of change in elevation result in smaller mesh elements compared to flatter areas having larger mesh elements. This function allowed for the efficient development of the initial 2D mesh that accurately depicts change in elevation across the model area. A mesh zone along the edge of White Bear Lake was used to refine the cell size in areas of steeper elevation change to better represent flow out of the lake.

In 2D modeling, breaklines act as borders for mesh elements to further refine the accuracy of the mesh. When placed along ridges, road crowns, or other places where the topography rapidly changes, breaklines can enforce mesh element borders along those features to accurately direct water flow. Breaklines were added to all roads within the model area to subdivide mesh elements along roadway crowns. Exhibit 3 shows the combined model elements including the 2D boundary, mesh elements, refinement zones, and breaklines.

NODES

ICM performs 1D calculations separately from the 2D mesh. At each designated node, point coupling allows flow to exchange between the 1D and 2D systems. Each node within the model correlates to a storm structure. Within ICM, each node was classified as Outfall 2D. For connection to the 2D surface, each node requires a “flood type” designation. All nodes were set to the “2D” flood type.

Culvert inlet and outlet points, and storm sewer discharge points were designated as Outfall 2D-type nodes. The Outfall 2D node type provides a location for flow to discharge from the 1D network onto the 2D meshed area. The 1D-2D linkage for the discharge points was set to “Depth”, which discharges water from the pipe to the water surface elevation at each point regardless of the node’s ground level elevation. Flow can also enter the 1D system at Outfall 2D locations.

CONDUITS

Table 4 details the culvert data that was included in the ICM model. The inputs to the model match the surveyed data that was obtained as part of the study. See Exhibit 4 for locations of the modeled culverts within the ICM model.

Table 4. Conduit Information

Conduit Location	Pipe Size (in)	Pipe Material	Surveyed Upstream Invert (ft)	Surveyed Downstream Invert (ft)
White Bear Lake Outlet	27”	RCP-A	924.35	921.37
Highway 96	48	RCP	918.70	917.41
Highway 61	48	CMP	918.54	918.80
Burlington Northern Railroad	48	RCP	919.24	918.63
Soo Line Railroad	48	RCP	918.42	918.26
Eagle Street	48	RCP	916.77	916.66
Park Avenue	36	CMP	917.56	917.44
East Street	28	RCP	915.39	914.13

MODEL VALIDATION

The results from the existing conditions model simulations were compared to recorded lake levels for the wet periods from 2018 to 2019. Additionally, the 100-year rainfall event was simulated to compare the high-water level from the rainfall event to the 100-year floodplain elevation on White Bear Lake.

The three time periods were chosen for their unique attributes. The 2018 rainfall event occurred when the lake level was below the outlet elevation and all of the runoff was captured and retained by the lake storage. The 2020 rainfall event occurred when the lake level was above the outlet and discharge from the lake occurred through the existing outlet culverts. The 2019 rainfall event was chosen as a longer-term simulation to verify response in the model from multiple rainfall events.

Figure 1 – 2018 Rainfall Event and Response – 9/19/18-9/21/18

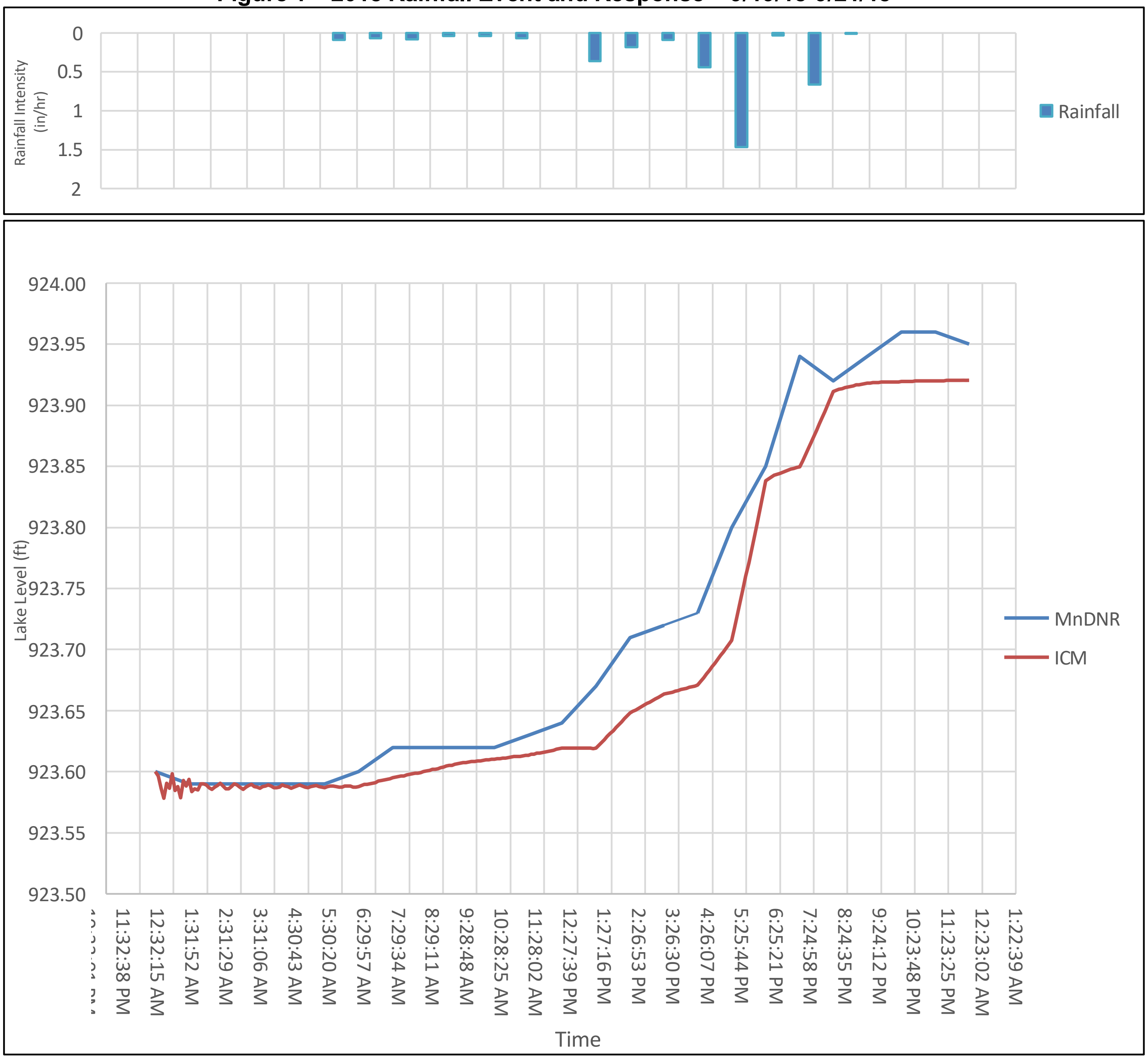


Figure 2 – 2019 Event and Response – 5/7/19-5/29/19

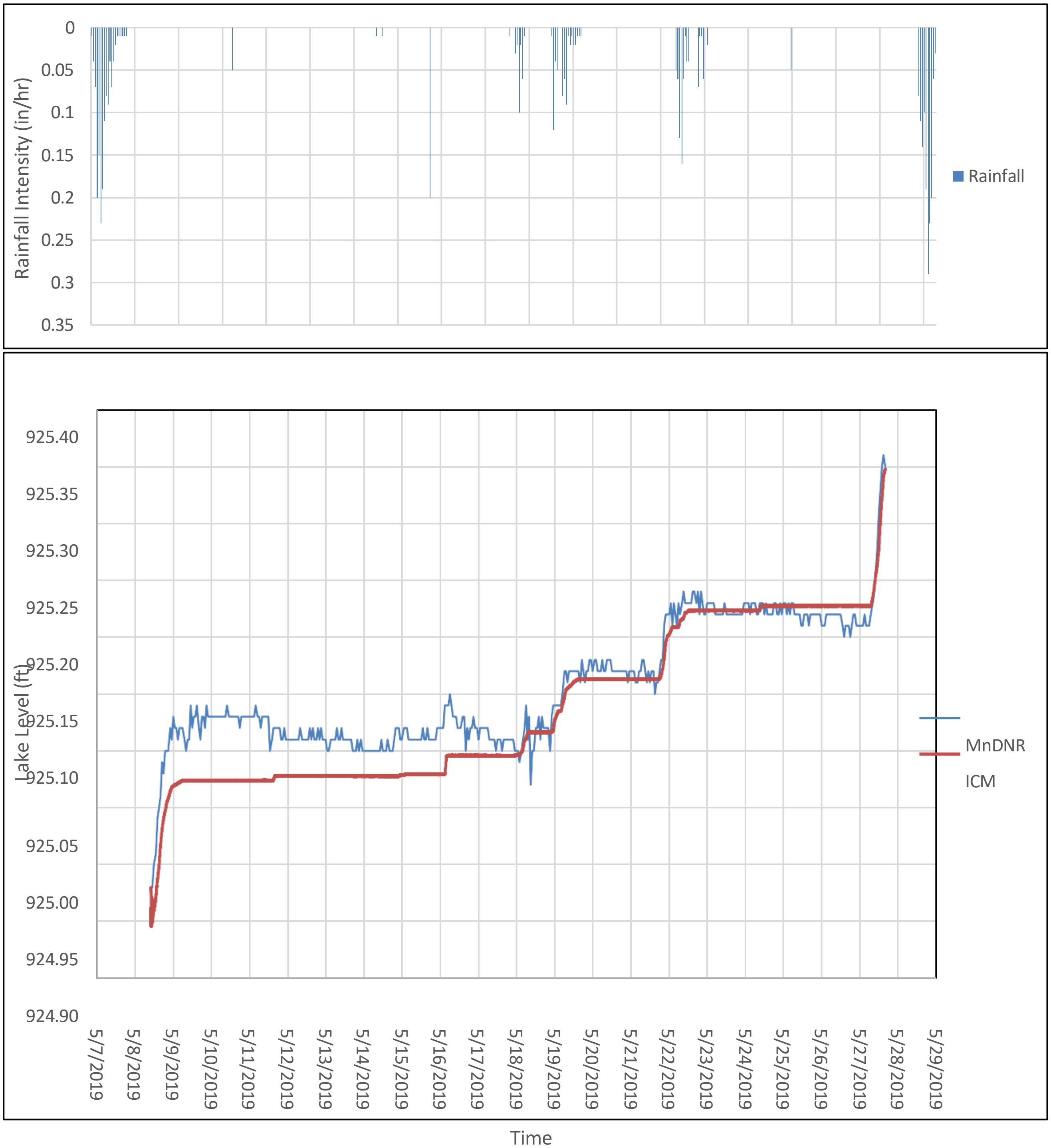
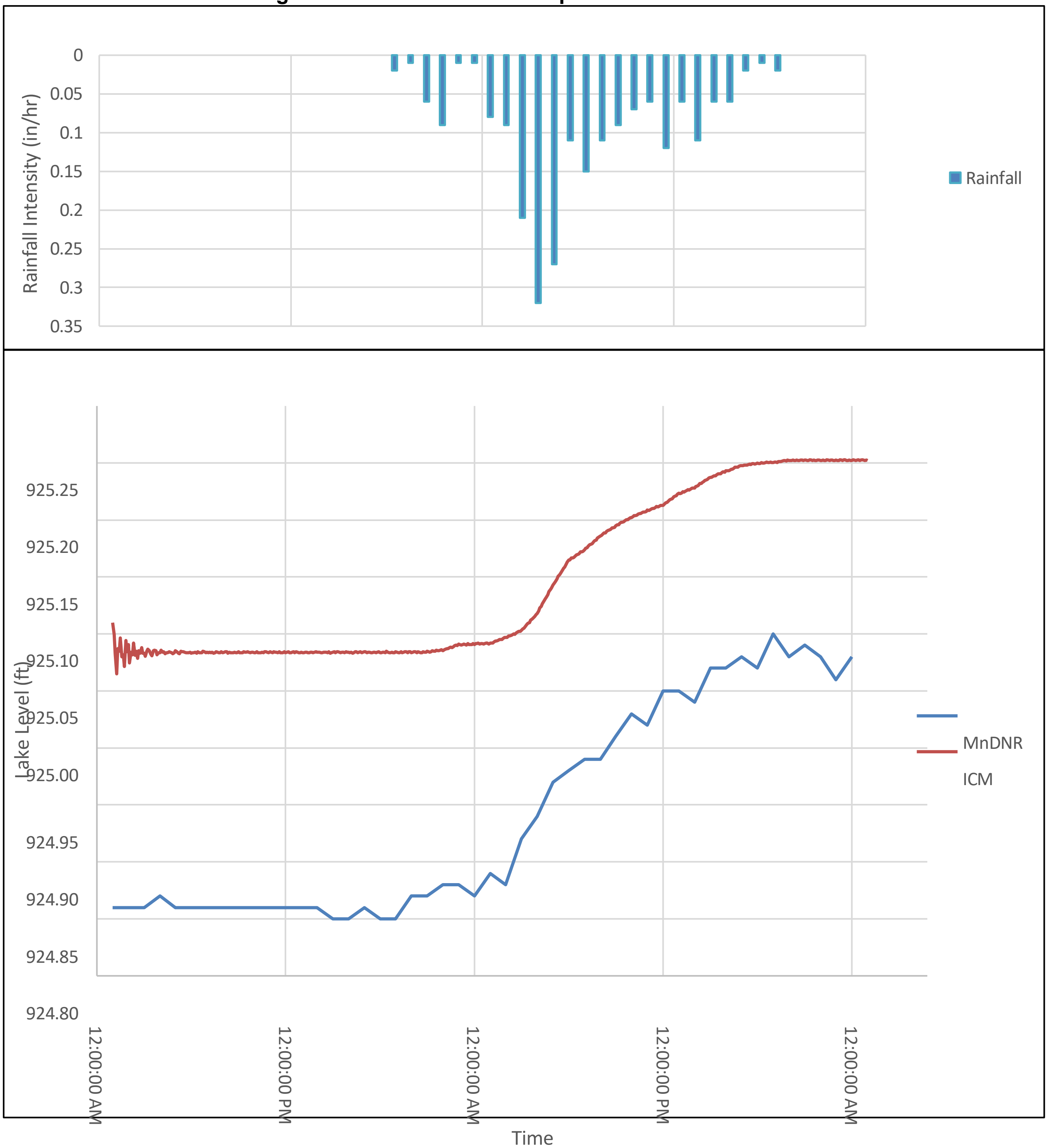


Figure 3 – 2020 Event and Response – 5/15/20-5/18/20



All three simulated rainfall events show good correlation for the rising limb of the storm event and similar peak elevations. No additional refinements were completed based on the validation performed against the recorded rainfall events and resulting high-water level analysis.

Alternatively, the 100-year rainfall event did not achieve a similar elevation to the reported 100-year floodplain elevation on White Bear Lake. This occurrence has been noted through various modeling that has been completed as part of this study and previous studies.

WHITE BEAR LAKE OUTLET ALTERNATIVES

The existing outlet from White Bear Lake is conveyed by twin 18"x27" reinforced concrete arch pipes. The arch pipes have upstream inverts of 924.35 and 924.41 per the survey dataset. The arch pipes cross the existing parking lot and discharge to the wetland northwest of the parking lot. There is minimal cover over the existing pipes which limits the ability to significantly raise the upstream invert elevation to retain more water within White Bear Lake.

Four proposed alternatives were analyzed as part of this modeling.

1. Raise the outlet invert elevation by 0.5 feet.
2. Raise the outlet invert elevation by 1.0 feet.
3. Construct a free-standing weir wall with crest elevation at 925.4.
4. Construct a free-standing weir wall with crest elevation at 926.0.

The alternatives are limited by the minimal freeboard that exists at the outlet of White Bear Lake along with the existing homes and infrastructure surrounding the lake as a whole.

Table 5. Outlet Alternatives Comparison – High-Water Level (ft)

Alternative	100-yr HWL	100-yr B2B HWL	2018 HWL	2020 HWL
Existing Condition	925.59	926.72	923.91	925.01
Raised by 0.5 ft	925.60	926.72	923.91	925.01
Raised by 1.0 ft	925.60	926.73	923.91	925.01
Weir Wall at 925.4	925.59	926.71	923.91	925.01
Weir Wall at 926.0	925.60	926.72	923.91	925.02

The high-water level for the 2018 event does not change across the alternatives. This is because the peak high-water level is below the outlet in existing conditions and all alternatives. This event acts as the control event for the alternatives analysis. All of the alternative analyses performed used an starting water surface elevation for White Bear Lake of 924.89 (Ordinary High-Water Level).

The analysis demonstrated (along with the modeling previously presented in Study 9A) that the lake levels are less sensitive to outlet elevations. This is due to the relatively large surface area of the lake in respect to the contributing drainage area to the lake. The incremental storage that is provided within White Bear Lake limits impacts to high-water level changes on the lake.

As a result of the analysis, it is recommended to further evaluate and perform detailed design of a free-standing weir wall at the existing outlet of White Bear Lake. This alternative would provide additional storage capacity to retain runoff and supplement the lake level as well as minimize impacts to the existing outlet culverts. The inclusion of a portion of the weir wall with removable stop-logs would allow for the lake level to be managed further as well as provide the ability for the lake level to be drawn down to the current outlet elevation to facilitate maintenance or other activities on the lake. The weir wall is assumed to be approximately 30 to 40 feet long and 3 to 4 feet high, depending on location and alignment in relation to the outlet culverts.

INFRASTRUCTURE RISK ASSESSMENT

HIGH WATER LEVEL CHANGE

Due to the minimal change in high-water levels across the simulated events and alternatives, it is assumed that impacts from high-water levels will be minimal from the proposed alternatives.

INFRASTRUCTURE IMPACT

The risk of damage to structures is minimal from high-water level changes, as previously documented.

The risk of damage to property open space is more significant. This risk is first discussed in Study 9A with the review of impacted properties at various high-water elevations. As the normal water level of White Bear Lake raises, there will be parcels around the lake that will lose significant usable space. Table 7 details ranges of impacts based on overall parcel area. Exhibit 7 shows the corresponding parcels and parcel identification numbers.

Table 6. Potential Parcel Access Loss

Impact Bucket	Range of Impact (% of Parcel Area)	Number of Parcels
Low	5-15%	35
Moderate	15-40%	8
High	>40%	59

COST IMPACTS

CAPITAL COSTS

The capital costs for the alternatives are listed in Table 7 as an order of magnitude cost. Alternatives 1 and 2 are grouped together as impacts and costs are assumed to be similar at this stage. Alternatives 3 and 4 are grouped together as impacts and costs are assumed to be similar at this stage. Costs detailed below are an estimate based upon historical bid prices for previous construction projects similar to the referenced alternative.

Table 7. Capital Cost Comparison

Cost Bucket	Alternative 1 and 2	Notes
Removals	$20,000	Pipes, Pavement, Curb
New Pipe	$132,000	660 LF of 18” x 27” RCP-A
Clearing and Grading	$8,000	Outlet Channel Grading, Removal of 2 trees
Pavement Replacement	$70,000	~1/4 acre and adjoining curb
Landscaping Replacement	$40,000	2 trees, seeding, wetland plantings
Construction Contingency[1]	$81,000	30% Contingency
Engineering, Construction Admin, Legal	$88,000	25% of Construction + Contingency Cost
Total	$439,000	
Cost Bucket	**Alternative 3 and 4**	**Notes**
Free Standing Weir Wall	$80,000	~30-40 feet long with removable stop-logs
Clearing and Grading	$20,000	Outlet Channel Grading, Excavation for Installation of Weir Wall
Landscaping Replacement	$8,000	Seeding, Natural/wetland plantings
Construction Contingency[1]	$32,000	30% Contingency
Engineering, Construction Admin, Legal	$35,000	25% of Construction + Contingency Cost
Total	$175,000	

LAND AND EASEMENT ACQUISTION COSTS

It is not expected that any of the outlet modifications would require land or easement acquisition due to the current location of the outlet being wholly within public park space at White Bear Lake county park.

ANNUAL OPERATION AND MAINTENANCE COSTS

For any of the alternatives, yearly operation and maintenance costs would be negligent as the system is a passive system. The outlet should be inspected yearly and following severe rainfall events to verify correct function and to remove any debris that collects at the outlet to prevent clogging and additional surcharge on White Bear Lake.

ADVANTAGES/DISADVANTAGES OF OUTLET MODIFICATION

FINANCIAL IMPACT

Minimal impact due to relatively minor cost implications for land/easement acquisition, and annual operations costs. Capital costs range from $175,000 to $439,000 based on Table 6 cost buckets.

REGULATORY IMPACT

Coordination with DNR on outlet modifications required.

SUSTAINABILITY IMPACT

Modifications to the outlet, paired with other proposed lake level augmentation, has the ability to raise the level on White Bear Lake over the long-term and limit occurrences of the lake level dropping below the managed level.

Increasing the normal water level of the lake by raising the outlet of White Bear Lake will likely impact homeowners around the lake through erosion and loss of usable property space. These impacts may be temporary, in terms of erosion, and reduce in severity as the system comes to balance. The loss of usable property space will be felt immediately as the lake level rises and will impact some landowners significantly and others may not notice the change.

CONCLUSIONS

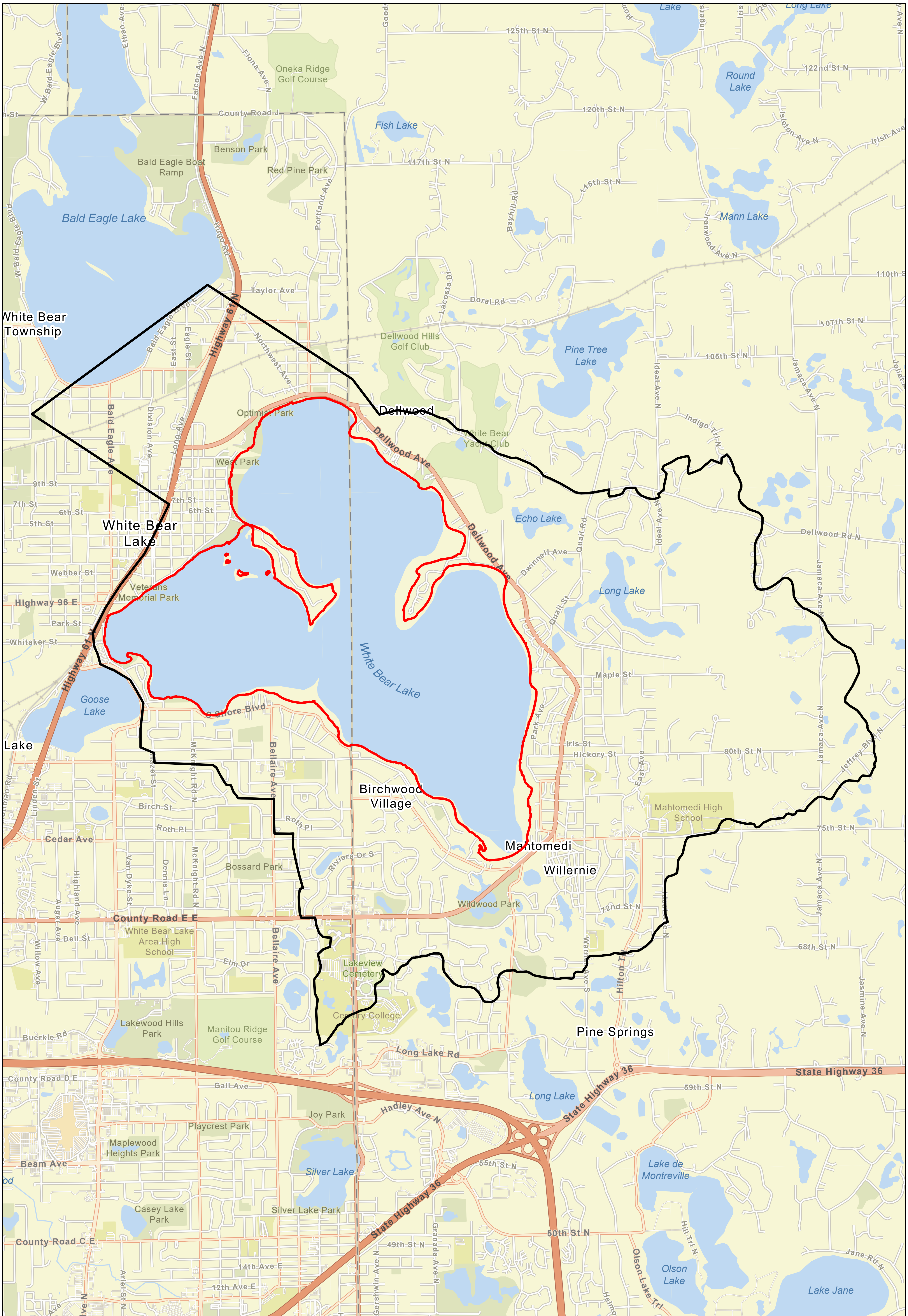
Based on the data collected and alternatives analyzed, the modification of the outlet of White Bear Lake allows for additional storage capacity on the lake, while impacts to high-water levels on the lake are minimal.

Kimley-Horn recommends the following as next steps:

- Detailed design of a free-standing weir wall at the outlet of White Bear Lake along with a section of the weir wall to be removable stop-logs to provide opportunity to draw down the lake or perform other maintenance, as needed.
- Review of a possible secondary outlet from White Bear Lake between the County Park and Boat Lauch areas.

Exhibits:

1. Exhibit 1 – Model and Lake Extents
2. Exhibit 2 – Landuse and Infiltration Reference
3. Exhibit 3 – Model Development
4. Exhibit 4 – Modeled Culverts
5. Exhibit 5 – Culvert Survey Data
6. Exhibit 6 – Topographic Survey Data
7. Exhibit 7 – Potential Parcel Impact Loss



0 0.28 0.55 1.1 Miles

N

Metropolitan Council, MetroGIS, MN Dept Natural Resources, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS

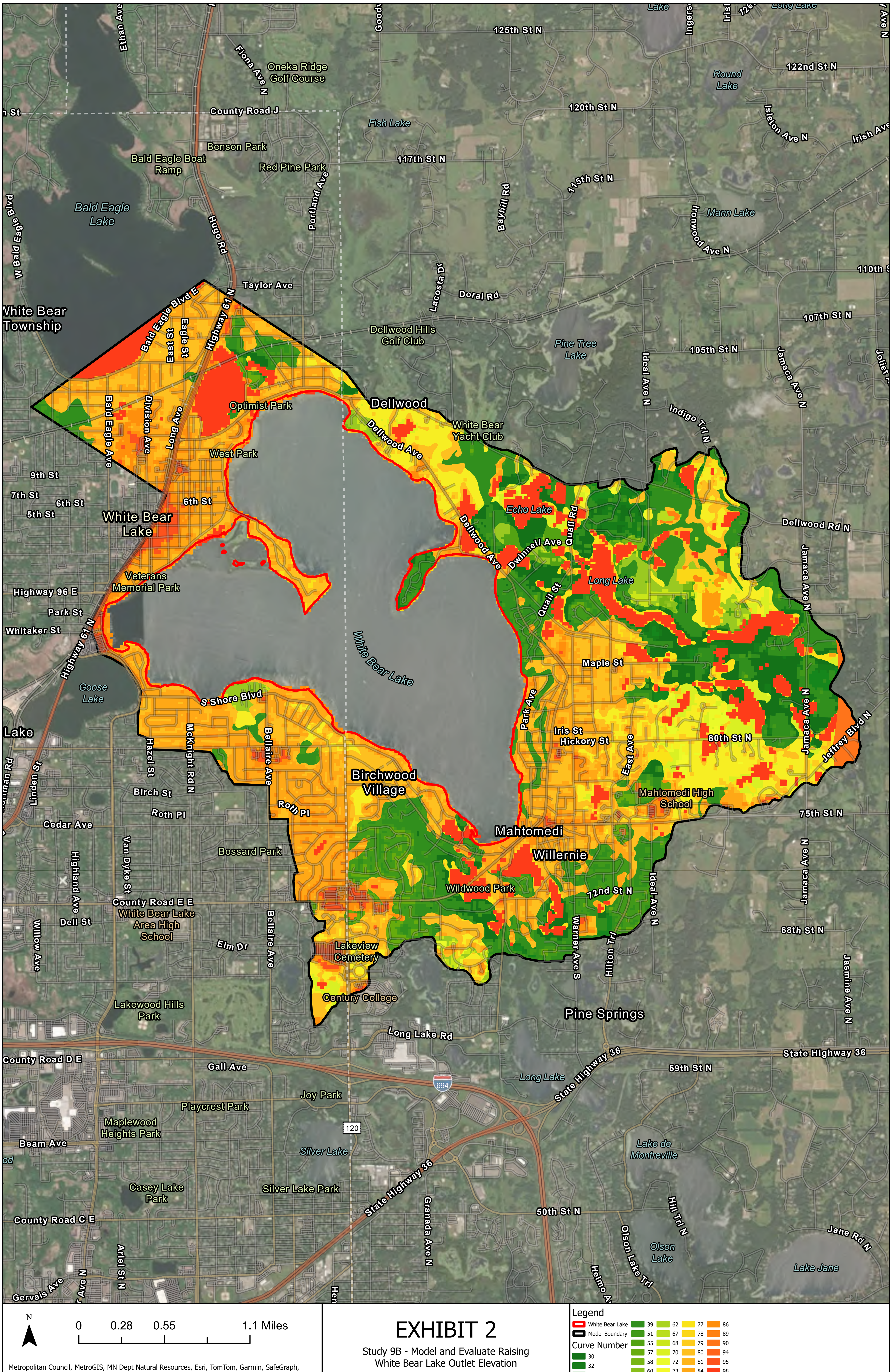
EXHIBIT 1

Study 9B - Model and Evaluate Raising White Bear Lake Outlet Elevation

10/21/2025

Legend

- White Bear Lake
- Model Boundary



Metropolitan Council, MetroGIS, MN Dept Natural Resources, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar

EXHIBIT 2

Study 9B - Model and Evaluate Raising White Bear Lake Outlet Elevation

10/21/2025

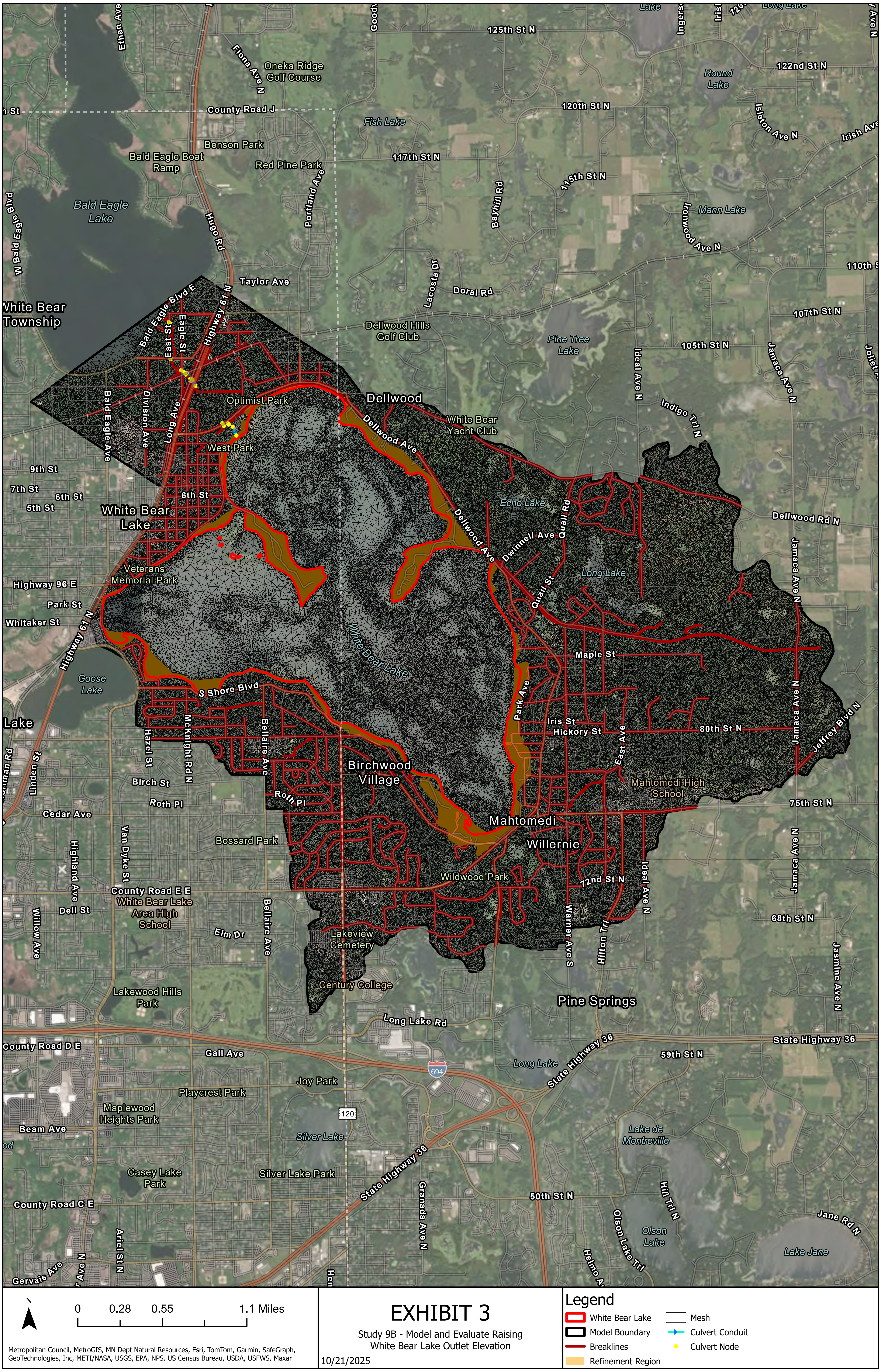


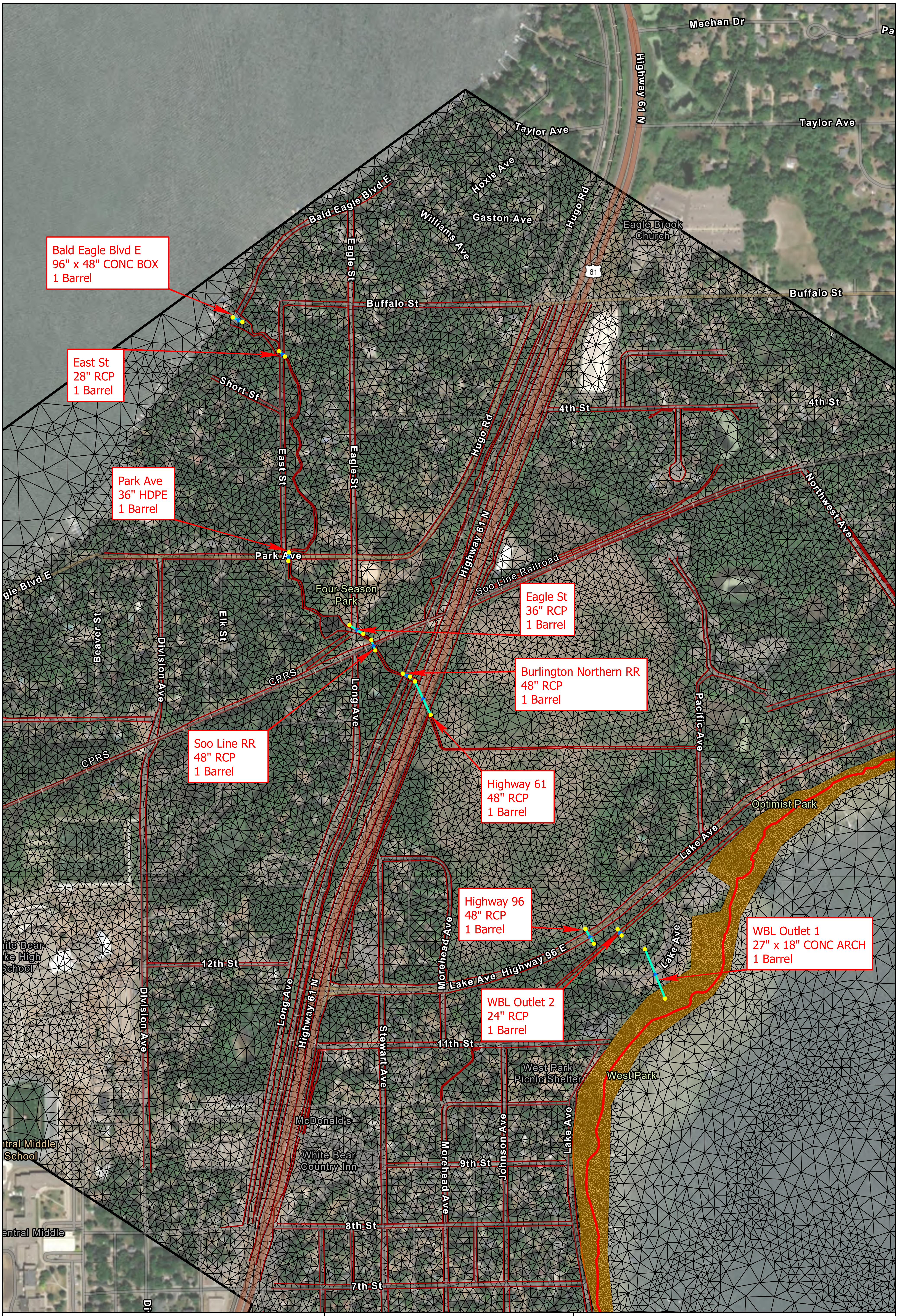
EXHIBIT 3

Study 9B - Model and Evaluate Raising White Bear Lake Outlet Elevation

10/21/2025

Legend

- White Bear Lake
- Model Boundary
- Breaklines
- Refinement Region
- Mesh
- Culvert Conduit
- Culvert Node



N

0 0.05 0.1 0.2 Miles

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EXHIBIT 4

Study 9B - Model and Evaluate Raising White Bear Lake Outlet Elevation

10/21/2025

Legend

- White Bear Lake
- Model Boundary
- Breaklines
- Refinement Region
- Culvert Conduit
- Culvert Node
- Mesh

EXHIBIT 5 - CULVERT SURVEY DATA

LEGEND

- FOUND MONUMENT
- FOUND CAST IRON MONUMENT
- SET MONUMENT MARKED LS XXXXX
- GATE VALVE / HYDRANT
- SANITARY MANHOLE
- CLEAN OUT
- STORM MANHOLE
- STORM CATCH BASIN
- FLARED END SECTION
- TRANSFORMER
- LIGHT
- GUY ANCHOR
- UTILITY POLE
- GUARD POST
- SIGN
- GAS METER
- GAS MANHOLE
- ELECTRIC MANHOLE
- ELECTRIC METER
- TELEPHONE PEDESTAL
- CABLE TV BOX
- COMMUNICATIONS MANHOLE
- 800 × SPOT ELEVATIONS
- DECIDUOUS TREE
- CONIFEROUS TREE
- ## REGULAR PARKING STALL COUNT
- BITUMINOUS SURFACE
- CONCRETE SURFACE
- BOUNDARY LINE
- EASEMENT LINE
- (100.00) DEED DISTANCE
- FEMA FLOOD ZONE LINE
- RIGHT-OF-WAY LINE
- SECTION LINE
- SETBACK LINE
- TIE LINE
- UNDERLYING / ADJACENT LOT
- RESTRICTED ACCESS
- BUILDING CANOPY
- BUILDING LINE
- CONCRETE CURB
- CHAIN LINK FENCE
- WOOD FENCE
- WIRE FENCE
- IRON FENCE
- 902 CONTOUR
- WETLAND LIMITS
- RETAINING WALL
- STONE RETAINING WALL
- POND / WATER LINE
- OVERHEAD WIRE
- SANITARY SEWER LINE
- STORM SEWER LINE
- WATERMAIN
- UNDERGROUND ELECTRIC
- UNDERGROUND GAS LINE
- OVERHEAD ELECTRIC WIRE

SURVEY NOTES

1. The bearing system is based on the Ramsey County coordinate system, NAD83 (2011).
2. The vertical datum is based on NGVD29/NAVD88. The originating bench mark is 6225 A referenced from the MnDOT Geodetic Database.

BENCHMARK #1
6225 A. Elev.=926.04

NORTH

0 300 600
SCALE IN FEET

NO	DATE	BY	CKD	APPR	COMMENT

I hereby certify that this plan, survey, or report was prepared by me or under my direct supervision and that I am a duly Licensed Land Surveyor under the laws of the State of Minnesota.

Print Name: Mark R. Salo

Date 10/03/2025 License # 43933

DATE ISSUED 10/03/2025

DRAWN BY DA
DESIGNED BY DA
CHECKED BY MS
PROJECT NO. 53115

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Engineering | Surveying | Planning | Environmental

TOPOGRAPHIC SURVEY

Kimley-Horn and Associates, Inc.
WATER SUPPLY STUDY
AND TECHNICAL ANALYSES
WHITE BEAR LAKE, MN

SHEET 1 OF 1
REV.

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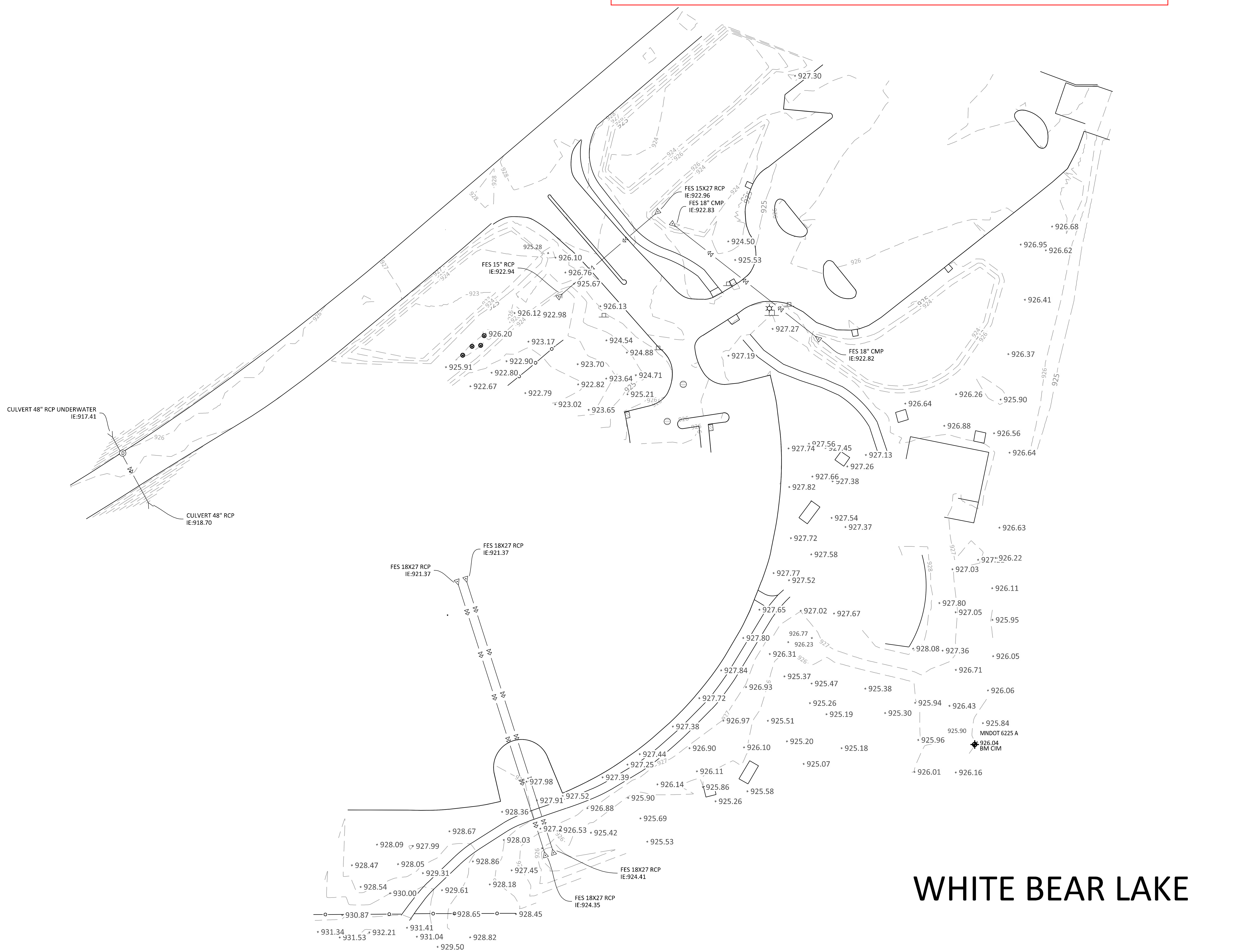
EXHIBIT 6 - TOPOGRAPHIC SURVEY DATA



LEGEND

- FOUND MONUMENT
- FOUND CAST IRON MONUMENT
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- DECIDUOUS TREE
- CONIFEROUS TREE
- ## REGULAR PARKING STALL COUNT
- BITUMINOUS SURFACE
- CONCRETE SURFACE
- BOUNDARY LINE
- EASEMENT LINE
- (100.00) DEED DISTANCE
- FEMA FLOOD ZONE LINE
- RIGHT-OF-WAY LINE
- SECTION LINE
- SETBACK LINE
- TIE LINE
- UNDERLYING / ADJACENT LOT
- RESTRICTED ACCESS
- BUILDING CANOPY
- BUILDING LINE
- CONCRETE CURB
- CHAIN LINK FENCE
- WOOD FENCE
- WIRE FENCE
- IRON FENCE
- 902 CONTOUR
- WETLAND LIMITS
- RETAINING WALL
- STONE RETAINING WALL
- POND / WATER LINE
- OVERHEAD WIRE
- SANITARY SEWER LINE
- STORM SEWER LINE
- WATERMAIN
- UNDERGROUND ELECTRIC
- UNDERGROUND GAS LINE
- OVERHEAD ELECTRIC WIRE

SURVEY NOTES

1. The bearing system is based on the Ramsey County coordinate system, NAD83 (2011).
2. The vertical datum is based on NGVD29/NAVD88. The originating bench mark is 6225 A referenced from the MnDOT Geodetic Database.

BENCHMARK #1
6225 A. Elev.=926.04

NORTH

SCALE 0 60 120 IN FEET

NO	DATE	BY	CKD	APPR	COMMENT

I hereby certify that this plan, survey, or report was prepared by me or under my direct supervision and that I am a duly Licensed Land Surveyor under the laws of the State of Minnesota.

Print Name: Mark R. Salo

Date 10/03/2025 License # 43933

DATE ISSUED 10/03/2025

DRAWN BY DA
DESIGNED BY DA
CHECKED BY MS
PROJECT NO. 53115

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TOPOGRAPHIC SURVEY

Kimley-Horn and Associates, Inc.
WATER SUPPLY STUDY
AND TECHNICAL ANALYSES
WHITE BEAR LAKE, MN

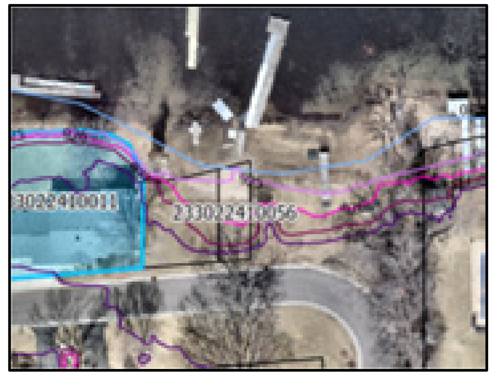
SHEET 1 OF 1
REV.

24.1S (LMS TECH) | DAVID ANDERSON | 10/6/2025 10:11:38 AM
L:\PROJECTS\53115\CAD\SURVEY\53115 SRVBASE.DWG:1

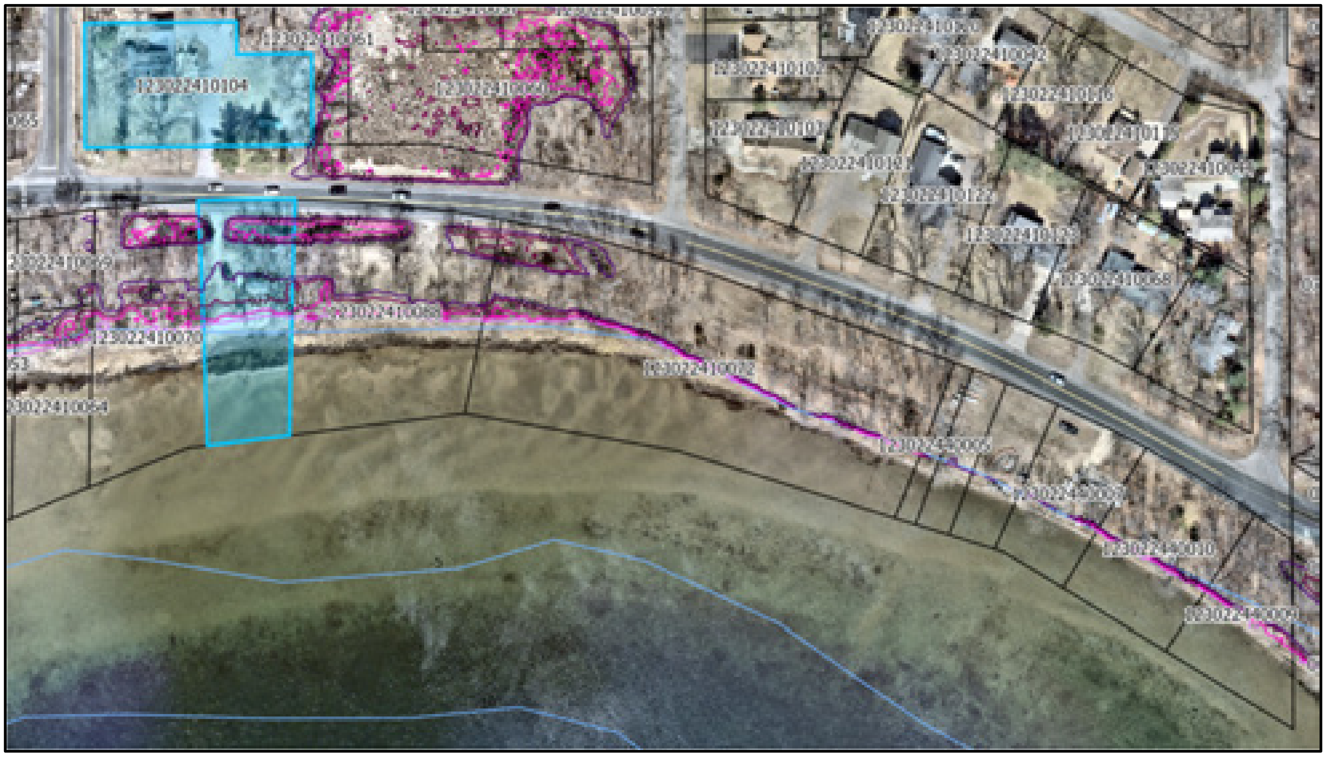
Exhibit 7 – Potential Parcel Impact Loss

High Impact - 40% Potential Parcel Access Loss

*Parcel loss assumes area below elevation 926.0

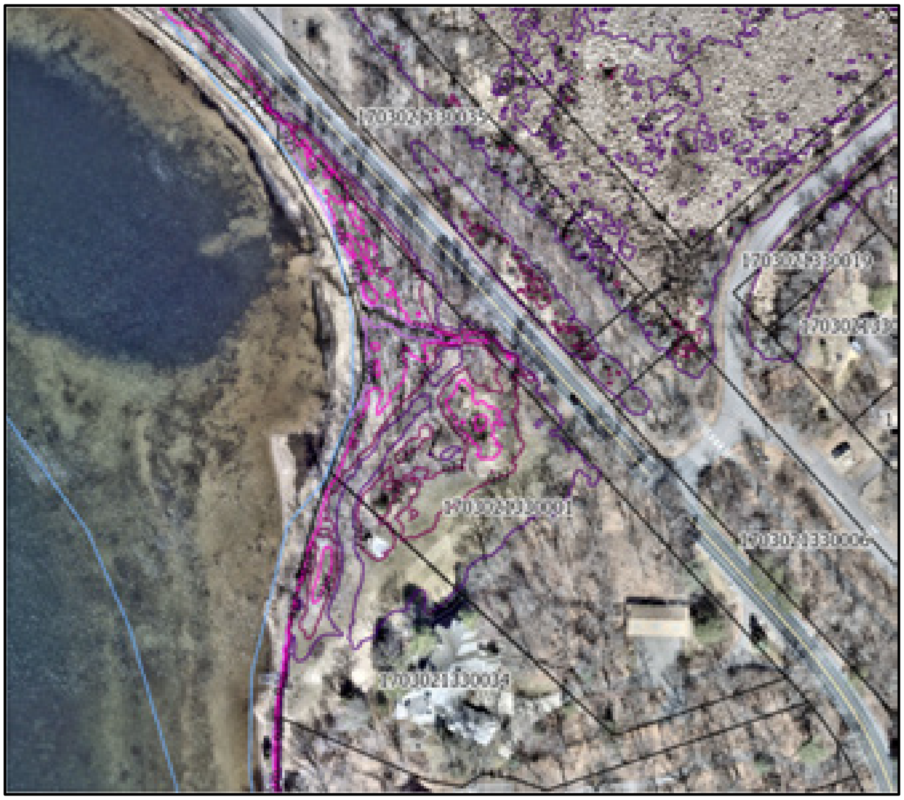


*Parcel loss assumes area below elevation 926.0



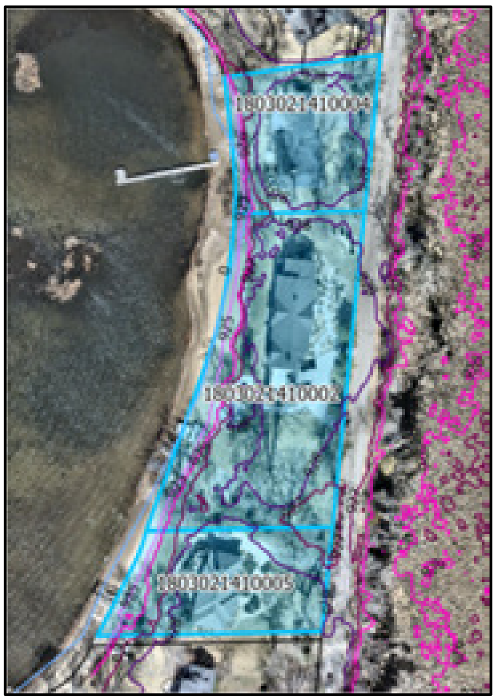
*Parcel loss assumes area below elevation 926.0

Moderate Impact - 15-40% Potential Parcel Access Loss



*Parcel loss assumes area below elevation 926.0

Low Impact - 5-15% Potential Parcel Access Loss



*Parcel loss assumes area below elevation 926.0